DESIGN DOCUMENTS
FINAL USACE SUBMISSION

NON-TIME-CRITICAL REMOVAL ACTION CLOSURE DESIGN

ELIZABETH MINE STRAFFORD, VERMONT

Prepared For:

U.S. Army Corps of Engineers
696 Virginia Road
Concord, Massachusetts 01742

March 30, 2009

URS

URS Corporation
477 Congress Street, Suite 900
Portland, ME 04101

EXECUTIVE SUMMARY

This Report presents the design basis and construction requirements for the Non-Time-Critical Removal Action (NTCRA) at the Elizabeth Mine (the Site) addressing the closure of tailing dams TP-1 and TP-2, and waste rock pile TP-3. Remediation of the Copperas Factories, as specified in the Record of Decision for the Site (U.S. Environmental Protection Agency [EPA], 2006), is also included in this design deliverable due to its location in the immediate area of the NTCRA activities. Work activities completed for this design were performed by URS Corporation (URS) under U.S. Army Corps of Engineers (USACE) contract number W912WJ-05-D-0005.

ES 1.0 PURPOSE AND SCOPE OF WORK

The Elizabeth Mine is an abandoned copper and copperas mine located in the towns of Strafford and Thetford, Vermont (Figure ES-1). The NTCRA area of the Site is located south and east of Copperas Hill and encompasses approximately 250 acres south of Vermont Route 132 and the West Branch of the Ompompanoosuc River (WBOR). The NTCRA area is situated within the Copperas Brook Watershed, as shown on Figure ES-2.

The basic elements of the NTCRA, as initially defined by EPA, are summarized below:

- **Surface water and groundwater diversion structures –** The installation of diversion ditches and a cut-off trench around the perimeter of TP-1, TP-2, and TP-3 to intercept and divert clean water around the tailing dams and waste rock/heap leach piles, to prevent clean water from contacting sulfide-bearing materials, and to intercept shallow groundwater that may be flowing into the tailing dams.

- **Slope stabilization –** Performance of design studies to identify stabilization requirements for the steep slopes of TP-1 and TP-2.

- **Infiltration barrier cover system –** The placement of an infiltration barrier cover over TP-1 and TP-2, likely consisting of a soil/vegetation layer, a drainage layer, a primary barrier, and possibly a secondary barrier to prevent water and oxygen from contacting the tailing, thus minimizing the acid rock drainage (ARD) generation as seepage discharging from the toe of TP-1.

- **Collection and treatment of the seeps along the toe of TP-1 –** The installation of a collection system to capture the seeps that discharge ARD along the toe of TP-1, and a combination of aerobic and anaerobic biological treatment systems to treat the water.

- **Preservation of a portion of TP-3 –** Intact preservation of a portion of TP-3, with no cover or substantial regrading within the preserved area. Some limited work will likely be needed to minimize the erosion in the preservation area. Since the maintenance costs associated with the preservation of TP-3 will be paid for by the State of Vermont, EPA deferred to the State for a determination regarding the extent of TP-3 to be preserved.

- **Collection and treatment of runoff from TP-3 –** Collection of surface water runoff from the preserved portion of TP-3 in an interceptor trench installed along the downgradient edge of the waste rock and heap leach piles and treatment of the runoff using a combination of aerobic and anaerobic biological systems.

One objective of the NTCRA was to consider whether a portion of TP-3 could remain intact in the interest of historic preservation. To preserve any undisturbed portion of TP-3 a separate water treatment system would be required. In 2003, the Vermont Agency of Natural Resources and the State Historic Preservation Officer announced to the community that the State of Vermont could not support any option that would substantially increase the long-term operation and maintenance costs. As a result, options to preserve portions of TP-3, along with the collection and treatment of the run-off from the TP-3 waste piles were no longer considered as part of the NTCRA design.

Prior to the implementation of the NTCRA design and construction activities, a Time-Critical Removal Action (TCRA) was implemented from 2003 to 2005 to stabilize Tailing Dam TP-1. The TCRA included construction of a buttress and foundation drain system along the north face of TP-1. The USACE, under direction of the EPA, initiated construction of several components of the NTCRA during 2006 and 2007, including diversion of surface water and the partial diversion of shallow groundwater around TP-1 and TP-2, and the grading and vegetative stabilization of the west side of TP-1. The NTCRA components complete through the 2007 construction season are shown on

Figure ES-3. There were no construction activities associated with the NTCRA closure design performed in 2008, however a pilot-scale horizontal drain installation program was performed in 2008 which included the installation and monitoring of four horizontal drains through the TP-1 buttress and starter dam. The objective of program was to provide supplemental foundation drainage, lower the piezometric level behind the buttress and starter dam, shorten the seepage pathway, and reduce the iron load discharging from the buttress drains to Copperas Brook and subsequently to the WBOR. Overall, the pilot drain installation met its objectives and the pilot project was considered a success.

The Record of Decision for the Site identified five other non-NTCRA areas as potential current or future threats to human health and the environment. These areas include the Upper and Lower Copperas Factories. The remedial alternative specified in the Record of Decision for the Copperas Factories includes placement of a 2-foot layer of soil over lead-contaminated soil within and surrounding the Upper and Lower Copperas Factories to eliminate human contact risk. The design for the Copperas Factories component of the Remedial Action has been completed as a parallel design effort with the NTCRA design due to the necessary integration of these activities.

The design for the remaining components of the Remedial Action will be included independently as part of the Remedial Design.

ES 1.1 Source Area Conditions Summary

The conceptual model of the Copperas Brook Watershed defines the source areas for the NTCRA as follows:

- TP-3 consists of sulfide- and metal-bearing mine wastes including waste ore, waste rock, and heap leach piles located at the top of the Copperas Brook drainage basin. TP-3 materials are unconsolidated, steeply sloped, highly erodible, and generally free of vegetative cover. The major transport mechanisms

for the TP-3 waste are erosion and surface water run-off, both of which transport contamination downstream from TP-3 to lower reaches of Copperas Brook.

- The TP-3 waste material is exposed to atmospheric conditions resulting in continual production of ARD as water cycles through the sulfide-bearing waste. TP-3 represents the most significant source of ore-content metals, including copper and zinc (but excluding iron), to Copperas Brook and the WBOR.

- The TP-3 waste materials are underlain by glacial till and bedrock. The unconsolidated, coarse-grain materials have high infiltration rates and are generally free-draining; there is no permanent water table located within the TP-3 wastes. Resulting from its origin as a functional feature of the copperas production infrastructure, TP-3 directs infiltration through the waste area, concentrating the discharge at the base of the upper area adjacent to the Upper Copperas Factory. The headwaters of Copperas Brook also originate in this area. The residence time for precipitation transfer is short and the storm hydrograph shows a rapid peak. Bedrock groundwater underlying the feature discharges into the lower portions of TP-3, contributing to the base flow of Copperas Brook and contributing additional water to the ARD generating process.

- TP-1 and TP-2 are tailing impoundments that fill the former Copperas Brook valley downstream of TP-3. The tailing generally overlies channel alluvium or organic material, representative of the former valley surface. These materials are underlain by a down-valley thickening sequence of glacial till. The till exhibits poor groundwater conductance and is considered an aquitard, although in areas near the base of the thickest sequence of glacial till the hydraulic conductivities are higher, possibly reflecting conditions of the underlying regolith. Based on hydraulic conditions between the till and the tailing, groundwater is generally discharging from the tailing into the underlying glacial till unit; however most of the groundwater within the tailing impoundment ultimately discharges from the toe of TP-1 as shallow groundwater or surface water.

- The bases of the tailing impoundments are saturated. Groundwater contained within the anoxic tailing found at depth in the tailing impoundments exhibits low concentrations of the non-iron contaminants of concern (i.e., cadmium, copper, zinc); however, concentrations of manganese, sulfate, and iron are elevated. Iron concentrations in groundwater in the vicinity of the oxidized tailing present at the former face of the tailing dam are significantly elevated. As a result, the drainage emanating from the toe of TP-1 represents the most significant source of iron to Copperas Brook and the WBOR.

- When complete, the NTCRA diversion structures will isolate the tailing impoundments from surface water run-on, and from shallow groundwater inflow in some areas. This includes the interception of surface water run-on and shallow

groundwater inflow to TP-2 and to the east side of TP-1; and the interception of surface water run-on to the west side of TP-1.

These source area conditions and their impact on the NTCRA design evaluation are shown graphically on Figures ES-4 and ES-5.

The conceptual model of the Copperas Brook Watershed defines the Copperas Factories source area for the Remedial Action as follows:

- The Upper and Lower Copperas Factories consist of stone foundations and debris scatter areas containing elevated levels of lead in the surficial soils. There is no indication of transport of significant concentrations of lead to other locations or media within the watershed.

The complete discussion of the NTCRA and Remedial Action source areas is provided in Section 2 of the Basis of Design Report.

ES 1.2 Closure Objectives

The specific cleanup objectives developed by EPA for the NTCRA were as follows:

- Achieve Vermont Water Quality Standards (VWQS) (chemical and biological) as well as other applicable standards in the WBOR by preventing or minimizing discharge of water with mine-related metals contamination to Copperas Brook and to the WBOR;
- Minimize the erosion and transport of tailing or contaminated soil into the surface waters of Copperas Brook and the WBOR;
- Evaluate the stability of waste piles (i.e., tailing, waste rock, and leach piles) and modify slope configurations (regrading, covering, or buttressing) as necessary to provide for an acceptable level of long-term stability;
- Consider measures to minimize and avoid an adverse effect on historic resources at the Site, as required by the National Historic Preservation Act; and
- Comply with all applicable, relevant, and appropriate regulations (ARARs) while achieving these objectives.

ES 2.0 WASTE ROCK PILE TP-3 CLOSURE DESIGN

TP-3 is a 12.8-acre mine waste feature located north and east of the North Open Cut, extending to the east beyond Mine Road. It consists of an estimated 150,000 cubic yards (cyds) of waste ore, waste rock, and heap leach piles with measured thicknesses up to 24 feet. Copperas Brook originates within the footprint of TP-3. With the exception of the area adjacent to Mine Road, topography in this area is steeply sloped (33 percent), with several terraces and incised channels located between the North Open Cut and Mine Road. The unconsolidated and largely unvegetated waste ore piles that comprise TP-3, coupled with the steep topography, result in mass erosion from this feature during periods of surface water runoff.

URS performed a mine hazard assessment of TP-3 in May 2007 which included a review of available geologic reports, mine process and mineral exploration documentation, interviews with spelunkers familiar with the mine, and a site reconnaissance. The mine hazard assessment visually evaluated ground stability in the vicinity of the North Open Cut and adits, manways, and shafts in the vicinity of the NTCRA work area (Figure ES-6). The mine hazard assessment designated equipment setbacks and exclusion zones around these features and the design specifications recommend that all work performed in and around the mine hazard areas be performed by contractors with experience in performing similar work. These recommendations are called-out on the TP-3 closure design drawings.

ES 2.1 TP-3 Closure Alternatives Identification and Evaluation

In accordance with the NTCRA Work Plan, the closure design of TP-3 required determination of the disposition of the waste rock pile in a manner that meets the following NTCRA closure requirements:

- Isolating waste rock from direct contact with surface water run-on and from contact with surface water flow in channels;
- Isolating waste rock from direct precipitation;
- Collecting and treating seepage to meet water quality standards, as necessary; and
- Meeting applicable regulatory solid waste closure requirements.

Based on evaluations of technologies for controlling and/or treating ARD, prior to the current phase of the NTCRA design the EPA concluded that source control was the preferred approach to address site sources. Source control measures were identified based on their ability to meet the following objectives:

- Allow for the achievement of VWQS as well as other applicable standards in the WBOR by preventing or minimizing discharge of water with mine-related metals contamination to Copperas Brook.
- Minimize the erosion and transport of waste ore into the surface waters of Copperas Brook.
- Modify the slope configurations of TP-3 as necessary to provide for an acceptable level of long-term stability.
- Consider measures to minimize and avoid an adverse effect on historic resources at the Site.
- Comply with ARARs.
- Minimize costs associated with potential long-term water treatment.
- Achieve the overall project requirement to meet water quality criteria at the point of compliance (i.e., Copperas Brook, immediately downstream of TP-1).

Based on these objectives and requirements, TP-3 closure alternatives were identified during NTCRA planning meetings and included:

- Excavation and Relocation, and
- In-Place Consolidation and Cover.

ES 2.2 TP-3 Alternative Evaluation and Selection

The two closure alternatives were developed to meet the objectives of the NTCRA by achieving isolation of the TP-3 mine waste from surface water and groundwater to minimize ARD, and allow for water quality standards for the WBOR and Lower Copperas Brook to be met. The excavation/relocation alternative meets NTCRA objectives. The waste relocation alternative would allow for the construction of a single waste cell which could be designed to isolate the waste from surface water and groundwater to facilitate the closure of TP-1. It was determined that the optimal disposition area for the TP-3 waste would be the TP-1 surface where the relocated waste will be used as fill to achieve final minimum grades required as part of the closure of TP-1.

During the alternative evaluation phase, it was determined that the in-place consolidation and cover alternative was less feasible than the excavation and relocation alternative due to several unfavorable factors. The present geometry of TP-3 and the geometry of the subgrade, as defined through subsurface excavations and borings, have insufficient area to allow for in-place closure of the entire waste volume. In total, it is estimated that approximately 55 percent of the TP-3 waste ore could be closed and covered in-place. The remaining waste volume would require relocation and cover, similar to the excavation and relocation alternative. The complete closure for this alternative would therefore require multiple waste cells, complex design of groundwater seepage in the area of the waste cell (through the required dissipation of pore water in the area beneath the

cover system), and the need to treat any significant seep flows as ARD sources. The alternative would also have significant operation and maintenance activities and provide little historic preservation benefits due to the extent of disturbance and cover requirements.

Based on these fundamental and significant limitations, the in-place consolidation and cover alternative was dropped from further consideration and the excavation relocation alternative was the selected remedy.

ES 2.3 TP-3 Design Approach and Criteria

The design criteria were determined during design planning activities and considered ARARs. For the closure of TP-3, the design criteria identify parameters specific to waste rock removal and subgrade treatment, surface water management, and slope and roadway restoration.

ES 2.3.1 Waste Rock Removal

The design criteria for waste rock excavation and removal and mine features excavation include the following:

- Excavate waste rock within the designated limit of waste to either bedrock or glacial till.
- Close in-place small areas of waste rock that are located beyond the excavation limit by covering with lime and topsoil and revegetating.
- Excavate ferricrete and altered glacial till.
- Dispose of waste rock on TP-1.

ES 2.3.2 Surface Water Management

Surface water management design criteria are as follows.

- Design permanent surface water structures for the modeled 100-year peak flow.
- Design the temporary detention basin structure for the modeled 25-year peak flow.
- Divert surface water on the west side of the North Open Cut by upgrading existing berms and channels.
- Divert surface water around the north end of the North Open Cut.
- Convey surface water over the bedrock surface along existing drainage alignments, as possible. Some field modification of bedrock slopes are anticipated to allow for creation of defined channels. Some field modifications of the drainage pathway are anticipated to bypass any areas of residual ore exposed in the bedrock surface.
- Convey surface water on the south end of the area along existing alignment over bedrock.
- Create a cross-slope diversion berm and use Copperas Road to divert surface flow on soil slopes into the bedrock channels.
- Divert stream flow away from the Upper Copperas Factory, as required by the Copperas Factory closure.
- Place high density polyethylene culverts under Copperas Road.
- Construct a temporary, construction-period sediment basin at Mine Road using a culvert/temporary riser inlet. The interim-period sediment basin shall meet Vermont Storm Water Management standards.
- Create a rip-rap-lined channel below Mine Road for Copperas Brook.

ES 2.3.3 Slope and Roadway Restoration

Slope and roadway restoration design criteria address subgrade treatment, mine feature closure, and roadway replacement. The parameters include the following:

Subgrade Treatment

- Ore-bearing subgrade likely to be encountered around the perimeter of the North Open Cut shall be graded to drain into the cut.
- Cover the exposed slopes with bark mulch, stone, or similar type material based upon constructed grade and revegetate, as required.
- Clean the bedrock surface through water jetting or mechanical scraping to remove residual waste rock from surface fissures and joints, as practicable.
- Assess the stability of exposed rock slope and take appropriate action, as needed.

Mine Features Closure

- The open manway located north of the North Open Cut is to be closed in general accordance with applicable guidance on protection of bats in mines.
- Any other mine openings exposed during TP-3 closure will be evaluated and closed as directed by the engineer following structural considerations.

Roadway Replacement

- Copperas Road is to be reconstructed. The design incorporates appropriate Vermont Agency of Transportation standards for roadway design.
- Access to property beyond TP-3 via Copperas Road shall be maintained during construction activities to the extent practical.
- Copperas Road shall be a single lane 12-foot travel way with 2-foot-wide shoulders, and gravel surface reconstructed at the same location and approximate grade as existing roadway.

- Mine Road shall be closed to vehicle access during construction, with work performed during non-school busing periods.
- Mine Road shall be a 24-foot travel way with 2-foot-wide shoulders, gravel surface, and reconstructed along the same alignment and grade. The road embankment shall provide construction-period sediment detention.
- Culverts under roads shall be designed to convey 100-year design storm peak flows.

The TP-3 closure is more fully described in Section 3 of the Basis of Design Report. The design details for the closure of TP-3 are provided on Drawings C-003, and C-005 through C-010 of Appendix D. Referenced Technical Specifications are provided in Appendix G.

ES 3.0 TAILING DAMS TP-1 AND TP-2 CLOSURE DESIGN

TP-1 and TP-2 cover 34 acres and contain approximately 2.8 million cyds of tailing. The tailing contributes acidity, base metals, and is the major source of iron to Copperas Brook and the WBOR. To achieve the NTCRA objectives, the closure design includes elements that would reduce the discharge from TP-1 and TP-2 to levels that would potentially result in Copperas Brook meeting water quality criteria downstream of TP-1.

ES 3.1 TP-1 and TP-2 Design Closure Analysis

The high acid generating potential of the tailing, as well as the leachable constituents of the tailing, impact surface water quality downgradient of the tailing dams through water runoff and seepage as well as from erosion and transport of tailing to downstream areas. The NTCRA closure objectives for TP-1 and TP-2 are therefore to restrict water contact with the tailing to the extent practical and to eliminate erosion of tailing into surface water channels. To achieve the closure objectives, a cover which reduces infiltration and

provides for grades sufficient to promote positive drainage and allows revegetation is required. Closure must comply with ARARS. Based upon criteria provided by Federal and State regulators, the minimum acceptable grade for the surface of TP-1 and TP-2 was determined to be 2 percent, after allowing for settlement.

To achieve the minimum slopes, filling or regrading is required. Based on post-TCRA ground topography of TP-1, achieving a minimum 2 percent closure surface grade for TP-1 through placement of surface fill requires a minimum of approximately 156,000 cyds of fill placement. This fill volume includes the volume necessary to allow for anticipated settlement following placement of the surface fill. During project planning meetings it was established that using the TP-3 waste rock as fill on TP-1 would provide a cost effective approach to achieve TP-1 design slopes, as well as provide for a suitable relocation area for the TP-3 material. For these reasons, it was concluded that relocating TP-3 waste rock onto TP-1 would maximize project benefits by fulfilling the following project requirements:

- Provide for the necessary fill placement on TP-1 to achieve the minimum design grades necessary for closure.
- Provide a final disposition location for TP-3 waste rock that would achieve waste isolation.

In order to meet water quality criteria at the point of compliance downgradient of the tailing dams, analyses were performed to evaluate the type of cover system necessary to incorporate into the design. The tailing analysis performed indicates that a soil/vegetation cover would not significantly reduce infiltration compared to existing conditions whereas infiltration through a geomembrane cover would be significantly reduced. Groundwater modeling was then used to assess the impact of cover types on TP-1 seepage rates. The model predicts that, in combination with the effects of the NTCRA perimeter surface water diversion channels, the effective elimination of the surface infiltration to the tailing impoundments caused by the use of a geomembrane

results in a decrease in the seepage flow rates discharging from the toe of TP-1 by more than 80 percent compared to pre-NTCRA levels. By contrast, model simulations of a soil/vegetation cover system in combination with the other NTCRA diversion elements results in a decrease in the TP-1 seepage rates of less than 20 percent.

Due to the significant iron loading from the TP-1 seeps impacting Copperas Brook and the WBOR, EPA concluded that it is more cost effective to minimize infiltration, to the extent practicable, as part of the tailing dam closure and reduce the amount of residual seepage which may require treatment. The use of a geomembrane cover system provides the additional benefit of reducing the availability of oxygen to the tailing and TP-3 wastes, further limiting potential long-term ARD generation.

ES 3.2 TP-1 and TP-2 Design Approach and Criteria

The design criteria were determined during design planning activities and considered ARARs. The design criteria identified parameters specific to waste rock fill placement, tailing closure, and surface cover. Each of these parameters is presented in the following sections.

ES 3.2.1 Waste Rock Fill Placement

Waste rock fill placement design criteria include the following:

- Final TP-1 and TP-2 subgrades are achieved by minor tailing regrade activities (discussed in the following section), and by placement of TP-3 waste rock.
- Waste rock fill shall be nominally compacted to create a relatively uniform, dense fill, minimizing nesting of large-sized materials, wood, or other debris.
- Placement of waste rock shall be performed to minimize infiltration through the regraded waste and into the tailing pile during placement.

- The top 6 inches of the fill surface shall be suitable as a geomembrane base layer, consisting of tailing or imported sand-sized material.

ES 3.2.2 Tailing Regrade

Tailing regrade design criteria include the following:

- The TP-1 slope extending from the dam crest to the buttress, and the TP-2 crest slope, shall not exceed 3 horizontal (H):1 vertical (V).
- Existing vegetation shall be stripped from the tailing surface prior to liner placement.
- The regraded tailing surface shall be suitable as liner subgrade.

ES 3.2.3 Infiltration Barrier Cover System

To achieve the NTCRA objective for closure, the TP-1 and TP-2 cover system includes the following elements:

- Regrading of TP-2 to create stable, maximum 3H:1V side slopes and a top slope of approximately 5 percent; but no less than 2 percent;
- Filling the top surface of TP-1 with waste rock and tailing to achieve a minimum slope of 2-percent (accounting for settlement);
- Regrading a portion of the north face of TP-1 to achieve a maximum slope of 3H:1V;
- Placing a 60-mil (0.06-inch-thick) geosynthetic membrane (i.e., geomembrane), made of linear low-density polyethylene (LLDPE) over TP-1 and TP-2;
- Placing a soil layer above the geomembrane consisting of 18 inches of onsite common borrow and 6 inches of topsoil;
- Constructing a subsurface drainage system consisting of a geocomposite drainage net and perforated piping network;
- Establishing a stable grass cover; and

- Constructing surface drainage features including on-cap broad grass swales with stone centers, and perimeter grass and riprap channels.

The cover system design incorporates the following assessments.

TP-1 Spillway

To support the current design a re-evaluation of the impact of the Probable Maximum Precipitation (PMP) event to the tailing dam and modified emergency spillway was performed. The PMP routing study found that:

- Water will be temporarily stored on TP-1 during a PMP event, but the dam will not overtop.
- The modified emergency spillway will convey runoff safely around the dam. The emergency spillway riprap will be displaced during peak runoff but erosion will be confined to the glacial till beneath and adjacent to the spillway and erosion of the tailing dam is unlikely.
- If site grades are left as-is, water discharging from the spillway may flow along the toe of the existing buttress under a Probable Maximum Flood (PMF) event. While the potential for eroding the buttress appears low, the NTCRA closure design includes raising the perimeter access road below TP-1 and adding riprap reinforcement to restrict Copperas Brook from reaching the buttress toe during a PMF event. The final determination on construction of this reinforcement will be made by the engineer after a review of site conditions following tailing removal from the toe area.

Copperas Brook Tailing Fan

As part of the closure of TP-1 and TP-2, the unvegetated and eroding tailing fan remaining below the toe of TP-1 following implementation of the TCRA will be removed and stream restoration methods will be used to recreate the stream channel through this area.

TP-1 Settlement Analysis

Settlement of the tailing in TP-1 post-closure condition resulting from stress increases induced by the fill placement and by post-closure dewatering was analyzed and the results incorporated into the design. The analysis found that long-term settlement ranges from negligible levels along the eastern side of TP-1 to between 0.5 and 0.75 feet through the center and in the northwestern portion of TP-1 where fill depths required to achieve the final subgrade are greatest. The settlement was found to be primarily derived from fill and cover placement, with dewatering stress settlement being less significant.

Slope Stability Evaluation

The stability of the TP-1 and TP-2 slopes were evaluated for both steady-state drained and post-earthquake loading conditions. These stability analyses determined that the design slopes have a steady-state seepage, and a post-earthquake factor of safety that exceeds the established minimum for tailing dams for all conditions assessed.

TP-1 Crest Height Extension Evaluation

The placement of the cover system on TP-1 will result in an increase in elevation of up to 5 feet along portions of the top crest of the tailing dam. The impact on the stability factor of safety resulting from this increase was evaluated and found to be acceptable for all conditions assessed.

Buttress Top Extension Evaluation

The top of the buttress fill on TP-1 will be raised approximately 4 feet using stone fill. The calculated factor of safety for the revised buttress condition was found to be acceptable for all conditions assessed.

The TP-1 and TP-2 closure is more fully described in Section 4 of the Basis of Design Report. The design details for the closure of TP-1 and TP-2 are provided on Drawing C-

002, and C-011 through C-019 of Appendix D. Technical Specifications are provided in Appendix G.

ES 4.0 COPPERAS FACTORIES REMEDIAL DESIGN

The remains of the former Copperas Factories include stone foundations and debris scatter associated with the former copperas processing operations. The foundations (identified as the Upper and Lower Copperas Factories) formerly housed evaporators, crystallizers, and packaging operations which were active during the early and mid 1800s. Some of these structures had significant amounts of lead (e.g., lead-lined tanks) and have resulted in lead-impacted soils in and around both the Upper and the Lower Copperas Factories.

ES 4.1 Copperas Factories Remedial Approach

The Copperas Factory remediation involves a combination of in-place covering of lead-impacted material with the possibility of some excavation and consolidation of lead-impacted material either within the Copperas Factories footprint or into a designated lead-waste disposal area on TP-1 or TP-2. Both the in situ covers and the consolidated lead disposal area include placement of a 2-foot thick cover over the waste to isolate the wastes from direct contact, in accordance with ARARs.

The design preserves the exposed foundations of the Upper and Lower Copperas Factories as visible features to the extent practicable. The primary elements of the Copperas Factories Remedial Action are:

- Remediate lead-impacted soil at the Upper and Lower Copperas Factories through in situ covering, or excavation and relocation to the designated lead-waste disposal area.

- Place a sufficiently thick soil cover over soil with a lead concentration equal to or exceeding 400 milligrams per kilogram to prevent direct human contact risk.
- Preserve Copperas Factory foundations, to the extent possible, or document historic resources that must be disturbed.
- Preserve historic artifacts, to the extent practicable.

Institutional controls (e.g., restrictive covenants) to protect the remedial action from damage will be required upon completion of the remedial construction.

ES 4.2 Copperas Factories Historic Preservation Criteria

Based on meetings held on May 1, 2007 and on October 4, 2007, the National Historic Preservation Act-expert consultant identified the following historic preservation criteria for the Copperas Factories:

- Do not over-restore the condition of the factory sites beyond their current state
- Maintain existing topography
- Promote stability of stone walls
- Perform historic data recovery
- Perform in-situ artifact preservation
- Use proper equipment to minimize disturbance of the area and historic features
- Perform work under appropriate Site supervision

ES 4.3 Copperas Factories Relationship with NTCRA Closure Activities

The Upper Copperas Factory is located within the TP-3 limit of waste identified for removal. The lead containing soils associated with the Lower Copperas Factory extend into the TP-3 waste rock identified for removal. Therefore, the lead removal associated

with these features must consider both the high acid generating potential of the TP-3 waste ore and the elevated lead content. Mixing of these materials and subsequent placement in a manner consistent with only lead closure requirements (i.e., isolation using a 2-foot soil cover) may result in the long-term generation of ARD through infiltration, as well as the potential for lead mobilization through the generation of acidic pore water. For this reason, neutralization of the lead-containing waste ore may be necessary, as determined by the engineer.

ES 4.4 Copperas Factories Remedial Design Approach

The approach for the Copperas Factories design is as follows:

- To the extent practical, place an in situ cover with a minimum of 24 inches of clean soil or stone over the lead-containing wastes.
- Consolidate the remaining portion of lead-containing wastes from both the Upper and Lower Copperas Factories into a designated waste cell located on TP-1 or TP-2. The cell shall be closed using interim stabilization methods pending final closure of the tailing impoundments.
- Perform confirmation tests at the time of closure to document that all identified lead-impacted materials are closed in accordance with these requirements.
- The Copperas Factories foundation walls will be left undisturbed, as practicable.
- Surface water drainage will be routed through the remediated area to minimize impact to the historic features and to the constructed cover systems.
- An historical resource data recover program will take place either prior to or coincident with the lead remediation activities in this area.

The Copperas Factory remediation is more fully described in Section 5 of the Basis of Design Report. The design details for the remediation of the Copperas Factories are provided on Drawing C-004 of Appendix D. Technical Specifications are provided in Appendix G.

UNDERGROUND WORKINGS AREA

WEST BRANCH OF THE OMPOMPANOOSUC RIVER

EAST BRANCH OF THE OMPOMPANOOSUC RIVER

SARGENT BROOK

COPPERAS BROOK

TP-1 AREA

NORTH CUT/ TP-3 AREA

TP-2 AREA

LORD BROOK

SITE

LORD BROOK

WEST BRANCH OF THE OMPOMPANOOSUC RIVER

OMPOMPANOOSUC RIVER

CONNECTICUT RIVER

VERMONT

SITE

0 4000 8000

SCALE in FEET

Source:
USGS 7.5-minute topographic quadrangles of South Strafford,VT (1981); Sharon, VT (1981); Chelsea, VT (1981); Hanover, NH (1988); and Lyme, NH (1983) obtained from Vermont Center for Geographic Information, Inc. Waterbury, VT in digital format (.tiff files) projected in the Vermont State Plane coordinate system (NAD83) from Digital Raster Graphic image files.
Historic site features and 1-meter interval contour base map obtained from Public Archaeology Lab (PAL), Pawtucket, Rhode Island, Report No. 1237.03, September 2002.
Water course data obtained from the Vermont Center for Geographic Information, Inc. Waterbury, VT and PAL, Report No. 1237.03, September 2002, modified based on site reconaissance.

URS Corporation
477 Congress Street
Suite 900
Portland, ME 04101-3453
Tel: 207.879.7686
Fax: 207.879.7685
www.urscorp.com

PROJECT NO:	39459945
DESIGN: FS	SCALE: 1"=4000'
APPROVED: JCC	DATE: MARCH 2009
DRAWN: CAM	FILE NO: EM_BASE

CLIENT: U.S. ARMY CORPS OF ENGINEERS

PROJECT: ELIZABETH MINE
BASIS OF DESIGN REPORT
STRAFFORD, VERMONT

U.S. Army Corps
Of Engineers
New England District

TITLE: SITE LOCUS

FIGURE NO: ES-1

P:\Project\USACE_13846\39459197_067\RI_FS\Figures\EM_BASE.dwg, FIG 1 SITE LOCUS, 3/26/2009 12:24:49 PM

LEGEND

- MINE OPENING
- EXTENT OF NTCRA
- PROPERTY LINE

NOTE:
Property lines obtained from Two Rivers-Ottauquechee Regional Commission (June 2007).

N
W E
S

ADIT
TP-1
ADIT
TP-2
SHAFT
MINESHAFT
MANWAY
UPPER ADIT
TP-3
ADIT
NEW BOSTON ROAD

P:\acad-project\USACE-ELIZABETH-MINE-STRAFFORD-VT\dwg\NTCRA Basis Of Design.dwg, FIG 2 NTC REMOVAL, 3/26/2009 12:50:55 PM

URS Corporation
477 Congress Street, Suite 900
Portland, ME 04101-3453
Tel: 207.879.7686
Fax: 207.879.7685
www.urscorp.com

U.S. Army Corps
Of Engineers
New England District

0 500 1000
SCALE IN FEET

PROJECT NO:	39459945		
DESIGN:	CAM	SCALE:	1" = 500'
APPROVED:	JCC	DATE:	MARCH 2009
DRAWN:	CAM	FILE NO:	NTCRA BASIS OF DESIGN

CLIENT: U.S. ARMY CORPS OF ENGINEERS

PROJECT: ELIZABETH MINE
BASIS OF DESIGN REPORT
STRAFFORD, VERMONT

TITLE: NON-TIME-CRITICAL
REMOVAL ACTION AREA

FIGURE NO.: ES-2

LEGEND

TOPOGRAPHIC CONTOURS (SURVEYED)

TREELINE

STONE RIPRAP

TP-1 WEST-SIDE SURFACE WATER DIVERSION CHANNEL

TP-1 WEST-SIDE TAILING REGRADE

ADIT

TP-1

TP-2 SURFACE WATER/ SHALLOW GROUNDWATER DIVERSION CHANNEL

TP-2

ADIT

ADIT

TP-1 EAST SIDE SURFACE WATER/ SHALLOW GROUNDWATER DIVERSION CHANNEL

TP-2 SURFACE WATER/SHALLOW GROUNDWATER DIVERSION CHANNEL – CONSTRUCTION PENDING

NEW BOSTON ROAD

N

W

E

S

P:\acad-project\USACE-ELIZABETH-MINE-STRAFFORD-VT\dwg\NTCRA Basis Of Design.dwg, FIG 6 NTCRA COMPONENTS, 3/26/2009 1:03:59 PM

URS Corporation
477 Congress Street, Suite 900
Portland, ME 04101-3453
Tel: 207.879.7686
Fax: 207.879.7685
www.urscorp.com

U.S. Army Corps Of Engineers New England District

0 300 600

SCALE IN FEET

PROJECT NO:	39459945		
DESIGN:	CAM	SCALE:	1" = 300'
APPROVED:	JCC	DATE:	MARCH 2009
DRAWN:	CAM	FILE NO:	NTCRA BASIS OF DESIGN

CLIENT: U.S. ARMY CORPS OF ENGINEERS

PROJECT: ELIZABETH MINE
BASIS OF DESIGN REPORT
STRAFFORD, VERMONT

TITLE: NON-TIME CRITICAL REMOVAL ACTION COMPONENTS DECEMBER 2007 CONDITIONS

DRAWING NO.: ES-3

Mechanism for Mine Waste and ARD Release for TP-3

(A) Oxygen and water (precipitation and snowmelt) interact with suflide rock and waste ore to create ARD which discharges to Copperas Brook and to groundwater.

(B) ARD impacted groundwater discharges to surface water in lower TP-3.

(C) Wind and water bourne transport of surface exposed mine waste.

(D) Water enters underground workings and contacts sulfide wall rock and waste rock, degrading water quality.

Major Issues for Closure

- Minimize contact of waste with water and oxygen.
- Steep topography limits closure options and makes complete in-place closure impractical.
- Groundwater discharge within limits of waste complicates potential in-place closure designs.
- Roads must be re-established following closure.
- Preservation of historic features must be addressed.
- Eliminate the need for water treatment.

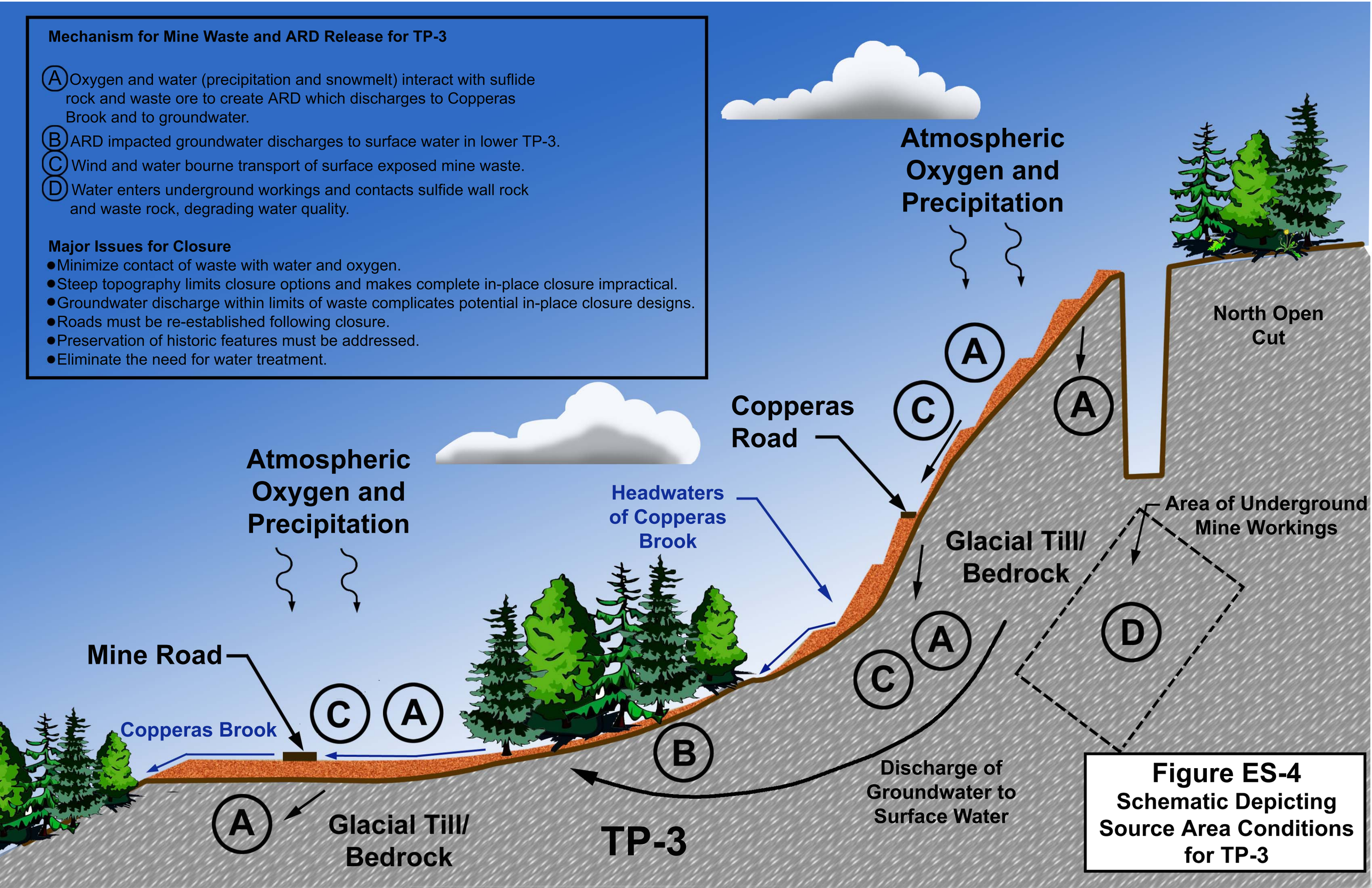


Figure ES-4
Schematic Depicting Source Area Conditions for TP-3

Mechanisms for Mine Waste and ARD Discharge from TP-1 and TP-2

- (A) Infiltration of precipitation and snowmelt into tailing.
- (B) Water infiltration from surface water channels and decant pond into tailing.
- (C) Shallow groundwater inflow to tailing.
- (D) Erosion of surface exposed oxidized tailing and transport into Copperas Brook by wind or mechanical means.
- (E) Erosion of TP-1 Toe-Area tailing by Copperas Brook.
- (F) Seepage from buttress drains/horizontal drains containing elevated iron, aluminium and sulfate.

Major Issues for Closure:

- Achieve long term stability.
- Reduce to the extent practical the need for water treatment by reducing flow rates discharging from the toe of TP-1. This includes:
  - Limit surface water runon and the infiltration of surface water and groundwater into tailing.
  - Promote run-off.

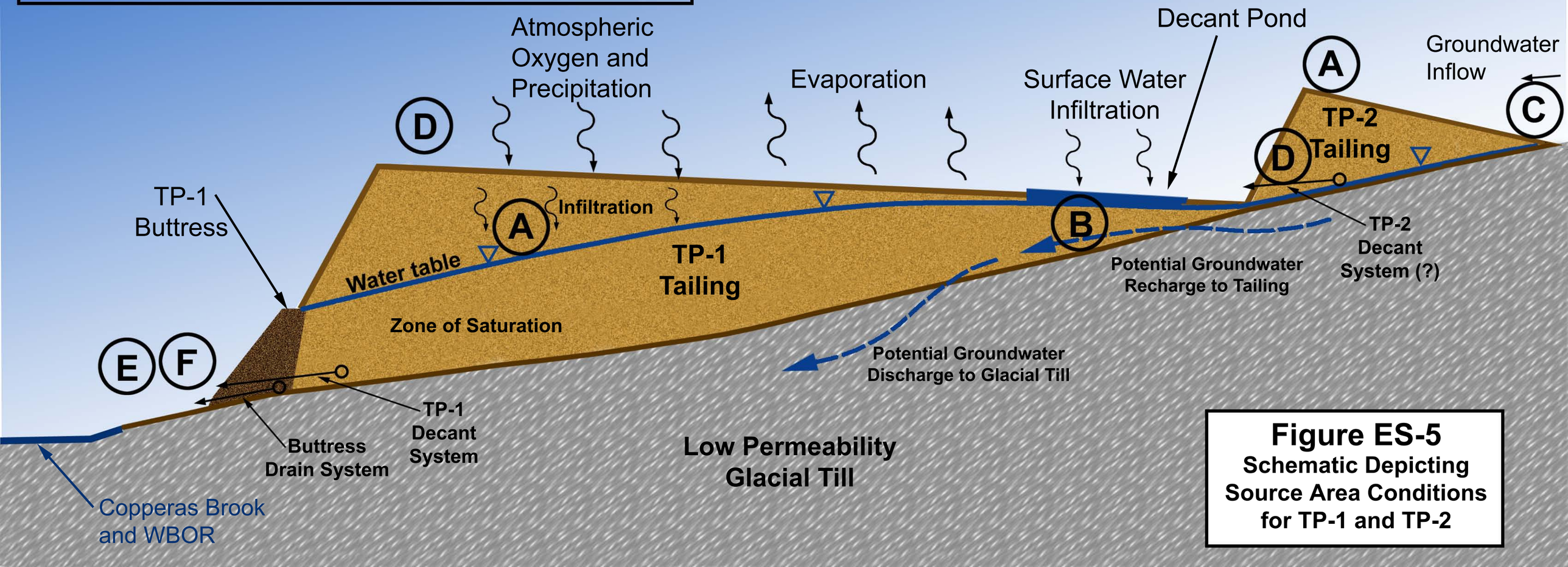


Figure ES-5
Schematic Depicting Source Area Conditions for TP-1 and TP-2

UNDERGROUND WORKINGS EXTEND APPROXIMATELY 350 METERS NORTH OF AIR SHAFT

FURNACE FLATS

WEST BRANCH OF THE OMPOMPANOOSUC RIVER

MINE POOL ACCESS

SARGENT BROOK

APPROXIMATE LOCATION OF UNDERGROUND WORKINGS

TYSON SMELTER AREA

TYSON SHAFT NO. 2

TYSON SHAFT NO. 1

TYSON MANWAY/ AIR SHAFT

NORTH OPEN CUT

ADIT

WWII-ERA INFRASTRUCTURE

COPPERAS BROOK

1898 ADIT

ADIT NO. 3

ADIT NO. 2

SOUTH OPEN CUT

LORD BROOK

SOUTH MINE

LORD BROOK

AIR SHAFT
ARTESIAN VENT
SOUTH VENT
VT ROUTE 132
MINE ROAD
COPPERAS ROAD
TURNPIKE ROAD
GOVE HILL ROAD
NEW BOSTON ROAD
JEEP TRAIL
COPPERAS HILL
MINE SHAFT
MANWAY
UPPER ADIT
TP-1
TP-2
TP-3
TP-4
1898 ADIT
North Open Cut
South Open Cut
Pit Lake
Waste Rock
Quarry
Foundation
Smelter
Reservoir
Terrace
Quartz Quarry
Roast Beds
Pumphouse

LEGEND

- UNDERGROUND WORKINGS
- MINE OPENING
- WASTE ROCK/TAILING
- STRUCTURE
- TRENCH
- EXISTING ROAD
- HAUL ROAD
- STREAM

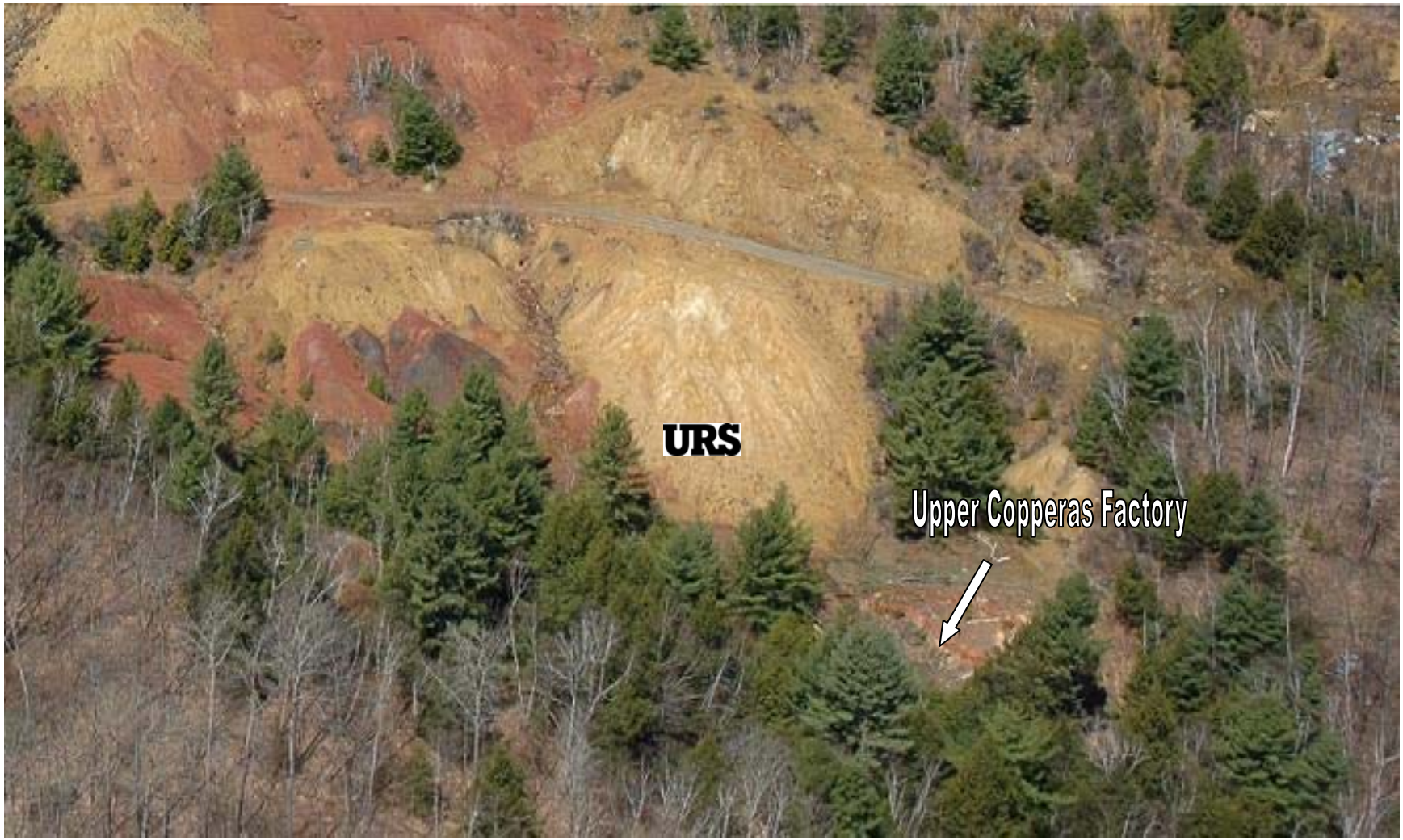
Sources:
USGS 7.5-minute topographic quadrangles of South Strafford,VT (1981); Sharon, VT (1981); Chelsea, VT (1981); Hanover, NH (1988); and Lyme, NH (1983) obtained from Vermont Center for Geographic Information, Inc. Waterbury, VT in digital formats (.tiff files) projected in the Vermont State Plane coordinate system (NAD83) from Digital Raster Graphic Image files.
Historic site features and 1-meter interval contour base map obtained from Public Archaeology Lab (PAL), Pawtucket, Rhode Island, Report No. 1237.03, September 2002.
Water courses data obtained from the Vermont Center for Geographic Information, Inc. Waterbury, VT and PAL, Report No. 1237.03, September 2002, modified based on site reconnaissance.

URS Corporation, 477 Congress Street, Suite 900, Portland, ME 04101-3453, Tel: 207.879.7686, Fax: 207.879.7685	U.S. Army Corps Of Engineers New England District	0 100 200 SCALE in METERS	PROJECT NO: 39459945; DESIGN: FS; SCALE: AS SHOWN; APPROVED: JCC; DATE: MARCH 2009; DRAWN: CAM; FILE NO: EM_BASE	CLIENT: U.S. ARMY CORPS OF ENGINEERS; PROJECT: ELIZABETH MINE BASIS OF DESIGN REPORT STRAFFORD, VERMONT	TITLE: PRIMARY PHYSICAL FEATURES	FIGURE NO: ES-6

P:\Project\USACE_13846\39459197_067\RI_FS\Figures\EM_BASE.dwg, FIG 3 PRIMARY FEATURES, 3/26/2009 1:08:45 PM

Executive Summary Supplement
2007 Site Photographs

TP-3 and North Open Cut, and Copperas Factories; west-facing view.



Upper Copperas Factory and TP-3, west-facing view.

TP-1 and TP-2, south-facing view with NTCRA and TCRA features completed to date and TP-1 toe tailing area.

TP-1 and TP-2 north-facing view with NTCRA and TCRA features completed to date.

Copperas Brook watershed features TP-1, TP-2 and TP-3; southwest-facing view.

Lower Copperas Factory/Lower TP-3 Area, south-facing view.

Lower Copperas Factory/Lower TP-3 Area, south-facing view.