UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
11201 Renner Boulevard
Lenexa, Kansas 66219

JUL 2 7 2018

MEMORANDUM

SUBJECT: Concurrence on Proposed Plan for an Early Action Interim Record of Decision Operable Unit 2 – Off Source Areas; Big River Mine Tailings Superfund Site CERCLIS ID#: MOD981126899

FROM: Jason Gunter, Remedial Project Manager for [signature]
Lead, Mining and Special Emphasis Branch

THRU: Gene Gunn, Branch Chief for [signature]
Lead, Mining and Special Emphasis Branch

TO: Mary P. Peterson, Director
Superfund Division

Attached for your review and approval is the proposed plan for an early interim remedial action at the Big River Mine Tailings Site, Operable Unit 2. The preferred alternative, Alternative 2- Focused Removal and Stabilization at Seven Candidate Locations with Continued Removal and Adaptive Management, was chosen over the other alternatives by the EPA based on the nine National Contingency Plan criteria. The preferred alternative provides the best balance of trade-offs and achieves the Interim Remedial Action Objectives, or IRAOs. This alternative provides the best remedial approach because:

- substantial remedial actions are proposed at accessible locations;
- data from these locations indicate potential unacceptable risks posed by site contaminants;
- data from these locations indicate that the proposed actions have the greatest potential for reducing potential unacceptable risks and reducing lead, cadmium and zinc entry into the creek and rivers; and
- a 12-year program is undertaken, whereby a robust monitoring program to support additional remedial actions based upon an adaptive management approach is implemented.

Alternative 2 provides the most aggressive adaptive management approach and offers the greatest potential for achieving the IRAOs in a predictable, controlled manner and potentially in the shortest time.

Because the preferred alternative will result in hazardous substances remaining on-site above health-based levels, a review will be conducted to ensure that the remedy continues to provide adequate protection to human health and the environment within five years after commencement of the remedial action.

The state of Missouri has reviewed the draft proposed plan and the EPA anticipates that the state will concur with the preferred alternative. The preferred alternative is estimated to cost approximately $23 million dollars. A public meeting has been set for 6:30 p.m. on August 16, 2018, in Park Hills, Missouri.

If you have any questions regarding this proposed plan, please contact me at (913) 551-7358.

Attachment

APPROVAL:

Mary P. Peterson 7/27/2018

Mary P. Peterson, Director Date

Superfund Division

PROPOSED PLAN FOR EARLY INTERIM ACTION

OPERABLE UNIT 2

OFF-SOURCE AREAS

BIG RIVER MINE TAILINGS SUPERFUND SITE

ST. FRANCOIS COUNTY, MISSOURI

Prepared by:

U. S. Environmental Protection Agency
Region 7
11201 Renner Boulevard
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July 2018

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A. INTRODUCTION

This proposed plan for the Early Interim Action at Operable Unit 2- Off-Source Areas, or OU2, of the Big River Mine Tailings Site, or site, is intended to inform and solicit the views of the affected community regarding the U.S. Environmental Protection Agency's preferred alternative to address lead contamination in stream sediment and floodplain soil in the Big River watershed in St. Francois County. The EPA is the lead agency and the Missouri Department of Natural Resources, or MDNR, is the state support agency. This proposed plan fulfills the public participation requirements under Section 117(a), 42 U.S.C. § 9617(a) of the Comprehensive Environmental, Response, Compensation, and Liability Act, or CERCLA, as amended and often called the Superfund Law, and Section 300.430(f)(2) of the National Contingency Plan, or NCP, 40 C.F.R. § 300.430(f)(2). The purpose of the proposed plan is to:

- Provide background information about the site;
- Identify the preferred alternative for the early interim remedial action at the site, and explain the reasons for the EPA's preference;
- Describe the other remedial alternatives;
- Solicit public review and comments on all the alternatives; and
- Provide information on how the public can be involved in the remedy selection process.

The EPA Site Identification Number is MOD981126899. This number may be used on the EPA's website to obtain information about the site.

This proposed plan highlights key information from the Remedial Investigation, or RI; the Baseline Ecological Risk Assessment, or BERA; and the Focused Feasibility Study, or FFS, recently released for OU2 of the site.

The preferred alternative is Alternative 2 — Focused Removal of Sediment at Seven Candidate Locations with Continued Removal and Adaptive Management.

For additional information regarding the proposed early interim remedial action, these and other documents are available in the Site Administrative Record, or AR, located at www.epa.gov/superfund/bigrivermine. You click on "Site Documents and Data," then "Administrative Records," and then "Big River Mine Tailings OU2." Additional documents are available for review at the following information repositories: St. Francois County Health Center or the EPA Regional Office in Lenexa, Kansas, at the addresses listed below:

St. Francois County Health Center
1025 West Main Street
Park Hills, Missouri
Hours: Monday-Friday from 8am-4pm
Saturday - Sunday – CLOSED

U.S. Environmental Protection Agency,
Region 7 Records Center
11201 Renner Boulevard
Lenexa, Kansas 66219
Hours: Monday – Friday 8am – 5pm
Saturday – Sunday - CLOSED

The EPA is interested in receiving public comments on the alternatives and on the rationale for the preferred alternative. The public comment period will begin July 28, 2018, and extends through August 28, 2018. After the public comment period ends, the EPA will review all comments and make a final decision for the early interim remedial action at the site. The community's preferences are an extremely important factor and will help determine the interim decision; therefore, we encourage the public to provide comments to the EPA. The EPA's decision will be explained in a document titled the "Interim Record of Decision," or IROD. Included in the IROD will be a responsiveness summary that responds in writing to significant comments received by the EPA during the public comment period. The EPA, in consultation with the MDNR, may modify this preferred alternative or select another alternative presented in this proposed plan based on new information or public comments.

A glossary of common Superfund terms is included in Appendix E at the end of this document.

B. SITE BACKGROUND AND HISTORY

The site is in southeastern Missouri, entirely within St. Francois County, approximately 70 miles southwest of St. Louis (see Appendix A, Figure 1). The first recorded mining in St. Francois County occurred at Mine-a-Gabore between 1742 and 1762. The important discoveries of disseminated lead in the Bonne Terre, Leadwood, and Flat River areas occurred in 1864. The introduction of the diamond drill in 1869 facilitated the discovery of additional reserves and output from the mines increased dramatically in the late 1800s. Mine output from St. Francois County peaked in 1942 when the concentrate equivalent of 197,430 tons of lead was produced. Mining ceased in the county in 1970 with the closing of St. Joe Lead Company's Federal mine.

The site resides within the Old Lead Belt, which is on the northeastern edge of the Precambrian igneous core of the St. Francois Mountains. This area was one of the world's largest lead mining districts, having produced more than nine million tons of pig lead. It has been estimated that some 250 million tons of mining and mill waste in the form of tailings and chat were produced in the Old Lead Belt from ore milling and beneficiation processes. In the past, mine waste was used extensively as aggregate for ballast in railroads, concrete, asphalt, and fill. Some mine waste is still used today as aggregate and fill. In the past, tailings were used as agricultural amendments due to the lime content.

Chat deposits include sand- to gravel-sized material resulting from the crushing, grinding, and dry separation of the ore material. Tailings deposits include sand- and silt-sized material resulting from the wet washing or flotation separation of the ore material. The mine waste contains elevated levels of lead and other heavy metals which pose a threat to human health and the environment. These mine wastes have contaminated soil, sediment, surface water, and groundwater. Mine waste also has been transported by wind and water erosion and manually relocated to other areas throughout St. Francois County. It has also been reported that mine waste has been used on residential properties for fill material and private driveways, used as aggregate for road construction, and placed on public roads around St. Francois County to control snow and ice in the winter.

To date, eight source areas of mine waste have been identified within the St. Francois County Site. Seven of these areas are within the Big River Watershed, shown on Figure 1 in Appendix A, and are listed below this section. The eighth source area, the Doe Run Pile, is situated in the St. Francis Watershed and is not part of this Early Interim Action.

- Desloge Pile (Big River Pile)
- National Pile
- Leadwood Pile
- Elvins Pile
- Bonne Terre Pile
- Federal Pile (St. Joe State Park)
- Hayden Creek

Part of the EPA's overall strategy for the site and St. Francois County is to address source control to reduce the continued transportation of mine waste. The sources of most of the lead contamination at the site are the large mine waste piles listed above this paragraph. The EPA, with cooperation from some of the potentially responsible parties, began addressing the mine waste piles and high risk residential properties as time-critical removal actions. The following section summarizes the history and status of each source area.

Source Areas

Desloge Pile, or Big River Pile

In 1887, the Desloge Lead Company acquired the Bogy Tract, formerly Mine-a-Joe, near Desloge, Missouri, and commenced its operations under the name Desloge Consolidated Lead Company. In 1890, operations began in Shaft No. 1, originally sunk in 1873 by Bogy to a depth of 224 feet, and the mill was started in 1893. By 1924, three shafts were operating with a fourth mill shaft being sunk so that ore could be hoisted directly into the crushing plant. The St. Joseph Lead Company took over the property in 1929 and operated it until 1958, when the Desloge Mill shut down.

The EPA and The Doe Run Resources Corporation entered into an Administrative Order on Consent, or AOC, in 1994 for a removal action to stabilize the Desloge Pile. Stabilization work on the Desloge Pile, or Big River Pile, was mostly completed by 2000. The pile is stabilized and is currently used as an on-site repository for lead-contaminated soil under a Repository Operation Plan, or ROP, for OU1.

National Pile

In May 1898, the St. Louis Smelting and Refining Company, or SLS&RC, a subsidiary of National Lead Company, purchased a block of land located near the Flat River station on the Mississippi River & Bonne Terre railroad, or MR&BT. The block included a working mine of the Flat River Lead Company, 1,295 acres, and the old Taylor mines, 900 acres. Shaft No. 1, sunk in 1893 by the Flat River Lead Company, was abandoned by SLS&RC. Shaft No. 2 was sunk in 1898, followed by Shaft No. 3 in 1899; and the first SLS&RC ore produced from the property came in 1900. A state-of-the-art electric powered mill with a capacity of 1,200 tons per day was completed in 1901. Ore obtained from the mine shafts and several other small producers was milled, and concentrates were shipped to National Lead Company's Collinsville, Illinois smelter. By 1910, four shafts had been sunk on the property. The property was sold to the St. Joseph Lead Company in 1933. St. Joseph Lead Company operated the National mine for several more years after the purchase, but hauled the ore underground to its mill at Federal.

The EPA issued a Unilateral Administrative Order in 2006 for a time critical removal action to stabilize the National Pile. Stabilization was completed in June of 2012.

Leadwood Pile

The St. Joseph Lead Company's mining operations at Leadwood commenced in the Leadwood area as early as 1894. During 1903-1904, St. Joseph Lead Company constructed the Hoffman mill in Leadwood near Shaft Nos. 12 and 14, with a capacity of 1,000 to 1,200 tons per day. A concise description of the Hoffman concentrating plant operation is given in the initial RI (Fluor Daniel 1995, page 2-74). Other St. Joseph Lead Company mines in the area included Shaft No. 10 at Gumbo and Shaft No. 11, known as the Hunt, at the northeast edge of Leadwood near the Big River. Leadwood operations covered about 560 acres. The Leadwood mill was modernized periodically, but ultimately closed by a strike in 1962.

The EPA issued a Unilateral Administrative Order for a removal action to stabilize the Leadwood Pile. The major earthwork at Leadwood was complete in June 2011. Remaining work includes additional storm water management to reduce dissolved zinc at the east seep and erosion area and the Leadwood Dam. The pile is stabilized and is currently used as an on-site repository for lead-contaminated soil under a Repository Operation Plan, or ROP, for OU1.

Elvins/Rivermines Pile

Flat River, Missouri, was the site of several mines and small concentrating works. A partial list of some of the companies with mining interests in the Flat River area, including the historic towns of Elvins, Central, and St. Francois, included the Flat River Lead Company, Central Lead Company, Doe Run Lead Company, Columbia Lead Company, Federal Lead Company and Commercial Lead Company. In the early years, the milling operations were small and conducted business at various locations. In 1891, The Doe Run Lead Company commenced mining in the Flat River area and subsequently acquired the properties of the Columbia Lead Company and Commercial Lead Company. By 1909, The Doe Run Lead Company controlled 6,548 acres in the Flat River area and carried on mining in seven shafts. In 1911, The Doe Run Lead Company consolidated its mill operations at Elvins to a 1,500 to 2,000 ton per day plant. The mill ceased operation in 1934. The property was acquired by St. Joe Lead Company in 1936 when The Doe Run Lead Company was dissolved.

The EPA issued a Unilateral Order for a time critical removal action to stabilize the Elvins/Rivermines Pile in 2005. All major earthwork was complete in June 2009. Remaining work includes the construction of storm water control measures to reduce elevated zinc concentrations in the discharge at the south end of the site. The pile is stabilized and will be used as an on-site repository for lead-contaminated soil under a ROP for OU1.

Bonne Terre Pile

The St. Joseph Lead Company was organized in 1864 and began mining operations at Bonne Terre in 1865 after purchasing the La Grave property. A mill was constructed, and several shafts were sunk thereafter. In 1883, the Bonne Terre mill and associated works were destroyed by fire, after which, a new and larger plant was constructed. The adjoining Desloge Lead Company mill, in operation since 1877, burned in 1884 and was subsequently purchased by the St. Joseph Lead Company. The smelter at Herculaneum was completed in 1892, and the furnaces from Bonne Terre were moved there. All Bonne Terre ore was smelted at Herculaneum thereafter.

The EPA issued two AOCs for the removal actions at the Bonne Terre Pile. The first was issued in 2001 and addressed the Western Portion, or Chat Pile, of Bonne Terre. The second was issued in 2003 and addressed the Eastern Portion, or Tailings Impoundment, of Bonne Terre. All construction was complete in 2007. The Eastern Portion of the site is currently used as an on-site repository for lead-contaminated soil under OU1.

Federal Pile

The Federal Lead Company, or Federal, was the corporate predecessor of the American Smelting and Refining Company, or ASARCO, and began operations in 1902 after acquiring various properties from the Irondale Lead Company, the Derby Lead Company, the Central Lead Company, the Missouri Lead Fields Company, the Union Lead Company and others. In 1907, Federal constructed a large mill, what is now the No. 3 mill at St. Joe State Park, with a capacity of 3,000 tons per day. A detailed inventory of shafts or mines operated by Federal (Buckley 1908) is presented in the Initial RI (Fluor Daniel 1995, page 2-58). By 1908, there were seven producing mines on Federal property and at least nine shafts. By 1910, Federal controlled 16,000 acres in St. Francois and Washington counties, and was one of three major producers in the district with St. Joseph Lead Company and The Doe Run Lead Company. Milling operations were consolidated at the Federal mill in 1911. The Federal mill burned in 1912 and was reconstructed. In October 1923, the St. Joseph Lead Company purchased all the Federal Lead Company holdings, including at least 12 shafts and the mill, which at that time was treating 4,800 tons per day. The Federal mill was permanently closed in 1970 when the mining operations in the area shifted to the Viburnum trend or New Lead Belt. St. Joe Lead Company donated 8,561 acres to the state of Missouri for use as a park in 1976. The successor to the St. Joe Lead Company was renamed The Doe Run Resources Corporation in 1994, and currently does business as The Doe Run Company.

The EPA entered into an Administrative Settlement Agreement and Order on Consent, or ASAOC, for a removal action with The Doe Run Resources Corporation and the MDNR Division of Parks in 2011 for the stabilization of the Federal Pile. Work will be completed at Federal in September of 2018.

Hayden Creek Mine

The Hayden Creek Mine is located one mile southwest of the town of Frankclay. St. Joe Lead Company discovered the ore body by random drilling in 1943. Underground development of the Hayden Creek, or No. 22 mine, started in 1949 with the sinking of the shaft. Further development was undertaken in 1951 with limited mining in 1952. Mine production averaged about 1,000 tons of ore per day. A 1,200 ton-per-day magnetic separation mill was constructed, but failed to operate satisfactorily; eventually, all ore produced was trucked to St. Joseph Lead Company's Leadwood mill for processing. The Hayden Creek mine was closed in 1958, and the facilities were demolished.

Hayden Creek will be remediated under the conditions set forth in the Consent Decree, or CD, for OU1. The Remedial Action Workplan for Hayden Creek will be developed by May of 2020.

Doe Run Pile

The Doe Run Lead Company was organized in 1886 or 1887, and began operations in the town of Doe Run on the old Wm. R. Taylor tract. The Doe Run Lead Company sank two shafts, one 110 feet and the other 47 feet deep at the Doe Run property. About 1890, The Doe Run Lead Company acquired a tract of land in the Flat River area, and in 1907 acquired additional properties formerly owned by the Union Lead Company and the Columbia Lead Company. As of about 1908, The Doe Run Lead Company operated four shafts, two in the town of Doe Run and two in the Flat River area. By 1910, The Doe Run Lead Company had eleven shafts in the Flat River area. The property was acquired by St. Joe Lead Company in 1936 when The Doe Run Lead Company was dissolved. St. Joe Lead Company sold the site of the Doe Run Pile to an individual in 1977. The Doe Run Pile is approximately 24 acres in a rural area, immediately south of the town of Doe Run.

The Doe Run pile has not been addressed. The EPA plans to address this pile as part of a separate OU.

Operable Units

There are currently four operable units designated at the site.

OU00 – Site-Wide Activities, consists of the removal activities at the Bonne Terre, Leadwood, Federal, Elvins, and National pile locations; residential properties; and high child exposure areas (e.g. playgrounds, daycare facilities).

OU1 – Residential Action and Source Control, consists of the stabilization of the Desloge Pile, stabilized in 2000, and remediation of residential properties and high child exposure areas exceeding a soil cleanup level of 400 milligrams per kilogram (mg/kg) or, parts per million (ppm) in St. Francois County. The remedial action focuses on the towns and rural residential properties surrounding Park Hills, Desloge, Bonne Terre, Leadwood, Leadington, and Doe Run. The ROD for OU1 was completed in September of 2011, and cleanup under OU1 is scheduled for completion by 2031.

OU2 – Off-Source Areas, the subject of this early interim action, includes the remedial action to address sediment and floodplain soil impacted with lead-contaminated mine waste.

OU3 – Interim Program and Halo Removal Action, consists of the removal action to address elevated blood lead levels at the site. OU3 was considered complete upon the effective date of the CD for OU1. The CD addresses any of the remaining obligations for OU3.

C. SITE CHARACTERISTICS

The primary land use within St. Francois County since mining operations have ended is agricultural crop and pasture land. Industrial activities consist of light manufacturing, aggregate production and construction. The population of St. Francois County is 65,246, with approximately 57 percent of the county population located in Farmington (16,522), Park Hills (8,717), Desloge (5,027), and Bonne Terre (6,853) (USCB 2014). The population of St. Francois County includes 21.3 percent under the age of 18; 14.4 percent over the age of 65; a median household income of $36,716; and a population density of approximately 144 people per square mile (sq. mi).

The site is located within the Salem Plateau section of the Ozark physiographic province. The topography is hilly with several hundred feet of relief with altitudes ranging from about 700 to 1,000 feet above mean sea level, or msl. The climate in St. Francois County is continental with cold winters and hot summers. Annual precipitation is approximately 40 inches with a rainy season in fall and winter. Average annual snowfall is 13.7 inches. Prevailing winds are from the south.

The site is located on the flanks of the St. Francois Mountains, a positive topographic structure in the southeast portion of the county composed of Precambrian granite and volcanic rocks. Cambrian sedimentary rocks are present above the Precambrian rocks and are, from oldest to youngest, the Lamotte Sandstone, Bonne Terre Formation, Davis Shale, Derby-Doe Run Dolomite, Potosi Dolomite and Eminence Dolomite.

The Bonneterre Formation is host to most of the ore bodies and is primarily composed of dolomite. The Bonneterre Formation is 200 to 400 feet thick. The dolomite occurs as halos around igneous knobs that extend into or through the Bonneterre Formation. Away from these igneous paleo-topographic highs, the Bonneterre Formation is composed of unmineralized limestone. The lower 100 feet contain a variety of depositional structures where the richest ore was concentrated. The most abundant sulfide minerals in the Bonneterre Formation are galena, sphalerite, chalcopyrite, pyrite, and marcasite. Sphalerite, or zinc ore, is restricted to certain areas of the district and is much less common than in the Tri-State Mining District of northeast Oklahoma, southwest Missouri, and southeast Kansas.

As set forth above, past mining operations have resulted in at least eight identified major mine waste areas in the form of tailings and chat deposits from smelting and mineral processing operations in St. Francois County. The mine waste contains elevated levels of lead and other heavy metals which pose a threat to human health and the environment. This threat is being addressed by stabilizing the mine waste deposits in place, which includes regrading and covering the mine waste deposits with clean rock and/or soil. In place stabilization of the mine waste deposits provides adequate protection when combined with institutional controls, such as site access restrictions (i.e. fences, rock barriers, etc.). Six of the mine waste deposits have been stabilized in place, and there are plans in place to address the remaining areas. The presence of mine waste has resulted in contaminated soil, sediment, surface water, and groundwater. Mine waste has also been transported by wind and water erosion and manually relocated to other areas throughout the county. Mine waste was also used on residential properties for fill material and private driveways, and as aggregate for road construction.

History of Investigations

The EPA and the Missouri Department of Health, or MDOH, began investigating the site in 1991. These investigations focused on the effects of the mine waste from the Desloge, or Big River, Pile. To investigate a broader area, the EPA performed a Listing Site Inspection in 1991 and a Site Assessment in 1992, which resulted in the site listing on the National Priorities List, or NPL, in 1992. The NPL is a national list of Superfund sites that prioritizes cleanups in order of the most serious contamination problems and greatest threats to human health and the environment.

The site inspection and site assessment identified potential sources of mine waste in the Big River watershed, determined the composition of these sources, and determined that there had been a release of mining-related contaminants, or heavy metals, to media within the Big River watershed. The site inspection and site assessment also identified uses of mine waste in the area and provided analytical data on soil, tailings, sediment, air, surface water and ground water near the mine waste piles. Geographically, the site investigation included the entire site. A limited number of samples were collected from mine waste, groundwater, sediment, and soil, and were analyzed for heavy metals. Overall, the results indicated elevated concentrations of a number of heavy metals in samples of mine waste, groundwater, sediment and soil.

OU1 Investigations

Studies conducted by the MDOH, including a Preliminary Public Health Assessment in 1994 and a lead exposure study in 1997, concluded that 17% of children tested in the mining area of St. Francois County possessed elevated levels of lead in their blood. As a result of elevated blood lead levels in children in 1997 and 1998, the MDOH followed the Exposure Study with the St. Francois and Jasper Counties Lead Intervention Study in 2000 as an effort to reduce the percentage of elevated blood lead levels in children at the site.

In 1997, the EPA entered into an AOC for a remedial investigation/feasibility study, or RI/FS. The site-wide RI was completed in 2006, and the FS for OU1 was completed and released in 2011. The FS developed the alternatives for the remedial action for the residential properties. The remedial alternatives developed and evaluated in the FS formed the basis of the proposed plan for OU1. The FS for OU1 is in the AR for the site.

In 2000, the EPA entered into an AOC with The Doe Run Resources Corporation, for the implementation of a soil testing and removal program and blood lead testing and control program within the site. This order provided that these programs would end when either the EPA issued a ROD for residential yards or after four years. In 2004, the EPA entered into another AOC for Removal Action to replace the 2000 order, which under its terms was expiring. The 2004 AOC was called the "Halo Removal Order." The Halo Removal Order designated six of the mine waste areas in St. Francois County: National; Elvins; Bonne Terre; Federal; Desloge; and, Leadwood. The Halo Removal Order required removal actions to address lead contaminated residential properties within the "halo" around each of these waste areas. The halo is defined as the area within 500 feet of chat and tailings waste, 1,000 feet from four identified smelters/calciners, and 100 feet from mine shafts.

At the end of the Interim Action, March 30, 2004, 1,955 residential yards had been sampled and 563 homeowners had refused sampling; for a 78% sampling rate. Under the Halo Removal Order, 27 additional yards have been sampled; of these yards, 22 were sampling refusals during the Interim Action; two were not within the Halo, but were sampled due to the presence of a child with elevated blood-lead levels; and two were childcare facilities.

The EPA issued the OU1 ROD on September 30, 2011. The EPA estimated that over 4,000 residential properties would qualify for the Remedial Action under OU1. The EPA and respondents have sampled nearly 5,000 residential properties and remediated nearly 1,300 properties to date.

OU2 Investigations

Investigations of the Big River Watershed, or OU2, began in the late 1970's, and are currently underway. The EPA BERA was completed in 2006, and can be found in the AR for the site. The EPA reviewed the existing data and collected the following information:

Soil

- 93 surface soil samples (81 samples, 1 background sample, and 11 duplicates) were collected from mine waste piles, off-site vegetated areas, and off-site unvegetated areas from the 0- to 12-inch depth interval.

- All surface soil samples were analyzed for total metals, percent moisture, total organic carbon, and pH.

- The preliminary screening identified lead and zinc as Contaminants of Potential Concern, or COPCs, for direct exposure to plants in soil, and zinc as a COPC for direct exposure to earthworms in soil. Therefore, a subset of the soil samples was also assessed for toxicity. Toxicity tests (plant and earthworm) were conducted across a gradient of lead contamination, considered to be the primary risk contributor at the site. Nine samples (eight sample locations plus a background location) were selected from the XRF results according to the targeted gradient and sent to the Region 7 EPA laboratory for toxicity testing and tissue analysis.

- Surface soil samples were assessed using plant germination toxicity tests according to American Society of Testing and Materials, or ASTM, E1963-02-Standard Procedures for Conducting

Terrestrial Plant Toxicity Tests. Earthworm toxicity samples were analyzed according to ASTM E1676-04 42-Day Toxicity test using Earthworms, or Eisenia fetida.

Surface Water

- 62 surface water samples (61 samples including 1 duplicate) were collected at a 0-12 inch depth interval. Surface water samples were filtered in the field to represent the dissolved portion of metals, which provides a better estimation of the bioavailable concentrations of contaminants present in surface waters. All surface water samples were analyzed for hardness, pH, temperature, specific conductance, turbidity, dissolved oxygen and oxidation reduction potential.

- Samples were collected from the following locations:
    - 34 samples from Big River;
    - 12 samples from Flat River Creek;
    - 3 samples from Hayden Creek;
    - 1 sample from Koen Creek;
    - 3 samples from Mineral Fork;
    - 6 samples from on-site ponds; and
    - 2 background samples upstream of Leadwood.

Sediment

- 62 sediment samples (61 samples including 1 duplicate) were collected at a 0-6 inch depth interval. The sediment samples were co-located with the surface water samples described above. All sediment samples were analyzed for total metals, Total Organic Carbon or TOC, Simultaneous Extracted Metals/Acid Volatile Sulfides or SEM/AVS, and percent moisture.

- Two sampling locations on the Big River upstream of the Leadwood pile appeared to represent background for the site.

Sieved Sediment and Pore Water Data

- Co-located sieved sediment and pore water, or dissolved fraction, was collected at a total of 12 locations (9 from the Big River, 2 from the Flat River Creek and 1 from Mineral Fork).

Sediment Toxicity

- Sediment toxicity was measured using the sediment quality triad (Chapman, 1990), which is a weight of evidence approach that includes the chemical analysis of sediment, toxicity testing and an evaluation of the benthic invertebrate community structure.

- Chemical analysis of sediment was accomplished through analysis of total metal concentrations in bulk sediment as well as through SEM/AVS analysis. SEM/AVS was used because the ecotoxicity of metals in sediment may be associated with the ratio of SEM to AVS.

- Amphipod, or Hyalella Azteca, Toxicity Tests were conducted to provide an additional line of evidence. A subset of the sediment samples was assessed for toxicity. Sediment samples for the invertebrate toxicity tests targeted the following gradient for lead: 50, 100, 150, 300, 600, 800, 1,200, and 2,400 mg/kg. Nine samples (eight sample locations plus a background location) were selected from the XRF results according to the targeted gradient and sent to an EPA contract laboratory for toxicity testing. All sediment toxicity samples were analyzed according to the Amphipod 42-day Test for Measuring the Effects of Sediment-associated Contaminants on Survival, Growth and Reproduction (EPA Test Method 100.4).

Macroinvertebrate Survey

- A macroinvertebrate survey was performed at 8 locations across the site corresponding to a gradient of metal concentrations in sediment (EPA, 2005b). Three replicates, and one sample each in a run and a pool were taken at 6 locations on the Big River.

- Two additional locations, one on Hayden Creek and one on Flat River Creek, were also sampled. These other two locations did not have adequate flow to sample replicates; therefore, sampling was restricted to one pool on Hayden Creek and one riffle, one run, and one pool on Flat River Creek.

- A total of 34 aquatic macroinvertebrate samples were collected and analyzed for seven metrics including total invertebrate counts, taxa richness, Ephemeroptera, Plecoptera, Trichoptera or EPT Index, % EPT, % dominance, dominant taxa, EPT/Chironomidae ratio, and % Chironomidae.

Assessment of Biota

- Terrestrial Biota Sampling included a risk evaluation of the vermivore community which focused on establishing protective levels of contamination that would also be protective of the less highly exposed receptor guilds (herbivores and carnivores). Terrestrial biota sampling focused on estimating risk to vermivore communities since remedial alternatives developed to be protective of vermivore communities will also be protective of herbivore and carnivore communities.

- The sampling plan for the BERA included earthworm tissue collection at the nine soil sampling locations corresponding to the earthworm and plant toxicity tests; however, earthworms could not be found at any of the sampling locations along the gradient. Therefore, preliminary earthworm tissue concentrations as well as earthworm tissue concentrations measured at the conclusion of the earthworm toxicity tests were used as a means of estimating doses due to earthworm ingestion.

Aquatic Biota Sampling

- 5 amphibian (frogs) samples were collected from on-site pond locations.

- 13 crayfish samples were collected from the following locations: Flat River Creek (3 samples); Big River (7 samples); Mineral Fork (1 sample); and, Hayden Creek (2 samples).

- 13 small fish samples were collected from the following locations: Mineral Fork (1 sample); Big River (9 samples); and, Flat River Creek (3 samples).

Results and conclusions from the BERA are included in the site AR. Much of the data collected is over 10 years old and may be considered misrepresentative of the current site conditions. After the BERA was completed, stabilization was finished at the Bonne Terre, Elvins, Leadwood, and National Piles. Respondents performed a supplemental investigation of the Big River starting in 2012 under the conditions of the 1997 RI/FS AOC. The purpose of the supplemental investigation was to identify and address any gaps in the existing dataset, as well as update the dataset to reflect current conditions. The following tasks were performed as part of the supplemental investigation:

- Task 1: Visual River Survey
- Task 2: Surface Sediment Collection
- Task 3: Visual Railbed Survey
- Task 4: Sediment Probing for Volume Estimates
- Task 5: Floodplain Soil Collection
- Task 6: Riverbank Soil Collection
- Task 7: Beach Material Collection
- Task 8: Geomorphic Evaluation
- Task 9: Porewater Collection
- Task 10: Fish and Crayfish Tissue Collection
- Task 11: Sediment Toxicity Testing
- Task 12: Earthworm Bioaccumulation

The following provides a summary of the findings of each task:

<u>Task 1: Visual River Survey</u>

- The Visual River Survey, or VRS, was conducted in March 2012. The purpose of the VRS was to document riverine characteristics and to identify the location and extent of physical features along the river to support the understanding of sediment stability, habitat, and potential risk exposure areas. The VRS was conducted on the Big River from river mile, or RM, 115.8 (upstream of the mining area) to RM 60.95 (downstream of the mining area).

- The following observations were recorded:
  - 27 eroded banks, which were much more prevalent in the lower 20 miles of the VRS.
  - 44 depositional areas.
  - 9 beach areas.
  - 42 bore holes which were in the upper reaches of the VRS (RM 112.3 to RM 105.7).

<u>Task 2: Surface Sediment Collection</u>

- Surface sediment was collected from 0-4 inches depth in August - September 2013, from the following reaches:

  - Big River at 23 locations from RM 120.7 to RM 62.4.
  - Flat River Creek at 6 locations from RM 6.7 to RM 0.0.
  - Mill Creek at 5 locations from RM 3.3 to RM 0.55.
  - Mineral Fork at 11 locations from RM 2.66 to RM 1.58.

- Results for lead concentration (in mg/kg) in the sediment are summarized as follows:

  - The background samples (n=3) in Big River (upstream of the mining impacted area) had a mean concentration of 26 mg/kg with a range of 22 to 32 mg/kg.
  - The samples within the mining impacted area (n=20) had a mean concentration of 1,034 mg/kg with a range of 319 mg/kg to 2,350 mg/kg; however, the samples collected in the

focus area of this Early Interim Action (n=7), which is located near the source areas, had a mean concentration of 1,527 mg/kg with a range of 809 mg/kg to 2,350 mg/kg. For more information on sediment sampling locations see Appendix A, Figure 2.

Task 3: Visual Railroad Survey

- The Visual Railroad Survey, or VRRS, was conducted in December 2012 to identify and delineate areas of eroded mine waste from railroad beds that are potential sources of mine waste contamination to the Big River Watershed. The VRRS was performed at 19 locations along Big River and tributaries within St. Francois County where the railroad beds were identified as being within approximately 50 ft. of Big River or a tributary (see Appendix A, Figure 3).

- Data collected in the VRRS were used to identify areas of historical and recent erosion, estimated sediment volumes of eroded areas, and confirm the distance of the eroded areas to the adjacent river or creek. In locations where additional measurements were made using an open reel tape measure, volume estimates of eroded railroad bed material were developed based on cross-section geometry of the eroded area.

- The following observations were recorded:

  - Survey sites were evaluated to characterize the extent of exposed and eroded railroad bed material as well as the distance of erosional areas to the nearest water body. Evidence of ongoing erosion was not observed at most of the surveyed railroad beds. At several survey sites, the observed erosional areas were greater than 50 ft. from the waterbody and it is unlikely that eroded material enters the waterbody.
  - Erosional areas within 50 ft. of a waterbody were observed at 5 of the 19 survey locations: HRR003, HRR009, HRR011, HRR012, and HRR014. The observed erosional areas from these survey locations are situated on or directly above riverbanks and constitute an active source of railroad bed material to the stream.
  - Comparisons of eroded railroad bed material volume estimates with results from sediment probing surveys suggest the historical railroad beds are a relatively minor source of material to the Big River watershed, as the estimated volumes of eroded material are orders-of-magnitude lower than estimated volumes of sediment in the Big River watershed. The VRRS indicated that chat eroding from historical railroad beds could, at most, account for only a very small proportion of the total sediment volume.

Task 4: Sediment Probing for Volume Estimates

- Sediment probing in Big River, Owl Creek and Flat River Creek was performed in November-December 2012, to help estimate current sediment volumes in depositional areas in the Big River and its tributaries. The accumulation of sediment within Big River at the locations evaluated suggests that these locations act as long-term sediment traps.

- To estimate the average thickness of the sediment in the selected depositional areas, 20 cross-sections of Big River and selected tributaries were evaluated (Appendix A, Figure 4).

- The following section summarizes the results from the Sediment Probing Study:
  - Three sediment probing transects were performed from the confluence of Big River with Owl Creek to the low-water crossing at the Bone Hole (BRFSSP01 through BRFSSP03).

Results from transects BRFSSP01 through BRFSSP03 indicated a depositional environment, with an estimated total volume between the transects of 547 cubic yards, or CY; the observed deposition is consistent with the low-water crossing slowing the flow of Big River and creating a depositional backwater area.

- Four sediment probing transects were performed in Big River adjacent to St. Francois State Park in which the 1,900 ft. long surveyed area contained approximately 22,000 CY of sediment. Gravel and sand bars were observed in each St. Francois State Park probing transect and contained approximately 70 percent of the estimated volume. The sand and gravel bars as well as the river bottom of this stretch of Big River are an area where sediments are stored along Big River.
- Sediment probing was performed along the lower 1,000 ft. of Owl Creek at three transects. Little sediment deposition was observed in the uppermost transect, and the creek bottom was scoured to bedrock at some locations along this transect. The Owl Creek transects contains approximately 1,206 CY of sediment.
- Ten sediment probing transects were performed in Flat River Creek from the drainage of the Elvins pile to the confluence with Big River. The estimated sediment volume in the lower 5 miles of Flat River Creek was 21,000 CY.

Task 5: Floodplain Soil Collection

- Floodplain soil sampling was performed in November-December 2012, along Big River to support the update to the 2006 BERA. Floodplain soil samples were collected from 0-12 inches depth at nine of the ten proposed transect locations along Big River including two reference locations upstream from the historic mining areas. The locations (Appendix A, Figure 5) provided relatively uniform coverage throughout the OU2 study area and included exposed riverbed material, riparian buffers, open fields, and low-lying forests near Big River.

- Results of the floodplain soil collection are as follows:

  - The background samples (n=10) in Big River (upstream of the mining impacted area) had a mean lead concentration of 38 mg/kg across the 100-year floodplain with a range of 16 mg/kg to 77 mg/kg.
  - The samples within the mining impacted area (n=34) had a mean lead concentration of 932 mg/kg with a range of 39 mg/kg to 2,260 mg/kg.
  - The floodplain soil sampling results show a trend of elevated lead levels in the floodplain within the historical mining area, especially in the floodplain soil that is more frequently flooded (e.g., 5-10 year floodplain). All results are shown in Appendix A, Figure 5. Please note that within each transect, the stations were sampled at equal distances across the 100-year floodplain. Station 1 was collected 5 feet away from the edge of the river bank and the additional stations were collected in ascending order moving away from the river bank.

Task 6: Riverbank Soil Collection

- Riverbank soil sampling was conducted in November-December 2012, along Big River to provide information on chemical concentrations of soils that may erode into Big River. Riverbank soil samples were collected from 2 inches deep at nine locations along Big River, including one reference location upstream from the historic mining areas (see Appendix A, Figure 6). At each location, one continuous vertical composite sample was collected from the approximate center of the exposed riverbank. The vertical composite sample extended from the top of the bank (just below the vegetation) to the waterline. Sample collection procedures were performed as described in Section 2.1.7 of the Field Sampling Plan (FSP, Integral 2012b).

- Results of the riverbanks sampling are as follows:

  - The background sample (n=1) in Big River (upstream of the mining impacted area) had a lead concentration of 28 mg/kg.
  - The riverbank samples within the OU2 Site (n=8) had a mean lead concentration of 1,009 mg/kg with a range of 32 mg/kg to 3,340 mg/kg.
  - Sample results for the riverbanks were not as consistent as the findings in floodplain soil. Elevated lead concentrations were found downstream of the Desloge pile moving downstream to the site boundary.
  - Most notably was the result of Station BRFSRB08. This sample was collected near the downstream boundary of the site and the lead concentration was 3,340 mg/kg. All results are listed in Appendix A, Figure 6.

Task 7: Beach Material Collection

- Beach material sampling was performed in November-December 2012. Beach material samples were collected from 0-4 inches deep at nine locations along Big River, including one reference location above the historic mining areas and one location in Flat River Creek (Appendix A, Figure 7). The selected locations provided relatively uniform coverage throughout the OU2 study area. Sample collection procedures were performed as described in Section 2.1.8 of the FSP (Integral 2012b).

- Results of the Beach Sampling are as follows:

  - The background sample (n=1) in Big River (upstream of the mining impacted area) had a lead concentration of 22 mg/kg.
  - The beach samples within the OU2 site (n=8) had a mean lead concentration of 1,288 mg/kg with a range of 19 mg/kg to 4,660 mg/kg.
  - Elevated lead concentrations with respect to the reference locations were found below the Desloge pile moving downstream to the boundary.
  - Most notably was the result of Station FRCFSBA01, which was located on Flat River Creek near the confluence with Big River. This sample had a lead concentration of 4,660 mg/kg. All results are listed in Appendix A, Figure 7.

Task 8: Geomorphic Evaluation

- The purpose of the Geomorphic Evaluation, or GE, was to characterize river features and dynamics related to sediment erosion, transport and storage within the Big River channel in support of the FFS.

- The primary objectives of the GE were to identify areas of bank instability, short-term and long-term storage, and sediment transport along the river profile such that the data obtained could be combined with other site-specific chemical and physical data and used to further the FFS and potential remedial design alternatives evaluation. Specifically, the data quality objectives, or

DQO, set forth by the Quality Assurance Project Plan, or QAPP, established the following fluvial geomorphic assessment objectives:

- Identify the rate of erosion from the riverbanks along Big River in OU2.
- Determine where the sediments are deposited and stored in OU2, and what is the volume of sediment stored in these areas.
- Identify the natural transport processes that control sediment stability.

- An approach based on the EPA-approved Watershed Assessment of River Stability and Sediment Supply, or WARSS (Rosgen, 2006) method that incorporates site-specific fluvial geomorphic properties/characteristics and provides a framework to calculate stream bank erosion rates, as well as the quantification and distribution of sediment was selected. The following gives a summary of the results of the GE. For more information please refer to the GE in the AR (The ELM Group, INC., 2014).

- Six Areas were subject to the GE, including one reference location.

- Results of the GE are listed as follows:

  - *Riparian assessments*
    - Based on field measurements and observations, the Big River riparian zone is high quality in most areas and there was evidence of human activity at each of the survey river reaches.
    - Riparian habitat assessment forms completed at each of the surveyed river reaches resulted in an average score of 38 (85%) indicating a riparian zone that supports dense native plant communities, the presence of large woody debris, and ample overhead canopy cover.
    - There were numerous observations during the VRS of large trees along the bank that had recently fallen resulting in a cut/collapsed bank of open soils. In addition, there were several riparian zones within the OU2 area where there is an absence of any native vegetation along the bank and the farm fields extend to the top of bank resulting in substantial bank cutting.

  - *Stream Classification Transition*
    - The stream classification for the Big River, based on the fluvial geomorphic survey, demonstrates properties that are consistent with a C4 stream type. The naming of Level II stream types combines the Level I letter (A through G) with the number representing the dominant bed material (1 through 6), resulting in names such as B3, C4, A2 and so on. In general, the C4 stream type has a very high sensitivity to disturbance, but has a good potential for recovery following disturbances. These streams also have very high stream bank erosion potential, depending on the presence of vegetation, resulting in a high sediment supply.

  - *Bank Erosion Rates*
    - Bank erosion was calculated at each of the bank pin locations (see Appendix A, Figure 8) that had a complete bank profile in both the 2012 and the 2013 surveys. To determine an erosion rate, the amount of erosion was evaluated for the length of time between surveys (November 2012 and June 2013).

- Erosion occurred at all bank pin locations except bank pin location 2, where a hillslope failure deposited sediment into the active bank profile used for the bank pin evaluations. Specifically, bank pin location 2 (BRFSGS-BP02) was not included in the calculations for bank erosion as the survey control point (used to link the 2012 and 2013 surveys) was buried under a fallen tree and field data/measurements were not considered representative of typical conditions. The calculated erosion rate for the bank pin locations (excluding bank pin location 2) varied from 0.04 ft./year to 2.44 ft./year, with an average rate of 0.74 ft./year during a period when discharge levels were elevated. The BEH1 scores for the surveyed banks ranged from 41.25 to 60.00 which correspond to a Very High to Extreme potential for erosion. Excluding Bank Pin No. 2, the average bank erosion rate (in/BE) for the combined river reaches that scored an Extreme BEHI rating is 0.44.

- *Sediment Transport and Storage*
  - Most of the river reaches that were surveyed demonstrated the capability to entrain and transport the sized sediments that were present in the river reaches, as evident from the sediment competence calculations based on the pebble counts, bars sieve analysis, and the fluvial geomorphic survey.
  - The river reaches surveyed for the fluvial geomorphic assessment were selected in part due to the presence of in-channel bar formations that could be measured via longitudinal profile and cross section surveys. Based on the calculation/estimation method, the estimated total volume of sediment stored in the bars of the surveyed reaches was 143,921 CY. This is only a small portion of the river's potential storage, as the floodplains store large quantities of riverine sediments.
  - The GE concluded that sediment sources primarily included unstable in-channel areas; specifically, the unstable cut slopes on the outside of meander bends are the primary source of sediment in the Big River watershed. Unstable slip slopes, on the inside of meander bends, constitute the remainder of the predominant sediment sources.

<u>Task 9: Porewater Collection</u>

- Porewater was collected in August-September 2013, using mini-peepers at 23 locations in Big River (including 3 reference locations) and at 6 locations in Flat River Creek (including 1 reference location). Locations of porewater samples can be found in Appendix A, Figure 9.

- Mini-Peepers were deployed using the sampling scheme in the FSP Addendum (Appendix A, Figure 10) and were retrieved after a 14-day equilibrium period.

- Analyses was conducted on the following parameters:
  - Dissolved metals.
  - Alkalinity, chloride, sulfate, pH, dissolved organic carbon, ammonia, and hardness.

- Results for dissolved lead (micrograms/liter, μg/L) are as follows:
  - Samples collected at the Big River background locations (n=3) had a mean lead concentration of 0.58 with a range of 0.144 to 1.38.

- The sample collected at Flat River Creek background location (n=1) had a lead concentration of 0.198.
- Samples collected in the Big River within the mining impacted area (n=20) had a mean lead concentration of 34.57 and a range of 3.49 to 69.
- Sampled collected in the Flat River Creek within the mining impacted area (n=5) had a mean lead concentration of 41.58 and a range of 19 to 77.4.

<u>Task 10: Fish and Crayfish Tissue Collection</u>

- Fish Tissue and Crayfish Tissue samples were collected in September 2013.

- Samples were collected at 7 locations, including one background location (see Appendix A, Figure 11).

- Three types of tissue samples were targeted at each location: composite sample of large fish (sunfish [3-9 inches] or suckers [6-12 inches]); composite sample of small fish (minnows or darters [2-5 inches]), and up to four composites of crayfish per location.

- Lead concentrations (mg/kg) for the tissue sampling are summarized below and all results are included in Appendix B, Table 1:

  - Background Sample at Big River (REFBRFSFCA)
    - Samples of sunfish fillets (n=4) had a mean lead concentration of 0.131 mg/kg with a range of 0.116 mg/kg to 0.148 mg/kg.
    - Samples of whole body sunfish (n=4) had a mean lead concentration of 0.748 mg/kg and a range of 0.516 mg/kg to 1.26 mg/kg.
    - Samples of whole body small fish (n=4) had a mean lead concentration of 1.01 mg/kg and a range of 0.429 mg/kg to 1.65 mg/kg.
    - Crayfish samples (n=2) had a mean lead concentration of 2.45 mg/kg.

  - Samples in Big River within the mining area
    - Samples of sucker fillets (n=8) had a mean lead concentration of 4.2 mg/kg with a range of 2.56 mg/kg to 6.24 mg/kg.
    - Samples of sunfish fillets (n=30) had a mean lead concentration of 8.76 mg/kg with a range of 2.44 mg/kg to 26.3 mg/kg.
    - Samples of whole body sunfish (n=30) had a mean lead concentration of 58.98 mg/kg with a range of 30.2 mg/kg to 124 mg/kg.
    - Samples of whole body small fish (n=24) had a mean lead concentration of 67.5 mg/kg with a range of 16.5 mg/kg to 291 mg/kg.
    - Samples of whole body crayfish (n=12) had a mean lead concentration of 78.2 mg/kg with a range of 50.3 mg/kg to 130 mg/kg.

<u>Task 11: Sediment Toxicity Testing</u>

- Macroinvertebrate communities are directly exposed to sediment and sediment pore water. To evaluate impacts to the macroinvertebrate community, the following data were used from a total of 20 sites on the Big River (see Appendix A, Figure 9):

- Total metals (barium, cadmium, lead in zinc) in field sieved sediment;
- Total solids;
- Grainsize;
- Acid Volatile Sulfide/Simultaneously Extracted Metals
- 42-Hyallela Azteca toxicity test;
- Dissolved metals in pore water collected using mini-peepers; and
- Alkalinity, chloride, sulfate, pH, dissolved organic carbon, ammonia, and hardness in pore water.

Task 12: Earthwork Bioaccumulation

- The primary objectives of the Task 12 investigation were to collect earthworms and co-located floodplain soil (0–12 in. [0–30 cm]) for tissue and soil chemistry to support the BERA update. The data from the Phase I investigation were used to select the proposed locations that provide spatial coverage in OU2 and to be representative of the observed range of metal concentrations. **Please note**: Earthworms were stored at room temperature and away from sunlight for 24 hours to allow depuration before tissue analysis.

- Samples were collected in May 2013 from 18 locations, including 2 background locations (see Appendix A, Figure 12).

- Results for the sampling under Task 12 are as follows:

  - The floodplain soil samples collected from the background locations (n=2) had a mean lead concentration of 40 mg/kg.
  - The worm tissue samples collected from the background locations (n=2) had a mean lead concentration of 8.2 mg/kg.
  - The floodplain soil samples collected from the mining impacted locations (n=16) had a mean lead concentration of 1,359 mg/kg with a range of 124 mg/kg to 2,400 mg/kg.
  - The worm samples collected from the mining impacted locations (n=16) had a mean lead concentration of 356 mg/kg and a range of 22.2 mg/kg to 851 mg/kg.

Please note: The risk calculations from the BERA and the 2012-2013 supplemental data are included in AR for the site.

D. SCOPE AND ROLE OF THE RESPONSE ACTION

This proposed plan sets forth the proposed response action and represents the EPA's early interim approach to address OU2, non-residential floodplain soil and stream sediment. OU2 includes lead-contaminated sediment and floodplain and soil present in the Big River from the Eaton Creek confluence near Leadwood moving downstream to the confluence with Mill Creek (approximately 37 river miles). OU2 also includes lead-contaminated sediment and floodplain soils in the Flat River Creek from the Elvins site moving downstream to the confluence with Big River (approximately 6 river miles).

The EPA proposes to address the floodplain soil and sediment in the upper reaches of the site as the first remedial action to expedite cleanup of the areas that pose the greatest and most immediate threats to human health and the environment. The early interim approach will allow the EPA to study the effects of proposed technologies on the overall stability and function of the Big River watershed. The iterative nature of the early interim approach proposed will both remove and stabilize some the most highly contaminated areas of the river and floodplain while assessing any unintended negative impacts to this dynamic system. This first remedial action for OU2 will address residual contamination that resulted from over 300 years of mining practices in the Old Lead Belt. Additional remedial actions at the site, such as the stabilization of the Doe Run Pile and areas further downstream may, be addressed under future proposed plans and RODs.

The estimated volume of sediment to be removed from the streams for the early interim remedial action is approximately 150,600 cubic yards. This estimate includes one removal cycle per year of sediment from the existing sediment trap at the Big River/Flat River Creek confluence (5,900 cy/year from years 1-11) along with the proposed locations in the FFS. Sediment that contains lead concentrations greater than or equal to 1,200 mg/kg will be targeted for the Early Interim Action. Removal of sediment greater than or equal to 1,200 mg/kg will include co-located sediment that is lower in metal concentrations that will not be separated during the early interim remedial action events. This will function as the initial reduction of metal concentrations that may lead to actions under the Final ROD to meet the Preliminary Remediation Goals, or PRGs. Specific locations are depicted in Appendix A, Figure 13.

Floodplain soil will be stabilized in place using different techniques depending on the specific reach to be addressed. The locations and stabilization techniques will be determined during the Remedial Design, or RD. Up to 4,000 feet of eroded river banks will be stabilized to prevent lead-contaminated soil from further eroding into the Big River. Eroding or unstable banks that are greater than or equal to 1,200 mg/kg lead will be targeted for the early interim remedial action. Stabilization of riverbanks that are greater than or equal to 1,200 mg/kg will function as the initial action to reduce riverbank erosion that contributes to elevated metal concentrations in the watershed. Further actions to achieve the PRGs, will be determined during the monitoring phase of the Early Interim Action. Riverbank removal will be avoided in areas where stable, existing riparian vegetation and bank toe exists that are not projected to erode and contribute as ongoing contamination to the river system and will be addressed under the final remedial actions for OU2 as determined by monitoring during the early interim remedial action.

E. SUMMARY OF SITE RISKS

Baseline Ecological Risk Assessment

The Baseline Ecological Risk Assessment, or BERA, was completed in 2006 and is included in the AR for the site. The BERA concluded that terrestrial receptors were at an unacceptable risk if estimated exposure doses exceeded Lowest Observed Adverse Effect Levels, or LOAELs. The terrestrial risk characterization found that vermivore communities are at unacceptable risk. The risk characterization also indicated potential risks to plants and soil invertebrates based on a comparison to Ecological Soil Screening Levels, or Eco-SSLs.

A weight-of-evidence approach was used to evaluate risk to aquatic communities using the Sediment Quality Guidelines, or SQGs, and National Ambient Water Quality Criteria, or NAWQC. The conclusion of the risk evaluation for aquatic communities is that the chronic NAWQC and Threshold Effects Concentration/Probable Effects Concentration, or TEC/PEC, sediment quality guidelines both accurately predicted potential effects.

Potential ecological risks were also identified for aquatic carnivorous communities, and unacceptable risks to kingfishers may exist. The risks to the kingfisher were most significant on the Big River and Flat River Creek during the summer months when crayfish are a plentiful food source.

Significant Habitats at Risk

Although low to moderate levels of metal contamination exist in sediment and surface water throughout the site, the evaluation of the aquatic habitats and aquatic media indicated that surface water and sediment in the following stream reaches present an unacceptable risk to aquatic communities:

- The Big River downstream of the Leadwood pile to the confluence of the Mill Creek; and
- The Flat River Creek downstream from Bannister Branch to the confluence of the Big River.

Elevated levels of metal contamination can be found in soil throughout the site due to the historical mining and smelting as well as the transportation of the mine-related material. In general, soil on the piles present the most unacceptable risk to vermivore communities. However, soils sampled at locations directly near the piles as well as some background locations sampled along haul roads appear to present an unacceptable risk to vermivore communities.

Most of the source areas were stabilized by 2012. To reflect current conditions, the respondents collected more recent data on sediment, pore water, fish and crayfish tissue, as well as a 42-day *Hyalella Azteca*, or amphipod, toxicity test. The 42-day toxicity test provides the information needed to develop a cleanup level for the protection of benthic invertebrate communities exposed to lead present in sediment. Moreover, any cleanup level that is selected should also be protective of threatened and endangered mussels in the Big River watershed. Based on the 42-day toxicity test, the following conclusions were made:

- 90% survival of *H. azteca* is predicted at a sediment lead concentration of 325 mg/kg.
- 85% survival of *H. azteca* is predicted at a sediment lead concentration of 581 mg/kg.
- 80% survival of *H. azteca* is predicted at a sediment lead concentration of 840 mg/kg.

Based on the results of the toxicity testing, the PRG for lead in sediment at the site is 581 mg/kg. For more information, please see Appendix C, EPA Recommended Cleanup Levels for Sediment and Soil.

The respondents also collected additional data in 2012 on floodplain soil and bioaccumulation in earthworms. Using the existing multiple lines of evidence, soil PRGs were calculated based on multiple receptors. The following soil PRGs were established for the site.

- Cadmium – 9.6 mg/kg based on protection of the American Woodcock.
- Lead – 730 mg/kg based on protection of the American Woodcock.
- Zinc – 590 mg/kg based on protection of the American Woodcock.

For more information on Soil PRGs, please see Appendix C, EPA Recommended Cleanup Levels for Sediment and Soil.

Human Health Risk Assessment

A Human Health Risk Assessment, or HHRA was not completed as part of the RI for OU2. There are potential exposure pathways to human receptors, specifically ingestion of fish and direct contact, incidental ingestion and inhalation of beach or gravel bar areas within OU2. Investigations conducted by the Missouri Department of Health and Senior Services, or MDHSS, indicate potential unacceptable risk to children from ingestion of fish from the Big River Watershed. The state of Missouri has a "Do Not Eat" fish advisory established for Sunfish, Carp, and Suckers on all of the Big River within OU2.

Based on data collected during the RI, there is potential unacceptable risk from exposure to beach or gravel bar areas with elevated lead concentrations and ingestion of fish with elevated lead concentrations. An HHRA will be conducted to support a final ROD for OU2.

The PRG for beach or gravel bar areas, 800 mg/kg, is based upon a child receptor under a high exposure duration scenario.

Basis for Action

Based on the results of the RI and the risk assessments, the EPA has determined that the preferred alternative, or one of the two other remedial alternatives presented in this interim proposed plan, is necessary to protect public health or welfare and the environment from hazardous substances released at the site.

Chemicals of Concern are listed below along with each media.

COC	Sediment	Soil	Beach/Gravel Bar	Fish Tissue	Surface Water
Cadmium		X			X
Lead	X	X	X	X	X
Zinc		X			X

This proposed plan addresses risks associated with lead, cadmium, and zinc to aquatic and terrestrial receptors at the site. Since this proposed plan focuses on ecological risk, a summary of the EPA Human Health Risk Assessment (2009) has not been included in this proposed plan. For further information, please refer to the HHRA in the Big River OU1 Administrative Record (AR #62119). **Please note:** The sediment and soil PRGs are protective of the ecological receptors evaluated. Residential exposure is intermittent under most conditions; however, if there are residential areas located in the floodplain, those will be addressed under the ROD for OU 1. More detail shall be provided during the development of the Final ROD for the site.

F. INTERIM REMEDIAL ACTION OBJECTIVES

Interim Remedial Action Objectives, or IRAOs, describe in general terms what a remedial action should accomplish to be protective of human health and the environment. IRAOs are statements that specify the environmental media of concern, contaminant type, potential exposure pathways to be addressed by remedial actions, receptors to be protected, and remediation goals or cleanup levels (40 CFR Section 300.430[e][2][i]). IRAOs are identified by reviewing and evaluating site characterization data, risk assessments, applicable or relevant and appropriate requirements or ARARs, and other relevant site information.

This proposed plan addresses the risk to human health and the environment resulting from exposure to sediment, floodplain soils, beach or gravel bar areas and fish tissue contaminated with lead mine waste. The IRAOs for the early interim remedial action are summarized below.

Children are potentially exposed to elevated concentrations of lead in fish tissue. As a result, the following early interim IRAOs were developed:

- Protect humans from eating fish from the site with lead above the state of Missouri fish advisory level of 0.3 mg/kg.

- Reduce lead concentrations in fish in the Big River and Flat River Creek below the state of Missouri fish advisory level for lead of 0.3 mg/kg.

Children are potentially exposed to elevated concentrations of lead at public beach areas along the Big River in St. Francois County. The following early interim IRAO is therefore developed as a protective measure to address the beach or gravel areas within OU2:

- Prevent child exposure to lead levels greater than or equal to 800 mg/kg at beach areas within St. Francois State Park or at other public access beaches.

The evaluation of potential ecological risks including the potential sediment toxicity to benthic organisms indicated that sediment near the source areas is potentially toxic to benthic organisms. As a result, the following early interim IRAO was developed to address potential effects to benthic organisms:

- Reduce cadmium, lead and zinc concentrations in sediment to protect aquatic life.

Dissolved concentrations of lead and cadmium in Big River and Flat River Creek exceed the Missouri surface water quality standards, or WQS, in the vicinity and downstream of former mining areas. Dissolved concentrations of zinc in Flat River Creek also exceeds the Missouri WQS. As a result, the following IRAO was developed:

- Reduce dissolved concentrations of lead, cadmium and zinc in the Big River and Flat River Creek to meet the Missouri WQS.

There is the potential for the downstream migration of sediment and floodplain soil that is contaminated with mining related metals. Within the site, elevated metal concentrations were found in floodplain soil, riverbank soil, beach areas, and sediment. As a result, the following I early interim IRAO was developed:

- Limit mobilization/migration of lead impacted soil and sediment particles from redistributing to the river.

Preliminary Remediation Goals

In general, PRGs are used to develop the long-term contaminant concentrations needed to be achieved to meet IRAOs by the remedial alternatives. These goals must comply with ARARs, or the basis for a waiver must be provided, and result in residual risk levels that fully satisfy the CERCLA requirements for the protection of human health and the environment. PRGs are based on ARARs, risk-based concentrations if standards are not available or not sufficiently protective, or background concentrations of contamination. PRGs may be further modified through the evaluation of alternatives and the remedy selection process.

The PRGs listed below will be used as a potential benchmark to stop actions at the proposed locations for removal. The initial Remedial Action Limit, or RAL, for sediment and soil is 1,200 mg/kg. Eroding banks with soil levels that exceed 1,200 mg/kg will be recontoured and stabilized. Techniques for stabilization will be determined during the RD. The areas designated for sediment removal will be excavated/dredged periodically until the PRGs are achieved.

Media	COC	PRG	Source
Sediment	Lead	581 mg/kg	Site-specific ecological bench mark
Soil			
	Cadmium	9.6 mg/kg	Site-specific ecological bench mark
	Lead	730 mg/kg	Site-specific Ecological bench mark
	Zinc	590 mg/kg	Site-specific Ecological bench mark
Beach/Gravel Bar	Lead	800 mg/kg	Child receptor under a high exposure duration scenario.
Surface Water			
	Cadmium		Missouri WQS
	Lead		Missouri WQS
	Zinc		Missouri WQS

G. SUMMARY OF ALTERNATIVES

Consistent with CERCLA, early interim actions should be protective of human health and the environment in the short term, and is intended to provide adequate protection until a final ROD is implemented; complies with or waives those federal and state requirements that are applicable or relevant and appropriate for the limited-scope action; and be cost-effective. Early interim actions may employ permanent solutions, alternative treatment technologies and resource recovery alternatives to the maximum extent practicable. Early interim actions need to be followed at some point with a final remedial action documented in a ROD.

Capital costs are those expenditures that are required to construct a remedial alternative. Operational and Maintenance, or O&M, costs are those post-construction costs necessary to ensure or verify the continued effectiveness of a remedial alternative and are estimated on an annual basis. Present worth is the amount of money which, if invested in the current year, would be sufficient to cover all the costs over time associated with a project, calculated using a discount rate of seven percent and a 30-year time interval. Construction time is the time required to construct and implement the alternative and does not include the time required to design the remedy, negotiate performance of the remedy with the responsible parties, or procure contracts for design and construction.

The FFS evaluated three remedial action alternatives. The No Action alternative was evaluated; however, the EPA believes that the No Action Alternative is not protective of human health and the environment and does not consider it a viable option. Each of the other two alternatives would require institutional controls to protect the remedy. The two action alternatives require sampling, excavation and disposal of lead contaminated sediment. Alternative 2 requires the stabilization of up to 4,000 feet of eroding riverbanks. Alternative 2 requires the removal of sediment at designated depositional areas used to trap sediment as it moves through the system. Alternative 3 requires complete removal of sediment that is greater than 1,200 mg/kg lead from the instream channel as well as removal and replacement of floodplain soil that is greater than 1,200 mg/kg. As set forth below, Alternative 2 is the EPA's preferred alternative for the Early Interim Action. Each alternative is presented in much greater detail in the FFS, which is part of the AR for the site. The remedial alternatives developed to address the IRAOs previously identified in this proposed plan for the site are presented below this section.

Alternative 1: No Action

Estimated Total Capital Cost: $0
Estimated Annual O&M Cost Range: $0
Estimated Present Worth Cost: $0
Estimated Construction Time Frame: zero months
Estimated Time to Achieve IRAOs: Infinite, IRAOs unachievable

The NCP requires that the EPA consider a no-action alternative against which other remedial alternatives can be compared. Under this alternative, no further action would be taken to monitor, control, or remediate the threat of lead contamination in sediment and floodplain soil at the site. Alternative 1 would not meet the IRAOs because it does not minimize or eliminate the existing or future human health and ecological risk at the site.

Alternative 2: Focused Removal at Seven Candidate Locations with Continued Removal and Adaptive Management

Estimated Total Capital Cost: $ 9.4 million
Estimated Annual O&M Cost Range: $5 thousand
Estimated Present Worth Cost: $ 23.135 million
Estimated Construction Time Frame: 8 years
Estimated Time to Achieve IRAOs: 12 years

The following elements are included in Alternatives 2 and 3, but to varying degrees, depends on any need of the element for the selected remedy using the adaptive management approach under either alternative:

- *Pre-remedy Baseline Sampling.* A comprehensive sampling event would be conducted prior to designing or conducting any remedial actions. This effort would include a compilation and analysis of data recently collected. The results of this event would be to both support the design and compare to monitoring events conducted after remedial action to evaluate the effectiveness of these actions. A sampling event of this scale would be approximately 330 samples, split into sediment, floodplain soil, beach/gravel bar, fish tissue and bank soils. Sampling would be limited to the Big River watershed upstream of Mill Creek. Sampling density would average seven samples per mile.

  Additional sampling efforts would be performed annually in years 3 to 9 to monitor effectiveness of the targeted actions. Sampling locations would be placed to provide supplemental fish, sediment and beach data to provide data to guide future adaptive management decisions in targeted areas. Unlike the scope of 2012 sampling, sediment pore water and sediment toxicity testing are not planned since the PRG for sediment is based on site-specific toxicity.

Reporting would follow the sampling event, and would summarize observed changes in lead concentrations in fish tissue and sediment. Temporal trends in the hazard index, or HI, values and lead concentrations for both media would be evaluated. Statistical correlation between lead concentrations in fish tissue and sediment would be evaluated.

Lead concentrations in sediment and fish tissue should decrease over time due to recent upland remediation activities and source reduction, as well as from dispersion and the import of cleaner sediments from upstream reaches. Trend plots would be developed to examine the potential rates of recovery in fish tissue concentrations. Once lead concentrations in fish tissue are below the fish advisory level of 0.3 mg/kg and the PRGs are achieved, the alternative would be evaluated to determine the status of achieving IRAOs 1 and 2.

- *Predesign Studies.* Additional activities under this alternative include several pre-design studies that will provide site specific data to guide the adaptive management process and design.
    - *Sediment Transport Modeling.* Sediment transport modeling will be scoped and performed based on the specific needs of the selected remedy. Various numerical models are available for one-, two-, or three-dimensional analyses, steady-state or unsteady time series. Model selection will be determined in cooperation with the EPA based on objectives related to the determination of potential contribution from tributaries and the needs of remedial design. Sediment transport modeling will also be used to support design of streambank erosion control measures, which may have specific issues associated with sediment transport such as material stability, local scour, and aggradation. The EPA will continue to monitor suspended sediment moving downstream of the site for a minimum of 3 more years. The stream gage located on Big River and Highway E (north of Bonne Terre) will be used for this purpose.
    - *Evaluation and Assessment of Eroding Banks.* An assessment of eroding streambank and bar locations within OU2 was performed using available aerial images. Google Earth™ and Bing™ images were reviewed. Field surveys will be conducted to visually assess bank condition and characterize COCs of failing or unstable river banks.
    - *Characterization of Flat River Creek Riparian Zone at National Pile.* Supplemental sampling will be conducted within the riparian zone along the Flat River Creek near the National site to assess COC characteristics and potential needs for remedial action.
    - *Evaluation of Erosive Floodplain Features and Establishing "Conservation Easements."* A landscape level review will be conducted within the limits of the Site to identify potential portions of the floodplain that may be erosive and potentially contributing to the Big River. This work will incorporate the results of the pre-design investigation to obtain additional floodplain soil data coupled with identification of former side channels, swales or eroding floodplains that may contribute sediments to the Big River. Historical mapping of former Big River channel characteristics will be reviewed as appropriate to support this analysis.
    - *Maintenance of Institutional Controls.* Both alternatives rely on continued use of institutional controls to manage human health risks associated with fish consumption (fish advisories), with periodic monitoring of metals concentrations in fish tissue and sediments. An additional institutional control may be considered to restrict use of the

discrete beach areas for a hypothetical child who recreates on beach areas at a conservatively high frequency (i.e. within the St Francois State Park or at public access beaches that may have higher concentrations and meet similar exposure criteria). Additionally, certain areas where erosive floodplains are likely to contribute metals to the rivers will be stabilized using techniques such as stone toe, seeding and plantings, and maintained to prevent contributions to the rivers.

- An additional institutional control may be considered to restrict use of the discrete beach areas for a hypothetical child who recreates on beach areas at a conservatively high frequency (i.e., within the St Francois State Park or at public access beaches that may have higher concentrations and meet similar exposure criteria). This would include warning signs regarding lead concentrations that are greater than 800 ppm in the beach areas along with outreach materials at the front gate of the facility.

- *Development of Site-Specific WQS.* Given the uniqueness of the geology of the site and the presence of naturally occurring lead in bedrock that is exposed to Big River flow, consideration will be given to the development of a site-specific WQS to reflect the effect of these sources. Site-specific criteria must consider the Total Maximum Daily Load, or TMDL, for each respective water body. Site-specific WQS may be developed during remedial design and will be documented in an Explanation of Significant Differences.

- *Monitoring of Remedy Effectiveness.* A robust monitoring program will be implemented to assess the effectiveness of the actions and make adaptive management decisions to ultimately achieve the IRAOs and PRGs. This monitoring program will include the following, at a minimum:

    - Monitor stabilized/remediated areas for erosion/deposition;

    - Periodic visual surveys in stabilized reaches upstream and downstream to monitor erosion/deposition (head cuts and down cuts);

    - Periodic surveying and sampling of the traps and/or depositional areas to monitor heavy metals moving through the system; and

    - Periodic sampling upstream of the site on Big River and Flat River Creek to monitor heavy metals moving into the system from upstream sources. These locations should be relatively close to the first sources found upstream.

In addition, Alternative 2 includes the following additional elements.

Operation of the Existing Sediment Trap and Overbank Settling Basin

The sediment trap at the Big River/Flat River Creek confluence would require periodic removal of sediment from the instream trap and the overbank settling basin. The in-stream sediment trap consists of a modified Newbury Riffle, which is a series of rock check dams that form an artificial riffle. The purpose of the riffle is to slow the water down and create sediment deposition upstream of the structure while allowing fish passage. The in-stream clean out volume is estimated to be approximately 3,950 CY/per cleanout, which is the estimated sediment trap capacity.

The overbank settling basin was designed to capture contaminated sediment during elevated flows. During high-water events, the basin allows a targeted size of sediment to fall out within the basin where it is held for later clean out. Initial estimates show that the settling basin may have the capacity to retain up to 150,000 cubic yards of sediment. The overbank settling basin will require cleanout of approximately 2,000 CY/event.

Sediment trap cleanout is assumed to occur one time per year, based on the information from the EPA pilot study. During the pilot study, the EPA contractors removed 3,950 cubic yards of lead-contaminated sediment (mean lead concentration of 2,107 ppm in the less than 2mm fraction). This volume was considered the maximum capacity of the instream trap. The EPA contractors also removed approximately 2,008 cubic yards of overbank material (mean lead concentration of 1,150 ppm in the less than 2mm fraction). This included most of the available material at the overbank cleanout location. The EPA continues to monitor the trap along with constant flow at a stream gage located approximately 4,000 feet upstream of the trap. Total annual volume (both instream and overbank) is approximately 5,950 CY. **Please note:** Cleanout frequency and volume is dependent on river flow. The EPA is currently in the process of using the sediment accumulation data along with the flow data from the stream gage to determine the relationship between stream flow and sediment deposition in the pilot study area. If stream flow can be used as a predictor of sediment accumulation in the pilot study area, this could reduce the amount of on-site monitoring required as part of the remedy; however, periodic monitoring of the traps will be required as part of the remedy. If the traps reach capacity, they would be subject to a clean out, provided that the lead concentration is greater than 581 ppm.

A list of sites has been developed that are the locations for the early interim remedial action under Alternative 2. Criteria for identification of these candidate areas are included below. Such actions will focus on sediment/bar removal in depositional areas. Effort will be made to avoid riffles and other important habitats.

A range of locations were identified for early interim remedial action based upon a set of risk-based, analytical and practical evaluation factors, and discussions among agencies and respondents. The primary evaluation factors are listed as follows:

1. St. Francois State Park beach areas (in addition to any other identified high-use beach area) with a surface weighted area concentration, or SWAC, above 800 mg/kg within the OU2 site.

2. Areas indicated by elevated ecological risk.

3. Proximity to source areas (e.g., near piles or tailings areas, railroad ballast with demonstrated high lead content).

4. Bank/floodplain areas having the potential for contribution to the Big River or Flat River Creek.

5. Passive depositional areas suitable for opportunistic sediment removal.

6. Accessibility by construction equipment.

A range of candidate locations were considered for remedial action. Appendix A, Figure 13 identifies the seven retained locations (denoted as A through H). Below are descriptions of the locations and a summary of the potential remedial actions at each location.

Location A: Passive Sediment Trap at Bone Hole. Location A is immediately upstream of the low water crossing near Bone Hole County Park (RM 104.8). General site features are shown in Exhibit 1-1. Location A has been identified for potential remedial activities due to the following characteristics:

1. The area is generally depositional due to the existing low water crossing.
2. Observed sediment lead concentrations are greater than 1,200 mg/kg.
3. Periodically used by the public.
4. The location is proximate to identified source areas.
5. Accessible for construction.

The focused excavation of an estimated 2,300 CY of sediments upstream of the low water crossing has been estimated using an average cut depth of 2 feet over 0.7 acre upstream of the low water crossing. Excavated sediments would be transported and offloaded at a staging location nearby to allow excess water to drain into a constructed settling basin prior to transportation to one of the designated repositories. Access for construction and removal of accumulated sediments can be accomplished by the development of an in-river low water access road and other upland modifications that may be used as future parking for planned recreational development of the associated county park land. Additionally, location A will capture the sediment moving downstream from location C. Location C is shown on the overall map in Appendix A, Figure 13.

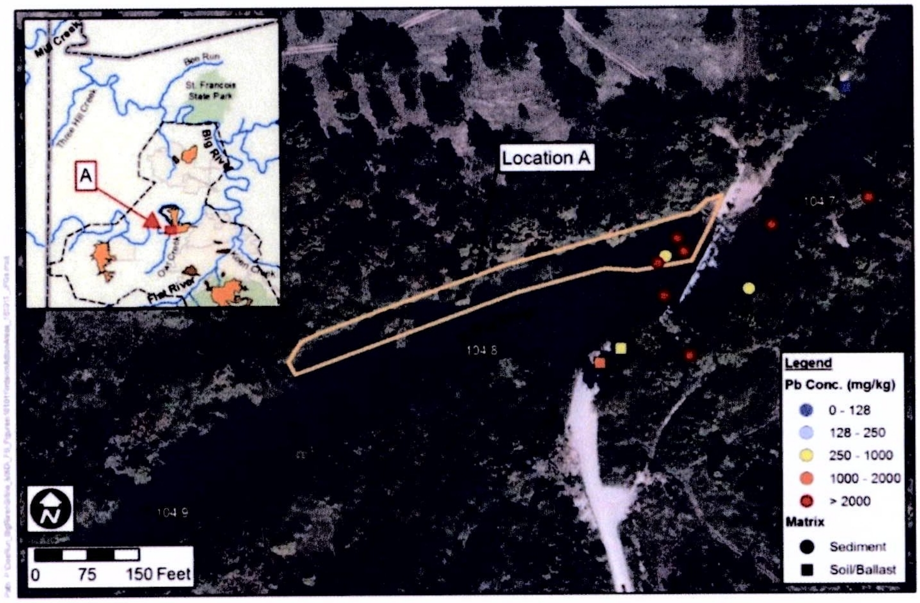

Exhibit 1-1. Location A: Passive Sediment Trap at Bone Hole

Location B: Downstream of Bone Hole. Location B is downstream of the low water crossing near Bone Hole (RM 104.5). General site features are shown in Exhibit 1-2. Location B has been identified for potential remedial activities due to the following characteristics:

1. Naturally depositional area where sediment accumulation is promoted as a bar feature.

2. Observed sediment lead concentrations are greater than 1,200 mg/kg.

3. Periodically used by the public.

4. The location is proximate to identified source areas.

5. Exploratory borings associated with the underground mine era are believed to be uncapped in this location.

6. Accessible for construction. Construction staging for this location is readily available from Location A, and any activities would generally be performed in conjunction with Location A.

The focused excavation of an estimated 6,700 CY of bar sediments downstream of the low water crossing was assumed. This removal quantity was estimated using an average cut depth of 2 feet over 2.1 acres. Staging, dewatering and construction access to this location is available from the same area as Location A. As appropriate, exploratory bore holes associated with the underground mining era would also be plugged in this location.

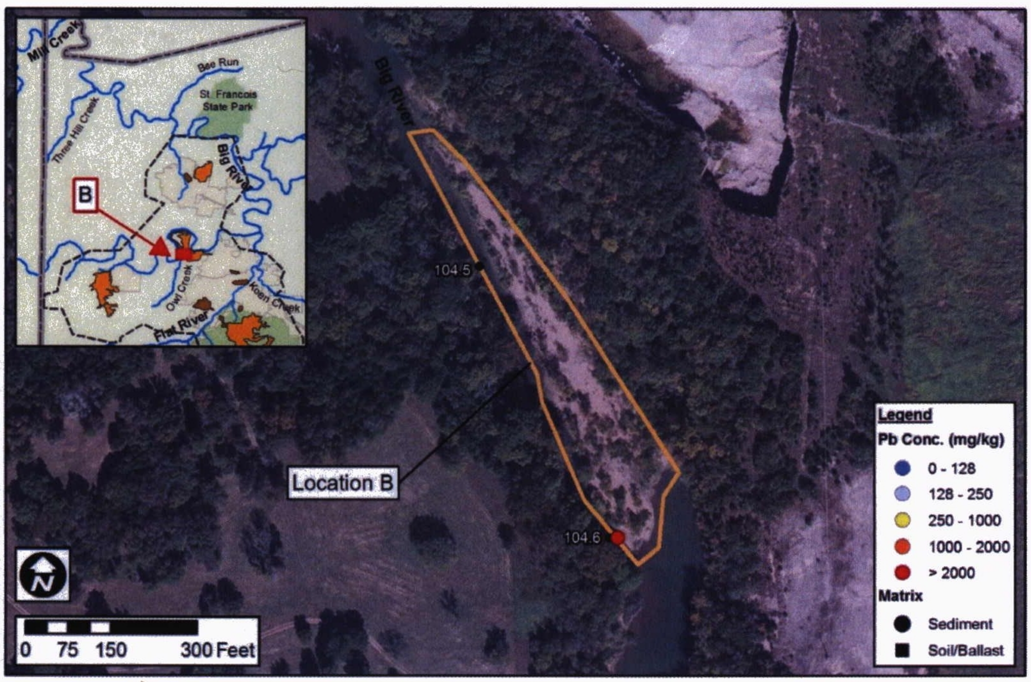

Exhibit 1-2. Location B: Downstream of Bone Hole

Location D: Flat River Creek Downstream of WWTP. Location D includes the depositional areas in Flat River Creek near the wastewater treatment plant, or WWTP (Flat River Creek RM 0.7 to 0.8). General site features are shown in Exhibit 1-3. Location D has been identified for potential remedial activities due to the following characteristics:

1. Naturally depositional area where sediment accumulation is within the river channel.
2. Observed sediment lead concentrations are greater than 1,200 mg/kg.
3. Is proximate to identified source areas.
4. Construction access to this location is readily available from associated WWTP area.

The focused excavation of an estimated 2,100 CY of sediments in Flat River Creek near the WWTP was assumed. The removal quantity was estimated using an average cut depth of 2 feet over 0.7acre. Excavated sediments would be transported and offloaded at a staging location nearby to allow excess water to drain into a constructed settling basin prior to transportation to a repository. Construction access to this location is available from the WWTP facility.

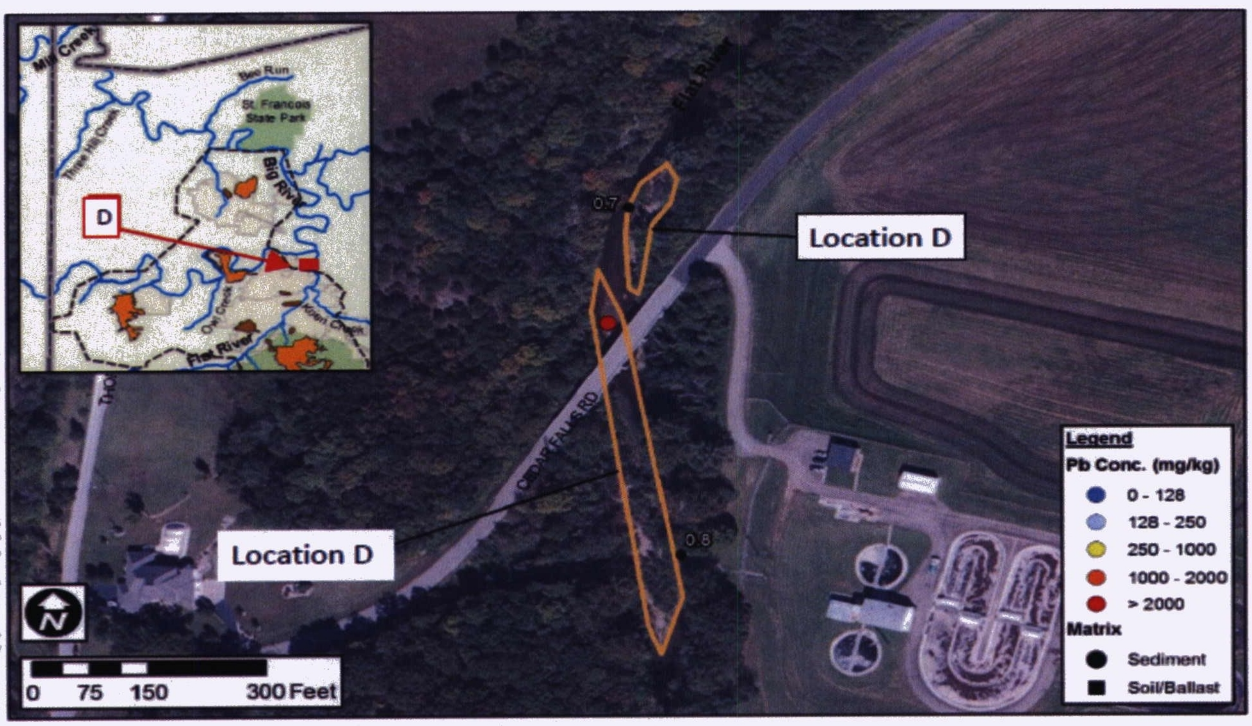

Exhibit 1-3. Location D: Flat River Creek Downstream of WWTP

Location E: Flat River Creek Mouth. Location E includes the depositional areas at the confluence of Flat River Creek and Big River that are currently not addressed by the existing sediment trap. General site features are shown in Exhibit 1-4. Location E has been identified for potential remedial activities due to the following characteristics:

1. Natural depositional area where sediment accumulation is promoted by river depth.

2. Observed sediment lead concentrations are greater than 1,200 mg/kg.

3. Is proximate to identified source areas.

4. Construction access to this location is readily available from the installed sediment trap across the Big River.

The focused excavation of an estimated 3,500 CY of sediment at the confluence of Big River and Flat River Creek was assumed. The removal quantity was estimated using an average cut depth of 2.5feet over 0.87acre. Sediments not currently addressed by the existing U.S. Army Corps of Engineers, or USACE, and the EPA sediment trap will be excavated. Evaluation of the potential impact to the sediment trap performance will be required prior to removal. Construction access is readily available from the sediment trap. This location could extend up Flat River Creek 500-1,000 feet to remove large gravel bars and maximize effectiveness.

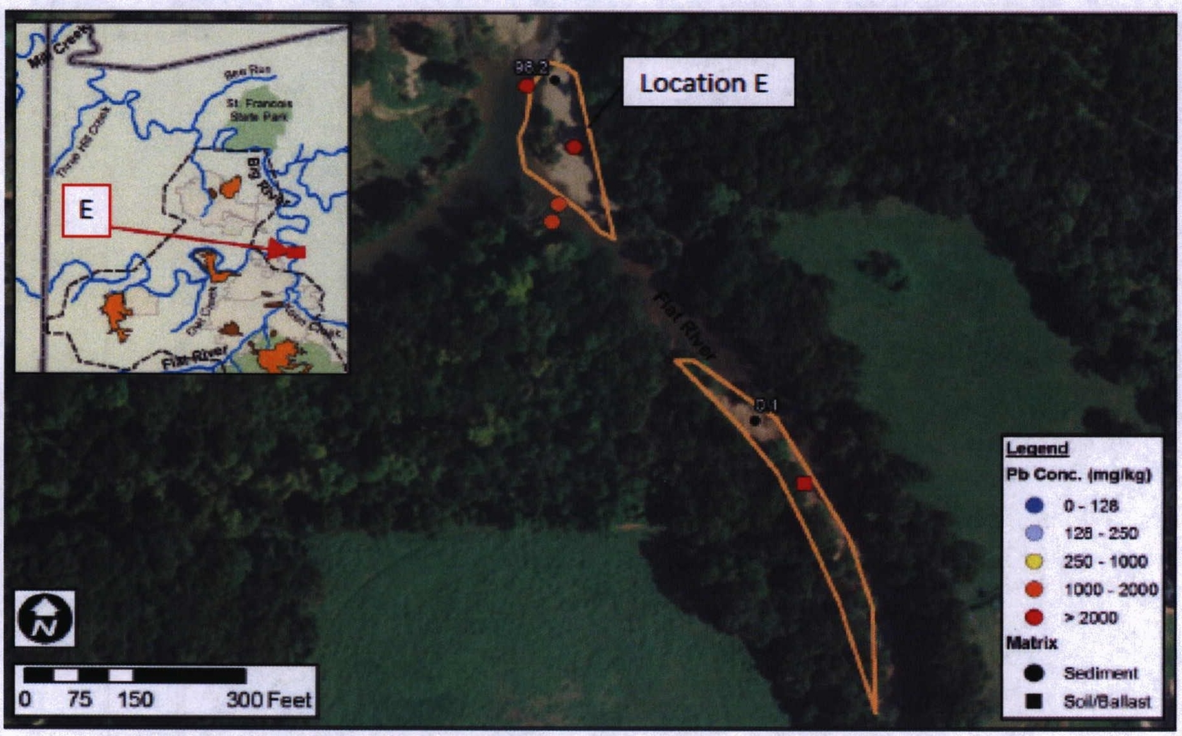

Exhibit 1-4. Location E: Flat River Creek Mouth

Location F: Beaches in St. Francois State Park. Location F includes discrete beach areas in St. Francois State Park that exceed a SWAC of 800 mg/kg for lead. General site features are shown in Exhibit 1-5. Location F has been identified for potential remedial activities due to the following additional characteristics:

1. Observed discrete sediment lead concentrations that exceed 1,200 mg/kg and a SWAC that exceeds 800 mg/kg.

2. The location is a reported use area for recreational swimming and fishing.

3. Construction access is readily available from an associated recreational use area within the park.

The focused excavation of an estimated 4,800 CY of beach material in St. Francois State Park was assumed. Three beaches were identified in ArcGIS using aerial imagery and named F1, F2, and F3 from upstream to downstream. SWACs were calculated for each beach by developing Thiessen polygons of all nearby sediment samples, clipping polygons to the beach boundaries, and calculating an area-weighted average of lead concentrations. Beaches F1 and F3 exceed 800 mg/kg, and were assumed to be removed with an average cut depth of 2 feet over 1.5 acres. Actual removal volume and area will be determined based on the results of the pre-design investigation.

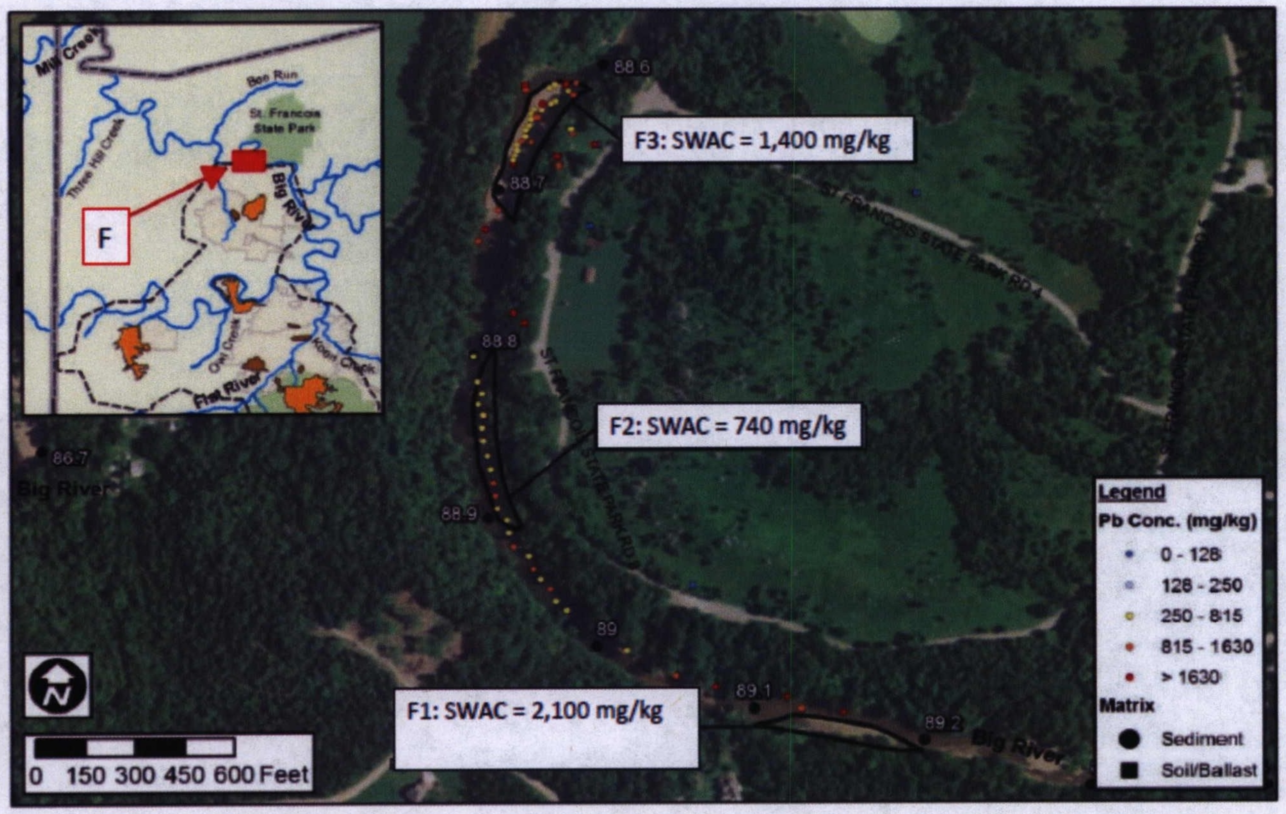

Exhibit 1-5. Location F: Beaches in St. Francois State Park

Location G: Sediment Bar Downstream of St. Francois State Park. Location G includes the depositional areas on the Big River in St. Francois State Park downstream of Coonville Creek (RM 88.0). General site features are shown in Exhibit 1-6. Location G has been identified for potential remedial activities due to the following characteristics:

1. While no sediment data are available for this location, similar depositional areas within St. Francois State Park upstream of this location have recorded elevated sediment lead concentrations (data will be collected to evaluate whether remedial actions are appropriate in this location).

2. Discussions with EPA and MDNR have suggested that this location contains naturally depositional areas within the river channel that are likely to have elevated sediment lead concentrations.

3. Construction access is readily available from an associated recreational use area within the park.

The removal of an estimated 2,300 CY of sediments in St. Francois State Park, downstream of Coonville Creek was assumed. The removal quantity was estimated using an average cut depth of 2 feet over 0.7acre. Excavated sediments would be transported and offloaded at a staging location nearby to allow excess water to drain into a constructed settling basin prior to transportation to a repository. Construction access is readily available from the state park.

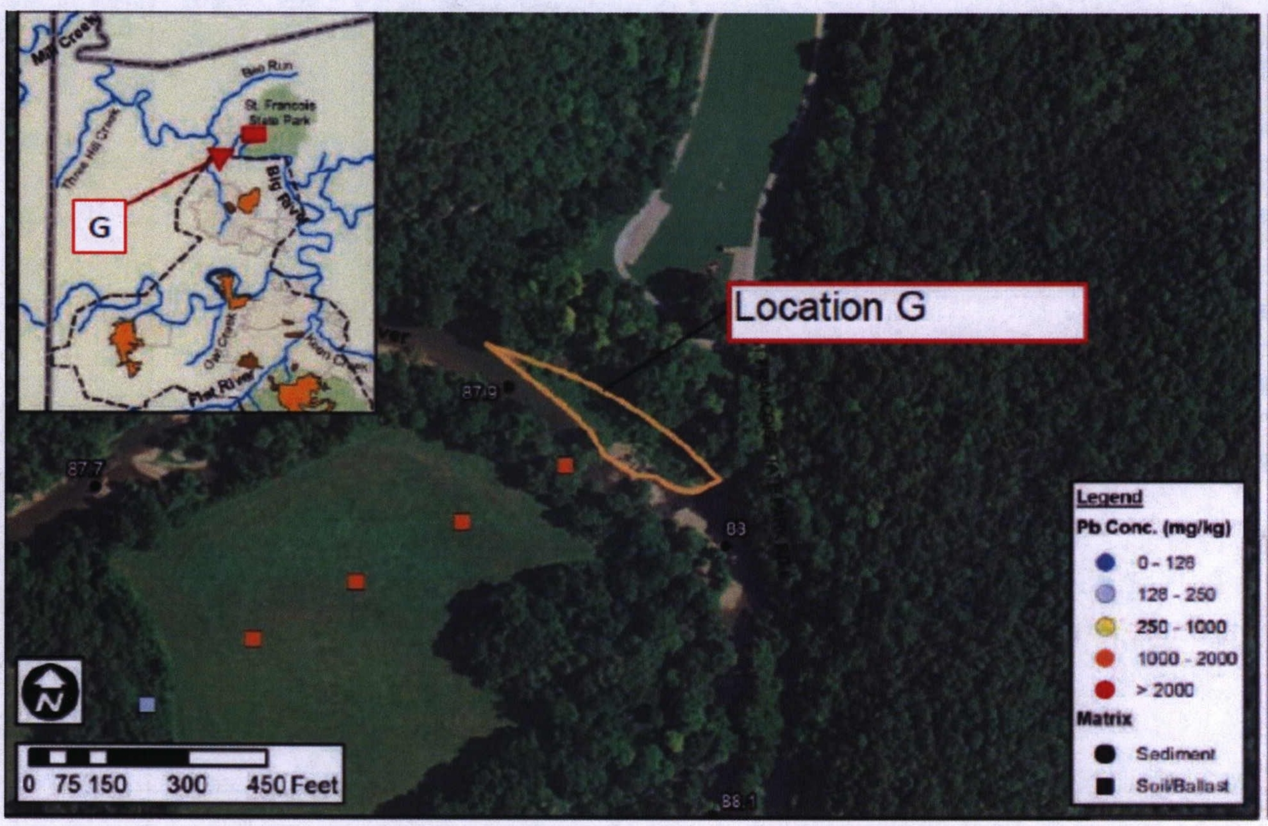

Exhibit 1-6. Location G: St. Francois State Park

*Location H: Flat River Creek – Main Stre*et. Location H includes the depositional areas on the Flat River Creek near Main Street (RM 3.8). General site features are shown in Exhibit 1-7. Characteristics of this location include the following:

1. Natural depositional area where sediment accumulation is promoted by river depth.
2. Observed sediment lead concentrations are greater than 1,200 mg/kg.
3. Is proximate to identified source areas.
4. Accessible for construction.

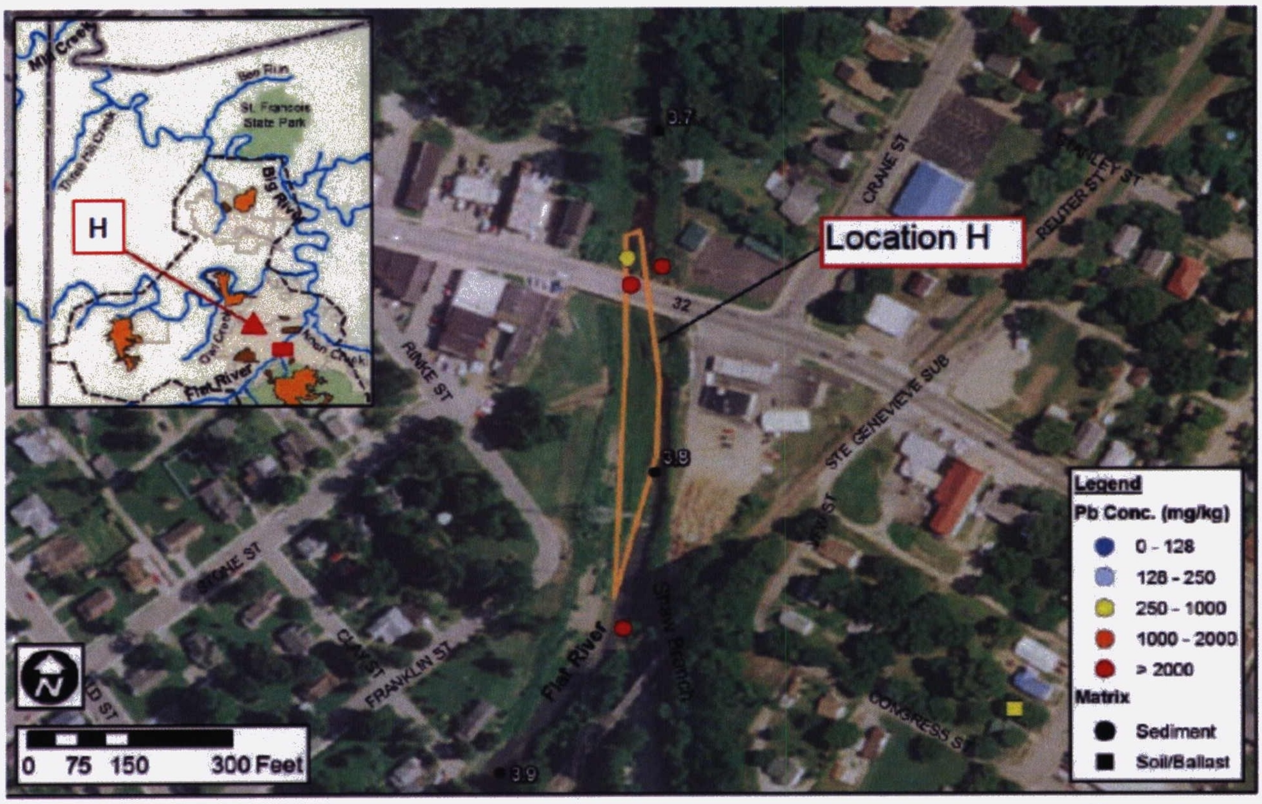

Exhibit 1-7. Location H: Flat River Creek – Main Street

Riverbank Stabilization

Alternative 2 also includes the stabilization of up to 4,000 feet of riverbanks (assumed for purposes of evaluation to occur at four different locations, each with a length of 1,000 feet and each being performed over a period of four separate years) that have been identified as being unstable and containing elevated lead concentrations that exceed 1,200 mg/kg. Multiple techniques will be designed and implemented to evaluate their effectiveness in reducing the contribution of metals to the river system from riverbanks and adjacent floodplain soil. The characteristics of riverbanks will be evaluated in conjunction with the pre-design studies. Specific locations to be selected as part of this action are based on the following criteria:

- Lead concentrations greater than or equal to 1,200 mg/kg lead.
- Unstable river banks will be targeted for action.

This alternative also includes the possible establishment of conservation easements and revegetation of these easements as 100-foot buffers along the banks to address floodplains contributing lead to the Big River and Flat River Creek. The alternative assumes that 0.25 mile of easement will be revegetated and established in conjunction with each of the bank stabilization projects in accordance with the following proposed implementation schedule:

Implementation Schedule

Implementation will follow the development of remedial designs and will be conducted preferentially in an upstream to downstream direction, unless otherwise determined. The schedule is subject to changes based upon field conditions, annual data collection and analysis and adaptive management decisions. The following timeframe and implementation schedule is estimated:

- Year 1: Baseline and Pre-Design Sampling
- Year 2: Remedial Design and Work Plan
- Years 1-4: Remedial Action of Targeted Action Locations
- Years 3-6: Bank Stabilization
- Years 4-11: Cleanout of Sediment at Targeted Action Locations
- Years 1-12: Maintenance of Fish Advisory
- Years 3-6: Conservation Easement
- Years 1-11: Cleanout of the EPA Pilot Study Sediment Trap
- Years 3-11: Monitoring
- Years 3-11: Evaluation and Reporting
- Years 11-12: Preparation of Summary Report

Alternative 3: Complete Dredging and Re-channelization

Estimated Total Capital Cost: $299.956 million
Estimated Annual O&M Cost Range: $0
Estimated Present Worth Cost: $316.085 million
Estimated Construction Time Frame: 7 years
Estimated Time to Achieve IRAOs: 7 years

Alternative 3 is intended to provide an upper bound on remediation scope, difficulty, and costs. Assumptions used to develop quantities and cost estimates are significant, and refinement of the quantities and costs would be required as part of the RD. Under this alternative, floodplain soils contributing to the river and sediments with lead concentrations greater than 1,200 mg/kg would be excavated or dredged and replaced with clean backfill. St. Francois State Park beach areas that are greater than 800 mg/kg would be excavated. Floodplain soils (>1,200 mg/kg) would be the threshold for removal. The scope of this alternative would also be refined based upon the predesign investigations. Please note: although this alternative is intended to provide an upper bound on scope, difficulty, and costs, it does not represent the upper bound that would be required in the Final ROD. Costs would be significantly higher if this alternative focused on the PRGs.

Sediments in depositional areas would be mechanically excavated or dredged. It is estimated that there are 14.0 miles of Big River and 4.9 miles of Flat River Creek that have sediments with concentrations greater than 1,200 mg/kg. Sediment removal would be focused at bars, pools, or other depositional features where fine sediments accumulate. To date, there has not been a comprehensive survey to identify and map depositional features or to estimate the volume of depositional sediment within the Big River or Flat River Creek. Sediment thickness surveys including NewFields (2007), Pavlowsky et al. (2010), ELM (2014), and Integral (2014b) were used to estimate the percentage of the river that contains depositional areas. For reference, the aerial bar survey determined that 43 percent of the 18.9 miles of the Big River and Flat River Creek with elevated lead concentrations had a bar feature. Additional depositional features such as pools are likely located between the bar features. For costing purposes, it was assumed that 13.2 of the 18.9 miles (70 percent) of Big River and Flat River Creek have depositional features. Note that many depositional features (i.e. bars, pools) may have riffles or runs at the same river mile that flow adjacent to the depositional feature. To account for this, an average removal width of 60 feet was assumed, even though channel widths varied from 60 to 250 feet. The average removal depth was assumed to be 3 feet in the Big River and 1 foot in the Flat River Creek. The total estimated sediment removal volume is 360,000 CY over 80.3 acres. It was also assumed that clean sediment backfill would be required at 50 percent of the locations within dredged areas to prevent additional scour and erosion of banks.

A predesign investigation would determine the specific locations for sediment removal. Approximately 600 samples would be collected in 18.9 miles of river (average of three samples per 500 feet). Additional major assumptions regarding sediment removal include:

- Sediment removal would include additional 15 percent removal (37,000 CY) to account for over excavation.
- All dredged material would be managed at one or more repositories consisting of tailings impoundments or chat piles.
- Due to the scale of removal, a water treatment facility will be required to treat water after sediments are dewatered. Water treatment costs are uncertain and depend on level of necessary water treatment (e.g. primary treatment versus secondary treatment).

- Sediment dredging would be conducted using smaller scale barge operations or specialty equipment suitable for use in the Big River. Operations would require at least three separate barge crews for five construction seasons. Factors that could increase the construction schedule include accessibility, storm events, or staging limitations.

Under Alternative 3, surface soils (assumed to be top 12 inches, for the purposes of cost estimating) within the Big River or Flat River Creek 100-year floodplain with lead SWACs greater than 1,200 mg/kg would be excavated. The 100-year floodplain for OU2 is 6,050 acres (including Big River and Flat River Creek) with approximately 3,650 acres downstream of source areas. Throughout the 3,650 acres, there were 322 floodplain soil samples collected in transects or clusters that were analyzed for lead. Forty-five percent of these samples had lead SWACs greater than 1,200 mg/kg.

Similar to sediment samples, floodplain soil samples were collected in a biased manner, focusing on easily accessible locations, soils directly adjacent the river, and locations that were previously identified as impacted. The actual percentage of floodplain soils that have lead concentrations greater than 1,200 mg/kg is unknown. However, for the purposes of the FFS, the percentage of floodplain soils with lead concentrations greater than 1,200 mg/kg is assumed to be 45 percent. Remedial actions within the floodplain under this alternative are expected to be focused on those areas of the floodplain that are erosive and potentially contributing materials to the Big River. Based upon a review of general landforms of the floodplain and Historic Channel Change Maps (Pavlowsky and Owen 2013) it is assumed that approximately 25 percent of floodplain areas exceeding 1,200 mg/kg are potentially contributing to the Big River. Less removal is expected upstream of Flat River Creek. Clean backfill and seeding would be required where all soils are removed. Additionally, it is assumed that 25 percent of the total area would require shoreline armoring to stabilize backfilled material and prevent erosion to the Big River.

A predesign investigation would determine the specific locations for floodplain soil removal. Approximately 3,560 samples would be collected over 3,560 acres of floodplain (average of one sample per acre). Samples would be collected from the top 12 inches of soil. Additional pre-design work would include a more detailed review of the floodplain to identify those areas potentially contributing to the Big River. Additional major assumptions include:

- Development of 30 separate access roads and staging locations at an assumed cost of $350,000 each. Cost includes easement or parcel acquisition and construction.
- Locations with lead concentrations less than 1,200 mg/kg that appear uncovered or erosive would have subsurface soils (i.e., 12 to 24 inches) sampled for lead. Revegetation or cover would be applied to subsurface soils with lead concentrations greater than 1,200 mg/kg.
- All dredged material would be managed at one or more repositories consisting of tailings impoundments or chat piles.
- Excavation would require at least five separate excavation crews for four construction seasons.

For costing purposes, the baseline sampling and pre-design sampling for both sediment and soil are assumed to occur in Year 1, the remedial design occurs in Year 2, and the remedial actions occur in Years 3 through 6. No maintenance is anticipated with this alternative. Post-remedy sampling would occur in Year 7.

H. EVALUATION OF ALTERNATIVES

The NCP, 40 C.F.R. Part 300, requires the EPA to evaluate remedial alternatives against nine criteria to determine which alternative is preferred. This analysis is performed during the FS. The detailed analysis in the FS provides an in-depth analysis of the three alternatives compared against the nine criteria. The FS is available in the AR for the site. An alternative must satisfy all nine criteria before it can be selected. The first step is to meet the threshold criteria, which are overall protection of human health and the environment and compliance with ARARs. In general, alternatives that do not satisfy these two criteria are rejected.

The second step is to compare the alternatives against a set of balancing criteria. The NCP establishes five balancing criteria which include long-term effectiveness and permanence; reduction in toxicity, mobility, or volume achieved through treatment; implementability; short-term effectiveness; and cost. The third and final step is to evaluate the alternatives based on modifying criteria, which are state and community acceptance.

Threshold Criteria

The following presents a brief description of how the alternatives satisfy the threshold criteria of overall protection of public health and the environment and compliance with ARARs.

Overall Protection of Human Health and the Environment

This criterion provides an overall assessment of whether an alternative meets the requirement that it is protective of human health and the environment. This criterion considers whether an alternative eliminates, reduces, or controls threats to human health and the environment through institutional controls, engineering controls, or treatment.

Alternative 1 does not provide protection for human health and the environment at the site because of the continued risk from lead-contaminated sediment, fish tissue, and floodplain soil. Alternative 1 does not meet the IRAOs identified for this site. Lead contaminated sediment, fish tissue, and floodplain soil will continue to pose exposure risk for an indefinite period.

Under Alternative 2, human health protectiveness may be achieved in the short term through remedial activities at the seven focused locations, riverbank restorations, the existing fish advisories, and routine sediment trap maintenance. In addition, concurrent natural recovery processes (e.g., natural import of clean sediment from upstream) could reduce metal concentrations in sediment, gravel bars (beach areas), stream banks, the water column and fish tissue. Recovery may be accelerated due to the focused removal of high concentration sediments, the prevention of erosion of floodplain soil to the rivers through the establishment of stable riverbanks and adjacent floodplains, the maintenance of the banks and easements and annual maintenance removal of accumulated sediments based upon monitoring. Periodic sampling and reporting of the fish tissue and sediment data in the SFCMA will provide additional information that may be considered by the State to modify or remove the fish advisories.

Achievement of the IRAOs should occur more quickly than under Alternative 1 and has the potential to be achieved within the 12-year adaptive management program period. This would be verified through monitoring. In summary, past control measures and planned actions coupled with an adaptive management process under Alternative 2 has the potential to result in the attainment of IRAOs for OU2 at the end of 12 years.

Alternative 3 is expected to ultimately be protective of human health and the environment with respect to COCs within the site boundaries. However, very significant destruction of existing habitat is expected and COCs are expected to be released to the greater environment. Removal activities would occur over 80 acres of depositional areas of the rivers and 401 acres of forested regions of the floodplain. Additional destruction and impact to the sediments and floodplains would occur from construction of access roads and staging. Remedial activities would continue over additional construction seasons. Recovery of impacted habitat could take years and even decades. Alternative 3 could also increase lead concentrations in fish for many years due to the extensive destruction of habitat and the likely increase in lead concentrations in the water column during the long construction schedule, slowing recovery.

Compliance with ARARS

This criterion valuates whether the alternative meets Federal and State environmental statutes, regulations, and other requirements that pertain to the site, or whether a waiver is justified.

Alternative 1 would not comply with ARARs in either the short term or near long term because the existing PRG for lead in sediment and floodplain soil would not be achieved due to the contributing effects of lead from mineralized bedrock and soils, and residual mine waste in the riverbanks and sediment.

Alternative 2 is considered to ultimately be compliant with ARARs because it may achieve the WQS over the long term. Over the short term, the WQS would not likely be achieved due to the disruption associated with the in-river work.

Alternative 3 is considered to ultimately be compliant with ARARs. However, water quality may deteriorate during remedial activities in the short term. COC concentrations are expected to decrease over the long term and meet the WQS.

Balancing Criteria

The following presents a brief description of how the alternatives developed in the Focused Feasibility Study, or FFS, satisfy the balancing criteria.

Long Term Effectiveness

This criterion addresses the results of a cleanup action in terms of the risk remaining at the site after the goals of the cleanup have been met. The primary focus of this evaluation is to determine the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes.

Alternative 1 provides no long-term effectiveness or permanence for the protection of human health and the environment. Alternative 1 provides no controls to manage residual risk associated with lead contamination to contaminated media at the site. Under Alternative 1, residual risks to human health and the environment would remain at or near current levels.

Under Alternative 2 and Alternative 3, the residual risks (the risk remaining after implementation) would be significantly reduced. Under both Alternative 2 and Alternative 3, the residual risk is the lead contamination left in place (less than 1,200 mg/kg) after the completion of the remedy. Fish advisories are reliably and adequately controlled by the MDHSS as part of their governance of all rivers within the state. Fish tissue concentrations are above the advisory concentration; however, the unacceptable risk associated with fish consumption is expected to decrease over the long term due to completed source control measures and on-going natural recovery processes.

Work included in Alternatives 2 and 3 should enhance the ongoing natural recovery processes by decreasing lead available to the system through the collection of lead containing sediment in the existing sediment trap and by reducing potential residual sources of lead contained in sediment and river bank soils. Under each of these alternatives, additional funding would be provided to sustain the fish advisories if state funding is eliminated. The difference in the rates of achieving the IRAOs between Alternatives 2 and 3 is unknown.

A cornerstone to a remedial approach for this site is monitoring progress towards achieving the IRAOs following remedial actions and modifying future actions using adaptive management principals. Alternative 2 reflects this approach more so than the other alternatives and represents the most aggressive adaptive approach and should result in achieving the IRAOs in a more controlled, effective and relatively expedited manner than the other alternatives.

Reduction of Toxicity, Mobility, or Volume of Contaminants Through Treatment

This criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the contaminants. This criterion evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.

Under Alternatives 1, 2, and 3 there is no reduction in the toxicity, mobility, or volume of contamination because lead contaminated soils are left in place. Although the exposure pathway would be eliminated or minimized, the toxicity and volume of the material would not be reduced by these alternatives. Proper long-term maintenance of the designated repositories is an important component of Alternatives 2 and 3 to ensure the significant reduction of heavy metal mobility.

Short Term Effectiveness

This criterion addresses the effects of the alternative during the construction until the early interim remedial action is complete, and the selected level of protection has been achieved.

Alternative 1 does not create any short-term risk to the local community or workers because no work will be performed under Alternative 1. Alternative 1 also does not create any short-term risk of environmental impact during construction since there is no construction under this alternative. Exposure pathways for the public and environment would remain.

Alternatives 2 and 3 provide improved short-term effectiveness as these alternatives include the active removal of additional sources in the river and associated stream banks.
Regarding short-term impacts associated with the alternatives, Alternative 1 does not result in any short-term impacts because no in-river or upland construction work is involved. Alternative 2 will likely result in some short-term impacts associated with the potential to suspend solids into the water column, thereby increasing concentrations of metals in the water, possible transport down the rivers and likely short-term increases in metals concentrations in fish tissue. Alternative 3, involving multiple construction seasons and more than 80 acres of river and approximately 400 acres of upland areas,

would result in extensive impacts that could last for years or even decades as the large area of river, associated riparian zones and upland habitats recover from the massive degree of construction involved in this alternative. It is expected that increases in suspended solids in the rivers and increases in fish tissue metals would be far greater under Alternative 3 compared to Alternative 2.

Implementability

This criterion addresses the technical and administrative feasibility of implementing a cleanup and the availability of various services and materials required during its implementation.

Alternative 1 does not require any implementation.

Alternative 3 is by far the most difficult to implement because of the many miles of river and large acreage of upland area to be investigated and subject to massive earthwork activities. Implementation of this alternative is also hindered by the need to obtain property access from numerous owners, many of whom will have to grant permission for extensive construction on their property over several construction seasons. In addition, access to the river by recreators will be interrupted during these construction seasons. Alternative 2 has logistical challenges but because locations selected for remedial actions under these alternatives were partly based upon accessibility, this alternative can be implemented much easier than Alternative 3.

Cost

Present value costs associated with the three alternatives are summarized below:

Alternative 1:	No Action	$0 million
Alternative 2:	Focused Removal and Stabilization at Seven Candidate Locations with Continued Removal and Adaptive Management	$23 million
Alternative 3	Complete Dredging and Re-Channelization	$316 million

It is important to note that uncertainties associated with these cost estimates significantly increases from Alternatives 1 through 3 as the complexity of the alternatives increases.

For the cost estimates for Alternative 2, capital costs are spread over a period of 12 years. A 7% discount rate was used to calculate the present worth. Additional information can be found in **Appendix B, Table 2.**

The capital costs for Alternative 3 are spread over a period of 7 years. A 7% discount rate was used to calculate the present worth. Additional information can be found in **Appendix B, Table 3.**

These estimates are approximate and made without detailed engineering data. The actual cost of the remedial action would depend on the final scope of the remedial action, actual length of time required to implement the alternative, and other unknown factors.

Modifying Criteria

The two modifying criteria of community and state acceptance are intended to assess the views of both groups regarding the alternatives. The EPA conducts meetings with representatives from MDNR, MDHSS, U. S. Agency for Toxic Substances and Disease Registry or ATSDR, St. Francois County Health Department, news media, visiting academics and students, and local citizens to address activities and policies at the site on a regular basis.

State/Support Agency Acceptance

The MDNR has been closely involved in the development of the RI/FS. State acceptance of the preferred alternative will be fully determined after the public comment period closes for the proposed plan and associated FS.

Community Acceptance

he preferred alternative will be reevaluated after the public comment period ends and will be modified or rejected, if necessary. A Responsiveness Summary, which addresses public comments, will be reviewed, evaluated and considered prior to any EPA decision on a remedy selection at this site. This summary will be part of the IROD.

I. PREFERRED ALTERNATIVE

The preferred alternative, Alternative 2- Focused Removal and Stabilization at Seven Candidate Locations with Continued Removal and Adaptive Management, was chosen over the other alternatives by the EPA based on the nine NCP criteria set forth above. The preferred alternative provides the best balance of trade-offs and achieves the IRAO. This alternative provides the best remedial approach because:

- substantial remedial actions are proposed at accessible locations;
- data from these locations indicate potential unacceptable risks posed by site contaminants;
- data from these locations indicate that the proposed actions have the greatest potential for reducing potential unacceptable risks and reducing lead, cadmium and zinc entry into the creek and rivers and;
- a 12-year program is undertaken whereby a robust monitoring program to support additional remedial actions based upon an adaptive management approach is implemented.

Alternative 2 provides the most aggressive adaptive management approach and offers the greatest potential for achieving the IRAOs in a predictable, and controlled manner and potentially in the shortest time.

The preferred alternative may be altered in response to public comment or new information.

The preferred alternative is expected to be protective of human health and the environment in the short term and is intended to provide adequate protection until a final remedy is implemented. The preferred alternative is expected to comply with or waive ARARs for the limited scope action, and be cost-effective. This proposed action is not intended to utilize permanent solutions and alternative treatment

(or resource recovery) technologies to the maximum extent practicable for this site. Because this proposed action does not constitute the final remedy for the site, the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principle element will be addressed by the final response action. Subsequent actions are planned to fully address the threats posed by conditions at the site.
Because the preferred alternative will result in hazardous substances remaining on-site above health-based levels, a review will be conducted to ensure that the remedy continues to provide adequate protection to human health and the environment within five years after commencement of the remedial action.

The following sections discuss how the preferred alternative meets these statutory requirements.

Protection of Human Health and the Environment

The preferred alternative will protect human health and the environment by achieving the IRAOs through conventional engineering measures along with natural stream processes. Unacceptable risks at the site are associated with sediment and floodplain soil that are elevated with cadmium, lead, and zinc. The preferred alternative reduces this risk through sediment removal and floodplain soil stabilization at selected reaches of Big River and Flat River Creek. Contaminated sediment will be removed from 7 depositional areas, which are strategically located to trap sediment as it moves downstream. The implementation of the preferred alternative will not pose unacceptable short-term risks or cross-media impacts.

Compliance with ARARs

In general, preferred alternatives should comply with ARARs unless waivers are granted. The preferred alternative is expected to eventually meet all chemical-specific, action-specific, and location-specific ARARs and does not involve any waivers. The ARARs for this proposed plan are included in Tables 4 through 6 in Appendix B.

Cost Effectiveness

The preferred alternative is a cost-effective solution to lead-contaminated sediment and floodplain soil at the site. The preferred alternative relies on conventional engineering methods and natural stream processes that are easily implemented.

Utilization of Permanent Solutions and Alternate Treatment Technologies

The preferred alternative utilizes a well-demonstrated remediation approach to lead-contaminated sediment that will provide an early interim remedy for sediment and floodplain soil at the site. Removal and replacement of contaminated residential soils permanently removes heavy metal contaminants as a potential source of exposure. Since no contaminated soils or sediment will be transported off-site, lead stabilization treatment is not required to prevent the soils or sediments from failing the Toxicity Characteristic Leaching Procedure, or TCLP, test. The preferred alternative best satisfies the statutory mandates for permanence.

Preference for Treatment

The preferred alternative does not utilize treatment to address the threats posed by the contaminated sediment and floodplain soil. The residual waste found in the sediment and floodplain soil is considered a principal threat waste, which is defined as mobile source material – surface soil or subsurface soil containing high concentrations of COCs that are (or potentially are) mobile due to wind entrainment, volatilization (e.g., volatile organic compounds), surface runoff, or sub-surface transport (OSWER, Publication 9380.3-06FS, 1991).
Additionally, no treatment technologies were identified that have definitively demonstrated the ability to reliably provide short- and long-term effectiveness, permanence, and meet the other NCP criteria. The extraordinary volume of materials and their location within a dynamic, fluvial environment would make treatment impracticable. Additionally, treatment technologies for metals in stream sediment are not readily available.

Under the preferred alternative for this site, contaminated sediment will be placed on the existing repositories located at the Bonne Terre East Tailings Pile, Desloge Pile (Big River Pile), Elvins (Rivermines) Pile, and Leadwood Pile. The contaminated sediment will be placed on the repositories, capped with a minimum of 12-inches of clean soil/rock, and revegetated with a site-specific seed mix. The placement of the clean cap will improve conditions on the mine waste piles by reducing the amount of wind-blown lead contaminated dust transported off the piles and will also reduce water infiltration of the piles. Since contaminated soil will not be transported off-site, treatment is not required to prevent the soils from failing the TCLP test.

J. COMMUNITY PARTICIPATION

A public meeting will be held on August 16, 2018, at 6:30 p.m. at Mineral Area College, North College Center, Rooms A, B, and C, 5270 Flat River Road, Park Hills, Missouri. The EPA will present the proposed plan, the preferred alternative, and receive public comments, both verbal and written.

Comments received at the public meeting, as well as written comments submitted during the comment period, will be addressed in the Responsiveness Summary section of the IROD, which is the document that formalizes the selection of the Early Interim Remedy. The public comment period will begin July 28, 2018, and extends through August 28, 2018.

All written or verbal comments should be addressed to:

Ms. Elizabeth Kramer, Community Engagement Specialist
Enforcement Coordination Office
U.S. Environmental Protection Agency, Region 7
11201 Renner Boulevard
Lenexa, Kansas 66219
Telephone: (913) 551-7186 or (800) 223-0425
E-mail: kramer.elizabeth@epa.gov

APPENDIX A

FIGURES

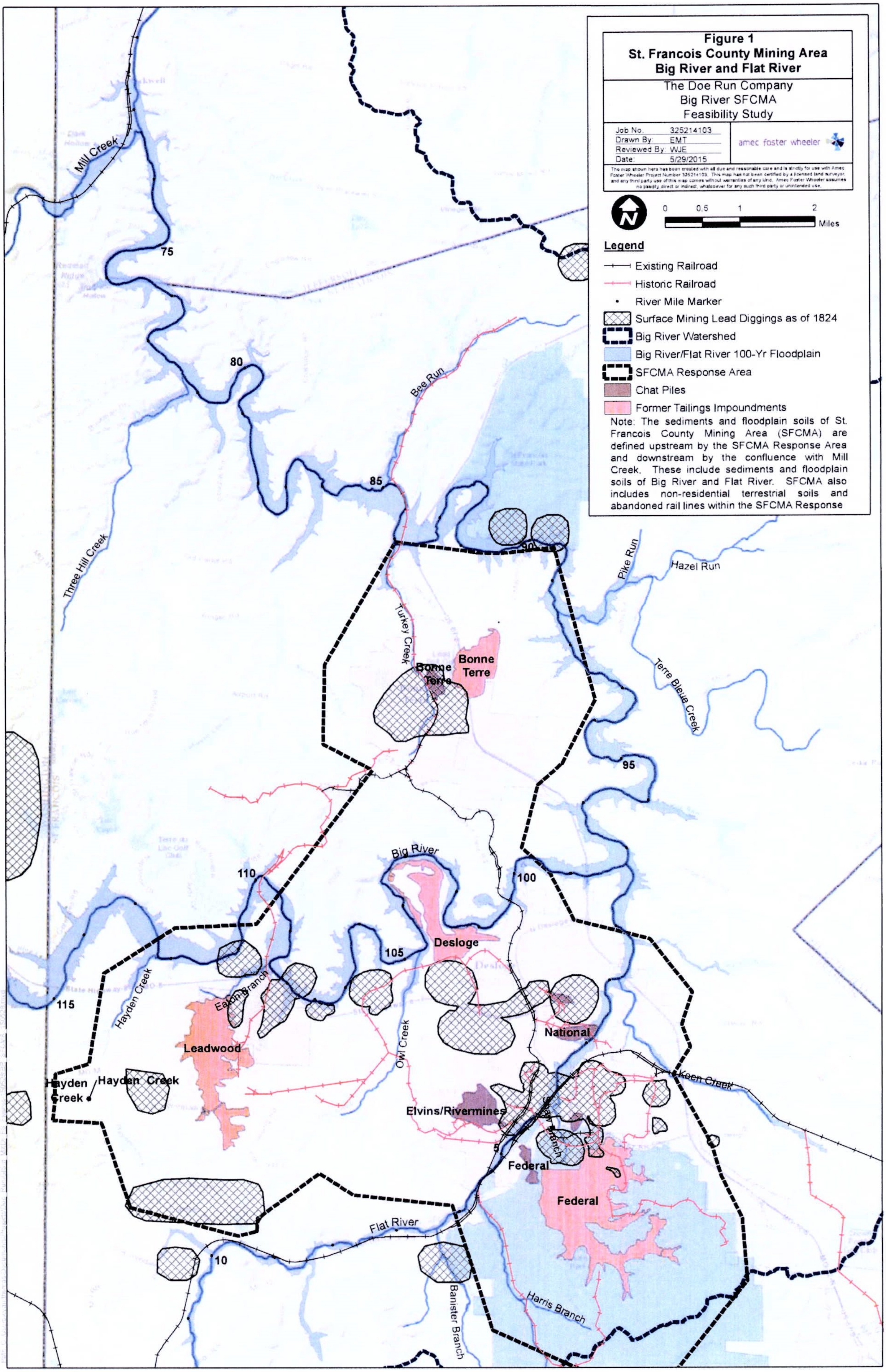
Figure 1
St. Francois County Mining Area
Big River and Flat River
The Doe Run Company
Big River SFCMA
Feasibility Study
Job No. 325214103
Drawn By: EMT
Reviewed By: WJE
Date: 5/29/2015
amec foster wheeler
The map shown here has been created with all due and reasonable care and is strictly for use with Amec Foster Wheeler Project Number 325214103. This map has not been certified by a licensed land surveyor, and any third party use of this map comes without warranties of any kind. Amec Foster Wheeler assumes no liability, direct or indirect, whatsoever for any such third party or unintended use.
N
0 0.5 1 2 Miles
Legend
Existing Railroad
Historic Railroad
River Mile Marker
Surface Mining Lead Diggings as of 1824
Big River Watershed
Big River/Flat River 100-Yr Floodplain
SFCMA Response Area
Chat Piles
Former Tailings Impoundments
Note: The sediments and floodplain soils of St. Francois County Mining Area (SFCMA) are defined upstream by the SFCMA Response Area and downstream by the confluence with Mill Creek. These include sediments and floodplain soils of Big River and Flat River. SFCMA also includes non-residential terrestrial soils and abandoned rail lines within the SFCMA Response
Mill Creek
75
80
Bee Run
85
90
Three Hill Creek
Pike Run
Hazel Run
Turkey Creek
Bonne Terre
Bonne Terre
Terre Bleue Creek
95
Big River
110
100
105
Desloge
115
Hayden Creek
Eaton Branch
Leadwood
Owl Creek
National
Hayden Creek
Hayden Creek
Koen Creek
Elvins/Rivermines
Shaw Branch
5
Federal
Federal
Flat River
10
Banister Branch
Harris Branch

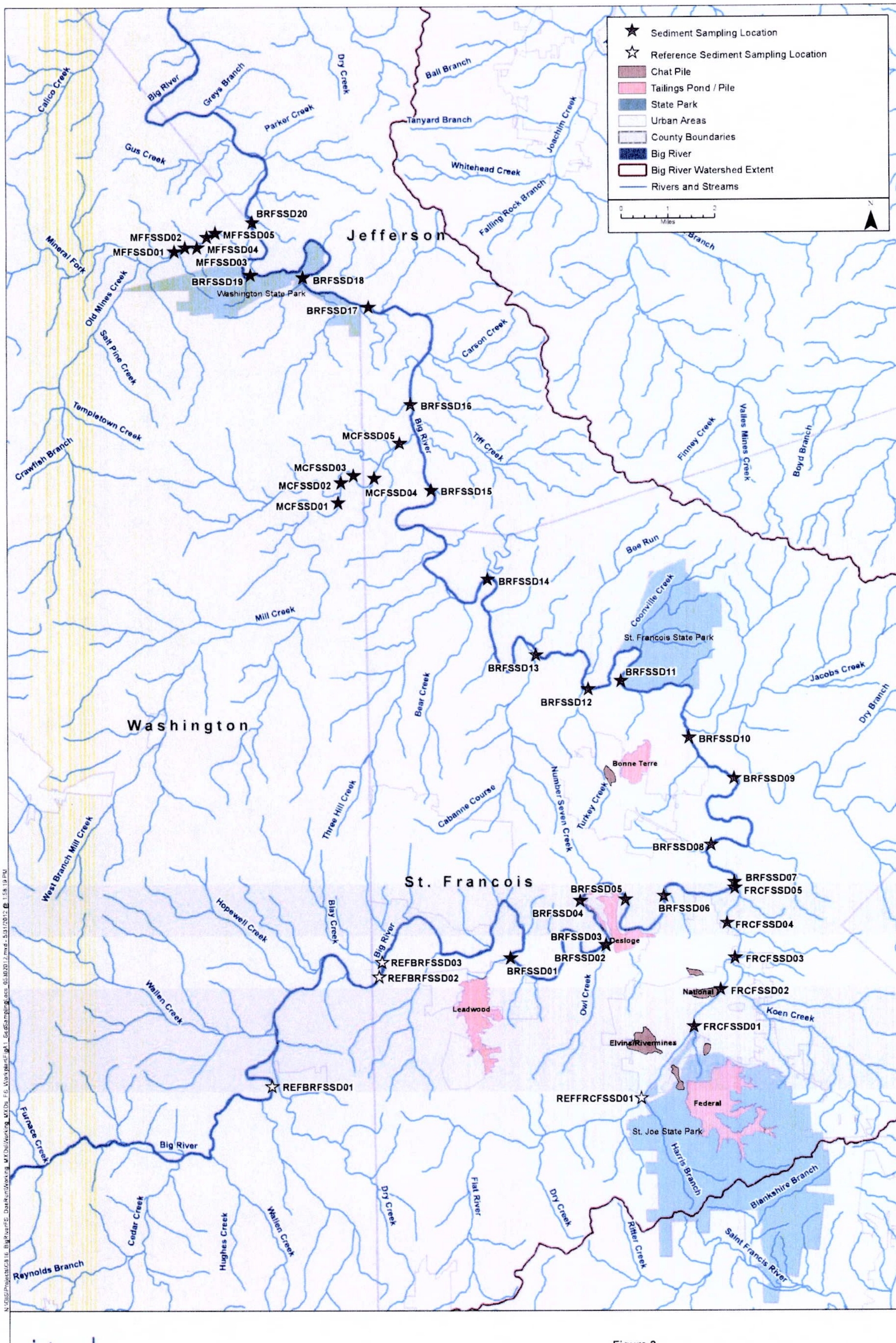

Figure 2.
Proposed Sediment Sampling Locations
River and Non-Residential Areas (OU-2)
St. Francois County Mining Area, Missouri

RR_

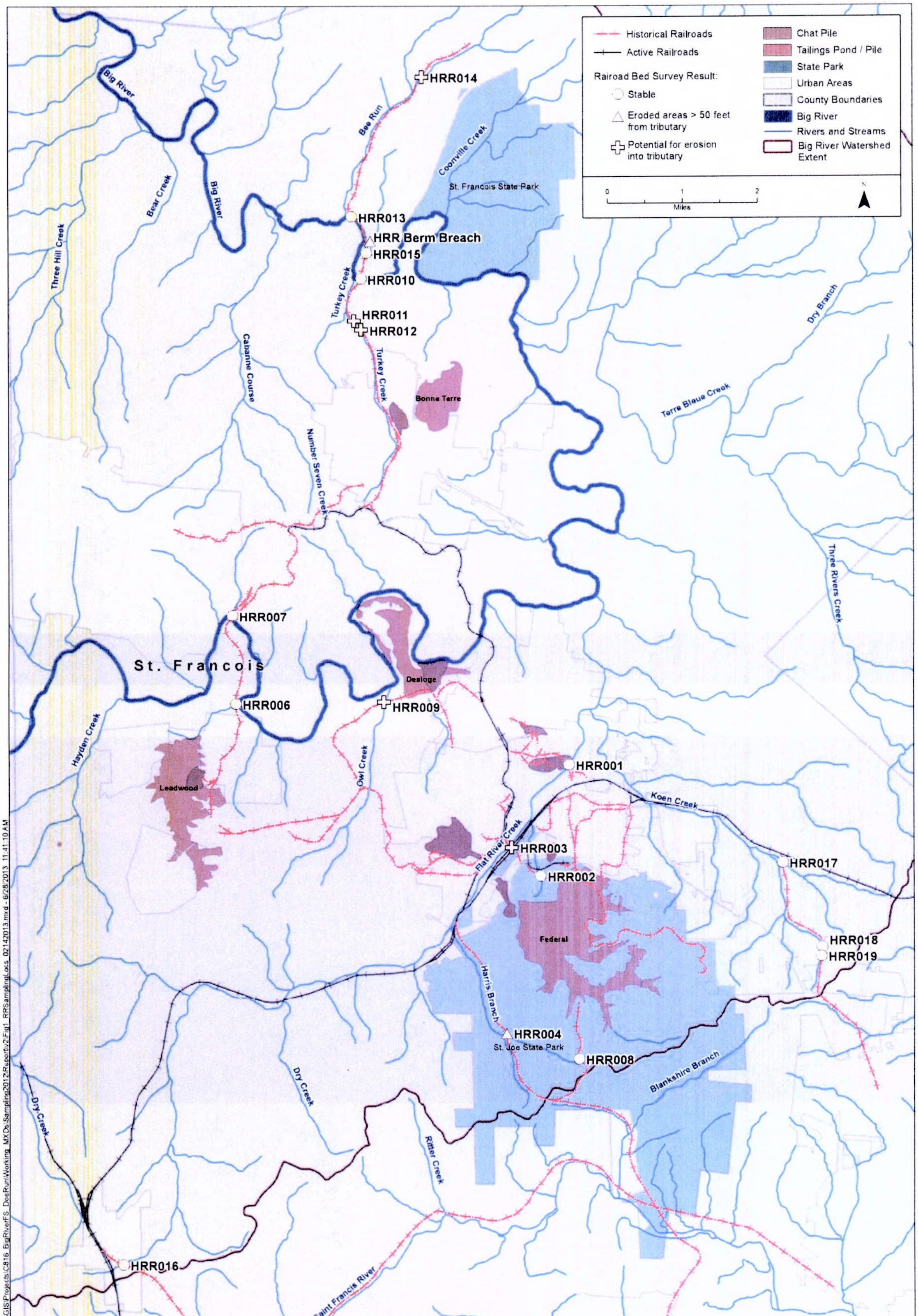

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Figure 3.
Visual Railroad Bed Survey Results
River and Non-Residential Areas (OU-2)
St. Francois County Mining Area, Missouri

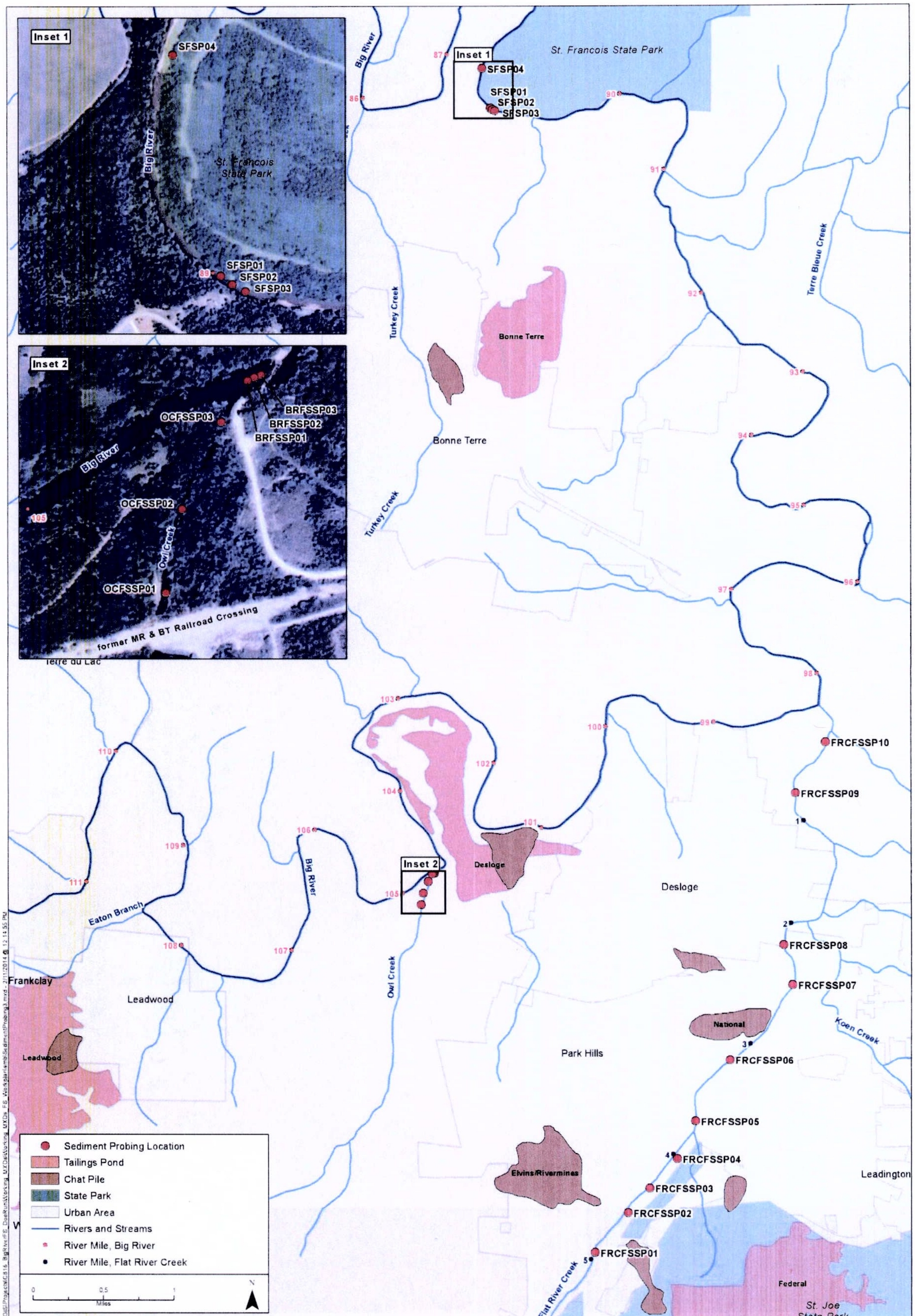

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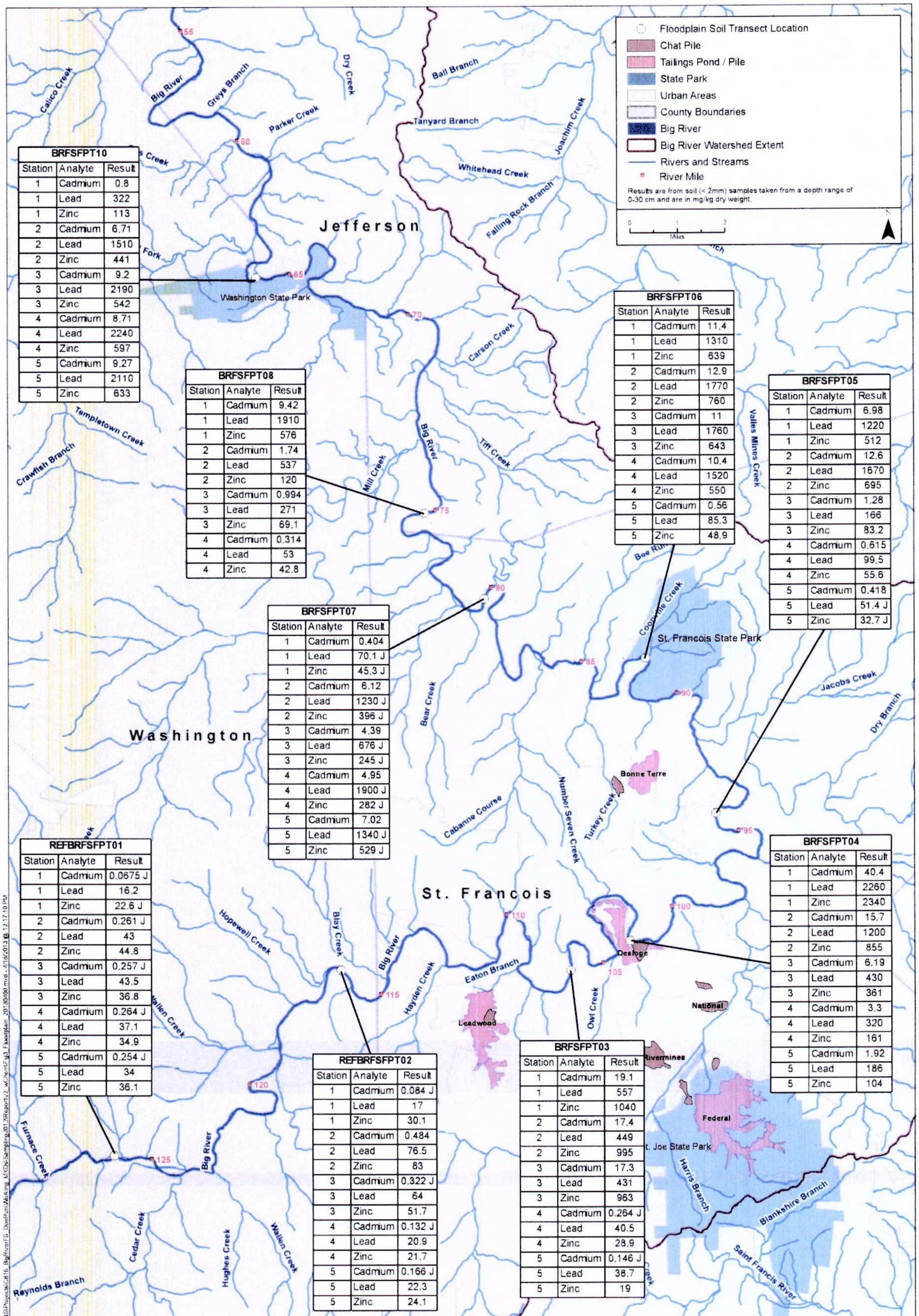
Figure 4.
Sediment Probing Locations
River and Non-Residential Areas (OU-2)
St. Francois County Mining Area, Missouri



BRFSFPT10

Station	Analyte	Result
1	Cadmium	0.8
1	Lead	322
1	Zinc	113
2	Cadmium	6.71
2	Lead	1510
2	Zinc	441
3	Cadmium	9.2
3	Lead	2190
3	Zinc	542
4	Cadmium	8.71
4	Lead	2240
4	Zinc	597
5	Cadmium	9.27
5	Lead	2110
5	Zinc	633

BRFSFPT08

Station	Analyte	Result
1	Cadmium	9.42
1	Lead	1910
1	Zinc	576
2	Cadmium	1.74
2	Lead	537
2	Zinc	120
3	Cadmium	0.994
3	Lead	271
3	Zinc	69.1
4	Cadmium	0.314
4	Lead	53
4	Zinc	42.8

BRFSFPT06

Station	Analyte	Result
1	Cadmium	11.4
1	Lead	1310
1	Zinc	639
2	Cadmium	12.9
2	Lead	1770
2	Zinc	760
3	Cadmium	11
3	Lead	1760
3	Zinc	643
4	Cadmium	10.4
4	Lead	1520
4	Zinc	550
5	Cadmium	0.56
5	Lead	85.3
5	Zinc	48.9

BRFSFPT05

Station	Analyte	Result
1	Cadmium	6.98
1	Lead	1220
1	Zinc	512
2	Cadmium	12.6
2	Lead	1670
2	Zinc	695
3	Cadmium	1.28
3	Lead	166
3	Zinc	83.2
4	Cadmium	0.615
4	Lead	99.5
4	Zinc	55.6
5	Cadmium	0.418
5	Lead	51.4 J
5	Zinc	32.7 J

BRFSFPT07

Station	Analyte	Result
1	Cadmium	0.404
1	Lead	70.1 J
1	Zinc	45.3 J
2	Cadmium	6.12
2	Lead	1230 J
2	Zinc	396 J
3	Cadmium	4.39
3	Lead	676 J
3	Zinc	245 J
4	Cadmium	4.95
4	Lead	1900 J
4	Zinc	282 J
5	Cadmium	7.02
5	Lead	1340 J
5	Zinc	529 J

REFBRFSFPT01

Station	Analyte	Result
1	Cadmium	0.0675 J
1	Lead	16.2
1	Zinc	22.6 J
2	Cadmium	0.261 J
2	Lead	43
2	Zinc	44.8
3	Cadmium	0.257 J
3	Lead	43.5
3	Zinc	36.8
4	Cadmium	0.264 J
4	Lead	37.1
4	Zinc	34.9
5	Cadmium	0.254 J
5	Lead	34
5	Zinc	36.1

BRFSFPT04

Station	Analyte	Result
1	Cadmium	40.4
1	Lead	2260
1	Zinc	2340
2	Cadmium	15.7
2	Lead	1200
2	Zinc	855
3	Cadmium	6.19
3	Lead	430
3	Zinc	361
4	Cadmium	3.3
4	Lead	320
4	Zinc	161
5	Cadmium	1.92
5	Lead	186
5	Zinc	104

REFBRFSFPT02

Station	Analyte	Result
1	Cadmium	0.084 J
1	Lead	17
1	Zinc	30.1
2	Cadmium	0.484
2	Lead	76.5
2	Zinc	83
3	Cadmium	0.322 J
3	Lead	64
3	Zinc	51.7
4	Cadmium	0.132 J
4	Lead	20.9
4	Zinc	21.7
5	Cadmium	0.166 J
5	Lead	22.3
5	Zinc	24.1

BRFSFPT03

Station	Analyte	Result
1	Cadmium	19.1
1	Lead	557
1	Zinc	1040
2	Cadmium	17.4
2	Lead	449
2	Zinc	995
3	Cadmium	17.3
3	Lead	431
3	Zinc	963
4	Cadmium	0.264 J
4	Lead	40.5
4	Zinc	28.9
5	Cadmium	0.146 J
5	Lead	38.7
5	Zinc	19

Figure 5.
Floodplain Soil Transect Results
River and Non-Residential Areas (OU-2)
St. Francois County Mining Area, Missouri

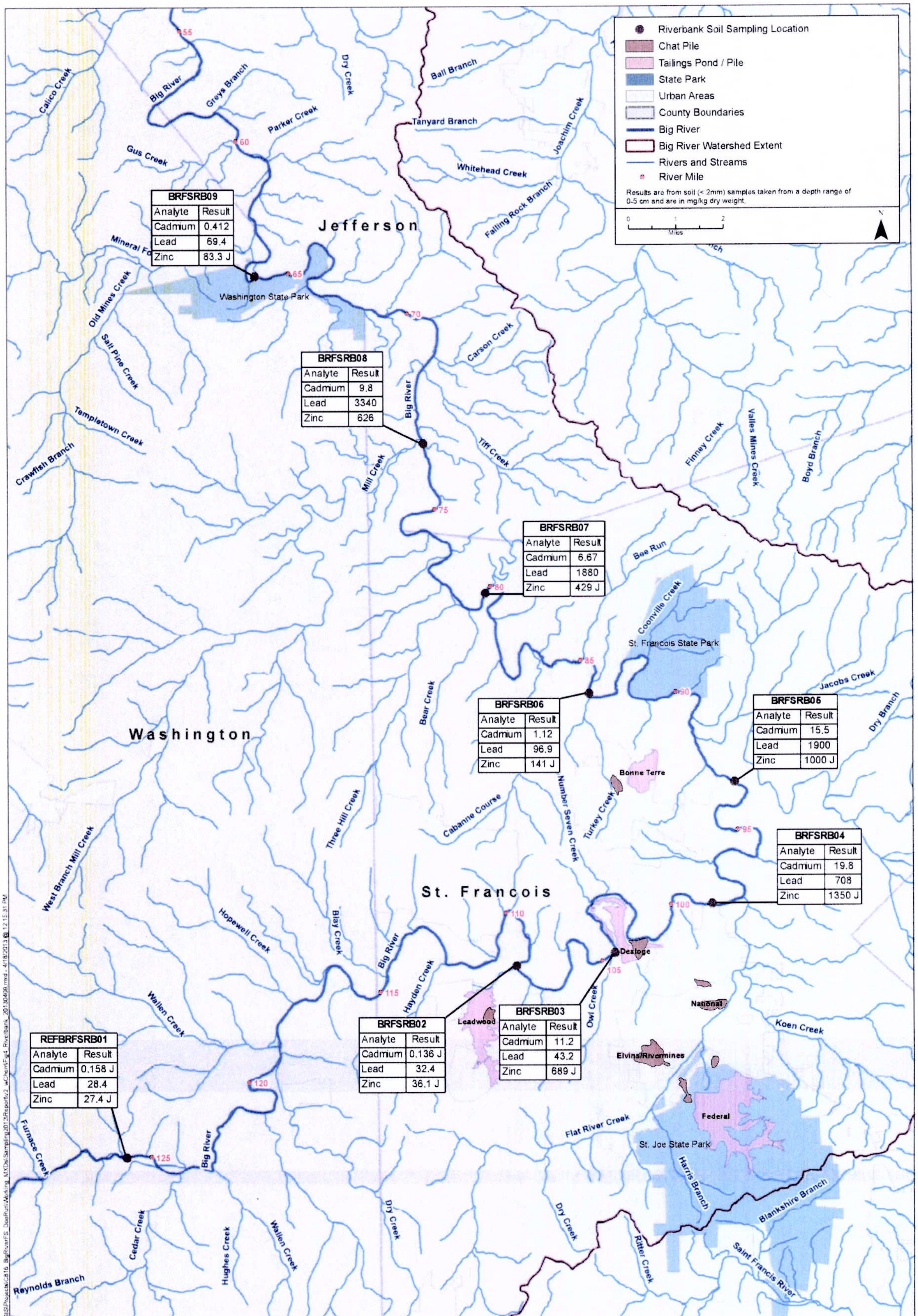


Figure 6.
Riverbank Sampling Results
River and Non-Residential Areas (OU-2)
St. Francois County Mining Area, Missouri

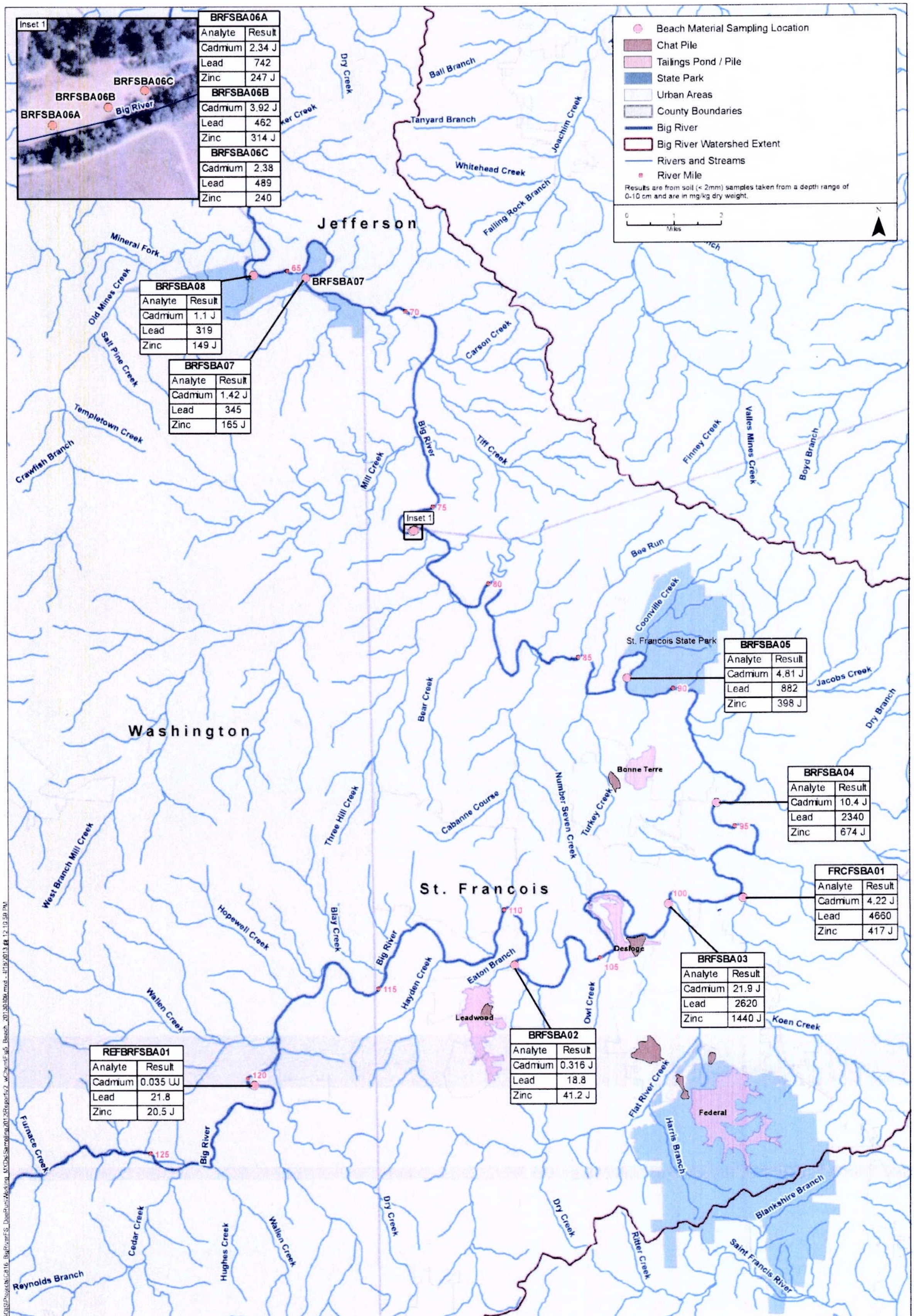


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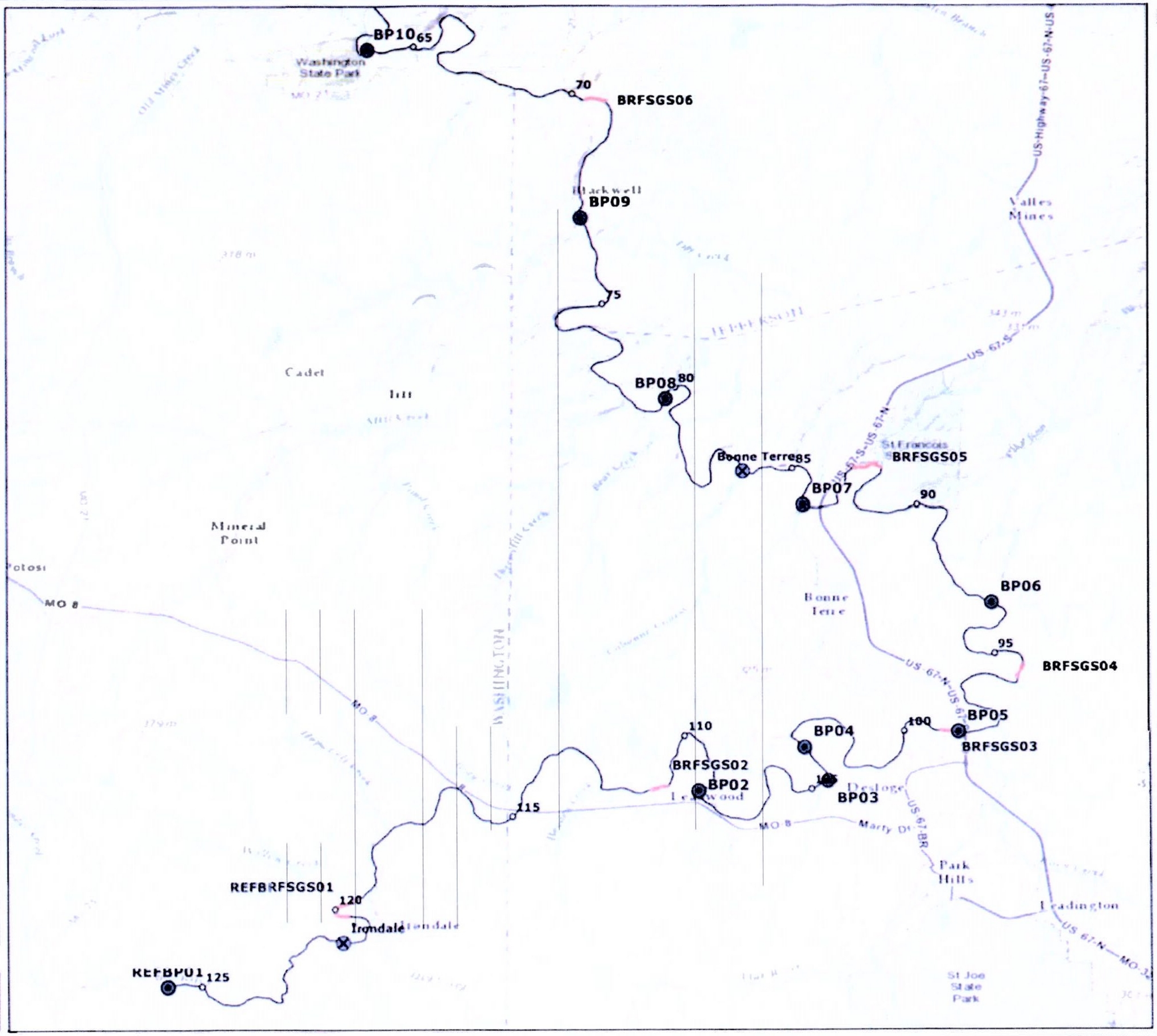
Figure 7.
Beach Material Sampling Results
River and Non-Residential Areas (OU-2)
St. Francois County Mining Area, Missouri



LEGEND

REACH EXTENT

BANK PIN LOCATION (INSTALLED NOVEMBER 2012)

APPROXIMATE RIVER CENTERLINE

USGS GAUGING STATION LOCATION

SOURCE:
1.SOURCES: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), AND THE

0 11,000 22,000

SCALE: 1" = 11,000'

TITLE:

Figure 8.

BIG RIVER FLUVIAL GEOMORPHIC SURVEY REACH EXTENTS, BANK PIN LOCATIONS, AND GAUGING STATIONS

LOCATION:

BIG RIVER
MISSOURI

DATE:

11/22/2013

FILENAME:

211073_FIGURE_4.mxd

THE ELM GROUP

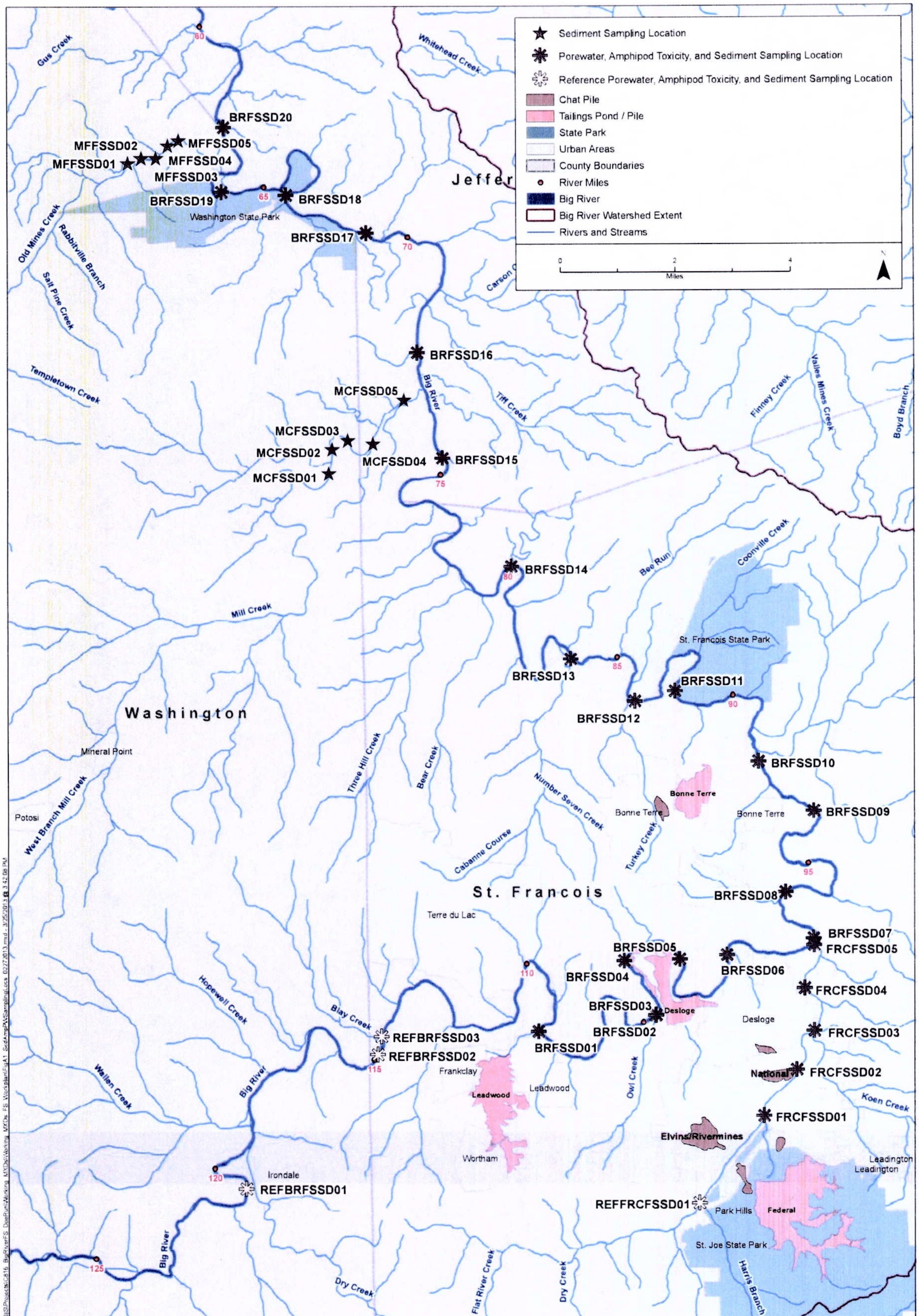


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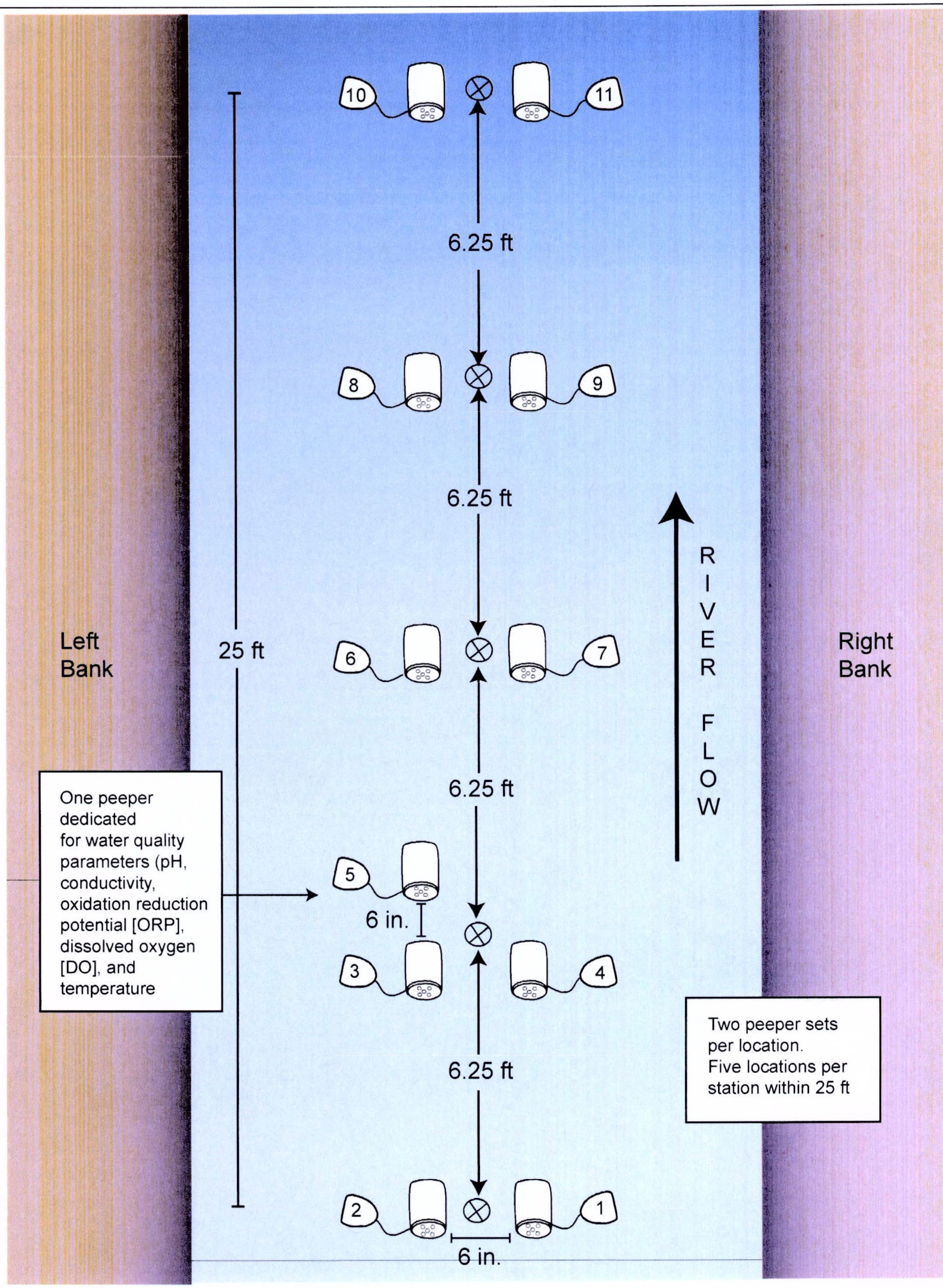
Figure 9.
Proposed Porewater, Amphipod Toxicity, and Sediment Sampling Locations
River and Non-Residential Areas (OU-2)
St. Francois County Mining Area, Missouri



integral consulting inc.

Figure 10.
Example of Porewater Sampling Scheme
River and Non-Residential Areas (OU-2)
St. Francois County Mining Area, Missouri

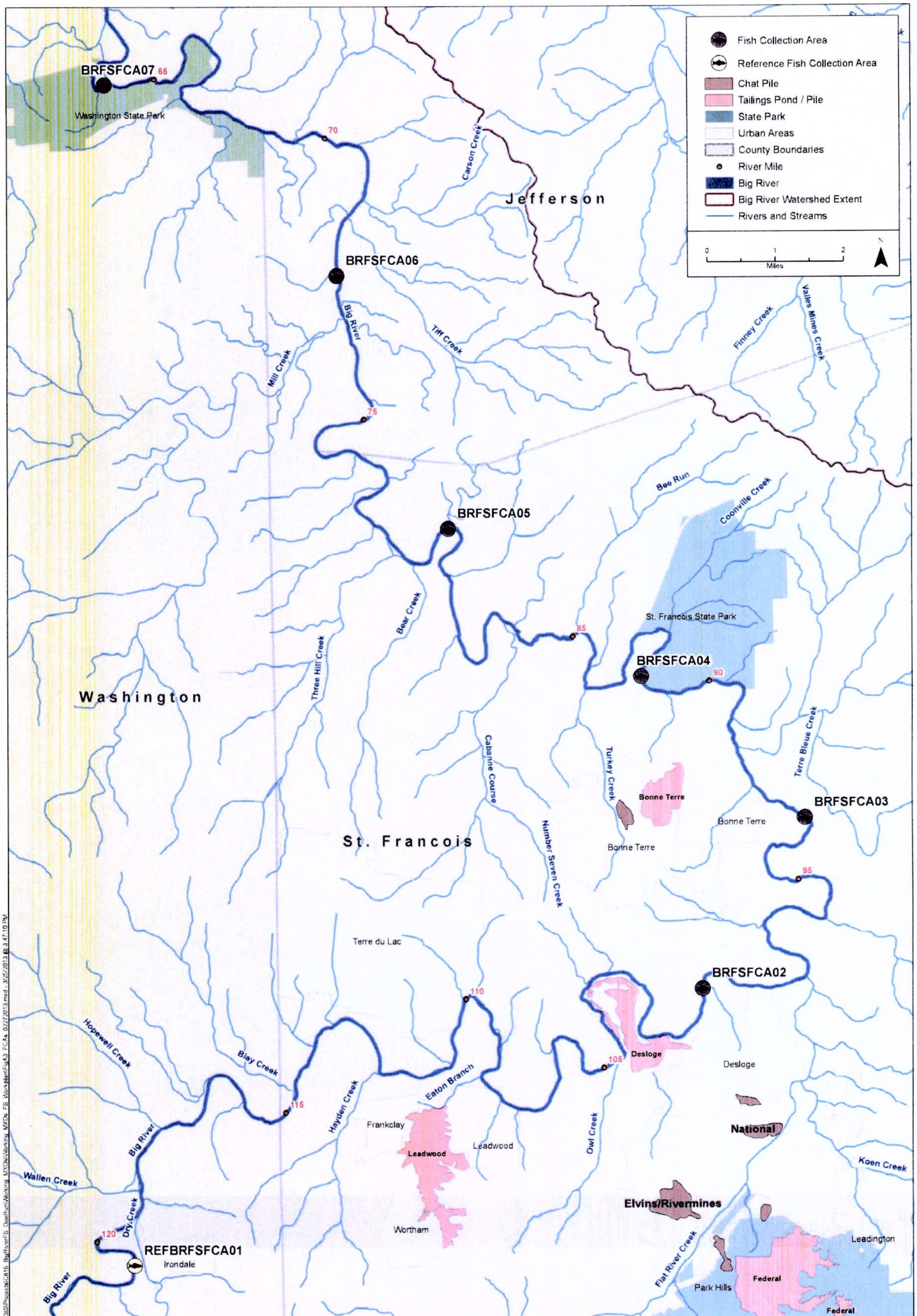


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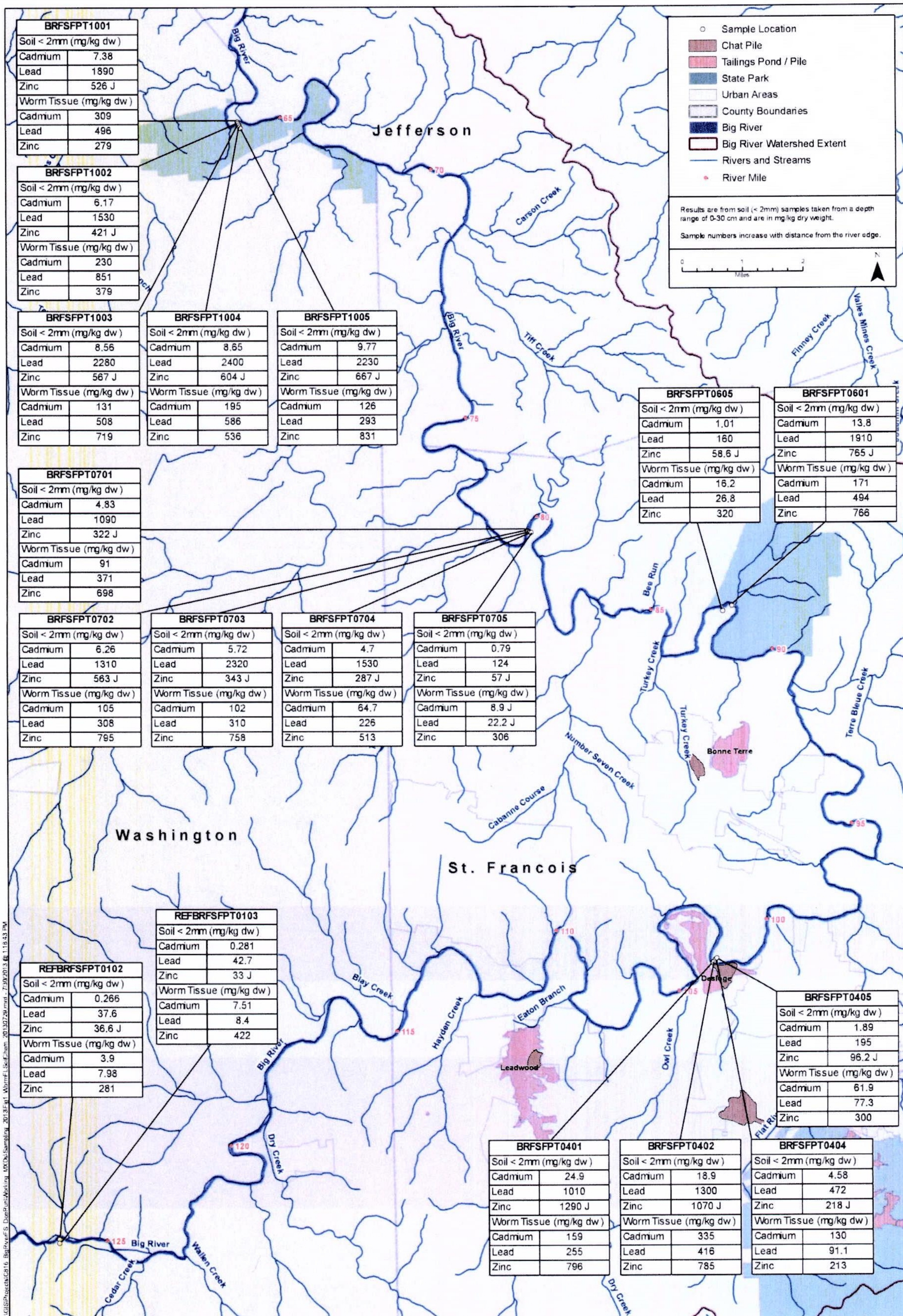
Figure 11.
Proposed Fish Collection Areas
River and Non-Residential Areas (OU-2)
St. Francois County Mining Area, Missouri



BRFSFPT1001	
Soil < 2mm (mg/kg dw)	
Cadmium	7.38
Lead	1890
Zinc	526 J
Worm Tissue (mg/kg dw)	
Cadmium	309
Lead	496
Zinc	279

BRFSFPT1002	
Soil < 2mm (mg/kg dw)	
Cadmium	6.17
Lead	1530
Zinc	421 J
Worm Tissue (mg/kg dw)	
Cadmium	230
Lead	851
Zinc	379

BRFSFPT1003	
Soil < 2mm (mg/kg dw)	
Cadmium	8.56
Lead	2280
Zinc	567 J
Worm Tissue (mg/kg dw)	
Cadmium	131
Lead	508
Zinc	719

BRFSFPT1004	
Soil < 2mm (mg/kg dw)	
Cadmium	8.65
Lead	2400
Zinc	604 J
Worm Tissue (mg/kg dw)	
Cadmium	195
Lead	586
Zinc	536

BRFSFPT1005	
Soil < 2mm (mg/kg dw)	
Cadmium	9.77
Lead	2230
Zinc	667 J
Worm Tissue (mg/kg dw)	
Cadmium	126
Lead	293
Zinc	831

BRFSFPT0605	
Soil < 2mm (mg/kg dw)	
Cadmium	1.01
Lead	160
Zinc	58.6 J
Worm Tissue (mg/kg dw)	
Cadmium	16.2
Lead	26.8
Zinc	320

BRFSFPT0601	
Soil < 2mm (mg/kg dw)	
Cadmium	13.8
Lead	1910
Zinc	765 J
Worm Tissue (mg/kg dw)	
Cadmium	171
Lead	494
Zinc	766

BRFSFPT0701	
Soil < 2mm (mg/kg dw)	
Cadmium	4.83
Lead	1090
Zinc	322 J
Worm Tissue (mg/kg dw)	
Cadmium	91
Lead	371
Zinc	698

BRFSFPT0702	
Soil < 2mm (mg/kg dw)	
Cadmium	6.26
Lead	1310
Zinc	563 J
Worm Tissue (mg/kg dw)	
Cadmium	105
Lead	308
Zinc	795

BRFSFPT0703	
Soil < 2mm (mg/kg dw)	
Cadmium	5.72
Lead	2320
Zinc	343 J
Worm Tissue (mg/kg dw)	
Cadmium	102
Lead	310
Zinc	758

BRFSFPT0704	
Soil < 2mm (mg/kg dw)	
Cadmium	4.7
Lead	1530
Zinc	287 J
Worm Tissue (mg/kg dw)	
Cadmium	64.7
Lead	226
Zinc	513

BRFSFPT0705	
Soil < 2mm (mg/kg dw)	
Cadmium	0.79
Lead	124
Zinc	57 J
Worm Tissue (mg/kg dw)	
Cadmium	8.9 J
Lead	22.2 J
Zinc	306

REFBRFSFPT0103	
Soil < 2mm (mg/kg dw)	
Cadmium	0.281
Lead	42.7
Zinc	33 J
Worm Tissue (mg/kg dw)	
Cadmium	7.51
Lead	8.4
Zinc	422

REFBRFSFPT0102	
Soil < 2mm (mg/kg dw)	
Cadmium	0.266
Lead	37.6
Zinc	36.6 J
Worm Tissue (mg/kg dw)	
Cadmium	3.9
Lead	7.98
Zinc	281

BRFSFPT0405	
Soil < 2mm (mg/kg dw)	
Cadmium	1.89
Lead	195
Zinc	96.2 J
Worm Tissue (mg/kg dw)	
Cadmium	61.9
Lead	77.3
Zinc	300

BRFSFPT0401	
Soil < 2mm (mg/kg dw)	
Cadmium	24.9
Lead	1010
Zinc	1290 J
Worm Tissue (mg/kg dw)	
Cadmium	159
Lead	255
Zinc	796

BRFSFPT0402	
Soil < 2mm (mg/kg dw)	
Cadmium	18.9
Lead	1300
Zinc	1070 J
Worm Tissue (mg/kg dw)	
Cadmium	335
Lead	416
Zinc	785

BRFSFPT0404	
Soil < 2mm (mg/kg dw)	
Cadmium	4.58
Lead	472
Zinc	218 J
Worm Tissue (mg/kg dw)	
Cadmium	130
Lead	91.1
Zinc	213

integral

Figure 12.
Metal Concentrations in Worm Tissue and Soil Less Than 2mm
River and Non-Residential Areas (OU-2)
St. Francois County Mining Area, Missouri

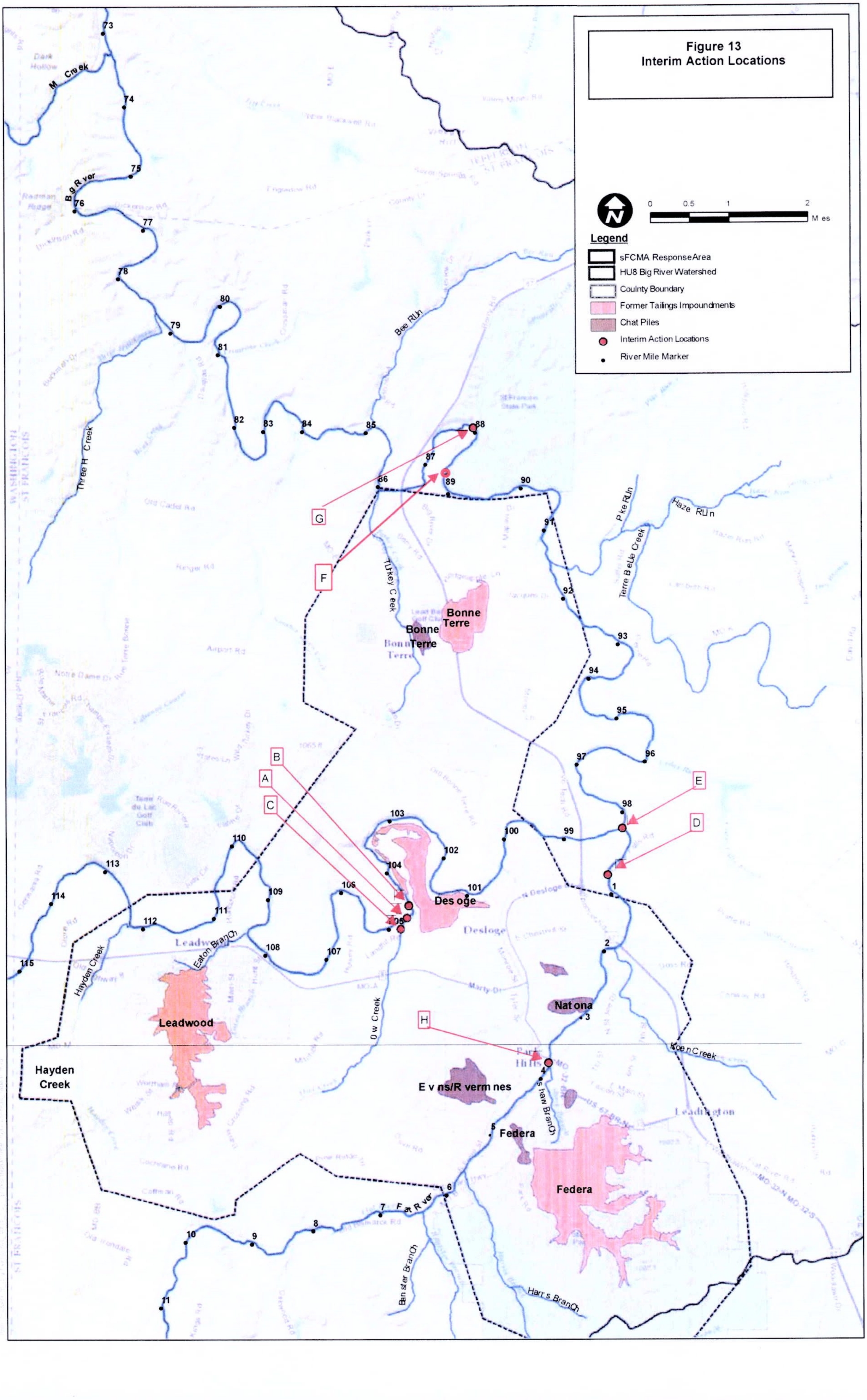


Figure 13
Interim Action Locations

APPENDIX B

TABLES

TABLE 1
Tissue Analytical Data
Metals by EPA 6020 and Lipids / Percent Moisture
Big River Mine Tailings Site

Location ID	Sample Number	Sample ID	Species	Sample Type	Sample Date	Analytical Method	Cadmium mg/kg	Lead mg/kg	Zinc mg/kg	Lipids mg/kg	Percent Moisture percent
BRFSFCA02	TS0029	BK-FCA2-001	Black redhorse	Fillet	09/17/13	6020/Lipids	0.149	6.24 J	95.8	0.330	79.8
BRFSFCA02	TS0034	LG-FCA2-001	Longear sunfish	Fillet	09/17/13	6020/Lipids	0.242	10.0 J	117	0.300	78.9
BRFSFCA02	TS0035	LG-FCA2-002	Longear sunfish	Fillet	09/17/13	6020/Lipids	0.167	4.95 J	98.2	0.490	78.3
BRFSFCA02	TS0036	LG-FCA2-003	Longear sunfish	Fillet	09/17/13	6020/Lipids	0.213	7.18 J	112	0.330	78.7
BRFSFCA02	TS0037	LG-FCA2-004	Longear sunfish	Fillet	09/17/13	6020/Lipids	0.299	15.6 J	144	0.330	78.5
BRFSFCA02	TS0038	LG-FCA2-005	Longear sunfish	Fillet	09/17/13	6020/Lipids	0.312	10.5 J	112	0.430	78.6
BRFSFCA02	TS0039	BK-FCA2-001	Black redhorse	Whole body	09/17/13	6020/Lipids	3.71	96.3 J	264	1.30	75.2
BRFSFCA02	TS0040	BK-FCA2-002	Black redhorse	Whole body	09/17/13	6020/Lipids	2.85	83.5 J	280	1.90	74.9
BRFSFCA02	TS0041	BK-FCA2-003	Black redhorse	Whole body	09/17/13	6020/Lipids	2.60	78.3 J	260	1.20	74.9
BRFSFCA02	TS0042	BK-FCA2-004	Black redhorse	Whole body	09/17/13	6020/Lipids	3.55	94.9 J	270	2.30	74.8
BRFSFCA02	TS0044	LG-FCA2-001	Longear sunfish	Whole body	09/17/13	6020/Lipids	2.31 J	68.2 J	201	2.20	74.3
BRFSFCA02	TS0045	LG-FCA2-002	Longear sunfish	Whole body	09/17/13	6020/Lipids	2.04	49.9 J	156	6.10	70.4
BRFSFCA02	TS0046	LG-FCA2-003	Longear sunfish	Whole body	09/17/13	6020/Lipids	1.90	70.3 J	194	2.80	73.3
BRFSFCA02	TS0047	LG-FCA2-004	Longear sunfish	Whole body	09/17/13	6020/Lipids	2.60	75.2 J	263	3.50	72.9
BRFSFCA02	TS0048	LG-FCA2-005	Longear sunfish	Whole body	09/17/13	6020/Lipids	2.05	72.4 J	207	3.10	71.7
BRFSFCA02	TS0049	DA-FCA2-001	Mixed darters	Whole body	09/17/13	6020/Lipids	2.32	43.9 J	340	2.90	71.7
BRFSFCA02	TS0050	SH-FCA2-001	Bleeding shiner	Whole body	09/17/13	6020/Lipids	2.32	55.6 J	604	1.10	77.6
BRFSFCA02	TS0051	ST-FCA2-001	Stonerollers	Whole body	09/17/13	6020/Lipids	5.74	291 J	785	3.00	75.0
BRFSFCA02	TS0053	GC-FCA2-001	Golden crayfish	Whole body	09/17/13	6020/Lipids	12.6	53.0	248	1.50	69.1
BRFSFCA02	TS0055	GC-FCA2-002	Golden crayfish	Whole body	09/17/13	6020/Lipids	16.5	66.6	276	1.70	68.8

TABLE 1 cont.
Tissue Analytical Data
Metals by EPA 6020 and Lipids / Percent Moisture
Big River Mine Tailings Site

Location ID	Sample Number	Sample ID	Species	Sample Type	Sample Date	Analytical Method	Cadmium mg/kg	Lead mg/kg	Zinc mg/kg	Lipids mg/kg	Percent Moisture percent
BRFSFCA03	TS0062	GE-FCA3-001	Goggle-eye bass	Fillet	09/18/13	6020/Lipids	**0.133**	**4.84**	**105**	**0.200**	**79.7**
BRFSFCA03	TS0063	GS-FCA3-001	Green sunfish	Fillet	09/18/13	6020/Lipids	**0.153**	**6.50**	**84.8**	**0.160**	**79.3**
BRFSFCA03	TS0064	GS-FCA3-002	Green sunfish	Fillet	09/18/13	6020/Lipids	**0.166**	**6.29**	**95.8**	**0.190**	**80.5**
BRFSFCA03	TS0065	LG-FCA3-001	Longear sunfish	Fillet	09/18/13	6020/Lipids	**0.277**	**26.3**	**109**	**0.240**	**78.4**
BRFSFCA03	TS0066	LG-FCA3-002	Longear sunfish	Fillet	09/18/13	6020/Lipids	**0.337**	**16.4**	**119**	**0.280**	**83.9**
BRFSFCA03	TS0067	NH-FCA3-001	Northern hogsucker	Whole body	09/18/13	6020/Lipids	**1.96**	**86.0**	**234**	**1.80**	**74.1**
BRFSFCA03	TS0072	GE-FCA3-001	Goggle-eye bass	Whole body	09/18/13	6020/Lipids	**1.39**	**47.4**	**157**	**1.20**	**75.0**
BRFSFCA03	TS0073	GS-FCA3-001	Green sunfish	Whole body	09/18/13	6020/Lipids	**1.04**	**42.8**	**135**	**1.40**	**75.4**
BRFSFCA03	TS0074	GS-FCA3-002	Green sunfish	Whole body	09/18/13	6020/Lipids	**0.977**	**31.2**	**127**	**1.30**	**74.1**
BRFSFCA03	TS0075	LG-FCA3-001	Longear sunfish	Whole body	09/18/13	6020/Lipids	**1.64**	**80.7**	**200**	**2.60**	**73.5**
BRFSFCA03	TS0076	LG-FCA3-002	Longear sunfish	Whole body	09/18/13	6020/Lipids	**1.82**	**71.1**	**215**	**3.60**	**73.5**
BRFSFCA03	TS0077	DA-FCA3-001	Mixed darters	Whole body	09/18/13	6020/Lipids	**1.76**	**64.6**	**320**	**1.90**	**71.5**
BRFSFCA03	TS0078	SH-FCA3-001	Bleeding shiner	Whole body	09/18/13	6020/Lipids	**1.51**	**43.0**	**460**	**1.80**	**76.7**
BRFSFCA03	TS0079	SH-FCA3-002	Telescope shiner	Whole body	09/18/13	6020/Lipids	**1.49**	**34.0**	**371**	**2.50**	**77.1**
BRFSFCA03	TS0080	ST-FCA3-001	Stonerollers	Whole body	09/18/13	6020/Lipids	**2.26**	**161**	**422**	**2.80**	**74.5**
BRFSFCA03	TS0081	GC-FCA3-001	Golden crayfish	Whole body	09/18/13	6020/Lipids	**12.6**	**130**	**153**	**1.30**	**68.7**
BRFSFCA03	TS0083	GC-FCA3-002	Golden crayfish	Whole body	09/18/13	6020/Lipids	**15.2**	**81.6**	**151**	**1.50**	**69.1**

TABLE 1 cont.
Tissue Analytical Data
Metals by EPA 6020 and Lipids / Percent Moisture
Big River Mine Tailings Site

Location ID	Sample Number	Sample ID	Species	Sample Type	Sample Date	Analytical Method	Cadmium mg/kg	Lead mg/kg	Zinc mg/kg	Lipids mg/kg	Percent Moisture percent
BRFSFCA04	TS0085	GR-FCA4-001	Golden Redhorse	Fillet	09/19/13	6020/Lipids	**0.113**	**4.67 J**	**54.8**	**0.300**	**80.8**
BRFSFCA04	TS0086	GR-FCA4-002	Golden Redhorse	Whole body	09/19/13	6020/Lipids	**0.774**	**35.0 J**	**127**	**1.70**	**75.2**
BRFSFCA04	TS0087	GR-FCA4-003	Golden Redhorse	Whole body	09/19/13	6020/Lipids	**0.726**	**38.0 J**	**123**	**1.80**	**75.1**
BRFSFCA04	TS0088	GR-FCA4-004	Golden Redhorse	Whole body	09/19/13	6020/Lipids	**0.788**	**43.3 J**	**123**	**2.00**	**75.4**
BRFSFCA04	TS0089	GR-FCA4-005	Golden Redhorse	Whole body	09/19/13	6020/Lipids	**0.897**	**39.3 J**	**126**	**2.00**	**75.1**
BRFSFCA04	TS0090	GE-FCA4-001	Goggle-eye bass	Fillet	09/19/13	6020/Lipids	**0.141**	**4.35 J**	**83.5**	**1.17**	**74.4**
BRFSFCA04	TS0091	GS-FCA4-001	Green sunfish	Fillet	09/19/13	6020/Lipids	**0.132**	**11.5 J**	**84.3**	**0.380**	**79.4**
BRFSFCA04	TS0092	LG-FCA4-001	Longear sunfish	Fillet	09/19/13	6020/Lipids	**0.308**	**11.4 J**	**103**	**0.350**	**78.9**
BRFSFCA04	TS0093	LG-FCA4-002	Longear sunfish	Fillet	09/19/13	6020/Lipids	**0.211**	**12.7 J**	**92.8**	**0.270**	**79.5**
BRFSFCA04	TS0094	LG-FCA4-003	Longear sunfish	Fillet	09/19/13	6020/Lipids	**0.181**	**12.1 J**	**120**	**0.330**	**79.3**
BRFSFCA04	TS0095	GR-FCA4-001	Golden Redhorse	Whole body	09/19/13	6020/Lipids	**1.39**	**59.3 J**	**145**	**2.90**	**72.5**
BRFSFCA04	TS0096	NH-FCA4-001	Northern hogsucker	Whole body	09/19/13	6020/Lipids	**1.61**	**49.6 J**	**178**	**2.50**	**75.2**
BRFSFCA04	TS0100	GE-FCA4-001	Goggle-eye bass	Whole body	09/19/13	6020/Lipids	**1.15**	**30.2 J**	**139**	**1.60**	**73.5**
BRFSFCA04	TS0101	GS-FCA4-001	Green sunfish	Whole body	09/19/13	6020/Lipids	**1.45**	**42.2**	**139**	**2.20**	**72.9**
BRFSFCA04	TS0102	LG-FCA4-001	Longear sunfish	Whole body	09/19/13	6020/Lipids	**3.59**	**58.9 J**	**180**	**3.50**	**71.7**
BRFSFCA04	TS0103	LG-FCA4-002	Longear sunfish	Whole body	09/19/13	6020/Lipids	**1.68**	**59.1 J**	**164**	**2.30**	**73.1**
BRFSFCA04	TS0104	LG-FCA4-003	Longear sunfish	Whole body	09/19/13	6020/Lipids	**1.81**	**69.4**	**190**	**2.70**	**71.4**
BRFSFCA04	TS0105	MD-FCA4-001	Missouri saddled darter	Whole body	09/19/13	6020/Lipids	**2.03**	**53.2 J**	**286**	**3.30**	**71.5**
BRFSFCA04	TS0106	SH-FCA4-001	Bleeding shiner	Whole body	09/19/13	6020/Lipids	**1.77**	**49.5 J**	**420**	**2.90**	**75.7**
BRFSFCA04	TS0107	ST-FCA4-001	Stonerollers	Whole body	09/19/13	6020/Lipids	**0.862**	**60.8 J**	**195**	**4.20**	**73.8**
BRFSFCA04	TS0108	SH-FCA4-002	Telescope shiner	Whole body	09/19/13	6020/Lipids	**1.25**	**29.7 J**	**321**	**3.90**	**72.8**
BRFSFCA04	TS0109	GC-FCA4-001	Golden crayfish	Whole body	09/19/13	6020/Lipids	**11.7**	**66.2**	**147**	**1.40**	**70.7**
BRFSFCA04	TS0110	GC-FCA4-002	Golden crayfish	Whole body	09/19/13	6020/Lipids	**12.9**	**78.5**	**135**	**1.70**	**68.4**
BRFSFCA04	TS0111	MD-FCA4-002	Missouri saddled darter	Whole body	09/19/13	6020/Lipids	**1.69**	**58.7**	**299**	**3.50**	**70.9**

TABLE 1 cont.
Tissue Analytical Data
Metals by EPA 6020 and Lipids / Percent Moisture
Big River Mine Tailings Site

Location ID	Sample Number	Sample ID	Species	Sample Type	Sample Date	Analytical Method	Cadmium mg/kg	Lead mg/kg	Zinc mg/kg	Lipids mg/kg	Percent Moisture percent
BRFSFCA05	TS0113	BK-FCA5-001	Black redhorse	Fillet	09/23/13	6020/Lipids	0.192	3.89 J	61.7	0.740	80.6
BRFSFCA05	TS0118	LG-FCA5-001	Longear sunfish	Fillet	09/23/13	6020/Lipids	0.312	15.5 J	101	0.310	79.6
BRFSFCA05	TS0119	LG-FCA5-002	Longear sunfish	Fillet	09/23/13	6020/Lipids	0.106	10.2 J	83.7	0.380	79.6
BRFSFCA05	TS0120	GE-FCA5-001	Goggle-eye bass	Fillet	09/23/13	6020/Lipids	0.0880	2.44 J	67.4	0.190	79.3
BRFSFCA05	TS0121	GE-FCA5-002	Goggle-eye bass	Fillet	09/23/13	6020/Lipids	0.117	3.78 J	78.4	0.310	79.8
BRFSFCA05	TS0122	BG-FCA5-001	Bluegill sunfish	Fillet	09/23/13	6020/Lipids	0.0710	2.74 J	82.8	0.300	80.2
BRFSFCA05	TS0123	BK-FCA5-001	Black redhorse	Whole body	09/23/13	6020/Lipids	2.65	92.0 J	109	2.00	74.4
BRFSFCA05	TS0124	NH-FCA5-001	Northern hogsucker	Whole body	09/23/13	6020/Lipids	2.55	55.3 J	171	2.10	75.7
BRFSFCA05	TS0128	LG-FCA5-001	Longear sunfish	Whole body	09/23/13	6020/Lipids	1.91	66.0 J	186	1.90	74.3
BRFSFCA05	TS0129	LG-FCA5-002	Longear sunfish	Whole body	09/23/13	6020/Lipids	1.23	71.4 J	154	2.50	73.3
BRFSFCA05	TS0130	GE-FCA5-001	Goggle-eye bass	Whole body	09/23/13	6020/Lipids	1.05	33.0 J	136	1.10	74.2
BRFSFCA05	TS0131	GE-FCA5-002	Goggle-eye bass	Whole body	09/23/13	6020/Lipids	1.06	35.8 J	138	1.20	74.5
BRFSFCA05	TS0132	BG-FCA5-001	Bluegill sunfish	Whole body	09/23/13	6020/Lipids	3.98	68.2 J	162	1.90	75.7
BRFSFCA05	TS0133	MD-FCA5-001	Missouri saddled darter	Whole body	09/23/13	6020/Lipids	1.40	53.0 J	212	3.40	73.0
BRFSFCA05	TS0134	SH-FCA5-001	Bleeding shiner	Whole body	09/23/13	6020/Lipids	0.868	34.9 J	308	3.10	75.9
BRFSFCA05	TS0135	ST-FCA5-001	Stonerollers	Whole body	09/23/13	6020/Lipids	1.06	114 J	225	5.30	73.5
BRFSFCA05	TS0136	SH-FCA5-002	Striped shiner	Whole body	09/23/13	6020/Lipids	0.625	16.5 J	228	4.00	74.2
BRFSFCA05	TS0137	GC-FCA5-001	Golden crayfish	Whole body	09/23/13	6020/Lipids	12.5	74.1	105	1.80	71.7
BRFSFCA05	TS0138	GC-FCA5-002	Golden crayfish	Whole body	09/23/13	6020/Lipids	8.46	50.3	95.8	2.00	69.4

TABLE 1 cont.
Tissue Analytical Data
Metals by EPA 6020 and Lipids / Percent Moisture
Big River Mine Tailings Site

Location ID	Sample Number	Sample ID	Species	Sample Type	Sample Date	Analytical Method	Cadmium mg/kg	Lead mg/kg	Zinc mg/kg	Lipids mg/kg	Percent Moisture percent
BRFSFCA06	TS0141	BK-FCA6-001	Black redhorse	Fillet	09/24/13	6020/Lipids	0.155	3.83 J	51.8	0.200	81.0
BRFSFCA06	TS0142	BK-FCA6-002	Black redhorse	Fillet	09/24/13	6020/Lipids	0.0740	2.67 J	51.8	0.180	80.9
BRFSFCA06	TS0143	BK-FCA6-003	Black redhorse	Fillet	09/24/13	6020/Lipids	0.0490	2.56 J	71.0	0.820	78.4
BRFSFCA06	TS0144	BK-FCA6-004	Black redhorse	Fillet	09/24/13	6020/Lipids	0.0320	4.18 J	48.8	0.290	80.5
BRFSFCA06	TS0145	BK-FCA6-005	Black redhorse	Fillet	09/24/13	6020/Lipids	0.0470	5.61 J	67.4	0.530	80.4
BRFSFCA06	TS0146	LG-FCA6-001	Longear sunfish	Fillet	09/24/13	6020/Lipids	0.154	7.97 J	82.4	0.190	78.4
BRFSFCA06	TS0147	LG-FCA6-002	Longear sunfish	Fillet	09/24/13	6020/Lipids	0.110	8.39 J	77.1	0.180	79.2
BRFSFCA06	TS0148	LG-FCA6-003	Longear sunfish	Fillet	09/24/13	6020/Lipids	0.141	8.94 J	76.5	0.200	75.2
BRFSFCA06	TS0149	BG-FCA6-001	Bluegill sunfish	Fillet	09/24/13	6020/Lipids	0.112	5.60	77.3	0.470	79.0
BRFSFCA06	TS0150	BG-FCA6-002	Bluegill sunfish	Fillet	09/24/13	6020/Lipids	0.214	9.12	95.0	0.410	79.5
BRFSFCA06	TS0151	BK-FCA6-001	Black redhorse	Whole body	09/24/13	6020/Lipids	1.70	65.3 J	105	1.20	77.4
BRFSFCA06	TS0152	BK-FCA6-002	Black redhorse	Whole body	09/24/13	6020/Lipids	0.892	62.5 J	102	1.40	74.4
BRFSFCA06	TS0153	BK-FCA6-003	Black redhorse	Whole body	09/24/13	6020/Lipids	1.10	40.1 J	111	4.90	70.9
BRFSFCA06	TS0154	BK-FCA6-004	Black redhorse	Whole body	09/24/13	6020/Lipids	0.978	106 J	121	2.50	74.3
BRFSFCA06	TS0155	BK-FCA6-005	Black redhorse	Whole body	09/24/13	6020/Lipids	0.505	35.6 J	105	1.70	75.7
BRFSFCA06	TS0156	LG-FCA6-001	Longear sunfish	Whole body	09/24/13	6020/Lipids	1.14	44.5 J	136	2.90	73.6
BRFSFCA06	TS0157	LG-FCA6-002	Longear sunfish	Whole body	09/24/13	6020/Lipids	1.20	65.8 J	131	2.30	74.1
BRFSFCA06	TS0158	LG-FCA6-003	Longear sunfish	Whole body	09/24/13	6020/Lipids	1.01	55.1	134	2.80	73.7
BRFSFCA06	TS0159	BG-FCA6-001	Bluegill sunfish	Whole body	09/24/13	6020/Lipids	1.45	51.9	151	2.50	74.8
BRFSFCA06	TS0160	BG-FCA6-002	Bluegill sunfish	Whole body	09/24/13	6020/Lipids	2.48	124	196	2.30	73.7
BRFSFCA06	TS0161	MD-FCA6-001	Missouri saddled darter	Whole body	09/24/13	6020/Lipids	1.14	46.7 J	216	2.90	71.8
BRFSFCA06	TS0162	SH-FCA6-001	Telescope shiner	Whole body	09/24/13	6020/Lipids	1.19	42.6 J	324	3.20	74.5
BRFSFCA06	TS0163	ST-FCA6-001	Stonerollers	Whole body	09/24/13	6020/Lipids	0.968	126 J	178	4.80	73.8
BRFSFCA06	TS0164	SH-FCA6-002	Bleeding shiner	Whole body	09/24/13	6020/Lipids	1.21	59.1 J	359	2.10	75.3
BRFSFCA06	TS0165	GC-FCA6-001	Golden crayfish	Whole body	09/24/13	6020/Lipids	6.32	109	108	1.60	67.8
BRFSFCA06	TS0166	GC-FCA6-002	Golden crayfish	Whole body	09/24/13	6020/Lipids	4.95	104	90.9	1.20	67.1

TABLE 1 cont.
Tissue Analytical Data
Metals by EPA 6020 and Lipids / Percent Moisture
Big River Mine Tailings Site

Location ID	Sample Number	Sample ID	Species	Sample Type	Sample Date	Analytical Method	Cadmium mg/kg	Lead mg/kg	Zinc mg/kg	Lipids mg/kg	Percent Moisture percent
BRFSFCA07	TS0174	GE-FCA7-001	Goggle-eye bass	Fillet	09/25/13	6020/Lipids	0.126	3.11	86.8	0.0900	79.2
BRFSFCA07	TS0175	BG-FCA7-001	Bluegill sunfish	Fillet	09/25/13	6020/Lipids	0.0890	4.82	87.6	0.250	79.7
BRFSFCA07	TS0176	GS-FCA7-001	Green sunfish	Fillet	09/25/13	6020/Lipids	0.171	4.74	68.2	0.280	79.5
BRFSFCA07	TS0177	LG-FCA7-001	Longear sunfish	Fillet	09/25/13	6020/Lipids	0.206	8.09	68.4	0.330	79.3
BRFSFCA07	TS0178	LG-FCA7-002	Longear sunfish	Fillet	09/25/13	6020/Lipids	0.137	6.63	72.1	0.150	78.8
BRFSFCA07	TS0179	NH-FCA7-001	Northern hogsucker	Whole body	09/25/13	6020/Lipids	0.895	44.4	151	3.10	74.2
BRFSFCA07	TS0184	GE-FCA7-001	Goggle-eye bass	Whole body	09/25/13	6020/Lipids	0.875	41.9	112	1.40	73.1
BRFSFCA07	TS0185	BG-FCA7-001	Bluegill sunfish	Whole body	09/25/13	6020/Lipids	1.26	59.5	134	2.80	74.7
BRFSFCA07	TS0186	GS-FCA7-001	Green sunfish	Whole body	09/25/13	6020/Lipids	2.12	83.8	115	2.10	74.8
BRFSFCA07	TS0187	LG-FCA7-001	Longear sunfish	Whole body	09/25/13	6020/Lipids	1.78	76.3	122	3.40	72.9
BRFSFCA07	TS0188	LG-FCA7-002	Longear sunfish	Whole body	09/25/13	6020/Lipids	2.37	82.4	129	3.10	73.5
BRFSFCA07	TS0189	MD-FCA7-001	Missouri saddled darter	Whole body	09/25/13	6020/Lipids	1.21	40.8	213	3.10	72.5
BRFSFCA07	TS0190	SH-FCA7-001	Telescope shiner	Whole body	09/25/13	6020/Lipids	1.01	29.4	296	4.30	73.9
BRFSFCA07	TS0191	ST-FCA7-001	Stonerollers	Whole body	09/25/13	6020/Lipids	0.569	78.3	127	5.10	73.3
BRFSFCA07	TS0192	SH-FCA7-002	Bleeding shiner	Whole body	09/25/13	6020/Lipids	1.06	33.5	291	3.10	75.8
BRFSFCA07	TS0193	GC-FCA7-001	Golden crayfish	Whole body	09/25/13	6020/Lipids	5.43	59.0	83.5	1.70	69.6
BRFSFCA07	TS0194	GC-FCA7-002	Golden crayfish	Whole body	09/25/13	6020/Lipids	5.11	66.1	80.4	1.80	67.1

TABLE 1 cont.
Tissue Analytical Data
Metals by EPA 6020 and Lipids / Percent Moisture
Big River Mine Tailings Site

Location ID	Sample Number	Sample ID	Species	Sample Type	Sample Date	Analytical Method	Cadmium mg/kg	Lead mg/kg	Zinc mg/kg	Lipids mg/kg	Percent Moisture percent
REFBRFSFCA	TS0202	LG-REFFCA-001	Longear sunfish	Fillet	09/16/13	6020/Lipids	0.0140 U	0.148 UJ	**85.0**	**0.300**	**79.7**
REFBRFSFCA	TS0203	GS-REFFCA-002	Green sunfish	Fillet	09/16/13	6020/Lipids	0.00500 U	0.127 UJ	**64.7**	**0.440**	**79.0**
REFBRFSFCA	TS0204	GS-REFFCA-003	Green sunfish	Fillet	09/16/13	6020/Lipids	0.00700 U	0.134 UJ	**72.1**	**0.680**	**79.0**
REFBRFSFCA	TS0205	GS-REFFCA-004	Green sunfish	Fillet	09/16/13	6020/Lipids	0.00900 U	0.116 UJ	**53.8**	**0.500**	**78.6**
REFBRFSFCA	TS0207	GR-REFFCA-001-R	Golden Redhorse	Whole body	09/16/13	6020/Lipids	0.0390 U	0.977 UJ	**117**	**1.80**	**75.3**
REFBRFSFCA	TS0212	LG-REFFCA-001	Longear sunfish	Whole body	09/16/13	6020/Lipids	**0.120**	1.26 UJ	**126**	**2.70**	**74.4**
REFBRFSFCA	TS0213	GS-REFFCA-002	Green sunfish	Whole body	09/16/13	6020/Lipids	0.0380 U	0.516 UJ	**100.0**	**2.70**	**73.7**
REFBRFSFCA	TS0214	GS-REFFCA-003	Green sunfish	Whole body	09/16/13	6020/Lipids	0.0360 U	0.578 UJ	**113**	**2.80**	**74.4**
REFBRFSFCA	TS0215	GS-REFFCA-004	Green sunfish	Whole body	09/16/13	6020/Lipids	0.0470 U	0.638 UJ	**92.1**	**2.90**	**73.1**
REFBRFSFCA	TS0217	DA-REFFCA-001	Mixed darters	Whole body	09/16/13	6020/Lipids	0.0670 U	0.534 UJ	**219**	**3.20**	**72.4**
REFBRFSFCA	TS0218	SH-REFFCA-001	Telescope shiner	Whole body	09/16/13	6020/Lipids	**0.114**	0.429 UJ	**321**	**2.80**	**76.1**
REFBRFSFCA	TS0219	ST-REFFCA-001	Stonerollers	Whole body	09/16/13	6020/Lipids	0.0610 U	1.65 UJ	**150**	**2.20**	**76.2**
REFBRFSFCA	TS0220	SH-REFFCA-002	Bleeding shiner	Whole body	09/16/13	6020/Lipids	**0.0990**	1.42 UJ	**369**	**2.90**	**76.7**
REFBRFSFCA	TS0221	GC-REFFCA-001	Golden crayfish	Whole body	09/16/13	6020/Lipids	**0.481**	3.14 U	**70.3**	**1.30**	**70.4**
REFBRFSFCA	TS0223	GC-REFFCA-002	Golden crayfish	Whole body	09/16/13	6020/Lipids	**0.306**	1.75 U	**60.8**	**0.890**	**69.7**

Notes:
Data reported to method detection limit
BOLD = detection
EPA = United States Environmental Protection Agency
mg/kg = milligrams per kilogram
J = estimated result
U = not detected at or above the stated level
AMEC completed a data quality review and qualifiers added during the review are included in this table.

Table 2. Alternative 2 Cost Estimates

	Description	Quantity	Unit	Unit Cost	Estimated Total
Capital Cost					
1	Baseline Sampling	1	LS	$1,200,000	$1,200,000
2	Sediment Transport Modeling	1	LS	$400,000	$400,000
3	Sampling of Eroding Banks	1	LS	$500,000	$500,000
4	Evaluation of Erosive Floodplain Features	1	LS	$100,000	$100,000
5	Characterization of Flat River Riparian Zone at National Pile	1	LS	$50,000	$50,000
6	Development of Site-Specific WQS	1	LS	$500,000	$500,000
7	Pre-Design Sampling for Targeted Action Locations	7	Each	$100,000	$700,000
8	Bank Stabilization at 1 Location for Total of 1000 feet of Eroding Bank	1000	LF	$700	$700,000
9	Location A: Passive Sediment Trap at Bone Hole				$759,000
10	Location B: Bone Hole Removal				$899,000
11	Location C: Flat River below WWTP				$693,000
12	Location D: Flat River Mouth				$575,000
13	Location E: Beaches in St. Francois State Park				$936,000
14	Location F: Sediment Bar Downstream St. Francois State Park				$738,000
15	Location G: Flat River - Main Street				
16	Construction Project Add-ons	0	LS		
17	Remedial Design & Work Plan	1	LS	$690,000	$690,000
18	**TOTAL CAPITAL COSTS**				**$9,440,000**

Table 2. Alternative 2 Cost Estimates cont.

	Description	Year	Frequency	Total Cost Per Event	Total Cost	Present Value
Present Value Analysis						
19	Baseline Sampling	1	Once	$1,200,000	$1,200,000	$1,121,000
20	Pre-Design Sampling	1	Once	$2,250,000	$2,250,000	$2,103,000
21	Remedial Design & Work Plan	2	Once	$690,000	$690,000	$603,000
22	Remedial Action of Targeted Action Locations	1 – 4	Varies	Varies	$4,600,000	$3,480,000
23	Bank Treatment	3 – 6	Once per year	Varies	$2,800,000	$2,071,000
24	Clean Out of Targeted Action Locations	4 –11	Once per year	$800,000	$6,400,000	$3,644,000
25	Maintenance of Fish Advisory	1 – 12	Once per year	$5,000	$60,000	$40,000
26	Conservation Easement	3 – 6	Once per year	$60,000	$240,000	$178,000
27	Clean Out USACE Sediment Trap	1 – 10	Once per year	$490,000	$5,390,000	$3,674,000
28	Monitoring	3 – 11	Once per year	$300,000	$2,700,000	$1,707,197
29	Evaluation & Reporting	3 – 11	Once per year	$100,000	$900,000	$569,066
30	Prepare Summary Report	12	Once	$200,000	$200,000	$88,802
31	**TOTAL PRESENT VALUE OF ALTERNATIVE**					**$19,279,000**
32	20% Contingency				20%	$3,855,800
33	**TOTAL PRESENT VALUE + CONTINGENCY**					**$23,135,000**

Notes:

1. All cost estimates are based on current understanding of the site as described in the FFS and should be considered preliminary. Cost estimates are conceptual in nature and subject to revision.
2. Unit cost estimates derived by Amec Foster Wheeler are based on sediment remediation projects of similar scale.
3. All costs are rounded where appropriate.
4. All cost estimates include material and labor, unless otherwise noted.
5. Present value calculations were performed using a discount rate of 7%.

Table 3. Alternative 3 Cost Estimates

	Description	Quantity	Unit	Unit Cost	Estimated Total
Capital Cost					
1	Baseline Sampling	1	LS	$1,200,000	$1,200,000
2	Sediment Transport Modeling	1	LS	$400,000	$400,000
3	Sampling of Eroding Banks	1	LS	$500,000	$500,000
4	Evaluation of Erosive Floodplain Features	1	LS	$100,000	$100,000
5	Development of Site-Specific WQS	1	LS	$500,000	$500,000
6	Sampling of Floodplain Soils	3,563	EA	$100	$356,000
7	Sampling of Sediments	567	EA	$100	$57,000
8	Dredging: Sediment Removal	360,000	CY	$62.90	$22,643,000
9	Dredging: Loading, Offsite Transportation and Disposal	573,000	Ton	$46.29	$26,525,000
10	Dredging: Water Treatment	32	Month	$1,300,000	$41,600,000
11	Dredging: Mobilization/Demobilization & Misc. Costs	1	LS	$26,935,500	$26,935,500
12	Excavation of Floodplain Soils Contributing to Big River or Flat River	647,000	CY	$40	$25,880,000
13	Soil Excavation: Transportation and Disposal	1,090,000	Ton	$25	$27,250,000
14	Soil Excavation: Backfill and Grading	647,000	CY	$17	$10,999,000
15	Soil Excavation: Armoring Remaining Soil with Pb > 1,200 mg/kg	100	Acres	$60,000	$6,013,000
16	Revegetation	401	Acres	$5,000	$2,004,000
17	Soil Excavation: Mobilization/Demobilization & Misc. Costs	1	LS	$28,396,500	$28,396,500
18	Construction Project Add-ons	1	LS	$39,628,000	$39,628,000
19	Remedial Design & Work Plan	1	LS	$38,968,000	$38,968,000
20	**TOTAL CAPITAL COSTS**				**$299,956,000**

Table 3. Alternative 3 Cost Estimates cont.

	Description	Year	Frequency	Total Cost Per Event	Total Cost	Present Value
Present Value Analysis						
21	Baseline Sampling	1	Once	$1,200,000	$1,200,000	$1,121,000
22	Pre-Design Sampling	1 – 2	Once per year	$1,913,000	$1,913,000	$1,729,000
23	Remedial Design & Work Plan	2 – 4	Once per year	$38,968,000	$38,968,000	$31,858,000
24	Sediment and Floodplain Soil Remediation	3 – 6	Once per year	$54,561,750	$218,247,000	$161,422,000
25	Project Add-Ons	3 – 6	Once per year	$9,907,000	$39,628,000	$29,310,000
26	Maintenance of Fish Advisory	1 – 7	Once per year	$5,000	$30,000	$24,000
27	Post-Remedy Sampling, Analysis and Reporting	7	Once	$500,000	$500,000	$311,000
28	**TOTAL PRESENT VALUE OF ALTERNATIVE**					**$225,775,000**
29	40% Contingency				40%	$90,310,000
30	**TOTAL PRESENT VALUE + CONTINGENCY**					**$316,085,000**

Notes:

1. All cost estimates are based on current understanding of the site as described in the FFS and should be considered preliminary. Cost estimates are conceptual in nature and subject to revision.
2. Unit cost estimates derived by Amec Foster Wheeler are based on sediment remediation projects of similar scale.
3. All costs are rounded where appropriate.
4. All cost estimates include material and labor, unless otherwise noted.
5. Present value calculations were performed using a discount rate of 7%.

Table 4. Chemical Specific ARARs

Regulatory Authority	Requirement	Status	Description	Applicable to:	
				Soil/ Sediment	Surface Water
Federal	USEPA Risk Reference Doses	To Be Considered	Risk reference doses are estimates of daily exposure levels that are unlikely to cause significant adverse non-carcinogenic health effects over a lifetime.	X	X
Federal	USEPA Carcinogen Assessment Group, Cancer Slope Factors	To Be Considered	Cancer Slope Factors are used to compute the incremental cancer risk from exposure to site contaminants and represent the most up-to-date information on cancer risk from USEPA's Carcinogen Assessment Group.	X	X
State	MO CWA – MDNR RSMo 644.006, 10 CSR 20-7.015	Relevant But Not Appropriate[1]	Established pollutant limits to various waters of the state.		X
State	MO CWA –MDNR RSMo 644.041, 10 CSR 20-7.015(9)	Applicable	Allows for the establishment of site-specific effluent limits		X
State	Missouri CWA – MDNR RSMo 644.006, 10 CSR 20-7.031(2)(3)(4)(5); Tables(A)(B)	Relevant But Not Appropriate[2]	Establishes criteria to protect uses of the waters of the state and defines anti degradation policy.		X
State	MO CWA –MDNR RSMo 644.041, 10 CSR 20-7-031(5)(S)	Applicable	Allows for the establishment of site-specific criteria		X
State	Human Health Risk Assessment (HHRA) Big River SFCMA	To Be Considered	Evaluates baseline health risk due to current site exposures and established contaminant levels in environmental media at the site for the protection of public health. A risk assessment approach using site data should be considered in determining cleanup levels because chemical specific ARARs are not available for constituents associated with mine wastes. Doe Run prepared a HHRA for Big River SFCMA utilizing additional recent surface water, pore water and sediment analytical and bioassay (fish and crayfish) data collected from field studies conducted during the summer and fall of 2013. This more recent HHRA has served as the basis for the evaluation of PECs and IRAOs within the FS.	X	X

Table 4. Chemical Specific ARARs

Regulatory Authority	Requirement	Status	Description	Applicable to:	
				Soil/ Sediment	Surface Water
State	Baseline Ecological Risk Assessment (BERA) for Big River SFCMA	To Be Considered	Evaluates baseline ecological risk due to current site exposures and established contaminant levels in environmental media at the site for the protection of aquatic and terrestrial biological communities and ecosystems. A risk assessment approach using site data should be considered in determining cleanup levels because chemical specific ARARs are not available for constituents associated with mine wastes. Doe Run prepared a BERA for Big River SFCMA utilizing additional recent surface water, pore water and sediment analytical and bioassay (fish and crayfish) data collected from field studies conducted during the summer and fall of 2013. This more recent BERA has served as the basis for the evaluation of PECs and IRAOs within the FS.	X	X
State	Probable Effects Concentrations	To Be Considered	Probable effects concentrations are screening level concentrations of metals in fresh water sediments above which adverse effects may be expected to occur. PECs identified by MacDonald *et. al. (*2009) include 4.98 mg/kg for Cd; 128 mg/kg for Pb; and 459 mg/kg for Zn. However, these PECs are strictly TBCs, as they are extremely conservative and there are no applicable or relevant and appropriate criteria for sediments *(from Annapolis Lead Mine Superfund Site ARARs).*	X	

[1] Background conditions make meeting this standard technically impracticable.

[2] Background conditions make meeting this standard technically impracticable.

Table 5. Location-Specific ARARs

Regulatory Authority	Requirement	Status	Description	Applicable to: Soil/ Sediment	Applicable to: Surface Water
Federal	Clean Water Act, Section 404 permits, Dredge or Fill Substantive Requirements, 33 USC 1251-1376, 40 CFR Parts 230-231	Applicable	Five conditions must be met before dredging and/or filling is allowed: 1. There must not be a practical alternative 2. No discharge of dredged or fill material may cause a violation of state WQSs, jeopardized T&E species, injure a marine sanctuary, or violate applicable toxic effluent standards. 3. Appropriate steps must be taken to minimize adverse effects. 4. Determine long-and short-term effects on chemical, physical, and biological components of the aquatic ecosystem. 5. No Discharge shall be permitted that will cause or contribute to significant degradation of the water.	X	X
Federal	16 USC 662(a)	Applicable	Whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose whatever, including navigation and drainage, by any department or agency of the US, or by any public or private agency under Federal permit or license, such department or agency first shall consult with the USFWS, DOI, and with the head of the agency exercising administration over the wildlife resources of the particular State wherein the impoundment, diversion, or other control facility is to be constructed, with a view to the conservation of wildlife resources by preventing loss of and damage to such resources as well as providing for the development and improvement thereof in connection with such water-resource development.	X	X
Federal	Endangered Species Act of 1973, 16 USC 1531-1599, 50 CFR Part 17 and 40 CFR 6.302, and Federal Migratory Bird Act 16 USC 703-712	Applicable	Determination of the presence of endangered and/or threatened species. Consideration given to potential effects of summer roost habitat impacts (Indiana bat, northern long-eared bat) or migratory birds from construction activities associated with riparian zone tree clearing activities.[1]	X	X
Federal	Floodplain Management Executive Order 11988, 40 CFR Part 6, Appendix A	Relevant and Appropriate	Requires federal agencies to evaluate the potential adverse effects associated with direct and indirect development of a floodplain. Alternatives that involve modification/construction within a floodplain may not be selected unless a determination is made that no practicable alternative exists. If no practicable alternative exists,	X	

[1] Note, ESA considered but not applicable to federally listed aquatic species that may occur in lower reaches of Big River as they do not occur on or near the Site

Table 5. Location-Specific ARARs

Regulatory Authority	Requirement	Status	Description	Applicable to: Soil/ Sediment	Surface Water
			potential harm must be minimized and action taken to restore and preserve the natural and beneficial values of the floodplain.		
Federal	Fish and Wildlife Conservation Act, 16 USC 2901-2912	Relevant and Appropriate	Requires federal agencies to utilize their statutory and administrative authority to conserve and promote conservation of non-game fish and wildlife species.	X	X
Federal	Protection of Wetlands Executive Order 11990, 40 CFR Part 6, Appendix A	Relevant and Appropriate	Requires federal agencies to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands. If remediation is required within wetland areas and no practical alternative exists, potential harm must be minimized, and action taken to restore natural and beneficial values.	X	X
Federal	National Historic Preservation Act, 16 USC 470, 40 CFR 6.301(c), 40 CFR Part 800	Relevant and Appropriate	Establishes procedures to provide for preservation of historical and archaeological data which may be destroyed through alteration of terrain as a result of a federal construction project for a federal licensed activity or program. Historic or archaeological value is currently unknown.	X	
Federal	Fish and Wildlife Coordination Act, 16 USC661-667, 40 CFR 6.302	Applicable	Requires consultation when a federal agency proposes or authorizes any modification of any water body, and must provide adequate provision for protection of fish and wildlife resources.	X	X
State	Department of Conservation, Endangered Species, 3 CSR 10-4:111	Applicable	Determination of the presence or absence of endangered or threatened species, and provides for regulation of non-game wildlife. Places restrictions on actions affecting protected species.	X	X

Table 6. Action-Specific ARARs

Action	Requirements	Status	Description	Applicable to:	
				Soil/ Sediment	Surface Water
Offsite Land Disposal	RCRA, Subtitle C, 40 CFR Parts 260-268 RCRA, Subtitle D, 40 CFR Parts 257-258 USDOT Requirements for the Transport of Hazardous Materials, 40 CFR 172	Applicable	Soil that is excavated for offsite disposal and constitutes a hazardous waste must be managed in accordance with the requirements of RCRA. 40 CFR 258, Criteria for Municipal Solid Waste Landfills, establishes requirements for the operation of landfills accepting non-hazardous solid waste. These requirements would be applicable to facilities used for the disposal of non-hazardous soil and/or sediment. Transportation of hazardous materials on public roadways must comply with the requirements of 49 CFR 172.	X	
Onsite Staging of Remedial Waste	40 CFR 264.554	Relevant and Appropriate	Regulates storage of remediation waste in a staging pile including; design, duration, performance criteria, and closure.	X	
Remedial Activities	Rivers and Harbors Act, Section 10, 33 CFR Parts 320-323	Relevant and Appropriate	Activities that could impede navigation and commerce are prohibited. Prohibits authorized obstruction or alteration of any navigable waterway.	X	
Impounded, Diverted, Controlled, or Modified Stream Drainage	Fish and Wildlife Coordination Act, 16 USC 662(a)	Relevant and Appropriate	Whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose whatever, including navigation and drainage, by any department or agency of the US, or by any public or private agency under federal permit or license, such department or agency first shall consult with the USFWS, DOI, and with the head of the agency exercising administration over the wildlife resources of the particular State wherein the impoundment, diversion, or other control facility is to be constructed, with a view to the conservation of wildlife resources by preventing loss of and damage to such resources as well as providing for the development and improvement thereof in connection with such water-resource development.	X	X
Discharge to Surface Water	Clean Water Act, 33 CFR 1342, 40 CFR Part 125	Relevant and Appropriate	Regulates discharges of pollutants to surface water. Implementation has been delegated to the State of Missouri. USEPA Publishes national recommended Ambient Water Quality Criteria (AWQC) for the protection of aquatic life and	X	X

Table 6. Action-Specific ARARs

Action	Requirements	Status	Description	Applicable to:	
				Soil/ Sediment	Surface Water
			human health. A revised AWQC was developed by the USEPA for discharging treated water to the waterway following dewatering of sediment.		
Dredging or Filling	Clean Water Act, 33 USC 1344, Section 404 permits, Dredge or Fill Substantive Requirements, 40 CFR Parts 230-231	Relevant and Appropriate	Five conditions must be meet before dredging and/or filling is allowed: 1. There must not be a practical alternative. 2. No discharge of dredged or fill material may cause a violation of state WQSs, jeopardized threatened or endangered species, injure a marine sanctuary, or violate applicable toxic effluent standards. 3. Appropriate steps must be taken to minimize adverse effects. 4. Determine long-and short-term effects on chemical, physical, and biological components of the aquatic ecosystem. 5. No discharge shall be permitted that will cause or contribute to significant degradation of the water.	X	X
Remedial Activities	Clean Water Act, 33 USC 1342, 40 CFR 122, Discharge of Storm water	Relevant and Appropriate	Regulates point and non-point storm water discharge associated with construction activities: includes requirements for BMPs and for pollution prevention plans.	X	
Transportation and Handling of Contaminated Sediments	U.S. Army Corps of Engineers Directive ERDC\EL TR-08-29	To Be Considered	Dredged or filled wastes generated in the remedial process for disposal off site as defined by the USACE Directive	X	
Transportation and Handling of Contaminated Sediments	EPA-540-R-05-012, OSWER 9355.0-85	To Be Considered	Guidance designed to assist USEPA staff managing sediment sites by providing a thorough overview of methods that can be used to reduce risk caused by contaminated sediment.	X	
Management of Hazardous Soil/Sediment	Missouri Hazardous Waste Management Regulation, 10 CSR 25-4.261	Applicable	Defines solid waste subject to regulations as hazardous waste under 10 CSR 25.	X	
Transportation of Waste	Missouri Solid Waste, Regulation 10 CSR 25-6.263	Applicable	Rules regarding Transportation of Hazardous Substances.	X	

Table 6. Action-Specific ARARs

Action	Requirements	Status	Description	Applicable to:	
				Soil/ Sediment	Surface Water
Discharge to Surface Water - TMDL Requirements	Missouri Clean Water Act – RSMo 644.006, 10 CSR 20-7.031 (4)(B)1, Tables (A) and (B)	Relevant and Appropriate	Established pollutant limits to various waters of the state. Establishes effluent standards that protect waters of the state. Designates beneficial uses for waters of the state and takes steps to determine if uses are attainable and what the TMDLs should be to protect the designated uses. TMDL established for Big River, Flat River Creek and Shaw Branch specifies targets to protect aquatic life from chronic exposure to dissolved concentrations of lead and zinc.	X	X
Remedial Activities	Missouri Air Regulation, 10 CSR 10-6.170	Relevant and Appropriate	Missouri air pollution regulations require persons that emit fugitive particulates to minimize emissions through use of all reasonable precautions. In addition, no visible fugitive dust transport is allowed beyond the lot line of the property where the emissions originate.	X	
Management of Storm Water	Missouri Water Regulation, 10 CSR 20-6.200	Applicable	These regulations define BMPs for land disturbances, including practices or procedures that would reduce the amount of metals in soils and sediments available for transport to waters of the state. Permits would not be required for actions taken under CERCLA, but the substantive provisions of these regulations would be applicable.		X

APPENDIX C

PRELIMINARY REMEDIAL GOALS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
11201 Renner Boulevard
Lenexa, Kansas 66219

JUN 21 2018

MEMORANDUM

SUBJECT: Proposed Preliminary Remediation Goals, Big River Mine Tailings Superfund Site, Operable Unit 2

FROM: Jason Gunter, Remedial Project Manager
Lead Mining and Special Emphasis Branch

TO: Gene Gunn, Chief
Lead Mining and Special Emphasis Branch

The EPA Region 7 Environmental Services and Technology Division was asked by the EPA Region 7 Superfund Division to calculate Preliminary Remediation Goals (PRGs) for instream and stream bank sediments for the Big River Mine Tailings Superfund Site (Site). Separate PRGs were developed for aquatic and terrestrial organisms.

Instream Sediment PRG

The instream/aquatic PRG for lead was calculated using the information provided in the memorandum titled "Recommended Lead Clean-Up Levels for Sediment" which is included in Attachment 1. The recommended PRG for lead in sediment is based on the survival of *Hyallela azteca*, an amphipod, in sediment. *Hyallela azteca* is a benthic macroinvertebrate that is commonly used to measure toxicity at sites with contaminated sediment. Sediment cleanup goals are commonly based on protection of benthic macroinvertebrates, as they are sensitive receptors that are directly exposed to sediment. Moreover, any cleanup goal that is selected should also be protective of threatened and endangered freshwater mussels in the Big River watershed. The cleanup goal based on the survival of macroinvertebrates is likely to be the most protective aquatic value for Big River.

The recommended PRG for lead in stream sediment based on the survival of benthic macroinvertebrates in sediment is 581 parts per million (ppm). This is based on a survival rate of 85% for *Hyallela azteca*. This PRG is based on the most recent and complete dataset available for the upper Big River watershed. This PRG is considered the final cleanup goal for the aquatic community in Big River.

Stream Bank Sediment/Soil (Non-Residential) PRG

The cleanup levels for non-residential floodplain soil are based on multiple receptors and more than one line of evidence. These soil cleanup levels are calculated based on potential effects to sensitive receptors with the greatest exposure to soil. Therefore, they should be protective of most native terrestrial plant and animal species. The wildlife cleanup levels proposed herein were developed using site-specific data collected as part of the Feasibility Study field investigations. For more information please see the memorandum titled "Recommended Cleanup Levels for Soil", which is included in Attachment 2. The recommended PRG for lead in floodplain soil is 730 ppm. This PRG is protective of avian and mammalian receptors and is considered the final cleanup goal for floodplain soil at the Site.

The PRGs described above represent the numeric cleanup values for lead contaminated Big River floodplain and instream sediments in non-residential settings within the Big River Superfund Site. If you have any questions, you can contact Jason Gunter at (913) 551-7358 or by email at gunter.jason@epa.gov.

Attachments

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
11201 Renner Boulevard
Lenexa, Kansas 66219

MAR 0 8 2018

MEMORANDUM

SUBJECT: Recommended Lead Cleanup Levels for Sediment
Big River Sediment (Operable Unit 2)
St. Francois County Mine Site

FROM: Venessa Madden, Ecological Risk Assessor
Environmental Data and Assessment Branch
Environmental Sciences and Technology Division

TO: Jason Gunter, Project Manager
Lead Mining and Special Emphasis Branch
Superfund Division

This memo provides recommended sediment cleanup levels for lead in the Big River based on data collected during field investigations in support of the feasibility study for OU2 of the St. Francois County Mine Site. The suite of data for the feasibility study includes sediment, pore water, fish and crayfish tissue concentrations, as well as a 42-day *Hyallela azteca* toxicity test (Integral, 2013). The 42-day toxicity test provides the information needed to develop a cleanup level for the protection of benthic invertebrate communities exposed to lead present in sediment. Sediment cleanup levels are commonly based on protection of benthic macroinvertebrates, as they are sensitive receptors that are directly exposed to sediment. Moreover, any cleanup level that is selected should also be protective of threatened and endangered freshwater mussels in the Big River watershed. The macroinvertebrate cleanup level is likely to be the most protective aquatic value.

Calculated Cleanup Level for the Protection of the Macroinvertebrate Community

Macroinvertebrate communities are directly exposed to sediment and sediment pore water. To evaluate impacts to the macroinvertebrate community, the following data were collected at a total of 20 sites on the Big River (Integral, 2013):

- Total metals (barium, cadmium, lead in zinc) in field sieved sediment;
- Total solids;
- Grainsize;
- Acid Volatile Sulfide/Simultaneously Extracted Metals (AVS/SEM);
- 42-*Hyallela Azteca* toxicity test;

- Dissolved metals in pore water collected using mini-peepers;
- Alkalinity, chloride, sulfate, pH, DOC, ammonia, and hardness in pore water.

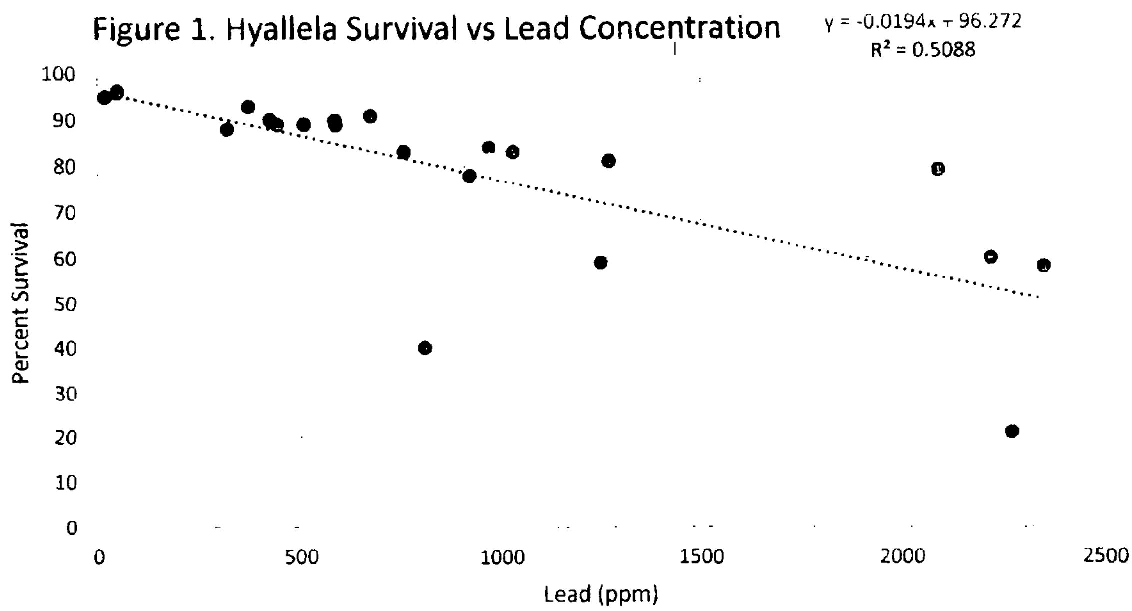
Metal toxicity is thought to represent cumulative toxicity of multiple metals with similar modes of toxic action. Therefore, metal toxicity hazards were first estimated using three hazard indices based on metal mixtures in sediments and pore waters. First, Probable Effect Concentration Quotients (PECQs) for individual metals were calculated by dividing total recoverable metal concentrations by PECs (MacDonald, Ingersoll, and Berger, 2000). Hazards for metal mixtures were estimated by summing these quotients (ΣPECQ) for cadmium, lead and zinc. The ΣPECQs greater than 1.5 (equivalent to a mean-PECQ of 0.5 for the 3 metals analyzed) were used to represent a presumptive toxicity threshold for the metal mixture.

Another hazard index for metal mixtures in sediment that can be calculated based on the available data is the Equilibrium Sediment Benchmark (ESB) index. The ESB index is calculated as the difference between the molar sum of SEM concentrations for cadmium, copper, lead, nickel and zinc, and the molar concentration of AVS, divided by the total organic carbon fraction of sediment ([PSEM–AVS]/foc). No metal toxicity in sediment is predicted if the ESB index is less than 130 mmol/g organic carbon; uncertain toxicity is predicted for index values between 130 mmol/g and 3000 mmol/g organic carbon; and toxicity is predicted for values greater than 3000 mmol/g organic carbon (USEPA, 2005). The third hazard index was based on pore water toxic units, which were calculated by dividing metal concentrations in sediment pore waters (peeper samples) by hardness-based chronic water quality criteria. Toxic units for the 3 metals were summed to produce a hazard index, with samples having less than 1.0 toxic units predicted to be nontoxic.

The ΣPECQ accurately predicted toxicity at all but two locations. The ESB index accurately predicted toxicity at all but four locations. Finally, the ΣPWTU accurately predicted toxicity at all but two sites. At sites where hazard indices did not correctly predict toxicity, factors that may impact toxicity other than metals were investigated. The first site where toxicity appeared to be evident, but where very low metal concentrations were found, was REFSSD01 (Irondale). At this location, ammonia nitrogen in pore water was elevated in comparison to other sites (5.85 mg/L). This level is roughly three times the chronic water quality criteria for ammonia (USEPA, 2013). Because of the potential toxicity of ammonia in pore water at this reference site, this site was not used to establish a reference envelope for toxicity. Another site where ammonia seems to play a role in toxicity is at BRFSSD01 (Leadwood). Although the metal concentrations are high, the ESB index predicts no toxicity due to the high levels of AVS. However, toxicity is evident compared to the reference sites. Again, it was found that ammonia concentrations at Leadwood exceed chronic criteria (7.6 mg/L).

When evaluating metal toxicity in sediment, Irondale and Leadwood were not used due to the potential effects of ammonia on the toxicity test results. In addition to the sites in which toxicity was not accurately predicted due to ammonia in pore water, we noticed a substantial relative percent difference in the duplicate sample for survival (at Location 17). In this instance, the more robust survival found in the duplicate was used for the dataset because it better matched the survival in neighboring downstream locations.

Therefore, based on the data described above, the effects of lead on the survival of *Hyallela azteca* at 42 days was evaluated using simple linear regression (Figure 1).



Using the regression equation in the figure above, ninety percent survival is predicted at a lead concentration of 325 ppm. Ninety percent was selected as a target endpoint as this is the survival in the controls of the test after 42 days. Eighty-five percent survival is predicted at a concentration of 581 ppm, while eighty percent survival is predicted at a concentration of 840 ppm.

The recommended cleanup level for lead in sediment in the Big River based on protection of the macroinvertebrate community is 325 mg/kg.

Additional Toxicity Data for the Big River

The U.S. Environmental Protection Agency Baseline Ecological Risk Assessment (USEPA, 2006)
A 42-day toxicity test for *Hyallela azteca* was also included in the EPA Baseline Risk Assessment (USEPA, 2006). Several issues were identified for this dataset, including contamination in the reference location and low survival in the control (although survival met acceptability criteria). A total of 9 locations were evaluated in the toxicity test, 6 of which were in the Big River. Of those locations, the PECQ predicted toxicity at 5 locations. Pore water data was only available for 3 locations, with the ΣPWTU predicting toxicity at all 3 locations. The ESB index could not be calculated based on the data available, but SEM/AVS ratios were available at 2 locations. The PECQ and ΣPWTU accurately predicted no toxicity at BR32. Toxicity was predicted at BR25, as noted by significant reductions in survival, growth and reproduction. Finally, toxicity was predicted at BR26, BR10 and BKG11, as noted by significant effects on growth. Given the limited size of the dataset, a regression model was not fitted to the data. However, significant effects on growth were found at BR04 and BKG11, where lead concentrations in sediment ranged from 339 mg/kg to 432 mg/kg. Significant effects on survival, growth and reproduction were found at BR25, where the lead concentration in sediment was 710 mg/kg. This data can be used to provide a range of cleanup levels between 339 and 710 mg/kg.
Table 1. Results from 42-day Toxicity Test

Location	SEM/AVS	PECQ	ΣPWTU	Growth (mg/org)	Reproduction (#offspring)	Percent Survival (42 days)	Lead (mg/kg)
BR32	NA	0.6	NA	0.79	15.8	88	40.3
BR04	NA	3.4 (4.2)	1.8	0.54*	9.3	94	339
BR25	NA	11.3 (30.6)	114.5	0.56*	3.7*	39*	710
BR26	0.641	13.9 (7.4)	1.2	0.49*	5.1	66	819
BR10	NA	1.8	NA	0.59*	6.2	77	2000
BKG11	0.154	4.4	NA	0.72*	10.9	91	432
Control				0.92	10.7	79	

Values in parentheses are for the sieved fraction.
*Statistically significant from control.

USGS Natural Resource Damage Assessment Report (Besser, Brumbaugh, Hardesty, and Ingersoll, 2009)

This study conducted a 28-day toxicity test using amphipods (*Hyallela azteca*) and juvenile mussels (*Lampsilis siliquoidea).* No significant toxicity was found for amphipods in the upper reaches of the Big River in St. Francois county, even at sediment lead concentrations as high as 1500 mg/kg. However, at this location, the 42-day toxicity test done as part of the feasibility study found 90 percent survival at 28 days, 86 percent survival at 35 days and 78 percent survival at 42 days. These results highlight the importance of chronic exposure. As the NRDA study was a 28-day toxicity test, this amphipod toxicity data should not be combined with results from a 42-day test (as was done in the Interim Record of Decision).

References

AMEC. (2014). *Data Report for Tasks 2,9,10 and 11 Investigations. Rver and Non-residential Areas (OU2). St. Francois County Mining Area, Missouri.* Ballwin, MO.

Besser, J. M., Brumbaugh, D. K., Hardesty, J. P., and Ingersoll, C. G. (2009). *Assessment of metal-contaminated sediments from Southeast Missouri (SEMO) mining district using sediment toxicity tests with amphipods and freshwater mussels. USGS, Columbia Environmental Research Center, Columbia, Missouri. Administrative Report 08-NRDAR.*

Integral. (2013). *Field Sampling Plan; River and Non-Residential Areas (OU2), St. Francois County Mining Area.* Seattle .

MacDonald, D. D., Ingersoll, C. G., and Berger, T. A. (2000). Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Arch. Environ. Contam. Toxicol.*, 39:20-31.

USEPA. (1999). *Data Collection for the Hazardous Waste Identification Rule.* Washington DC: Office of Solid Waste.

USEPA. (2005). *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmaks (ESBs) for Protection of Benthic Organisms: Metal Mixtures (Cadmium, Copper, Lead, Nickel, and Zinc).* Washington DC: EPA-600-Q2-011.

USEPA. (2006). *Ecological Risk Assessment, Big River Mine Tailings Site, St. Francois County, Missouri. U.S. Environmental Protection Agency, Kansas City, KS.*

USEPA. (2013). *Aquatic Life Ambient Water Quality Criteria for Ammonia.* Washington DC: Office of Water 4304T.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
11201 Renner Boulevard
Lenexa, Kansas 66219

MAR 0 8 2018

MEMORANDUM

SUBJECT: Recommended Cleanup Levels for Soil
St. Francois County Mine Site (OU2)

FROM: Venessa Madden, Ecological Risk Assessor
Environmental Data and Assessment Branch
Environmental Sciences and Technology Division

Venessa Madden

TO: Jason Gunter, Project Manager
Lead Mining and Special Emphasis Branch
Superfund Division

Per your request, we have developed ecological cleanup levels for cadmium, lead and zinc for OU2 soil for the St. Francois County Mine Site. These soil cleanup levels are calculated based on potential effects to sensitive receptors with the greatest exposure to soil. Therefore, they should be protective of the majority of native terrestrial plant and animal species. The wildlife cleanup levels proposed herein were developed using site-specific data collected as part of the Feasibility Study field investigations (Integral, 2013), and the assumptions cited in Appendix E of the revised Feasibility Study (Amec, 2015). The cleanup levels for terrestrial plant species are based on the effects of lead and zinc on native floristic quality (Struckhoff, Stroh, and Grabner, 2013).

The cleanup levels recommended here are based on multiple receptors and more than one line of evidence. Consequently, a range of values is provided. This allows the risk manager to see results based on various inputs and assumptions, and to therefore make a well-informed risk management decision regarding final cleanup levels for the site.

Derivation of Soil Cleanup Levels For Wildlife

The terrestrial exposure pathway that frequently drives ecological risk assessments at mining sites is the intake of soil by ground-feeding insectivores, also known as vermivores. Vermivores are sensitive species for two reasons. First, there is a relatively higher percentage of soil (hence metals) in their diets. Second, the soil invertebrates they consume have a relatively higher metal concentration in their tissue. Cleanup levels that are protective for vermivores should also be protective of other less sensitive guilds of terrestrial wildlife.

American Woodcock and American Robin

The first set of soil cleanup levels is based on exposure to avian species that forage for soil invertebrates, the American Woodcock and American Robin. Woodcocks were selected as a receptor due to their higher dietary exposure to soil. Robins are also exposed to contaminated soil via the diet, albeit not as highly as the woodcock. However, they are a more common year-around resident in southeast Missouri. Woodcocks tend to be fairly specialized in their foraging habits, with earthworms composing upwards of 80-90% of the typical diet (Sperry, 1940). The remainder of the diet is composed of other soil invertebrates (such as beetle larvae) and some plant material. Robins consume a varied diet of soil invertebrates and plant material, which varies by season (Wheelwright, 1986).

The dose to each avian receptor was modeled based on site-specific data; however, metal concentrations in vegetation are based on regression equations presented in the Eco-SSLs (USEPA, 2005a, 2005b, 2007) (Table 5). Concentrations in earthworms were calculated using the same approach as that used in the revised FS; however, the complete floodplain dataset was used (Table 5). Toxicity Reference Values for birds are the same as that used in the revised FS. The Area Use Factor for woodcocks is based on a residence time of 9 months a year (0.67); whereas the AUF for robins is based on a residence time of 12 months (1.0). Specific exposure factors and TRVs can be found in Table 4.

Short-Tailed Shrew

The second set of soil cleanup levels is based on exposure to a mammalian species, the short-tailed shrew. For the purposes of setting these cleanup levels, the diet is assumed to be the same as that used in the revised FS. Concentrations in vegetation are based on regression equations presented in the Eco-SSLs (USEPA, 2005a, 2005b, 2007) (Table 5). Concentrations in earthworms were calculated using the same approach as that used in the revised FS; however, the complete floodplain dataset was used (Table 5). TRVs for mammals are the same as that used in the revised FS. The AUF is set at 1 because shrews are not migratory and their home ranges are small, fitting easily within the area of the site. Specific-exposure factors and TRVs can be found in Table 4.

Dose equations can be found in Tables 1 through 3. It is important to note that the cleanup levels for lead were adjusted based on site-specific bioavailability. A bioavailability adjustment factor of 63% was used based on data from the Big River floodplain (Beyer, *et al.*, 2016) . Site-specific bioavailability information is not available for cadmium or zinc. Consequently, the cleanup levels are based on 100% bioavailability.

DERIVATION OF SOIL CLEANUP LEVELS FOR PLANTS

The floristic quality of vegetation growing in a variety of lead mining contaminated sites was assessed by USGS (Struckhoff, Stroh, and Grabner, 2013). Using regression techniques, concentrations of lead and zinc at which one would expect to see 10 percent reductions in floristic quality can be predicted. A ten percent reduction in floristic quality can be expected at lead concentrations of 663 mg/kg and zinc concentrations of 311 mg/kg.

PROPOSED SOIL CLEANUP LEVELS

Cadmium
Cleanup levels for cadmium range from 5.5 mg/kg for the Short-tailed Shrew, 9.6 mg/kg for the American Woodcock, and 32 mg/kg for the American Robin (Tables 1 through 3).

Lead
Cleanup levels for lead range from 3200 mg/kg for the Short-tailed Shrew, 730 mg/kg for the American Woodcock, and 1400 mg/kg for the American Robin (Tables 1 through 3). For plants, the value in which a 10% decline in floristic quality is predicted is 663 mg/kg.

Zinc

Cleanup levels for zinc range from 1660 mg/kg for the Short-tailed Shrew, 590 mg/kg for the American Woodcock, and 1900 mg/kg for the American Robin (Tables 1 through 3). For plants, the value in which a 10% decline in floristic quality is predicted is 311 mg/kg.

Table 1. Calculated Cleanup Levels for Cadmium based on Average Daily Dose.

	FIR(avg) (mg/kgDW/day)	FD_{ew}	C_{ew} (mg/kg)	FD_{veg}	C_{veg} (mg/kg)	FD_{soil}	C_{soil} (mg/kg)	C_{INsoil}	ADD (mg/kgBW/day)	TRV (mg/kgBW/day)	HQ
Shrew	0.13	0.76	100.32	0.11	0.69	0.13	5.50	1.70	10.01	10.00	1.00
Woodcock	0.14	0.84	175.10	0.10	0.94	0.06	9.60	2.26	20.99	21.10	0.99
Robin	0.08	0.45	583.68	0.50	1.79	0.05	32.00	3.40	21.20	21.10	1.00

Table 2. Calculated Cleanup Levels for Lead based on Average Daily Dose.

	FIR(avg) (mg/kgDW/day)	FD_{ew}	C_{ew} (mg/kg)	FD_{veg}	C_{veg} (mg/kg)	FD_{soil}	C_{soil} (mg/kg)	C_{INsoil}	ADD (mg/kgBW/day)	TRV (mg/kgBW/day)	HQ
Shrew	0.13	0.76	736.00	0.11	24.53	0.13	3200.00	8.07	80.10	80.00	1.00
Woodcock	0.14	0.84	167.90	0.10	10.70	0.06	730.00	6.59	11.32	11.30	1.00
Robin	0.08	0.45	322	0.50	15.4	0.05	1400.00	7.24	11.22	11.30	1.00

Table 3. Calculated Cleanup Levels for Zinc based on Average Daily Dose.

	FIR(avg) (mg/kgDW/day)	FD_{ew}	C_{ew} (mg/kg)	FD_{veg}	C_{veg} (mg/kg)	FD_{soil}	C_{soil} (mg/kg)	C_{INsoil}	ADD (mg/kgBW/day)	TRV (mg/kgBW/day)	HQ
Shrew	0.13	0.76	2954.80	0.11	16.97	0.13	1660.00	7.41	320.23	320.00	1.00
Woodcock	0.14	0.84	1050.20	0.10	9.50	0.06	590.00	6.38	130.76	131.00	1.00
Robin	0.08	0.45	3382.00	0.50	18.31	0.05	1900.00	7.50	130.08	131.00	1.00

Table 4. Wildlife Exposure Factors (all values are based on the values cited in the revised FS, unless otherwise noted).

Receptor	Shrew	Woodcock	Robin
Normalized Food Ingestion Rate (mg/kgBW/day)	0.13	0.14[2]	0.08[1]
Soil Ingestion (percentage diet)	0.13	0.064[2]	0.05[3]
Earthworm (percentage diet)	0.76	0.84[4]	0.45[5]
Plant (percent diet)	0.11	0.10[4]	0.50[5]
Area Use Factor	1.0	0.67	1.0
TRV – Cadmium (mg/kgBW/day)	10	21.1	21.1
TRV – Lead (mg/kgBW/day)	80	11.3	11.3
TRV – Zinc (mg/kgBW/day)	320	131	131

1 – NIR estimated using allometric equation (Nagy, 1987) and an average body weight of 81 g (USEPA, 1993).
2 – 50th percentile of values reported in Tables 1 and Table 3 of Eco-SSL Attachment 4-1 (USEPA, 2003).
3 – Soil Ingestion based on reported values (Beyer, Conner, and Gerould, 1994), and adjusted based on the percentage of soil invertebrates in diet.
4 – Values reported for North America (Sperry, 1940).
5 – Values reported for Central US (Wheelwright, 1986).

Table 5. Modeled concentrations in earthworms and plants.

Cadmium (mg/kg)	Equation
$C_{(earthworm)}$	$18.24*(Csoil)$
$C_{(plant)}$	$0.546*\ln(Csoil) - 0.475$
Lead (mg/kg)	Equation
$C_{(earthworm)}$	$0.23*(Csoil)$
$C_{(plant)}$	$0.561*\ln(Csoil) - 1.328$
Zinc (mg/kg)	Equation
$C_{(earthworm)}$	$1.78*(Csoil)$
$C_{(plant)}$	$0.554*\ln(Csoil) - 1.575$

References

Amec. (2015). *Feasibility Study, St. Francois County Mine Site (OU2).*

Beyer, W. N., Basta, N. T., Chaney, R. L., Henry, P. F., Mosby , D. E., Rattner, B. A., Weber, J. S. (2016). Bioaccessibility tests accurately estimate bioavailability of lead to quail. *Environ Toxicol Chem*, 35: 2311–2319.

Beyer, W. N., Conner, E., & Gerould, S. (1994). Estimates of Soil Ingestion by Wildlife. *J. Wildl. Manag.*, 58:375-382.

Integral. (2013). *Field Sampling Plan; River and Non-Residential Areas (OU2), St. Francois County Mining Area.* Seattle WA.

Nagy, K. A. (1987). Field Metabolic Rate and Food Requirement Scaling in Mammals and Birds. *Ecol. Monographs*, 57:111-128.

Sperry, C. (1940). Food Habits of a Group of Shore Birds; Woodcock, Snipe, Knot, and Dowitcher. *Wildl. Res. Bull. 1*, 37 pp.

Struckhoff, M. A., Stroh, E. D., & Grabner, K. W. (2013). Effects of Mining-Associated Lead and Zinc Soil Contamination on Native Floristic Quality. *Journal of Environmental Management*, 20-28.

USEPA. (1993). *Wildlife Exposure Factors Handbook.* Office of Research and Development. EPA/600/R-93/187a.

USEPA. (2003). *Ecological Screening Levels.* Chicago, IL: USEPA Region 5.

USEPA. (2005). *Ecological Soil Screening Levels for Cadmium. Interim Final. OSWER Directive 9285.7-65.* Washington, DC: USEPA Office of Solid Waste and Emergency Response.

USEPA. (2005). *Ecological Soil Screening Levels for Lead. Interim Final. OSWER Directive 9285.7-70.* Washington, DC: USEPA Office of Soild Waste and Emergency Response.

USEPA. (2005). *Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). Attachment 4-1 - Exposure Factors and Bioaccumulation Models for Derivation of Wildlife Eco-SSLs. Oswer Directive 9285.7-55.* Washington, DC: USEPA Office of Sold Waste and Emergency Response.

USEPA. (2007). *Ecological Soil Screening Levels for Zinc, Interim Final. OSWER Directive 9285.7-73.* Washington, DC: USEPA Office of Solid Waste and Emergency Response.

Wheelwright, N. T. (1986). The Diet of American Robins: an Analysis of U. S. Biological Survey Records. *Auk*, 103: 710-725.

APPENDIX D

GLOSSARY OF TERMS

APPENDIX D: GLOSSARY OF TERMS

This glossary defines many of the technical terms used in relation to the Big River Mine Tailings Site in this proposed plan. The terms and abbreviations contained in this glossary are often defined in the context of hazardous waste management and apply specifically to work performed under the Superfund program. Therefore, these terms may have other meanings when used in a different context.

Administrative Record (AR): All documents which the the EPA considers or relies upon in selecting the response action at a Superfund site, culminating in the Record of Decision for remedial action.

ARAR: Applicable or relevant and appropriate requirements.

Baseline Human Health Risk Assessment (HHRA): A document that provides an evaluation of the potential threat to human health in the absence of any remedial action.

Baseline Ecological Risk Assessment (BERA): A document that provides an evaluation of the potential threat to the environment in the absence of any remedial action.

Bioavailability: A risk assessment term; the fraction of an ingested dose that crosses the gastrointestinal epithelium in the stomach and becomes available for distribution to internal target tissues and organs.

Capital Cost: Direct (construction) and indirect (non-construction and overhead) costs including expenditures for equipment, labor, and materials necessary to implement remedial actions.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): A federal law passed in 1980 and modified in 1986 by the Superfund Amendments and Reauthorization Act. The acts created a special tax that went into the Trust Fund, commonly known as Superfund, to investigate and clean up abandoned or uncontrolled hazardous waste sites. Under the program, the EPA can either: (1) pay for site cleanup when parties responsible for the contamination cannot be located or are unwilling or unable to perform the work, or (2) take legal action to force parties responsible for site contamination to clean up the site or pay back the federal government the cost of the cleanup.

Contaminant: Any physical, chemical, biological, or radiological substance or matter that can have an adverse effect on human health or environmental receptors.

Contaminant of Concern (COC): A substance detected at a hazardous waste site that has the potential to affect receptors adversely due to its concentration, distribution, and mode of toxicity.

Discount Rate: A percentage rate used in present worth analyses to identify the cost of capital and operation and maintenance expenses. It is used to value a project using the concepts of the time-value of money where future cash flows are estimated and discounted to give them a present value.

Dolomite: A sedimentary rock containing greater than 50% of the mineral dolomite; often found with calcite in forming limestone, another sedimentary rock.

Expanded Site Inspection (ESI): A field investigation that typically follows a preliminary assessment and is designed to collect more extensive information on a hazardous waste site. The information is used to score a site using the Hazardous Ranking System to determine whether a response action is needed.

Exposure Pathways: The course a chemical or physical agent takes from a source to an exposed organism. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route.

Feasibility Study (FS): A report that analyzes the practicability of potential remedial actions; i.e., a description and analysis of potential cleanup alternatives for a site on the National Priorities List.

Groundwater: Water filling spaces between soil, sand, rock and gravel particles beneath the earth's surface, which often serves as a source of drinking water.

National Contingency Plan (NCP): The federal regulation that guides the Superfund program.

National Priorities List (NPL): The EPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial action under Superfund. The list is based primarily on the score a site receives from the Hazard Ranking System.

Operable Unit (OU): Term for each number of separate activities undertaken at a site as part of a Superfund site cleanup.

Operation and Maintenance (O&M): Activities conducted at a site after response actions occur to ensure that the cleanup or containment system continues to be effective.

Pore Water: Water filling spaces between soil, sand, rock and gravel particles within the streambed sediment.

Present Worth: The amount of money necessary to secure the promise of future payment or series of payments at an assumed interest rate.

Proposed Plan: A plan for a site cleanup that is available to the public for comment which summarizes remedy alternatives and presents the EPA's preferred alternative or cleanup approach.

Record of Decision (ROD): A public document that explains which cleanup alternative(s) will be used at a National Priorities List site.

Remedial Action: The actual construction or implementation phase of a Superfund site cleanup.

Remedial Investigation (RI): An in-depth study designed to gather data needed to determine the nature and extent of contamination at a Superfund site, establish site cleanup criteria, identify preliminary alternatives for remedial action, and support technical and cost analyses of alternatives. The remedial investigation is usually done with the feasibility study. Together they are usually referred to as the RI/FS.

Removal Action: Short-term immediate actions taken to address releases of hazardous substances that require an expedited response.

Responsiveness Summary: A summary of oral and/or written public comments received by the EPA during a comment period on key EPA documents, and the EPA's response to those comments.

Salem Plateau: A dissected karst plain located in south central Missouri and northern Arkansas consisting of rolling uplands and rugged hills with deeply entrenched stream valleys and ranges between about 1,000 feet to 1,400 feet in elevation. There are abundant sinkholes, caves, springs, and losing streams.

Simultaneously Extracted Metals/Acid Volatile Sulfides (SEM/AVS): Procedure used for the determination of acid volatile sulfide (AVS) and for selected metals that are solubilized during the acidification step (simultaneously extracted metal, SEM). As a precipitant of toxic heavy metals, sulfide is important in controlling the bioavailability of metals in anoxic sediments. Research has established that the relative amounts of SEM and AVS are important in the prediction of potential metal bioavailability; if the molar ration of SEM for bivalent metals to AVS exceeds one, the toxic heavy metals in that sample are potentially bioavailable.

Toxicity: The degree to which a chemical substance (or physical agent) elicits a deleterious or adverse effect upon the biological system of an organism exposed to the substance over a designated time period.

Vermivore: Animals that feed almost exclusively on worms.