Remedial Investigation
Executive Summary

Ely Copper Mine Superfund Site
Vershire, Vermont
Remedial Investigation / Feasibility Study
EPA Task Order No. 0024-RI-CO-017L

REMEDIAL ACTION CONTRACT
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FOR

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Region 1

BY

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Nobis Project No. 80024

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ACRONYMS

ABA	Acid Base Accounting
ADL	Arthur D. Little, Inc.
AMD	Acid Mine Drainage
ARARs	Applicable or Relevant and Appropriate Requirements
ARD	Acid Rock Drainage
ATV	Acoustic Televiewer
AVS	Acid Volatile Sulfides
AWQC	Ambient Water Quality Criteria
BERA	Baseline Ecological Risk Assessment
Bgs	Below Ground Surface
CBRs	Critical Body Residues
CEC	Calculation Exchange Capacity
cfs	Cubic Feet per Second
CLP	Contract Laboratory Program
COCs	Contaminants of Concern
COPCs	Contaminants of Potential Concern
COPECS	Contaminants of Potential Ecological Concern
CRREL	U.S. Army Cold Regions Research and Engineering Laboratory
CSM	Conceptual Site Model
CTEs	Central Tendency Exposures
cy	Cubic Yards
DAS	Delivery of Analytical Services
DO	Dissolved Oxygen
DQO	Data Quality Objectives
EB-LR	Ely Brook – Lower Reach
EB-MR	Ely Brook – Middle Reach
EB-UR	Ely Brook – Upper Reach
EBOR	East Branch of the Ompompanoosuc River
EBT	Ely Brook Tributaries
EB-UR	Ely Brook – Upper Reach
EcoSSLs	Ecological Soil Screening Levels
EDD	Estimated Daily Dose

ACRONYMS (cont.)

EEQ	Ecological Effect Quotient
EF	Enrichment Features
ELCR	Excess Lifetime Cancer Risk
EPA	US Environmental Protection Agency
EPC	Exposure Point Concentration
EU	Exposure Units
FS	Feasibility Study
ft	Feet
gpm	gallons per minute
GW	Groundwater
HHRA	Human Health Risk Assessment
HI	Hazard Index
HPFM	Heat Pulse Flow Meter
HQ	Hazard Quotients
IEUBK	Integrated Exposure Uptake Biokinetic
ILCR	Incremental Lifetime Cancer Risks
IR	Incremental Risk
K	Hydraulic Conductivity
LWA	Lower Waste Area
MBs	Magnitude of Background Factors
MCL	Maximum Contaminant Level
mg/Kg	Milligrams per Kilogram
mi	Miles
mi^2	Square Miles
mmhos/cm	Milli-mhos per centimeter; unit for paste conductivity
NA	Not Available or Not Applicable
NCP	National Contingency Plan
NOBIS	Nobis Engineering, Inc.
NPL	National Priorities List
NRWQC	National Recommended Water Quality Criteria
OEME	Office of Environmental Measurement and Evaluation
ORB	Ore Roast Bed

ACRONYMS (cont.)

ORP	Oxidation Reduction Potential
OTV	Optical Televiewer
OU1	Operable Unit 1
PCBs	Poly-Chlorinated Biphenyls
PRGs	Preliminary Remediation Goals
QA/QC	Quality Assurance / Quality Control
RfDs	Reference Doses
RI	Remedial Investigation
RI/FS	Remedial Investigation / Feasibility Study
RMEs	Reasonable Maximum Exposures
ROD	Record of Decision
RQD	Rock Quality Determination
RSL	Regional Screening Level
SEM	Simultaneously Extracted Metals
SHB	Schoolhouse Brook
Site	Ely Mine Superfund Site
SLERA	Screening Level Environmental Risk Assessment
Solute	Simple 2 Dimensional Model for Solute Transport
SOW	Statement of Work
SP	Spontaneous Potential
SPLP	Synthetic Precipitation Leaching Procedure
SPR	Single Point Resistance
su	Standard Units
SVOCs	Semi-Volatile Organic Compounds
SW	Surface Water
SWPA	Surface Water Protection Act
TAL	Target Analyte List
Task Order	Task Order Number 0024-RI-CO-017L
T $CaCO_3$/1000t	Tons of calcium carbonate equivalent per 1000 tons of material
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TRVs	Toxicity Reference Valves

ACRONYMS (cont.)

TSS	Total Suspended Solids
UCL	Upper Confidence Limit
µg/dL	Micrograms per decaliter
µg/L	Micrograms per Liter
µm	Micrometer
µS/m	Micro Siemens per meter
URS	URS Corporation
U.S.	United States
USACE	US Army Corps of Engineers
USBOM	US Bureau of Mines
USDA	US Department of Agriculture
USGS	US Geological Survey
UWA	Upper Waste Area
VCMC	Vermont Copper Mining Company
VOCs	Volatile Organic Compounds
VTDEC	Vermont Department of Environmental Conservation
VTGWES	Vermont Groundwater Enforcement Standards
VTWQS	Vermont Water Quality Standards
WBOR	West Branch Ompompanoosuc River
WOE	Weight-of-Evidence
XRF	X-ray Fluorescence

ES EXECUTIVE SUMMARY

This Operable Unit 1 (OU1) Remedial Investigation (RI) Report documents the nature and extent of contamination for the Ely Mine Superfund Site located in Vershire, Vermont (hereafter referred to as the "Site"). See Figure ES-1 for the location of the Ely Mine. This RI Report was prepared by Nobis Engineering, Inc. (Nobis) for the United States Environmental Protection Agency (EPA) under Contract Number EP-S1-06-03, Task Order Number 0024-RI-CO-017L (Task Order). The work was performed in accordance with the September 27, 2007 EPA Statement of Work (SOW) and the Work Plan Amendment No. 4 dated July 28, 2010.

EPA creates operable units to allow areas of the Site that are ready for a cleanup action to move forward while allowing additional investigation of other areas. For the Ely Mine, the following operable units have been created:

- OU1 will include the waste rock, tailing, and roast beds along with the surface water, soil, and sediment for all areas of the Ely Brook Valley except the Smelter and Slag Areas and any underground shaft and adits. The OU1 areas are shown in Figure ES-2.

- Operable Unit 2 (OU2) includes all Site groundwater impacts, source zones related to the underground shafts and adits, soil and sediment impacts related to the Smoke Flue, Smelter, and Slag Areas, surface water and sediment impacts in SHB and the EBOR. The OU2 areas are shown in Figure ES-2.

The RI will present the information available for both OU1 and OU2. A supplemental RI will be performed to gather and present the additional data and information that is required to complete the OU2 RI.

The purpose of the RI is to: (1) determine the nature and extent of contamination in soil, sediment, groundwater, air, and surface water, both on the Site and in the surrounding areas, (2) evaluate the fate and transport of contaminants, and (3) assess human health and ecological risks. Overall, the RI has determined that contamination is largely the result of the activities associated with the extraction and processing of ore, along with the on-site disposal of waste rock and tailings. The ore extraction, processing, and waste disposal activities left behind tailings, waste rock and slag that have spread the constituents of the ore (particularly cobalt,

copper, and iron) over a large area, making them more accessible to human and ecological receptors than they were prior to mining activities. The ongoing migration of contaminants from the waste rock and tailings has caused the presence of contaminants in soil, sediment, surface water, and groundwater at concentrations that are above levels observed in background study areas, and at levels that could pose a threat to public health and the environment. A Site Sketch is shown in Figure ES-3, and Site study areas with demonstrated contaminant impacts are shown in Figure ES-4.

The RI, including the Human Health and Ecological Risk Assessments, also concluded the following:

- The leaching of metals from the waste rock and tailings is causing severe ecological impacts to the amphibians, benthic invertebrates, and fish in Ponds 4 and 5, Vernal Pool 1 (VP-1), Ely Brook, five tributaries of Ely Brook, and Schoolhouse Brook (SHB). The areas with severe ecological impacts associated with surface water within the Ely Brook Valley are shown on Figure ES-5. The areas with severe ecological impacts associated with surface water within SHB are shown on Figure ES-6.

- The sediments within Ponds 4 and 5, Ely Brook, five tributaries of Ely Brook, and within several depositional areas in SHB are also contributing to the severe ecological impacts observed at the Site. The areas with severe ecological impacts associated with sediments within the Ely Brook Valley are shown on Figure ES-5. The areas with severe ecological impacts associated with sediments within SHB are shown on Figure ES-6.

- Human contact with the surface water and sediments of the Ponds, Ely Brook, and SHB does not represent a threat to human health.

- Human contact with the mine waste and soil contaminated with cobalt, copper, and iron represents a potential health threat to people that may come into contact with these materials for 350 days per year. A potential threat would also exist for a construction worker or someone causing substantial disturbance of the mine waste and subsequently inhaling mine-contaminated particulate matter more than 60 days per year. The area where cobalt, copper, and iron concentrations in soil exceed the site-specific preliminary remediation goals (PRGs) is shown on Figure ES-7.

- Groundwater beneath and adjacent to the waste rock piles, tailings, and Slag Pile and Smelter Areas is contaminated and is not suitable for human consumption. The area where groundwater is contaminated above federal and state standards is shown on Figure ES-8.

- Limited recreational use of the Site does not represent a threat to human health.

SITE DESCRIPTION AND HISTORY

The Site is an abandoned copper mine located in Vershire, Orange County, Vermont. The Site encompasses approximately 350 acres along the south slope of Dwight Hill, to the north of SHB and South Vershire Road. The Site includes features such as waste rock and mine process waste piles, intact and collapsed adits and shafts, remnant foundations of former mine operation buildings, a 1,500-foot-long smoke flue, and over 3,000 linear feet (ft) of underground workings. Waste areas include former ore roast beds, waste rock piles, a tailings pile, a former smelter area, and a slag pile, all located within the watershed of Ely Brook (Figure ES-4). Ely Brook joins SHB at the southern margin of the Site. SHB flows eastward approximately 1.75 miles (mi) to its confluence with the East Branch of the Ompompanoosuc River (EBOR). A major eastern tributary to Ely Brook, Ely Brook Tributary 2 (EBT2), drains from a former reservoir and a series of ponds located east of the mine waste areas.

The Site lies within the Devonian Gile Mountain Formation, in which the primary ore minerals include pyrrhotite, chalcopyrite with minor sphalerite and pyrite (Slack, et al., 2001). The Site was added to the Superfund listing in September 2001 due to environmental impacts from acid rock drainage (ARD) on Ely Brook and SHB. The Site is also eligible for the National Register of Historic Places due to its historical aspects (Hathaway, et al., 2001).

The Ely Copper Mine is one of three major historic copper mines located within Besshi-type ore deposits that comprise the Vermont Copper Belt including the Elizabeth, Ely, and Pike Hill Mines within a 20 mi long area from south to north in the belt. The ore body was discovered in 1813 with significant mining activities beginning in 1853 by the Vermont Copper Mining Company (VCMC) and lasting until 1905 (PAL, 2005). Ore roasting at the ORB began concurrently with the initial construction of the smelter in 1867 to reduce the sulfur content of the

ore prior to smelting. Mine operations experienced a boom between 1872 and 1880, a period during which Ely Village expanded and the Town of Vershire grew to a population of about 1,900 in contrast to today's population of about 630 people. By 1876, sulfur fumes from the roast beds and smelter had eliminated the vegetation in the valley. A stone slab flue approximately ¼ mi long was built from the smelter up the eastern side of the valley with the intention of reducing fumes in the valley, but the flue reportedly never functioned effectively. By 1879 the smelter building was expanded to 24 furnaces and a length of 700 ft to accommodate ore from the Pike Hill Mines. During this time, the smelter slag pile was expanding south of the building toward SHB. Between 1883 and the close of the mine in 1905, ownership changed hands several times and production was sporadic. An attempt to rejuvenate copper production in 1900 was unsuccessful due to both the lack of ore at the 3,500-ft downdip limit of the mine and low copper prices. In 1905, equipment was stripped from the Site and buildings were sold, moved, or demolished. In 1917, a flotation mill was constructed in an attempt to recover copper from the mine dumps. The flotation mill operated for only a short period until the end of World War I, at which time the price of copper fell, closing the operation. In 1949-50, attempts were made to recover copper from the mine waste piles and 60,000 tons of waste rock/ore assayed at about 1% copper were transported to the Elizabeth Mine for processing. Since 1950, the Site has been used for timber management and recreational activities, including hunting, snowmobile riding, and horseback riding. The Site is often visited by those interested in the remnants of the mining activities or the Site geology. ATV tracks are observed on several of the waste piles.

SITE INVESTIGATIONS

Since 1998, a considerable amount of data has been generated as the result of various investigation programs conducted at the Site. EPA has retained the U.S. Army Corps of Engineers (USACE), the U.S. Geological Survey (USGS), URS Corporation (URS), and Nobis to perform work at the Site. Additional information has been contributed from studies performed by the State of Vermont. In 2002, the USACE, in cooperation with the USGS, completed a study of spring runoff from the Site to characterize the geochemical diversity of water sources in the Ely Brook Watershed, which included sampling from seeps in mine waste areas, Ely Brook and tributaries, SHB, and the EBOR. This study documented highly acidic and highly metal-laden runoff from the mine areas (Holmes, et al., 2002). Between 1998 and 2007, the USGS conducted sampling surveys and completed a series of studies at the Site, which included

sampling and analysis of the various solid mine waste materials and sediment to characterize the materials, assess their acid-generating potential, and assess their potential for leaching metals (Piatak, et al., 2004a; 2004b; 2007).

From 2005 through 2008, URS, in conjunction with the USACE and EPA, completed extensive field studies, including a habitat characterization study of the Site (URS, 2005; 2008). Field investigations included test pits, borings, monitoring well installations, and the collection of surface water and sediment (over 30 locations), surface and subsurface soil (over 150 locations), and groundwater samples (approximately 30 wells) from the Site (URS, 2008). URS evaluated surface and subsurface soil samples from waste areas and transition zones around waste areas, including off-site background soil metals concentrations. These data have been incorporated directly into the Remedial Investigation/Feasibility Study (RI/FS) analytical database for the Site.

In 2007, the Vermont Department of Environmental Conservation (VTDEC) completed an aquatic life use attainment assessment of Ely Brook, SHB, and the EBOR. The assessment included the evaluation of fish and macroinvertebrate community data, which indicated impairment for portions of SHB and Ely Brook likely related to runoff from the Site (VTDEC, 2007). In 2006 and 2007, the USGS, in conjunction with EPA, conducted a detailed characterization of surface water, sediment, porewater, and fish and macroinvertebrate communities in Ely Brook, SHB, and the EBOR in support of the Aquatic Baseline Ecological Risk Assessment for the Site (Aquatic BERA; Techlaw, 2008; Seal, et al., 2010). These studies included toxicity tests of surface water, sediment and porewater form each surface water reach.

In 2009, Nobis completed extensive supplemental field investigations to complete the RI. Investigations included sampling of surface/subsurface soil (over 80 samples), groundwater (2 rounds from over 40 wells), surface water (2 rounds over 30 locations, including 4 vernal pools), porewater (7 locations), sediment (16 locations) and small mammal and invertebrate biota sampling along 12 transects. Residential drinking water samples were also collected from 6 locations near the Site. Overburden, shallow, and deep bedrock well installations were completed, along with packer testing and borehole geophysical characterization of the deep bedrock at the Site (Nobis, 2010). Soil sampling included on-site laboratory X-ray fluorescence (XRF) analysis of over 340 soil samples from an extensive network of 26 sample transects. Sediment sampling of the Lower Reach of Ely Brook included detailed evaluation of three

sediment transects to assess the vertical distribution of waste rock sediment in the brook. Investigations included the collection of soil and sediment samples for geotechnical analyses to document the physical characteristics of waste materials and support the feasibility study evaluation of remedial options. Biota sampling to support the terrestrial BERA included 8 composite samples of invertebrates and 107 small mammals from 5 transects in select transition zone areas.

CONTAMINANT SOURCE AREAS

Waste material from over 100 years of mining activities can be found across the entire Site, from the mine entrances high on Dwight Hill to SHB. The major issue at the Ely Mine is ARD, which occurs when sulfide mineral-bearing rock and ore are exposed to oxidizing conditions through natural weathering processes. At the Site, ARD occurs in response to the oxidation of waste rock, waste ore, tailings, slag, and roasted ore. The contaminated water that flows from the underground adits and shafts is more commonly referred to as Acid Mine Drainage (AMD), which occurs when sulfide mineral-bearing rock and ore are exposed to oxygen and water, thereby creating a low-pH leachate (contaminated water percolating through the impacted soil and infiltrating the groundwater). At low pH, many of the metals that were bound in the ore and native soil become soluble and dissolve into the leachate. The leachate from the Site often contains elevated levels of aluminum, cadmium, cobalt, copper, iron, manganese, and zinc that are likely from the locally mined ore. Aluminum and manganese are also contributed by the leaching of metals in the native soil. In addition to the oxidation of the sulfide-bearing minerals, the cyclic formation and subsequent dissolution of evaporative metal salts on exposed waste ore and tailings also contributes to ARD at the Site. Metal salts form on the surfaces of the tailings and waste ore as metal-containing acidic moisture evaporates. The metals stored in these salts are dissolved and remobilized during subsequent rainfall events. This run-off is eventually conveyed to receiving streams, resulting in an increase in the waterway's metals concentration and load.

Metals associated with ARD at the Site have been detected at elevated concentrations in groundwater, surface water, soil, and sediment. ARD directly affects both groundwater and surface water quality at the Site by lowering the pH and contributing elevated concentrations of metals to these media. This also occurs at the outlet of the adits, where impacted mine waters discharge directly to the ground surface as AMD. In addition, the tailings, weathered waste ore,

roasted ore, and byproducts generated from the smelting process (i.e., slag) have been transported from the original areas of deposition by erosion and re-distributed nearby, causing elevated concentrations of metals in the soil adjacent to the waste areas. Some of these materials have been conveyed by overland flow, resulting in elevated concentrations of metals in sediment along these Site drainage ways, including: Ely Brook, four tributaries to Ely Brook, SHB, and the Ompompanoosuc River.

The RI divided the Site into several sub-areas that may be contributing contamination to the surface water, groundwater, or sediment. The sub-areas (shown in Figure ES-4) that fall within OU1 are the: Upper Waste Area (UWA); Lower Waste Area (LWA); Tailings Area; and Ore Roast Bed (ORB). The sub-areas within OU2 are the Smelter Area, the Smoke Flue, and the Slag Pile Area. In addition, due to the significant volume of mine waste present in the sediment of Ely Brook (Lower and Middle Reaches), this area is also considered a potential waste source. Evaluation of results from each of these areas has led to the following findings.

Operable Unit 1 Source Areas

UWA – The UWA covers an area of approximately 8.5 acres and is comprised of a series of terraced, overlapping mine waste rock piles of varying thickness in the upper portion of the Ely Brook Valley on the south side of Dwight Hill. The UWA sits just downslope of the Main Shaft for the underground workings. A series of 6 shafts and 2 adits are found within and adjacent to the UWA and a series of ponds (Pond 1 through Pond 5) define the downslope extent of the UWA. Figure ES-4 shows the UWA.

The UWA waste piles are up to 22 ft thick. Native soil underlies portions of the UWA, but some of the waste sits directly on bedrock. The primary limits of the UWA were defined by the physical presence of mine waste. This delineation generally coincides with areas where cobalt, copper, and iron exceed soil PRGs and contains about 73,000 cubic yards (cy) of mine waste. Groundwater extends into the lower portion of the piles, particularly during spring snowmelt and after periods of substantial rain. Water coming into contact with the mine waste creates an acidic leachate containing high levels of contamination that drains from the UWA into groundwater and several tributaries of Ely Brook (EBT2, EBT3, and EBT4). Average surface soil copper concentrations in the UWA are over 2.7 times greater than PRGs and 39 times greater than background maximums.

LWA – The LWA occupies approximately 6.4 acres of bare waste rock in the central portion of the Site, below the UWA and the foundation of the Former Flotation Mill, and between the ORB and Ely Brook. Figure ES-4 shows the LWA.

There are no distinct piles in the LWA. The waste material is relatively thin, typically on the order of 5 ft thick, in contrast to the thicker waste piles in the UWA. A relatively thin layer of native soil with variable thickness underlies the LWA. It is possible that some of the waste sits directly on or in close proximity to bedrock. The primary limits of the LWA were defined by the physical presence of mine waste. This delineation generally coincides with areas where cobalt, copper, and iron exceed soil PRGs and contains an estimated 29,000 cy of waste rock. Two major Site surface water features, the Ely Brook Tributaries 2 and 3 (EBT2 and EBT3), dissect and drain portions of the LWA. EBT3 merges into EBT2 prior to Ely Brook and the combined flow represents one of the most significant tributaries to Ely Brook. Groundwater extends well into the waste within the LWA. Water coming into contact with the mine waste creates an acidic leachate containing high levels of contamination that drains from the LWA into groundwater and several tributaries of Ely Brook (EBT2, EBT3, and EBT5). These tributaries run across the waste within the LWA. Average surface soil copper concentrations in the LWA are over 2.9 times greater than PRGs and 40 times greater than background maximums.

Tailings Area – The Tailings Area is located within the northwest portion of the LWA and encompasses approximately 0.7 acres. The tailings waste is a remnant of the operation of the Former Flotation Mill and are a fairly uniform fine sand/silt material produced from mined ore. There is no well defined tailing pile, but EBT3 has cut a channel that exposes this waste. A relatively continuous layer of glacial till approximately 10 ft thick is interpreted to underlie the Tailings Area, which may limit impact to groundwater beneath the tailings pile. Figure ES-4 shows the Tailings Area.

The primary limits of the Tailings Area were defined by the physical presence of tailings and contain about 3,600 cy of mine waste. Similar to the LWA, the Tailings Area is saturated with groundwater and portions of this waste source material form the watershed of EBT3. Water coming into contact with the tailings creates an acidic leachate containing high levels of contamination that drains from the Tailings Area into groundwater and EBT3. Average surface

soil copper concentrations in the Tailings Area are over 1.5 times greater than PRGs and 20 times greater than background maximums.

ORB – The ORB is located abutting the eastern margin of the access road, southeast of the LWA and covers a 2.2 acre area that is approximately 900 ft long and 200 ft wide. The ORB was the primary location for the roasting of ore excavated from the Ely Mine. Figure ES-4 shows the ORB.

The ORB waste is about 8 ft thick and contains approximately 10,330 cy of roasted ore. The western limit of the ORB is demarked by a high stone slab retaining wall. The sparsely vegetated ORB soils are distinguishable from soils in the adjacent LWA by the deep red color of the hematite-rich soil. A small tributary to Ely Brook, EBT1, crosses the roast beds and the access road at a location where the retaining wall has collapsed. An abandoned exploratory shaft is located along the northeast margin of the ORB. The roasted ore in this area still contains significant levels of metals, but the waste material does not produce acidic leachate and appears to be a much less significant source of contamination than the UWA, LWA, and Tailings Area. Average surface soil copper concentrations in the ORB are over 1.2 times greater than PRGs and 17 times greater than background maximums.

Ely Brook Lower and Middle Reaches – Ely Brook Lower Reach (EB-LR) and Middle Reach (EB-MR) contain significant accumulations of waste rock alluvium that has eroded from the UWA, LWA, and Tailings Area. The waste is up to 3.5 ft thick within the stream channel and portions of the floodplain. The estimated volume of waste material within the banks of EB-MR is 580 cy, encompassing an area of <0.5 acres. The estimated volume of waste material in EB-LR is 3,950 cy, encompassing an area of 2.5 acres. The waste rock alluvium within Ely Brook contains concentrations of cobalt, copper, and iron in exceedance of the PRGs and may be a contributing source to the surface water impacts. Figure ES-4 shows Ely Brook Lower and Middle Reaches.

Operable Unit 2 Source Areas

Smelter Area – The Smelter Area is located along the north Side of South Vershire Road and is flat with a vegetated area at the northwest portion, a barren waste rock area in the central portion, and an area of small waste rock and debris piles along the southwest margin. The

northern limit of the area is marked by a stone slab retaining wall and steep slope leading up to an access road. Several partially-buried stone-slab smelter bases are located along the central portion of the area marking the former location of the smelter building, which extended to the southeast beneath the existing road location. Figure ES-4 shows the Smelter Area.

Waste materials in the Smelter Area include waste rock, oxidized ore, slag, and building demolition debris estimated to range from 2 to 16 ft thick, with an estimated volume of 31,120 cy over an area of 3.8 acres. Similar to the UWA and LWA, the soil within the Smelter Area contains high levels of cobalt, copper, and iron. It is estimated that approximately half the thickness of waste material in the Smelter Area is groundwater-saturated. Groundwater results from downgradient wells in the Slag Pile Area show shallow overburden groundwater to be significantly impacted, which is likely in part due to the wastes beneath the Smelter Area. Average surface soil copper concentrations in the Smelter Area are over 2.4 times greater than PRGs and 33 times greater than background maximums.

Smoke Flue – The Smoke Flue is a unique feature of the Site, designed to convey sulfurous fumes away from the valley. It extends approximately 1500 ft northeast to the top of the adjacent hillside and is constructed of two parallel stone walls topped by flat schist slabs. There are no known significant quantities of waste material associated with the Smoke Flue. Based on its intended use, soils in the vicinity of the flue were sampled to determine if they were impacted by smelter exhausts. While levels of several metals were detected at concentrations above background levels, the smoke flue is not considered an area of significant contamination. The smoke flue is not believed to represent a threat to groundwater or surface water.

Slag Pile Area – The Slag Pile Area lies beneath South Vershire Road and extends south, where a south-facing exposure of the slag (approximately 10 ft high) reveals the glassy, slag material with slag pot impressions set back a short distance from SHB. The Slag Pile Area has an estimated volume of 25,000 cy of slag spread over an area of 4.2 acres and is up to 16 ft thick. The limit of slag on the north of South Vershire Road is not known and the slag is intermixed with the waste within the Smelter Area. Observations of slag material in the streambed and freshly exposed slag material along the southeastern most portion of the area (where the slag pile forms a portion of the stream bank) indicate that the slag is eroding into SHB. Testing performed by the USGS indicates that the slag has the potential to impact groundwater and surface water. Figure ES-4 shows the Slag Pile Area. Average surface soil

copper concentrations in the Slag Pile Area are over 4.3 times greater than PRGs and 60 times greater than background maximums.

SURFACE WATER AND SEDIMENT

Sampling of surface water between 2000 and 2009 has documented the extent of ARD impacts to Ely Brook (including its tributaries and Ponds), SHB, and the EBOR. Results are discussed in the sections below.

Ely Brook – Ely Brook is a first order stream and the primary drainage pathway from the Site. Its watershed encompasses approximately 0.42 square miles (mi^2) with the highest elevation above 1,350 ft, dropping over 380 ft from the headwater to its confluence with SHB at an elevation of 970 ft. The brook flows approximately 1 mi from its headwaters along the southern slope of Dwight Hill to the confluence with SHB (URS, 2008 and Seal, et al., 2010). As a result of the relatively steep topography in the Ely Brook Valley, flow in the brook and tributaries is very flashy and highly dependent on rainfall and snow melt events. Previous studies by Holmes, et al., (2002) and URS (2008) have shown the extreme flows resulting from spring runoff events and rain events. Typically, brook discharge recovers very quickly to base flow conditions.

Ely Brook is fed on the east by three significant tributary streams referred to as the EBT1, EBT2, and EBT4, as shown on Figure ES-4. Three tributaries, EBT1, EBT2, and EBT4, divide Ely Brook into three reaches referred to as the Upper, Middle, and Lower reaches. EBT3 merges with EBT2 and becomes EBT2 prior to reaching Ely Brook.

Ely Brook Headwaters – The Ely Brook Headwaters begin at the headwaters of Ely Brook and extends 1,800 ft in length to the confluence with tributary EBT4. This reach is characterized by a steep gradient with little sediment deposition and essentially no impact from Site sources. The biological assessment of the Upper Reach indicated good ecological health, suggesting that Ely Brook does have the potential to support aquatic life if mine-related impacts are abated. Surface water quality was generally good, with only a few instances of concentrations above water quality standards and those were found in unfiltered samples that may have contained particulate matter. Sediment and surface water concentrations in Ely Brook Headwaters were above background but below levels considered to be harmful to aquatic life.

Ely Brook Upper Reach – Ely Brook Upper Reach (EB-UR) begins at the confluence with tributary EBT4 and extends about 1,700 ft to the confluence with tributary EBT2. This reach has a moderate gradient and relatively low sediment deposition. The biological assessment of the Middle Reach indicated a severely impacted ecological community. The benthic community failed Vermont criteria for biological integrity. The benthic community contains 98% fewer organisms and suffered a 75% reduction in diversity as a result of the contamination from tributary EBT4. Testing of the sediments in the Upper Reach confirmed that they were toxic to aquatic life. Average Upper Reach surface water copper concentrations are 33 times greater than PRGs and 236 times greater than background maximum concentrations. Aluminum was also detected above PRGs in more than 20% of Upper Reach surface water samples. Average Upper Reach sediment copper concentrations are 9 times greater than PRGs and 27 times greater than background maximum concentrations.

EB-MR – The EB-MR begins at the confluence with tributary EBT2 and extends about 660 ft to the confluence with the southernmost Ely Brook Tributary, EBT1. This reach has a moderate gradient and relatively low sediment deposition below the confluence with EBT2. Average Middle Reach surface water copper concentrations are 143 times greater than PRGs and 1,024 times greater than background maximum concentrations. Aluminum, cadmium, copper, iron, and zinc were also detected above PRGs in more than 20% of Middle Reach surface water samples. Average Middle Reach sediment copper concentrations are 23 times greater than PRGs and 69 times greater than background maximum concentrations.

EB-LR – The EB-LR begins at the confluence with tributary EBT1 and extends about 1,200 ft to the confluence with SHB. This reach has a relatively low gradient, with significant sediment depositional areas, including waste rock, and a significantly broader floodplain area than the upper reaches. The Lower Reach floodplain area is broad in a portion of the stream that has low banks and a poorly-defined channel, resulting in a somewhat braided character to the stream. Along the lowermost section of the Lower Reach, which flows along the western margin of the Smelter Area, the channel is partially bermed on the eastern bank, in part with slag waste, as far down as South Vershire Road. This biological assessment of the Lower Reach also indicated a severely impacted ecological community and failed Vermont criteria for biological integrity. Similar to the Middle Reach, the Lower Reach contains 98% fewer organisms and suffered a 90% reduction in diversity as a result of the combined contamination from the Middle

Reach and tributary EBT2. Average Lower Reach surface water copper concentrations are 271 times greater than PRGs and 1,943 times greater than background maximum concentrations. Aluminum, cadmium, copper, iron, and zinc were also detected above PRGs in more than 20% of Lower Reach surface water samples. Average Lower Reach sediment copper concentrations are 15 times greater than PRGs and 45 times greater than background maximum concentrations.

Ely Brook Tributaries – Ely Brook is fed from the east by three significant tributary streams, EBT1, EBT2 (which also includes EBT3, EBT5, and the outflow from Ponds 1 through 5), and EBT4, as shown on Figure ES-4. Surface water metal concentrations in Ely Brook increase at each tributary confluence. The most significant increase in metal concentrations occurs at EBT2, with aluminum and iron increasing by a factor of 15, copper increasing by a factor of 6, and zinc increasing by a factor of 9.

EBT1 shows metal concentrations only slightly above criteria along the downstream margin of the ORB, with concentrations farther downstream at two orders of magnitude higher than above the access road. As a result of the disparity between concentrations at these two parts of EBT1, the high metal concentrations downstream are attributable to waste rock used along the roadbed. Average EBT1 surface water copper concentrations are 90 times greater than PRGs and 646 times greater than background maximum concentrations. Aluminum, cadmium, copper, iron, and zinc were also detected above PRGs in more than 20% of EBT1 surface water samples. Average EBT1 sediment copper concentrations are 10 times greater than PRGs and 29 times greater than background maximum concentrations.

Tributary EBT2, which includes EBT3, carries the majority of the metal and sulfate load from the waste pile areas to Ely Brook. ARD/AMD-impacted discharge from the Lower Adit and groundwater discharge along the eastern margin of Ponds 4 and 5 contribute to significant metals and sulfate loading of surface water in Pond 5 and to a lesser extent, Pond 4, both of which also drain to EBT2. Average EBT2 surface water copper concentrations are 423 times greater than PRGs and 3,032 times greater than background maximum concentrations. Aluminum, cadmium, chromium, copper, iron, nickel, and zinc were also detected above PRGs in more than 20% of EBT2 surface water samples. Average EBT2 sediment copper concentrations are 11 times greater than PRGs and 33 times greater than background maximum concentrations.

EBT3 emanates from the western portion of the UWA and merges with EBT2 prior to discharging to Ely Brook. Average EBT3 surface water copper concentrations are 880 times greater than PRGs and 6,304 times greater than background maximum concentrations. Aluminum, cadmium, chromium, copper, iron, nickel, and zinc were also detected above PRGs in more than 20% of EBT3 surface water samples. Average EBT3 sediment copper concentrations are 13 times greater than PRGs and 37 times greater than background maximum concentrations.

EBT4 receives water draining from Shaft No.4 and a seep at the base of the UWA. Average EBT4 surface water copper concentrations are 334 times greater than PRGs and 2,394 times greater than background maximum concentrations. Aluminum, cadmium, copper, mercury, and zinc were also detected above PRGs in more than 20% of EBT4 surface water samples. Average EBT4 sediment copper concentrations are 9 times greater than PRGs and 25 times greater than background maximum concentrations.

An estimate of the relative contribution of contamination from the tributaries was performed as part of the RI. EBT2 contributes about 92% of the load to Ely Brook, of which about 40% is attributed to the contribution from EBT3, which flows into EBT2 prior to joining Ely Brook. Meanwhile, EBT4 contributes less than 8% of the copper load to Ely Brook. Downstream of the EBT2 confluence, surface water metals concentrations are relatively stable to the confluence with SHB. This indicates that fluctuations in the copper load due to surface water mixing reactions, sorption, and dissolution from stream sediment, or groundwater discharge appear to be minor relative to these upstream tributaries. Sediment copper concentrations in EBT2, EBT3, EBT4, and Ponds 4 and 5 are above the PRG.

SHB – SHB originates south of Vershire Center and has a drainage area encompassing 9.7 mi^2. SHB drops approximately 886 ft from its headwaters to its confluence with the Ompompanoosuc River. Ely Brook joins SHB at the base of the Ely Brook valley, along the south side of South Vershire Road. Below the confluence, SHB forms the southern margin of the Site adjacent to the Slag Pile Area and flows an additional 1.75 mi before its confluence with the Ompompanoosuc River (Seal, et al., 2010). Stream reaches were described by USGS (2010) by flow characteristics and stream bottom composition within a majority of the stream.

Although SHB provides substantial dilution to the flow from Ely Brook, the entire reach of SHB from Ely Brook to the Ompompanoosuc failed Vermont criteria for biological integrity for both benthic organisms and fish. The biological assessment of SHB indicated a severely impacted ecological community. The stream segment directly below the confluence with Ely Brook contains 98% fewer organisms and also suffered a 75% reduction in diversity as a result of the contamination from the Ely Brook. While the biological quality remains poor for the entire reach to the Ompompanoosuc River, SHB does show some signs of recovery with the diversity at 50% of the level measured upstream of Ely Brook at the location just upstream of the confluence with the Ompompanoosuc River. Surface water concentrations of copper are substantially lower in SHB as compared to Ely Brook, but remain over 10 times greater than the water quality standards in the reach just below Ely Mine and remain 2-3 times the water quality standards just prior to the Ompompanoosuc River.

SHB Lower Reach has been defined to include sampling stations located from the EBOR confluence to a distance approximately 2,860 meters upstream. Average SHB Lower Reach surface water copper concentrations are 5.5 times greater than PRGs and 9.4 times greater than background maximum concentrations. No other metals were detected above PRGs in more than 20% of SHB Lower Reach surface water samples. Average SHB Lower Reach sediment copper concentrations are 1.6 times greater than PRGs and 9.9 times greater than background maximum concentrations.

SHB Upper Reach has been defined to include sampling stations located between 2,860 meters (measured from the EBOR confluence) and the Ely Brook confluence (at approximately 3,260 meters). Average SHB Upper Reach surface water copper concentrations are 16 times greater than PRGs and 27 times greater than background maximum concentrations. Aluminum was also detected above PRGs in more than 20% of SHB Upper Reach surface water samples. Average SHB Upper Reach sediment copper concentrations are 2.3 times greater than PRGs and 14 times greater than background maximum concentrations.

EBOR – The EBOR is one of two branches that meet to form the 23-mi long Ompompanoosuc River system whose drainage area encompasses 136 square miles (mi^2). The EBOR headwaters are located in the northwest corner of Vershire; the river then flows east and south into Thetford. The confluence of the EBOR and West Branch of the Ompompanoosuc River (WBOR) is just upstream of the Union Village Dam in Thetford, below which a USGS gauging

station is maintained. The Ompompanoosuc River then flows southeast to its confluence with the Connecticut River in Norwich, Vermont.

The substantial dilution that occurs when SHB flows into the Ompompanoosuc River appears to allow the biological communities to withstand the contaminant load from the Site. However, a decrease in the abundance and diversity in the biological communities is still observed after this point and the surface water still occasionally contains copper levels above water quality criteria. Overall, the biological quality remains good and the Ompompanoosuc meets Vermont biological criteria.

Average EBOR surface water copper concentrations are 2.4 times greater than PRGs and 4.2 times greater than background maximum concentrations. Aluminum was also detected above PRGs in more than 20% of EBOR surface water samples. Average EBOR sediment copper concentrations are 0.7 times greater than PRGs and 5.7 times greater than background maximum concentrations.

Vernal Pools – The surface water quality in four vernal pools was sampled during the RI program. Three of the vernal pools, designated VP-2, VP-3, and VP-4 are not impacted by Site contamination. The fourth, VP-1, was found to contain site-related contamination, particularly copper and iron at concentrations that present a threat to the health of aquatic organisms (amphibians) that use the vernal pool.

GROUNDWATER

ARD from the waste piles, tailings, and slag has mixed with the overburden groundwater in areas beneath and adjacent to the UWA, LWA, and Tailings Area source areas. The ORB does not appear to be impacting groundwater. The overall result is an area of groundwater that contains metals at levels exceeding federal and state criteria for groundwater and drinking water. Impacted shallow groundwater is generally confined to the area directly underlying or closely downgradient of UWA, LWA, and Smelter and Slag Pile Area footprints. Figure ES-8 shows the extent of the overburden and bedrock groundwater contamination. Aluminum, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, and zinc are the COCs in Site groundwater. Because the predominant flow path for water is towards Ely Book and SHB, only a limited area of contamination was found in the bedrock within the Ely

Brook Valley. The exception is the underground mine features, including the shafts and adits, which are likely contaminated. The contaminated groundwater from the UWA, LWA, and Tailings Area discharges to Ely Brook and contributes to the ecological impacts in the brook. The groundwater from the UWA and underground workings may also be a source of contamination to Ponds 4 and 5. In the Smelter Area and Slag Pile Area, groundwater within and immediately below the waste material and slag is impacted. Site groundwater impacts will be evaluated as part of the OU2 RI.

RESIDENTIAL DRINKING WATER

Groundwater samples collected from drinking water sources in the vicinity of the Site did not detect metals or geochemical parameter concentrations indicative of a potential impact from the Site.

HUMAN HEALTH RISK ASSESSMENT (HHRA) SUMMARY

Nobis prepared the HHRA of the Site for the USEPA (Nobis, 2011b). The HHRA presents a description of the risk assessment methods employed for the Site, as well as a summary of the results. The objective of the HHRA was to estimate potential current and future human health risks from the presence of contamination in the soil, groundwater, sediment, and surface water. The HHRA quantitatively evaluates non-cancer health hazards, cancer risks, and lead exposures.

Data from soil, sediment, groundwater, surface water, and fish tissue were evaluated to identify maximum analyte concentrations for comparison to screening level benchmarks to determine human health contaminants of potential concern (COPCs). With regard to soil, the entire Site was combined as a single exposure area because the potential for exposure and contaminant distribution patterns do not indicate any unique areas of potential exposure. For surface water, three exposure areas were considered: the on-site tributaries/Ponds/Ely Brook, SHB below the Ely Brook confluence and the EBOR below the SHB confluence. Potential risk from groundwater was evaluated for individual flow units, including, overburden, shallow bedrock, and deep bedrock. Off-site groundwater was evaluated separately using residential well sample results. Fish tissue data were used to assess potential risk in SHB and the EBOR.

Exposure scenarios are the assumptions used to define the potential use that may bring a person into contact with contamination. For the Ely Mine, the following exposure scenarios were considered:

- The potential risk to a person living on or adjacent to the Site and coming into contact with Site soil or indoor dust that originated as Site soil. The person was assumed to come into contact with the soil or dust for 350 days per year.

- The potential risk to a person installing a drinking water well in the contaminated groundwater at the Ely Mine Site and consuming 2 liters of water every day.

- The potential risk to a person visiting the Site 104 times per year and coming into contact with contaminated soil.

- The potential risk to a person visiting the Site 22 times per year and wading and/or swimming in Ely Brook or SHB.

- The potential risk to a person whose work activities would require disturbance of the mine waste and inhaling the dust 60 days per year.

The results presented above for the HHRA indicate the following:

For The OU1 Media and Areas

- Surface and subsurface soils in the OU1 area contain levels of cobalt, copper, and iron that could represent an unacceptable threat to human health for children residing on and near the Site and coming into contact with the contamination 350 days per year.

- Surface and subsurface soil in the OU1 area would not represent an unacceptable threat to human health for adults residing on and near the Site and coming into contact with the contamination 350 days per year.

- Human contact with the soil in the OU1 area under less frequent exposure scenarios (recreational activities) was not considered to represent an unacceptable threat to human health.

- Human contact with sediment and surface water as a result of recreational activities in the OU1 area were also not considered to represent an unacceptable threat to human health.

- An unacceptable risk was not found to be associated with a person working in the waste material in the OU1 area for up to 60 days per year. More frequent contact, however, would result in an unacceptable risk associated with the inhalation of manganese and aluminum dust. The aluminum and manganese concentrations in soil were not significantly different from those measured in background locations.

While OU1 does not address groundwater as a response area, it is recognized that the cleanup of OU1 waste areas may indirectly improve groundwater quality since those waste areas are significant sources of the groundwater contamination.

For The OU2 Media and Areas

- Overburden and shallow bedrock groundwater at the Site contain contaminants that would represent an unacceptable threat to human health if used as a source of drinking water. The contaminants that are found above levels that are considered acceptable for human ingestion include: aluminum, antimony, cadmium, cobalt, copper, iron, manganese, molybdenum, nickel, and zinc.

- Surface and subsurface soils in the OU2 source area (Smelter/Slag Area) contain levels of cobalt, copper, and iron that would represent an unacceptable threat to human health for children residing on and near the Site and coming into contact with the contamination 350 days per year.

- Human contact with the soil in the OU2 area under less frequent exposure scenarios (recreational activities) was not considered to represent an unacceptable threat to human health.

- Human contact with sediment, and surface water as a result of recreational activities in the OU2 area were also not considered to represent an unacceptable threat to human health.

- An unacceptable threat was not found to be associated with a person working in the waste material in the OU2 area for up to 60 days per year. More frequent contact, however, would result in an unacceptable threat associated with the inhalation of manganese and aluminum dust. The aluminum and manganese concentrations in soil were not significant different from background locations.

AQUATIC BERA SUMMARY

An aquatic BERA was performed on the aquatic habitats potentially affected by the Site. The major aquatic habitats at the Site consisted of:

- Ely Brook and its tributaries;

- Several small ponds (Ponds 1 to 5) which serve as the headwaters for Ely Brook Tributary 2 (EBT2) (note: Pond 1, the furthest upstream - and largest - of the five ponds, was used as a reference location because it was found to be unaffected by conditions at the Site);

- Vernal pools;

- SHB; and

- Ompompanoosuc River.

Results from toxicity tests on sediment, surface water, and porewater along with analysis of the benthic and fish communities provided multiple measurement endpoints to assess potential risk. The following seven types of measurement endpoints were used in the BERA:

- Comparison of the contaminants of potential ecological concern (COPECs) levels in sediment, porewater, and surface water samples to published sediment or surface water benchmarks.

- Assessment of the bioavailability of divalent metals in sediment samples by measuring the Acid Volatile Sulfides (AVS) and Simultaneously Extracted Metals (SEM).

- Performance of toxicity tests in the laboratory by exposing sensitive life stages of aquatic invertebrates and fish to sediment, porewater, and surface water samples from the waterways.

- Performance of toxicity tests in the ponds by exposing wood frog eggs and tadpoles kept in floating cages.

- Comparison of the COPECs levels in whole fish collected from the waterways to literature-derived Critical Body Residues (CBRs).

- Quantification of the structure and function of the benthic invertebrate community and fish community in the waterways.

- Use of food chain modeling to calculate an Estimated Daily Dose (EDD) to insectivorous and piscivorous wildlife receptors from exposure to surface water and aquatic biota (winged aquatic insects and fish); compare these EDDs to Toxicity Reference Values (TRVs) from the literature.

- The results of the Aquatic BERA are summarized below.

Location	Overall Risk Conclusion/Chemicals of Concern
Pond 2	Minor risk detected for water column invertebrates and amphibians due to elevated manganese concentrations in the water. No risk detected for the benthic invertebrate community.
Pond 3	Minor risk detected for benthic invertebrate community, water column invertebrates, and amphibians due to elevated manganese concentrations in the sediment and the water.
Pond 4	Severe risk detected for amphibians and minor risk detected for benthic invertebrate community due to elevated copper concentrations in the sediment.
Pond 5	Severe risk detected for benthic invertebrate community, water column invertebrates, and amphibians due to elevated copper concentrations in the sediment and the water.
Ely Brook and its tributaries	Severe risk detected for benthic invertebrate community and the fish community as a result of ARD.
Schoolhouse Brook	Severe risk detected for benthic invertebrate community and the fish community as a result of ARD being released from the OU1 source areas.

- The Aquatic BERA documented that severe ecological impacts have occurred as a result of the release of ARD with toxic levels of metals from the Site waste areas into the surface water and sediment within the OU1 area including: Ely Brook, the tributaries of Ely Brook, and Ponds 4 and 5. The upstream (reference) areas of the Ely Brook headwaters and Pond 1 supported healthy populations of benthic invertebrates, further documenting that the Site is a significant source of ecological impairment.

- The Aquatic BERA also documented that severe ecological impacts have occurred as a result of the release of ARD with toxic levels of metals from the OU1 waste areas into OU2 surface water and sediment. Specifically, this finding applies to SHB. The upstream (reference) areas of SHB supported healthy populations of benthic invertebrates and fish, further documenting that the Site is the source of observed ecological impairment downstream of the confluence with Ely Brook. OU2 will specifically address any ecological threats associated with the sediment within SHB and the Ompompanoosuc River as well as the final restoration of these surface waters.

TERRESTRIAL BERA

The Terrestrial BERA presents the ecological assessment for terrestrial habitats potentially affected by contaminants associated with historical mining operations at the Site. The objective

of the Terrestrial BERA was to describe the likelihood, nature, and severity of observed or potential adverse effects to ecological receptors resulting from their exposure to mining-related contaminants currently present at the Site. In addition to evaluating terrestrial risk, the assessment looks at potential risk to the four vernal pools identified within the study area that were not assessed as part of the Aquatic BERA (Techlaw, 2008). Four potential vernal pools/complexes were identified as VP-1 through VP-4.

Sampling and subsequent ecological risk analysis focused on determining the potential for significant adverse ecological effects in the vegetated areas that border the barren surface of the waste piles and any vernal pools located therein. Potential ecological receptors are outlined in the BERA. These include state or federally–listed threatened bat species, known as the Indiana bat and the Eastern Small-Footed bat, which use the mine openings to hibernate. The target communities and receptors selected to evaluate potential ecological impacts include terrestrial plants, soil invertebrates, herbivorous birds and mammals, invertivorous birds and mammals, carnivorous birds and mammals, and the aquatic and amphibian communities associated with the on-site vernal pools.

The conceptual site model (CSM) includes exposure pathways for plants (direct soil contact), soil invertebrates (ingestion and contact with soil), birds and mammals (soil ingestion and food), and vernal pool species (contact and ingestion with surface water and sediment). Assessment endpoints include the survival, growth, and reproduction of plants, invertebrates, mammals, birds, and aquatic/amphibious vernal pool species. Results from soil, biota (invertebrates and small mammals) and surface water samples were used for comparison to conservative screening benchmarks obtained from a variety of sources as part of a preliminary Screening Level Environmental Risk Assessment (SLERA), including Ecological Soil Screening Levels (EcoSSLs) and PRGs for soil, ambient water quality criteria and other published sources for surface water.

Ecological risks were assessed by comparing media concentrations to benchmark values and modeled exposure concentrations to TRVs. The following table summarizes the findings of this risk analysis.

Receptor Group	Overall Risk Conclusion/Contaminants of Concern for OU1
Terrestrial Plants	The barren areas of the Site represent a significant adverse impact to the plant community. The primary cause of the impact is the acidity of the soil and porewater. There is the potential for adverse impact to individual terrestrial plants as a result of the contaminant concentrations at the Site. The COPCs are copper and, to a lesser extent, zinc. The overall impact on the plant community outside the barren waste areas was not considered significant.
Soil Invertebrates	The barren areas of the Site represent a significant adverse impact to the soil invertebrate community. The primary cause of the impact is the acidity of the soil and porewater. There is the potential for adverse impact to individual soil invertebrates as a result of the contaminant concentrations at the Site. The COPCs are copper and, to a lesser extent, zinc. The overall impact on the soil invertebrate community outside the barren waste areas was not considered significant.
Herbivorous Birds	The Terrestrial BERA concluded that significant ecological impacts to this receptor were unlikely.
Invertivorous Birds	The Terrestrial BERA concluded that significant ecological impacts to this receptor were unlikely.
Carnivorous Birds	The Terrestrial BERA concluded that significant ecological impacts to this receptor were unlikely.
Herbivorous Mammals	The Terrestrial BERA concluded that significant ecological impacts to this receptor were unlikely.
Invertivorous Mammals	The Terrestrial BERA concluded that significant ecological impacts to this receptor were unlikely.
Carnivorous Mammals	The Terrestrial BERA concluded that significant ecological impacts to this receptor were unlikely.

The only significant terrestrial ecological threat in the OU1 area is the impairment of the plant and soil invertebrate communities in the barren areas of the Site. Although concentrations of metals detected in the vegetated (non-barren) areas at the Site were higher than plant and soil invertebrate benchmarks, field observations suggest that the toxicity of the Site material is substantially reduced when the waste is incorporated into a natural soil. Areas along the fringe of the barren waste areas have concentrations of metals comparable to the barren waste areas yet these areas support a plant community and soil invertebrates. Other factors, such as the highly acidic porewater and acid salts within the waste along with the absence of any organic matter to support vegetation are likely to be more significant factors in the absence of vegetation on the barren areas. When a soil horizon forms and provides organic matter, the plant community appears to be able to exist. As a result, a clear chemical-specific threat to the plant or soil invertebrate community is not identified for OU1 of the Site. The general Terrestrial BERA conclusion for OU1 is that the Site conditions, primarily the acidic waste material and

associated acid salts and porewater have created barren areas which represent a local, yet significant, ecological harm to the plant and soil invertebrate community resulting in a loss of the critical ecological support functions including nutrient cycling, habitat, food, and soil stabilization to limit erosion. The barren areas of the Site are generally consistent with the source areas shown in Figure ES-4.

No significant ecological risk was identified for the other terrestrial receptors within the OU1 area. The hazard quotients were generally low for the mammal and bird receptors. In addition, the biota sampling suggested that most metals (particularly selenium and zinc) were not accumulating in tissue. Only copper was detected at concentrations that were statistically different from reference biota tissue samples, although individual samples suggested that some accumulation of aluminum and iron may occur. OU2 will address the ecological risk associated with the vernal pools and the Smelter/Slag area as well as any ecological risk associated with the underground mining workings.

CONCLUSIONS

Based on the results of the RI program, including the human health and ecological risk assessments, the ongoing release of ARD from the Site is causing significant impacts to surface water, sediment, and groundwater. The most significant observations and conclusions derived from these studies are summarized below.

- An estimated 172,050 cy of waste rock, tailings, roasted ore, and slag related to historical mining activities contain metals that exceed site-specific soil criteria within the Ely Brook Valley at the Site. The UWA constitutes the largest volume of mine waste (73,000 cy), followed by the Smelter Area (31,120 cy), LWA (29,000 cy), Slag Pile Area (25,000 cy), ORB (10,330 cy) and the Tailings Area (3,600 cy). An estimated 8,318 cy of waste rock sediment is present within the impacted zones of Ely Brook and its tributaries and Ponds.

- Field XRF results from surface soil and sediment were used to refine the limits of mine waste areas. The relatively sharp copper concentration gradients observed in soil around the perimeter of mine waste areas allows for a high degree of confidence in

identifying soils above the site-specific criterion of 629 milligrams per kilogram (mg/kg) and correlates well with direct visual observations of mine waste and staining in soil.

- Three significant tributaries, EBT1, EBT2 (which includes EBT3), and EBT4, are responsible for the majority of contaminant transport from the waste areas to Ely Brook. Tributary EBT2 carries the greatest metals load, followed by EBT4, and EBT1.

- The UWA and LWA comprise the dominant source of metals loading and acidity to downstream surface water. The potential impact to surface water from the Tailings Area is masked by the impacts from the UWA and the LWA. Smelter slag is also a leachable source of metals that may impact SHB. In contrast, the ORB soil is not likely to have a significant impact on groundwater or surface water.

- The UWA waste rock piles are largely unsaturated, but mounding of groundwater above the glacial till during high flow periods may result in groundwater interaction with the lower-most portion of the piles. The high copper and acidity concentrations observed from seeps and monitoring wells confirm the significant impact these piles have on overburden and shallow bedrock groundwater in this area.

- Discharge of groundwater from the Main Adit, the Lower (Deep) Adit, and Shaft No.4 contribute to significant impacts to downgradient surface water. The Main Adit discharge is interpreted to represent the decant point for the water that resides within the open cavity created by the underground shafts and adits (mine pool).

- Waste sources in the LWA and Tailings Area are saturated with groundwater. As a result, overburden and shallow bedrock groundwater within the LWA mine waste footprint is impacted by ARD and metals. Downgradient migration of impacted groundwater is limited. The groundwater plume beneath the Tailings Area appears limited to the shallow overburden unit.

- Groundwater results from the ORB meet groundwater criteria. Surface water impacts observed downgradient of this area are interpreted to be attributable to waste rock fill along the access road nearby.

- Evaluation of metals loading to SHB from groundwater in the Smelter Area and the Slag Pile indicates that metals loading from Ely Brook is more than two orders of magnitude greater than that of the groundwater and therefore, likely masks any detectable contribution from groundwater. Furthermore, it is unclear as to whether groundwater discharge alone would result in an exceedance of the surface water criteria in SHB.

- Groundwater results do not show a significant impact to deep bedrock from surface mine waste sources.

- ARD-related discharges to surface water and sediment in Ely Brook below the confluence with EBT4 have resulted in severe impacts to the aquatic biota of Ely Brook and SHB. Ecological impacts to the EBOR appear to be insignificant based on the evaluation of multiple measurement endpoints discussed in the aquatic BERA.

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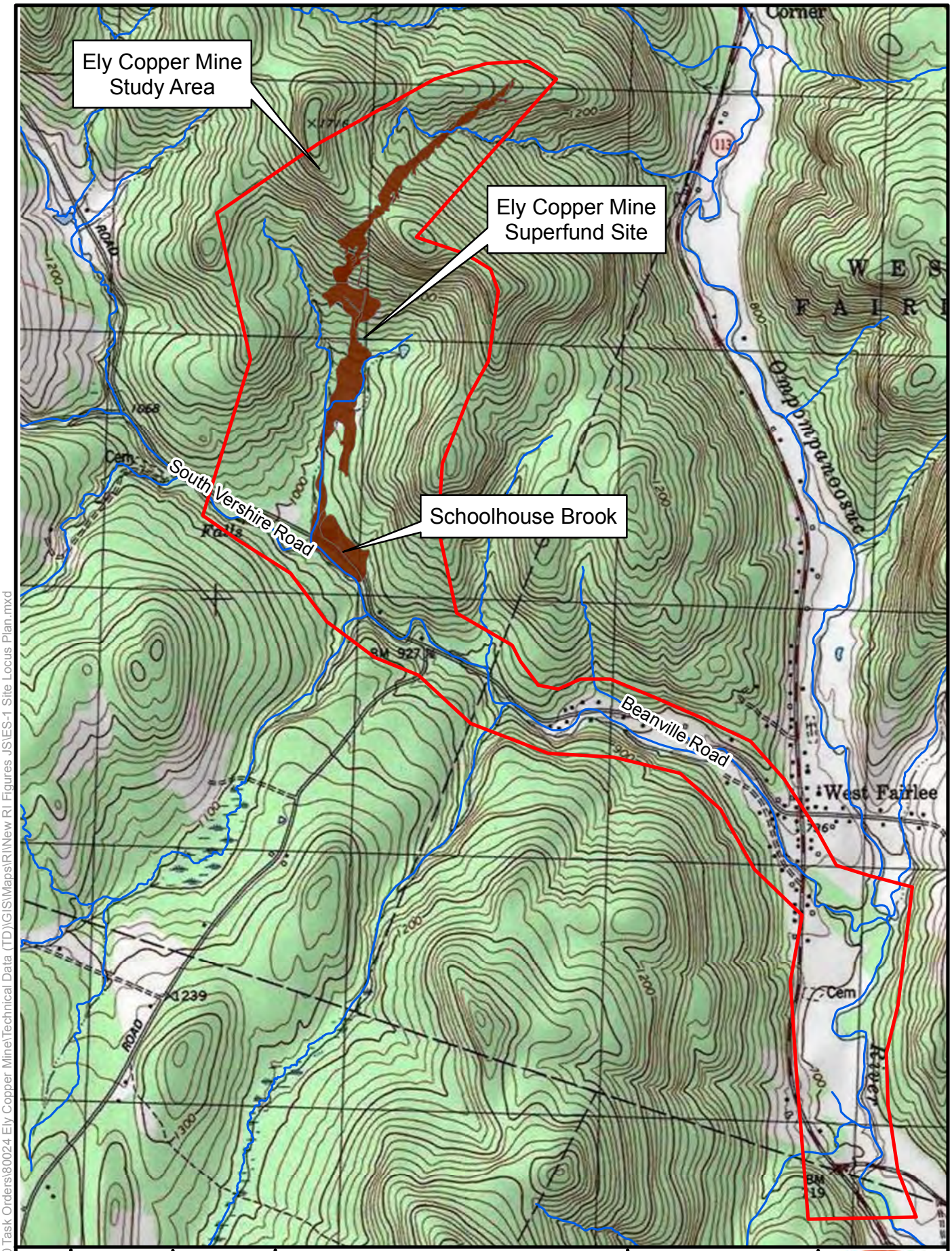

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June 24, 2011	Revision No. 00

APPROXIMATE SCALE
0 400 800 1,600
Feet

Quadrangle Location

USGS TOPOGRAPHIC MAP
VERSHIRE, VERMONT
1981; (Photo-inspected 1983)

FIGURE ES-1
Site Locus
Ely Copper Mine
Vershire, Vermont

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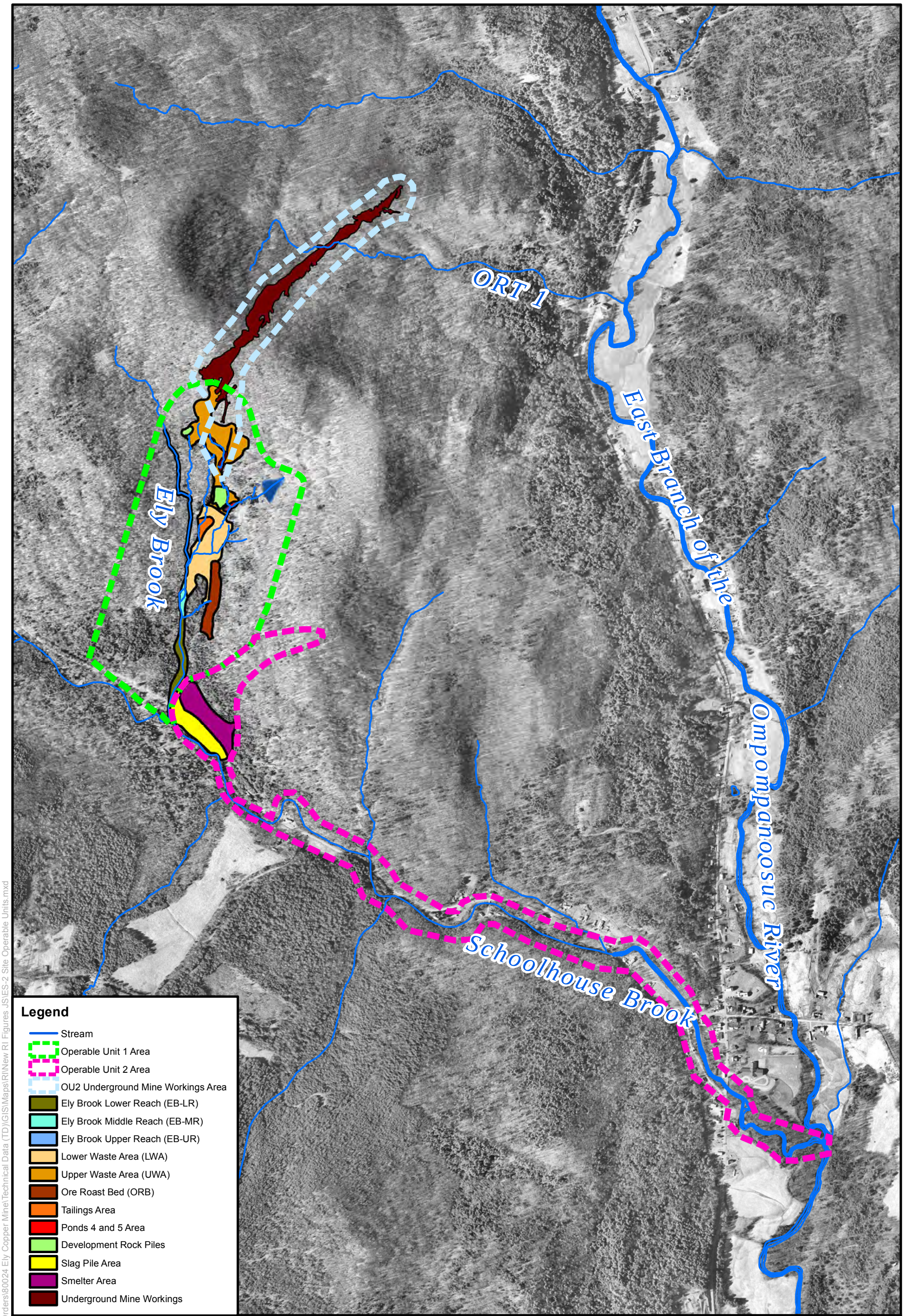

FIGURE ES-2

Site Operable Units
Ely Copper Mine
Vershire, Vermont

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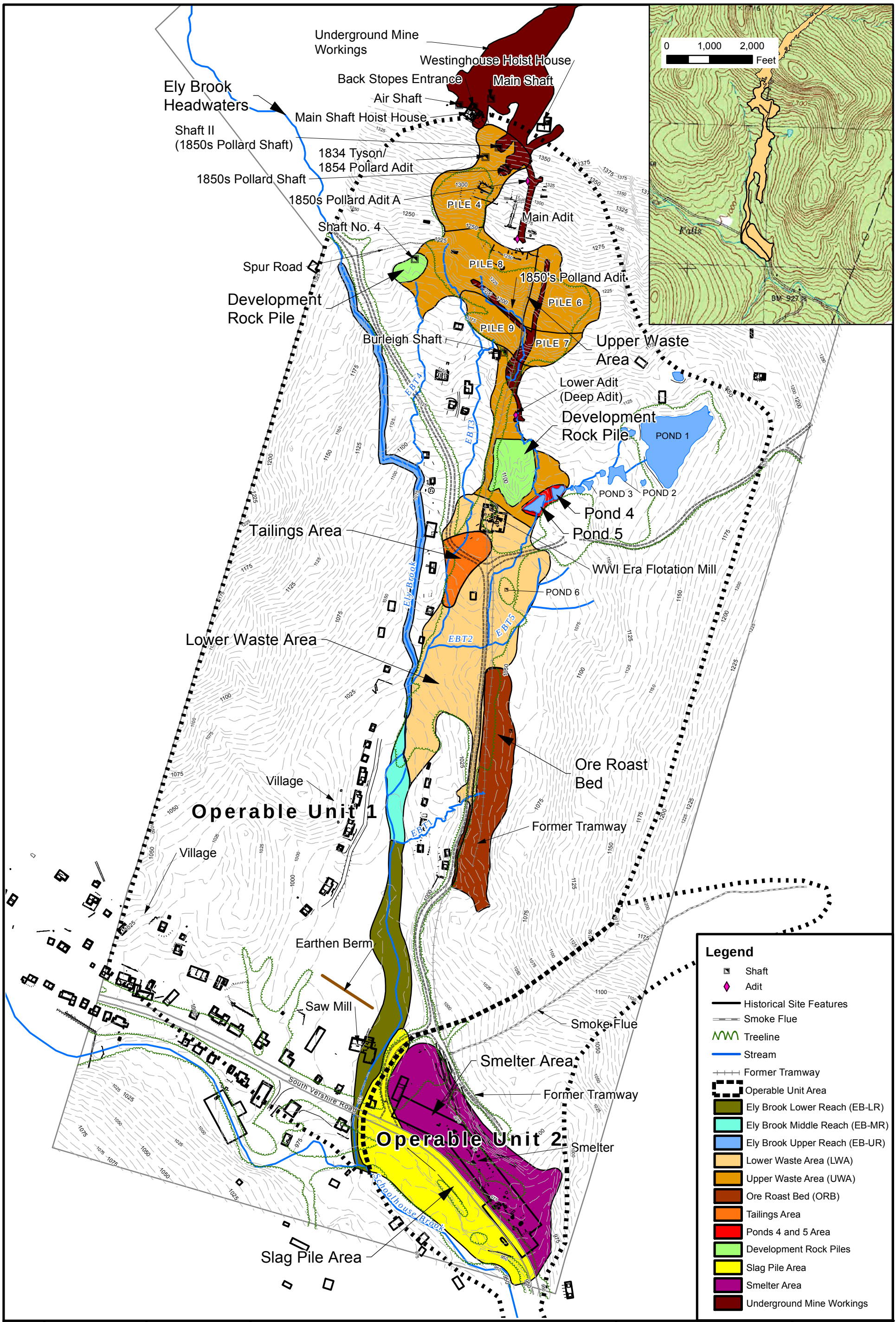

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APPROXIMATE SCALE
0 150 300 600 Feet

NOTE: Elevations shown are feet above mean sea level (FT-AMSL).

FIGURE ES-3

Site Sketch
Ely Copper Mine
Vershire, Vermont

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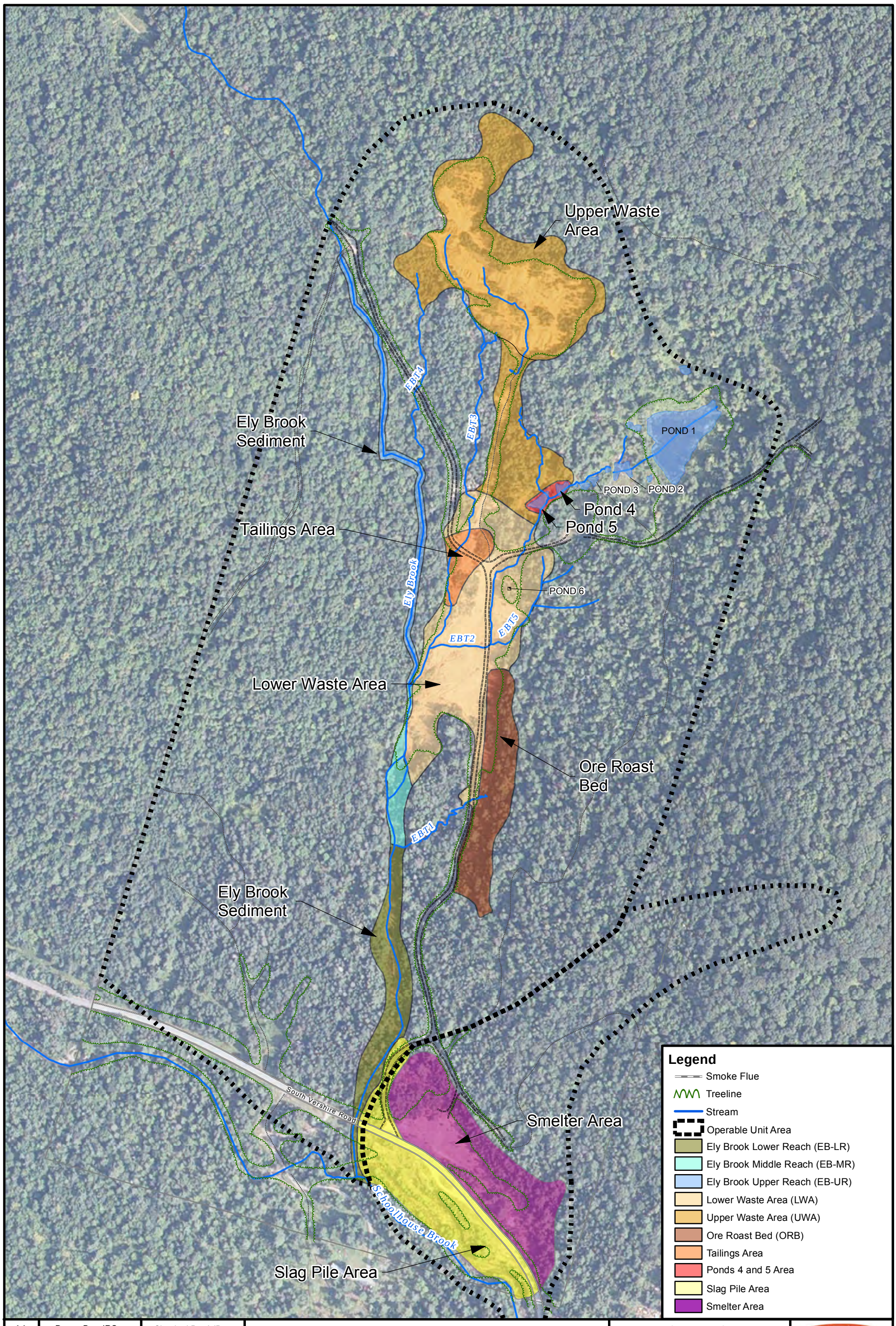

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APPROXIMATE SCALE
0 150 300 600 Feet

FIGURE ES-4

Site Study Areas
Ely Copper Mine
Vershire, Vermont

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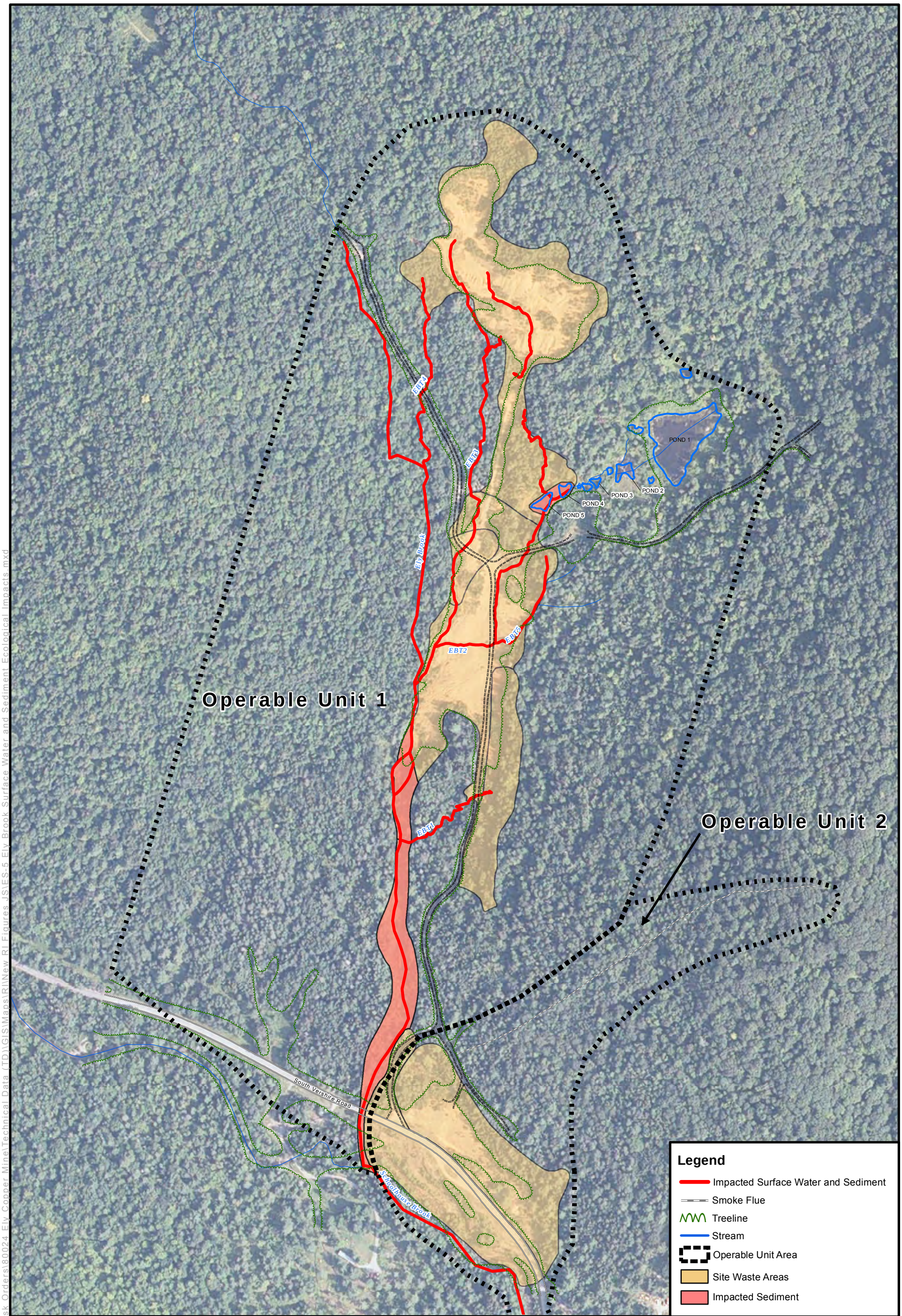

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APPROXIMATE SCALE
0 150 300 600 Feet

FIGURE ES-5
Ely Brook Surface Water and Sediment Ecological Impact
Ely Copper Mine
Vershire, Vermont

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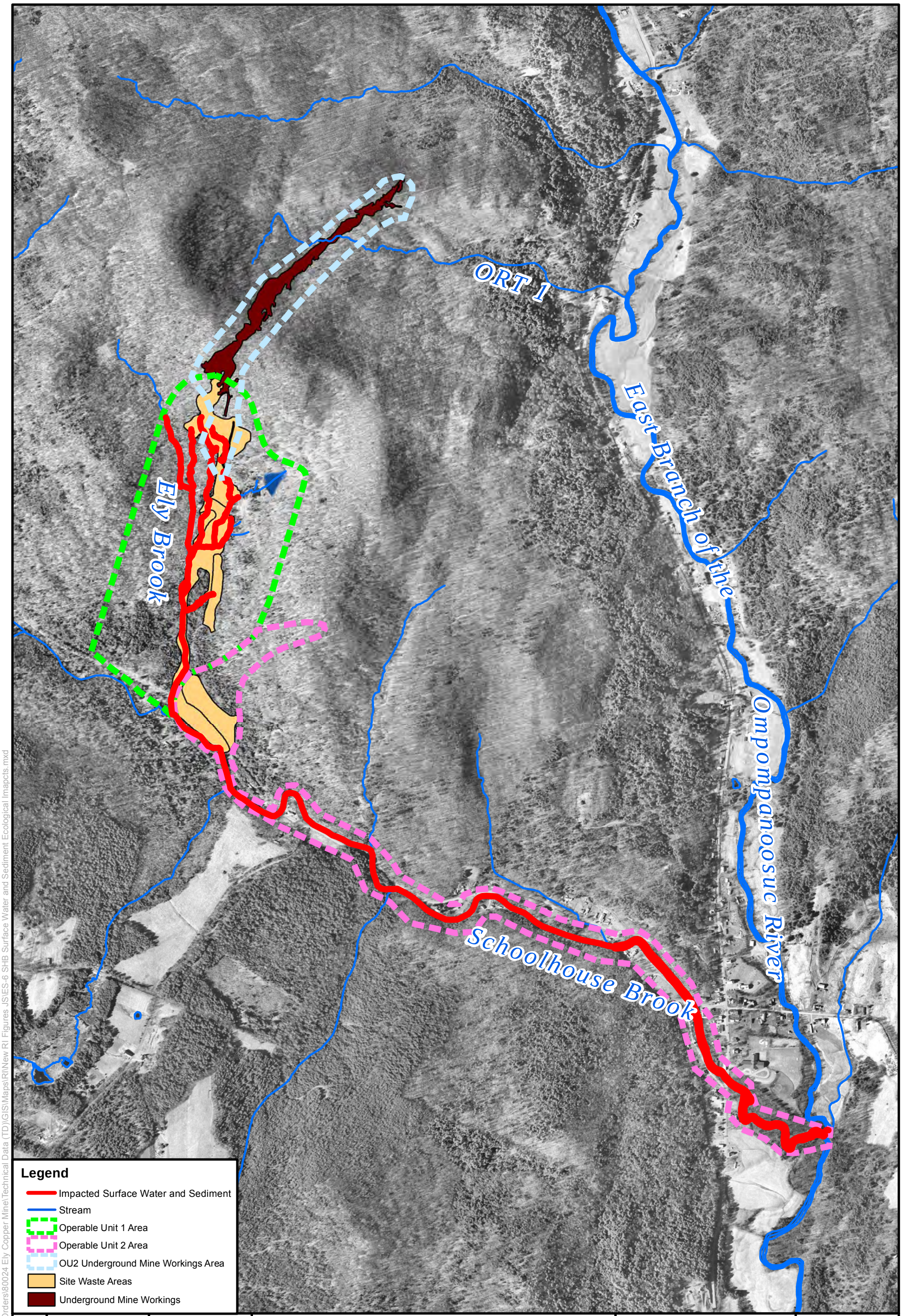

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APPROXIMATE SCALE
0 500 1,000 2,000 Feet

FIGURE ES-6
SHB Surface Water and Sediment Ecological Impacts
Ely Copper Mine
Vershire, Vermont

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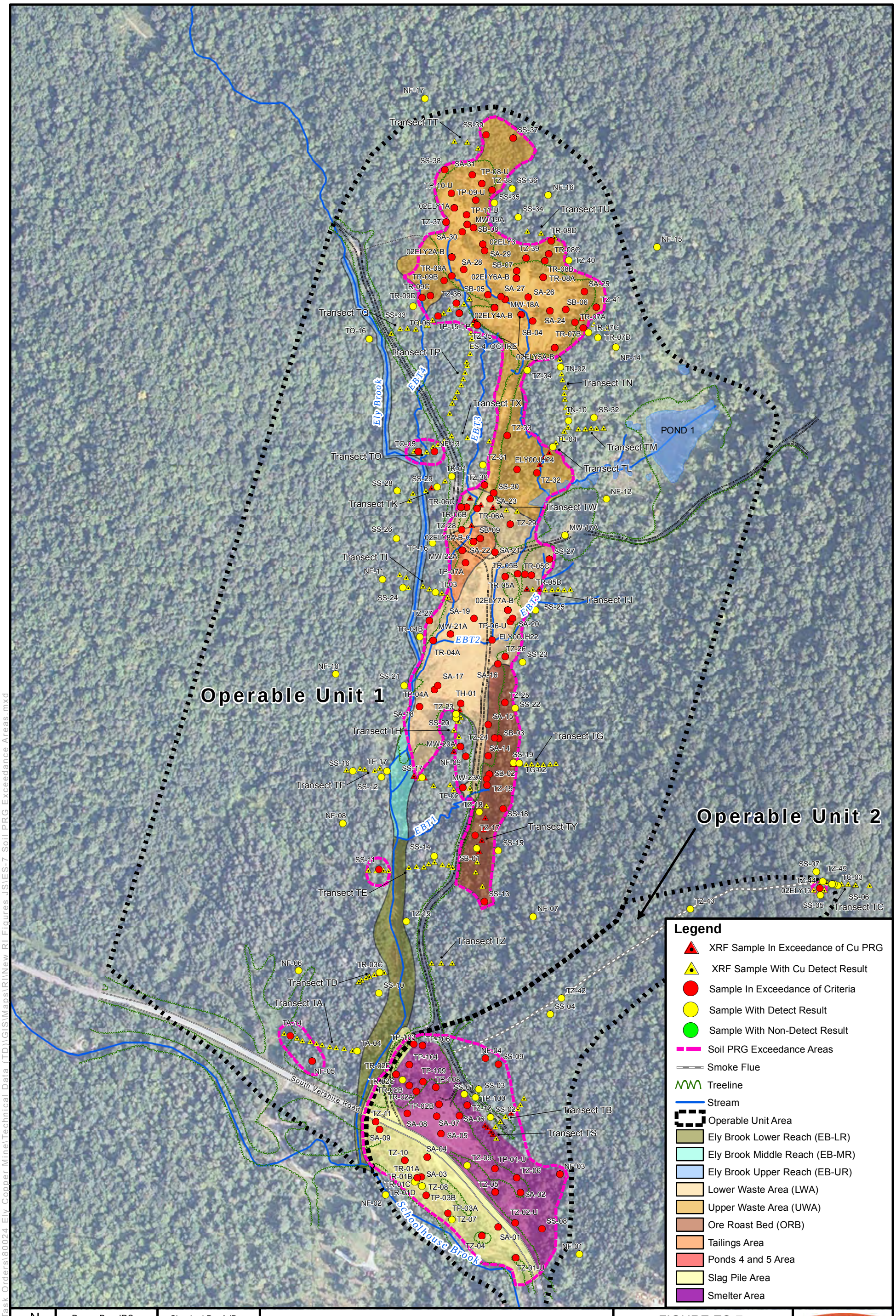

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APPROXIMATE SCALE
0 150 300 600 Feet

NOTES:
PRG

Cobalt	24	mg/kg
Copper	629	mg/kg
Iron	44,800	mg/kg

FIGURE ES-7
Soil PRG
Exceedance Areas
Ely Copper Mine
Vershire, Vermont

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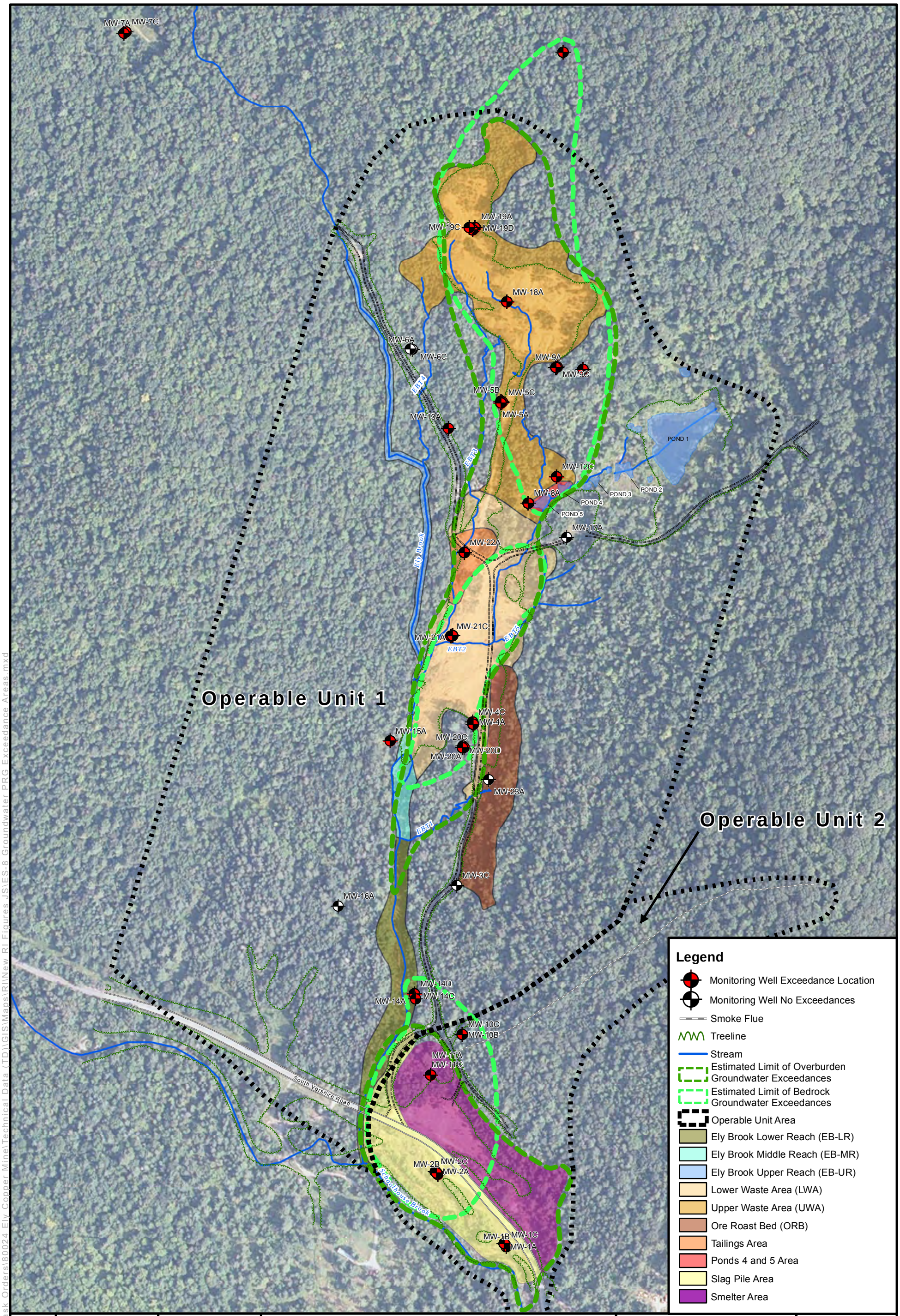

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APPROXIMATE SCALE
0 150 300 600 Feet

FIGURE ES-8
Groundwater PRG Exceedance Areas
Ely Copper Mine
Vershire, Vermont

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