FREEPORT-McMoRAN

Freeport-McMoRan Chino Mines Company
P.O. Box 10
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November 5, 2024

Certified Mail # 70190140000026680891

Mr. Jonas Armstrong, Director
Water Protection Division
New Mexico Environment Department
P.O. Box 5469
Santa Fe, New Mexico 87502

Dear Mr. Armstrong:

Re: Draft Feasibility Study for the Lampbright Investigation Unit
Chino Administrative Order on Consent (AOC)

Freeport-McMoRan Chino Mines Company (Chino) submits under separate cover the *Draft Feasibility Study (FS) for the Lampbright Investigation Unit (LIU)* under the Chino Administrative Order on Consent (AOC). This *Draft FS* is submitted per Appendix A, Section 2.7.7. of the AOC to the New Mexico Environment Department (NMED). Prior to the development of this *FS* and as per Appendix A, Section 2.6 of the AOC, NMED issued the pre-FS Remedial Action Criteria (RAC) for the LIU in a letter dated July 10, 2024. NMED stated therein:

> *Chino shall commence the FS tasks within sixty (60) days of receiving this letter as stated in the AOC, SOW, Section 2.7. Chino shall submit the draft FS within one hundred twenty (120) days of receiving this letter.*

Additionally, NMED is not electing to identify a Pre-FS RAC for sediments but requested that Chino provide a description in the FS of the aquatic habitat at locations in Tributary 2A at site 2206 and in Tributary 2 at site T2S10 which exceeded the probable effects concentration for copper for sediment. To support the description discussed in Section 3.1.1 of the FS, attached are photo documentation of the dry conditions at these temporary rainfall pool sample locations.

The *Draft FS* was submitted today in electronic form to Mr. David Mercer. Please contact Ms. Pam Pinson at (575) 912-5213 with any questions or comments concerning this draft feasibility study for the LIU.

Sincerely,

Sherry Burt-Kested

Sherry Burt-Kested, Manager
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Tributary 2A sediment sample site 2206, November 1, 2024

Tributary 2 sediment sample site T2S10, November 1, 2024

DRAFT

Freeport-McMoRan Chino Mines Company

Lampbright Investigation Unit Feasibility Study

Lampbright Investigation Unit
Chino Mine Investigation Area, Grant County, New Mexico

November 2024

Lampbright Investigation Unit Feasibility Study

Lampbright Investigation Unit
Chino Mine Investigation Area, Grant County, New Mexico

November 2024

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Acronyms and Abbreviations

95UCL	95 percent upper confidence limit
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirements
Bd	*Batrachochytridium dendrobatidis*
bgs	below ground surface
BIOME	BIOME, Ecological & Wildlife Research
CCP	closure/closeout plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Chino	Freeport-McMoRan Chino Mines Company
CLF	Chiricahua leopard frog
COPC	constituent of potential concern
DAF	dilution attenuation factor
DP	Discharge Permit
ERA	ecological risk assessment
Formation	Formation Environmental, LLC
FS	feasibility study
Golder	Golder Associates, Inc.
HHRA	human health risk assessment
HI	hazard index
HWCIU	Hanover/Whitewater Creeks Investigation Unit
IA	Investigation Area
IU	Investigation Unit
LIU	Lampbright Investigation Unit
LOEC	Lowest Observed Effect Concentration
LSA	Lampbright stockpile area
LSO	Lampbright Stockpile Operations
mg/kg	milligram per kilogram
mg/L	milligram per liter
NCP	National Contingency Plan

Neptune	Neptune and Company, Inc.
NMAC	New Mexico Administrative Code
NMED	New Mexico Environmental Department
NOEC	No Observed Effect Concentration
pCu	cupric ion activity (pCu2+)
PEC	probable effects concentration
PLS	pregnant leach solution
RAC	Remedial Action Criteria
RAO	Remedial Action Objective
RI	remedial investigation
ROD	Record of Decision
SESAT	Southwest Endangered Species Act Team
SGFB	small ground-feeding bird
site	Chino Mine Investigation Area in Grant County, New Mexico
SPLP	synthetic precipitation leaching procedure
SRK	SRK Consulting, Inc.
STSIU	Smelter/Tailing Soils Investigation Unit
SX/EW	solvent extraction/electrowinning
TBC	to be considered
TDS	total dissolved solids
TEC	threshold effect concentration
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

1 Introduction

This Feasibility Study (FS) was prepared for Freeport-McMoRan Chino Mines Company (Chino) to develop and evaluate potential remedial alternatives for the Lampbright Investigation Unit (LIU) at the Chino Mine Investigation Area (IA) in Grant County, New Mexico (the site). This FS has been developed in accordance with the requirements in the Administrative Order on Consent (AOC; New Mexico Environmental Department [NMED 1994]) following Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidance. The AOC, effective December 23, 1994, addresses effects of historical operations at Chino's copper mining and processing facilities in Grant County, New Mexico within the AOC IA. The AOC distinguishes between historical mineral processing activities and current operations at Chino. This FS addresses remedial action objectives (RAOs) for current conditions and evaluates remedial alternatives based on FS criteria (United States Environmental Protection Agency [USEPA] 1998).

As discussed in the LIU remedial investigation (RI; Arcadis U.S., Inc. [Arcadis] 2012), many of the activities to be addressed under the AOC for the LIU are being addressed under discharge permit (DP)-related programs (i.e., Sitewide Abatement and the DP-376 Corrective Action). Article IIA of the AOC states:

> *"to avoid duplication of environmental closure activities to the extent that the Investigation Area is subject to existing Discharge Plans, those Discharge Plans shall not be incorporated into this AOC and shall continue to govern compliance with applicable provisions of the New Mexico Water Quality Act...but the Discharge Plan areas...can be subject to investigation and remediation if necessary...if the media is not being addressed by the Discharge Plan." (AOC, p. 2)*

Media governed by discharge plans include surface water, sediment, and groundwater. Compliance for those media within the discharge permit boundary will continue to proceed under discharge permit requirements unless some aspect of these media is not covered. For completeness, these media will be discussed in this FS, but remedial alternatives will be covered in the sitewide abatement process.

1.1 Background

The LIU is one of six Investigation Units (IUs) within the Chino Mine IA identified in the AOC (Figure 1-1). The Smelter IU and Tailings and Soil IU were later combined to become the Smelter/Tailing Soils Investigation Unit (STSIU) and Hanover IU and Whitewater IU were combined to become the Hanover/Whitewater Creeks Investigation Unit (HWCIU), thus reducing the six IUs to four, including the Sitewide Ecological IU. The Chino Mine IA includes all areas where environmental media may have been affected by historical operations at mining and processing facilities in the LIU. The LIU is located in the northeast corner of the Chino Mine IA, east of the Santa Rita Open Pit and the Kneeling Nun Ridge (Figure 1-1). The LIU includes the area surrounding the Lampbright stockpile area (LSA) that may be affected by historical releases from copper leaching operations, including Lampbright Draw.

The LSA is comprised of the Main Lampbright Stockpile, the South Lampbright Stockpile, and the Southwest Lampbright Stockpile. The Main and South stockpiles are leach stockpiles and the Southwest stockpile is a waste rock stockpile. The stockpiles are adjacent to one another, built mostly within a tributary valley (Tributary 1) of Lampbright Draw. Plans are in development for the addition of a northern stock and leach pile and a potential expansion of the South and Southwest stockpiles along Tributary 1 (Freeport-McMoRan 2016, 2022). The main facilities associated with the leaching operation, shown on Figure 1-2, are the LSA, a solvent extraction/electrowinning (SX/EW) plant, and associated solution collection impoundments and pipelines.

Drainages (arroyos) referred to as Tributaries 1 and 2, and 2A occur within the immediate area of the LSA (Figure 1-2). The LSA is located within the Tributary 1 drainage upstream of Reservoir 8. Tributary 2A is a small drainage located between Tributaries 1 and 2 and drains into Tributary 2. The Tributary 2 drainage occurs east of the LSA and captures runoff north of the DP-376 plan (see Figure 1-2 for plan boundary). Tributary 2 joins Tributary 1 about one mile to the south, draining into Lampbright Draw. The North Cut Diversion, located just northeast of the LSA, carries surface water runoff from areas north of the mine into Tributary 2.

Lampbright Draw is a stream that is dry most of the year and flows only during storm events. Tributaries to Lampbright Draw include Rustler Canyon, located approximately five miles southeast of the pit, and Martin Canyon, located approximately five miles east of Hurley. Lampbright Draw runs southwest into the Whitewater Creek drainage in the San Vicente Basin, joining Whitewater Creek near Faywood, NM. These surface water drainages generally only have flow occurring during and immediately after high intensity precipitation events or during the period of spring runoff from snow melt at higher elevations, although some areas in Martin and Rustler canyon will have more persistent pools. Hydrologic classification has not been conducted on Lampbright Draw or its tributaries; therefore, these characterizations are general for the purposes of site investigation and do not constitute a formal stream classification.

In accordance with the AOC Scope of Work, an RI for the LIU was conducted to generate the data necessary to evaluate the potential effects to human health and the environment from historically affected media in the LIU. Data have been collected in the LIU starting in 1995 and continuing to present day to determine potential impacts to soil, sediment, surface water, and groundwater from historical mineral processing activities. The human health risk assessment (HHRA; Neptune and Company, Inc. [Neptune] 2012) and ecological risk assessment (ERA; Formation Environmental, LLC [Formation] 2018) have shown that some areas of the LIU may have elevated metals and depressed pH in soil, sediment, or surface water but unacceptable risk in the AOC-administrated area (excluding the DP-376 plan boundary) is unlikely, as described in Section 3.1.1.

NMED issued the following Pre-FS Remedial Action Criteria (RAC) for the LIU (NMED 2024), which are used in this FS for guidance on areas needing remediation under the AOC:

Soil RAC

NMED did not identify soil Pre-FS RAC for ecological or human health specific for the LIU because risk was determined to be low in the LIU for all chemicals.

NMED did state the Pre-FS RAC for STSIU soils should be considered in the LIU FS process, however, which were:

- Area-weighted 95% upper confidence limit (95UCL) concentration of 1,600 milligrams per kilogram (mg/kg) copper (0 to 6 inches), with monitoring required if above 1,100 mg/kg.
- Cupric ion activity (pCu2+) (hereafter referred to as "pCu") greater than 5 where copper is greater than 327 mg/kg. However, note that Chino interprets this RAC to actually mean NMED selected the LIU Pre-FS RAC cupric ion activity (pCu2+) less than 5 where copper is greater than 327 mg/kg.

These are included in Table 1 list of Pre-FS RAC for the LIU. NMED stated the likelihood of area-weighted 95UCL for copper exceeding 1600 in the LIU is very low. Similarly, likelihood of average pCu2+ exceeding 5 where copper is high (> 327 mg/kg) is unlikely. This FS evaluated the data to verify that likelihood.

Surface Water RAC

The surface water RAC are water quality criteria (acute and chronic) contained in New Mexico Administrative Code (NMAC) §20.6.4. NMED notes that these criteria will be addressed by DP-376 or DP 1340 Sitewide Abatement as per the following Stage 1 investigations:

- Golder, 2007b. Stage 1 Task 1 Addendum: Assessment of Available Data and Work Plans for Vadose Zone and Surface Water Investigations. February 15, 2007.
- Golder, 2009c. Task 1 Addendum: Surface Water and Vadose Zone Investigations,
- Characterization of Intermittent Baseflow along Lampbright Tributary 1. August 27, 2009.
- Golder, 2010. Tributary 2 Corrective Action Monitoring Report.

- Additional consideration of risks specific to the Chiricahua leopard frog (CLF) are not required to be considered as a Pre-FS RAC based on the results of the 2020 survey (BIOME 2020). However, if CLF are encountered within the LIU or adjacent tributaries in the future, additional consideration of CLF risks will be required for protection of this endangered species.

Sediment RAC

- The NMED is not electing to identify a Pre-FS RAC for sediments at this time, but requests that Chino provide a description in the FS of the aquatic habitat at the locations where the copper probable effects concentration (PEC) discussed in the ERA were exceeded. If the PEC exceedance corresponds with an area of persistent benthic habitat, risk in that area may be higher than predicted elsewhere within the LIU and should be discussed in the FS.

Groundwater RAC

- Groundwater quality criteria for domestic water supply, human health protection, and irrigation contained in NMAC §20.6.2.3103. These standards are regulated under DP-376, DP-591, and DP-1340. NMED approved the April 19, 2011, Groundwater Quality Pre-FS RAC for Drainage Sediments (Arcadis 2010a, 2011a) report for the STSIU on May 9, 2011, and concluded in the approval letter that there is no potential for groundwater contamination from drainage of sediments that initially exceeded NMED Dilution Attenuation Factors (DAFs). NMED approved this Report for STSIU and acknowledges that the data is applicable to LIU and, therefore, potential leaching of drainage sediments to ground water will not need to be pursued in the LIU FS. Because groundwater is regulated under discharge permits within the sitewide abatement program and is not of concern outside the discharge permit boundary, NMED did not develop Pre-FS RAC for groundwater under the AOC.

The FS and Record of Decision (ROD) will be completed consistent with the National Contingency Plan (NCP). Pre-FS RAC are consistent with the use of preliminary remediation goals by USEPA in the NCP; therefore, new information can be used to refine the Pre-FS RAC and selection of alternatives (§300.430I(2)(i) NCP). Final remediation goals will be determined in the ROD. Further details about the Pre-FS RAC are presented in Section 2.4.

1.2 Objectives

The primary objectives of this FS are to identify potential remedial areas and remedial technologies to address contaminated soil, sediment, surface water, and groundwater in the LIU. This document addresses the current characterization of contamination of all four abiotic media. As stated in Section 1.1, remedial technology alternatives for sediment, surface water, and groundwater at the LIU will be discussed under the sitewide abatement program. Soils and surface water are the only media to be addressed under the AOC for remedial alternatives, and RAOs were developed to define the basis for remediation, including numerical Pre-FS RAC as discussed in the previous section. Remedial technologies described herein were assessed using the CERCLA FS criteria (Section 4.3, USEPA 1988) to determine their potential to meet the RAOs.

Remedial technology alternatives were evaluated using the following criteria: overall protection of human and ecological receptors, compliance with Applicable or Relevant and Appropriate Requirements (ARARs); long-term effectiveness and permanence; reduction in toxicity, implementability; and cost. The FS process includes the following steps:

- Summarize RAOs and Pre-FS RAC that address the key risk drivers and potential routes of exposure.
- Identify areas where potential remedial action(s) may be necessary to address RAOs and Pre-FS RAC.
- Identify and screen potential remedial technologies.
- Develop remedial alternatives.
- Evaluate the remedial alternatives considering the FS criteria.

The above steps will be used to guide the selection of the preferred remedial alternatives.

1.3 Summary of Related Current Activities

Between the start of the AOC process in April 1995 and July 2022, investigations related to the LIU included DP-related investigations and concurrent AOC RI and risk assessments. Each of the investigations directly relevant to the LIU are described in more detail in Section 2.

The current DP-related investigations include:

- DP-376: This DP addresses corrective action for an accidental discharge of pregnant leach solution (PLS) to Tributary 2 from the Lampbright north cut in the LIU in 2007. Condition 22F of DP-376 included a post-corrective action monitoring plan for Tributary 2. The monitoring was completed in December 2010.
- DP-1340: The renewed supplemental discharge permit for closure DP-1340 was issued in 2020 and governs closure and post-closure at the site. DP-1340 establishes the closure/closeout plan (CCP) for the site and was revised to reflect changes in mine operations and site conditions in accordance with regulations and permit conditions. Chino submitted a draft revised CCP to NMED in 2018 (Freeport McMoRan 2018). Chino will prepare an amended CCP at the time of closure that will reflect actual, rather than anticipated, conditions at the end of active mining. Components of DP-1340 related to the LIU include:
  - Conditions 30 through 33: a Sitewide Abatement process is proceeding according to NMAC §20.6.2.4106 and Conditions 30 through 33 of DP-1340. The Stage 1 abatement investigation is reported in the Site-Wide Stage 1 Abatement Plan, Revised Final Site Investigation Report (Golder Associates, Inc. [Golder]

2016), which characterizes the vadose zone, superseding the previous report limited to groundwater characterization (Golder 2008c).

- Condition 83: a study was completed (Golder 2007) to evaluate the hydrologic conditions beneath the tailings impoundments, waste rock piles, and leach ore stockpiles. The study was completed to fulfill Condition 83 of DP-1340 and update the Comprehensive Groundwater Characterization Study.
- Condition 92: the North Area groundwater flow model is a three-dimensional groundwater flow model of the north mine area and the Santa Rita Open Pit. The model was completed in accordance with Condition 92 of DP-1340 (Golder 2006a; NMED 2005a).
- Closure/closeout activities for DP-376 facilities (Lampbright Stockpiles and Reservoir 8 areas): these activities included submittal of CCPs for present and planned future extensions of the Lampbright Waste Rock and Leach Stockpiles.
- Closure/closeout activities for DP-591 facilities (SX/EW Plant and Reservoirs 5, 6, and 7).

The key reports associated with these discharge plans are listed below:

- Freeport McMoRan. 2016. North Lampbright Waste Rock Stockpile Extension Closure/Closeout Plan. Chino Mines Company. Prepared for NMED, MMD. January.
- Freeport McMoRan. 2018. Closure/Closeout Plan Update. Chino Mines Company. Prepared for NMED, MMD. February.
- Freeport McMoRan. 2022. North Lampbright Leach Stockpile Extension Closure/Closeout Plan. Chino Mines Company. Prepared for NMED, MMD. April.
- Golder. 2006b. Addendum to Chino Mine Final Lampbright Stage 1 Abatement Report. Submitted to Chino Mines. May 26.
- Golder. 2006a. Report on North Mine Area Groundwater Flow Model: Chino Mine, New Mexico. January.
- Golder. 2007. Chino Mines Company, DP-1340 Condition 83 – Hydrologic Study, Final Report. June.
- Golder. 2008c. Sitewide Stage 1 Abatement Final Investigation Report. Submitted to Freeport McMoRan Chino Mines Company. July 18.
- Golder. 2009. Sitewide Stage 1, Task 1 Addendum: Surface Water and Vadose Zone Investigation Report for Characterization of Intermittent Base Flow Along Lampbright Tributary 1. Submitted to Freeport McMoRan Chino Mines Company. October 12.
- Golder. 2010. Post Corrective Action Monitoring Report: Discharge of PLS to Tributary 2, Lampbright Draw New Mexico. Submitted to Freeport-McMoran Chino Mines Company. December.
- Golder. 2016. Draft Sitewide Stage 1 Abatement, Revised Final Investigation Report. Submitted to Freeport McMoRan Chino Mines Company. March 31.

The RI and risk assessments conducted under the AOC at the LIU pertinent to this FS include:

- Arcadis. 2012. Administrative Order on Consent, Chino Mines Company. Remedial Investigation Report, Lampbright Investigation Unit. 2nd Revision, December.
- Formation. 2018. Ecological Risk Assessment for the Lampbright Investigation Unit Chino Mine Investigation Area, Grant County, New Mexico. Prepared for New Mexico Environment Department. May 2018, (Section 5, General Risk Assessment Uncertainties, updated in 2019).
- Neptune. 2012. Chino Mines Company Administrative Order on Consent Lampbright Investigation Unit Human Health Risk Assessment. Revision 1. Prepared for New Mexico Environment Department. November.

The concurrent RIs and FSs completed or being conducted at other AOC IUs include:

- Ecological IU – To have a comprehensive baseline investigation for the entire AOC investigative area, including all IUs, the Ecological IU RI Report was completed in 2001 (Arcadis 2001). The Sitewide ERA Report was completed in 2005 (NewFields 2005). Feasibility studies are being completed on an IU-specific basis.
- Hurley Soils IU – Following completion of the Phase I RI Report in 1998 (Golder 1998), the Pre-FS RAC were established for the IU (NMED 2005b), interim remedial actions were completed in 2007 (Golder 2008a), and a Hurley Soils IU FS was completed in 2008 (Golder 2008b). The ROD was issued in September 2009.
- HWCIU – An AOC Phase I RI Report was completed for the HWCIU in 2000 (Golder 2000), and draft ERAs and HHRAs were completed in 2015 and 2008, respectively (Formation 2015; Neptune 2008). Interim remedial actions were completed and reported in 2021, and a residual risk assessment was completed in 2023. Preparation of the FS will be initiated in 2024.
- STSIU – An AOC RI Report was completed for the STSIU in 2008 (SRK 2008a, 2008b); HHRAs and ERAs also were completed for the IU in 2008 (Gradient Corporation 2008; NewFields 2008). The Pre-FS RAC was established for the STSIU in 2010 and 2011 (NMED 2010, 2011). A draft STSIU FS was submitted in March 2023 (Arcadis 2023b). Comments on the FS from NMED were received in November 2023 and are being addressed.

Reports completed that provided key information for the Lambright risk assessments, RI, Pre-FS RAC, and this FS include:

- Arcadis. 2010b. Terrestrial Invertebrate Copper Bioaccumulation and Bioavailability Study for Smelter/ Tailing Soils Investigation Unit. Prepared for Chino Mines Company, Hurley, New Mexico.
- Arcadis. 2011a. Groundwater Quality Pre-feasibility Study Remedial Action Criteria for Drainage Sediments. Smelter Tailings Investigation Unit, Chino Mines, Vanadium, New Mexico. April.
- Arcadis. 2013. Development of Site-Specific Copper Criteria Interim Report. Prepared for Chino Mines Company. Submitted to NMED. March.
- Arcadis. 2018. Phytotoxicity and Vegetation Community Study, Smelter Tailings Soils Investigation Unit. September.
- Arcadis. 2023a. Year 5 Report on pH Monitoring to Evaluate the Effect of the White Rain on the Smelter/Tailings Soils Investigation Unit. March.

- Arcadis. 2023b. Smelter/Tailings Soils Investigation Unit Feasibility Study. Smelter Tailings Soils Investigation unit. Chino Mine Investigation Area, Grany County, New Mexico. Draft. March.
- BIOME, Ecological & Wildlife Research (BIOME). 2020. Chiricahua Leopard Frog Surveys for the Lampbright Investigation Unit. Grant County, New Mexico – Fall 2019. February.
- Daniel B. Stephens & Associates, Inc. 2000. Comprehensive Vegetation Survey of the Chino Mine, Grant County, New Mexico.
- Golder. 1999. Comprehensive Groundwater Characterization Study, Phase 3 Report. January.
- Golder. 2010. Post Corrective Action Monitoring Report: Discharge of PLS to Tributary 2, Lampbright Draw New Mexico. Submitted to Freeport-McMoran Chino Mines Company. December.
- Gradient Corporation. 2008. Human Health Risk Assessment. Smelter/Tailings Soils Investigation Unit, Hurley, New Mexico. Gradient Corporation (prepared for New Mexico Environment Department), Cambridge, MA.
- Neptune. 2008. Administrative Order on Consent, Chino Mines Company. Human Health Risk Assessment. Hanover and Whitewater Creek Investigation Units. Neptune and Company, Inc. (prepared for New Mexico Environment Department), Los Alamos, NM.
- NewFields. 2006. Chino Mines Administrative Order on Consent. Site-wide Ecological Risk Assessment. February 2006.
- SRK. 2008a. Chino Mines Company, Hurley, New Mexico. Administrative Order on Consent, Remedial Investigation Report for the Smelter/Tailing Soils Investigation Unit, Revision 2. SRK Consulting, Inc., Lakewood, CO. February.

Most of these reports are briefly described in the RI (Arcadis 2012), HHRA (Neptune 2012), or ERA (Formation 2018) for the LIU or in the draft STSIU FS (Arcadis 2023b). The Chiricahua Leopard Frog (CLF) Survey for the Lampbright Investigation Unit (BIOME 2020) is described below because it was completed after those reports were written and is not described in the draft STSIU FS.

Chiricahua Leopard Frog Survey

The purpose of the CLF survey, completed in 2019, was to provide more information related to the presence/absence of the CLF and its potential habitat within the LIU based upon conclusion in the ERA. The surveyed area was based on information available on presence of CLF and critical habitat designations in the LIU. The historical information on the CLF for this area is as follows.

In 2007, the United States Fish and Wildlife Service (USFWS) included Lampbright Draw and its tributaries within Recovery Unit 8 as part of their final species recovery plan for the CLF. The recovery unit also included Martin and Rustler Canyons within the STSIU and other drainages in HWCIU, and the recovery plan indicated that populations of the frog were present at numerous locations within Lampbright Draw and its tributaries until the late 1990s and possibly later (USFWS 2007, 2023). Jennings (2005) confirmed all populations within the LIU had been extirpated by 2004 as a result of chytridiomycosis resulting from infection by a pathogenic fungus, *Batrachochytridium dendrobatidis (Bd).* The recovery plan indicated that small populations within STSIU and HWCIU were possibly present in 2007. Therefore, Jennings conducted field surveys starting in 2007 and documented the spread of the fungus during annual surveys and *Bd* swabbing of anurans in the Chino Mine IAs. In Ash and Bolton Springs, to the west of the Lampbright Draw, Jennings documented persistence of CLF from

2007 to 2015, with a loss of CLF in Ash Spring and great reductions in numbers at Bolton Spring by 2015 (BIOME 2020). CLF were last observed in West Fork Lampbright Draw in 1997 and in Rustler Canyon in 1998.

The final critical habitat designation was published in the March 20, 2012, Federal Register (USFWS 2012), indicating the presence of one critical habitat unit within the STSIU at Ash and Bolton Springs. To the east of the LIU, a critical habitat was also established along the Mimbres River, outside of the Chino Mine IU areas. No critical habitat was defined within the LIU, presumably because of the extirpation caused by chytridiomycosis in the late 1990s.

The Southwest Endangered Species Act Team (SESAT 2008) noted that the first critical step in assessing adverse effects to CLF is identifying whether habitat occurs in the project area, whether it is currently occupied, and whether it is likely to be occupied in the future. The potential for dispersal also must be evaluated, which was defined by USFWS (2007) in their habitat designation as the 1-3-5 Rule:

> *“Chiricahua leopard frogs are reasonably likely to disperse 1.0 mile (mi) (1.6 kilometers (km)) overland, 3.0 mi (4.8 km) along ephemeral or intermittent drainages (water existing only briefly), and 5.0 mi (8.0 km) along perennial water courses (water present at all times of the year), or some combination thereof not to exceed 5.0 mi (8.0 km).”*

An unoccupied habitat is defined as:

> *“Sites that support all of the constituent elements necessary for Chiricahua leopard frogs, but where surveys have determined the species is not currently present. The lack of individuals or populations in the habitat is assumed to be the result of reduced numbers or distribution of the species such that some habitat areas are unused. It is expected that these areas would be used if species numbers or distributions were greater. Site occupancy can also change due to immigration and colonization, which may occur anytime during the warmer months (and is most likely to occur during the summer monsoons). If extant populations occur within reasonable dispersal distance of a site under assessment that is supporting suitable habitat, colonization is likely to occur and surveys more than once a year as part of project planning or effects analysis may be warranted to assess presence/absence.”*

In the LIU, suitability of habitat for CLF is unknown. However, as mentioned above, populations were historically observed in the LIU drainages but have not been observed during more recent surveys due to the chytridiomycosis fungus. The LIU ERA evaluated the possibility of habitat being occupied currently based on the above guidance and criteria and determined it unlikely due to dispersal distances from Ash and Bolton Springs, but presence of the CLF could not be entirely dismissed in either Tributary 1 or Tributary 2 or in Lampbright Draw. Its presence is of concern because copper concentrations in surface water exceeded the lowest hardness-adjusted No Observed Effect Concentration (NOEC) for CLF reported in the ERA in 19 of 94 samples (14 of 26 total locations) in both Tributary 1 and 2 and the Lowest Observed Effect Concentration (LOEC) for CLF at two locations in Tributary 1 and one location in Tributary 2 (see Section 3.2).

As part of the process for finalizing the ERA, Formation (2018) indicated that the uncertainties in the ERA related to the presence/absence of the CLF and its potential habitat within the LIU were a limiting factor in the decision-making process for the LIU (Formation 2018). To address these uncertainties, in September 2019, Chino submitted a workplan for the survey of the LIU drainages and adjacent drainages for the presence of CLF and to document the habitat within the drainages. The NMED approved the workplan, and the study was completed in late September 2019 by Chino’s contractor BIOME and was attended by representatives from Chino, NMED, and Formation. The CLF habitat and its presence or absence was documented. A draft of the survey findings was submitted to NMED for review in February 2020. A final version of the survey findings was approved by NMED on September 10, 2020, which led to final approval of the LIU ERA. The CLF survey concluded:

1. No CLF of any life stage were observed within any of the available habitats surveyed. Although the previous surveys that detected CLF in West Fork identified tadpoles (Jennings 1998), the current surveys were unable to identify CLF presence.
2. Although there are potentially suitable and marginal habitats within the LIU by Recovery Plan definition, these sites are limited to small, isolated pools that are subject to complete drying and have limited aquatic vegetation development for egg-laying. These habitats do not provide stability for all life stages of CLF and, therefore, should be considered marginal, not contributing to the regional metapopulation.
3. Rustler Canyon contains potential habitat but is currently unoccupied. The potentially suitable CLF habitat is located nearly 4 miles from the ephemeral drainages of the LIU. These distances are beyond the criteria set by the 1-3-5 Rule for dry terrestrial, intermittent, or perennial aquatic habitats.
4. Given the current absence of CLF populations and existing hydrological conditions of West Lampbright, Tributary 1, and Tributary 2 and 2A, the potential for CLF to occur in the LIU is very low.

1.4 AOC vs. Discharge Permit Requirements

The AOC between Chino and NMED was executed on December 23, 1994, and requires Chino to conduct the following work:

- Assess present LIU condition in the IA associated with risks to public health and welfare of the environment.
- To the extent necessary to select a remedy or remedies, evaluate alternative remedial technologies appropriate for the IU in the IA.
- Implement the selected remedy or remedies.

FS activities that were identified in the AOC Scope of Work include, but are not limited to:

- Description of current situation;
- Treatability studies and identification and screening of potential applicable technologies;
- Development of remedial alternatives;
- Initial screening of remedial alternatives;
- Detailed evaluation of remedial alternatives;
- Description and justification of preferred alternatives; and
- Production of the FS report.

This FS addresses the above bullets where applicable. Because unacceptable risk was not found for the LIU for ecological or human receptors, remedial technology and alternative descriptions are streamlined herein.

1.5 Organization of FS

This FS was prepared to determine and fulfil the needed data requirements of the AOC identified FS activities. The FS is organized as follows:

- Section 1.0: Introduction
- Section 2.0: Regulatory Components of the FS
- Section 3.0: Description of Current Situation for Abiotic Media
- Section 4.0: Identification of Potentially Applicable Technologies
- Section 5.0: Assembly, Development, and Analysis of Remedial Alternatives
- Section 6.0: References.

2 Regulatory Components of the FS

This section summarizes the regulatory components associated with the LIU FS, including LIU-specific FS tasks required by the AOC (Section 2.1), and the LIU ARARs (Section 2.2), RAOs (Section 2.3), Pre-FS RAC (Section 2.4), and study boundaries (Section 2.5).

2.1 AOC FS Tasks

Description of Current Situation

Updates to the current situation are detailed in Sections 3.

Treatability Studies and Identification and Screening of Potentially Applicable Technologies

Technologies for treating metal contamination in soil, sediment, and surface water that creates risk to receptors in the LIU are identified in Section 4. Groundwater contamination from surface runoff and leaching from sediments in the drainages close to the stockpiles is possible. However, groundwater and/or sediment remediation technologies will be addressed under the discharge plans and sitewide abatement program. The technology under the AOC that is identified to carry forward for the LIU is no action because no active treatment is needed for soil, sediment, or surface water. No treatability studies are recommended.

Evaluation of Remedial Alternatives

After review of remedial technologies, the remedial alternatives of no action and monitoring are the two alternatives evaluated in this FS. Only these two are evaluated because the risk assessments conclude that there is no unacceptable risk to humans or ecological receptors in the LIU area that is covered by the AOC. The advantages and disadvantages of these two alternatives are discussed.

Description and Justification of Preferred Alternative

In this FS Report, Chino describes and justifies the preferred alternative based on the evaluation above.

2.2 Applicable or Relevant and Appropriate Requirements

ARARs are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address the situation at a CERCLA site. The requirement is applicable if the jurisdictional prerequisites of the standard show a direct correspondence when objectively compared to conditions at the site. An applicable federal requirement is an ARAR. An applicable state requirement is an ARAR only if it is more stringent than the federal ARAR.

If the requirement is not legally applicable, then the requirement is evaluated to determine whether it is relevant and appropriate. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable, address problems or situations similar to the circumstances of the proposed response action (relevant) and are well suited to the conditions (appropriate) of the site. A requirement must be determined to be both relevant and appropriate in order to be considered an ARAR.

The criteria for determining relevance and appropriateness are listed in 40 Code of Federal Regulations (CFR), Section 300.400(g)(2), and include general comparisons between the following:

- The purpose of the requirement and the purpose of the action;
- The medium regulated or affected by the requirement and the medium contaminated or affected at the site;
- The substances regulated by the requirement and the response action contemplated at the site;
- Any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the site;
- The type of place regulated, and the type of place affected by the release; and
- Any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resources at the site.

According to the USEPA CERCLA guidance, a requirement may be "applicable" or "relevant and appropriate," but not both (USEPA 1988). Identification of ARARs must be done on a site-specific basis and involves a two-part analysis: first, a determination of whether a given requirement is applicable; and then, if it is not applicable, a determination of whether it is, nevertheless, both relevant and appropriate. When the analysis determines that a requirement is not applicable but is both relevant and appropriate, the requirement must be complied with the same degree as if it were applicable.

ARARs are generally divided into three categories: chemical specific; location specific; and action specific in accordance with USEPA guidance (USEPA 1988):

- Chemical Specific: Chemical specific ARARs are generally health or risk based numerical values or methods applied to site-specific conditions that results in the establishment of a cleanup level. Many potential ARARs associated with particular response alternative (such as closure) can be characterized as action-specific but include numerical values or methods to establish them so they fit in two categories, chemical-specific and action-specific.
- Location Specific: Location specific ARARs are included for environmentally sensitive areas including riparian and other hydrologic resources, and biological and other natural resources are the resource categories relating to location-specific requirements potentially affected by the LIU remedial actions.
- Action Specific: Action specific ARARs are included for the potential remedial actions that will be used in the LIU.

This classification was developed to aid in the identification of ARARs. Some ARARs do not fall precisely into one group or another. ARARs are identified on a site-specific basis for remedial actions where CERCLA authority is the basis for cleanup.

For the determination of relevance and appropriateness, the pertinent criteria were examined to determine whether the requirements address problems or situations sufficiently similar to the circumstances of the release or response action contemplated, and whether the requirement is well suited to the site. A negative determination of relevance and appropriateness indicates that the requirement does not meet the pertinent criteria.

To qualify as a state ARAR under CERCLA, a state requirement must be:

- A state law or regulation;
- An environmental or facility law or regulation;
- Promulgated;

- Substantive;
- More stringent than federal requirements;
- Identified in a timely manner; and
- Consistently applied.

To constitute an ARAR, a requirement must be substantive. Therefore, in some cases only the substantive provisions of requirements identified as ARARs in this analysis are considered to be ARARs. Permits are considered to be procedural or administrative requirements though may contain substantive requirements that are ARARs which must be attained and/or qualify as “to be considered” (TBC) materials that may be used in determining the necessary level of cleanup for protection of human health or the environment.

Provisions of generally relevant federal and state statutes and regulations that were determined to be procedural or not environmental in nature, including permit requirements, are not considered ARARs. CERCLA Section 121(e)(1), (42 USC Section 9621(e)(1)), states that “No Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely on-site, where such remedial action is selected and carried out in compliance with this section.” Consistent with 40 CFR, the term “on-site” is defined for purposes of this ARARs discussion as “the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementations of the response action.”

In addition to ARARs, non-promulgated advisories, proposed standards, criteria, guidance, or policy documents developed by the federal or state government, or other information referred to as TBC materials may also be used in conjunction with ARARs to achieve an acceptable level of risk at a site. Although not legally binding, TBCs may be used when determining protective cleanup levels or response actions where no ARARs exist, or where ARARs alone would not be sufficiently protective of human health and the environment. Because TBCs are not ARARs, their early identification is not mandatory.

The state permit conditions for the Chino Mine shall be considered TBC materials and considered in the FS for developing remedial alternatives.

Chino had the primary responsibility for identifying ARARs for the LIU. Preliminary potential ARARs of the LIU were identified in the RI (Arcadis 2012) and the potential ARARs are completed in this FS, presented in Tables 2-1, 2-2, and 2-3. Pursuant to the definition of the term “on-site” in 40 CFR Section 300.5, the area that is considered part of the remedial action is the LIU (see Section 2.5).

2.3 Remedial Action Objectives

This section identifies the environmental media for the LIU where potentially unacceptable risks were determined to exist through the risk assessments completed during the RI, as well as the constituents determined to be responsible for the potential for unacceptable risk. This section also presents the specific RAOs developed for the LIU for each media of interest.

RAOs are medium-specific goals designed to protect human health and the environment. RAOs serve to focus an FS and provide context for the overall scope of potential cleanup activities at a site. Each RAO specifies: the contaminant of concern; the relevant exposure routes and receptors; and an acceptable contaminant concentration or range of concentrations for each exposure pathway.

The LIU RI provided datasets for the LIU HHRA and the LIU-specific ERA and determined if any constituents present in the environmental media should be considered constituents of potential concern (COPCs). The risk assessments were implemented according to appropriate guidance and methodologies, which along with the detailed results from the assessments, were previously presented in the LIU HHRA and ERA reports (Neptune 2012; NewFields 2006; Formation 2018). The Neptune HHRA and Formation ERA are discussed in detail in Section 3.1.1.

The sitewide and LIU-specific ERAs (NewFields 2006; Formation 2018) considered sensitive representative receptors from a number of receptor classes including mammals, birds, plants, and invertebrates. The ERAs evaluated direct contact for plants and invertebrates and incidental soil ingestion and food-chain transfer for birds and mammals. Based upon conclusions in the ERA, a CLF survey was completed in 2019 to provide more information related to the presence/absence of the CLF and its potential habitat within the LIU. The survey results indicated an absence of CLF populations and based existing hydrological conditions of West Lampbright, Tributary 1, and Tributary 2 and 2A, the potential for CLF to occur in the LIU is very low and, therefore, ecological risk is low for LIU.

The comprehensive HHRA performed by Neptune (2012) determined if any chemicals present in environmental media at the site are responsible for potentially unacceptable risk to human receptors in the context of plans for future site use. The human receptor classes evaluated in the HHRA included current and future commercial ranchers, present and future residents, present trespassers, future recreators, and future construction workers. Specific pathways considered during the HHRA included direct dermal contact with surface soil, incidental ingestion of surface soil, inhalation of dust from upland surface soil, incidental ingestion of sediment, dermal contact with sediment, and incidental ingestion of surface water. The conclusions of the HHRA indicate risk is low or within the range of background (Neptune 2012).

Based on the findings from the LIU RI Report, HHRA and ERAs (Arcadis 2011b, 2012; Neptune 2012; NewFields 2006; Formation 2018), the RAOs for the LIU include:

- Prevent the ingestion of copper by the small ground-feeding bird (SGFB) receptor at levels that result in unacceptable population-level risks.
- Toxicity to vegetation or other biological elements of habitat should be reduced to levels that allow for a self-sustaining ecosystem and prevent adverse impacts on local wildlife populations or subpopulations. In areas where habitat function is degraded due to toxicity of elevated copper concentrations and/or decreased pH from either smelter emissions or contamination released from tailings impoundments, remedial actions should focus on the restoration of wildlife habitat.
- Restore water quality to water quality objectives that are protective of beneficial uses within a reasonable timeframe and maintain existing water quality that complies with water quality objectives. RAOs should reduce the likelihood of contact between surface water and soils/sediments that contain heavy metal contaminants at concentrations that could cause deleterious effects to aquatic receptor populations.
- Restore groundwater quality to water quality objectives that are protective of the domestic water supply and human health, and irrigation.

2.4 Pre-FS RAC

Soil

Pre-FS RAC for the LIU soils were predicated on Pre-FS RAC for soil developed to protect wildlife receptors in the STSIU. In a letter dated September 16, 2010, and then amended via a dispute resolution letter dated March 3, 2011, NMED provided Chino with a Pre-FS RAC for the STSIU (NMED 2010, 2011). Based upon the information documented in the STSIU risk assessments, as well as the comments and input provided from all parties, NMED determined the Pre-FS RAC values for ecological receptors exposed to soil in the STSIU to be:

- To reduce soil toxicity to plants from copper concentrations (at 0 to 6 inches below ground surface [bgs]) to pCu greater than or equal to 5. The reduction in toxicity applies to locations where the copper concentration is greater than 327 mg/kg.
- To reduce copper soil toxicity to SGFB to copper concentrations less than or equal to 1,600 mg/kg (at 0 to 6 inches bgs). The SGFB Pre-FS RAC is applicable to the 95 percent upper confidence limit (95UCL) of the area-weighted average concentration of copper in surface soil (0 6 inches bgs) within exposure units in the STSIU. In addition, NMED required monitoring for copper concentrations in surface soil between 1,100 and 1,600 mg/kg.

Although unacceptable risk to wildlife receptors was not identified in the LIU ERA, NMED selected these same two Pre-FS RAC to protect ecological receptors in the LIU.

Surface Water

NMED selected the Pre-FS RAC for surface water based upon the State of New Mexico Standards for Interstate and Intrastate Surface Waters, NMAC §20.6.4 for risk to aquatic life. The Pre-FS RAC for all constituents is NMAC §20.6.4, including all approaches and tools listed in the Code which provide options for site-specific application.

Sediment

The NMED is not electing to identify a Pre-FS RAC for sediments at this time, but requests that Chino provide a description in the FS of the aquatic habitat at the locations where the copper PEC was exceeded. If the PEC exceedance corresponds with an area of persistent benthic habitat, risk in that area may be higher than predicted elsewhere within the LIU and should be discussed in the FS.

Groundwater

Groundwater quality criteria for domestic water supply, human health protection, and irrigation contained in NMAC §20.6.2.3103. These standards are regulated under DP-376, DP-591, and DP-1340. NMED approved the April 19, 2011, Groundwater Quality Pre-FS RAC for Drainage Sediments Report under the STSIU (Arcadis 2011a) on May 9, 2011, and concluded in the approval letter that there is no potential for groundwater contamination from drainage of sediments that initially exceeded NMED DAFs. NMED approved the report and acknowledged the applicability of the data to the LIU, thus potential leaching of drainage sediments to groundwater will not need to be pursued in the LIU FS. Because groundwater is regulated under discharge permits within the sitewide abatement program and is not of concern outside the discharge permit boundary, NMED did not develop Pre-FS RAC for groundwater under the AOC.

Based on the final Pre-FS RAC issued for the STSIU in a letter dated March 2011, NMED stated:

> *Since the FS and ROD will be completed consistent with the NCP, new information can be used to refine RACs and selection of alternatives. This is supported by the NCP in §300.430(e)(2)(i) which states "Establish remedial action objectives specifying contaminants and media of concern, potential exposure pathways, and remediation goals. Initially, preliminary remediation goals are developed based on readily available information, such as chemical-specific ARARs or other reliable information. Preliminary remediation goals should be modified, as necessary, as more information becomes available during the RI/FS. Final remediation goals will be determined when the remedy is selected. Remediation goals shall establish acceptable exposure levels that are protective of human health and the environment…" It must be noted that NMED's pre-FS RACs are equivalent to preliminary remediation goals referred to in the NCP.*"

Thus, Pre-FS RAC are consistent with the use of preliminary remediation goals by USEPA in the NCP, and new information can be used to refine the Pre-FS RAC and selection of alternatives. Final remediation goals for the LIU will be documented in the ROD.

2.5 AOC Study Boundaries for LIU

As described in the AOC SOW, the LIU includes:

- Tributary 1 channel downgradient of Dam 8;
- The North Cut Diversion;
- Tributary 2 and any other waterways downstream of the facilities that may have been impacted by a historical release.

The main surface features in the LIU are Tributary 1 below the DP-376 permit boundary and Tributary 2 below the North Cut Diversion (Figure 1-2). The AOC SOW description also lists T17S, R11W, Section 30 and 31 as containing the IU, but the AOC lists adjacent Sections as part of the overall IA in Article V.A.14 (T17S, R12W, Sections 23, 24, 25, 26, 27, 28, 35 and 36) (NMED 1994). In follow up discussions and approval of the LIU RI Proposal (NMED 2010), NMED acknowledged that T17S, R11W, Section 30 and 31 were the primary focus. T17S, R12W, Sections 23 and 24 are located north of State Highway 152. Reservoir 5 is located in T17S, R12W, Section 26. T17S, R12W, Section 27, 28 and 35 include the Santa Rita Open Pit. NMED agrees that Sections 26, 27, 28 and 35 will be investigated and closed under DP-459 or DP-1340.

Lampbright Leach System operations are part of current, ongoing mine operations regulated under DP-376, DP-591 and DP-1340. As specified in the AOC,

> *"to the extent that the Investigation Area is subject to existing Discharge Plans, those Discharge Plans shall not be incorporated into this AOC and shall continue to govern compliance with applicable provisions of the New Mexico Water Quality Act" (AOC, p.2).*

The AOC agreement avoids duplication of closure activities by specifying that areas governed by existing discharge permits would not be incorporated into the AOC; however, specific media within DP areas could be incorporated into the AOC if not addressed by the DPs. The AOC LIU is intended to address areas and/or media not currently covered by DPs in LIU.

Chino submitted a letter to NMED in October 2009 specifically addressing the AOC Scope of Work for the LIU and subsequent activities addressed by other regulatory requirements. The AOC accounts for such overlaps in

Article IIA and XII.J. As such, sediment, surface water, and groundwater are clearly addressed under ongoing Sitewide Abatement and DP-376 Corrective Action activities but are referenced herein for completeness and to address any outstanding AOC data needs.

3 Description of Current Situation for Abiotic Media

The following sections describe the current understanding of the physical characteristics of the LIU soil, surface water, groundwater, and sediment based on previous field investigations. Section 3.1 summarizes the conceptual site model and studies supporting the model; Section 3.2 addresses the nature and extent of COPCs in the LIU and locations that exceed or meet the Pre-FS RAC; and Section 3.3 discusses areas that require potential remedial action as a result of the evaluation and the program under which they will be addressed.

3.1 Conceptual Site Model

The conceptual site model for sources associated with the LIU is presented in the RI for LIU (Arcadis 2012) as well as in the risk assessments (Neptune 2012; Formation 2018 [updated in 2019]). The primary potential source of COPCs is from Lampbright Stockpile Operations (LSO), which includes low-grade ore, waste rock, historical mine water, leachate from the copper leaching operation known as PLS, and raffinate (i.e., recycled PLS following removal of copper) associated with historical and current operations and releases. Releases also include fugitive dust from ore and waste rock at the LSO. Raffinate sprayed or dripped onto the stockpiles may have been a localized historical release. Other releases may include seepage of meteoric water, raffinate spray, and/or PLS releases to groundwater, stormwater, or overland flow.

Potential secondary sources are upland soils downwind of the stockpiles exposed to fugitive dust and raffinate spray. COPCs deposited on upland soils could be transported into the LIU tributaries and/or absorbed by biotic media within the LIU. In addition, COPCs in groundwater could be transported to surface water via seeps and springs or be adsorbed onto sediments within the LIU tributaries.

Secondary release mechanisms include potential infiltration to groundwater of PLS via historical overland flow within the collection system. PLS and raffinate have also been unintentionally discharged from the LSO and main Lampbright Stockpile on several occasions into the LIU tributaries; these releases are discussed in Section 3.2.

Both primary and secondary release mechanisms within the LIU have potentially affected several media:

- Upland soil;
- Surface water
- Sediment
- Biotic media
- Groundwater.

DP-376, DP-591, and DP-1340 address any groundwater impacts from the historical or current activities due to infiltration to groundwater. The Revised Final Site Investigation Report (Golder 2016) summarizes stage 1 results for evaluating the nature and extent of effects on groundwater and media affecting groundwater based on 20 years of investigations, including data from 72 wells, surface water, soil, and sediment (including data collected for the AOC), and vadose zone characterization data.

As discussed in the Lampbright ERAs and HHRAs (Formation 2018 [updated in 2019]; Neptune 2012), potential ecological receptors for the LIU are birds, mammals, aquatic receptors, and the vegetation community, and potential human health risk receptors are present and future commercial ranchers, present trespassers, present and future residents, future recreators, and future construction workers. Figure 3-1 illustrates the site conceptual site model via pathway segments and mechanisms required to understand how potential contamination occurred, including the source, release, and transport of mineral processing constituents.

Primary exposure pathways for ecological receptors varied by receptor type and include:

- Avian: incidental ingestion and direct contact with soil, surface water and sediments;
- Aquatic: direct contact with surface water and sediment; and
- Plants: direct contact with soil.

Potential exposure pathways for human receptors include incidental ingestion and dermal contact with surface soil or sediment, and inhalation of re-suspended dust from surface soil and sediment.

Prevailing winds tend to be from the north and west blowing to the south and east (Chino 1995); therefore, surface soils in the northeast or eastern side of the LSA are not likely to be affected by fugitive dust and were used as reference soils representing the mineralized soil in the LIU (Arcadis 2012). After fugitive dust deposits onto downwind soils, metals and other inorganic constituents may be further redistributed by a combination of physical (air and water erosion) and/or chemical (leaching) processes.

3.1.1 Previous Investigations

The soil, surface water, sediment, and groundwater in the LIU were evaluated in the LIU RI (Arcadis 2011b, 2012), the HHRA (Neptune 2012), and the ERA (Formation 2018 [updated in 2019]) against screening decision criteria prior to the development and issuance of the Pre-FS RAC. Historical screening decision criteria are shown in Table 3-2 of the LIU RI (Arcadis 2012); 2023 criteria are shown in Table 3-1 herein. The following sections summarize the findings of the RI, HHRA, and ERA.

LIU RI Findings (Arcadis 2012)

The LIU RI Proposal was completed by Arcadis in 2010 and the RI Report was completed in 2012, addressing nature and extent of constituents in soil, surface water, sediment, and groundwater.

Soil. Samples were collected from 21 locations downwind of the LSA in areas potentially exposed to fugitive dust. Six reference area locations were sampled upwind of the LSA to the northwest and southwest. At each location, a surface soil (0 to 1 inch bgs) and a shallow soil (0 to 6 inches bgs) sample was collected. The surface soil samples were used to evaluate human health risk and the shallow samples to evaluate ecological risk. Each soil sample was a composite of six sub-samples within a 100- by 100-foot grid. Sample results are presented in Tables 3-2 and 3-3.

Only arsenic concentrations were greater than human health decision criteria at the time the RI (Arcadis 2012) was written; however, concentrations were not statistically different from background, and background concentrations were also greater than the RI human health decision criteria. Arsenic is not associated with ore processing and was not retained as a COPC in the RI, but was evaluated in the 2012 HHRA along with other constituents.

For shallow soil, the RI concluded that the maximum values of aluminum, barium, chromium, copper, lead, selenium, vanadium, and zinc exceeded the RI ecological decision criteria at that time; of those, copper, selenium, and zinc had 95UCL values that exceeded decision criteria. However, the mean concentrations of these constituents were not significantly different than the reference area concentrations, except for aluminum and vanadium. These constituents were not identified as COPCs in the Site-wide ERA (New Fields 2005), nor associated with ore processing. Thus, neither constituent was retained for risk assessment in the LIU. Although briefly mentioned, pCu was not evaluated in the RI.

Surface water. Seventy (70) samples with dissolved concentrations were collected from Tributary 1 in 1995, 2007, and 2008, and between 13 and 21 samples (depending on the constituent) were collected from Tributary 2 between 2008 and 2010 as part of the post-corrective action monitoring program. These samples were either shallow alluvial water (technically groundwater) samples or surface water expressed from the shallow alluvial groundwater, mostly collected as part of the sitewide abatement program (the 1995 sample [ERA-36] was under the AOC). Four rainfall pool samples were additionally collected in 2010 for the RI on Tributary 2 (includes Tributary 2A) to supplement the surface water data and represent more recent concentrations in actual surface water.

These surface water data were compared to ecological decision criteria values available at that time but not to human health criteria because the pathway was incomplete for human consumption of surface water. For Tributary 1, the maximum, but not the mean, detected concentrations of aluminium and copper above aquatic life chronic decision criteria, and neither exceeded their respective acute decision criteria. Cadmium was not detected in any sample, but the detection limit was above chronic decision criteria for cadmium. Therefore, the ERA further evaluated these COPCs. Surface water COPCs retained for Tributary 1 were recommended to be addressed under DP programs rather than the AOC. The ERA partially followed this recommendation by removing locations from consideration under the AOC that were within the DP boundary on Figure 1-2.

For Tributary 2, maximum aluminum, cadmium, copper, lead, and zinc concentrations were greater than chronic aquatic life decision criteria; mean lead and cadmium concentration exceeded chronic criteria; and cadmium, copper and zinc maximum concentrations exceeded acute aquatic life criteria for the Corrective Action monitoring samples in 2008. In contrast, rainfall pool samples collected for the AOC in Tributary 2 years later did not show concentrations above ecological decision criteria for any metal. Under the Corrective Action Agreement, historical mining-related sources have been removed from Tributary 2, thus, concentrations should be low. However, as documented in the Post Corrective Action Monitoring Report (Golder 2010), drainage from mineralized veins was also occurring. Given the low concentrations in rainfall pools in 2010, the RI stated that Tributary 2 did not warrant further evaluation for surface water in an ERA. For Tributary 2A, all concentrations (or detection limits) were less than chronic or CLF LOEC decision criteria. Given the low concentrations and absence of substantial historical sources of constituents, the RI stated that Tributary 2A did not warrant further evaluation for surface water in an ERA. However, the ERA did include Tributary 1, 2, and 2A when evaluating the metals with exceedances, and focused on cadmium, copper, lead, and zinc data between October 2007 and September 2008 in Tributary 1 and between July 2008 and September 2010 in Tributary 2.[1]

Sediment. The nature and extent of potential sediment impacts to Tributary 1 were identified and discussed in the 2009 and 2016 site investigations conducted by Golder (Golder 2009, 2016). The reports showed that surface sediment downstream of SBR8 (most upstream and potentially impacted location of Tributary 1) exhibits low total

[1] Aluminum was added to these ERA tables (also shown in Tables 3-7 and 3-8 herein) because of some observed exceedances of hardness-adjusted water quality criteria.

metals concentrations, low leachable metals concentrations, and no potential to generate acid (see Section 2.8.1 in Golder 2009). These conclusions did not change in the 2016 report.

The nature and extent of potential sediment impacts to Tributary 2 and 2A down to the confluence with Tributary 1 has been discussed in detail in the Post Corrective Action Monitoring Report (Golder 2010), which was prepared to satisfy requirements associated with the accidental October 2007 release from Chino to Tributary 2 (affected 2.6 miles). The impacted sediment (16,000 cubic yards) was removed by March 2008. The report showed that residual impacts have diminished in the sediment and are now similar to pre-spill conditions. Supplemental data collected for this tributary were consistent with the report data (Golder 2010).

In 2010, four new sediment samples co-located with four rainfall pool samples were collected from 0 to 6 inches bgs to supplement data collected for DP programs. The sediment data collected for the RI were consistent with previously collected data. Thus, all sediment data were combined to represent the conditions throughout the length of each stream. In Tributary 1, between 10 and 22 samples were analyzed for the constituents of interest. In Tributary 2A, seven sediment samples were analyzed for copper and four sediment samples were analyzed for the remaining constituents of interest. In Tributary 2, 24 sediment samples were analyzed for copper and zinc and 16 samples were analyzed for the remaining constituents of interest.

Sediment copper concentrations in Tributaries 1, 2, and 2A were sufficiently above background or ecological decision criteria to warrant further evaluation in a risk assessment. However, the RI recommended that the ephemeral nature of the tributaries should be considered when deciding whether an ERA for aquatic organisms is warranted, based upon a comparison to consensus-based threshold effect concentrations (TECs) or PECs (MacDonald et al. 2000). The maximum concentration of chromium, lead, and zinc measured in Tributary 1 sediments was above the TECs but not the PECs. The maximum concentration of nickel in Tributary 2 sediments was above its respective TEC and PEC, and the maximum zinc concentration was above the TEC but not the PEC.

Because site use is low in the drainages, it is unlikely that humans would be exposed to sediments in the tributaries of LIU. Also, concentrations of metals in sediments are much lower than the LIU soil data. Given that the comparison of LIU soil data to human health decision criteria did not show that any constituent should be retained as a COPC, it is unlikely that exposure to the lower-concentration sediments by humans would result in risk; therefore, the RI recommended that sediments should not need to be evaluated in the HHRA.

Groundwater. No Pre-FS RAC were developed for groundwater because groundwater is addressed under ongoing Sitewide Abatement and DP-376 Corrective Action activities. The groundwater discharge plan program for Chino is described in the AOC RI Background Report (Chino 1995). Pursuant to the discharge plan program, Chino maintains DPs for various aspects of its operation including:

- DP-591 – Permits Chino to process ~23 million gallons of PLS per day. Quarterly monitoring of eight groundwater monitoring wells, weekly visual inspections of the downgradient slope of the PLS pond, and visual inspections of the pond liner (twice in 5 years).
- DP-376, Lampbright Leach System (Lampbright Leach Stockpile and Reservoir 8) – Permits Chino to apply ~23 million gallons per day of raffinate to low-grade leach stockpiles covering approximately 830 acres. Requires monitoring water levels in reservoirs 7, 3A, and 6, submittal of a closure plan for the entire Lampbright Leach System, and quarterly monitoring of 33 groundwater monitoring wells plus the Spring Below Reservoir 8 for total dissolved solids (TDS), sulfate, inorganics, and total petroleum hydrocarbons, and quarterly or annual monitoring of an additional 26 groundwater wells for TDS and sulfate.

  - Nine groundwater monitoring wells are upgradient from the Lampbright Leach System and used for background. Seven groundwater monitoring wells located downgradient from Reservoir 8 are sampled.

- DP-1340, Supplemental Discharge Permit – Requires Chino to prepare a CCP that reflects anticipated conditions at the end of active mining and post-closure. Covers the entire Chino Mine site.

The program is designed to evaluate:

- Whether constituents derived from sources associated with the Lampbright Leach Stockpile operations are affecting groundwater;
- Horizontal and vertical extent of vadose zone and groundwater contamination (if any); and
- Groundwater/surface water relationships, including the seep located downgradient of Reservoir 8 (SRB8).

The following work was completed to address these questions. A hydrologic study (Golder 2007) was completed to evaluate the hydrologic conditions beneath the tailings impoundments, waste rock piles, and leach ore stockpiles. The study was completed to fulfil Condition 83 of DP-1340 and update the Comprehensive Groundwater Characterization Study. A North Area groundwater flow model and three-dimensional model of the north mine area and the Santa Rita Open Pit were also completed in accordance with Condition 92 of DP-1340 (Golder 2006a). Groundwater flows from beneath the Main and South Lampbright Stockpile surfaced upstream of Reservoir 8. Groundwater flow from beneath the Southwest Lampbright Stockpile that surfaces in Tributary 1 downgradient of Reservoir 8 was estimated at less than 0.2 gallon per minute.

Conclusions for Tributary 1 in 2009 were as follows:

- Concentrations of regulated constituents in shallow alluvial water and its occasional surface expression are low and generally within groundwater standards; concentrations of regulated constituents in bedrock groundwater are generally lower than in the shallow alluvial water and its surface expression.
- Tributary 1 is an area of groundwater convergence, with bedrock groundwater flowing laterally toward the wash and vertically upward underneath the wash. The upward gradient may temporarily reverse during short-duration floods.
- Most groundwater is removed by evapotranspiration, and the remaining small amounts of groundwater occur as isolated occurrences of shallow alluvial water. Consequently, shallow alluvial water is not a distinct, permanent, or continuous component separate from bedrock groundwater.
- Tributary 1 is ephemeral. Baseflow (the surface expression of shallow alluvial water) is temporally and spatially discontinuous, and when present, occurs as seeps and stagnant pools with little or no flow.
- Shallow alluvial water, its surface expression, and bedrock groundwater between SBR8 (just upstream of LB7S) to several hundred feet downgradient exhibit mining impacts.
- The collective seasonal effect of runoff on shallow alluvial water is to decrease the concentration of dissolved constituents, as would be expected in a largely unmineralized natural watershed.

Overall, the results for Tributary 1 indicated that constituents in shallow alluvial water and baseflow do not have the potential to affect bedrock groundwater because of a dominant upward gradient, and that surface sediment does not have the potential to affect shallow alluvial water, baseflow, or runoff (Golder 2009, 2016).

For Tributary 2, groundwater quality meets standards in all but the northern reach, where groundwater is affected primarily by sulfate and TDS, but also by some manganese impacts. Natural and anthropogenic sources other than the 2007 spill may play a role (Golder 2010). There is no complete pathway to groundwater from surface water via storm flow in upper Tributary 2.

In the northeast section of the LIU, low pH was found in one well, likely from the naturally mineralized pyritic rock in the area, and possibly from potentially acid-generating sediment and weathered bedrock near a stormwater outfall and incised channel in the area (Golder 2010).

2016 Sitewide Stage 1 Abatement Report Findings (Golder 2016)

The Golder (2016) sitewide abatement program stage 1 report was not completed when the 2012 RI was written. To investigate the extent of increasing TDS near the East Sump, two additional wells were installed approximately 1,000 feet east of the Main Lampbright Stockpile after the first sitewide abatement report (Golder 2008c) was written. Also, additional surface and sediment monitoring was completed. The groundwater results for the LIU are similar to those reported in the RI, except for the following additional information: when evaluating all groundwater data, two isolated impacted shallow groundwater areas of Tributary 1 were identified. The first is from Reservoir 8 by the stockpile to SBR8, and the second is at a location 375 feet farther south along Tributary 1. Groundwater in the first location is elevated in sulfate, TDS, and some metals, and often is low in pH. Groundwater in the second location farther downstream contains only sulfate and TDS elevated above groundwater standards. The zone of impacted groundwater in the second location extends no farther than 300 feet downstream along Tributary 1 (see Figure 5-1 and Table 5-2 in Golder 2016). The most recent data (see Table 5-2 in Golder 2016) indicate the second location may meet standards, but the results fluctuate over time, creating uncertainty.

Some groundwater areas outside the drainage east of South Lampbright Stockpile and upper Tributary 1 have elevated TDS concentrations (see Figure 5-1 in Golder 2016) and are being remediated under the discharge permit program. The two new wells had TDS, manganese, and sulfate concentrations above groundwater criteria. A pump was installed in two of the wells within this area and concentrations have decreased, with most well concentrations meeting or decreasing toward meeting the standards.

The headwaters of Tributary 2 exceeded groundwater quality standards for sulfate and TDS, but the concentrations appear to be due to the natural mineralized conditions in the area because concentrations are similar to 1998, prior to mineral processing occurring nearby.

Overall, the results indicate nearly all of the potentially impacted groundwater discharges to the stockpile materials (into buried Tributary 1). It then daylights at the toe of the Lampbright Stockpiles, along with PLS and other solutions, where it is collected. A small amount of groundwater flow bypasses Tributary 1 near the topographic divide of Tributaries 1 and 2 and some of that water is causing the elevated TDS in groundwater east of the main Stockpile, which is being mitigated with a pump. Thus, the extent of the impact to groundwater in the LIU outside operational boundaries is small and being managed under the sitewide abatement program.

The report also evaluated sediment and surface water in the Lampbright Area. The report states that Tributaries 1 and 2 are gaining streams, with groundwater discharging into the surface of the drainages, but the water is then typically lost through evapotranspiration because of their ephemeral nature. NMED considered these tributaries ephemeral in 2005, with the applicable criteria being livestock watering and wildlife habitat (NMED 2005c). To characterize the vadose zone materials, surface sediment was collected in 2009, and only one exceedance of the iron drinking water standard was identified from the synthetic precipitation leaching procedure (SPLP) data,[2] data used to predict groundwater concentrations. The report concludes that the Tributary 1 area sediment/soil does not

[2] Golder (2016) states there is an exceedance of selenium drinking water standard Table A2-1 and shows the exceedance is of iron.

have the potential to cause standards for groundwater or surface water to be exceeded. In the Tributary 2 area, the extent of impacted sediment was minimal, given that the spill corrective action removed all impacted sediment, whether historical or spill-related. Post-corrective action surface water monitoring data confirmed that the remedy was successful (Golder 2016).

Conclusions from surface water (including shallow alluvial water) monitoring from 2007 to 2010 for Tributary 1 were similar to conclusions presented in the LIU RI:

- Shallow alluvial groundwater and base flow do not have the potential to affect bedrock groundwater because of the dominant vertical upward hydraulic gradient.
- Shallow alluvial groundwater and bedrock groundwater just south of SBR8 occasionally exceed standards for TDS and sulfate. However, shallow alluvial groundwater does not exceed the surface water criteria for livestock water and wildlife uses.
- The collective seasonal effect of runoff on shallow alluvial groundwater decreases the concentration of dissolved constituents.

Conclusions from surface water monitoring from 2008 to 2010 for Tributary 2 were also similar to previous conclusions:

- No samples exceeded the surface water criteria for livestock or wildlife uses.

LIU HHRA Findings (Neptune 2012)

Neptune (2012) evaluated the risks to human health posed by constituent concentrations in the LIU using data from the RI. Neptune calculated both cancer risks and non-cancer hazards for potential receptors on the site to the soil, sediment, and surface water. Exposure from ingestion of biota or groundwater was not evaluated. Exposure of future residents from vegetables grown in gardens was excluded because the poor soil quality requires clean amendments for a productive garden. Also, groundwater exposure to future residents from upland leaching of constituents was not addressed in the HHRA because groundwater is covered under DP 376/Corrective Action and the sitewide abatement regulatory program.

The HHRA methodology was consistent with USEPA guidelines and followed a two-tiered approach: a screening level and refined assessment. The screening-level Tier I assessment applied conservative exposure and chemical toxicity assumptions, assuming exposure levels equal to the maximum detected concentrations of constituents of interest on the site. The screening identified five COPCs to be carried forward to the Tier II assessment (aluminum, arsenic, chromium VI, cobalt, and manganese). The refined Tier II analysis used the 95UCL of COPC concentrations and reasonable maximum estimates in the risk equations. The Tier II results indicated incremental lifetime cancer risk did not exceed NMED’s risk management threshold of 1×10^{-5} for residential exposure to the two COPCs that have potential for cancer risk, arsenic, and chromium VI. Non-cancer hazard indices (HI) also did not exceed the risk threshold of 1 for any COPC or receptor except for construction worker exposure to dust (HI=1.3), which may result in nervous system effects, largely from manganese in the dust generated from soil on the road by vehicle traffic. However, Neptune (2012) indicated such risk is unlikely and is a result of conservative assumptions employed on the quantity of dust generated by vehicle traffic on unpaved roads used in the potential exposure assessment. Additionally, LIU site concentrations of COPCs were not significantly higher than concentrations at both the LIU reference area and the STSIU ERA reference area, although some individual samples were slightly higher than one of the reference locations. Because manganese soil concentrations on the site are not significantly elevated above the LIU reference data, and marginally elevated above the STSIU reference data used in the sitewide ERA, the HHRA conclusion on risk to human health was that it does not appear to be unacceptable. Therefore, NMED did not establish human health Pre-FS RACs for any constituent for the LIU.

LIU ERA Findings (Formation 2018)

The Sitewide ERA (NewFields 2006) was completed and used as the basis to streamline the IU-specific ERA for the LIU (Formation 2018 [updated in 2019]). The methodology used for the risk assessments was consistent with USEPA guidelines and used conservative, default assumptions whenever site-specific data were not available. The methodology and parameter selection are described in the Sitewide ERA Technical Memorandum No. 1 (Schafer and Associates 1999a) and the sampling and analytical approach are described in Sitewide ERA Technical Memorandum No. 2 (Schafer and Associates 1999b). The receptors included terrestrial vegetation (upland and non-perennial drainages) and terrestrial wildlife, including herbivorous, insectivorous, and omnivorous birds; raptors, herbivorous mammals, granivorous, and omnivorous mammals; ruminants, and mammalian predators. The risk assessment evaluated exposures from direct contact, incidental soil ingestion, and ingestion of prey items. These same receptors were evaluated for the LIU ERA.

The Sitewide ERA (NewFields 2006) concluded no significant risks to ecological receptors were within the LIU; however, data within the LIU used in the Sitewide ERA were limited, and a more in-depth evaluation using data from the LIU RI was completed in the LIU ERA (Formation 2018 [updated 2019]). Based on previous analyses in the Sitewide ERA and the LIU RI, chromium, copper, lead, molybdenum, selenium, and zinc in shallow soils (0- to 6-inches bgs, sieved to less than 2 millimeters) were evaluated for risk to terrestrial wildlife in the LIU. None of the exposure point concentrations (95UCL) of the five COPCs produced a hazard quotient for the lowest adverse effect level greater than 1 for any wildlife receptor, indicating risk to terrestrial wildlife in the LIU is expected to be low.

Risk to vegetation was evaluated using pCu. The Sitewide ERA (NewFields 2006) showed that phytotoxicity testing in a greenhouse using site soils suggested vegetation toxicity is positively correlated to increases in copper concentrations and inversely correlated to pH (Arcadis 2018). Thus, these two parameters of pH and copper were integrated into one parameter, cupric ion activity (pCu), to evaluate vegetation toxicity. Cupric ion activity incorporates both copper and pH because copper becomes more bioavailable and toxic as a free ion in the soil at lower pH. The probable effect level of pCu sitewide was defined as 5 based on the phytotoxicity and community studies in the sitewide ERA (NewFields 2006) and, therefore, was selected as part of the Pre-FS RAC for vegetation for the LIU. For the LIU, pCu was not below the Pre-FS RAC in any of the soil samples evaluated in the ERA except one immediately east of the stockpiles and two reference locations, indicating low risk to vegetation. The Sitewide ERA (NewFields 2006) concluded that pCu effects decrease in areas more distant from the historical smelter. The LIU is far from this smelter, which is why concern for upland soils is limited and restricted to fugitive dust from local LIU operations, rather than the copper smelter emissions or windblown tailings near Hurley, which were of concern for the STSIU. The LIU ERA stated that it is unlikely that the observed pCu values outside of the reference areas will have widespread habitat quality impacts that would significantly decrease their value as wildlife habitat.

For surface water, the LIU ERA evaluated risk to aquatic life from cadmium, copper, lead, and zinc. The LIU ERA compared concentrations to acute and chronic aquatic life criteria (NMAC §20.6.4) and to CLF acute and chronic criteria, after adjustments for hardness. One location in Tributary 2 exceeded zinc acute criteria (LBT-11), and it is uncertain if this location occurs in a naturally mineralized area. Two exceedances of cadmium chronic criteria on Tributary 2 in 2008 also were noted but more recent data after 2008 were unavailable. The LIU ERA also found that two locations of surface water samples exceeded the CLF hardness adjusted chronic LOEC. However, one sample location with an exceedance (LB7S) occurred at the edge of the boundary of DP-376 (Figure 1-2). Since the sample location occurred inside an operational area and outside of the AOC boundary, risk management decisions will be addressed under DP-376 and the Chino Mine Sitewide Abatement Plan. The LIU ERA states that the other location with an exceedance (LBT1-BF1) of copper during the RI in 2008 (which exceeded both the CLF LOEC and aquatic life criteria) could not be located during the ERA and may no longer be impacted due to source control at Dam 8. However, the historical exceedance is included in the updated nature and extent evaluation of this FS. The LIU ERA stated that data from monitoring wells that are part of the Sitewide Abatement process that are in the vicinity of the former sampling location could be useful in making risk management decisions. The LIU ERA also recommended that habitat conditions present within the drainage be taken into consideration as part of the risk management process for the LIU. Overall, because of the zinc exceedance at LBT-11, the ERA could not conclude with certainty that risk from surface water was low in Tributary 2. The ERA concluded risk was low in Tributary 1.

For sediments, the LIU ERA concluded that risks to aquatic life from sediment exposure appear to be lower than those predicted for the other IUs at the Site; however, copper concentrations in sediment exceeded the PEC at six locations (three locations within Tributary 1, two locations within Tributary 2A, and one location in Tributary 2). The quality of aquatic habitat or the permanence of the water at the locations where the PECs were exceeded had not been formally characterized making the prediction of risk at these locations uncertain. However, the LIU ERA concluded that given the small number of PEC exceedances observed, widespread risks to the aquatic community from exposure to COPCs in sediment is expected to be low within the LIU drainages. If the PEC exceedances correspond with areas of persistent benthic habitat, risk in those areas may be higher than predicted elsewhere. That said, some of the locations identified in the LIU ERA fall under the current operational footprint. Specifically, six locations with copper detected in sediment above the PEC are within the AOC operational boundary, as follows:

<u>Tributary 1:</u>

- 2214, copper is 721 mg/kg.
- 2215, copper is 260 mg/kg.
- 376-2005-04, copper is 295 mg/kg.

<u>Tributary 2A:</u>

- 2202, copper is 183 mg/kg.
- 2206, copper is164 mg/kg.

<u>Tributary 2:</u>

- TS210, copper is 199 mg/kg.

Although not mentioned in the ERA (which states only 2214 and 2215 are within DP 376 boundaries), as stated in the pre-FS RAC, locations 2214, 2215, and 376-2005-04 are within the footprint of the proposed Kessel stockpile, and 2206 (RAC letter incorrectly stated 2202) has been excavated and subsumed in the Lampbright Far East Containment Area. These areas fall under DP 376 (but only if Kessel stockpile approved and constructed for the first three). Also, although locations 2202 and TS210 are outside the current operational DP boundary, they only slightly exceed the 149 mg/kg PEC. Location TS210 contained low copper concentrations below the PEC in the more recent years of 2009 and 2010 as expected because Tributary 2 was remediated.

In addition to these samples with copper exceedances, the ERA discusses a nickel exceedance of the PEC at location T2S6 in 2008 (but note that, a location very close to that sample [location 65+40] was identified during the FS process that showed nickel was not exceeded in that area in later years).

The quality of aquatic habitat or the permanence of the water at the locations where the PECs were exceeded had not been formally characterized making the prediction of risk in the ERA at these locations uncertain. However, the ERA concluded that given the small number of PEC exceedances observed, widespread risks to the aquatic community from exposure to COPCs in sediment is expected to be low within the LIU drainages. If the PEC exceedances correspond with areas of persistent benthic habitat, risk in those areas may be higher than predicted elsewhere.

While not a direct measure of potential surface water risk, SPLP data can predict whether COPCs detected in sediment would leach into surface water when present at potentially toxic concentrations. The ERA showed that, when compared to surface water criteria, no SPLP data exceeded the lowest hardness-adjusted criteria for cadmium, copper, lead, or zinc. These results suggest that sediment in Tributary 1 is not expected to be a significant source of COPC leaching to surface water. Additionally, the ERA mentions that application of a water effect ratio, as was performed for the STSIU but not for the LIU, might show lower toxicity than indicated by comparisons to the criteria.

In summary, the LIU ERA concluded that risks to the terrestrial vegetation and wildlife communities due to site COPCs are generally low. Aquatic habitat in the LIU is limited, primarily due to lack of persistent water sources. For the aquatic community, the ERA concluded that the risks are generally low, but several uncertainties exist regarding the presence and quality of habitat and a location with zinc surface water concentration above acute aquatic life criteria on Tributary 2. The LIU ERA stated that no direct measurement of sediment or surface water toxicity were available for the ERA and such measurements could be considered as part of the FS process if required to make risk management decisions. Of note, this FS summarizes the results, including Sitewide Abatement results, and findings show that ephemeral drainage data consistently indicate low likelihood of widespread risk to aquatic life populations beyond the operational discharge permit boundary, and therefore, does not recommend such toxicity studies be conducted. The LIU ERA also recommended updated surveys of CLFs and their habitat in the IU to determine if elevated levels of copper and other COPCs represent unacceptable risks. These surveys were conducted in 2019, as discussed in Section 1.3. CLFs were not found, and the potential for them to occur in the LIU was determined to be extremely limited, and thus CLFs were not considered at risk.

3.1.2 Previous Remedial Actions

A release of PLS occurred in October 2007 and travelled down Tributary 2 from the Lampbright North Cut for approximately 2.6 miles to a point just upstream of the confluence with Tributary 1. The nature and extent of potential sediment impacts to Tributary 2 and 2A down to the confluence with Tributary 1 is discussed in detail in the Post Corrective Action Monitoring Report (Golder 2010), which was prepared to satisfy the requirements associated with the 2007 release. Between October 2007 and March 2008, Chino removed approximately 16,000 cubic yards of impacted sediment and pumped a large volume of impacted surface water back to the mine process water circuit. Surface water, sediment, and groundwater were monitored over the course of a year. The report showed that residual impacts diminished in the sediment and returned to be similar to pre-spill conditions.

Supplemental data collected for this tributary (see Nature and Extent section) were consistent with the post-corrective action data.

3.1.3 Data Collection and Other Activities

As recommended in the LIU ERA, additional data needed for the LIU FS were collected on the CLF (see Section 3.1.1). However, no other additional data beyond the data available for the LIU RI were collected for the FS under the AOC, although monitoring and data collection in the LIU continues under the sitewide abatement program.

3.2 Nature and Extent of Contamination

As discussed in Section 3.1.1, the LIU RI (Arcadis 2012) evaluated and mapped the nature and extent of COPCs in site soil, surface water, and sediment, which was updated for this FS by evaluating site data against 2023 screening-level decision criteria as described below. The Stage 1 sitewide abatement report (Golder 2016) discussed the limited nature and extent of groundwater contamination in the LIU as being generally within or near the discharge permit boundary of the stockpiles.

Tributary 2 was remediated along the entire drainage in October 2007. This section presents the pre-remediation exceedances as well as more recent exceedances of threshold criteria for the COPCs discussed in the RI, HHRA, and ERA (which were updated when new hardness data was obtained or when New Mexico criteria changed). Figures based on these data include an asterisk where an exceedance does not represent conditions since full recovery from remediation. Sample collection dates were used to identify samples collected from Tributary 2 during recent conditions (i.e., since 2009, after the effect of disturbance from remediation has passed) versus prior to remediation to identify which data are not representative of current conditions.

Soil. Arsenic was initially identified in the LIU RI as potential risk to human health based on comparison to conservative screening criteria (updated to 2023 in Table 3-1). In the LIU HHRA, arsenic, aluminum, chromium, cobalt, and manganese were initially retained as potential risk to human health in the screening Tier 1 analysis. The nature and extent of these COPCs relative to the screening concentrations are shown on Figures 3-3 through 3-6. However, except for aluminium, the site mean concentrations in surface soil did not significantly differ from the mean reference concentrations in statistical tests (Neptune 2012). Aluminium is not elevated due to mineral processing according to the HHRA and RI. Therefore, no exceedance can be attributed to mining.

For shallow soil on the site (0 to 6 inches bgs, which affects ecological receptors), aluminum, barium, boron chromium, copper, lead, selenium, vanadium, and zinc had samples that were greater than the initial conservative ecological decision screening criteria (updated to 2023 in Table 3-2). Figures 3-7 through 3-16 show the locations of shallow soil exceedances, of which many were in the reference area. Tables 3-2 and 3-3 show the concentrations of all constituents in soil evaluated in the RI at surface (0 to 1 inch bgs) and shallow (0 to 6 inches bgs) depths, respectively, and indicate if the site concentrations exceeded both the decision criteria and the maximum background value. The RI determined that only aluminum and vanadium means were statistically higher in the site area shallow soil compared to reference area soil. However, these two constituents are not associated with ore processing (Arcadis 2012), nor were of ecological concern in the LIU ERA (Formation 2018); therefore, they are not retained as COPCs in shallow soil for the FS and have no Pre-FS RAC. Copper concentrations in the soil at all locations sampled did not exceed the soil Pre-FS RAC of 1,600 mg/kg, nor the monitoring threshold of the avian soil Pre-FS RAC of 1,100 mg/kg (maximum site soil is 319 mg/kg; maximum reference soil is 514 mg/kg) (Table 3-3). Additionally, the plant Pre-FS RAC threshold for concern based on pCu was not met by any site sample location. Although pCu was less than 5 in one onsite location (Figure 3-16), the copper concentration was below the background concentration of 327 mg/kg. To be of concern relative to the plant Pre-FS RAC, the soil sample must have a pCu less than 5 and copper concentration greater than 327 mg/kg. Two reference locations were below the pCu of 5 and above the 327 mg/kg copper criteria of the plant Pre-FS RAC, which supports that background concentrations in the area are high from the natural minerology of the area.

Surface Water. Surface water data collected in the LIU are presented in Tables 3-4 through 3-8 for Tributary 1, Tributary 2, and Lampbright Draw. Lampbright Draw is below the confluence of the two tributaries. To compare to aquatic life criteria, data are reported as dissolved concentrations except aluminum and selenium, which are reported as total recoverable concentrations, when available. When not available, true for aluminum for some samples, the criteria were compared to dissolved concentrations, even though aluminum concentrations should be compared to total recoverable concentrations when pH is greater than 6.5 and less than 9 (pH falls in this range for all data since 2008).

For surface water, most of the data were alluvial surface water or surface expression of the alluvial water (Table 3-4), collected under the Sitewide Abatement program. These data were treated as if they were surface water. In Tributary 2, shallow alluvial surface water data were collected from 2007 to 2010 as part of the Post-Corrective Action Monitoring program (see the RI summary in Section 3.1.1 for details). Except for the 1995 surface water sample that might be a rainfall pool at ERA 36, Tributary 1 samples were all based on alluvial surface water (Table 3-4). Four rainfall pool samples were collected in 2010 in Tributary 2 (including one in Tributary 2A) for the LIU RI to supplement alluvial surface water data, and those four represent the most recent rainfall pool conditions available that do not include alluvial shallow groundwater (Table 3-5). With the exception of some cadmium data collected after January 2008 (10 of 70 samples in Tributary 1) in locations with hardness less than 275 micrograms per liter and one selenium sample collected in 1995 (0.04 selenium detection limit), all detection limits[3] for surface water data were less than decision criteria.

Given CLF are unlikely to be in the LIU (BIOME 2020), the Pre-FS RAC for surface water are based only on acute or chronic aquatic life criteria, but exceedances of CLF NOEC and LOEC thresholds for toxicity (a threatened species, so NOECs are included) are also discussed below to capture the analysis in the ERA.

The LIU RI compared concentrations to older acute and chronic aquatic life criteria, which have since been updated to 2023 in the NMAC in Table 3-1. The comparisons below sometimes differ from results reported in the LIU RI because of the update. Additionally, actual hardness values at sampled locations in Tributary 1 were reported in the 2016 sitewide abatement report (Appendix A in Golder 2016), which were used in this FS, rather than the estimated hardness of 400 mg/L used in the older LIU RI and ERA. However, the estimated hardness (using calcium and magnesium data) for the non-rainfall pool data in Tributary 2 is still used in this FS because hardness is not available for that tributary in the Sitewide Abatement report. The rainfall pool data (except ERA-36) include values for hardness.[4]

[3] Unless stated otherwise, method detection limits are reported in tables accompanying in this FS. Every station in Tributary 1 except the 1995 ERA 36 sample was sampled and analyzed fall 2007 to January 2008 at adequate detection limits and showed no exceedances of cadmium water quality criteria.

[4] Because the CLF NOEC and LOEC do not affect remedial decisions, the hardness-adjusted CLF thresholds are the same ones used in the ERA (not updated to match hardness results in Golder 2016).

In Tributary 1, constituent concentrations are largely non-detectable concentrations throughout the drainage (Table 3-4; Figures 3-17 through 3-23). Arsenic, cadmium, chromium, selenium, lead, and nickel concentrations were reported as non-detects. Of 71 samples collected since 2007, five samples at three locations had aluminum concentrations that exceeded chronic criteria and only three of those samples exceeded acute criteria (Table 3-4; Figure 3-17). Aluminum exceedance is unlikely a result of mineral processing, however. For zinc, five samples were detectable, of which none exceeded chronic or CLF NOEC or LOEC criteria (Figure 3-23; Table 3-7). For copper, 34 samples were detectable (Table 3-4), of which 10 detections at six locations exceeded the lowest CLF NOEC criteria and two exceeded CLF LOEC criteria (Figure 3-19; Table 3-7). Three of the copper concentrations at two locations (two at LB7S, and one at LBT1-BF1) exceeded chronic aquatic life criteria and one sample (at LB7S) exceeded the acute criteria (Tables 3-4 and 3-7). In summary, for Tributary 1 the data show only two surface water locations exceeding the Pre-FS RAC for COPCs for chronic criteria that could be elevated due to historical mineral processing, and only one of those two (LB7S) exceeds the acute criterion.

Acute criteria are generally applied to ephemeral streams, but chronic criteria were applied in the ERA because there may be intermittent sections of the streams with aquatic populations. For this FS, Tributary 1 was found to be ephemeral and thus acute criteria apply. The LIU ERA states that the Tributary 1 drainage has been characterized as ephemeral, with baseflow described in Golder (2009) as temporally and spatially discontinuous, and when present, occurring as seeps and stagnant pools with little or no flow. The BIOME (2020) report photographs agree with this description. The ERA states that this ephemeral nature should be considered in the FS, meaning exceedances of the acute criteria are more applicable. When acute criteria are applied to Tributary 1, there is only one exceedance of the Pre-FS RAC criteria (the acute version of the Pre-FS RAC). That location (LB7S) is within the DP boundary and will be addressed under the sitewide abatement program (Table 3-4).

Note that, in response to the ERA's recommendation to evaluate the monitoring well data near LBT1-BF1 that has a chronic criteria exceedance, the well data were examined. Golder's site investigation data (Golder 2016) indicated no detection or exceedance of copper CLF LOEC of 0.0223 milligram per liter (mg/L) in the groundwater in the closest well north of this location (see Table 5-2 in Golder 2016, well 376-2007-03, less than 0.01 mg/L). TDS and sulfate groundwater criteria also were not exceeded at the well at this location (376-96-04, other metals not sampled), which supports low impacts from mineral processing in this area. These results support a conclusion for this FS that unacceptable risk to aquatic life and the CLF in the LBT1-BF1 area is not expected.

In Tributary 2 (includes Tributary 2A), 34 samples (includes rainfall pools) collected since 1999[5] (of which two were dry) were analyzed for copper, iron, manganese, and zinc (Table 3-5). At least 21 to 23 samples were collected for the remaining constituents (Table 3-5). In the Corrective Action monitoring samples of alluvial water and 1999 samples, aluminum, cadmium, copper, lead, manganese, nickel, or zinc concentrations exceeded chronic aquatic life criteria in only one to five samples at four locations. A number of those samples at two of the locations (LBT-11 and LBT-12) also exceeded acute criteria, through 2008 (Table 3-5). However, conditions improved after 2008 because only zinc exceeded the chronic or acute criteria (Pre-FS RAC) in later years as the stream recovered from the remedial corrective action (at LBT-11).

For the 2010 rainfall pools, copper exceeded the CLF NOEC in three of the four rainfall pools, but none of the rainfall pools had concentrations above the Pre-FS RAC or CLF LOEC for any metal of concern (Figures 3-17

[5] 2007 data and April 2008 alluvial water data in Tributary 2 representing ongoing recovery from the remedial action in 2007 were excluded in the ERA analysis.

through 3-23, Tables 3-5 and 3-8). The alluvial water and 1999 locations also had four samples with exceedances of the CLF copper NOEC as well as one exceedance of the CLF copper LOEC in 2008 at one location, LBT-11 (Table 3-8). However, the 2010 rainfall pool samples are representative of the most recent surface water exposure in this tributary and indicate copper and zinc in surface water are unlikely to be affecting aquatic populations, especially given CLF were not found in the LIU tributaries.

Zinc in the shallow alluvial water exceeded chronic criteria at only one location (LBT-11) in 2009 and 2010 (Tables 3-5 and 3-8). The elevated zinc concentrations appear to be isolated because criteria for zinc were not exceeded in samples collected from upstream (up to LBT-16) or downstream (down to LBT-10) of LBT-11 (Figure 3-23). As stated in the ERA, Tributary 2 is partially located in a mineralized area; given the isolated nature of the exceedances, it is likely that a relatively small area of naturally occurring zinc may be influencing the data observed at LBT-11. In summary, after recovery from the corrective action by 2009, only one location in Tributary 2 exceeded a surface water Pre-FS RAC (LBT-11), which was for zinc, and the exceedance likely related to natural mineralized veins.

In Lampbright Draw, which is downstream of the confluence of Tributaries 1 and 2, all constituents sampled were at low concentrations or not detected, and none exceeded CLF criteria or Pre-FS RAC chronic or aquatic criteria (Table 3-6).

Sediment. NMED did not identify Pre-FS RAC for sediments but requested that a description of aquatic habitat be provided in the FS at locations where the copper PEC was exceeded in the ERA (NMED 2024). For sediment, the RI indicated that copper concentrations in Tributaries 1 and 2 (including Tributary 2A) were sufficiently above background or ecological decision criteria to potentially warrant further evaluation in a risk assessment but a risk evaluation was not ultimately recommended due to ephemeral nature of the tributaries. The results of the sampling were as follows:

In Tributary 1, 20 locations were sampled starting in 1995, and chromium, copper, lead, and zinc exceeded the TEC in some samples, but only copper exceeded the PEC, with exceedances in three locations (Table 3-9). In Tributary 2 (including 2A), 57 samples at 33 locations were sampled starting in 1995 (some repeatedly sampled from 2008 to 2010 during post-correction monitoring), and cadmium, copper, lead, nickel, or zinc exceeded the TEC in a number of samples (Table 3-10). Copper and nickel also exceeded their PECs, with copper exceedances in 12 locations, and a nickel exceedance in one location (Figures 3-24 through 3-28). In Tributary 2, copper no longer exceeded the PEC by 2009, after recovery from post-corrective actions (Table 3-10).[6] Lead also had one exceedance of its PEC in 1995 (Figure 3-26) but not in later years after Tributary 2 was remediated. Nickel was not sampled after 2008 at the one location with a PEC exceedance (T2S6), but it is in the same general location as the rainfall pool, 65+40 (Figure 3-27), which did not exceed the nickel PEC in 2010, indicating that general location appeared to have recovered. In Lampbright Draw downstream from the confluence of the two tributaries, three locations were sampled for cobalt and copper, and copper exceeded the TEC in two locations but not the PEC (Table 3-11; Figure 3-25B). Thus, the most recent data post recovery support no PEC exceedances in Tributary 2 or Lampbright Draw but copper exceedances occur in three locations in Tributary 1.

Because no formal classification of permanence of the water where PECs were exceeded has occurred, the 2018 ERA did not follow the RI recommendation of no risk evaluation for sediment, and instead evaluated ecological risk to sediment at 24 of the 54 locations, which included the 1995 locations on Tributary 1 and 2A that were not

[6] Removal of sediments can create temporary flushing and increase COPCs at the surface, but they can disappear due to runoff and dilution within a year or two.

remediated after the spill and excluded 1995 locations on Tributary 2 that were remediated.[7] The ERA indicated that potential risks from copper in sediments are elevated in some areas. The ERA (and pre-FS RAC) identified the locations of concern exceeding the PEC as three locations in Tributary 1 sampled in 1995 (2214, 2215) and in 2009 (376-05-04), two locations in Tributary 2A sampled in 1995 (2202 and 2206) and one location in Tributary 2 sampled in July 2008 (T2S10) (Figure 3-25A).[8] The ERA also indicated possible concern with the nickel concentration exceeding its PEC at T2S6 in July 2008 (Figure 3-27). This differs from a conclusion that risk is minimal in Tributary 2 because the ERA includes 2008 data when the tributary may still be recovering from remediation disturbance that occurred in late 2007 and early 2008.

The three Tributary 1 locations with exceedances are inside the discharge permit operational boundary (Figure 3-25A), and are to be addressed under that program, whereas the Tributary 2 and 2A locations with exceedances are outside the discharge permit operational boundary. When outside the boundary, the remedial evaluation is under the AOC and part of this FS. However, as mentioned above, the July 2008 exceedances in Tributary 2 may be due to temporary disturbance from post-corrective actions before contaminated sediment is fully flushed away, which is supported by the nickel and copper data obtained in 2009 and 2010 for those locations, which did not exceed the PEC. Thus, only the two locations in Tributary 2A (2202 and 2206) with more recent copper exceedances of the PEC are the remaining locations of concern to evaluate under the AOC. One of those locations, 2206, was excavated and removed as part of the Far East containment area, leaving 2202 as the sole location of concern.

Additionally, sediment exposure may not be as critical given the tributaries are dry most of the time with non-persistent pools that do not support a large community of benthic organisms. Therefore, the persistence of the flow in the areas with exceedances was also evaluated. The LIU ERA states that the tributaries are partly ephemeral (flow only during rainfall events) and partly intermittent (have seasonal flow from groundwater or runoff events). Golder (2007) mapped 15 seeps and springs in Tributary 1 and Tributary 2, indicating some perennial pools occur in localized areas of surface water expression.

In 2019 CLF surveyors described the habitat of these tributaries (BIOME 2020):

> *"In general, habitats farther north are lower in quality, more susceptible to completely drying out, have shallower basins, and less developed aquatic vegetation than sites surveyed within the West Fork of Lampbright Draw and Rustler Canyon. Sites within Tributary 2 above the junction of Tributary 1 are classified as marginal habitat for CLF. There is a notable downstream gradient of increasing habitat quality from Tributary 2A to the West Fork of Lampbright Draw, probably consistent with the water that is held in the drainage above bedrock level at various sites along the drainage. Although there are several locations with plunge pools or intermittent springs in this section of Tributary 2, these habitats are small, reliant upon rainfall for replenishment, and are considered intermittent-ephemeral with regards to aquatic habitats and temporal water presence. Approximately 1.5 miles upstream of its junction with Rustler Canyon, the West Fork of Lampbright Draw contained the first surveyed perennial habitat with several permanent pools and well-established phreatophytic vegetation. This site is approximately one mile downstream of the confluence with the Tributary 1 drainage and nearly 1.5 miles downstream of the LIU boundary."*

[7] Tributary 2 was sampled again post-corrective action monitoring, not in the exact same locations as in 1995 but along the drainage; the more recent data collected supersedes the 1995 data.

[8] The April 2008 sediment data shown in Table 3-10 were not included in the ERA (Table 3-12); however, data were included from July 2008.

In addition to narrative descriptions, photographs assist in determining the habitat quality of locations with sediment exceedances. Photographs were taken in Tributary 2A in 2013 of areas with seeps or pools (all photographs are from BIOME 2020). No seeps or pools occurred at Tributary 2A sediment locations with PEC exceedances (locations 2206 and 2202 shown on Figure 3-16), and the first seep photographed was just downstream of these locations. The photographs on Tributary 2A first were taken in May 2013 and are shown on Figure 3-29, which supports that aquatic habitat at that seep and in Tributary 2A in general is very limited with no wetland or aquatic vegetation. In May of 2019, the same downstream seep location in 2A was described as a "spring feeding very shallow pools" (BIOME 2020; Figure 3-29), further supporting that, where there was a seep on Tributary 2A (which notably was not on the locations with exceedances), the habitat was minimal. Location T2S10 in Tributary 2 (which exceeded the copper PEC only in 2008, not later) is shown on Figure 3-30 and is described in May 2019 as "series of small pools, up to 8 inches deep, some vegetation", and the photograph shows very little habitat but does appear to have persistent vegetation. This same location in September 2019 coalesced into one shallow pool with limited benthic habitat (Figure 3-30). However, this location appears to have recovered from remediation disturbance by 2009. Location T2S6, which exceeded the nickel PEC only in 2008 and appears to have recovered after the remediation, similarly had only a small pool with very limited vegetation in September 2019 (Figure 3-31). Tributary 1 had no obvious seeps or pools (Figure 3-32).

This description and the photographs of the tributary habitat in the report support the ephemeral nature of the tributaries in the impacted locations, and that the limited exceedances of sediment in the few pools that are outside the DP boundary are unlikely to create risk to aquatic populations in the LIU. Also, the ERA indicates that the PECs used were based on non-mineralized areas, and that the PEC threshold could be higher if developed for a mineralized area as shown in the Tri-States Mining District in Missouri, Oklahoma, and Kansas study (MacDonald et al. 2009), at least for nickel.

Sediment Leaching to Surface or Groundwater. The Pre-FS RAC letter for LIU (NMED 2024) concluded there is no potential for groundwater contamination from drainage of sediments exceeding a DAF of 1 based on STSIU study results (Arcadis 2011a) and preliminary LIU data at locations 1-1 and 1-2. Thus, there is no pre-FS RAC for groundwater. This conclusion is supported when evaluating all the LIU data for this FS against updated 2021 screening criteria. NMED soil screening levels were compared to sediment concentrations at LIU to evaluate risk of leaching from sediments to groundwater using the maximum (Cw) of four types of sediment screening values, as recommended in NMED (2021), which were: Risk-based criteria, New Mexico Groundwater criteria, maximum contaminant level-based DAF 1, and maximum contaminant-level-based DAF 20 criteria (see Table 3-14).

The sediment concentrations were compared to the Cw and also to background concentrations, if the site concentration exceeded the Cw. Only constituents that had sediment concentrations exceeding a DAF of 1 at LIU were compared in Table 3-14 (arsenic, barium, cadmium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, and zinc). Only one arsenic location and one cobalt location exceeded both the Cw and background value, and only at one location each (rainfall pool 65+40 for arsenic in 2010, location 2214 for cobalt in 1995; Table 3-14). The results for this solid phase analysis using updated 2021 criteria produced results similar to the earlier STSIU analyses using 2009 criteria. The results for the STSIU study in 2009 also found limited exceedances across all the STSIU drainages, with only one to three samples of lead, copper, and arsenic samples exceeding both a DAF of 20 and the background sediment concentrations.

Leaching of the COPCs also needs to be tested to fully evaluate the sediment to groundwater pathway. Using the SPLP, sediment in Tributary 1 was assessed in conjunction with an analysis of acid base accounting and groundwater quality criteria for COPCs. None of the Tributary 1 samples were acid-generating (Table 3-15) or exceeded groundwater quality criteria except one iron sample (Table 3-16). The STSIU also had an iron exceedance in the leaching test, and the Arcadis (2011a) STSIU study demonstrated the exceedance of iron did not occur when based on a more site-specific evaluation of iron.

Lastly, in the LIU ERA, the sediment to surface water pathway was evaluated by comparing leaching results to surface water criteria. Two sediment samples from Tributary 1 were analysed for concentrations of solid phase and leachable COPCs using SPLP to evaluate leaching potential of surface water COPCs. The procedure was conducted over different depths for cadmium, copper, lead, and zinc. The sediments were not found to be a significant source of COPC leaching to surface water for ecological COPCs (Table 3-13; also see Formation 2018).

3.3 Locations to be Evaluated for Remedial Alternatives

This section presents an evaluation of the locations for potential remediation based on exceedances remaining in Tributary 2. Locations that exceed Pre-FS RAC in areas under the AOC program and outside the current and future DP boundaries were evaluated. The nature and extent evaluation in the previous section indicates no individual locations in soil exceed the Pre-FS RAC for plants, and no individual locations exceed the soil avian Pre-FS RAC of 1,600 mg/kg or the soil monitoring Pre-FS RAC of 1,100 mg/kg. This result supports the pre-FS RAC letter statement that risk to plants and wildlife from soil is unlikely. For surface water, only one location exceeded a Pre-FS RAC, which was a pre-FS RAC for zinc (LBT-11, Figure 3-33); it is uncertain whether the exceedance is due to mineral processing or natural mineralization in the area (Formation 2018). Sediment has no Pre-FS RAC, but NMED requested evaluation of habitat quality at locations exceeding PECs. The locations with continued exceedances of the PEC after recovery from remedial activities (after 2008) are shown in Figure 3-33. Of these locations, habitat quality was discussed in Section 3.2 for the three sediment locations that both exceeded the copper or nickel PEC and are not under the DP program (2202, 2206 for copper and T2S6 for nickel). Persistent benthic habitat has not been identified at these three sediment locations, indicating limited potential risk to aquatic life; additionally, location 2206 (Figure 3-33) was excavated in the Far East Containment Area disturbance and therefore is no longer an exceedance.

In summary, Figure 3-33 shows the four locations with sediment or surface water exceedances under the AOC area that are outside the DP boundary (locations outside the red boundary, which are 2202, 2206 [has been excavated], LBT-11, and T2S6). None of these locations pose a risk to human receptors (Neptune 2012), and no widespread risk to ecological receptors at the population-level are expected in these small, localized areas with exceedances (Formation 2018). Surveys did not identify any endangered or threatened aquatic life in the LIU, and the threatened CLF appears to have been extirpated due to a fungus. Thus, only population-level effects need to be considered for remediation. Because there is no human health or population-level ecological risk, no remedy is required. Nonetheless, remedial technologies and alternatives were evaluated in this FS for soil, surface water, and sediment, as requested by NMED.

The weighting criteria for evaluating and comparing the alternatives includes protection of human health and the environment (e.g., populations and communities). Each alternative was evaluated to determine whether implementation of the alternative would improve the current condition versus produce more harm than good to these populations and communities.

4 Identification of Potentially Applicable Technologies

This section identifies and screens technologies that may be included in remediation alternatives for the LIU. A comprehensive list of technologies and process options that are potentially applicable to this site is developed to cover all the applicable general response actions. The list of technologies is then screened to develop a refined list of potentially feasible technologies that can be used to develop remediation alternatives for the site. Brief descriptions of the potential remediation technologies for the LIU and discussion of the screening results are provided below.

General response actions are broad categories of remedial actions that can be combined to meet remedial actions at a site. The following general response actions are generally applicable to most sites and provide a context for identifying applicable technologies:

- No Action
- Institutional Controls
- Monitoring
- Containment
- Excavation and Disposal
- In-Situ and Ex-Situ Treatment
- Reuse and Recycling.

Only no action, monitoring, excavation, containment, and in-situ/ex-situ treatment are explicitly addressed for soil because institutional controls are not needed due to a lack of exceedances that would cause human health risk that would restrict use. Containment, excavation, and disposal as well as reuse and recycling are not addressed because too little material has exceedances due to mining (none found) to be of concern to excavate or reuse.

For surface water, only no action, monitoring, containment, excavation, and disposal, and in-situ treatment are explicitly addressed. Institutional controls are not needed due to a lack of exceedances that would cause human health risk that would restrict use. Ex-situ treatment is not needed because of no exceedances in adjacent soils. Materials involved for removal are too small to evaluate reuse and recycling.

Section 4.1 discusses remedial technologies for soil and Section 4.2 discusses remedial technologies for surface water and sediment.

4.1 Soil

The preliminary screening and evaluation based on USEPA (1988) of the potential soil remedial technologies determines which remedial technologies should be retained for consideration as part of the comprehensive FS alternatives analysis for the site. The preliminary screening in this section of each remedial technology is based on USEPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988) and will include an evaluation of the effectiveness and implementability. A detailed evaluation of cost was not completed for this FS based on the information presented below and in Section 5. Potential use of institutional controls, consistent with CERCLA guidance (USEPA 2010) may be warranted for implementation of specific remedial technologies. If the remedial technology is considered viable, it will be retained for consideration as part of the sitewide remedial alternatives analysis in Section 5.

A brief explanation of these soil remedial technologies is described below and a preliminary screening of each technology for soil is presented in Table 4-1.

4.1.1 No Action

This remedial technology consists of leaving the site soils in their current condition without performing any soils/vegetation removal or treatment, engineering controls, or institutional controls as part of the remediation efforts. This technology is provided as a baseline for screening other technologies if this alternative is selected and other technologies were to be applied in the future. This No Action alternative is summarized as Technology No. 1 in Table 4-1. Contaminants will naturally attenuate over time. This technology does not provide additional mechanisms to prevent contaminant exposure to site receptors and is effective if contaminants naturally attenuate over time. There are no costs associated with no action and the technology is considered implementable.

Screening Result

No Action is being retained as a possible action (does not involve remediation under the AOC) because remediation may derive no benefit. It is also being retained as a baseline for comparison with other remedial technologies in the FS and for potential use in conjunction with other technologies if a technology is selected.

4.1.2 Monitoring

This remedial technology consists of leaving the site soils in their current condition without performing any soils/vegetation removal or treatment, engineering controls, or institutional controls as part of the remediation efforts. As part of this technology, a monitoring program would be implemented to observe and document the occurrence of natural attenuation of site contaminants to even lower than they currently are, which are already at levels not of concern. Monitoring would include collection of qualitative and quantitative samples of LIU media such as surface soils, vegetation, and other biotic media. This technology is provided as a baseline for screening other technologies and is summarized as Technology No. 2 in Table 4-1. This technology does not provide additional mechanisms to prevent contaminant exposure to site receptors but would inform decisions to control exposure. The technology has been and can be implemented at the site. Costs are associated with the types and duration of monitoring selected.

Screening Result

Monitoring is not being retained because the 1,100 mg/kg threshold requiring monitoring in soils has not been exceeded in the LIU (Tables 3-1 through 3-3), and the threshold criteria for plants (pCu) is also already met. Monitoring attenuation is only needed if contaminants are elevated to a level of concern.

4.1.3 Soil Amendments – Limestone and/or Organic Matter

Many soil amendment technologies exist for reducing metals bioavailability, toxicity, and mobility in soils. They rely on changing soil chemistry to affect the solubility or mobility of site contaminants within the soil column, and/or improve vegetative cover or speciation. Several soil amendments are described further below including, pH adjustment via lime addition and/or organic matter, tilling (Section 4.1.4), ferrihydrite (Section 4.1.5) and chelating agents (Section 4.1.6). The pH adjustment and/or organic matter addition technology is summarized as Technology No. 3a in Table 4-1. Arcadis (2017) conducted a pilot study for the STSIU on amendment effectiveness. The study indicated that liming is recommended for soils with low pH. The pH of soils identified herein is much higher. All site soils have pH greater than 6 except one location with a pH of 4.6 (L-08, Table 3-3), and soils with such high pH would not benefit from lime additions because they already have a high buffering capacity. Organic matter can bind metals but was not recommended after the STSIU amendment study was completed because cow manure brought in weedy plants that degraded the habitat (however, other forms of organic matter could be considered). This technology is considered implementable. Costs are moderate and include procurement of amendments, equipment, and application, as well as long term costs of application which are considered moderate.

Screening Result

No COPCs failed the Pre-FS RAC in soil, implementation of the technology is not necessary; therefore, this technology is not retained for further evaluation.

4.1.4 Soil Amendments – Tilling or Ripping

Soil mixing by using mechanical tilling technology is being evaluated as part of this FS for use at the site as part of the comprehensive remedial alternative. Initially, the ground surface vegetation is cleared and grubbed using a bulldozer and/or excavator. Following vegetation clearing, the tilling is conducted using a 140 blade (or similar) attached to a bulldozer to mix to a pre-determined depth of soil. In areas requiring soil mixing with limited access to larger equipment, hand tilling equipment can be used as an alternative to the bulldozer to mix soils. Tilling is less intrusive in general; it lowers disruption to habitat and lowers carbon footprint compared to alternatives relying on excavation.

Based on the pilot study in the STSIU that employed tilling and amendments (Arcadis 2017), tilling has the potential to attenuate metals and to raise acidic soil pH to more neutral conditions. Plant coverage, pH, and soil chemistry would be monitored post-tilling operations. As part of the remedial design phase, additional soil sampling (contaminant levels and soil chemistry) within the soil treatment column would be conducted to determine if tilling alone would be appropriate technology and the appropriate soil mixing depth within each soil treatment area to raise pH in acidic soils.

Tilling is considered implementable. Costs will generally be more than soil amendments without tilling, but generally less than excavation and soil cover. The soil amendments and tilling technology is summarized as Technology No. 3b in Table 4-1.

Screening Result

Because there have not been exceedances of Pre-FS RAC in soil, implementation of the technology is not necessary; therefore, this technology is not retained for further evaluation.

4.1.5 Soil Amendments – Ferrihydrite

The addition of ferrihydrite to soils containing copper has been observed to bind copper, reduce free Cu^{2+} activity, and total soluble and labile concentrations of copper. Effectiveness would be determined via conducting a pilot treatability study and potentially bench scale treatability study to determine the loading rate of ferrihydrite or if other amendments such as lime or magnesium oxide would be beneficial. Implementability and costs would also be determined during the pilot or bench scale studies, though it is considered to be an implementable technology. The overall technology is considered to have moderate costs with low to moderate costs associated with long term operation and maintenance. The soil amendments - ferrihydrite technology is summarized as Technology No. 3c in Table 4-1.

Screening Result

Because there have not been exceedances of Pre-FS RAC in soil, implementation of the technology is not necessary; therefore, this technology is not retained for further evaluation.

4.1.6 Soil Amendments – Chelating Agents

The application of chelating agents as a potential soil remedial technology is included as part of a comprehensive remedial alternative. Specifically, chelating agents were evaluated for use in the following soil remedial technologies:

- Soil Washing (Ex-Situ); and
- Soil Washing (In-Situ).

Chelating agents are compounds that are added to the soil for removing a metal from soils as part of a soil washing technique. The effectiveness and implementability of this technology would be determined during pilot treatability studies and would consider accessibility of soil washing materials. Costs associated with the use of chelating agents is considered high. The use of chelating agents in the soil washing processes is discussed below and summarized as Technologies No. 3d1 and No. 3d2 in Table 4-1.

4.1.6.1 Soil Washing (Ex-Situ)

Ex-situ soil washing is a soil remedial technique consisting of removing and concentrating contaminants from bulk soil using separation methodologies. Soil washing can be applied to soils containing heavy metals. The resulting concentrated soil containing the contaminants must be characterized for further treatment and/or offsite disposition. The “clean” portion of the separated soil is also characterized to determine if it meets the criteria for on-site reuse to be returned to the excavations or if it requires further treatment and/or offsite disposition.

The design of the soil washing process, including the size of scrubber unit, type of soil washing detergent, and soil handling requirements, are determined via a pilot treatability study and during the remedial design.

Screening Result

Because there have not been exceedances of Pre-FS RAC in soil, implementation of the technology is not necessary; therefore, this technology is not retained for further evaluation.

4.1.6.2 Soil Washing (In-Situ)

In-situ soil washing consists of introducing a chelating agent into the soil. The chelating agent assists in mobilizing the contaminant within the soil column and allows it to become more soluble in the groundwater. The groundwater, containing the site contaminant, is then extracted with a groundwater extraction system for treatment and/or disposal.

The design of the soil washing process, including the target injection/infiltration rates of the chelating solution, recovery methods (e.g., recovery trench, regularly spaced extraction wells), and treatment plant requirements, are determined via a pilot treatability study and during the remedial design.

Screening Result

Because there have not been exceedances of Pre-FS RAC in soil, implementation of the technology is not necessary; therefore, this technology is not retained for further evaluation.

4.1.7 Phytoremediation

Phytoremediation consists of planting vegetation (trees and/or plants) that can uptake the contaminants located in the soil and subsequently remediate the soils. Trees and/or plants remove the site contaminants when the roots take in water and nutrients from the surrounding impacted soils. Metals are stored in the roots, stems, or leaves of the vegetation, effectively removing them from the soil. Activities that are associated with the implementation of phytoremediation include selection of the proper tree and plant species, site preparation (potentially clearing and grubbing existing vegetation), planting, and operation, maintenance, and monitoring to ensure that the trees and plants are being established. Costs include the vegetation, planting and maintenance of vegetation and are considered moderate to high as compared to other technologies. The phytoremediation technology is implementable only if species able to support phytoremediation can be supported in this area. This technology is summarized as Technology No. 4 in Table 4-1.

Screening Result

Because there have not been exceedances of Pre-FS RAC in soil, implementation of the technology is not necessary; therefore, this technology is not retained for further evaluation.

4.1.8 Summary and Identification of Data Needs

The following soil remedial technologies were evaluated in the preliminary screen:

- No Action [retained].
- Monitoring [not retained].
- Soil Amendments:
  - Limestone and Organic Matter [not retained]
  - Tilling or Ripping [not retained]
  - Ferrihydrite [not retained]
  - Use of Chelating Agent: Soil Washing (Ex-Situ) [not retained]
  - Use of Chelating Agent: Soil Washing (In-Situ) [not retained].
- Phytoremediation [not retained].

No additional data gaps need to be considered based on this preliminary screen of remedial alternatives for soil.

A summary of retained and not retained remedial technologies is included in Table 4-1. The retained technology is No Action.

4.2 Sediment and Surface Water

A preliminary screening and evaluation based on USEPA guidance (1988) of the potential sediment and surface water remedial technologies was used to determine which remedial technologies should be retained for consideration as part of the comprehensive alternatives evaluation for the site. Seven technologies were identified and are described below. A preliminary screening of each technology in presented in Table 4-2.

4.2.1 No Action

This remedial technology consists of leaving the drainage areas known to contain surface water or sediments with levels of site contaminants above surface water or sediment Pre-FS RAC values (occurs only in four locations under the AOC program; Figure 3-33) in their current condition without performing any soil, sediment, vegetation, groundwater and/or surface water removal or treatment. This technology is being retained (does not involve remediation under the AOC) and serves as a baseline control to compare to other potential surface water remedial technologies, if any were to be implemented in the future should this alternative be selected. The technology is not inherently effective at removing contaminants or exposure pathways, but they may naturally attenuate over time or be remediated under the sitewide abatement program. There are no costs associated and it is considered implementable. This technology is summarized as Technology No. 1 in Table 4-2.

Screening Result

No Action is being retained as a remedial alternative.

4.2.2 Monitoring

This remedial technology consists of leaving the drainage areas known to contain surface water or sediments with levels of site contaminants above surface water or sediment Pre-FS RAC values in their current condition without performing any soil, sediment, vegetation, groundwater and/or surface water removal or treatment. Exceedances occur only in two locations (LBT-11 and 2202), given the sample exceedance of nickel in 2008 is considered recovered based on the results in the sample in almost the same location that was collected in later years. As part of this technology, a monitoring program would be applied to these locations, implemented to observe and document the occurrence of natural attenuation of site contaminants. Monitoring would include collection of qualitative and quantitative samples of site media such as surface water and sediments in drainages. Costs are associated with the types of monitoring and duration. This technology is being retained to serve as an alternative action (does not involve remediation under the AOC) and the monitoring data could be used as a baseline to compare drainage condition to future conditions if other potential surface water remedial technologies are implemented. This technology is summarized as Technology No. 2 in Table 4-2.

Screening Result

Monitoring is being retained as an alternative and can be used as a baseline control for comparison with other remedial technologies in the FS, if other technologies are employed.

4.2.3 Excavation

This remedial technology consists of the removal of soils and/or sediments from the specified drainage areas (e.g., the four locations discussed in Section 3.3 and shown on Figure 3-33). This is considered to be generally effective, technically implementable, as seen with the removal of sediments in Tributary 2 to remove the effects of the spill. There are possible exceptions regarding implementability in certain areas of the site that are more difficult to access with equipment and personnel due to terrain conditions and presence of mature trees that would ideally be retained given the length of time needed to reestablish. This technology would need to be paired with monitoring to ensure adequate material has been removed. Construction costs are expected to be moderate and operation and the long-term maintenance costs required are expected to be low to moderate. This technology is summarized as Technology No. 3 in Table 4-2.

Screening Results

Excavation of sediments is an effective and technically implementable way of removing contaminated sediments from surface water. Sediment and surface water are being addressed under the sitewide abatement program, even if outside the DP boundary (see Golder 2016); therefore, this technology is not being retained for further consideration. As an example of the sitewide program activities, pumps were installed in wells in 2011 in the East Lampbright area to intercept impacted groundwater, reduce sulfate and TDS, and meet groundwater and surface water quality standards. The program is responsible for monitoring the LIU tributaries and adjusting remediation as needed to meet standards and conditions of the discharge permits. The program also evaluates if some of the exceedances are from natural mineralization, and thus, can be retained at higher concentrations.

4.2.4 In-Stream Removal of Suspended Sediments

This remedial technology consists of in-stream removal of suspended sediments via construction of settling basins within the stream drainage area pathway. The contaminants are adhered to the suspended sediments located within the surface water, subsequently contributing to the exceedances of the surface water Pre-FS RAC values. Removal of the suspended sediments containing the contaminants will result in lowering the total contaminant concentrations in the surface water. There may still be a potential for dissolution of contaminants from sediments into the dissolved phase.

Multiple settling basins would be constructed at specified locations along the drainage area to capture sediments at different points along the surface water drainage pathway. The location, size, and materials of the settling basins would be determined during the remedial design but should be effective at capturing contaminated sediments. The settling basins would be located in areas that are easily accessible by construction equipment for removal of the accumulated sediments, and thus should be implementable. The frequency of sediment removal from the settling pools will depend on the rate of sediment accumulation and would be determined during the remedial design. Construction costs are expected to be moderate and operation and the long-term maintenance costs required are expected to be moderate to high. This technology is summarized as Technology No. 4 in Table 4-2.

Screening Results

In-stream removal of sediments seems to be an effective, technically implementable, and cost-effective way of removing contaminated sediments from surface water. However, sediment leaching and surface water are being addressed under the sitewide abatement program, even if outside the DP boundary (see Golder 2016); therefore, active remediation is not addressed further in the FS.

4.2.5 Limestone Treatment

This ex-situ remedial technology consists of the installation of limestone features within the surface water drainage area to passively treat surface water with contaminant levels above the Pre-FS RAC levels. PLS is acidic-metal laden water utilized at the leach stockpiles. Its release can decrease pH, causing toxic metals to dissociate from sediments and suspended sediment. The limestone will increase the pH, which will bind metals to oxides and reduce their toxicity if pH in the water and sediments is low.

Limestone features would require installation at multiple locations along the surface water drainage areas. The multiple locations of the limestone features would provide increased treatment of the surface water as it progresses down the drainage area. The limestone features installation may consist of the construction of a waterfall using limestone masses to increase surface water contact of the water with the limestone. In addition, limestone may be installed as armoring and/or chips. Initial costs are high, with long term costs considered to be low compared to excavation and in-stream removal of suspended sediments. The final design and location of the limestone features would be determined during the remedial design. This technology may not be effective if pH is not low, and data do not support pH is sufficiently low. This technology is summarized as Technology No. 5 in Table 4-2.

Screening Results

Limestone treatment might be an effective and technically implementable way of removing contaminated sediments from the surface water as well as increasing water hardness, which may further improve water quality. However, the pH of the sediment and waters at the few locations of concern and in the LIU drainages in general is not acidic (Tables 3-4 through 3-6), the sediments have not been acidic since the 2000s (Tables 3-9 through 3-11), are not acid generating (Table 3-13) and thus it is unlikely liming will decrease metal toxicity. Further, sediment leaching and surface water are being addressed under the sitewide abatement program, even if outside the DP boundary (see Golder 2016); therefore, this technology is not being retained for further consideration.

4.2.6 In-Situ Treatment

This in-situ remedial technology consists of the insertion of an alkaline fluid into the active channel and bar sediments in the drainages of the LIU to treat surface water with contaminant levels above the Pre-FS RAC levels.

In-situ treatment would need to be evaluated using a pilot study to determine the effectiveness of this technology on LIU sediments; however, given that pH is not low in the sediments, in-situ treatment is unlikely to be beneficial or effective. It is not easily implemented due to large infrastructure requirements. Costs are considered to be high both during the construction and operation and maintenance phases. This technology is summarized as Technology No. 6 in Table 4-2.

Screening Results

In-situ treatment with alkaline fluid in a system that generally does not have low pH is likely an ineffective way of treating contaminated sediments and water. Further, sediment leaching and surface water are being addressed under the sitewide abatement program, even if outside the DP boundary (see Golder 2016); therefore, this technology is not being retained for further consideration.

4.2.7 Groundwater Pumping and Re-directing Outflow from Stockpiles

This remedial technology consists of intercepting impacted groundwater and pumping it back into the leach stockpiles. This technology is already employed as part of the sitewide abatement program but possibly could be enhanced beyond current efforts. Construction costs would therefore be low, with long term operation and maintenance high compared to other remediation technologies. This technology is summarized as Technology No. 7 in Table 4-2.

Screening Results

This treatment is an effective way of treating contaminated ground and surface water near the stockpiles within the DP boundary, or in the eastern zone where groundwater is moving between Tributary 1 and 2 from the stockpiles. This treatment is being effectively used under the sitewide abatement program (Golder 2016) and will continue to be treated under the program as needed. It is assumed natural attenuation will reduce concentrations in the sediments. Therefore, this technology is not further discussed under the FS.

4.2.8 Summary and Identification of Data Needs

The following sediment and surface water remedial technologies were evaluated in the preliminary screen:

- No Action [retained].
- Monitoring [retained].
- Excavation [not retained].
- In-stream Removal of Suspended Sediments [not retained].
- Limestone Treatment [not retained].
- In-situ Treatment [not retained].
- Groundwater Pumping and Re-directing Outflow from Stockpiles [not retained].

Besides ongoing sampling activities, there are no additional data needs that need to be considered based on this preliminary screen of remedial alternatives for sediment or surface water.

A summary of retained remedial technologies is included in Table 5-2.

5 Assembly, Development, and Analysis of Remediation Alternatives

Remediation technologies retained after screening (Section 4) are examined in this section as remediation alternatives to identify one or more options that will address site RAOs.

5.1 Alternatives – Copper and pCu in Soil

Only one alternative has been developed to consider for remediation of copper and pCu within the LIU, which is actually not a remedial action because it is the “no action” alternative. Because no exceedances of Pre-FS RAC for copper or pCu have been observed, general response actions that treat source areas or exposure pathways are not necessary nor evaluated further in this FS.

- Alternative 1: No Action.

This alternative would leave the site for upland soil for total metals and pCu in its current state.

5.2 Alternatives – Metals in Surface Water and Sediment

Two alternatives have been retained and developed to consider for remediation for total metals in surface water and sediment within the LIU.

- Alternative 1: No Action
- Alternative 2: Monitoring

5.2.1 Alternative 1: No Action

A no action alternative is included for surface water and sediment management of metals exceeding Pre-FS RAC or sediment PEC criteria, which were found to be zinc, copper, and nickel. However, only one surface water exceedance of Pre-FS RAC occurred, which was for zinc, which may have been due to natural mineralization. NMED did not specify any Pre-FS RAC for sediment in the LIU, which was supported by this FS finding that the locations with sediment exceeding the PEC have limited habitat value. For these reasons, general response actions that treat source areas or exposure pathways for surface water or sediment are not necessary. Additionally, the sitewide abatement program is responsible for remediating exceedances of water quality criteria and any concerns with contamination in surface water and groundwater and associated sediments will be addressed under that program. Thus, the no action alternative for surface water and sediment is viable for the LIU.

5.2.2 Alternative 2: Monitoring

In this alternative, Tributaries 1, 2A, or 2 could be monitored to document natural attenuation of the few areas with exceedances of water quality criteria or sediment PECs. This alternative is already being implemented under the sitewide abatement program and would be supported for continuation by this FS and could be further enhanced with additional monitoring (see Section 5.5.2) beyond the sitewide abatement program.

5.3 Evaluation Criteria

The remediation alternatives developed in Section 5.1 and 5.2 are evaluated against nine weighting criteria in this Section. From this evaluation, a final remediation alternative is recommended for each remedial component (e.g., media - metal).

The descriptions provided below include the major activities for each remedy at sufficient level of detail for the purposes of evaluating the weighting criteria in this FS. Detailed designs, sampling and analysis plans, inspection and monitoring plans, and other documents necessary for implementing the alternatives will be prepared at a later date after the remedy has been selected and documented in the ROD. Remedial alternatives analysis is based on the full list of USEPA evaluation criteria (except cost effectiveness), including:

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness and permanence;

- Reduction of toxicity, mobility, or volume;
- Short-term effectiveness;
- Implementability;
- NMED acceptance; and
- Community acceptance.

Cost effectiveness was not used as an evaluation criterion for this FS based on the information presented in Section 5.3.2.5.

In addition to the above standard EPA evaluation criteria, the remedial alternatives will be evaluated using green remediation criteria, which may include, but may not be limited to, conservation of natural resources, carbon footprint, greenhouse gas emissions, and sustainability of the design.

The first two criteria are considered threshold criteria. Threshold criteria are minimum requirements that must be satisfied by an alternative. These criteria are applied to individual alternatives, but not used in the comparative evaluation of alternatives. The next five are the balancing criteria. Comparative evaluation is based on the balancing criteria used to assess tradeoffs between each alternative.

The remaining two criteria, state and community acceptance are modifying criteria and are more difficult to assess at the FS stage. Typically, after the FS is finalized, an alternative is selected as the proposed remedial action. The proposed remedial action is described along with the basis for its selection in the Proposed Plan. The evaluation of the modifying criteria is based on the state and public comments on the FS and the Proposed Plan. State and community concerns, and any resulting changes in the selected remedial actions, are documented in the ROD for the site. Therefore, the two modifying criteria are not evaluated yet in this draft document but can be added at a later date when comments are received.

Each of the remedial alternatives have been summarized in Tables 5-4 through 5-5 for: soils – copper and pCu, sediment and surface water – metals.

5.3.1 Threshold Criteria

Under CERCLA, remediation alternatives must meet the following two threshold requirements:

- Overall protection of human health and the environment; and
- Compliance with ARARs.

5.3.1.1 Protection of Human Health and Environment

This criterion addresses the degree to which an alternative is protective of human health and the environment, considering both long-term and short-term risks. Overall protectiveness is a threshold criterion used to eliminate from further consideration those alternatives that do not achieve adequate protection of human health or the environment. The ability of the alternatives to achieve RAOs is part of the evaluation of this criterion. This criterion considers the evaluation of other criterion, especially long-term effectiveness and permanence; reduction of toxicity, mobility and volume; and short-term effectiveness, to summarize the overall effectiveness of the alternative to meet these other criterion. Because this criterion provides a comprehensive evaluation, it is used to screen individual alternatives, but not used in a comparative evaluation of the alternatives.

5.3.1.2 Compliance with ARARs

This criterion addresses whether or not the alternative meets ARARs, which were defined in Section 2. As with overall protectiveness, compliance with ARARs is a threshold criterion that much be met for an alternative to be selected.

5.3.2 Balancing Criteria

5.3.2.1 Long-term Effectiveness and Permanence

This criterion addresses the results of remedial actions in terms of the risk remaining at the site after the response action objectives have been met and the reliability of the remedial action at reducing risks over an extended period of time. The primary focus of this evaluation is the extent and effectiveness of the control that may be required to manage the risks posed by the contaminants in the long-term.

5.3.2.2 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the degree to which a remediation alternative reduces the toxicity of contaminants, the ability of the contaminants to migrate into the accessible environment, or the volume/quantity of the contaminated material. This criterion focuses the analysis of the preference for treatment under CERCLA. Effectiveness and reliability of treatment are addressed under long-term effectiveness and permanence and are not addressed under this criterion.

5.3.2.3 Short-term Effectiveness

This criterion addresses short-term effects on human health and the environment while the alternative is being implemented. The following factors should be addressed as appropriate for each alternative: protection of community and workers during construction, environmental impacts, amount of time to implement the remedial actions.

5.3.2.4 Implementability

This criterion addresses the degree of difficulty in implementing each alternative. Implementability can be divided into three categories: technical feasibility, administrative feasibility, and availability of services and materials. Implementability is a key criterion for more complex alternatives and reliance on innovative technology increases. Implementability issues are important because they address the potential for schedule delays, cost increases, and remedy failure to achieve the intended results. The evaluation considers the following:

- *Technical Feasibility.* Addresses site-specific factors that could prevent successful implementation of an alternative. As previously mentioned in Section 4 implementability issues could include physical interferences, such as bedrock, steep slopes, or limited access.
- *Administrative Feasibility.* The degree of difficulty anticipated due to regulatory constraints such as permit approvals and degree of coordination between regulatory agencies and stakeholders.
- *Availability of Services and Materials*. The availability of labor, equipment, and materials to implement the alternatives.

5.3.2.5 Cost

The criterion is generally used to consider the costs of implementing each alternative including capital costs and operating, monitoring, and maintenance costs. Costs that are excessive compared to the overall effectiveness may be considered as one of several factors used to eliminate an alternative. Alternatives providing effectiveness and implementability similar to that of another alternative, but at a higher cost, may be eliminated.

While this criterion typically plays a key role in the decision-making process for remedy selection, it did not play such a role in this FS because the monitoring threshold for soil was not achieved and no Pre-FS RAC were exceeded for soil. Further, while the No Action and Monitoring alternatives are evaluated for surface water and sediment, costs associated with Monitoring are always higher when compared with No Action (which has no costs) and thus a cost comparison is not informative. Considering this, more focus is placed on the other eight evaluation criteria, as described below.

5.3.3 State and Community Acceptance

The last two evaluation criteria are not evaluated in this draft LIU FS. These criteria will be addressed in the ROD and could be added to the final version of this FS.

5.3.4 Green Remediation

Factors for each remedial alternative that will be evaluated will also be evaluated as a green alternative, which may include, but may not be limited to, conservation of natural resources (fuel), carbon footprint, greenhouse gas emissions, and sustainability of the design.

5.4 Evaluation of Soils Alternatives – Copper and pCu

As presented in Section 3, all sample-specific concentrations were within Pre-FS RAC criteria for pCu and copper. It is therefore appropriate to evaluate only the single remaining alternative after the initial screening in Section 4, which is as follows:

- Alternative 1: No Action.

The No Action alternative meets threshold criteria, as there is no risk to human health and the environment given the current state of the soils that meet the NMED ARAR of the Pre-FS RAC and all other ARARS. Balancing criteria are also met by this alternative. The alternative is effective in both the short and long term, given that the current state of metals concentrations and pCu in the soil meets Pre-FS RAC that is protective of plants and wildlife. The alternative does not reduce toxicity; however, no reduction in toxicity is required to be protective. Mobility and volume are also not reduced. Mobility via wind dispersal and dust provides a potentially complete exposure pathway to human receptors. As discussed in the RI, risk to human receptors from the dust is low, and as such the Pre-FS RAC do not include criteria for human receptors. The No Action alternative is implementable and it is a green alternative in that no gas emissions would be lost and resources would be conserved. The detailed evaluation of this alternative for the nine weighting criteria plus green remediation criteria is outlined in Table 5-1.

5.4.1 Preferred Alternative – Surface Water and Sediment

The No Action alternative is the preferred alternative selected for sediment and surface water.

5.5 Evaluation of Sediment and Surface Water Alternatives – Metals

As described in Section 3, only one location of surface water, which was in Tributary 2, had a zinc exceedance of the Pre-FS water quality criteria in a shallow alluvial sample. Tributary 1 is ephemeral (no springs) in locations with the highest concentrations (exceedances of PEC), and those concentrations do not exceed acute criteria.

Sediment exceedances are not an issue because NMED did not provide any Pre-FS RAC for sediment COPCs.

While the somewhat ephemeral nature of Tributary 2 also minimizes risk to the aquatic population, implementation of one of the two alternatives evaluated below may be warranted in Tributary 2 with its single exceedance of a Pre-FS RAC that may or may not be due to mining.

As discussed in Section 5 and outlined in Table 5-3, the remedial alternatives are:

- Alternative 1: No Action.
- Alternative 2: Monitoring.

5.5.1 No Action

The sitewide abatement program covers both surface water and sediment of the LIU tributaries (and groundwater); thus, the No Action alternative is implementable and allows for the current remedial design to be conducted under the ARAR compliance of the program. Human health and the environment are both protected through the sitewide abatement program. Therefore, the No Action alternative can meet these threshold criteria depending on the performance of the sitewide abatement program.

Because the No Action alternative allows for independent operation of the sitewide abatement program, any remediation, monitoring, or other actions would be conducted under that program. As such, the long-term and short-term effectiveness and permanence of the No Action alternative depends on the performance of the sitewide abatement program. This alternative does not reduce the toxicity, mobility, or volume of contaminants beyond what the program achieves, but the amount achieved is designed to meet state water quality standards. Habitat would not be disturbed by this alternative beyond that which occurs as part of the program, which is protective of habitat in the short-term. This is a green alternative in that it would conserve the current program to protect the natural resources and would not result in additional greenhouse gas emissions. The detailed evaluation of this alternative for the nine weighting criteria plus green remediation criteria is outlined in Table 5-2.

5.5.2 Monitoring

The monitoring alternative is the same as the no action alternative, except monitoring of Tributary 2 would be conducted outside of the sitewide abatement program. Monitoring is implementable as it has been ongoing in the tributaries in alluvial water, well water and in leachate of the sediments as part of the sitewide abatement program. Sediment has also been monitored as part of the AOC program. The sitewide abatement program already includes monitoring the tributaries, and it is uncertain any benefit would be derived from additional monitoring of Tributary 2, which has been remediated after the unplanned release in 2007 and has been shown to have recovered (Golder 2016). This alternative possibly would provide observations that could inform decisions on additional actions to those performed under the sitewide abatement program.

The monitoring alternative can be used to further evaluate natural attenuation of metals and the effectiveness of work performed under sitewide abatement on the sediments, as sediment concentrations are not compared to PECs under the sitewide abatement program. This would provide more certain long-term effectiveness and permanence of the protectiveness of the sediment, in addition to the protection of surface water and groundwater monitored under the sitewide abatement program. Although monitoring is not a remedy, it allows for complete understanding of risks to aquatic life and identification of potential non-compliance with threshold criteria if other locations are found in non-compliance during the monitoring. The monitoring could be the first step in additional actions. Similarly, while the alternative would not reduce toxicity, mobility, or volume, it can be used to evaluate all three aspects. Limited additional effort is required to conduct this monitoring alternative. Overall, the weighting criteria of the monitoring alternative itself for protection of human health and environment, compliance with ARARs, short and long-term effectiveness and permanence, reduction of toxicity mobility, or volume, are expected to have a similar rating as the No Action alternative, except the alternative would generally cost more because of the additional monitoring. The area that would be monitored for Alternative 2 for surface water and sediment beyond that done for the sitewide abatement program is presented on Figure 3-33.

Similar to the No Action alternative, vegetation and habitat would not be disturbed by the monitoring alternative with the exception of minor bioturbation of vehicles and sampling personnel activities. Active remedial actions would likely produce more harm than good because risk assessments show that human health and the environment are protected under current conditions. Greenhouse gas emissions associated with shipping samples, sampling analysis, and light vehicle use associated with the transportation of samples would occur on a limited basis. A disadvantage of this alternative is that it expends funds and greenhouse gas emissions to monitor an area that does not require remediation due to the lack of risk to human health and the environment. Therefore, monitoring would be conducted “just in case” an issue arises and needs treatment; however, a remedial issue is not likely to occur and monitoring may be a waste of resources. The sitewide abatement program would likely capture any new issues arising from the Stockpiles. The detailed evaluation of this alternative for the nine weighting criteria plus green remediation criteria is outlined in Table 5-2.

5.5.3 Preferred Alternative – Surface Water and Sediment

The No Action alternative was selected as the preferred alternative for surface water and sediment because the monitoring under the sitewide abatement program is expected to be sufficient and additional monitoring would be redundant, increase costs unnecessarily, and would not be the most sustainable alternative.

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Tables

TABLE 2-1
CHEMICAL-SPECIFIC POTENTIALLY APPLICABLE STANDARDS FOR THE LIU

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY

Regulatory Program/Authority	Citation	Medium of Potential Interest	Notes
Safe Drinking Water Act, Federal	40 Code of Federal Regulations (CFR) 141 Subpart F	Groundwater, Surface Water	Establishes primary drinking standards for public water systems.
Safe Drinking Water Act, Federal	40 CFR 143, Subpart B	Groundwater, Surface Water	Establishes secondary non-enforceable health goals for public water systems at levels resulting in no known or anticipated adverse health effects.
Clean Air Act, Federal	40 CFR 50	Air	Establishes primary and secondary ambient air quality standards.
Clean Air Act, Federal	40 CFR 60	Air	Establishes (referenced by NMED Air Quality Control Regulation 652) performance standards for new sources based on the specific source categories defined in the regulation.
Air Quality Control Act, State	20.2.3 New Mexico Administrative Code (NMAC)	Air	Establishes ambient air quality standards.
Air Quality Control Act, State	20.2.78 NMAC	Air	Defines emissions standards for hazardous air pollutants.
New Mexico Water Quality Act	20.6.2.7.VV NMAC	Groundwater, Surface Water	Definition of a toxic pollutant.
New Mexico Water Quality Act	20.6.2.3101 NMAC	Groundwater	Designates groundwater with total dissolved solids <=10,000 milligrams per liter as potential source of drinking water.
New Mexico Water Quality Act	20.6.4 NMAC	Surface Water	Provides water quality standards for human contact of surface waters. Defines water quality standards for livestock watering. This statute includes an anti-degradation policy, general water quality standards, primary contact standards, and wildlife standards.
New Mexico Water Quality Act	20.6.2.3103(A) NMAC	Groundwater	Establish human health standards for groundwater quality.
New Mexico Water Quality Act	20.6.2.3103(B) NMAC	Groundwater	Establishes additional standards for domestic water supplies.
New Mexico Water Quality Act	20.6.2.3103(C) NMAC	Groundwater	Establishes groundwater quality standards for irrigation use.
Resource Conservation and Recovery Act, Federal	40 CFR 261.24	Soil	Regulates the determination of hazardous wastes by defining the maximum concentrations of listed contaminants as measured using the Toxicity Characteristic Leaching Procedure.
CERCLA, Federal	40 CFR 300 Title 1, Section 101, 111	All Media	References the National Oil and Hazardous Substances Contingency Plan. Establishes funding and provisions for cleanup at hazardous waste sites.

TABLE 2-2
ACTION-SPECIFIC POTENTIALLY APPLICABLE STANDARDS FOR THE LIU

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY

Regulatory Program/Authority	Citation	Medium of Potential Interest	Notes
CERCLA	40 Code of Federal Regulations (CFR) 300 Title 1, Section 101, 111	All Media	References the National Oil and Hazardous Substances Contingency Plan. Establishes funding and provisions for cleanup at hazardous waste sites.
SARA	42 United States Code (USC) 9601	All Media	Establishes cleanup standards and response actions, including the Applicable or Relevant and Appropriate Requirements process (i.e., Applicable Standards).
Clean Water Act - National Pollution Discharge Elimination System	40 CFR 122 40 CFR 125	Surface Water	Requires permits for discharging pollutants from any point source into waters, lists hazardous substances and water-quality parameters, and defines the criteria and standards for issuances of permits, determining compliance, and granting variances. Establishes Best Management Practices to prevent releases of toxic constituents to surface waters.
Clean Water Act	40 CFR 230 40 CFR 231 Section 404	Surface Water	Requires permits for discharging dredged or fill materials into the navigable waters, including wetlands or floodplains. Permits (Sec 404) are issued if the state has authorization, otherwise, Nation Wide Permits can be issued by the United States Army Corps of Engineers. Applies to all stream modifications, including underground and surface mining activities.
Rivers and Harbors Act of 1899	33 CFR 320 33 CFR 330	Surface Water	Regulates disposal/discharge of dredged or fill materials into United States waters, including intermittent streams.
Resource Conservation and Recovery Act (RCRA)	40 CFR 241	Soil	Specifies performance requirements for land disposal of wastes.
RCRA	40 CFR 261	Soil	Defines criteria for identifying and classifying hazardous wastes.
RCRA	40 CFR 262	Soil	Establishes standards for generators of hazardous wastes, including requirements for waste shipment packaging, labeling, and manifests. Requirements may be applicable if remediation activities are performed at the Smelter/Tailing Soils Investigation Unit and waste generated are hazardous.
RCRA	40 CFR 263	Soil	Establishes standards for transporters of hazardous wastes.
RCRA	40 CFR 264	Soil	Establishes standards for owner and operators of facilities for the treatment, storage, and disposal of hazardous wastes.
RCRA	40 CFR 268	All Media	Establishes treatment standards for hazardous constituents, identifies wastes that are restricted from land disposal and defines the limited circumstances under which they may be land disposed.
United States Department of Transportation Regulations	49 CFR 173, 178, 179	Soil	Establishes requirements for packaging and shipment of hazardous waste.
CERCLA Off-Site Response Policy	OSWER 9634.11	All Media	Defines criteria for qualifying an off-site hazardous waste disposal facility.
Clean Air Act	42 USC Sections 7401 et. seq.	Air	Requires formulation of air quality standards and source performance standards.
New Mexico Hazardous Waste Act (NMHWA), New Mexico Environmental Department (NMED) Hazardous Waste Bureau (HWB)	New Mexico Statutes Annotated (NMSA) 1978, Sections 74-4-1 through 74-4-14	Hazardous Waste	Regulates treatment, storage, and disposal of hazardous waste to ensure maintenance to the quality of the state's environment.
NMHWA, NMED HWB	20.4.1.200 NMAC	Hazardous Waste	Defines criteria for identifying and classifying hazardous waste.
NMHWA, NMED HWB	20.4.1.300 NMAC	Hazardous Waste	Defines standards applicable to generators of hazardous wastes for packaging, labeling, and manifesting waste for transport.
NMHWA, NMED HWB	20.4.2.400 NMAC	Hazardous Waste	Defines standards applicable to the transportation of hazardous waste.

TABLE 2-2
ACTION-SPECIFIC POTENTIALLY APPLICABLE STANDARDS FOR THE LIU

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY

Regulatory Program/Authority	Citation	Medium of Potential Interest	Notes
NMHWA, NMED HWB	20.4.1.900 NMAC	Hazardous Waste	Identifies hazardous wastes which are restricted from land disposal.
New Mexico Solid Waste Management Regulations	20.9.1 NMAC	Solid Waste	Regulates the permitting, design, location, and operation of solid waste disposal facilities.
New Mexico Water Quality Act (NMWQA)	NMSA 1978, Sections 74-6-1 through 74-6-17	Groundwater, Surface Water	Bans non-permitted discharge of any water contaminant.
NMWQA	20 NMAC 6.2, Section 1-201	Groundwater, Surface Water	Requires that NMED be notified of any discharge which could affect surface water or groundwater quality.
NMWQA	20 NMAC 6.2, Section 3-104	Groundwater	Discharge plan may be required for any discharge affecting groundwater quality.
NMWQA	20 NMAC 6.2, Section 4-103	Groundwater, Surface Water	Abatement standards and requirements for the vadose zone, groundwater and surface water.
Occupational Safety and Health Act	29 CFR 1910, 1926, 1954	All Media	These standards establish safety requirements for hazardous waste operations and sets exposure limits of chemicals.
RCRA	42 USC Sections 8901 et. seq.	Hazardous Waste	Regulates treatment, storage, and disposal of hazardous waste and encourages resource conservation and recycling.

TABLE 2-3
LOCATION-SPECIFIC POTENTIALLY APPLICABLE STANDARDS FOR THE LIU

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY

Regulatory Program/Authority	Citation	Medium of Potential Interest	Notes
National Historic Preservation Act	36 Code of Federal Regulations (CFR) 63	Historic, Archaeological	Establishes procedures for determining a property's eligibility for inclusion in the National Register of Historic Places.
National Historic Preservation Act	36 CFR 800	Historic, Archaeological	Requires that federal agencies consider the effects of actions on historic properties and archaeological resources.
National Historic Preservation Act of 1979	36 CFR 296 43 CFR 7	Historic, Archaeological	Establishes procedures to be followed by federal land managers in providing protection for archaeological resources.
Standards and Guidelines for Archaeology and Historic Preservation	48 CRF 44716	Archaeological	Provides guidelines for conducting archaeological surveys.
American Indian Religious Freedom Act of 1978	42 United States Code (USC) 1996	Cultural	Requires consultation with local tribes if a project could effect ceremonial, religious, or burial sites.
American Indian Graves Freedom and Reparation Act	25 USC 3001 through 25 USC 3013	Cultural	Requires that project activities cease if Native American graves are discovered.
Migratory Bird Treaty Act	50 CFR 10, 21	Wildlife	Prohibits pursuit, hunting, taking, capture, possession, or killing of all migratory birds or their nests or eggs.
Bald and Golden Eagle Protection Act	50 CFR 10, 22	Wildlife	Prohibits taking or killing of bald and golden eagles.
Endangered Species Act of 1973	40 CFR 17 and 50 CFR 402	Plant, Wildlife	Requires that actions do not jeopardize endangered species or adversely modify their critical habitat, and establishes the process for consulting with the United States Fish and Wildlife Service.
Fish and Wildlife Coordination Act	40 CFR 6.302g	Surface Water	Requires that federal agencies be consulted prior to modifying any stream so that wildlife will be protected.
Endangered Species Act	16 USC 1531	Wildlife	Protects endangered species and restricts activities within their habitat.
Resource Conservation and Recovery Act (RCRA)	40 CFR 241.202	All Media	Establishes standards for sitting RCRA solid-waste disposal facilities.
Fish and Wildlife Coordination Act	40 CFR 6.302	Rivers	Protects wildlife habitats and prevents the modification of streams or rivers that effect fish or wildlife.
Executive Order, 11990	40 CFR 6 Appendix A	Wetlands	Protects wetlands and regulates activities conducted in a wetland area in order to minimize potential destruction, loss or degradation of the wetlands.
Clean Water Act	40 CFR 230 33 CFR 320-330	Wetlands	Prohibits filling of wetlands and prohibits the discharge dredged or filled material to a wetland without a permit.
Executive Order, 11988	40 CFR 6 Appendix A	Floodplains	Restricts the types of activities that can be conducted within a floodplain to minimize harm and preserve natural values.
New Mexico Cultural Properties Act	New Mexico Statutes Annotated (NMSA) 18.6	Historic, Archaeological	Requires identification of cultural resources, assessment of potential effects, and consultation with the State Historic Preservation Officer.
New Mexico Wildlife Conservation Act, and New Mexico Endangered Plant Act	NMSA 17-2-27 through NMSA 17-2-46	Plant, Wildlife	Establishes the State's authority to conduct an investigation for the purpose of identifying endangered and threatened species and developing (if necessary) an appropriate management plan for ensuring the protection of such species.
New Mexico Prehistoric and Historic Sites and Preservation Act	NMSA 1978, Sections 18-8-1 through 18-8-8	Historic, Archaeological	Requires identification of historic resources, assessment of potential impacts, and consultation with State Historic Preservation Office.

TABLE 2-3
LOCATION-SPECIFIC POTENTIALLY APPLICABLE STANDARDS FOR THE LIU

Regulatory Program/Authority	Citation	Medium of Potential Interest	Notes
National Environmental Policy Act	42 USC Section 4331 et. seq.	Ecosystems	Policy to encourage harmony between humans and the environment to minimize environmental damages and support health and welfare. The Act encourages coordination and cooperation between government agencies in planning and conduction of any action that will affect the government.
National Environmental Policy Act	40 CFR Part 6	Ecosystems	Procedures requiring integration of all applicable federal laws and executive orders into the environment review process mandated under the Act.

TABLE 3-1
INITIAL SCREENING DECISION CRITERIA FOR NATURE AND EXTENT EVALUATION (UPDATED TO 2023)

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LIU FEASIBILITY STUDY REPORT

Constituent	Surface soil		Shallow Soil		Sediment		Surface Water[a] (Tributary 1; hardness 94-400 mg/L)		Surface Water[a] (Tributary 2; hardness 152-400 mg/L)	
	Human Health Criteria[b]		Ecological Criteria[c]		Ecological Criteria		Ecological Criteria (Pre-FS RAC)		Ecological Criteria (Pre-FS RAC)	
	RSL (Resident)	RSL (Industrial)	Criteria	Note	TEC	PEC	Acute (mg/L)	Chronic (mg/L)	Acute (mg/L)	Chronic (mg/L)
Aluminum	77,000	1,100,000	26,300	95th %ile[d]	---	---	0.75 / 3.14-10.07[e,f]	0.087 /1.26-4.03[e,f]	0.75 / 6.07-10.07[e,f]	0.087 / 2.43-4.03[e,f]
Arsenic	0.68 (Max ref = 7.2)	3 (Max ref = 7.2)	43	Eco SSL-A	---	---	0.34	0.15	0.34	0.15
Barium	15,000	220,000	181	Eco SSL-I	---	---	---	---	---	---
Boron	16,000	230000	6.4	95th %ile[d]	---	---	---	---	---	---
Beryllium	160	2,300	21	Eco SSL-M	---	---	---	---	---	---
Cadmium	7.1	100	11	BERA-A	0.99	4.98	0.0017-0.0065[f]	0.0007-0.002[f]	0.0027-0.0065[f]	0.001-0.002[f]
Chromium III	120,000	1,800,000	26	Eco SSL-A	43.4	111	0.54-1.77[f]	0.07-0.23[f]	0.80-1.77[f]	0.10-0.23[f]
Cobalt	23	350	120	Eco SSL-A	---	---	---	---	---	---
Copper	3,100	47,000	268 / 514	SiteW ERA-A / Max Ref	31.6	149	0.013-0.05[f]	0.008-0.029[f]	0.02-0.05[f]	0.013-0.029[f]
Iron	55,000	820,000	32,900	95th %ile[d]	---	---	---	---	---	---
Lead	400	800	23 / 35	SiteW ERA-A	35.8	128	0.06-0.28[f]	0.002-0.011[f]	0.102-0.28[f]	0.004-0.011[f]
Manganese	1,800	26,000	4,000	Eco SSL-M	---	---	2.92-4.74[f]	1.62-2.62[f]	3.43-4.74[f]	1.90-2.62[f]
Molybdenum	390	5,800	9.7 / 15	SiteW ERA-A / Max Ref	---	---	---	---	---	---
Nickel	1,400	18,000	130	Eco SSL-M	22.7	48.6	0.04-1.5[f]	0.05-0.17[f]	0.67-1.5[f]	0.074-0.17[f]
Selenium	390	5,800	0.6 / 1.2	SiteW ERA-A / Max Ref	---	---	0.02	0.005	0.02	0.005
Vanadium	390	5,800	7.8 / 39	Eco SSL-A / Max Ref	---	---	---	---	---	---
Zinc	23,000	350,000	46 / 878	SiteW ERA-A / Max Ref	121	459	0.15-0.564[f]	0.12-0.428[f]	0.234-0.564[f]	0.177-0.428[f]
pCu	---	---	<6 / <5	SiteW ERA-P / Pre-FS RAC	---	---	---	---	---	---

Notes:

[a]Surface water criteria are from NMAC 20.6.4.900, updated from the remedial investigation values in Arcadis (2012) to February 8, 2023. Hardness was also updated when calculating criteria based on values in Golder (2016) or using magnesium and calcium data to estimate hardness.

[b]USEPA Region 6 Human Health Medium-Specific Screening Levels, Residential Soil and Industrial Indoor Worker (updated to 2023). If background higher, background (Max ref in parentheses) was the decision criteria (except on Figures 3-2 through 3-16).

Maximum of reference locations (Max ref) is background threshold used for nature and extent analysis of site locations in Tables with exceedances, but soil maps (Figures 3-2 through 3-16) applied human health or ecological criteria to all site and reference locations equally.

[c]Ecological soil decision criteria are either an EcoSSL, value from sitewide ERA receptor, or 95 percentile sitewide ERA updated to upland only (left of slash). If background higher, background threshold was the criteria (right of slash).

[d]Soil threshold was set to 95 percentile of upland surface soil concentrations reported for aluminum, boron, and iron in Appendix E of the Sitewide ERA (Newfields 2005) because no EcoSSL was available, and the 95 percentile was not of concern for risk from mining activities in the Sitewide ERA.

[e]Surface water criteria are dissolved, except aluminum and selenium are based on total recoverable metal. Hardness-adjusted total aluminum criteria are applied to water of pH 6.5 to 9 (right of slash); dissolved unadjusted aluminum criteria are applied when pH < 6.5 (left of slash).

[f]This criteria is hardness dependent. The equation to compute criteria presented in NMAC Section 20.6.4 (effective 2023) was used to compute drainage-specific decision criteria.

1. Results are shown in milligrams per kilogram (mg/kg) for soil and sediment and in milligrams per liter (mg/L) for surface water, except for pCu (pCu is unitless).

2. pCu = -log(cupric ion activity), is 6 in the LIU remedial investigation based on the lower DEL in the Sitewide ERA but the LIU ERA, completed in 2018, specified decision criteria with confidence of significant effects is at pCu<5, and thus the Pre-FS RAC for plants is pCu < 5 when copper > 327 mg/kg.

Acronyms and Abbreviations:

--- = no criteria for this constituent/media.
95%ile = 95 percentile
BERA = Baseline Ecological Risk Assessment
Eco SSL-A = Ecological soil screening level for avian receptors
Eco SSL-I = Ecological soil screening level for invertebrate receptors
Eco SSL-M = Ecological soil screening level for mammalian receptors
ERA = Ecological Risk Assessment
NMAC = New Mexico Administrative Code
PEC = probable effects concentration
Pre-FS RAC = pre-feasiblity study Remedial Action Criteria
RSL = regional screening level.
SiteW ERA-A = Baseline Sitewide Ecological Risk Assessment (small ground feeding bird receptors soil screening level)
SiteW ERA-P = Baseline Sitewide Ecological Risk Assessment (plant receptors soil screening level)
TEC = threshold effects concentration
USEPA = United States Environmental Protection Agency

References:

Arcadis U.S., Inc. (Arcadis). 2012. Administrative Order on Consent, Chino Mines Company. Remedial Investigation Report, Lampbright Investigation Unit. 2nd Revision, December.

Golder Associates, Inc. (Golder). 2016. Site-Wide Stage 1 Abatement Plan. Revised Final Site Investigation Report. March.

NewFields. 2005. Chino Mines Administrative Order on Consent Site-Wide Ecological Risk Assessment. Revision 1. November.

TABLE 3-2
LIU SURFACE (0-1 INCHES) SOIL DATA

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Sample Location	Type	Year	Al	As	Ba	Be	B	Cd	Cr	Co	Cu	Fe	Pb	Mn	Mo	Ni	Se	V	Zn	pH
L-01	Site	2010	6,870	2.8	58.3	0.29	2.9	0.50	10	8.6	411	16,200	34.6	460	22.3	6.6	0.8	19	72.9	--
L-02	Site	2010	21,700	**9.1**	105	1.2	7.9	0.72	43.5	11.1	275	29,300	16.7	610	8.8	32.7	0.81	50.0	117.0	--
L-03	Site	2010	18,300	3.3	148	0.71	1.8	0.62	22.7	10.0	317	22,900	25.7	364	13.8	13.6	0.75	49.2	90.1	--
L-04	Site	2010	10,000	4.5	76	0.8	1.4	0.35	11.1	7.2	188	18,900	15.7	245	11.3	9.1	0.29	23.7	89	--
L-05	Site	2010	10,700	4.1	93.7	0.58	5.1	1.10	12.1	14	431	14,100	58	1,100	17.3	8.9	<0.1	23.9	117.0	--
L-06	Site	2010	10,400	1.5	91	0.52	<0.81	0.22	5.5	6.9	171	16,800	14.4	191	11.2	6.0	0.40	13.3	64.0	--
L-07	Site	2010	13,100	5.6	153	0.68	5.7	1.5	12.7	17.8	614	17,000	45.1	1,040	22.7	11.4	<0.92	25.2	164.0	--
L-08	Site	2010	15,100	2.1	123	0.51	0.81	0.42	19.1	11	371	24,400	29.9	458	23.3	10.6	0.89	40.5	122	--
L-09	Site	2010	12,400	3.0	149	0.79	1.6	0.32	8.7	10.3	116	23,400	15.3	316	4.30	11.1	0.44	24.2	70.1	--
L-10	Site	2010	12,100	3.5	112	0.85	2.6	0.46	8.3	13.1	176	25,100	17	402	6.6	13.5	0.33	23.8	94.7	--
L-11	Site	2010	10,300	3.6	100.0	0.58	3.7	0.93	10.4	10.7	277	12,600	63.2	859	9.3	8.2	<0.58	23.6	112	--
L-12	Site	2010	13,400	2.5	97.3	0.51	<0.81	0.46	14.4	7.8	285	22,400	21.1	328	16.4	8.1	0.45	37	84	--
L-13	Site	2010	28,800	1.6	486	0.74	0.84	0.9	31.1	14	197	32,300	23.0	754	8.0	15.2	0.52	59.9	120.0	--
L-14	Site	2010	16,000	1.4	65.0	0.60	0.89	0.81	22.4	15.5	278	25,900	15.9	660	7.8	12.8	0.5	54.1	92.4	--
L-15	Site	2010	14,900	2.3	110	0.61	1.4	0.8	12.3	10.6	214	20,700	24.0	553	7.1	8.1	0.32	35.2	97.7	--
L-16	Site	2010	10,400	1.4	100	0.68	1.6	0.69	11.7	8.3	145	13,700	15.1	614	5.1	6.9	0.5	30	48	--
L-17	Site	2010	12,500	5	89	0.60	4	0.88	12.2	9.5	271	13,100	47.3	634	7.9	7.8	0.57	25	84	--
L-18	Site	2010	24,000	1.6	397	1	5.0	1.5	6.2	10.9	238	20,100	20.9	580	5.7	5.4	<0.1	40.9	84.5	--
L-19	Site	2010	25,600	**9.1**	125	1.4	10.9	1.10	44.8	9.9	247	28,900	24.9	389	7.8	33.4	<0.4	41.7	106.0	--
L-20	Site	2010	26,100	**28.3**	133	1.1	10.9	1	57	8.7	223	22,600	21.1	727	6.9	33.0	<0.1	49.4	112.0	--
L-21	Site	2010	8,730	4	135	1	4.3	1.20	10	12.5	266	13,500	66.7	1,440	12.8	10.2	<0.35	20.8	125	--
R-1	Reference	2010	12,000	***6***	85	0.78	3.6	0.60	14	17.2	599	26,000	29	752	33.7	11.0	1.10	24.8	403	--
R-2	Reference	2010	10,200	***4.6***	114	0.45	3.8	0.70	13.6	11.7	734	23,000	54.2	783	42.0	8.9	0.9	26.9	114.0	--
R-3	Reference	2010	9,300	***4.2***	93	0.45	3.5	0.69	12.1	11.9	614	18,700	41.1	807	28	8.2	0.79	23.5	101.0	--
R-4	Reference	2010	7,370	***3.7***	65.7	0.34	3.3	0.39	9.6	8.7	477	17,100	30.0	356	26.9	6.2	0.80	19.3	81.2	--
R-5	Reference	2010	9,170	***1.9***	119	0.62	2.9	0.85	6.6	8.9	343	14,600	22.4	680	14.6	5.9	0.77	21.2	69.6	--
R-6	Reference	2010	11,600	***1.0***	93.2	0.77	2.1	0.59	6.8	6.3	159	12,300	15.2	447	5.9	4.7	0.58	21	42.8	--
2001	Reference	1995	15,300	***7.2***	128	1.2	3.6	0.68	16	22.5	170	29,500	38.6	1,430	5.2	18	0.5	27	886.0	6.1
2009	Reference	1995	10,600	***4.7***	115	0.3	3.3	0.42	6.3	10.9	204	30,300	25.1	802	2.1	9.1	0.20	99.7	36.8	6.5
2002	Site	1995	--	--	--	--	--	--	--	6.5	186	--	--	--	--	--	--	73.6	--	8.4
2003	Site	1995	12,400	**9.0**	96	0.6	1.4	<0.2	7.6	9.3	294	26,900	28.2	246	12.4	11.9	1	16.3	107	5.1
2004	Site	1995	--	--	--	--	--	--	--	7	172	--	--	--	--	--	--	217	--	5.0
2005	Site	1995	29,400	**14.1**	141	1.12	8.40	2.03	51.4	16.4	152	23,700	22.0	712	0.6	35.5	1.50	42.8	243.0	8.1
2006	Site	1995	--	--	--	--	--	--	--	9.4	150	--	--	--	--	--	--	**566**	--	4.5
2010	Site	1995	9,930	4.2	124	0.5	2.5	0.23	7.8	6	199	20,600	19.8	222	7.2	8.4	0.4	261.0	18	5.0
2011	Site	1995	--	--	--	--	--	--	--	6.5	146	--	--	--	--	--	--	146	--	5.4
2012	Site	1995	--	--	--	--	--	--	--	10.1	69.1	--	--	--	--	--	--	62.8	--	7.0
2007	Site	1995	14,700	2.7	223	0.4	<1.2	<0.2	12.2	10.5	88.1	19,100	19.3	729	0.8	12.0	0.20	30	140	6.7
2008 (duplicate of 2007)	Site	1995	13,000	3.0	193	0.41	<1.2	0.24	10.4	13.0	214	17,400	21.8	818	3.4	8.6	0.3	24	191	5.8
SS102	Site	2006	13,900	2.2	228	0.6	<1.7	0.41	99	**24**	201	34,200	20.1	615	5.3	26.2	0.24	125	73.1	5.8

Notes:

1. All samples were collected from 0-1 inch below ground surface.
2. All results presented in milligram per kilogram (mg/kg).
3. < is used for values below the method detection limit.
4. Shading is used to identify reference locations.
5. **Bold** is used for site locations exceeding the updated USEPA Screening Human Health Criteria (2023) for Regional Screening Level Residential values (https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide) listed in Table 3-1, except not bolded if does not exceed background (maximum reference concentration).
6. **Bold** and *italics* is used for reference locations (gray shading) representing background areas exceeding the updated 2023 residential screening criteria in Table 3-1.
7. In refined the Tier 2 human health risk assessment, only Mn strongly contributed to a high hazard index for dust, but was not considered a realistic risk because the quantity of dust was conservatively overestimated.

TABLE 3-3
LIU SHALLOW (0-6 INCHES) SOIL DATA

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Sample Location	Type	Year	Al	As	Ba	Be	B	Cd	Cr	Co	Cu	Fe	Pb	Mn	Mo	Ni	Se	V	Zn	pH	pCu
L-01	Site	2010	8,320	3.4	76.2	0.43	4.3	0.59	15	10.2	253	22,600	**38.8**	684	6.9	9	0.9	27	85.4	6.2	6.8
L-02	Site	2010	21,300	7.1	90.7	1.1	**6.8**	0.57	**46.1**	8.6	108	25,200	13.3	432	2.2	33.8	0.47	**47.8**	89.5	7.3	8.8
L-03	Site	2010	23,800	3.7	234	0.99	1.9	0.72	**28.7**	10.8	167	26,000	25.5	517	4.9	18.1	0.33	**61.1**	91.1	5.5	6.6
L-04	Site	2010	19,500	6.9	**183**	1.5	1.6	0.54	17.5	6.7	75.1	25,300	19.8	323	2.2	14.8	0.6	34.4	107	6.6	8.5
L-05	Site	2010	10,900	9.4	80.2	0.84	4.6	0.76	**28.4**	9	152	25,100	**107**	759	4.3	8.8	<0.44	**64.6**	76.1	5.9	7.1
L-06	Site	2010	13,800	1.3	112	0.87	0.86	0.32	5.9	10.1	118	18,200	15.1	431	2.3	8.1	0.38	14.7	71.6	4.6	6.2
L-07	Site	2010	12,100	5.7	120	0.75	4.7	0.9	17.3	10.7	246	16,500	**37.1**	760	5.5	9.3	<0.58	36.9	96.1	5.5	6.1
L-08	Site	2010	15,100	2.1	111	0.57	<0.81	0.59	18.6	13	319	22,600	29.8	673	8.9	10.9	<0.3	**39.9**	125	4.2	**4.6**
L-09	Site	2010	16,800	3.2	**216**	0.92	3.4	0.28	11.9	8.6	25.8	25,500	16.9	371	0.89	13.1	0.61	29.9	65.2	7.6	10.7
L-10	Site	2010	12,200	3.5	110	0.87	2.9	0.33	7.7	9.6	65.9	27,400	15	331	1.7	13.8	0.56	23.4	63.4	7.5	9.5
L-11	Site	2010	10,700	6.3	94.5	0.78	4.7	0.71	21.7	8.2	95.2	23,900	**88.5**	837	2.3	9.3	0.42	**52.3**	118	6.2	7.9
L-12	Site	2010	14,800	1.7	99.3	0.63	<0.81	0.42	15.3	9.4	102	21,600	13.6	542	2.4	8.4	<0.1	**41**	79	5.0	6.7
L-13	Site	2010	23,500	1.4	**375**	0.65	<0.81	0.9	18.9	9	85.4	23,300	21.3	738	2.2	11.5	<0.1	37.2	90.2	6.2	8.0
L-14	Site	2010	14,600	1.1	65.1	0.54	<0.81	0.68	16.7	11.1	106	20,600	**35.9**	570	1.7	10.9	<0.2	**42.9**	62.3	5.3	6.9
L-15	Site	2010	16,400	1.8	136	0.67	<0.81	0.6	11.4	8.4	133	19,800	18.9	552	2.6	7.8	0.49	33.5	89.1	5.7	7.0
L-16	Site	2010	12,000	1.2	99	0.75	1.4	0.53	11.9	6.5	61.4	15,400	13.1	476	1.4	6.8	0.3	36	33	6.0	8.2
L-17	Site	2010	13,100	7	110	0.74	4	0.66	20.2	9.8	114	17,600	**47.8**	709	2.7	9.2	<0.6	**41**	56	6.0	7.5
L-18	Site	2010	**28,900**	1.3	**566**	1	4.2	1.7	4.4	8.7	80.9	19,700	14.4	548	0.92	4.5	<0.3	37.2	61.7	6.0	7.9
L-19	Site	2010	25,800	8.4	125	1.3	**12.5**	0.92	**46.7**	8.4	76	27,500	17.2	340	0.98	35.4	<0.3	**43.4**	69.6	7.6	9.4
L-20	Site	2010	**29,600**	35.9	127	1.3	**10.9**	1	**63**	7.5	63.3	23,200	14.4	637	1.3	39.8	<0.3	**59.2**	99.7	7.2	9.3
L-21	Site	2010	9,440	4	127	1	4.1	0.81	12	8.8	100	16,500	**80.4**	841	2.9	9.3	<0.3	29.4	118	5.9	7.5
R-1	Reference	2010	14,800	8.5	131	1.4	3.5	0.99	17	21.3	322	32,100	***28***	1,650	9.6	18.4	***0.95***	***28.8***	***878***	5.2	***5.5***
R-2	Reference	2010	10,100	4.7	120	0.53	3.3	0.74	15.5	11.5	***506***	18,600	***35.1***	868	***15.1***	8.7	***1.2***	***28.4***	***97.4***	5.1	***4.9***
R-3	Reference	2010	9,910	5.6	93	0.62	3.6	0.71	18.4	12.1	***514***	21,500	***32.8***	875	***14***	8.9	***0.85***	***38.9***	***94.2***	5.1	***4.9***
R-4	Reference	2010	7,260	5.4	61.8	0.45	3.2	0.53	14.2	10.7	***308***	21,200	***29.4***	535	9.2	7.5	***0.73***	***25.8***	***89.9***	4.7	***5.1***
R-5	Reference	2010	9,920	0.81	78.7	0.68	1.4	0.33	4.3	3.8	57.3	10,200	11.2	247	1.5	3.4	0.15	***19.6***	24.1	5.3	7.6
R-6	Reference	2010	11,300	0.72	77.7	0.74	1.9	0.45	4.8	4.1	35.2	9,330	10.5	249	0.8	3.3	0.53	***18***	23.6	5.6	8.5

Notes:

1. All samples were collected from 0-6 inch below ground surface.
2. All results are presented in milligram per kilogram (mg/kg).
3. < indicates value below the method detection limit.
4. Shading is used to identify reference locations.
5. **Bold** indicates constituents exceeded screening ecological criteria **and** background value in Table 3-1 (but corresponding Figures show exceedances of ecological criteria only, not background).
6. **Bold** and *italics* is used for reference locations (gray shading) representing background areas exceeding ecological screening criteria in Table 3-1.

   Even if some site concentrations are bolded, Ba, Cr, Cu, Pb, Se, and Zn means were not statistically significantly higher than reference mean (Arcadis 2012 Remedial Investigation), and thus not of concern for ecological risk from mineral processing.

   Additionally, the ecological risk assessment (ERA; Formation 2018) indicated B and Al were not constituents of potential concern (COPCs) for ecological risk in the Sitewide ERA, and not of concern at the concentrations observed at LIU.

   The LIU ERA also stated that V is not of concern as the bird Ecological Soil Screening Level (EcoSSL) is too low since all reference areas exceed the avian EcoSSL; mammal EcoSSL of 280 mg/kg may be more appropriate (and V is not from mineral processing.)

   Additionally, in the refined LIU ERA, lowest-adverse-effect-level (LOAEL) based hazard quotients were <1 for the most sensitive bird and mammal receptors for Cd, Cu, Pb, Mo, Se, and Zn, further supporting minimal risk.
7. **Bold** and red text exceeds the pre-feasiblity study Remedial Action Criteria (pre-FS RAC) for soil or LOAEL of ERA receptor; **none exceed**. (For pCu, pre-FS RAC are not met when **both** pCu (< 5) and copper criteria (> 327 mg/kg) are not met, which is true for only 2 reference samples.)

References:

Arcadis. 2012. Administrative Order on Consent, Chino Mines Company. Remedial Investigation Report, Lampbright Investigation Unit. 2nd Revision, December.

Formation Environmental (Formation). 2018. Ecological Risk Assessment for Lampbright Investigation Unit Chino Mine Investigation Area, Grant County, New Mexico. Prepared for New Mexico Environment Department. (Section 5, General Risk Assessment Uncertainties, updated 2019).

TABLE 3-4
SURFACE WATER DATA, TRIBUTARY 1

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Location ID	Sample Type	Sample Date	pH	Hardness	Al (Total)	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	Se (Total)	V	Zn
LB7S	Shallow Alluvial Water	10/4/2007	7.97	149	**3.61**	< 0.025	0.0294	< 0.002	0.154	< 0.0002	33.8	< 0.006	< 0.006	0.00214	< 0.06	< 0.003	6.55	0.0233	0.0144	< 0.01	< 0.003	0.0059	< 0.01
		11/27/2007	7.89	126	**4.45**	< 0.025	0.0253	< 0.002	0.151	< 0.0002	32.2	< 0.006	< 0.006	**0.0116**	< 0.06	< 0.003	6.03	0.0103	0.0089	< 0.01	< 0.003	0.0062	< 0.01
		1/9/2008	7.95	94	0.56	< 0.025	0.0259	< 0.002	0.143	< 0.0002	33.6	< 0.006	< 0.006	0.00388	< 0.06	< 0.003	6.34	0.0084	0.0162	< 0.01	< 0.003	0.0052	< 0.01
		4/2/2008	8.01	---	---	< 0.025	0.0277	< 0.002	0.137	< 0.002	36.3	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	6.70	0.0102	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		6/18/2008	8.13	116	---	< 0.025	0.0261	< 0.002	0.137	< 0.002	35.3	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	6.81	< 0.004	< 0.008	< 0.01	< 0.003	0.0055	< 0.01
		8/20/2008	7.91	117	---	< 0.025	0.0251	< 0.002	0.128	< 0.002	33.1	< 0.006	< 0.006	< 0.010	< 0.006	< 0.0075	6.49	< 0.004	< 0.008	< 0.01	< 0.003	0.0053	< 0.01
		9/16/2008	7.91	114	---	< 0.025	0.0272	< 0.002	0.146	< 0.002	34.5	< 0.006	< 0.006	***0.027***	< 0.06	< 0.0075	6.41	< 0.004	< 0.008	< 0.01	< 0.003	0.0052	< 0.01
376-2005-04	Shallow Alluvial Water	10/4/2007	7.74	624	***19.40***	< 0.025	0.143	< 0.002	0.117	< 0.0002	165	< 0.006	0.008	0.00211	< 0.06	< 0.003	40.5	1.89	0.0337	< 0.01	< 0.003	< 0.005	< 0.01
		11/27/2007	8.1	398	3.0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		1/9/2008	8.07	368	1.97	< 0.025	0.0804	< 0.002	0.088	< 0.0002	119	< 0.006	0.008	0.00574	< 0.06	< 0.003	27.2	0.0206	0.038	< 0.01	< 0.003	< 0.005	< 0.01
		2/20/2008	---	378	< 0.08	< 0.025	0.0831	< 0.002	0.092	< 0.002	117	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	26.5	0.0248	0.0289	< 0.01	< 0.003	< 0.005	< 0.01
		4/2/2008	7.88	392	---	< 0.025	0.072	< 0.002	0.08	< 0.002	117	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	24.6	0.0131	0.0136	< 0.01	< 0.003	< 0.005	< 0.01
		6/18/2008	8.13	412	---	< 0.025	0.0638	< 0.002	0.082	< 0.002	120	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	26.1	0.0048	0.012	< 0.01	< 0.003	< 0.005	< 0.01
		8/20/2008	7.87	473	---	< 0.025	0.0758	< 0.002	0.07	< 0.002	124	< 0.006	< 0.006	< 0.010	< 0.006	< 0.0075	29	< 0.004	0.0101	< 0.01	< 0.003	< 0.005	< 0.01
		9/16/2008	7.99	385	---	< 0.025	0.069	< 0.002	0.091	< 0.002	114	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	24.3	0.008	0.0151	< 0.01	< 0.003	< 0.005	0.0101
376-2005-05	Shallow Alluvial Water	10/6/2007	7.51	1230	***19.30***	< 0.025	0.0404	< 0.002	0.053	< 0.0002	332	< 0.006	< 0.006	0.00358	< 0.06	< 0.003	84.6	0.348	0.0192	< 0.01	< 0.003	< 0.005	< 0.01
		11/27/2007	7.8	1140	***26.5***	< 0.025	0.0406	< 0.002	< 0.04	< 0.0002	288	< 0.006	< 0.006	0.00154	< 0.06	< 0.003	69.7	< 0.004	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		1/9/2008	7.41	768	0.09	< 0.025	0.0333	< 0.002	< 0.04	< 0.0002	241	< 0.006	< 0.006	0.00329	< 0.06	< 0.003	66.7	< 0.004	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		2/20/2008	7.61	1020	< 0.08	< 0.025	0.0382	< 0.002	< 0.04	< 0.002	299	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	75.9	< 0.004	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		4/2/2008	7.2	1010	---	< 0.025	0.0385	< 0.002	< 0.04	< 0.002	296	< 0.006	< 0.006	0.015	< 0.06	< 0.0075	69.6	0.02	< 0.008	< 0.01	< 0.003	< 0.005	0.0981
		5/13/2008	7.64	931	---	< 0.025	0.0508	< 0.002	< 0.04	< 0.002	284	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	69.3	0.253	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		6/18/2008	7.95	976	---	< 0.025	0.0429	< 0.002	< 0.04	< 0.002	286	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	70.3	0.004	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		8/20/2008	7.28	721	---	< 0.025	0.0397	< 0.002	< 0.04	< 0.002	188	< 0.006	< 0.006	< 0.010	< 0.006	< 0.0075	53.5	0.0545	< 0.008	< 0.01	< 0.003	< 0.005	0.0106
		9/16/2008	7.39	505	---	< 0.025	0.0319	< 0.002	< 0.04	< 0.002	133	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	36	0.0121	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
LBT1-BF1	Surface expression of shallow alluvial water	10/4/2007	7.71	594	< 0.08	< 0.025	0.0686	< 0.002	< 0.04	< 0.0002	152	< 0.006	< 0.006	0.0023	< 0.06	< 0.003	47.8	0.0348	0.0235	< 0.01	< 0.003	< 0.005	< 0.01
		11/27/2007	7.74	646	< 0.08	< 0.025	0.0756	< 0.002	< 0.04	< 0.0002	165	< 0.006	< 0.006	0.0027	< 0.06	< 0.003	51.1	< 0.004	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		1/9/2008	7.69	353	< 0.08	< 0.025	0.0319	< 0.002	< 0.04	< 0.0002	105	< 0.006	< 0.006	0.00269	< 0.06	< 0.003	33.2	< 0.004	0.0156	< 0.01	< 0.003	< 0.005	< 0.01
		2/20/2008	7.68	556	< 0.08	< 0.025	0.0410	< 0.002	< 0.04	< 0.002	155	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	48.1	0.007	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		4/1/2008	7.72	609	---	< 0.025	0.0486	< 0.002A	< 0.04	< 0.002	158	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	48.7	0.004	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		8/20/2008	7.89	381	---	< 0.025	0.0465	< 0.002	< 0.04	< 0.002	95.5	< 0.006	< 0.006	< 0.010	< 0.006	< 0.0075	30.2	0.0394	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		9/16/2008	7.86	320	---	< 0.025	0.0722	< 0.002	< 0.04	< 0.002	83.6	< 0.006	< 0.006	**0.036**	< 0.06	< 0.0075	26.9	0.0603	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
2408	Surface expression of shallow alluvial water	10/5/2007	7.72	591	< 0.08	< 0.025	0.0633	< 0.002	< 0.04	< 0.0002	156	< 0.006	< 0.006	0.00244	< 0.06	< 0.003	47.6	0.0785	0.0238	< 0.01	< 0.003	< 0.005	< 0.01
		11/27/2007	7.59	691	0.16	< 0.025	0.0673	< 0.002	< 0.04	< 0.0002	178	< 0.006	< 0.006	0.0033	< 0.06	< 0.003	54.6	0.19	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		1/9/2008	7.7	346	< 0.08	< 0.025	0.0378	< 0.002	< 0.04	< 0.0002	107	< 0.006	< 0.006	0.00316	< 0.06	< 0.003	33.8	< 0.004	0.0186	< 0.01	< 0.003	< 0.005	< 0.01
		2/20/2008	7.76	514	< 0.08	< 0.025	0.0493	< 0.002	< 0.04	< 0.002	141	< 0.006	< 0.006	0.011	< 0.06	< 0.0075	43.8	< 0.004	< 0.008	< 0.01	< 0.003	< 0.005	0.0174
		4/1/2008	7.71	602	---	< 0.025	0.0659	< 0.002	< 0.04	< 0.002	161	< 0.006	< 0.006	0.01	< 0.06	< 0.0075	49.1	0.0466	< 0.008	< 0.01	< 0.003	< 0.005	0.0113
		8/20/2008	7.73	359	---	< 0.025	0.0534	< 0.002	< 0.04	< 0.002	89.2	< 0.006	< 0.006	< 0.010	< 0.006	< 0.0075	27.4	0.0732	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		9/16/2008	7.8	285	---	< 0.025	0.0491	< 0.002	< 0.04	< 0.002	76.3	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	22.3	0.0702	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
2409	Surface expression of shallow alluvial water	10/5/2007	8.03	545	< 0.08	< 0.025	0.111	< 0.002	< 0.04	< 0.0002	152	< 0.006	< 0.006	0.00489	< 0.06	< 0.003	46.4	0.0169	0.0233	< 0.01	< 0.003	< 0.005	< 0.01
		11/27/2007	7.74	643	0.73	< 0.025	0.110	< 0.002	< 0.04	< 0.0002	162	< 0.006	< 0.006	0.0153	< 0.06	< 0.003	53.6	0.0062	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		1/9/2008	8.04	349	< 0.08	< 0.025	0.0699	< 0.002	< 0.04	< 0.0002	110	< 0.006	< 0.006	0.00581	< 0.06	< 0.003	33.1	0.0046	0.0138	< 0.01	< 0.003	< 0.005	< 0.01
		2/20/2008	8.07	488	< 0.08	< 0.025	0.0862	< 0.002	< 0.04	< 0.002	142	< 0.006	< 0.006	0.01	< 0.06	< 0.0075	43.6	0.0058	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		4/1/2008	8.13	577	---	< 0.025	0.105	< 0.002	< 0.04	< 0.002	150	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	49.2	< 0.004	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		8/25/2008	8.34	351	---	< 0.025	0.0845	< 0.002	< 0.04	< 0.002	96.8	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	28.9	< 0.004	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		9/17/2008	7.99	219	---	< 0.025	0.0477	< 0.002	< 0.04	< 0.002	58.5	< 0.006	< 0.006	0.014	< 0.06	< 0.0075	17.4	0.0305	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
376-96-04	Shallow Alluvial Water	10/5/2007	7.32	430	0.13	< 0.025	0.0777	< 0.002	< 0.04	< 0.0002	117	< 0.006	< 0.006	0.00177	< 0.06	< 0.003	29.5	0.121	0.0221	< 0.01	< 0.003	< 0.005	< 0.01
		11/27/2007	7.14	479	< 0.08	< 0.025	0.0749	< 0.002	< 0.04	< 0.0002	129	< 0.006	< 0.006	0.00144	< 0.06	< 0.003	30.4	0.413	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		1/10/2008	7.17	366	< 0.08	< 0.025	0.0674	< 0.002	< 0.04	< 0.0002	115	< 0.006	< 0.006	0.00159	< 0.06	< 0.003	26.8	0.0854	0.0152	< 0.01	< 0.003	< 0.005	< 0.01
		2/19/2008	7.12	426	< 0.08	< 0.025	0.0703	< 0.002	< 0.04	< 0.002	128	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	30.9	0.174	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		4/2/2008	7.01	428	---	< 0.025	0.0731	< 0.002	< 0.04	< 0.002	127	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	29.7	0.182	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		5/13/2008	7.23	405	---	< 0.025	0.0696	< 0.002	< 0.04	< 0.002	122	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	28.7	0.256	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		6/18/2008	7.86	422	---	< 0.025	0.0686	< 0.002	< 0.04	< 0.002	127	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	30.9	0.354	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		8/20/2008	7.26	358	---	< 0.025	0.0561	< 0.002	< 0.04	< 0.002	93.6	< 0.006	< 0.006	< 0.010	< 0.006	< 0.0075	23.9	0.0916	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		9/17/2008	7.29	324	---	< 0.025	0.044	< 0.002	< 0.04	< 0.002	90.3	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	22.1	0.175	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01

TABLE 3-4
SURFACE WATER DATA, TRIBUTARY 1

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Location ID	Sample Type	Sample Date	pH	Hardness	Al (Total)	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	Se (Total)	V	Zn
2410	Surface expression of shallow alluvial water	10/5/2007	7.89	348	< 0.08	< 0.025	0.0705	< 0.002	< 0.04	< 0.0002	113	< 0.006	< 0.006	0.00184	< 0.06	< 0.003	23.5	0.0325	0.0217	< 0.01	< 0.003	< 0.005	< 0.01
		11/29/2007	7.82	431	0.21	< 0.025	0.0887	< 0.002	< 0.04	< 0.0002	124	< 0.006	< 0.006	0.00456	0.094	< 0.003	25.9	0.144	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		1/10/2008	7.7	280	< 0.08	< 0.025	0.0513	< 0.002	< 0.04	< 0.0002	96.5	< 0.006	< 0.006	0.00159	< 0.06	< 0.003	20.0	0.0205	0.0177	< 0.01	< 0.003	< 0.005	< 0.01
		2/19/2008	7.55	390	< 0.08	< 0.025	0.0630	< 0.002	< 0.04	< 0.002	123	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	24.4	0.017	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		4/1/2008	8.01	436	---	< 0.025	0.0805	< 0.002	0.044	< 0.002	133	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	27.3	0.0206	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		5/13/2008	8.0	519	---	< 0.025	0.0899	< 0.002	< 0.04	< 0.002	157	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	42.2	0.256	< 0.008	< 0.01	0.00348	< 0.005	< 0.01
		8/26/2008	8.1	368	---	< 0.025	0.0713	< 0.002	< 0.04	< 0.002	114	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	22.5	0.178	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		9/23/2008	8.13	317	---	< 0.025	0.0735	< 0.002	< 0.04	< 0.002	94.6	< 0.006	< 0.006	0.013	< 0.06	< 0.0075	20.8	0.336	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
LB6	Shallow Alluvial Water	10/5/2007	7.95	180	< 0.08	< 0.025	0.0066	< 0.002	0.046	< 0.0002	65.6	< 0.006	< 0.006	0.00254	< 0.06	< 0.003	2.85	0.0739	0.0167	< 0.01	< 0.003	< 0.005	< 0.01
		1/9/2008	7.77	134	0.36	< 0.025	0.0067	< 0.002	0.06	< 0.0002	64.1	< 0.006	< 0.006	0.0033	< 0.06	< 0.003	2.68	0.0298	0.0158	< 0.01	< 0.003	< 0.005	< 0.01
		2/19/2008	7.76	189	< 0.08	< 0.025	0.0108	< 0.002	0.053	< 0.002	73.1	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	3.14	0.022	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		4/1/2008	7.75	186	---	< 0.025	0.0076	< 0.002	0.044	< 0.002	71.1	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	2.88	0.0336	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		5/13/2008	7.96	186	---	< 0.025	0.0085	< 0.002	0.043	< 0.002	75.6	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	3.72	0.146	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		6/18/2008	8.02	180	---	< 0.025	0.006	< 0.002	0.044	< 0.002	72.3	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	3.25	0.173	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		8/27/2008	7.88	160	---	< 0.025	0.0051	< 0.002	0.054	< 0.002	60.1	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	2.56	0.0671	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
		9/22/2008	7.96	128	---	< 0.025	0.0047	< 0.002	0.064	< 0.002	48.2	< 0.006	< 0.006	< 0.01	< 0.06	< 0.0075	2.18	0.0635	< 0.008	< 0.01	< 0.003	< 0.005	< 0.01
ERA-36	Surface water	9/9/1995	---	400	0.03	0.121	0.116	---	0.029	< 0.003	---	< 0.01	---	0.017	< 0.10	< 0.040	---	0.0138	0.0202	< 0.01	< 0.04	< 0.005	< 0.01

Notes:
1. Data are from the Sitewide Abatement program (Golder 2008c, 2010, 2016).
2. Laboratory results are presented in milligrams per liter (mg/L) dissolved unless indicated (e.g., Al and Se are total recoverable concentrations).
3. **Bold** data are > pre-FS chronic criteria, if available in Table 3-1.
4. **Bold** and *italicized* data are > pre-FS RAC acute criteria, if available in Table 3-1.
5. Selenium and aluminum criteria (latter for pH 6.5 to 9) data are compared to are based on total recoverable concentrations, but only dissolved are available; all are below detection limit, so assumed to be below pre-FS RAC.
6. Cadmium cannot be compared to criteria when detection limit was below decision criteria in Table 3-1 ($\leq$ 0.002).
7. Hardness was assumed to be 400 mg/L for ERA-36, based on LIU Ecological Risk Assessment (ERA) assumption (i.e., sample called ERA-34 in LIU ERA but is ERA-36 in the sitewide ecological remedial investigation).

Acronyms and Abbreviations:
--- = not analyzed
< = not detected. Detection limit shown.
NMAC = New Mexico Administrative Code
pre-FS RAC = pre-feasiblity study Remedial Action Criteria

References:

Golder Associates, Inc. (Golder.) 2008c. Chino Mines Company. Site Wide Stage 1 Abatement, Final Investigation Report. July 18.
Golder. 2010. Post Corrective Action Monitoring Report: Discharge of PLS to Tributary 2, Lampbright Draw New Mexico. Submitted to Freeport-McMoran Chino Mines Company. December.
Golder. 2016. Site-Wide Stage 1 Abatement Plan. Revised Final Site Investigation Report. March.

Acute and Chronic Calculations for Hardness-Dependent
New Mexico Water Quality Criteria Calculations
Lampbright Investigation Unit (20.6.4 NMAC)

COPCs	m_A	b_A	Conversion factor (CF)
Acute			
Aluminum (Al)	1.3695	1.8308	1
Cadmium (Cd)	0.9789	-3.866	1.136672-[(ln hardness)(0.041838)]
Chromium (Cr) III	0.819	3.7256	0.316
Copper (Cu)	0.9422	-1.7	0.96
Lead (Pb)	1.273	-1.46	1.46203-[(ln hardness)(0.145712)]
Manganese (Mn)	0.3331	6.4676	1
Nickel (Ni)	0.846	2.255	0.998
Zinc (Zn)	0.9094	0.9095	0.978
Chronic			
Aluminum (Al)	1.3695	0.9161	1
Cadmium (Cd)	0.7977	-3.909	1.101672-[(ln hardness)(0.041838)]
Chromium (Cr) III	0.819	0.6848	0.86
Copper (Cu)	0.8545	-1.702	0.96
Lead (Pb)	1.273	-4.705	1.46203-[(ln hardness)(0.145712)]
Manganese (Mn)	0.3331	5.8743	1
Nickel (Ni)	0.846	0.0584	0.997
Zinc (Zn)	0.9094	0.6235	0.986
Criteria (μg/L) = exp(m_A [ln(hardness)] + b_A)(CF)			

TABLE 3-5
SURFACE WATER DATA, TRIBUTARY 2

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Location ID	Sample Date	Field Parameter: pH	Al	Al (Total)	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	Na	Se (Total)	V	Zn	Hardness
Surface Water Data - 1999																								
September 1999																								
ERA 35	9/30/1999	--	0.0378	<0.034	<0.136	0.0924	--	0.0253	**0.0052**	636	<0.01	--	**0.0302**	0.0185	--	183	0.226	<0.01	0.0169	--	<0.04	<0.005	0.517	400
ERA 36	9/30/1999	--	<0.03	<0.033	<0.121	0.116	--	0.029	<0.003	182	<0.01	--	0.017	<0.01	<0.04	31.2	0.0138	<0.0202	<0.01	--	<0.04	<0.005	<0.01	400
Shallow Alluvial Water																								
April 2008																								
LBT-12	4/24/2008	**4.2**	***76.1***	--	<0.0250	0.0362	0.0366	0.096	***0.32***	560	<0.0060	0.633	***0.401***	0.31	<0.0075	438	***49.8***	<0.0080	***1.56***	48.4	0.009	<0.0050	***82.4***	400
LBT-13	4/24/2008	7.99	<0.0800	--	<0.0250	0.0329	<0.0020	0.046	<0.0020	396	<0.0060	<0.0060	<0.0100	<0.0600	<0.0075	191	0.6	<0.0080	<0.0100	38.3	<0.0030	<0.0050	0.131	400
LBT-07	4/23/2008	7.08	<0.0800	--	<0.0250	0.0261	<0.0020	<0.0400	**0.003**	465	<0.0060	0.0119	0.021	<0.0600	<0.0075	136	2.48	<0.0080	<0.0100	27.9	<0.0030	<0.0050	0.252	400
LBT-08	4/23/2008	7.86	0.081	--	<0.0250	0.0278	<0.0020	0.055	<0.0020	651	<0.0060	<0.0060	0.023	<0.0600	<0.0075	279	0.218	<0.0080	<0.0100	50.6	<0.0030	<0.0050	0.0129	400
LBT-11	4/23/2008	6.3	0.196	--	<0.0250	0.0288	<0.0020	0.057	***0.038***	232	<0.0060	0.918	***0.247***	0.239	**0.111**	110	***19.5***	<0.0080	0.181	19.4	<0.0030	<0.0050	***11***	400
LBT-09	4/23/2008	7.69	<0.0800	--	<0.0250	0.0318	<0.0020	0.05	<0.0020	389	<0.0060	<0.0060	<0.0100	<0.0600	<0.0075	122	0.0145	<0.0080	<0.0100	38.2	<0.0030	<0.0050	<0.0100	400
LBT-10	4/23/2008	8.1	<0.0800	--	<0.0250	0.0425	<0.0020	0.064	<0.0020	271	<0.0060	<0.0060	0.011	<0.0600	<0.0075	93.9	0.037	0.015	<0.0100	39.4	0.0042	<0.0050	<0.0100	400
July 2008																								
LBT-12	7/23/2008	7.87	<0.08	--	<0.025	0.0587	<0.002	<0.04	**0.0042**	423	<0.006	<0.006	<0.01	<0.06	<0.0075	206	0.986	<0.008	<0.01	16	<0.003	<0.005	0.2	400
LBT-16	7/23/2008	7.66	<0.08	--	<0.025	0.116	<0.002	<0.04	<0.002	496	<0.006	<0.006	<0.01	<0.06	<0.0075	153	0.0951	<0.008	<0.01	16.3	<0.003	<0.005	<0.01	400
LBT-13	7/23/2008	7.41	<0.08	--	<0.025	0.0759	<0.002	<0.04	<0.002	439	<0.006	<0.006	<0.01	<0.06	<0.0075	75.1	0.327	<0.008	<0.01	9.27	<0.003	<0.005	0.02	400
LBT-07	7/22/2008	7.44	<0.08	--	<0.025	0.0985	<0.002	<0.04	<0.002	324	<0.006	<0.006	0.012	<0.06	<0.0075	73.5	0.456	<0.008	<0.01	13	<0.003	<0.005	0.07	400
LBT-08	7/22/2008	7.98	0.102	--	<0.025	0.0926	<0.002	<0.04	<0.002	301	<0.006	<0.006	0.011	<0.06	<0.0075	68.6	0.359	<0.008	<0.01	13	<0.003	<0.005	0.05	400
LBT-11	7/22/2008	7.74	<0.08	--	<0.025	0.0844	<0.002	<0.04	0.0028	264	<0.006	0.0273	0.026	<0.06	0.0244	62.1	0.887	<0.008	0.011	12.7	<0.003	<0.005	**0.51**	400
LBT-09	7/22/2008	7.19	<0.08	--	<0.025	0.0786	<0.002	<0.04	<0.002	429	<0.006	<0.006	<0.01	<0.06	<0.0075	99.4	0.236	<0.008	<0.01	12.1	<0.003	<0.005	0.02	400
LBT-15	7/22/2008	8.05	<0.08	--	<0.025	0.0874	<0.002	<0.04	<0.002	224	<0.006	<0.006	<0.01	<0.06	<0.0075	44.4	0.0905	<0.008	<0.01	8.35	<0.003	<0.005	<0.01	400
LBT-10	7/21/2008	7.58	<0.08	--	<0.025	0.115	<0.002	<0.04	<0.002	434	<0.006	<0.006	<0.01	<0.06	<0.0075	133	0.107	<0.008	<0.01	10.5	<0.003	<0.005	<0.01	400
LBT-14	7/21/2008	8.12	<0.08	--	<0.025	0.11	<0.002	<0.04	<0.002	432	<0.006	<0.006	<0.01	<0.06	<0.0075	130	0.0349	0.008	<0.01	12.8	<0.003	<0.005	<0.01	400
May 2009																								
LBT-16	DRY	---	---	--	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	400
LBT-11	5/6/2009	7	---	--	---	---	---	---	---	152	---	---	0.0053	<0.060	---	45.9	2.3	---	---	16.8	---	---	***2.33***	400
LBT-10	DRY	---	---	--	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	400
September 2009																								
LBT-17	9/21/2009	7.3	---	--	---	---	---	---	---	407	---	---	0.0045	<0.06	---	95.6	0.0436	---	---	28.5	---	---	<0.01	400
LBT-16	9/21/2009	7.67	---	--	---	---	---	---	---	252	---	---	0.0036	<0.06	---	84.7	0.0058	---	---	8.79	---	---	<0.01	400
LBT-11	9/17/2009	6.99	---	--	---	---	---	---	---	159	---	---	0.0107	<0.06	---	46.2	0.446	---	---	14.8	---	---	***0.61***	400
LBT-10	9/17/2009	7.06	---	--	---	---	---	---	---	179	---	---	0.0069	<0.06	---	43.1	0.0238	---	---	9.29	---	---	<0.01	400
September 2010																								
LBT-17	9/21/2010	7.85	---	---	---	---	---	---	---	416	---	---	0.00286	<0.060	---	115	0.0169	---	---	36.8	---	---	<0.0100	400
LBT-16	9/24/2010	7.67	---	---	---	---	---	---	---	137	---	---	0.00451	<0.060	---	40.9	<0.0040	---	---	8.79	---	---	<0.0100	400
LBT-11	9/21/2010	7.66	---	---	---	---	---	---	---	141	---	---	0.00267	<0.060	---	37.3	0.828	---	---	13.9	---	---	***1.09***	400
LBT-10	9/23/2010	7.92	---	---	---	---	---	---	---	150	---	---	0.00939	<0.060	---	34.7	0.0109	---	---	10.8	---	---	<0.0100	400
Rainfall Pool Data - September 2010																								
Trib 2A-SW	9/23/2010	8.09	<0.0172	---	<0.00043	0.047	<0.00049	0.0343	0.000038	93.5	0.0023	<0.00095	0.0052	<0.0273	<0.00019	29.8	0.0246	0.017	0.0034	11.6	0.00057	0.0009	0.0025	359
38+20-SW	9/23/2010	7.57	<0.0172	---	<0.00043	0.0416	<0.00049	<0.0253	<0.000036	44.2	0.00048	<0.00095	0.0074	<0.0273	0.00012	9.93	0.0148	0.012	0.0016	2.96	0.00043	0.00084	0.00099	152
130+00-SW	9/23/2010	7.48	<0.0172	---	<0.00043	0.0479	<0.00049	<0.0253	<0.000036	68.6	0.00074	<0.00095	0.0089	<0.0273	<0.00019	14.5	0.0037	0.02	0.0024	6.65	0.00061	0.0013	0.0042	232
65+40-SW	9/23/2010	7.65	0.0189	---	<0.00043	0.057	<0.00049	<0.0253	<0.000036	69.2	0.00049	<0.00095	0.0091	<0.0273	0.00005	16.1	0.0353	0.0128	0.0028	5.33	0.00063	0.00087	0.0016	241

TABLE 3-5
SURFACE WATER DATA, TRIBUTARY 2

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Notes:
1. Data from the 1990s are from the Remedial Investigation Background Report (Chino 1995).
2. Data since 2008 are from DP-376 - Post-Correct Action Monitoring Report (Golder 2010), except the two Ecological Risk Assessment (ERA) samples, which are from the Ecological Remedial Investigation (Arcadis 2001), after cleanup.
3. Laboratory (non-field) results are presente in milligrams per liter (mg/L) dissolved unless indicated (e.g., Se is total recoverable; only two locations had data available for Al total recoverable concentrations, thus, dissolved also shown and compared to total criteria).
3. **Bold** data are > pre-FS chronic criteria, if available in Table 3-1.
4. **Bold** and *italicized* data are > pre-FS RAC acute criteria, if available in Table 3-1.
5. Selenium and aluminum criteria (latter for pH 6.5 to 9) are based on total recoverable concentrations, but only dissolved are available; all are below detection limit, so assumed to be below pre-FS RAC.
6. pH < 6.5 is also bolded to identify when aluminum acute and chronic criteria not adjusted for hardness, of 0.75 and 0.087 mg/L, respectively, are applied. Most locations do not have total aluminum, thus, criteria were applied to dissolved for those.

Acronyms and Abbreviations:
--- = not analyzed
< = not detected. Detection limit shown.
NMAC = New Mexico Administrative Code
pre-FS RAC = pre-feasiblity study Remedial Action Criteria

References:

Arcadis. 2001. Revised Phase II RI Report for the Ecological IU., Prepared for Chino Mines Company, Hurley, New Mexico. August.
Freeport-McMoRan Chino Mines Company (Chino). 1995. Administrative Order on Consent Investigation Area, Remedial Investigation Background Report, Chino Mine Investigation Area. Prepared for New Mexico Environmental Department. October.
Golder. 2010. Post Corrective Action Monitoring Report: Discharge of PLS to Tributary 2, Lampbright Draw New Mexico. Submitted to Freeport-McMoran Chino Mines Company. December.

Acute and Chronic Calculations for Hardness-Dependent (20.6.4 NMAC)
New Mexico Water Quality Criteria Calculations
Lampbright Investigation Unit

COPCs	m_A	b_A	Conversion factor (CF)
Acute			
Aluminum (Al)	1.3695	1.8308	1
Cadmium (Cd)	0.9789	-3.866	1.136672-[(ln hardness)(0.041838)]
Chromium (Cr) III	0.819	3.7256	0.316
Copper (Cu)	0.9422	-1.7	0.96
Lead (Pb)	1.273	-1.46	1.46203-[(ln hardness)(0.145712)]
Manganese (Mn)	0.3331	6.4676	1
Nickel (Ni)	0.846	2.255	0.998
Zinc (Zn)	0.9094	0.9095	0.978
Chronic			
Aluminum (Al)	1.3695	0.9161	1
Cadmium (Cd)	0.7977	-3.909	1.101672-[(ln hardness)(0.041838)]
Chromium (Cr) III	0.819	0.6848	0.86
Copper (Cu)	0.8545	-1.702	0.96
Lead (Pb)	1.273	-4.705	1.46203-[(ln hardness)(0.145712)]
Manganese (Mn)	0.3331	5.8743	1
Nickel (Ni)	0.846	0.0584	0.997
Zinc (Zn)	0.9094	0.6235	0.986
Criteria (µg/L) = $\exp(m_A[\ln(\text{hardness})] + b_A)(CF)$			

TABLE 3-6
DOWNSTREAM SURFACE WATER DATA, LAMPBRIGHT DRAW

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Location ID	Sample Date	Field Parameter: pH	Al	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	Se (Total)	V	Zn	Calculated or Assumed Hardness
Early 1990s																						
LBS2	12/20/91	7.8	--	--	--	--	--	<0.0007	--	--	--	--	--	<0.02	--	--	--	--	--	--	<0.005	400
LBS2	02/13/92	7.9	--	--	--	--	--	<0.0007	--	<0.003	--	--	--	<0.02	--	--	--	--	--	--	--	400
LBS2	03/03/92	7.5	--	--	--	--	--	<0.0007	--	<0.003	--	--	--	<0.02	--	--	--	<0.004	--	--	--	400
LBS2	04/02/92	7.8	--	--	--	--	--	<0.0007	--	--	--	--	--	<0.02	--	--	--	--	--	--	--	400
LBS2	05/26/92	7.8	--	--	--	--	--	<0.0007	--	<0.003	--	--	--	<0.02	--	--	--	<0.004	--	--	<0.005	400
LBS2	08/20/92	--	--	--	--	--	--	--	--	<0.003	--	<0.004	--	<0.02	--	--	--	--	--	--	<0.005	400
LBS2	08/24/92	8.7	--	--	--	--	--	--	--	<0.003	--	--	--	<0.02	--	--	--	--	--	--	<0.005	400
LBS2	07/13/93	6.5	--	--	--	--	--	<0.05	--	<0.05	--	<0.05	--	<0.05	--	--	--	--	--	--	<0.005	400
LBS2	08/30/93	6.7	--	--	--	--	--	<0.0007	--	<0.003	--	--	--	<0.02	--	--	--	<0.004	--	--	--	400
LBS2	12/06/94	7.4	--	--	--	--	--	<0.04	--	--	--	--	--	<0.05	--	--	--	<0.05	--	--	--	400
LBS2	07/24/91	6.6	--	--	--	--	--	<0.0007	--	<0.003	--	--	--	<0.02	--	--	--	<0.004	--	--	<0.005	400
LBS2	07/25/91	6.6	--	--	--	--	--	<0.0007	--	--	--	--	--	<0.02	--	--	--	--	--	--	--	400
LBS2	08/02/91	6.6	--	--	--	--	--	--	--	<0.003	--	--	--	<0.02	--	--	--	<0.004	--	--	<0.005	400
LBS2	08/05/91	6.7	--	--	--	--	--	--	--	<0.003	--	--	--	<0.02	--	--	--	--	--	--	<0.005	400
LBS2	12/20/91	7.7	--	--	--	--	--	<0.0007	--	<0.003	--	--	--	<0.02	--	--	--	--	--	--	<0.005	400
LBS2	01/29/92	8	--	--	--	--	--	<0.0007	--	<0.003	--	<0.004	<0.002	<0.02	--	<0.001	--	<0.004	--	--	<0.005	400
LBS2	02/14/92	7.8	--	--	--	--	--	<0.0007	--	<0.003	--	--	--	<0.02	--	--	--	<0.004	--	--	--	400
LBS2	04/03/92	7.3	--	--	--	--	--	<0.0007	--	<0.003	--	--	--	<0.02	--	--	--	--	--	--	--	400
LBS2	05/21/92	6.9	--	--	--	--	--	--	--	<0.0007	--	--	--	<0.02	--	--	--	--	--	--	--	400
LBS2	05/26/92	7.9	--	--	--	--	--	<0.0007	--	<0.003	--	--	--	<0.02	--	--	--	<0.004	--	--	<0.005	400
LBS2	06/23/93	7.3	--	--	--	--	--	<0.0007	--	<0.003	--	--	--	<0.02	--	--	--	<0.004	--	--	--	400
LBS2	08/30/93	6.6	--	--	--	--	--	<0.0007	--	<0.003	--	--	<0.002	<0.02	--	<0.001	--	<0.004	--	--	--	400
LBS2	12/06/94	7.5	--	--	--	--	--	<0.04	--	<0.05	--	--	--	<0.05	--	--	--	<0.05	--	--	<0.05	400
October/November 2007 Post-Spill																						
LBT-02	10/25/2007	---	<0.080	<0.025	---	---	---	<0.002	96.7	<0.006	<0.006	<0.010	<0.060	<0.0075	18.9	0.05	---	<0.010	---	---	<0.010	319
LBT-04	11/7/2007	6.7	<0.080	<0.025	---	---	---	<0.002	103	<0.006	<0.006	<0.010	<0.060	<0.0075	23	0.02	---	<0.010	---	---	<0.010	352
LBT-05	11/7/2007	6.73	<0.080	<0.025	---	---	---	<0.002	97.1	<0.006	<0.006	<0.010	<0.060	<0.0075	21	0.01	---	<0.010	---	---	<0.010	329
April 2008																						
LBT-05	4/23/2008	7.25	<0.0800	<0.0250	0.0771	<0.0020	<0.0400	<0.0020	135	<0.0060	<0.0060	<0.0100	<0.0600	<0.0075	28.4	<0.0040	<0.0080	<0.0100	<0.0030	<0.0050	<0.0100	400
July 2008																						
LBT-02	7/21/2008	7.46	<0.08	<0.025	0.137	<0.002	<0.04	<0.002	246	<0.006	<0.006	<0.01	<0.06	<0.0075	55.4	0.0343	<0.008	<0.01	<0.003	<0.005	<0.01	400
LBT-04	7/21/2008	6.99	<0.08	<0.025	0.133	<0.002	<0.04	<0.002	167	<0.006	<0.006	<0.01	<0.06	<0.0075	34.6	0.0372	<0.008	<0.01	<0.003	<0.005	<0.01	400
LBT-05	7/21/2008	**6.4**	<0.08	<0.025	0.108	<0.002	<0.04	<0.002	151	<0.006	<0.006	<0.01	<0.06	<0.0075	32.6	0.235	<0.008	<0.01	<0.003	<0.005	<0.01	400
May 2009																						
LBT-05	5/5/2009	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
September 2009																						
LBT-05	9/16/2009	7.45	---	---	---	---	---	---	118	---	---	0.0042	<0.06	---	26	0.0153	---	---	---	---	<0.01	400
September 2010																						
LBT-05	9/22/2010	7.35	---	---	---	---	---	---	123	---	---	<0.00100	<0.060	---	26.8	1.11	---	---	---	---	<0.0100	400

TABLE 3-6
DOWNSTREAM SURFACE WATER DATA, LAMPBRIGHT DRAW

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Notes:

1. Data from the 1990s are from the Remedial Investigation Background Report (Chino 1995) before remediation of spill in 2007, and had some copper exceedances.
2. Data since 2008 are from DP-376 - Post-Correct Action Monitoring Report (Golder 2010), and exceedances were removed during remediation.
3. Laboratory (non-field) results are in milligrams per liter (mg/L) dissolved unless indicated (e.g., Se is total recoverable; no data were available for Al total recoverable concentrations).
3. **Bold** data are > pre-FS RAC chronic criteria, assuming 400 milligrams per kilogram (mg/kg) hardness, and if available in Table 3-1.
4. ***Bold*** and *italicized* data are > pre-FS RAC acute criteria, assuming 400 mg/L hardness, if criteria available in Table 3-1.
5. pH < 6.5 is also bolded to identify when aluminum acute and chronic criteria not adjusted for hardness of 0.75 and 0.087, respectively, are applied.

Acronyms and Abbreviations:

--- = not analyzed
< = not detected. Detection limit shown.
pre-FS RAC = pre-feasiblity study Remedial Action Criteria

References:

Freeport-McMoRan Chino Mines Company (Chino). 1995. Administrative Order on Consent Investigation Area, Remedial Investigation Background Report, Chino Mine Investigation Area. Prepared for New Mexico Environmental Department. October.
Golder. 2010. Post Corrective Action Monitoring Report: Discharge of PLS to Tributary 2, Lampbright Draw New Mexico. Submitted to Freeport-McMoran Chino Mines Company. December.

Acute and Chronic Calculations for Hardness-Dependent New Mexico Water Quality Criteria Calculations Lampbright Investigation Unit

COPCs	m_A	b_A	Conversion factor (CF)
Acute			
Aluminum (Al)	1.3695	1.8308	1
Cadmium (Cd)	0.9789	-3.866	1.136672-[(ln hardness)(0.041838)]
Chromium (Cr) III	0.819	3.7256	0.316
Copper (Cu)	0.9422	-1.7	0.96
Lead (Pb)	1.273	-1.46	1.46203-[(ln hardness)(0.145712)]
Manganese (Mn)	0.3331	6.4676	1
Nickel (Ni)	0.846	2.255	0.998
Zinc (Zn)	0.9094	0.9095	0.978
Chronic			
Aluminum (Al)	1.3695	0.9161	1
Cadmium (Cd)	0.7977	-3.909	1.101672-[(ln hardness)(0.041838)]
Chromium (Cr) III	0.819	0.6848	0.86
Copper (Cu)	0.8545	-1.702	0.96
Lead (Pb)	1.273	-4.705	1.46203-[(ln hardness)(0.145712)]
Manganese (Mn)	0.3331	5.8743	1
Nickel (Ni)	0.846	0.0584	0.997
Zinc (Zn)	0.9094	0.6235	0.986
Criteria (µg/L) = exp(m_A [ln(hardness)] + b_A)(CF)			

TABLE 3-7
SHALLOW ALLUIVIAL WATER COPCS, TRIBUTARY 1
COMPARED TO NMWQC AND CHIRICAHUA LEOPARD FROG TOXICITY THRESHOLDS, ADAPTED FROM ERA
FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Location	Date	COPC (µg/L)					mg/L	Hardness-Adjusted Acute NMWQC Pre-FS RAC [1]					Hardness-Adjusted Chronic NMWQC [1]				
		Al (T)	Cd (D)	Cu (D)	Pb (D)	Zn (D)	Hardness	Al (T)	Cd (D)	Cu (D)	Pb (D)	Zn (D)	Al (T)	Cd (D)	Cu (D)	Pb (D)	Zn (D)
Frog Criteria for > 400 mg/L	Leopard Frog NOEC (1a)	--	53.7	9.6	--	217	400	--	--	--	--	--	--	--	--	--	--
	Leopard Frog LOEC (1b)	--	311	22.3	--	--	400	--	--	--	--	--	--	--	--	--	--
	Leopard Frog GM NOEC (1c)	--	111	29.1	--	275	400	--	--	--	--	--	--	--	--	--	--
	Leopard Frog GM LOEC (1d)	--	311	128	--	--	400	--	--	--	--	--	--	--	--	--	--
LB7S	10/4/2007	**3,610**	<0.2	2.1	<3	<10	149	5906	2.6	20	99	230	2366	1.0	13	4	174
	11/27/2007	4,450	<0.2	*11.6*	<3	<10	126	4694	2.2	17	83	197	1881	0.9	11	3	150
	1/9/2008	556	<0.2	3.9	<3	<10	94	3143	1.7	13	281	564	1259	2.0	29	11	428
	4/2/2008	--	<2	<10	<7.5	<10	---	---	6.5	50	281	564	---	2.0	29	11	428
	6/18/2008	--	<2	<10	<7.5	<10	116	4192	2.1	15	76	183	1679	0.8	10	3	139
	8/20/2008	--	<2	<10	<7.5	<10	117	4241	2.1	16	77	185	1699	0.8	10	3	140
	9/16/2008	--	<2	***27***	<7.5	<10	114	4093	2.0	15	74	180	1640	0.8	10	3	137
376-05-04	10/4/2007	**19,400**	<0.2	2.1	<3	<10	624	10071	6.5	50	281	564	4035	2.0	29	11	428
	11/27/2007	3,000	--	--	--	--	398	10071	6.5	49	279	562	4035	2.0	29	11	426
	1/9/2008	1,970	<0.2	5.7	<3	<10	368	10071	6.1	46	258	523	4035	1.9	27	10	396
	2/20/2008	< 0.08	<2	<10	<7.5	<10	378	10071	6.2	47	265	536	4035	1.9	28	10	406
	4/2/2008	--	<2	<10	<7.5	<10	392	10071	6.4	49	275	554	4035	2.0	29	11	420
	6/18/2008	--	<2	<10	<7.5	<10	412	10071	6.5	50	281	564	4035	2.0	29	11	428
	8/20/2008	--	<2	<10	<7.5	<10	473	10071	6.5	50	281	564	4035	2.0	29	11	428
	9/16/2008	--	<2	<10	<7.5	10.1	385	10071	6.3	48	270	545	4035	2.0	28	11	413
376-05-05	10/6/2007	**19,300**	0.2	3.6	<3	<10	1,230	10071	6.5	50	281	564	4035	2.0	29	11	428
	11/27/2007	**26,500**	<0.2	1.5	<3	<10	1,140	10071	6.5	50	281	564	4035	2.0	29	11	428
	1/9/2008	87	<0.2	3.3	<3	<10	768	10071	6.5	50	281	564	4035	2.0	29	11	428
	2/20/2008	< 0.08	<2	<10	<7.5	<10	1,020	10071	6.5	50	281	564	4035	2.0	29	11	428
	4/2/2008	--	<2	*15*	<7.5	98	1,010	10071	6.5	50	281	564	4035	2.0	29	11	428
	5/13/2008	--	<2	<10	<7.5	<10	931	10071	6.5	50	281	564	4035	2.0	29	11	428
	6/18/2008	--	<2	<10	<7.5	<10	976	10071	6.5	50	281	564	4035	2.0	29	11	428
	8/20/2008	--	<2	<10	<7.5	10.6	721	10071	6.5	50	281	564	4035	2.0	29	11	428
	9/16/2008	--	<2	<10	<7.5	<10	505	10071	6.5	50	281	564	4035	2.0	29	11	428
LBT1-BF1	10/4/2007	< 0.08	<0.2	2.3	<3	<10	594	10071	6.5	50	281	564	4035	2.0	29	11	428
	11/27/2007	< 0.08	<0.2	2.7	<3	<10	646	10071	6.5	50	281	564	4035	2.0	29	11	428
	1/9/2008	< 0.08	<0.2	2.7	<3	<10	353	10071	5.8	44	247	504	4035	1.9	26	10	382
	2/20/2008	< 0.08	<2	<10	<7.5	<10	556	10071	6.5	50	281	564	4035	2.0	29	11	428
	4/1/2008	--	<2	<10	<7.5	<10	609	10071	6.5	50	281	564	4035	2.0	29	11	428
	8/20/2008	--	<2	<10	<7.5	<10	381	10071	6.3	47	267	540	4035	2.0	28	10	409
	9/16/2008	--	<2	***36***	<7.5	<10	320	10071	5.3	40	223	461	4035	1.7	**24**	9	349
2408	10/5/2007	< 0.08	<0.2	2.4	<3	<10	591	10071	6.5	50	281	564	4035	2.0	29	11	428
	11/27/2007	162	<0.2	3.3	<3	<10	691	10071	6.5	50	281	564	4035	2.0	29	11	428
	1/9/2008	< 0.08	<0.2	3.2	<3	<10	346	10071	5.7	43	242	495	4035	1.8	26	9	375
	2/20/2008	< 0.08	<2	*11*	<7.5	17	514	10071	6.5	50	281	564	4035	2.0	29	11	428
	4/1/2008	--	<2	*10*	<7.5	11	602	10071	6.5	50	281	564	4035	2.0	29	11	428
	8/20/2008	--	<2	<10	<7.5	<10	359	10071	5.9	45	251	512	4035	1.9	27	10	387
	9/16/2008	--	<2	<10	<7.5	<10	285	10071	4.8	36	198	415	4035	1.6	22	8	314
2409	10/5/2007	< 0.08	<0.2	4.9	<3	<10	545	10071	6.5	50	281	564	4035	2.0	29	11	428
	11/27/2007	729	<0.2	*15*	<3	<10	643	10071	6.5	50	281	564	4035	2.0	29	11	428
	1/9/2008	< 0.08	<0.2	5.8	<3	<10	349	10071	5.8	44	244	499	4035	1.8	26	10	378
	2/20/2008	< 0.08	<2	*10*	<7.5	<10	488	10071	6.5	50	281	564	4035	2.0	29	11	428
	4/1/2008	--	<2	<10	<7.5	<10	577	10071	6.5	50	281	564	4035	2.0	29	11	428
	8/25/2008	--	<2	<10	<7.5	<10	351	10071	5.8	44	245	501	4035	1.8	26	10	380
	9/17/2008	--	<2	*14*	<7.5	<10	219	10071	3.7	28	150	326	4010	1.3	17	6	247
376-96-04	10/5/2007	134	<0.2	1.8	<3	<10	430	10071	6.5	50	281	564	4035	2.0	29	11	428
	11/27/2007	< 0.08	<0.2	1.4	<3	<10	479	10071	6.5	50	281	564	4035	2.0	29	11	428
	1/10/2008	< 0.08	<0.2	1.6	<3	<10	366	10071	6.0	46	256	521	4035	1.9	27	10	394
	2/19/2008	< 0.08	<2	<10	<7.5	<10	426	10071	6.5	50	281	564	4035	2.0	29	11	428
	4/2/2008	--	<2	<10	<7.5	<10	428	10071	6.5	50	281	564	4035	2.0	29	11	428
	5/13/2008	--	<2	<10	<7.5	<10	405	10071	6.5	50	281	564	4035	2.0	29	11	428
	6/18/2008	--	<2	<10	<7.5	<10	422	10071	6.5	50	281	564	4035	2.0	29	11	428
	8/20/2008	--	<2	<10	<7.5	<10	358	10071	5.9	45	251	510	4035	1.9	27	10	387
	9/17/2008	--	<2	<10	<7.5	<10	324	10071	5.4	41	226	466	4035	1.7	24	9	353
2410	10/5/2007	< 0.08	<0.2	1.8	<3	<10	348	10071	5.7	44	243	497	4035	1.8	26	9	377
	11/29/2007	209	<0.2	4.6	<3	<10	431	10071	6.5	50	281	564	4035	2.0	29	11	428
	1/10/2008	< 0.08	<0.2	1.6	<3	<10	280	10071	4.7	35	194	408	4035	1.6	22	8	309
	2/19/2008	< 0.08	<2	<10	<7.5	<10	390	10071	6.4	48	274	552	4035	2.0	29	11	418
	4/1/2008	--	<2	<10	<7.5	<10	436	10071	6.5	50	281	564	4035	2.0	29	11	428
	5/13/2008	--	<2	<10	<7.5	<10	519	10071	6.5	50	281	564	4035	2.0	29	11	428
	8/26/2008	--	<2	<10	<7.5	<10	368	10071	6.1	46	258	523	4035	1.9	27	10	396
	9/23/2008	--	<2	*13*	<7.5	<10	317	10071	5.3	40	221	457	4035	1.7	24	9	346

TABLE 3-7
SHALLOW ALLUIVIAL WATER COPCS, TRIBUTARY 1
COMPARED TO NMWQC AND CHIRICAHUA LEOPARD FROG TOXICITY THRESHOLDS, ADAPTED FROM ERA

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Location	Date	COPC (µg/L)					mg/L	Hardness-Adjusted Acute NMWQC Pre-FS RAC [1]					Hardness-Adjusted Chronic NMWQC [1]				
		Al (T)	Cd (D)	Cu (D)	Pb (D)	Zn (D)	Hardness	Al (T)	Cd (D)	Cu (D)	Pb (D)	Zn (D)	Al (T)	Cd (D)	Cu (D)	Pb (D)	Zn (D)
Frog Criteria for > 400 mg/L	**Leopard Frog NOEC (1a)**	--	53.7	9.6	--	217	400	--	--	--	--	--	--	--	--	--	--
	Leopard Frog LOEC (1b)	--	311	22.3	--	--	400	--	--	--	--	--	--	--	--	--	--
	Leopard Frog GM NOEC (1c)	--	111	29.1	--	275	400	--	--	--	--	--	--	--	--	--	--
	Leopard Frog GM LOEC (1d)	--	311	128	--	--	400	--	--	--	--	--	--	--	--	--	--
LB6	10/5/2007	< 0.08	<0.2	2.5	<3	<10	180	7651	3.1	23	122	273	3065	1.1	15	5	207
	1/9/2008	356	<0.2	3.3	<3	<10	134	5107	2.4	18	89	209	2046	0.9	12	3	158
	2/19/2008	< 0.08	<2	<10	<7.5	<10	189	8179	3.3	24	128	285	3277	1.2	15	5	216
	4/1/2008	--	<2	<10	<7.5	<10	186	8002	3.2	24	126	281	3206	1.1	15	5	213
	5/13/2008	--	<2	<10	<7.5	<10	186	8002	3.2	24	126	281	3206	1.1	15	5	213
	6/18/2008	--	<2	<10	<7.5	<10	180	7651	3.1	23	122	273	3065	1.1	15	5	207
	8/27/2008	--	<2	<10	<7.5	<10	160	6511	2.8	21	107	245	2609	1.0	13	4	186
	9/22/2008	--	<2	<10	<7.5	<10	128	4797	2.3	17	84	200	1922	0.9	11	3	152
ERA-36[a]	9/9/1995	--	<3	*17*	<40	<10	400	--	6.5	50	281	564	4035	2.0	29	11	428

Footnotes:

[a]ERA-34 is the station name for the sediment sample but is ERA-36 when sampled for surface water for the sitewide ecological remedial investigation (called by its sediment label, ERA-34, in surface water table in LIU Ecological Risk Assessment [ERA]).

(1)Calculated with equation 1 (acute) or 2 (chronic) of New Mexico Administrative Code (NMAC) 20.6.4.900(I), Effective February 8, 2023.
(1a)Highest no-effect concentration observed in Little and Calfee 2008, adjusted for hardness of 400 milligrams per liter (mg/L) reported in LIU ERA.
(1b)Lowest effect concentration observed in Little and Calfee 2008, adjusted for hardness of 400 mg/L reported in ERA.
(1c)Geometric mean of No Observed Effect Concentration (NOEC) concentrations for all endpoints observed Little and Calfee 2008, adjusted for hardness of 400 mg/L in LIU ERA.
(1d)Geometric mean of Lowest Observed Effect Concentration (LOEC) concentrations for all endpoints observed in Little and Calfee 2008, adjusted for hardness at 400 micrograms per liter (µg/L) in LIU ERA.

Notes:
1. Light gray shaded cells present decision criteria for comparison after hardness adjustments; bolded if exceeded. White (i.e., unshaded) cells present actual sample data.
2. No studies were available to develop a Leopard frog NOEC or LOEC for lead; an amphibian toxicity reference value is 20,000 µg/L (Harfenist et al. 1989; Schafer and Associates 1999a,b), much higher than observed.
3. *Italicized* data exceeded a Chiricahua Leopard Frog NOEC.
4. **Bold** data exceeded a Chiricahua Leopard Frog LOEC.
5. Data highlighted yellow exceeded NMWQC chronic aquatic life criteria, but not Pre-FS RAC.
6. Data highlighted orange exceeded NMWQC acute aquatic life criteria; (is Pre-FS RAC for this ephemeral stream).
7. No hardness data provided for 2007/2008 sitewide abatement program data (those with assumed 400 mg/L hardness).
8. pH falls between 6.5 and 9; thus, aluminum is hardness adjusted.
9. New Mexico Water Quality Criteria (NMWQC) = Pre-FS RAC.

Acronyms and Abbreviations:
-- = Not available
< = Not detected; detection limit shown
COPC = constituent of potential concern
D = dissolved
pre-FS RAC = pre-feasiblity study Remedial Action Criteria
T = total

References:

Harfenist, A., T. Power, K.L. Clark, and D.B. Peakall. 1989. A review and evaluation of the amphibian toxicological literature. Can. Widl. Serv. Tech. Rep. Ser. No. 61, Ottawa. 222 p.
Little, E.E. and R.D Calfee. 2008. Toxicity of Herbicides, Pesticides, and Metals to the Threatened Chiricahua Leopard Frog (Rana chiricahuensis). USGS, Columbia Environmental Research Center. Prepared for USFWS and New Mexico Fish and Game. July.
Schafer and Associates. 1999a. Chino Administrative Order of Consent - Sitewide Ecological Risk Assessment Technical Memorandum No. 1: ERA Workplan. CMC Agreement No. C59938.
Schafer and Associates. 1999b. Chino Administrative Order of Consent - Sitewide Ecological Risk Assessment Technical Memorandum No. 2: ERA Sampling and Analysis Data Needs. CMC Agreement No. C59938.

Acute and Chronic Calculations for Hardness-Dependent New Mexico Water Quality Criteria Calculations Lampbright Investigation Unit			
COPCs	m_A	b_A	Conversion factor (CF)
Acute			
Aluminum (Al)	1.3695	1.8308	1
Cadmium (Cd)	0.9789	-3.866	1.136672-[(ln hardness)(0.041838)]
Chromium (Cr) III	0.819	3.7256	0.316
Copper (Cu)	0.9422	-1.7	0.96
Lead (Pb)	1.273	-1.46	1.46203-[(ln hardness)(0.145712)]
Manganese (Mn)	0.3331	6.4676	1
Nickel (Ni)	0.846	2.255	0.998
Zinc (Zn)	0.9094	0.9095	0.978
Chronic			
Aluminum (Al)	1.3695	0.9161	1
Cadmium (Cd)	0.7977	-3.909	1.101672-[(ln hardness)(0.041838)]
Chromium (Cr) III	0.819	0.6848	0.86
Copper (Cu)	0.8545	-1.702	0.96
Lead (Pb)	1.273	-4.705	1.46203-[(ln hardness)(0.145712)]
Manganese (Mn)	0.3331	5.8743	1
Nickel (Ni)	0.846	0.0584	0.997
Zinc (Zn)	0.9094	0.6235	0.986

TABLE 3-7
SHALLOW ALLUIVIAL WATER COPCS, TRIBUTARY 1
COMPARED TO NMWQC AND CHIRICAHUA LEOPARD FROG TOXICITY THRESHOLDS, ADAPTED FROM ERA
FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Location	Date	COPC (µg/L)					mg/L	Hardness-Adjusted Acute NMWQC Pre-FS RAC [1]					Hardness-Adjusted Chronic NMWQC [1]				
		Al (T)	Cd (D)	Cu (D)	Pb (D)	Zn (D)	Hardness	Al (T)	Cd (D)	Cu (D)	Pb (D)	Zn (D)	Al (T)	Cd (D)	Cu (D)	Pb (D)	Zn (D)
Frog Criteria for > 400 mg/L	Leopard Frog NOEC (1a)	--	53.7	9.6	--	217	400	--	--	--	--	--	--	--	--	--	--
	Leopard Frog LOEC (1b)	--	311	22.3	--	--	400	--	--	--	--	--	--	--	--	--	--
	Leopard Frog GM NOEC (1c)	--	111	29.1	--	275	400	--	--	--	--	--	--	--	--	--	--
	Leopard Frog GM LOEC (1d)	--	311	128	--	--	400	--	--	--	--	--	--	--	--	--	--

Criteria (µg/L) = $\exp(m_A [\ln(\text{hardness})] + b_A)(CF)$

TABLE 3-8
SHALLOW ALLUIVIAL AND SURFACE WATER COPCS, TRIBUTARY 2
COMPARED TO NMWQC AND CHIRICAHUA LEOPARD FROG TOXICITY THRESHOLDS, ADAPTED FROM ERA,
STARTING IN JULY 2008

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Location	Date	COPC (µg/L)					mg/L
		Al	Cd	Cu	Pb	Zn	Hardness
Shallow Alluvial Water							
Criteria for ≥ 400 mg/L hardness sites (LBT-07 to LBT-17, ERA-36)	**Acute NMWQC pre-FS RAC (1)**	10071	6.54	49.6	281	564	400
	Chronic NMWQC pre-FS RAC (1)	4035	2.03	29.3	10.9	428	400
	Leopard Frog NOEC (1a)	--	53.7	9.6	--	217	400
	Leopard Frog LOEC (1b)	--	311	22.3	--	--	400
	Leopard Frog GM NOEC (1c)	--	111	29.1	--	275	400
	Leopard Frog GM LOEC (1d)	--	311	128	--	N/A	400
LBT-07	7/22/2008	<80	<2	*12*	<7.5	70	400
LBT-08	7/22/2008	100	<2	*11*	<7.5	50	400
LBT-09	7/22/2008	<80	<2	<10	<7.5	20	400
LBT-10	7/21/2008	<80	<2	<10	<7.5	<10	400
	9/17/2009	--	--	6.9	--	<10	400
	9/23/2010	--	--	9.4	--	<10	400
LBT-11	7/22/2008	<80	2.8	***26***	24	***510***	400
	5/6/2009	--	--	5.3	--	**2330**	400
	9/17/2009	--	--	*10.7*	--	***610***	400
	9/21/2010	--	--	2.7	--	***1090***	400
LBT-12	7/23/2008	<80	4.2	<10	<7.5	200	400
LBT-13	7/23/2008	<80	<2	<10	<7.5	20	400
LBT-14	7/21/2008	<80	<2	<10	<7.5	<10	400
LBT-15	7/22/2008	<80	<2	<10	<7.5	<10	400
LBT-16	7/23/2008	--	<2	<10	<7.5	<10	400
	9/21/2009	--	--	3.6	--	<10	400
	9/24/2010	--	--	4.5	--	<10	400
LBT-17	9/21/2009	--	--	4.5	--	<10	400
	9/21/2010	--	--	2.9	--	<10	400
ERA-36	9/9/1995	--	<3	*17*	<40	<10	400
Rainfall Pools							
Trib2A-SW Criteria	**Acute NMWQC (1)**	10071	5.91	44.76	251	512	--
	Chronic NMWQC (1)	4035	1.95	26.7	10	387	--
	Leopard Frog NOEC (1a)	--	49	8.72	--	196	--
	Leopard Frog LOEC (1b)	--	286	20.4	--	N/A	--
	Leopard Frog GM NOEC (1c)	--	102	9.12	--	250	--
	Leopard Frog GM LOEC (1d)	--	286	40	--	N/A	--
Trib2A-SW	9/23/2010	<17.2	0.038	5.2	<0.019	2.5	359
38+20-SW Criteria	**Acute NMWQC (1)**	3143	1.69	19.92	101.56	234.15	--
	Chronic NMWQC (1)	1259	0.71	12.81	3.96	177.35	--
	Leopard Frog NOEC (1a)	--	26	4.18	--	89.8	--
	Leopard Frog LOEC (1b)	--	148	9.77	--	--	--
	Leopard Frog GM NOEC (1c)	--	53	12.7	--	114	--
	Leopard Frog GM LOEC (1d)	--	148	55.8	--	--	--
38+20-SW	9/23/2010	<17.2	<0.036	*8.9*	<0.020	0.99	152
130+00-SW Criteria	**Acute NMWQC (1)**	10071	3.94	29.67	159.3	343.96	--
	Chronic NMWQC (1)	4035	1.41	18.38	6.21	260.52	--
	Leopard Frog NOEC (1a)	--	35	6	--	132	--
	Leopard Frog LOEC (1b)	--	205	14	--	--	--
	Leopard Frog GM NOEC (1c)	--	73	18.3	--	168	--
	Leopard Frog GM LOEC (1d)	--	205	80	--	--	--
130+00-SW	9/23/2010	<17.2	<0.037	*9.4*	<0.021	4.2	232
65+40-SW Criteria	**Acute NMWQC (1)**	10071	3.5	30.75	165.82	356.07	**--**
	Chronic NMWQC (1)	4035	0.85	18.99	6.46	269.69	**--**
	Leopard Frog NOEC (1a)	--	36	6.21	--	137	**--**
	Leopard Frog LOEC (1b)	--	211	14.5	--	--	**--**
	Leopard Frog GM NOEC (1c)	--	76	18.9	--	174	**--**
	Leopard Frog GM LOEC (1d)	--	211	83	--	--	**--**
65+40-SW	9/23/2010	0.0189	<0.038	*9.1*	0.053	1.6	241

TABLE 3-8
SHALLOW ALLUIVIAL AND SURFACE WATER COPCS, TRIBUTARY 2
COMPARED TO NMWQC AND CHIRICAHUA LEOPARD FROG TOXICITY THRESHOLDS, ADAPTED FROM ERA,
STARTING IN JULY 2008

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Footnotes:

(1)Calculated with equation 1 (acute) or 2 (chronic) of New Mexico Administrative Code (NMAC) 20.6.4.900(I), Effective February 8, 2023.

(1a) Highest no-effect concentration observed in Little and Calfee 2008, adjusted for hardness reported in Ecological Risk Assessment (ERA).

(1b)Lowest effect concentration observed in Little and Calfee 2008, adjusted for hardness reported in ERA.

(1c)Geometric mean of No Observed Effect Concentration (NOEC) concentrations for all endpoints observed Little and Calfee 2008, adjusted for hardness.

(1d)Geometric mean of Lowest Observed Effect Concentration (LOEC) concentrations for all endpoints observed in Little and Calfee 2008.

Notes:

1. Light gray shaded cells present decision criteria for comparison after hardness adjustments (same hardness for all but rainfall pools). White (i.e, unshaded) cells present actual sample data.
2. No studies were available to develop a Leopard frog NOEC or LOEC for lead; an amphibian toxicity reference value is 20,000 micrograms per liter (µg/L) (Harfenist et al. 1989; Schafer and Associates 1999a,b), much higher than observed.
3. *Italicized* data exceeded a Chiricahua Leopard Frog NOEC.
4. **Bold** data exceeded a Chiricahua Leopard Frog LOEC.
5. Data highlighted yellow exceeded NMWQC chronic aquatic life criteria (is pre-FS RAC for this stream).
6. Data highlighted orange exceeded NMWQC acute aquatic life criteria.
7. No hardness data provided for 2007/2008 sitewide abatement program data (those with 400 milligrams per liter [mg/L] hardness). Hardness was estimated based on available data or calculations using calcium and magnesium data (400 mg/L is calculated).
8. New Mexico Water Quality Criteria (NMWQC) = Pre-FS RAC.

Acronyms and Abbreviations:

-- = Not available

< = Not detected; detection limit shown
COPC = constituent of potential concern
N/A = Not applicable
pre-FS RAC = pre-feasiblity study Remedial Action Criteria

References:

Harfenist, A., T. Power, K.L. Clark, and D.B. Peakall. 1989. A review and evaluation of the amphibian toxicological literature. Can. Widl. Serv. Tech. Rep. Ser. No. 61, Ottawa. 222 p.

Little, E.E. and R.D Calfee. 2008. Toxicity of Herbicides, Pesticides, and Metals to the Threatened Chiricahua Leopard Frog (Rana chiricahuensis). USGS, Columbia Environmental Research Center. Prepared for USFWS and New Mexico Fish and Game. July.

Schafer and Associates. 1999a. Chino Administrative Order of Consent - Sitewide Ecological Risk Assessment Technical Memorandum No. 1: ERA Workplan. CMC Agreement No. C59938.

Schafer and Associates. 1999b. Chino Administrative Order of Consent - Sitewide Ecological Risk Assessment Technical Memorandum No. 2: ERA Sampling and Analysis Data Needs. CMC Agreement No. C599

Acute and Chronic Calculations for Hardness-Dependent
New Mexico Water Quality Criteria Calculations
Lampbright Investigation Unit

COPCs	m_A	b_A	Conversion factor (CF)
Acute			
Aluminum (Al)	1.3695	1.8308	1
Cadmium (Cd)	0.9789	-3.866	1.136672-[(ln hardness)(0.041838)]
Chromium (Cr) III	0.819	3.7256	0.316
Copper (Cu)	0.9422	-1.7	0.96
Lead (Pb)	1.273	-1.46	1.46203-[(ln hardness)(0.145712)]
Manganese (Mn)	0.3331	6.4676	1
Nickel (Ni)	0.846	2.255	0.998
Zinc (Zn)	0.9094	0.9095	0.978
Chronic			
Aluminum (Al)	1.3695	0.9161	1
Cadmium (Cd)	0.7977	-3.909	1.101672-[(ln hardness)(0.041838)]
Chromium (Cr) III	0.819	0.6848	0.86
Copper (Cu)	0.8545	-1.702	0.96
Lead (Pb)	1.273	-4.705	1.46203-[(ln hardness)(0.145712)]
Manganese (Mn)	0.3331	5.8743	1
Nickel (Ni)	0.846	0.0584	0.997
Zinc (Zn)	0.9094	0.6235	0.986

Criteria (µg/L) = $\exp(m_A [\ln(hardness)] + b_A)(CF)$

TABLE 3-9
SEDIMENT DATA, TRIBUTARY 1

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
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Location ID	Date	Al	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	Se	V	Zn	pH
TEC							**0.99**		**43.4**		**31.6**		**35.8**				**22.7**			**121**	
PEC							**4.98**		**111**		**149**		**128**				**48.6**			**459**	
Mid to Late 1990s																					
2214	5/1995	19,500	2.51	184	0.87	2.1	<0.2	7,320	12.5	22.4	**721**	23,400	22.6	8,900	1,050	10.4	12.7	0.5	25.1	*208*	4.13
2215	5/1995	--	--	--	--	--	--	--	--	13.5	**260**	--	--	--	--	--	--	--	--	--	4.98
2216	5/1995	14100	2.41	143	0.86	1.2	<0.2	3330	8.57	9.85	138	15400	14.5	3800	426	1.92	8.1	0.3	20.1	72.5	6.05
2218	5/1995	--	--	--	--	--	--	--	--	6.24	*37.8*	--	--	--	--	--	--	--	--	--	7.04
2219	5/1995	--	--	--	--	--	--	--	--	6.96	*58.4*	--	--	--	--	--	--	--	--	--	7.85
2220	5/1995	5,750	1.41	111	0.4	1.2	<0.2	7,990	4.91	5.33	*32.9*	9,660	14.6	2,260	507	<0.6	<2.1	0.1	16.5	45.6	7.55
2221	5/1995	5,110	1.54	52.6	0.3	<1.2	<0.2	2,990	4.17	6.13	30	10,500	12.6	2,780	484	<0.6	2.2	<0.1	17.3	50	8.12
2222	5/1995	--	--	--	--	--	--	--	--	8.1	30.2	--	--	--	--	--	--	--	--	--	7.7
2223	5/1995	--	--	--	--	--	--	--	--	7.24	*52.1*	--	--	--	--	--	--	--	--	--	8.03
2224	5/1995	8,190	1.05	81.1	0.33	1.4	<0.2	3,160	6.77	7.03	*46.2*	12,300	10.1	2,850	449	<0.6	3.3	<0.1	22.6	59.6	8.04
ERA-34	9/9/1999	8,210	1	135	--	1.2	0.5	2,670	6	8	*57*	11,700	28	--	509	--	5	0.16	16	65	--
2009																					
2408	5/5/2009	--	<20	--	--	--	--	--	*61*	10	*50*	--	19	--	--	<10	<10	--	78	78	--
2409	5/5/2009	--	<20	--	--	--	--	--	*86*	11	*68*	--	18	--	--	<10	<10	--	81	78	--
2410	5/6/2009	--	<20	--	--	--	--	--	*79*	14	*72*	--	22	--	--	<10	<10	--	73	120	--
376-2005-04	5/5/2009	--	<20	--	--	--	--	--	*86*	18	**296**	--	25	--	--	<10	10	--	76	*137*	--
376-2005-05	5/6/2009	--	<20	--	--	--	--	--	41	10	*99*	--	27	--	--	<10	<10	--	74	102	--
376-96-04	5/6/2009	--	<20	--	--	--	--	--	*59*	14	*76*	--	24	--	--	<10	<10	--	85	108	--
LBT1-BF1	5/5/2009	--	<20	--	--	--	--	--	*55*	13	*147*	--	*37*	--	--	<10	<10	--	83	103	--
2010																					
1-1	12/9/2010	--	2.6	101	--	--	0.27	9900	12.5	8.39	*51.5*	19900	10.7	7000	531	0.6	10.2	0.14	37.9	58	8.1
1-2	12/9/2010	--	2.7	106	--	--	0.35	7700	9	8.87	*44*	21000	11	6200	584	0.5	8.3	0.11	34.9	81	7.9

Notes:
1. Results are presented in milligrams per kiligram (mg/kg).
2. Results exclude subsurface samples.
3. *Italicized* data are greater than the threshold effect concentration (TEC).
4. **Bold** data are greater than probable effects concentration (PEC).
5. The three ecological risk assessment (ERA) sample results were averaged.
7. < = Not detected at method detection limit, which is shown.
8. -- = Not available

TABLE 3-10
SEDIMENT DATA, TRIBUTARY 2

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Location ID	Date	Al	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	Se	V	Zn	pH
TEC							**0.99**		**43.4**		**31.6**		**35.8**				**22.7**			**121**	
PEC							**4.98**		**111**		**149**		**128**				**48.6**			**459**	
Mid 1990s																					
2201	5/1995	--	--	--	--	--	--	--	--	11.2	*129*	--	--	--	--	--	--	--	--	--	8.05
2202	5/1995	12000	4.72	137	0.79	2.11	<0.21	7,630	8.32	11.7	**183**	21600	21.2	2930	440	1.19	13.7	0.2	17.9	118	7.98
2203	5/1995	--	--	--	--	--	--	--	--	13.6	*46.9*	--	--	--	--	--	--	--	--	--	7.91
2206	5/1995	9440	4.6	88.5	0.59	<1.2	<0.2	3,040	4.96	12.9	**164**	14500	21.7	1590	348	5.74	8.35	0.2	9.22	89.8	7.32
2207	5/1995	--	--	--	--	--	--	--	--	8.9	*75.2*	--	--	--	--	--	--	--	--	--	7.73
2211	5/1995	7,900	4.27	82.8	0.62	1.6	0.28	4,150	7.01	11	*125*	19,900	18.6	2,600	514	2.41	11.8	0.2	17	112	7.83
2204	5/1995	22600	4.76	342	0.89	1.43	0.93	11,200	17.3	10.7	**253**	22600	*55*	4180	729	0.63	15.2	1	24.6	*228*	7.46
2205	5/1995	--	--	--	--	--	--	--	--	6.41	**200**	--	--	--	--	--	--	--	--	--	4.14
2208	5/1995	12000	6.09	91.3	0.47	<1.3	*1.77*	5,350	6.03	6.75	*133*	18500	**171**	4420	560	<0.64	11.1	1.7	14.7	*427*	7.4
2209	5/1995	10,100	2.26	108	0.81	4.5	<0.2	43,800	4.88	4.56	*36*	14,200	11.9	3,370	191	<0.6	5.9	1	9.67	31	8.09
2210	5/1995	--	--	--	--	--	--	--	--	8.1	*48.5*	--	--	--	--	--	--	--	--	--	7.98
2212	5/1995	--	--	--	--	--	--	--	--	8.14	*51.1*	--	--	--	--	--	--	--	--		7.8
2213	5/1995	--	--	--	--	--	--	--	--	13.2	*78.9*	--	--	--	--	--	--	--	--		8.05
2228	5/1995	--	--	--	--	--	--	--	--	10.8	*107*	--	--	--	--	--	--	--	--	--	7.82
2229	5/1995	5,670	4.23	68.2	0.64	2.2	<0.2	3,230	6.38	11.2	*113*	17,100	29	1,620	469	0.73	9.4	0.1	13.2	104	7.78
2231	5/1995	9,150	8.33	116	0.69	1.7	*1.28*	15,300	11.8	12.6	*122*	17,300	19.2	2,700	636	<0.6	12.7	0.1	16.8	*156*	7.85
ERA-30	9/9/1999	8,710	2.9	111	--	1.1	0.6	9,450	8	9	102	16,067	*39*	--	511	2	10	--	14	91	7.53
April 2008																					
T2S7	4/28/2008	8,100	4.89	194	0.945	<4.0	0.51	20,500	7.22	24.9	**234**	24,100	17.2	2,520	1,420	1.04	17.9	0.312	14.8	*185*	7.31
T2S8	4/28/2008	10,300	18.5	121	1.03	<4.0	0.69	25,500	12.6	21.1	**359**	22,300	26	3,310	846	1.89	19.4	0.426	23.3	*260*	7.43
T2S9	4/28/2008	10,700	4.14	124	0.889	<4.0	0.6	10,200	11.2	14.6	**168**	23,200	32	3,420	656	1.75	15.6	0.301	23.8	*260*	7.3
T2S10	4/23/2008	8,860	5.43	115	0.871	<4.0	*1.51*	10,800	11	15.1	**207**	20,300	*62.5*	3,120	566	1.91	15.9	0.442	23	*400*	7.29
T2S11	4/23/2008	11,600	5.99	149	1.2	<4.0	0.83	18,700	24.8	14.5	**201**	29,200	24.2	3,410	754	1.52	21.7	0.339	40.7	*295*	7.43
T2S12	4/23/2008	8,910	10.9	142	0.876	<4.0	0.82	11,100	14.8	12.9	**166**	23,500	31.1	2,900	629	1.31	18.5	0.342	29.7	*291*	7.59
T2S6	4/23/2008	9,550	6.13	134	0.959	<4.0	0.67	8,720	17	11.7	**189**	26,200	*76.6*	2,890	610	1.86	17.2	0.319	37.7	*281*	7.23
T2S5	4/23/2008	9,230	5.07	121	0.878	<4.0	0.32	7,960	12.4	10.4	**207**	22,500	*59.5*	2,680	564	2.22	13.3	0.265	27.1	*181*	6.9
T2S4	4/23/2008	8,140	3.96	102	0.663	<4.0	<0.20	17,100	9.09	8.78	*98.2*	21,300	27.2	3,110	497	2.63	11.7	0.213	22.9	105	7.37
T2S3	4/23/2008	13,300	4.6	159	0.834	<4.0	0.43	14,100	20.7	8.18	*97.2*	18,600	27.2	3,690	917	2.64	16	0.361	27.1	110	7.25
T2S2	4/23/2008	12,000	1.64	547	0.536	<4.0	0.24	9,420	7.99	11.4	*118*	15,900	12.8	5,420	1,270	3.45	9.04	<0.200	23.6	98.1	6.99
T2S1	4/23/2008	8,460	2.39	69.5	0.599	<4.0	<0.20	4,500	8.6	8.86	*125*	20,700	20.4	4,240	509	2.48	10.5	<0.200	23.4	118	7.6
July 2008																					
T2S7	7/23/2008	6,270	5.38	136	0.669	<4.0	0.36	10,500	7.9	9.12	*56.1*	17,400	10.3	2,250	770	1.2	20.6	0.34	14.2	110	7.31
T2S8	7/23/2008	5,380	3.35	73.6	0.519	<4.0	0.36	8,870	7.7	7.67	*71.7*	11,700	8.2	1,590	456	1.57	17.6	<0.200	12.1	95.6	7.25
T2S9	7/23/2008	8,070	3.21	98.9	0.797	<4.0	0.65	18,000	9.2	9.27	143	19,000	11.4	2,360	460	1.73	13.7	0.231	18.3	*150*	7.13
T2S10	7/22/2008	6,670	3.86	68	0.765	<4.0	0.52	6,560	9.3	8.53	**199**	16,200	11.2	1,680	337	1.46	*45.3*	0.299	18.5	*177*	7.15
T2S11	7/22/2008	7,690	3.05	89	0.926	<4.0	0.46	6,750	15.5	7.78	*94*	16,300	11.8	1,830	405	1.39	19.4	<0.200	21.8	*151*	7.38
T2S12	7/22/2008	5,240	3.56	62.4	0.8	<4.0	0.41	6,760	13	7.66	*126*	19,300	10.4	1,880	405	1.22	*38.6*	0.333	22.4	*138*	7.34
T2S6	7/22/2008	6,860	4.54	101	0.743	<4.0	0.59	6,260	12.6	9.25	*140*	18,100	11.5	1,770	476	2	**51**	<0.200	25.5	*168*	7.1
T2S5	7/22/2008	5,820	5.8	54.8	0.76	<4.0	0.35	9,410	7.3	7.01	*123*	17,500	8.9	2,660	425	1.42	*26.7*	0.284	20.8	121	7.35
T2S4	7/22/2008	7,870	3.8	121	0.882	<4.0	0.54	4,710	7.8	8.13	*91.9*	22,700	12.3	1,920	411	1.85	*44.7*	0.22	24	*168*	7.18
T2S3	7/21/2008	5,960	3.15	54.4	0.608	<4.0	0.43	5,780	7	8.26	*103*	16,800	9	2,790	430	1.39	*34.1*	<0.200	17.9	111	7.41
T2S2	7/21/2008	7,470	2.1	213	0.478	<4.0	0.29	6,470	5.2	8.61	*99*	12,300	7.6	4,080	547	1.39	15.6	<0.200	16.1	88.8	7.24
T2S1	7/21/2008	5,650	2.12	65.5	0.477	<4.0	0.32	5,430	6.5	7.46	*94.1*	14,600	8.1	2,870	457	1.95	21.4	<0.200	18.6	80	6.98

TABLE 3-10
SEDIMENT DATA, TRIBUTARY 2

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Location ID	Date	Al	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	Se	V	Zn	pH
TEC							**0.99**		**43.4**		**31.6**		**35.8**				**22.7**			**121**	
PEC							**4.98**		**111**		**149**		**128**				**48.6**			**459**	
May 2009																					
T2S7	5/5/2009	--	--	--	--	--	--	33,200	--	--	*72.6*	16,600	--	2,700	910	--	--	--	--	108	7.74
T2S10	5/5/2009	--	--	--	--	--	--	7,120	--	--	*126*	17,800	--	2,260	561	--	--	--	--	*202*	7.34
T2S3	5/5/2009	--	--	--	--	--	--	14,300	--	--	*76.1*	19,100	--	2,850	529	--	--	--	--	*128*	7.72
T2S1	5/6/2009	--	--	--	--	--	--	6,930	--	--	*79*	19,500	--	3,960	588	--	--	--	--	116	8.04
September 2009																					
T2S7	9/21/2009	--	--	--	--	--	--	13,600	--	--	*50.5*	14,600	--	2,690	1,120	--	--	--	--	*138*	7.54
T2S10	9/17/2009	--	--	--	--	--	--	9,110	--	--	*107*	13,300	--	1,900	520	--	--	--	--	*171*	7.19
T2S3	9/17/2009	--	--	--	--	--	--	6,000	--	--	*70.4*	17,000	--	2,680	510	--	--	--	--	112	7.63
T2S1	9/16/2009	--	--	--	--	--	--	4,550	--	--	*52.1*	14,600	--	3,100	412	--	--	--	--	88.9	7.95
September 2010																					
T2S7	9/21/2010	--	--	--	--	--	--	8,260	--	--	*37.4*	18,900	--	2,450	603	--	--	--	--	*126*	7.55
T2S10	9/21/2010	--	--	--	--	--	--	6,010	--	--	*84.8*	12,500	--	1,920	525	--	--	--	--	*210*	6.76
T2S3	9/21/2010	--	--	--	--	--	--	6,370	--	--	*90.2*	15,500	--	2,890	361	--	--	--	--	107	7.53
T2S1	9/21/2010	--	--	--	--	--	--	11,300	--	--	*63.5*	17,000	--	5,370	656	--	--	--	--	92.9	8.01
September 2010 at Rainfall Pools																					
TRIB-2A	9/23/2010	9570	3.2	141	0.66	0.81	0.17	4,520	9.1	11.7	*38.4*	19,200	17	3,460	545	4.2	9.1	<0.5	23.4	84	7.72
38+20	9/23/2010	14100	5.7	190	0.87	2.1	0.49	13,100	16.1	9.2	*71.5*	19,700	23.4	3,110	623	1.8	13.2	<0.59	25.3	*136*	7.91
65+40	9/23/2010	18500	6.6	239	1.1	2.3	0.52	16,100	21.6	10.7	*92.3*	23,100	28.8	3,960	716	2.4	16.3	<0.5	31	*162*	7.66
130+00	9/23/2010	10700	3.3	112	0.62	0.81	0.36	7,250	10.4	8.3	*77.9*	22,800	19.1	4,560	529	4.9	9.7	<0.5	31.3	*124*	8.34

Notes:
1. Results are presented in milligrams per kiligram (mg/kg).
2. Results exclude subsurface samples.
3. *Italicized* data are greater than the threshold effect concentration (TEC).
4. **Bold** data are greater than probable effects concentration (PEC).
5. Quality control samples (duplicates) are not included because only original data are being used for the Feasibility Study.
7. < = Not detected at method detection limit, which is shown.
8. -- = Not available

TABLE 3-11
SEDIMENT DATA, DOWNSTREAM OF TRIBUTARY 1 AND TRIBUTARY 2

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Location ID	Date	Co	Cu	pH
1995				
2225	5/1995	5.97	*44.5*	8.23
2226	5/1995	5.66	*39.1*	8.1
2227	5/1995	3.74	12.4	7.42

Notes:

1. Results are presented in milligrams per kiligram (mg/kg).
2. Results exclude subsurface samples.
3. *Italicized* data are greater than the threshold effect concentration (TEC).
4. **Bold** data are greater than probable effects concentration (PEC) (i.e., none).
5. Only the constituents listed were sampled.

TABLE 3-12
SEDIMENT COPCs COMPARED TO CRITERIA, AS SHOWN IN ERA

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Sample Location	Type	Tributary	Sample Date	Cadmium TEC=0.99 PEC = 4.98	Chromium TEC=43.4 PEC=111	Copper TEC=31.6 PEC=149	Lead TEC=35.8 PEC= 128	Nickel TEC=22.7 PEC=48.6	Zinc TEC=121 PEC=459
2214	Site	1	1995	<0.2	12.5	***721***	22.6	12.7	*208*
2215	Site	1	1995	---	---	***260***	---	---	---
2216	Site	1	1995	<0.2	8.57	*138*	14.5	8.1	72.5
2218	Site	1	1995	---	---	*37.8*	---	---	---
2219	Site	1	1995	---	---	*58.4*	---	---	---
2220	Site	1	1995	<0.2	4.91	*32.9*	14.6	<2.1	45.6
2221	Site	1	1995	<0.2	4.17	30	12.6	2.2	50
2222	Site	1	1995	---	---	30.2	---	---	---
2223	Site	1	1995	---	---	*52.1*	---	---	---
2224	Site	1	1995	<0.2	6.77	*46.2*	10.1	3.3	59.6
ERA-34-1	Site	1	9/9/1999	0.52	6.1	*59.7*	23.3	7.6	71.4
ERA-34-2	Site	1	9/9/1999	0.57	5.9	*57.4*	30.2	5	64.3
ERA-34-3	Site	1	9/9/1999	0.5	<5.1	*54.1*	30.6	3.8	58.8
2408	Site	1	5/5/2009	---	*61*	*50*	19	<10	78
2409	Site	1	5/5/2009	---	*86*	*68*	18	<10	78
2410	Site	1	5/6/2009	---	*79*	*72*	22	<10	120
376-2005-04	Site	1	5/5/2009	---	*86*	***296***	25	<10	*137*
376-2005-05	Site	1	5/6/2009	---	*41*	*99*	27	<10	102
376-96-04	Site	1	5/6/2009	---	*59*	*76*	24	<10	108
LBT1-BF1	Site	1	5/5/2009	---	*55*	*147*	*37*	<10	103
1-1	Site	1	12/9/10	0.27	12.5	*51.5*	10.7	10.2	58
1-2	Site	1	12/9/10	0.35	9	*44*	11	8.3	81
2201	Site	2A	1995	---	---	*129*	---	---	---
2202	Site	2A	1995	<0.2	8.32	***183***	21.2	13.7	118
2203	Site	2A	1995	---	---	*46.9*	---	---	---
2206	Site	2A	1995	<0.2	4.96	***164***	21.7	8.35	89.8
2207	Site	2A	1995	---	---	*75.2*	---	---	---
2211	Site	2A	1995	0.28	7.01	*125*	18.6	11.8	112
TRIB 2A	Site	2A	9/23/2010	0.17	9.1	*38.4*	17	9.1	84
130+00	Site	2	9/23/2010	0.36	10.4	*77.9*	19.1	9.7	*124*
38+20	Site	2	9/23/2010	0.49	16.1	*71.5*	23.4	13.2	*136*
65+40	Site	2	9/23/2010	0.52	21.6	*92.3*	28.8	16.3	*162*

TABLE 3-12
SEDIMENT COPCs COMPARED TO CRITERIA, AS SHOWN IN ERA

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Sample Location	Type	Tributary	Sample Date	Cadmium TEC=0.99 PEC = 4.98	Chromium TEC=43.4 PEC=111	Copper TEC=31.6 PEC=149	Lead TEC=35.8 PEC= 128	Nickel TEC=22.7 PEC=48.6	Zinc TEC=121 PEC=459
T2S1	Site	2	7/21/2008	0.32	6.5	*94.1*	8.1	21.4	80
	Site	2	9/16/2009	---	---	*52.1*	---	---	88.9
	Site	2	9/21/2010	---	---	*63.5*	---	---	92.9
T2S10	Site	2	7/22/2008	0.52	9.3	***199***	11.2	*45.3*	*177*
	Site	2	9/17/2009	---	---	*107*	---	---	*171*
	Site	2	9/21/2010	---	---	*84.8*	---	---	*210*
T2S11	Site	2	7/22/2008	0.46	15.5	*94*	11.8	19.4	*151*
T2S12	Site	2	7/22/2008	0.41	13	*126*	10.4	*38.6*	*138*
T2S2	Site	2	7/21/2008	0.29	5.2	*99*	7.6	15.6	88.8
T2S3	Site	2	7/21/2008	0.43	7	*103*	9	*34.1*	111
	Site	2	9/17/2009	---	---	*70.4*	---	---	112
	Site	2	9/21/2010	---	---	*90.2*	---	---	107
T2S4	Site	2	7/22/2008	0.54	7.8	*91.9*	12.3	*44.7*	*168*
T2S5	Site	2	7/22/2008	0.35	7.3	*123*	8.9	26.7	*121*
T2S6	Site	2	7/22/2008	0.59	12.6	*140*	11.5	**51**	*168*
T2S7	Site	2	7/23/2008	0.36	7.9	*56.1*	10.3	20.6	110
	Site	2	9/21/2009	---	---	*50.5*	---	---	*138*
	Site	2	9/21/2010	---	---	*37.4*	---	---	*126*
T2S8	Site	2	7/23/2008	0.36	7.7	*71.7*	8.2	17.6	95.6
T2S9	Site	2	7/23/2008	0.65	9.2	*143*	11.4	13.7	*150*

Notes:
1. Results are presented in milligrams per kiligram (mg/kg).
2. Quality control samples (duplicates) are not included because only original data are being used for the Feasibility Study.
3. *Italicized* data are greater than the threshold effect concentration (TEC).
4. **Bold** data are greater than probable effects concentration (PEC) (i.e., none).
5. --- = No data for this constituent at this location.
6. These data are duplicated from the Lampbright Inestigation Unit Ecological Risk Assessment, which excluded sediment data in April 2008 and May 2009 (shown in Tables 3-9 and 3-10).

TABLE 3-13
LIU SEDIMENT LEACHING PROCEDURE DATA COMPARED TO SURFACE WATER QUALITY CRITERIA, TRIBUTARY 1

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Sediment Sample ID (inches below ground surface)	Sample Date	Metal Analysis			
		Cadmium	Copper	Lead	Zinc
		µg/L	µg/L	µg/L	µg/L
Lowest Water Quality Benchmark		**0.70**	**8.5**	**2.4**	**115**
1-1 (0-0.5)	12/9/2010	<0.5	3.4	0.4	8
1-1 (1-1.5)	12/9/2010	<0.5	3.8	1.4	6
1-1 (2-2.5)	12/9/2010	<0.5	4	1.3	11
1-2 (0-0.5)	12/9/2010	<0.5	4.9	0.3	0.3
1-2 (1.5-2)	12/9/2010	<0.5	6.1	0.2	3

Notes:

1. Results are presented in micrograms per liter (µg/L) and based on lowest hardness of 94 mg/L for Tributary 1.
2. Data are from Golder (2016) or Formation (2018). See Table 3-16 for other analytes.
3. < = Analyte not detected above Method Detection Limit and displayed as less than the Practical Quantification Limit (PQL).
4. The number shown in parentheses beside the parameter name (e.g., "Aluminum (1312)") is the U.S. Environmental Protection Agency-specified laboratory extraction me method
5. USEPA 1312 was the method used for the synthetic precipitation leaching procedure.

Reference:

Formation Environmental (Formation). 2018. Ecological Risk Assessment for Lampbright Investigation Unit Chino Mine Investigation Area, Grant County, New Mexico. Prepared for New Mexico Environment Department. (Section 5, General Risk Assessment Uncertainties, updated 2019).

Golder Associates, Inc. (Golder). 2016. Site-Wide Stage 1 Abatement Plan. Revised Final Site Investigation Report. March.

TABLE 3-14
SCREENING OF SEDIMENT TO GROUNDWATER PATHWAY FOR METALS WITH DAF > 1

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Sample ID	Sample Date	Total Metals Analysis											
		As	Ba	Cd	Co	Cu	Fe	Pb	Mn	Mo	Ni	Se	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
NMED RISK-BASED SSL-DAF 1[1a]		**0.0250**	**135**	**0.47**	**0.27**	**27.8**	**348**	**--**	**131**	**2.0**	**24.2**	**0.511**	**371**
NMED RISK-BASED SSL-DAF 20[1b]		**0.499**	**2,700**	**9.39**	**5.40**	**556**	**6,960**	**--**	**2,630**	**39.8**	**485**	**10.2**	**7410**
NMGW/MCL-based SSL-DAF 1[1c]		**0.292**	**82**	**0.376**	**--**	**46**	**--**	**13.5**	**--**	**--**	**--**	**--**	
NMGW/MCL-BASED SSL-DAF 20[1d]		**5.83**	**1,650**	**7.52**	**--**	**915**	**--**	**270**	**--**	**--**	**--**	**--**	
NMED FINAL Sediment Screening Level (Cw)[1e]		**5.83**	**2,700**	**9.39**	**5.40**	**915**	**6,960**	**270**	**2,630**	**39.8**	**485**	**10.2**	**7410**
Background[f]		**4.8**	**---**	**1.0**	**21.5**	**327**	**58,200**	**---**	**---**	**---**	**---**	**---**	**---**
2214	1995	2.5	184.0	<0.2	**22.4**	721	23400	23	1050	10.4	12.7	0.5	208
2215	1995	--	--	---	13.5	260	--	---	--	--	---	--	--
2216	1995	2.4	143.0	<0.2	9.9	138	15400	15	426	1.9	8.1	0.3	73
2218	1995	--	--	---	6.2	38	--	---	--	--	---	--	--
2219	1995	--	--	---	7.0	58	--	---	--	--	---	--	--
2220	1995	1.4	111.0	<0.2	5.3	33	9660	15	507	<0.6	<2.1	0.1	46
2221	1995	1.5	52.6	<0.2	6.1	30	10500	13	484	<0.6	2.2	<0.1	50
2222	1995	--	--	---	8.1	30	--	---	--	--	---	--	--
2223	1995	--	--	---	7.2	52	--	---	--	--	---	--	--
2224	1995	1.1	81.1	<0.2	7.0	46	12300	10	449	<0.6	3.3	<0.1	60
ERA-34	9/9/99	1.47	135	0.5	7.7	57	11700	19	509	5.5	5.5	0.2	65
2408	5/5/09	<20	--	---	6.8	50	--	18	171	<10	<10	--	<0.64
2409	5/5/09	<20	--	---	4.6	68	--	22	12	<10	<10	--	<0.6
2410	5/6/09	<20	--	---	8.1	72	--	25	--	<10	<10	--	--
376-2005-04	5/5/09	<20	--	---	18.0	296	--	27	--	<10	<10	--	137
376-2005-05	5/6/09	<20	--	---	10.0	99	--	24	--	<10	<10	--	102
376-96-04	5/6/09	<20	--	---	13.0	76	--	37	--	<10	<10	--	103
LBT1-BF1	5/5/09	<20	--	---	13.0	147	--	11	--	<10	<10	--	103
1-1	12/9/10	2.6	101	0.27	8.4	52	19900	11	531	0.6	10.2	0.14	58
1-2	12/9/10	2.7	106	0.35	8.9	44	21000	---	584	7700	8.3	0.11	81
2201	1995	--	--	---	11.2	129	--	21	--	--	---	--	--
2202	1995	4.72	137	<0.2	11.7	183	21600	---	440	1.19	13.7	0.2	118
2203	1995	--	--	---	13.6	47	--	22	--	--	---	--	--
2206	1995	4.6	88.5	<0.2	12.9	164	14500	---	348	5.74	8.4	0.2	90
2207	1995	--	--	---	8.9	75	--	19	--	--	---	--	--
2211	1995	4.27	82.8	0.28	11.0	125	19900	17	514	2.41	11.8	0.2	112
TRIB 2A	9/23/10	3.2	141	0.17	11.7	38	19200	19	545	4.2	9.1	<0.5	84
130+00	9/23/10	3.3	112	0.36	8.3	78	22800	23	529	4.9	9.7	<0.5	124
38+20	9/23/10	3.3	112	0.49	9.2	72	22800	8	623	4.9	13.2	<0.5	136
65+40	9/23/10	**6.6**	239	0.52	10.7	92	23100	---	716	2.4	16.3	<0.5	162
T2S1	7/21/08	2.12	65.5	0.32	7.7	94	14600	---	457	1.95	21.4	<0.200	80
	9/16/09	--	--	---	---	52	14600	11	412	--	---	--	89
	9/21/10	--	--	---	---	64	17000	---	656	--	---	--	93
T2S10	7/22/08	3.86	68	0.52	8.5	199	16200	---	337	1.46	45.3	0.299	177
	9/17/09	--	--	---	---	107	13300	12	520	--	---	--	171
	9/21/10	--	--	---	---	85	12500	10	525	--	---	--	210
T2S11	7/22/08	3.05	89	0.46	7.8	94	16300	8	405	1.39	19.4	<0.200	151
T2S12	7/22/08	3.56	62.4	0.41	7.7	126	19300	9	405	1.22	38.6	0.333	138
T2S2	7/21/08	2.1	213	0.29	8.6	99	12300	---	547	1.39	15.6	<0.200	89

TABLE 3-14
SCREENING OF SEDIMENT TO GROUNDWATER PATHWAY FOR METALS WITH DAF > 1

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Sample ID	Sample Date	Total Metals Analysis											
		As	Ba	Cd	Co	Cu	Fe	Pb	Mn	Mo	Ni	Se	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
NMED RISK-BASED SSL-DAF 1[1a]		**0.0250**	**135**	**0.47**	**0.27**	**27.8**	**348**	**--**	**131**	**2.0**	**24.2**	**0.511**	**371**
NMED RISK-BASED SSL-DAF 20[1b]		**0.499**	**2,700**	**9.39**	**5.40**	**556**	**6,960**	**--**	**2,630**	**39.8**	**485**	**10.2**	**7410**
NMGW/MCL-based SSL-DAF 1[1c]		**0.292**	**82**	**0.376**	**--**	**46**	**--**	**13.5**	**--**	**--**	**--**	**--**	
NMGW/MCL-BASED SSL-DAF 20[1d]		**5.83**	**1,650**	**7.52**	**--**	**915**	**--**	**270**	**--**	**--**	**--**	**--**	
NMED FINAL Sediment Screening Level (Cw)[1e]		**5.83**	**2,700**	**9.39**	**5.40**	**915**	**6,960**	**270**	**2,630**	**39.8**	**485**	**10.2**	**7410**
Background[f]		**4.8**	**---**	**1.0**	**21.5**	**327**	**58,200**	**---**	**---**	**---**	**---**	**---**	**---**
T2S3	7/21/08	3.15	54.4	0.43	8.3	103	16800	---	430	1.39	34.1	<0.200	111
	9/17/09	--	--	---	---	70	17000	12	510	--	---	--	112
	9/21/10	--	--	---	---	90	15500	9	361	--	---	--	107
T2S4	7/22/08	3.8	121	0.54	8.1	92	22700	12	411	1.85	44.7	0.22	168
T2S5	7/22/08	5.8	54.8	0.35	7.0	123	17500	10	425	1.42	26.7	0.284	121
T2S6	7/22/08	4.54	101	0.59	9.3	140	18100	---	476	2	51.0	<0.200	168
T2S7	7/23/08	5.38	136	0.36	9.1	56	17400	---	770	1.2	20.6	0.34	110
	9/21/09	--	--	---	---	51	14600	8	1120	--	---	--	138
	9/21/10	--	--	---	---	37	18900	11	656	--	---	--	93
T2S8	7/23/08	3.35	73.6	0.36	7.7	72	11700	0	456	1.57	17.6	<0.200	96
T2S9	7/23/08	3.21	98.9	0.65	9.3	143	19000	0	460	1.73	13.7	0.231	150

Footnotes:

1a to 1e = New Mexico Environment Department Risk Assessment Guidance for Site Investigations and Remediation, Volume 1: Soil Screening Guidance for Human Health Risk Assessments, Appendix A, Table A-3, dated November 2021 (NMED 2021).

f = Background values reported in Smelter/Tailing Soils Investigation Unit sediment to groundwater study (Arcadis 2011a) as background based on upper tolerance limit from background report (Chino 1995) data calculated in Gradient Corporation (2008), except cobalt which was calculated from same dataset for this feasibility study.

Notes:

1. The samples evaluated are the same as those evaluated in Table 3-12, which were selected as representative for evaluation after remediation in the Ecological Risk Assessment (ERA).
2. **Bold** data exceeds Cw and Background.
3. < = Analyte not detected above Method Detection Limit (MDL) and displayed as less than the Practical Quantification Limit (PQL; typically five times the MDL).

Acronyms and Abbreviations:

Cw = Maximum of four types of sediment screening values, as recommended in NMED 2021
DAF = dilution attenuation factor
MCL = maximum contaminant level
mg/kg = milligram per kilogram
NMED = New Mexico Environmental Departmer
NMGW = New Mexico groundwater
SSL = soil screening level

References:

Arcadis. 2011a. Groundwater Quality Pre-feasibility Study Remedial Action Criteria for Drainage Sediments. Smelter Tailings Investigation Unit, Chino Mines, Vanadium, New Mexico. April.

Freeport-McMoRan Chino Mines Company (Chino). 1995. Administrative Order on Consent Investigation Area, Remedial Investigation Background Report, Chino Mine Investigation Area. Prepared for New Mexico Environmental Department. October.

Gradient Corporation. 2008. Human Health Risk Assessment. Smelter/Tailings Soils Investigation Unit, Hurley, New Mexico. Gradient Corporation (prepared for New Mexico Environment Department), Cambridge, MA.

TABLE 3-15
ACID BASE ACCOUNTING DATA, SEDIMENT, TRIBUTARY 1

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Sample ID (inches bgs)	Sample Date	Paste pH	Paste EC	CEC	Sulfur				ABA Results				Acid Generating Potential
					Residual	Sulfide	Sulfate	Total	AGP	ANP	Net Neutralizing Potential	ANP/AGP	
		S.U.	mS/cm	meq/100g	%	%	%	%	$tCaCO_3/kt$	$tCaCO_3/kt$	$tCaCO_3/kt$	$tCaCO_3/kt$	
376-05-05	5/5/2009	7.96	< 1	13.0	< 0.010	< 0.010	< 0.010	< 0.010	<0.300	11.1	11.0	74.0	Not Acid Generating
LBT1-BF1	5/5/2009	8.13	< 1	14.0	< 0.010	< 0.010	< 0.010	< 0.010	<0.300	10.1	10.0	67.3	Not Acid Generating
2408	5/5/2009	8.15	< 1	12.2	< 0.010	< 0.010	< 0.010	< 0.010	<0.300	7.10	6.95	47.3	Not Acid Generating
2409	5/6/2009	8.05	< 1	13.4	< 0.010	< 0.010	< 0.010	< 0.010	<0.300	6.10	5.95	40.7	Not Acid Generating
376-96-04	5/6/2009	7.89	< 1	15.3	< 0.010	< 0.010	< 0.010	< 0.010	<0.300	3.00	2.85	20.0	Not Acid Generating
2410	5/6/2009	7.70	< 1	17.6	< 0.010	< 0.010	< 0.010	< 0.010	<0.300	5.10	4.95	34.0	Not Acid Generating
1-1 (0-0.5 inches bgs)	12/9/2010	---	---	---	0.03	<0.1	0.01	0.03	0.9	18	17.1	20	Not Acid Generating
1-1 (1-1.5 inches bgs)	12/9/2010	---	---	---	<0.1	<0.1	<0.1	<0.1	<0.5	8	7.5	16	Not Acid Generating
1-1 (2-2.5 inches bgs)	12/9/2010	---	---	---	<0.1	<0.1	<0.1	<0.1	<0.5	6	5.5	12	Not Acid Generating
1-2 (0-0.5 inches bgs)	12/9/2010	---	---	---	<0.1	<0.1	<0.1	<0.1	<0.5	13	12.5	26	Not Acid Generating
1-2 (1.5-2 inches bgs)	12/9/2010	---	---	---	<0.1	0.01	<0.1	0.01	0.3	6	5.7	20	Not Acid Generating

Notes:
1. Data are from Golder (2016).
2. The actual or estimated limit is shown; values below the method detection limit are presented with "<".

Acronyms and Abbreviations:
ANP = Acid Neutralization Potential
AGP = Acid Generation Potential
bgs = below ground surface
CEC = cation exchange capacity
EC = Electrical Conductivity
meq/100 g = milliequivalents per 100 grams
mS/cm = milliSiemens per centimeter
S.U. = Standard Units
tCaCO3/kt - Tons of Calcium Carbonate per Kiloton Material

Reference:
Golder Associates, Inc. (Golder). 2016. Site-Wide Stage 1 Abatement Plan. Revised Final Site Investigation Report. March.

TABLE 3-16
SEDIMENT LEACHING PROCEDURE DATA FOR GROUNDWATER EVALUATION

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

Sample Name	Sample Date	pH (S.U.)	Carbonate Alkalinity (mg/L as CaCO3)	Bicarbonate Alkalinity (mg/L as CaCO3)	Alkalinity (Total) (mg/L as CaCO3)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)	NO_2+NO_3 as N (mg/L)
Groundwater Standards (Total and Dissolved)														
New Mexico Criteria														
Domestic Water		6-9 acceptable	--	--	--	1000 D	--	250 D	--	--	--	--	600 D	--
Human Health		--	--	--	--	--	--	--	1.6 D	--	--	--	--	--
Irrigation Water		--	--	--	--	--	--	--	--	--	--	--	--	--
USEPA MCL									4 D					NO_2:1, NO_3:10
376-2005-05	5/5/2009	8.60	4.20	61.7	65.9	82.0	16.4	0.510	0.980	5.30	6.60	2.16	10.3	0.220
LBT1-BF1	5/5/2009	8.76	7.2	61.5	68.7	86	16.5	0.65	1.030	5.3	8.7	2.29	11	0.22
2408	5/5/2009	8.72	6.10	55.8	62.0	76.0	14.5	1.38	0.780	3.80	13.0	2.01	16.5	0.170
2409	5/6/2009	8.72	6.00	55.7	61.7	98.0	13.1	0.860	0.590	3.60	11.0	2.17	7.74	0.260
37619-96-04	5/6/2009	8.94	12.0	58.7	70.7	120	14.6	1.02	0.770	3.90	13.5	2.62	5.71	<0.05
2410	5/6/2009	8.24	<1.00	77.2	77.2	260	53.4	2.75	0.560	9.40	14.9	4.35	127	0.670
1-1 (0-0.5 inches bgs)	12/9/2010	--	--	--	--	--	5.3	--	--	1.3	0.0045	0.8B	--	--
1-1 (1-1.5 inches bgs)	12/9/2010	--	--	--	--	--	0.7B	--	--	<1.0	0.0034	1B	--	--
1-1 (2-2.5 inches bgs)	12/9/2010	--	--	--	--	--	0.8B	--	--	<1.0	0.0029	1.1B	--	--
1-2 (0-0.5 inches bgs)	12/9/2010	--	--	--	--	--	5.8	--	--	1.5	0.0059	1B	--	--
1-2 (1.5-2 inches bgs)	12/9/2010	--	--	--	--	--	6.9	--	--	1.3	0.0035	1B	--	--

Sample Name	Sample Date	Aluminum (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Lithium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
Groundwater Standards (Total and Dissolved)																						
New Mexico Criteria																						
Domestic Water		--	--	--	--	--	--	--	--	1 D	***1 D***	--	--	0.2 D	--	--	--	--	--	--	--	10 D
Human Health		--	0.01 D	2 D	0.004D	--	0.005 D	0.05 D	--	--	--	0.015 D	--	--	0.002 D	--	--	0.05 D	0.05 D	0.03 D	--	--
Irrigation Water		5 D	--	--	--	0.75 D	--	--	0.05 D	--	--	--	--	--	--	1 D	0.2 D	0.13	--	--	--	--
USEPA MCL			0.01 D	2 D	0.004 D		0.005 D	0.1 D		1.3 D [AL]		0.015 D [AL]			0.002 D			0.05 D				
Metals																						
376-05-05	5/5/2009	0.300	<0.02	0.020	<0.002	<0.04	<0.0002	<0.006	<0.006	0.0148	0.200	<0.003	<0.02	0.007	<0.0002	<0.008	<0.01	<0.002	<0.0002	<0.001	<0.005	<0.01
LBT1-BF1	5/5/2009	1.000	<0.02	0.030	<0.002	0.04	<0.0002	<0.006	<0.006	0.0155	0.5	<0.003	<0.02	0.01	<0.0002	<0.008	<0.01	<0.002	<0.0002	<0.001	<0.005	<0.01
2408	5/5/2009	1.00	<0.02	0.020	<0.002	0.050	<0.0002	<0.006	<0.006	0.0078	0.400	<0.003	<0.02	0.009	<0.0002	<0.008	<0.01	<0.002	<0.0002	<0.001	<0.005	0.020
2409	5/6/2009	1.10	<0.02	0.020	<0.002	0.060	<0.0002	<0.006	<0.006	0.0079	0.500	<0.003	<0.02	0.010	<0.0002	<0.008	<0.01	<0.002	<0.0002	<0.001	0.005	<0.01
376-96-04	5/6/2009	2.90	<0.02	0.030	<0.002	0.050	<0.0002	<0.006	<0.006	0.0137	***1.4***	<0.003	<0.02	0.020	<0.0002	<0.008	<0.01	<0.002	<0.0002	<0.001	0.006	<0.01
2410	5/6/2009	<0.08	<0.02	0.040	<0.002	<0.04	<0.0002	<0.006	<0.006	0.0175	<0.06	<0.003	<0.02	<0.004	<0.0002	<0.008	<0.01	<0.002	<0.0002	0.002	<0.005	<0.01
1-1 (0-0.5 inches bgs)	12/9/2010	0.670	<0.002	0.010	--	--	<0.0005	0.0008B	0.0002B	0.003	0.44	0.0004B	--	0.015B	--	0.001B	<0.003	0.0005	--	--	0.0045	0.008
1-1 (1-1.5 inches bgs)	12/9/2010	1.120	<0.002	0.016	--	--	<0.0005	0.0008B	0.00025B	0.004	0.73	0.001	--	0.02B	--	0.0008B	<0.003	0.0002	--	--	0.0034	0.006
1-1 (2-2.5 inches bgs)	12/9/2010	1.360	<0.002	0.018	--	--	<0.0005	0.0008B	0.00023B	0.004	0.8	0.001	--	0.02B	--	0.0008B	<0.003	0.0002	--	--	0.0029	0.011
1-2 (0-0.5 inches bgs)	12/9/2010	0.47	0.0008B	0.01	--	--	<0.0005	<0.002	0.00016B	0.00	0.24	0.0003B	--	0.012B	--	0.0011B	0.0006B	0.0003	--	--	0.0059	0.0003B
1-2 (1.5-2 inches bgs)	12/9/2010	0.16B	0.0009B	0.01	--	--	<0.0005	<0.002	0.00006B	0.01	0.08	0.0002B	--	<0.03	--	0.0017B	<0.003	0.0004	--	--	0.0035	0.003B

Notes:
1. All results are for dissolved fraction.
2. Data are from Golder (2016), compared to updated 2023 criteria.
3. **Bold** and ***Italicized*** data exceeds one of the groundwater criteria.

Acronyms and Abbreviations:
-- = Not available
AL = action level (no more than 10% of samples can exceed)
bgs = below ground surface
B = Laboratory data qualifier for estimated value
CaCO3 = calcium carbonate
D = dissolved
MCL = maximum contaminant level
mg/L = milligrams per liter
S.U. = Standard Units
TDS = total dissolved solids
USEPA = United States Environmental Protection Agency

Reference:
Golder Associates, Inc. (Golder). 2016. Site-Wide Stage 1 Abatement Plan. Revised Final Site Investigation Report. March.

TABLE 4-1
SOIL REMEDIAL TECHNOLOGIES

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY REPORT

No.	REMEDIAL TECHNOLOGY	DESCRIPTION	PRELIMINARY SCREENING			CONCLUSION
			EFFECTIVENESS	IMPLEMENTABILITY	COST	
1	**No Action**	No further active response actions.	Contaminants will naturally attenuate over time in soil. Does not provide additional mechanisms to prevent contaminant exposure to site receptors.	Is considered implementable.	There are no costs associated with no action.	Being retained for evaluation as part of a remedial alternative.
2	**Monitoring**	No further active response actions. Monitoring will be conducted to prove the occurrence of natural remediation.	Contaminants will naturally attenuate over time. Does not provide additional mechanisms to prevent contaminant exposure to site receptors.	Is considered implementable.	Costs are associated with types of monitoring (quantitative and/or qualitative) and monitoring duration selected.	Not being retained for remedial alternatives at this time.
3	**Soil Amendments**					
3a	Limestone and Organic Matter	pH adjustment via lime and/or organic matter.	Liming may not improve a plant community or reduce uptake into plants unless pH is very low and pH is above 6, except one location with pH of 4.6 (not that low).	Is considered implementable.	Costs are moderate and include purchase and transport of amendments to the site, and equipment for application. Minimal soil handling is required as soils generally remain in place, minimizing transportation and disposal costs. Long term operation and monitoring costs are considered low to moderate.	Not being retained for remedial alternatives at this time.
3b	Tilling or Ripping	Tilling (or ripping) de-compacts soil and provides additional dilution of metals and has potential to raise alkaline pH conditions to more neutral pH conditions pending existing pH levels within the soil treatment area being tilled. Plant coverage, pH, and soil chemistry would be monitored post-tilling operations.	Tilling is most effective in compacted soils (e.g., flat rocky habitats). It is potentially effective at raising acidic pH to neutral conditions and making contaminants less bioavailable to site receptors without the introduction of lime and/or organic matter.	Is considered implementable.	Tilling includes increased efforts and costs as compared to adding lime or other amendments without tilling. However, minimal soil handling is required as soils generally remain in place, minimizing transportation and disposal costs compared to excavation and soil cover. Long term operation and monitoring costs are considered low to moderate.	Not being retained for remedial alternatives at this time.
3c	Ferrihydrite	Ferrihydrite is mixed into the impacted soils to reduce the copper bioavailability to site receptors.	Effectiveness would be determined via conducting a pilot treatability study and potentially bench scale treatability study to determine the loading rate of ferrihydrite. Because iron is being introduced to the soils, evaluations would be conducted to verify that the iron levels are acceptable from a human health and ecological perspective.	This technology is considered to be implementable. A pilot treatability study would be required to determine the most effective soil mixing technique.	Cost will depend on soil mixing technique determined and market value of the amendment materials. The overall technology is considered to have moderate costs and is comparable to the costs of the lime and OM amendments being tested as part of the Amendment Study. Long term operation and monitoring are considered low to moderate.	Not being retained for remedial alternatives at this time.
3d1	Use of Chelating Agent: Soil Washing (Ex-Situ)	Ex-situ soil washing includes removal of contaminants from soil using separation methodologies, including "washing" the soils with a detergent and/or chelating agent solution. The resulting clean portions of soil can be returned to the site for reuse and the resulting wash mixture and contaminated soil fines would be characterized for final disposition.	Is potentially effective at removing copper from soil. However, level of effectiveness would have to be verified via a pilot treatability study.	A pilot treatability study would be required to determine implementability. Factors to consider to evaluate implementability include, but are not limited to identification of an adequate water source, the size of scrubber unit needed, type of soil washing detergent, and soil handling requirements.	Ex-situ soil washing is labor intensive and requires a high level of soil handling (excavation, washing, soil replacement). Requires disposal of used wash solution and potentially portions of soil. Cost savings include utilizing remediated soil for onsite reuse, reducing imported backfill required. Costs for construction and future operation and monitoring activities, however, are considered high.	Not being retained for remedial alternatives at this time.
3d2	Use of Chelating Agent: Soil Washing (In-Situ)	In-situ soil washing includes introducing a chelating agent into the soil. The objective of the chelating agent is to mobilize the copper within the soil column. The copper becomes soluble within the groundwater and the groundwater is subsequently extracted for treatment and/or disposal with a groundwater extraction system.	Is potentially effective at removing copper from soil. However, level of effectiveness would have to be verified via a pilot treatability study.	A pilot treatability study would be required to determine implementability. Factors to consider to evaluate implementability include, but are not limited to determining target infiltration/injection rates, groundwater recovery methods, and treatment plant requirements.	In-situ soil washing is labor intensive and requires the introduction of the chelating agent into the soils, installation or modification of groundwater extraction system, and extracted groundwater treatment and/or disposal. Costs for construction and future operation and monitoring activities are considered high.	Not being retained for remedial alternatives at this time.
4	**Phytoremediation**	Phytoremediation consists of planting vegetation that can take up the contaminants located in the soil and subsequently remediate the soils. Plants and/or trees would be selected that are able to bioaccumulate and/or degrade the site contaminants.	Phytoremediation is potentially effective at remediating site contaminants. Contaminant reduction would take several years to achieve and would not immediately reduce potential exposure to site receptors. A preliminary remedial design evaluation would be required to determine if the naturally existing conditions at the site (e.g., humidity, access to groundwater, soil conditions) could support phytoremediating plant species.	Assuming that the naturally occurring site conditions can support phytoremediation plant species, phytoremediation is generally considered implementable at the Site. There may be certain areas of the site that may not support the phytoremediation species (due to slopes, percent soil coverage, access to groundwater, and soil conditions).	Costs include the cost of the individual plants/trees, planting, and operation and monitoring. Operation and monitoring is considered moderate to high, as remediation of the site contaminants is directly dependent on the success of the plants/trees to thrive over an extended period of time. Costs are considered moderate to high as compared to other technologies.	Not being retained for remedial alternatives at this time.

TABLE 4-2
SEDIMENT AND SURFACE WATER REMEDIAL TECHNOLOGIES

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY

No.	REMEDIAL TECHNOLOGY	DESCRIPTION	PRELIMINARY SCREENING			CONCLUSION
			EFFECTIVENESS	IMPLEMENTABILITY	COST	
1	No Action	No further active response actions for sediment or surface water.	Contaminants will naturally attenuate over time or be remediated under the sitewide abatement program. Does not provide additional mechanisms to prevent contaminant exposure to site receptors.	Is considered implementable.	There are no costs associated with no action.	Being retained for evaluation as a part of a remedial alternative.
2	Monitoring	No further active response actions for surface water. Monitoring to be conducted to prove the occurrence of natural remediation.	Contaminants will naturally attenuate over time or be remediated under the sitewide abatement program. Does not provide additional mechanisms to prevent contaminant exposure to site receptors.	Is considered implementable.	Costs are associated with types of monitoring (quantitative and/or qualitative) and monitoring durations selected.	Being retained for evaluation as a part of a remedial alternative.
3	Excavation	Excavation includes removing impacted in-drainage sediments and/or upland soils determined to be contributing to surface water impacts.	Is considered highly effective at reducing the presence of site contaminants.	Is considered to be generally technically implementable with the exception of certain areas of the site that are more difficult to access with equipment and personnel due to terrain conditions and presence of mature trees.	Costs are considered to be moderate and include equipment use and maintenance, material handling and transport, and characterization and final disposition. Long term O&M costs related to BMPs are considered to be low to moderate.	Not being retained for evaluation as a part of a remedial alternative.
4	In-Stream Removal of Suspended Sediments	Consists of construction of settling basins within the stream drainage areas to allow for sediments to descend to bottom of the pool and accumulate. Accumulated impacted sediments would be removed by mechanical methods.	Is considered to be effective at capturing contaminated sediments.	Is considered to be technically implementable. Some portions of drainage areas may be restricted from construction of pools due to equipment accessibility restrictions.	Costs are considered to be moderate during construction of the settling pools. Long term O&M costs are considered to be moderate to high as compared to excavation and surface water treatment.	Not being retained for evaluation as a part of a remedial alternative.
5	Limestone Treatment	Consists of installation of features, such as limestone, within the surface water drainage pathway. As the surface water passes over the feature (e.g., limestone) the pH is elevated, subsequently making the contaminants (copper) less bioavailable to site receptors.	Is considered effective at raising surface water pH as long as acidic surface water makes contact with the limestone features. However, pH is generally high in the area, already buffered, and limestone may not accomplish the objective of reducing contaminants, and they may not be that bioavailable in the first place.	Is considered to be technically implementable. Some portions of drainage areas may be restricted from installation of limestone features due to equipment accessibility restrictions.	Costs are considered to be high during construction of the limestone features. Long term O&M costs are considered to be low compared to excavation and in-stream removal of suspended sediments.	Not being retained for evaluation as a part of a remedial alternative.
6	In-Situ Treatment	Consists of insertion of alkaline fluid into the sediments and banks of the drainage. The alkaline wash will raise pH and sequester metals in the sediments, subsequently reducing mobilization of the contaminants (copper) to surface water.	Is considered effective at raising pH and lowering metals concentrations in surface water as long as the majority of metals loading is coming from sediments, and pH is low. However, pH is generally high in the area, so unlikely to be very effective.	Is considered to have low implementability. There are large infrastructure requirements and some portions of the drainage area may be restricted due equipment accessibility restrictions.	Costs are considered to be high both during the construction and O&M phases when compared to other remedial options.	Not being retained for evaluation as a part of a remedial alternative.
7	Groundwater Pumping and Re-directing Outflow from Stockpiles	Consists of intercepting impacted groundwater and pumping it back into the leach stockpiles, beyond what is currently being implemented as part of the sitewide abatement program.	Is considered effective at controlling offsite discharge from onsite sources.	Is considered to be implementable and is currently being implemented as part of the sitewide abatement program.	Costs are considered to be low for construction but high for O&M phases.	Not being retained for evaluation as a part of a remedial alternative.

TABLE 5-1
DETAILED EVALUATION OF REMEDIAL ALTERNATIVES - SOILS

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY

ALTERNATIVE	DESCRIPTION	THRESHOLD CRITERIA		BALANCING CRITERIA					MODIFYING CRITERIA		GREEN REMEDIATION
		OVERALL PROTECTION	COMPLIANCE WITH ARARs	LONG-TERM EFFECTIVENESS AND PERMANENCE	REDUCTION OF TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	IMPLEMENTABILITY	COST EFFECTIVENESS	NMED ACCEPTED	COMMUNITY ACCEPTANCE	
1	No Action	Does not provide any form of overall protection for ecological receptors.	Compliant with ARARs.	Effective in the long term. Anthropogenic or background natural impacts may continue to influence the soils. However, samples collected of current conditions indicate that soils do not require remedial action to achieve Remedial Action Criteria.	Does not reduce toxicity, mobility, or volume. However, reduction of toxicity is not required due to the current soil condition.	Effective in the short-term. Current conditions meet pre-Feasibility Study Remedial Action Criteria.	Is implementable at the site, as no action is required.	There are no costs associated with this alternative.	Not applicable at this time.	Not applicable at this time.	No additional resources would be required to implement this alternative.

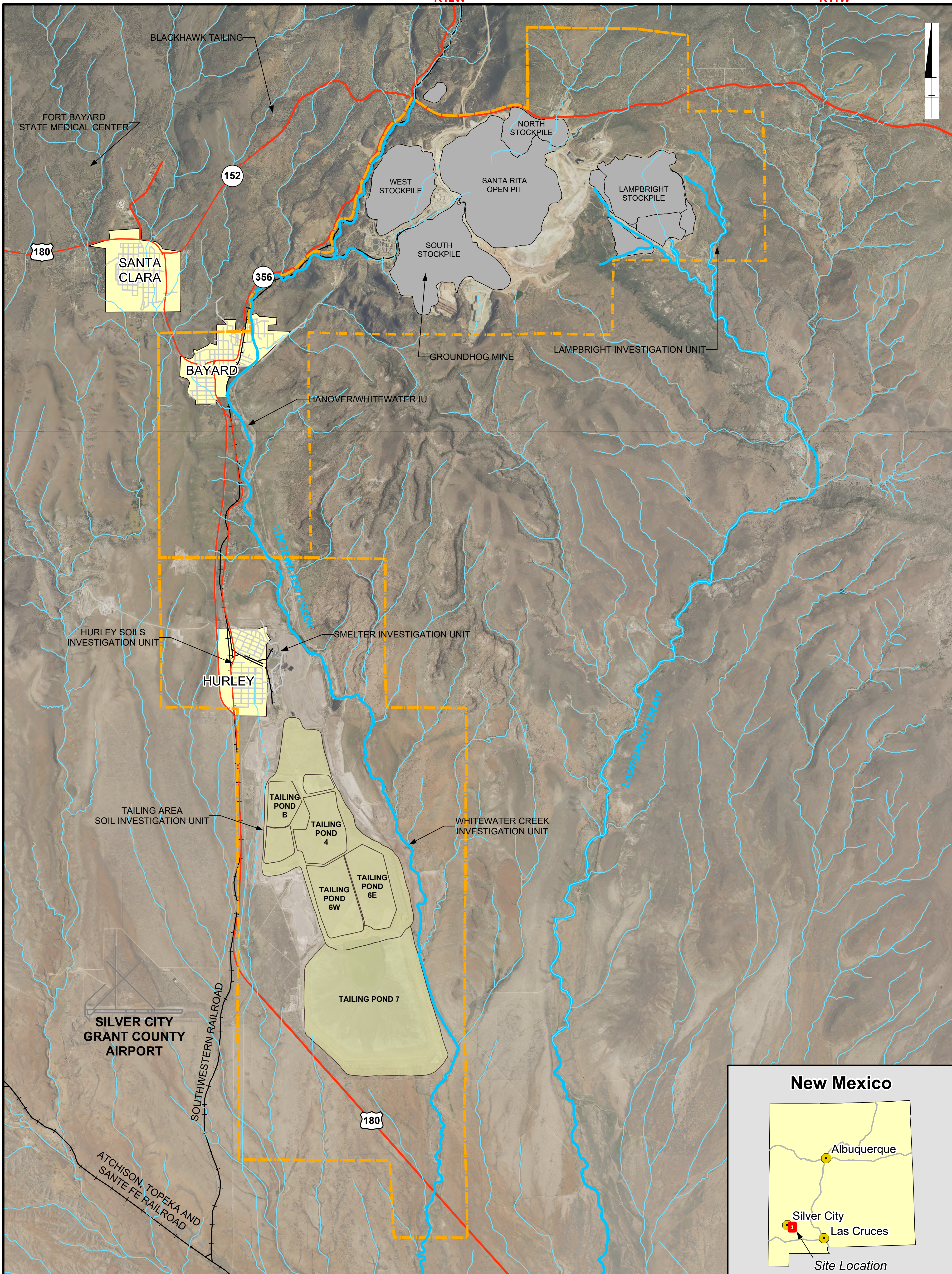
TABLE 5-2
DETAILED EVALUATION OF REMEDIAL ALTERNATIVES - SURFACE WATER AND SEDIMENT

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT IU FEASIBILITY STUDY

ALTERNATIVE	DESCRIPTION	THRESHOLD CRITERIA		BALANCING CRITERIA					MODIFYING CRITERIA		GREEN REMEDIATION
		OVERALL PROTECTION	COMPLIANCE WITH ARARs	LONG-TERM EFFECTIVENESS AND PERMANENCE	REDUCTION OF TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	IMPLEMENTABILITY	COST EFFECTIVENESS	NMED ACCEPTED	COMMUNITY ACCEPTANCE	
1	No Action	Does not provide any form of additional protection of human health and the environment but none appears to be needed under the AOC program. Leaves further action under the sitewide abatement program and protection of human health and the environment depends on that program.	ARARs implemented via the sitewide abatement program.	Effectiveness and permanence depend on the performance of the sitewide abatement program and compliance with requirements associated with the program.	Does not reduce toxicity, mobility or volume.	Effective in the short-term with the sitewide abatement program in place	Is implementable at the site, as no action is required.	There are no costs associated with this alternative.	Not applicable at this time	Not applicable at this time	No additional resources would be required to implement this alternative.
2	Monitoring	The ability of this alternative to satisfy this criterion is high because it provides additional protection beyond the sitewide abatement program by adding monitoring that would provide quality control on the sitewide abatement program. Any issues that arise would be observed and additional actions under the sitewide abatement program would be taken.	ARARs implemented via the sitewide abatement program.	Effectiveness and permanence depend on the performance of the sitewide abatement program and compliance with requirements associated with the program. This alternative may be redundant to the sitewide abatement program, or provide a form of quality control.	Does not reduce toxicity, mobility, or volume, but can be used to assess all three.	Effective in the short-term with the sitewide abatement program in place	This remedy is implementable at the site with limited additional effort.	Costs are relatively higher than No Action.			Emissions and fuel use would be limited to those associated with light vehicles and sample shipping/analysis. Vegetation and habitat would not be disturbed by this alternative.

Figures

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
Path: T:_ENV\Chino\2024\Lampbright\pro\Lampbright_Figures\Lampbright_Surface_Soil_Figures.aprx



LEGEND:

- Railroad
- Town Roads
- Major Roads
- Major Drainages
- AOC Boundary

Note:
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1 2 Miles
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

LAMPBRIGHT INVESTIGATION UNIT AREA
SITE OVERVIEW

ARCADIS

FIGURE
1-1

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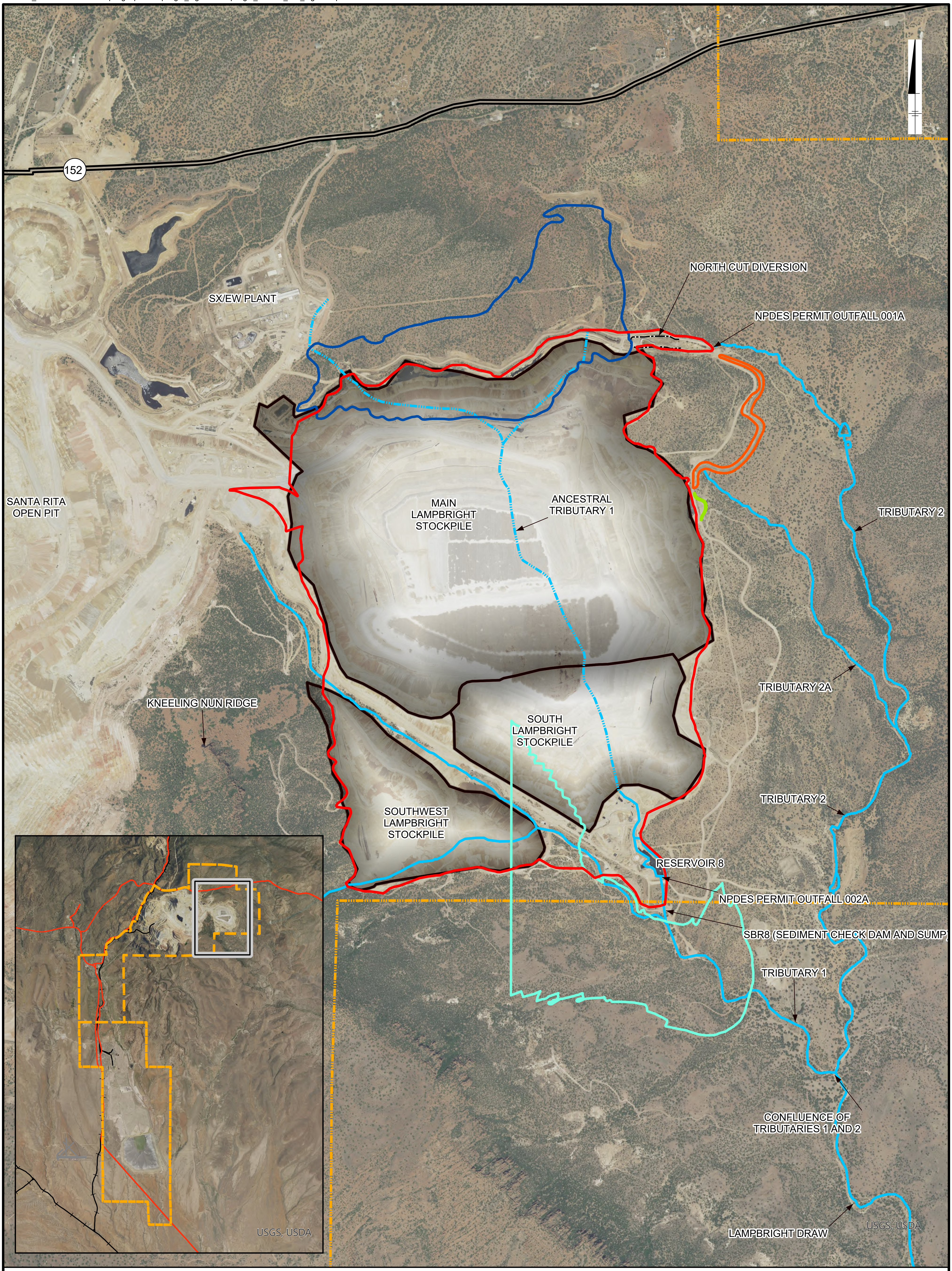
Path: T:_ENV\Chino\2024\Lampbright\pro\Lampbright_Figures\Lampbright_Surface_Soil_Figures.aprx



LEGEND:

- Major Road
- Ancestral Tributaries
- Tributaries
- AOC Boundary
- DP-376 Boundary
- Pipeline Corridor New Disturbance
- Far East Containment New Disturbance
- Proposed Kessel Stockpile
- Proposed North Lampbright Leach Stockpile

0 1,500 3,000 Feet

GRAPHIC SCALE

Note:
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

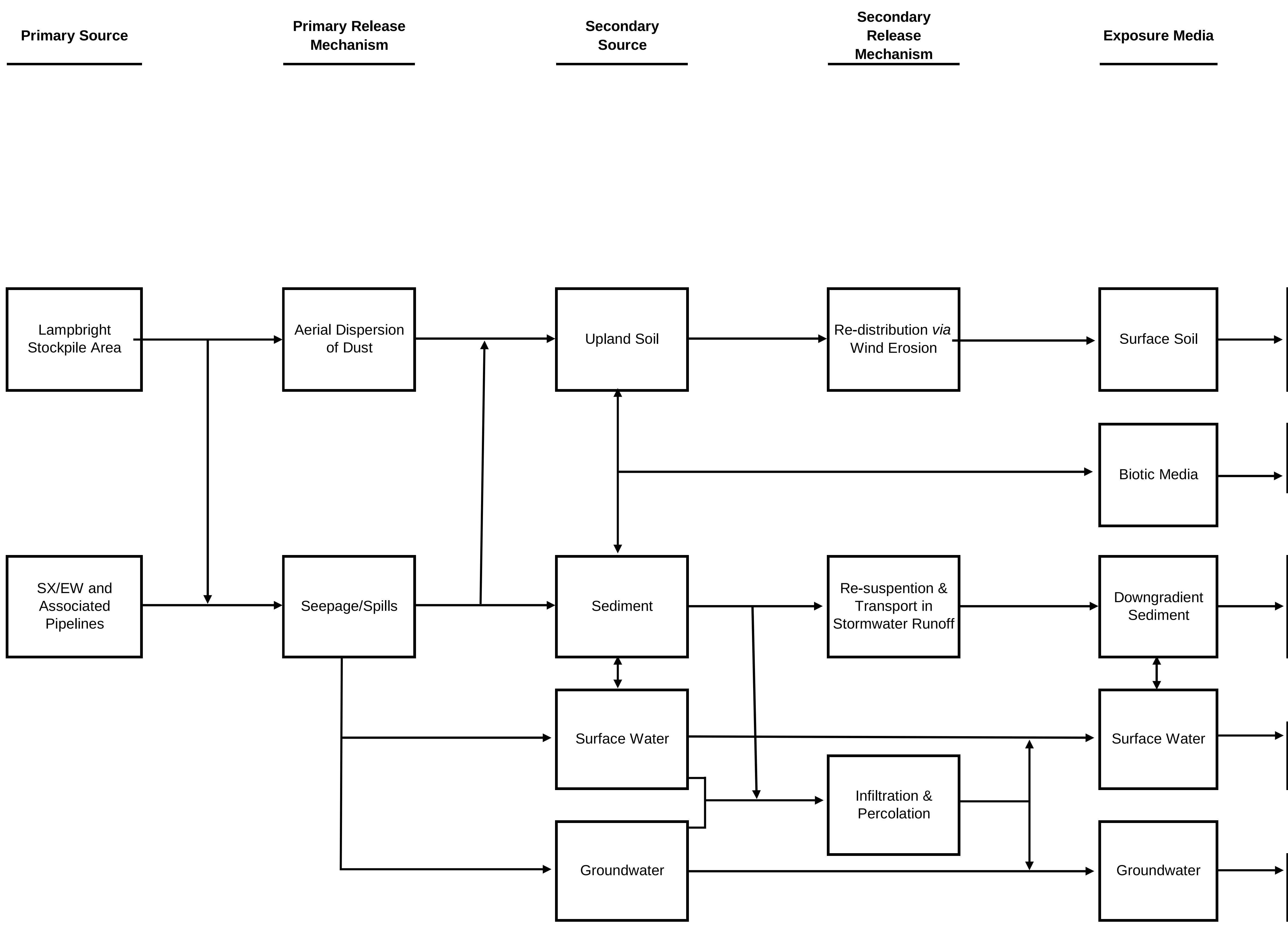
FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

AOC BOUNDARY AND
INVESTIGATION UNITS

ARCADIS

FIGURE
1-2



Exposure Media	Exposure Route	Future Resident	Trespasser/Recreators	Construction Workers	Ecological - Avian	Ecological - Mammals	Ecological - Plants	Ecological - Aquatic Life
Surface Soil	Direct Contact	●	●	●	●	●	●	o
	Ingestion	●	●	●	●	●	o	o
	Inhalation	●	●	●	o	o	o	o
Biotic Media	Direct Contact	o	o	o	o	o	o	o
	Ingestion	o	o	o	●	●	o	o
Downgradient Sediment	Direct Contact	*	*	*	*	*	o	*
	Ingestion	*	*	*	*	*	o	*
	Inhalation	*	*	*	o	o	o	o
Surface Water	Direct Contact	o	o	o	*	*	o	*
	Ingestion	o	o	o	*	*	o	*
Groundwater	Direct Contact	o	o	o	o	o	o	o
	Ingestion	o	o	o	o	o	o	o

LEGEND:

* Potentially complete exposure pathway to be evaluated for risk under Administrative Order on Consent, but investigated under Discharge Permit 376 Corrective Action and Site Wide Abatement.

● Potentially complete exposure pathway.

o Incomplete, or potentially complete but considered insignificant exposure pathway.

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

CONCEPTUAL SITE MODEL FOR LAMPBRIGHT INVESTIGATION UNIT

ARCADIS

FIGURE 3-1

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LEGEND:

- Sample Location >HH Decision Criteria (> 0.68 mg/kg)
- Tributaries
- Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1,500 3,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

ARSENIC SURFACE SOIL (0-1 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-2

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Path: T:_ENV\Chino\2024\Lampbright\pro\Lampbright_Figures\Lampbright_Surface_Soil_Figures.aprx

LEGEND:
- Sample Location <HH Decision Criteria (<77,000 mg/kg)
- Tributaries
- Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1,500 3,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

ALUMINUM SURFACE SOIL (0-1 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-3

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
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LEGEND:

Sample Location <HH Decision Criteria (<120,000 mg/kg)

Tributaries

Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1,500 3,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

CHROMIUM SURFACE SOIL (0-1 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-4

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
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LEGEND:

- Sample Location >HH Decision Criteria (>23 mg/kg)
- Sample Location <HH Decision Criteria (<23 mg/kg)
- Tributaries
- Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1,500 3,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

COBALT SURFACE SOIL (0-1 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-5

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
Path: T:_ENV\Chino\2024\Lampbright\pro\Lampbright_Figures\Lampbright_Figures.aprx

LEGEND:

- Sample Location <HH Decision Criteria (<1,800 mg/kg)
- Tributaries
- Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1,500 3,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

MANGANESE SURFACE SOIL (0-1 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-6

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
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LEGEND:

- Sample Location >Eco Decision Criteria (>26,300 mg/kg)
- Sample Location <Eco Decision Criteria
- Tributaries
- Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1,500 3,000
Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

ALUMINUM SHALLOW SOIL (0-6 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-7

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
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LEGEND:

- Sample Location >Eco Decision Criteria (>181 mg/kg)
- Sample Location <Eco Decision Criteria
- Tributaries
- Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1,500 3,000
Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

BARIUM SHALLOW SOIL (0-6 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-8

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
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LEGEND:

- Sample Location >Eco Decision Criteria (>6.4 mg/kg)
- Sample Location <Eco Decision Criteria
- Tributaries
- Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1,500 3,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

BOROn SHALLOW SOIL

(0-6 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-9

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
Path: T:_ENV\Chino\2024\Lampbright\pro\Lampbright_Figures\Lampbright_Shallow_Soil_Figures.aprx

LEGEND:

- Sample Location >Eco Decision Criteria (>26 mg/kg)
- Sample Location <Eco Decision Criteria
- Tributaries
- Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1,500 3,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

CHROMIUM SHALLOW SOIL (0-6 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-10

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
Path: T:_ENV\Chino\2024\Lampbright\pro\Lampbright_Figures\Lampbright_Shallow_Soil_Figures.aprx

LEGEND:

- Sample Location >Eco Decision Criteria (268 mg/kg)
- Sample Location <Eco Decision Criteria
- Tributaries
- Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1,500 3,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

COPPER SHALLOW SOIL (0-6 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-11

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
Path: T:_ENV\Chino\2024\Lampbright\pro\Lampbright_Figures\Lampbright_Shallow_Soil_Figures.aprx

LEGEND:

- Sample Location >Eco Decision Criteria (>23 mg/kg)
- Sample Location <Eco Decision Criteria
- Tributaries
- Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1,500 3,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

LEAD SHALLOW SOIL (0-6 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-12

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
Path: T:_ENV\Chino\2024\Lampbright\pro\Lampbright_Figures\Lampbright_Shallow_Soil_Figures.aprx

LEGEND:

- Sample Location >Eco Decision Criteria (>0.6 mg/kg)
- Sample Location <Eco Decision Criteria
- Tributaries
- Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1,500 3,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

SELENIUM SHALLOW SOIL (0-6 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-13

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
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LEGEND:

- Sample Location >Eco Decision Criteria (>7.8 mg/kg)
- Sample Location >HH Decision Criteria (>390 mg/kg)
- Tributaries
- Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)
*This location is the only location that exceeds residential screening human health criteria with 566 mg/kg found in surface (not shallow) soil.

0 1,500 3,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

VANADIUM SHALLOW SOIL (0-6 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-14

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
Path: T:_ENV\Chino\2024\Lampbright\pro\Lampbright_Figures\Lampbright_Shallow_Soil_Figures.aprx

LEGEND:

- Sample Location >Eco Decision Criteria (>46 mg/kg)
- Sample Location <Eco Decision Criteria
- Tributaries
- Major Road

Note:
All results in milligrams per kilogram (mg/kg)
USGS NAIP Imagery (Acquisition Date is May 16, 2020)

0 1,500 3,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

ZINC SHALLOW SOIL (0-6 INCHES) CONCENTRATIONS

ARCADIS

FIGURE
3-15

LEGEND:

pCu concentrations of soil samples

- pCu < 5 (pre-FS RAC)
- pCu < 6
- pCu > 6

If pCu < 5 and copper > 327, then pre-FS RAC threshold for plants is not met.

- Tributaries

Number at location = copper concentration (mg/kg).

NOTES:
- If copper > 1100 mg/kg, bird pre-FS RAC for monitoring is exceeded, if copper > 1600 mg/kg, bird pre-FS RAC for possible remediation is exceeded. See labeling.
- Sample ID prefix of "L" indicates a LIU site sample. Prefix of "R" indicates a reference sample.

0 1,000 2,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

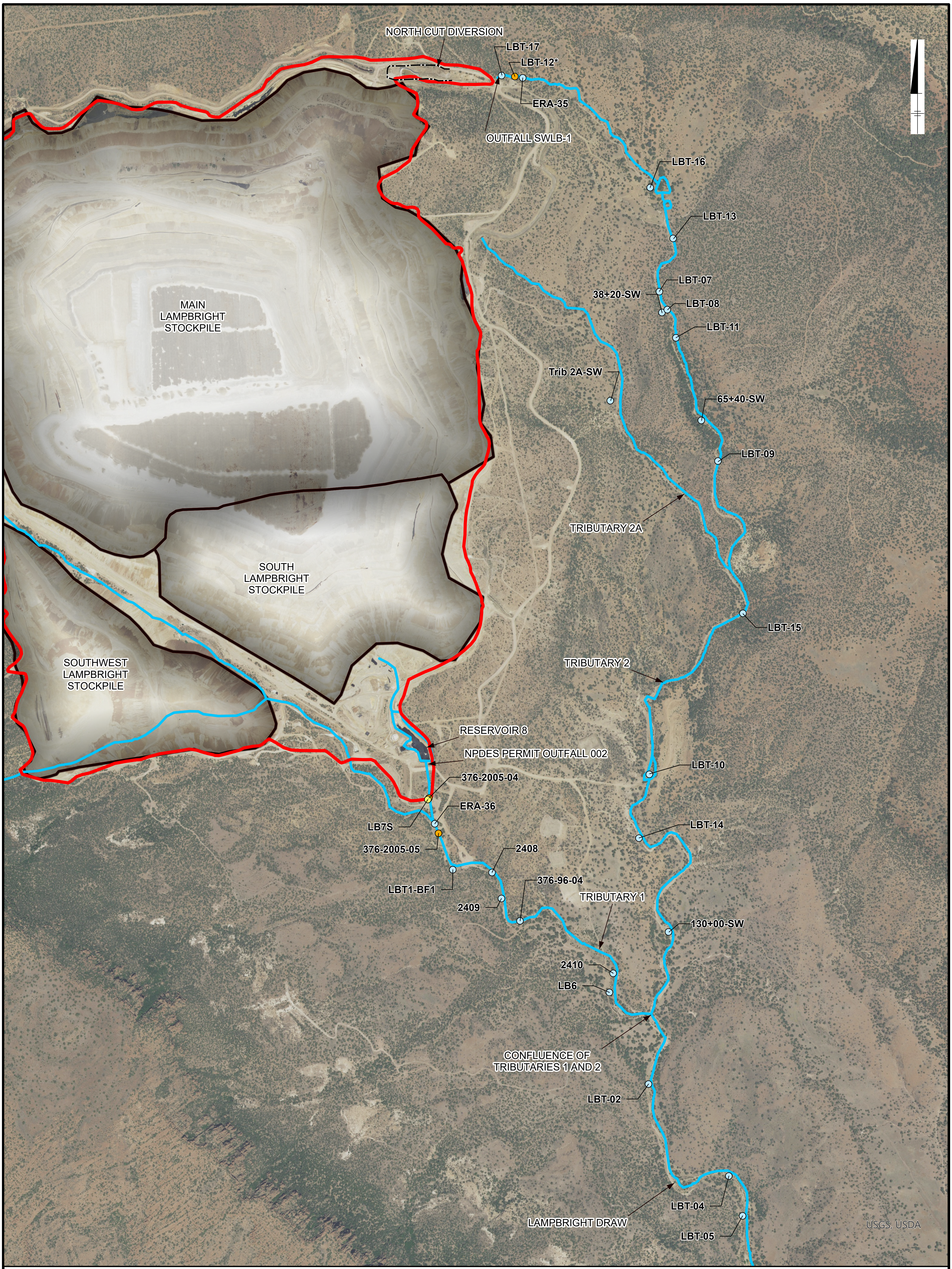
LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

COPPER CONCENTRATIONS AND pCu OF THE SOIL SAMPLES

ARCADIS

FIGURE
3-16

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000



LEGEND:

Aluminum Surface Water Concentration

- > pre-FS RAC acute criteria (> 0.75 - 10.07 mg/L)
- > pre-FS RAC chronic criteria (> 0.087 - 4.03 mg/L)
- < pre-FS RAC chronic criteria
- Tributaries
- DP-376 Boundary

NOTES:
(1) No CLF LOEC or NOEC threshold available.
(2) *Recovered from remediation (by July 2008) after exceedance observed.

Abbreviations:
CLF= Chiricahua Leopard Frog
LOEC = lowest effect concentration
NOEC = no-effect concentration

0 1,000 2,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

SURFACE WATER LOCATIONS AND ECOLOGICAL CRITERIA EXCEEDANCES FOR ALUMINUM

ARCADIS

FIGURE
3-17

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
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LEGEND:

Cadmium Surface Water Concentrations

- > pre-FS RAC acute criteria (> 0.0017-0.0065 mg/L)
- > pre-FS RAC chronic criteria (> 0.0007 to 0.002 mg/L)
- Undetected
- Tributaries
- DP-376 Boundary

NOTES:

(1) No location exceeded the CLF NOEC (0.026 to 0.0537 mg/L).

(2) *Last sampled before remediation (ERA 35) or before full recovery from remediation (LBT-11) or before 2009 (LBT-12).

Abbreviations:

CLF= Chiricahua Leopard Frog

NOEC = no-effect concentration

0 1,000 2,000 Feet

GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

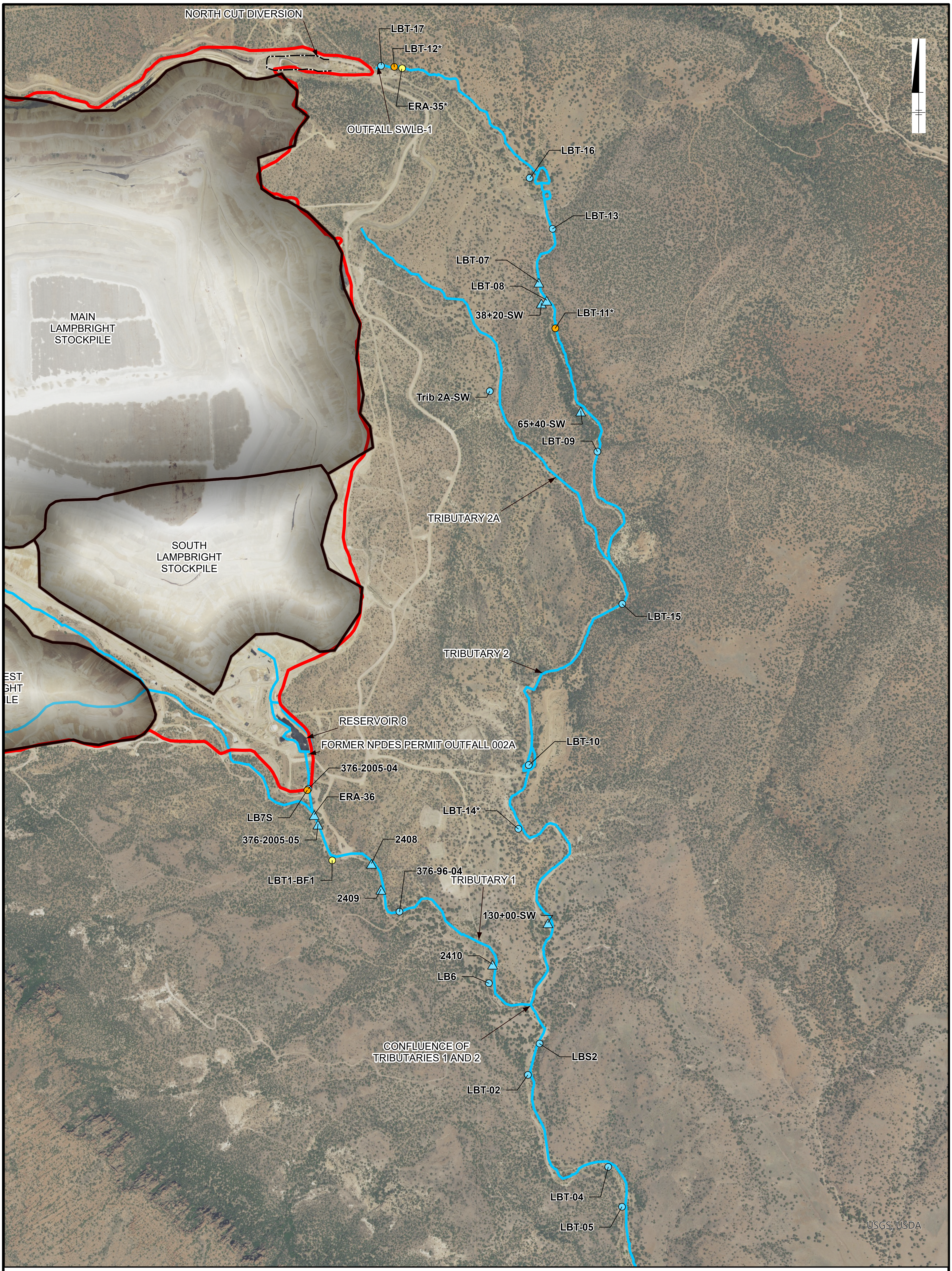
LAMBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

SURFACE WATER LOCATIONS AND ECOLOGICAL CRITERIA EXCEEDANCES FOR CADMIUM

ARCADIS

FIGURE
3-18

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000



LEGEND:

Copper Surface Water Concentration

- > pre-FS RAC acute criteria (> 0.013 - 0.05 mg/L)
- > pre-FS RAC chronic criteria (> 0.008 - 0.029 mg/L)
- > Chiricahua Leopard Frog NOEC (> 0.00418 - 0.0096 mg/L)
- < pre-FS RAC chronic criteria
- Tributaries
- DP-376 Boundary

NOTES:

(1) *Recovered from remediation (by 2009) after exceedance observed, or sampled prior to remediation (ERA 35).

(2) All samples exceeding the chronic pre-FS RAC also exceed the CLF LOEC (0.0097 to 0.0223 mg/L).

Abbreviations:

CLF= Chiricahua Leopard Frog
LOEC = lowest effect concentration
NOEC = no-effect concentration

0 1,000 2,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

SURFACE WATER LOCATIONS AND ECOLOGICAL CRITERIA EXCEEDANCES FOR COPPER

ARCADIS

FIGURE
3-19

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
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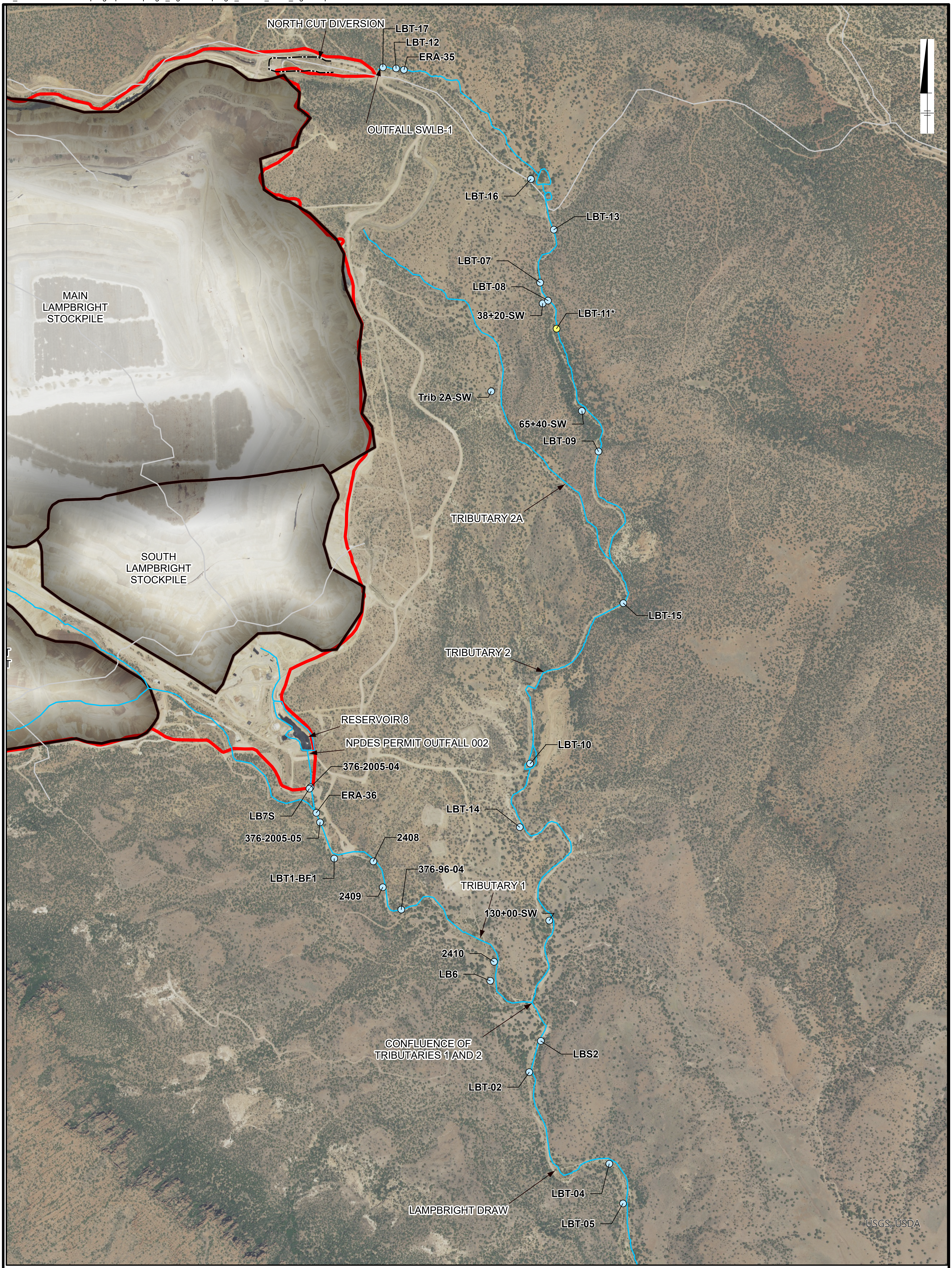


LEGEND:

Lead Surface Water Concentrations

- > pre-FS RAC chronic criteria (> 0.002 - 0.011 mg/L)
- < pre-FS RAC chronic criteria
- Tributaries
- DP-376 Boundary

NOTES:
(1) No CLF LOEC or NOEC threshold available.
(2) *Recovered from remediation (by July 2008) after exceedance observed.

Abbreviations:
CLF= Chiricahua Leopard Frog
LOEC = lowest effect concentration
NOEC = no-effect concentration

0 1,000 2,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

SURFACE WATER LOCATIONS AND ECOLOGICAL CRITERIA EXCEEDANCES FOR LEAD

ARCADIS

FIGURE
3-20

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000

LEGEND:

Manganese Surface Water Concentration

- > pre-FS RAC acute criteria (> 2.92 - 4.74 mg/L)
- < pre-FS RAC chronic criteria (< 1.62 - 2.62 mg/L)
- Tributaries
- DP-376 Boundary

NOTES:
(1) No CLF LOEC or NOEC threshold available.
(2)*Recovered from remediation (by July 2008) after exceedance observed.

Abbreviations:
CLF= Chiricahua Leopard Frog
LOEC = lowest effect concentration
NOEC = no-effect concentration

0 1,000 2,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

SURFACE WATER LOCATIONS AND ECOLOGICAL CRITERIA EXCEEDANCES FOR MANGANESE

ARCADIS

FIGURE
3-21

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000

LEGEND:

Nickel Surface Water Concentrations

- > pre-FS RAC acute criteria (> 0.04 - 1.5 mg/L)
- < pre-FS RAC chronic criteria (< 0.05 - 0.17 mg/L)
- Tributaries
- DP-376 Boundary

NOTES:
(1) No CLF LOEC or NOEC threshold available.
(2)*Recovered from remediation (by July 2008) after exceedance observed.

Abbreviations:
CLF= Chiricahua Leopard Frog
LOEC = lowest effect concentration
NOEC = no-effect concentration

0 1,000 2,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

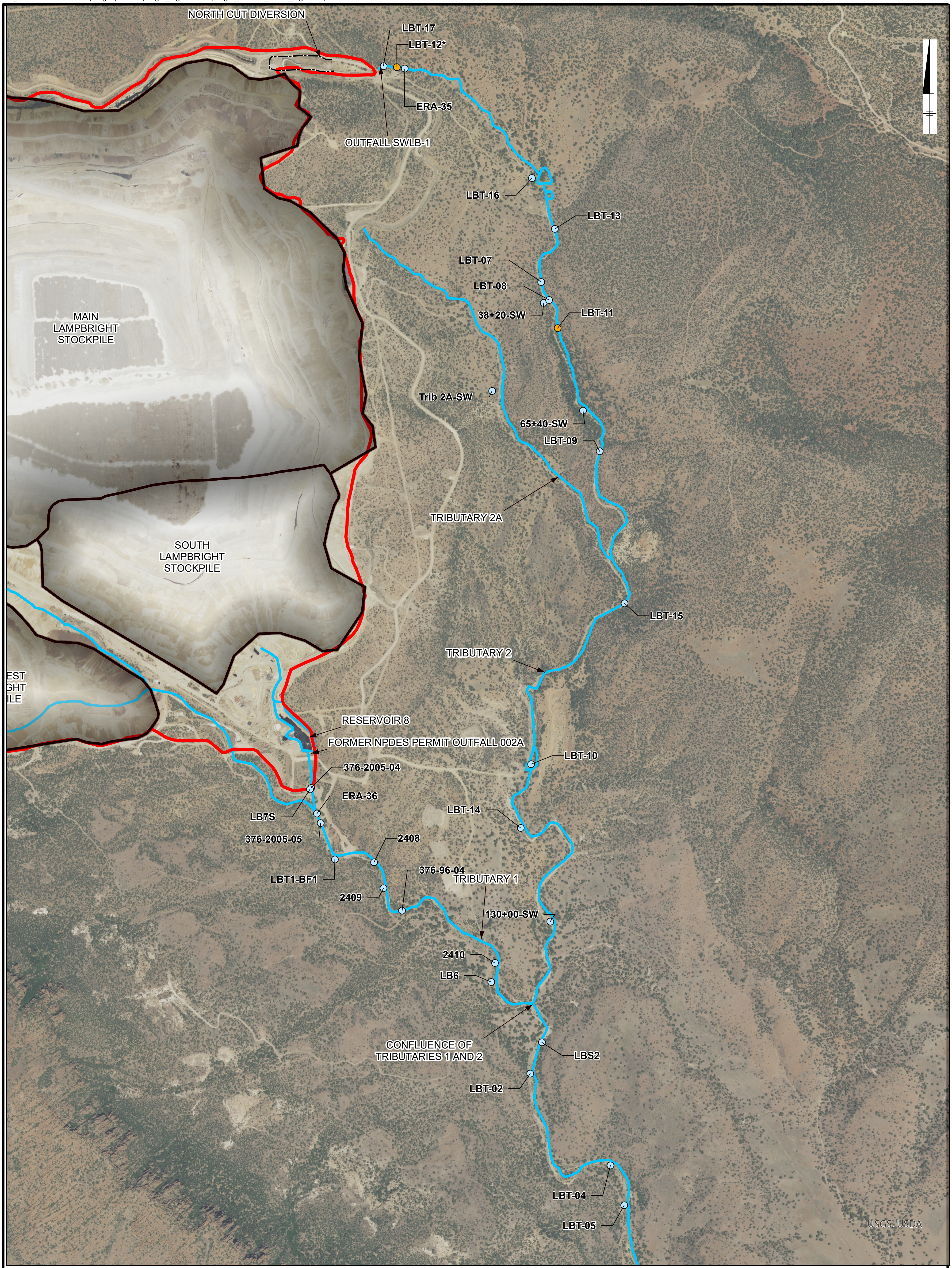
LAMBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

SURFACE WATER LOCATIONS AND ECOLOGICAL CRITERIA EXCEEDANCES FOR NICKEL

ARCADIS

FIGURE
3-22

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
T:_ENV\Chino\2024\Lampbright\pro\Lampbright_Figures\Lampbright_Surface_Water_Figures.aprx



LEGEND:

Zinc Surface Water Concentration

- > pre-FS RAC acute criteria (> 0.15 to 0.564 mg/L)
- < pre-FS RAC chronic criteria (< 0.12 to 0.428 mg/L)
- Tributaries
- DP-376 Boundary

NOTES:
(1) No CLF LOEC threshold was identified.
(2) *Recovered from remediation (by July 2008) after exceedance observed.

Abbreviations:
CLF= Chiricahua Leopard Frog
LOEC = lowest effect concentration

0 1,000 2,000 Feet
GRAPHIC SCALE

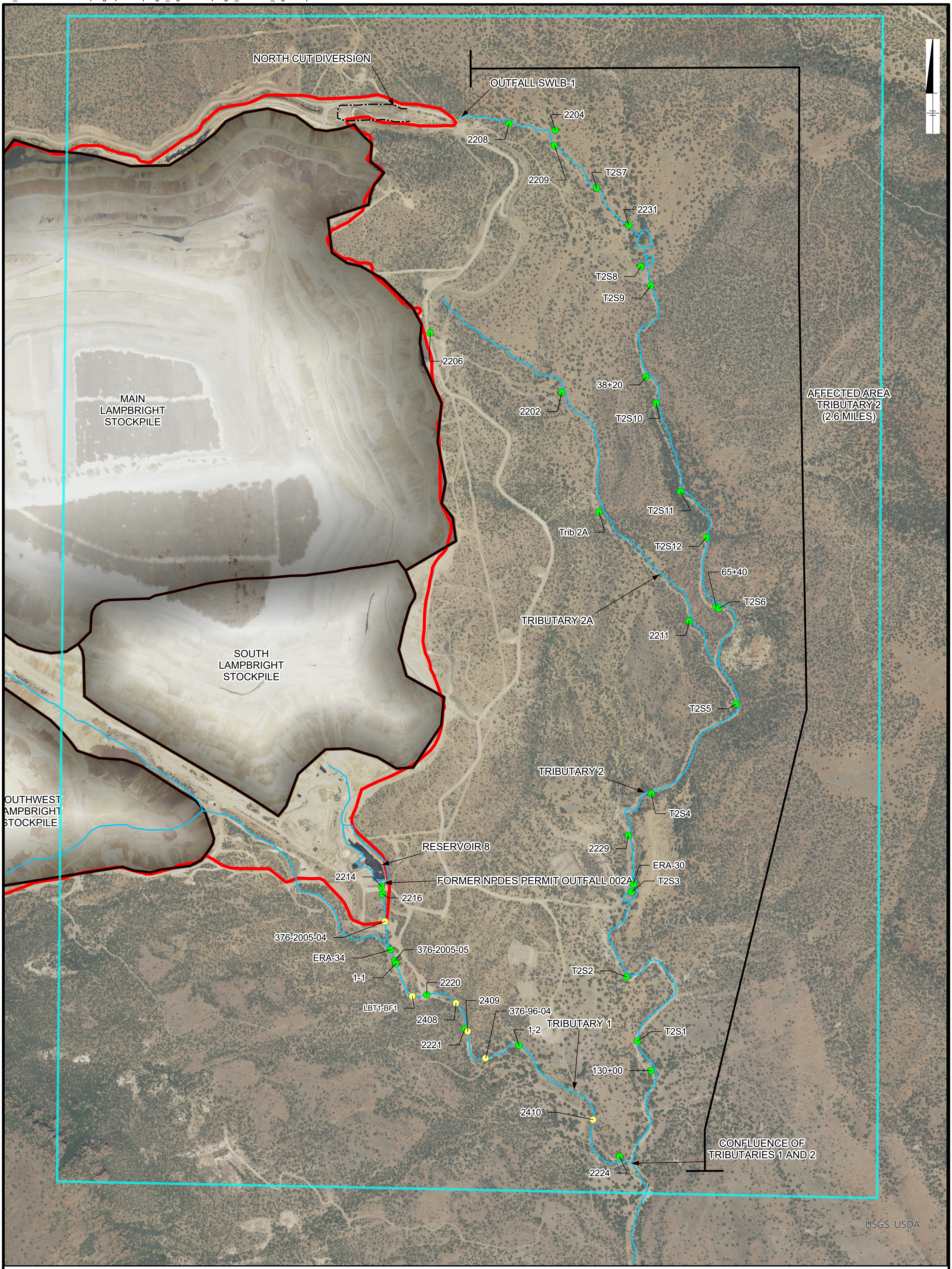
FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

SURFACE WATER LOCATIONS AND ECOLOGICAL CRITERIA EXCEEDANCES FOR ZINC

ARCADIS

FIGURE
3-23



LEGEND:

Chromium Sediment Concentration

- < Probable effects concentration (< 111 mg/kg)
- < Threshold effects concentration (< 43.mg/kg)
- Drainage
- DP-378 Boundary

NOTES:
(1) Affected Tributary 2 = Unplanned discharge of pregnant leach solution in October 2007, remediated and recovered by 2009.
(2) All data shown are from 1995 to 2010.

0 500 1,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

CHROMIUM SEDIMENT SAMPLES WITH EXCEEDANCES

ARCADIS

FIGURE
3-24

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
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LEGEND:

Copper Sediment Concentration

- ≥ Probable effects concentration (≥ 149 mg/kg)
- ≥ Threshold effects concentration (≥ 31.6 mg/kg)
- < Threshold effects concentration
- Drainage
- DP-376 Boundary

NOTES:

(1) Affected Tributary 2 = Unplanned discharge of pregnant leach solution in October 2007, remediated and recovered by 2009.
(2) All data shown are from 1995 to 2010, including concentrations that are high due to impacts prior to Tributary 2 recovery from spill and remediation.
(3) *Recovered from remediation (by 2009) to below the PEC, after PEC exceedance observed.
(4) **Last sampled in 1995.

0 500 1,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

COPPER SEDIMENT SAMPLES WITH EXCEEDANCES

ARCADIS

FIGURE
3-25A

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
T:_ENV\Chino\2024\Lampbright\pro\Lampbright_Figures\Lampbright_Sediment_Figures.aprx

LEGEND:

Copper Sediment Concentration

- ≥ Probable effects concentration (≥ 149 mg/kg)
- ≥ Threshold effects concentration (≥ 31.6 mg/kg)
- < Threshold effects concentration
- Drainage
- DP-376 Boundary

NOTES:

(1) Affected Tributary 2 = Unplanned discharge of pregnant leach solution in October 2007, remediated and recovered by 2009.

(2) All data shown are from 1995 to 2010, including concentrations that are high due to impacts prior to Tributary 2 recovery from spill and remediation.

(3) *Recovered from remediation (by 2009) to below the PEC, after PEC exceedance observed.

(4) **Last sampled in 1995.

0 500 1,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

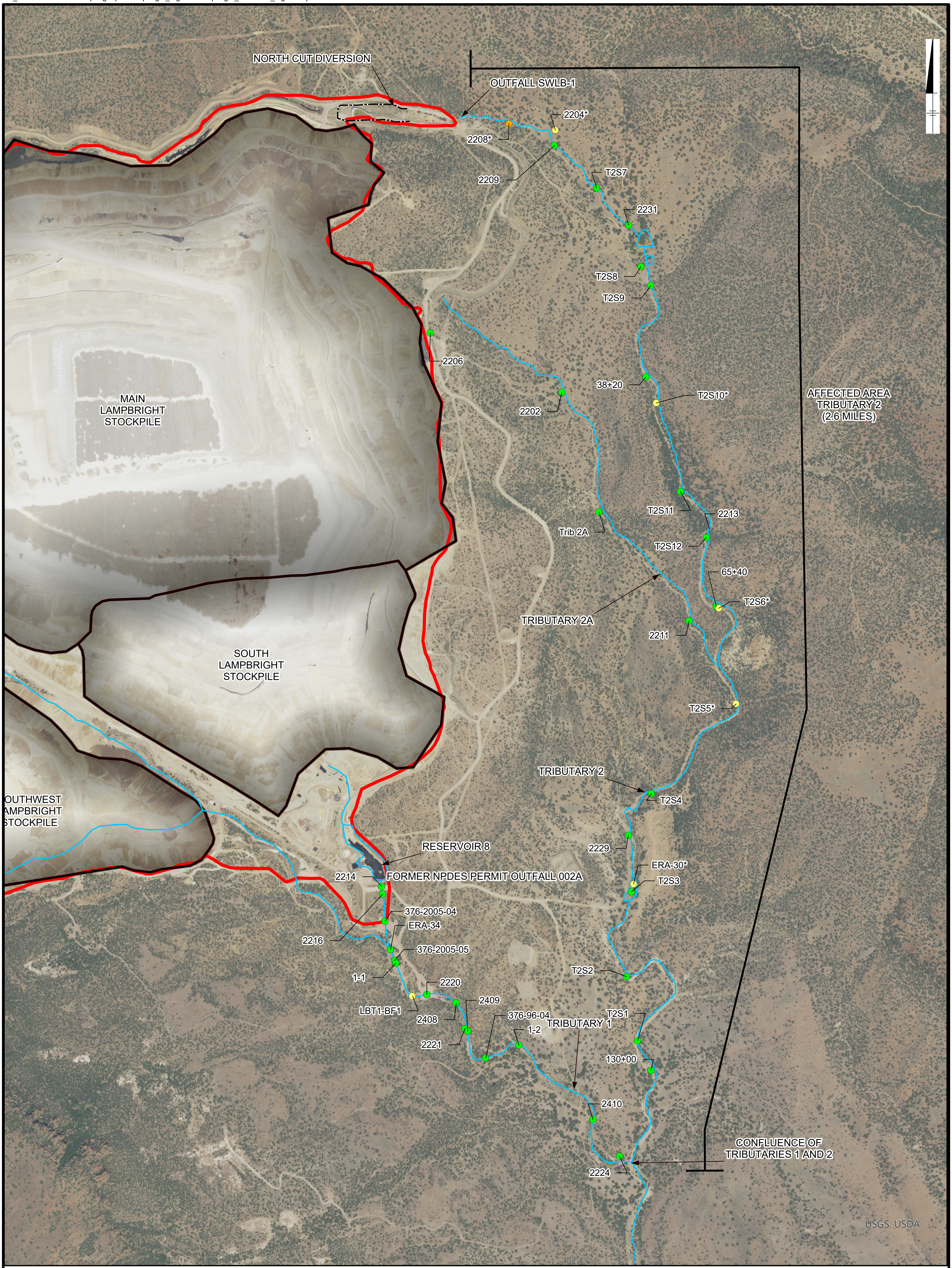
LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

COPPER SEDIMENT SAMPLES WITH EXCEEDANCES

ARCADIS

FIGURE
3-25B

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
T:_ENV\Chino\2024\Lampbright\pro\Lampbright_Figures\Lampbright_Sediment_Figures.aprx



LEGEND:

Lead Sediment Concentration

- ≥ Probable effects concentration (≥ 128 mg/kg)
- ≥ Threshold effects concentration (≥ 35.8 mg/kg)
- < Threshold effects concentration
- Drainage
- DP-376 Boundary

NOTES:

(1) Affected Tributary 2 = Unplanned discharge of pregnant leach solution in October 2007, remediated and recovered by 2009.
(2) All data shown are from 1995 to 2010, including concentrations that are high due to impacts prior to Tributary 2 recovery from spill and remediation.
(3) *Last sampled before 2009, year of full recovery.

0 500 1,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

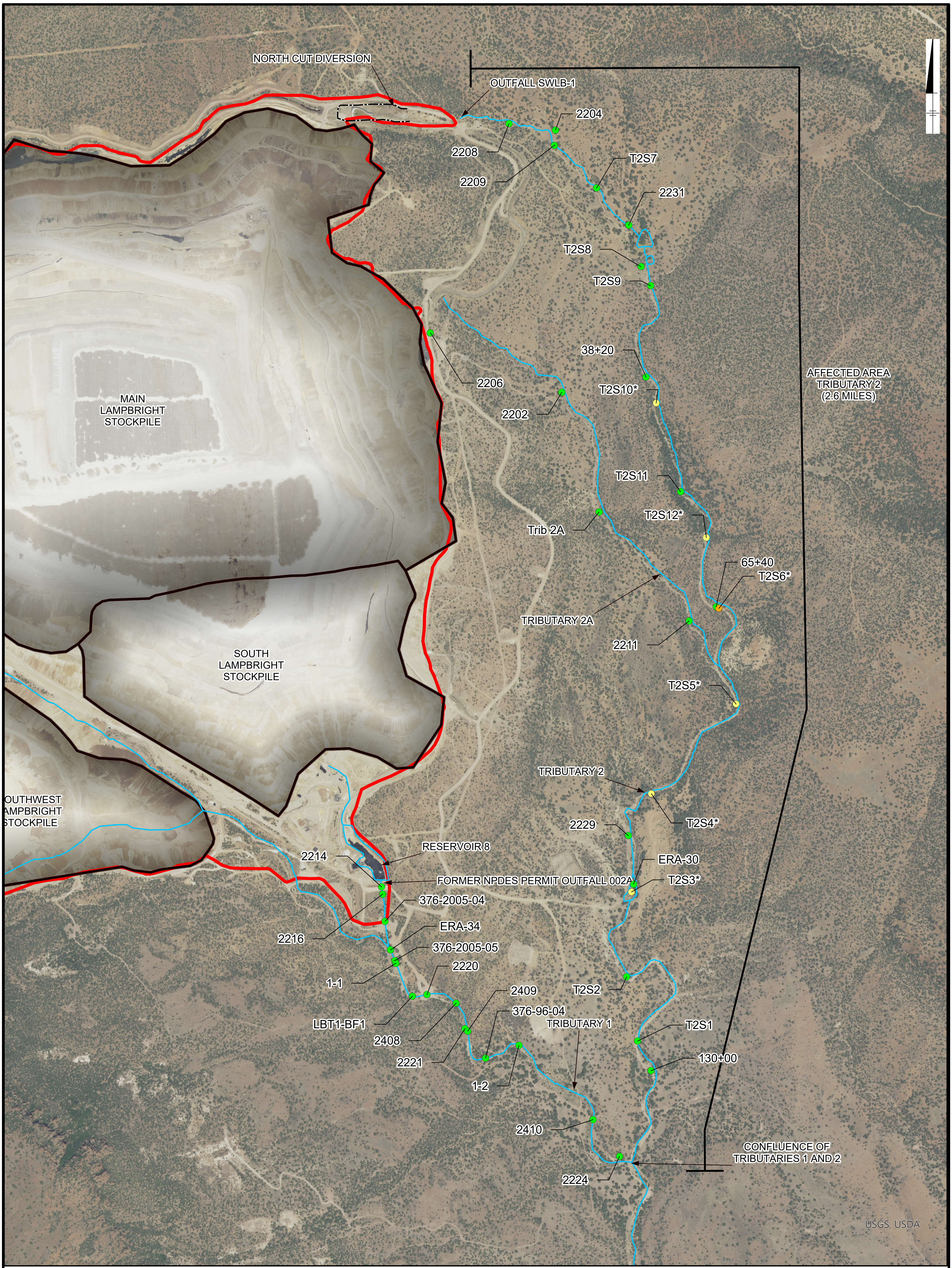
LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

LEAD SEDIMENT SAMPLES WITH EXCEEDANCES

ARCADIS

FIGURE
3-26

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000



LEGEND:

Nickel Sediment Concentration

- ≥ Probable effect concentration (≥ 48.6 mg/kg)
- ≥ Threshold effects concentration (≥ 22.7 mg/kg)
- < Threshold effects concentration
- Drainage
- DP-376 Boundary

NOTES:

(1) Affected Tributary 2 = Unplanned discharge of pregnant leach solution in October 2007, remediated and recovered by 2009.
(2) All data shown are from 1995 to 2010, including concentrations that are high due to impacts prior to Tributary 2 recovery from spill and remediation.
(3) *Recovered from remediation (by 2009) to below the PEC, after PEC exceedance observed.

0 500 1,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

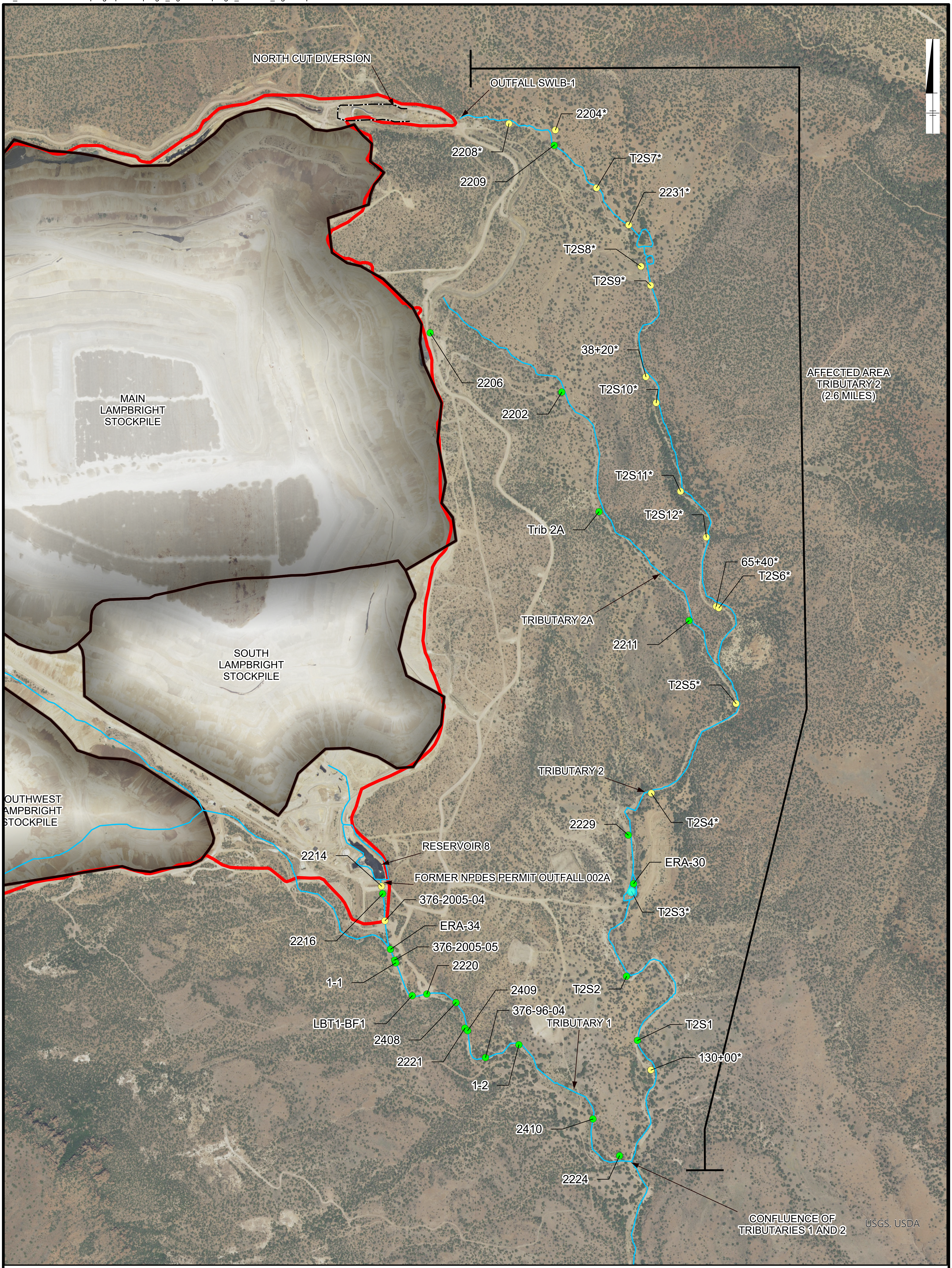
LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

NICKEL SEDIMENT SAMPLES WITH EXCEEDANCES

ARCADIS

FIGURE
3-27

OFFICE: LAKEWOOD DB: MLM TM: MB PM: AT
PROJECT# B0063543.0000
T:_ENV\Chino\2024\Lampbright\pro\Lampbright_Figures\Lampbright_Sediment_Figures.aprx



LEGEND:

Zinc Sediment Concentration

- < Probable effects concentration (< 459 mg/kg)
- < Threshold effects concentration (< 121 mg/kg)
- Drainage
- DP-376 Boundary

NOTES:

(1) Affected Tributary 2 = Unplanned discharge of pregnant leach solution in October 2007, remediated and recovered by 2009.

(2) All data shown are from 1995 to 2010, including concentrations that are high due to impacts prior to Tributary 2 recovery from spill and remediation.

(3) *Recovered from remediation (by 2009) to below the PEC, after PEC exceedance observed.

0 500 1,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

ZINC SEDIMENT SAMPLES WITH EXCEEDANCES

ARCADIS

FIGURE
3-28

Figure 3-29A

Photograph: 1

Description:
Evidence of Seeps, Pools, and Springs

Location:
Tributary 2A

Latitude: 32.78920
Longitude: -108.02309

Photograph taken by:
Field Reconnaissance Team (BIOME 2020)

Date: 5/30/2014

Figure 3-29B

Photograph: 2

Description:
Perennial Reach

Location:
Tributary 2A

Latitude: 32.78920
Longitude: -108.02309

Photograph taken by:
Field Reconnaissance Team (BIOME 2020)

Date: 5/30/2014

Figure 3-29C

Photograph: 3

Description:
Seep with limited wetland or aquatic vegetation

Location:
Tributary 2A

Latitude: 32.78920
Longitude: -108.02309

Photograph taken by:
Field Reconnaissance Team (BIOME 2020)

Date: 5/30/2014

Figure 3-29D

Photograph: 4

Description:
Seep with limited wetland or aquatic vegetation

Location:
Tributary 2A

Latitude: 32.78920
Longitude: -108.02309

Photograph taken by:
Field Reconnaissance Team (BIOME 2020)

Date: 5/1/2019

Figure 3-30A

Photograph: 1

Description:
Pool

Location:
Location T2S10, Tributary 2

Latitude: 32.792149
Longitude: -108.021291

Photograph taken by:
Field Reconnaissance Team (BIOME 2020)

Date: 5/28/2019

Figure 3-30B

Photograph: 2

Description:
Pool

Location:
Location T2S10, Tributary 2

Latitude: 32.792149
Longitude: -108.021291

Photograph taken by:
Field Reconnaissance Team (BIOME 2020)

Date: 5/23/2023

Figure 3-31

Photograph: 1

Description:
Pool

Location:
Location T2S6, Tributary 2

Latitude: 32.786712
Longitude: -108.019314

Photograph taken by:
Field Reconnaissance Team (BIOME 2020)

Date: 9/1/2019

Figure 3-32A

Photograph: 1

Description:
Low presence of pools, seeps, and springs

Location:
Tributary 1

Latitude: 32.77322
Longitude: -108.02330

Photograph taken by:
Field Reconnaissance Team (BIOME 2020)

Date: 5/30/2013

Figure 3-32B

Photograph: 2

Description:
Low presence of pools, seeps, and springs

Location:
Tributary 1

Latitude: 32.76312
Longitude: -108.01640

Photograph taken by:
Field Reconnaissance Team (BIOME 2020)

Date: 5/30/2013

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PROJECT# B0063543.0000
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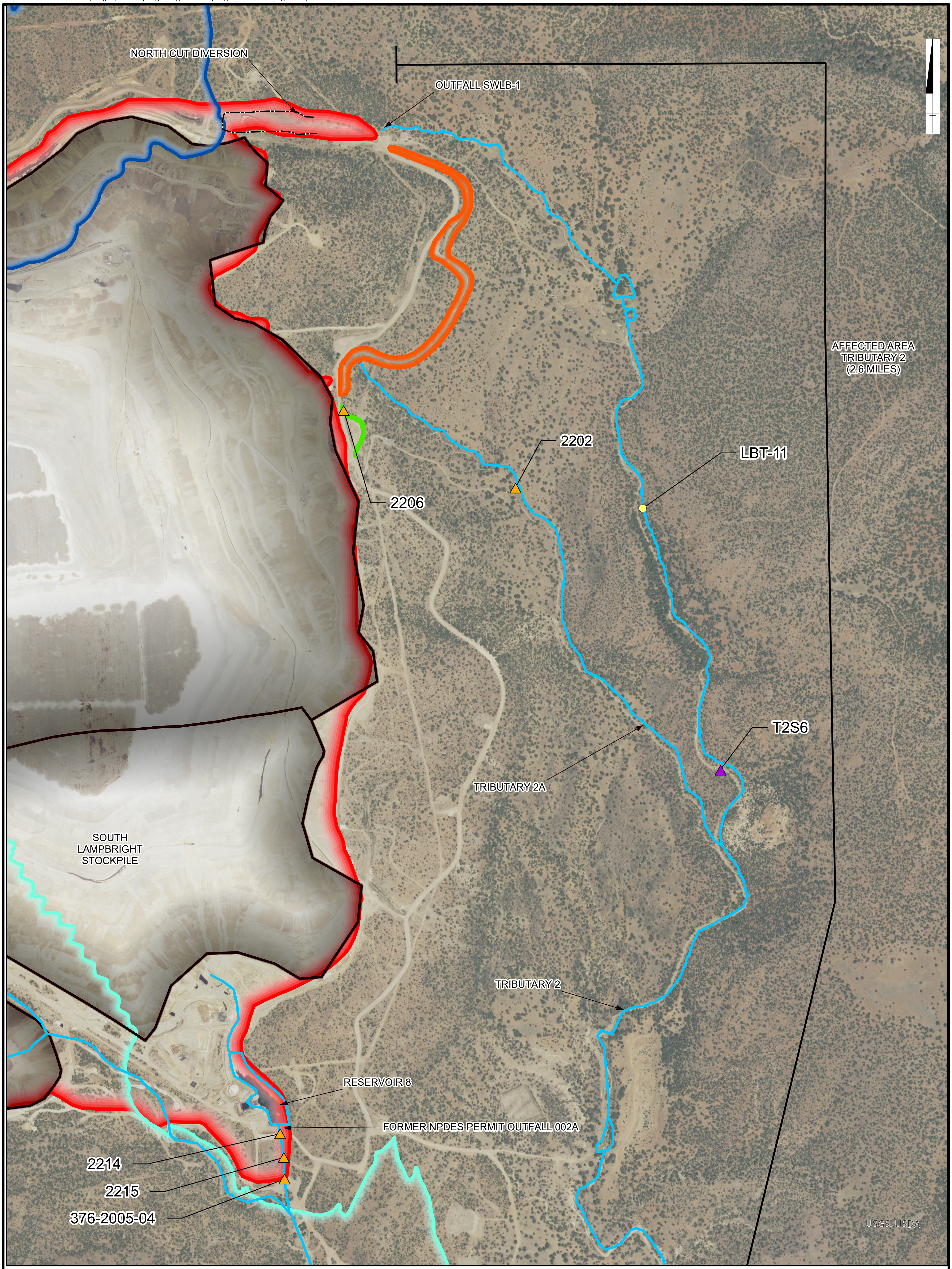

LEGEND:

- ▲ (orange) Exceedance of probable effect concentration (PEC) for copper in sediment
- ▲ (purple) Exceedance of probable effect concentration (PEC) for nickel in sediment
- ● (yellow) Surface water exceedance of Pre-FS RAC for zinc
- Drainage
- DP-376 Boundary
- Proposed North Lampbright Leach Stockpile
- Proposed Kessel Stockpile
- Far East Containment New Disturbance
- Pipeline Corridor New Disturbance

NOTES:
- Acute criteria of the Pre-FS RAC were applied to Tributary 1 because of its ephemeral nature.
- Surface water exceedance of Pre-FS RAC for zinc is likely due to localized mineralization and sediment exceedance areas will be evaluated as part of the sitewide abatement program.

0 500 1,000 Feet
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

LAMPBRIGHT INVESTIGATION UNIT FEASIBILITY STUDY

LOCATIONS EXCEEDING PRE-FS RAC OR PECS INSIDE AND OUTSIDE OF DISCHARGE PERMIT BOUNDARY AFTER RECOVERY PERIOD

ARCADIS

FIGURE
3-33

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