



**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY REGION 8**

**DENVER, CO 80202-1129**

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**<http://www.epa.gov/region08>**

Ref: 8EPR-ER

**ACTION MEMORANDUM AMENDMENT**

**SUBJECT:** Request for a Ceiling Increase, Exemption from the 12-Month Statutory Limits, and a Change in Scope for a CERCLA Removal Action at the Golf Tunnel Located near St. Elmo, Chaffee County, Colorado (with attachments)

**FROM:** Hays Griswold  
Federal On-Scene Coordinator

**THRU:** Laura Williams, Unit Leader  
Emergency Response

**TO:** David A. Ostrander, Director  
Emergency Response & Preparedness Program

Site ID#: 08WB

**I. PURPOSE**

The purpose of this Action Memorandum Amendment (Amendment) is to request and document approval of a ceiling increase, exemption from the 12-month statutory limit, and to modify the scope of work for the time-critical removal action (TCRA) described in the June 20, 2011, Action Memorandum for the Golf Tunnel Site (Site), located near St. Elmo, Chaffee County, Colorado, (see Attachments 1 and 2 for locations). This Action Memorandum Amendment also explains the reasons for the increased estimated costs of this removal action.

Since the original Action Memorandum was approved, it has been determined that the U.S. Environmental Protection Agency (EPA) may need to perform substantially more work at greater cost to rehabilitate and plug the Tunnel than originally estimated. This was substantiated when all bids for construction of the bulkhead came in significantly higher than expected.

The original Action Memorandum's estimated costs were focused on plugging the adit and, for cost comparison purposes, used cost figures from similar recent mining remediation efforts in the Region, which were apparently low for the industry. In addition, fuel, construction labor and equipment costs have risen significantly since the original estimate.

This Amendment discusses actions to mitigate threats to public health or welfare or the environment caused by acid mine drainage (AMD) containing toxic metals flowing into Chalk

Creek past a branch of the Colorado Division of Wildlife (CDW) Fish Hatchery and into the Arkansas River.

Conditions at the Site present a threat to public health or welfare or the environment and meet the criteria for initiating a time-critical removal action under 40 CFR Section 400.415(b)(2) of the National Contingency Plan (NCP). Additionally, the potential exists for the natural creation of a dam from internal mine structure collapse along with ice dams formed over the winter that could back up contaminated water and result in a catastrophic blowout causing great harm to Chalk Creek fishing and the State fish hatchery. This removal action involves no nationally-significant or precedent-setting issues. This TCRA will not establish any precedent for how future response actions will be taken and will not commit the EPA to a course of action that could have a significant impact on future responses or resources.

This Amendment includes a brief summary of the information that has been generated for this Site and the nearby U.S. Forest Service (USFS) site. For more information, see the Final Phase II Engineering Evaluation/Cost Analysis (EE/CA) that can be found on file (478 pages) or on disk in pdf format with this document in the Administrative Record at the EPA Regional Office Records Center or the Administrative Records Repository set up at the Buena Vista Public Library, 310 East Main Street, Buena Vista, CO, near the Site. Although the EE/CA produced by USFS is not related to this action, it provides a wealth of background information on the entire mining district.

## **II. SITE CONDITIONS AND BACKGROUND**

The original Golf Tunnel Action Memorandum was for a TCRA and was signed June 20, 2011. The original project ceiling was \$795,000 to install as many as two engineered reinforced bulkheads (massive plugs) to stop the flow of the contaminated water coming out of the Golf Tunnel (Tunnel) and, thereby, suffocate the reaction that generates AMD.

Site Name:	Golf Tunnel
Superfund Site ID (SSID):	08WB
CERCLIS Number:	CON00082843
Site Location:	near St. Elmo, Chaffee County, CO
Lat/Long:	38°40'49.44 N/106°21'31.97W
Potentially Responsible Party:	
NPL Status:	not on the NPL
Removal Start Date:	
Category Removal:	Time-Critical, Fund Lead

### **A. Site Description**

The Tunnel (also called an "adit," driven at the mine's 2200 level) is located on the western slopes of Chrysolite Mountain adjacent to Chalk Creek at an elevation of 10,360 feet. It is a mill-level cross-cut, driven to access underground mine workings including the Mary Vein below the main workings. Discharging a constant 60 to 165 gpm year-round, it is the lowest working level of the Mary Murphy Mine. The Tunnel flows into a small pond that discharges into a small unlined channel prior to entering the South Fork of Chalk Creek (See Attachment 2) about 200 feet away.



## **1. Removal Site Evaluation**

The watershed first came under scrutiny in 1986 after a fish kill at the CDW Chalk Cliffs Fish Rearing Unit. The kill was attributed to elevated concentrations of metals in Chalk Creek during spring runoff. Water quality sampling at that time found zinc and cadmium at levels exceeding State water quality standards. The effects were a reduction of the number of brown trout and elimination of young fish for a 12-mile stretch below the mining district. Metal concentrations in Chalk Creek peaked in the vicinity of the Mary Murphy Mine and the Iron Chest tailing piles. At that time it was suspected that interaction between mine drainage, creek flows and the tailing piles contributed most of the metals in the stream. A loading analysis developed from flow and metals concentration data showed that 85 percent of the metals load exiting the main adit was attributed to one inflow from the north drift on the Mary Vein. The inflow constituted only 1.5 percent of the total discharge from the adit, but at high flow the Tunnel out-flow had a total zinc concentration of 190,200 micrograms per liter (ug/L). The contaminated inflow was traced back to an ore chute on a high-sulfide stope (mined-out portion of vein) on the north vein, which drained 15 gpm. This same high-concentration source also accounts for 70 percent of the zinc load discharging from the Golf adit.

## **2. Physical Location**

The Golf Tunnel (or adit) is one of many mining facilities within the Chalk Creek Mining District. The district is in the upper reaches of Chalk Creek near the small historical mining town of St. Elmo, CO. The Golf Tunnel is located at Latitude 38° 40' 49.44 N and Longitude -106° 21' 31.97" W.

## **3. Site Characteristics**

The Chalk Creek Mining District is about 15 miles west of Nathrop, CO, and includes the Alpine, St. Elmo and Romley sub-districts. The district was a significant producer of gold, silver, copper, lead and zinc, especially in the 1930s. Most of the production came from the Mary Murphy Mine. Veins in granitoid rocks of the Mt. Princeton Tertiary-age batholith host the ore. This district and region contain the most mines with significant and potentially significant environmental problems, in part because water drains from many of the underground workings. Several mines in this district have been reclaimed as part of a program administered by the Colorado Division of Minerals and Geology. In many cases, physical hazards were addressed, with less emphasis on environmental concerns. However, some of the worst environmental problems were mitigated, and mine and natural waters in this mining district are tested regularly in a monitoring program. Historically, mining was the only land-use in the area. Today the district is a scenic tour route, with very few year-round residents, but with many summer residences scattered about the area.

#### **4. Release or Threatened Release into the Environment of a Hazardous Substance, Pollutant or Contaminant**

The Golf Tunnel discharges AMD water at 53 gpm containing significantly elevated concentrations of several heavy metals. It is demonstrated that the zinc and other metals have increased since 2010 and are above acute and chronic concentrations of water quality standards (WQS) (79 and 69, respectively for zinc, based on the Site-specific hardness of 50 mg/L). For example, zinc was detected at 87 ug/L in Chalk Creek upstream of the Golf Tunnel adit discharge and at 510 ug/L downstream of the Golf Tunnel discharge. Although survey data indicate the trout population is present and appears to be reproducing, it is noted that the population is less robust in the reaches associated with the adit discharge. The degree of chronic effects to the population cannot be evaluated without a significant level of effort that would have to occur over an extended period of study. The adit flow and measured concentrations of metals indicate that the Golf Tunnel and the associated Mary Murphy 1400 level discharge are significant contributors of mine-related heavy metals into Chalk Creek.

#### **Threats to the Public Health or Welfare**

The following are descriptions of the threats posed to the human population by the specific contaminants found in the Tunnel drainage.

##### **Lead**

There is a potential for humans to be exposed to the lead coming from the mine drainage by consuming fish caught in the lower reaches of Chalk Creek or from the Arkansas River. Lead is classified as a B2 carcinogen by the EPA, and lead compounds are known to cause acute health effects. (The classification as a carcinogen is the result of animal studies determining that these compounds are probable human carcinogens). Lead can enter the body via ingestion and inhalation. Children appear to be the segment of the population at greatest risk from toxic effects of lead. Initially, lead travels in the blood to the soft tissues (heart, liver, kidney, brain, etc.). Then it gradually redistributes to the bones and teeth where it tends to remain. Children exposed to high levels of lead have exhibited nerve damage, permanent mental retardation, colic, anemia, brain damage and death.

##### **Cadmium**

The same can be said for the cadmium coming from the Tunnel drainage. Cadmium has been shown to be a carcinogen in both animal studies (Takenaka, et al., 1983) and occupationally exposed groups of humans (Thun et al., 1985) via the inhalation route of exposure. The Carcinogenic Assessment Group (CAG) has classified cadmium as a Group B1--Probable Human Carcinogen for inhalation only, based on limited evidence of carcinogenicity in humans from occupational studies (EPA 1985b). Exposure to toxic amounts of cadmium by either inhalation or ingestion will cause cadmium to accumulate in the renal system and eventually cause kidney failure (EPA 1985a).



## **Copper**

Copper in the Tunnel drainage is more deleterious to aquatic life as discussed below. In this case, health effects to humans from copper are unlikely. Copper is an essential element necessary for maintaining good health in humans, but high doses can be harmful. Oral ingestion of high amounts of copper may cause vomiting, diarrhea, stomach cramps and nausea. Chronic ingestion of high amounts of copper can cause liver and kidney damage.

### **Threats to the Environment**

The threats to the environment, specifically to the aquatic life in Chalk Creek and the Arkansas River and the sensitive systems in the impacted part of the watershed, have generally been described previously and are thoroughly documented in the administrative record and the EE/CA document (also in the record) mentioned previously. In addition, the potential exists over time for collapses in the Tunnel and for ice dams formed during the winter to back up contaminated water, resulting in a catastrophic blowout and causing great harm to Chalk Creek fishing and the State's Chalk Creek Hatchery. The following are descriptions of the threats to the environment posed by the specific contaminants found in the Tunnel drainage.

## **Zinc**

Zinc concentrations in the Tunnel drainage range from 4,591 ug/L to 65,150 ug/L. Zinc produces acute toxicity in freshwater organisms over a range of concentrations from 90 to 58,100 ug/L and appears to be less toxic in harder water. Acute toxicity is similar for freshwater fish and invertebrates. In many types of aquatic plants and animals, growth, survival and reproduction can all be adversely affected by elevated zinc levels. A final acute-chronic ratio for freshwater species of 3.0 has been reported. Some researchers have speculated that exposure to excessive amounts of zinc may constitute a hazard to animals. Laboratory studies and findings in animals living near lead-zinc smelters suggest that excessive exposure to zinc may produce bone changes, joint afflictions and lameness.

## **Cadmium**

Cadmium is found in the Tunnel drainage to range from 21 ug/L to 322 ug/L. Laboratory experiments suggest that cadmium may have adverse effects on reproduction in fish at levels present in lightly to moderately polluted waters. Cadmium is highly toxic to wildlife; it is cancer-causing and teratogenic and potentially mutation-causing, with severe sublethal and lethal effects at low environmental concentrations. It bio-accumulates at all trophic levels, accumulating in the livers and kidneys of fish. Crustaceans appear to be more sensitive to cadmium than fish and mollusks. Cadmium can be toxic to plants at lower soil concentrations than other heavy metals and is more readily taken up than other metals.

## **Copper**

Copper concentrations range as high as 326 ug/L. Copper produces acute toxicity in freshwater animals and data are available for species in 41 Genera. At a hardness of 50 mg/l, the general range in sensitivity is from 16.74 ug/l for Ptychocheilus to 10,240 ug/l for Acroneuria. Data for eight species indicate that acute toxicity also decreases with increases in alkalinity and total organic carbon. Chronic values are available for 15 freshwater species and range from 3.873 ug/l for brook trout to 60.36 ug/l for northern pike. Fish and invertebrate species seem to be about equally sensitive to the chronic toxicity of copper. Copper is highly toxic in aquatic environments and has effects in fish, invertebrates and amphibians. Copper will bio-concentrate in many different organs in fish (potential low, however) and mollusks. Copper sulfates and other copper compounds are algacides, with sensitive algae potentially affected by free copper at low ppb concentrations. Toxicity tests have been conducted on copper with a wide range of freshwater plants, and their sensitivities are similar to those of animals.

### **5. NPL Status**

The Golf Tunnel, the Mary Murphy Mine and the other mining facilities in the Chalk Creek Mining District are not on the National Priority List (NPL).

### **6. Maps, Pictures and Other Graphic Representations**

Location and Site maps are included as Attachments 1 and 2.

#### **B. Other Actions to Date**

##### **1. Previous Actions**

There have been no Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) removal actions conducted at the Golf Tunnel. The state of Colorado has investigated the Tunnel to determine the feasibility of plugging it. They determined that plugging was a feasible approach, and the location of the plug and a preliminary design are being determined..

##### **2. Current Actions**

There are no other removal actions being taken or proposed at the Golf Tunnel.

#### **C. Federal, State and Local Authorities' Roles**

##### **1. Federal, State and Local Actions to Date**

The State, USFS, locals and the EPA have been conducting numerous investigations of the environmental problems in the area, as evident by the documents that can be found in the administrative record for this memorandum. Some mitigating activities



have also been conducted with the limited funding available. However, the action proposed in this document is beyond the resources currently available to the State or local entities.

## **2. Potential for Continued State/Local Response**

The State, using funds from USFS and the EPA, conducted investigations of the Tunnel as mentioned above. The State has acquired the needed resources to rehabilitate the Tunnel and is proceeding with that action. However, neither the State nor the local authorities have the resources to conduct the proposed removal (tunnel plugging) at this Site. The State is expected to remain involved in the removal planning, will have an active role in the removal action, and is supportive of this proposed removal.

### **III. THREATS TO PUBLIC HEALTH OR WELFARE OR THE ENVIRONMENT, AND STATUTORY AND REGULATORY AUTHORITIES**

Heavy metals are being released from the Site via mechanical transport of solid contaminants (via adit drainage and pile sheet-flow and/or leachate) into Chalk Creek and subsequently, the Arkansas River. Release also occurs when sulfide-produced, acidified waters drain from the Tunnel into Chalk Creek and, subsequently, the Arkansas River.

Aquatic life in Chalk Creek is significantly impacted. Aquatic life in the Arkansas River segment below the Chalk Creek confluence is being exposed to elevated concentrations of heavy metals being transported from the Site, via creek waters, into the river. Also, consumption of fish taken from the Arkansas River segment below the Chalk Creek confluence is a potential direct human exposure pathway to toxic concentrations of creek/river-borne, heavy metal contaminants.

The removal action will address the release or substantial threat of release of hazardous substances at the Site. The conditions at the Site present a threat to public health or welfare or the environment and meet the criteria for initiating a removal action under 40 CFR section 300.415(b)(2) of the NCP. The EPA has considered all the factors described in 40 CFR 300.415(b)(2) of the NCP and determined that the following factors apply at the Site.

- (i) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants;*

Humans and the surrounding surface and aquatic environment can be adversely affected by heavy metals released from the Site upon direct contact with Site waste rock fractions, discharge waters and/or creek/river waters below the Site. In addition, human consumption of fish taken from river segment(s) below the creek/river confluence could result in adverse human exposure to Site-released contaminants.

- (ii) Actual or potential contamination of drinking water supplies or sensitive ecosystems;*

The ongoing release of elevated concentrations of heavy metals and/or acidic liquids from the Site will have a deleterious effect on downstream aquatic life. In addition, seasonal flooding

(snow-melt runoff) can add significant volumes of sulfide-laden waste rock to the creek and/or river channel.

*(iv) High levels of hazardous substances or pollutants or contaminants, largely at or near the surface, that may migrate;*

The Site contains high concentrations of heavy metals, including zinc, cadmium, copper and lead, in ground, surface and mine drainage waters. These heavy metals are "hazardous substances" as defined by Section 101(14) of CERCLA, 42 U.S.C. Section 9601(14). Release of these contaminants from the Site has been documented in the aforementioned studies and reports.

*(v) Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released;*

Seasonal snow-melt and heavy mountain rain showers will continue to exacerbate the release of the toxic metals from the Tunnel and other mine drainage areas unless some mitigating action is taken soon. In addition, as mentioned previously, studies have indicated that the release of these metals is actually on the increase.

*(vii) The availability of other appropriate federal or state response mechanisms to respond to the release;*

No other agency has the resources to respond to this release.

*(vii) Other situations or factors that may pose threats to public health or welfare of the United States or the environment.*

Contamination from this Site can potentially enter the food chain via aquatic life and by human consumption of fish taken from the Arkansas River below the Chalk Creek confluence.

#### **IV. EXEMPTION FROM STATUTORY LIMITS**

##### **A. Emergency Exemption**

1. There are relatively elevated toxic metal concentrations detected in surface water in the recent analytical results collected from Chalk Creek. Zinc concentrations in surface water are significantly above State water quality standards in Chalk Creek, and zinc concentrations appear to be increasing at one of the primary sources in the watershed. For example, the 1990 zinc concentrations in surface water collected during low flow from the Golf Tunnel, (discharging into Chalk Creek) ranged from approximately 10,000 ug/L to 19,700 ug/L. The 2007 zinc concentrations measured at this same location, also during low flow, were at 28,100 ug/L.

Mining-related releases from the Golf Tunnel create conditions that are toxic to fish in Chalk Creek, as clearly evident by the occasional fish kills in the CDW fish rearing unit. Zinc and cadmium concentrations in the adit discharge result in acute toxicity to aquatic species at the levels reported. The detected concentrations of zinc discharging from the adit, 28,100 ug/L, result in a zinc concentration of 510 ug/L in Chalk Creek



downstream of the adit discharge. These concentrations are significantly above the acute and chronic water quality standards for zinc (79 and 69, respectively, based on the Site-specific hardness of 50 mg/L). As mentioned above, there is an indication of increasing zinc concentrations from the adit source based on comparison of the 1990 to 2007 data – significantly increasing the threat to the environment. The zinc concentrations have remained constantly above acute and chronic water quality standards in Chalk Creek downstream of the source.

These heavy metals coming from the mine and out of the Golf Tunnel are “hazardous substances” as defined by Section 101(14) of CERCLA, 42 U.S.C. Section 9601(14). Accordingly, release of these hazardous substances into the environment from this Site poses an immediate threat to public health or the environment.

2. Immediate response actions are required to limit public and environmental exposure to the spread of AMD-contaminated water. Additionally, collapses in the Tunnel and ice dams forming over the winter could back up contaminated water and result in a catastrophic release of AMD contaminated water that would cause great harm to Chalk Creek fishing and the State’s Chalk Creek Hatchery.

## **V. PROPOSED ACTIONS AND ESTIMATED COSTS**

### **A. Proposed Actions**

#### **1. Proposed Action Description**

The proposed removal action involves installing as many as two engineered reinforced concrete bulkheads (massive plugs) in the Tunnel to stop the flow of contaminated water coming out of the Tunnel. The bulkheads will be placed at locations in the Tunnel that have been investigated and determined to be sound enough to withstand the hydrostatic pressures anticipated. The bulkheads are expected to back up the mine drainage, which will eventually reach a static equilibrium at a point where the retained water will find its way out via the pre-mining natural groundwater seeps. By retaining water in the mine workings, the inundated portions of the workings will be denied oxygen to produce acid and leach metals – reducing some of the contamination source areas. It is anticipated that the contamination in the water from the mine, while moving through the fractured bedrock along the pre-mining groundwater courses, will be attenuated to some extent by the non-mineralized and somewhat neutralizing country rock. The bulkhead or bulkheads would be constructed with piping through them and fitted with relief valves to use should any problem arise that would require that the system be drained. The hydrostatic head will be reduced or the water routed for, or hooked up to, treatment.

With regard to post-removal Site controls, the plug is designed for a hundred-year life span. No maintenance of the plug is anticipated. The plug is designed with a pipe and valve incorporated for release of water should that become necessary. Also incorporated in the plug is a smaller pipe with a pressure gauge installed to monitor

pressure behind the plug. There will be monitoring of the plug conducted by both the USFS and the state of Colorado Department of Natural Resources, Division of Reclamation, Mining and Safety personnel. Both entities will be working on and monitoring other projects that have been done in the mining district. This project is just one more of the many different areas of the district that these agencies will be monitoring.

## **2. Contribution to Remedial Performance**

The effort will, to the extent practical, contribute to any future remedial effort at the Site. However, no further federal action is anticipated at this time.

## **3. EE/CA**

This action will be a TCRA. Because it has been determined that the threats involved warrant a TCRA, no EE/CA is required.

## **4. Applicable or Relevant and Appropriate Requirements (ARARs)**

Removal actions conducted under CERCLA are required, to the extent practicable considering the exigencies of the situation, to attain ARARs. In determining whether compliance with an ARAR is practicable, the lead agency may consider appropriate factors, including the urgency of the situation and the scope of the removal action to be conducted. A list of potential ARARs was provided in the original Action Memorandum. Considering the removal action proposed in this Action Memorandum, entering and constructing a bulkhead in the Golf Tunnel, no ARARs have been identified for this action.

## **5. Project Schedule**

The removal action is planned for a late June 2013 start and a November 2013 completion.

### **B. Estimated Costs\***

Substantially more effort will be required to rehabilitate Golf Tunnel than was estimated in the original June 2011 Action Memorandum.

Extramural Regional Allowance Costs:

	Original Estimate	Change	Revised Estimate
Contractor Costs	\$650,000	\$ 950,000	\$1,650,000
Other Extramural Costs	\$ 15,000	\$ 20,000	\$ 35,000
20% Contingency	\$130,000	\$ 195,000	\$ 325,000
<b>Total Removal Project Ceiling</b>	<b>\$795,000</b>	<b>\$1,165,000</b>	<b>\$1,960,000</b>

\*EPA direct and indirect costs, although cost recoverable, do not count toward the removal ceiling for this removal action. Liable parties may be held financially responsible for costs incurred by the EPA as set forth in Section 107 of CERCLA.



**VI. EXPECTED CHANGE IN THE SITUATION SHOULD ACTION BE DELAYED OR NOT TAKEN**

Heavy metal contaminated water will continue to drain from the Golf Tunnel and continue to impact the aquatic life in Chalk Creek. Heavy runoff flows out of the Tunnel will continue to threaten the aquatic life in the creek and the fish in the CDW Chalk Creek Fishery.

A human health risk exists from a potential blowout that could result in heavy metals being released from the Site, through potential direct contact with Site waste rock fractions, discharge waters and/or creek/river waters below the Site. In addition, human consumption of fish taken from river segment(s) below the creek/river confluence could result in adverse human exposure to Site-released contaminants.

The potential exists for the natural creation of a dam from internal mine structure collapse and along with ice dams formed over the winter could back up contaminated water and result in a catastrophic blowout and cause great harm to Chalk Creek fishing and the State fish hatchery.

**VII. ENFORCEMENT**

See the Enforcement Addendum prepared in conjunction with the original Action Memorandum.

**VIII. RECOMMENDATION**

This decision document amends the selected removal action for the Golf Tunnel Site near St. Elmo in Chaffee County, Colorado, developed in accordance with CERCLA as amended and is not inconsistent with the NCP. This decision is based on the administrative record for the Site.

Site conditions continue to meet the NCP Section 300.415(b)(2) criteria for a removal and the CERCLA Section 104(c) emergency exemption from the 12-month limitation, and I recommend your approval of the proposed increase of \$1,165,000 from the original project ceiling of \$795,000. The removal project ceiling, if approved, will be \$1,960,000, all of which will be funded from the Fiscal Year 2013 Regional removal allowance.

Approve: \_\_\_\_\_



David A. Ostrander  
Director  
Emergency Response & Preparedness

Date: \_\_\_\_\_

7/30/13

Disapprove: \_\_\_\_\_

David A. Ostrander  
Director  
Emergency Response & Preparedness

Date: \_\_\_\_\_

## **Enforcement Addendum**

### **SUPPLEMENTAL DOCUMENTS**

Support/reference documents which may be helpful to the reader and/or have been cited in the report may be found in the Administrative Record File at the Superfund Records Center for the EPA Region 8, 1595 Wynkoop Street, Denver, Colorado 80202.

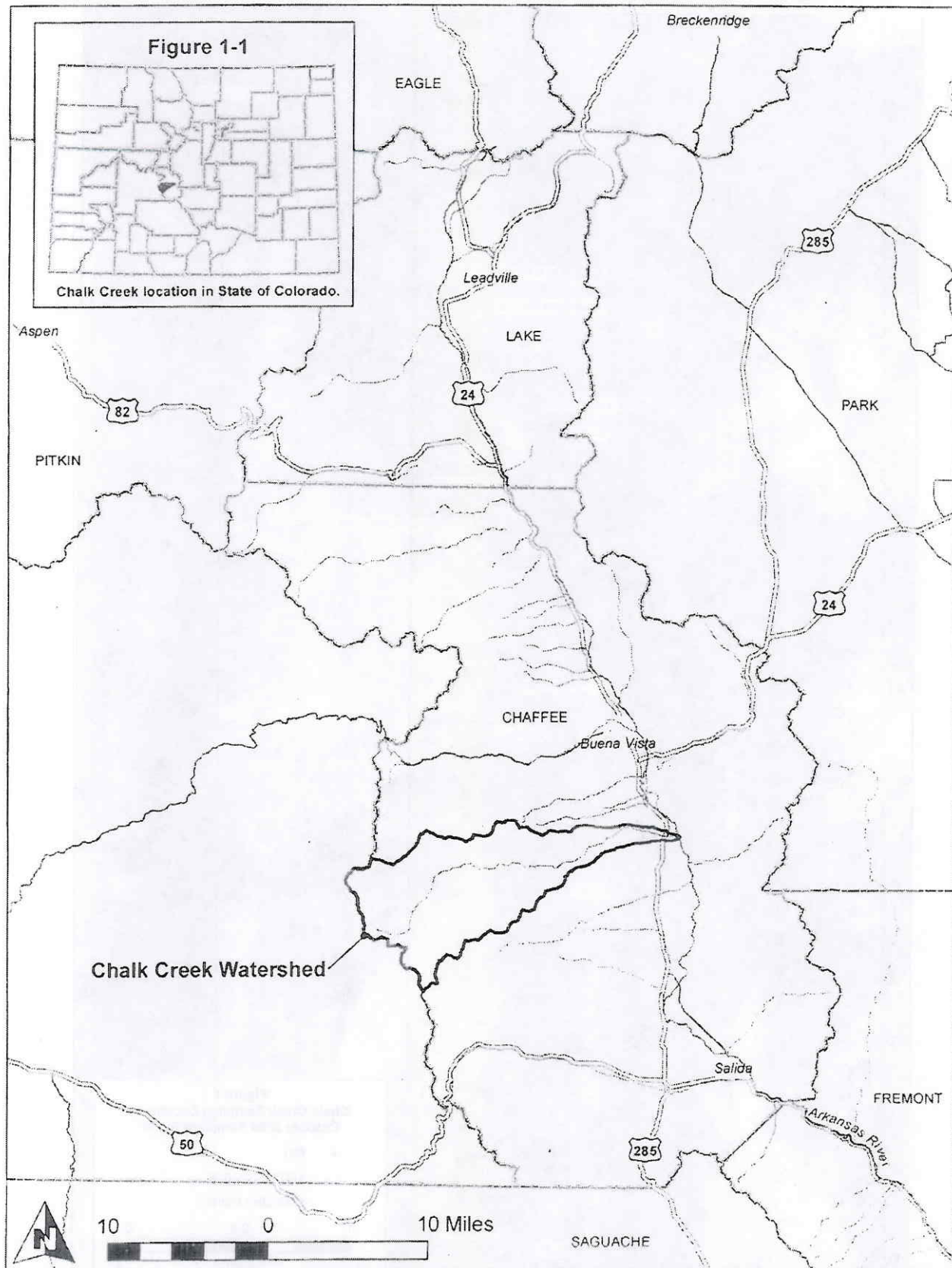
Attachment 1: Location Site Map

Attachment 2: Detail Site Map

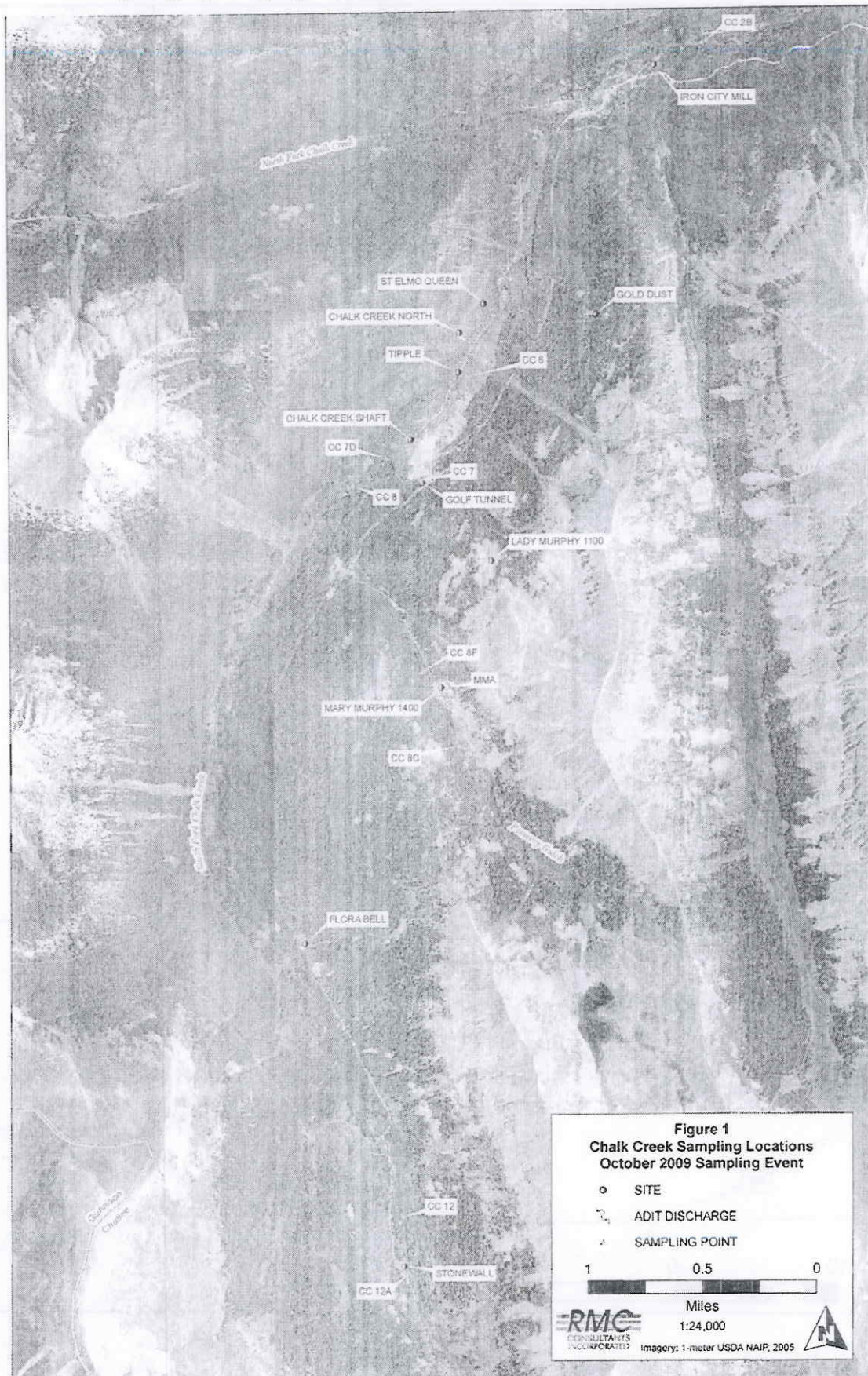
Attachment 3: Analytical Results of Golf Tunnel Drainage Water



# ATTACHMENT 1



# ATTACHMENT 2





# ATTACHMENT 3

Table 2. Water quality analyses of the Golf Tunnel Drainage

Date	Temp C°	pH	Conductivity µmhos/cm	Flow cfs	Alkalinity mg/L	Sulfate mg/L
4-90	---	6.75	---	0.033	50	---
9-90	8.2	7.37	387	---	44	247
6-91	6.7	7.22	532	0.254	47	366
10-91	5.5	7.72	367	---	---	---
3-92	2.7	7.68	---	0.106	---	---
5-92	7.2	7.33	296	0.157	50	185
8-92	0	7.58	443	---	37	220
3-93	2.1	7.52	270	---	48	184
6-93	4.9	7.32	342	0.183	56	233
9-93	5.9	7.22	430	0.142	48	258
4-94	1.2	7.43	264	0.042	---	---
6-94	8.4	7.14	716	0.136	37	510
8-94	6.2	7.62	435	0.154	38	253
Date	Zn µg/L	Mn µg/L	Cd µg/L	Cu µg/L	Pb µg/L	Fe µg/L
4-90	5900	2400	21	<det	<det	<det
9-90	1800	15000	85	<100	15	220
6-91	43410	34010	238	260	38	502
10-91	11170	10580	74	9	<50	160
3-92	5457	3316	34	<8	5	62
5-92	5070	2469	29	30	11	2912
8-92	19130	17660	112	22	18	107
13-93	5933	3900	39	<1	<1	11
6-93	11360	27080	95	30	11	1702
9-93	11830	11940	67	22	13	95
4-94	4591	2764	25	6	<4	17
6-94	65150	58358	322	326	150	568
8-94	13642	12325	80	114	125	2092

