ADDENDUM DAMAGE ASSESSMENT PLAN FOR SOUTHEAST MISSOURI LEAD MINING DISTRICT: MADISON COUNTY MINES SITE

May 2015

Prepared for:

State of Missouri
Missouri Department of Natural Resources

U.S. Fish and Wildlife Service
U.S. Department of the Interior

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EXECUTIVE SUMMARY

Mining and smelting sites within Madison County in Missouri are located within the Southeast Missouri Lead Mining District (SEMOLMD), an area that was mined extensively for lead and zinc for more than a century. As a result of this mining and related activities, large amounts of metals including cadmium, lead, zinc, and nickel were released and are continuing to be released into Missouri's environment. Cadmium, lead, zinc, and other metals associated with mining are potentially toxic to a wide variety of plants and animals.

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and implementing regulations, the Director of the Department of Natural Resources (MDNR) and the U.S. Department of the Interior (DOI) are Trustees for natural resources in the Madison County Mines Site (MCM). 40 C.F.R. § 300.600 and § 300.605. Natural resources over which MDNR exercises trusteeship include surface waters (rivers, lakes, streams, etc.), ground water, soils, air, plants, and animals; DOI has trusteeship for natural resources managed or controlled by the DOI, including migratory birds and endangered species, and their supporting ecosystems. As Trustees, the State of Missouri and DOI act on behalf of the public for these resources affected by the MCM Site and have the authority to assess whether the resources and their services have been injured as a result of release(s) of hazardous substances. (See generally 43 C.F.R Part 11) Injuries to natural resources can occur if the resources are exposed for some time period to concentrations of hazardous substances that are high enough to cause specific adverse effects. For example, injuries can occur if lead and/or zinc concentrations in surface waters are so high that relevant water quality criteria are exceeded. Plants and animals are injured if they die, cannot reproduce normally, become sick or are otherwise negatively affected as defined under relevant laws and regulations. 43 C.F.R. § 11.62.

If the Trustees determine that release(s) of hazardous substances have injured natural resources, the Trustees may pursue compensation (damages) to restore, rehabilitate, replace, or acquire the equivalent of the injured natural resources and their services. The Trustees collect compensation from the party or parties determined to be legally responsible for the releases, referred to as potentially responsible parties (PRPs). The Trustees then use the compensation (typically money) recovered to restore, rehabilitate, replace or acquire the equivalent of the injured natural resources. 42 U.S.C. § 9611(i).

The processes through which the Trustees evaluate injuries to natural resources associated with the release(s) of hazardous substances, determine appropriate compensation for those injuries and plan and implement restoration is called natural resource damage assessment and restoration (NRDAR). DOI promulgated and published NRDAR regulations which implement the natural resource damages provisions in the CERCLA. 43 C.F.R. Part 11. These CERCLA NRDAR regulations provide procedures by which trustees can identify natural resource injuries, quantify those injuries, determine appropriate damages for the injured resources and the services they provide, and restore those injured resources. The NRDAR process includes a number of different phases, specifically:

- Pre-assessment
- Assessment planning

- Assessment
- Post-Assessment Planning and Implementation

The Fish and Wildlife Service (FWS), on behalf of DOI, and the State of Missouri have been pursuing NRDAR for portions of the SEMOLMD: Big River Mine Tailings Site and the Viburnum Trend. In July 2014, the Trustees completed the Pre-Assessment Phase for the Madison County Mines Site, which culminated in a Pre-Assessment Screen (PAS) and Determination (MDNR and DOI 2014). In the PAS, in accordance with applicable regulations, the Trustees concluded that further investigation and assessment of natural resource injuries and damages were warranted at the Madison County Mines Site. (43 C.F.R §§11.24 and 11.25).

The Trustees are in the assessment planning phase of NRDAR. (43 C.F.R §§ 11.30 – 11.38). The purpose of an Assessment Plan "is to ensure that the [natural resource damages] assessment is performed in a planned and systematic manner and that methodologies selected for the Injury Determination, Quantification, and Damage Determination phases, can be conducted at a reasonable cost." (43 C.F.R. § 11.30). In 2009, the Trustees released a Phase I Natural Resource Damage Assessment Plan (DAP) for a portion of the SEMOLMD that included the Big River Mine Tailings Site and the Viburnum Trend[1].

This document will serve as an addendum to the earlier DAP and will serve to incorporate the Madison County Mines (MCM) Site into the SEMOLMD DAP. The Addendum describes the affected natural resources in the MCM Site and the activities and studies that the Trustees currently intend to pursue in the MCM Site assessment (see Exhibit ES-1).

Both the Addendum and the DAP are living documents and continually will be developed and refined as the NRDAR progresses and additional information becomes available.[2] Potential changes to this Addendum may include the addition of new studies and/or the modification of the planned studies identified in this document as well as other documents prepared by the Trustees during the NRDAR process, such as a Restoration Compensation and Determination Plan.

At this time, the Trustees' assessment activities are focused on four resources: surface water, geological, groundwater, and biotic resources. Assessment activities will include comparing site specific data collected from previous investigations to literature benchmarks such as aquatic life criteria, sediment quality guidelines, ecological toxicological benchmarks for soil, maximum contaminant levels for drinking water, in order to determine if there are exceedances constituting injury. In addition, the Trustees plan to conduct site specific studies. Specific studies anticipated to date include transition zone soil characterization, songbird exposure investigations, and crayfish population and in-situ toxicity studies. A draft of the crayfish population and in-situ

[1]See http://www.fws.gov/midwest/es/ec/nrda/SEMONRDA/documents/finalapsemomdphase11-7-09.pdf for Final Phase I Damage Assessment Plan for Southeast Missouri Lead Mining District: Big River Mine Tailings Superfund Site, St. Francois County and Viburnum Trend Sites, Reynolds, Crawford, Washington, and Iron Counties.

[2]The CERCLA NRDAR regulations allow an Assessment Plan to "be modified at any stage of the assessment as new information becomes available." 43 CFR §11.32(e).

toxicity study plan is appended to this Addendum. Drafts of plans for other studies will be made available to the public for review and comment as they are developed.

The opinions, suggestions, and other input of the public are important factors that the Trustees consider when making decisions during the course of a NRDAR. A number of documents produced during the course of the NRDAR will be released to the public for review and comment. Specific anticipated opportunities for public involvement include commenting on this Addendum, assessment work plans, and any restoration plans. Each public comment period will last for at least 30 days. Comments may be submitted in writing to one or both of the addresses below.

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The Trustees also recognize the special interests of Madison County landowners. Much of the land is privately held and conducting some of the assessment activities described in this Addendum will require access to private properties. The Trustees understand that this access is dependent upon the permission of the landowners and will work with landowners to secure the needed permissions before beginning any fieldwork activities.

The complete list of companies that mined at the MCM Site over the years is extensive; some no longer exist due to bankruptcy, dissolution, buyouts, mergers or similar corporate events. A list of companies that engaged in mining and/or mining-related activities at OU-2 releasing hazardous substances into the MCM environment, or activities that exacerbated the situation include: Anschutz Mining Corporation and NL Industries Inc. The Trustees may identify other PRPs in the course of pursuing this NRDAR.

In 2009 the Trustees received compensation for injuries to natural resources and the services they provide at the Little St. Francis River Chat Pile and Catherine Mine under the ASARCO Bankruptcy settlement.

In accordance with the CERCLA NRDAR regulations, in July 2013, the Trustees sent the identified PRPs a Notice of the Intent to Perform an Assessment, along with a copy of the a PAS,

and invited them to participate in a cooperative assessment (43 C.F.R. § 11.32(a)(2)(iii)(A)). If the Trustees reach an agreement with any or all of the identified PRPs to conduct a cooperative assessment, the Addendum will be updated to reflect that relationship and describe any updates or modification in assessment activities. The revised Addendum will be made available for public comment and review. As the MCM Site NRDAR progresses, the Trustees retain the right to participate in cooperative assessment activities with one or more PRPs at any time.

Exhibit ES-1: Assessment Activities for Madison County Mines Site NRDAR

NATURAL RESOURCE(S)	STUDY	STATUS
INJURY DETERMINATION AND QUANTIFICATION		
Terrestrial Habitat and Geologic Resources	Soil metal characterization in transition zones near mine and mill sites	Potential
Aquatic Biota	Crayfish population and toxicity	Planned
Terrestrial Biota	Small Mammals	Potential
Terrestrial Biota	Songbird Exposure	Potential
Ground Water	Exceedances of Regulatory Standards	Potential
Geologic Resources	Exceedances of Literature-Based Impact Thresholds	Planned
PATHWAY DETERMINATION		
All	Fate and Transport	Planned
DAMAGES DETERMINATION		
Aquatic Habitat	Primary Restoration Estimate	Post injury studies
Terrestrial Habitat	Primary Restoration Estimate	Post injury studies
Terrestrial Habitat	Habitat Equivalency Analysis	Post injury studies
Ground Water	Replacement Cost Estimation	Potential

The public can learn more about the MCM Site NRDAR by visiting the website:
http://www.dnr.mo.gov/env/hwp/sfund/nrda.htm
and/or
http://www.fws.gov/midwest/semonrda

CHAPTER 1 INTRODUCTION

The Madison County Mines Site is a subdistrict of the Southeast Missouri Lead Mining District (SEMOLMD). The SEMOLMD is a large area of historic and current lead and other heavy metals mining that is comprised of two main subdistricts: the Old Lead Belt and the Viburnum Trend (also known as the New Lead Belt). (See Exhibit 1 for a map of SEMOLMD.) The Phase I Natural Resource Damage Assessment Plan (DAP) described proposed natural resource damage assessment activities within the SEMOLMD at the Big River Mine Tailings Site and the Viburnum Trend. This document will serve as an addendum to the DAP and will incorporate the Madison County Mines Site into the assessment activities underway in the greater SEMOLMD natural resource damage assessment and restoration (NRDAR). The Madison County Mines (MCM) Site is described in more detail in Sections 1.1 and 1.2.

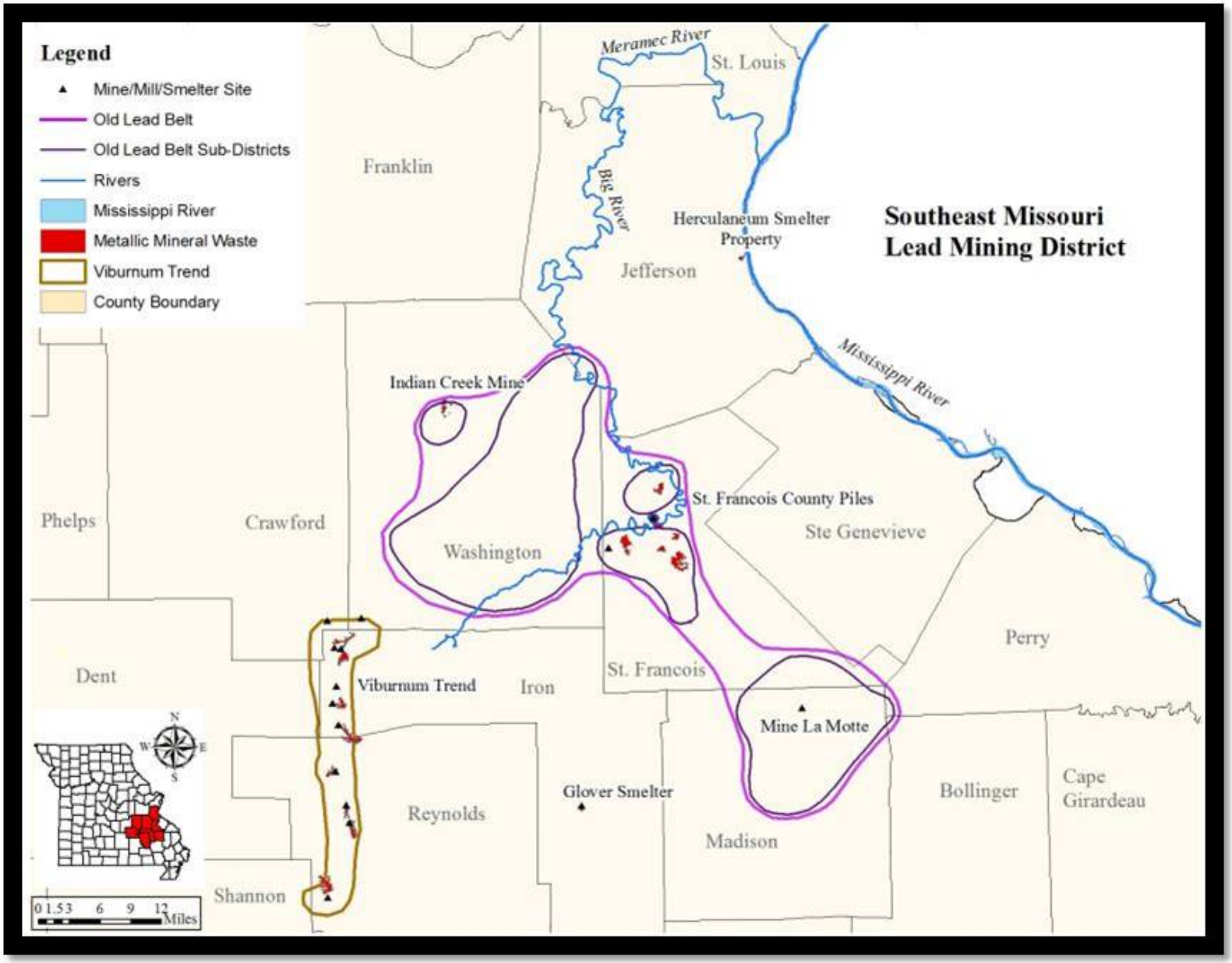
The Old Lead Belt is located approximately 60 miles south – southwest of St. Louis and includes, in addition to St. Francois County, parts of Jefferson, Franklin, Washington, Madison, Perry, and St. Genevieve Counties. The Madison County mining area is sometimes referred to as a separate sub-district from the rest of the Old Lead Belt in St. Francois County due to some distinctions in mineralogy and geology. For purposes of this NRDAR document, we have included Madison County into the Old Lead Belt. The Old Lead Belt lies on the eastern edge of the Ozark Uplift, characterized by rolling hills dissected by narrow floodplain, creek, and river valleys.

NRDAR, as set forth in the CERCLA NRDAR regulations, (43 C.F.R. Part 11) is designed to be an iterative process, meaning data is collected and evaluated and the plans for assessment activities can be added to or revised over time. Likewise, an assessment plan is a living document, and as previously mentioned, may be modified or amended as the extent of injury is evaluated and new NRDAR needs identified. See the Final Phase I Damage Assessment Plan for Southeast Missouri Lead Mining District: Big River Mine Tailings Superfund Site, St. Francois County and Viburnum Trend Sites, Reynolds, Crawford, Washington, and Iron Counties (Mosby et al. 2009) which provides an overview of the NRDAR process. (http://www.fws.gov/midwest/es/ec/nrda/SEMONRDA/documents/finalapsemomdphase11-7-09.pdf)

1.1 MADISON COUNTY MINES SITE DESCRIPTION

The Madison County Mines Superfund Site is located near Fredericktown, Missouri at the southern end of the Old Lead Belt Mining District of Southeast Missouri on the southeastern edge of the Ozark Uplift in Missouri. The principal drainage system for the Madison County Mines Site is the south flowing Little St. Francis River and its tributaries.

Exhibit 1: Map of the Southeast Missouri Lead Mining District



The Madison County Mines Superfund Site contains six operable units (See Exhibit 2).

- OU1 – Northern Madison County Unit, including Mine La Motte Recreational Area (MLMRA), Harmony Lake, Copper Mines (also known as Basler Mines), Lindsey Mine, Offset Mine, and Old Jack Mine
- OU2 – Anschutz Subsite, including A, B, C, D, and E Tailings Areas (historically known as Madison Mine)
- OU3 – Madison-Wide Residential
- OU4 – Conrad Tailings and Ruth Mine
- OU5 – Catherine Mines, Skaggs Piles, the Little St. Francois River Subsite (LSFR), and the transect of the overhead tram from the Skaggs subsite to the LSFR subsite.
- OU6 – Hickory Nut Mines and Silver Mines
- OU7 – Little St. Francis River Watershed

The MCM PAS addressed three of the major mine, mill, and/or smelter sites in the Madison County Mines Superfund Site where potentially responsible parties (PRPs) may have NRDAR liability. The Trustees will be focusing assessment efforts on Operable Unit 2, which includes the Anschutz Subsite for NRDAR. Streams draining OU2 include Little St. Francis River, Spiva Branch, ,Goose Creek, Tollar Branch, Saline Creek, and possibly other named and unnamed tributaries to the Little St. Francis River. Please see Appendix A for a map of OU2.

1.1.1 Response Activities at the MCM Superfund Site

The MCM was placed on the National Priorities List under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 2003. A variety of actions have been taken at the MCM Superfund Site by the U.S. Environmental Protection Agency (EPA); some under agreements with PRPs, some under remedial authorities pursuant to Records of Decision, and some as fund-lead under EPA's removal authority. The removal actions have focused on excavating contaminated residential yards and supplying bottled water to residents with contaminated wells. Hundreds of residential yards are potentially contaminated from mill waste transport and erosion within the MCM Superfund Site. The majority of the Anschutz Tailings (historically known as Madison Mine) property in OU2 was stabilized and capped under an agreement with EPA. Records of Decision have been filed for OU3 (residential properties, which included the Little St. Francis River subsite), OU4 (Conrad Tailings), and OU5 (Catherine/Skaggs Piles).

Exhibit 2: Map of Madison County Mines Superfund Site

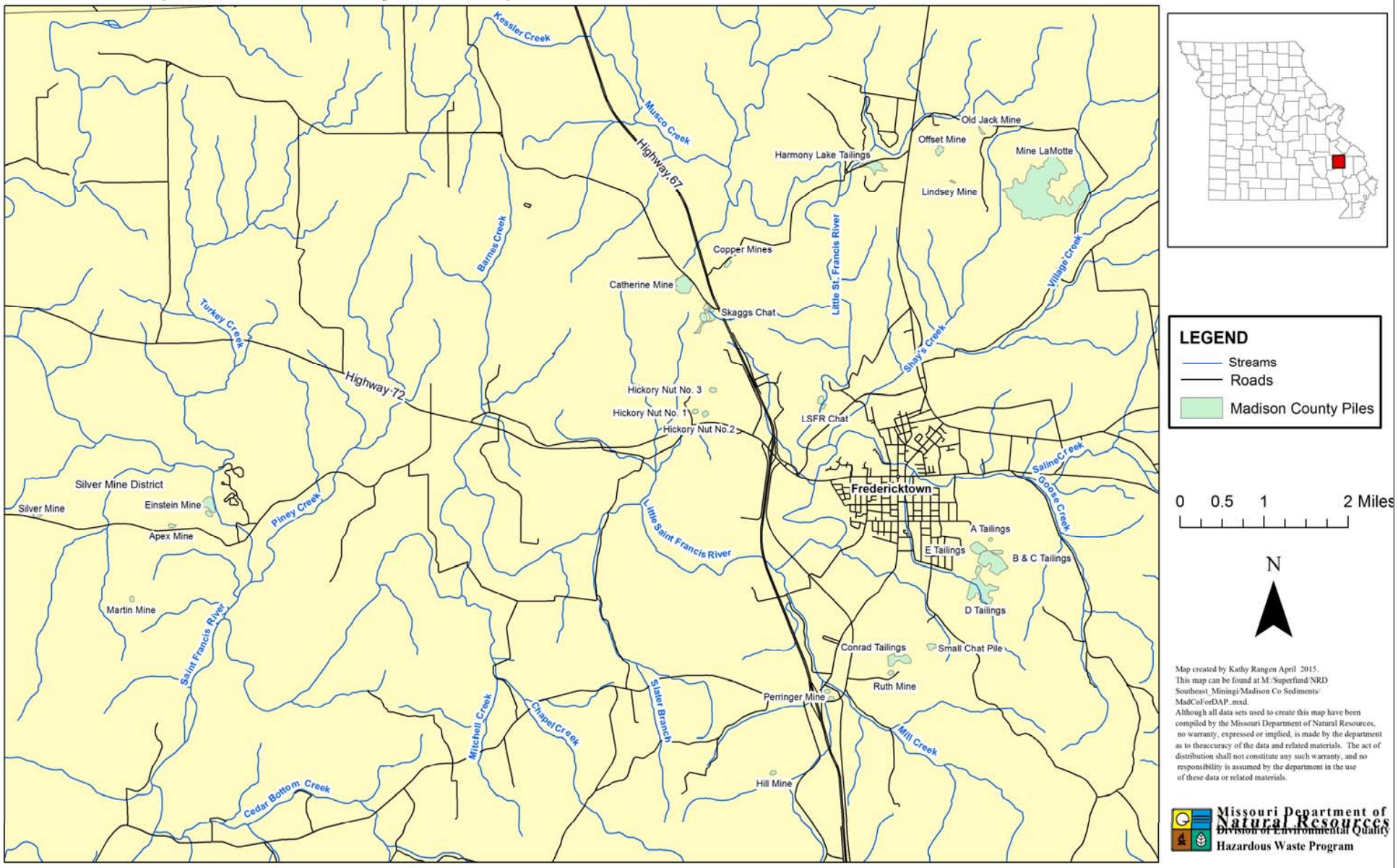


Exhibit 3: Tailings and Chat Distribution in the MCM Site

Site	Estimated Tailings/Chat Acreage	Estimated Transition Zone Acreage	Total Acreage
OU2 (Madison Mine) (Total	146	118	265
- A Tailings	3	8	11
- B Tailings	4	9	13
- C Tailings	44	28	72
- D Tailings	70	49	119
- E Tailings	18	15	33
- Small Chat Pile	7	9	16

* Mine wastes no longer visible from aerial photography.

There is also an area-wide remedial investigation (RI) that characterizes the nature and extent of contamination on and away from the piles that was written in 2008. As part of that RI, an Ecological Risk Assessment (ERA) for OU3 was completed by the EPA in 2006. Since then a Supplemental Remedial Investigation/Focused Feasibility Study (RI/FS) was initiated in 2011 for OUs 1, 2, 3, 5 and 6. The RI/FS for OUs 1, 2 and 6 remain in draft form while the others have been completed. This includes the supplemental ERA for OUs 1, 2 and 6.

The supplemental ERA found adverse impacts to terrestrial and aquatic habitat from mining activities throughout the MCM Site. The ERA indicated that the MLMRA Slime Pond, the wetland at Copper Mines and the Met Pond on the Anschutz Site all pose an acute and chronic toxicity risk to benthos. There is also clear evidence of phytotoxicity to terrestrial plants in mine waste areas. Hazard quotient (HQ) analyses of herbivores (>100) show a high likelihood of toxic effects from mining activities at the Old Jack Mine and Anschutz Site. Terrestrial vermivores show the same risk (HQ >100) for metals toxicity at the Copper Mines Tailings Area and the Old Jack Mine.

Exhibit 4: Chronology of CERCLA Activities at the MCM Site Compiled by EPA in a 2013- 5 Year Review.

Event or Activity	Date
Missouri Department of Conservation Investigation of Flood Event	1980
MDNR Preliminary Assessment of Presence of Hazardous Waste	July 1983
MDNR Preliminary Assessment/Site Investigation	February 1986
Site Characterization Report	1990
Final Expanded Site Inspection Report	July 1995
Administrative Order on Consent for Site Characterization	March 1999
Final Report on PRP Search	January 2000
Administrative Order on Consent for Harmony Lake Removal Action	June 2000
Removal Action on Harmony Lake	September 2000
Administrative Order on Consent for Removal Action at Harmony Lake	November 2000

PRP Characterization Summary-Draft Report	November 2000
Madison County Health Department Request for EPA Assistance	June 2002
Unilateral Administrative Order on Consent for Removal Response Activities	August 2002
Removal Action-Fredericktown Farm Supply	August 2002
Removal Assessment-Madison Mine/Fredericktown	August 2002
Removal Action- Madison Mine/Fredericktown	March 2003
Administrative Order on Consent for Removal Site Investigation	June 2003
Site Listing to the National Priority List	September 2003
Removal Assessment Summary Report	February 2003
Removal Action Madison County Mines	August 2004
ASTDR Public Health Assessment	April 2005
Feasibility Study	July 2005
Ecological Risk Assessment	May 2006
Removal Action Summary-Madison County Mines	April 2007
Final Baseline Human Health Risk Assessment	July 2007
Final Area-Wide Remedial Investigation Report	April 2008
Removal Action Summary Report-Fredericktown	June 2008
Interim Record of Decision OU3-Residential Soils	February 2009
RA Start OU1-Resdential Soils	February 2009
Feasibility Study OU4-Conrad Tailings	May 2011
Record of Decision OU4-Conrad Tailings	September 2011
Feasibility Study OU5-Catherine Mine and Skaggs Tailings	June 2012
Record of Decision OU5- Catherine Mine and Skaggs Tailings	September 2012
Remedial Design-OU4-Conrad Tailings	September 2012

1.2 NATURAL RESOURCE DAMAGE ASSESSMENT ACTIVITIES AT MCM SITE

The Trustees have completed the Pre-Assessment Phase for the MCM Site NRDAR. The main product of the pre-assessment phase is the MCM Site PAS, which was issued in June 2014.[3] In the PAS, the Trustees confirmed the following:

(a) Heavy metals have been and are being released into the environment;
(b) Natural resources have been adversely affected by these releases;
(c) Contaminant concentrations are sufficient to injure natural resources;
(d) The data needed to conduct NRDAR are available or can be obtained at a reasonable cost; and
(e) Completed or planned response actions would neither completely restore the injured natural resources nor compensate the public for the injuries.

[3] The PAS is available at: http://www.dnr.mo.gov/env/hwp/sfund/nrda.html and http://www.fws.gov/midwest/semonrda

Based on these criteria, the Trustees decided to pursue additional NRDAR activities. To that end, the Trustees developed this Addendum to the DAP as the assessment plan for the MCM Site. This Addendum describes activities that will collect and generate information for determining the nature and extent of natural resources injuries and contaminant pathways.

This Addendum summarizes Chapter 2 (Background) from the Assessment Plan. More specifically this Addendum discusses the MCM Site's natural resources; identifies the primary hazardous substances of concern; and describes the processes that resulted in the releases of the hazardous substances to the sites and surrounding areas. The remaining portions of the Assessment Plan, as listed/described below are not covered in this document to prevent unnecessary duplication. The information in those chapters can be found in the original Assessment Plan, which can be found at the link given in footnote 2.

- Chapter 3 (Role of Trustees) identifies the Trustees, describes the nature of their trusteeship, and provides an overview of the NRDAR process that the Trustees plan to follow.
- Chapter 4 (The Southeast Missouri Lead Mining District NRDAR) provides an overview of studies proposed at the time the DAP was written (2009). This Addendum provides an overview of proposed or contemplated studies for MCM Site only.
- Chapter 5 (Quality Assurance Management) establishes the general procedures used in developing project-specific quality assurance plans.

CHAPTER 2 AFFECTED NATURAL RESOURCES AT AND FROM THE MADISON COUNTY MINES SITE

The MCM Site supports a variety of natural resources potentially affected by mining-related contamination, including rivers and lakes, ground water, terrestrial and aquatic organisms, and geologic/terrestrial resources. As described in the Final Pre-Assessment Screen and Determination for Madison County Mines Site, Madison County, Missouri (USFWS and MDNR 2014), these habitats support a wide variety of fish, birds, and other wildlife. A number of species present in the area are included on state or federal threatened and endangered species lists or are otherwise of special concern. The following paragraphs briefly summarize key features of the assessment area's natural resources, including what makes the area unique and the threat posed to these resources by mining-related contamination.

2.1 SURFACE WATER RESOURCES: RIVERS AND STREAMS

Surface water resources are defined as "the waters of the United States, including the sediments suspended in water or lying on the bank, bed, or shoreline" (43 C.F.R. §11.14(pp)). Exhibits 8 through 12 (in the SEMOLMD DAP) and the following paragraphs summarize key information about the area's surface water resources, including a brief description of each river or creek, biota supported by each waterway, and potential contamination.

The MCM contains numerous Ozark streams, all tributaries to the St. Francis River. Ozark-type streams are typically characterized as clear, with good water quality, high hardness, moderate gradient, gravel and bed-rock dominated, with riffle-pool complexes. Higher order Ozark streams are typically spring-fed and are dominated by groundwater recharge at low flow.

2.1.1 St. Francis River and Tributaries Surface Water

As discussed in the PAS (USFWS and MDNR 2014), the principal drainage system for MCM Site is the Little St. Francis River and its tributaries. EPA conducted surface water sampling in the Little St. Francis River and its tributaries in 2006. The National Ambient Water Quality Criteria (NAWQC) for Cd, Copper (Cu), Ni, Pb and Zn was calculated using site specific hardness data collected from the water sample. Maximum concentrations of dissolved Pb (21.5 µg/l) in Sweetwater Branch exceeded the chronic NAWQC for Pb (4 µg/l). Dissolved Cu (25.3 µg/l) from Spiva Branch exceeded the chronic NAWQC for Cu (7 µg/l) and the chronic NAWQC for Ni (113 µg/l) was also exceeded with dissolved Ni (3480 µg/l) from an unnamed creek on the north end of the Anschutz Property.

Additionally, the MDNR listed 1.7 miles of Saline Creek, a tributary of the Little St. Francis River that flows through mine impacted areas, as impaired or potentially impaired in the state's water quality report (Section 305(b) of the Clean Water Act), but it was not approved for the state impaired waters (Section 303(d) of the Clean Water Act), which is approved by the Missouri Clean Water Commission after a total maximum daily load (TMDL) is completed. Saline Creek was listed because of dissolved Ni.

Sediment samples collected in the MCM Site had maximum concentrations of Cd at 34.6 mg/kg, Cu at 10,100 mg/kg, Ni at 5700 mg/kg, Pb at 13,000 mg/kg, and Zn at 2900 mg/kg (Appendix A, Table 3 in SEMOLMD DAP). The highest concentration of Pb was found in sediment in the Little St. Francis River near the Little St. Francis River Chat pile, and the highest concentrations of Cd, Cu and Ni from the Tollar Branch on the Anschutz Property (EPA 2011a).

The 2011 ERA found sediment samples analyzed from tributaries to the Little St. Francis River to have metal concentrations that could adversely impact aquatic life communities. Based on sampling conducted by Environmental Strategies Corporation in 2000, the Little St. Francis River has at least 4 miles of contaminated sediment which exceed the Probable Effect Concentration(PECs) for Pb from the confluence of Logtown Branch to just below the confluence of Sweetwater Branch. A sample taken approximately 0.2 miles below City Lake was also above the PEC for Pb. Many of the tributaries to the Little St. Francis River were also above the PECs for Pb, Cd, Cu, and/or Ni including 1.4 miles of Sweetwater Branch (above and below Mine La Motte Lake), approximately 1 mile of Village Creek, and 6.6 miles of Shays Creek (above and below Slime Pond). MDNR sampling of Saline Creek below the confluence of an un-named tributary that drains the A tailings pond at the Anschutz mine exceeded the PEC for Pb and Ni.

MacDonald et al. (2000) identified consensus-based freshwater sediment quality guidelines: the Probable Effect Concentrations (PECs) and Threshold Effect Concentrations (TECs). PECs represent concentrations of contaminants above which adverse effects on sediment-dwelling organisms are expected to occur frequently. TECs represent concentrations of contaminants in

sediment below which adverse effects on sediment-dwelling organisms are expected to occur infrequently. The TEC and PEC values for cadmium, lead and zinc and copper and nickel appear below in Exhibit 5.

Exhibit 5: TEC and PEC Values for Mining-Related Metals

Contaminant	TEC Value ppm	PEC Value ppm
Cadmium	0.99	4.98
Lead	35.8	128
Zinc	121	459
Copper	31.6	149
Nickel	22.7	48.6

2.2 GEOLOGIC RESOURCES

In the context of a natural resource damage assessment, geologic resources are defined as "those elements of the Earth's crust such as soils, sediments, rocks, and minerals, including petroleum and natural gas, that are not included in the definitions of ground [water] and surface water resources" (43 C.F.R. §11.14(s)).

Exhibit 6: Potentially Impacted Water Bodies

OU	WATERBODY	IMPAIRMENT/REASON
OU1/OU2	Little St. Francois River	Pb/Missouri 303(d); Above PEC for Pb in sediments using Freshwater Sediment Quality Guidelines (MacDonald et al 2000)
OU2 Madison (Anschutz) Mine	Saline Creek	Dissolved Ni/Section 305(b) of Clean Water Act (EPA 2014)
OU2 Madison (Anschutz) Mine	Tollar Branch	Likely heavy metal sediment contamination due to proximity to mining operations and tailings pile.
OU2 Madison (Anschutz) Mine	Goose Creek	Habitat degradation/ Section 305(b) of Clean Water Act
OU2 Madison (Anschutz) Mine	Spiva Branch	Dissolved Cu and Ni/ National Ambient Water Quality Criteria (NAWQC)

In its natural state, the area's soils support diverse ecosystems, such as oak savanna and deciduous woodland. However, many geologic resources within the Missouri SEMOLMD are either currently covered by mine waste piles or fall within the footprints of former piles. Heavy

metals from mine, mill, and smelter wastes can be toxic to soil microbes and reduce the ability of a soil to function in a normal and productive way (Mosby et al. 2009).

Madison County is subdivided into the St. Francois Mountains on the western side and the Salem Plateau on the eastern side of the county. Topographically, the St. Francois Mountains comprise a geologically mature landscape with rounded ridges and meandering streams that occupy comparatively wide valleys. In a few locations, rivers and streams cut across ridges, forming steep canyons (EPA 2014).

Much of the Site is underlain by Paleozoic (Cambrian) sedimentary rocks that rest on Precambrian crystalline rocks or basement complex which form the St. Francois Mountains. The sedimentary formations vary in thickness and locally thin out or pinch out against structural highs of the basement complex (St. Francois Mountains). The rock formations present in the area include the following from the Precambrian basement: (1) the Lamotte Sandstone, (2) the Bonneterre Dolomite, (3) the Davis Formation, and (4) the Derby-Doe Run Dolomite. Soil formed from these formations is predominantly clays with comparatively low permeability. Soil profiles and horizons are generally well developed (EPA 2014).

Most lead mineralization in the Madison County area occurs within the lower part of the Bonneterre Dolomite on the flanks of buried or exposed Precambrian topographic highs, generally within a few hundred feet of the boundary where the underlying Lamotte Sandstone pinches out. Lead ore, primarily in the mineral galena, and other metallic minerals occur as deposits that have replaced dolomite crystals in portions of the Bonneterre Dolomite. The ore occurs in horizontal sheets along bedding planes, cavity fillings and linings on the walls of joints and fractures. The deposits extend laterally for hundreds of feet and may extend 200 feet vertically. However, mineralization in the Silver Mines area is distinct, consisting of quartz veins in the Precambrian basement complex that contain galena, wolframite (iron tungstate) and additional sulfide minerals as primary ore phases for additional metals such as tungsten and silver (EPA 2011).

2.3 GROUND WATER

Groundwater is described as occurring both within unconsolidated overburden soils and bedrock. Groundwater within the overburden materials is less abundant than in the bedrock due to the generally low permeability and thin character of the local soils. Two main aquifers are identified in the area: the Bonneterre Transition Zone and the Davis Formation/Whetstone Creek member (Dames & Moore 1990). These two aquifers are separated by the Lower Bonneterre Formation which serves as an aquitard or confining bed that impedes the exchange of water between the two aquifers.

The Bonneterre Transition Zone is mudstone that grades downward into dolomitic sand. The sand has an estimated hydraulic conductivity on the order of 3.1 feet per day. The Whetstone Creek Member is a medium- to coarse-grained crystalline dolomite with interbedded gray and green shales. This unit is locally a major source of groundwater and is considered to be a more significant water-bearing unit in the area due to its higher hydraulic conductivity estimated at 11 feet per day. Groundwater flow within the region is poorly defined, but under natural or

undisturbed conditions is projected to follow the overall topographic gradients. Flow within both unconsolidated overburden and bedrock is expected to be from upland areas to lower topographic areas such as along the major drainage courses. Mine workings, including open and collapsed stopes, tunnels and rooms, are expected to locally alter groundwater flow. Rates of groundwater flow are unknown but expected to be potentially high based on the aggregate pumping required to dewater the Madison Mine workings, being on the order of 1,000 to 1,500 gallons per minute. Consequently, most of the lead mines within the Bonneterre Formation are expected to be at least partly flooded. Mine workings associated with the Silver Mines area are also expected to be partly flooded based on observations of drainage emanating from some mine adits (EPA 2014).

Groundwater at the Site is predominantly alkaline in nature, attributed mostly to the presence of sedimentary dolomite and limestone. Alkaline groundwater buffers the dissolution of metals and has been attributed as a major reason for the lack of dissolved metals in groundwater outside the former mining and processing locations at the Site where limited detection has been observed. There are an estimated 2000 private wells at the Site potentially used for consumption or, potable water. These include both shallow wells in the unconsolidated overlying soils and deeper wells penetrating the Cambrian sedimentary rock, the Pre-Cambrian basement formations, or both (EPA 2014).

2.4 BIOTIC RESOURCES

2.4.1 Threatened and Endangered Species

Congress delegated responsibility to the FWS for the conservation, including recovery, of federally listed endangered or threatened species, except for marine mammals. The Endangered Species Act and associated federal regulations establish the FWS' authorities for endangered species programs. Several federally threatened and endangered species occur in the MCM Site or near (within Madison County) the MCM Site. The Missouri Department of Conservation's Natural Heritage Database was used to determine threatened, imperiled, or endangered species for this section of the report (http://mdc.mo.gov/your-property/greener-communities/heritage-program; accessed 12/5/2014).

The federally listed endangered gray bat (*Myotis grisescens*) occupies a limited geographic range in limestone karst areas of the southeastern United States. With rare exception, the gray bat roosts in caves year-round. Most gray bats migrate seasonally between hibernating and maternity caves. Gray bats are active at night, foraging for insects over water or along shorelines, and they need a corridor of forest riparian cover between roosting caves and foraging areas. They can travel as much as 20 kilometers (12 miles) from their roost caves to forage. The MCM Site has the potential to impact the gray bat.

The Indiana bat (*Myotis sodalis*), federally listed as endangered, historically occupied much of the eastern half of the United States. The bat hibernates in caves, but during warmer seasons roosts principally under the bark of trees. Maternity colonies are formed mostly in riparian and floodplain forests associated with small to medium-sized streams. They have also been found along tree-lined drainage ditches. Indiana bats are active at night foraging for aquatic insects and

Lepidoptera at a height of 2 to 30 meters over water and under riparian and floodplain trees. The MCM Site has the potential to impact the Indiana bat.

The northern long-eared bat (*Myotis septentrionalis*) is federally proposed as endangered. The range of the bat includes much of the eastern and north central United States. The northern long-eared bat is in danger from extinction due to the spread of white-nose syndrome (WNS). This bat hibernates in caves and mines; during summer the species will roost singly or in colonies underneath bark, in cavities, or in crevices of both live and dead trees. Unfortunately WNS has been found in hibernacula of several counties in Missouri including Iron County which is adjacent to Madison County. The MCM Site has the potential to impact this fragile species.

Habitat requirements for the endangered American burying beetle (*Nicrophorus americanus*), particularly reproductive habitat requirements, are not fully understood at this time. The American burying beetle has been found in various types of habitat, including oak-pine woodlands, open fields, oak-hickory forest, open grasslands, and edge habitat. The MCM Site has the potential to impact the American burying beetle.

The MCM Site has the potential to impact the endangered plant, running buffalo clover (*Trifolium stoloniferum*). Habitat requirements include mesic areas of partial to filtered sunlight where a prolonged pattern of moderate periodic disturbance occurs. It is often found in regions underlain with limestone or other calcareous bedrock. It has been reported in a variety of habitats, including mesic woodlands, savannahs, floodplains, stream banks, sandbars, grazed woodlots, mowed paths, old logging roads, jeep trails, skidder trails, mowed wildlife openings within mature forest, and steep ravines. Mead's milkweed (*Asclepias meadii*) is a federally threatened species that also has the potential to be impacted by mining activities at MCM Site. This milkweed requires moderately wet (mesic) to moderately dry (dry mesic) upland tallgrass prairie or glade/barren habitat characterized by vegetation adapted for drought and fire. It persists in stable late-successional prairie.

Several federally listed freshwater mussel species occur in the vicinity of the MCM Site. Freshwater mussels are bivalved mollusks that are relatively immobile, spending their entire lives partially or completely buried in the stream bottom. They are suspension feeders, using their gills to remove suspended particles in the water column. These animals have a complex life cycle that includes a brief, obligatory parasitic stage on fish. Host fish specificity vary among mussels. While some mussel species appear to require a single host species, others can complete their life cycle on several fish species. The Rabbitsfoot (*Quadrula cylindrical cylindrical*) is a species of mussel that is threatened by the effects from mining at the MCM Site.

The Bachman's sparrow (*Peucaea aestivalis*), a federally endangered species, is a small migratory songbird that breeds in the forests of the central and eastern United States. They nest in areas of scattered scrubby vegetation and build their nests on the ground against or under a grass tuft or low shrub. Nesting areas include dry, open pine or oak woods with brushy or overgrown hillsides or overgrown fields with thickets and brambles. The sparrow forages on the ground for seeds of herbaceous plants or pine and insects. The MCM Site has the potential to impact the Bachman's sparrow.

2.4.2 Vegetation

Prior to settlement, the area had a mixture of forests, glades, open woodlands and small prairies in the basins. Today the more rugged sections of the MCM Site are wooded, and there are extensive acreages of national forest. Large areas of woodlands and igneous glades remain. Open areas and some forested areas are used as cropland, pasture, meadows, and overgrown areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants (Nigh and Schroeder 2002).

Historically, Madison County contained woodlands, forests, glades and cliff communities found on igneous substrates; this community structure was found nowhere else in the Ozarks. Today the area is forested in second-growth oak and oak-pine. Woodlands cover hillsides and riparian corridors. Shortleaf pine was once prevalent but is much reduced in extent (Nigh and Schroeder 2002). The SEMOLMD is the northern extent of short-leafed pine, which was extensively logged in the 19th century. Short-leafed pine still occurs in upland areas of the SEMOLMD including parts of Madison County. Currently, native forests are characterized by a variety of oak species (*Quercus* spp.), hickory species (*Carya* spp.), eastern red cedar (*Juniperus* spp.), dogwoods (*Cornus* spp.) and redbuds (*Cercis* spp.), ash species (*Fraxinus* spp.) and associated shrubs, grasses, legumes, and wild herbaceous plants.

Chat piles and tailings impoundments at the MCM Site do not support normal succession of terrestrial vegetation. Un-remediated mine waste piles tend to be barren or sparsely vegetated. Acres of barren and vegetated mine waste piles have been identified and measured as part of Superfund site investigation activities, and many are readily apparent in aerial photographs.

The loss of vegetation, resulting from phytotoxicity, is an injury under CERCLA NRDAR regulations (43 C.F.R. §11.62(f)(i)). While plant productivity and changes in plant species composition in mine waste areas can be affected by mine waste characteristics unrelated to the presence of contaminants (e.g., the wastes' water retention ability and/or organic content), available evidence suggests that contamination in some areas affected by mine wastes is sufficiently toxic to cause decreases in plant productivity, changes in species diversity, and/or changes in species composition.

Struckhoff et al. (2013) investigated the effects of mining-associated metals (lead and zinc) contamination on native floristic quality. These studies were conducted in the SEMOLMD and used Mean C (Coefficient of Conservatism) and Floristic Quality Index (FQI) as the primary end points for assessing reduction in floristic quality. Lead inhibits the growth of plants, photosynthesis (due to reduced enzyme activity), cell division and respiration, water absorption and other physiological functions of plants (Fargasova 2001). Zinc can cause a decrease in enzymes required for photosynthesis and can decrease hydrolysis in plants that are watered with zinc solutions as low at 650 ug/L (Pahlsson 1989).

Results from the floristic quality study showed that Pb at a concentration in soil of 661 mg/kg can cause a 10% reduction in Mean C and a 10% reduction of FQI at 663 mg/kg. Zinc studies showed that a soil Pb value of 448 mg/kg can reduce Mean C by 10% and FQI can be reduced by 10% at 311 mg/kg of Zn. The research showed that Pb and Zn concentrations in soil and floristic

quality are inversely related. Less tolerant species of disturbance (i.e. have a higher Mean C) are most negatively affected by increasing metals concentrations in the soils. FQI can be very useful for determining community-level effects of soil metals contamination.

2.4.3 Aquatic and Amphibious Species

Aquatic organisms found at the MCM Site include a wide variety of fishes. Among these are a number of larger or recreationally important fish species such as smallmouth bass (*Micropterus dolomieui*), rock bass (*Amploplites rupestris*), longear sunfish (*Lepomis megalotis*), and several sucker species. Smaller fish species include minnows and darters.

Many species of aquatic organisms are present in the MCM Site surface waters, and some may have been and/or continue to be impacted by metals contamination. The longnose darter (*Percina nasuta*) is state listed as endangered and can be found in the St. Francis River watershed. As mentioned in section 2.4.1 above, freshwater mussels occur in the St. Francis River basins. These streams are important refuges for mussel species of concern including the federally endangered rabbitsfoot (*Quadrula cylindrica cylindrica*).

Elevated heavy metal concentrations have been documented in a variety of biological tissues at the MCM Site. Fish, macrobenthic invertebrates, earthworms, plants, and small rodent tissues have been found with elevated metal concentrations. Fish in the Little St. Francis River have shown elevated concentrations of lead and the biochemical effects of lead downstream of the Site (EPA 2006).

EPA Region 7 documented toxicity to *Hyalella azteca* using sediment pore water collected from the Little St. Francis River in the Madison County Mines Site Ecological Risk Assessment (2006). It was further found in the ERA that macroinvertebrate EPT Richness is reduced in the Little St. Francis River as compared to the control site, the Castor River.

2.4.4 Birds

Birds make use of both aquatic and terrestrial habitat in and potentially affected by the Madison County Site within SEMOLMD. These areas generally fall within the Ozark Upland physiographic area, in which over 100 bird species breed (Fitzgerald et al. 2000). Special-status avian species occurring in the MCM Site include the state ranked “vulnerable” bald eagle (*Haliaeetus leucocephalus*) and the greater roadrunner (*Geococcyx californianus*). In recent years, populations of special-status species such as the northern harrier (Circus cyaneus), Swainson's hawk (*Buteo swainsoni*), and cerulean warbler (*Dendroica cerulean*) have declined. (Fitzgerald et al. 2000). Bachman’s sparrow (*Peucaea aestivalis*), a state endangered migratory bird is also at risk at the MCM Site. Other ground-feeding song birds likely to occur in Madison County that are birds of conservation concern include field sparrows, worm-eating warbler, hooded warbler, Kentucky warbler, Louisiana water thrush, northern bobwhite quail, and wood thrush. Ground-feeding birds are of particular concern due to their propensity to incidentally ingest contaminated soil, as indicated below (See Appendix B).

Beyer et al (2004) and Sileo et al (2003) documented exposure and toxic effects to migratory birds resulting from releases of mining-related heavy metals into sediments and terrestrial environments in the Tri-State Mining District. Concentrations of lead, zinc, and/or cadmium in MCM Site mill waste are comparable to concentrations in mill waste and sediment found to cause a toxic effect to migratory birds in the Beyer and Sileo studies.

A more recent study of lead toxicity to songbirds in the SEMOLMD by Beyer et al (2013) examined sites with soil lead concentrations between 1,000-3,200 mg/kg. Songbirds collected included American robins (*Turdus migratorius*) and northern cardinals (*Cardinalis cardinalis*). Earthworms were analyzed to find levels of 33–4,600 mg Pb/kg dry weight (dw) in tissues. Vermivore songbirds were likely to have toxic effects from the ingestion of these earthworms. Tissue analysis of the songbirds in the study showed mean tissue Pb concentrations in songbirds collected from the contaminated sites were greater ($p>0.05$) than those in songbirds from reference sites by factors of 8 in blood, 13 in liver, and 23 in kidney. The authors concluded that soils in the SEMOLMD contaminated by mining and smelting (with lead levels >1,000 mg/kg) are poisoning ground feeding birds.

Stratus Consulting (2014) evaluated Beyer's songbird data compared to other well documented studies on birds exposed to lead in an effort to quantify injury. Stratus developed injury 'bins' that contained ranges of soil contamination that correspond to levels of habitat injury as measured by lead in songbird tissues. The bins designated increasingly severe levels of injury to birds corresponding to increasing levels of soil lead contamination Stratus also identified a soil concentration of 345 ppm lead as a point at which injury to birds begins as indicated by delta-aminolevulinic acid dehydratase (ALAD) inhibition in SEMOLMD cardinals. An ALAD inhibition of greater than 50% is considered injury by the CERCLA NRDAR regulations (43 C.F.R. §11.62(f)(4)).

The MCM Site ERA concluded there was unacceptable risk to several model organisms representing a variety of ecological niches or feeding guilds (EPA 2006). The screening level risk assessment concluded that there was unacceptable risk from exposure to lead, zinc, and/or cadmium to vermivores and piscivores.

Birds exposed to metals at the MCM Site may also have been impacted by mining-related habitat losses (see "Vegetation" section above). Less vegetative cover and lower quality vegetative habitat mean fewer insects, fruits, and seeds for smaller birds to consume. Plants also provide food for small mammals, which in turn are the prey of larger birds. Mining-related impacts to plants therefore represent a loss of habitat that can reverberate through the food web to the highest-level predators.

2.4.5 Mammals

The Madison County Site mammals rely on both aquatic and terrestrial habitats. Mammals within the MCM Site include raccoon (*Procyon lotor*), coyote (*Canis latrans*), striped skunk (*Mephitis mephitis*), bobcat (*Lynx rufus*), black bear (*Ursus americanus*) whitetail deer (*Odocoileus virginianus*), red fox (*Vulpes vulpes*), mice, shrews, voles and various other small rodents. Special-status mammals include the Missouri-endangered plains spotted skunk (*Spilogale putorius interrupta*), and the federally-endangered gray bat (*Myotis grisescens*),

Indiana bat (*Myotis sodalis*), and the proposed-endangered northern long-eared bat (*Myotis septentrionalis*). Lack of vegetation in barren chat mining areas limits habitat and food resources for mammals. Small mammals may also be experiencing direct toxic effects from exposure to metals from mining wastes. Particularly at risk are terrestrial vermivores which ingest earthworms with gut soils as well as ingesting incidental surface soils. Region 7 (EPA 2006) took earthworm samples at two contaminated locations in MCM Site and one background sample. The results showed that the earthworms found at the contaminated sites contained between (approximately) 19-43% higher lead concentrations than the earthworms found at the background location.

2.5 CONTAMINANTS OF CONCERN

For assessment planning purposes, the Trustees will focus on cadmium (Cd), lead (Pb), zinc (Zn), copper (Cu), and nickel (Ni); these hazardous substances have significant potential for toxicity to many different natural resources. Based on existing relevant data, the Trustees know that these metals are commonly found at elevated levels in soils, sediments, and/or surface waters at the MCM Site. The Trustees recognize that other contaminants and conditions may adversely affect natural resources at the MCM Site. After reviewing results from studies conducted under the DAP, the Trustees will consider additional hazardous substances, including but not limited to, cobalt (Co), and manganese (Mn), if warranted. The following paragraphs, however, focus on the primary hazardous substances, their toxicology, and associated environmental hazards.

2.5.1 Cadmium

Cadmium (Cd) is not biologically essential or beneficial to any known living organism and is toxic to all known forms of life (Eisler 2000). Freshwater[4] animals tend to be most heavily impacted by cadmium contamination. Impacts to freshwater animals include death, reduced growth, and inhibited reproduction (Eisler 2000). In freshwater systems, the lethal effects of cadmium can be reduced by limiting exposure time and increasing water hardness[5] (Eisler 2000). Sublethal effects of cadmium in freshwater organisms include decreases in plant standing crop, decreases in growth, inhibition of reproduction, immobilization, and population alterations (Eisler 2000). Mammals and birds are comparatively resistant to the toxic[6] effects of cadmium, though exposure to high levels can be fatal (Eisler 2000).

Animals can be exposed to environmental cadmium through inhalation or ingestion. Cadmium is a known carcinogen, a known teratogen, and a probable mutagen (Eisler 2000; ATSDR 2012). Studies investigating carcinogenicity have focused on mammals. Cadmium has been shown to cause tumors in the prostate, testes, and hematopoietic (blood-related) systems in rats (ATSDR

[4] Freshwater refers to waters that are not saline (salty).

[5] Water hardness is a measure of the content of certain naturally-occurring elements in water, especially calcium and magnesium.

[6] Toxins cause direct injury to an organism as a result of physiochemical interaction. Carcinogens cause cancer (for example, tumors, sarcomas, leukemia). Mutagens cause permanent genetic change. Teratogens cause abnormalities during embryonic growth and development.

2012). Based on studies in mice and bacteria, cadmium may be mutagenic (Ferm and Layton 1981, as cited in Eisler 2000). When present, cadmium is detected in particularly high concentrations in the leaves of plants and the livers and kidneys of vertebrates (ATSDR 2012; Scheuhammer 1987, as cited in Eisler 2000).

2.5.2 Lead

Lead is not biologically essential or beneficial to any known living organism (Eisler 2000). It can be incorporated into the bodies of individual organisms by inhalation, ingestion, absorption through the skin, and (in mammals) placental transfer from the mother to the fetus (Eisler 2000). Toxic in most chemical forms, lead negatively affects survival, growth, reproduction, development, and metabolism of most animals under controlled conditions, but its effects are substantially modified by numerous physical, chemical, and biological variables. Younger, immature organisms tend to be more susceptible to lead toxicity (Eisler 2000). When absorbed in excessive amounts, lead has carcinogenic or co-carcinogenic properties (Eisler 2000). In large amounts, it is also a mutagen and a teratogen (Eisler 2000).

It has been demonstrated that aquatic animals experience adverse effects such as reduced survival, impaired reproduction, and reduced growth (Eisler 2000). As with cadmium, increased water hardness decreases lead bioavailability to aquatic animals (Wong et al. 1978 and NRCC 1973, both as cited in Eisler 2000). Early research suggested that birds are unlikely to show adverse effects from environmental lead (except when lead objects such as shot are directly ingested); however, there is now a body of evidence linking waterfowl poisoning with ingestion of lead-contaminated sediments, especially in the Coeur d'Alene area of Idaho (Chupp and Dalke 1964, Blus et al. 1991, Beyer et al. 1998, Heinz et al. 1999, all as cited in Eisler 2000). There are few data regarding the effect of environmental lead on mammalian wildlife (Eisler 2000).

Lead also can harm plant species. Generally, large amounts must be present in soils before terrestrial plants are affected, although sensitivity varies widely among species (Demayo et al. 1982). Effects of lead toxicity in plants include reduced plant growth, photosynthesis, mitosis, and water absorption (Demayo et al. 1982).

2.5.3 Zinc

Zinc (Zn) is an essential trace element for all living organisms, and zinc deficiency in animals can cause a variety of adverse effects (Eisler 2000; ATSDR 2005). Zinc is also toxic at high concentrations, although its toxicity depends on its chemical form and other environmental parameters (Eisler 2000). Zinc is not carcinogenic, although in certain chemical forms, zinc can be mutagenic (Thompson et al. 1989, as cited in Eisler 2000). Zinc is teratogenic to frog and fish embryos, but there is no conclusive evidence of teratogenicity in mammals (Dawson et al. 1988 and Fort et al. 1989, both as cited in Eisler 2000).

Environmental effects of excess zinc can be significant at relatively low concentrations (Eisler 2000). Terrestrial plants can die from excess zinc in the soil (Eisler 2000). Freshwater animals can also experience adverse effects, including reduced growth, reproduction, and survival (Eisler 2000). Ducks experience pancreatic degeneration and death when fed diets containing high

concentrations of zinc (Eisler 2000). Mammals can generally tolerate greater than 100 times their minimum daily zinc requirement (NAS 1979, Wentink et al. 1985, Goyer 1986, Leonard and Gerber 1989, all as cited in Eisler 2000), but levels that are too high affect their survival, metabolism, and well-being (Eisler 2000).

2.5.4 Copper

Copper is an essential nutrient for most organisms. However, contamination above various concentration and bioavailability thresholds are toxic (Rainbow and Luoma, 2011). Copper is among the most toxic of the heavy metals to aquatic biota, but birds and mammals are relatively resistant to copper toxicity. Phytotoxicity caused by copper is rare in higher plants, but has been documented on mine spoils (Eisler, 1988a).

Excess copper causes altered permeability of cellular membranes and causes a reaction that creates free radicals that oxidize lipids (Aeseth and Norseth, 1986). In aquatic invertebrates copper causes gill damage and in fishes it interferes with osmoregulation (Hodson et al. 1979). Copper also interferes with energy metabolism and can reduce the activities of enzymes that regulate ATP syntheses (Hansen et al. 1992). Copper is toxic to algae and is often used in ponds and other aquatic applications as an algaecide.

Copper is toxic to mammals only at high concentrations due to their ability to excrete excess copper. However, diets high in copper fed to domestic sheep have been found to cause liver damage, impaired reproduction, and death (Eisler, 1998). Similarly, high copper diets fed to ducklings have been demonstrated to be fatal (Wood and Worden, 1973).

There is not definitive evidence that copper is carcinogenic, mutagenic, or teratogenic except under grossly elevated exposure (Eisler, 1998a).

2.5.5 Nickel

Nickel (Ni) is uniformly present in the biosphere. Nickel in the environment from natural or anthropogenic sources is transported through the system by chemical and physical processes and through biological transport mechanisms (National Academy of Sciences [NAS] 1975; World Health Organization (WHO) 1991). Nickel is an essential micronutrient for many species of microorganisms and plants and several species of vertebrates, including chickens, cows, goats, pigs, rats, and sheep (WHO 1991). The WHO classifies nickel compounds in Group 1 (human carcinogens) and metallic nickel in group2B (possible human carcinogen; WHO 1991).

Adverse effects of excess nickel are documented for bacteria, algae, yeasts, plants, protozoans, mollusks, crustaceans, insects, annelids, echinoderms, fishes, amphibians, birds, and mammals (Eisler 1998b). The majority of terrestrial plants are nickel-intolerant species and are restricted to soils of relatively low nickel content; some plants without specific nickel tolerance can accumulate nickel, but at a cost of reduced growth (Rencz and Shilts 1980). Birds, especially waterfowl feeding in nickel polluted areas, are at risk due to the high accumulation of nickel in aquatic food plants (Eastin and O'Shea 1981). In mammals, the toxicity of nickel is a function

of the chemical species of nickel, dose, and route of exposure. Toxic effects of nickel to mammals are documented for respiratory, cardiovascular, gastrointestinal, hematological, musculoskeletal, hepatic, renal, dermal, ocular, immunological, developmental, neurological, and reproductive systems (NAS 1975; WHO 1991).

2.6. CONFIRMATION OF EXPOSURE[7]

The result of mining, milling and smelting activities is past and ongoing exposure of natural resources–land, water, plants and animals–to metals, potentially causing injuries to these resources and the services they provide to humans and the environment. The Trustees intend to investigate and document these losses through the studies set forth in this Assessment Plan.

A substantial body of information is already available demonstrating past and ongoing exposure of the MCM Site natural resources to hazardous substances as evidenced below.

2.6.1 Surface Water

Metal concentrations, particularly those of zinc and lead, have exceeded the ambient water quality criteria (AWQC) in samples collected by USEPA in 2006 at Sweetwater Branch, Harmony Lake tailings, Spiva Branch, and an unnamed creek on the north end of the Anschutz Property. Sediment concentrations of metals in waterways of the MCM Site exceed published toxicity benchmarks for the protection of aquatic life (MacDonald et al. 2000). The highest concentration of Pb in sediments was found in the Little St. Francis River near the Little St. Francis River Chat pile (EPA 2011a).

2.6.2 Geologic Resources

EPA's work on the MCM Superfund Site has documented high concentrations of contaminants in mine wastes and nearby soils at levels that exceed both national average soil concentrations and concentrations toxic to vegetation (EPA 2011a).

2.6.3 Groundwater

Studies have found concentrations of metals in the shallow aquifer that are higher than background concentrations by up to an order of magnitude and that exceed ground water criteria (Black & Veatch 2008). These wells have shown an unacceptable risk if used as a drinking water source and may be a risk to non-human receptors as well. EPA is planning further studies of the groundwater surrounding the chat/tailings piles at the MCM Site.

[7] The CERCLA NRDAR regulations require that exposure of at least one of the natural resources identified as potentially injured "has in fact been exposed to the released substances" (43 CFR §11.37(a)). This Plan confirms that a variety of potentially-injured resources have been exposed to hazardous substances, including cadmium, lead, and zinc.

2.6.4 Biotic Resources

The 2006 ERA for MCM Site showed elevated levels of lead in the tissues of fish collected in Mill Creek and Little St. Francis River along with a decrease in the abundance of some sensitive species of benthic macroinvertebrates. Toxicity tests indicate that sediments from the Little St. Francis River and its tributaries pose an acute and chronic toxicity risk to benthos. There is evidence supporting of phytoxicity to terrestrial plants in mine waste areas. Also, according to the 2006 ERA, there is a potential hazard to woodcocks, shrews, earthworms, blue herons, and vermivores.

Altogether, these data confirm that natural resources in the MCM Site have been, and continue to be, exposed to elevated levels of metals resulting in injuries to natural resources.

2.7 PRELIMINARY DETERMINATION OF RECOVERY PERIOD[8]

Recovery period is defined under 43 C.F.R. §11.14(gg) 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 authorized official and documented in the Assessment Plan." Several factors can influence estimates of recovery time, including ecological succession patterns, growth or reproductive patterns, life cycles, ecological requirements of plants and animals (including their reaction or tolerance to the hazardous substances involved), biological recruitment potential, the bioaccumulation and extent of hazardous substances in the food web and the chemical, physical and biological removal rates of the hazardous substances.

As noted in previous sections of this Addendum, substantial mining activities in the MCM Site were undertaken for more than a century, and measurements of metals in the environment demonstrate that these contaminants have been present at levels associated with adverse impacts to natural resources for decades.

Data from similar sites in other locations, and research presented in the technical literature, suggest a recovery period on the order of at least decades in the absence of active remediation or restoration efforts beyond those already implemented or planned. Metals are elements and may change their chemical form or become dispersed in the environment, but they do not break down or degrade. Elevated levels of metals have been and continue to be present in a wide variety of natural resources within the MCM Site. Available information suggests that natural processes will take a very long time to remove the contamination or render it biologically unavailable, given the amounts present and the environmental processes involved.

The Trustees recognize that implemented or planned actions through Superfund or other programs may hasten the recovery of some resources at the MCM Site. However, information currently available to the Trustees indicates that planned or implemented actions are not

[8] The CERCLA NRDAR regulations require than an assessment plan include a preliminary estimate of the time needed for injured resources to recover (43 CFR §11.31(a)(2)).

sufficient in scope or design to change the preliminary finding that adverse mining-related impacts to natural resources in the MCM Site are likely to persist for decades or longer.

2.8 QUALITY ASSURANCE MANAGEMENT

The CERCLA NRDAR regulations require that the Trustees develop a Quality Assurance Plan (QAP) that "satisfies the requirements listed in the NCP and applicable EPA guidance for quality control and quality assurance plans." 43 CFR §11.31(c)(2). A QAP is needed to ensure the validity of data collected as part of the NRDAR and to provide a solid foundation for the Trustees' subsequent decisions. Also relevant to this effort are the FWS guidelines developed under the Information Quality Act of 2001. All information developed in this NRDAR will be in compliance with these guidelines. Please refer to Final Phase I Damage Assessment Plan for Southeast Missouri Lead Mining District: Big River Mine Tailings Superfund Site, St. Francois County and Viburnum Trend Sites, Reynolds, Crawford, Washington, and Iron Counties (Mosby et al. 2009) for more detailed information regarding quality assurance practices.

CHAPTER 3 OVERVIEW OF CURRENTLY PROPOSED AND/OR CONTEMPLATED STUDIES.

At this time, one assessment study is planned for the MCM Site, with another study in the development stage. The crayfish population and in situ toxicity study, a draft of which is included as Appendix B for public review and comment, is planned for spring and summer 2015. The transition zone study plan is currently in development. Once a draft has been completed, it will be made available to the public for review and comment. The transition zone study has not been scheduled, but it is anticipated that field work will begin in the fall of 2015 and be completed by the end of 2015.

The crayfish study will evaluate crayfish density and other population metrics in riffle habitat at various streams impacted by OU-2. A second phase of the study will place caged crayfish in a subset of study streams to serve as an in-situ toxicity evaluation. These results will be compared to reference streams and stream reaches that drain other upstream mining areas that could be used to establish baseline conditions. A draft study plan is contained in Appendix B.

The transition zone soil study will be designed to characterize the scope of soil contamination surrounding mine and mill dumps in OU-2. This study will be conducted using XRF meters to record metals concentrations in transects leading away from mine or mill waste. A subset of the samples will be submitted for confirmatory laboratory analyses.

Other potential studies could include migratory bird exposure study, small mammal exposure, food web analyses, and groundwater injury quantification.

Injury data collected through studies discussed above will be used to establish pathway determinations, which describes fate and transport of contaminants and food-web uptake. The data collected through these studies will also support injury quantification—the extent and severity of injury. This injury quantification information will then be used to determine the

amount of compensation owed to the public for the loss of, destruction of, and injury to natural resources and their associated services in the subsequent phase of the NRDAR process.

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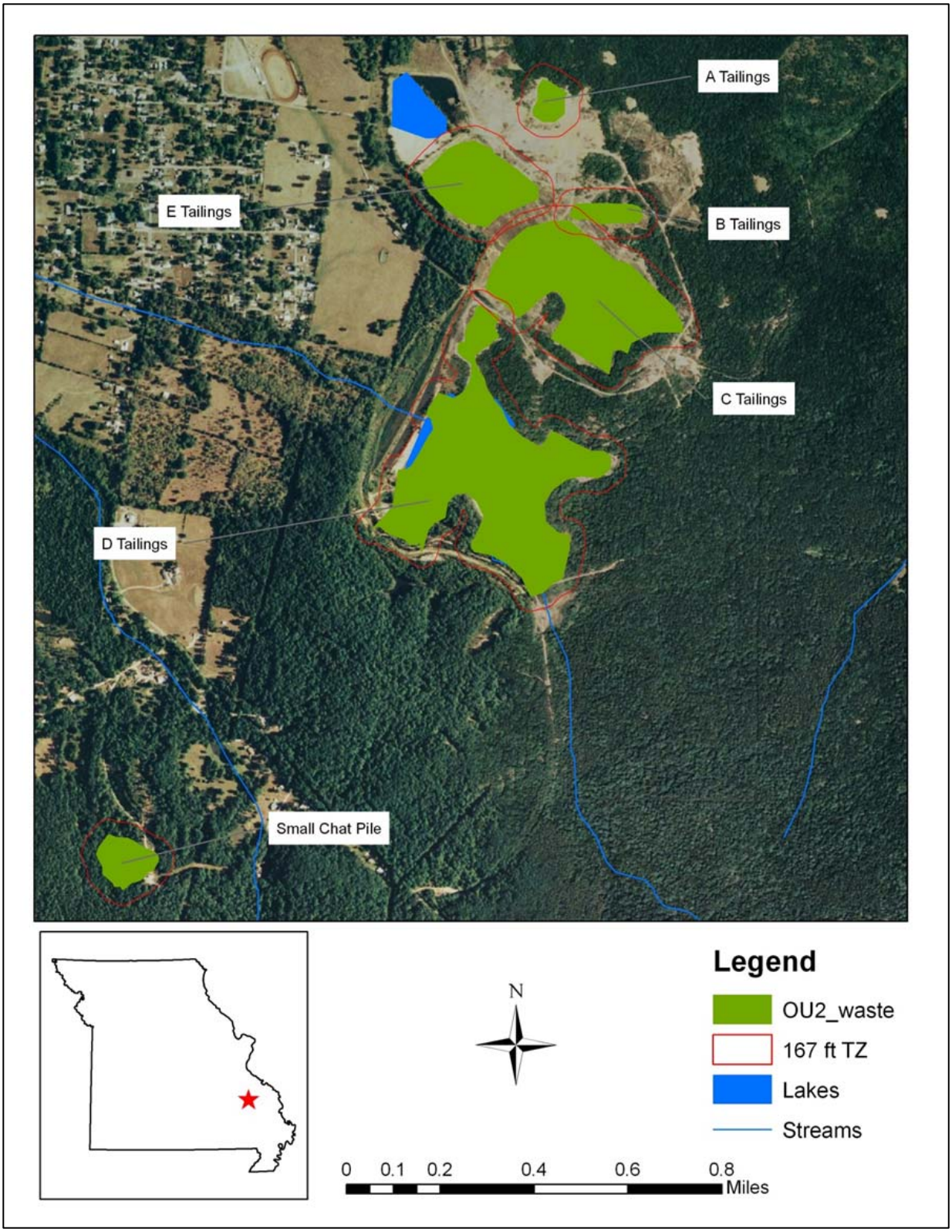
APPENDIX A

Map of Madison County Mines Site OU2

Figure 1. Map of Madison County Mines Site showing mine waste of OU2 with transition zone buffer of 167 feet.



APPENDIX B

Crayfish Population and In Situ-Toxicity Study Plan