EPA 542-R-07-019
September 2007
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REMEDIATION SYSTEM EVALUATION (RSE)

CENTRAL CITY/CLEAR CREEK SUPERFUND SITE
ARGO TUNNEL WATER TREATMENT PLANT
IDAHO SPRINGS, COLORADO

Report of the Remediation System Evaluation
Site Visit Conducted May 16, 2007

Final Report
September 2007

NOTICE

Work described herein was performed by GeoTrans, Inc. (GeoTrans) for the U.S. Environmental Protection Agency (U.S. E.P.A). Work conducted by GeoTrans, including preparation of this report, was performed under EPA contract 68-C-02-092 to Dynamac Corporation, Ada, Oklahoma. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

EXECUTIVE SUMMARY

A Remediation System Evaluation (RSE) involves a team of expert scientists and engineers, independent of the site, conducting a third-party evaluation of site operations. It is a broad evaluation that considers the goals of the remedy, site conceptual model, above-ground and subsurface performance, and site closure strategy. The evaluation includes reviewing site documents, visiting the site for up to 1.5 days, and compiling a report that includes recommendations to improve the system. Recommendations with cost and cost savings estimates are provided in the following four categories:

- Improvements in remedy effectiveness
- Reductions in operation and maintenance costs
- Technical improvements
- Gaining site closeout

The recommendations are intended to help the site team identify opportunities for improvements. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation by the RSE team, and represent the opinions of the RSE team. These recommendations do not constitute requirements for future action, but rather are provided for the consideration of all stakeholders.

Clear Creek originates in the mountains near Colorado's Continental Divide and runs 60 miles east and several thousand feet lower in elevation to Golden, Colorado, a western suburb of Denver, Colorado and then discharges to the South Platte River north of Denver. The drainage basin encompasses approximately 400 square miles, including a portion of the Colorado Mineral Belt, which includes several mining districts in Clear Creek and Gilpin Counties. Due to the rich mineralization, these two counties became some of the most heavily mined areas of Colorado, with gold and silver accounting for the vast majority of the mining. As part of ore extraction activities, the miners constructed tunnels. Acidic, metal-rich water from these mine tunnels has continued to enter Clear Creek and its tributaries at many locations. The Argo Tunnel and Big Five Tunnel, located in Idaho Springs, Colorado, are two of the tunnels that EPA and CDPHE have focused on to reduce acid and metals loading to Clear Creek. The Argo Tunnel Water Treatment Plant (Argo WTP), which is located at the entrance of the Argo Tunnel, treats the discharge from these two tunnels as well as acidic and metals laden ground water from nearby Virginia Canyon. Although other sources of acid mine drainage and other remedies comprise this Superfund Site, the RSE team was specifically asked to focus its review on the Argo WTP.

In general, the RSE team found a competent and attentive operations team that was effectively meeting the challenges of a complex water treatment system. The observations and recommendations contained in this report are not intended to imply a deficiency in the work of either the system designers or operators, but are offered as constructive suggestions in the best interest of the EPA, the public, and the facility. These recommendations have the benefit of being formulated based on operational data unavailable to the original designers.

Recommendations are provided in three of the four categories: effectiveness, cost reduction, and technical improvement. No recommendations are provided regarding site closure. The recommendations for improving system effectiveness are as follows:

- Further consider the risks associated with future blowouts of the Argo Tunnel and the costs of implementing blowout control and come to a decision whether or not to move forward with blowout control. The majority of this recommendation would be implemented by CDPHE and EPA staff. Contractor support might be on the order of $20,000. If blowout control is implemented, the costs have been estimated to be on the order of $3 million to $5 million.

- Evaluate if the discharge of acidic and metals-rich ground water from Virginia Canyon should be better controlled during high flow events by either bypassing flow from the Argo Tunnel discharge or by increasing storage or treatment capacity. The majority of this recommendation would be implemented by CDPHE and EPA staff. Contractor support might be on the order of $10,000. Increased storage capacity could be achieved by implementing blowout control.

- Monitor the air in the treatment plant and confirm that appropriate medical monitoring of treatment plant operators is occurring given the potential for high metals dust in the treatment plant air. This recommendation might cost $2,000 to implement.

Recommendations for cost reduction include the following:

- Install a new platform and two new filter presses to facilitate solids handling and reduce operator labor. The site team has received a cost estimate of $560,000 to make this modification. Making this change should reduce operator labor and improve plant operations, with an estimated savings of $100,000 per year.

- Realize additional reductions in labor in a few years as a result of improving plant operations and addressing issues that have resulted from the conversion from caustic to lime. When current issues associated with the lime feed system, solids handling, filter scaling, and solids build up in the equalization basin are addressed, labor costs might be further reduced by $50,000 per year. Capital costs of $100,000 to $350,000 might be needed to address the filter scaling. The capital costs for other changes are included in the technical improvement recommendations.

- Consider improvements to the treatment system that will allow solids recycling as originally anticipated to improve the density of the clarifier underflow and the filter cake and to reduce lime and chemical usage. Design and implementation of the change suggested in this report might cost $75,000 to implement, but might result in $55,000 per year in savings, primarily from reduced solids transport and disposal costs.

In total, the RSE team identified approximately $205,000 per year in potential savings that could result from an investment of $960,000. Recommendations for technical improvement include the following:

- Reduce discharge of recycled solids and high pH water to equalization basins by modifying the mounting of the pH probe, improving filter press operations, and piping flow from the underbasin to the reaction tanks instead of the equalization basin.

- Improve the lime feed system by creating a recycling loop for the upper portion of the feed system and considering changes in metering pump design.

- Provide additional compressed air capacity to provide redundancy during high flow periods and to provide aeration associated with the solids recycling recommendation.

- Reduce solids wasting flow rate by reducing air flow to the diaphragm pumps with the use of a regulator and timer.

- Consider construction of an on-site solids disposal repository as a contingency to disposal at a landfill unless a closer evaluation of costs suggests that more substantial savings can be realized than suggested in this report.

- Consider additional improvements suggested by the site team, including the potential use of an autosampler for collecting effluent samples, a new turbidity meter for better control of the treatment process, and reserve lime or caustic storage.

The estimated capital costs for making these technical improvements are approximately $157,000. It is noted, however, that some of these changes would be needed to realize the above-mentioned additional reductions in labor in a few years.

A table summarizing the recommendations, including estimated costs and/or savings associated with those recommendations, is presented in Section 7.0 of this report.

PREFACE

This report was prepared as part of a project conducted by the United States Environmental Protection Agency Office of Superfund Remediation and Technology Innovation (U.S. EPA OSRTI) in support of the "Action Plan for Ground Water Remedy Optimization" (OSWER 9283.1-25, August 25, 2004). The objective of this project is to conduct Remediation System Evaluations (RSEs) at selected pump and treat (P&T) systems that are jointly funded by EPA and the associated State agency. The project contacts are as follows:

Organization	Key Contact	Contact Information
U.S. EPA Office of Superfund Remediation and Technology Innovation (OSRTI)	Charles Sands	2777 South Crystal Drive 5th Floor Mail Code 5204P Arlington, VA 22202 phone: 703-603-8857 sands.charles@epa.gov
Dynamac Corporation (Contractor to U.S. EPA)	Daniel F. Pope	Dynamac Corporation 3601 Oakridge Boulevard Ada, OK 74820 phone: 580-436-5740 fax: 580-436-6496 dpope@dynamac.com
GeoTrans, Inc. (Contractor to Dynamac)	Doug Sutton	GeoTrans, Inc. 2 Paragon Way Freehold, NJ 07728 phone: 732-409-0344 fax: 732-409-3020 dsutton@geotransinc.com

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1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000 and 2001 Remediation System Evaluations (RSEs) were conducted at 20 Fund-lead pump and treat (P&T) sites (i.e., those sites with pump and treat systems funded and managed by Superfund and the States). Due to the opportunities for system optimization that arose from those RSEs, EPA OSRTI has incorporated RSEs into a larger post-construction complete strategy for Fund-lead remedies as documented in *OSWER Directive No. 9283.1-25, Action Plan for Ground Water Remedy Optimization*. OSRTI has since commissioned RSEs at additional Fund-lead sites. An independent EPA contractor is conducting these RSEs, and representatives from EPA OSRTI are participating as observers.

The RSE process was developed by the US Army Corps of Engineers (USACE) and is documented on the following website:

http://www.environmental.usace.army.mil/library/guide/rsechk/rsechk.html

An RSE involves a team of expert scientists and engineers, independent of the site, conducting a third-party evaluation of site operations. It is a broad evaluation that considers the goals of the remedy, site conceptual model, above-ground and subsurface performance, and site closure strategy. The evaluation includes reviewing site documents, visiting the site for up to 1.5 days, and compiling a report that includes recommendations to improve the system. Recommendations with cost and cost savings estimates are provided in the following four categories:

- Improvements in remedy effectiveness
- Reductions in operation and maintenance costs
- Technical improvements
- Gaining site closeout

The recommendations are intended to help the site team (the responsible party and the regulators) identify opportunities for improvements. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation by the RSE team, and represent the opinions of the RSE team. These recommendations do not constitute requirements for future action, but rather are provided for the consideration of all site stakeholders.

The Clear Creek/Central City Superfund Site Argo Tunnel Water Treatment Plant was selected by EPA OSRTI based on a recommendation from EPA Region 8 and the Colorado Department of Public Health and Environment. The site team is primarily looking for cost-reduction strategies that will allow the system to more cost-effectively maintain its designed level of protectiveness. This report provides a brief background on the site and current operations, a summary of observations made during a site visit, and recommendations regarding the remedial approach. The cost impacts of the recommendations are also discussed.

1.2 TEAM COMPOSITION

The team conducting the RSE consisted of the following individuals:

Peter Rich, Civil and Environmental Engineer, GeoTrans, Inc.
Doug Sutton, Environmental Engineer, GeoTrans, Inc.
Rodger Hosier, Civil and Environmental Engineer, Tetra Tech RMC, Inc.
David Bohmann, Environmental Engineer, GeoTrans, Inc.

1.3 DOCUMENTS REVIEWED

Author	Date	Title
Thomas R. Wildeman	1/1/1983	Chemistry of the Argo Tunnel Water, Idaho Springs, Colorado
Black & Veatch	2/8/1983	Remedial Action Master Plan, Central City, Mines Drainage Sites
EPA	9/30/1987	Record of Decision – OU1
CDM	9/21/1990	Clear Creak Phase II Remedial Investigation
EPA	9/30/1991	Record of Decision – OU3
CDM	1/13/1994	Clear Creek Remedial Design: Argo Tunnel Active Treatment System Treatability Report, Bench-Scale Testing Draft Technical Memorandum
CDM	7/25/1994	Clear Creek Remedial Design: Argo Tunnel Active Treatment System Pre-Pilot Testing Evaluations Draft Technical Memorandum
CDM	5/12/1995	Clear Creek Remedial Design: Argo Tunnel Active Treatment System Additional Bench-Scale Testing Technical Memorandum
Infilco Degremont, Inc.	1983 – 1998	Assorted Instructions for System Installation, Engineering Drawings, and Communications with Project Team Regarding Design.
CDPHE	5/28/1999	Correspondence to Mr. Cevaal (CDM) from CDPHE (Ron Abel): Summary of Concerns with the Argo Tunnel Treatment Facility, Items Relating to Design and Construction Monitoring, 5/19/1999
J.E. Reynolds & Associates	4/28/2000	Engineering Evaluation: Argo Tunnel Active Treatment Facility, Idaho Springs, Colorado
Canadian Environmental and Metallurgical, Inc.	5/2001	High Density Sludge Process Pilot Scale Neutralization of Argo Tunnel Acidic Drainage
CDPHE	2002	Clear Creek/Central City Site Repository: Summary of Sludge Drying Pilot Tests
EPA	9/22/2003	Record of Decision Amendment – OU3
EPA	9/29/2004	Record of Decision – OU4
CDPHE	2004	Five Year Review

Golder Associates	5/15/2006	Argo Water Treatment Facility O&M Project Annual Report August 1, 2004 through July 31, 2005
Golder Associates	10/2006	Argo Water Treatment Facility O&M Project Annual Report August 1, 2005 through July 31, 2006
CDPHE	2006	Lime System Specifications
Golder Associates	3/24/2006	Clear Creek/Central City Superfund Site, Laboratory Testing and Material Characterization
Golder Associates	4/5/2006	Clear Creek/Central City Superfund Site, Repository Ste Characterization Assessment Cost Estimates Update
Golder Associates	10/2006	Argo Water Treatment Facility O&M Project Monthly Report September 2006
Golder Associates	11/2006	Argo Water Treatment Facility O&M Project Monthly Report October 2006
Golder Associates	12/2006	Argo Water Treatment Facility O&M Project Monthly Report November 2006
Goff Engineering and Surveying	12/23/2006	Argo Water Treatment Facility – Filter Press Modifications Structural Engineering Fee Proposal
Golder Associates	1/2007	Argo Water Treatment Facility O&M Project Monthly Report December 2006
Golder Associates	2/2007	Argo Water Treatment Facility O&M Project Monthly Report January 2007
Golder Associates	3/2007	Argo Water Treatment Facility O&M Project Monthly Report February 2007
Golder Associates	4/2007	Argo Water Treatment Facility O&M Project Monthly Report March 2007
CDPHE	4/20/2007	Argo Tunnel Source Control
CDPHE	2002 to present	Argo WTP Effluent Data
CDPHE	2006 to present	Virginia Canyon and Big Five Tunnel Data

1.4 PERSONS CONTACTED

The following individuals associated with the site were present for the visit:

Mary Scott, Project Manager, CDPHE
Mike Holmes, Remedial Project Manager, EPA Region 8
Lee Josselyn, Project Manager, Golder Associates
Victor Wirick, Incoming Project Manager, Golder Associates

1.5 SITE LOCATION, HISTORY, AND CHARACTERISTICS

1.5.1 LOCATION

Clear Creek originates in the mountains near Colorado's Continental Divide and runs 60 miles east and several thousand feet lower in elevation to Golden, Colorado, a western suburb of Denver, Colorado and then discharges to the South Platte River north of Denver. The drainage basin encompasses approximately 400 square miles, including a portion of the Colorado Mineral Belt, which includes several mining districts in Clear Creek and Gilpin Counties. Due to the rich mineralization, these two counties became some of the most heavily mined areas of Colorado, with gold and silver accounting for the vast majority of the mining. As part of ore extraction activities, the miners constructed tunnels. Acidic, metal-rich water from these mine tunnels has continued to enter Clear Creek and its tributaries at many locations. The Argo Tunnel and Big Five Tunnel, located in Idaho Springs, Colorado, are two of the tunnels that EPA and CDPHE have focused on to reduce acid and metals loading to Clear Creek. The Argo Tunnel Water Treatment Plant (Argo WTP), which is located at the entrance of the Argo Tunnel treats the discharge from these two tunnels as well as acidic and metals laden ground water from nearby Virginia Canyon. Figure 1-1 indicates the locations of the Argo Tunnel, Argo WTP, Big Five Tunnel, and Virginia Canyon.

Although other sources of acid mine drainage and other remedies comprise this Superfund Site, the RSE team was specifically asked to focus its review on the Argo WTP.

1.5.2 HISTORICAL PERSPECTIVE

Occasionally, one of the mine tunnels will produce a "blowout" releasing large quantities of water and sediment in a short period of time. A blowout can happen when debris, likely fallen from the tunnel roof, temporarily impounds water. Water pressure behind the debris dam eventually builds to the point where the dam material and everything behind it are pushed forcefully from the mouth of the tunnel. A blowout from the Argo Tunnel in 1980 focused EPA's attention on Clear Creek and was a significant factor when, three years later, EPA included the Site on the Superfund National Priorities List (NPL).

The Site was nominated for listing on the NPL in 1982 and added to the NPL in September 1983. Initially, EPA anticipated at least six Operable Units (OUs) for the Site: treatment of the acid drainage from five specific mine tunnels (OU1), remediation of the five tailings and waste rock piles near those tunnels (OU2), source control at the Argo Tunnel (OU3), blowout control at the Argo Tunnel (OU4), regional ground water contamination (OU5), and upstream mine tunnel discharges and tailings (OU6). Later, largely as a result of public comment received on the feasibility study for OU2, EPA combined OU3 and OU4 into a comprehensive remedial investigation and feasibility study of the Argo Tunnel and OU5 and OU6 into what has come to be known as the Phase II remedial investigation and feasibility study. One Record of Decision (ROD) was signed for both the Argo and Phase II studies. Together these studies are reflected in EPA planning documents as OU3, an expanded version of the original OU3.

The ROD for OU1 - Acid Mine Drainage Treatment - was signed September 30, 1987. The selected remedy was treatment of the acid discharges from five mine tunnels using an innovative technology, man-made wetlands. On June 15, 1988, EPA gave the lead for remedial design for OU1 to CDPHE. The lead for the Phase II remedial investigation and feasibility study was also given to CDPHE at that time.

The ROD for OU3 was signed on September 30, 1991 and amended the OU1 ROD. The OU3 ROD included, among other items, treatment of the Argo Tunnel mine water discharge. The OU3 ROD specified a more conventional treatment plant rather than man-made wetlands because the required large land area was not available near the Argo Tunnel. No action was specified to control blowouts from any of the mine tunnels. The Argo WTP began full operation on April 7, 1998 treating the discharge from the Argo Tunnel. The discharges from the Virginia Canyon ground water and Big Five Tunnel were added to the Argo WTP influent in 2006.

1.5.3 POTENTIAL SOURCES

The Argo Tunnel, Big Five Tunnel, and Virginia Canyon ground water are considered indefinite sources of acid mine drainage, requiring source control measures to occur on a continuous and indefinite basis.

The following table summarizes the flow rates, pH, and concentrations of predominant metals for each of these sources.

Parameter	Argo Tunnel*	Big Five Tunnel*	Virginia Canyon*
Average Flow (gpm)	200 to 450	15 to 40**	5 to 180**
pH	3	5.5	3
Iron (mg/L)	120	65	3
Manganese (mg/L)	90	30	90
Aluminum (mg/L)	20	5	80
Zinc (mg/L)	40	8	92
Copper (mg/L)	4	1	9

**All values are approximate based on historical data.*
***Flows to treatment plant can be controlled*

1.5.4 HYDROGEOLOGIC SETTING

The Argo Tunnel is 4.16 miles long and was used for drainage and transporting ore and waste rock to the mill. The Argo Tunnel reportedly was effective at draining many mines in the area. The drainage from the tunnel is relatively constant over the course of a year relative to infiltration from rainfall, but may vary from year to year from as low as 200 gpm to as high as 670 gpm. The lower flow rates of 200 gpm to 300 gpm were prevalent from the beginning of operation through 2006, which the site team reports were generally dry years. To date, 2007 has reportedly been a relatively wet year, and the flow rates from the tunnel have been on the higher end, requiring the treatment plant to handle approximately 450 gpm of influent, with flows from Virginia Canyon controlled to only 25 gpm.

The site team reports two large historic blowouts of the Argo Tunnel plus a few smaller blowouts (registering approximately 1,000 gpm over a few days). The first recorded blowout was reportedly in 1943 as a result of explosive work that was being conducted in the area. The second blowout occurred in 1980 and had an unknown cause but was presumably related to a partial collapse of the tunnel roof that blocked water flow and eventually gave way. The larger blowouts reportedly have the capability of large scale fish kills and interrupting the potable water supply for Golden and other municipalities. The smaller blowouts reportedly occurred during periods of high flow and were more readily diluted by the high flows of the creek.

1.5.5 POTENTIAL RECEPTORS

The segment of Clear Creek from the Argo Tunnel to Golden, Colorado is used for recreational (e.g., fishing, kayaking, etc.) and industrial uses as well as the potable water supply for Golden and other municipalities.

2.0 SYSTEM DESCRIPTION

2.1 SYSTEM OVERVIEW

The Argo WTP began full operation on April 7, 1998 treating the discharge from the Argo Tunnel, and the facility was deemed Operational and Functional on September 30, 1999. The discharge from the Virginia Canyon ground water was added to the WTP influent in January 2006 and the Big Five Tunnel discharge was added to the WTP influent in May 2006. The Argo WTP has had difficulty operating according to its design parameters and has undergone a number of evaluations in an attempt to improve performance.

2.2 COLLECTION SYSTEM

Discharge is collected from the Argo Tunnel through a grate located outside of the tunnel entrance that feeds directly into the WTP equalization basins. Discharges from the Virginia Canyon ground water and the Big Five Tunnel empty from pipe ends located in front of the Argo Tunnel and drain through the grate into the equalization basins. Mixing of the different flows therefore occurs immediately prior to the equalization basins. The ground water in Virginia Canyon is collected in a buried drain and conveyed from the collection area by gravity through HDPE pipe to the Argo location. The flow can be controlled by an actuated valve operated from the WTP control system. Flow from the Virginia Canyon collection can be as high as 180 gpm but during high flow periods is controlled to a lower flow rate so that the total influent to the WTP is within its treatment capacity. Uncollected ground water in Virginia Canyon eventually discharges to Clear Creek. The discharge from the Big Five Tunnel feeds by gravity into tanks at the Big Five Tunnel entrance and is then pumped on an intermittent basis to the Argo location. The tanks at the Big Five Tunnel location also receive water from a small seep that occurs along the Department of Transportation right-of-way at the nearby entrance to Interstate 70. Pumping from the Big Five collection tanks to the Argo location typically occurs six times a day for 40 minutes at 90 gpm, plus siphoned water on a continuous basis at 10 gpm.

2.3 TREATMENT SYSTEM

The treatment system adjusts pH and removes metals through chemical precipitation. The plant was originally designed to use caustic for pH adjustment but the caustic addition system was replaced by a lime feed system in late 2005 to reduce chemical costs. The WTP is divided into two identical treatment trains. Overall, the WTP has the following primary treatment components:

- Two 140,000-gallon equalization basins
- One lime storage and feed system
- Two rapid mix tanks with mixers
- Two pH meters to control lime adjustment
- Two Infilco-Degremont, Inc. reaction tank and clarifier units designed for minimum flow of 110 gpm and maximum flow of 350 gpm.
- One gravity sand filter with three bays with a total bed area of 240 square feet

- One hydrochloric acid metering system to lower pH after metals removal
- Solids handling pumps and two solids thickening tanks (5,000 gallons each)
- One 40-cubic foot filter press with automatic start/stop
- One 105-cubic foot filter press
- One 30 x 30 x 10 foot underbasin to receive backwash and water from floor drains
- One 30 x 30 x 10 foot underbasin to serve as a clear well to supply backwash or discharge by gravity to Clear Creek
- One programmable logic controller for the metals precipitation system
- One programmable logic controller for the lime feed system
- One programmable logic controller for the 40 cubic foot filter press
- One programmable logic controller for the balance of the system

The WTP also includes inactive caustic storage tanks and a carbon dioxide addition system that were used for pH adjustment before conversion to the lime system.

The WTP building has two floors, with treatment system, janitorial closet, workshop, and electrical control room on the bottom floor and office space, restrooms, and meeting areas on the top floor. An elevator is present for transportation between the floors.

2.4 MONITORING PROGRAM

Compliance monitoring consists of weekly effluent samples, monthly filter cake samples, and quarterly influent and stream samples. Effluent results are reported monthly in the Discharge Monitoring Report. Water samples are analyzed for pH, total suspended solids, hardness, total dissolved solids, and 12 metals. Filter cake samples are analyzed for eight toxic metals. Additional monitoring through Hach kits and sensors are used for controlling the WTP.

3.0 SYSTEM OBJECTIVES, PERFORMANCE, AND CLOSURE CRITERIA

3.1 CURRENT SYSTEM OBJECTIVES AND CLOSURE CRITERIA

The 1991 ROD for OU3 specified a number of objectives for the remedy, including waste piles, slope stabilization, and other measures. The one objective that applies to the Argo WTP is as follows:

> "Reducing contaminant loading from the mine drainage tunnels, for the contaminants of concern at the site, to levels which will allow state stream standards, and state table value standards (where they have been determined to be relevant and appropriate) to be met."

This objective pertains to long-term acid mine drainage source control. The parameters of concern that are monitored for the Discharge Monitoring Report are provided in the following section.

3.2 TREATMENT PLANT OPERATION STANDARDS

The treatment plant has the following discharge requirements.

Constituent	Units	30-Day Average	Daily Limits
pH			6.5-9
TSS	Ppm	20	30
Hardness	Ppm		
Iron	Ppb	15800	
Arsenic	Ppb	Report	400
Nickel	Ppb	850	Report
Silver	Ppb	0.02	0.62
Zinc	Ppb	225	Report
Aluminum	Ppb		
Cadmium	Ppb	3	5
Lead	Ppb	4.75	219
Copper	Ppb	17	35
Manganese	Ppb	800	Report
Calcium	Ppb		
Magnesium	Ppb		
TDS	Ppm		

4.0 FINDINGS AND OBSERVATIONS FROM THE RSE SITE VISIT

4.1 FINDINGS

The observations provided below are not intended to imply a deficiency in the work of the system designers, system operators, or site managers but are offered as constructive suggestions in the best interest of the EPA and the public. These observations have the benefit of being formulated based upon operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of acid mine drainage treatment have changed over time.

4.2 COMPONENT PERFORMANCE

4.2.1 COLLECTION SYSTEM

The collection system performs adequately under normal flow conditions but would not be capable of handling a large blowout from the Argo Tunnel. High flow from even relatively small blowouts (e.g., on the order of 1,000 gpm for a few days) would likely overwhelm the collection grate and treatment system capacity, resulting in discharge of untreated water from the Argo Tunnel to Clear Creek.

The RSE team did not evaluate the collection system design for Virginia Canyon. The system is capable of providing flows of up to 180 gpm. However, the collection system does not appear to be the limiting factor for this contribution of flow. Rather, the limiting step is the hydraulic capacity of the treatment plant. During high flow periods, the volume of water from the Argo and Big Five Tunnels requires reducing the flow from the Virginia Canyon collection system by adjusting a valve. During the RSE visit, flows were high due to spring runoff, and although the Virginia Canyon collection system was capable of providing 180 gpm, the flow was controlled to 25 gpm. As a result, approximately 155 gpm of impacted ground water from Virginia Canyon was discharging to Clear Creek due to a lack of capacity in the treatment plant and the decision to preferentially collect water from the Argo Tunnel.

4.2.2 EQUALIZATION BASINS

The equalization basins receive acid mine drainage flows from three sources, each with different chemistries. In addition, they receive water from backwashing the filters, from floor drains, filter press filtrate, and discharge of approximately 20 gpm of reacted water from between the rapid mix tanks and the reaction tanks from the pH probe housings. As a result of the mixing of flows with different chemistries, substantial precipitation occurs within the equalization basins leading to solids settling and clogging of the lines between the equalization basins and the treatment trains. At the time of the RSE, one of the valves controlling flow from the equalization basins was open 100% resulting in 300 gpm of flow to the corresponding treatment train, and the other valve was open 35% resulting in 300 gpm of flow to its corresponding treatment train. To maintain the 300 gpm of flow through one clogged line during high flow periods, the level in the equalization basins needs to increase, resulting in less storage and equalization capacity of these basins.

4.2.3 LIME STORAGE AND FEED SYSTEM

The lime storage and feed system was installed in June 2005 and fully replaced the caustic system in November 2005. The lime system includes a silo for storage, a slurry mix tank in the enclosure along with the silo, piping from the lime enclosure to the WTP, a day tank within the WTP for additional mixing, and diaphragm metering pumps for addition. An automatic flush is present to address clogging in the lines from the enclosure to the WTP but manual flushing is utilized for the 1-inch lines from the day tank to the feed location. Frequent blockages occur in these 1-inch lines resulting in lowered system pH and reduced metals removal until the blockage is addressed.

Automatic notifications of lime reserves provide little time (2 to 3 days) until lime runs low. The site team is aware of this and can order lime on a sufficiently frequent basis to maintain reserves; however, the operators are often hesitant to require lime deliveries at sufficient frequency because it results in less than a full load of lime being delivered and lime delivery drivers express frustration at delivering incomplete loads.

Issues with poor lime quality have caused problems with grit accumulating throughout the system. The grit has clogged lines in the lime feed system and settled in the reaction tanks, requiring additional maintenance. The site team has tried an alternate vendor but still has inconsistent lime quality.

4.2.4 pH ADJUSTMENT

Lime is added to the rapid mix tanks to increase the pH to 10.1 as determined by pH probes located between the rapid mix tanks and the reaction tanks. This pH set point has been chosen based on experience regarding the pH that is needed to reliably meet the manganese discharge limit of 800 ug/L. The pH probes foul and require cleaning and recalibration every few days. To facilitate this routine practice, the operators have created a stilling well where the pH probes experience a lower flow rate and can be pulled for maintenance twice a day without causing an uncontrolled release of process water from the probe location. This stilling well results in a constant discharge of approximately 10 gpm per treatment train of process water from between the rapid mix tanks and the reaction tanks. The 20 gpm (i.e., 10 gpm from each train) is discharged to the flow drain, which drains to one of the building underbasins and is eventually returned to the equalization basins.

Lime usage varies with flow and averages approximately 55,000 pounds per month. Peak lime usage occurred in May 2007 with approximately 180,000 pounds used.

4.2.5 CHEMICAL REACTION AND PRECIPITATION SYSTEM

The chemical reaction and precipitation system is a packaged unit designed by Infilco Degremont, Inc. that includes a reaction tank connected directly upstream of a settling tube clarifier. The reaction tank has a concentric design such that influent comes in through the bottom center draft tube of the tank, flows upward past the mixer impeller and polymer feed (where polymer is added to promote flocculation), over baffles, then down between the baffles and the outer part of the tank, and finally up to the top for discharge to the clarifier. The inner draft tube in the tank supposedly increases the reaction time and particle interaction to promote production of a dense floc and reduce the amount of pin floc. This design, however, results in solids settling prematurely in the outer portion of the reaction tank. Settling solids include grit from the lime system and metal hydroxide floc. The settling is most pronounced at lower flows and/or with solids recycling.

The settling tube design of the clarifier requires frequent cleaning of the settling tubes to prevent flow paths from becoming restricted. The settling tubes, however, are likely required for effective settling given the relatively small size of the clarifiers relative to process flow rates.

Solids are wasted from the bottom of the clarifier by air operated diaphragm pumps.

4.2.6 MEDIA FILTERS

The effluent from the clarifiers flows by gravity through a filter comprised of three equally sized cells. Each cell is 8 feet by 10 feet in horizontal dimensions and is designed for a capacity of 350 gpm (4.375 gpm per square foot). The system is designed for a backwash of 1,200 gpm at 20 psig and a surface wash at 80 gpm at 80 psig. This backwash rate corresponds to 15 gpm per square foot, which is comparable to typical filter applications; however, the plant operators report that the filters do not effectively backwash. During backwash, the filter bed does not expand as anticipated, and during the RSE site visit, the plant operators were actually bypassing the filters in order to keep the plant running. The plant operators have tried a number of solutions including adding the hydrochloric acid to decrease the pH prior to the filters rather than after the filters. They have also tried replacing the filter media and experimenting with the addition of air scouring to the backwash routine. The air scour attempt, however, was unsuccessful because the filter material had already consolidated prior to initiating the air scour. In addition, unequal distribution of the air indicating that the air distributors were not level or clogged.

Although the plant is able to meet discharge standards while bypassing the filters, minor upsets in the clarifier that would normally be addressed by a filter otherwise result in plant shutdowns or effluent quality excursions.

4.2.7 SOLIDS HANDLING

Solids are wasted from the sludge bed at the bottom of the clarifiers at 20 gpm through 1.5-inch PVC. The wasted solids are stored temporarily in the sludge storage/thickening tank before being dewatered in one of the two filter presses. The site team reports that solids wasting flows are too high and that more water than necessary is extracted from the clarifiers during wasting.

Two filter presses are in operation. One is a 40-cubic foot filter press from the original design. It is elevated above the plant floor and has an automatic shutoff. Although it was designed to dump directly into a rolloff bin, the addition of a second filter press beneath it requires (due to space constraints) that this 40-cubic foot filter press dump onto the floor. The other filter press was added after plant startup when a higher volume of sludge was produced than expected (due to a lower than expected density in the clarifier underflow and a lower than expected percent solids value in the filter cake). This second filter press is 105 cubic feet. It is located on the plant floor, requires manual operation, and also dumps to the plant floor. The pressed solids from the floor (from either press) are thus transported in a labor-intensive process by a small skid steer and by shovel into a rolloff bin.

Solids are disposed of in the Front Range Landfill located in Erie, Colorado, which is approximately 100 miles round trip from the site. The solids content from the clarifier is approximately 3.5% and the solids content of the pressed solids is approximately 15%.

4.2.8 CONTROLS

The treatment plant is controlled by the following four independent programmable logic controllers.

- One programmable logic controller for the metals precipitation system
- One programmable logic controller for the lime feed system
- One programmable logic controller for the 40 cubic foot filter press
- One programmable logic controller for the balance of the system

Controls for the Big Five Tunnel are achieved through radio telemetry.

The plant is attended from 7am to 5pm daily. The plant controls include a number of alarms that contact an operator on call, and the controls are accessible remotely using a project laptop.

4.3 Components Or Processes That Account For Majority of Annual Costs

Annual O&M costs are approximately $900,000 to $1,000,000 per year as summarized below.

Item Description	Estimated Annual Cost
Labor: Oversight and Project Management	$60,000
Labor: System Operation	$446,000
Utilities: Electricity	$35,000
Utilities: Natural Gas and Potable Water	$17,000
Chemicals	$109,000
Solids Transport and Disposal	$139,000
Monitoring Analytical Costs	$19,000
Routine Maintenance Equipment & Materials	$72,000
Non-Routine Maintenance Equipment & Materials	$60,000
Other Supplies	$9,000
Total Estimated Annual Cost	**$966,000**

Notes:
- *Excludes cost for CDPHE staff*
- *Chemical cost based on FY07 budget*
- *Transport and disposal costs based on FY06 actual*

4.3.1 Utilities

Electricity, which is utilized for operating the air compressors, pumps, and other motors within the plant, comprises the majority of the utility costs. Natural gas for heating costs approximately $12,000 per year, and city water for mixing polymer costs approximately $5,000 per year. The costs for phones and other similar services are likely included in the "Other Supplies" category.

4.3.2 Chemicals

As currently operated, the budget for chemicals includes $73,000 for lime, $15,000 for polymer, and $21,000 for hydrochloric acid.

4.3.3 Labor

Labor for the plant is divided into project management and operator categories. Project management is limited to less than 10 hours per week, which is reasonable for a plant of this complexity. Operator labor comprises the rest of the labor budget. A total of approximately 11,000 labor hours are budgeted for the site each year. The plant is staffed by the following individuals:

- A lead operator that works 8-hour days during the week and has primarily administrative responsibility, quality control, and technical lead on special maintenance/improvement projects

- A maintenance person that assists the lead operator and has responsibilities that are evenly split between maintenance activities and operations

- Two duty operators that each work four 10-hour days per week, with overlap on one of those days for heavier maintenance items, and responsibility for responding to alarms

- One assistant operator/laborer that works each day, primarily operating the filter presses, conducting janitorial activities, and cleaning up

- Two additional employees are brought in for help during high flow periods to allow for 24-hour coverage.

As indicated, the plant is staffed by four people per day plus an additional person during high flow periods.

4.3.4 TRANSPORT AND DISPOSAL

Transport and disposal costs for solids disposal are reportedly approximately $9.60 per cubic yard plus $370 per trip for each 18 cubic yard rolloff bin, plus a markup charged by the contractor on all reimbursable items.

4.3.5 CHEMICAL ANALYSIS

The chemical analysis costs are for the monitoring required for the NPDES permit equivalent. The costs represent weekly water samples that are analyzed for pH, total suspended solids, hardness, total dissolved solids, and 12 metals plus filter cake samples that are analyzed for eight toxic metals.

4.4 RECURRING PROBLEMS OR ISSUES

The site team reports the following recurring problems or issues:

- Labor intensive solids handling
- Labor intensive cleaning of the backwash underbasin and equalization tanks
- Clogging/scaling of filters
- Ice build-up on the building roof
- Lack of redundant air supply during high flow periods
- Poor lime quality and grit that settles throughout system
- Blockages in the lime feed system

4.5 REGULATORY COMPLIANCE

The treatment plant generally meets discharge standards. The manganese discharge limit of 800 ug/L is the most difficult standard for the plant to meet and is the primary cause for the large lime requirements and large quantity of sludge generated by the treatment process. The plant has exceeded this standard occasionally over the past several years as the treatment process has been improved. The plant occasionally experiences bypasses, including one immediately prior to the RSE site visit that resulted from a shortage of lime.

4.6 TREATMENT PROCESS EXCURSIONS AND UPSETS, ACCIDENTAL CONTAMINANT/REAGENT RELEASES

There have been no reported major upsets or accidents since the plant began operation other than the bypasses mentioned previously.

4.7 SAFETY RECORD

A reportable incident occurred in January 2007 due to snow/ice sliding off of the treatment plant roof. Administrative controls were in place but were not sufficient to prevent the incident. Engineering controls are being sought to prevent future incidents. Plant health and safety inspections are conducted on a bimonthly basis. This frequency is reduced from the original monthly basis after it was determined that bimonthly was sufficient.

5.0 EFFECTIVENESS OF THE SYSTEM TO PROTECT HUMAN HEALTH AND THE ENVIRONMENT

5.1 GROUND WATER

Ground water is addressed by this remedy through the interception of acidic, metal-rich ground water from Virginia Canyon. However, the purpose of intercepting the ground water is to protect nearby surface water (i.e., Clear Creek). During high flow periods, the treatment system lacks capacity to address all of the flow from the two tunnels and from Virginia Canyon. Current practice is to limit the flow that is accepted from the Virginia Canyon collection system, which means that uncollected water discharges to Clear Creek. Although the iron concentration in the Virginia Canyon water is substantially lower than that of the Argo Tunnel water, the manganese and pH are comparable between the two sources, and the aluminum, zinc, and copper are higher in the Virginia Canyon water.

5.2 SURFACE WATER

Surface water is the primary environmental media of concern at this site. The intent of the remedy is to protect Clear Creek against acid and metals loading from the abandoned Argo and Big Five Tunnels. The treatment plant is currently able to intercept and treat this discharge under most conditions. However, there is no infrastructure to protect against short-lived (e.g., on the order of a day) high flow events that exceed 700 gpm. Under most high flow events, the flow of Clear Creek will also be high such that a discharge above standards or a bypass will not likely result in harm to the ecosystem or uses of the water. Based on discussions during the RSE site visit, large blowouts during low, normal, or high flow periods would likely result in harm to the ecosystem and a temporary shut down of the water supply system for Golden, Colorado.

5.3 AIR

Air is not a primary environmental media of concern for the Argo WTP remedy. However, the indoor air quality of the plant is of interest to the health of the operators. The current solids handling practices result in substantial metals dust, including iron, manganese, aluminum, zinc, and copper. This dust, when inhaled, could lead to health concerns for the plant workers.

5.4 SOIL

Not applicable.

5.5 WETLANDS AND SEDIMENTS

Not applicable.

6.0 RECOMMENDATIONS

Cost estimates provided herein have levels of certainty comparable to those done for CERCLA Feasibility Studies (-30%/+50%), and these cost estimates have been prepared in a manner consistent with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July, 2000.

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

6.1.1 EVALUATE AND DECIDE ON NEED FOR BLOWOUT PREVENTION

Although the treatment plant routinely meets its discharge criteria and reduces discharge of acidic, metal-rich water to Clear Creek from the Argo Tunnel, Big Five Tunnel, and Virginia Canyon ground water, it is incapable of handling flows of over 700 gpm. Therefore, bypasses of the treatment system would likely occur during relatively short-lived flows of 1,000 gpm, such as those that were witnessed in 1995 and 1998. A significant bypass of the treatment plant could also occur during a blowout if debris in the tunnel were to block the flow of water and then suddenly give way. Site documents indicate that the volume of such a blowout could be on the order of 71 acre-feet.

Short-lived periods of flow over 700 gpm might occur on a fairly regular basis during the snow melt season, especially if the full volume of intercepted ground water from Virginia Canyon is considered (rather than controlled by a valve). These high flow discharge events would likely occur during periods of high flow for Clear Creek such that the environmental impacts would be reduced. However, a large blowout could occur during any season and could have significant impacts on the ecology of the creek and on downstream public water systems that draw water from Clear Creek. Therefore, the site stakeholders should come to agreement on how to address the potential for future blowouts. One side of the argument stresses that historic blowouts have occurred infrequently, and it is uncertain as to how many decades may pass before another blowout occurs. This side of the argument suggests that the $3 million to $5 million might be better spent on other aspects of the site. The other side of the argument stresses the severity impacts to the Clear Creek ecosystem and to the temporary shut down of the Golden, Colorado public water supply if a blowout occurs. Immediate harm to the public could also occur if the creek is being used for recreational purposes (e.g., fishing, kayaking, etc.) near the tunnel when a large blowout occurs.

This RSE has focused on the water treatment plant operation, and it is beyond the scope of the RSE to fully consider the risks associated with potential tunnel blowouts. However, it is important to note that the reported estimated capital costs for controlling future blowouts (and controlling tunnel flow in general), is only equal to 3 to 5 years of treatment plant O&M and likely comparable to the design and construction costs of the treatment plant. Therefore, the costs of this improvement would be relatively low compared to the long-term costs for this site. If the risks are substantial, the reported estimated capital cost is likely worth the investment. Control of tunnel blowouts was a component of the original ROD and one of the primary aspects of the site that gained the attention of CDPHE and EPA.

This evaluation will likely primarily involve interaction of EPA and CDPHE staff and management. Contractor costs to support this evaluation might be on the order of $20,000 for a limited paper review and meeting attendance.

6.1.2 Evaluate Importance of Complete Collection and Treatment of the Virginia Canyon Ground Water

During the high flow season, the treatment plant operators need to partially close the valve that controls flow from Virginia Canyon so that the treatment plant can accommodate the flow from the Argo and Big Five Tunnels. This approach, however, means that the Virginia Canyon collection system is effectively bypassed and acidic and metal-rich ground water in Virginia Canyon discharges to Clear Creek. As indicated in Section 1.5.3 of this report, the metals concentrations for aluminum, zinc, and copper are higher in the Virginia Canyon ground water than they are in the Argo Tunnel water. It is recommended that the site team evaluate the need to completely collect and treat the impacted ground water from Virginia Canyon. The RSE team sees the following potential outcomes of such an evaluation:

- Bypasses of the Virginia Canyon ground water collection system occur during periods of high flow in Clear Creek and are sufficiently diluted such that there are no adverse impacts to human health or the environment.

- The water quality of the Virginia Canyon ground water is worse than that of the Argo Tunnel such that during periods of high flow all of the Virginia Canyon ground water should be collected and treated and the Argo Tunnel water should be bypassed, if necessary.

- The loadings to Clear Creek from Virginia Canyon, the Argo Tunnel, and Big Five Tunnel are unacceptable, and modifications should be made to allow complete capture of all sources during the typical snowmelt season.

If the evaluation results in the third potential outcome, then one of the modifications that might be appropriate is including flow control for the Argo Tunnel such that the discharge of the Argo Tunnel could be stored while the flow from Virginia Canyon is addressed. If 100 gpm of discharge from the Argo Tunnel were to be stored for a period of 60 days, the total stored volume would be 8.6 million gallons or 26.5 acre-feet of water. This is approximately one third of the volume that would need to be controlled for a large blowout. Therefore, there is additional benefit to constructing a bulkhead for the Argo Tunnel for blowout/flow control.

Implementation of this recommendation is likely accomplished by CDPHE and EPA staff evaluating the flows from all of these acid mine drainage sources against the existing the NPDES permit equivalent and loading calculations. Further effort by CDPHE and EPA might be needed to prepare an Explanation of Significant Differences if the evaluation resulted in a different treatment strategy than is currently in place. Contractor support for this evaluation would likely be limited to organizing and preparing data for CDPHE and EPA to review. The cost for this support might be $10,000.

6.1.3 Evaluate Indoor Air Quality for Metals and Confirm Medical Monitoring for Plant Workers

The currently used solids handling process results in accumulation of solids on the floor and process equipment. When it dries, fine metal oxide dust can be produced that can negatively impact indoor air quality and work safety. It is recommended that indoor air quality be tested and compared to OSHA standards and that project managers confirm that medical monitoring of plant workers is being conducted to test blood levels of appropriate metals. This recommendation should cost less than $2,000 to implement.

6.2 RECOMMENDATIONS TO REDUCE COSTS

6.2.1 INSTALL NEW FILTER PRESSES

The current approach to dewatering solids is labor intensive and inefficient for two primary reasons. First, the large filter press is located on the floor and dumps the filter cake on the floor such that the filter cake needs to be manually placed in rolloff bins. Second, the large filter press does not have an automated shutoff, which requires additional operator attention and prevents the staff from starting a run before leaving for the evening. The site team has been considering a capital improvement to the plant that would involve extending the elevated platform where the current smaller filter press sits and replacing both filter presses with new automated 80 cubic-foot presses. Both presses would sit on the elevated platform and would dump into rolloff bins. The estimated capital cost is approximately $560,000 for this improvement. Although the cost is relatively high compared to annual costs, the modification should result in one less full time employee for operations at a projected annual savings of approximately $100,000 per year. In addition, by directly dumping to the rolloff bins, less solids will be on the floor, which will reduce the amount of metal dust in the plant and the amount of solids that are washed down drains to the underbasin and eventually to the equalization basin. This should improve indoor air quality (health and safety) and facilitate plant maintenance.

The RSE team recommends that this capital improvement be implemented. The estimated capital costs appear reasonable. Competitive bids should be obtained if they have not been already.

6.2.2 REALIZE SAVINGS FROM IMPROVED OPERATIONS IN FY09

Implementing Recommendation 6.2.1 should help reduce labor costs from $506,000 to approximately $406,000. Given the complexity of plant operations, maximum additional savings would likely be limited to an additional $50,000 per year if major recurring issues are resolved and labor can be reduced by one full-time worker to a half-time worker such that the plant operates with 3.5 employees during most of the year and 4 or 4.5 employees during the high flow season. The major issues to be addressed include installing the filter presses mentioned above, addressing the lime grit problem, addressing the filter scaling problem, and addressing other items listed in this RSE. Together, problems with the lime feed system and filter scaling have dominated the operations notes since August 2006 indicating that substantial operator and project management time has been devoted to addressing these issues. For example, activities regarding filter modifications and repair were noted on 12 days during January 2007, 17 days during February 2007, and 8 days during March 2007. Both of these issues result from conversion of caustic to lime and will eventually be resolved. The RSE team expects that these time-consuming issues will continue or new issues will arise in FY08 but that by FY09, the issues will be addressed and potential labor reductions might be possible. The lime problems are currently being addressed by the site team, and an additional suggested item for improvement is provided in Section 6.3 of this report. Below are three approaches to addressing the problems with the filters beyond those that are being attempted by the site team.

Approach #1 – Replace Filter Media in All Three Filter Cells and Implement Well-Designed Air Scour

The implementation of a well-designed air scour system is likely critical for future filter use. Even if anti-scaling agents or other improvements are made to the process water, air scour improves expansion of the filter bed and reduces the amount of water used for backwashing. Although air scour has been attempted, a well-designed system with effective air distribution on new, unconsolidated media has not been attempted. This approach involves replacing the filter media in each filter cell and installing effective air scour systems to be used with backwashing for all three cells. This modification, if feasible, might be accomplished for $100,000.

Approach #2 –Replace Filters with New Units that Have Integrated Air Scour for Backwashing

If the current filters cannot be modified to include effective air scour, the site team might consider installing new filter units that include effective air scour. This approach might cost $200,000 to remove the existing filters, replace them with other units, and provide additional air compressors/blowers for air scouring. Due to the increased capital cost, this approach should only be used if the modification of the current filter cells is not feasible or not practical.

Approach #3 – Precipitate Metals at a Lower pH and Remove Remaining Manganese with Potassium Permanganate and Greensand Filters

Potassium permanganate addition and greensand filters were considered earlier in the design but were eliminated from consideration due to the cost of reagents. The estimated cost for potassium permanganate was over $400,000 per year to achieve oxidation of the manganese. However, this analysis was done on the treatment system influent and the amount of potassium permanganate was based on the total influent of manganese to the plant rather than the manganese that was present in the effluent of the clarifier. The site team currently operates the metals removal system at pH 10.1 and has tried to reduce it in the past but could not meet the manganese discharge standard of 800 ug/L at a lower pH. Under this approach, the site team would reduce the pH to various set points and monitor the manganese levels in the clarifier effluent. As the pH decreases, less lime will be required, less sludge will be generated, and less scaling will occur on the filters. However, the manganese levels will increase requiring an increased level of potassium permanganate and greensand. The savings associated with this approach are difficult to calculate. Testing may indicate that savings in reduced sludge disposal, lime usage, and hydrochloric acid usage are offset by potassium permanganate costs. A 90% reduction in the manganese concentrations by metals precipitation would result in permanganate costs of $40,000 per year. The costs of permanganate would likely offset the savings from reduced lime usage and sludge generation.

The primary reduction in sludge volume would likely result from a decrease in the production of magnesium hydroxide. Sludge volumes have not increased as a result of the transition from using caustic to lime, suggesting that the use of lime is not adding to sludge volume. It is noted that magnesium concentrations decrease from approximately 120 mg/L in the influent to approximately 40 mg/L in the effluent. Because magnesium hydroxide typically forms at a higher pH, a reduced pH should decrease the amount formed. The primary reduction in scaling would result from lower calcium concentrations in the clarifier effluent. The product of the current calcium and sulfate concentrations exceed the solubility product for calcium sulfate, suggesting that it may be contributing to filter scaling. Furthermore, scaling was not an issue when caustic was used for pH adjustment.

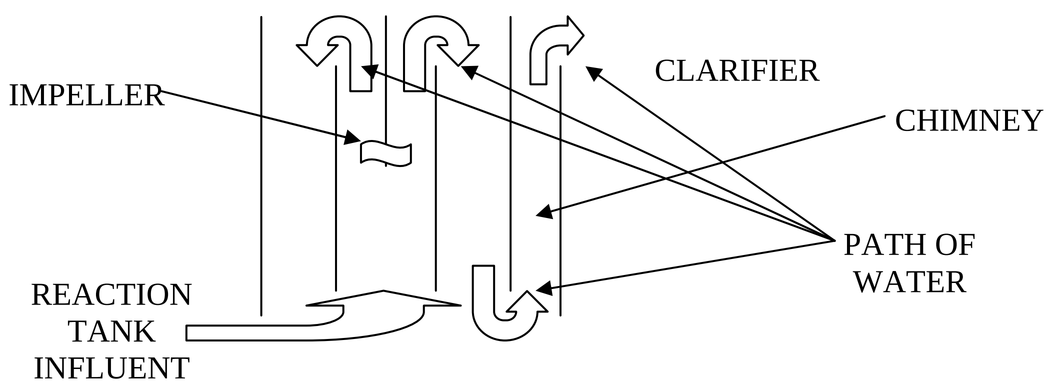
The cost for implementing this approach may be as high as $350,000 to pilot this approach, remove the existing filters and replace them with greensand filters with a total hydraulic capacity of over 700 gpm, and add air scour capability for backwashing. Given the substantial capital cost and the negligible savings, this approach should only be considered if other approaches to resolving the filter scaling are unsuccessful or if the site team is confident that substantially lower permanganate use would be required than assumed here.

6.2.3 IMPROVE METALS TREATMENT BY SOLIDS RECYCLING

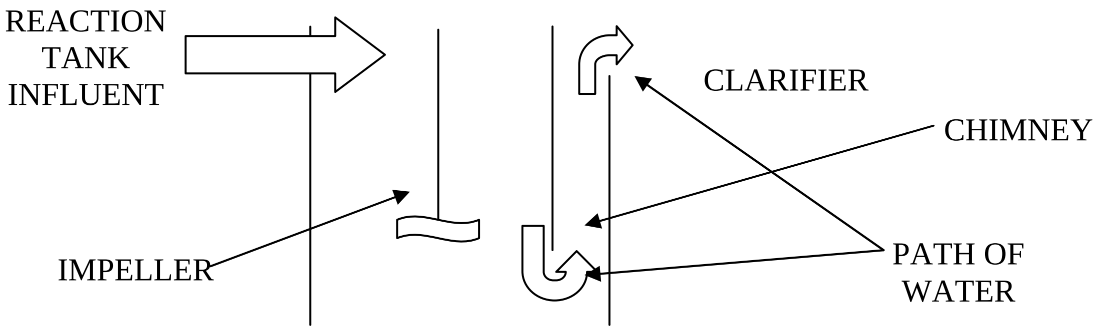
After labor, solids transport and disposal and chemicals represent the next largest cost categories. In FY06, solids transport and disposal cost approximately $140,000. As indicated in Recommendation 6.3.6, the on-site repository may not provide substantial savings. Therefore, reduction in this cost category will need to result from either decreased solids production or increased solids density. The cost for chemicals is mostly for lime. Together, the hydrochloric acid and polymer are half the cost of the lime. No alternatives for hydrochloric acid or polymer are suggested. For decreasing pH after solids removal, sulfuric acid would increase sulfate concentrations and carbon dioxide would increase carbonate concentrations, further increasing the potential for scaling. As a result, reductions in lime and other chemical usage, if it is going to occur, will need to result from removing metals at a lower pH. This would reduce lime usage, reduce hydrochloric acid usage, and reduce solids generation. The RSE team provides the following approach for consideration.

The WTP was originally conceived to use solids recycling, but the design has seemingly prevented this from being implemented. Convincing small scale pilot tests conducted at the plant, however, suggest that solids recycling in a high density sludge (HDS) configuration can substantially reduce lime usage and increase sludge density. The site team has reportedly attempted solids recycling previously at relatively low flow rates (e.g., 5% of influent flow), but efforts have been complicated by solids settling in the chimney of the reaction chamber and blocking the flow to the clarifier. Effective solids recycling likely needs to be conducted at a higher flow rate to increase the solids concentration and the flow in the reaction chamber. It is also apparent that modifications would need to be made to the reaction chamber to prevent solids from settling in the chimney between the reaction tank and the clarifier.

With the current reaction tank design, water must flow up past the impeller in the center of the tank, over a baffle into the outer portion of the tank, down to the bottom of the tank, and then up the entire height of the tank over a baffle into the clarifier (see figure below).



This is a relatively tortuous path for the solids-laden water to travel. Typically, a baffle is provided to prevent the turbulence associated with mixing from affecting the clarifier; however, this design appears to include additional separation. Solids settling within the chimney might be greatly reduced if the inner walls of the reaction tank were removed and the baffle between the tank and the chimney was raised/shortened so that the mixing of the impeller would prevent solids from settling in the tank and the upward path to the clarifier is shortened. The influent location and impeller and mixer design may need to be modified to provide adequate mixing in this larger tank volume. A figure of the potential revised design is shown below.



If this approach is not possible, the site team might consider adding additional mixing or turbulence to the existing chimney area to prevent settling.

An effective solids recycle ratio and other parameters might be taken from the results of the previous pilot test, but it is acknowledged that the pilot test was conducted before the contributions from the Big Five Tunnel and Virginia Canyon were added. With aeration, the pilot tests suggested that increased sludge density and manganese removal could be achieved with pH 9.5. A reduction in lime and hydrochloric acid usage is expected but is hard to predict. It appears reasonable to assume that sludge density in the clarifier underflow might double and that pressed sludge volumes might decrease by half due to the lesser mass of solids (less lime and precipitate from a lower operating pH) and likely a drier filter cake. If this is the case, the number of press pulls would be reduced, which would help operate the plant at reduced labor (See Recommendation 6.2.2), and the cost to dispose of sludge would decrease by $70,000 per year. The reduced pH and improved solids settling would theoretically help reduce the solids loading or scaling on the filters. The above savings would be partially offset by the cost of aeration, which might require a 20 horsepower compressor as indicated in the pilot test report. The cost of electricity to operate this compressor might be $15,000 per year, reducing the potential savings from solids recycling to $55,000 per year.

The capital costs for implementing this change might include $75,000 for design and implementation of the change to the reaction tanks and aeration. The capital cost of additional aeration is included in Recommendation 6.3.3. The selection and testing of system parameters (e.g., solids recycling ratio, pH set point, etc.) would be determined by testing from the current project management team and plant operators. It is assumed that once the lime and filter issues are addressed that the current level of staffing could conduct the necessary testing and work out operational issues by FY09.

6.3 RECOMMENDATIONS FOR TECHNICAL IMPROVEMENT

6.3.1 REDUCE DISCHARGE OF RECYCLED SOLIDS AND HIGH pH WATER TO EQUALIZATION BASINS

The project team reports solids build up in the equalization basins that require a substantial level of effort to clean. During the RSE site visit, the line from the equalization basin for treatment train #1 was fouling. The valve controlling flow from the basin to the treatment train was 100% open with 300 gpm of process flow. By comparison, the value for train #2 was only 35% open with 300 gpm of process flow. This fouling will eventually require that solids be removed from the equalization basin and the pipe. If this cleaning is necessary during the high flow period when both trains are needed, a bypass would likely occur due to insufficient capacity.

The solids build up and fouling of the equalization basins is likely primarily the result of high solids and high pH water being returned to the equalization basins from a number of sources including the floor drains, filter backwashing, filter press filtrate, and a constant drain of 10 gpm from each of the pH probe mounting locations. The solids settle in the equalization basin, and the high pH of this post rapid-mix process water reacts with the metals laden acidic water from the tunnels and Virginia Canyon forming additional solids. In March 2007, this post rapid-mix process water was approximately 13% of the volume of acid mine drainage entering the equalization basins. At a pH of 10.1, substantial solids generation can occur within the equalization basins. There are two primary suggestions for reducing the return of this high pH water to the equalization basins.

Modify Mounting of pH Probes

The pH probes are currently mounted in a "still well" type configuration in which approximately 10 gpm of process water from between the rapid mix tank and reaction tank for each treatment train is drained through a 3 inch pipe where the probe is mounted. The project team conveyed that this configuration was used to facilitate removal of the pH probe and to reduce the flow velocity around the probe to reduce fouling. The flow velocity around the pH probe can be reduced by branching off of and returning to the main process line rather than discharging 10 gpm of water to the floor drain. Easy insertion and removal of the valve could be accomplished by isolating the mounting area on this branched line with two valves or by using an insertion and removal type mounting that allows the probe to be inserted/removed without interrupting process flow. This modification to both treatment trains could likely be made for under $5,000.

Pipe Return from Underbasin to Rapid Mix Tanks Rather than Equalization Tanks

The high solids and pH water from the underbasin could be piped back to the rapid mix tank instead of the equalization tank. The underbasin would serve to equalize flow, and a variable speed drive and flow meter could be installed in the line to maintain a relatively constant flow from the underbasin to keep the treatment trains in equilibrium. This modification would likely cost $20,000 to implement.

6.3.2 IMPROVE LIME FEED SYSTEM

Clogging of the lime feed system has been a recurring problem. The RSE team recommends the following improvement.

Lime feed systems are usually designed to constantly circulate slurry in a looped system in order to minimize the formation of obstructions in pipes, valves, and pumps carrying the slurry. The lime feed systems at the Argo WTP do not include this feature. Instead, piping between the mix tank below the lime silo and the day tank in the WTP building is cleaned with an automatic water flush. For pipes, pumps, and valves between the day tank and points of application, only a manual flushing system is available. Because flow rates through these components are lower and manual flushing can be overlooked (or omitted during evening hours), more frequent blockages occur.

The upper lime feed system could be modified to constantly circulate flow in a loop from the slurry mixing tank to the treatment building and back. Slurry would circulate constantly at flow rates greater than the peak needed for pH control. The circulation line would need to be adequately sized to provide lime to both treatment trains or two separate recirculation lines (one per train) would be needed.

Peristaltic hose pumps might prove to be less maintenance intensive than other pump types for this service.

For the lower system, metering pumps could withdraw slurry directly from the circulating pipe system (thus eliminating the need for the existing day tank). In a manner similar to the existing operations, the metering pumps would then inject lime slurry into the influent flow at rates paced to maintain the desired pH. If clogging of the currently installed diaphragm style chemical metering pumps and appurtenances continues to be problematic after the grit removal system is installed, variable speed peristaltic hose pumps could be a viable alternative.

The above modifications, including purchasing of new metering pumps for both the upper and lower feed systems, might be accomplished for $20,000. Improved operation, a reduction in maintenance, and fewer alarm callouts should result.

6.3.3 PROVIDE ADDITIONAL COMPRESSED AIR CAPACITY

The plant operators and project manager stated that the maximum compressed air capacity is used by the treatment plant during high flow periods. Some processes need to be timed appropriately to have sufficient capacity. Given the importance of compressed air in operating the plant (metering pumps, filter presses, wasting pumps, etc.), the plant would need to run at reduced capacity during a high flow period if one of the air compressors needed service. This would likely result in a plant bypass. Additional compressed air capacity should be provided for redundancy. Additional capacity would likely cost $60,000 for an additional 40 horsepower of compressed air capacity.

6.3.4 REDUCE SOLIDS WASTING FLOW RATE

During the site visit, the plant operators indicated that the flow rate of the diaphragm wasting pumps was too high and entrained more water than necessary. The RSE team suggests that this flow be controlled by reducing the air flow rate to the pumps with regulators and by adding timers to waste sludge periodically rather than continuously. This modification can be implemented at a cost of about $2,000.

6.3.5 CONSIDER CONSTRUCTION OF AN ON-SITE SOLIDS DISPOSAL REPOSITORY AS A CONTINGENCY TO DISPOSAL AT A LANDFILL

The site team has been considering the construction of an on-site repository near the former Druid Mine for solids disposal from this and other operable units for the site. Efforts to date have focused on the constructability of the material anticipating that the repository would include both below grade and above grade sections. The consistency of dewatered solids, however, does not have the properties necessary for above grade construction. The estimated costs for the repository include an HDPE liner, leachate collection system, HDPE cover, and revegetation. The RSE team agrees with the concept of the on-site repository as a contingency to landfill disposal but has some suggestions with regard to design.

The RSE team recommends the use of a below grade repository only for the solids from the WTP. It is suggested that the repository consist of an excavated area that can be backfilled with solids and then covered with excavated material and revegetated. Above ground portions of the repository are not recommended, and the HDPE liner and leachate collection system are not necessary in the opinion of the RSE team. The repository will be built within the area drained by the Argo Tunnel such that any water that does drain from the solids will be recaptured by the tunnel and WTP. The amount of water retained in the solids that could potentially drain is very low compared to the amount of precipitation that may infiltrate. As such, the liner and leachate collection system are added features that will create additional work without providing much benefit.

A repository could be built each year for that year's anticipated solids disposal volume and covered at the end of each season. Due to potential access issues, use of the repository may not be appropriate in winter, but for the greatest return on investment, the repository should be accessible during the spring for the high flow snow melt season. For the winter months that the repository is not accessible, disposal could continue at the landfill. Assuming 25% of the solids generated from the plant each year would be taken to a landfill, approximately 2,700 cubic yards of disposal volume in a repository may be required for the remainder of the solids. Assuming a depth of 6 feet, this translates to an area of approximately 12,000 square feet or 0.28 acres. The cost to construct and close a repository of this size should be less than $50,000. Initial costs for road improvements might cost $25,000 based on estimates provided by the site contractor, who has presumably reviewed the current conditions.

The savings from avoiding landfill disposal at current rates would be similar. Current transport and disposal costs are reported as $370 per load of 18 cubic yards for transport, $9.60 per cubic yard for disposal, and a markup by the site contractor for reimbursable costs. Including the markup, the unit rates are closer to $450 per load of 18 cubic yards for transport and $11.50 per cubic yard for disposal. The disposal costs would be eliminated, and because of the closer proximity of the on-site repository, the transport cost might be $300 instead of $450 per load. The savings would therefore be approximately $54,000 per year. As a result, the RSE team recommends that the on-site repository, in the manner described here, be considered as a contingency if transport and disposal rates for the landfill increase substantially or repository construction and closure can be accomplished for under $40,000.

6.3.6 ADDITIONAL IMPROVEMENTS

The site team had other suggestions for improvements that could facilitate plant operations. Some of these that the RSE team supports include the following:

- Autosampler – Currently, six four-hour composite effluent samples are collected on weekly basis for the discharge monitoring report. This can be time consuming, and if efforts are going to be made to reduce labor in the future, an autosampler would be appropriate.

- Turbidity meter – The plant operators and project managers indicated that the current turbidity meter is not effective at detecting the small pin floc in the clarifier effluent that typically signals sludge baulking will occur. A different turbidity meter might provide a better warning so that the treatment process can be adjusted. One potential option is the SOLITAX turbidity and suspended solids analyzer by Hach, which costs approximately $5,000.

- Additional lime storage – The site team also suggested the need for additional lime storage given that a bypass recently occurred as a result of a lime shortage. During high flow periods, the current lime storage capacity provides little time between alarms and coordinating the next lime shipment. Lime is currently delivered to the site in 45,000-pound loads, which is sufficient for 20 days of normal operation but only seven or eight days during high flow periods. The site team could consider either additional lime storage or a backup supply of caustic to use while a new shipment of lime is expected.

The RSE team suggests that $25,000 might be appropriate to acquire/install the above items.

6.4 CONSIDERATIONS FOR GAINING SITE CLOSE OUT

No recommendations provided in this category.

6.5 CONSIDERATIONS FOR IMPLEMENTATION

The RSE team provides the following suggestions for implementing the above recommendations. Priority should be given to those recommendations that could be implemented relatively quickly and can result in a significant improvement to plant operation. Recommendations 6.1.3 (air quality and medical monitoring), 6.2.1 (new filter presses), 6.3.1 (reducing solids and caustic discharge to equalization basins), 6.3.2 (improving lime feed system), and 6.3.4 (reduce solids wasting rate) could be implemented immediately. Recommendations 6.1.2 (evaluate discharge from Virginia Canyon) and 6.3.3 (additional compressed air capacity) should be implemented before the next snow melt season. Recommendation 6.2.2 should be considered during the low flow period during the summer and early fall of 2008, and recommendations 6.1.1 and 6.2.3 should be considered after these other recommendations have been addressed.

7.0 RECOMMENDATIONS

The observations and recommendations contained in this report are not intended to imply a deficiency in the work of either the system designers or operators, but are offered as constructive suggestions in the best interest of the EPA and the public. These recommendations have the benefit of being formulated based upon operational data unavailable to the original designers.

Recommendations are provided in three of the four categories: effectiveness, cost reduction, and technical improvement. Table 7-1 summarizes the costs and cost savings associated with each recommendation. Capital costs, the change in annual costs, and the change in life-cycle costs are presented for each recommendation.

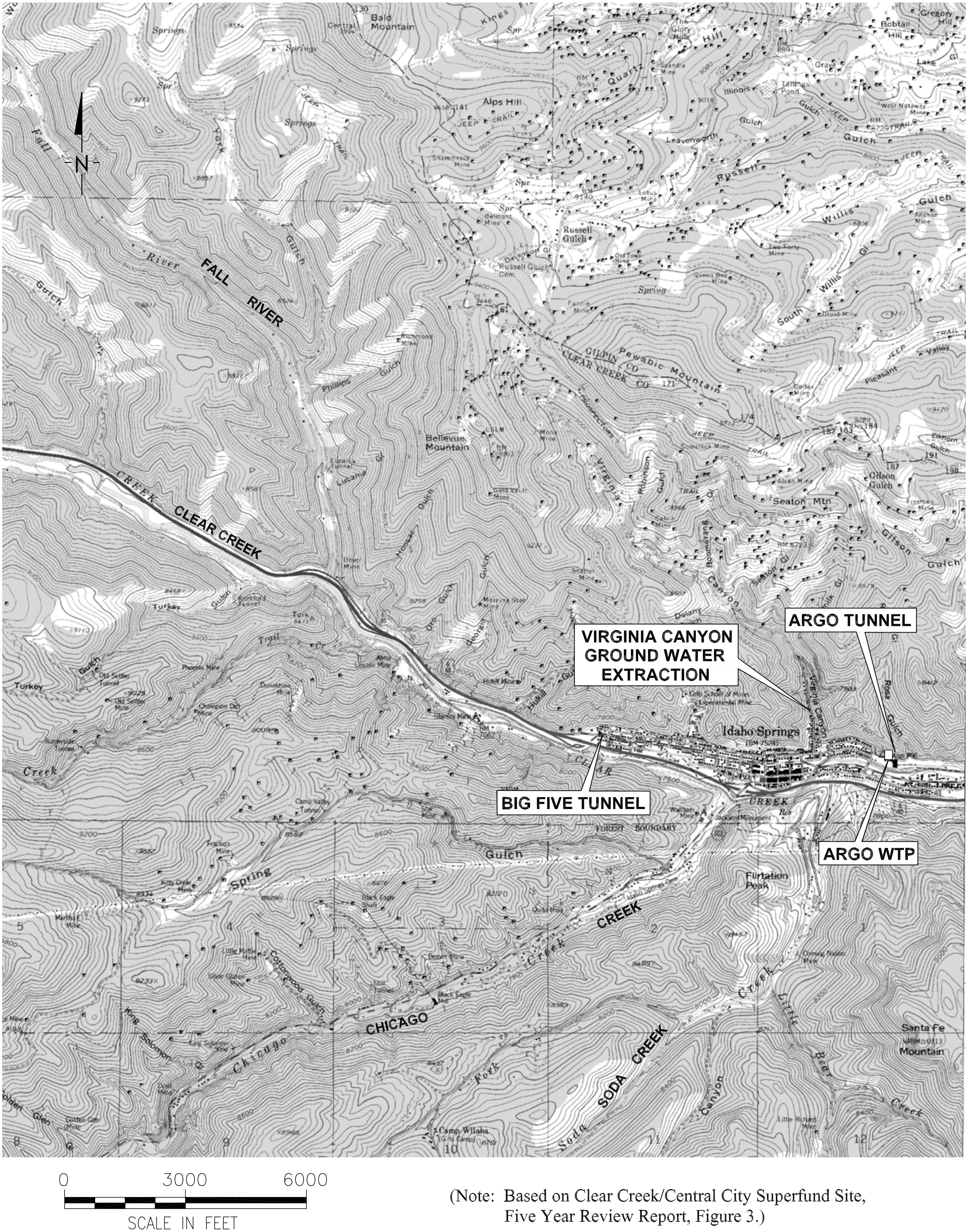
Table 7-1. Cost Summary Table

Recommendation	Reason	Additional Capital Costs ($)	Estimated Change in Annual Costs ($/yr)	Estimated Change in Life-Cycle Costs $*	Estimated Change in Life-Cycle Costs (net present value) $**
6.1.1 Evaluate and Decide on Need for Blowout Prevention	Effectiveness	$20,000	$0	$20,000	$20,000
6.1.2 Evaluate Importance of Complete Collection and Treatment of the Virginia Canyon Ground Water	Effectiveness	$10,000	$0	$10,000	$10,000
6.1.3 Evaluate Indoor Air Quality for Metals And Confirm Medical Monitoring for Plant Workers	Effectiveness	$,2000	$0	$2,000	$2,000
6.2.1 Install New Filter Presses	Cost Reduction	$560,000	($100,000)	($2,440,000)	($1,054,000)
6.2.2 Realize Savings from Improved Operations in FY09	Cost Reduction	$100,000 To $350,000	($50,000)	($1,400,000) To ($1,150,000)	($707,000) To ($457,000)
6.2.3 Improve Metals Treatment by Solids Recycling	Cost Reduction	$75,000	($55,000)	($1,575,000)	($812,000)
6.3.1 Reduce Discharge of Recycled Solids and High pH Water to Equalization Basins	Technical Improvement	$25,000	$0	$25,000	$25,000
6.3.2 Improve Lime Feed System	Technical Improvement	$20,000	$0	$20,000	$20,000
6.3.3 Provide Additional Compressed Air Capacity	Technical Improvement	$60,000	$0	$60,000	$60,000
6.3.4 Reduce Solids Wasting Flow Rate	Technical Improvement	$2,000	$0	$2,000	$2,000
6.3.5 Consider Construction of an On-Site Solids Disposal Repository as a Contingency to Disposal at a Landfill	Technical Improvement	$25,000	$4,000	($95,000)	($40,000)
6.3.6 Additional Improvements	Technical Improvement	$25,000	$0	$25,000	$25,000

Costs in parentheses imply cost reductions
* assumes 5 years of operation with a discount rate of 0% (i.e., no discounting)
** assumes 5 years of operation with a discount rate of 5% and no discounting in the first year

FIGURES

FIGURE 1-1. MAP OF AREA ADDRESSED BY THE ARGO WTP.



(Note: Based on Clear Creek/Central City Superfund Site, Five Year Review Report, Figure 3.)