



ecology and environment, inc.

Global Environmental Specialists

720 Third Avenue, Suite 1700
Seattle, Washington 98104
Tel: (206) 624-9537, Fax: (206) 621-9832

September 8, 2017

Mr. Brooks Stanfield, On-Scene Coordinator
United States Environmental Protection Agency, Region 10
1200 Sixth Avenue, Mail Stop ECL-133
Seattle, Washington 98101

Re: Contract Number: EP-S7-13-07
Technical Direction Document Number: 16-07-0002
Cinnabar Mine Integrated Assessment

Dear Mr. Stanfield:

Enclosed please find the final Integrated Assessment report for the Cinnabar Mine site which is located near Yellow Pine, Idaho.

If you have any questions regarding this submittal, please call Renee Nordeen at (206) 624-9537 or me at (206) 920-1739.

Sincerely,

ECOLOGY AND ENVIRONMENT, INC.

Steven G. Hall
START-IV Removal Team Leader

cc: Ken Marcy, Site Assessment Manager, EPA, Portland, Oregon Mail Stop 000
Linda Ader, START-IV Site Assessment Team Leader, E & E, Seattle, Washington
Renee Nordeen, START IV Project Manager, E & E, Seattle, Washington

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**Cinnabar Mine
Integrated Assessment**

Yellow Pine, Idaho

**Contract Number EP-S7-13-07
Technical Direction Document Number: 16-07-0002**

September 2017

Prepared for:

**United States Environmental Protection Agency
1200 Sixth Avenue
Seattle, Washington 98101**

Prepared by:

**ECOLOGY AND ENVIRONMENT, INC.
720 Third Avenue, Suite 1700
Seattle, Washington 98104**

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List of Abbreviations and Acronyms

<u>Abbreviation/ Acronym</u>	<u>Definition</u>
%Rs	percent recoveries
µg/g	micrograms per gram
µg/L	micrograms per liter
ACM	asbestos containing materials
AET	Apparent Effect Threshold
bgs	below ground surface
BMP	best management practices
BS	blank spike
CCC	criterion continuous exposure for chronic exposure
cfs	cubic feet per second
CLP	Contract Laboratory Program
CMC	criterion maximum concentrations for acute exposure
CRQL	contract required quantitation limit
DOM	dissolved organic matter
DQOs	Data Quality Objectives
E & E	Ecology and Environment, Inc.
EFSFSR	East Fork of South Fork Salmon River
EPA	United States Environmental Protection Agency
FR	USFS Road
IA	Integrated Assessment
IDEQ	Idaho Department of Environmental Quality
J	estimated quantities
LTP	Lower Tailings Pile
MEL	Manchester Environmental Laboratory
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MS/MSD	Matrix Spike/Matrix Spike Duplicate
ng/L	nanograms per liter
ng	nanograms
NPL	National Priorities List
PA	Preliminary Assessment
PCB	Polychlorinated Biphenyls
PEC	Probable Effect Concentration
PPE	Probable Point of Entry
QA/QC	Quality Assurance/Quality Control
R	Rejected sample result
RML	Removal Management Levels
redox	oxidation-reduction

List of Abbreviations and Acronyms (cont.)

Abbreviation/

Acronym

Definition

RPD	Relative Percent Difference
RSE	Removal Site Evaluation
RSL	Region Screening Level
SI	Site Inspection
SIP	Site Inspection Prioritization
SOW	Statement of Work
SPLP	Synthetic Precipitation Leaching Procedure
SQL	Sample Quantitation Limit
SSSP	Site-Specific Sampling Plan
START	Superfund Technical Assessment and Response Team
TAL	Target Analyte List
TDL	Target Distance Limit
TEC	Threshold Effect Concentration
USFS	United States Forest Service
USGS	United States Geological Survey
UTV	Utility terrain vehicles

1

Introduction

Ecology and Environment, Inc. (E&E) was tasked by the United States Environmental Protection Agency (EPA) to provide technical support for completion of an Integrated Assessment (IA) at the Cinnabar Mine Site which is located near Yellow Pine, Idaho. E & E completed the IA activities under Technical Direction Document Number 16-07-0002, which was issued under EPA, Region 10, Superfund Technical Assessment and Response Team (START)-IV Contract number EP-S7-13-07. The purpose of an IA is to combine aspects of a Removal Site Evaluation (RSE) for the EPA Removal Program with a Site Inspection (SI) for the EPA Site Assessment Program, combining field efforts and reporting results within one document. The specific goals for this IA are intended to address the objectives presented below:

- Collect sufficient data to document any eminent threat or potential threat to human health or the environment posed by the site;
- Determine whether there are some potential removal options that would reduce impacts to human health and the environment;
- Collect and analyze samples to characterize the potential sources and determine the potential for off-site migration of contaminants;
- Provide EPA with adequate information to determine whether the site may be eligible for placement on the National Priorities List (NPL).

Completion of this IA included reviewing site information, determining regional characteristics, collecting receptor information within the site's range of influence, executing a sampling plan, and producing this report. This report is organized as follows:

- Executive Summary – A summary of the activities and conclusion of the work performed in the execution of this project;
- Section 1, Introduction – Authority for performance of this work, goals for the project, and summary of the report contents;
- Section 2, Site Description and Background – Locational information for the site, a description of the site, and a summary of previous investigations for the site and surrounding areas;
- Section 3, Media Sampling Activities – A summary of sampling activities including sample location information, a summary of sample collection methodologies; and a summary of analytical protocols applied to the samples;

- Section 4, Quality Assurance/Quality Control (QA/QC) – Summary of the laboratory data;
- Section 5, Removal Site Evaluation – A discussion of RSE criteria and a discussion of sampling results with regards to the removal evaluation criteria;
- Section 6, Conceptual Site Model – A discussion of key aspects regarding the fate and transport of the primary contaminants of concern (arsenic and mercury) at the Cinnabar Mine site and downgradient locations;
- Section 7, Removal Option Alternatives – A discussion of potential removal activities for the site; Section 8, Site Surface Water Migration Pathway and Targets – A discussion of SI reporting criteria, a description of site sources, a discussion of sampling results of site sources, a description of the surface water migration pathway, a description of migration pathways targets within the site’s range of influence, and a discussion of target sample results;
- Section 9, Summary and Conclusions – A summary of the investigation and recommendation for the site based on the information gathered during the investigation; and
- Section 10, References – An alphabetical listing of references cited throughout the text.

2

Site Description and Background

This section describes the background of the site including location, description, and previous investigations conducted at the site and surrounding areas.

2.1 Site Location

Site Name:	Cinnabar Mine
CERCLIS Identification Number:	IDD980665160
Latitude:	44.919085
Longitude:	-115.290683
Point of measurement:	Concrete staging pad
Legal Description:	Township 18 North, Range 10 East, Sections 6 and 7
County:	Valley
Congressional District:	1
Site Owner:	J.J. Oberbillig Estate

2.2 Site Description & Background

The Cinnabar Mine is located approximately 15 miles east of Yellow Pine, Idaho on Forest Service Road #374 in Valley County, Idaho (Figure 2-1). The site encompasses approximately 50 acres within the 575 acres of patented claims comprising the Cinnabar Mine. The 575 acres of land are on a mixture of privately owned lands and United States Forest Service (USFS) lands. This IA focuses on the potential sources located on privately owned portions of the site. The parcel boundaries are depicted on Figure 2-2, and while the majority of the site is located on privately owned land, it appears that a small portion of the upper yellow tailings pile and all of the lower tailings are located on land managed by USFS.

The site is located within the Payette National Forest, adjacent to the Frank Church/River of No Return Wilderness Area to the north and east, and the Boise National Forest to the south. Features at the site include five tailings piles (designated as the lowest tan tailings pile, the previously capped and seeded tailings pile [also called the tailings impoundment], three upper red tailings piles, and upper yellow tailings pile), an area of ponded water in the northwest corner of the upper yellow tailings pile, three adits (designated as Adit 1, Adit 2, and Adit 3), an adit pond associated with Adit 2, a capped and seeded landfill, a former mill building, a former dormitory, a former cook house, two concrete pads, and former residential buildings. In addition, the East Fork and West Fork of Cinnabar

2 Site Description and Background

Creek run through the site. (Figure 2-2). Two tailings impoundments once existed at the site on USFS land. The lower impoundment failed during high floods in 1965 and the upper impoundment structure, constructed in the 1950s, was approximately 18 feet tall with approximately five to six feet of tailings behind the impoundment (USFS 1996). This impoundment was later filled with tailings (this feature is discussed further in the previous investigations section below).

Water discharges from several mine adits and surface drainages above the site to West Fork Cinnabar Creek. West Fork Cinnabar Creek flows through the tailings piles in a diversion channel which was initially constructed in 1992 and reconstructed during a 1996 EPA Removal Action (discussed further below). West Fork Cinnabar Creek flows into Cinnabar Creek which flows into Sugar Creek below the mine site.

Mercury mining operations began at Cinnabar Mine in 1921 and ceased in 1958. The deposit was discovered in 1902, with subsequent development commencing in 1921 under United Mercury Mines Company (also known as Hermes Mine). Production is reported to have been intermittent prior to 1930. In 1942, the mine was worked by Bonanza Mining, Inc., and then Holly Minerals took over during the 1950s. Mr. J.J. Oberbillig is listed as the president of the mine at the time it was incorporated in 1921 (Mitchell 2000). Historically, the ore processing was conducted on-site. The initial method used was to roast the ore, mercuric sulfide, or cinnabar with oxygen to produce free mercury vapor and sulfuric dioxide gas. The mercury vapor was collected after cooling by flue condensers. Allegedly, this process was uncontrolled; during operations, elemental mercury could be collected from the walls and rain-gutters of the process buildings. A fire in 1956 destroyed the processing mill and the mill was subsequently rebuilt. The new mill processed ore using a method which coupled wet flotation with electro-separation (E & E 1999). A settlement between EPA and the J.J. Oberbillig estate was reached that set aside funds for future cleanup activities at the site.

2.3 Previous Investigations

Numerous investigations by various parties have been conducted at the site. Below is a discussion of the investigations based on available information. A timeline of investigations is presented in Figure 2-3.

In August 1979, EPA conducted a non-sampling inspection of the site and concluded the site did not pose an environmental or public health threat (EPA 1979).

In September 1984, Idaho Department of Health and Welfare's Division of Environment and the Central District Health Department conducted an investigation of the site. The following conditions and sample results were noted (the locations of the samples were not reported and only mercury concentrations were reported):

2 Site Description and Background

- **Sodium Carbonate Decahydrate:** Approximately fifty 55-gallon drums were noted between the mill and living quarters. No samples of the contents were collected.
- **Diesel:** A 120,000-gallon tank with approximately 3,000 gallons of product was noted. The location of the tank was not reported. One sample of the material was collected which determined the material to be #2 diesel fuel.
- **Transformers:** Two empty transformers that spilled oily material to the ground as well as another intact transformer were noted. The location of the transformers was not reported. There was no vegetation in the area of the spilled transformers. No samples of the spilled material were collected.
- **Unknown Substances:** Drums with unknown contents were noted inside the mill buildings. Some of drums contained a white substance and some a blue-green material. Samples of the contents were not collected.
- **Tailings Piles:** Samples were collected from the red tailings and the tan tailings. The sample from the red tailings indicated the presence of mercury at 4.8 micrograms per gram ($\mu\text{g/g}$) and the sample from the tan tailings indicated the presence of mercury at 12.4 $\mu\text{g/g}$.
- **Creeks:** “Several” surface water samples were collected from the creek; this is assumed to be West Fork Cinnabar Creek. Two surface water samples collected “a few meters above the disturbed area” did not indicate the presence of mercury; a sample collected from the middle of the mine area indicated mercury at 0.8 micrograms per liter ($\mu\text{g/L}$), and a sample collected from Sugar Creek below the confluence with Cinnabar Creek had a concentration of 0.5 $\mu\text{g/L}$ of mercury. Six sediment samples were also collected from Cinnabar Creek and mercury concentrations ranged from 3.5 $\mu\text{g/g}$ (above the mine) to 99.7 $\mu\text{g/g}$. Sediment from Sugar Creek indicated a mercury concentration of 18.4 $\mu\text{g/g}$.

A mill stack was noted in West Fork Cinnabar Creek. Surface water and sediment samples were collected near the stack. The surface water sample indicated 59 $\mu\text{g/L}$ of mercury and the sediment sample result was 445.7 $\mu\text{g/g}$.

Based on conditions noted at the site and sampling results, it was recommended the site be given a high priority for cleanup and stabilization of the tailings to prevent additional erosion into the creek. (Clark and Lappin 1984)

In June 1985, based on the recommendations in the September 1984 report, EPA conducted a Preliminary Assessment (PA) at the site (Weston 1985). The objectives of the PA were:

- Determine if polychlorinated biphenyl (PCB)-contaminated materials were present; and
- Further determine the extent of mercury contamination through the collection of soil, creek sediment, surface water, and atmospheric sampling.

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Sample locations from EPA's 1985 Preliminary Assessment are presented on Figure 2-4 and sample results are provided in Table 2-1. Based on the sampling results, removal of the stack, diesel oil and storage tank, and transformers was recommended. Additional sampling of Cinnabar Creek and Sugar Creek also was recommended.

In May 1988, the USFS Krassel Ranger District received a notice of an oil spill on the East Fork of the South Fork of the Salmon River (EFSFSR). The lessee, Pioneer Metals, reported the 120,000-gallon tank had a tap removed and a valve opened which resulted in a release of oil into Cinnabar Creek (this is assumed to be West Fork Cinnabar Creek which runs through the site). Pioneer Metals attempted to divert snowmelt to the creek, constructed berms at the creek, placed absorbent material around the tank, and placed oil-saturated dirt on the tailings pile. (Weston 1994)

In 1988, the USFS prepared a macroinvertebrate report to document conditions in West Fork Cinnabar Creek near the site. Eight aquatic macroinvertebrate samples were collected from two stations (Station A and Station B). Station A was located on West Fork Cinnabar Creek downstream of the mine in the area affected by the diesel spill. Station B was located east of the mine as a control station. The report concluded there were severe stress conditions in the ecosystem at Station A. (Weston 1994)

In September 1991, the USFS conducted sampling of the tailings at the site behind an embankment on West Fork Cinnabar Creek. The locations of the samples were not provided other than the description of "behind the embankment." The samples were analyzed for arsenic, lead, mercury, and zinc. Sample results were compared to EPA maximum concentration of contaminants for toxicity characteristic. Sample results and screening levels are provided in Table 2-2. Based on these results and conditions at the site, a time critical removal action was recommended to construct a diversion ditch around the edge of the tailings and impoundment structure and divert West Fork Cinnabar Creek to a "historic diversion channel." The USFS removal action commenced in September 1992, and it appears this work was conducted solely on USFS land. The tailings were saturated approximately eight inches below the surface and the removal action was modified to include the construction of a spillway west of the outlet channel, labeled as "wood box culvert" (Figure 2-5). (USFS 1992; Weston 1994).

In 1993, USFS conducted a PA at the site. No samples were collected as a part of this investigation. The investigation was a review of existing data, a site visit, and an assessment of the surface water migration pathway. The report concluded the site presented an impact on the environment and food chain of the surface water migration pathway and recommended further characterization of the sources at the site.

Also in 1993, Idaho Department of Environmental Quality (IDEQ) prepared a Site Inspection Prioritization (SIP) report for the EPA. SIPs are intended to determine non-sampling data gaps, provide a summary of information that fulfills Hazard

2 Site Description and Background

Ranking System needs, and include a summary of the file reviews completed. No conclusions or recommendations were included in this report.

In 1994, EPA conducted a SI at the Cinnabar Mine. A total of 13 samples were collected as part of this investigation. These samples included three tailings samples, one soil sample at the mill building, one soil sample near debris and drums, two background soil samples, and six sediment samples from West Fork Cinnabar Creek including one background sediment sample. The fallen stack was in West Fork Cinnabar Creek, and the sample collected here was a sediment sample. Sample locations are depicted in Figure 2-6. Surface soil sample results are provided in Table 2-3. Sediment sample results are provided in Table 2-4. All samples were analyzed for TAL metals. Samples were compared to background samples and evaluated based on the criteria outlined in Section 6 of this document. Six analytes (arsenic, cadmium, copper, mercury, thallium, and zinc) were detected at significant concentrations with respect to background in the surface soil samples. The majority of the significant concentrations were detected from the mill sample. Three analytes (cobalt, mercury, and thallium) were detected at elevated concentrations with respect to background in the sediment samples. Because cobalt was not likewise detected at significant concentrations in the source samples, cobalt is not attributable to site contamination. There were no recommendation provided in the report.

In August 1996, EPA prepared an Action Memorandum to conduct a time critical removal action at the site. The activities outlined in the Action Memorandum included minimizing the amount of surface runoff from the tailings piles into West Fork Cinnabar Creek; creating a lined “landfill” on-site; removing the stack from West Fork Cinnabar Creek and placing it in the on-site “landfill”; stabilizing the 55-gallon drums of caustic material, cleaning the three large oil/fuel tanks; removing oil/fuel contaminated soils and transporting them off-site for disposal; and removing asbestos-containing materials (ACM) from the on-site boilers and placing them in the on-site “landfill.” In September 1996, USFS prepared a Time Critical Action Memorandum for the site giving EPA approval to conduct a removal on the Federally-managed portion of the site in addition to the removal which would also be carried out on the private portion of the site. The activities performed on USFS land include opening the USFS road and covering tailings after re-routing West Fork Cinnabar Creek into the old diversion. (EPA 1996; USFS 1996)

This time critical removal action was conducted in September and October 1996. The following is a brief description of the removal activities conducted:

- **On-Site Landfill:** A landfill was constructed northwest of the tailings pile. The dimensions of the landfill were 60 feet long by 30 feet wide. The landfill contains two sections of retort, PCB-contaminated transformer carcasses and debris, ACM, spent personal protective equipment, and mercury-contaminated soil.
- **Retort Removal and Temporary Cap:** Two sections of retort used in the processing of mercury were partially buried in West Fork Cinnabar Creek. The sections of retort were removed, the open ends of each section were

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capped, and these were placed in the on-site landfill. Upon removal of the retort sections, it was noted elemental mercury had been released to the creek as a result of water flowing through the sections of the retort. Approximately 5 to 10 cubic yards of contaminated sediments were removed from the creek. The sediments were placed on a tarp and allowed to dewater. Afterwards, the sediments were mixed with concrete, transferred to 55-gallon drums, and placed in the on-site landfill.

- **Asbestos-containing Materials:** ACM had previously been identified in the laboratory hood in the mill building, in a boiler in the cookhouse, and another boiler located in a partially demolished metal building south of the cookhouse. The ACM associated with the metal building boiler was bagged and placed in the on-site landfill. The other two locations were not addressed as the building were deemed unsafe to enter.
- **Oil Tanks and Contaminated Soil:** Four fuel tanks were noted at the site (designated as Tanks 1 through 4). Tanks 1 through 3 were located on a concrete pad and Tank 4 was located between the metal building and the cookhouse. Tank 1 was noted to be leaking product to soils at the base of the concrete pad as a result of numerous bullet holes around the valve. The tanks were drained, cleaned, and rendered unusable. Approximately 40 cubic yards of oil-contaminated soil were excavated beneath the concrete and pad of Tank 1 and staged for off-site disposal.
- **Drums and Containers:** Approximately 50 drums of soda ash were located in the southwest area of the site and in the mill building. The contents of the drums were staged with the oil-contaminated soil for off-site disposal. The empty drums were placed in the on-site landfill.
- **PCB Transformers and Debris:** Two transformers, their parts, and associated debris were removed and placed in the on-site landfill.
- **Reconstruction of Diversion Channel:** The USFS had attempted to return West Fork Cinnabar Creek and other surface water to a historical diversion channel around the lower tailings pile (LTP) in 1992. This attempt was unsuccessful as their machinery repeatedly became stuck in the slurry in the LTP. The original diversion had been implemented by the mining company in the 1950s to keep water out of the LTP impoundment. Reportedly, during a flood in the 1960s the creek eroded the bank of the diversion channel thereby allowing the creek to return to a natural drainage pathway through the LTP. The reconstruction of the diversion channel was conducted in four phases:
 - **Phase I:** This phase consisted of funneling the majority of site surface water and runoff through the creek blowout and through the sediment impoundment created to reduce the amount of suspended materials impacting downstream water quality; removal of debris from the old diversion channel and excavation of a 7-foot wide channel bottom to the correct grade to create the appropriate drainage; and transportation and stockpiling of large rock from a nearby quarry to be used in armoring the sides of the diversion channel.
 - **Phase II:** This phase consisted of armoring the sloped sides and bottom of the diversion channel with the large rock; grading and

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excavation of shelves on the sloped sides of the channel to control erosion; transportation and stockpiling of small rock from a nearby quarry and placement in the bottom of the diversion channel to act as rip rap and thereby minimize suspended sediments in the creek water; and installation of a large sediment impoundment (a depression in the channel lined with geotextile material and large rocks to act as a sediment trap) midway between the blowout and the bottom of the diversion channel.

- **Phase III:** In this phase, an earthen dam with an underflow dam was constructed above the blowout, and water from West Fork Cinnabar Creek was diverted around the blowout to the newly constructed diversion channel while blowout repairs were made. The repairs to the blowout included: removing the temporary sediment impoundment below the blowout; keying rock into the bottom of the blowout so that the banks north and south of the blowout were tied in; transporting clean soil from another area of the site and packing it around the base rocks followed by a geotextile cover, more rock, and more soil; and building up the blowout area bank to the level and grade of the north and south banks, followed by additional armoring with large rocks consistent with the lower diversion channel.
- **Phase IV:** This phase included removal of the earthen and underflow dam above the blowout, final grading of the slopes, installation of erosion control measures above the diversion channels, and removal of the temporary rock road for disposal in the LTP.
- **Lower Tailings Pile Stabilization:** As noted above, the USFS was not able to conduct work on the LTP because of site conditions. The USFS was successful in constructing a spillway in the LTP impoundment berm. The spillway was constructed in order to reduce the pressure on the LTP impoundment from water accumulation behind the berm. Over the years, the creek traversed the LTP causing extensive erosion of the LTP cap and carved a deep gully through the tailings in the central area thereby mobilizing sediment to the lower watershed.

Upon completion of the diversion channel and sufficient drying of the LTP, grading and stabilization efforts commenced. Live trees and debris were removed from the southeast slope of the LTP as clean surface soil was bulldozed into two stockpiles at the base of the slope. The clean soil was used to regrade the LTP, thereby removing some of the exposed tailings berms above the LTP grade. All tailings above the grade were needed in order to fill in the central drainage area eroded by the creek. Additional fill material (from the west slope of the diversion channel) had to be imported to complete the filling and grading activities. The eroded channel in front of the box culvert was filled with rock and not sealed which would allow infiltrating water to pass under the berm. Geotextile material was installed over the newly graded tailings prior to laying of the cap. Across the center of the LTP, running southwest to northeast, a

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slightly depressed surface water drainage feature was installed and overlain with a second layer of geotextile material. Medium-sized rock was used to line the edges of this drainage area followed by small rock rip rap being placed directly in the drainage channel on top of the geotextile. Finally, USFS personnel spread seed and hay over the LTP. Rocks, trees, and debris were placed across the seeded areas.

During the removal action, a total of 84 samples, including 13 soil samples, nine sediment samples, four product samples, three tailings samples, five water samples, 13 mixed soil/tailings samples, and 37 mixed sediment/tailings samples, were collected. Some samples were analyzed in the field, some samples were analyzed at an off-site fixed laboratory, and some samples were analyzed both in the field and at an off-site fixed laboratory for PCBs and/or priority pollutant metals. Soil and sediment sample results are provided in Table 2-5 (only those samples submitted for off-site fixed laboratory analysis are included in this table and PCB results are not included because no PCBs were detected above the instrument detection limit) and surface water sample results are provided in Table 2-6. These samples were not compared to any regulatory criteria nor a background in the report. Antimony, arsenic, beryllium, chromium, copper, lead, mercury, nickel, thallium, and zinc were detected above the method detection limit in the soil/tailings/sediment samples. Antimony, arsenic, mercury, thallium, and zinc were detected above the method detection limit in the surface water samples. Locations of the surface water/sediment samples are provided on Figure 2-7. The samples were utilized to reflect contaminant conditions at the conclusion of the removal. The removal action was deemed as successful; however, it was noted there were still concerns at the site with regards to contamination left on site and not addressed due to safety concerns. (E & E 1996)

In July 1998, EPA amended the scope of work of the existing Action Memorandum. The amendment was to address additional mercury contamination in soil below and adjacent to West Fork Cinnabar Creek and address oil-contaminated soil. Another time critical removal action was conducted at the site from July 1998 through August 1998. The following is a brief discussion of the activities that occurred during the removal:

- **On-Site Landfill:** A new landfill was constructed adjacent and to the north of the landfill that was constructed during the 1996 time critical removal action. The dimensions of the new landfill were similar to the 1996 landfill.
- **Mercury-Contaminated Soil:** Mercury-contaminated soil associated with the retorts that were removed from West Fork Cinnabar Creek during the 1996 time critical removal action required capping. These soils were capped in place. Sediment traps were placed in the creek upgradient and downgradient of the mercury-contaminated soil area. A sump pump was utilized to divert the creek water from above the contaminated area. Following the excavation of the original area of contamination, additional elemental mercury was observed in the excavated area. Excavation and removal continued until elemental mercury was no longer observed in the excavation. The removed soils were mixed with cement prior to placement

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in the on-site landfill. No information regarding the amount of excavated material was included in the report.

- **Oil-Contaminated Soil:** A very wet area with an oil sheen was observed in puddled standing water; however, nearby vegetation did not appear to be stressed. Five test pits were excavated during the removal to assist in gauging the amount of oil and the rate of migration. After 24 hours, only one of the pits contained any oil product. Given the apparent stability of the oil in this location and the difficulty in extracting it from an area that was so saturated, no removal actions occurred in this area. The test pits were refilled and the area was revegetated.
- **Stabilization of the Tailings Piles:** The upper three tailings piles were heavily eroded and portions were migrating into the West Fork Cinnabar Creek. The slope of the piles was reduced to 3:1 which resulted in each pile covering more area; however, it also reduced the chance of the creek further eroding the piles during flood and/or high water events. A French drain (consisting of rip-rap and a geotextile liner) was installed in West Fork Cinnabar Creek to avoid entrainment of sediments into the creek during the removal. Once the piles were regraded, woody debris was scattered on their surfaces to assist in preventing further erosion and aid in stabilization of the piles until they could be planted and vegetation sprouted. The piles were seeded with a native grass seed mixture.
- **Signage and Access Restriction:** Signs were posted at various locations around the site to inform visitors of the potential contamination at the site. Waterbars (which would inhibit vehicular traffic to the site) were installed on USFS Road #374 during demobilization to restrict recreational access to the site. Finally, the temporary road/bridge on Sugar Creek was removed during demobilization.

During this removal action, a total of 22 samples (19 soil samples and three tailings samples) were collected. The locations of the samples are presented in Figure 2-8. All samples were analyzed in the field with a field-portable x-ray fluorescence (XRF) analyzer for mercury and arsenic. No samples were submitted for off-site fixed laboratory analysis because the removal action was driven by visible beads of mercury. Sample results are provided in Table 2-7. Mercury concentrations ranged from 24 mg/kg to 169 mg/kg. Arsenic concentrations ranged from 92 mg/kg to 180 mg/kg.

The removal was deemed to have been effective at reducing the risk of public exposure to on-site hazards and in reducing the risk of significant continuing releases of hazardous material to the environment. (E & E 1998)

In August 2003, the USFS performed a time-critical removal action at the USFS owned portion of the site. The objectives of the removal action were to:

- Remove the remaining tailings along West Fork Cinnabar Creek, and
- Regrade the tailings within the LTP impoundments in order for surface water flow to be directed away from the tailings.

These objectives were met by sloping the tailings to a 3:1 grade and placing rip rap along the stream to prevent erosion from high flows. The tailings were also

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covered with a geotextile liner and a minimum of 18 inches of topsoil, seed, and mulch.

In August 2004, EPA returned to the site to regrade the upper red tailing pile and place seed mixture on the pile to reduce the risk of erosion of the tailings into West Fork Cinnabar Creek. No samples were collected as part of this work. (E & E 2014)

In 2011, the United States Geological Survey (USGS) began sampling water quality stations in the EFSFSR watershed several miles downstream of the mine. The locations of the monitoring stations are provided on Figure 2-9. The samples were analyzed for unfiltered and filtered metals and field parameters including temperature, pH, and specific conductivity. Results of this sampling are provided in Table 2-8. The samples were compared to fresh water criterion maximum concentrations for acute exposure (i.e., CMC) and criterion continuous exposure for chronic exposure (i.e., CCC) for the protection of aquatic life (see Section 5.1.2). Filtered arsenic and lead were not detected above the CMC or the CCC in any of the samples collected. Filtered mercury was detected above the CCC at the Sugar Creek location in 11 of the samples collected. Filtered mercury was not detected above either the CMC or CCC in any of the other locations (USGS 2014a, 2014b, 2014c, 2014d, 2014e). Based in part on the elevated mercury concentration detected in the surface water sample from Sugar Creek above the confluence with the EFSFSR, concern was expressed that contamination may be migrating from the tailings piles at Cinnabar Mine and impacting surface water and sediments in Cinnabar Creek, Sugar Creek, and the EFSFSR.

Based on the concerns expressed in the previous study, EPA conducted a removal assessment in August 2014. During the assessment a total of 29 samples (13 surface water, 11 sediment, and five surface soil) were collected. Sample locations are depicted on Figure 2-10. The surface water samples were submitted to an off-site fixed laboratory for analysis of unfiltered and filtered arsenic, lead, and mercury by EPA Contract Laboratory Method (CLP) Statement of Work (SOW) ISM01.3 and hardness by Method SM 2340B. The sediment samples were submitted for analysis of total arsenic, lead, and mercury by CLP SOW ISM01.3. The surface soil samples were submitted to an off-site fixed laboratory for analysis of synthetic precipitation leaching procedure (SPLP) arsenic, lead, and mercury by EPA Method 1312 (SPLP extraction), 200.2 (metals digestion), and EPA Method 200.8 (metals analysis). (E & E 2014)

The surface water sample results and the SPLP results for the surface soil samples were compared to the fresh water CMC and CCC for the protection of aquatic life. The sediment samples were compared to consensus-based sediment quality guidelines as developed by McDonald et. al. (2000) using both the threshold effect concentrations (TEC) and probable effect concentrations (PEC). In addition, the surface water and sediment samples were evaluated as outlined in Section 6 of this document. (E & E 2014)

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Surface water samples results are provided in Table 2-9. In five of the unfiltered samples, total mercury exceeded the CCC of 0.012 µg/L (Etheridge 2015). Sample results indicate the presence of unfiltered and filtered arsenic in samples from Cinnabar Creek and Adit 1, unfiltered lead in one sample from Cinnabar Creek and Adit 1, and unfiltered mercury in Adit 1 at elevated concentrations with respect to background concentrations. (E & E 2014)

Sediment sample results are provided on Table 2-10. Sample results indicate the presence of arsenic at concentrations that exceed the TEC and PEC in all of the samples collected including both background samples. The results also indicate the presence of mercury in sediment at concentrations that exceed the TEC and PEC in all samples except the background sediment sample. Lead was not detected above either screening level in any of the sediment samples collected. In addition, arsenic was detected at elevated concentrations in one sample from Cinnabar Creek and mercury was detected in two samples from Cinnabar Creek at elevated concentrations with respect to background concentrations. (E & E 2014)

The SPLP results for the surface soil samples (Table 2-11) indicate the presence of arsenic and mercury at concentrations that exceed the CCC and CMC in three of the four sample locations. The SPLP results also indicate the presence of mercury at concentrations that exceeds the CCC in the fourth sample. (E & E 2014)

Concurrent with the removal assessment in August 2014, USGS representatives collected surface water and sediment samples from streams, adits, and an area of ponded water. Additional samples were collected in June and July 2015. Sample locations are depicted on Figure 2-11. Sample results are presented in Tables 2-12 (surface water), 2-13 (sediment), and 2-14 (surface soil). Surface water samples were compared to CMCs and CCCs. Sediment samples were compared to recommended sediment quality guidelines for sediment quality standards and cleanup screening levels (Avocet 2011) and consensus-based TECs (MacDonald et al. 2000), and tailings and soil samples were compared to EPA Removal Management Levels (RMLs) and EPA Regional Screening Levels (RSLs). In addition, the surface water and sediment samples were also evaluated as outlined in Section 6 of this report. (Holloway et al. 2016)

Surface water sample results (Table 2-12) indicate the presence of filtered mercury at concentrations that exceed the CCC in nine of the samples collected including in the background sample collected upstream of the mine. In addition, mercury, methylmercury, arsenic and arsenic III were detected at elevated concentrations with respect to background concentrations.

Sediment sample results (Table 2-13) indicate the presence of mercury at concentrations that exceed the least conservative (i.e., highest) screening level in 11 of the 13 samples collected. Arsenic was detected at concentrations that exceeded the most conservative (i.e., lowest) screening level in 10 of the 13 samples and two of these concentrations also exceeded the least conservative (i.e.,

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highest) screening level. In addition, arsenic, mercury, and methylmercury were detected at elevated concentrations with respect to background concentrations.

Soil sample results (Table 2-14) indicate the presence of mercury at concentrations that exceed both screening levels in all five of the samples collected. Arsenic was detected at concentrations that exceeded most conservative (i.e., lowest) screening level in all five samples and the least conservative (i.e., highest) screening level in three of the samples.

3

Media Sampling Activities

A Site-Specific Sampling Plan (SSSP) for the Cinnabar Mine IA was developed by START prior to field sampling (E & E 2016). The SSSP describes the sampling strategy, sampling methodology, and analytical parameters used to investigate the site. With few exceptions, the IA field activities were conducted in accordance with the SSSP. Deviations from the SSSP are described, when applicable, in this section and in the sampling location discussions in Section 5, 6, and 7. Sample Plan Alteration Forms are provided in Appendix A.

The primary IA sampling event was conducted from August 22, 2016 through August 26, 2016 by EPA and START with the assistance of the USCG. EPA conducted additional site sampling on September 12, and EPA also collected samples for a mesocosm study on October 5, 17, 24 and November 9. A total of 155 samples were collected. The samples consisted of:

- **August Sampling:** 108 samples – 41 soil/sediment, 26 surface water, 26 dissolved surface water, 13 porewater, and 2 blanks;
- **September Sampling:** 15 samples – 1 soil, 6 surface water, 6 dissolved surface water, and 2 blanks; and
- **Mesocosm Study:** 32 samples – 6 soil, 25 water, 1 blank.

The sample collection methods and results for EPA's porewater samples and mesocosm study are discussed in a report by an EPA member of the Environmental Services Unit, in Appendix B.

Sample types and methods of collection are described below. A list of all samples collected for laboratory analysis under this IA is contained in Table 3-1. Sample locations are provided on Figure 3-1. Samples collected as part of this IA were submitted for off-site fixed laboratory analysis for unfiltered and filtered Target Analyte List (TAL) metals, methylmercury, filtered mercury and methylmercury, filtered total organic carbon (TOC), filtered sulfide, grain size, low level total mercury, sulfate, and agronomics. One sample was analyzed for PCBs. Photographic documentation of the IA field activities are provided in Appendix C.

Alphanumeric identification numbers applied by START to each sample location (e.g. CC01SW) are used in the report as the sample location identifiers. Table 3-2 summarizes the sample coding system used for formulating sample numbers.

3.1 Sampling Methodology and Locations

Grass, leaves, other vegetative material, rocks, and other debris unsuitable for analysis were removed from samples as much as possible prior to being placed into sample containers. Samples were stored on ice, in coolers, and continuously maintained under custody. Sampling methods for each sample types are described below. Sample information including sample locations, sample date and time, and sampler were collected on hand-held devices. Sample collection forms are provided in Appendix D.

3.1.1 Surface Soil

3.1.1.1 Sample Methodology

Surface soil (0 to 6 inches below ground surface [bgs]) grab samples were collected using dedicated plastic scoops. Collected material was placed in a dedicated plastic bowl, thoroughly homogenized, and placed into a pre-labeled sample containers.

3.1.1.2 Sample Locations

A total of 16 surface soil samples, including one background sample, were collected for the IA. Sample BG01SS was collected upgradient of the site from an area anticipated to not be influenced by mining and milling activities. A total of six samples (BS01SS through BS05SS) were collected from a potential borrow source area in the western portion of the site. A total of nine samples (TP01SS through TP09SS) were collected from the tailings piles; of these samples three were collected from the yellow tailings (TP01, TP04, and TP05) and six were collected from the red tailings (TP02, TP03, TP06, TP07, TP08, and TP09). One sample, RT01SS, was collected from soil near the former mill building. Finally, one sample, OS01SS, was collected from an area where oily soil was noted; this sample was only submitted for PCB analysis.

3.1.2 Surface Water

3.1.2.1 Sampling Methodology

Surface water grab samples were collected either by hand-dipping the sample container into the water or through dedicated Teflon-lined tubing using a peristaltic pump. Samples requiring preservation were preserved at the end of each sampling day.

As a part of the field sampling for this IA, a subset of the surface water samples were field-filtered with dedicated 0.45 micron filters at the sampling location. The results for surface water samples collected with 0.45 micrometer filters, which are commonly referred to as “dissolved” phase concentrations, will be described as “filtered” in this report. The results of unfiltered surface water samples, which are commonly referred to as “total” concentrations and which include the “dissolved” fractions as well as particulates that are too large to pass through the filter, will be referred to as “unfiltered” in this report.

At co-located surface water/sediment locations, the surface water samples were collected prior to collection of the sediment samples. Samples were collected

from downstream to upstream to avoid potential cross-contamination of downstream sample locations.

3.1.2.2 Sample Locations

A total of 63 surface water samples (32 unfiltered and 31 filtered) were collected during the IA from on-site adits, an area of pooled water on-site, West Fork Cinnabar Creek, Cinnabar Creek, and Sugar Creek. Surface water samples were collected from the three on-site adits (AD01SW through AD03SW and AD01SWD through AD03SWD). Samples AD01SW/AD01SWD were collected from Adit 1 located north of the former mill building. Samples AD02SW/AD02SWD were collected from Adit 2 adjacent to an on-site pond. Samples AD03SW/AD03SWD were collected from Adit 3 located on the southwest portion of the site behind a pile of metal debris. Sample AD04SW was collected from a seep in an area of oily water. Two samples (WT01SW and WT01SWD) were collected from an area of ponded water on the northwest corner of the upper yellow tailings pile. Twenty-two samples (WF01SW through WF07SW and WF01SWD through WF07SWD, including sample replicates at some locations) were collected from West Fork Cinnabar Creek. Ten samples (CC01SW through CC05SW and CC01SWD through CC05SWD) were collected from Cinnabar Creek. Twelve samples (SC01SW through SC05SW and SC01SWD through SC05SWD, including duplicates at the SC01SW/SC01SWD location) were collected from Sugar Creek. Two attribution samples (UT01SWQ and UT01SWD) were collected from an unnamed tributary to Sugar Creek to determine the potential for surface water and/or sediment contributing to contamination concentrations downstream in Sugar Creek. Finally, a total of six background samples (BG01SW through BG03SW and BG01SWD through BG03SWD) were collected. Location BG01 was from an unnamed stream upgradient of the mine site, location BG03 was upgradient of the confluence of West Fork Cinnabar Creek and Cinnabar Creek, and location BG02 was upgradient of the confluence with Cinnabar Creek and Sugar Creek. The in-water distances between sample locations is provided in Table 3-3.

3.1.3 Surface Sediment

3.1.3.1 Sampling Methodology

Surface sediment samples (0 to 4 centimeters) were collected using dedicated scoops. Collected material was thoroughly homogenized in dedicated plastic bowls. The sample material was decanted of as much water as possible prior to placement into pre-labeled sample containers. At co-located surface water/sediment locations, the surface water samples were collected prior to collection of the sediment samples. Samples were collected from downstream to upstream to avoid potential cross-contamination of downstream sample locations.

3.1.3.2 Sample Locations

A total of 26 sediment samples were collected. The majority were co-located with the surface water sample locations. Additional sediment samples were collected for the mesocosm experiment. See Table 3-3 for distances between sediment sample locations.

3.2 Analytical Protocol

All samples collected during this IA were submitted to off-site fixed laboratories for analysis. The following samples were submitted to the EPA's Manchester Environmental Laboratory (MEL), a CLP laboratory, and/or a subcontract laboratory for analysis. Analytical methods and reporting limits are provided in Table 3-4. Chain-of-Custody documentation is provided in Appendix E.

3.2.1 Manchester Environmental Laboratory

Samples for the following analyses were submitted to MEL:

- **Filtered low level mercury (water):** 26 samples.
- **Filtered mercury plus methylmercury (water):** 14 samples.
- **Filtered organic carbon (water):** 39 samples.
- **Filtered sulfate (water):** 39 samples.
- **Low level total mercury plus methylmercury (water):** 39 samples.
- **Total organic carbon (sediment):** 25 samples.

3.2.2 ChemTex Laboratories

Samples for the following analyses were submitted to ChemTex, a CLP laboratory:

- **Unfiltered TAL metals plus hardness (water):** 27 samples.
- **Filtered TAL metals plus hardness (water):** 13 samples.
- **TAL metals (surface soil and sediment) including mercury:** 41 samples.

3.2.3 ALS Laboratory

Samples for the following analyses were submitted to ALS Laboratories, a START subcontracted laboratory:

- **Filtered sulfide (water):** 25 samples.
- **Grain size (sediment):** 25 samples.
- **Methylmercury (surface soil/sediment):** 47 samples.

4

Quality Assurance/Quality Control

QA/QC data are necessary to determine precision and accuracy and to demonstrate the absence of interferences and/or contamination of sampling equipment, glassware and reagents. Specific QC requirements for laboratory analyses are incorporated in the *Contract Laboratory Program Statement of Work for Inorganic Analyses* (EPA 2015). These QC requirements or equivalent requirements found in the analytical methods were followed for analytical work on the project. This section describes the QA/QC measures taken for the project and provides an evaluation of the usability of data presented in this report.

Data from the START-subcontracted laboratories were reviewed by a START chemist. Data qualifiers and labels were applied as necessary according to the following guidance:

- EPA (2009) *Guidance for Labeling Externally Validated Laboratory Data for Superfund Use*.
- EPA (2016b) *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review*.

In the absence of other QC guidance, method- and/or SOP-specific QC limits were also utilized to apply qualifiers to the data.

4.1 Satisfaction of Data Quality Objectives

The following EPA (EPA 2000) guidance document was used to establish data quality objectives (DQOs) for this project:

- *Guidance for the Data Quality Objectives Process* (EPA QA/G-4), EPA/600/R-96/055.

EPA determined that definitive data without error and bias determination would be used for the sampling and analyses conducted during the field activities. The data quality achieved during the field work produced sufficient data that met the DQOs stated in the SSSP (E & E 2016). A detailed discussion of accomplished project objectives is presented in the following sections.

4.2 QA/QC Samples

Trip blank QA samples were not required for this project. Trip blanks are only required for volatile organic compound analysis. A rinsate blank sample was collected for all samples collected using nondedicated sampling equipment. QC samples included matrix spike/matrix spike duplicate (MS/MSD) and/or blank

spike (BS) samples at a rate of one MS/MSD and/or BS per 20 samples per matrix.

4.3 Project Specific Data Quality Objectives

The laboratory data were reviewed to ensure that DQOs for the project were met. The following describes the laboratories' and/or field team's abilities to meet project DQOs for precision, accuracy and completeness and the field team's ability to meet project DQOs for representativeness and comparability. The laboratories and the field team were able to meet DQOs for the project.

4.3.1 Precision

Precision measures the reproducibility of the sampling and analytical methodology. Laboratory and field precision is defined as the relative percent difference (RPD) between duplicate sample analyses. The laboratory duplicate samples or MS/MSD samples measure the precision of the analytical method. The RPD values were reviewed for all commercial laboratory samples. No sample results were qualified based on precision outliers; therefore the project DQO for precision was met.

4.3.2 Accuracy

Accuracy indicates the conformity of the measurements to fact. Laboratory accuracy is defined as the MS/MSD/BS percent recoveries (%Rs) for all laboratory analyses. The %R values were reviewed for all MS/MSD/BS analyses. A total of 22 sample results (approximately 1.2 % of the data) were qualified as estimated quantities (J) based on MS/MSD/BS outliers; therefore the project DQO for accuracy of 90% was met.

4.3.3 Completeness

Data completeness is defined as the percentage of usable data (usable data divided by the total possible data). All laboratory data were reviewed for data validation and usability. No sample results were rejected (R); therefore the project DQO for completeness of 90% was met.

4.3.4 Representativeness

Data representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point or environmental condition. The number and selection of samples were determined in the field to account accurately for site variations and sample matrices. The DQO for representativeness was met.

4.3.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. Data produced for this site followed applicable field sampling techniques and specific analytical methodology. The DQO for comparability was met.

4.4 Laboratory QA/QC Parameters

The laboratory data also were reviewed for holding times/temperatures/sample containers, laboratory blank samples, rinsate blank sample, and serial dilution analyses. These QA/QC parameters are summarized below.

4.4.1 Holding Times/Temperatures/Sample Containers

All sample temperatures and containers were acceptable. A total of 14 sample results (approximately 0.7% of the data) were qualified as estimated quantities (J) based on holding time outliers.

4.4.2 Laboratory Blanks

All laboratory blanks met the frequency criteria. The following inorganic potential contaminants of concern were detected in the laboratory blanks:

Antimony, mercury, silver, thallium, methylmercury, manganese, selenium.

See the data validation memoranda for results qualified based on blank contamination.

4.4.3 Rinsate Blank

The rinsate blank met the frequency criteria. The following inorganic potential contaminant of concern was detected in the rinsate blank:

Low level total mercury.

The low level total mercury result for sample 16384151 was less than five times the rinsate blank result and was qualified as not detected (U) by the secondary data reviewer.

4.4.4 Serial Dilution Analyses

Serial dilution analyses met the frequency and percent difference criteria.

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5

Removal Site Evaluation

5.1 Results Reporting Criteria

Analytical results reported in the summary tables show all analytes detected above the laboratory detection limits in bold type. For the RSE portion of this IA, the sample results have been compared to risk-based screening levels to help evaluate whether the site poses an increased risk to human health or the environment. Descriptions of the screening levels used for the RSE are provided below, and analytes that exceed screening levels are highlighted in the tables.

For the Site Inspection portion of the IA, the sample results were also compared to background concentrations, as described in Section 7. The comparison of sample results to background concentrations is useful in assessing overall site conditions and in particular determining the contribution of contamination from site sources.

The analytical summary tables present all detected compounds, but only those detected analytes that exceed screening levels are discussed in the report text.

In some cases, analytical results required qualification. For the purposes of discussion, qualifiers are not included in the results discussion. Please see the analytical data tables or data validation memoranda in Appendix E for information regarding qualifiers. Based on EPA Region 10 policy, the results for common earth crust elements (aluminum, calcium, iron, magnesium, potassium, and sodium), which are included in the TAL metals analyte list, are not discussed or evaluated as part of this investigation. In addition, the sediment samples were analyzed for grain size analysis. This information is used by the Site Assessment Program for determining whether the background sample matrix is similar to the release sample matrix. Grain size comparison discussions are provided in Section 7.

The following is a brief description of the applicability of the various screening levels that will be considered for evaluation of the sampling results. The screening levels, by matrix, are provided in Tables 5-1 through 5-3.

5.1.1 Soil Screening Level

Soil screening levels are provided in Table 5-1.

The EPA RMLs are chemical-specific concentrations for individual contaminants in soil and groundwater that may be used to support the decision for EPA to undertake a removal action. They are not necessarily health protective concentrations for chronic exposure, and exceedance of an RML by itself does not imply that adverse health effects will occur. RMLs help identify areas, contaminants, and conditions where a removal action may be appropriate. RMLs are not de facto cleanup standards and should not be used as such. Sites where contaminant concentrations fall below RMLs are not necessarily “clean” and further action or study may be warranted under the Superfund program, and sites with contaminant concentrations above the RMLs may not necessarily warrant a removal action dependent upon such factors as background concentrations, the use of site-specific exposure scenarios, or other program considerations. Soil sample results for the site have been compared to the RMLs for residential soil. (EPA 2016c)

The EPA RSLs are used as guidelines at cleanup sites to determine whether levels of contamination found at a site may warrant further investigation or site cleanup. RSLs are more conservative risk-based values for individual analytes than RMLs. The RSLs are considered to be protective for humans (including sensitive populations) over a lifetime; however, RSLs are not always applicable to a particular site and do not address non-human health endpoints, such as ecological impacts. The RSLs are calculated without specific information, but they may be re-calculated using site-specific data. The RSLs are used for site “screening” and can be used as initial cleanup goals, if applicable. RSLs are not de facto cleanup standards and should not be applied as such. Their role in site screening is to help identify areas, contaminants, and conditions that require further federal attention at a particular site. They are useful tools for identifying initial cleanup goals at a site. Soil sample results for the site have been compared to the RSLs for ingestion, dermal contact, and inhalation in soil. (EPA 2016d)

The IDEQ has developed IDTLs to assess the level of contamination at sites. These levels are human-health risk-based concentrations. The levels reported are not site-specific; however, site-specific concentrations may be generated. IDTLs are not enforceable (DEQ 2004). Although these criteria are provided in Table 5-1, they are not being used in the evaluation of sample results.

5.1.2 Surface Water Screening Levels

Aquatic life criteria for toxic chemicals are the highest concentration of specific pollutants or parameters in water that are not expected to pose a significant risk to the majority of species in a given environment or a narrative description of the desired conditions of a water body being "free from" certain negative conditions (EPA 2016a).

Surface water screening levels are provided in Table 5-2. For this RSE, the sample results were compared to fresh water criterion maximum concentrations for acute exposure (i.e., CMC) and criterion continuous exposure for chronic exposure (i.e., CCC) for the protection of aquatic life values from the State of Idaho Water Quality Criteria for Aquatic Life (IDAPA 58.01.02). For total

mercury, the freshwater CMC value of 1.4 µg/L from EPA (EPA 2016a) and the CCC value of 0.012 µg/L from the 2004 Idaho Water Quality Standards (IDAPA 58.01.02) have been used for the filtered fraction. No CMC or CCC values have been established for methylmercury.

5.1.3 Sediment Screening Levels

Sediment screening levels are presented in Table 5-3.

Sediment quality guidelines have been developed by MacDonald et al. (2000). These guidelines have calculated threshold effect concentrations which provide a basis for predicting the absence of sediment toxicity and probable effect concentrations and for assessing sediment quality conditions in freshwater ecosystems.

In cooperation with various Regional Sediment Evaluation Teams, Avocet Consulting updated sediment screening levels for Washington, Oregon, and Idaho. These values updated freshwater Apparent Effects Thresholds (AETs) that were more reliable similar to those created for marine AETs. (Avocet 2011)

5.2 Sample Results

Arsenic, mercury, and methylmercury concentrations for surface water, surface soil, and sediment are depicted in Figures 5-1 through 5-3.

5.2.1 Soil Sample Results

5.2.1.1 Background Sample

Background soil sample results are provided in Tables 5-4 and 5-5. Sample results indicate the presence of arsenic at a concentration that exceeds the RSL, which is the more conservative (i.e., lower) screening level.

5.2.1.2 Borrow Source

The results for samples collected from a potential on-site borrow source are provided in Table 5-4. Sample results indicate the presence of antimony, arsenic, mercury, and thallium at concentrations that exceeded at least one screening level. Antimony was detected at concentrations that exceeded the RSL (i.e., the lower and therefore more conservative) screening level in all five of the samples collected. Arsenic was detected at concentrations that exceeded both the RSL and RML in all five of the samples collected. Arsenic concentrations ranged from 194 mg/kg to 399 mg/kg and were approximately three times higher than the RML of 68 mg/kg. Mercury exceeded the RSL in all five samples and the RML in four of the samples. Of these four samples, the concentrations ranged from 285 mg/kg to 664 mg/kg and were at least nine times higher than the RML. Thallium was detected at concentrations that exceeded the RSL in all five samples and the RML in two.

5.2.1.3 Tailings Piles

Tailings pile sample results are provided in Table 5-5. Sample results indicate the presence of antimony, arsenic, cobalt, mercury, and thallium at concentrations

that exceeded at least one screening level. Antimony was detected at concentrations that exceeded the RSL in five of the nine samples collected from the tailings piles and in the one sample collected from the former mill building. Arsenic was detected at concentrations that exceeded the RML in all samples collected from the yellow tailings pile, red tailings pile, and the former mill building. Arsenic concentrations ranged from 396 mg/kg to 2,440 mg/kg, with concentrations in all samples at least five times higher than the RML, and up to 20 times higher in two samples. Cobalt was detected at a concentration that exceeded the RSL in one sample collected from the yellow tailings pile. Mercury exceeded the RSL in all of the samples collected from the tailings piles and former mill and also exceeded the RML in seven samples (three samples from the yellow tailings pile, three samples from the red tailings pile, and the one sample from the former mill building). Of the samples detected above the RML for mercury (33 mg/kg), mercury concentrations ranged from 51.1 mg/kg to 975 mg/kg, which is almost 30 times the RML. Thallium was detected above the RSL in all 10 of the tailings / mill building samples and above RML in nine of the 10 samples.

5.2.2 Surface Water Sample Results

The surface water sample results, including hardness, unfiltered metals, and filtered metals, are summarized in Tables 5-6 through 5-11. The following subsections of the report discuss the results as compared to the surface water screening levels (CCCs and CMCs). Note that the comparison of the results to screening levels focuses on the filtered fraction, because the screening levels for the detected metals apply to the dissolved fraction.

Also, note that total mercury was included with the unfiltered metals analyses, but the results for all samples were below the standard method reporting limits, and therefore the results are not included on Tables 5-6 through 5-11. In the filtered samples, "low-level" total mercury analyses were performed with lower reporting levels, and those results are included in the tables with the methylmercury results.

5.2.2.1 Background and Attribution Samples

Background and attribution surface water sample results are provided in Tables 5-6 through 5-11. Copper was one of the metals detected in both the unfiltered and filtered background samples, with concentrations ranging from 6.3 µg/L to 6.7 µg/L (unfiltered) and from 6.4 µg/L to 7.1 µg/L (filtered).

Copper exceeded the hardness-calculated CCC in three of the filtered background and attribution samples and exceeded the hardness-calculated CMC in one. In addition, total mercury was detected above the CCC in one filtered background sample.

5.2.2.2 Poned Water Samples

Poned water surface water sample results are provided in Table 5-6. Arsenic was detected at a concentrations of 229 µg/L (unfiltered) and 193 µg/L (filtered). Arsenic was also detected at a concentration of 659 µg/L in the unfiltered seep sample (no filtered sample was collected). Copper was detected at concentrations of 6.9 µg/L (unfiltered) and 7.4 µg/L (filtered).

Arsenic and total mercury were present in the filtered ponded water sample at concentrations that exceeded the CCC value, but below the CMC value, for each compound.

5.2.2.3 Adit Samples

Adit surface water sample results are provided in Table 5-7. Arsenic concentrations ranged from 32.4 µg/L to 43.3 µg/L (unfiltered) and 26 µg/L to 48 (filtered). None of the filtered samples exceeded the CCC or CMC for arsenic.

Copper concentrations ranged from 6.2 µg/L to 6.8 µg/L (unfiltered) and 6.4 µg/L to 6.5 µg/L (filtered). In the filtered samples copper and exceeded the CCC but not the CMC in two of the three adit samples.

Total mercury was detected above the CCC but not the CMC in all three of the filtered adit water samples, with concentrations ranging from 35.1 nanograms per liter (ng/L) to 68.9 ng/L.

5.2.2.4 West Fork Cinnabar Creek Samples

West Fork Cinnabar Creek surface water samples results are provided in Table 5-8. Arsenic was detected at concentrations ranging from 6.3 µg/L to 28.7 µg/L (unfiltered) and 6.9 µg/L to 27.6 µg/L (filtered). Copper was detected in all seven samples, with concentrations ranging from 6.4 µg/L to 6.8 µg/L (unfiltered) and 6.1 µg/L to 7.0 µg/L (filtered). None of the filtered arsenic or copper results exceeded the CCC or CMC.

In the five filtered samples analyzed for total mercury, concentrations ranged from 70.5 µg/L to 97.9 µg/L, all of which exceeded the CCC but not the CMC.

5.2.2.5 Cinnabar Creek

Cinnabar Creek surface water sample results are provided in Table 5-9. Arsenic concentrations ranged from 9.4 µg/L to 15.2 µg/L (unfiltered) and 10 µg/L to 13 µg/L (filtered), and copper ranged from 6.4 µg/L to 6.8 µg/L in both the unfiltered and filtered samples. None of the filtered arsenic or copper results exceeded the CCC or CMC.

The sample results also indicate the presence of total mercury at concentrations that exceed the CCC but not the CMC in all samples collected from Cinnabar Creek, with concentrations ranging from 26.9 ng/L to 39 ng/L.

5.2.2.6 Sugar Creek

Sugar Creek surface water sample results are provided in Table 5-10. Arsenic concentrations ranged from 3.7 µg/L to 13.3 µg/L (unfiltered) and 3.3 µg/L to 13.8 (filtered), and none of the filtered results exceeded the CCC or CMC.

Copper was detected at concentrations that ranged from 6.4 µg/L to 6.6 µg/L (unfiltered) and 6.4 µg/L to 6.7 µg/L (filtered). Two of the filtered samples exceeded the CCC but not the CMC.

In the filtered samples submitted for low-level analysis, total mercury concentrations ranged from 7.93 µg/L to 11 ng/L, with none exceeding the CCC or CMC.

5.2.2.7 September 2016 Surface Water Sampling

The results for surface water samples collected by EPA in September 2016 are provided in Table 5-11. Unfiltered mercury concentrations in samples collected from the West Fork Cinnabar Creek ranged from 143 µg/L to 320 ng/L, and filtered mercury ranged from 39.4 µg/L to 43.7 ng/L. All four filtered samples from the West Fork Cinnabar Creek exceeded the CCC of 12 ng/L. In the sample collected from Sugar Creek, unfiltered mercury was 25.7 ng/L and filtered mercury was 7.43 ng/L.

Methylmercury concentrations all samples were low, with a maximum unfiltered concentration of 0.114 ng/L and a maximum filtered concentration of 0.107 ng/L, both of which were collected from Sugar Creek.

5.2.3 Sediment Sample Results

The analytical results of the sediment samples, including TAL metals, methylmercury, TOC, and grain size, are presented in Tables 5-12 through 5-16. Additional discussion of the metals results with respect to the screening levels are presented in the following subsections.

5.2.3.1 Background and Attribution Samples

Background and attribution sediment sample results are provided in Tables 5-12 through 5-16. The results indicate that antimony, arsenic, and nickel exceeded at least one screening level in at least one of the background/attribution samples. Mercury exceeded the least conservative (i.e., highest) screening level in two of the background samples and the attribution sample.

5.2.3.2 Poned Water Sample

Poned water sediment sample results are provided in Table 5-12. Arsenic was detected at a concentration of 1,570 mg/kg, and mercury was detected at a concentration of 491 mg/kg, both of which exceeded all of the respective sediment screening levels. Antimony and cadmium were also detected at concentrations that exceeded all of their screening levels, and nickel was detected at a concentration that exceeded two of the screening levels.

5.2.3.3 Adit Samples

Adit sediment sample results are provided in Table 5-13. Sample results indicate the presence of antimony, arsenic, cadmium, copper, mercury, and nickel at concentrations that exceed at least one of the screening levels. Antimony was detected at concentrations that exceeded all of its screening levels in two of the samples and at concentrations that exceeded the most conservative screening level in one sample. Arsenic was detected at concentrations that exceeded all of its screening levels in all three samples at up to 20 times the highest screening level. Arsenic concentrations ranged from 158 mg/kg to 2,440 mg/kg. Cadmium was

detected at concentrations that exceeded the most conservative screening level in all three of the samples and one sample also exceeded the least conservative screening level. Copper and nickel were detected at concentrations that exceeded at least one screening level in one sample each. Finally, mercury was detected at concentrations that exceeded all of the screening levels in all of the samples. Mercury concentrations ranged from 206 mg/kg to 1,600 mg/kg and the concentration in the sediment sample collected from Adit 2 were three orders of magnitude greater than the highest screening level.

5.2.3.4 West Fork Cinnabar Creek Samples

West Fork Cinnabar Creek sediment sample results are provided in Table 5-14. Sample results indicate the presence of antimony, arsenic, cadmium, lead, mercury, and nickel at concentrations that exceeded at least one screening level in the West Fork Cinnabar Creek sediment samples. Antimony was detected at concentrations that exceeded the most conservative (i.e., lowest) screening level and the least conservative (i.e., highest) screening level in all seven of the sediment samples. Arsenic was detected at concentrations that exceeded the most conservative screening level in all seven of the samples collected and at concentrations that exceeded the least conservative screening level in six of the samples. Arsenic concentrations that exceeded both the most conservative and least conservative screening levels ranged from 152 mg/kg to 245 mg/kg. Cadmium was detected at concentrations that exceeded the most conservative screening level in six of the samples collected. Lead was detected at a concentration that exceeded the most conservative screening level in one sample. Mercury was detected at concentrations that exceeded all of its screening levels in all of the samples collected at concentrations at least 10 times higher than the least conservative screening level. Mercury concentrations ranged from 6.8 mg/kg to 131 mg/kg. Finally, nickel was detected at a concentration that exceeded the most conservative screening level in two samples, one of which also exceeded the least conservative screening level.

5.2.3.5 Cinnabar Creek Samples

Cinnabar Creek sediment sample results are provided in Table 5-15. Sample results indicate the presence of antimony, arsenic, cadmium, mercury, and nickel at concentrations that exceeded at least one screening level. Antimony was detected at concentrations that exceeded the most conservative (i.e., lowest) screening level in all of the samples and also at concentrations that exceeded the least conservative (i.e. highest) screening level in two of the samples. Arsenic and cadmium were detected at concentrations that exceeded the most conservative screening level in all of the samples and at a concentration that exceeded the least conservative screening level in one sample each. Mercury was detected at concentrations that exceeded all its screening levels in all of the samples, at concentrations at least five times the highest screening level. Mercury concentrations ranged from 3.9 mg/kg to 468 mg/kg. Finally, nickel was detected at concentrations that exceeded the most conservative screening level in the two most upstream samples.

5.2.3.6 Sugar Creek Samples

Sugar Creek sediment sample results are provided in Table 5-16. Sample results indicate the presence of antimony, arsenic, cadmium, and mercury at concentrations that exceed at least one of the screening levels. Antimony and arsenic were detected at concentrations that exceeded the most conservative (i.e., lowest) screening level in all five of the samples, with arsenic concentrations ranging from 20.1 mg/kg to 64.1 mg/kg. Cadmium was detected at a concentration that exceeded the most conservative screening level in one sample. Finally, mercury was detected at concentrations that exceeded all of its screening levels at concentrations at least ten times higher than the highest screening level. Mercury concentrations ranged from 8.8 mg/kg to 128 mg/kg.

6

Conceptual Site Model

This section discusses key aspects regarding the fate and transport of the primary contaminants of concern, arsenic and mercury, at the Cinnabar Mine site and downgradient locations. Information pertaining to the concentrations and extent of these and other contaminants in site sources and environmental media is presented in Sections 2 and 5.2.

6.1 Contaminant Sources

The primary sources of contaminants addressed in the Cinnabar Mine IA are drainage from collapsed adits and various tailings piles, including red tailings (calcines) and yellow and tan tailings (flotation tailings). Other contaminant sources have been the subject of previous removal actions and reports. Information on the geology, mineralization, mining operations, and ore concentration and thermal processing at the Cinnabar Mine that is germane to characterization of these sources is summarized below.

6.1.1 Geology and Mineralization of the Cinnabar Mine

The geology of the region and the Cinnabar Mine area is detailed in Schrader and Ross (1926), Currier (1935), Worthen (1943a; 1943b), and Mitchell (2000).

The regional geology as described by Mitchell (2000) follows. The area is underlain by granitic rocks of the Idaho batholith and by metamorphosed sedimentary rocks that are part of a large roof pendant. The Idaho batholith in this area is composed of medium-grained biotite granodiorite and coarse-grained muscovite-biotite granite. Regionally, the metasedimentary rocks are folded into a large, tight, northwest-plunging, overturned syncline and have been metamorphosed to the amphibolite facies. Intrusion of the granitic plutons of the Idaho batholith locally altered the carbonate metasedimentary rocks to skarn zones. The older rocks are intruded by dikes of various compositions associated with the Challis Volcanics.

Mitchell (2000) described the mineralization in the area as follows. The mines in the Stibnite area, located to the west of the Cinnabar Mine, are low-grade disseminated gold deposits with local concentrations of antimony, silver, and tungsten. The orebodies are located along the Meadow Creek shear zone and related structures. The gold, antimony, and tungsten deposits formed from hydrothermal fluids which rose through the shear zone. All three types of deposits may be cogenetic. The deposits are localized by changes in the strike or dip of the

main fault zone, which strikes generally north-south, and by the intersection of subsidiary northeast-trending faults within the main fault zone. Breccia zones at the base of thrust sheets cap the Yellow Pine and West End deposits. Mineralization occurred in several pulses, accompanied by hydrothermal alteration of the host rocks. Pyrite (iron sulfide, FeS_2), arsenopyrite (iron-arsenic sulfide, FeAsS), and gold were deposited first, accompanied by sodium- and potassium-metasomatism and sericitization of the wall rocks. The gold values are carried by the pyrite and arsenopyrite. Considerable movement along the Meadow Creek shear zone is believed to have taken place between the deposition of the gold and the later phases of mineralization.

Fine-grained tungsten minerals, dominantly scheelite, formed after the gold. Antimony-silver mineralization overlaps the late phase of tungsten mineralization. Stibnite (antimony sulfide, Sb_2S_3) occurs as disseminations, microveinlets, stockworks, massive lenses, small quartz-stibnite veins that fill fissures, and euhedral crystals coating late fractures. Silicification overlapped the end of the stibnite crystallization. Sericitization, accompanied by mercury mineralization, was the final ore-forming event in the area. The mercury mineralization was targeted at the Cinnabar Mine (also referred to as the Hermes Mine) and the Fern Mines (located south of the Cinnabar Mine). The mercury deposits are zoned vertically with respect to the paleosurface. The mercury deposits formed at or near to the surface, and the scheelite and stibnite formed at somewhat lower levels. (Mitchell 2000)

More detailed information on mineralization of the mercury deposits that include the Cinnabar Mine as described by Schrader and Ross (1926) is presented below:

“Most of the quicksilver ore is in limestone that has undergone igneous metamorphism and subsequent silicification, but cinnabar has also been noted in unsilicified limestone. The silicified limestone that accompanies the typical ore is composed largely of a fine-grained aggregate of quartz grains, frequently termed jasperoid, with sericite filling cracks and forming small irregular masses that apparently replace the quartz. The aplitic rocks in the T tunnel of the Hermes mine, however, were sericitized but not silicified. Pyrite grains, some of which have a tendency to crystal form, are scantily distributed and appear to have been produced later than both the quartz and the sericite. Cinnabar in small, irregular grains and in thin coatings on some of the pyrite grains was the latest mineral to form during the original mineralization. Some of it is in narrow seams in fractured jasperoid. In places such seams are so abundant as to indicate marked brecciation prior to the deposition of the cinnabar.”

Currier (1935) notes that “cinnabar is the only prominent sulphide mineral in the deposits, but in places a small amount of pyrite and a very little stibnite occur with the cinnabar, indicating a possible genetic connection between the mercury deposits and some or all of the antimony deposits in the area.”

6.1.2 Mining Operations

Mining operations during various phases of mining at the Cinnabar Mine are described in Schrader and Ross (1926), Currier (1935), Worthen (1943a; 1943b), and Mitchell (2000). Mining was performed underground, with three adits connecting the underground mine workings to the surface facilities. Worthen (1943b) notes that water was encountered widely in the mine workings and needed to be actively managed.

6.1.3 Ore Concentrating and Processing

In general, processing of mercury ore is a relatively straightforward process, usually involving roasting of the ore to thermally decompose the mercury compounds present in the ore and collecting the resulting elemental mercury in a condensing system. At some mercury mines, beneficiation of the ore has been practiced. At the Cinnabar Mine, roasting of cinnabar ore was conducted with rotary furnaces until 1956. After 1956, the ore was milled and cinnabar was concentrated using flotation and electro-separation. Thermal ore processing practices as of 1943 are described in Worthen (1943b).

Thermal processing of the ore resulted in calcines, which presently appear to be located at the “red tailings” piles at the Cinnabar Mine. The red color of the calcines is likely due to the presence of compounds of oxidized iron, at least some of which originated from the pyrite noted to be locally associated with the cinnabar mineralization (Schrader and Ross 1926; Currier 1935). The flotation tailings appear to be currently located in the tailings impoundment, tan tailings pile, and upper yellow tailings pile area.

6.1.4 Contaminants in Ore Concentrating and Processing Wastes

Based on available historical information on geology and mineralogy, the only native mercury species documented at the Cinnabar Mine is cinnabar (HgS). Cinnabar is expected to be present in ore, waste rock, and areas of the site with naturally occurring mercury mineralization. Elemental mercury was produced on site by thermal processing of the cinnabar ore. Elemental mercury has been identified in contaminated soils at the site during previous investigations and removal activities. It is possible that some residual cinnabar that was not broken down by thermal processing could be present in the calcines, and some residual cinnabar not recovered by flotation could be present in the flotation (tan and yellow) tailings.

Site-specific information regarding other forms of mercury that may be present in the calcines is not available. In general, other forms of mercury are more commonly formed in furnaces, such as were used at the Cinnabar Mine, than in retorts, used to thermally process mercury ore at other mines, because furnaces internally heat the ores, mixing exhaust gases from the fuel with mercury vapor. In general, extended X-ray adsorption fine structure (EXAFS) spectroscopy studies of mercury mine wastes indicate that the mercury species likely to form during the thermal processing of mercury ores include mercury sulfides (e.g., metacinnabar [m-HgS], mercuric oxide (HgO), mercury chlorides (e.g., HgCl₂), corderoite (Hg₃S₂Cl₂), and schuetteite (HgSO₄-H₂O), all of which are more soluble

than cinnabar and may represent an important source of soluble mercury at mercury mine sites with furnaces (Rytuba 2002; Lowry et al. 2004).

Arsenopyrite is the dominant form of arsenic in the stibnite and arsenical-gold deposits mined at the Meadow Creek and Yellow Pine mines (e.g., Mitchell 2000). However, information on the forms of arsenic occurring in the zone of mercury mineralization targeted by the Cinnabar Mine is lacking.

Calcines, or red tailings, and flotation tailings were sampled as part of the 1996 time-critical removal action, 1998 removal action, 2014 removal assessment, and the IA. Concentrations of total arsenic and mercury are presented in Tables 2-5, 2-7, and 5-5.

6.2 Wind Transport

Contaminants contained in or adsorbed to calcines, flotation tailings, and contaminated soil can be transported both within a site and offsite as windblown particles. The potential for aeolian (wind) transport of contaminated particles is dependent on snow cover, vegetative cover, soil moisture, and grain size distribution of the soil exposed to wind action. No field studies were performed during the IA or previous investigations to evaluate wind transport of contaminants.

6.3 Volatilization and Emission of Mercury

A potential pathway for release of mercury from both naturally enriched areas and anthropogenic sources, including mercury-contaminated sites, is emission to the atmosphere. In general, forms of mercury that may be volatilized and emitted include elemental mercury ($\text{Hg}(0)$), dimethylmercury ($(\text{CH}_3)_2\text{Hg}$), and mercury (II) as mercuric chloride (HgCl_2), mercuric bromide (HgBr_2), or mercuric (II) hydroxide ($\text{Hg}(\text{OH})_2$) (ATSDR 1999; Nacht et al. 2004). At the Cinnabar Mine, it is expected that the vast majority of mercury that may be subject to volatilization would be in the form of elemental mercury, $\text{Hg}(0)$. No field studies were performed during the IA to evaluate volatilization and emission of mercury.

6.4 Groundwater and Surface Water Transport

Transport of contaminants in groundwater and surface water is occurring at the Cinnabar Mine. Surface water transport includes bed load sediment transport, suspended particulate transport, and dissolved phase transport. Migration of particulates occurs as a result of erosion and entrainment of soil and sediment particles. Particulate transport also may occur in groundwater. Factors and processes that may be influencing these transport mechanisms are generally discussed in the sections below. Interpretations of the IA results and previous investigations pertaining to these factors and processes also are discussed below.

Leaching is the process by which inorganic elements are released from the solid phase into the aqueous phase by dissolution and desorption processes. Leaching of inorganics from contaminant sources is occurring at the Cinnabar Mine site. Leaching of inorganic elements from naturally mineralized bedrock and soil also

is occurring. Leached contaminants are being transported in groundwater and surface water.

In general, the potential for leaching of inorganic elements is related to the solubility of the various forms of the element, the amount of water percolating through the materials containing the elements, pH and oxidation-reduction (redox) potential, tendencies of various species of the elements to form complexes and adsorb to solids materials, and microbiological activity. Generally, such water may include precipitation and snowmelt and other sources of groundwater (e.g., infiltrated surface water or underflow). The amounts and rates of water percolating through the materials depend on the flow paths and other site-specific hydrologic conditions. The flow pathways of both groundwater and surface water determine the chemical, physical, and biological environments in which leaching and mobilization of inorganic elements may occur.

The amounts of inorganic elements leached to groundwater are controlled primarily by the amounts of the elements present; rate of release; hydrologic factors such as dispersion, advection, and dilution; and geochemical processes such as interrelated processes of redox, adsorption-desorption, and precipitation/dissolution; and aqueous speciation.

Specific factors controlling release and migration of inorganic elements in sulfide minerals include presence and flux of water and oxygen, which are required for oxidation reactions that dissolve sulfide minerals. These factors are controlled by hydrogeologic/hydrologic factors such as diffusion of oxygen, flow of oxygenated groundwater, and fluctuation of the water table. Other factors associated with oxidation of sulfide minerals are ferric iron; bacteria that catalyze the oxidation reactions; heat generated from the exothermic oxidation reactions; mineralogy of the sulfides and the materials in which oxidation is occurring; and acid neutralization reactions.

6.4.1 Erosion and Mass Wasting

Erosion includes the physical processes by which moving surface water transports solid materials, such as surface water runoff and stream erosion. In general, mass wasting is the downslope movement of soil and rock under the influence of gravity; it includes creep, slides, debris flows, slumps, rock flows, rockfalls, and block glides.

Surface runoff, also known as overland flow, is the flow of water that occurs when stormwater, meltwater, or other sources flows over the ground surface rather than infiltrating into the subsurface. Such conditions may occur when the soil is saturated to full capacity, when rain falls at a rate exceeding the rate that the soil can absorb it, or because of low-permeability soils or other materials at the surface or at a shallow depths. Runoff is a primary agent in soil erosion by water, and includes splash erosion, sheet erosion, rill erosion, and gully erosion. Runoff also may include erosion of the soil beneath the snowpack during snowmelt when meltwater percolates downward through the snowpack and erodes soil particles at the soil surface.

Stream erosion occurs with water flow in a channel. Initially, stream erosion is usually predominantly downward and headward, resulting in steep banks and head cuts. After a base level is reached, the stream erosion typically becomes dominated by lateral erosion. Stream erosion is greatest during times of high discharge, when more and faster-moving water is available to carry a larger sediment load. Erosion is accomplished by not only the moving water, but by suspended abrasive particles and larger bed load particles (e.g., pebbles, cobbles, and boulders).

Generally, the potential for transport by erosion is dependent on the slope of the erosional surface; the surface area of exposed materials subjected to erosion; the size, shape, and density of the grains; the cohesiveness of the material; and the frequency and magnitude of precipitation and runoff events.

Etheridge (2015) describes the physical elements associated with erosion in the USGS study area (Etheridge 2015), which includes the Cinnabar Mine area, as follows:

“The study area includes 42.9 mi² of steep mountain terrain ranging from 5,930 to 9,310 ft in elevation. Seventy-one percent of the study area slopes at a gradient greater than 30 percent (USGS 2012), resulting in occasional mass wasting and substantial surface erosion during periods of rainfall and snowmelt runoff. Mean annual precipitation is 31 in., falling mostly as snow between October and April. Peak snowmelt and streamflow typically occur between May and July and low flows occur from September to January (Kuzis 1997).”

Based on historical photographs, the tailings piles at the Cinnabar Mine have previously had steep slopes and exhibited clear evidence of surface runoff, including formation of rills. The tailings also exhibited undercutting by stream erosion. Erosion by downcutting in the stream channel also may have occurred where the tailings had been previously been disposed of or deposited into the stream channel at rates exceeding the capability of the stream to transport the material downstream.

Previous removal actions have included relocating tailings and armoring stream channels to reduce erosion by undercutting and stream erosion. Removal actions also have included regrading, including reducing of slopes, and attempts to establish vegetation to reduce surface runoff. Review of the IA photographs did not reveal obvious visual indications of undercutting of banks or downcutting in the areas of the tailings. The review of IA photographs also reveals that vegetation has not been fully established on the tailings. The IA photographs did not reveal obvious visual indications of rilling of the exposed tailings. However, the presence of lag gravel at the tailings surface, contrasting with the comparatively fine-grained nature of the underlying material, was observed widely in IA tailings sample locations. This suggests that finer materials have been removed by erosion

since the previous removal actions, possibly including erosion by wind, stormwater runoff, and/or snowmelt.

Tailings that have historically entered West Fork Cinnabar Creek by mass wasting and erosion have been subject to surface water transport downstream of the site within West Fork Cinnabar Creek, Cinnabar Creek, Sugar Creek, and further downstream, as evidenced by bed sediment sample results (see Section 6.4.7.1 below). It is not known how much of the present bed sediment distribution in West Fork Cinnabar Creek and downstream creeks is due to historical mass wasting and erosion of tailings and ongoing downstream transport versus possible continued addition of tailings to the creek at the site.

In addition to bed sediment, erosion results in suspended particulate transport. Suspended sediment transport is discussed in Section 6.4.7.1.

6.4.2 Factors and Processes Affecting Mobility of Mercury

This section summarizes general information on the mobility of mercury in the environment. Those factors and processes thought to be pertinent to groundwater and surface water transport at the Cinnabar Mine site are discussed in Sections 6.4.5 through 6.4.7.

In general, mercury concentrations in mine drainage vary widely. This is caused by several factors. The most important factors are the solubility of the mercury phases with which the mine drainage interacts and the amount and adsorption capacity of the particulate phases present.

Mercury speciation is also an important variable in assessing the potential environmental impact on water quality and toxicity to biota. The mercury species present in mine drainage are strongly affected by chemical processes that occur when mine drainage reacts with mine wastes and surface waters. Adsorption of mercury and methylmercury onto iron oxyhydroxide and aluminum phases is an important process that controls the concentration of mercury species in streams impacted by mercury mine drainage. As a result, most of the mercury species present in streams impacted by mine drainage are present in the particulate phases and the concentrations of dissolved mercury species are relatively low (Rytuba 2000).

Redox, precipitation-dissolution, aqueous complexation, and adsorption and desorption reactions strongly influence the fate and transport of mercury in the environment. Biogeochemical reactions also are of great importance to the fate and transport of mercury. Methylation of mercury results in the formation of methylmercury, which is significantly more toxic than inorganic forms of mercury. Numerous studies on these subjects have been published. Except as noted, the information presented below is adapted from one recent literature review of such studies presented by Barringer et al. (2013). Additional general information and results of site-specific studies pertaining to methylation and other aspects of fate and transport of mercury are presented in an EPA's methylation study report, provided in Appendix B.

6.4.2.1 Oxidation-Reduction

Mercury exists in the environment in three stable oxidation states: Hg(0), Hg(I), and Hg(II). The mercury oxidation states and the various chemical forms that exist for each oxidation state vary in their toxicity as well as their solubility, their tendency to form complexes and adsorb, and their availability for microbial processes. As such, redox reactions have a profound influence on mercury concentrations and mobility in groundwater. Both abiotic and biotic (primarily microbial) processes can drive mercury redox transformations.

6.4.2.2 Adsorption and Desorption

Iron geochemistry is intimately associated with mercury geochemistry. Studies show that Hg(II) (as an Hg-Cl complex) sorbs to pyrite (FeS_2) under anaerobic conditions, and Hg(II) sorbs to iron oxides at $\text{pH} > 5.5$. Evidence from field studies, including some at mine sites, suggests that sorption of mercury to iron hydroxides serves to reduce the mobility of mercury in the aqueous environment. Formation of aqueous and solid-phase sulfides appears to control Hg(II) concentrations in tailings-contaminated sediments at some mines.

6.4.2.3 Organic and Inorganic Complexation

Mercury (Hg(II)) can be present as $\text{Hg}(\text{OH})_2$, HgCl_2 , and other minor hydroxide (OH^-) and chloride (Cl^-) complexes, as well as in complexes with various organic anions, depending on pH, redox potential, chloride concentrations, and concentrations of dissolved organic matter (DOM). It has been observed that where DOM is absent or present in low concentrations in fresh waters, mercury could be present as hydroxide and chloride complexes. At low to moderate pH and moderate to high chloride concentrations, chloride complexes would be most likely. In the presence of dissolved sulfide, mercury sulfide species may form.

Mercury tends to form strong complexes with S^{2-} and, in DOM, Hg(II) binds preferentially to sulfur-containing functional groups such as thiols.

In environments under anoxic conditions, mercury can form complexes such as dissolved HgS , HgS_2^{2-} , $\text{Hg}(\text{SH})_2$, HgSH^+ , HgOHSH , and HgClSH . Although metals typically bind to acid sites (carboxyls, phenols, ammonium, alcohols, and thiols), in organic matter Hg(II) binds preferentially to thiols and other reduced sulfur groups, forming strong covalent-like bonds. These sulfur-bearing groups are found in moderate abundance in organic matter in soils, in some surface water, and in wastewater. When the mercury/DOM ratio is high (e.g., greater than 10,000 nanograms (ng) mercury to 1 milligram of DOM), mercury also binds to the more abundant but less Hg-selective oxygen functional groups (i.e., carboxyl). Binding of Hg(II) with DOM is less strong at low pH than at high pH because the extent of protonation of functional groups serving as Hg(II) ligands on DOM increases as pH decreases. It has been shown that, due to the affinity of Hg(II) for thiol groups on DOM, DOM can dissolve cinnabar, inhibiting or preventing precipitation of metacinnabar and aggregation of HgS nanoparticles.

6.4.2.4 Methylation and Demethylation

An important transformation of inorganic mercury that affects the mobility and toxicity of mercury is methylation to methylmercury (including monomethylmercury or dimethylmercury) in soil, sediment, and waters. Methylmercury, a form of Hg(II), is the most common form of organic mercury and is soluble, mobile, and quickly enters the aquatic food chain. Methylmercury is substantially more toxic than other forms of mercury and is accumulated to a greater extent in biological tissue than are inorganic forms of mercury (ATSDR 1999). The processes of methylation are complex and not fully understood. Factors understood to affect methylation of mercury are total mercury concentrations; organic matter content; acid-volatile sulfide in sediment; and pH, dissolved organic carbon, and dissolved sulfate in water. Methylation of Hg(II) in soils and surface-water occurs under anoxic conditions by dissimilatory sulfate-reducing bacteria. Dissimilatory iron-reducing bacteria also are able to methylate Hg(II). Populations of both types of bacteria have been found to coexist in stream-bottom sediments.

At low sulfate (SO_4^{2-}) concentrations, the methylating activity of sulfate-reducing bacteria is stimulated, but at high sulfate concentrations the methylating activity may be inhibited because precipitated sulfides may incorporate the mercury. However, the mercury in aqueous HgS complexes, which may form in the presence of dissolved sulfide, was found to be bioavailable to the methylating bacteria.

High concentrations of DOM and salinity also were shown to inhibit Hg(II) methylation because the Hg was complexed into forms that were not bioavailable to the methylating bacteria. Although DOM can inhibit mercury bioavailability by complexing the mercury, DOM can also prevent HgS nanoparticles from aggregating, thereby leaving the HgS nanoparticles bioavailable.

Mercury demethylation also occurs in stream and lake sediments. In sediment experiments, demethylation of methylmercury was shown to be carried out by sulfidogenic and methanogenic bacteria, which are obligate anaerobes. One study showed that, although the mercury methylation process was inhibited by low pH (4.4) conditions, demethylation of methylmercury did not appear to be similarly affected for the pH range 4.4 to 8; however, inhibition of demethylation occurred at $\text{pH} < 4.4$.

6.4.2.5 Colloids and Particulates

Formation of colloids in groundwater and surface water may provide a means of either immobilizing or facilitating transport for various contaminants, including mercury. Variations in the mineralogy and porewater chemistry in mine tailings can significantly influence the extent of colloid release, influencing the potential for particulate-facilitated mercury transport. Distinguishing between particulate (colloidal) and dissolved mercury in water is important because the speciation can affect bioavailability and methylation potential.

Sorption of Hg(II) onto stable and immobile aquifer solids can limit concentration and mobility of mercury in groundwater. On the other hand, if the Hg(II) binds to colloids under conditions where the colloids are stable and mobile, concentrations and mobility of Hg(II) in groundwater can increase. Because of their large surface area relative to their volume, small particles and colloids can provide many sorption sites for strongly sorbing contaminants whose mobility would otherwise be minimal through soils and groundwater. Movement of such colloids can be triggered by chemical or physical disturbance of soils and sediments.

Colloids can be formed by clay minerals; oxides and hydroxides of iron, aluminum, and manganese; silica; humic and fulvic acids; carbonates; phosphates; and bacteria and viruses. Colloids are found in surface water, soil, sediment porewaters, and groundwater. Changes in pH and redox reactions can cause dissolution or precipitation reactions that can form or release colloidal particles.

6.4.3 Factors and Processes Affecting Transport of Mercury in Groundwater

This section summarizes general information on factors and processes affecting transport of mercury in groundwater. Those factors and processes thought to be pertinent to groundwater transport at the Cinnabar Mine site are discussed in Sections 6.4.5 through 6.4.7.

In general, inorganic elements can migrate directly into groundwater from sources that lie within the saturated zone or by leaching from overlying source materials. Transport and concentrations of contaminants in groundwater are governed by the processes of advection, hydrodynamic dispersion (including mechanical dispersion and molecular diffusion), adsorption/desorption, precipitation and dissolution, and recharge. Leaching and migration of inorganic elements in groundwater is affected by groundwater flow pathways and the geochemical conditions present at any given time and at any given location along those pathways.

Release and migration of inorganics in sulfide minerals are controlled by the presence and flux of water and oxygen; ferric iron; bacteria that catalyze the oxidation reactions; heat generated from the exothermic oxidation reactions; mineralogy of the sulfides and the materials in which the oxidation is occurring; and acid neutralization reactions.

In general, many trace inorganics are strongly adsorbed onto surfaces of minerals and organic compounds in soils and sediments, limiting their mobility in the environment. The strong adsorptive capabilities of secondary clay minerals, hydrous iron, aluminum and manganese oxides, and humic material have been well demonstrated, and may be responsible for retardation of transport of trace metals in groundwater.

Rytuba (2000) describes interactions of mine drainage and calcines commonly seen at mercury mines as follows. Mercury concentrations increase substantially in mine drainage as the water flows through and reacts with calcines and waste

rock. Mine drainage dissolves the more soluble mercury phases present in the waste rock and calcines, in which the mercury is commonly present in relatively soluble phases such as mercury sulfates and oxy-chlorides that were formed during thermal processing. As the mine drainage mixes with oxygenated stream waters, dissolved iron (II) becomes oxidized to iron (III) and forms an iron oxyhydroxide precipitate. The iron oxyhydroxide effectively adsorbs mercury as well as methylmercury. As a result of this adsorption, the relative proportions of the dissolved forms of both these mercury species decreases downstream and the mercury species are transported primarily in the particulate phase. If the stream flow is slow, the iron oxyhydroxide commonly accumulates on the surface of the streambed as a floc (commonly referred to as yellowboy). Mercury and methylmercury adsorption onto iron oxyhydroxide substrate is an important process that controls the concentration of mercury species in streams impacted by mercury mine drainage.

In general, filtered samples (0.45 micrometer pore size filter) of mine drainage always have lower concentrations of mercury indicating that a significant portion of the mercury present is adsorbed onto particulate phases and colloids (Rytuba 2000). Colloids have been variously defined as particles with diameters less than 10 micrometers (Puls et al. 1991) and as particles usually less than 1 micrometer in one dimension (Kretchmar and Schafer 2005) that generally are sufficiently small so as to pass the 0.45 micrometer pore-size filters commonly used to collect filtered water samples. Colloids can be composed of both organic and inorganic materials. In addition to having a high surface area per mass and volume, colloidal particles consisting of dissolved organic carbon, clay minerals, and iron oxides also are highly reactive sorbents for a variety of contaminants, including inorganic elements. Migration of inorganic elements in groundwater may be significantly affected by the formation of and adsorption of trace inorganics onto colloids. As with other aquifer solids, if the colloidal particles are immobile, the colloids will serve to inhibit the migration of inorganics that adsorb to the colloids. On the other hand, if the colloids are mobile in groundwater, they could facilitate transport of the inorganics rather than inhibit it.

Multiple factors control the formation and mobilization of colloids in groundwater and surface water. Large changes in aqueous geochemistry can result in supersaturated conditions in which inorganic colloidal species are formed. Decreases in pH or changes in redox conditions can cause the dissolution of soil materials or geologic matrix cementing agents, promoting the release of colloidal particles. Decreases in the ionic strength of an aqueous phase can enhance stability of colloids and promote their transport. Studies have shown that particles with diameters greater than 1 micrometer may actually move faster in groundwater than the average groundwater flow velocity in porous media due to effects such as size exclusion from smaller pore spaces. The significance of colloidal mobility as a transport mechanism ultimately depends on the presence of sufficient quantities of reactive particles in groundwater (e.g., Puls et al. 1991).

6.4.4 Mercury Species at Cinnabar Mine

The native mercury at the Cinnabar Mine site is in the form of cinnabar (HgS), which is expected to be present in flotation tailings, naturally mineralized bedrock and soil, and to a lesser degree, in calcines. Cinnabar is minimally soluble under most environmental conditions. Site-specific information regarding other forms of mercury that may be present in the calcines is not available. As noted above, thermal processing of mercury ore resulted in vapor phase and liquid elemental mercury (Hg(0)).

No other information on the mercury species at the Cinnabar Mine is available. In general, thermal processing in furnaces commonly results in secondary forms of mercury, including chloride and sulfate species that are significantly more soluble than cinnabar.

Samples of flotation tailings (yellow tailings) and calcines (red tailings) were collected for SPLP analysis in 2014. SPLP arsenic and mercury results are summarized in Table 2-11. Total mercury and arsenic concentrations are typically higher in the flotation tailings than the calcines, but the SPLP arsenic and mercury concentrations are generally higher for the calcines than the yellow tailings, suggesting that the forms of arsenic and mercury present in the calcines are more readily soluble, at least under slightly acidic conditions simulated by the SPLP test. This observation is generally consistent with information regarding the solubility of mercury species expected to be formed during roasting of cinnabar ore in furnaces (discussed above).

6.4.5 Groundwater at Cinnabar Mine

Information on groundwater and hydrogeology at the Cinnabar Mine is limited. No soil borings or monitoring wells have been installed at the site to assess subsurface soil, bedrock, or hydrologic conditions. The groundwater flow pathways at the Cinnabar Mine have not been characterized. Groundwater emerges into the underground mine workings and eventually discharges as surface water from the adits. As noted above, it is likely that at least some of the adit discharge occurs as underflow (groundwater) in the unconsolidated materials in the West Fork Cinnabar Creek valley. Such underflow and groundwater derived from infiltration of precipitation and snowmelt and groundwater migrating laterally through the unconsolidated materials from other sources is expected to flow through native alluvium in the valley and locally emerge as surface water at gaining reaches of West Fork Cinnabar Creek and other surface water features (e.g., seeps/springs). It is likely that at least some of the groundwater that emerges as surface water has contacted and been impacted by mine wastes, including calcines and flotation tailings.

In general, leached contaminants enter groundwater directly where/when groundwater immerses source materials (e.g., calcines, flotation tailings, waste rock, and contaminated soil), and by leaching and downward transport toward groundwater where groundwater level is beneath the source materials. Leaching of inorganic elements from naturally mineralized bedrock and soil and migration via groundwater and surface water also is occurring

In general, in settings where groundwater is discharging to a surface waterbody (i.e. gaining conditions), groundwater contributes to chemical loading of the surface water body by advective groundwater flow. As noted above, gaining conditions are suspected to occur in West Fork Cinnabar Creek at least locally at times in the area of the Cinnabar Mine. This is supported by results of porewater sampling performed as part of the EPA methylation study (Appendix B). Porewater samples were collected using Macro-Rizon samplers (Rhizosphere Research Products) outfitted with 0.15 micrometer filters. Porewater filtered total mercury concentrations are presented graphically in Figure 6-1. The EPA porewater study identified a relatively strong correlation between collocated porewater and surface water filtered total mercury concentrations, and concluded that shallow groundwater flow may be an important source of filtered total mercury in the stream during low flow conditions. Those results and other results and observations presented in this section support that conclusion.

Locally gaining conditions are supported by another important observation of the EPA porewater results. The filtered total mercury concentration of the porewater sample at the WF05 location (816 ng/L) is an order of magnitude greater than that of the collocated surface water sample (97.9 ng/L), which is the highest filtered total mercury concentration observed in the stream surface water samples during the IA. The large difference in filtered total mercury concentrations is likely explained by dilution of groundwater by surface water within the hyporheic zone – the zone where groundwater and surface water are mixed in shallow stream bed sediments.

It should be noted that, in general, various interrelated physical and biogeochemical processes can be active in the transition zone between groundwater and surface water, including redox-driven sorption reactions, microbial and plant uptake, and mixing with overlying surface water. These processes can create strong vertical solute concentration gradients over short distances and considerably alter the chemical character of groundwater that discharges into the surface water. In many cases, processes active near the groundwater/surface water interface will decrease or attenuate dissolved chemical concentrations as groundwater approaches the point of discharge. In view of these general processes and the processes known to influence transport of mercury in groundwater (see Section 6.4.3), the porewater sample results are likely representative of hyporheic zone conditions, and may be significantly lower than groundwater concentrations.

6.4.6 Adit Discharge

Each of the three adits (Adits 1, 2, and 3) at the Cinnabar Mine discharges to the surface. Adit discharge reflects impacts of groundwater flow through mineralized rock and underground mine workings. As noted in Section 6.1.2, groundwater entering the mine required active management during mine operations. Based on available information on the configuration of the underground workings, with the adits at a structurally low position, it is expected that groundwater will continue to enter the mine and discharge to the surface through the adits. Flow rates of the

adits at the times of IA sampling were visually estimated to be low. The adits portals are collapsed, and it is likely that some adit discharge occurs as underflow (i.e., groundwater) through unconsolidated soil materials near and downgradient of the collapsed portals. Adit discharge also contributes directly to surface water flow in West Fork Cinnabar Creek and, likely, indirectly to stream flow via groundwater.

Contaminants are present in samples of surface water discharging from Adits 1, 2, and 3. Sample results are presented in Tables 2-12 and 5-7. Adit discharge is discussed further in Section 6.4.7.

6.4.7 Surface Water Transport

In general, surface water transport processes include transport of dissolved and suspended particulate phase materials and bed load transport. Surface water transport of contaminants generally entails the physical movement of dissolved or suspended particulate phase chemicals with the flow direction of surface water systems. Materials transported as suspended load may be deposited at locations downstream under low energy conditions. These general processes are discussed below.

6.4.7.1 Bed Load Sediment Transport

In general, sediment bed load transport is the process by which solid materials are moved downstream by moving water—including movement by rolling, sliding, and saltation—and deposited in a downstream location. Bed load transport is primarily dependent on sediment grain size and shape, flow velocity, and stream bed morphology. At the Cinnabar Mine, bed load transport of contaminants has historically occurred as evidenced by the presence of site contaminants in stream bed sediment samples collected as part of the IA (see Tables 5-14 through 5-16) and previous investigations (e.g., see Table 2-10 and 2-13). Concentrations of total arsenic and mercury and methylmercury in IA samples of stream bed, background, adit, and ponded area sediment are presented graphically in Figure 6-2. Sediment samples in Figure 6-2 are arrayed generally from upstream (left) to downstream (right), with samples collected from features not immediately on the stream channel (adits and area of ponded sediment) or from background/attribution locations positioned on the figure at locations where drainage from the features is expected to enter the stream channel. It is likely that downstream transport of contaminated bed load sediment will continue to occur, consisting at a minimum of contaminated sediment already present in the stream bed or banks at any locations potentially subject to scour. Should any tailings or other mine waste or contaminated soil be eroded into the channel and settle out as bed load, those materials also would be subject to downstream migration. Potential ongoing and future erosion and mass wasting are discussed in Section 6.4.1.

6.4.7.2 Surface Water Dissolved Phase Transport

In general, dissolved phase chemicals enter surface water by influx of groundwater under gaining flow conditions and by dissolution and/or desorption of chemicals from rock and mineral particles in contact with the surface water,

including bed and suspended sediment. The magnitude of surface water dissolved transport is generally dependent on groundwater influx and tendency of contaminants to dissolve or desorb from the bed or suspended sediments.

IA (August and September 2016) and USGS (Etheridge 2015 and Holloway et al. 2016) surface water sampling results are interpreted to indicate that transport of contaminants in the dissolved phase in surface water is occurring presently at the Cinnabar Mine site and downstream water bodies. Concentrations in filtered surface water samples of selected parameters, including arsenic (total), mercury (total), and methylmercury, are presented graphically in Figures 6-1 (IA August 2016), 6-3 (IA September 2016), 6-4 (USGS August 2014), and 6-5 USGS (July 2015). In each figure, locations of samples of creek, background, adit, and the ponded area are arrayed generally from upstream (left) to downstream (right), with samples collected from features not immediately on the stream channel (adits and area of ponded sediment) or from background/attribution locations positioned on the figure at locations where drainage from the features is expected to enter the stream channel.

As shown in Figures 6-1 and 6-3 through 6-5, for any given sampling event, West Fork Cinnabar Creek surface water exhibited the highest filtered total mercury and arsenic concentrations within the area of the tailings (including calcines and yellow/tan flotation tailings). The concentrations generally decreased with distance downstream within West Fork Cinnabar Creek, Cinnabar Creek, and Sugar Creek, likely due to dilution.

The highest sampling density within the immediate mine area for any given synoptic surface water sampling event was achieved as part of the August 2016 IA sampling event, in which samples were collected from near the downstream end of the calcines (station WF05), near the downstream end of the yellow tailings (station WF04), and near the northeastern end of the tailings impoundment. The sample location from station WF05 contained the highest concentration of filtered total mercury (97.9 ng/L). Similarly, the sample from WF05 collected during the September 2016 IA sampling event exhibited the highest filtered total mercury concentration (43.7 ng/L) of the four samples collected. As discussed in Section 6.4.5, the porewater sample collected from WF05 also contained the highest filtered total mercury concentration (816 ng/L). These results collectively suggest that the calcines are a significant source of the filtered total mercury loading to the creek, at least during low flow periods. This conclusion is further supported by general information on the nature of mercury in calcines (see Section 6.1.4) and SPLP results (see Section 6.4.4).

Surface water sampling performed during the IA and USGS stream monitoring activities (Etheridge 2015 and Holloway et al. 2016) employed the use of 0.45 micrometer filters to collect filtered samples. Concentrations in samples collected with 0.45 micrometer filters are commonly referred to as “dissolved” concentrations. As noted in Section 6.4.5, the EPA porewater sampling (see Appendix B and Section 6.4.5) employed Macro-Rhizon samplers with 0.15

micrometer filters to sample the “dissolved” fraction concentrations presented herein and in Appendix B.

Total concentrations of arsenic were generally similar to the dissolved concentrations at each sample location for each sampling event. This is interpreted to indicate that transport of arsenic in the surface water is dominated by dissolved phase transport, and that the source of the arsenic is groundwater. In creek surface water samples, filtered total mercury concentrations are strongly correlated to filtered arsenic concentrations (e.g., $R^2 = 0.82$, $p < 0.00001$ for the August IA samples; see Figure 6-6), further suggesting that groundwater is an important source of the filtered (“dissolved”) mercury loading to the stream.

6.4.7.3 Surface Water Particulate Transport

In general, suspended phase transport of particulates depends primarily on flow velocity and turbulence, grain size and shape, and grain density. Temporal changes in the flow, particularly flow velocity, strongly influence whether particulate materials at a given location are subject to erosion or deposition at a given time. Materials that are deposited under one set of physical and chemical conditions may be subject to subsequent entrainment and transport under another set of conditions.

As noted above, surface water sampling performed during the IA and USGS stream monitoring activities (Etheridge 2015; Holloway et al. 2016) employed 0.45 micrometer filters, and porewater sampling employed 0.15 micrometer filters to unfiltered samples. Concentrations in samples collected with 0.45 micrometer filters are commonly referred to as “dissolved” phase concentrations. Concentrations in unfiltered samples are often referred to as “total” concentrations, which include the “dissolved” fractions as well as particulates that are too large to pass through the filter. In this report, the term total is used to refer to as the total recoverable concentrations, as opposed to concentrations of various species, such as methylmercury or arsenic (III), that represent a fraction of the total recoverable concentrations.

IA and USGS (Etheridge 2015 and Holloway et al. 2016) surface water sampling results indicate that transport of contaminants as particulates in surface water is occurring presently at the Cinnabar Mine site and downstream water bodies. Available results of unfiltered surface water concentration of selected parameters, including arsenic (total) and mercury (total), and iron (total) are presented graphically in Figures 6-1 (IA August 2016), 6-3 (IA September 2016), and 6-5 USGS (July 2015). In each figure, locations of samples of creek, background, adit, and the ponded area are arrayed generally from upstream (left) to downstream (right), with samples collected from features not immediately on the stream channel (adits and area of ponded sediment) or from background/attribution locations positioned on the figure at locations where drainage from the features is expected to enter the stream channel.

As shown in Figures 6-1 and 6-3 through 6-5, for any given sampling event, West Fork Cinnabar Creek surface water exhibited the highest unfiltered total mercury

and arsenic concentrations within the area of the tailings (including calcines and yellow/tan flotation tailings). The concentrations generally decreased with distance downstream within West Fork Cinnabar Creek, Cinnabar Creek, and Sugar Creek, likely due to dilution.

In general, suspended particulates in surface water represented by unfiltered sample concentrations include any suspended particles that are too large to pass through the filter. Such particles may include eroded soil particles and sediment particles that become re-suspended and entrained during periods of higher flow. Such particles also may include particles formed by chemical precipitation in the water (e.g., iron oxyhydroxides) such as described in Sections 6.4.2, 6.4.3, and 6.4.5.

Although iron concentrations are generally low at the Cinnabar Mine site, pyrite was observed during mining and some iron oxyhydroxide precipitate (yellowboy) has been observed locally during the IA at Adit 2 (photo 32, Appendix C), Adit 3 (photos 33 and 34, Appendix C), and “seep area” (identified as location AD04 in Figure 3-1), all of which drain into West Fork Cinnabar Creek.

Limited available unfiltered total iron surface water results (USGS July 2015 sampling) are presented graphically in Figure 6-5. The form(s) of total iron present in these samples is not known, but it is possible that at least some is in the form of iron oxyhydroxide. Samples from locations expected to possibly contain iron oxyhydroxide derived from the Cinnabar Mine drainage are limited to samples from five locations V (Adit 2), W and G (near WF03), C (near CC01), S (near SC03), and Q (between SC01 and SC02). Concentrations of unfiltered total iron and unfiltered total mercury are highest at location W and G, the nearest location downstream of the tailings (calcines and flotation tailings), and generally decrease with distance downstream until reaching location Q, which exhibits a nearly two-fold increase in unfiltered total mercury and six-fold increase in unfiltered total iron. The reason(s) for the increase at downstream location Q is not clear. Paired results of unfiltered total iron and unfiltered total mercury were compared. When the sample from location Q is excluded from the regression, there is a significant positive correlation ($R^2 = 0.99$, $p = 0.005$) between unfiltered total mercury and unfiltered total iron in stream samples (see Figure 6-7), suggesting that mercury may be adsorbed onto the iron-containing particles.

Limited paired filtered and unfiltered total mercury sample results collected by USGS in July 2015 from the same five locations expected to possibly contain iron oxyhydroxide derived from the Cinnabar Mine were evaluated. When the four sample pairs (excluding the sample from downstream location Q) are evaluated, concentrations of filtered and unfiltered total mercury appear to be possibly correlated ($R^2 = 0.74$) although not significantly ($p = 0.14$; see Figure 6-7). This possible correlation, in conjunction with the strong correlation between filtered total mercury and filtered total arsenic (see Section 6.4.7.2 and Figure 6-6), suggests that much of the total unfiltered mercury in the stream samples was derived from groundwater. For the four selected sample pairs, the ratios of unfiltered to filtered total mercury range from 2.8 to 5.6 and average 4.2. In other

words, for those samples, the percent of all mercury in the samples represented by the filtered fraction range from 15 to 26 percent, and average 20 percent.

Although only four paired filtered and unfiltered total mercury samples were collected during the September 2016 IA surface water sampling, a similar trend is evident (see Figure 6-3), with an average of approximately 19 percent of the total mercury present in the filtered fraction.

The above observations, in conjunction with other site data presented in this section and commonly observed behavior of mercury at mine sites (see Section 6.4.3), suggest that much of the unfiltered total mercury in the IA and July 2015 USGS stream samples is adsorbed onto iron-containing particles (possibly iron oxyhydroxide). If such leaching and migration from groundwater to surface water was occurring at these times, mercury-bearing particulates could potentially have formed and migrated in groundwater, the groundwater/surface water mixing zone, or after emerging into surface water. For those times, if the unfiltered total mercury results represent loading predominantly by groundwater, then the total mercury loading from groundwater estimated based on the filtered total mercury results would be underestimated by a factor of approximately five.

Results of USGS surface water monitoring (Etheridge 2015) at Site 5 (USGS stream gaging station 13311450 – Sugar Creek near Stibnite, Idaho) indicate significant total mercury loading, most of which is likely attributable to Cinnabar Mine. Selected sample and stream gaging results are provided in Table 2-8. Based on those results, most of the total mercury loading occurs during periods of high discharge (as measured at USGS stream gaging station 13311450 – Sugar Creek near Stibnite, Idaho) during spring snowmelt. Based on a positive correlation between streamflow and concentrations of suspended sediment (based on weight percentage of particles less than 62.5 micrometers), unfiltered aluminum, and unfiltered total mercury in surface water samples collected at Site 5, total mercury loading is attributed (Etheridge 2015) predominantly to surface runoff and stream channel erosion. These results are influenced by samples representing a summer rainfall event (August 14, 2014 sample), and two samples collected during snowmelt – a peak of record streamflow (May 25, 2014 sample) and a peak snowmelt runoff sample (May 14, 2013 sample). Stream discharge on the day of the August 14, 2014 summer rainfall event was 18.6 cfs, and 194 and 185 cfs during the May 2014 and May 2013 snowmelt events, respectively. By comparison, the Sugar Creek discharge rates ranged from 11.6 to 13.8 cfs during the July 23-25, 2015 stream sampling, and was 8.14 cfs during the September 21, 2016 IA sampling.

For the USGS surface water monitoring at Site 5 (Etheridge 2015), the ratio of unfiltered to filtered total mercury in samples corresponding to the peak of record streamflow (May 25, 2014) and a peak snowmelt runoff sample (May 14, 2013) are 90.3 and 87.1, respectively. The ratio for the samples collected on the day of the summer rainfall event (August 14, 2014) and two samples collected during snowmelt is 217. Stream discharge on the other days of sampling range from 5.8 to 133 cfs. Ratios of unfiltered to filtered total mercury for available sample pairs

collected on these other days range from 1.5 to 43. For those sample pairs collected on days when stream discharge was greater than 50 cfs, the ratios range from 5.6 to 43 and average 16. For those sample pairs collected on days when stream discharge was less than 50 cfs (excluding the summer rainfall event on August 14, 2014), ratios of unfiltered to filtered total mercury are generally lower, ranging from 1.5 to 9.1, with all but the highest value less than or equal to 6.1, and with an average of 4.1. These ratios of unfiltered to filtered total mercury are similar to those observed for paired unfiltered and filtered total mercury samples collected from West Fork Cinnabar Creek, described above for the September low stream discharge IA and USGS July 2015 sampling events. This observation suggests the possibility that much of the mercury at Site 5 during periods when stream discharge is less than 50 cfs may be similar in nature to the mercury in West Fork Cinnabar Creek during the periods of low flow sampled during the IA and July 2015 USGS sampling.

Loading of such suspected groundwater-derived mercury likely also occurs during periods of higher discharge; however, such groundwater inputs would be expected to be masked by the comparatively much larger particulate loading by erosion.

6.5 Methylmercury at Cinnabar Mine

Selected IA samples were analyzed directly for methylmercury. IA results are presented for tailings (Table 5-5), ponded surface water (Table 5-6), adit surface water (Table 5-7), surface water from West Fork Cinnabar Creek (Table 5-8), Cinnabar Creek (Table 5-9), Sugar Creek (Table 5-10), and sediment from the ponded area (Table 5-12), adit portal areas (Table 5-13), West Fork Cinnabar Creek (Table 5-14), Cinnabar Creek (Table 5-15), and Sugar Creek (Table 5-16).

Methylmercury trends and results of studies assessing methylation potential are addressed in detail in EPA's methylation study. Results are presented in a report provided in Appendix B. In general, concentrations of methylmercury in site samples are fairly low.

Selected results of samples collected as part of that study, specifically including results of porewater sampling to assess current conditions at the Cinnabar Mine, are incorporated into this Section.

6.6 Summary

The main conclusions regarding the fate and transport of arsenic and mercury at the Cinnabar Mine site and downgradient locations are as follows:

- Mining and ore processing operations at the Cinnabar Mine have resulted in accumulations of calcines and flotation tailings at the mine. The chemical forms of mercury in these waste types are not known, but likely include cinnabar, particularly in the flotation tailings, and more soluble forms of mercury, particularly in the calcines.
- Calcines and tailings have been historically subject to erosion, and, although previous removal actions (including regrading and attempts to

establish a vegetative cover) have been implemented to reduce erosion, erosion by stormwater and snowmelt likely remains an important mechanism to transport mercury into West Fork Cinnabar Creek and downstream waterbodies. The chemical form(s) of mercury in such erosion-derived particulates is not known.

- Although no investigations have directly evaluated groundwater conditions at the Cinnabar Mine, it is likely that groundwater, including adit discharge underflow and groundwater resulting from infiltration of precipitation, snowmelt, and surface water, flows through calcines and flotation tailings and leaches mercury, arsenic, and other inorganic elements from the mine wastes. Emergence of such impacted groundwater into surface water is readily apparent in results of filtered total mercury surface water and sediment porewater samples.
- Available surface water data (Holloway et al. 2016) and general observations about mercury fate and transport at other mercury mine sites collectively suggest that some of the total mercury detected in unfiltered surface water samples is associated with iron-bearing particulates, possibly including iron oxyhydroxide.
- Although available supporting data are limited, an apparent correlation between unfiltered and filtered total mercury concentrations in surface water collected during the IA and by USGS (Holloway et al. 2016), in conjunction with the strong correlation between filtered total mercury and filtered total arsenic and other site-specific observations, suggests that much of the total unfiltered mercury in the stream samples was derived from groundwater influx into the stream at the times of sampling. It is not clear whether such mercury-bearing particulates may have formed in groundwater, the groundwater/surface water mixing zone, or after emerging into surface water. To the extent that such groundwater-derived loading of mercury particulates in surface water may be occurring, the degree of groundwater-derived mercury loading to surface water would be underestimated if unfiltered total mercury concentrations are assumed to represent erosion-derived loading and estimates of groundwater-derived mercury loading are based solely on filtered total mercury concentrations. Based on ratios between unfiltered and filtered total mercury concentrations in surface water, such particulate-associated mercury comprises approximately 80 percent of all mercury loading during periods of generally low stream discharge.

7

Conceptual Removal Action Alternatives

This section identifies a range of conceptual removal action alternatives that may be employed to reduce mercury and arsenic impacts on surface water and sediment at the Cinnabar Mine site in order to decrease the potential for uptake by aquatic biota. Specific removal action objectives are not established at this time due to the uncertainties associated with contaminant transport mechanisms that are described in Section 6. However, this section presents four removal alternatives that provide a general guide for future actions to be considered as the conceptual site model is refined. This section also includes a discussion on site access issues that limit the feasibility of several alternatives. The following four removal alternatives are presented:

- Alternative 1 (A1): Engineered Soil Media and Vegetative Cover
- Alternative 2 (A2): Selective Grading and Vegetative Buffer Strips
- Alternative 3 (A3): Tailings Consolidation and Stream Relocation
- Alternative 4 (A4): Full-Scale Removal Options

7.1 Site Access Considerations

Access to the site is via one of two roads. The shortest route originating from the entrance of the Stibnite Mine at the intersection of Forest Service Road 412 and Forest Service Road 374 follows Sugar Creek northeast for approximately 2.5 miles on Forest Service Road 374 before turning south along Cinnabar Creek for another 2.5 miles. This section of road is currently gated and closed at the downstream end near the Stibnite Mine and at the upstream end at the Cinnabar Mine. The road, which includes a primitive crossing of Sugar Creek (ford), is constricted in width along both Sugar Creek and Cinnabar Creek because of erosion. Based on pictures of the pinch points provided by the Nez Perce Tribe, it is estimated that the road may not allow passage of vehicles greater than 6 feet in width. Significant road improvements would be required in order to access Cinnabar Mine from this route. It should be noted that the USFS has closed this road at the intersection with the Stibnite Mine road and installed a gate; therefore, permission to use this route will require completion of the USFS permitting process. In addition, based on previous EPA removal actions at the site, it is likely the USFS would require the closure of this access road at the completion of removal activities. The construction and removal of an access road to the mine could significantly increase the time and cost to the project, particularly if the enhanced road is required to be deconstructed and/or reclaimed. An additional

concern with rebuilding of this access road is potential negative impacts to fish habitat in Sugar Creek.

Sugar Creek provides critical habitat for the federal-listed threatened bull trout and steelhead, and Cinnabar Creek is critical habitat for bull trout. Because of the site's altitude, work would likely be conducted late in the summer, which coincides with typical spawning times in both creeks. This restricts the ability to cross Sugar Creek with motorized vehicles unless a temporary bridge is placed at the ford. It is assumed that the consultation process with natural resource trustees would be significant if road building along the Sugar Creek route were required.

The second route to the site travels approximately 3 miles south along Forest Service Road 412 toward the Stibnite Airport and then turns east on Forest Service Road 375 along the EFSFSR before turning north on a primitive road up Fern Creek. This primitive road winds over a ridge at approximately 8,600 feet above sea level and drops down to the Cinnabar Mine site after several steep switchbacks. Road conditions are presumed to be in better shape than the Sugar Creek route; however, it is approximately twice as long and contains several tight switchbacks that could limit the mobilization of heavy machinery. Utility terrain vehicles (UTVs) required 3-point turns on some of the switchbacks during the 2016 field assessment.

In general, access to the site for equipment, materials, and personnel will be a critical element of a potential removal action and will need to be further evaluated during the planning and design phase of any selected removal action. Some of the options considered below could be performed with smaller vehicles such as UTVs with small trailers, which would require fewer road improvements. As the scale of the removal options increase, the need for larger pieces of earth moving equipment increases, which would require more significant road improvements. Depending on the scope, significant road improvements could involve a lengthy planning and coordination period followed by extensive road construction, bridge installation, and/or road deconstruction. The costs for road improvement planning and construction could be relatively higher and therefore less feasible for a smaller-scale, lower cost removal option, but these costs may be relatively lower and therefore more feasible for a larger-scale, higher cost removal option.

7.2 Alternative 1 – Engineered Soil Media and Vegetative Cover

There are many types of erosion and sediment control best management practices (BMPs) for controlling surface water runoff; however, most require some level of maintenance that is not practicable at this remote site. Therefore, permanent, post-construction BMPs that prevent the contaminants from migrating from the tailings piles to surface water are recommended. Typically, these include slope protection controls such as grading, mulching, and seeding to minimize erosion. Significant grading or moving of piles would require the use of heavy machinery and is therefore deemed less feasible due to road access limitations and overall remoteness of the site. However, a vegetative cover can be established through the

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application of an engineered soil media, which would not require heavy machinery and therefore would not require significant road improvements.

A successful vegetative cover requires adequate organic matter, nutrient levels, and biological activity that are typically provided in topsoil. Agronomic testing of the tailings indicate that the material is largely void of these essential nutrients and organic matter. Therefore, simply adding fertilizer and seed mix to the tailings will not likely produce or sustain a vegetative cover. Additionally, the borrow source that was identified at the site contains elevated concentrations of metals (Section 5.2.1) that make it unsuitable as a potential cover soil. Due to a lack of local topsoil borrow material and access limitations at the site, it is deemed impractical to import and apply topsoil on top of the tailings for vegetation growth. An alternative to importing topsoil is to apply an engineered soil media to the tailings prior to seeding. Engineered soils contain combinations of wood fibers, biopolymers, biochar, and other constituents that promote microbial activity that is essential for permanent vegetative cover, and it can be applied hydraulically with small-scale equipment. A slow release fertilizer and design seed mix is added to the engineered soil media and applied to the tailings using a hydroseeder, which could be mobilized to the site using a UTV without significant road improvements. A flexible growth medium is then applied in the same fashion on top of the engineered soil that combines chemical and mechanical bonding techniques to hold the growth medium in place and promote accelerated germination. A growth medium that provides up to 18 months of erosion control for seed to germinate and establish root structure is recommended.

A bench scale test is currently being performed on samples of the yellow tailings in a research greenhouse using an engineered soil, fertilizers, and a flexible growth medium. The study is intended to provide an indication of the level of success this alternative may have under ideal environmental conditions and to evaluate if the tailings material poses a toxicity issue to the plants due to elevated metals concentrations. Preliminary results of the study indicate that the native grass species did not sustain growth after the first leaf stage (week 3) following germination, and many species died or went dormant. However, a rogue tall fescue, known as KY-31 (*lolium arundinaceum*), performed very well throughout the 14-week trial. As a result, a second trial has been initiated using only the tall fescue seed to verify the likelihood of success using this plant species. As of week seven of this trial, the tall fescue had germinated and appeared to be thriving. A specialist at the Idaho NRCS field office in Emmett, Idaho, indicated that a seed mix consisting of tall fescue, intermediate wheatgrass, and a legume such as clover would be acceptable for erosion control at the site, given that the native grasses did not survive.

Results of the bench scale test will be provided under separate cover following completion of the second trial. If the tall fescue proves to grow successfully under ideal bench-scale conditions, it may be beneficial to plant a small test plot on the tailings during future field investigations in order to evaluate its effectiveness under actual site conditions.

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The 1998 EPA removal action included seeding and mulching the tailings piles with a native grass seed mix that was not successful. It has been reported that a nutrient fertilizer was applied to the tailings, but details and specifications of the amendments are unknown. Assuming the amendment contained adequate organic matter and nutrients, it is possible that the reason the 1998 revegetation effort did not succeed is simply due to a toxicity effect occurring to native grass species.

Advantages:

- Cost-effective source control for tailings runoff;
- Reduces runoff and infiltration volumes through evapotranspiration;
- Reduces runoff velocities and erosion potential;
- Avoids the need to import and spread topsoil;
- No maintenance required; and
- Does not involve the mobilization and use of heavy machinery, although a small trailer-mounted hydroseeder will be required.

Disadvantages:

- Does not address potential contaminant migration pathways occurring in the subsurface;
- Even if the bench scale testing provides encouraging results under ideal conditions, the feasibility of this option under normal site conditions contains some uncertainty;
- A vegetative cover could provide a source of dissolved organic carbon infiltrating through the mine tailings, which may increase the potential for dissolved inorganic mercury mobilization and mercury methylation.
- Wildlife may damage the plantings;
- Possible uptake of metals in plants that may be consumed by wildlife, although it should be noted that mercury does not tend to enter plant roots for most species; and
- Requires a local source of water to operate hydroseeder.

Cost Estimate:

Costs associated with this option include the application of an engineered soil media, fertilizers, seed, and flexible growth media to the tailings, all of which can be purchased in 50-pound bags that can be transported to the site using UTVs or all-terrain vehicles. Based on delineations using Google Earth, the total area to be treated is approximately 4.5 acres of tailings, although the total area may be reduced to focus on slopes adjacent to the stream. Initial unit material estimates for engineered soil media and seeding include about 540 pounds per acre of fertilizer, 3,330 pounds per acre engineered soil media, 2,870 pounds per acre flexible growth media, and 234 pounds per acre of seed mix, resulting in roughly 9.5 tons of material to be transported.

It is assumed that the only equipment required for mobilization is a 300-gallon, trailer-mounted hydroseeder that can be towed behind a UTV, and that no road improvements are necessary. The road contains very tight turns that may require the trailer to be un-hitched while the UTV completes the turn. It is assumed that the trailer is light enough for a 4-man crew to safely walk the trailer around the

turn; however, the pump and tank may need to be removed and reconnected in order to complete some of the turns.

The cost for this option is estimated to be \$144,000. This cost assumes the availability of a water source from West Fork Cinnabar Creek or one of the flowing adits. The cost does not include engineering design, oversight, or maintenance costs. A conceptual layout of this alternative is shown in Figure 7-1.

7.3 Alternative 2 – Selective Grading and Vegetative Buffer Strips

A gently sloping vegetated area between the tailings piles and the stream would act to filter runoff before it reaches the stream. The Idaho BMP Manual (Idaho 2005) recommends a minimum width of 20 feet for vegetative buffer strips. Therefore, in areas where tailings contain a steep slope down to the stream banks, it will be necessary to pull those tailings away from the stream as much as possible and reduce the slopes where feasible. Tall, dense grasses mixed with willows and alder provide good traps for filtering runoff. Willows also may provide phytostabilization of mercury compounds in the root zone (Wang 2004). Temporary erosion control measures such as filter socks may be required until the vegetative cover is established. Once established, vegetative buffer strips generally do not require maintenance. However, without a vegetative cover on the tailings, the buffer strips will eventually be overwhelmed with tailings deposition and cease to provide any benefit. Therefore, this option includes the actions outlined in Alternative 1, Engineered Soil Media and Vegetative Cover.

Runoff from tailings piles can also be reduced by roughening the slopes of the tailings prior to application of engineered soil media and plantings. This would be accomplished by creating horizontal grooves, furrows, and depressions along the face of steep slopes using a tracked dozer or excavator, which would be required in order to construct the vegetative and sand filter strips. The ponded area that is located on the yellow tailings, as shown in Figure 2-2, would also be removed under this alternative. This may be accomplished by grading and filling the depression that forms the ponded area and routing surface water to quickly drain to the West Fork Cinnabar Creek without ponding.

Sand filters, such as were constructed at the Stibnite Mine, were also considered under this alternative. Research indicates that the sand filters at the Stibnite Mine have reduced arsenic contamination in Meadow Creek adjacent to mine tailings (Dovick et. al. 2015). However, based on the 2016 field assessment, it does not appear that a suitable source of clean, coarse sand is available at the site. Therefore, it is assumed that sand would need to be transported to the site, which would require major road improvements that would significantly increase costs as well as impact water quality along Sugar and West Fork Cinnabar Creeks. As a result, sand filters are not deemed feasible as a part of this alternative.

Advantages:

- Filters tailings from runoff before it reaches the creek;

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- Willows have the potential to provide shade, which may improve stream temperatures in West Fork Cinnabar Creek. A USGS report (Etheridge 2015) noted that the Sugar Creek station exceeded the Maximum Daily Average Temperature for spawning salmonids 47% of the time. As Cinnabar Creek drains to Sugar Creek, elevated temperatures may also be present in Cinnabar Creek;
- Reduces the volume of stormwater entering the stream via evapotranspiration;
- Vegetation such as willow trees would provide a permanent feature that would not require maintenance;
- Slope roughening will reduce runoff volumes and velocities to limit erosion from the tailings into the creek, trap sediments, and aid in establishing vegetation; and
- Reduces methylmercury production from the ponded area on the tailings.

Disadvantages:

- Does not address potential contaminant migration pathways occurring in the subsurface;
- Requires mobilization of earth-moving machinery and possible road improvements;
- Vegetative buffer strips are only effective if constructed in conjunction with revegetation (i.e., source control) efforts on the tailings piles. Without a vegetative cover on the tailings, the filters would eventually become overwhelmed with tailings deposition and would require maintenance to avoid failure; and
- Short-term impacts may occur as a result of working with machinery near the stream, which requires the use of construction BMPs such as filter socks.

Cost Estimate:

This alternative assumes that road maintenance is necessary, and that compact excavators and dozers can be mobilized to the site via the Fern Creek route. Costs associated with this option include removing approximately 700 cubic yards of tailings from the streambanks and spreading on top of the piles away from the slopes. Included in this alternative is removal of the ponded area located on top of the yellow tailings, willow planting along the streambanks, and complete vegetation of the piles as outlined in Alternative A. The cost for this option is estimated to be \$262,000. This cost assumes the availability of a water source from West Fork Cinnabar Creek or one of the flowing adits. It is assumed that maintenance would not be required following the completion of this alternative. Figure 7-2 presents a conceptual layout of the work outlined in this alternative.

7.4 Alternative 3 – Tailings Consolidation and Stream Relocation

This removal option involves consolidating the separate tailings piles into one location to isolate the tailings from the stream. This alternative reduces the overall

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surface area of tailings that contributes runoff to the stream, thereby reducing the volume of tailings that are transported off-site via runoff. For instance, red tailings located on the west side of West Fork Cinnabar Creek could be relocated and combined with the red and yellow tailings on the east side of the creek. In addition, once the tailings have been consolidated, the creek may be relocated further away from the consolidated piles, creating more surface area to construct vegetative filter strips. Furthermore, analytical results indicate that the red tailings contain lower concentrations of metals than the yellow tailings (Table 2-11 and Table 5-5). Therefore, the red tailings can be used to isolate the yellow tailings from surface water runoff, although the red tailings (calcines) may contain a more soluble form of mercury as described in Section 6.1.4 and 6.4.4. Alternatively, the borrow source material may also be placed on top of the consolidated tailings, although these soils contain concentrations of heavy metals above screening levels (Section 5.2.1.2) that may exclude them for use as a clean cover material.

Heavy machinery would be needed to excavate and relocate the tailings under this alternative, which would require significant road and access improvements. It is assumed that this alternative would utilize the Sugar Creek road in order to mobilize heavy machinery and haul trucks to the site. In order to use the Sugar Creek route, it is assumed that a temporary bridge must be constructed at the Sugar Creek ford, as well as across West Fork Cinnabar Creek through the tailings at the mine site. Other road improvements may be required along the route, including road widening and shoulder stabilization along steep slopes.

It is estimated that approximately 25,000 cubic yards of tailings and 550 linear feet of creek would need to be relocated under this alternative. In addition, water flowing from Adit 1 would be rerouted to the south so that it would discharge into the West Fork Cinnabar Creek near the confluence with the East Fork Cinnabar Creek. After earthwork activities are complete, the site would be vegetated in accordance with Alternatives 1 and 2. A conceptual layout of the work outlined for this alternative is shown in Figure 7-3.

Advantages:

- Reduces the surface area of tailings that is subject to stormwater runoff;
- Minimizes the volume of tailings transported to the stream via stormwater runoff;
- Reduces the volume of stormwater runoff from tailings via evapotranspiration; and
- Creates larger riparian buffer to filter runoff before reaching the stream.

Disadvantages:

- Does not address potential contaminant migration pathways occurring in the subsurface;
- Short term water quality and fish habitat impacts may result from repairing/constructing access roads and excavating near the stream; and
- High costs.

Cost Estimate:

This cost estimate was based on relocation of 25,000 cubic yards of tailings and 550 feet of stream. It is assumed that five days of haul road maintenance will be required along Sugar and West Fork Cinnabar Creeks, including construction of a temporary bridge across Sugar Creek and a temporary bridge across West Fork Cinnabar Creek at the mine site. The total cost is estimated to be \$1,047,000 for this alternative.

7.5 Alternative 4 – Full-Scale Removal Options

In order to control the potential contaminant migration pathways, the source material must be isolated from hydrologic conditions. This is typically accomplished by excavating the contaminated tailings and placing them in an engineered repository or landfill that eliminates or controls contaminant transport mechanisms. This section includes a discussion of three potential options for future consideration at the site, including an on-site repository, a “high and dry” repository, and off-site disposal at the Stibnite Mine. Figure 7-4 displays a conceptual layout of the three options discussed in this section.

An on-site repository involves removal and consolidation of the tailings piles for disposal in an engineered repository located at the mine site. This option minimizes transportation costs associated with hauling the tailings long distances for disposal. However, siting a repository at the mine site has inherent design limitations, namely that it lies in a basin that is subject to several surface water drainages and groundwater sources as evidenced by the East Fork and West Fork Cinnabar Creeks (and tributaries), the three flowing mine adits, and the large seep originating from the former cook house building area (sample location AD04). Since these sources have not been fully characterized, there are uncertainties surrounding the feasibility of siting, designing, and constructing an on-site repository. During the August 2016 field reconnaissance, the area southwest of Adit 3 was identified as a potential borrow source and repository location because it is upgradient of the adits and the confluence of the East and West Fork Cinnabar Creeks. This area is confined laterally by steep slopes to the south and west, and by surface water drainage from West Fork Cinnabar Creek and a chute that drains the cliffs in the southwest corner of the basin. Given the lateral constraints and uncertainties associated with depth to groundwater, this area may be limited in volume capacity to dispose of all of the contaminated material on site. Another concern with this repository location is that the existing surface soil, which was identified as a potential borrow source for capping, contains elevated metals that exclude it for use as a clean cover material.

A second option under this alternative involves removing the tailings from the mine site and disposing them in a repository located in an area up and out of the basin (i.e., “high and dry”). For example, one such potential location is situated approximately 700 feet above the site on the ridge flanking the western portion of the mine. This ridge may be accessible via an existing road that travels up the mountain, beginning near the former dormitory building. The condition of this road is unknown and would need to be evaluated for suitability and/or improvements. A small east-west trending ridgeline below the radio towers may

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provide a suitable repository location. Repository construction would require excavating the top of the ridge for tailings placement, and using the overburden to cover the tailings. A geotechnical evaluation would likely be required to assess the stability of subsurface soils and adjacent slopes, which could involve mobilizing a drill rig to the repository location.

A third option under this alternative consists of hauling the tailings off-site for disposal at the Stibnite Mine. This option requires discussion and agreements with the mine owner and operator, Midas Gold Corporation. Disposal options may include re-processing the tailings and/or placement in an approved disposal facility located at the Stibnite Mine.

Under each of these options, heavy machinery would be needed to complete the removal actions, which would require significant road and access improvements as outlined under Alternative 3 (Section 7.4). Restoration activities would also be required after the material is removed from the site, including, but not limited to, re-grading the site, stream bypass and reconstruction, and re-vegetation. It should be noted that this alternative does not address contaminant loadings that are contributed from the adits.

Advantages:

- Complete removal of contaminant source materials at the site.

Disadvantages:

- May require landowner agreements;
- Short term water quality and fish habitat impacts may result from repairing/constructing access roads and excavating near the stream; and
- High costs.

Cost Estimate:

Developing a cost estimate for a full scale removal is difficult due to the uncertainties and limitations associated with the options discussed in this section. A rough cost estimate is provided for the “high and dry” repository option assuming that an on-site repository is deemed infeasible and the necessary agreements are not reached with Midas Gold. This cost estimate is largely influenced by the volume of material that requires disposal, which is currently unknown. Based on approximations of surface area, side slopes, and assumed depths of the various tailings piles, this cost estimate assumes that 60,000 cubic yards of material requires disposal. The estimate also assumes that restoration and grading will be required for 1,000 linear feet of stream, and that 10 days of haul road maintenance will be required along Sugar Creek, Cinnabar Creek, and the road accessing the repository site. The total cost for this alternative is estimated to be \$2,604,000.

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8

Site Inspection, Potential Sources, Surface Water Migration Pathway and Targets

This section discusses IA analytical evaluation criteria, potential sources associated with the site, surface water migration pathway and potential targets within the site's range of influence (Figure 7-1). At the direction of the EPA Task Monitor, the ground water migration, soil exposure, and air migration pathway have not been included due to a lack of possible receptors for these pathways, as well as the site's remote location. Sample location descriptions are discussed in Section 3. Sample locations are depicted on Figure 3-1.

8.1 Analytical Results Evaluation

Analytical results reported in the summary tables show all analytes detected above the laboratory detection limits in bold type. Analytical results indicating significant/elevated concentrations of contaminants with respect to background concentrations are shown underlined and in bold type. For the purposes of this investigation, significant/elevated concentrations of source/target samples include those concentrations that are:

- Equal to or greater than the sample's Contract Required Quantitation Limit (CRQL) or the Sample Quantitation Limit (SQL) when a non-CLP laboratory was used; and
- Equal to or greater than the background sample's CRQL or SQL when the background concentration was below detection limits; or
- At least three times greater than the background concentration when the background concentration equals or exceeds the detection limits.

8.1.1 Results Reporting

The analytical summary tables present all detected compounds, but only those detected analytes at potential sources and targets meeting the significant/elevated concentration criteria are discussed in the report text. All detected concentrations are discussed for the background samples.

In some cases, analytical results required qualification. For the purposes of discussion, qualifiers are not included in the results discussion. Please see the analytical data tables or data validation memoranda in Appendix E for information regarding qualifiers. Based on EPA, Region 10 policy, the common

8 Site Inspection, Potential Sources, Surface Water Migration Pathway and Targets

earth crust elements (aluminum, calcium, iron, magnesium, potassium, and sodium) are not discussed or evaluated as part of this investigation.

Arsenic, mercury, and methylmercury concentrations are depicted on Figures 5-1 through 5-3.

8.1.2 Background Samples Analytical Results

8.1.2.1 Background Surface Soil Samples

Background surface soil sample results are provided in Table 5-5. Sample locations are discussed in Section 3.1.1 above. Sample results indicate the presence of antimony, arsenic, barium, cadmium, chromium, cobalt, copper, manganese, and mercury, nickel, vanadium, and zinc.

8.1.2.2 Background and Attribution Surface Water Samples

Background and attribution surface water sample results are provided in Tables 5-6 through 5-11. Sample locations are discussed in Section 3.1.2 above. Sample results indicate the presence of unfiltered and filtered copper in samples BG02SW/BG02SWD and BG04SW/BG04SWD; the presence of unfiltered and filtered arsenic and unfiltered and filtered copper in samples UT01SW/UT01SWD; and the presence of unfiltered and filtered copper samples BG03SW/BG03SWD and filtered total mercury in BG03SWD. The attribution sample (as outlined above in Section 3) is used to determine whether tributary streams (possibly containing other sources of contamination outside of the Cinnabar Mine sources) are contributing to contamination in water bodies downstream of Cinnabar Mine. Concentrations in the attribution sample were consistent with concentrations from the upstream and downstream Sugar Creek samples, indicating there is not likely an additional source of contamination from this waterbody.

8.1.2.3 Background and Attribution Sediment Samples

Three background (BG02SD, BG03SD, and BG04SD) and one attribution (UT01SD) samples were collected as part of this investigation. Five TAL metals (barium, chromium, lead, manganese, and zinc) were detected in sample BG02SD. Thirteen TAL metals (arsenic, barium, beryllium, chromium, cobalt, copper, lead, manganese, mercury, nickel, thallium, vanadium, and zinc) and methylmercury were detected in sample BG03SD. Fourteen TAL metals (antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, thallium, vanadium, and zinc) and methylmercury were detected in sample BG04SD. Eleven TAL metals (antimony, arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, vanadium, and zinc) and methylmercury were detected in sample UT01SD. Grain size analysis was also conducted on all of the sediment samples collected. Grain size for background and release samples generally contained less than 25% fines; however, there were a few outliers. Those outliers are discussed below in the release samples where applicable. Fines are considered to be the total percentage of silt and clays in the sample. The grain size between background and release samples appears to be comparable.

8 Site Inspection, Potential Sources, Surface Water Migration Pathway and Targets

8.2 Potential Sources

The site contains multiple tailings piles and adits. Of these, the upper red and upper yellow piles were evaluated as part of this IA as were Adits 1, 2, and 3 as described in Section 2 above.

8.2.1 Tailings Piles Volumes

Based on aerial photography, the surface area of the upper red and upper yellow tailings piles are estimated to be 171,114.9 square feet as follows:

- Upper Red Tailings pile: 124,618.2 square feet and
- Upper Yellow tailings pile: 46,496.7 square feet.

Based on topography and visual observations the depth of the piles is estimated to be 20 feet. Based on this information, the volumes of the tailings piles are estimated as follows:

- **Upper Red Tailings Pile:** $124,618.2 \times 20 \text{ feet} = 2,492,364 / 27$ to convert to cubic yards = 92,309.77
- **Upper Yellow tailings pile:** $46,496.7 \times 20 \text{ feet} = 929,934 / 27$ to convert to cubic yards = 34,442.

8.2.2 Tailings Piles Sample Results

Tailings pile sample results are provided in Table 5-5. Sample locations are discussed in Section 3.1.1 above. Sample results from the samples collected from the yellow tailings pile indicate the presence of antimony, arsenic, beryllium, cadmium, mercury, methylmercury, thallium and zinc at significant concentrations with respect to background concentrations. Sample results from the samples collected from the red tailings piles indicate the presence of antimony, arsenic, beryllium, cadmium, mercury, thallium and zinc at significant concentrations with respect to background concentrations. Finally, sample results of the tailings collected near the former mill building indicate the presence of antimony, arsenic, cadmium, lead, mercury, thallium and zinc at significant concentrations with respect to background concentrations.

8.2.3 Adits Volumes

The flow rates of the Adits 1, 2, and 3 are not reported nor have they been documented during previous investigations. The first documentation of water flowing from the adits is the 1996 Removal Report. As a conservative measure, the volume of flow for each adit is estimated to be 0.1 cubic feet per second (cfs). The estimated flow rate for one day for each adit is calculated to be 320 cubic feet as follows:

- $0.1 \text{ cfs} \times 60 \text{ seconds per minute} = 6 \text{ cubic feet per minute}$
- $6 \text{ cubic feet per minute} \times 60 \text{ minutes per hour} = 360 \text{ cubic feet per hour}$
- $360 \text{ cubic feet per hour} \times 24 \text{ hours per day} = 8,640 \text{ cubic feet per day};$
or 320 cubic yards per day (i.e., 8,600 cubic feet / 27 cubic feet per cubic yard).

8 Site Inspection, Potential Sources, Surface Water Migration Pathway and Targets

8.2.4 Adits Sample Results

Sample results for Adits 1, 2, and 3 are presented in Tables 5-7 (surface water) and 5-13 (sediment). Adit 1 is located to the southeast of the upper red tailings piles. Surface water sample results indicate the presence of unfiltered and filtered arsenic and filtered total mercury at significant concentrations with respect to background concentrations. Sediment sample results indicate the presence of arsenic, beryllium, cadmium, cobalt, manganese, mercury, methylmercury, selenium, thallium, and zinc at significant concentrations with respect to background concentrations. The grain size analysis for this sample indicated a high presence (54.69%) of silt.

Adit 2 is located south of the site. Surface water sample results indicate the presence of unfiltered and filtered arsenic at significant concentrations with respect to background concentrations. Sediment sample results indicate the presence of antimony, cobalt, and mercury at significant concentrations with respect to background concentrations.

Adit 3 is located in the southwest of the site behind a pile of rubble. Surface water sample results indicate the presence of unfiltered and filtered arsenic and dissolved (i.e., filtered) methylmercury at significant concentrations with respect to background concentrations. Although methylmercury was detected at a significant concentration with respect to the background concentration, the detected concentration of 0.129 ng/L is below the national average of methylmercury in streams of 0.19 ng/L. Sediment sample results indicate the presence of antimony, arsenic, cadmium, cobalt, lead, mercury, and zinc at significant concentrations with respect to background concentrations.

8.3 Surface Water Migration Pathway

The surface water migration pathway Target Distance Limit (TDL) begins at the probable point of entry (PPE) of surface water runoff from the site sources to a surface water body and extends downstream for 15 miles. Figure 7-1 depicts the surface water TDL for the Cinnabar Mine.

The two-year 24-hour rainfall event for the site is 2.4 inches (NOAA 1973). The average annual precipitation in Stibnite, Idaho (which is located approximately 2 miles from the site) is 31.14 inches (WRCC 2016). Soil survey data is not available for the area of the site; however, based on description of the soil samples collected at the site, soils consist of sandy silt. Flood maps are not available for the area near the site; however, there are numerous reports of localized flooding events at the site.

8.3.1 Overland Route

Multiple PPEs are present at the site. PPE 1 is the entire area where tailings are in direct contact with West Fork Cinnabar Creek. PPE 2 is where flow from Adit 1 enters West Fork Cinnabar Creek. PPE 3 is where flow from Adit 2 enters West Fork Cinnabar Creek. Finally, PPE 4 is where flow from Adit 3 enters West Fork Cinnabar Creek.

8 Site Inspection, Potential Sources, Surface Water Migration Pathway and Targets

West Fork Cinnabar Creek flows through the tailings piles at the site for approximately 0.5 mile to the confluence with Cinnabar Creek. From the most downstream PPE, this creek flows for approximately 2.1 miles to the confluence with Sugar Creek. Sugar Creek flows for approximately 2.7 miles to the confluence with EFSFSR. The TDL concludes approximately 9.7 miles downstream in EFSFSR. Surface water flow rates are not available for West Fork Cinnabar Creek or Cinnabar Creek. Based on field observations, the flow rates for both these creeks are estimated to be less than 10 cfs. Average stream flow rates on Sugar Creek from 2012 to 2016 ranged from 20.1 to 25.6 cfs (USGS 2017a). Average stream flow rates for EFSFSR from 2012 to 2016 ranged from 30.7 to 42.4 cfs (USGS 2017b).

8.3.2 Drinking Water Targets

Surface water is not used as a drinking water source within the TDL.

8.3.3 Human Food Chain Targets

Fish catch data are not provided for any of the surface water bodies within the TDL. Sport fishing occurs on Sugar Creek and EFSFSR within the 15-mile TDL. The types of fish sought is not recorded nor are these streams included within Idaho Department of Fish and Game fishing regulations; therefore, it is assumed that species sought in these creeks include steelhead and salmon (IDFG 2017). It is estimated that at least 1 pound of fish is caught for human consumption from both of these surface water bodies within the 15-mile TDL.

8.3.4 Environmental Targets

Cinnabar Creek provides critical habitat for the Federal-listed threatened bull trout (*Salvelinus confluentus*) and Sugar Creek provides critical habitat for the Federal-listed threatened bull trout (*Salvelinus confluentus*) and the Federal-listed threatened Steelhead (*Oncorhynchus mykiss*). The EFSFSR provides habitat for the Federal-listed threatened Snake River Spring and Summer Chinook salmon (*Oncorhynchus tshawytscha*). The Payette National Forest, the Frank Church/River of No Return Wilderness Area, and the Boise National Forest are all within the TDL. There is no wetland frontage within the TDL.

8.3.5 Surface Water Sample Results

8.3.5.1 Ponded Water Sample

Ponded water sample results are provided in Table 5-6. Sample locations are discussed in Section 3.1.2 above. Sample results indicate the presence of unfiltered and filtered arsenic, unfiltered and filtered manganese, filtered) total mercury, and unfiltered methylmercury at elevated concentrations with respect to background concentrations.

8.3.5.2 West Fork Cinnabar Creek Samples

West Fork Cinnabar Creek surface water sample results are provided in Table 5-8. Sample locations are discussed in Section 3.1.2 above. Sample results indicate the presence of unfiltered and filtered arsenic at elevated concentrations with respect to background concentrations in six of seven samples collected. Total mercury

8 Site Inspection, Potential Sources, Surface Water Migration Pathway and Targets

was detected at elevated concentrations in the filtered fraction with respect to background concentrations in all samples for which the analysis was conducted. Finally, methylmercury was detected in the filtered fraction at elevated concentrations with respect to background concentrations in three of the five samples for which the analysis was conducted.

8.3.5.3 Cinnabar Creek Samples

Cinnabar Creek surface water sample results are provided in Table 5-9. Sample locations are discussed in Section 3.1.2 above. Sample results indicate the presence of unfiltered and filtered arsenic and filtered methylmercury at elevated concentrations with respect to background concentrations.

8.3.5.4 Sugar Creek Samples

Sugar Creek surface water sample results are provided in Table 5-10. Sample locations are discussed in Section 3.1.2 above. Sample results indicate the presence of total mercury and methylmercury at elevated concentrations with respect to background concentrations in the filtered fractions of samples collected from Sugar Creek. The most downstream sample from which elevated concentrations were detected is located approximately 4.3 miles downstream from the most upstream sample on West Fork Cinnabar Creek.

8.3.5.5 September 2016 Surface Water Samples

Surface water sample results for samples collected by EPA in September 2016 are provided in Table 5-11. Sample locations are discussed in Section 3.1.2 above. The background location established for West Fork Cinnabar Creek was not collected during the September EPA sampling event; therefore, these samples are not evaluated. Sample results indicate the presence of unfiltered and filtered total mercury at elevated concentrations with respect to background concentrations in the sample collected from Sugar Creek.

8.3.6 Sediment Sample Results

8.3.6.1 Ponded Water Sample

Ponded water sediment sample results are provided in Table 5-12. Sample locations are discussed in Section 3.1.3 above. Sample results indicate the presence of antimony, arsenic, beryllium, cadmium, cobalt, lead, mercury, nickel, thallium, and zinc at elevated concentrations with respect to background concentrations. The grain size analysis for this sample indicated a high presence (68.28%) of silt.

8.3.6.2 West Fork Cinnabar Creek Samples

West Fork Cinnabar Creek sediment sample results are provided in Table 5-14. Sample locations are discussed in Section 3.1.3 above. Sample results indicate the presence of antimony, barium, cadmium, cobalt, lead, manganese, mercury, nickel, and thallium at elevated concentrations with respect to background concentrations in one or more samples. Notably, antimony and cobalt were present at elevated concentrations in six of these seven samples, and mercury was present at elevated concentrations in five of these seven samples.



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8.3.6.3 Cinnabar Creek Samples

Cinnabar Creek sediment sample results are provided in Table 5-15. Sample locations are discussed in Section 3.1.3 above. Sample results indicate the presence of antimony, cadmium, and mercury at elevated concentrations with respect to background concentrations. Antimony and cadmium were present at elevated concentrations in all five samples and mercury was present at elevated concentrations in four of these five samples.

8.3.6.4 Sugar Creek Samples

Sugar Creek sediment sample results are provided in Table 5-16. Sample locations are discussed in Section 3.1.3 above. Sample results indicate the presence of antimony, cobalt, mercury, and nickel at elevated concentrations with respect to background concentrations. Mercury was detected at elevated concentrations in the three samples collected closest to Cinnabar Mine.

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9

Summary and Conclusions

The Cinnabar Mine site is a former mercury mine and mill located 15 miles east of Yellow Pine, Idaho. The former mine is located on both private lands and lands administered by the USFS. The site is located within the Payette National Forest adjacent to the Frank Church/River of No Return Wilderness and the Boise National Forest. Mining activities began at the site in 1921 and ceased in 1958. Cinnabar Mine has been the source of numerous historical investigations and time-critical removal actions; however, contamination remains at the site and continues to impact West Fork Cinnabar Creek, Cinnabar Creek, and Sugar Creek.

The IA field event, that is the subject of this report, was conducted from August 22, 2016 through August 26, 2016 with additional sampling conducted on September 12 by EPA and collection of mesocosm study samples collected on October 5, 17, 24 and November 9. A total of 155 samples were collected to assist in determining if any eminent threat or potential threat to human health or the environment posed by the site and to provide EPA with adequate information to determine whether the site is eligible for placement on the NPL.

Tables 9-1 (soil), 9-2 (surface water), and 9-3 (sediment) present summaries of the removal screening level comparisons for arsenic, total mercury, and methylmercury.

9.1 Sources

9.1.1 Tailings Piles

Numerous tailings piles are present at the site including the previously capped and seeded tailings pile, the lowest tan tailings pile, the upper red tailings piles, and the upper yellow tailings piles. The lowest tan tailings pile and previously capped and seeded tailings pile were not evaluated as part of this IA because they are located on lands managed by the USFS. Samples were collected from the upper red tailings piles and the upper yellow tailings piles. A total of nine samples were collected from the tailings pile and one sample was collected near the former mill building. The surface area of the tailings piles are estimated to be 131,383 square feet. Based on the sample results, the tailings piles are a source of contamination at the site.

9.1.1.1 Removal Assessment Evaluation

Sample results for the tailings piles indicate the presence of antimony, arsenic, cobalt, mercury, and thallium at concentrations that exceeded screening levels, with arsenic, mercury and thallium above screening levels in all of the tailings piles samples.

9.1.1.2 Site Inspection Evaluation

Sample results indicate the presence of antimony, arsenic, beryllium, cadmium, lead, mercury, thallium, zinc, and methylmercury at significant concentrations with respect to background concentrations in one or more tailings piles. Of these analytes, antimony, arsenic, cadmium, mercury, and thallium were present at significant concentrations in every tailings pile sample.

9.1.2 Adits

Three flowing adits are known to be present at the site. All three adits were flowing during the field sampling event. Co-located unfiltered and filtered surface water/sediment samples were collected from each of the adits. The total volume of water discharged per day from the adits was estimated to be 6,463 gallons per day. Based on the sample results, the adits are a source of contamination at the site.

9.1.2.1 Removal Assessment Evaluation

Surface water sample results indicate the presence of filtered mercury at concentrations that exceed screening levels in all three adit samples, and copper at concentrations that exceeded the screening levels in Adits 2 and 3. Sediment sample results indicate the presence of antimony, arsenic, cadmium, and mercury at concentrations that exceeded the screening levels in all three of the sediment samples, and copper and nickel exceeded screening levels in one sample each. Many of the exceedences were at least an order of magnitude greater than the analyte-specific screening level.

9.1.2.2 Site Inspection Evaluation

Surface water sample results indicate the presence of unfiltered and filtered arsenic in all three of the samples at significant concentrations with respect to background concentrations. Total mercury (at Adit 1) and methylmercury (at Adit 3) were detected in the filtered fraction at significant concentrations with respect to background concentrations. Sediment sample results indicate the presence of antimony, arsenic, beryllium, cadmium, cobalt, lead, manganese, mercury, methylmercury, selenium, thallium, and zinc at significant concentrations with respect to background concentrations in one or more samples. Only cobalt and mercury were detected at significant concentrations in all three of the adit samples.

9.2 Targets**9.2.1 Ponded Water Area**

An area of ponded water is located in the northeast corner of the previously graded and seeded tailings piles. The ponded water area supports tadpoles and

vegetation. One co-located unfiltered and filtered surface water/sediment sample set was collected from the edge of the ponded water.

9.2.1.1 Removal Assessment Evaluation

Surface water sample results indicate the presence of filtered arsenic and mercury at concentrations that exceeded screening levels. Sediment sample results indicate the presence of antimony, arsenic, cadmium, mercury, nickel, and zinc at concentrations that exceeded screening levels.

9.2.1.2 Site Inspection Evaluation

Surface water sample results indicate the presence of unfiltered and filtered arsenic, unfiltered and filtered manganese, and filtered mercury and methylmercury at elevated concentrations. Sediment sample results indicate the presence of antimony, arsenic, beryllium, cadmium, cobalt, lead, mercury, nickel, thallium, and zinc at elevated concentrations.

9.2.2 West Fork Cinnabar Creek

West Fork Cinnabar Creek flows through the upper red and upper yellow tailings piles through the site to the confluence with Cinnabar Creek. Based on the sample results discussed below, contamination appears to be migrating from site sources to West Fork Cinnabar Creek.

9.2.2.1 Removal Assessment Evaluation

Surface water sample results indicate the presence of filtered total mercury above the screening level all five samples analyzed for mercury. Sediment sample results indicate the presence of antimony, arsenic, and mercury at concentrations that exceeded screening levels in all seven of the sediment samples; cadmium at concentrations that exceeded screening levels in six of the sediment samples; and nickel and lead at concentrations that exceeded the screening levels in two and one of the sediment samples, respectively. Antimony, arsenic, and mercury were detected at concentrations that exceeded screening levels by at least an order of magnitude.

9.2.2.2 Site Inspection Evaluation

Surface water sample results indicate the presence of unfiltered and filtered arsenic at elevated concentrations in all samples collected. Total mercury was detected at elevated concentrations in the dissolved fraction of all samples for which the analysis was conducted. Finally, methylmercury was detected at elevated concentrations in the dissolved fraction of three of the five samples for which the analysis was conducted. Sediment sample results indicate the presence of antimony, barium, cadmium, cobalt, lead, manganese, mercury, nickel, and thallium at elevated concentrations in one or more samples. Notably, antimony and cobalt were present at elevated concentrations in six of these seven samples, and mercury was present at elevated concentrations in five of these seven samples.

9.2.3 Cinnabar Creek

Cinnabar Creek provides critical habitat for the Federal-listed threatened bull trout (*Salvelinus confluentus*). Cinnabar Creek flows into Sugar Creek. Based on the sample results discussed below, contamination from site sources appear to be migrating and impacting Cinnabar Creek.

9.2.3.1 Removal Assessment Evaluation

Surface water sample results indicate the presence of filtered total mercury above the screening level in all five samples collected from Cinnabar Creek. Sediment sample results indicate the presence of antimony, arsenic, cadmium, and mercury at concentrations that exceeded screening levels in all of the samples, and nickel was detected at concentrations that exceeded the screening levels in two of the five samples collected. Antimony and mercury were detected in some of the samples at concentrations that exceeded screening levels by at least an order of magnitude.

9.2.3.2 Site Inspection Evaluation

Surface water sample results indicate the presence of unfiltered and filtered arsenic and filtered methylmercury at elevated concentrations. Sediment sample results indicate the presence of antimony, cadmium, and mercury at elevated concentrations. Antimony and cadmium were present at elevated concentrations in all five samples and mercury was present at elevated concentrations in four of the samples.

9.2.4 Sugar Creek

Sugar Creek provides critical habitat for the Federal-listed threatened bull trout (*Salvelinus confluentus*) and the Federal-listed threatened Steelhead (*Oncorhynchus mykiss*). Sugar Creek flows into the EFSFSR which provides habitat for the Federal-listed threatened Snake River Spring and Summer Chinook salmon (*Oncorhynchus tshawytscha*). Finally, Sugar Creek and EFSFSR are within the Payette National Forest, the Frank Church/River of No Return Wilderness Area, and the Boise National Forest. Based on the sample results, contamination from the site is migrating to downstream targets.

9.2.4.1 Removal Assessment Evaluation

Surface water sample results indicate the presence of filtered copper at concentrations that exceeded screening levels in two of the samples collected. Sediment sample results indicate the presence of antimony, arsenic, and mercury at concentrations that exceeded screening levels in all of the samples and cadmium at a concentration that exceeded a screening level in one sample. Antimony and mercury were detected at concentrations that exceeded screening levels by at least an order of magnitude.

9.2.4.2 Site Inspection Evaluation

Sample results indicate the presence of mercury and methylmercury at elevated concentrations in the dissolved fraction of samples collected from Sugar Creek. The most downstream sample from which elevated concentrations were detected is located approximately 4.3 miles downstream from the most upstream sample on

West Fork Cinnabar Creek. Sediment sample results indicate the presence of antimony, cobalt, mercury, and nickel at elevated concentrations with respect to background concentrations. Mercury was detected at elevated concentrations in the two samples collected closest to Cinnabar Mine.

9.3 Conceptual Site Model

The results of this IA and other recent sampling events were reviewed in an attempt to develop the understanding of the fate and transport of arsenic and mercury at the Cinnabar Mine site and downgradient locations. A detailed summary of this review, including current conclusions and uncertainties, is provided in Section 6.

9.4 Removal Alternatives

Samples were collected from a potential on-site borrow source, and the results indicate the presence of antimony, arsenic, mercury, and thallium at concentrations that exceeded screening levels in all of the borrow source samples. Arsenic and mercury concentrations were at least an order of magnitude in excess of the screening levels. Arsenic concentrations ranged from 194 mg/kg to 399 mg/kg and mercury concentrations ranged from 29.8 mg/kg to 664 mg/kg. Based on these sample results, it is assumed this may not be an acceptable source of cover material for the contaminated tailings piles.

Three potential removal alternatives were evaluated as part of this IA. A summary of the alternatives including advantages, disadvantages, and estimated costs are provided in Table 9-4.

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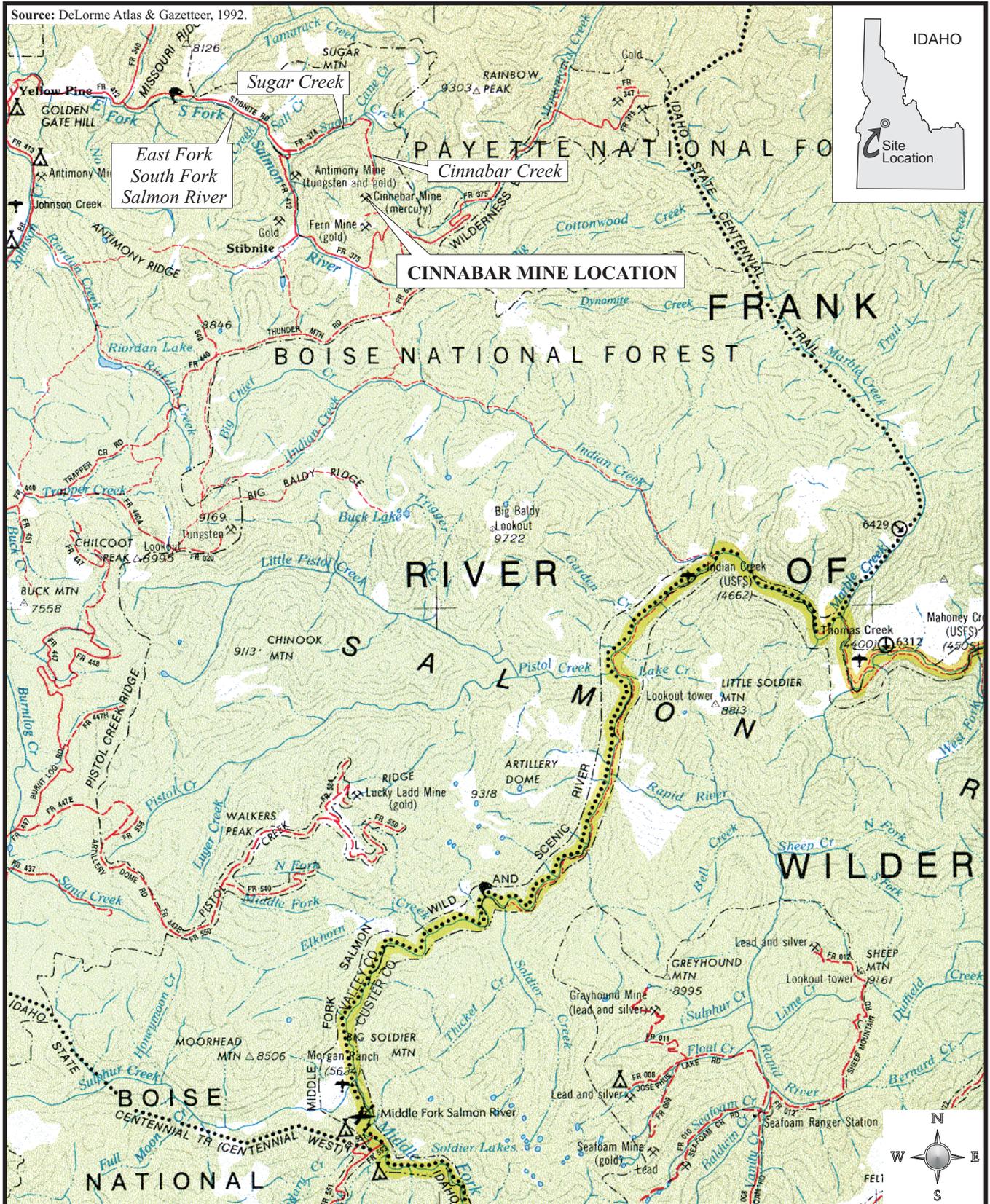
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Figures

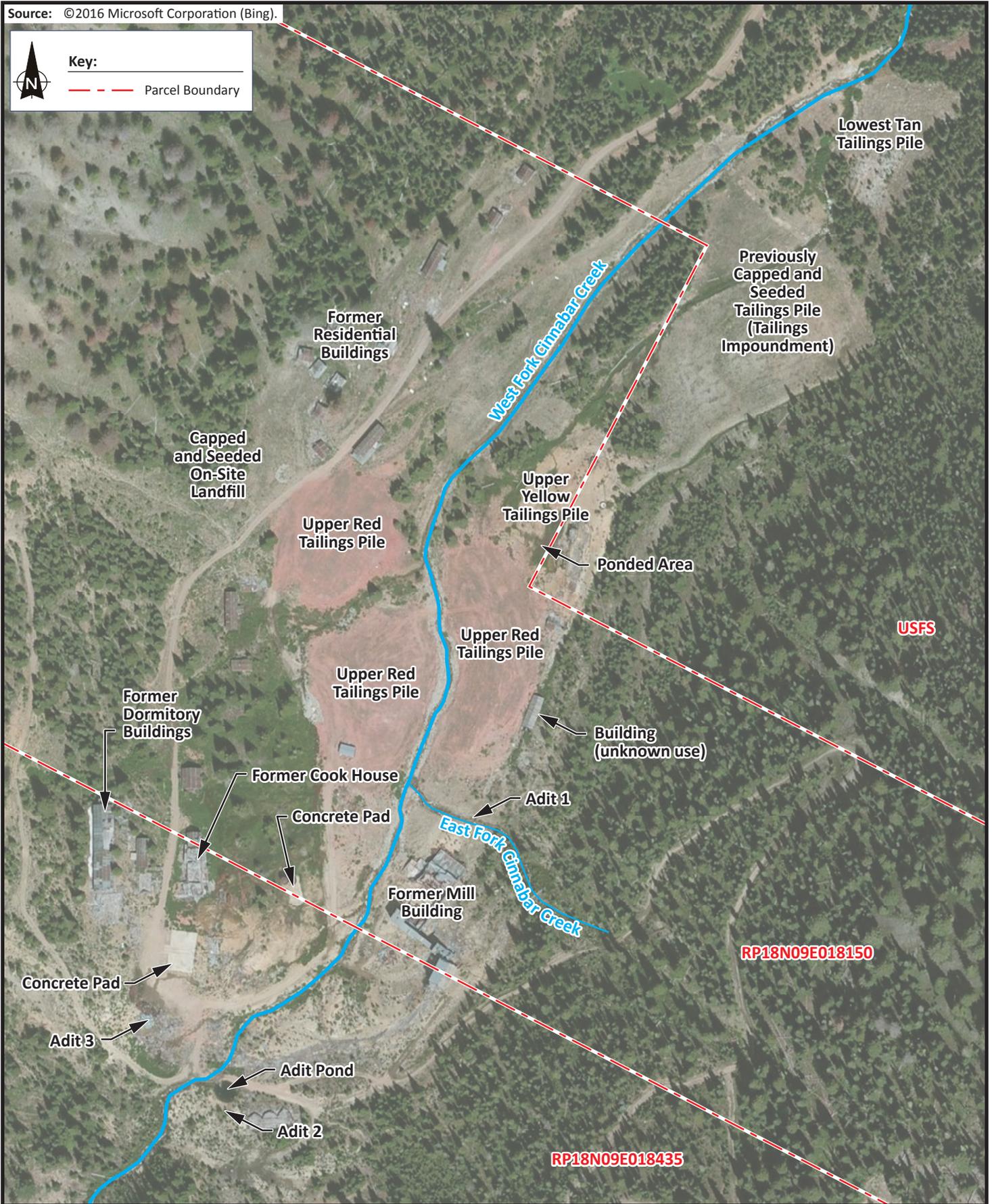
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Source: DeLorme Atlas & Gazetteer, 1992.



 <p>ecology and environment, inc. Global Environmental Specialists Seattle, Washington</p>	<p>CINNABAR MINE SITE Yellow Pine, Idaho</p>		<p>Figure 2-1 SITE VICINITY MAP</p>	
	<p>0 1.5 3 Approximate Scale in Miles</p>	<p>Date: 11-27-16</p>	<p>Drawn by: AES</p>	<p>10:START IV\14070008\fig 2-1</p>

Key:
 Parcel Boundary



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CINNABAR MINE SITE
 Yellow Pine, Idaho

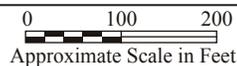
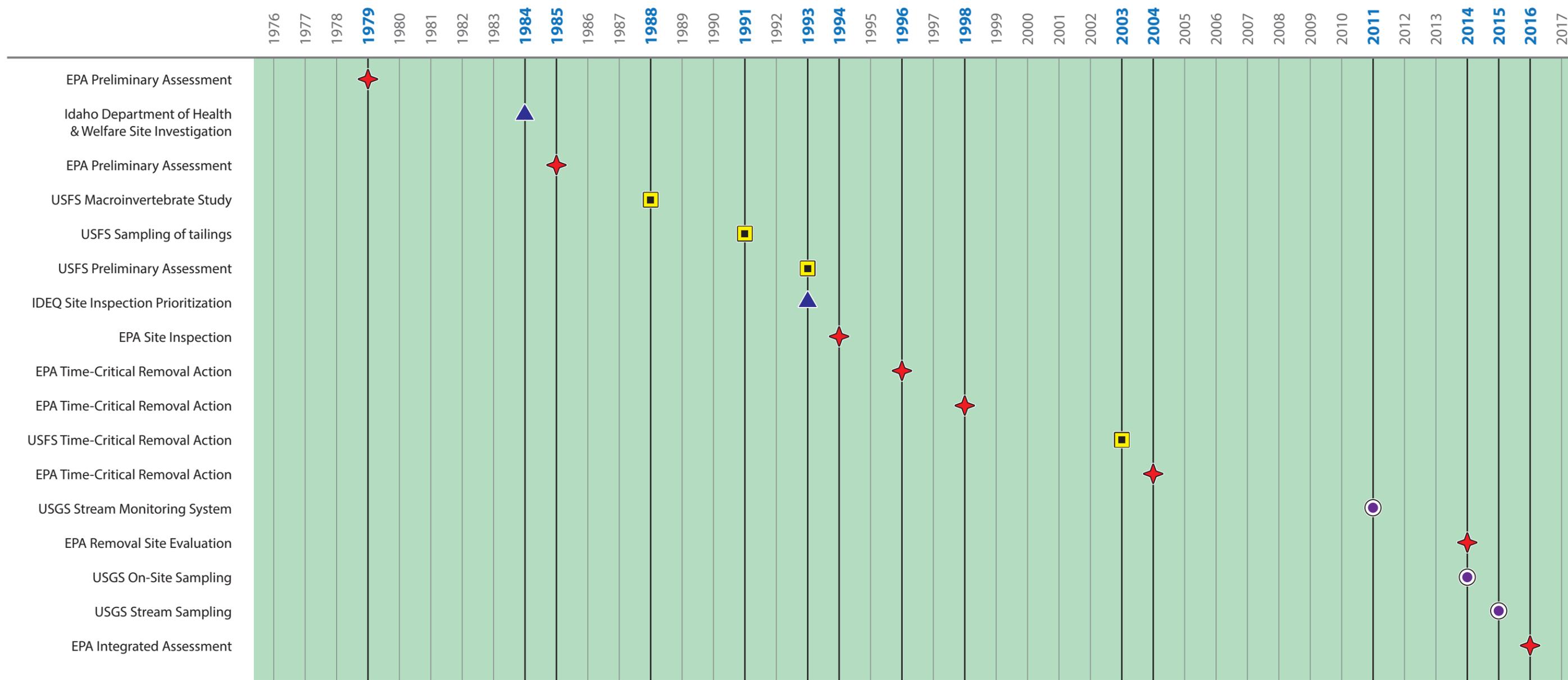


Figure 2-2
 SITE MAP

Date:
 7/20/17

Drawn by:
 AES

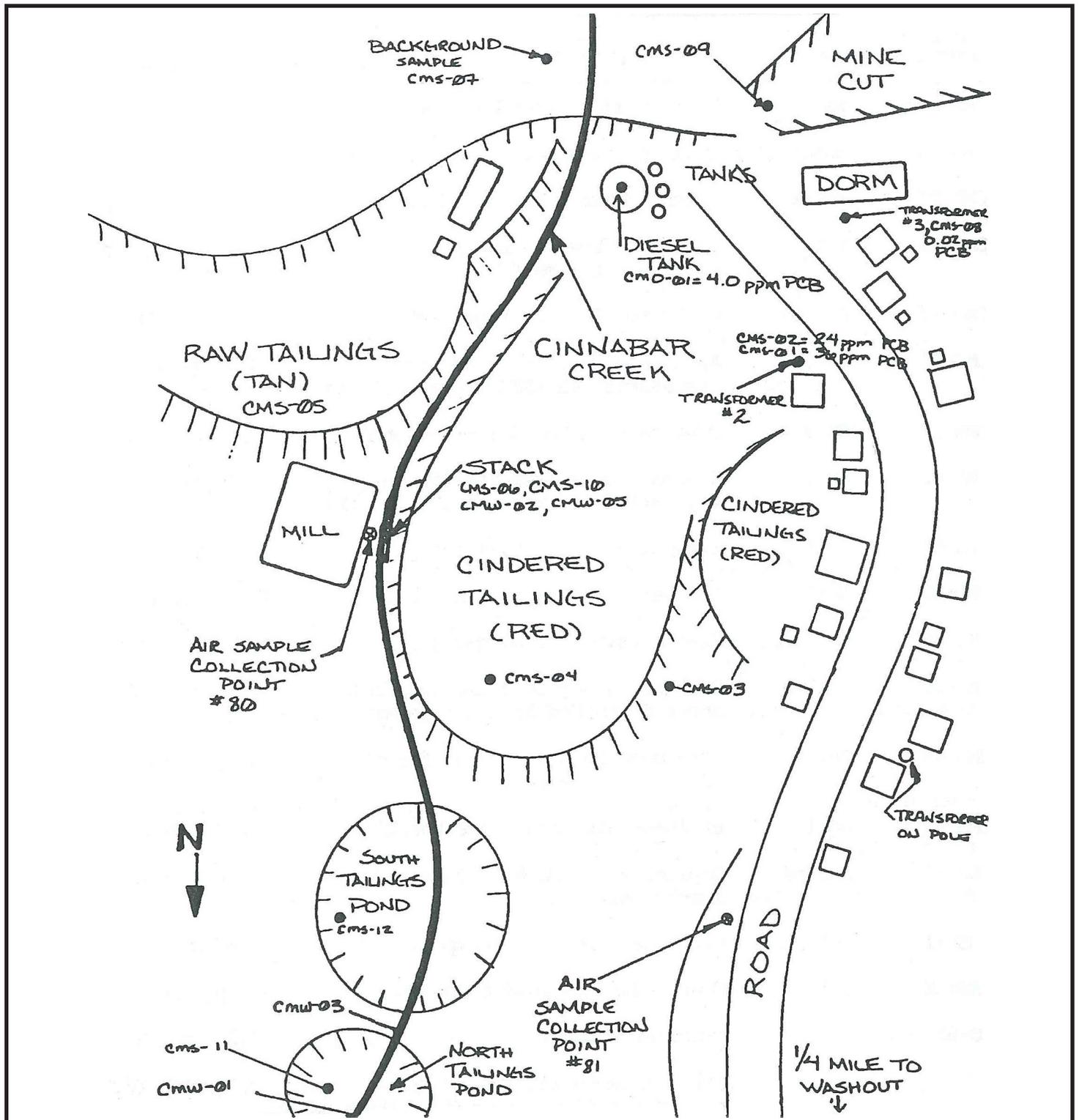
10:START-IV\14070008\fig 2-2



Key:

- ★ United States Environmental Protection Agency
- ▲ State of Idaho
- United States Forest Service
- United States Geologic Survey

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Source: Weston, Preliminary Site Assessment, June 26, 1985.

Note: Figure is not to scale.

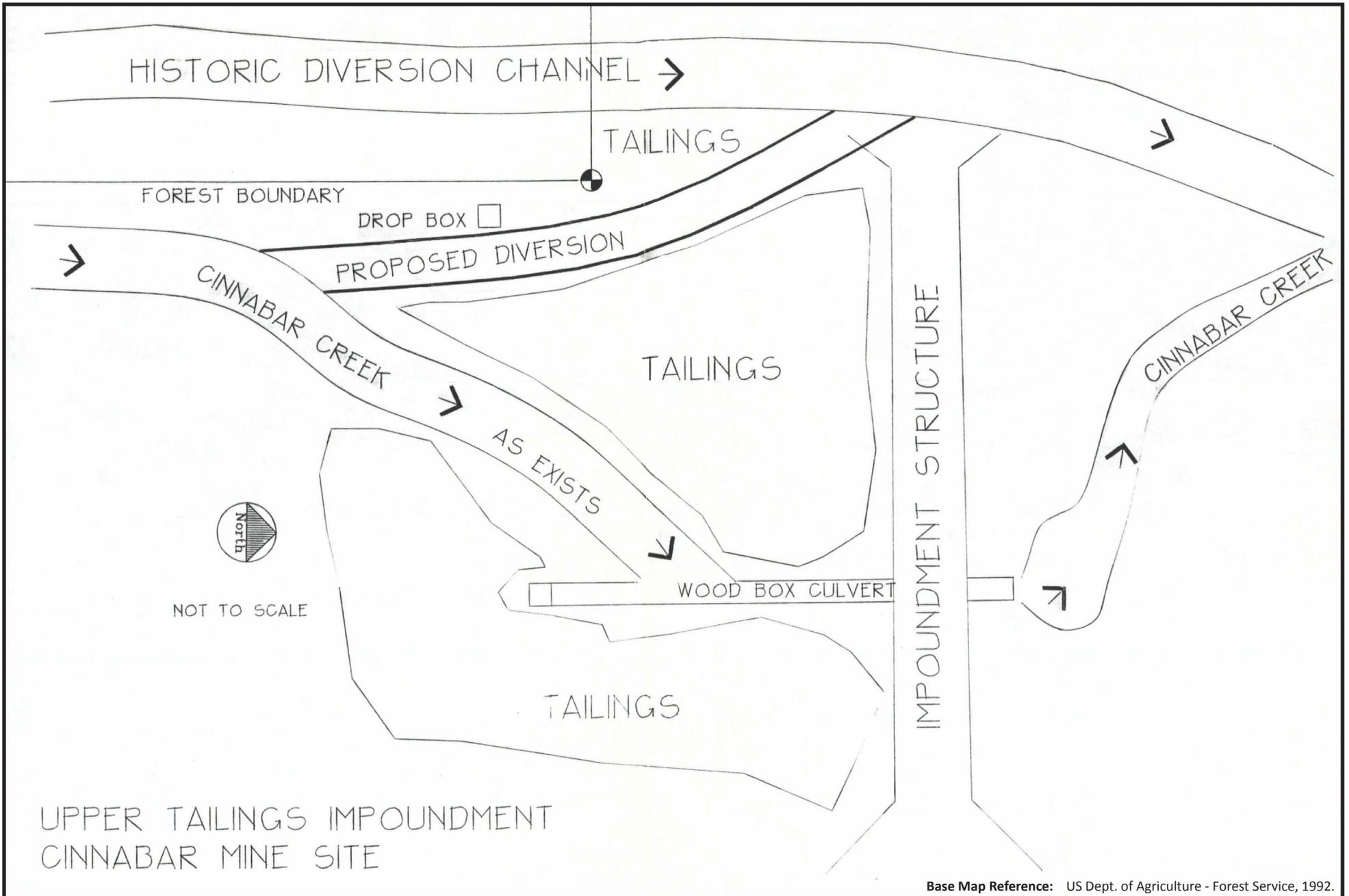


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Yellow Pine, Idaho

Figure 2-4
1985 PRELIMINARY ASSESSMENT
SAMPLE LOCATION MAP

Date:	Drawn by:	
2/15/17	AES	10:START-IV\14070008\fig 2-4



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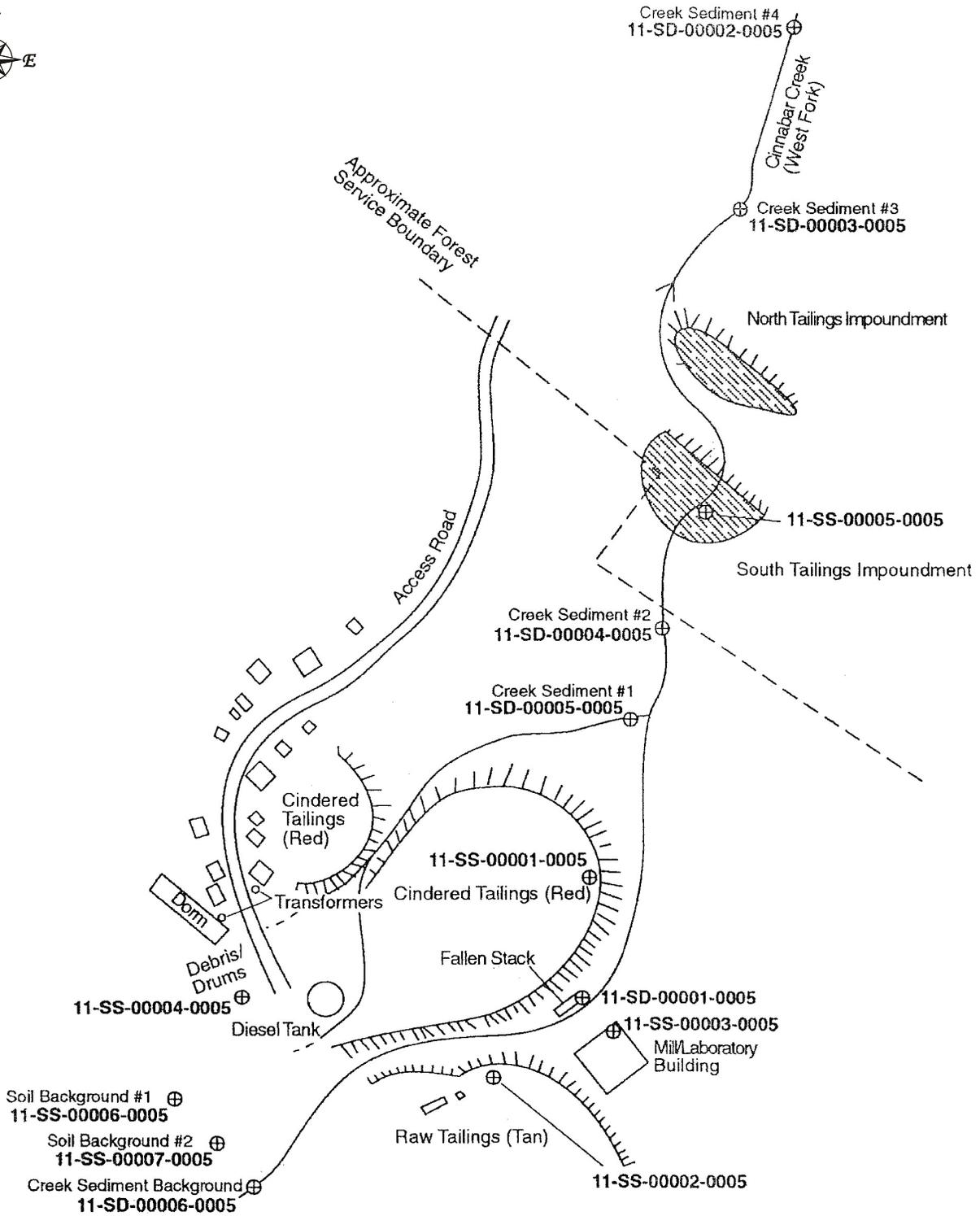
CINNABAR MINE SITE
Yellow Pine, Idaho

Figure 2-5
1992 REMOVAL ACTION PLAN

Date:
2/15/17

Drawn by:
AES

10:START-IV\14070008\fig 2-5



Note: Figure is not to scale.

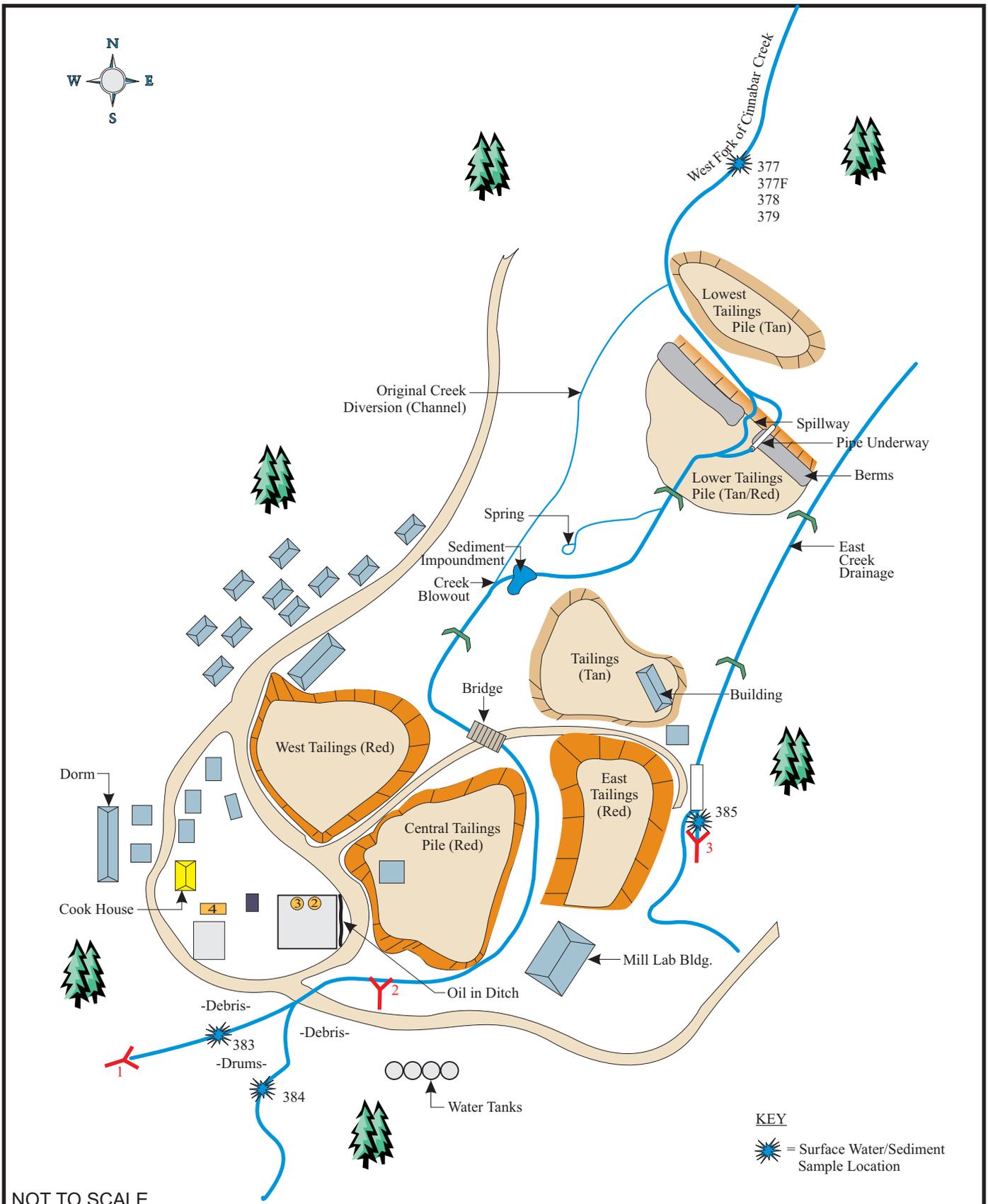


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CINNABAR MINE SITE
Yellow Pine, Idaho

Figure 2-6
1994 SITE INSPECTION
SAMPLE LOCATION MAP

Date:	Drawn by:	
2/15/17	AES	10:START-IV\14070008\fig 2-6



NOT TO SCALE

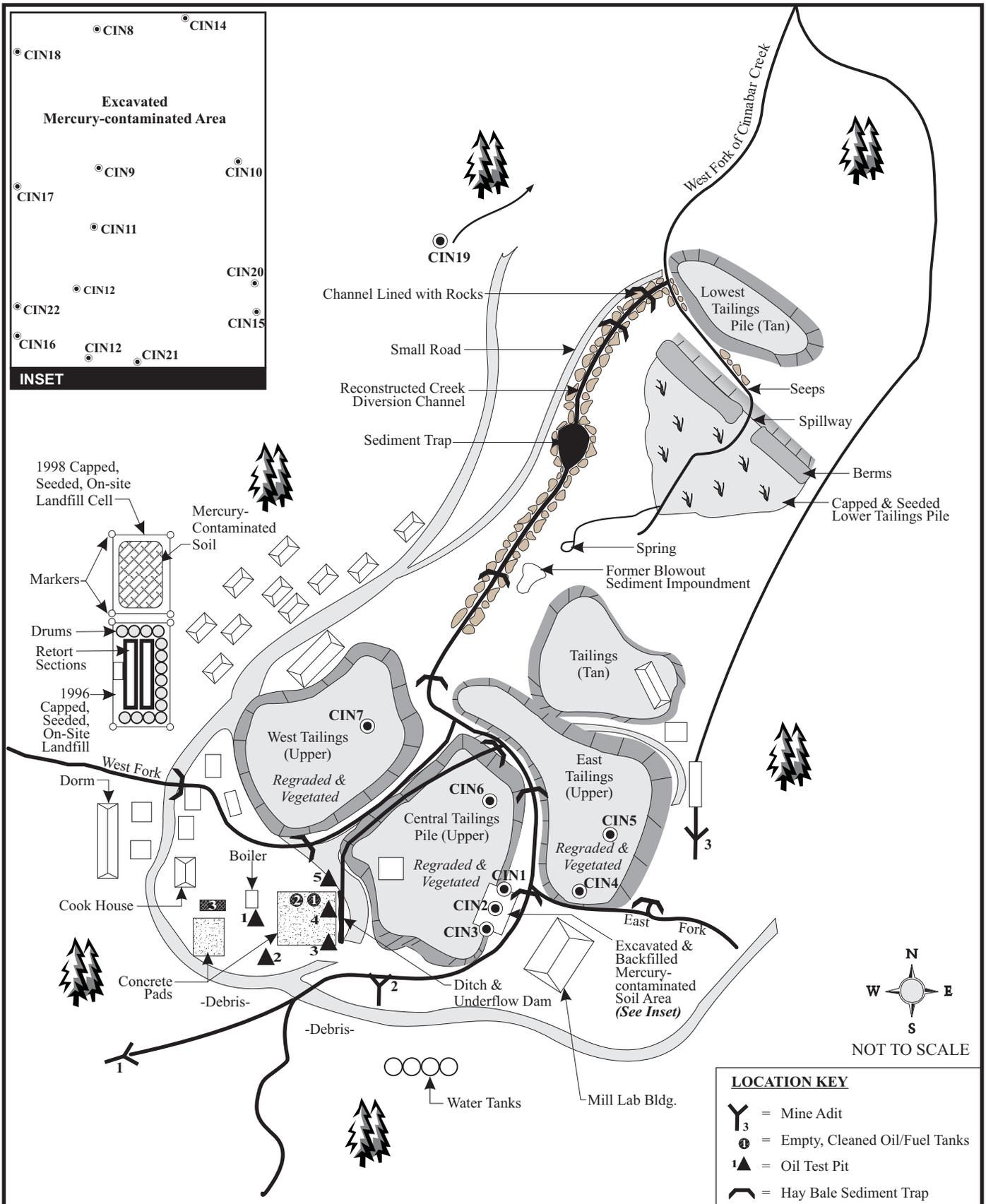
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CINNABAR MINE SITE
 Yellow Pine, Idaho

Source: E&E 1996.

Figure 2-7
 1996 SURFACE WATER/SEDIMENT
 SAMPLE LOCATIONS

Date: 3-6-17	Drawn by: 10:START-IV\14070008\fig 2-7
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CINNABAR MINE SITE
Yellow Pine, Idaho

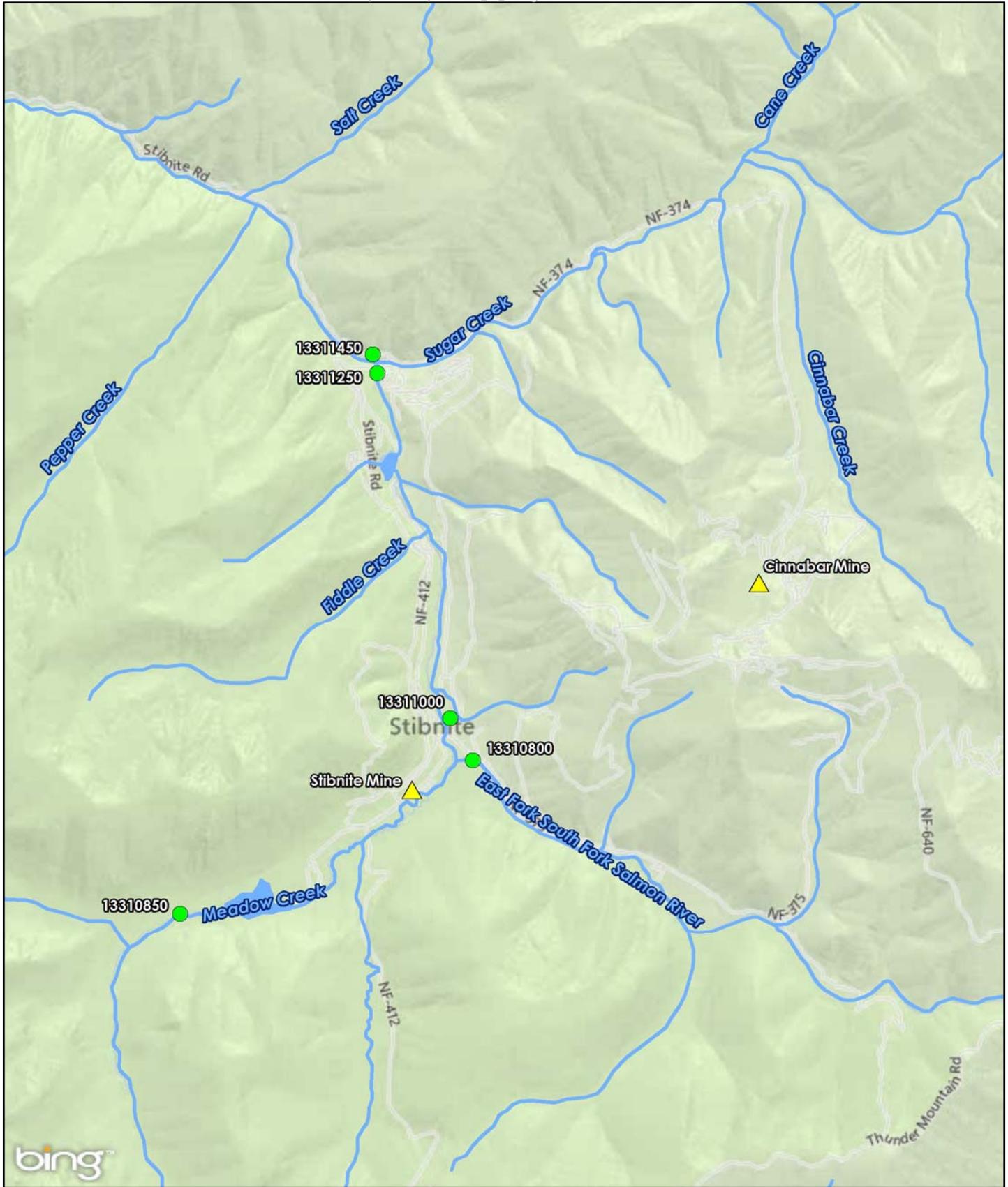
Source: E&E 1996.

Figure 2-8
1998 SAMPLE LOCATION MAP

Date:
3-6-17

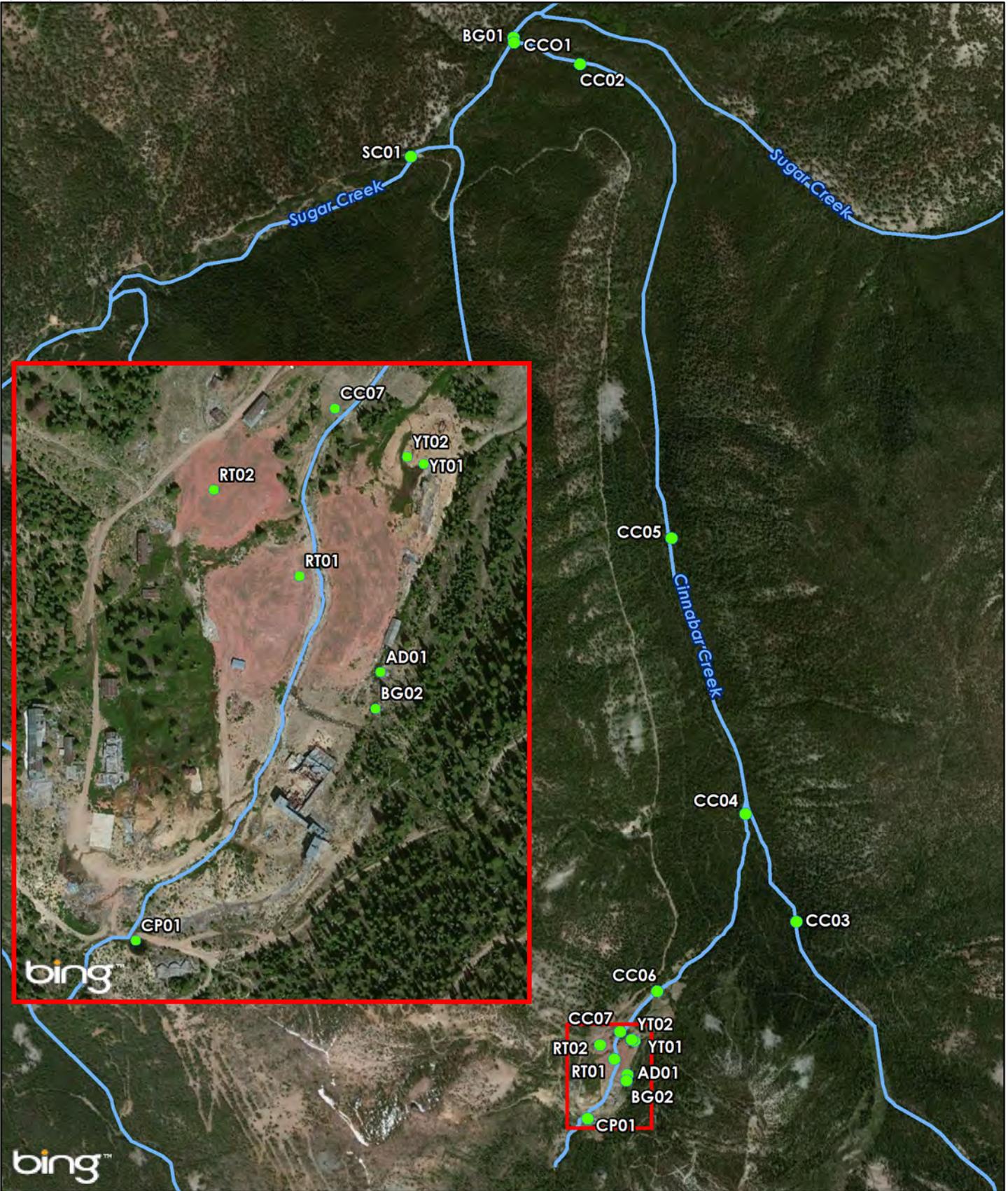
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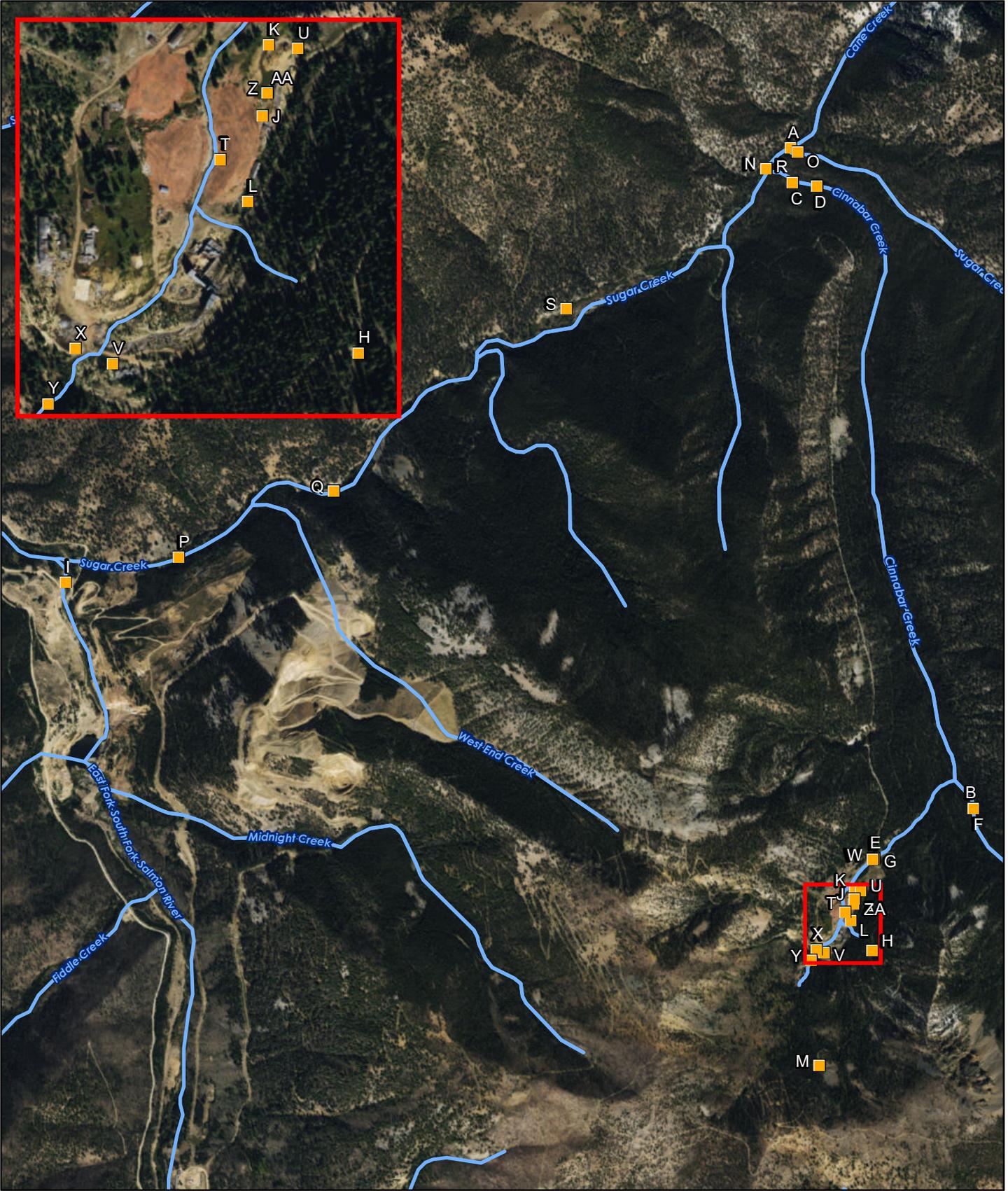
Sources: 2013 Microsoft

<ul style="list-style-type: none">● USGS Sample Locations▲ Mines	<p align="center">Figure 2-9 USGS Stream Monitoring Station Locations Cinnabar Mine Yellow Pine, Idaho</p>	<p align="center">0 0.25 0.5 1 Miles</p> <p align="center"></p>
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Imagery Source: 2014 Microsoft Bing

<p>● Sample Locations (Aug 2014)</p>	<p>Figure 2-10 2014 EPA Sample Locations Cinnabar Mine Yellow Pine, Idaho</p>	<p>↑ N 0 500 1,000 2,000 Feet</p> <p> ecology and environment, inc. Global Environmental Specialists</p>
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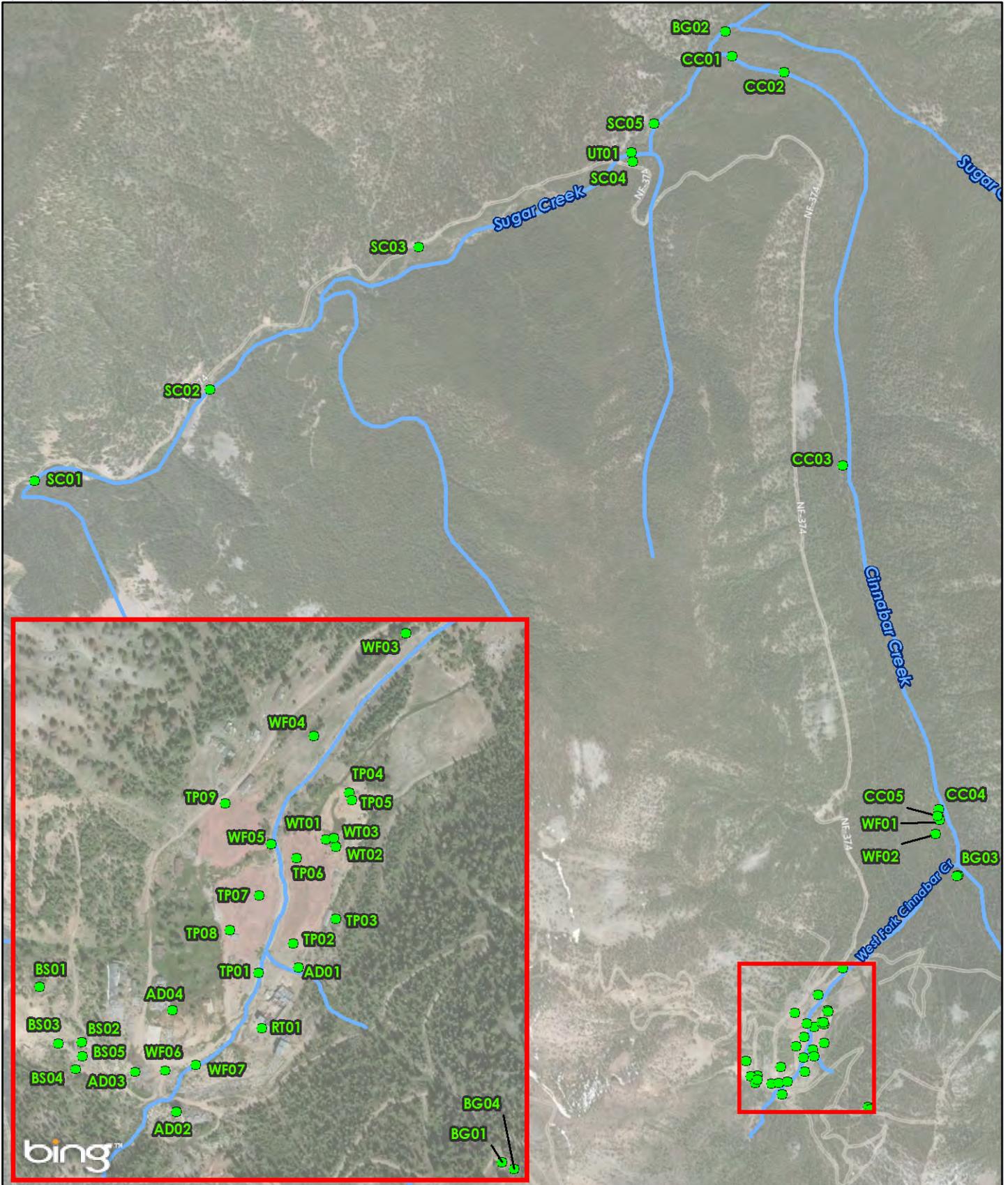


 USGS Sample Locations

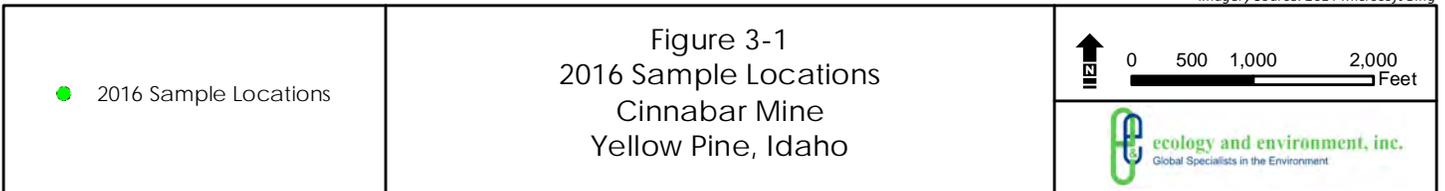
Figure 2-11
2014 USGS Sample Locations
Cinnabar Mine
Yellow Pine, Idaho


0 500 1,000 2,000 Feet

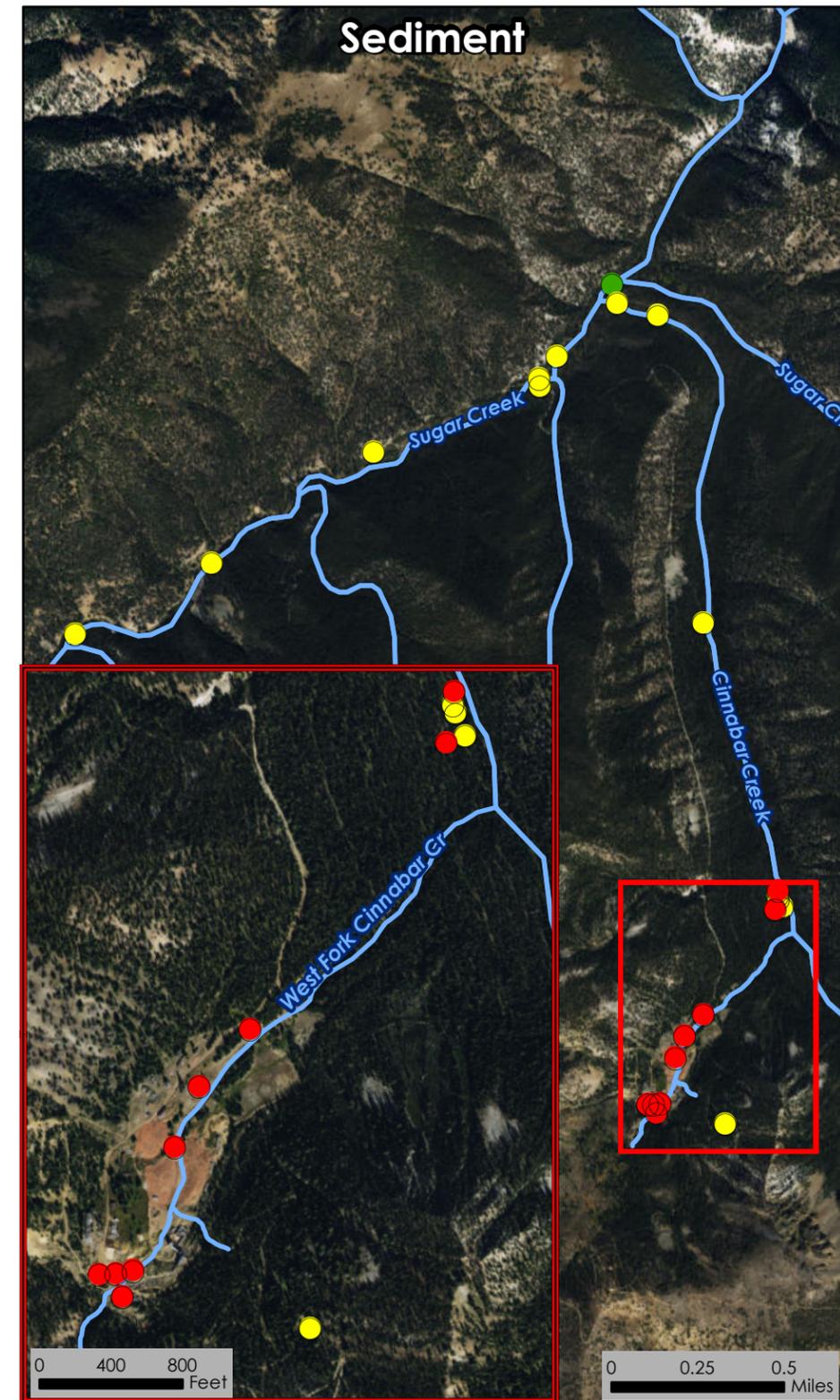
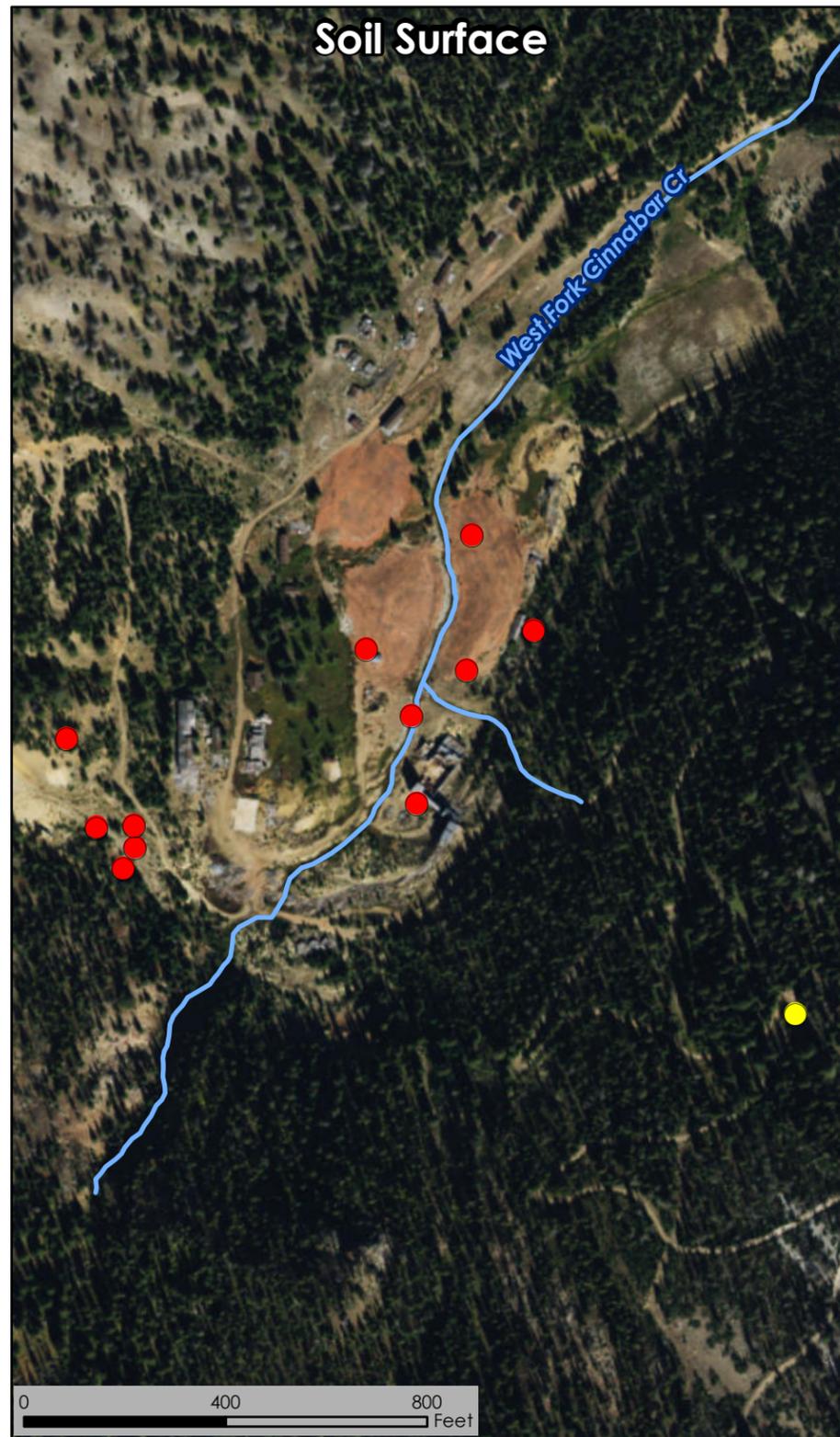
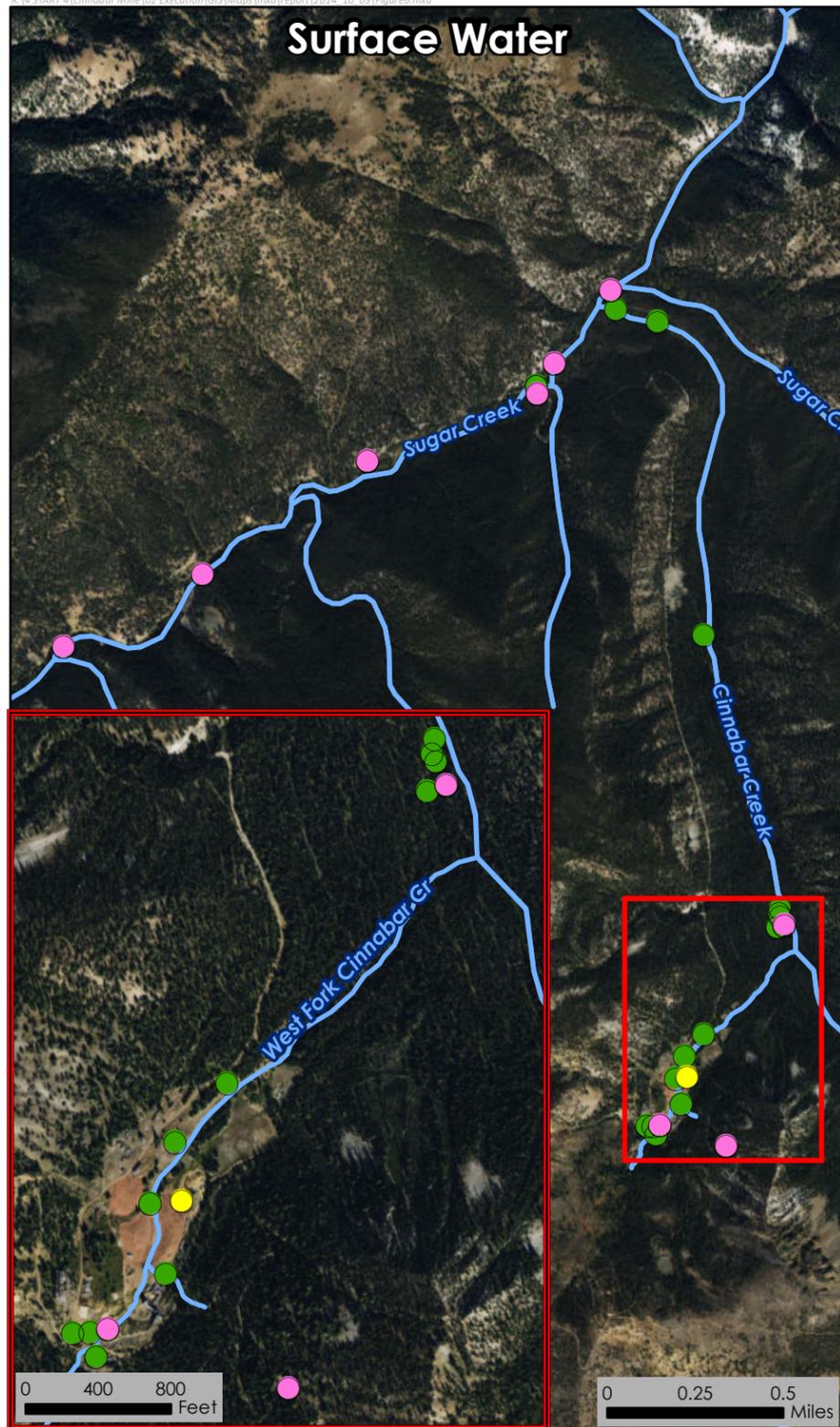
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Imagery Source: 2014 Microsoft Bing

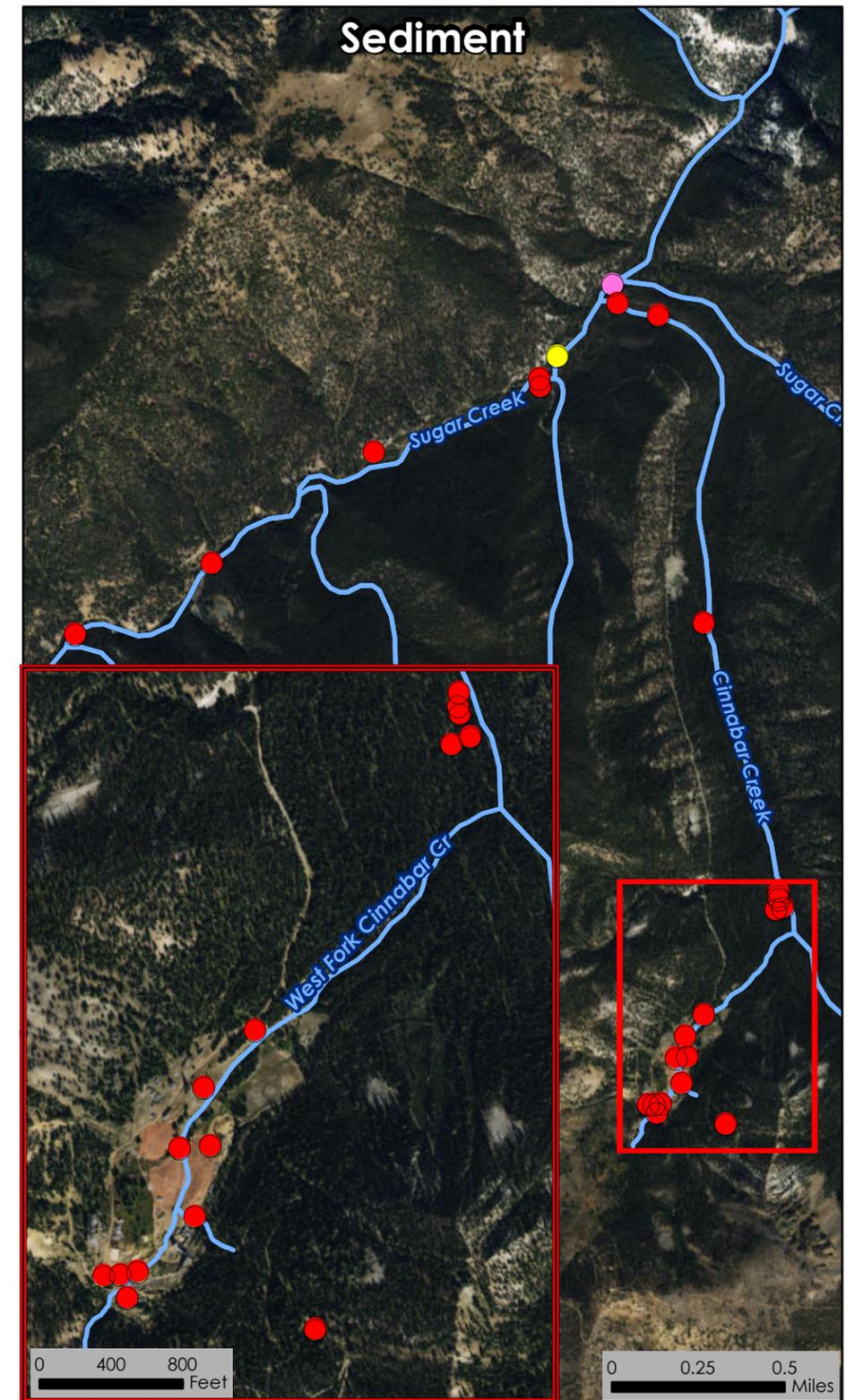
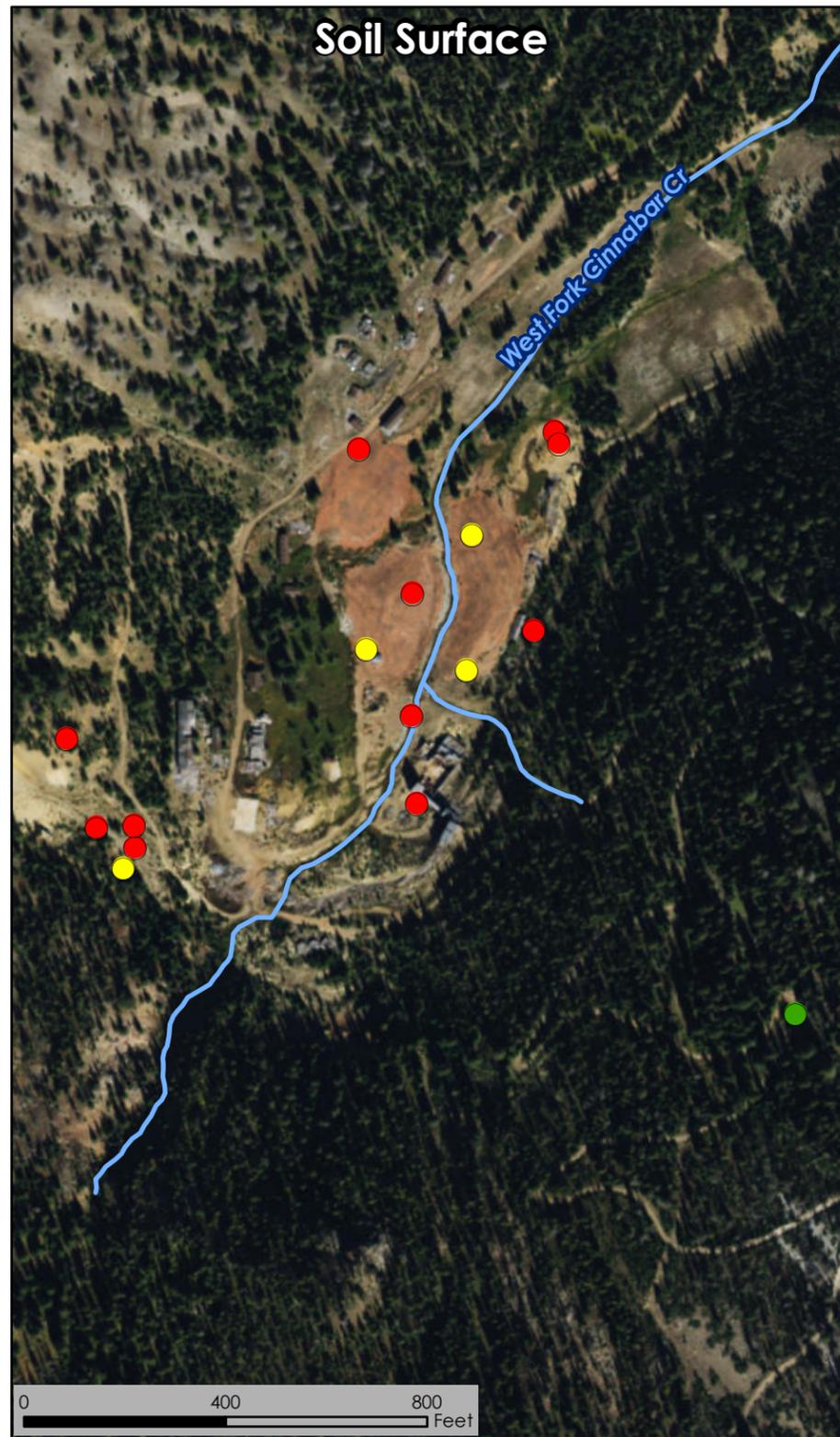
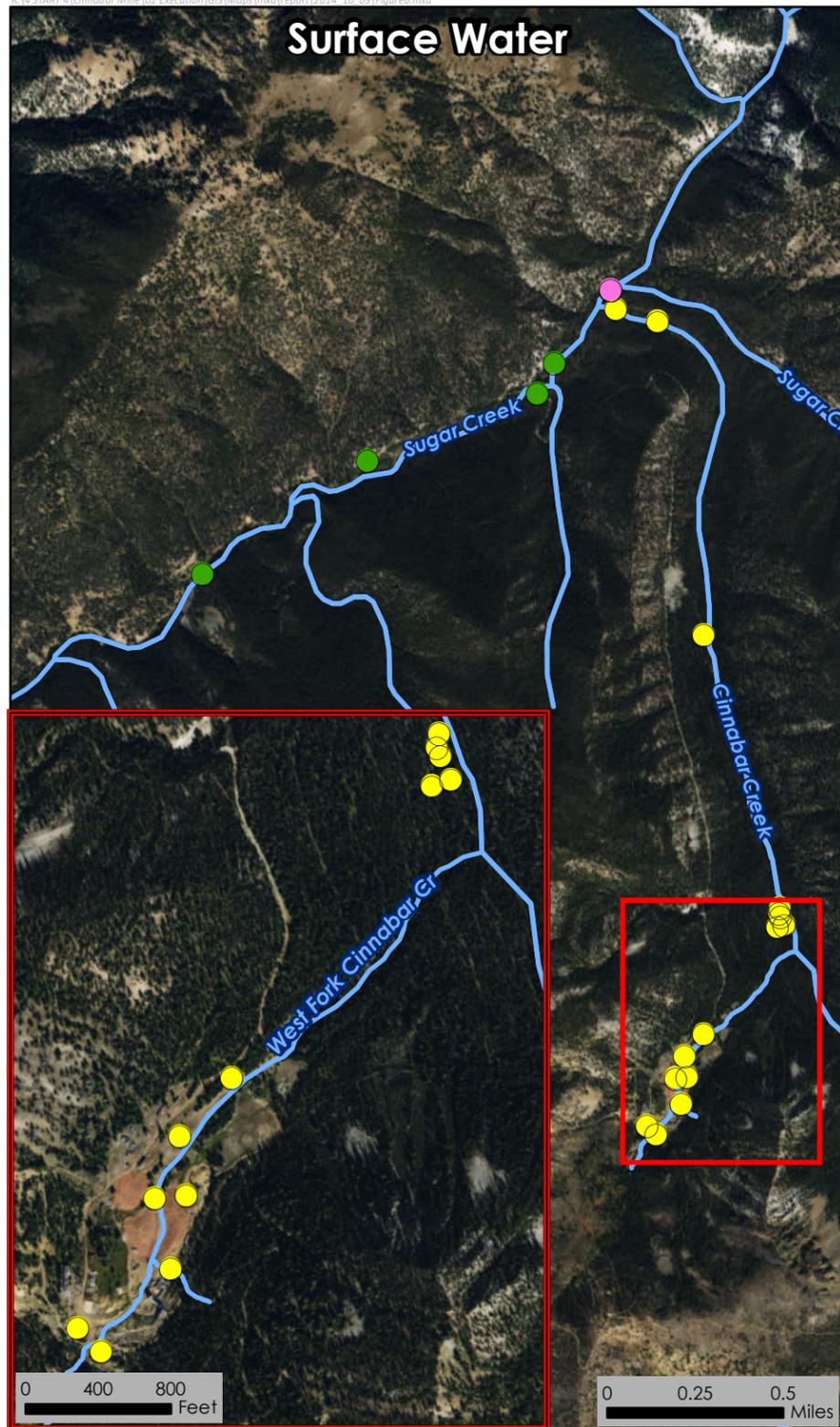


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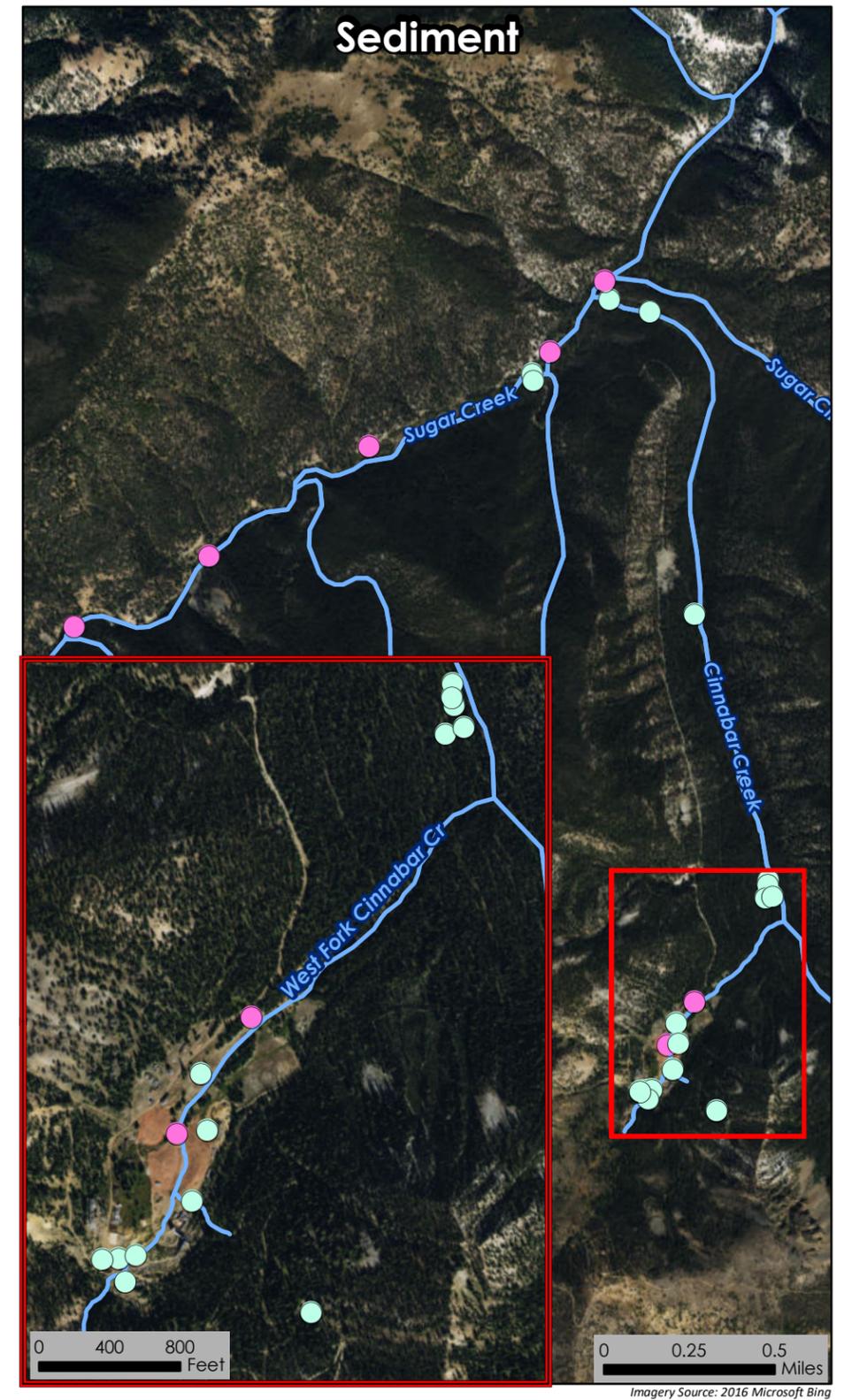
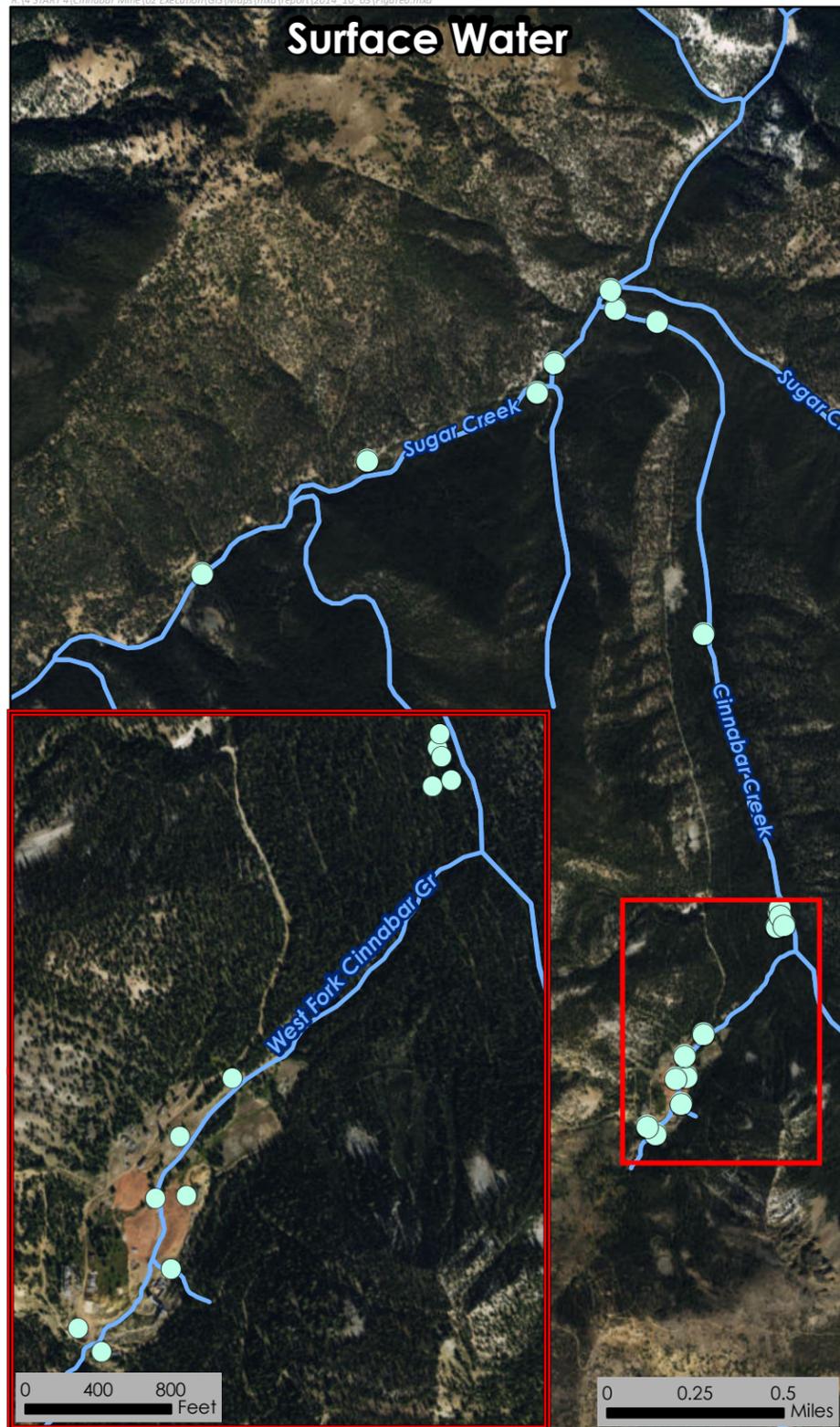
Filtered Surface Water Screening Criteria = 150 ug/L	Soil Surface Screening Criteria = 0.68 mg/kg	Sediment Screening Criteria = 9.79 mg/kg
● <149	● <0.67	● <9.78
● 150 - 339	● 0.68-67	● 9.79-119
● >340	● >68	● >120
● Not Detected	● Not Detected	● Not Detected

Figure 5-1
Arsenic Sampling Results (2016)
Cinnabar Mine
 Yellow Pine, Idaho



Filtered Surface Water Screening Criteria = 12 ng/L	Soil Surface Screening Criteria = 11 mg/kg	Sediment Screening Criteria = 0.18 mg/kg
● <11	● <10	● <0.17
● 12-1399	● 11-32	● 0.18-0.65
● >1400	● >33	● >0.66
● Not Detected	● Not Detected	● Not Detected

Figure 5-2
Mercury Sampling Results (2016)
Cinnabar Mine
 Yellow Pine, Idaho



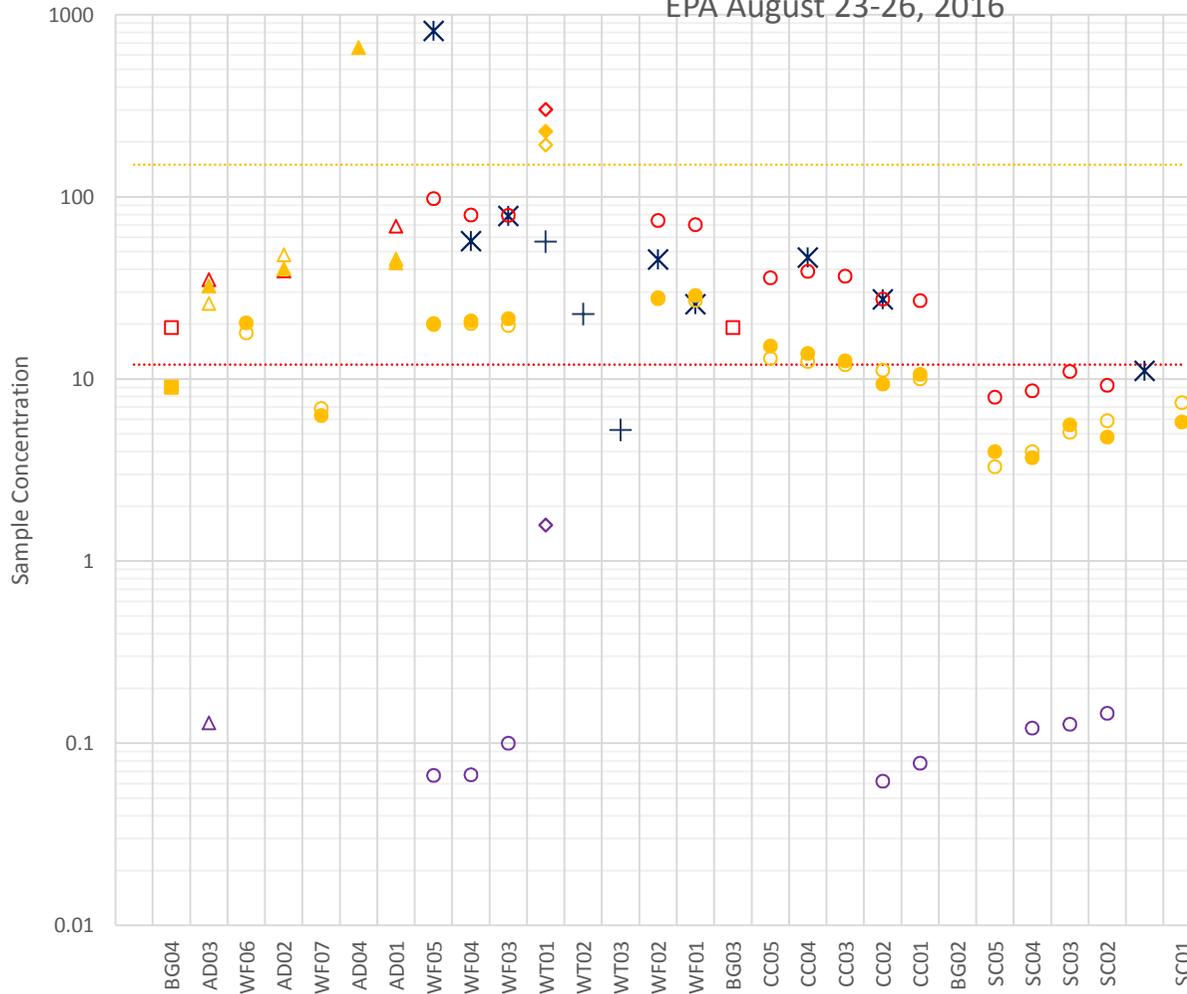
- Sample Location
No applicable screening levels available
- Not Detected

Figure 5-3
Methyl Mercury Sampling Results (2016)
Cinnabar Mine
 Yellow Pine, Idaho



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Figure 6-1
 Surface Water and Pore Water
 Arsenic, Mercury, and Methylmercury
 EPA August 23-26, 2016



- ✕ Porewater Filtered Total Mercury (ng/L) - Creek
- + Porewater Filtered Total Mercury (ng/L) - Poned Area
- Background Filtered Total Mercury (ng/L)
- △ Adit Filtered Total Mercury (ng/L)
- ◇ Pond Filtered Total Mercury (ng/L)
- Creek Filtered Total Mercury (ng/L)
- ⋯ CCC for Mercury - 12 ng/L
- △ Adit Filtered Methylmercury (ng/L)
- ◇ Pond Filtered Methylmercury (ng/L)
- Creek Filtered Methylmercury (ng/L)
- Background Unfiltered Arsenic (µg/L)
- ▲ Adit Unfiltered Arsenic (µg/L)
- ◆ Pond Unfiltered Arsenic (µg/L)
- Creek Unfiltered Arsenic (µg/L)
- Background Filtered Arsenic (µg/L)

Figure 6-2
 Bed Sediment
 Arsenic, Mercury, and Methylmercury
 EPA August 23-26, 2016

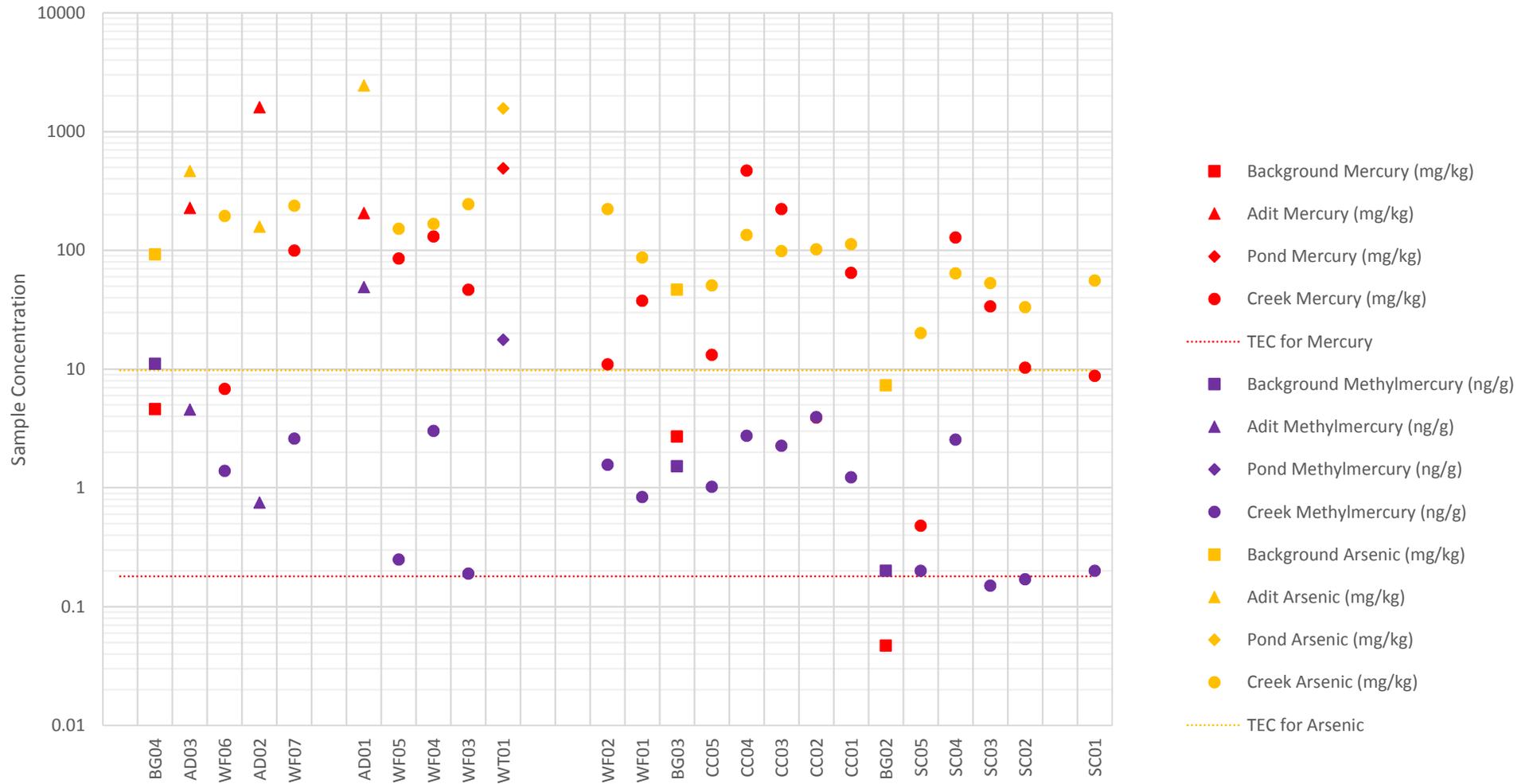


Figure 6-3
Surface Water
Mercury
EPA September 21, 2016

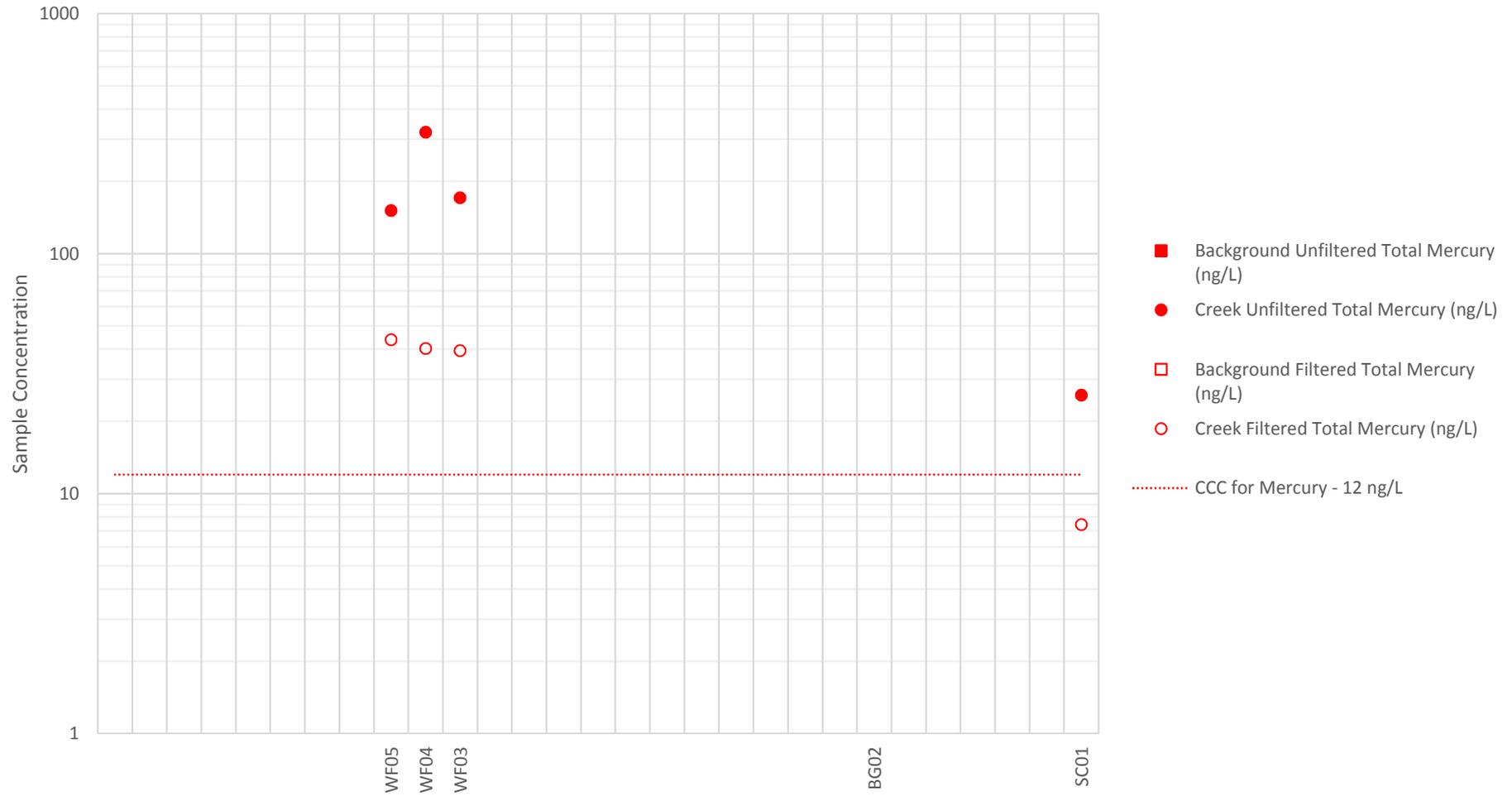


Figure 6-4
 Surface Water
 Arsenic, Mercury, Methylmercury, and Sulfate
 USGS August 18-19, 2014

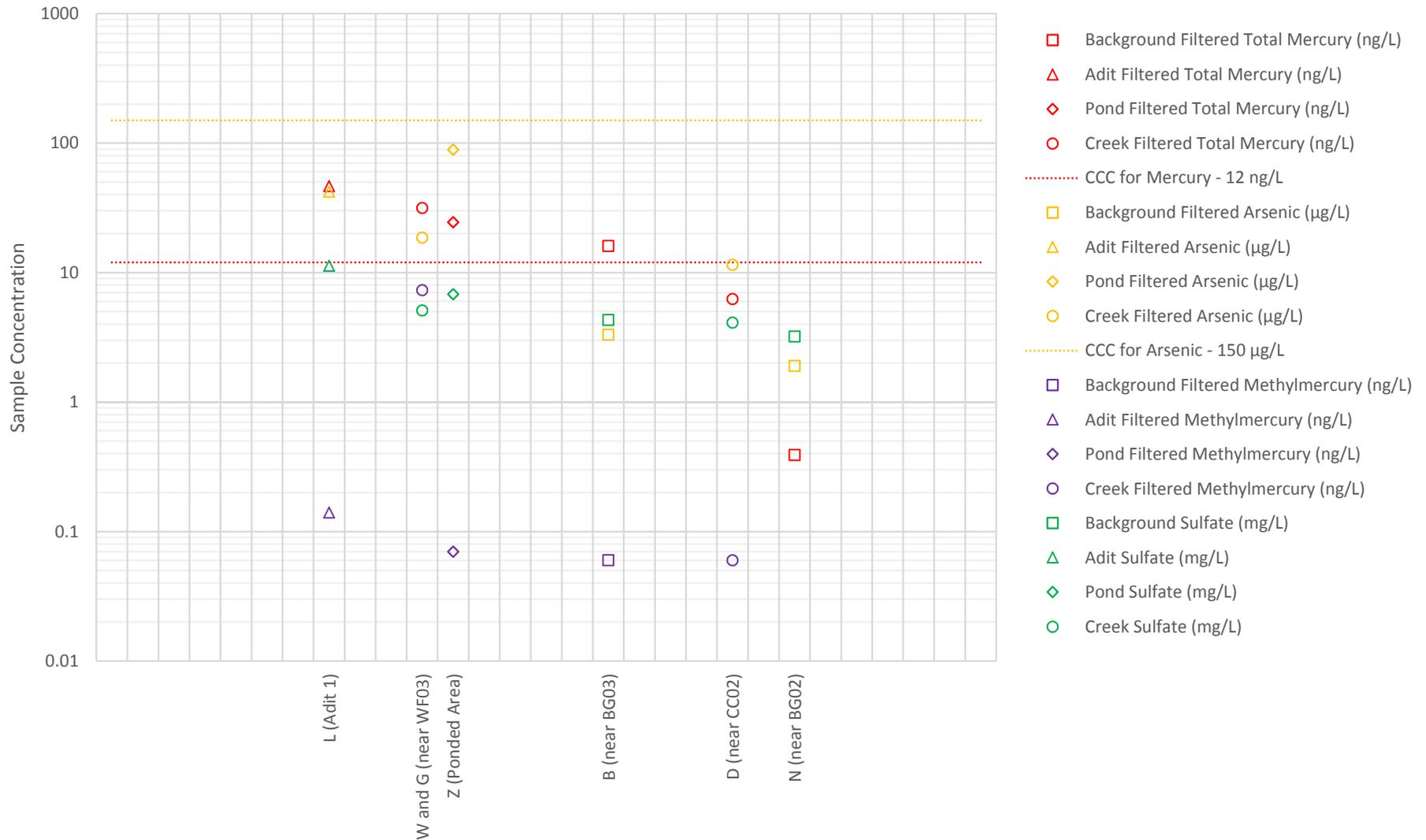


Figure 6-5
 Surface Water
 Arsenic, Mercury, Methylmercury, Iron, and Sulfate
 USGS July 23-25, 2015

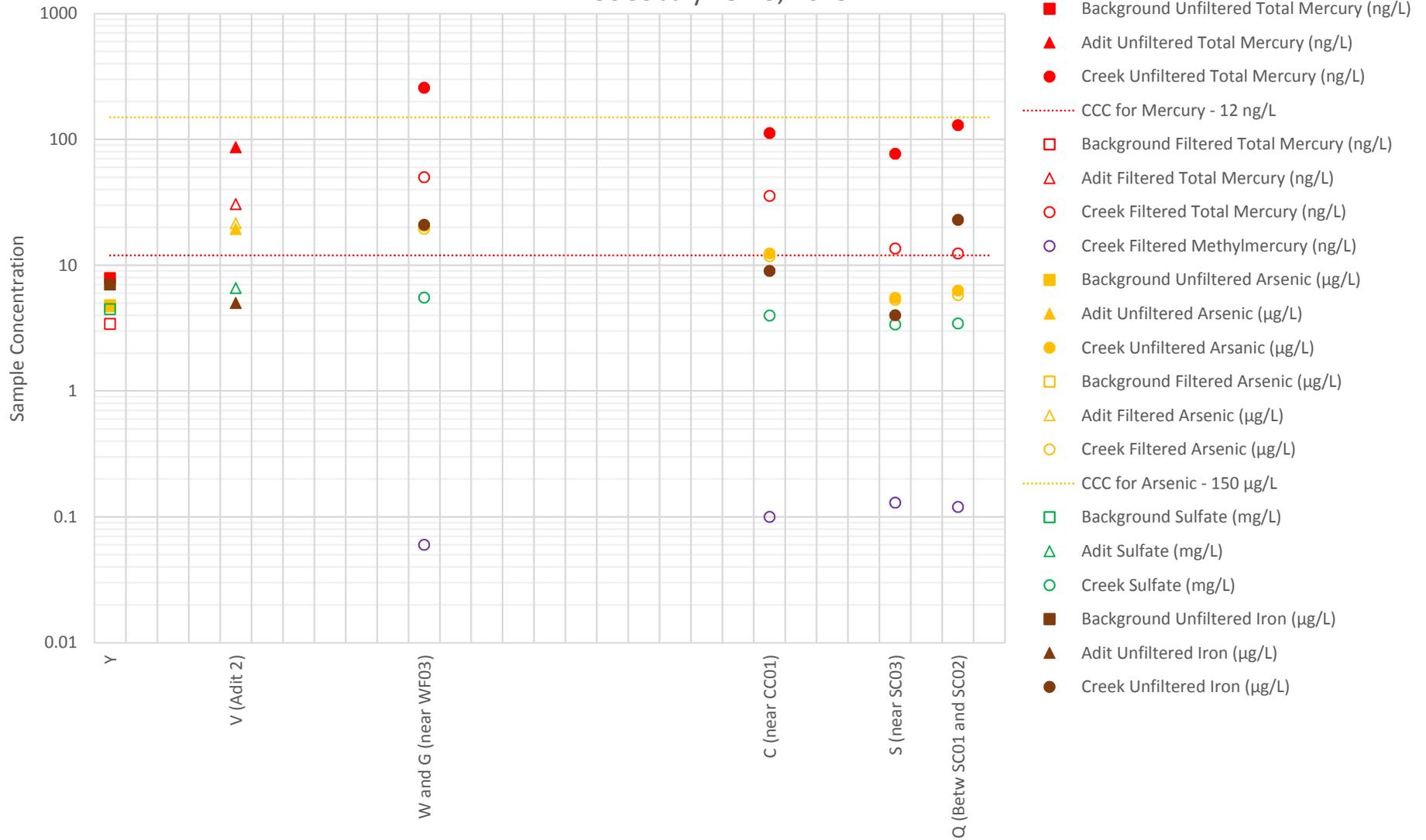


Figure 6-6
Surface Water Filtered Arsenic vs. Filtered Total Mercury
EPA August 23-26, 2016

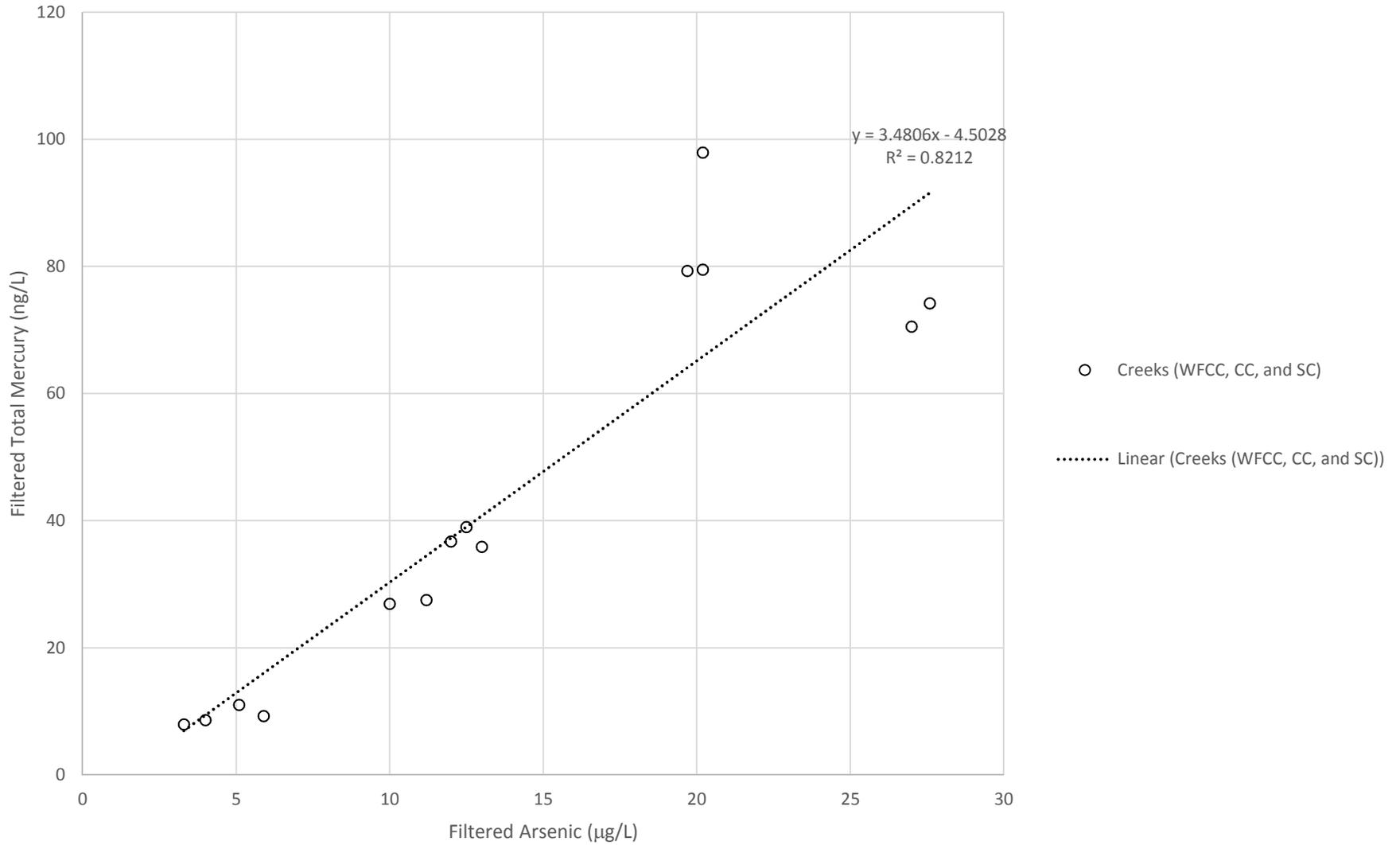
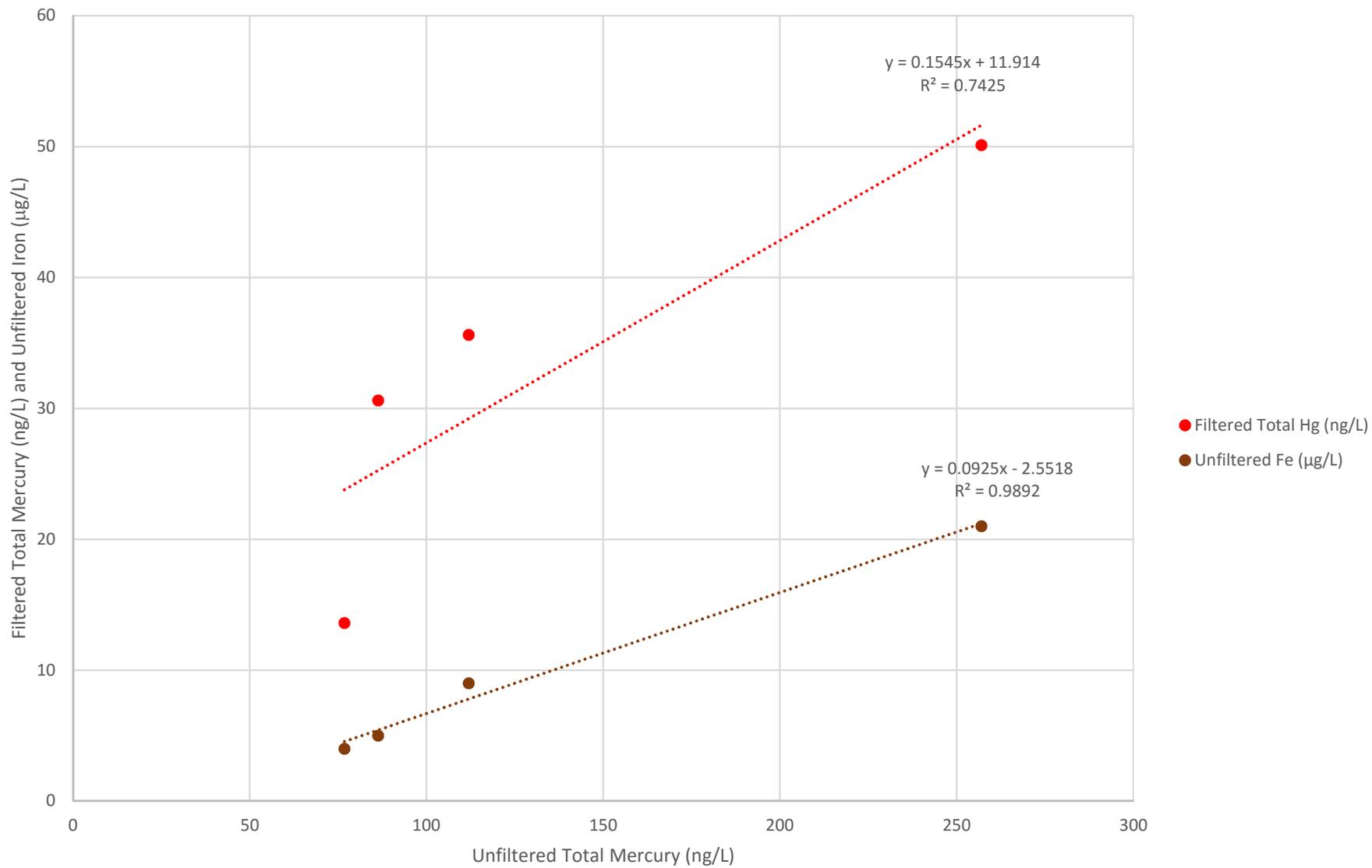
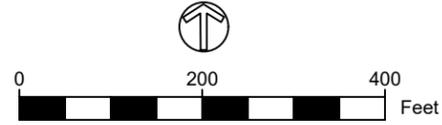


Figure 6-7
Surface Water Unfiltered Total Mercury vs. Filtered Total Mercury and Unfiltered Iron
USGS July 23-25, 2015

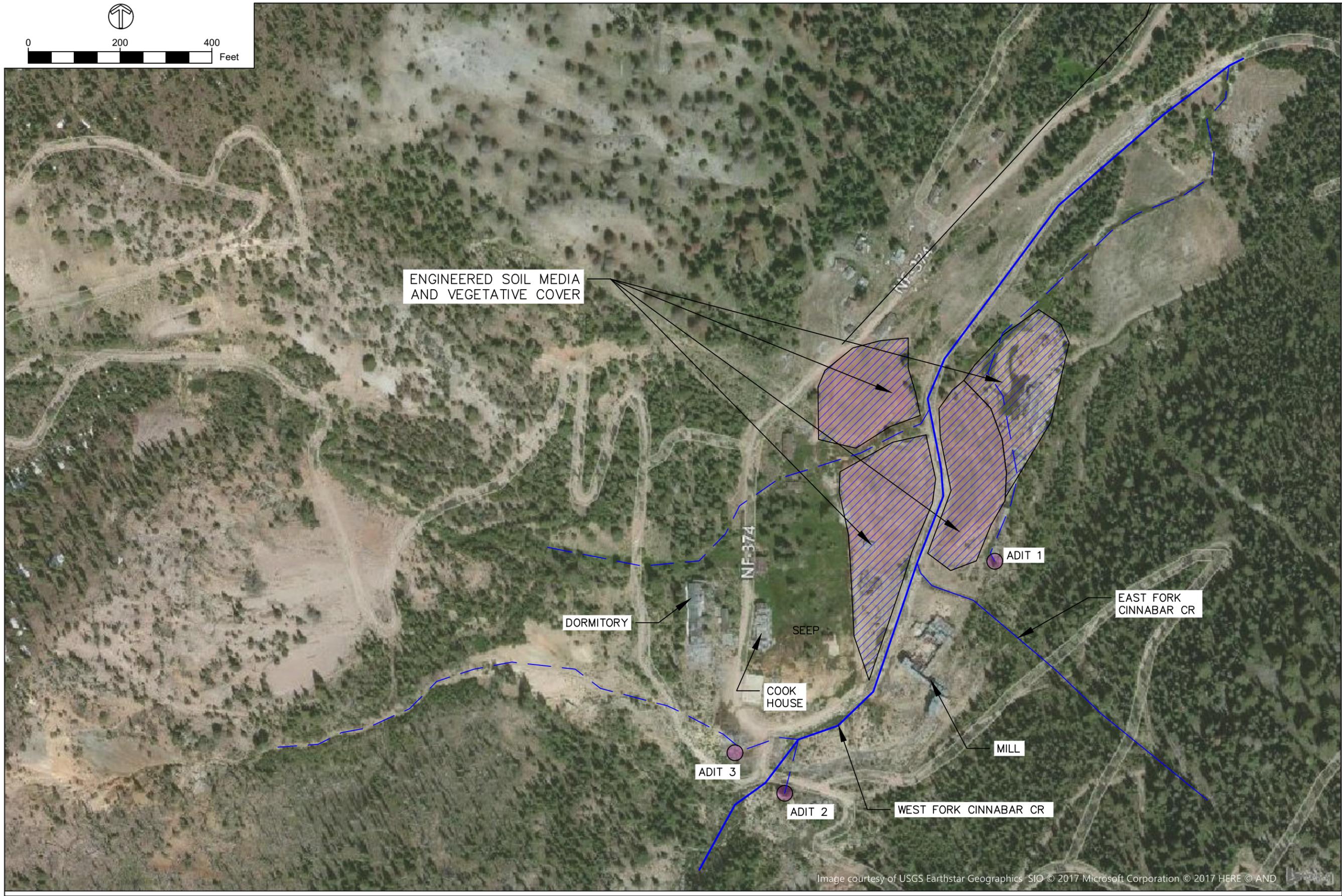


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Symbol	Description	Date	Approved
A			

SIZE B
IF SHEET IS LESS THAN 11"x17" IT IS REDUCED PRINT - SCALE REDUCED ACCORDINGLY ONE INCH

Designed by	J. CHATRIAND	Date	6/28/17
Drawn by	TJC	TDD No.	16-07-0002
Reviewed by		PAM No.	
Approved by	WASHINGTON DEPARTMENT OF REVENUE	File name	AS SHOWN
		Print date	
		Dwg code	

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Seattle, Washington 98104
(206) 624-9537



VALLEY COUNTY IDAHO
CINNABAR MINE SITE
YELLOW PINE, IDAHO
REMOVAL ACTION
ALTERNATIVE 1

FIGURE number:
7-1

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Tables

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Table 2-1 1985 Preliminary Assessment Sample Results

Sample Number	Sample Matrix	Sample Location	Sample Results	Analytical Parameter
CMS-07	Soil	Background	15.0 ppm	Mercury
CMS-04	Soil	Red tailings composite	10.0 ppm	Mercury
CMS-03	Soil	Edge of vegetation and red tailings pile	11.0 ppm	Mercury
CMS-05	Soil	Tan tailings composite	81.0 ppm	Mercury
CMS-09	Soil	Drainage area near adit	400 ppm	Mercury
CMS-12	Soil	Composite south tailings pond	400 ppm	Mercury
CMS-11	Soil	Composite north tailings pond	1000 ppm	Mercury
CMW-01	Water	North tailings pond effluent	<0.001 ppm	Mercury
CMW-03	Water	South tailings pond effluent	<0.001 ppm	Mercury
CMW-02	Water	Effluent from stack	4.9 ppm	Mercury
CMW-05	Water	Effluent from stack (duplicate of CMW-02)	8.3 ppm	Mercury
CMS-06	Sediment	West Fork Cinnabar from stack	1200 ppm	Mercury
CMS-10	Sediment	Duplicate CMS-06	2300 ppm	Mercury
80	Air	Near mill	<0.5 total micrograms	Mercury
81	Air	Command post	<0.5 total micrograms	Mercury
CMS-08	Soil	Beneath Transformer #3	0.2 ppm	PCB
CMO-01	Product	Storage tank	4.0 ppm	PCB
CMS-01	Soil	Beneath Transformer #2	36.0 ppm	PCB
CMS-02	Soil	Duplicate of CMS-01	24.0 ppm	PCB

Source: Weston 1985.

Note: Bold type indicates the sample result is above the MDL.

Key:

MDL = Method Detection Limit.
 PCB = Polychlorinated biphenyls.
 ppm = parts per million.

Table 2-2 **1991 USFS Sample Results**

Analyte (ppm)	EPA Maximum concentration of contaminants for toxicity	Sample		
		1	2	3
Mercury	0.2	200	180	60
Lead	5.0	3.3	19	34.4
Arsenic	5.0	189	181	229

Source: USFS 1992.

Note: Bold type indicates the sample result is above the MDL.

Highlighted cells indicate the sample result exceeds the EPA maximum concentration of contaminants for toxicity characteristics.

Key:

MDL = Method Detection Limit.

ppm = parts per million.

Table 2-3 1994 Site Inspection Soil Samples Analytical Results Summary

EPA Sample ID	94294011	94294012	94294010	94294005	94294009	94294008	94294006
CLP Sample ID	MJM246	MJM250	MJM251	MJM241	MJM240	MJM244	MJM245
Station Location	11-SS-00006-0005	11-SS-00007-0005	11-SS-00005-005	11-SS-00001-0005	11-SS-00004-0005	11-SS-00003-1005	11-SS-00002-0005
Description	Background		South Tailings Impoundment	Red Tailings Pile	Drum Area	Mill	Tan Tailings Pile
Target Analyte List Metals (mg/kg)							
Aluminum	14000	2750	8430	11800	8540	5510	2310
Antimony	39.6 J	46.4 J	27.4 J	38.5 J	14.5 J	9.8 J	34.5 J
Arsenic	226 J	40.0 J	471 J	1210 J	84.2 J	108 J	472 J
Barium	58.3	33.7	68.4	75.8	37.3	93.7	55.3
Beryllium	0.96	0.25	0.68	1.2	0.48	0.33	0.81
Cadmium	0.15 U	0.20 U	0.14 U	0.18 U	0.19 U	0.56	0.17 U
Calcium	6530 J	4650 J	18900 J	4340 J	2620 J	112000 J	709 J
Chromium	26.6	3.3	10.6	10.6	7.4	28.2	4.0
Cobalt	13.7	1.9	6.8	11.1	3.8	2.4	5.9
Copper	15.6	5.4	15.1	14.6	5.5	48.6	17.5
Iron	17800	3560	12000	12000	5610	9460	9750
Lead	7.7	4.6	4.7	8.3	10.5	18.9	6.1
Magnesium	6760	901	5490	2160	1480	2630	249
Manganese	601 J	277 J	331 J	232 J	132 J	185 J	253 J
Mercury	26.7	44.6	98.6	8.9	35.5	1770	110
Nickel	21.6	2.8	12.0	19.4	5.9	4.9	15.7
Potassium	3100 J	478 J	1890 J	3070 J	1730 J	1150 J	524 J
Selenium	0.30 U	0.54	0.28 U	0.35 U	0.39 U	0.40 U	0.34 U
Silver	0.15 U	0.20 U	0.14 U	0.18 U	0.19 U	0.20 U	0.17 U
Sodium	361 UJ	139 UJ	120 UJ	129	4540	1990	86.8 UJ
Thallium	2.4	0.54 J	8.2	9.8	3.2	0.92 J	6.3
Vanadium	22.0	5.4	10.4	12.6	5.0	12.0	6.8
Zinc	21.8	17.6	27.6	35.7	19.3	319	33.7

Source: Weston 1994.
 Note: Bold type indicates the sample result is above the CRDL.
 Underline type indicates the sample result is significant as defined in Section 7.

Key:
 CLP = Contract Laboratory Program.
 CRDL = EPA Contract Required Detection Limits.
 EPA = United States Environmental Protection Agency.
 ID = Identification.
 J = The analyte was positively identified, but the associated numerical value is an estimated quantity because quality control criteria were not met.
 mg/kg = milligrams per kilogram.
 U = Analyzed but not detected.

Table 2-4 1994 Site Inspection Sediment Samples Analytical Results Summary

EPA Sample ID	94294014	94294013	94294015	94294016	94294017	94294018	94294019
CLP Sample ID	MJM243	MJM242	MJM252	MJM255	MJM247	MJM253	MJM248
Station Location	11-SD-00006-005	11-SD-00001-005	11-SD-00002-0005	11-SD-00005-1005	11-SD-00003-0005	11-SD-00004-0005	11-SD-00005-0005
Description	Background	Creek Sediment					
		Fallen Stack in West Fork Cinnabar Creek	#4 300 Feet Below Rip Rap	Duplicate of #4	#3 150 Feet below Rip Rap	#2 50 Feet Below Creek Confluence	#1 150 Feet Above Creek Confluence
Target Analyte List Metals (mg/kg)							
Aluminum	24300	12400	5790	11000	4500	26700	3070
Antimony	34.9 J	31.3 J	16.7 J	23.7 J	18.1 J	21.5 J	27.9 J
Arsenic	250 J	761. J	220 J	369 J	191 J	350 J	326 J
Barium	132	74.4	33.4	71.4	23.8	109	23.1
Beryllium	1.8	0.9	0.74	2.3	0.6	2.6	0.46
Cadmium	0.44 U	0.17 U	0.19 U	0.26 U	0.17 U	0.27 U	0.17 U
Calcium	24300 J	13000 J	114400 J	16900 J	32800 J	407100 J	10600 J
Chromium	38.8	19.1	7.1	15.2	4.3	31.2	4.0
Cobalt	12.7	9.6	8.5	31.9	6.6	50.8	1.9
Copper	39.6	29.6	11.2	25.1	4.5	27.0	6.6
Iron	29800	21000	7270	13700	5830	23000	7680
Lead	6.9	7.0	2.3 UJ	5.1	2.6	6.9	3.6
Magnesium	21700	9610	3440	8600	1740	27800	3890
Manganese	3380 J	622 J	266 J	630 J	161 J	1510 J	96.1 J
Mercury	7.3	410	35.2	91.3	18.0	69.6	9.58
Nickel	37.7	24.2	11.3	32.6	9.4	49.3	5.1
Potassium	2970 J	2890 J	1090 J	1770 J	979 J	3880 J	784 J
Selenium	1.1	0.33 U	0.39 U	0.53 U	0.34 U	0.53 U	0.33 U
Silver	0.44 U	0.17 U	0.19 U	0.26 U	0.17 U	0.27 U	0.17 U
Sodium	480	184	149 UJ	211 UJ	115 UJ	275 UJ	137 UJ
Thallium	0.97 J	6.0	4.5	8.4	4.1	8.6	10.7
Vanadium	33.5	19.3	7.0	14.7	5.0	32.0	5.1
Zinc	53.7	68.3	30.6	100	23.7	94.4	18.3

Source: Weston 1994.

Note: Bold type indicates the sample result is above the CRDL.
 Underline type indicates the sample result is significant as defined in Section 7.

Key:

- CLP = Contract Laboratory Program.
- CRDL = EPA Contract Required Detection Limits.
- EPA = United States Environmental Protection Agency.
- ID = Identification.
- J = The analyte was positively identified, but the associated numerical value is an estimated quantity because quality control criteria were not met.
- mg/kg = milligrams per kilogram.
- U = Analyzed but not detected.

Table 2-5 1996 Time Critical Removal Action Laboratory Soil/Sediment Sample Results

Sample ID	96090322	96090326	96090330	96090342	96090362	96090374	96090378	96090390	96090394	96090397		
Sample Matrix	Sediment	Tailings	Tailings	Soil	Sediment/ Tailings	Soil/ Tailings	Sediment	Sediment/ Tailings	Sediment/ Tailings	Sediment/Soil		
Sample Location	North End of Retort Adjacent to West Fork Cinnabar Creek			Tan Tailings Pile	East Red Tailings Pile	Native Soil	Former Retort Area	Impoundment Berm Northeast Corner of Lower Tailings Pile	West Fork Cinnabar Creek	Test Pit 1	Test Pit 2	Test Pit 2
Target Analyte List	Metals (mg/kg)											
Antimony	44.6 J	111 J	1010 J	3.9 J	106 J	70.2 J	57.8 J	48.2 J	81.0 J	59.2 J		
Arsenic	267	2540	1150	41.5	496	247	420	335	543	234		
Beryllium	0.69	1.0	0.84	1.4 U	0.61 U	0.24 U	1.3 U	0.65 U	0.46 U	0.91 U		
Cadmium	0.22 U	0.21 U	0.19 U	0.17 U	0.29 U	0.15 U	0.21 U	0.22 U	0.22 U	0.24 U		
Chromium	19.2 J	3.4 J	5.5 J	34.5 J	10.4 J	4.3 J	24.1 J	14.9	5.5	25.2		
Copper	36.2 J	10.2 UJ	7.5 UJ	14.9	25.2	13.5	18.3	14.6 J	10.2 J	14.2 J		
Lead	4.6 J	4.4 J	6.7 J	10.8	85.3	3.3	6.9	28.2	8.6	7.5		
Mercury	423 J	1120 J	16.9 J	4.5 J	890 J	366 J	99.2 J	1130 J	9270 J	19.7 J		
Nickel	17.7 J	24.9 J	15.6 J	18.7	11.6	4.6	23.2	13.2	8.4	13.9		
Selenium	2.8 U	2.7 U	2.3 U	2.6 U	2.4 U	2.3 U	3.3 U	2.7 U	2.7 U	3.0 U		
Silver	0.81 UJ	0.78 UJ	0.69 U	0.79 UJ	0.72 UJ	0.68 UJ	0.99 UJ	0.80 UJ	1.0 UJ	0.86 UJ		
Thallium	1.9	41.4	7.9	0.74 U	4.7	3.9	8.7	2.7	5.2	1.1		
Zinc	45.9 J	53.10 J	35.3 J	62.3 J	396 J	13.6 J	64.4 J	26.8 J	27.3 J	32.2 J		

Source: E & E 1996.

Note: Bold type indicates the sample results is above the MDL.

Key:

ID = Identification.

J = The associated numerical value is an estimated quantity because the reported concentrations were less than the contract required detection limits or because quality control criteria limits were not met.

MDL = Method Detection Limit.

mg/kg = milligrams per kilogram.

U = The material was analyzed for but was not detected. The associated numerical value is the sample quantitation limit.

Table 2-6 1996 Time Critical Removal Action Laboratory Surface Water Sample Results

Sample ID	96090377U	96090377F	96090379	96090383	96090384	96090385
Sample Location	West Fork Cinnabar Creek (Unfiltered)	West Fork Cinnabar Creek (Filtered)	Duplicate of 96090377 (Unfiltered)	Adit 1	West Fork Cinnabar Creek	Adit 3
Target Analyte List Metals (µg/L)						
Antimony	8.4 J	4.2 J	4.0 J	4.6 J	2.6 J	1.8 J
Arsenic	72.0	34.4	35.6	21.4	2.3	12.7
Beryllium	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Cadmium	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U
Chromium	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U	4.8 U
Copper	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U
Lead	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U
Mercury	1.4 J	0.43 J	1.3 J	0.26 J	0.14 U	0.14 U
Nickel	17.1 U	17.1 U	17.1 U	17.1 U	17.1 U	17.1 U
Selenium	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U
Silver	7.3 U	7.3 U	7.3 U	7.3 U	7.3 U	7.3 U
Thallium	0.25	0.16 U	0.16 U	0.16 U	0.16 U	0.47
Zinc	5.1 U	5.1 U	5.1 U	52.9	5.1 U	5.2

Source:

E & E 1996.

Note:

Bold type indicates the sample results is above the MDL.

Key:

µg/L = micrograms per liter.

ID = Identification.

J = The associated numerical value is an estimated quantity because the reported concentrations were less than the contract required detection limits or because quality control criteria limits were not met.

MDL = Method Detection Limit.

U = The material was analyzed for but was not detected. The associated numerical value is the sample quantitation limit.

Table 2-7 1998 Removal Action XRF Soil Sample Results

Sample Number	Sample Matrix	Mercury in Soil mg/kg	Arsenic in Soil mg/kg
CIN 1	Soil	166	NR
CIN 2	Soil	78	NR
CIN 3	Soil	84	NR
CIN 4	Soil	118	NR
CIN 5	Tailings	24	NR
CIN 6	Tailings	104	NR
CIN 7	Tailings	169	NR
CIN 8	Soil	94	159
CIN 9	Soil	136	180
CIN 10	Soil	68	148
CIN 11	Soil	105	131
CIN 12	Soil	43	146
CIN 13	Soil	116	129
CIN 14	Soil	96	92
CIN 15	Soil	77	144
CIN 16	Soil	153	156
CIN 17	Soil	48	161
CIN 18	Soil	34	133

Source: E & E 1998.

Key:

mg/kg = milligrams per kilogram.

NR = Analysis for this element was not run on this sample.

Table 2-8 2011 to 2016 USGS Surface Water Monitoring Stations Samples Analytical Results

Station Number CMC CCC	Sample Date	Temp (°C)	Specific Conductance (µS/cm @ 25°C)	pH (standard units)	Arsenic (µg/L)		Lead ^a (µg/L)		Mercury (µg/L)		
					Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	
					340 150	NA NA	65 2.5	NA NA	1.4 0.012	NA NA	
13310850 - Meadow Creek (Background)	9/20/2011	5.8	74	7.8	1.4	1.7	0.016	0.06	< 0.005	< 0.005	
	9/22/2011	5	75	6.9	1.27	1.3	0.011	0.01	NP	NP	
	10/17/2011	4.1	63	8.1	1.3	1.5	0.077	0.19	< 0.005	< 0.005	
	12/14/2011	0.1	72	7.8	1.4	1.4	0.041	0.05	NP	NP	
	5/17/2012	3.2	34	7.2	0.88	1.7	0.027	0.2	NP	NP	
	6/13/2012	6.8	37	7.4	0.85	1.2	0.036	0.12	NP	< 0.005	
	8/29/2012	6.7	77	7.6	1.5	1.5	0.064	0.07	NP	NP	
	11/6/2012	4	64	7.7	1.2	1.2	NP	< 0.04	NP	NP	
	3/27/2013	0.2	67	7.6	1.3	1.2	< 0.025	< 0.04	NP	NP	
	5/8/2013	3.9	39	7.5	0.81	1.4	0.052	0.27	NP	NP	
	5/14/2013	2.2	32	7.3	0.77	1.8	0.029	0.37	< 0.005	< 0.005	
	5/30/2013	2.5	42	7.9	0.79	0.81	0.037	< 0.04	NP	NP	
	6/25/2013	7.1	46	7.9	0.82	0.98	< 0.025	< 0.04	NP	NP	
	4/24/2014	2	50	7.5	0.91	1.1	0.074	0.1	NP	NP	
	5/15/2014	3.7	42	7.6	0.82	1.6	< 0.04	0.21	< 0.005	< 0.005	
	5/18/2014	2.6	36	7.4	0.61	0.98	< 0.04	< 0.11	NP	NP	
	5/23/2014	3.1	31	7.4	0.84	4	< 0.04	0.88	< 0.005	0.014	
	6/10/2014	6.8	36	7.6	0.78	0.98	< 0.04	0.04	NP	NP	
	6/24/2014	9.9	40	7.6	0.83	0.85	< 0.04	< 0.04	NP	NP	
	8/12/2014	10.4	71	7.8	1.2	1.5	NP	< 0.04	NP	NP	
	9/30/2014	6.6	74	7.7	1.2	1.3	NP	< 0.04	< 0.005	< 0.005	
	3/18/2015	1.2	45	7.3	0.87	1	0.045	0.05	< 0.005	< 0.005	
	5/6/2015	2.1	36	7.2	0.76	1	< 0.04	0.06	< 0.005	0.01	
	5/19/2015	3.8	39	7.2	0.81	0.73	< 0.04	0.06	< 0.005	< 0.005	
	6/10/2015	7.4	44	7.1	0.8	1	0.105	< 0.04	< 0.005	< 0.005	
	8/25/2015	NP	NP	NP	NP	1.4	1.7	< 0.04	< 0.04	< 0.005	< 0.005
	9/29/2015	NP	NP	NP	NP	1.4	1.6	< 0.04	< 0.04	< 0.005	< 0.005
	2/23/2016	0	73	7.6	7.6	1.3	1.5	< 0.04	< 0.04	< 0.005	< 0.005
	3/29/2016	NP	NP	NP	NP	1.1	1.1	< 0.04	< 0.04	< 0.005	< 0.005
	5/10/2016	2.6	35	7.4	7.4	0.69	0.99	< 0.04	0.05	< 0.005	< 0.005
	6/14/2016	5.7	42	7.5	7.5	0.78	0.7	< 0.04	< 0.04	< 0.005	< 0.005
	8/9/2016	7.4	73	7.6	7.6	1.2	1.4	0.03	0.02	< 0.005	< 0.005
10/4/2016	3.5	82	7	7	1.3	1.3	0.021	< 0.02	< 0.005	< 0.005	
3/14/2017	2	67	6.1	6.1	1.1	11.3	< 0.02	0.03	< 0.005	< 0.005	

Table 2-8 2011 to 2016 USGS Surface Water Monitoring Stations Samples Analytical Results

Station Number CMC CCC	Sample Date	Temp (°C)	Specific Conductance (µS/cm @ 25°C)	pH (standard units)	Arsenic (µg/L)		Lead ^a (µg/L)		Mercury (µg/L)	
					Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
					340 150	NA NA	65 2.5	NA NA	1.4 0.012	NA NA
13310800 - EFSFSR above Meadow Creek	9/19/2011	8.4	78	8.1	12.4	11.8	0.025	0.04	< 0.005	< 0.005
	10/17/2011	4.2	75	8.3	10.9	10.2	0.051	< 0.4	< 0.005	< 0.005
	12/14/2011	0.3	77	8.7	12.2	11.9	< 0.025	< 0.04	NP	NP
	5/17/2012	3.9	36	7.5	4.8	6.4	0.05	1.94	NP	NP
	6/13/2012	5.6	44	7.4	5.3	5.3	0.105	0.17	NP	0.008
	8/28/2012	8.6	76	7.7	12.5	11.9	0.043	< 0.04	NP	NP
	11/6/2012	2.6	73	7.7	11.1	9.9	0.038	< 0.04	NP	NP
	3/26/2013	0.1	76	8.4	12.8	11.6	< 0.025	< 0.04	NP	NP
	5/7/2013	4.6	50	7.6	8.2	8.5	0.069	0.1	NP	NP
	5/14/2013	3	35	7.5	4.6	6.5	0.041	0.27	0.007	0.04
	5/30/2013	4.1	47	7.8	5.7	5.2	< 0.025	< 0.04	NP	NP
	6/25/2013	7.5	56	8	6.8	7.3	< 0.025	< 0.04	NP	NP
	4/24/2014	1.7	64	7.8	11.6	10.9	< 0.04	0.05	NP	NP
	5/15/2014	4.6	53	7.8	9	9.5	< 0.04	0.07	0.006	0.014
	5/18/2014	3.4	53	7.8	6.9	7.6	< 0.04	0.12	NP	NP
	5/23/2014	5.9	40	7.5	5.7	8.2	< 0.04	0.34	0.006	0.051
	6/10/2014	8.9	44	7.8	5	5.6	< 0.04	0.06	NP	NP
	6/24/2014	9.7	55	7.8	7.3	7.1	< 0.04	< 0.04	NP	NP
	8/12/2014	11	73	8	10.3	11.1	NP	< 0.04	NP	NP
	9/30/2014	6.7	77	7.9	10.6	11.5	< 0.04	< 0.04	< 0.005	0.006
	3/18/2015	2.3	61	7.7	9.8	10.6	0.105	0.06	0.01	0.014
	5/5/2015	6.1	43	7.5	5.1	6.5	< 0.04	0.12	0.005	0.032
	5/19/2015	5	43	7.6	4.6	4.5	< 0.04	< 0.04	0.005	0.009
	6/9/2015	9.8	56	7.7	6.6	6.6	0.08	0.05	< 0.005	0.01
	8/25/2015	NP	NP	NP	11.3	12.1	< 0.04	< 0.04	< 0.005	0.006
	9/29/2015	NP	NP	NP	11.6	11.9	< 0.04	< 0.04	< 0.005	0.006
	2/23/2016	0.1	83	7.8	12.3	13.4	< 0.04	0.04	0.005	0.008
	3/29/2016	NP	NP	NP	12.3	12	< 0.04	< 0.04	< 0.005	< 0.005
	5/10/2016	3.5	41	7.6	4.9	5.5	< 0.04	0.08	0.008	0.022
	6/14/2016	5.8	52	7.7	6.2	6	< 0.04	< 0.04	< 0.005	0.007
8/9/2016	9.1	74	7.9	11	12.3	< 0.02	0.02	< 0.005	0.005	
10/4/2016	4	80	7.7	11.8	12.5	< 0.02	0.02	< 0.005	0.007	
3/14/2017	2.6	75	6.7	NP	NP	NP	NP	NP	NP	

Table 2-8 2011 to 2016 USGS Surface Water Monitoring Stations Samples Analytical Results

Station Number CMC CCC	Sample Date	Temp (°C)	Specific Conductance (µS/cm @ 25°C)	pH (standard units)	Arsenic (µg/L)		Lead ^a (µg/L)		Mercury (µg/L)	
					Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
					340 150	NA NA	65 2.5	NA NA	1.4 0.012	NA NA
13311000 - EFSFSR at Stibnite	9/20/2011	10.5	63	7.9	32.6	32.4	0.021	< 0.04	< 0.005	< 0.005
	9/22/2011	7	81	7.9	31.2	31	0.008	0.017	NP	NP
	10/18/2011	1.4	89	7.8	23.2	22.3	0.057	0.11	< 0.005	< 0.005
	12/14/2011	0.1	95	8.2	25.2	23.7	0.025	0.18	NP	NP
	5/18/2012	4.4	45	7.6	15.5	15.9	0.034	0.15	NP	0.019
	6/13/2012	8	46	7.6	12.7	13	0.027	0.11	NP	0.007
	8/28/2012	13.3	94	7.9	33.1	32.9	0.026	0.06	NP	NP
	11/7/2012	3.4	88	7.7	21.1	20.9	< 0.025	< 0.04	< 0.005	< 0.005
	3/26/2013	0.8	96	7.9	34.9	28.8	NP	< 0.04	NP	NP
	5/7/2013	5.6	53	7.9	17.5	38.3	0.061	4.21	< 0.005	0.071
	5/14/2013	5.6	38	NP	11.1	13.4	0.044	0.31	< 0.005	0.019
	5/30/2013	5.7	52	7.8	15.3	13.9	0.026	< 0.04	< 0.005	< 0.005
	6/25/2013	8.2	62	7.9	15.7	17.4	0.032	< 0.04	< 0.005	< 0.005
	8/13/2013	NP	93	8	29.5	31	< 0.025	0.06	NP	NP
	10/22/2013	NP	NP	NP	24.3	25.4	< 0.04	< 0.04	NP	NP
	4/25/2014	1.6	84	7.5	46.9	44.9	< 0.04	0.05	NP	NP
	5/16/2014	2.5	56	7.6	24.9	26.2	< 0.04	0.25	0.005	0.017
	5/19/2014	2.4	52	7.9	19.8	19.9	< 0.04	0.15	< 0.005	0.037
	5/24/2014	6.8	40	7.6	13	17.9	0.079	0.6	< 0.005	0.04
	6/11/2014	4.1	45	7.6	12.7	12.7	< 0.04	0.07	NP	NP
	6/25/2014	7.3	59	7.7	18.2	17	NP	< 0.04	NP	NP
	8/13/2014	10.9	90	7.9	29.7	33.3	NP	< 0.04	NP	NP
	9/30/2014	7.8	95	7.8	27.4	30.7	0.041	< 0.04	< 0.005	< 0.005
	3/18/2015	4	78	7.7	31.3	37	0.046	0.08	0.006	0.011
	5/6/2015	4	46	7.5	9.8	13.3	0.067	0.1	< 0.005	0.013
	5/19/2015	6.7	47	7.6	10.1	11	< 0.04	0.13	< 0.005	0.007
	6/10/2015	8.9	59	7.5	12.8	13.3	0.175	0.04	< 0.005	0.005
	8/25/2015	NP	NP	NP	32.4	34.4	< 0.04	< 0.04	< 0.005	0.007
	9/29/2015	NP	NP	NP	28.1	30	< 0.04	0.2	< 0.005	0.005
	2/24/2016	0	108	7.6	23.7	26.2	< 0.04	0.06	< 0.005	< 0.005
3/30/2016	NP	NP	NP	37.7	40.3	< 0.04	< 0.04	< 0.005	< 0.005	
5/11/2016	1.9	47	7.5	16.3	16.9	< 0.04	0.1	0.006	0.01	
6/15/2016	5.1	55	7.6	13.5	14.4	< 0.04	0.05	< 0.005	< 0.005	
8/10/2016	5.8	92	7.3	24.5	27.9	0.04	0.02	< 0.005	< 0.005	
10/4/2016	5	98	7.7	26.4	30.2	0.022	0.04	< 0.005	0.006	
4/11/2017	0.1	96	7.2	NP	NP	NP	NP	< 0.005	0.304	

Table 2-8 2011 to 2016 USGS Surface Water Monitoring Stations Samples Analytical Results

Station Number CMC CCC	Sample Date	Temp (°C)	Specific Conductance (µS/cm @ 25°C)	pH (standard units)	Arsenic (µg/L)		Lead ^a (µg/L)		Mercury (µg/L)	
					Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
					340 150	NA NA	65 2.5	NA NA	1.4 0.012	NA NA
13311250 - EFSFSR above Sugar Creek	9/21/2011	8	113	8.1	69.6	72	< 0.015	0.05	< 0.005	< 0.005
	9/22/2011	NP	109	8	77.9	77.9	0.025	0.03	NP	NP
	10/18/2011	4.4	100	8	51.9	54	0.043	NP	< 0.005	0.009
	12/15/2011	0.1	118	7.9	66.9	62.9	0.044	< 0.04	NP	NP
	5/18/2012	4.9	48	7.7	22.4	26.5	0.03	0.15	NP	0.015
	6/14/2012	4.5	52	7.4	21.8	22.4	0.081	0.21	< 0.005	0.006
	8/29/2012	12.4	113	8	84.7	70.8	NP	< 0.04	< 0.005	< 0.005
	11/7/2012	4	102	7.9	57.2	55.7	< 0.025	0.05	< 0.005	< 0.005
	3/27/2013	1.4	115	8.1	65.5	69.6	< 0.025	< 0.04	< 0.005	< 0.005
	5/8/2013	3.1	61	8.1	28.7	35.6	0.085	0.25	< 0.005	0.017
	5/14/2013	6.5	43	7.3	17.4	24.4	0.036	0.47	< 0.005	0.037
	5/30/2013	5.3	58	7.9	27.5	25.7	< 0.025	< 0.04	< 0.005	< 0.005
	6/26/2013	7.8	69	8	31.7	34.4	< 0.025	0.05	< 0.005	< 0.005
	10/22/2013	NP	NP	NP	63.2	66.2	NP	0.08	NP	NP
	4/25/2014	2.6	105	7.7	71.5	69.6	< 0.04	0.06	NP	NP
	5/16/2014	3.8	66	7.7	40	40.3	< 0.04	0.14	0.006	0.013
	5/19/2014	4.4	58	7.8	33.1	32.1	< 0.04	0.11	< 0.005	0.011
	5/24/2014	6.8	46	7.7	23.3	30.5	0.059	0.33	0.005	0.023
	6/11/2014	5.5	51	7.7	23.9	24.6	< 0.04	0.05	NP	NP
	6/25/2014	5.5	51	7.7	34.5	39	NP	0.05	NP	NP
	8/13/2014	12.9	107	8.1	91.2	110	0.051	0.1	NP	NP
	10/1/2014	7.4	116	7.9	108	150	0.043	0.13	< 0.005	0.005
	3/19/2015	1.2	97	7.6	56.4	65.2	0.047	0.08	0.007	0.01
	5/6/2015	4	50	7.5	24.3	29.2	< 0.04	0.08	< 0.005	0.011
	5/20/2015	4.9	50	7.4	23.7	23.8	< 0.04	0.05	< 0.005	< 0.005
	6/10/2015	10.1	65	7.7	35	39.1	0.053	< 0.04	< 0.005	< 0.005
	8/24/2015	NP	NP	NP	98.1	128	< 0.04	0.14	< 0.005	< 0.005
	9/30/2015	NP	NP	NP	102	124	< 0.04	< 0.04	< 0.005	< 0.005
	2/24/2016	1.2	126	8.1	86.4	109	< 0.04	0.04	< 0.005	< 0.005
	3/30/2016	NP	NP	NP	91.4	110	< 0.04	< 0.04	< 0.005	< 0.005
5/11/2016	3.2	54	7.5	28.2	30.6	< 0.04	0.09	0.007	0.009	
6/15/2016	6.6	63	7.7	34.2	35.4	< 0.04	0.04	< 0.005	< 0.005	
8/10/2016	12.4	110	8	94.5	113	0.04	0.06	< 0.005	< 0.005	
10/5/2016	5.4	120	7.8	93.5	114	< 0.02	0.03	< 0.005	0.006	
4/11/2017	2	113	8	NP	NP	NP	NP	< 0.005	0.009	

Table 2-8 2011 to 2016 USGS Surface Water Monitoring Stations Samples Analytical Results

Station Number CMC CCC	Sample Date	Temp (°C)	Specific Conductance (µS/cm @ 25°C)	pH (standard units)	Arsenic (µg/L)		Lead ^a (µg/L)		Mercury (µg/L)	
					Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
					340 150	NA NA	65 2.5	NA NA	1.4 0.012	NA NA
1311450 - Sugar Creek near Stibnite	9/21/2011	7.2	138	8.2	19.2	22.5	< 0.015	3.61	0.005	0.017
	10/18/2011	2.8	134	8.2	20.5	20.4	0.026	< 0.04	0.008	0.012
	12/15/2011	0.4	144	8.6	31.1	32.7	0.04	< 0.04	NP	NP
	5/18/2012	6	64	7.8	7.4	9.2	0.063	0.34	NP	0.76
	6/14/2012	4.9	77	7.9	7.7	8	0.06	0.13	0.012	0.1
	8/29/2012	11.8	137	8.3	19.1	20.7	< 0.025	< 0.04	0.007	0.02
	11/7/2012	4.7	135	8.2	17.7	18.6	< 0.025	< 0.04	0.008	0.041
	3/27/2013	1.7	126	8.3	17.9	22.1	< 0.025	< 0.04	< 0.005	0.016
	5/8/2013	6	66	7.9	7.8	9.2	0.087	0.23	0.012	0.294
	5/14/2013	6.9	55	7.7	8.4	35.1	0.099	2.6	0.302	26.3
	5/31/2013	3.1	85	8.1	8.2	7.6	< 0.025	< 0.04	0.008	0.095
	6/26/2013	6.8	95	8.2	7.8	8.3	0.027	< 0.04	0.01	0.036
	10/22/2013	NP	NP	NP	11.6	12.8	< 0.04	< 0.04	NP	NP
	4/25/2014	3.6	104	8	12.7	13.6	< 0.04	0.13	0.01	0.045
	5/16/2014	4.7	77	7.9	7.8	10.6	0.1	0.49	0.032	0.642
	5/19/2014	5	72	7.9	8.2	10.2	0.048	0.32	0.016	0.682
	5/25/2014	3.6	61	7.6	7	14.9	0.091	1.08	0.031	2.8
	6/11/2014	6.8	70	7.9	6.6	7.9	< 0.04	0.1	0.011	0.146
	6/25/2014	8.8	82	8	7.8	7.6	< 0.04	< 0.04	0.01	0.056
	8/14/2014	8.8	117	8	10.4	14.2	< 0.04	0.15	0.019	4.13
	10/1/2014	5.4	139	8.2	12.9	14.1	0.049	< 0.04	0.008	0.024
	3/19/2015	1.5	98	7.7	10.1	11.5	0.088	0.17	0.012	0.073
	5/6/2015	5	68	7.8	7.1	8.8	0.057	0.16	< 0.005	0.359
	5/20/2015	5.2	71	7.7	7.2	7	< 0.04	0.05	0.013	0.186
	6/10/2015	11.5	NP	NP	7.4	7.4	< 0.04	< 0.04	0.014	0.063
	8/26/2015	NP	NP	NP	15.2	15.9	< 0.04	< 0.04	0.009	0.082
	9/30/2015	NP	NP	NP	15.6	16.6	< 0.04	< 0.04	0.007	0.031
	2/24/2016	-0.1	143	7.8	17.8	19.2	< 0.04	< 0.04	0.01	0.02
	3/31/2016	NP	NP	NP	13.8	14.4	< 0.04	0.04	0.01	0.036
	5/11/2016	7.4	80	7.6	7.9	10.1	< 0.04	0.16	0.017	0.232
6/15/2016	5.8	86	7.9	7.7	8.1	< 0.04	0.07	0.01	0.085	
8/10/2016	12.7	136	8.2	14.3	15.2	< 0.02	0.02	0.008	0.032	
10/5/2016	3.8	144	7.9	15.4	16.5	< 0.02	< 0.02	0.006	0.027	

Source: USGS 2017a, 2017b, 2017c, 2017d, 2017e

Note: Bold type indicates sample results are greater than the MDL.

^a The lead criteria is hardness dependent. A hardness of 100 µg/L is assumed for all the samples displayed on this table. Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.

Key:

- < = Less than.
- ° C = degrees Celsius.
- µg/L = micrograms per liter.
- µS/cm = micro Siemens per centimeter.
- CCC = Criterion Continuous Concentration
- CMC = Criterion Maximum Concentration.
- EFSFSR = East Fork South Fork Salmon River.
- MDL = Method Detection Limits.
- NA = Not applicable.
- NP = The data for this parameter was not provided.
- Temp = Temperature.

Table 2-9 2014 EPA Surface Water Samples Analytical Results Summary

EPA Unfiltered Metals Sampled ID		14334303	14334333	14334336	14334300	14334306	14334312	14334315	14334318	14334323	14334326	14334309	14334331	14334321	
EPA Unfiltered Metals Sample ID		14334304	14334334	14334337	14334301	14334307	14334313	14334316	14334319	14334324	14334327	14334310	14334332	14334322	
Unfiltered Metals CLP Sample ID		MJGXC2	MJGXE2	MJGXE4	MJGXC0	MJGXC4	MJGXC8	MJGXD0	MJGXD2	MJGXD6	MJGXD8	MJGXC6	MJGXE0	MJGXD4	
Filtered Metals CLP Sample ID	Water Quality Criteria - Aquatic Life	MJGXC3	MJGXE3	MJGXE5	MJGXC1	MJGXC5	MJGXC9	MJGXD1	MJGXD3	MJGXD7	MJGXD9	MJGXC7	MJGXE1	MJGXD5	
Station Location		BG01SW	BG02SW	BG02SW ^a	CC01SW	CC02SW	CC03SW	CC04SW	CC05SW	CC06SW	CC07SW	SC01SW	AD01SW	CP01SW	
Description	CMC	CCC	Background			Cinnabar Creek						Sugar Creek	Adit 1*	Adit Pond	
Hardness (mg/L)															
Hardness	NA	NA	34.9	50	51	66.4	71.3	35.5	57.4	57.6	61.7	70.5	39.5	82	91.7
Unfiltered Metals (µg/L)															
Arsenic	NA	NA	10.0 U	7.9 JQ	7.9 JQ	<u>11.4</u>	<u>11.6</u>	4.3 JQ	<u>12.9</u>	9.8 JQ	<u>15.2</u>	<u>18.0</u>	3.5 JQ	<u>38.1</u>	<u>18.1</u>
Calcium	NA	NA	12200	12400	12600	20900	22500	10300	17200	17800	17100	19300	13200	19500	25800
Lead	NA	NA	1.0 U	1.0 U	1.0 U	<u>1.1</u>	1.0 U	<u>3.9</u>							
Magnesium	NA	NA	1080 JQ	4640 JQ	4750 JQ	3420 JQ	3650 JQ	2350 JQ	3520 JQ	3180 JQ	4650 JQ	5400	1600 JQ	8060	6610
Mercury	NA	NA	0.20 U	0.20 U	0.20 U	0.20 U	0.2 U	0.20 U	0.061 JQ	0.20 U	0.10 JQ	0.11 JQ	0.20 U	0.15 JQ	<u>0.36</u>
Filtered (0.45 micrometer) Metals (µg/L)															
Arsenic	340	150	2.8 JQ	6.7 JQ	6.8 JQ	9.6 JQ	<u>10.5</u>	3.3 JQ	<u>13.6</u>	<u>14.8</u>	<u>18.7</u>	<u>17.9</u>	4.7 JQ	<u>42.4</u>	<u>16.4</u>
Lead	20.2 - 58.8 ^b	0.79 - 2.29 ^c	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Mercury	1.4	0.012	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U

Source: E & E 2014.

Notes: Bold type indicates the sample result is above the CRQL.

Underline type indicates the sample result is elevated as defined in Section 7.

*For the 2014 investigation this adit was identified as Adit 1; however, for the 2016 investigation, the adit was renumbered as Adit 2.

^a Duplicate Sample

^b The freshwater criterion for lead is expressed as a function of the hardness for the respective sample. The criterion was calculated using the following equation: CMC (dissolved) = exp{mA [ln(hardness)]+ bA} (CF). The parameters used are specified in Appendix B-Parameters for Calculating Freshwater Dissolved Metals Criteria That Are Hardness-Dependent (EPA 2009) and Idaho Water Quality Standards Subsection 210.c.ii (IDAPA 58.01.02).

^c The freshwater criterion for lead is expressed as a function of the hardness for the respective sample. The criterion was calculated using the following equation: CCC (dissolved) = exp{mC [ln (hardness)]+ bC} (CF) . The parameters used are specified in Appendix B-Parameters for Calculating Freshwater Dissolved Metals Criteria That Are Hardness-Dependent (EPA 2009) and Idaho Water Quality Standards Subsection 210.c.ii (IDAPA 58.01.02).

Key:

µg/L = micrograms per liter.

CCC = Criterion continuous concentration.

CLP = Contract Laboratory Program.

CMC = Criterion maximum concentration.

CRQL = Contract Required Quantitation Limit.

EPA = United States Environmental Protection Agency

ID = Identification

J = The associated numerical value is an estimated quantity.

mg/L = milligrams per liter.

Q = Detected concentration is below the contract required quantitation limit but is above the method detection limit.

U = The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

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Table 2-10 2014 EPA Sediment Samples Analytical Results Summary

EPA Sample ID	Avocet SQS		MacDonald Consensus-Based TEC	14334305	14334335	14334338	14334302	14334308	14334314	14334317	14334320	14334325	14334328	14334311
CLP Sample ID				MJGXB0	MJGXB8	MJGXB9	MJGXE6	MJGXB1	MJGXB3	MJGXB4	MJGXB5	MJGXB6	MJGXB7	MJGXB2
Station Location	SL1 SL2			BG01SD	BG02SD	BG02SD ^(a)	CC01SD	CC02SD	CC03SD	CC04SD	CC05SD	CC06SD	CC07SD	SC01SD
Description				Background			Cinnabar Creek							Sugar Creek
Total Metals (mg/kg)														
Arsenic	14	120	9.79	10.5	102	113	113	188	90.2	217	262	207	<u>520</u>	49.7
Lead	360	>1300	35.8	7.2 JH	5.4 JH	4.9 JH	1.7 JH	2.1 JH	6.7 JH	4.6 JH	6.5 JH	7.0 JH	6.7 JH	7.8 JH
Mercury	0.66	0.8	0.18	0.015 JQ	18.3 JK	10.6 JK	20.4 JK	12.4 JK	4.3 JK	<u>152 JK</u>	<u>80.1 JK</u>	12.1 JK	54.4 JK	3.5 JK

Source: E & E 2014.

Note: Bold type indicates the sample result is above the Contract Required Quantitation Limit.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.
 Orange highlight indicates the sample result exceeds the least conservative (i.e., highest) screening level.
 Underline type indicates the sample result is elevated as defined in Section 7.
 (a) Duplicate Sample

Key:

CLP = Contract Laboratory Program.
 EPA = United States Environmental Protection Agency.
 H = High bias.
 ID = Identification.
 J = The associated value is an estimated quantity.
 K = Unknown bias.
 mg/kg = milligrams per kilogram.
 Q = Detected concentration is below the Contract Required Quantitation Limit but is above the Method Detection Limit.
 TEC = Threshold effect concentration.

Table 2-11 2014 EPA Tailings Pile Samples Analytical Results Summary

EPA Sample ID Station Location Description	Water Quality Criteria - Aquatic Life		14334329	14334330	14334339	14334340	14334341	
	YC01SS		YT01SS	YT02	RT01	RT01 ^(a)	RT02	
	CMC	CCC	Yellow Tailings		Red Tailings			
Synthetic Precipitation Leaching Procedure (µg/L)								
Arsenic	340	150	7.20	342	691	696	1630	
Lead	65	2.5	0.28 JH	0.050 U	0.20 JH	0.42 JH	0.23 JH	
Mercury	1.4	0.012	2.02	0.050 U	3.96	6.21	1.16	

Source: E & E 2014.

Note: Bold type indicates the sample result is above the Contract Required Quantitation Limit.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.
 Orange highlight indicates the sample result exceeds the least conservative (i.e., highest) screening level.
 (a) Duplicate Sample
 Lead criteria is hardness dependent. A hardness value of 100 is assumed for these samples.

Key:
 CCC = Criterion continuous exposure.
 CLP = Contract Laboratory Program.
 CMC = Criterion maximum concentration.
 EPA = United States Environmental Protection Agency
 ID = Identification
 J = The identification of the analyte is acceptable; however, the reported value is an estimate.
 H = High bias.
 U = The analyte was not detected at or above the reported value. The associated value is either the sample quantitation limit or the sample detection limit.

Table 2-12 2014 to 2015 USGS Filtered Surface Water Sample Analytical Results

Location	Sample Date	Mercury ng/L	Methylmercury ng/L	Arsenic mg/L	Arsenic III mg/L	Lead mg/L
Water Quality Criteria-Aquatic Life CMC		1400	NA	0.34	NA	0.065
Water Quality Criteria-Aquatic Life CCC		12	NA	0.15	NA	0.0025
Cinnabar Creek above Cinnabar mine site - Background	8/18/2014	16	0.06	0.0033	0.0003 U	0.01 U
West Fork Cinnabar headwater - Background	6/26/2015	NP	NP	0.0053	0.0009	0.01 U
West tributary to Cinnabar Creek above mine site - Background	7/25/2015	3.41	0.04 U	0.0047	0.0005 U	0.01 U
East tributary to Cinnabar Creek above mine site - Background	7/25/2015	7.5	0.04 U	0.0092	0.0005 U	0.01 U
Spring #1 above Cinnabar mine site	6/26/2015	NP	NP	0.0035	0.0005 U	0.01 U
Upper mine adit; Cinnabar site	7/25/2015	30.6	0.04 U	0.0215	0.0009	0.01 U
Lower mine adit at Cinnabar mine site	8/19/2014	46.5	0.14	0.0421	0.0008	0.01 U
Wetland on Cinnabar tailings	8/19/2014	24.5	0.07	0.089	0.0215	0.01 U
W Fork Cinnabar Creek below Cinnabar mine site	8/19/2014	31.5	7.3	0.0186	0.0083	0.01 U
Cinnabar Creek immediately below mine site	7/25/2015	50.1	0.06	0.0195	0.0009	0.01 U
Cinnabar Creek above Sugar Creek	8/18/2014	6.25	0.06	0.0115	0.0003 U	0.01 U
Cinnabar Creek above confluence with Sugar Creek	7/23/2015	35.6	0.1	0.0118	0.0007	0.01 U
Sugar Creek above confluence with Cane Creek - Attribution	7/23/2015	3.11	0.04 U	0.0016	0.0005 U	0.01 U
Cane Creek above confluence with Sugar Creek - Attribution	7/23/2015	2.92	0.04 U	0.0023	0.0005 U	0.01 U
Sugar Creek above Cinnabar Creek	8/18/2014	0.39	0.04 U	0.0019	0.0003 U	0.01 U
Sugar Creek below road crossing	7/24/2015	13.6	0.13	0.0053	0.0005	0.01 U
Sugar Creek below road crossing	7/24/2015	NP	NP	0.0055	0.0006	0.01 U
Sugar Creek above West End Creek	7/24/2015	12.4	0.12	0.0058	0.0007	0.01 U
Sugar Creek above USGS 1331450	6/28/2015	9.38	0.38	0.01	0.0005 U	0.01 U
EFSF Salmon above Sugar Creek	6/28/2015	3	0.05	0.0641	0.0132	0.01 U

Source: Holloway et al, 2016

Notes: Bold type indicates the sample result is above the MDL.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.
 Underline type indicates the sample result is elevated as defined in Section 7.

Key:

- CCC = Criterion Continuous Concentration.
- CMC = Criterion Maximum Concentration.
- MDL = Method Detection Limit.
- mg/L = milligrams per liter.
- NA = Not applicable. There is no screening criteria for this analyte from this source.
- NP = No value was reported.
- ng/L = nanograms per liter.
- U = The analyte was not present in this sample at or above the reported value.

Table 2-13 2014 to 2015 USGS Sediment Samples Analytical Results Summary

Site Name	Sample Date	Methylmercury ppb	Mercury ppm	Arsenic ppm	Lead ppm
Avocet SQS - SL1		NA	0.66	14	360
Avocet SQS - SL2		NA	0.8	120	>1300
MacDonald Consensus-Based TEC		NA	0.18	9.79	35.8
Cinnabar Creek East Fork - Background	8/18/2014	7.57	102	6.3	9.49
Spring #1 above Cinnabar mine site - Background	6/26/2015	NP	4.62	29	11.1
East tributary to Cinnabar Creek above mine site - Background	7/25/2015	2.1	1.74	38	2.52
Wetland sediment (pool)	8/19/2014	<u>26</u>	813	849	23.7
Cinnabar Creek below mine site.	7/25/2015	1.19	14.7	69.1	9.65
Cinnabar Creek below mine site	8/19/2014	2.98	169	137	7.64
Cinnabar Creek above sugar Creek	8/18/2014	4.33	160	96.9	5.54
Cinnabar Creek above confluence with Sugar Creek	7/23/2015	8.21	149	103	5.92
Sugar Creek above confluence with Cane Creek - Attribution	7/23/2015	0.17 U	0.02	8.8	15.6
Cane Creek above confluence with Sugar Creek - Attribution	7/23/2015	0.17 U	0.07	10.5	11.7
Sugar Creek below Cinnabar Creek	8/18/2014	0.17	11.7	0.22	12.6
Sugar Creek below road crossing	7/24/2015	0.51	11.5	37.7	9.56
Sugar Creek above West End Creek	7/24/2015	0.55	9.65	26.7	9.75

Source: Holloway et al, 2016

Notes: Bold type indicates the sample result is above the MDL.

Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.

Orange highlight indicates the sample result exceeds the least conservative (i.e., highest) screening level.

Underline type indicates the sample result is elevated as defined in Section 7.

Key:

MDL = Method Detection Limit.

NA = Not applicable. There is no screening criteria for this analyte from this source.

NP = No result was reported.

ppb = parts per billion

ppm = parts per million

SQS = Sediment Quality Standards.

TEC = Threshold Effect Concentration

U = The analyte was not present in this sample at or above the reported value.

Table 2-14 2014 USGS Tailings and Soil Samples Analytical Results Summary

Site Name	Sample Date	Methylmercury ppb	Mercury ppm	Arsenic ppm	Lead ppm
EPA Residential RML		2300	33	68	400
EPA Residential RSL		7800	11	0.68	400
Lower floatation tailings	8/19/2014	11.9	1710	1030	7.55
Upper floatation tailings	8/19/2014	12.3	1180	453	8.87
Lower calcine tailings	8/19/2014	2.6	375	34.4	9
Upper calcine tailings	8/19/2014	0.37	520	10.5	9.31
Wetland soil	8/19/2014	48	1450	1140	11.1

Source: Holloway et al, 2016

Notes: Bold type indicates the sample result is above the MDL.

Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.

Orange highlight indicates the sample result exceeds the least conservative (i.e., highest) screening level.

Key:

EPA = United States Environmental Protection Agency.

MDL = Method Detection Limit.

ppb = parts per billion.

ppm = parts per million.

RML = Removal Management Level.

RSL = Regional Screening Level.

Table 3-1 Sample and Analytical Summary

EPA Sample ID	Station Location	CLP Sample ID	Sample Date	Time	Matrix	Sampler	TAL Metals	TOC	Sulfate	Sulfide	Low Level Mercury	Methyl Mercury	Grain Size	PCBs	Agronomics	Total Mercury
Surface Soil Samples																
16344200	TP01SS	MJHQH0	8/23/2016	1213	SS	USCG	X					X			X	
16344201	TP02SS	MJHQH1	8/23/2016	1235	SS	USCG	X					X			X	
16344202	TP03SS	MJHQH2	8/23/2016	1250	SS	USCG	X					X				
16344203	TP04SS	MJHQH3	8/23/2016	1301	SS	USCG	X					X			X	
16344204	TP05SS	MJHQH4	8/23/2016	1310	SS	USCG	X					X			X	
16344205	TP06SS	MJHQH5	8/23/2016	1318	SS	USCG	X					X			X	
16344206	TP07SS	MJHQH6	8/23/2016	1332	SS	USCG	X					X				
16344207	TP08SS	MJHQH7	8/23/2016	1345	SS	USCG	X					X			X	
16344208	TP09SS	MJHQH8	8/23/2016	1406	SS	USCG	X					X				
16344209	RT01SS	MJHQH9	8/23/2016	1425	SS	USCG	X					X				
16344210	BS01SS	MJHQL6	8/24/2016	1115	SS	USCG	X					X				
16344211	BS02SS	MJHQM0	8/24/2016	1127	SS	USCG	X					X			X	
16344212	BS03SS	MJHQL9	8/24/2016	1142	SS	USCG	X					X			X	
16344213	BS04SS	MJHQL8	8/24/2016	1157	SS	USCG	X					X				
16344214	BS05SS	MJHQL7	8/24/2016	1206	SS	USCG	X					X			X	
16384164	OS01SS		9/21/2016	1100	SS	CE								X		
Total Surface Water Samples																
16344256	AD01SW	MJHQM6	8/24/2016	1406	SW	USCG	X									
16344257	AD02SW	MJHQM7	8/24/2016	1455	SW	USCG	X									
16344258	AD03SW	MJHQM8	8/24/2016	1612	SW	USCG	X									
16344259	WF01SW	MJHQJ7	8/24/2016	1301	SW	USCG	X									
16344260	WF02SW	MJHQJ0	8/24/2016	1358	SW	USCG	X									
16344261	WF03SW	MJHQL3	8/24/2016	1530	SW	USCG	X									
16344262	WF04SW	MJHQL4	8/24/2016	1616	SW	USCG	X									
16344263	WF05SW	MJHQL5	8/24/2016	1648	SW	USCG	X									
16344264	WF06SW	MJHQN9	8/26/2016	0840	SW	USCG	X									
16344265	WF07SW	MJHQP0	8/26/2016	1101	SW	USCG	X									
16344266	AD04SW	MJHQP2	8/25/2016	1540	SW	USCG	X		X							
16344269	WT01SW	MJHQJ1	8/24/2016	1604	SW	USCG	X									
16344272	CC01SW	MJHQF8	8/23/2016	1403	SW	USCG	X									
16344273	CC02SW	MJHQF9	8/23/2016	1450	SW	USCG	X									
16344274	CC03SW	MJHQG0	8/23/2016	1638	SW	USCG	X									
16344275	CC04SW	MJHQJ4	8/24/2016	1133	SW	USCG	X									
16344276	CC05SW	MJHQJ5	8/24/2016	1203	SW	USCG	X									
16344278	SC01SW	MJHQE6	8/22/2016	1626	SW	USCG	X									
16344279	SC02SW	MJHQE7	8/22/2016	1733	SW	USCG	X									
16344280	SC03SW	MJHQE8	8/22/2016	1820	SW	EPA	X									
16344281	SC04SW	MJHQG1	8/23/2016	1229	SW	USCG	X									
16344282	SC05SW	MJHQG2	8/23/2016	1343	SW	USCG	X									
16344283	UT01SW	MJHQN8	8/26/2016	0954	SW	USCG	X									
16344284	BG02SW	MJHQG3	8/23/2016	1420	SW	USCG	X									
16344285	BG03SW	MJHQJ6	8/24/2016	1233	SW	USCG	X									
16344286	BG04SW	MJHQE5	8/26/2016	1134	SW	USCG	X									
16384150	SC01SW		9/21/2016	1000	SW	CE					X	X				
16384151	BG02SW		9/21/2016	1200	SW	CE					X	X				
16384152	WF04SW		9/21/2016	1400	SW	CE					X	X				
16384153	WF03SW		9/21/2016	1330	SW	CE					X	X				
16384154	WF03SW		9/21/2016	1330	SW	CE					X	X				
16384155	WF05SW		9/21/2016	1430	SW	CE					X	X				
Dissolved Surface Water Samples																
16344289	AD01SWD	MJHQM3	8/24/2016	1403	SWD	USCG	X				X	X				
16344290	AD02SWD	MJHQM4	8/24/2016	1440	SWD	USCG	X				X	X				
16344291	AD03SWD	MJHQM5	8/24/2016	1620	SWD	USCG	X				X	X				
16344292	WF01SWD	MJHQJ8	8/24/2016	1302	SWD	USCG	X				X	X				
16344293	WF02SWD	MJHQJ9	8/24/2016	1402	SWD	USCG	X				X	X				
16344294	WF03SWD	MJHQL0	8/24/2016	1530	SWD	USCG	X				X	X				
16344295	WF04SWD	MJHQL1	8/24/2016	1616	SWD	USCG	X				X	X				

Table 3-1 Sample and Analytical Summary

EPA Sample ID	Station Location	CLP Sample ID	Sample Date	Time	Matrix	Sampler	TAL Metals	TOC	Sulfate	Sulfide	Low Level Mercury	Methyl Mercury	Grain Size	PCBs	Agronomics	Total Mercury
16344296	WF05SWD	MJHQL2	8/24/2016	1648	SWD	USCG	X				X	X				
16344297	WF06SWD	MJHQN6	8/26/2016	0843	SWD	USCG	X									
16344298	WF07SWD	MJHQN7	8/26/2016	1101	SWD	USCG	X									
16344303	WT01SWD	MJHQK0	8/24/2016	1611	SWD	USCG	X				X	X				
16344306	CC01SWD	MJHQG6	8/23/2016	1357	SWD	USCG	X				X	X				
16344307	CC02SWD	MJHQG7	8/23/2016	1445	SWD	USCG	X				X	X				
16344308	CC03SWD	MJHQG8	8/23/2016	1636	SWD	USCG	X				X	X				
16344309	CC04SWD	MJHQJ2	8/24/2016	1123	SWD	USCG	X				X	X				
16344310	CC05SWD	MJHQJ3	8/24/2016	1207	SWD	USCG	X				X	X				
16344312	SC01SWD	MJHQE9	8/22/2016	1622	SWD	USCG	X									
16344313	SC02SWD	MJHQF0	8/22/2016	1722	SWD	USCG	X				X	X				
16344314	SC03SWD	MJHQF1	8/22/2016	1806	SWD	EPA	X				X	X				
16344315	SC04SWD	MJHQG4	8/23/2016	1233	SWD	USCG	X				X	X				
16344316	SC05SWD	MJHQG5	8/23/2016	1337	SWD	USCG	X				X	X				
16344317	UT01SWD	MJHQN5	8/26/2016	0957	SWD	USCG	X									
16344318	BG02SWD	MJHQG9	8/23/2016	1431	SWD	USCG	X				X	X				
16344319	BG03SWD	MJHQE4	8/24/2016	1234	SWD	USCG	X				X	X				
16344320	BG04SWD	MJHQN3	8/26/2016	1140	SWD	USCG	X									
16384157	SC01SWD		9/21/2016	1000	SWD	CE					X	X				
16384158	BG02SWD		9/21/2016	1200	SWD	CE					X	X				
16384159	WF04SWD		9/21/2016	1400	SWD	CE					X	X				
16384160	WF03SWD		9/21/2016	1330	SWD	CE					X	X				
16384161	WF03SWD		9/21/2016	1330	SWD	CE					X	X				
16384162	WF05SWD		9/21/2016	1430	SWD	CE					X	X				
Sediment Samples																
16344216	AD01SD	MJHQE0	8/24/2016	1410	SD	USCG	X	X				X	X			
16344217	AD02SD	MJHQM1	8/24/2016	1457	SD	USCG	X	X				X	X			
16344218	AD03SD	MJHQM2	8/24/2016	1620	SD	USCG	X	X				X	X			
16344219	WF01SD	MJHQK1	8/24/2016	1304	SD	USCG	X	X				X	X			
16344220	WF02SD	MJHQK2	8/24/2016	1404	SD	USCG	X	X				X	X			
16344221	WF03SD	MJHQK7	8/24/2016	1551	SD	USCG	X	X				X	X			
16344222	WF04SD	MJHQK8	8/24/2016	1630	SD	USCG	X	X				X	X			
16344223	WF05SD	MJHQK9	8/24/2016	1654	SD	USCG	X	X				X	X			
16344224	WF06SD	MJHQN1	8/26/2016	0852	SD	USCG	X	X				X	X			
16344225	WF07SD	MJHQN2	8/26/2016	1105	SD	USCG	X	X				X	X			
16344229	WT01SD	MJHQK3	8/24/2016	1615	SD	USCG	X	X				X	X			
16344232	CC01SD	MJHQF2	8/23/2016	1413	SD	USCG	X	X				X	X			
16344233	CC02SD	MJHQF3	8/23/2016	1455	SD	USCG	X	X				X	X			
16344234	CC03SD	MJHQF4	8/23/2016	1643	SD	USCG	X	X				X	X			
16344235	CC04SD	MJHQK4	8/24/2016	1143	SD	USCG	X	X				X	X			
16344236	CC05SD	MJHQK5	8/24/2016	1212	SD	USCG	X	X					X			
16344238	SC01SD	MJHQE1	8/22/2016	1634	SD	USCG	X	X				X	X			
16344239	SC02SD	MJHQE2	8/22/2016	1735	SD	USCG	X	X				X	X			
16344240	SC03SD	MJHQE3	8/22/2016	1820	SD	EPA	X	X				X	X			
16344241	SC04SD	MJHQF5	8/23/2016	1249	SD	USCG	X	X				X	X			
16344242	SC05SD	MJHQF6	8/23/2016	1346	SD	USCG	X	X				X	X			
16344243	UT01SD	MJHQN0	8/26/2016	1006	SD	USCG	X	X				X	X			
16344244	BG01SS	MJHQP1	8/25/2016	1200	SS	USCG	X					X				
16344245	BG02SD	MJHQF7	8/23/2016	1440	SD	USCG	X	X				X	X			
16344246	BG03SD	MJHQK6	8/24/2016	1237	SD	USCG	X	X				X	X			
16344247	BG04SD	MJHQM9	8/26/2016	1157	SD	USCG	X	X				X	X			
Porewater Samples																
16344324	WF01PW		8/24/2016	1350	PW	CE		X	X	X	X	X				
16344325	WF02PW		8/24/2016	1330	PW	CE		X	X	X	X	X				
16344326	WF03PW		8/24/2016	1720	PW	CE		X	X	X	X	X				
16344327	WF04PW		8/24/2016	1700	PW	CE		X	X	X	X	X				
16344328	WF05PW		8/24/2016	0930	PW	CE		X	X	X	X	X				
16344330	WT01PW		8/25/2016	1200	PW	CE		X	X	X	X	X				

Table 3-1 Sample and Analytical Summary

EPA Sample ID	Station Location	CLP Sample ID	Sample Date	Time	Matrix	Sampler	TAL Metals	TOC	Sulfate	Sulfide	Low Level Mercury	Methyl Mercury	Grain Size	PCBs	Agronomics	Total Mercury
16344331	WT02PW		8/25/2016	1045	PW	CE		X	X	X	X	X				
16344332	WT03PW		8/24/2016	1130	PW	CE		X	X	X	X	X				
16344333	SC01PW		8/22/2016	1645	PW	CE		X	X	X	X	X				
16344334	CC02PW		8/23/2016	1600	PW	CE		X	X	X	X	X				
16344335	CC04PW		8/24/2016	1130	PW	CE		X	X	X	X	X				
16344336	BG02PW		8/24/2016	1415	PW	CE		X	X	X	X	X				
Quality Control Samples																
16344287	RI01WT	MJHQP3	8/25/2016	1429	SW	CE	X									
16344321	R101SWD	MJHQP4	8/29/2016	1429	SWD	CE	X									
16344338	RI02WT		8/25/2016	1400	PW	CE		X	X	X	X	X				
16354250	Blank		8/30/2016	1500	QC	CE					X	X				
16384156	Blank		9/21/2016	0830	QC	CE					X	X				
16384163	Blank		9/21/2016	0830	QC	CE					X	X				
Mesocosm Experiment Samples																
16404407	Tailings 1 - Unamended		10/5/2016	1030	PW	CE		X	X		X	X				
16404408	Tailings 2 - Unamended		10/5/2016	1030	PW	CE		X	X		X	X				
16404409	Tailings 3 - Unamended		10/5/2016	1030	PW	CE		X	X		X	X				
16404410	Tailings 4 - Proganics		10/5/2016	1030	PW	CE		X	X		X	X				
16404411	Tailings 5 - Proganics		10/5/2016	1030	PW	CE		X	X		X	X				
16404412	Tailings 6 - Proganics		10/5/2016	1030	PW	CE		X	X		X	X				
16404419	Blank		10/5/2019	0900	QC	CE		X	X		X	X				
16404420	Leaching Water		10/5/2019	1415	SW	CE		X	X		X	X				
16424401	Tailings 1 - Unamended		10/17/2016	1100	PW	CE		X	X		X	X				
16424402	Tailings 2 - Unamended		10/17/2016	1100	PW	CE		X	X		X	X				
16424403	Tailings 3 - Unamended		10/17/2016	1100	PW	CE		X	X		X	X				
16424404	Tailings 4 - Proganics		10/17/2016	1100	PW	CE		X	X		X	X				
16424405	Tailings 5 - Proganics		10/17/2016	1100	PW	CE		X	X		X	X				
16424406	Tailings 6 - Proganics		10/17/2016	1100	PW	CE		X	X		X	X				
16434401	Tailings 1 - Unamended		10/24/2016	1700	PW	CE		X	X	X	X	X				
16434402	Tailings 2 - Unamended		10/24/2016	1700	PW	CE		X	X	X	X	X				
16434403	Tailings 3 - Unamended		10/24/2016	1700	PW	CE		X	X	X	X	X				
16434404	Tailings 4 - Proganics		10/24/2016	1700	PW	CE		X	X	X	X	X				
16434405	Tailings 5 - Proganics		10/24/2016	1700	PW	CE		X	X	X	X	X				
16434406	Tailings 6 - Proganics		10/24/2016	1700	PW	CE		X	X	X	X	X				
16454401	Tailings 1 - Unamended		11/9/2016	1000	PW	CE		X	X	X	X	X				
16454402	Tailings 2 - Unamended		11/9/2016	1000	PW	CE		X	X	X	X	X				
16454403	Tailings 3 - Unamended		11/9/2016	1000	PW	CE		X	X	X	X	X				
16454404	Tailings 4 - Proganics		11/9/2016	1000	PW	CE		X	X	X	X	X				
16454405	Tailings 5 - Proganics		11/9/2016	1000	PW	CE		X	X	X	X	X				
16454406	Tailings 6 - Proganics		11/9/2016	1000	PW	CE		X	X	X	X	X				

Table 3-1 Sample and Analytical Summary

EPA Sample ID	Station Location	CLP Sample ID	Sample Date	Time	Matrix	Sampler	TAL Metals	TOC	Sulfate	Sulfide	Low Level Mercury	Methyl Mercury	Grain Size	PCBs	Agronomics	Total Mercury
16454407	Tailings 1 - Unamended		11/9/2016	1300	SD	CE		X	X			X				X
16454408	Tailings 2 - Unamended		11/9/2016	1300	SD	CE		X	X			X				X
16454409	Tailings 3 - Unamended		11/9/2016	1300	SD	CE		X	X			X				X
16454410	Tailings 4 - Proganics		11/9/2016	1300	SD	CE		X	X			X				X
16454411	Tailings 5 - Proganics		11/9/2016	1300	SD	CE		X	X			X				X
16454412	Tailings 6 - Proganics		11/9/2016	1300	SD	CE		X	X			X				X

Key:

- CE = Chris Eckley.
- CLP = Contract Laboratory Program.
- EPA = United States Environmental Protection Agency.
- ID = Identification.
- PW = Porewater.
- SD = Sediment.
- SS = Surface Soil.
- SW = Surface Water.
- SWD = Dissolved Surface Water.
- TAL = Target Analyte List.
- USCG = United States Coast Guard.
- X = Indicates the sample was analyzed for this parameter.
- TOC = Total Organic Carbon

Table 3-2 Sample Coding Key

Digits	Description	Code	Key
1,2	Sampling Area	AD	Adit
		BG	Background
		BS	Borrow Source
		CC	Cinnabar Creek
		SC	Sugar Creek
		TP	Tailings Pile
		UT	Unnamed Tributary
		WF	West Fork Cinnabar Creek
		WT	Wetland
3,4	Consecutive Sample Number	01	First number of a sampling area
5,6,(7)	Matrix Code	GWD	Dissolved Groundwater
		PW	Porewater
		SW	Surface Water
		SWD	Dissolved Surface Water
		SD	Sediment
		SS	Surface Soil

Table 3-3**In-Water Surface Water/Sediment Distances**

Starting Location	End Location	In-Water Distance (feet)
AD02SW/AD02SWD	WF06SW/WF06SWD	86.00
WF06SW/WF06SWD	WF07SW/SWF07SWD	69.00
WF07SW/SWF07SWD	WF05SW/WF05SWD	234.00
WF05SW/WF05SWD	WF04SW/WF04SWD	366.00
WF04SW/WF04SWD	WF03SW/SW03SWD	459.00
WF03SW/SW03SWD	WF02SW/WF02SWD	2250.00
WF02SW/WF02SWD	WF01SW/WF01SWD	181.00
BG03SW/BG03SWD	WF01SW/WF01SWD	139.00
WF01SW/WF01SWD	CC05SW/CC05SWD	51.00
CC05SW/CC05SWD	CC04SW/CC04SWD	79.00
CC04SW/CC04SWD	CC03SW/CC03SWD	4276.00
CC03SW/CC03SWD	CC02SW/CC02SWD	5188.00
CC02SW/CC02SWD	CC01SW/CC01SWD	669.00
BG02SW/BG02SWD	CC01SW/CC01SWD	606.00
CC01SW/CC01SWD	SC05SW/SC05SWD	1345.00
SC05SW/SC05SWD	UT01SW/UT01SWD	580.00
SC05SW/SC05SWD	SC04SW/SC04SWD	574.00
UT01SW/UT01SWD	SC04SW/SC04SWD	112.50
SC04SW/SC04SWD	SC03SW/SC03SWD	2935.00
SC03SW/SC03SWD	SC02SW/SC02SWD	3256.00
SC02SW/SC02SWD	SC01SW/SC01SWD	2711.00

Table 3-4 Analytical Methods and Reporting Limits

Analyte	Method	Water Reporting Limit	Soil/Sediment Reporting Limit
Aluminum	ICP-AES	200 µg/L	20 mg/kg
Antimony	ICP-AES (Water) ICP-MS (Soil/Sediment)	60 µg/L	1 mg/kg
Arsenic	ICP-AES (Water) ICP-MS (Soil/Sediment)	10 µg/L	0.5 mg/kg
Barium	ICP-AES	200 µg/L	20 mg/kg
Beryllium	ICP-AES	5 µg/L	0.5 mg/kg
Cadmium	ICP-AES (Soil/Sediment) ICP-MS (Water)	1 µg/L	0.5 mg/kg
Calcium	ICP-AES	5000 µg/L	500 mg/kg
Chromium	ICP-AES	10 µg/L	1 mg/kg
Cobalt	ICP-AES	50 µg/L	5 mg/kg
Copper	ICP-AES (Soil/Sediment) ICP-MS (Water)	2 µg/L	2.5 mg/kg
Dissolved Sulfide	Standard Method SM-4500-S2-D	0.05 mg/L	X
Grain Size	ASTM D422	X	0.0001 grams
Hardness	ICP-AES	33 µg/L	NA
Iron	ICP-AES	100 µg/L	10 mg/kg
Lead	ICP-AES (Soil/Sediment) ICP-MS (Water)	1 µg/L	1 mg/kg
Low -Level Mercury	EPA 1631E	0.5 ng/L	X
Magnesium	ICP-AES	5000 µg/L	500 mg/kg
Manganese	ICP-AES	15 µg/L	1.5 mg/kg
Mercury	CVAA	0.2 µg/L	0.1 mg/kg
Mercury	EPA 7471B	X	0.10 mg/kg
Methyl Mercury	EPA 1630	0.05 ng/L	1.0 ng/kg
Nickel	ICP-AES	40 µg/L	4 mg/kg
Potassium	ICP-AES	5000 µg/L	500 mg/kg
Selenium	ICP-AES (Soil/Sediment) ICP-MS (Water)	5 µg/L	3.5 mg/kg
Silver	ICP-MS	1 µg/L	0.50 mg/kg
Sodium	ICP-AES	5000 µg/L	500 mg/kg
Sulfate	EPA 300.0	0.3 mg/L	X
Sulfide	EPA 9030B Modified	0.1 - 20 mg/L	X
Thallium	ICP-AES (Water) ICP-MS (Soil/Sediment)	25 µg/L	0.5 mg/kg
Total Organic Carbon	PSEP Method (Soil/Sediment) Standard Method 5310B (Water)	1.0 mg/L	500 mg/kg
Vanadium	ICP-AES	50 µg/L	5 mg/kg
Zinc	ICP-AES	60 µg/L	6 mg/kg

Key:

- µg/L = micrograms per liter.
- AES= Atomic Emission Spectrometer.
- ICP = Inductively coupled argon plasma.
- mg/kg = milligrams per kilogram.
- mg/L = milligrams per liter.
- MS = Mass spectrometric detection.
- ng/kg = nnaograms per kilogram.
- ng/L = nanograms per liter.
- X = Samples were not analyzed for this parameter.

Table 5-1 Soil Screening Levels

Analyte Name	EPA Residential RML (mg/kg)	EPA Residential RSL (mg/kg)	Idaho IDTL (mg/kg)
Antimony	94	31	4.77
Arsenic	68	0.68	0.391
Barium	46000	15000	896
Beryllium	470	160	1.63
Cadmium	210	71	1.35
Chromium (III)	350000	120000	2130
Chromium (VI)	30	0.3	7.9
Cobalt	70	23	NA
Copper	9400	3100	921
Lead	400	400	49.6
Manganese	5500	1800	223
Mercury	33	11	0.00509
Methyl Mercury	23	7.8	NA
Nickel	4600	1500	59.1
Selenium	1200	390	2.03
Silver	1200	390	0.189
Thallium	2.3	0.78	1.55
Vanadium	1200	390	NA
Zinc	70000	NA	886

Source: EPA 2016c, 2016d.

Key:

- EPA = United States Environmental Protection Agency.
- IDTL = Initial Default Target Level.
- mg/kg = milligrams per kilogram.
- NA = Not applicable. There is no screening criteria for this analyte from this source.
- RML = Removal Management Level.
- RSL = Regional Screening Level.

Table 5-2 Surface Water Screening Levels

Analyte Name	Water Quality Criteria – Aquatic Life (µg/L)		Matrix	Note	Source
	CMC	CCC			
Antimony	NA	NA			
Arsenic	340	150	Dissolved		IDEQ
Barium	NA	NA			
Beryllium	NA	NA			
Cadmium	1.3	0.6	Dissolved	Hardness ⁽¹⁾	IDEQ
Chromium (III)	570	74	Dissolved	Hardness ⁽¹⁾	IDEQ
Chromium (VI)	16	11	Dissolved		IDEQ
Cobalt	NA	NA			
Copper	17	11	Dissolved	Hardness ⁽¹⁾	IDEQ
Lead	65	2.5	Dissolved	Hardness ⁽¹⁾	IDEQ
Manganese	NA	NA			
Mercury	1.4	0.012	Dissolved		EPA (CMC) IDEQ (CCC)
Methyl Mercury	NA	NA	Dissolved		
Nickel	470	52	Dissolved	Hardness ⁽¹⁾	IDEQ
Selenium	20	5	Total		IDEQ
Silver	3.4	NA	Dissolved	Hardness ⁽¹⁾	IDEQ
Thallium	NA	NA			
Vanadium	NA	NA			
Zinc	120	120	Dissolved	Hardness ⁽¹⁾	IDEQ

Note: (1) Aquatic life criteria for these metals are a function of total hardness (mg/L as calcium carbonate), the pollutants water effect ration (WER) as defined in Subsection 210.03.c.iii and multiplied by an appropriate dissolved conversion factor as defined in Subsection 210.02. For comparative purposes only, the example values displayed in this table are shown as dissolved metal and correspond to a total hardness of one hundred (100) mg/L and a water effect ration of one (1.0).

Key:

- CCC = Criterion Continuous Concentration.
- CMC = Criterion Maximum Concentration.
- EPA = United States Environmental Protection Agency
- IDEQ = Idaho Department of Environmental Quality
- NA = Not applicable. There is no screening criteria for this analyte from this source.

Table 5-3 Sediment Screening Levels

Analyte Name	Avocet SQS (mg/kg)		MacDonald Consensus- Based TEC (mg/kg)
	SL1	SL2	
Aluminum	NA	NA	NA
Antimony	0.3	12	NA
Arsenic	14	120	9.79
Barium	NA	NA	NA
Beryllium	NA	NA	NA
Cadmium	2.1	5.4	0.99
Calcium	NA	NA	NA
Chromium	72	82	43.4
Cobalt	NA	NA	NA
Copper	400	1200	31.6
Iron	NA	NA	NA
Lead	360	>1300	35.8
Magnesium	NA	NA	NA
Manganese	NA	NA	NA
Mercury	0.66	0.8	0.18
Methyl Mercury	NA	NA	NA
Nickel	26	110	22.7
Potassium	NA	NA	NA
Selenium	11	>20	NA
Silver	0.58	1.7	NA
Thallium	NA	NA	NA
Vanadium	NA	NA	NA
Zinc	3200	>4200	121

Source: Avocet 2011, MacDonald 2000.

Key:

mg/kg = milligrams per kilogram.
 NA = Not applicable. There is no screening criteria for this analyte from this source.
 SQS = Sediment Quality Standard.
 TEC = Threshold Effect Concentration.

Table 5-4 August 2016 Borrow Source Soil Samples Analytical Results Summary

EPA Sample ID CLP Sample ID Station Location Description	EPA Residential RML	EPA Residential RSL	16344244 MJHQP1 BG01SS Background	16344210 MJHQL6 BS01SS	16344211 MJHQM0 BS02SS	16344212 MJHQL9 BS03SS	16344213 MJHQL8 BS04SS	16344214 MJHQL7 BS05SS
Target Analyte List Metals (mg/kg)			Barrow Source					
Aluminum	NA	NA	29200	11900	11800	10000	13900	9870
Antimony	94	31	1.5	46.7	81.5	61.1	74.2	83.2
Arsenic	68	0.68	51.3	222	320	267	194	399
Barium	46000	15000	86.7	62.3	65.6	58.2	120	68.1
Beryllium	470	160	0.26 JQ (SQL = 0.72)	0.56	0.67	0.62	0.61	0.64
Cadmium	210	71	0.53	1.5	2.4	1.8	1.4	2.7
Calcium	NA	NA	7980	16500	6210	11900	5920	8940
Chromium	350000	120000	31.3	27.4	28.7	23.2	28.5	24.5
Cobalt	70	23	13.2	18.6	17.3	13.1	21.3	15.8
Copper	9400	3100	13.0	20.3	20.9	16.7	27.8	24.4
Iron	NA	NA	23400	24000	25600	18400	24800	27000
Lead	400	400	6.7	3.6	4.3	7.5	5.5	3.8
Magnesium	NA	NA	34700	11500	7940	9870	7570	8960
Manganese	5500	1800	595 JL	720	620	617	934	869
Mercury	33	11	1.1	664	285	307	29.8	406
Nickel	4600	1500	18.9	27.3	30.3	22.2	27.2	31.8
Potassium	NA	NA	1150	3040	3770	2100	2710	2920
Thallium	2.3	0.78	0.46 U	2.4	1.7	2.2	1.5	7.5
Vanadium	1200	390	31.9	24.0	26.1	18.6	24.9	22.9
Zinc	70000	NA	38.6	28.2	34.6	24.8	37.1	34.2
Methyl Mercury (ng/g)								
Methyl Mercury	23000	7800	0.56	2.25	7.54	1.34	9.96	3.31

Note: Bold type indicates the sample result is above the CRQL.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.
 Orange highlight indicates the sample result also exceeds the least conservative (i.e., highest) screening level.

Key:

- CLP = Contract Laboratory Program.
- CRQL = Contract Required Quantitation Limit.
- EPA = United States Environmental Protection Agency.
- ID = Identification.
- J = The associated value is an estimated quantity.
- L = Low bias.
- MDL = Method detection limit.
- mg/kg = milligrams per kilogram.
- MRL = Method Reporting Limit.
- ng/g = nanograms per gram.
- NA = Not applicable. There is no screening criteria for this analyte from this source.
- Q = Detected concentration is below the MRL/CRQL but is above the MDL.
- RML = Removal Management Level.
- RSL = Regional Screening Level.
- SQL = Sample Quantitation Limit.
- U = The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the SQL or the sample detection limit.

Table 5-5 August 2016 Tailings Pile Surface Soil Samples Analytical Results Summary

EPA Sample ID	Residential	Residential	16344244	16344200	16344203	16344204	16344206	16344207	16344208	16344201	16344202	16344205	16344209
CLP Sample ID			MJHQP1	MJHQH0	MJHQH3	MJHQH4	MJHQH6	MJHQH7	MJHQH8	MJHQH1	MJHQH2	MJHQH5	MJHQH9
Station Location			BG01SS	TP01SS	TP04SS	TP05SS	TP07SS	TP08SS	TP09SS	TP02SS	TP03SS	TP06SS	RT01SS
Description			Background	Yellow Tailings			Red Tailings						Former Mill Building
Target Analyte List Metals (mg/kg)													
Aluminum	NA	NA	29200	11400	2470	7790	6570	11600	9470	7150	11300	9440	7790
Antimony	94	31	1.5	27.8	43.4	45.8	34.5	14.3	18.6	72.0	20.1	32.2	63.7
Arsenic	68	0.68	51.3	396	1080	2440	2020	607	1440	702	561	563	433
Barium	46000	15000	86.7	74.6	84.6	179	72.1	66.0	77.2	110	84.1	72.6	68.5
Beryllium	470	160	0.26 JQ (SQL = 0.72)	0.35 JQ	1.6	1.5	0.70	1.1	1.1	1.0	1.1	1.1	0.64
Cadmium	210	71	0.53	3.0	8.4	20.2	13.5	4.4	10.4	6.4	3.3	4.3	3.6
Calcium	NA	NA	7980	17000	1210	1370	2180	1080	1080	941	952	1490	18200
Chromium	350000	120000	31.3	24.1	6.9	10.8	8.2	13.4	10.5	6.0	10.1	12.6	18.4
Cobalt	70	23	13.2	13.6	12.9	10.7	4.2	34.5	6.7	15.1	11.4	12.9	13.0
Copper	9400	3100	13.0	29.0	15.7	13.9	21.7	9.7	11.7	7.7	8.0	18.9	32.3
Iron	NA	NA	23400	28600	21200	23900	26700	14000	25500	15000	12700	15900	21800
Lead	400	400	6.7	12.3	10.4	9.6	5.0	7.3	5.8	5.7	6.3	8.6	29.7
Magnesium	NA	NA	34700	13300	772	933	877	406 JQ	534	217 JQ	465 JQ	581	13500
Manganese	5500	1800	595 JL	625 JL	731 JL	447 JL	128 JL	339 JL	304 JL	94.3 JL	377 JL	236 JL	568 JL
Mercury	33	11	1.1	402	975	562	107	15.1	60.0	16.2	51.1	21.6	381
Nickel	4600	1500	18.9	29.6	45.7	40.4	12.6	18.1	15.4	11.1	17.8	15.1	26.1
Potassium	NA	NA	1150	2770	758	1650	1870	2840	2690	3400	3580	3010	1810
Thallium	2.3	0.78	0.46 U	3.3	32.9	26.2	11.6	6.9	11.9	1.5	6.3	4.9	4.9
Vanadium	1200	390	31.9	23.1	9.6	12.6	7.1	13.7	12.5	5.9	10.3	10.9	19.5
Zinc	70000	NA	38.6	186	79.5	73.7	40.4	32.4	38.6	33.9	35.4	44.4	224
Methyl Mercury (ng/g)													
Methyl Mercury	23000	7800	0.56	2.94	1.57	1.14	0.63	0.42	1.28	0.09 JQ	0.47	0.20 JQ	0.7

Note: Bold type indicates the sample result is above the CRQL.
 Underline type indicates the sample result is significant as defined in Section 7.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.
 Orange highlight indicates the sample result also exceeds the least conservative (i.e., highest) screening level.

Key:

- CLP = Contract Laboratory Program.
- CRQL = Contract Required Quantitation Limit.
- EPA = United States Environmental Protection Agency.
- ID = Identification.
- J = The associated value is an estimated quantity.
- L = Low bias.
- MDL = Method Detection Limit.
- mg/kg = milligrams per kilogram.
- MRL = Method Reporting Limit.
- NA = Not Applicable. There is no screening criteria for this analyte for this source.
- ng/g = nanograms per gram.
- Q = Detected concentration is below the MRL/CRQL but is above the MDL.
- RML = Removal Management Level.
- RSL = Regional Screening Level.
- SQL = Sample Quantitation Limit.
- U = The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the SQL or the sample detection limit.

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Table 5-6 August 2016 Ponded Water and Seep Surface Water Samples Analytical Results Summary

EPA Sample ID (Unfiltered)			16344286	16344269	16344266
CLP Sample ID (Unfiltered)			MJHQE5	MJHQJ1	MJHQP2
Station Location (Unfiltered)			BG04SW	WT01SW	AD04SW
EPA Sample ID (Filtered)			16344320	16344303	X
CLP Sample ID (Filtered)			MJHQN3	MJHQK0	X
Station Location (Filtered)			BG04SWD	WT01SWD	X
Description	CMC	CCC	Background	Ponded Area	Seep Area
Hardness (mg/L)					
Hardness (Unfiltered)	NA	NA	34.0	117	58.1
Hardness (Filtered)	NA	NA	33.2	120	X
Unfiltered Target Analyte List Metals (µg/L)					
Arsenic	NA	NA	9.0 JQ (SQL = 10)	229	659
Calcium	NA	NA	7980	29500	15900
Copper	NA	NA	6.7	6.9	10.0
Iron	NA	NA	100 U	308	13400
Lead			1.0 U	0.28 JQ	1.8
Magnesium	NA	NA	3420 JQ	10400	4440
Manganese	NA	NA	15 U	47.4	459
Filtered (0.45 micrometer) Target Analyte List Metals (µg/L)					
Arsenic	340	150	9.0 JQ (SQL = 10)	193	X
Calcium	NA	NA	7620	30400	X
Copper	Hardness Dependent		6.4	7.4	X
	CMC (hardness calculation):		6.0	20.2	X
	CCC (hardness calculation):		4.4	13.3	X
Iron	NA	NA	100 U	101	X
Magnesium	NA	NA	3430 JQ	10800	X
Manganese	NA	NA	15.0 U	41.0	X
Filtered (0.45 micrometer) Mercury (ng/L)					
Mercury	1400	12	19.1*	302	X
Methyl Mercury	NA	NA	0.053 UJL *	1.58 JL	X

Note: Bold type indicates the sample result is above the CRQL.
 Underline type indicates the sample result is elevated as defined in Section 7.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.
 Orange highlight indicates the sample result also exceeds the least conservative (i.e., highest) screening level.
 * This sample was not analyzed for these constituents. The results from sample BG03SW/BG03SWD are being used to evaluate significant/elevated concentrations.

Key:

- µg/L = microgram per liter.
- CCC = Criterion Continuous Concentration.
- CLP = Contract Laboratory Program.
- CMC = Criterion Maximum Concentration.
- CRQL = Contract Required Quantitation Limit.
- EPA = United States Environmental Protection Agency.
- ID = Identification.
- J = The associated value is an estimated quantity.
- MDL = Method Detection Limit.
- MRL = Method Reporting Limit.
- NA = Not applicable. There is no screening criteria for this analyte from this source.
- ng/L = nanograms per liter.
- Q = Detected concentrations is below the MRL/CRQL but is above the MDL.
- SQL = Sample Quantitation Limit.
- U = The material was analyzed for, but was not detected above the levels of the associated value. The associated value
- X = The sample was not analyzed for this parameter.

Table 5-7 August 2016 Adit Surface Water Samples Analytical Results Summary

EPA Sample ID (Unfiltered)			16344286	16344256	16344257	16344258
CLP Sample ID (Unfiltered)			MJHQE5	MJHQM6	MJHQM7	MJHQM8
Station Location (Unfiltered)			BG04SW	AD01SW	AD02SW	AD03SW
EPA Sample ID (Filtered)			16344320	16344289	16344290	16344291
CLP Sample ID (Filtered)			MJHQN3	MJHQM4	MJHQM5	MJHQJ8
Station Location (filtered)			BG04SWD	AD01SWD	AD02SWD	AD03SWD
Description	CMC	CCC	Background	Adit 1	Adit 2	Adit 3
Hardness (mg/L)						
Hardness (Unfiltered)	NA	NA	34.0	93.5	35.1	46.1
Hardness (Filtered)	NA	NA	33.2	95.7	39.4	45.2
Unfiltered Target Analyte List Metals (µg/L)						
Arsenic	NA	NA	9.0 JQ (SQL = 10)	<u>43.3</u>	<u>40.3</u>	<u>32.4</u>
Calcium	NA	NA	7980	22700	9700	12600
Copper	NA	NA	6.7	6.2	6.6	6.8
Magnesium	NA	NA	3420 JQ	8950	2650 JQ	3560 JQ
Filtered (0.45 micrometer) Target Analyte List Metals (µg/L)						
Arsenic	340	150	9.0 JQ (SQL = 10)	<u>45.5</u>	<u>48.0</u>	<u>26.0</u>
Calcium	NA	NA	7620	22700	10700	12100
Copper	Hardness Dependent		6.4	6.4	6.4	6.5
	<i>CMC (hardness calculation)</i>		6.0	16.3	7.1	8.1
	<i>CCC (hardness calculation)</i>		4.4	10.9	5.1	5.8
Magnesium	NA	NA	3430 JQ	9480	3090 JQ	3630 JQ
Filtered (0.45 micrometer) Mercury (ng/L)						
Mercury	1400	12	19.1*	68.9	39.1	35.1
Methyl Mercury	NA	NA	0.053 UJL*	0.058 UJL	0.055 UJL	<u>0.129 JL</u>

Note: **Bold type** indicates the sample result is above the CRQL.
Underline type indicates the sample is elevated as defined in Section 7.
Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.
Orange highlight indicates the sample result also exceeds the least conservative (i.e., highest) screening level.
 * This sample was not analyzed for these constituents. The results from sample BG03SW/BG03SWD are being used to evaluate significant/elevated concentrations.

Key:

- µg/L = microgram per liter.
- CCC = Criterion Continuous Concentration.
- CLP = Contract Laboratory Program.
- CMC = Criterion Maximum Concentration.
- CRQL = Contract Required Quantitation Limit.
- EPA = United States Environmental Protection Agency.
- ID = Identification.
- J = The associated value is an estimated quantity.
- MDL = Method Detection Limit.
- MRL = Method Reporting Limit.
- NA = Not applicable. There is no screening criteria for this analyte from this source.

Table 5-8 August 2016 West Fork Cinnabar Creek Surface Water Samples Analytical Results Summary

EPA Sample ID (Unfiltered)			16344286	16344265	16344264	16344263	16344262	16344261	16344260	16344259
CLP Sample ID (Unfiltered)			MJHQE5	MJHQP0	MJHQN9	MJHQL5	MJHQL4	MJHQL3	MJHQJ0	MJHQJ7
Station Location (Unfiltered)			BG04SW	WF07SW	WF06SW	WF05SW	WF04SW	WF03SW	WF02SW	WF01SW
EPA Sample ID (Filtered)			16344320	16344298	16344297	16344296	16344295	16344294	16344293	16344292
CLP Sample ID (Filtered)			MJHQN3	MJHQN7	MJHQN6	MJHQL2	MJHQL1	MJHQL0	MJHQJ9	MJHQJ8
Station Location (Filtered)			BG04SWD	WF07SWD	WF06SWD	WF05SWD	WF04SWD	WF03SWD	WF02SWD	WF01SWD
Description	CMC	CCC	Background	West Fork Cinnabar Creek						
Hardness (mg/L)										
Hardness (Unfiltered)	NA	NA	34.0	124	86.8	79.5	76.9	75.7	94.9	100
Hardness (Filtered)	NA	NA	33.2	112	82.9	79.5	73.9	72.4	93.5	93
Unfiltered Target Analyte List Metals (mg/L)										
Arsenic	NA	NA	9.0 JQ (10 SQL)	6.3 JQ	<u>20.3</u>	<u>19.9</u>	<u>20.8</u>	<u>21.4</u>	<u>27.9</u>	<u>28.7</u>
Calcium	NA	NA	7980	35500	24100	22100	21300	21100	28700	30200
Copper	NA	NA	6.7	6.4	6.6	6.8	6.7	6.5	6.3	6.4
Magnesium	NA	NA	3420 JQ	8520	6470	5890	5750	5610	5670	6010
Filtered (0.45 micrometer) Target Analyte List Metals (mg/L)										
Arsenic	340	150	9.0 JQ (10 SQL)	6.9 JQ	<u>17.9</u>	<u>20.2</u>	<u>20.2</u>	<u>19.7</u>	<u>27.6</u>	<u>27.0</u>
Calcium			7620	31600	22900	22100	20500	20100	28200	28100
Copper	Hardness Dependent		6.4	6.1	6.6	6.7	6.6	6.7	6.5	7.0
	CMC (hardness calculation)		6.0	18.9	14.3	13.7	12.8	12.6	16.0	15.9
	CCC (hardness calculation)		4.4	12.5	9.7	9.3	8.8	8.6	10.7	10.7
Magnesium	NA	NA	3430 JQ	8060	6250	5940	5480	5390	5620	5570
Filtered (0.45 micrometer) Mercury (ng/L)										
Mercury	1400	12	19.1*	X	X	<u>97.9</u>	<u>79.5</u>	<u>79.3</u>	<u>74.2</u>	<u>70.5</u>
Methyl Mercury	NA	NA	0.053 UJL *	X	X	0.0665 JL	0.0670 JL	0.100 JL	0.056 UJL	0.056 UJL

Note: Bold type indicates the sample result is above the CRQL.
 Underline type indicates the sample is elevated as defined in Section 7.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.
 Orange highlight indicates the sample result also exceeds the least conservative (i.e., highest) screening level.
 * This sample was not analyzed for these constituents. The results from sample BG03SW/BG03SWD are being used to evaluate significant/elevated concentrations.

Key:

- µg/L = microgram per liter.
- CCC = Criterion Continuous Concentration.
- CLP = Contract Laboratory Program.
- CMC = Criterion Maximum Concentration.
- CRQL = Contract Required Quantitation Limit.
- EPA = United States Environmental Protection Agency.
- ID = Identification.
- J = The associated value is an estimated quantity.
- MDL = Method Detection Limit.
- MRL = Method Reporting Limit.
- NA = Not applicable. There is no screening criteria for this analyte from this source.
- ng/L = nanograms per liter.
- Q = Detected concentrations is below the MRL/CRQL but is above the MDL.
- SQL = Sample Quantitation Limit.
- U = The material was analyzed for, but was not detected above the levels of the associated value. The associated value is either the SQL or the sample detection limit.
- X = The sample was not analyzed for this parameter.

Table 5-9 August 2016 Cinnabar Creek Surface Water Samples Analytical Results Summary

EPA Sample ID (Unfiltered)	Water Quality Criteria - Aquatic Life		16344285	16344276	16344275	16344274	16344273	16344272
			MJHQJ6	MJHQJ5	MJHQJ4	MJHQG0	MJHQF9	MJHQF8
CLP Sample ID (Unfiltered)			BG03SW	CC05SW	CC04SW	CC03SW	CC02SW	CC01SW
Station Location (Unfiltered)			16344319	16344310	16344309	16344308	16344307	16344306
EPA Sample ID (Filtered)			MJHQE4	MJHQJ3	MJHQJ2	MJHQG8	MJHQG7	MJHQG6
CLP Sample ID (Filtered)			BG03SWD	CC05SWD	CC04SWD	CC03SWD	CC02SWD	CC01SWD
Station Location (Filtered)			Cinnabar Creek					
Description	CMC	CCC	Background					
Hardness (mg/L)								
Hardness (Unfiltered)	NA	NA	40.4	70.3	68.9	71.1	73.3	75.3
Hardness (Filtered)	NA	NA	41.3	67.4	68.2	74.4	73.4	74.5
Unfiltered Target Analyte List Metals (µg/L)								
Arsenic	NA	NA	10 U	<u>15.2</u>	<u>13.8</u>	<u>12.6</u>	9.4 JQ	<u>10.6</u>
Calcium	NA	NA	12000	21200	20800	22300	22500	24100
Copper	NA	NA	6.9	6.4	6.8	6.6	6.8	6.5
Filtered (0.45 micrometer) Target Analyte List Metals (µg/L)								
Arsenic	340	150	10 U	<u>13.0</u>	<u>12.5</u>	<u>12.0</u>	<u>11.2</u>	<u>10.0</u>
Calcium	NA	NA	12100	20200	20500	23400	23500	23900
Copper	Hardness Dependent		7.1	6.7	6.8	6.5	6.4	6.6
	<i>CMC (hardness calculation)</i>		7.4	11.7	11.9	12.9	12.7	12.9
	<i>CCC (hardness calculation)</i>		5.3	8.1	8.2	8.8	8.7	8.8
Filtered (0.45 micrometer) Mercury (ng/L)								
Mercury	1400	12	19.1	35.9	39.0	36.7	27.5	26.9
Methyl Mercury	NA	NA	0.053 UJL	0.051 UJL	0.051 UJL	0.050 UJL	<u>0.0618 JL</u>	<u>0.0777 JL</u>

Note: Bold type indicates the sample result is above the CRQL.
 Underline type indicates the sample is elevated as defined in Section 7.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.

Key:

- µg/L = microgram per liter.
- CCC = Criterion Continuous Concentration.
- CLP = Contract Laboratory Program.
- CMC = Criterion Maximum Concentration.
- CRQL = Contract Required Quantitation Limit.
- EPA = United States Environmental Protection Agency.
- ID = Identification.
- J = The associated value is an estimated quantity.
- MDL = Method Detection Limit.
- MRL = Method Reporting Limit.
- NA = Not applicable. There is no screening criteria for this analyte from this source.
- ng/L = nanograms per liter.
- Q = Detected concentrations is below the MRL/CRQL but is above the MDL.
- SQL = Sample Quantitation Limit.
- U = The material was analyzed for, but was not detected above the levels of the associated value. The associated value is either the SQL or the sample detection limit.

Table 5-10 August 2016 Sugar Creek Surface Water Samples Analytical Results Summary

EPA Sample ID (Unfiltered)			16344284	16344282	16344283	16344281	16344280	16344279	16344278
CLP Sample ID (Unfiltered)			MJHQG3	MJHQG2	MJHQN8	MJHQG1	MJHQE8	MJHQE7	MJHQE6
Station Location (Unfiltered)			BG02SW	SC05SW	UT01SW	SC04SW	SC03SW	SC02SW	SC01SW
EPA Sample ID (Filtered)			16344318	16344316	16344317	16344315	16344314	16344313	16344312
CLP Sample ID (Filtered)			MJHQG9	MJHQG5	MJHQN5	MJHQG4	MJHQF1	MJHQF0	MJHQE9
Station Location (Filtered)			BG02SWD	SC05SWD	UT01SWD	SC04SWD	SC03SWD	SC02SWD	SC01SWD
Description	Water Quality Criteria - Aquatic Life		Background	Sugar Creek	Attribution	Sugar Creek			
	CMC	CCC							
Hardness (mg/L)									
Hardness (Unfiltered)	NA	NA	39.1	53.9	56.2	53.9	52.3	52.5	51.9
Hardness (Filtered)	NA	NA	38.4	52.5	54.9	52.9	50.2	51.9	54.2
Unfiltered Target Analyte List Metals (µg/L)									
Arsenic	NA	NA	10.0 U	4.0 JQ	13.3	3.7 JQ	5.6 JQ	4.8 JQ	5.8 JQ
Calcium	NA	NA	13900	18200	19700	18200	17700	17600	17100
Copper	NA	NA	6.3	6.5	6.4	6.6	6.5	6.4	6.5
Filtered (0.45 micrometer) Target Analyte List Metals (µg/L)									
Arsenic	340	150	10.0 U	3.3 JQ	13.8	4.0 JQ	5.1 JQ	5.9 JQ	7.4 JQ
Calcium	NA	NA	13900	17700	19200	17800	16700	17200	17700
Copper	Hardness Dependent		6.5	6.4	6.6	6.4	6.7	6.6	6.5
	<i>CMC (hardness calculation)</i>		6.9	9.3	9.7	9.3	8.9	9.2	9.6
	<i>CCC (hardness calculation)</i>		5.0	6.5	6.8	6.6	6.3	6.5	6.7
Filtered (0.45 micrometer) Mercury (ng/L)									
Mercury	1400	12	0.573 U	<u>7.93</u>	X	<u>8.62</u>	<u>11.0</u>	<u>9.24</u>	X
Methyl Mercury	NA	NA	0.051 UJL	0.051 UJL	X	<u>0.121 JL</u>	<u>0.127 JL</u>	<u>0.146 JL</u>	X

Note: Bold type indicates the sample result is above the CRQL.
 Underline type indicates the sample is elevated as defined in Section 7.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.

Key:

- µg/L = microgram per liter.
- CCC = Criterion Continuous Concentration.
- CLP = Contract Laboratory Program.
- CMC = Criterion Maximum Concentration.
- CRQL = Contract Required Quantitation Limit.
- EPA = United States Environmental Protection Agency.
- ID = Identification.
- J = The associated value is an estimated quantity.
- MDL = Method Detection Limit.
- MRL = Method Reporting Limit.
- NA = Not applicable. There is no screening criteria for this analyte from this source.
- ng/L = nanograms per liter.
- Q = Detected concentrations is below the MRL/CRQL but is above the MDL.
- SQL = Sample Quantitation Limit.
- U = The material was analyzed for, but was not detected above the levels of the associated value. The associated value is either the SQL or the sample detection limit.
- X = The sample was not analyzed for this parameter.

Table 5-11 September 2016 EPA Surface Water Samples Analytical Results

EPA Sample ID (Unfiltered)	Water Quality Criteria - Aquatic Life		16384155	16384152	16384153	16384154	16384151	16384150
Station Location (Unfiltered)			WF05SW	WF04SW	WF03SW		BG02SW	SC01SW
EPA Sample ID (Filtered)			16384162	16384159	16384160	16384161	16384158	16384157
Station Location (Filtered)			WF05SWD	WF04SWD	WF03SWD		BG02SWD	SC01SWD
Description	CMC	CCC	West Fork Cinnabar Creek				Background	Sugar Creek
Unfiltered Mercury (ng/L)								
Mercury	NA	NA	151	320	143	171	0.665 U	<u>25.7</u>
Methyl Mercury	NA	NA	0.0956 JL	0.0777 JL	0.0832 JL	0.0939 JL	0.054 UJL	0.114 JL
Filtered (0.45 micrometer) Mercury (ng/L)								
Mercury	1400	12	43.7	40.2	39.9	39.4	0.646 U	<u>7.43</u>
Methyl Mercury	NA	NA	0.0629 UJL	0.0752 UJL	0.0624 UJL	0.0682 UJL	0.054 UJL	0.107 JL

Note: Bold type indicates the sample result is above the CRQL.
 Underline type indicates the sample is elevated as defined in Section 7.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.

Key:

- CCC = Criterion Continuous Concentration.
- CLP = Contract Laboratory Program.
- CMC = Criterion Maximum Concentration.
- CRQL = Contract Required Quantitation Limit.
- EPA = United States Environmental Protection Agency.
- ID = Identification.
- J = The associated value is an estimated quantity.
- MDL = Method Detection Limit.
- MRL = Method Reporting Limit.
- NA = Not applicable. There is no screening criteria for this analyte from this source.
- ng/L = nanograms per liter.
- U = The material was analyzed for, but was not detected above the levels of the associated value. The associated value is either the SQL or the sample detection limit.

Table 5-12 August 2016 Ponded Water Sediment Sample Analytical Results Summary

EPA Sample ID CLP Sample ID Station Location Description	Avocet SQS		MacDonald Consensus- Based TEC	16344247 MJHQM9 BG04SD	16344229 MJHQK3 WT01SD
	SL1	SL2		Background	Ponded Area
Target Analyte List Metals (mg/kg)					
Aluminum	NA	NA	NA	4310	4290
Antimony	0.3	12	NA	6.4	36.4
Arsenic	14	120	9.79	92.3	1570
Barium	NA	NA	NA	39.6	61.1
Beryllium	NA	NA	NA	0.66	2.3
Cadmium	2.1	5.4	0.99	0.78	13.0
Calcium	NA	NA	NA	6990	2480
Chromium	72	82	43.4	8.1	15.6
Cobalt	NA	NA	NA	2.2 JQ (SQL = 5.0)	7.8
Copper	400	1200	31.6	13.8	21.7
Iron	NA	NA	NA	6460	33700
Lead	360	>1300	35.8	3.6	11.2
Magnesium	NA	NA	NA	2340	884
Manganese	NA	NA	NA	245	422 JL
Mercury	0.66	0.8	0.18	4.6	491
Nickel	26	110	22.7	21.1	66.3
Potassium	NA	NA	NA	718	1130
Thallium	NA	NA	NA	1.5	36.1
Vanadium	NA	NA	NA	8.4	19.0
Zinc	3200	>4200	121	19.2	148
Methyl Mercury (ng/g)					
Methyl Mercury	NA	NA	NA	11.1	17.7
Total Organic Carbon (mg/kg)					
Total Organic Carbon	NA	NA	NA	100000 JK	30000
Grain Size (Percent)					
Gravel, Medium	NA	NA	NA	3.28	5.11
Gravel, Fine	NA	NA	NA	5.68	1.55
Sand, Very Coarse	NA	NA	NA	14.98	2.21
Sand, Coarse	NA	NA	NA	16.27	1.24
Sand, Medium	NA	NA	NA	12.13	0.66
Sand, Fine	NA	NA	NA	13.68	1.26
Sand, Very Fine	NA	NA	NA	3.53	1.16
Silt	NA	NA	NA	19.61	68.28
Clay	NA	NA	NA	1.31	21.66

Note: Bold type indicates the sample result is above the CRQL.
 Underline type indicates the sample result is elevated as defined in Section 7.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.
 Orange highlight indicates the sample result also exceeds the least conservative (i.e., highest) screening level.

Key:

- CLP = Contract Laboratory Program.
- CRQL = Contract Required Quantitation Limit.
- EPA = United States Environmental Protection Agency.
- ID = Identification.
- J = The associated value is an estimated quantity.
- L = Low bias.
- MDL = Method Detection Limit.
- mg/kg = milligrams per kilogram.
- MRL = Method Reporting Limit.
- NA = Not applicable. There is no screening criteria for this analyte from this source.
- ng/g = nanograms per gram.
- Q = Detected concentration is below the MRL/CRQL but is above the MDL.
- SQL = Sample Quantitation Limit.
- SQS = Sediment Quality Standard.
- TEC = Threshold Effect Concentration.

Table 5-13 August 2016 Adit Sediment Samples Analytical Results Summary

EPA Sample ID CLP Sample ID Station Location Description	Avocet SQS		MacDonald Consensus- Based TEC	16344247	16344216	16344217	16344218
				MJHQM9	MJHQE0	MJHQM1	MJGQM2
				BG04SD	AD01SD	AD02SD	AD03SD
	SL1	SL2		Background	Adit 1	Adit 2	Adit 3
Target Analyte List Metals (mg/kg)							
Aluminum	NA	NA	NA	4310	8440	3590	5940
Antimony	0.3	12	NA	6.4	9.1	56.2	70.7
Arsenic	14	120	9.79	92.3	2440	158	464
Barium	NA	NA	NA	39.6	109	37.7	70.5
Beryllium	NA	NA	NA	0.66	3.4	0.41 JQ	0.78
Cadmium	2.1	5.4	0.99	0.78	18.2	1.7	3.9
Calcium	NA	NA	NA	6990	9390	2110	2110
Chromium	72	82	43.4	8.1	20.9	10.9	16.2
Cobalt	NA	NA	NA	2.2 JQ (SQL = 5.0)	38.1	14.8	14.1
Copper	400	1200	31.6	13.8	25.0	33.9	15.1
Iron	NA	NA	NA	6460	40300	10900	23500
Lead	360	>1300	35.8	3.6	7.7	2.1	35.0
Magnesium	NA	NA	NA	2340	9790	2340	3310
Manganese	NA	NA	NA	245	1820	306	512
Mercury	0.66	0.8	0.18	4.6	206	1600	227
Nickel	26	110	22.7	21.1	57.2	16.1	20.5
Potassium	NA	NA	NA	718	1610	1130	1650
Selenium	11	>20	NA	2.4 JQ	4.1 JL	0.49 JQ	0.93 JQ
Thallium	NA	NA	NA	1.5	15.7	3.9	4.1
Vanadium	NA	NA	NA	8.4	22.5	8.3	18.5
Zinc	3200	>4200	121	19.2	115	20.7	115
Methyl Mercury (ng/g)							
Methyl Mercury	NA	NA	NA	11.1	48.9	0.75	4.56
Total Organic Carbon (mg/kg)							
Total Organic Carbon	NA	NA	NA	10000 JK	97000	3040	6920
Percent Solids (percentage)							
Gravel, Medium	NA	NA	NA	3.28	0.18	34.70	17.01
Gravel, Fine	NA	NA	NA	5.68	0.79	21.35	27.78
Sand, Very Coarse	NA	NA	NA	14.98	1.15	18.77	18.02
Sand, Coarse	NA	NA	NA	16.27	3.23	12.74	10.52
Sand, Medium	NA	NA	NA	12.13	5.08	7.08	7.07
Sand, Fine	NA	NA	NA	13.68	8.29	6.24	8.67
Sand, Very Fine	NA	NA	NA	3.53	2.66	0.99	2.57
Silt	NA	NA	NA	19.61	54.69	1.60	9.02
Clay	NA	NA	NA	1.31	16.43	0.23	3.19

Note: Bold type indicates the sample results is above the CRQL.
 Underline type indicates the sample result is elevated as defined in Section 7.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.
 Orange highlight indicates the sample result also exceeds the least conservative (i.e., highest) screening level.

Key:

- CLP = Contract Laboratory Program.
- CRQL = Contract Required Quantitation Limit.
- EPA = United States Environmental Protection Agency.
- ID = Identification.
- J = The associated value is an estimated quantity.
- L = Low bias.
- MDL = Method Detection Limit.
- mg/kg = milligrams per kilogram.
- MRL = Method Reporting Limit.
- NA = Not applicable. There is no screening criteria for this analyte from this source.
- ng/g = nanograms per gram.
- Q = Detected concentration is below the MRL/CRQL but is above the MDL.
- SQL = Sample Quantitation Limit.
- SQS = Sediment Quality Standard.
- TEC = Threshold Effect Concentration.

Table 5-14 August 2016 West Fork Cinnabar Creek Sediment Samples Analytical Results Summary

EPA Sample ID CLP Sample ID Station Location Description	Avocet SQS		MacDonald Consensus- Based TEC	16344247	16344225	16344224	16344223	16344222	16344221	16344220	16344219
	SL1	SL2		MJHQ1M9 BG04SD	MJHQN2 WF07SD	MJHQN1 WF06SD	MJHQK9 WF05SD	MJHQK8 WF04SD	MJHQK7 WF03SD	MJHQK2 WF02SD	MJHQK1 WF01SD
				Background	West Fork Cinnabar Creek						
Target Analyte List Metals (mg/kg)											
Aluminum	NA	NA	NA	4310	5860	5400	5350	2390	5750	4110	3390
Antimony	0.3	12	NA	6.4	24.5	17.2	25.2	31.9	19.3	25.5	19.3
Arsenic	14	120	9.79	92.3	238	195	152	167	245	223	86.9
Barium	NA	NA	NA	39.6	209	58.5	44.3	235	38.2	245	51.8
Beryllium	NA	NA	NA	0.66	0.86	0.40 JQ	0.37 JQ	0.25 JQ	0.45	0.37 JQ	0.28 JQ
Cadmium	2.1	5.4	0.99	0.78	2.4	1.3	1.9	0.89	2.2	1.6	1.5
Calcium	NA	NA	NA	6990	7940	1680	1410	11200	9460	12400	7230
Chromium	72	82	43.4	8.1	13.6	5.0	8.8	2.2	12.5	5.7	5.7
Cobalt	NA	NA	NA	2.2 JQ (SQL = 5.0)	36.5	27.8	5.1	507	5.6	19.5	4.3 JQ
Copper	400	1200	31.6	13.8	23.5	15.8	7.8	7.7	9.9	7.0	5.8
Iron	NA	NA	NA	6460	18500	5700	14700	4980	18900	8370	9200
Lead	360	>1300	35.8	3.6	7.7	3.3	4.1	63.4	2.9	3.0	1.7
Magnesium	NA	NA	NA	2340	6270	725	3320	6200	5570	4380	2270
Manganese	NA	NA	NA	245	1330 JL	356 JL	245 JL	1560 JL	329 JL	979	122
Mercury	0.66	0.8	0.18	4.6	99.5	6.8	85.2	131	46.5	11.0	37.6
Nickel	26	110	22.7	21.1	31.3	10.3	12.2	192	14.7	11.3	9.6
Potassium	NA	NA	NA	718	1590	1370	1080	403	1270	964	949
Thallium	NA	NA	NA	1.5	2.8	0.73	1.1	0.74	6.4	0.80	0.63
Vanadium	NA	NA	NA	8.4	14.5	5.1	9.9	5.9	11.9	8.3	6.1
Zinc	3200	>4200	121	19.2	30.6	30.6	34.5	29.2	38.5	24.0	27.2
Methyl Mercury (ng/g)											
Methyl Mercury	NA	NA	NA	11.1	2.60	1.39	0.25 JQ	3.02	0.19 JQ	1.57	0.84
Total Organic Carbon (mg/kg)											
Total Organic Carbon	NA	NA	NA	100000 JK	9210	9280	6450	5850	10300	5970	6730
Percent Solids (percentage)											
Gravel, Medium	NA	NA	NA	3.28	18.88	21.84	26.49	31.10	27.61	34.10	26.63
Gravel, Fine	NA	NA	NA	5.68	14.66	29.05	26.36	33.96	35.27	28.63	36.22
Sand, Very Coarse	NA	NA	NA	14.98	16.10	22.34	15.47	18.36	17.24	21.50	22.44
Sand, Coarse	NA	NA	NA	16.27	16.33	13.76	11.21	7.51	8.31	13.66	11.8
Sand, Medium	NA	NA	NA	12.13	11.17	7.27	7.35	2.80	4.31	5.07	5.58
Sand, Fine	NA	NA	NA	13.68	10.27	5.53	5.94	1.81	4.31	2.76	3.61
Sand, Very Fine	NA	NA	NA	3.53	2.92	0.95	1.61	0.34	1.23	0.43	0.63
Silt	NA	NA	NA	19.61	8.29	1.65	4.44	1.04	3.05	0.84	1.33
Clay	NA	NA	NA	1.31	1.46	0.3	0.51	0.06	0.19	0.11	0.06

Note: Bold type indicates the sample result is above the CRQL.
 Underline type indicates the sample result is elevated as defined in Section 7.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.
 Orange highlight indicates the sample result also exceeds the least conservative (i.e., highest) screening level.

Key:
 CLP = Contract Laboratory Program.
 CRQL = Contract Required Quantitation Limit.
 EPA = United States Environmental Protection Agency.
 ID = Identification.
 J = The associated value is an estimated quantity.
 MDL = Method Detection Limit.
 mg/kg = milligrams per kilogram.
 MRL = Method Reporting Limit.
 NA = Not applicable. There is no screening criteria for this analyte from this source.
 ng/g = nanograms per gram.
 Q = Detected concentration is below the MRL/CRQL but is above the MDL.
 SQL = Sample Quantitation Limit.
 SQS = Sediment Quality Standard.
 TEC = Threshold Effect Concentration.

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Table 5-15

August 2016 Cinnabar Creek Sediment Samples Analytical Results Summary

EPA Sample ID CLP Sample ID Station Location Description	Avocet SQS		MacDonald Consensus- Based TEC	16344246 MJHQK6 BG03SD	16344236 MJHQK5 CC05SD	16344235 MJHQK4 CC04SD	16344234 MJHQF4 CC03SD	16344233 MJHQF3 CC02SD	16344232 MJHQF2 CC01SD
	SL1	SL2		Background	Cinnabar Creek				
Target Analyte List Metals (mg/kg)									
Aluminum	NA	NA	NA	12300	5780	8230	5630	2150	5340
Antimony	0.3	12	NA	1.5 U	14.3	14.7	9.5	9.6	10.1
Arsenic	14	120	9.79	46.6	50.7	135	98.4	102	113
Barium	NA	NA	NA	64.6	41.5	68.4	43.0	34.5	66.0
Beryllium	NA	NA	NA	0.76	0.43 JQ	0.54 JQ	0.29 JQ	0.21 JQ	0.27 JQ
Cadmium	2.1	5.4	0.99	0.63 JQ (SQL = 0.76)	<u>2.6</u>	<u>1.6</u>	<u>1.0</u>	<u>1.1</u>	<u>1.0</u>
Calcium	NA	NA	NA	4090	5820	5610	4040	1310	3680
Chromium	72	82	43.4	19.4	9.3	13.8	8.9	3.3	8.3
Cobalt	NA	NA	NA	55.5	41.7	25.6	11.9	5.4	9.5
Copper	400	1200	31.6	26.4	11.0	13.9	8.3	2.7	7.5
Iron	NA	NA	NA	15800	15200	16100	10800	7790	10600
Lead	360	>1300	35.8	3.9	3.1	3.3	4.7	0.95	3.2
Magnesium	NA	NA	NA	4290	3250	5150	3650	670	2930
Manganese	NA	NA	NA	528	358	330	187 JL	67.2 JL	211 JL
Mercury	0.66	0.8	0.18	2.7	13.2	468	223	3.9	64.7
Nickel	26	110	22.7	69.1	32.5	34.8	20.6	7.1	14.1
Potassium	NA	NA	NA	866	959	1820	1120	626	1250
Thallium	NA	NA	NA	1.4	0.67 U	1.4	1.7	2.5	1.1
Vanadium	NA	NA	NA	28.1	13.7	16.0	10.0	3.8 JQ	9.2
Zinc	3200	>4200	121	108	48.6	61.0	28.2	10.3	22.7
Methyl Mercury (ng/g)									
Methyl Mercury	NA	NA	NA	1.52	1.02	2.75	2.26	3.95	1.23
Total Organic Carbon (mg/kg)									
Total Organic Carbon	NA	NA	NA	31000	7170	6440	4990	2310	4180
Percent Solids (percentage)									
Gravel, Medium	NA	NA	NA	37.60	40.89	15.59	0.54	37.45	11.67
Gravel, Fine	NA	NA	NA	23.97	27.07	11.48	14.19	28.90	19.72
Sand, Very Coarse	NA	NA	NA	18.54	18.35	15.97	16.81	19.23	12.61
Sand, Coarse	NA	NA	NA	8.17	9.83	18.94	15.77	9.52	22.38
Sand, Medium	NA	NA	NA	6.05	4.72	16.63	19.87	4.09	19.54
Sand, Fine	NA	NA	NA	7.13	2.57	13.77	25.35	1.49	11.72
Sand, Very Fine	NA	NA	NA	1.98	0.40	1.71	3.83	0.13	1.87
Silt	NA	NA	NA	4.52	0.83	2.2	3.92	0.27	2.29
Clay	NA	NA	NA	0.28	0.04	0.28	0.58	0.07	0.15

Note:

Bold type indicates the sample result is above the CRQL.

Underline type indicates the sample result is elevated as defined in Section 7.

Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.

Orange highlight indicates the sample result also exceeds the least conservative (i.e., highest) screening level.

Key:

CLP = Contract Laboratory Program.
CRQL = Contract Required Quantitation Limit.
EPA = United States Environmental Protection Agency.
ID = Identification.
J = The associated value is an estimated quantity.
L = Low bias.
MDL = Method Detection Limit.
mg/kg = milligrams per kilogram.
MRL = Method Reporting Limit.
NA = Not applicable. There is no screening criteria for this analyte from this source.
ng/g = nanograms per gram.
Q = Detected concentration is below the MRL/CRQL but is above the MDL.
SQL = Sample Quantitation Limit.
SQS = Sediment Quality Standard.
TEC = Threshold Effects Concentration.

Table 5-16 August 2016 Sugar Creek Sediment Samples Analytical Results Summary

EPA Sample ID	Avocet SQS		MacDonald Consensus- Based TEC	16344245	16344242	16344243	16344241	16344240	16344239	16344238
CLP Sample ID	SL1	SL2		MJHQF7	MJHQF6	MJHQN0	MJHQF5	MJHQE3	NJHQE2	MJHQE1
Station Location				BG02SD	SC05SD	UT01SD	SC04SD	SC03SD	SC02SD	SC01SD
Description	SL1	SL2		Background	Sugar Creek	Attribution	Sugar Creek			
Target Analyte List Metals (mg/kg)										
Aluminum	NA	NA	NA	3690	3940	4620	12000	9770	5080	2320
Antimony	0.3	12	NA	0.94 U	<u>6.8</u>	6.3	6.8	5.3	2.5	3.3
Arsenic	14	120	9.79	7.3	20.1	53.9	64.1	53.0	33.3	55.8
Barium	NA	NA	NA	24.4	30.6	36.3	103	62.5	36.5	21.8
Cadmium	2.1	5.4	0.99	0.51 U	0.14 JQ	0.75	1.3	0.32 JQ	0.28 JQ	0.16 JQ
Calcium	NA	NA	NA	1010	1190	5520	4610	3070	1420	653
Chromium	72	82	43.4	3.3	6.5	6.4	19.8	14.3	6.1	2.7
Cobalt	NA	NA	NA	1.5 JQ (SQL = 7.2)	2.3 JQ	3.3 JQ (SQL = 6.3)	<u>11.7</u>	7.0	3.4 JQ	1.4 JQ
Copper	400	1200	31.6	1.8 JQ	1.8 JQ	4.3	11.0	5.2	3.2	1.4 JQ
Iron	NA	NA	NA	7420	8690	9150	21100	13800	9510	4990
Lead	360	>1300	35.8	6.4	4.3	5.1	7.0	4.9	3.5	3.2
Magnesium	NA	NA	NA	904	1490	3540	6420	5280	2090	773
Manganese	NA	NA	NA	159	185	119 JL	469	147	128	125
Mercury	0.66	0.8	0.18	0.094 U	<u>0.48</u>	71.5	<u>128</u>	33.7	10.3	8.8
Nickel	26	110	22.7	2.2 JQ (SQL = 5.8)	2.6 JQ	4.9 JQ (SQL = 5.0)	<u>16.5</u>	<u>10.8</u>	4.5	1.7 JQ
Potassium	NA	NA	NA	929	890	940	2130	1650	1120	697
Vanadium	NA	NA	NA	4.6 JQ (SQL = 7.2)	7.0	7.1	20.7	14.9	8.0	3.8 JQ
Zinc	3200	>4200	121	26.0	23.1	20.2	51.5	39.5	26.2	12.8
Methyl Mercury (ng/g)										
Methyl Mercury	NA	NA	NA	0.4 U	0.4 U	<u>15.0</u>	2.55	0.15 JQ	0.17 JQ	0.4 U
Total Organic Carbon (mg/kg)										
Total Organic Carbon	NA	NA	NA	1120	2560	13200	13500	6660	1530	1250
Percent Solids (percentage)										
Gravel, Medium	NA	NA	NA	21.92	6.58	20.61	1.67	27.96	0.87	12.59
Gravel, Fine	NA	NA	NA	29.27	37.51	14.78	2.24	18.05	1.59	28.76
Sand, Very Coarse	NA	NA	NA	37.32	42.67	7.21	5.45	17.11	17.26	39.48
Sand, Coarse	NA	NA	NA	12.71	9.23	9.67	11.59	4.07	43.02	15.81
Sand, Medium	NA	NA	NA	1.63	2.94	12.81	24.86	3.88	24.40	2.92
Sand, Fine	NA	NA	NA	0.37	1.75	15.83	36.98	20.55	11.59	0.96
Sand, Very Fine	NA	NA	NA	0.04	0.19	3.12	7.20	6.53	1.26	0.12
Silt	NA	NA	NA	0.03	0.58	5.66	6.26	5.53	1.56	0.09
Clay	NA	NA	NA	0.06	0.05	0.77	1.82	0.66	0.22	0.03

Note:
 Bold type indicates the sample result is above the CRQL.
 Underline type indicates the sample result is elevated as defined in Section 7.
 Yellow highlight indicates the sample result exceeds the most conservative (i.e., lowest) screening level.
 Orange highlight indicates the sample result also exceeds the least conservative (i.e., highest) screening level.

Key:

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mg/kg = milligrams per kilogram.

MRL = Method Reporting Limit.

NA = Not applicable. There is no screening criteria for this analyte from this source.

ng/g = nanograms per gram.

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SQL = Sample Quantitation Limit.

SQS = Sediment Quality Standard

TEC = Threshold Effect Concentration.

U = The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the SQL or the sample detection limit.

Table 9-1 Soil Sample Screening Level Summary Table

		Background	Borrow Source (Table 5-4)	Tailings (Table 5-5)
	No. of Samples	1	5	10
Arsenic	> RSL	1	5	10
	> RML	0	5	10
Mercury	> RSL	0	5	10
	> RML	0	4	7
Methyl Mercury	> RSL	0	0	0
	> RML	0	0	0

Key:

- > = Above.
- No. = Number.
- RML = Removal Management Level.
- RSL = Regional Screening Level.

Table 9-2 Surface Water Sample Screening Level Summary

		Background	Ponded Water (Table 5-6)	Adits (Table 5-7)	West Fork Cinnabar Creek (Table 5-8)	Cinnabar Creek (Table 5-9)	Sugar Creek (Table 5-10)	September West Fork (Table 5-11)	September Cinnabar Creek (Table 5-11)
	No. of Samples	4	1	3	5 to 7	5	4 to 6	4	1
Filtered Arsenic	> CCC	0	1	0	0	0	0	X	X
	> CMC	0	0	0	0	0	0	X	X
Filtered Mercury	> CCC	2	1	3	5 of 5	5	0 of 4	4	0
	> CMC	0	0	0	5 of 5	0	0 of 4	0	0
Filtered Methylmercury	> CCC	NA	NA	NA	NA	NA	NA	NA	NA
	> CMC	NA	NA	NA	NA	NA	NA	NA	NA

Key:

- > = Above.
- CCC = Criterion Continuous Concentration.
- CMC = Criterion Maximum Concentration.
- NA = There is no applicable screening level for this analyte.
- No. = Number.
- X = The sample was not analyzed for this parameter.

Table 9-3 Sediment Screening Level Sample Summary

		Background	Ponded Area (Table 5-12)	Adit (Table 5-13)	West Fork Cinnabar Creek (Table 5-14)	Cinnabar Creek (Table 5-15)	Sugar Creek (Table 5-16)
	No. of Samples	4	1	3	7	5	5
Arsenic	> SQL SL1	2	1	3	7	5	5
	> SQS SL2	0	1	3	6	1	0
	> TEC	3	1	3	7	5	5
Mercury	> SQS SL1	3	1	3	7	5	5
	> SQS SL2	3	1	3	7	5	5
	> TEC	3	1	3	7	5	1
Methylmercury	> SQL SL1	NA	NA	NA	NA	NA	NA
	> SQS SL2	NA	NA	NA	NA	NA	NA
	> TEC	NA	NA	NA	NA	NA	NA

Key:

> Above.

NA = There is no applicable screening level for this analyte.

No. = Number.

SQS SL1 = Sediment Quality Standard Screening Level 1.

SQS SL2 = Sediment Quality Standard Screening Level 2.

TEC = Threshold Effect Concentration.

Table 9-4 Summary of Removal Action Alternatives

Removal Alternative	Key Advantage	Key Disadvantage	Estimated Cost
A1 – Engineered Soil Media and Vegetative Cover	<ul style="list-style-type: none"> ▪ Cost-effective source control for tailings runoff; ▪ Reduces runoff velocities and volume; ▪ Avoids the need to import and spread topsoil; and ▪ Does not require mobilization and use of any heavy machinery. 	<ul style="list-style-type: none"> ▪ Does not address potential contaminant migration pathways occurring in the subsurface; ▪ May contribute to dissolved inorganic mercury mobilization and methylmercury production; ▪ Possible uptake of metals in plants that may be consumed by wildlife; and, ▪ The success of long-term vegetation establishment under site conditions remains uncertain. 	\$144,000
A2 – Selective Grading and Vegetative Buffer Strips	<ul style="list-style-type: none"> ▪ Filters tailings from runoff before it reaches the stream; ▪ Willows provide shade which may improve stream temperatures; and ▪ Reduces runoff velocities and volume. ▪ Reduces methylmercury production from the ponded area on the tailings 	<ul style="list-style-type: none"> ▪ Short-term water quality impacts due to road construction and excavation near the stream; and ▪ Does not address potential contaminant migration pathways occurring in the subsurface. 	\$262,000
A3 – Tailings Consolidation and Stream Relocation	<ul style="list-style-type: none"> ▪ Reduces contributing area and sediment load from tailings runoff; and ▪ Creates larger riparian buffer area to filter runoff before reaching the stream. 	<ul style="list-style-type: none"> ▪ Short-term water quality and fish habitat impacts due to road construction and excavation near the stream; ▪ Does not address potential contaminant migration pathways occurring in the subsurface; and ▪ High costs. 	\$1,047,000
A4 – Full-Scale Removal	<ul style="list-style-type: none"> ▪ Complete removal of contaminant sources 	<ul style="list-style-type: none"> ▪ Short-term water quality and fish habitat impacts due to road construction and excavation near the stream; and ▪ High cost. 	\$2,604,000

The costs include estimates for capital costs using unit rates provided by R. S. Means 2017 and engineering estimates based on volume calculations and production rates from similar projects. Since O&M costs were not included, the net present value of capital was not calculated. The cost estimate assumes that construction starts this year and does not account for a delayed starting period.