



EPA 542-R-13-004

July 2013

Office of Solid Waste and Emergency Response
Office of Superfund Remediation and
Technology Innovation

**Optimization Review
Bunker Hill Mining and Metallurgical Complex
Superfund Site
Central Treatment Plant (CTP)**

Kellogg, Shoshone County, Idaho

OPTIMIZATION REVIEW

**BUNKER HILL MINING AND METALLURGICAL COMPLEX
SUPERFUND SITE
CENTRAL TREATMENT PLANT (CTP)
KELLOGG, SHOSHONE COUNTY, IDAHO**

Report of the Optimization Review
Site Visit Conducted at the Bunker Hill Mining and Metallurgical Complex Superfund Site
April 19, 2012

July 31, 2013

EXECUTIVE SUMMARY

Optimization Background

The EPA's working definition of optimization is as follows:

“Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness.”⁽¹⁾

An optimization review considers the goals of the remedy, available site data, conceptual site model (CSM), remedy performance, protectiveness, cost-effectiveness and closure strategy. A strong interest in sustainability has also developed in the private sector and within Federal, State and Municipal governments. Consistent with this interest, optimization now routinely considers green remediation and environmental footprint reduction during optimization reviews.

An optimization review includes reviewing site documents, interviewing site stakeholders, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. 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, and represent the opinions of the optimization review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the EPA Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive,

¹ U.S. Environmental Protection Agency. 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28

planning documents such as work plans, sampling plans and quality assurance project plans (QAPP).

Detailed consideration of EPA policy was not part of the scope of work for this optimization review. EPA Region 10 and the EPA Office of Superfund Remediation and Technology Innovation (OSRTI) will address EPA policy issues when considering the technical recommendations provided in this report.

Site-Specific Background

The Bunker Hill Mining and Metallurgical Complex Superfund Site includes all areas of the Coeur d'Alene Basin where mining-related contamination occurred and encompasses a 21-square mile "Box" along Interstate 90 surrounding the former smelter complex. Operable Unit 1 (OU1) includes the populated areas and Operable Unit 2 (OU2) includes the non-populated areas within the "Box." Operable Unit 3 (OU3) includes areas outside of the "Box" from near the Idaho-Montana border to the State of Washington where mining-related contamination is present. Contaminants of concern in soil, sediments, surface water and groundwater are specific heavy metals which include arsenic, cadmium, lead, mercury and zinc. The 2001 OU2 Record of Decision (ROD) Amendment (also referred to as the Mine Water ROD Amendment) indicated that remediation would include acid mine drainage (AMD) source control, AMD collection, AMD storage, AMD treatment, sludge management and monitoring. AMD treatment is currently provided by the Central Treatment Plant (CTP) which is the focus of this optimization review. The CTP has been operating since 1974 and needs various upgrades and repairs. According to the 2000 *CTP Master Plan* (Appendix E of the Mine Water Management Remedial Investigation/Feasibility Study, CH2MHill, 2001), upgrades are needed to improve effluent quality, reduce sludge production, increase system reliability and optimize capital and operating costs. Several CTP upgrades were made prior to the optimization review, and several other upgrades, unrelated to the optimization review are planned.

Summary of CSM

The CSM for the Site was not reviewed as this optimization review was focused solely on the operations of the CTP.

Summary of Findings

The following is a brief summary of the key findings from the optimization review:

- The CTP is operated effectively and meets current discharge standards under normal operating conditions; however, exceedances (primarily for zinc) have occurred during high flows associated with spring runoff.
- Mitigation efforts were identified prior to this review to reduce the amount of AMD discharge by reducing surface water infiltration. A key potential mitigation which has been identified would involve a diversion of the West Fork of Milo Creek, which could potentially reduce Kellogg Tunnel AMD flow by approximately 50 percent.

- Approximate zinc concentrations in the influent sources to the CTP are:
 - Kellogg Tunnel: 100 milligrams per liter (mg/L) (up to 500 mg/L during high flows)
 - Smelter Closure Area: 15 mg/L
 - Sources identified in the 2012 Upper Basin ROD Amendment for future collection and conveyance to the CTP:
 - OU2 sources: 24.5 mg/L
 - OU3 – Woodland Park, Osburn Drain and Gem #3: 4.12 mg/L
 - OU3 (other) sources: 2.54 mg/L

- Ferguson Contracting (Ferguson) staffs the CTP with two operators for 8 hours per day, 7 days per week. Ferguson provides additional off-hour staffing during high flow periods (typically spring runoff). Routine operator labor expenses are approximately \$350,000 per year out of a total operation and maintenance (O&M) cost of approximately \$942,000 per year.

- Approximately 2.4 tons of lime are used in the CTP per day at a current cost of approximately \$250 per ton or \$18,000 per month. Polymer costs for flocculation are reported to be approximately \$3,000 per month.

- Power costs are approximately \$110,000 per year with a demand of approximately 200 kilowatts (KW). The electricity usage of 1.8 million kilowatt-hours (kWh) per year is the primary contributor to the CTP's energy footprint.

- CTP compliance monitoring requirements include the collection and analysis of approximately 300 samples per year. Laboratory costs from 2006 to 2011 were reported to be approximately \$120,000 per year. Sampling frequencies for 2012 and future years have been reduced by the site team prior to the optimization review by 50 percent. Based on the optimization team review, the new monitoring frequencies are appropriate.

- The following improvements have been implemented at the CTP within the last 10 years:
 - Constructed the direct feed branch of the mine water pipeline to provide gravity flow of AMD directly to the CTP.
 - Refurbished the thickener.
 - Increased the CTP hydraulic capacity to 5,000 gallons per minute (gpm) by replacing the launder drop box in the thickener and the pipeline between the thickener and polishing pond.
 - Constructed a new waste sludge line from the CTP to the sludge disposal pond at the Central Impoundment Area (CIA).
 - Replaced the lime storage and feed system and converted from hydrated to quick lime.
 - Constructed a new control building and updated the plant control system.

- Upgraded the plant electrical system.
- Installed a new backup generator (750 KW) capable of providing energy to operate the entire plant.
- Installed a new sludge recycle pump.
- Improvements proposed by the site team for the CTP, include the following:
 - Add a granular media filter system to allow the plant to operate in the high-density sludge (HDS) mode, improving metals removal effectiveness and reducing sludge volume by approximately 67 percent.
 - Replace the existing rapid mix tank (Reactor A) with a properly designed reactor and mixer.
 - Replace the aeration basin (Reactor B) with a new basin, mixer and aeration system.
 - Replace the manual polymer feed system with an automatic batching system.
 - Remove the polishing pond to provide space for the filter system.
 - Replace the remaining, older sludge recycle and wasting pumps.
 - Add an influent flow meter.
- The CTP is effectively mitigating a major source of metals loading to the South Fork of the Coeur D'Alene River (SFCDR); however, effectiveness and operator requirements are strained during high flows and components of the system are over 30 years old and should be replaced with modern, more effective and efficient equipment.
- Additional contributors to the SFCDR metals loading have been identified and can be treated in an expanded and upgraded system.
- The effort to meet stringent anticipated water quality discharge standards could delay system expansion significantly, require excessive capital and continuous operating expense for minimal load reduction and may still result in non-compliance for manganese and possibly other discharge standards.

Summary of Recommendations

The following recommendations are provided to improve remedy effectiveness, reduce cost and provide technical improvement:

Improving effectiveness:

- Expand plant to a capacity of 20,000 gpm without filtration using a phased approach and using the proven CTP low-density sludge technology to treat the identified sources at a reasonable capital cost (approximately \$13MM) and O&M expense (additional \$650,000 per year). Considerations behind this recommendation include:

- Filtration is not recommended due to the substantial cost increase (approximately \$18MM in additional capital cost and \$1MM per year in additional O&M expense), relative uncertainty in the total flow to be treated, relative uncertainty in the water quality to be treated and relative uncertainty regarding the performance of the expanded CTP.
 - Expansion to a capacity of 20,000 gpm will allow the maximum collection of additional metals sources as needed without requiring an additional clarifier and the expansion of the CTP footprint. It will also allow collection from the bulk of identified sources and treat a large percentage of the identified metal mass contribution.
 - The expanded CTP should be able to meet the proposed zinc and lead discharge standards. The anticipated cadmium limit might be achieved without filtration. The expanded CTP with or without filtration would not be capable of achieving the anticipated manganese discharge standard and may not be capable of meeting limits for newly regulated metals including mercury, selenium and thallium depending on influent levels. The relevance of the manganese standard is questionable because it is based on human consumption of shellfish, which are not present in SFCDR. Greensand filtration or ion exchange would be required to achieve reliable manganese treatment below the discharge standard. However, the capital cost (\$10MM range) and O&M cost (additional \$300,000 per year) to add either of these processes to a 20,000 gpm system are high. Selenium is especially difficult to remove if it is present above the anticipated discharge standard; therefore, treatment by reverse osmosis will likely be required for consistent compliance. The addition of reverse osmosis to the upgraded CTP would require capital costs in the \$40MM range and O&M costs in the \$7MM per year range.
 - The system without filtration should be operated for an extended period of time in an interim or pilot mode to evaluate system performance relative to meeting discharge standards and the potential need, costs and benefits of adding any or all of the filtration, ion exchange and reverse osmosis steps.
 - Additional operational tests such as varying sludge recycle rates or polymer addition rates should also be conducted during this period to optimize treatment effectiveness and possibly reduce O&M expenses. This interim testing period would allow the site team to reduce significant metals loading from additional sources, as needed.
- Do not convert to HDS mode operation at this time as filtration would be necessary.

Reducing cost:

- Perform a cost-benefit analysis to support final decision-making on the West Fork of Milo Creek Diversion.

- Include variable frequency drives for the replacement sludge recycle and discharge pumps and mixers to reduce electric costs and improve efficiency.

Technical improvement:

- Consider the addition of two new Reactor A basins during CTP expansion. Currently, only one new Reactor A basin is proposed, which simplifies lime addition due to one application point. However, the one Reactor A approach would also complicate lime addition because there would be two pH probes controlling the feed rate and this would require flow splitting to the two Reactor B basins that are proposed. For complete redundancy and simpler control, it may be better to construct two new Reactor A basins.

Site closure – no recommendations are provided as the CTP operation will be ongoing for the foreseeable future.

Environmental footprint:

- The above recommendations will reduce electricity usage, which will result in reductions to the energy and air emission footprints.
- Consider using treated process water for lime slaking and polymer batching to reduce potable water use and associated costs.
- Evaluate the potential for manganese metal recovery if this is also a possibility at other sites managed by the EPA where treatment residuals with manganese are sent to a landfill for disposal. This evaluation should be based on numerous potential sources of treatment residuals rather than having the potential for multiple site teams independently evaluating its potential and getting distracted from higher priorities.

NOTICE AND DISCLAIMER

Work described herein, including preparation of this report, was performed by Tetra Tech GEO (TtGEO) for the U.S. Environmental Protection Agency under Work Assignment 2-58 of EPA contract EP-W-07-078 with Tetra Tech EM, Inc., Chicago, Illinois. The report was approved for release as an EPA document, following the Agency's administrative and expert review process.

This optimization review is an independent study funded by the EPA that focuses on protectiveness, cost-effectiveness, site closure, technical improvements and green remediation. Detailed consideration of EPA policy was not part of the scope of work for this review. This report does not impose legally binding requirements, confer legal rights, impose legal obligations, implement any statutory or regulatory provisions, or change or substitute for any statutory or regulatory provisions. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Recommendations are based on an independent evaluation of existing site information, represent the technical views of the optimization review team, and are intended to help the site team identify opportunities for improvements in the current site remediation strategy. These recommendations do not constitute requirements for future action, rather they are provided for consideration by the EPA Region and other site stakeholders.

While certain recommendations may provide specific details to consider during implementation, these are not meant to supersede other, more comprehensive planning documents such as work plans, sampling plans and quality assurance project plans (QAPP), nor are they intended to override Applicable or Relevant and Appropriate Requirements (ARARs). Further analysis of recommendations, including review of EPA policy may be needed prior to implementation.

PREFACE

This report was prepared as part of a national strategy to expand Superfund optimization from remedial investigation to site completion implemented by the EPA Office of Superfund Remediation and Technology Innovation (OSRTI)⁽²⁾. The project contacts are as follows:

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² U.S. Environmental Protection Agency (EPA). 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

LIST OF ACRONYMS

µg/L	micrograms per liter
AMD	acid mine drainage
ARAR	applicable or relevant and appropriate requirements
Btu	British thermal unit
Cd	cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIA	central impoundment area
CO _{2e}	carbon dioxide equivalents of global warming potential
CSM	conceptual site model
CTP	central treatment plant
EPA	U.S. Environmental Protection Agency
Ferguson	Ferguson Contracting
ft ²	square feet
g/L	grams per liter
gpm	gallons per minute
gpd	gallons per day
HDPE	high-density polyethylene
HDS	high-density sludge
HP	horsepower
IDEQ	Idaho Department of Environmental Quality
lb	pound
LDS	low-density sludge
LTM	long-term monitoring
LTMO	long-term monitoring optimization
mg/L	milligrams per liter
MM	million
Mn	manganese
MSDS	material safety data sheet
NPDES	National Pollutant Discharge Elimination System
O&M	operation and maintenance
OSRTI	Office of Superfund Remediation and Technology Innovation
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
Pb	lead
P&T	pump and treat
PTM	principal threat materials
QAPP	Quality Assurance Project Plan
RAO	remedial action objective
ROD	Record of Decision
RSE	remediation system evaluation
SAP	sampling and analysis plan
SCADA	supervisory control and data acquisition

SEFA	Spreadsheets for Environmental Footprint Analysis
SFCDR	South Fork of the Coeur D'Alene River
TtGEO	Tetra Tech GEO
TSS	total suspended solids
U.S.	United States
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VFD	variable frequency drive
WQS	Idaho Stream Water Quality Standards
WWTP	waste water treatment plant
yr	year
Zn	zinc

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1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000 and 2001, independent site optimization reviews called Remediation System Evaluations (RSE) were conducted at 20 operating Fund-lead pump and treat (P&T) sites (i.e., those sites with P&T systems funded and managed by Superfund and various States). Due to the opportunities for system optimization that arose from those RSEs, the U.S. Environmental Protection Agency Office of Superfund Remediation and Technology Innovation (OSRTI) has incorporated RSEs into a larger post-construction complete strategy for Fund-lead remedies as documented in *Office of Solid Waste and Emergency Response (OSWER) Directive No. 9283.1-25, Action Plan for Ground Water Remedy Optimization*. Concurrently, the EPA developed and applied the Triad Approach to optimize site characterization and development of a conceptual site model (CSM). The EPA has since expanded the definition of optimization to encompass investigation stage optimization using Triad Approach best management practices (BMP), optimization during design, RSEs and long-term monitoring optimization (LTMO). The EPA's definition of optimization is as follows:

“Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness.”⁽³⁾

As stated in the definition, optimization refers to a “systematic site review”, indicating that the site as a whole is often considered in the review. Optimization can also be applied to a specific aspect of the remedy (for example, focus on LTMO or focus on one particular operable unit [OU]), but other site or remedy components are typically considered to the degree that they affect the focus of the optimization. An optimization review typically considers the goals of the remedy, available site data, CSM, remedy performance, protectiveness, cost-effectiveness and closure strategy. For the purposes of this optimization review effort, the focus of review was on one remedial element, the Central Treatment Plant (CTP).

A strong interest in sustainability has also developed in the private sector and within Federal, State and Municipal governments. Consistent with this interest, OSRTI has developed a

³ U.S. Environmental Protection Agency. 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28

Methodology for Understanding and Reducing a Project's Environmental Footprint and supporting *Spreadsheets for Environmental Footprint Analysis (SEFA)* to assist the conduct of environmental footprint analyses for site cleanup (www.cluin.org/greenremediation), and now routinely considers green remediation and environmental footprint reduction during optimization reviews.

The review includes reviewing site documents, potentially visiting the site for one day, and compiling this report which includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. 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, and represent the opinions of the optimization review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the EPA Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans and quality assurance project plans (QAPP).

The national optimization strategy includes a system for tracking consideration and implementation of the optimization review recommendations and includes a provision for follow-up technical assistance from the optimization review team as mutually agreed upon by the site management team and EPA OSRTI.

Purpose of Optimization at the Bunker Hill Mining and Metallurgical Complex Superfund Site – Central Treatment Plant (CTP)

Environmental contamination of surface water, groundwater, soil and sediment occurred at the Bunker Hill Mining and Metallurgical Complex Superfund Site as a result of mining, milling and smelting activities. Contaminants of concern in the impacted media are arsenic, cadmium, lead, mercury and zinc. The surface water and groundwater remedy includes the CTP, which treats acid mine drainage (AMD) from the Kellogg Tunnel and minimal flows that are generated from the principal threat materials cell and smelter closure area drains.

The site was selected by the EPA OSRTI for optimization based on a nomination from the EPA's Abandoned Mine Lands Team. The optimization review was focused on current CTP operations and proposed upgrades and expansion. The optimization review includes discussion and

evaluation of influent sources, metals mass loading, discharge criteria, solids handling and operating costs.

This EPA-funded optimization review is an independent study that focuses on protectiveness and cost-effectiveness. Detailed consideration of EPA policy was not part of the scope of work for this review. EPA Region 10 and EPA OSRTI will address EPA policy when considering the technical recommendations provided in this report.

1.2 TEAM COMPOSITION

The optimization review team consisted of the following individuals:

Table 1: Optimization Review Team Composition

Name	Affiliation	Phone	Email
Peter Rich	Tetra Tech GEO	410-990-4607	peter.rich@tetratech.com
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The following individuals from the EPA OSRTI also participated in the optimization site visit:

- Kathy Yager, EPA OSRTI
- Jenn Edwards, EPA OSRTI

1.3 DOCUMENTS REVIEWED

The following documents were reviewed. The reader is directed to these documents for additional site information that is not provided in this report.

- *OU2 Mine Water ROD Amendment*, EPA, 2001
- *Bunker Hill Mine Water Management Remedial Investigation/Feasibility Study*, CH2M Hill, April 2001
- *Proposed Plan, Upper Basin of the Coeur d'Alene River*, EPA, July 2010
- *Phase 2 Testing Results Bunker Hill Mine Water Treatability Study*, URS Greiner and CH2M Hill, November 2000
- *Design Considerations for Phase I and Phase 2 CTP Upgrades Draft*, CH2M Hill, January 20, 2012
- *Documentation of Estimated CTP Expansion and Water Treatment Costs Presented in the Draft Final FFS Report for the Upper Basin of the Coeur d'Alene River*, CH2M Hill, February 28, 2012
- *Canyon Creek Phase II Treatability Study*, CH2M Hill, October 2006

- *Operations & Maintenance Services Central Treatment Plant Sampling and Analysis Plan (SAP)*, Ferguson Contracting, Inc., July 2011
- *2010 Five-Year Review OUI, OU2 and OU3*, EPA Region 10, November 2010
- *CTP Expansion Costs.xls*, Cost estimating spreadsheets developed by CH2M Hill, September 12, 2006.

1.4 QUALITY ASSURANCE

This optimization review utilized existing environmental data to evaluate remedy performance and make recommendations to improve the remedy. The quality of the existing data is evaluated by the optimization review team prior to using the data for these purposes. The evaluation for data quality includes a brief review of how the data were collected and managed (where practical, the site QAPP is considered), the consistency of the data with other site data, and the use of the data in the optimization evaluation. Data that are of suspect quality are either not used as part of the optimization review or were used with the quality concerns noted. Where appropriate, this report provides recommendations made to improve data quality.

1.5 PERSONS CONTACTED

A site visit was conducted on April 19, 2012. In addition to the optimization review team and the EPA OSRTI personnel, the following individuals associated with the site were present:

Table 2: Persons Contacted during Optimization Evaluation

Name	Affiliation	Phone	Email
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The EPA contracts the U.S. Army Corps of Engineers (USACE) to subcontract and oversee the CTP operator, Ferguson Contracting (Ferguson), and CH2M Hill for the CTP study and conceptual design. Apex Engineering is contracted by Ferguson to help address CTP operating/control issues.

2.0 SITE BACKGROUND

2.1 LOCATION

The Bunker Hill Mining and Metallurgical Complex Superfund Site (Site) is located in the Silver Valley area of Northern Idaho, Shoshone County, near the city of Kellogg. The Site includes a 21-square mile area (the “Box”) along Interstate 90 and is divided into three OUs to focus investigation and cleanup efforts. OU1 considers the populated areas of the Site and OU2 considers the non-populated areas, both of which are located within the “Box.” OU3 includes the remaining area outside of the “Box” where mining-related contamination is located.

The surface water and groundwater remedy at the Site includes the CTP, which treats AMD; the CTP is the focus of this optimization review report.

2.2 SITE HISTORY

2.2.1 HISTORIC LAND USE AND FACILITY OPERATIONS

The 2001 *OU2 Mine Water Record of Decision (ROD) Amendment*, the July 2010 *Proposed Plan, Upper Basin of the Coeur d'Alene River* prepared by the EPA, and the January 2012 *Design Considerations for Phase I and Phase 2 CTP Upgrades Draft* prepared by CH2M Hill provide the following information regarding historic land use and facility operations:

- The Bunker Hill Mine began operation in 1885 and continued until the 1980s. The mine consists of a complex network of about 150 miles of underground tunnels and 6 miles of underground shafts. The shafts extend to more than 1 mile below the land surface. The mine was part of the Bunker Hill Mining Complex (Complex), which occupied approximately 350 acres between the towns of Smelterville and Kellogg. The Complex was an integrated mining, milling and smelting operation.
- Liquid and solid waste from the Complex was discharged directly into the South Fork of the Coeur d'Alene River prior to 1928.
- After 1928, a Central Impoundment Area (CIA) was developed in a nearby floodplain to accept AMD and wastewater from the Complex. This discharge was collected in a pond and allowed to settle solids before liquids were discharged into the river.
- In 1974, the CTP was built to receive and treat wastewater from the CIA collection pond before it was discharged into the river. A complex system of pumps, pipelines and channels have been constructed since the CTP was built to deliver the AMD and wastewater from the Bunker Hill Mine and Smelter Complex to the CTP. The Bunker Hill Smelter was decommissioned and demolished in the late 1990s and thus, those industrial flows are no longer generated.

- In 1999, a new pipeline was constructed from the Kellogg Tunnel portal of the Bunker Hill Mine to the lined flow equalization pond to store water to be treated at the CTP.

The CTP, CIA, Kellogg Tunnel portal and other CTP-related features are shown in Figure 2-1 (see Attachment A). These features include the principal threat materials (PTM) cell and smelter closure area, Sweeney Area Pipeline (water collection and conveyance), lined pond (for flow equalization and side-stream storage) and unlined sludge disposal cell (lagoon).

The CTP flow diagram is shown in Figure 5-2 (see Attachment A). The CTP facilities include lime feed and polymer feed pumps, a rapid mix tank (Reactor A), aeration basin (Reactor B), flocculation (floc) tank, thickener, sludge recycling and wasting pumps, a polishing pond, flow measurement equipment and discharge pipes and pumping to Bunker Creek.

Planning and studies have been underway for several years to modernize the CTP and expand its capacity to allow the capture and treatment of additional metal contaminant sources. The site team stated that CH2M Hill is tasked with design through the 30 percent level; the U.S. Army Corps of Engineers (USACE) will then likely lead a design/build effort to upgrade and expand the CTP. The schedule for this work is not known to the optimization review team. An upgraded CTP design flow rate and sources to be treated have not been finalized.

2.2.2 CHRONOLOGY OF ENFORCEMENT AND REMEDIAL ACTIVITIES

The chronology of enforcement and remedial activities at the Site was not reviewed as part of this optimization review.

2.3 POTENTIAL HUMAN AND ECOLOGICAL RECEPTORS

The primary potential receptors are environmental fauna and recreational and residential users in contact with surface water and sediments in the South Fork of the Coeur D'Alene River (SFCDR), SFCDR tributaries and downstream water bodies.

2.4 EXISTING DATA AND INFORMATION

2.4.1 SOURCES OF CONTAMINATION

With the exception of understanding known and potential influent flow volumes, chemistry and mass as related to CTP operations and capacity, discussion of the various sources of contamination at the Site is beyond the scope of this review. Flow volumes, chemistry and mass are presented in Section 5.0

2.4.2 GEOLOGY AND HYDROGEOLOGY

Discussion of the geology and hydrogeology of the Site is beyond the scope of this review.

2.4.3 SOIL CONTAMINATION

Discussion of the soil contamination at the Site is beyond the scope of this review.

2.4.4 SOIL VAPOR CONTAMINATION

Discussion of soil vapor contamination, if any, is beyond the scope of this review.

2.4.5 GROUNDWATER CONTAMINATION

Groundwater impacted by heavy metals contributes to surface water impacts in the SFCDR. The nature of the groundwater flow and the interaction with surface water are beyond the scope of this review.

2.4.6 SURFACE WATER CONTAMINATION

The CTP operation currently intercepts a portion of the water that would contribute to SFCDR metals loading treats the intercepted water and discharges the treated water to surface water. Currently, less than 10 percent of the average flow from identified adit drainage and groundwater sources is intercepted from the combined OU2 and OU3 basins. Due to the high metals concentrations in the intercepted water, approximately 33 percent of the metals loading is intercepted. The discharge of treated water to surface waters abides by limits established in an expired National Pollutant Discharge Elimination System (NPDES) permit. A new NPDES permit and limits would be required for another entity to operate the CTP. The permit limits and compliance with those limits are discussed in Sections 3.0 and 4.0 of this report, respectively.

3.0 DESCRIPTION OF PLANNED OR EXISTING REMEDIES

3.1 REMEDY AND REMEDY COMPONENTS

The CTP was originally designed to operate as a high-density sludge (HDS) process, but currently is operated as a low-density sludge (LDS) system, with a low recycle rate from the thickener to the flash mixer reactor. Sand filters included in the original construction of the CTP have been removed and some form of filtration would need to be provided for a return to the HDS mode of operation.

The CTP treats the largest single contribution of AMD in the SFCDR drainage basin from the Bunker Hill Mine (Kellogg Tunnel portal); other significant contributions come from OU2 groundwater and discharges in Canyon Creek and Nine Mile Creek (OU3 Upper Basin), which are upstream of the City of Kellogg. These contributing sources were not specifically reviewed as part of the optimization review effort, however.

The current operating systems at the Site include the following:

- Kellogg Tunnel portal collection and conveyance to the CTP or lined pond
- Principal threat materials cell and smelter closure area water collection and conveyance (Sweeney Area Pipeline) to the lined pond
- CTP
- CIA sludge disposal
- Bunker Creek discharge

Previously planned CTP upgrades and expansion include:

- Collection of additional OU2 groundwater
- Collection of OU3 groundwater and adit flows
- Expansion and upgrade of existing CTP
- Addition of filtration to the CTP
- Discharge to the SFCDR

The following sections describe water collection and CTP features; these are shown in the figures included in Attachment A.

3.1.1 COLLECTION

3.1.1.1 Kellogg Tunnel (KT) Portal

The KT Portal is currently the primary source of influent (currently > 95 percent) to the CTP. AMD flows from the Bunker Hill Mine at a typical rate of 1,000 to 1,500 gallons per minute (gpm). The site team monitors the quality of KT Portal discharge regularly; this data indicates when the quality changes and when additional operational attention may be required. Typical characteristics of the KT Portal discharge are: pH of 2.5-3.0, zinc concentration of 100 mg/L, manganese concentration of 100 mg/L, lead concentration of 0.6 mg/L and cadmium concentration of 0.2 mg/L. Flow rates increase to over 5,000 gpm during the spring runoff period and metals concentrations also increase during these higher flow periods.

3.1.1.2 PTM/Sweeney Area Pipeline

The PTM/Sweeney Area Pipeline is a smaller source of non-AMD influent (typically less than 10 gpm) to the CTP. This wastewater is continuously gravity-fed to the lined pond and then periodically pumped to the CTP. Typical characteristics of the Sweeney/Outfall 004 water are: pH of 7.0, zinc concentration of 15 mg/L, lead concentration of 0.05 mg/L and cadmium concentration of 2 mg/L.

3.1.1.3 Lined Pond Pump Station Discharge

Lined Pond Pump Station Discharge is a composite of KT discharge (when it is not directly fed to the CTP), PTM/Sweeney area water, precipitation and other smaller sources. The lined pond has a 7 million gallon capacity and is used for storage when the CTP is shut down for maintenance or repairs or when the influent rate is above 2,500 gpm. It should be noted that this pond provides capacity for only a relatively short duration. To increase storage capacity for treatment emergencies, the EPA has an agreement in place with the mine owner to ensure that additional waters can be stored in the mine.

3.1.2 CENTRAL TREATMENT PLANT

3.1.2.1 Lime Feed

There are two 100-ton silos for storing and feeding quick lime. The silos are equipped with fill lines, dust collectors on the roof, bottom cones with bin activators, volumetric screw feeders that discharge into the slurry tank, one slurry tank per silo, a grit removal system and slurry feed pumps.

The slurry is maintained at about 16 percent (by weight), which is fairly high. There is a cross-over screw conveyor that allows a feeder in one silo to feed lime to the other slurry tank. This feature provides an added measure of redundancy.

The slurry is made in batches to allow cooling of the slurry tanks. During spring runoff, lime usage spikes, going from an average of about 3 tons to 5 tons per day. Lime dosages vary from about 0.25 gram/liter (g/L) during the winter to as high as 1.44 g/L during the spring.

3.1.2.2. *Reactor A*

The rapid mix tank (Reactor A) receives only the recycled sludge from the thickener and the lime slurry feed. Plant influent flows directly to Reactor B. Lime slurry feed is intermittent and is controlled by the pH in the second reactor, Reactor B.

3.1.2.3. *Reactor B*

Flow discharges from the rapid mix tank (Reactor A) to Reactor B by gravity. Reactor B is an open earth-formed basin with a mechanical surface aerator in the center. Flow enters at one side. Due to the swirling motion of the water caused by the surface aerator, the flow is directed toward the effluent launder, causing short-circuiting.

The effluent from Reactor B passes through an abandoned flocculation tank that is full of sludge. However, the site team stated the flocculation equipment was not adequate in keeping the solids in suspension through this basin, and that the materials settled. In response, the site team shut off the mixing equipment and allows the process flow stream to pass through the tank. Given the amount of sludge contained in the tank, there could be slug discharges that would affect the operation of the thickener during high flow periods.

3.1.2.4. *CTP Thickener*

The CTP thickener is essentially a large clarifier (approximately 210-foot diameter) as it has no mechanism for “thickening” the sludge. The center “flocculation” well is undersized and contains no means of mixing or flocculating other than what can be achieved by the velocity and energy of the influent water. The side water depth was reported by the operator to be about 10 feet. In windy conditions, there could be agitation of the basin contents and degradation of effluent quality. During the Site visit, the water in the thickener was observed to be very clear, indicating that the sludge blanket was near the floor of the thickener as is expected in LDS mode. When operated in the HDS mode, there would be more solids carryover from this tank, hence the need for filtration.

Based on a flow rate of 5,000 gpm and a diameter of 210 feet, the approximate hydraulic surface loading rate for this thickener (clarifier) would be about 200 gpd per square feet (ft²) of surface area. Typically for a lime floc clarifier, design loading rates can be anywhere between 800 and 1,200 gpd/ft². At the current loading rate, the quality of effluent from this thickener should be (and is) exceptionally high.

3.1.2.5. *Polymer Addition*

Polymer is fed to the influent stream of the thickener. The polymer batching system is entirely manual, and uses bag feed of dry polymer.

3.1.2.6. *Polishing Basin and Discharge*

Effluent from the thickener flows by gravity through a “polishing” basin that currently is full of sludge up to within 2 feet of the basin water surface. Peak flows through this basin could cause the settled solids to become re-suspended and to discharge with the effluent. Final effluent flows

down a cascade structure that provides some re-aeration prior to discharge to Bunker Creek. There is an effluent flow measuring device ahead of the cascade.

3.1.2.7. *Sludge Recycle*

A portion of the generated sludge is continuously recycled from the thickener to Reactor A per the HDS design. The current LDS system has a lower recycle rate and would typically have a different process flow configuration; however, the site team has effectively operated the system in the LDS mode.

3.1.2.8. *Sludge Disposal*

Sludge is pumped from the thickener directly to an approximately 5-acre sludge disposal lagoon located on the CIA. Approximately 90,000 gallons of dilute sludge is discharged to the lagoon per day by manual pumping at about 600 gpm for 150 minutes. The sludge consolidates and water evaporates and infiltrates (the site team reports that the infiltration rate is very low). The lagoon is about half full and has an estimated 6 to 10 years of lifespan remaining under current operation. The lagoon is unlined and the potential for leaching exists, but the ground surface is the top of a tailings deposit. Any new lagoon would be lined to prevent water from draining into the tailings deposits. There is available area on the CIA for additional sludge lagoons, so liquid sludge handling will be a viable long-term option as long as the clear water after sludge setting can be effectively removed and additional lagoons can be approved with community and State concurrence. With this condition, one of the benefits of the HDS process, improved sludge dewatering capability is diminished in value. Furthermore, the site team indicated that there was not much difference in the lime dose for the current operation compared to the pilot testing of the HDS process.

3.1.3 PROPOSED CTP UPGRADES AND EXPANSION

The CTP is operating near capacity in its current condition and cannot effectively treat water from additional sources. In spite of the CTP deficiencies discussed above, the CTP effectively meets discharge criteria (from the expired NPDES Permit) during average flow periods; treatment difficulties occur with high (> 2,500 gpm) flow during spring runoff. In addition to plans for system expansion, proposed discharge standards are more stringent and will require filtration and possibly additional processes for the CTP. The site team has developed conceptual level costs for CTP upgrades and expansion to 2,500; 5,000; 10,000; 15,000; or 20,000 gpm design capacities. Expansion of the CTP to a 10,000; 15,000; or 20,000 gpm design capacity will allow collection and treatment of the identified metals sources in OU2 and OU3.

3.2 REMEDIAL ACTION OBJECTIVES AND STANDARDS

The 2001 *Mine Water ROD Amendment* identifies the following remedial action objectives (RAOs):

- Prevent the release of untreated AMD, which has metals concentrations that greatly exceed protective water quality standards, into Bunker Creek and the SFCDR.

- Reduce the concentrations and total pounds per day of metals discharged into Bunker Creek and the SFCDR to improve overall water quality in the Coeur D’Alene River Basin.
- Upgrade the CTP to meet current water quality standards and improve reliability and efficiency.
- Reduce the volume of sludge generated at the CTP to maximize existing sludge storage capacity.
- Provide for LDS storage needs.
- Reduce the quantity of AMD generated by the mine.
- Reduce the long-term AMD management costs. The forthcoming 2012 ROD Amendment for the Upper Basin has many RAOs including restoring surface water designated for beneficial use as drinking water and meeting water quality standards.

The main treatment objectives of the CTP from the 2000 *CTP Master Plan* are:

- Acceptable effluent quality
- Minimum sludge production
- Maximum system reliability
- Acceptable capital and operation and maintenance (O&M) costs

3.3 PERFORMANCE MONITORING PROGRAMS

The CTP process monitoring program consists of semi-weekly, weekly and bi-weekly sampling events. The monitoring program from the *Sampling Analysis Plan* prepared by Ferguson Contracting in July 2011 is summarized in Table 3:

Table 3: CTP Laboratory Sampling Schedule

Sample Location	Analytes	Sampling Frequency
006 Outfall (CTP Effluent)	Cadmium (Cd), Lead (Pb), Manganese (Mn), Zinc (Zn), Total Suspended Solids (TSS), pH	Composite sample collected 3 days per week during CTP operation (typically Mondays, Wednesdays, and Fridays)
Kellogg Tunnel	Cd, Pb, Mn, Zn, TSS, pH	Grab sample collected 2 days per week
PTM 004/Sweeny Pump Station Sump	Cd, Pb, Zn, TSS, pH	Grab sample collected bi-weekly
Lined Pond Pump Station Discharge	Cd, Pb, Zn, TSS, pH	Grab sample collected weekly during pumping events

In addition, operators field measure pH and turbidity in Reactors A and B and the thickener to verify process control and performance.

3.3.1 TREATMENT PLANT OPERATION STANDARDS

The standards for discharging the water treated at the CTP to surface water (Bunker Creek) are based on a NPDES permit that expired in 1991⁴ and are summarized in Table 4 along with anticipated final remedy limits.

Table 4: Current and Anticipated Future CTP Discharge Limits

Parameter	Current Limit (Monthly Average) (µg/L)	Future Limit (Monthly Average) (µg/L)
Arsenic	NL	50
Cadmium	50	2.8
Copper	150	31.7
Lead	300	85.2
Mercury	1	0.01
Selenium	NL	4.1
Silver	NL	21.9
Thallium	NL	0.47
Zinc	730	244
Aluminum	NL	71.2
Iron	NL	819
Manganese	NL	81.9
pH	6.0 to 10.0	6.5 to 9.0
Total Suspended Solids	20	20
Dissolved Oxygen	NL	>6
Temperature	NL	<19

NL- no limit; µg/L – microgram/liter

Expansion to increase the CTP capacity will include a discharge pipeline directly to the SFCDR because the current I-90 Bunker Creek culverts are undersized for a 100-year flood and, as a result, additional flow to Bunker Creek is not feasible. In addition, the proposed discharge location would reduce undesirable recharge to groundwater from Bunker Creek. During normal flows, the system effectively meets the current discharge limits. The change from HDS operation improved settling, and zinc is typically well below the discharge limit, however, zinc limits have been exceeded during high flow and during operating upsets.

Anticipated future discharge limits, provided by the site team, that are based on State of Idaho Stream Water Quality Standards (WQS), include considerable reductions from existing limits and the inclusion of several previously unregulated metals, including: arsenic, selenium, silver, thallium, aluminum, iron and manganese. The site team has expressed some uncertainty regarding the relevance of the proposed manganese limit (because it is based on human consumption of shellfish, which are not present in the SFCDR), iron limit and thallium limit. The anticipated zinc and lead limits could still be met without upgrading the CTP to include filtration.

⁴ NPDES permitting is not required at Superfund sites. CERCLA requires substantive compliance with permits.

The anticipated cadmium limit might be achieved without filtration, but would likely be more consistently met with filtration. The manganese limit would not be met even with added filtration and would require the addition of greensand filtration or ion exchange tertiary treatment with additional associated capital costs in the \$10MM range and O&M costs in the \$300,000 per year range for a 20,000 gpm system. Anticipated limits for mercury, selenium and thallium could also present problems for treatment even with filtration added. The optimization review team could not find expected influent quality and treatability information for several metals. Selenium is especially difficult to remove, and if it is present above the anticipated limit, reverse osmosis will likely be required for consistent compliance. The addition of reverse osmosis to the upgraded CTP would require capital costs in the \$40MM range with O&M costs in the \$7MM per year range (Estimating Water Treatment Cost, EPA, August 1979).

Currently zinc levels in the discharge from the CTP are typically lower than those found in the SFCDR at Kellogg. Existing manganese levels in surface water were not found in available data. Table 5 includes a comparison of metals concentrations in the CTP main influent source, planned influent sources, CTP discharge, receiving waters, current CTP, anticipated CTP limits, local sewer district discharge limits and discharge limits for an operating mine treatment system for comparison.

Table 5: Metal Concentration Comparison (µg/L)

Source	Zn (total)	Cd	Pb	Mn	Average/Max Flow (gpm)	Average Zn Loading (lb/day)
Existing Influent (Kellogg Tunnel from Sept, Oct, Nov 2011 DMRs)	>100,000	>100	>400	>50,000	>1200	>1,400
Existing Discharge (avg. Sept, Oct, Nov 2011 DMRs)	197	4	10	13,250	1,300/5,000*	3 (>99.5percent reduction)
Existing Discharge Limit (monthly avg.)	730	50	300	NS	-	-
Proposed Discharge Limit (monthly avg.)	244	2.8	85.2	81.9	-	-
SFCDR Water Quality at Kellogg (USGS 2006 SF-269 unfiltered median)	621	4.17	9.54	NA	50,000 min 72,000 max ~200,000 avg	1492
SFCDR Sewer District Limits, (avg. monthly)	802	5.3	63	NS	3,000 (Page, Idaho WWTP)	-
OU2 Groundwater (avg.)	24,452	-	-	-	3,900/4,400	1146
OU3 Woodland Park, Osburn Drain, Gem #3	4,123	-	-	-	4,701/5,623	233
Other OU3 ROD Amendment H2O	2,543	-	-	-	7,602/11,538	232
Hecla Lucky Friday Mine NPDES Permit, Mullan (Discharge Limits)	71	0.7	30	NS	-	-

Notes:

Zn – zinc; Cd – cadmium; Pb – lead; Mn –manganese; gpm – gallons per day; lbs/day – pounds per day; NS – no standard; NA – no analysis; WWTP – wastewater treatment plant; DMR – discharge monitoring reports.

Existing discharge standards from expired NPDES ID 000007-8; Proposed discharge standards from Bunker Hill Discharge Quality and Monitoring Plan, CH2M Hill, 2007.

SFCDR Sewer District limits from NPDES Permit #002130-0 (flow <4.3 MGD), Response to Comments, June 2004; (Variances granted Page, Mullan, Smelterville WWTPs); currently in renewal discussions.

OU2 and OU3 information from revised Table 5.1, CH2M Hill, 2012.

*construction of the West Fork of Milo Creek diversion would reduce the maximum flow to about 2500 gpm.

Treating to the stream standards requires the construction of the filters and other substantial upgrades potentially including ion exchange and reverse osmosis, which will present a significant capital and O&M cost increase. However, there are several factors limiting further consideration of a variance regarding the CTP discharge, as follows:

- Pursuant to Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), all Superfund remedial actions must be protective of human health and the environment and must comply with applicable or relevant and appropriate requirements (ARAR).
- The EPA has received a significant volume of negative input from other waste treatment plant operations including municipal and industrial plants, which complain about the validity of stringent effluent standards.
- The optimization review team is advised that if the Bunker Hill Mine were to be sold to a new owner and re-opened, they would be responsible for the treatment of flows or for reimbursement to EPA for the treatment of flows, from the Bunker Hill Mine.

4.0 CONCEPTUAL SITE MODEL

This optimization review focuses on current CTP operations and proposed upgrades and expansion. Discussion of a CSM including AMD sources, transport and fate is beyond the scope of this review.

5.0 FINDINGS

5.1 GENERAL FINDINGS

This section presents the observations and interpretations of the optimization review team. The observations and interpretations provided below are not intended to imply a deficiency in the work of the system designers, system operators or site managers. 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 treatment have changed over time.

5.2 INFLUENT COLLECTION AND DIVERSION

The following is summary information on influent volumes, chemistry and mass loading for current and flows identified by the site team.

5.2.1 KELLOGG TUNNEL INCLUDING WEST FORK OF MILO CREEK

The base flow from this source is 1,000 to 1,500 gpm with zinc concentrations of about 100 mg/L. During spring runoff, flows increase from 1,500 to 6,700 gpm, and effluent zinc concentrations rise from approximately 100 to approximately 500 mg/L (with peaks over 600 mg/L). The average zinc loading from this source is over 1,400 pounds per day (lbs/day).

Mitigation efforts to reduce the amount of AMD discharge by reducing surface water infiltration have been previously identified by the Site team. The main potential mitigation identified by the site team would involve a diversion of the West Fork of Milo Creek. The site team estimates that the diversion could potentially reduce Kellogg Tunnel AMD flow and total metals loading by about 50 percent.

5.2.2 SMELTER CLOSURE AREA

The water collected in the smelter closure area and other minor sources are discharged to the lined pond prior to being pumped to the CTP. This water is typically 10 gpm or less and is not AMD. Zinc concentrations are in the range of 15 mg/L.

5.2.3 OTHER OU2 SOURCES

The site team estimates that currently uncollected groundwater flow volumes from the OU2 area are approximately 3,900 gpm with an average zinc concentration estimated at 24.5 mg/L for an average daily load of 1,100 lbs/day. The actual flow volumes and concentrations are being studied by EPA to better quantify both water quality and quantity.

5.2.4 OU3 UPPER BASIN SOURCES

The site team indicates that there are 21 previously identified AMD adit drainage sources in the OU3 Upper Basin (upstream of the CTP), as well as six additional areas with impacted groundwater.

Three of the sources: Woodland Park groundwater, Osburn Drain groundwater and Gem No. 3 adit drainage, have been grouped together by the site team as the initial sources to collect in OU3. Collection would require extensive drains, and a lengthy pipeline to the CTP. The combined total average flow of the three sources is estimated at 4,701 gpm with an average zinc concentration of 4.12 mg/L for a total zinc loading of 233 lbs/day.

The other 24 sources combined have a total average flow of 2,901 gpm and an average zinc concentration of 1.83 mg/L for a 63 lbs/day load.

5.3 CURRENT CTP PERFORMANCE

The CTP meets existing discharge standards (as provided in the expired NPDES Permit) under normal operating conditions (see Table 4) and effective operator attention; however, exceedances have occurred during high flows associated with spring runoff. The Reactor B tank is clearly not an optimal mixing vessel and the downstream flocculation tank has been abandoned in place by letting sludge fill it. The oversized thickener has overcome the shortcomings of the reactor portion of the system.

The polymer batching system is economical from a chemical cost standpoint, but associated labor costs are high because it is a time consuming operation. The polishing basin is filled with sludge to within a few feet of the surface; it would be more effective if it were cleaned out routinely to reduce the potential for upset.

The original sand filters were housed in a low profile metal building near the polishing basin and have been completely removed. If new filters are to be constructed, either they would need to be the low head auto-backwashing type or the deep bed type. The deep bed type will require intermediate pumping, a clear well and dedicated backwash supply pumps.

The plant has a control room overlooking the thickener. A modern supervisory control and data acquisition (SCADA) system is provided in the plant for overseeing and controlling the operation. The SCADA system cannot be accessed via the internet. An auto-dialer is used to generate alarms and notify operators of problems during un-manned periods.

Recent Improvements at the CTP

- The site team has recently made the following improvements to the CTP:
 - Constructed the direct feed branch of the mine water pipeline to provide gravity flow of AMD directly to the CTP.
 - Refurbished the thickener.

- Increased the hydraulic capacity of the thickener to 5,000 gpm by replacing the launder drop box in the thickener and the pipeline between the thickener and polishing pond.
 - Constructed a new waste sludge line from the CTP to the sludge disposal pond at the CIA.
 - Replaced the lime storage and feed system and converted from hydrated to quick lime.
 - Constructed a new control building and updated the plant control system.
 - Upgraded the plant electrical system.
 - Installed a new backup generator (750 kilowatts [kW]) capable of providing energy to operate the entire plant.
 - Installed a new sludge recycle pump.
- Improvements proposed by the site team for the CTP, include the following:
 - Add a granular media filter system to allow the plant to operate in the HDS mode, improving metals removal effectiveness and reducing sludge volume by approximately 50 percent.
 - Replace the existing rapid mix tank (Reactor A) with a more effectively designed reactor and mixer.
 - Replace the aeration basin (Reactor B) with a new basin, mixer and aeration system.
 - Replace the manual polymer feed system with an automatic batching system.
 - Remove the polishing pond to provide space for the filter system.
 - Replace the remaining older sludge recycle and wasting pumps.
 - Add an influent flow meter.

5.4 REGULATORY COMPLIANCE

The site team noted that the CTP discharge has exceeded the current discharge limits for zinc during high flow events, typically due to spring runoff.

5.5 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF ANNUAL COSTS

Table 6 provides a breakdown of the anticipated ongoing annual costs to operate the current CTP based on information provided by the site team (actual costs from 2006 through 2011) and/or as costs estimated by the optimization review team based on discussions with the site team.

Table 6: Summary of Annual Operating Costs

Item	Approximate Annual Cost
Project Management – U.S. Army Corps of Engineers Labor	\$30,000
Routine Operation and Maintenance (O&M) Labor	\$350,000
Routine Maintenance Other Direct Costs (ODCs) / Subcontractors	\$90,000
O&M Overtime for High Flows (2011)	\$40,000
Process Analysis	\$60,000
Electricity	\$110,000
Lime	\$219,000
Polymer	\$36,000
Equipment	\$7,000
Total	\$942,000

5.5.1 UTILITIES

Power costs are approximately \$110,000 per year at an approximate rate of \$0.062 per kilowatt hour (kWh) from Avista. This represents a demand of approximately 200 kW. Large consumers of electricity in the system include continuously operating motors for the 25 horsepower (HP) rapid mix tank (Reactor A) mixer, the 50 HP aeration tank (Reactor B) mixer and the sludge recycle pump.

5.5.2 NON-UTILITY CONSUMABLES

Approximately 2.4 tons of lime is used in the CTP per day at a current cost of about \$250 per ton or \$18,000 per month. Polymer costs for flocculation are reported to be about \$3,000 per month.

5.5.3 LABOR

Project management costs include USACE project management of approximately one half day per month for routine management and contracting support, plus additional costs for contract renewals and meetings as needed. Costs for EPA management are not included. Costs for CH2M Hill related to investigation, testing and design for CTP upgrades are not included.

Ferguson staffs the CTP with two operators for 8 hours per day, 7 days per week. Ferguson provides additional off-hour staffing during high flow periods (typically spring runoff). Ferguson subcontracts Apex Engineering for CTP controls and engineering maintenance and repairs (typically for 1 day per month). The operating staff completes system checks with readings of pH, turbidity and flow at multiple locations in the system plus lime addition, polymer batching, pump maintenance, line cleaning, process sampling for laboratory analysis and reporting of collected data.

5.5.4 CHEMICAL ANALYSIS

The CTP *Sampling and Analysis Plan (SAP)* (July 2011) monitoring requirements (see Table 3) include approximately 300 samples per year. Samples analyzed by contract laboratories cost about \$112 per sample for regular turnaround and about \$205 per sample for 24-hour turnaround.

Additional sampling and analysis beyond SAP requirements is expected for quality assurance and unforeseen testing. Annual laboratory costs are expected to be approximately \$60,000 per year. Costs from 2006 to 2011 were reported by the site team to be approximately \$120,000 per year; sampling frequencies for 2012 and future years have been reduced based on the July 2011 SAP requirements. The optimization review team believes that the new SAP monitoring requirements are appropriate.

5.6 CTP UPGRADE AND EXPANSION COST ESTIMATES

The latest cost information for recommended improvements to the CTP is contained in a draft technical memorandum entitled *Documentation of Estimated CTP Expansion and Water Treatment Costs Presented in the Draft Final FFS Report for the Upper Basin of the Coeur D’Alene River, Bunker Hill Superfund Site* (CH2M Hill; February 28, 2012). The costs presented in this memorandum are only at the level of accuracy of cost curves, since the facilities have not yet been designed and accurate cost estimating is not possible. Table 7 therefore presents the approximate capital and O&M costs for the upgrade and expansion to varying capacities, developed from data extracted from CH2M Hill’s September 12 2006 cost estimation spreadsheets (CH2M Hill, 2006).

Table 7: Upgrade and Expansion Cost Comparison With and Without Filtration

Flow Capacity (gpm)	Capital for Non-Filter Related Upgrades (\$MM)	Additional O&M for Non-Filter Related Upgrades (\$MM/yr)	Capital for Filter Related Upgrades (\$MM)	Additional O&M for Filter Related Upgrades (\$MM/yr)	Combined Increases - Capital/O&M (\$MM/\$MM/yr)
2,500 (existing)	3.5	0	2.9	0.24	6.4/0.24
5,000	4.2	0.089	6.3	0.372	10.5/0.46
10,000	5.4	0.276	12.1	0.591	17.5/0.87
15,000	6.1	0.470	18.2	0.813	24.3/1.28
20,000	7.0	0.655	24.0	1.025	31.0/1.68

“MM” = million; yr – year; gpm – gallons per minute.

The following observations are noteworthy:

- With new filters, the cost of labor is expected to increase by one full-time employee; power and maintenance costs also increase.
- For the upgrade without filters, the cost of labor would not increase with the CTP expansion and improvements. Lime and polymer usage would increase. Maintenance costs would likely decrease and electric costs would decrease slightly for similar flow, because of updated and more efficient equipment, and would increase slightly for large flows; however, these maintenance and electric changes were not factored in the comparison and are considered minimal in comparison to other costs.

- An additional sludge disposal cell could be required for the upgrade without filtration at an estimated cost of \$6.1 million (MM) (414,000 cubic yards). This is not shown in Table 7.
- The additional O&M costs are added to the current O&M costs of approximately \$940,000/yr.
- The West Fork of Milo Creek diversion cost estimate (CH2M Hill 2009) is \$8.74MM. Without filtration, the savings for not treating the diverted flow (2,500 gpm estimated maximum flow) would be approximately \$500,000 (capital) and \$100,000/yr (O&M) based on the values in Table 7, indicating that it would take more than 80 years (non-discounted) to recover the costs of implementing the diversion. If filtration is added to the CTP, the extra combined cost would be approximately \$3.5MM capital and \$200,000/yr O&M indicating that it would take approximately 26 years (non-discounted) to recover the costs. The actual cost recovery periods are longer if the calculations are made based on average flow rates instead of maximum flow rates.
- Adding filtration is very costly for minimal additional mass removal. For example, adding filters and upgrading the existing plant, while maintaining the 2,500 gpm capacity would result in an additional \$13.6MM expended over 30 years (non-discounted). By comparison, expanding the plant to a 10,000 gpm capacity without filtration would cost the same amount over the 30 years but would enable the collection and treatment of up to 7,500 gpm in additional flows, as needed. It could also enable the removal of more than 1,000 lbs/yr of added zinc and other associated metals loading.

5.7 APPROXIMATE ENVIRONMENTAL FOOTPRINTS ASSOCIATED WITH REMEDY

5.7.1 ENERGY, AIR EMISSIONS, AND GREENHOUSE GASES

The primary contributor to the energy footprint is the electricity usage of 1.8 million kWh per year. Avista is the electricity provider for the Site; based on a preliminary review of Avista's Integrated Resource Plan, it appears that approximately 50 percent of the electricity is generated from hydropower, approximately 35 percent from natural gas, and approximately 15 percent from coal. Based on this generation mix, the electricity is also a major contributor of the greenhouse gases and other air emissions associated with CTP operation. The other largest contributor to the greenhouse gas and other emissions is associated with lime mining/manufacturing and transportation to the Site.

The EPA Spreadsheets for Environmental Footprint Analysis (SEFA) were used to estimate the energy and air footprints. The results for key energy and air annual footprint metrics are summarized in Table 8.

Table 8: Summary of Energy and Air Annual Footprint Results

Green and Sustainable Remediation Parameter	Approximate Annual Value
Greenhouse Gas Emissions (carbon dioxide equivalents [CO _{2e}])	2,400 tons
Total NOx + Sox + PM emissions	34,000 pounds (lbs)
Total Hazardous Air Pollutant (HAP) Emissions	250 lbs
Total Energy Use	50,000 MMBtus
Voluntary Renewable Energy Use	NA

Notes: CO_{2e} = carbon dioxide equivalents of global warming potential
 MMBtus = 1,000,000 Btus

Based on the assumptions made in SEFA, approximately 60 percent of the carbon dioxide (CO₂) footprint is from lime usage and approximately 40 percent is from electricity usage. Other contributions, including personnel transport and laboratory analysis, are negligible in comparison.

5.7.2 WATER RESOURCES

An average of 8,136 gpd (May 2011 to April 2012) of potable water is used for lime slaking, polymer batching and sanitary and cleaning purposes. Water that is intercepted as part of the remedy is discharged to surface water, which would be the natural fate of the water in the absence of the remedy.

5.7.3 LAND AND ECOSYSTEMS

Operation of the remedy does not have secondary effects on local land and ecosystems.

5.7.4 MATERIALS USAGE AND WASTE DISPOSAL

The primary materials usage is the lime and polymer usage. Waste disposal associated with this remedy is to a basin in the CIA. This approximately 5-acre, 15-foot deep basin has been in operation since about 1997 and is about two thirds full. Additional space is available for additional disposal basins adjacent to the current basin. Limited waste is sent to offsite landfills for disposal.

5.8 SAFETY RECORD

The site team did not report any safety concerns or incidents.

6.0 RECCOMENDATIONS

This section provides several recommendations related to remedy effectiveness, cost control and technical improvement. Note that while the recommendations provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans and QAPPs.

Cost estimates provided in this section have levels of certainty comparable to those done for CERCLA Feasibility Studies (-30 percent /+50 percent) and have been prepared in a manner generally consistent with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July, 2000. This optimization review was unique in its focus on the CTP and the proposed CTP expansion and upgrades. CTP upgrade and expansion costs have already been estimated by the site team and are included in Table 7; the impacts of recommendation on costs are explained in the text below. The recommendations are summarized in Table 9; life-cycle cost implications are not calculated because of uncertainty regarding the CTP expansion schedule.

The CTP is effectively mitigating a major source of metals loading to the SFCDR; however, effectiveness and operator requirements are strained during high flows. Components of the system are over 30 years old and should be replaced with modern, more effective and efficient equipment. Additional contributors to SFCDR metals loading have been identified and can be treated in an expanded and upgraded system.

The main concern of the optimization review team is that the effort to meet stringent anticipated water quality discharge standards will delay system expansion significantly, require excessive capital and continuous operating expense for minimal load reduction and may still result in non-compliance for manganese and possibly other discharge standards. The optimization review team, therefore, recommends a phased approach using the proven CTP LDS technology for an expansion to treat the identified sources at a reasonable capital and operating expense. The site team can then evaluate system performance and ambient surface water quality under various conditions for an extended period of time to pilot test and evaluate the applicability, cost and benefit of additional system modifications potentially including filtration, ion exchange and reverse osmosis.

This optimization review is an independent study funded by the EPA that focuses on protectiveness and cost-effectiveness. Detailed consideration of EPA policy was not part of the scope of work for this review. EPA Region 10 and EPA OSRTI will address EPA policy when considering the technical recommendations provided in this report.

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

6.1.1 EXPAND PLANT TO 20,000 GPM CAPACITY WITHOUT FILTRATION

The optimization review team recommends proceeding with expanding the plant to a capacity of 20,000 gpm, while maintaining the LDS operation, including all of the following proposed upgrades:

- Replace the existing rapid mix tank (Reactor A) with a properly designed reactor and mixer.
- Replace the aeration basin (Reactor B) with a new basin, mixer and aeration system.
- Replace the manual polymer feed system with an automatic batching system.
- Replace the remaining older sludge recycle and wasting pumps.
- Add an influent flow meter.

These are the same recommendations discussed in Section 5.3 with the exception of the recommendation to add filtration.

Cost for the additional 20,000 gpm capacity (versus 10,000 or 15,000 gpm) is comparatively low. The total estimated increase in capital and O&M costs over a 30-year period (non-discounted) is approximately \$27MM (not including sludge disposal cells closure and construction) (CH2M Hill Upgrade Existing CTP Cost Opinion Tables, 9/12/2006). The proposed 20,000 gpm capacity is within the existing thickener (clarifier) capacity. The 20,000 gpm capacity would allow the maximum treatment of additional metals sources as needed, without having to provide an additional clarifier and expand the CTP footprint. Based on the source information provided by the site team (Table 5), the 20,000 gpm capacity would also enable treatment of a large percentage of the identified metal mass contribution. Operation of the current CTP indicates that the anticipated zinc and lead limits can be met during operation at lower flows even though the current CTP has a substandard aeration and flocculation process. An upgraded and expanded system should also be able to meet the anticipated zinc and lead limits.

The filtration step would add significant cost and would provide questionable benefit as follows:

- The anticipated cadmium limit might be achieved by the LDS system without filtration but might be more consistently met with filtration.
- The expanded CTP with filtration (as currently proposed) would not be capable of meeting the limits for newly regulated metals including mercury, selenium and thallium.
- The expanded CTP with filtration (as currently proposed) would not be capable of meeting the proposed manganese limit of 0.0819 mg/L. The relevance of the manganese standard is questionable because it is based on human consumption of shellfish, which are not present in SFCDR. If manganese treatment to this limit was required, manganese

could likely be reduced to about 0.5 to 1.0 mg/L by increasing the pH to 10 standard units or higher. Additional treatment would be required to attempt to reduce the manganese to the proposed discharge limit of 0.0819 mg/L. Greensand filtration or ion exchange would be to achieve appropriate treatment technologies for achieving more consistent manganese treatment below the limit. However, the capital cost (\$10MM range) and operating costs (additional \$300,000 per year) to add either of these processes to a 20,000 gpm system would be very high for manganese removal alone.

- Installing and operating a filtration step for a 30-year period is estimated to cost an additional \$54MM over the \$27MM noted above. (Assuming the LDS consolidated sludge generation volume is three times the HDS consolidated sludge generation volume, \$12.2MM in sludge disposal cell construction costs could be saved by HDS implementation over a 30-year period partially offsetting the \$54MM filtration cost.)
- Selenium is especially difficult to remove, and if it is present above the anticipated limit, it would not be adequately addressed by filtration. Reverse osmosis would likely be required for consistent compliance. The addition of reverse osmosis to the upgraded CTP would require capital cost in the range of \$40MM range expense with O&M costs in the \$7MM per year range.

Given the substantial cost increase, the relative uncertainty in the total flow to be treated, the relative uncertainty in the water quality to be treated and the relative uncertainty in treatment plant performance of an expanded treatment system, the optimization review team recommends installation and optimization of a system without filtration. The system without filtration should be operated for an extended period of time in an interim or pilot mode to evaluate system performance relative to standards and the potential need, costs and benefits of adding any or all of the filtration, ion exchange and reverse osmosis steps. Based on system performance over this extended period, the site team could consider other improvements to the thickener (for example, radial effluent launders, flocculation in the center well) prior to considering filtration. Additional operational tests such as varying sludge recycle rates or polymer addition rates (potentially even eliminating recycling and polymer addition) should also be tested during this period to optimize treatment effectiveness and possibly reduce operating costs. This interim testing period would allow the site team to reduce significant metals loading from additional sources, as needed. During this time, various tertiary treatment processes such as filtration, greensand filtration, ion exchange and reverse osmosis could be tested at bench scale and potential pilot scale on a small portion of the system effluent.

6.1.2 DO NOT CONVERT TO HDS AT THIS TIME

Filtration would be necessary for HDS mode operation to reduce solids in the discharge. As long as the CTP does not have filtration it should not operate in HDS mode.

The HDS process has a proven track record for reliability and offers the benefits of making the most efficient use of the lime coagulant/flocculant and producing a sludge that can be readily dewatered. However, because the long-term sludge disposal practice at this facility consists of discharging liquid sludge directly from the thickener to a lagoon where consolidation through

evaporation occurs, the benefit of achieving a sludge that can be more readily dewatered is only marginal. The lagoon contents under current LDS operation appear to be solidifying and consolidating well. There was a concern expressed during the Site visit that lagoon expansion would require a significant land area that may be wanted for other purposes. Those other purposes are unknown but there appears to be vast land area available on the CIA such that expansion of the lagoon system should not pose a problem. The future lagoon will be lined to avoid leaching of water into the subsurface, but an underdrain or other means can be constructed to help remove water from the basins.

If the sludge were dewatered using a plate and frame filter press and hauled to a remote Site for disposal, this particular benefit of the HDS process would be much more technically and fiscally attractive.

The *Canyon Creek Phase II Treatability Study* (CH2M Hill October 2006, page 4-9) discusses the benefits of the HDS process in regard to the sizing of the thickener. It indicates that for a process flow rate of 1,200 gpm and using the HDS process, the area required for the thickener would be 2,152 ft² (a diameter of 52 feet). Extrapolating the flow rate up to 5,000 gpm would result in an area requirement of 8,970 ft² (a diameter of 106 feet). Extrapolating the flow rate up to 20,000 gpm would result in a diameter of 212 feet. The existing thickener has a diameter of about 210 feet and has recently been refurbished. This unit, therefore, should be capable of remaining in service for the long-term and have more than enough surface area to adequately settle particles developed in the LDS process, possibly even at the higher design flow rate. From a capital investment standpoint, it is questionable what benefit there would be in converting to HDS since the capacity of the thickener appears to be more than adequate for the projected design flow.

During the Site visit, the impact on lime dose associated with the conversion to HDS was briefly discussed. The site team indicated that there would not be a significant change in the lime dose once the HDS process was re-incorporated. One of the reported benefits of the HDS process is a reduction in the lime and coagulant requirement. If the requirement for lime is not changed significantly, especially since the cost of lime is one of the major O&M cost components for the CTP and the thickener is adequate for expansion to a 20,000 gpm design flow, the need for conversion to HDS is questionable.

6.2 RECOMMENDATIONS TO REDUCE COSTS

6.2.1 PERFORM ADDITIONAL COST-BENEFIT ANALYSIS OF THE WEST FORK OF MILO CREEK DIVERSION

The West Fork of Milo Creek diversion cost estimate (CH2M Hill 2009) is \$8.74MM. The savings for not treating the diverted 2,500 gpm (maximum flow) without filtration is about \$500,000 in capital costs and \$100,000/yr (non-discounted) in O&M costs (Table 7), requiring more than 80 years to recover the costs. If filtration is added, the extra combined cost is about \$3.5MM in capital costs and \$200,000/yr (non-discounted) O&M costs, requiring approximately 26 years to recover the costs. Therefore, the diversion could be cost-effective only if the CTP includes filtration. The actual cost recovery or payback periods are significantly longer for

calculations based on average flow rates estimated at approximately 600 to 700 gpm rather than the maximum flow rate of 2,500 gpm.

Based on the information provided, due to the very long payback, the optimization review team recommends a thorough cost-benefit analysis be performed to support final decision-making on the West Fork of Milo Creek Diversion.

6.2.2 VARIABLE FREQUENCY DRIVES (VFDs) FOR REPLACEMENT MOTORS

Several sludge recycle and discharge pumps and mixers have large (10+) HP motors that are older and will be replaced with system upgrades. As the CTP is expanded and upgraded and these older motors are replaced they should include variable frequency drives (VFD) to reduce electric costs and improve efficiency. Capital costs for the VFDs and cost savings will depend on the final design criteria, but VFDs on pumps are likely to save 10 to 25 percent of total CTP electric costs, equating to \$10,000 to \$25,000 of savings per year depending on the final CTP design. The cost of a VFD for each large (approximately 50 HP) motor is typically about \$5,000.

6.3 RECOMMENDATIONS FOR TECHNICAL IMPROVEMENT

6.3.1 CONSIDER TWO NEW REACTOR A'S DURING CTP EXPANSION

Currently the plant influent is directed to Reactor B which is equipped with a bridge mounted mechanical surface aerator. Lime is added in the rapid mix tank (Reactor A), immediately upstream from Reactor B. Recycle flow from the thickener co-mingles with the applied lime slurry in Reactor A, and then the flow discharges to Reactor B. This is the typical flow pattern for the HDS system, but not for an LDS lime precipitation process. In a typical LDS process, all the influent flow passes through the flash mix tank where it has complete exposure to the lime slurry. Following intensive flash mixing, the coagulated water flows on to the next reactor where longer retention time allows the lime precipitation process to be completed. In the CTP, the surface aerator provides the potential for oxidation of certain metals to further enhance the removal efficiency.

The current flow path is limiting the effectiveness of the LDS process in several ways. In Reactor A, or the rapid mix tank, only the recycled sludge from the thickener is treated with the lime slurry. The plant influent bypasses Reactor A, thus influent contaminants must come in contact with the effluent from Reactor A in Reactor B for removal to occur. Reactor B is subject to significant short-circuiting due to the configuration of influent and effluent entry and exit piping, and more importantly, due to the swirling motion imparted in the water by the surface aerator. Much of the influent raw water passes through Reactor B without coming in contact with lime; therefore, it is not effectively treated.

The lime feed system consists of the silos, volumetric feeders, slurry tanks and centrifugal slurry pumps that discharge slurry to Reactor A. Control of the lime slurry flow rate is based on a pH sensor in Reactor B. The slurry feed pumps appeared to run continuously in a loop from the slurry tank, out to Reactor A, and back to the slurry tank. When the pH drops below the set point, the automated valves at Reactor A open and slurry is discharged into Reactor A. The cycle time

on this open-close sequence is approximately every 30 seconds or longer. During the “off” period, no lime is being fed and recycled sludge is passing through Reactor A without slurry application. As a result of the intermittent lime slurry feed and the short-circuiting in Reactor B, the process is not achieving the best removal efficiency. In spite of these short-comings, the overall process still appears to be achieving the required removal efficiencies.

Currently, it is proposed that only one new Reactor A be constructed as part of the upgraded facilities. While this approach simplifies the lime addition due to one application point, it tends to complicate the lime addition because two pH probes would then control the feed rate. It also requires flow splitting to the two Reactor B basins that are proposed. Flow must also be split upstream of the Reactor B basins. For complete redundancy and for simpler control, it may be better to construct two new Reactor A basins. The specific benefits for constructing two new Reactor units include:

1. Redundancy. Similar to the configuration of the two Reactor B units, providing two Reactor A units will ensure that the plant will not be completely shut down if one Reactor A is out.
2. Better lime dose control. The pH is monitored in Reactor B and lime is added in Reactor A. With only one Reactor A, the flow from Reactor A must be split between the two Reactor B units. If the flow split is not accurate, the Reactor B receiving the lesser flow will experience a drop in pH that may not be effectively satisfied by addition of lime slurry to the common Reactor A. The control system would at best overdose in Reactor A causing higher than needed pH in the Reactor B getting the higher flow proportion. This would result in poor lime dose control and a waste of lime. It would be more efficient to return separated flows to two Reactor A units that have been accurately measured with flow meters, sense the pH in the separate Reactor B units, and adjust the lime dose accordingly for each treatment train.
3. Better process optimization. Slightly different pH targets can be established in two separate treatment trains to fine tune the process control during full scale operation. This approach provides a side-by-side comparison and allows the operations staff to determine impacts of changing the pH set-point on the overall process efficiency. With only one Reactor A, both trains must always operate at the same pH, and this opportunity for full scale process optimization is lost.

Based on the site team cost estimates, a second Reactor A would cost approximately \$700,000.

6.4 CONSIDERATIONS FOR GAINING SITE CLOSE OUT

Close out is not a part of this optimization review. The CTP operation is indefinite.

6.5 RECOMMENDATIONS RELATED TO ENVIRONMENTAL FOOTPRINT REDUCTION

The above recommendations provide substantial opportunity to reduce the remedy footprint. Recommendations to reduce the electricity usage will result in reductions to the energy and air emission footprints. In addition, options are suggested for reducing motor size and operation to decrease or eliminate potable water that is used for lime slaking and polymer batching. Reductions in process monitoring accomplished with the July 2011 SAP will reduce the contributions of the remedy footprint associated with laboratory analysis.

Once the system is optimized as suggested and electricity usage is better understood, the site team can consider the potential application of renewable energy at the Site.

6.5.1 METALS RECOVERY

A 1997 analysis of the residual solids from the CTP showed that the dry solids in the sludge cells is approximately 25 percent iron oxides and hydroxides, 25 percent zinc oxides and hydroxides, 22 percent manganese oxides and hydroxides, 14 percent gypsum, 12 percent magnesium oxides and hydroxides and 2 percent aluminum oxides and hydroxides. Assuming typical oxidation states for these metals and the associated number of oxide and hydroxide anions per metal ion, the dry solids in the sludge are approximately 13 percent iron, 16 percent zinc, 14 percent manganese, 14 percent gypsum, 5 percent magnesium and 1 percent aluminum. The 1997 analysis concluded that ten to 20 million pounds (5,000 to 10,000 tons) of dry solids are likely generated each year. The quantity currently in the sludge pits is unknown, but is likely over 200,000 tons. The two metals that are likely of highest potential value are the zinc and the manganese. Therefore, this analysis focuses on these two metals.

- Manganese – According to the U.S. Geological Survey (USGS), the United States relies on imports for 100 percent of medium to high quality manganese ore. In 2010, the United States imported up to 489,000 metric tons of manganese ore (35 to 40 percent manganese), up to 326,000 metric tons of ferromanganese (typically over 75 percent manganese), and up to 297,000 metric tons of silicomanganese (typically over 65 percent manganese). The primary use for manganese is in steel production. Other uses of manganese include battery production, chemical production and stainless steel production. The material safety data sheet (MSDS) for a common alkaline battery reports that the battery is comprised of 35 to 40 percent manganese dioxide (23 to 26 percent manganese). These latter uses typically require high purity (for example, 99.97 percent pure) manganese, which is achieved by leaching the manganese from ore with sulfuric acid and then electrolytically purifying the leached manganese in an electro-winning process. The International Manganese Institute estimated that the average ore content in the market place in 2011 was approximately 32.8 percent. Based on this information, it would seem that the residual solids (approximately 14 percent manganese) would need to compete with manganese ores that are of substantially higher grade. The price of manganese ore is commonly measured in dollars per metric ton unit (i.e., \$ per 1 percent of manganese in a metric ton of ore). The USGS reports that the cost for manganese ore delivered to the United States with an average manganese content of 40 to 46 percent manganese was approximately \$9 per metric ton unit in 2010 and 2011. Manganese ore

with 40 percent would cost approximately \$360 per metric ton of ore (\$0.36 per kg or \$0.16 per pound of ore). This pricing approach partially accounts for some of the variability of the manganese content of ore. For example, assuming the same cost per metric ton unit, the price of the treatment residuals at the CTP would be approximately \$126 per metric ton. However, given the significantly lower grade (14 compared to 40 percent) of the treatment residuals, the value would likely be significantly less or impractical given the increased processing needed.

The above pricing likely refers primarily to very large amounts of manganese used in steel production, given that approximately 90 percent of all mined manganese is used in steel production. However, the use of high grade electrolytic manganese for specialty uses is increasing in demand. In addition, electrolytic manganese involves significantly more processing and perhaps allows more flexibility in the source of the manganese. Despite the low manganese concentration of the treatment residuals, there may be companies within the United States that might consider using the treatment residuals for the manganese content. Battery recyclers (for example, www.toxco.com and www.batteryrecycling.com) extract manganese dioxide and zinc from recycled batteries. The optimization review team, however, is unaware if their processes or their end customers could benefit from the manganese and zinc in the treatment residuals. Additionally, some companies are apparently attempting to produce electrolytic manganese in the United States based on very low grade deposits. For example, American Manganese, Inc. (www.americanmanganeseinc.com) appears to have a business model for producing electrolytic manganese from ores with manganese content as low as 4.5 percent. A preliminary economic assessment on their webpage suggests the ability to recover 108 million lbs of manganese per year from these deposits with an electro-winning plant assuming a recovery rate of 90 percent and a cost for recovery (mining and processing) of \$0.44 per lb. For comparison, assuming the same 90 percent recovery rate, the treatment residuals would yield approximately 2.5 million pounds of manganese per year, and current “reserves” in the sludge pits likely exceeds 50 million lbs. Manganese removal rates at the CTP will likely increase (perhaps double) in the near future to meet the NPDES permit requirements. As a result, significantly more manganese may become available. Hickman Williams and Company is an existing and established provider of manganese products (ferroalloy and electrolytic manganese) within the United States and may also see value in the manganese content of the treatment residuals. The optimization review team is referencing the above companies and the American Manganese, Inc. business model as potential examples of use for the existing and future treatment residuals. The above references are not intended to support or endorse the companies or business models or recommend business with these particular firms.

- Zinc – According to the USGS, zinc is the fourth largest tonnage of production (after iron, aluminum and copper). Zinc has a number of uses including metal coating (i.e., galvanized steel), bronze and brass production, and various compounds used by the rubber, chemical and paint industries. Zinc is primarily mined as a sulfide ore. Zinc ore is both mined in the United States and imported. Zinc ores commonly contain more than 60 percent zinc, and the process for extracting the zinc is highly dependent on sulfide nature of the ore. Because the treatment residuals are not sulfides, it would appear challenging,

and potentially costly, to attempt to separate the zinc from the ore using common processes.

It would not be practical to separate the treatment residuals into different constituents at the Site, and if metals recovery is pursued, the treatment residuals would be sent to either a manganese recovery operation or a zinc recovery operation. Given the potential challenges of processing the residuals for zinc, and the apparent possibilities for pursuing manganese recovery, the optimization review team suggests potentially pursuing manganese recovery over zinc recovery, if metals recovery is pursued at all. The optimization review team also notes that the demand for manganese appears to be increasing and that the manganese in the residuals may have the potential to become more valuable over time, particularly if the manganese content of the treatment residuals significantly increases as the optimization review team projects. The optimization review team, however, believes that metals recovery is a secondary priority relative to the treatment plant upgrades and other remedial activities intended to protect human health and the environment. Manganese metal recovery may also be a possibility at other sites managed by the EPA, including the ARGO tunnel site (Colorado) where treatment residuals with manganese are sent to a landfill for disposal. The optimization review team suggests that EPA OSRTI further evaluate the potential for manganese metal recovery based on numerous potential sources of treatment residuals rather than have the potential for multiple site teams independently evaluating its potential and being distracted from higher priorities.

6.5.2 HYDROELECTRIC POWER

The flow rate of approximately 1,500 gpm and the hydraulic head of 120 feet associated with the collected AMD have a fluid horsepower of approximately 45. Losses due to turbine efficiency and energy conversion would likely reduce this to approximately 15 HP of useable energy or 11 kW of electricity. This would translate to approximately 5 percent of the total electrical demand for the Site and a value of approximately \$6,000 per year in electricity costs. Unfortunately, the collected AMD is not an appropriate fluid for hydropower given the precipitation of metals and the anticipated fouling of the turbines. The site team already reports significant metals precipitation and fouling of influent lines. The optimization review team expects that labor and materials to address the fouling would exceed the cost savings from the electricity generated on an annual basis. The capital costs would never be recovered and electricity generation would likely be significantly lower than projected due to down time. For these reasons, the optimization review team does not recommend pursuing hydropower on the collected AMD.

The future upgrades will involve pumping the treated water to the final outfall. As a result, hydropower is not appropriate for the treated water because it would take more energy to pump the water and generate electricity from it than it would to discharge the water.

6.5.3 REDUCE CITY WATER USE

From May 2011 through April 2012, an average of 8,135 gpd was used in the CTP. The majority of the water use is for lime slaking and polymer batching. The site team should consider using the treated water from the CTP for these purposes to reduce potable water use and associated costs.

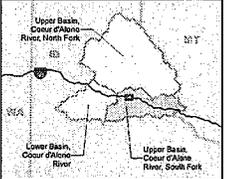
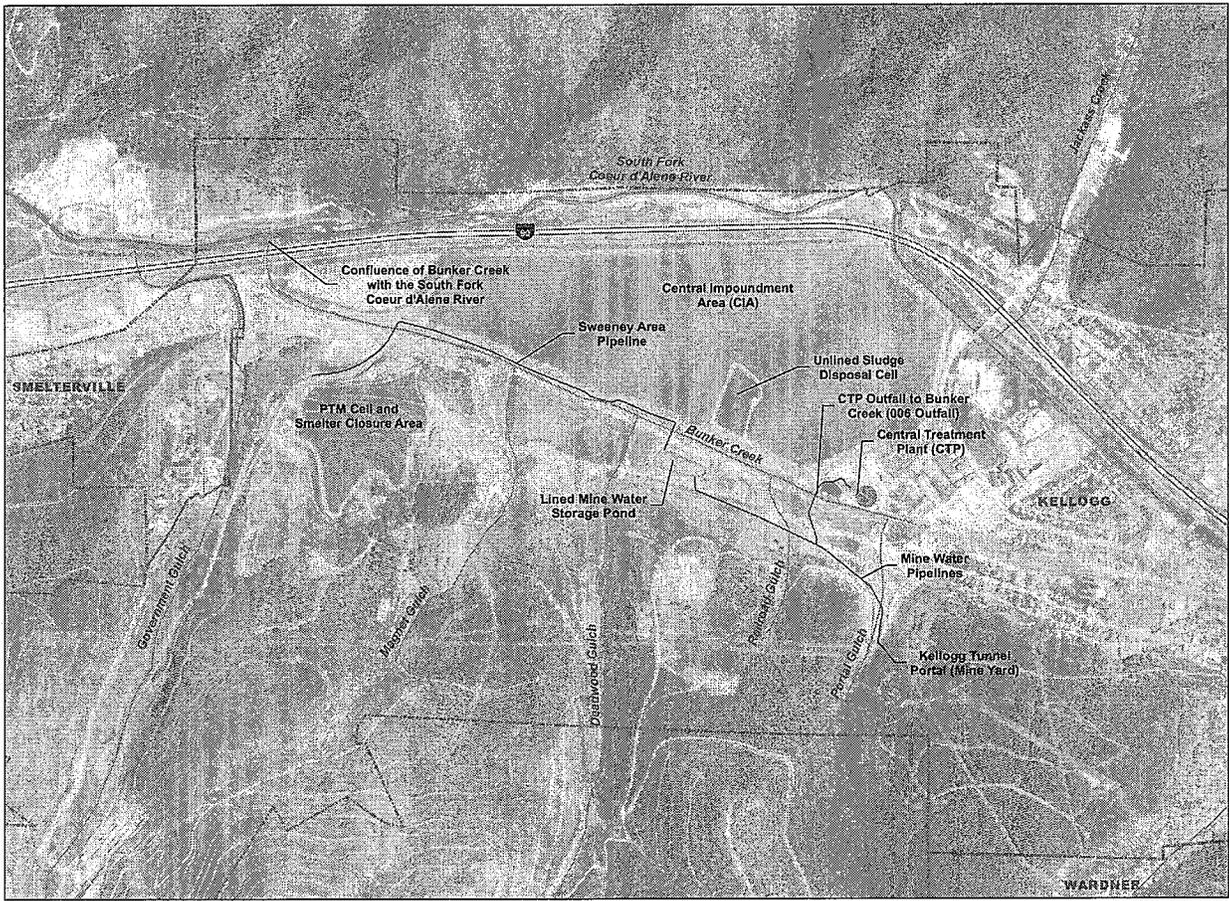
Table 9: Recommendations Summary

Recommendation	Reason	Change in Cost*
6.1.1 Expand Plant to 20,000 gpm Capacity Without Filtration	Effectiveness	See Table 7
6.1.2 Do Not Convert To HDS At This Time	Effectiveness	Not Quantified
6.2.1 Perform Additional Cost-Benefit Analysis of the West Fork of Milo Creek Diversion	Cost Reduction	Not recommended
6.2.2 Variable Frequency Drives (VFDs) For Replacement Motors	Cost Reduction	Not Quantified
6.3.1 Consider Two New Reactor A's During CTP Expansion	Technical Improvement	Not Quantified
6.5.1 Metals Recovery	Environmental Footprint Reduction	Not Quantified
6.5.2 Hydroelectric Power	Environmental Footprint Reduction	Not Recommended
6.5.3 Reduce City Water Use	Environmental Footprint Reduction	Not Quantified

* Due to the nature of this review concerning the CTP expansion and the uncertain expansion schedule, cost impacts were not quantified. gpm – gallons per minute; CTP – central treatment plant; HDS –high-density sludge.

ATTACHMENT A:

SELECT FIGURES FROM SITE DOCUMENTS



- Pipeline
- River/Creek
- City Limit

0 300 600 1,200 Feet

Base Map Data:
 NHDPlus Hydrography, 2005;
 ESRI (Roads, Jurisdictional Boundaries, 2006);
 IDWR (Aerial Imagery, 2006)

Figure 2-1
Central Treatment Plant and
Related Features
BUNKER HILL SUPERFUND SITE
 EPA

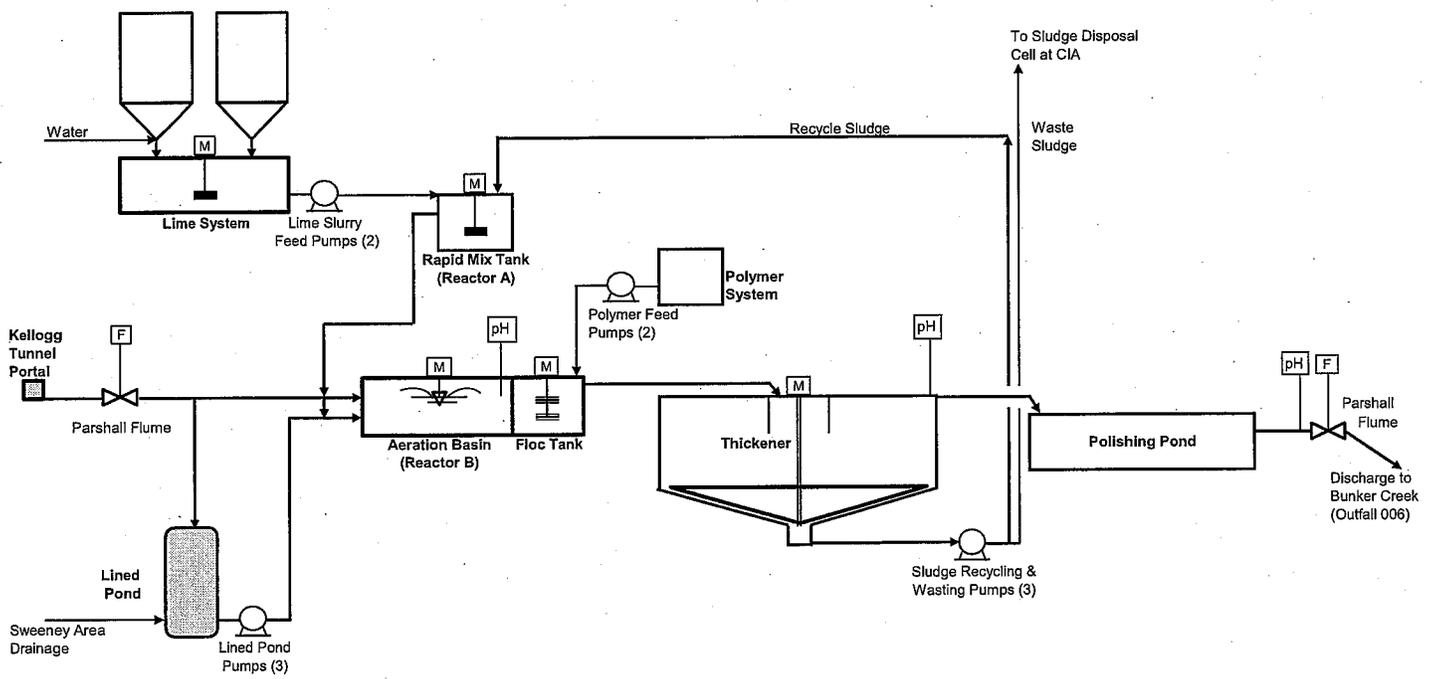
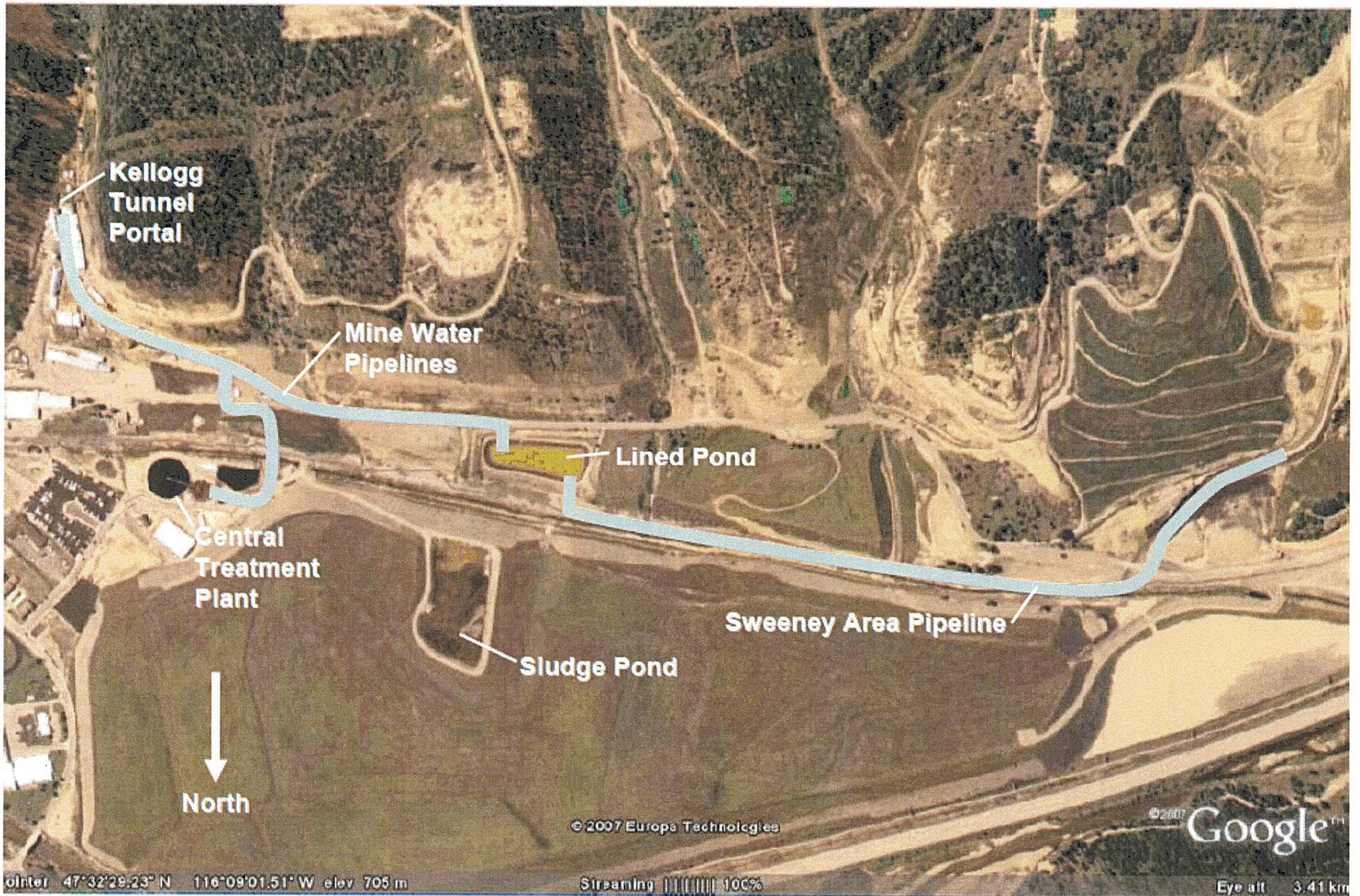


Figure 5-2
Bunker Hill CTP Flow Sheet
 BUNKER HILL SUPERFUND SITE



Source: 2006 Google Earth™

FIGURE 3
CTP-RELATED INFRASTRUCTURE