FOCUSED FEASIBILITY STUDY (FFS) ADDENDUM

EAGLE MINE SITE
MINTURN, COLORADO

February 2017

NewFields
Perspective. Vision. Solutions.

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MINTURN, COLORADO

Prepared for:
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February 2017

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Focused Feasibility Study Addendum

Eagle Mine Site, Minturn, Colorado

The *Focused Feasibility Study* (FFS) (NewFields 2013) evaluated alternatives that are designed to achieve Water Quality Standards (WQS) for cadmium, copper, and zinc in the Eagle River as it passes through the Eagle Mine Site (Site). After the FFS was finalized, Colorado's surface water standard for arsenic was identified as an applicable or relevant and appropriate requirement (i.e., ARAR) by the Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (State). The purpose of this FFS Addendum is to include arsenic information in the FFS and in the Administrative Record. The FFS Addendum will, in part, determine if the alternatives identified in the FFS will capture arsenic in a manner similar to the capture of cadmium, copper, and zinc.

Much of the data presented in this FFS Addendum were collected in the spring of 2015 under the guidance of a *FFS Addendum, Arsenic Sampling Plan* (NewFields 2015a). The data were submitted in the *FFS Addendum, 2015 Arsenic Results* (NewFields 2015b).

1 INTRODUCTION

1.1 Site Location and Mine History

The Site is located in Eagle County, Colorado between Minturn and Red Cliff and is bordered by the White River National Forest to the south and west. The Eagle River and two of its principal tributaries, Cross Creek and Rock Creek, flow through the Site (Figure 1). The Site includes the underground mill and mine workings of the Eagle Mine along with associated waste rock piles and tailings.

Mining began in this area in 1879 and 1880 with the establishment of the Belden, Black Iron, and Little Chief mines near Gilman, and the Horn Silver and Wyoming Valley mine near Red Cliff. In 1906 the Eagle Mining & Milling Company erected the Iron Mask Mill, a 150-ton per day mill at Belden, the railroad siding below Gilman. By 1916, the Empire Zinc Company of Colorado (a subsidiary of The New Jersey Zinc Company) completed the consolidation of the principal mines and mine claims in the Gilman and Belden areas into what are now known as the Eagle Mine. Large-scale lead and zinc mining in Colorado ended in 1977 when the Eagle Mine closed.

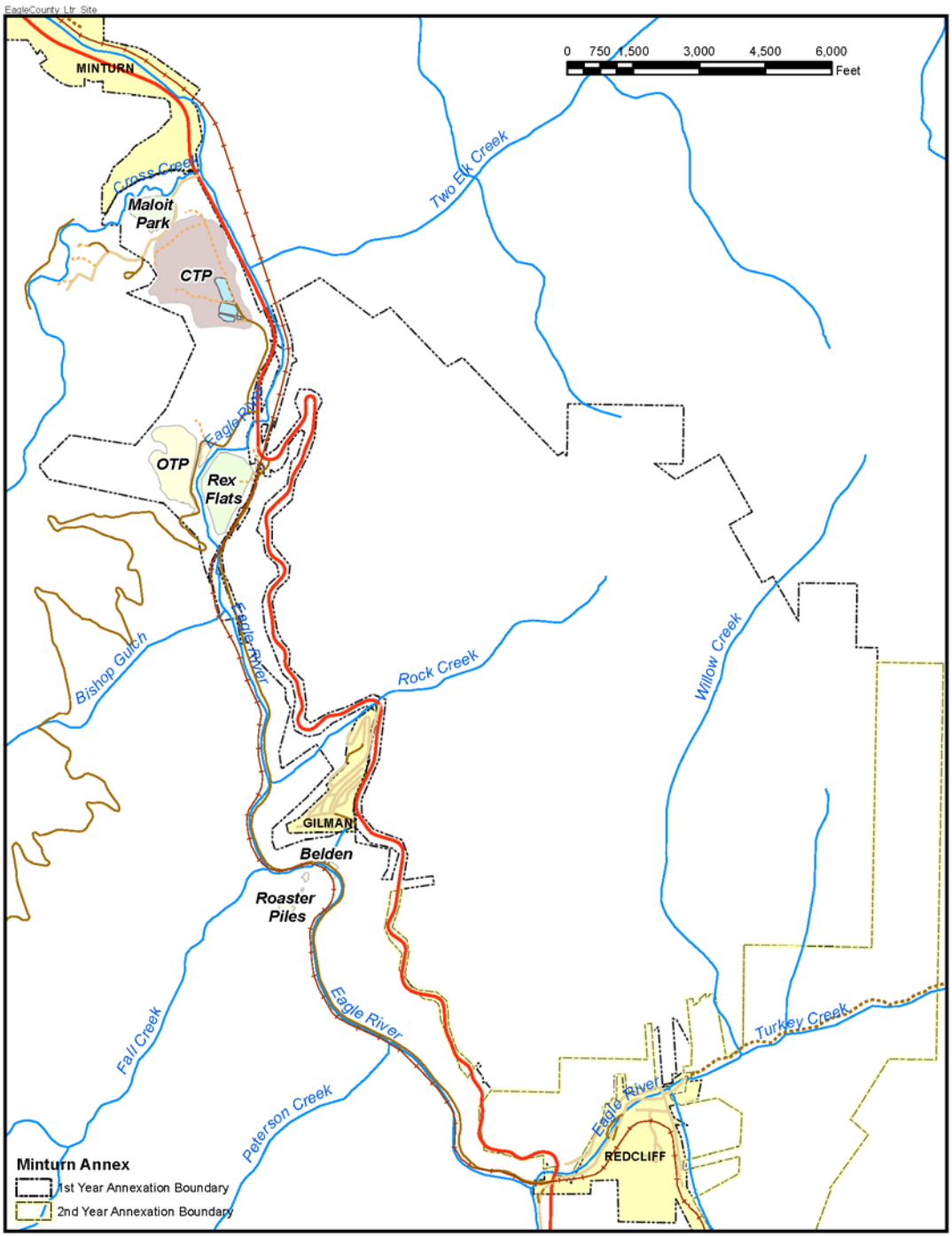

Figure 1 Eagle Mine Site

1.2 Sources of Arsenic

Arsenic occurs naturally in soils and rock at 1.8 milligrams per kilogram (mg/kg) with higher concentrations in mineralized areas where it occurs as a sulfide (arsenide) or oxide (arsenate). The sulfide mineral arsenopyrite (FeAsS) occurs very sparsely in the Eagle Mine as a coating on marcasite (FeS_2) in certain ores of lead and zinc (Lovering,

Tweto and Lovering 1978). The tailings at the Consolidated Tailings Pile (CTP) and Old Tailings Pile (OTP) contain 50 to 2,620 mg/kg arsenic based on samples from four test holes (Engineering-Science 1985). Arsenic was found in samples of mine waste in the Gilman/Belden area ranging from 53 to 2,060 mg/kg (DER, Dames & Moore 1997; FFS Table 13). At the Belden railroad siding that served the Eagle Mine mill and the older mills that predated it, samples contained up to 22,300 mg/kg arsenic (FFS Table 11). In 1993, EPA's contractor, Ecology and Environment, collected three composite samples of zinc concentrates from the mill at Belden; 1) thickener tanks, 2) concentrate storage bins, and 3) spilled material on the floor of storage bin. The arsenic concentrations ranged from 37 to 53 mg/kg.

2 ARSENIC SAMPLING AND RESULTS

Arsenic samples from the Eagle River have been collected since 2012; the program was expanded in 2015 to include both groundwater and surface water samples. A summary of the sample locations and sample collection dates in 2015 is presented in Table 1. The groundwater sample locations are shown on Figure 2. Figure 3 presents the surface water sampling locations in the Eagle River and its tributaries.

Table 1 Sample Locations and Collection Dates, 2015

Sample Site	Location	Sample Collection Dates
Groundwater		
BTS-1 in Belden	Well in Copper Tipple Extraction Trench	March 7, March 19, and April 7, 2015
BW-9R in Belden	Well near Copper Tipple Building	March 7, March 19, and April 7, 2015
EDS-3, Rock Creek	Well at the base of Rock Creek	March 7, March 19, and April 7, 2015
Mill Level in Belden	Underground mine workings	January 15 and March 26, 2015
Surface Water		
E-3	Upper Eagle River, background	March 13, March 27, April 13 and April 27, 2015
E-10	Eagle River below Belden and above Rock Creek confluence	March 13, March 27, April 13 and April 27, 2015
E-12A	Eagle River above Highway 24 bridge	March 13, March 27, April 13 and April 27, 2015
E-15	Eagle River at USFS Boneyard, below Cross Creek	March 13, March 27, April 13 and April 27, 2015
E-22	Eagle River above Gore Creek	March 13, March 27, April 13 and April 27, 2015
T-18	Cross Creek	March 13, March 27, April 13 and April 27, 2015
T-10 Lower Rock Creek	Rock Creek discharge to Eagle River	March 13, March 19, March 27, April 13 and April 27, 2015
T-10A Upper Rock Creek	Culvert under Highway 24 at Gilman	March 27, March 19, March 27, April 13 and April 27, 2015
OTP Ditch Seep	At Tigwon Road culvert	March 19 and March 27, 2015

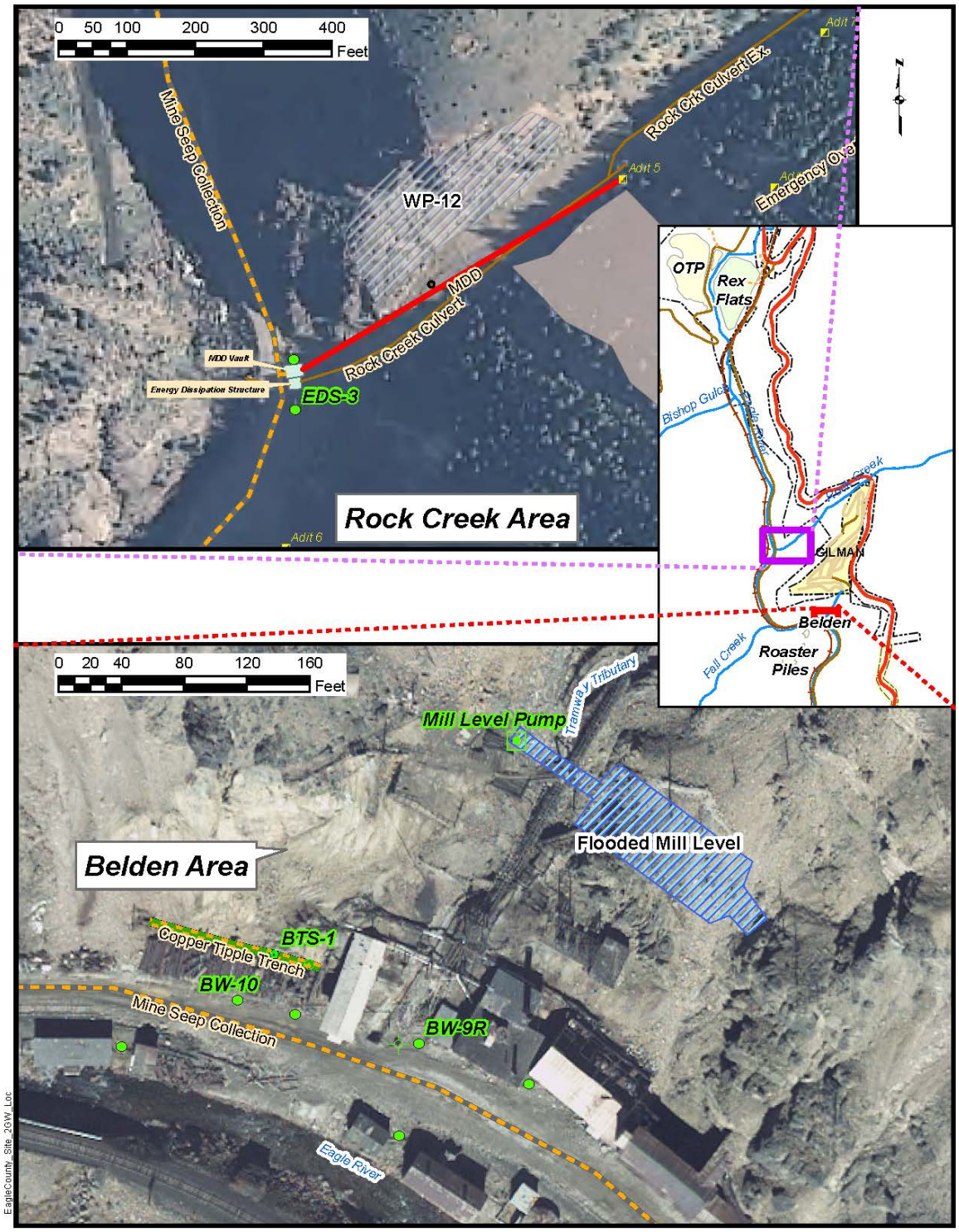

Figure 2 Groundwater Monitoring Locations

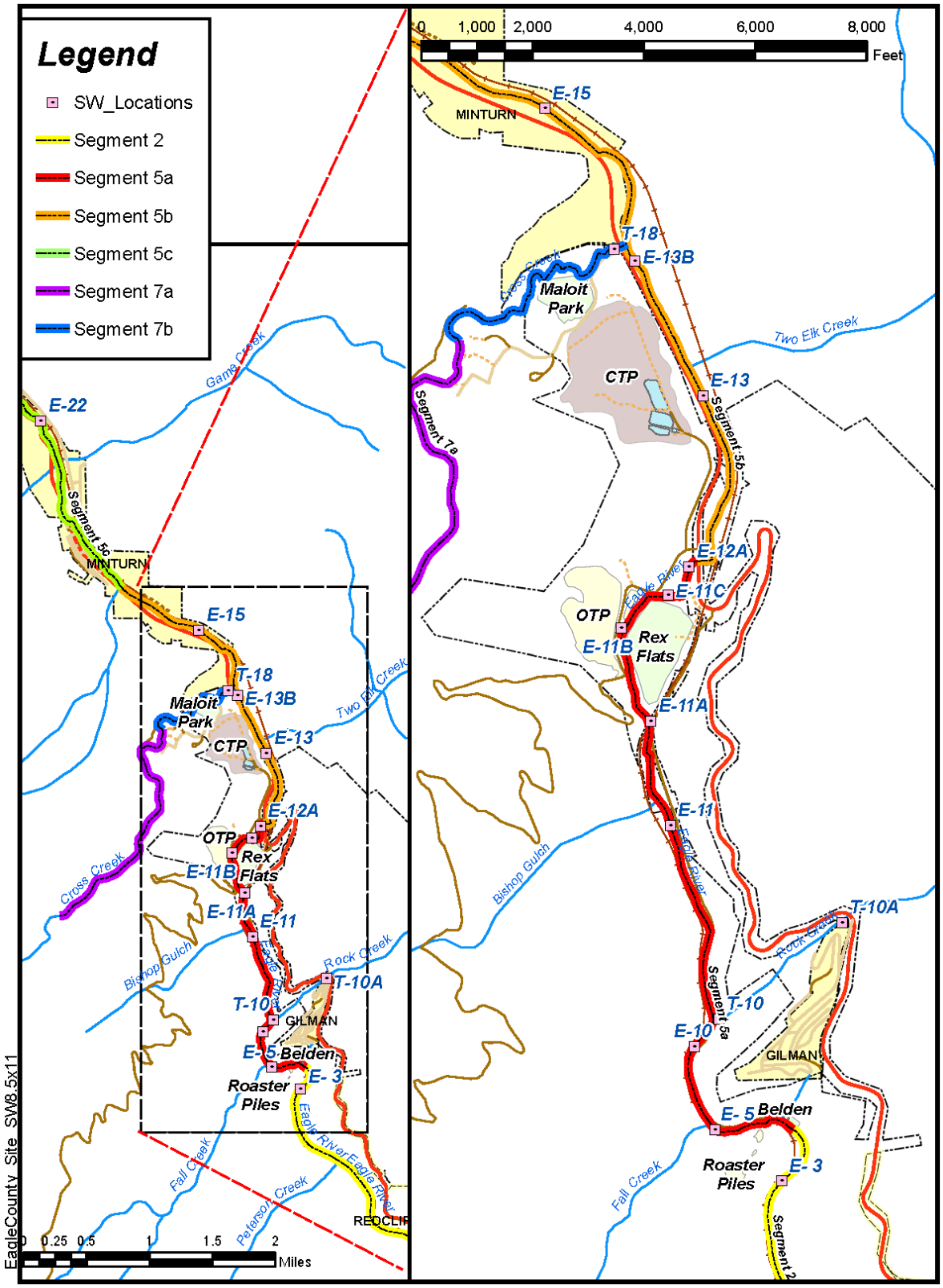

Figure 3 Surface Water Monitoring Locations and Eagle River Basin Segments

All samples were analyzed for total arsenic as shown in Table 2.

Table 2 Analytical Method and Target Detection Limit

Parameter	Method[(1)]	Target Detection Limit
Arsenic, total (unfiltered)	200.8 [(1)]	0.0002 mg/L

[(1)] Methods for Chemical Analysis of Water and Wastes and Method 200.8 (EPA 1983, 1994).

AccuTest Laboratories, Mountain States analyzed the samples for the project. Since arsenic concentrations in surface water were found near the target detection limit, the laboratory provided estimated concentrations between the laboratory practical quantitation limit (PQL), which was the target detection limit, and the laboratory's established method detection limit (MDL). Concentrations beneath the PQL are estimated. Validation results are reported in the Data Quality Assessment Memorandum provided in Appendix B of the *FFS Addendum, 2015 Arsenic Results* (NewFields 2015b).

Arsenic results for groundwater samples are presented in Table 3. Field measurements are presented in Appendix A of the FFS Addendum 2015 Arsenic Results (NewFields 2015b).

Table 3 Total Arsenic in Groundwater Samples

Sample Date	BW-10 Belden	BW-9R Belden	BTS-1 Belden	EDS-3 Rock Creek	Mill Level Belden
10/1/2013	1.1	NS	NS	NS	NS
3/6/2014	0.57	NS	NS	NS	NS
5/19/2014	0.11	NS	NS	NS	NS
9/23/2014	0.45	NS	NS	NS	NS
1/15/2015	NS	NS	NS	NS	0.0012
3/7/2015	NS	0.0026	0.183	0.0032	NS
3/26/2015	NS	NS	NS	NS	0.0016
3/19/2015	NS	0.0022	0.0326	0.0015	NS
4/7/2015	NS	0.0027	0.0183	0.0013	NS
Average	0.56	0.0025	0.078	0.002	0.0014

Notes: All units are in mg/L

Where practical, surface water sample collection coincided with the existing March-April bi-monthly surface water sampling program for the Site pursuant to the annual Site monitoring program (NewFields 2014). Arsenic results for surface water samples are presented in Table 4. Surface water field measurements are presented in Appendix A of the *FFS Addendum, 2015 Arsenic Results* (NewFields 2015b.

Table 4 Total Arsenic in Surface Water Samples

Date	Sample Location						
	E- 3	E-10	E-12A	E-15	E-22	T-10 Rock Creek	T-18 Cross Creek
10/18/12	0.36	0.26	0.36	0.23	0.43	2.3	*ND*
3/12/13	NS	0.58	0.72	0.35	0.5	1.8	*ND*
3/22/13	0.2	0.86	0.65	0.46	0.43	1.5	0.2
4/5/13	0.25	0.41	0.45	0.49	0.56	3.1	0.27
4/19/13	*ND*	0.34	0.52	0.49	0.44	2	*ND*
5/3/13	0.34	0.59	0.64	0.44	0.43	2	*ND*
9/30/13	*ND*	*ND*	0.2	*ND*	*ND*	2.6	*ND*
3/20/14	*ND*	0.4	0.29	0.31	0.31	1.9	0.51
4/3/14	*ND*	0.28	0.29	0.2	0.26	1.7	*ND*
4/17/14	0.35	0.46	0.92	0.47	0.45	1.4	0.25
9/24/14	0.22	*ND*	0.23	*ND*	*ND*	2.5	*ND*
3/13/15	0.2	0.25	0.31	0.25	0.31	1.4	***0.14***
3/19/15	NS	NS	NS	NS	NS	2.2	NS
3/27/15	***0.16***	0.21	0.23	0.25	0.26	1.4	***0.14***
4/13/15	0.31	0.26	0.31	0.32	0.29	1	***0.16***
4/27/15	0.21	0.2	0.32	0.21	0.3	1.1	0.2
10/19/15	0.18	0.13	0.24	0.16	0.27	2	0.084

Notes: All units are in µg/L
ND = Not detected at a detection limit of 0.2 µg/L.
NS = Not sampled
Values in Bold Italics are detections between the MDL and the PQL.

3 ARSENIC LOAD ESTIMATES

The term "metal loading" is commonly used to identify and quantify the input from mining-related sources to surface water. In this report, loading is used to quantify input from sources and to estimate the load that the FFS alternatives could intercept or divert. Here, loads are expressed in pounds of arsenic per day (lbs/day). Metal loads are calculated using the following formulas depending on the units of the measured flow.

Load (lbs/day) = flow (cfs) x metal concentration (mg/L) x 5.4 (units conversion factor)

Load (lbs/day) = flow (gpm) x metal concentration (mg/L) x 0.0116 (units conversion factor)

Load calculations are not exact and should be regarded as estimates. Load estimates are dependent upon a number of assumptions and involve uncertainty. Inherent in each computation of load is the calculated error associated with the measurement of metal concentration and stream flow (up to ±25 percent analytical error and ±10 percent flow error). In the analysis of loading, it is assumed the computed load incorporates these errors and, as such, retains a compounded error of at least ±20 percent.

3.1 Rock Creek Arsenic Load

In Table 5, the average arsenic load in Rock Creek is calculated using T-10 sample results (Table 4 this report) and flow measurements collected between 2012 and 2015 (see Table A-3, NewFields 2015b). Load estimates for T-10 are thought to contain less than 20 percent compounded error because the flows are small enough to be measured in containers of known volume; either a 55-gallon barrel or by calculation using flow velocity in a culvert of known dimensions.

Table 5 Arsenic Load in Rock Creek at T-10

Sample Date	T-10 Concentration (µg/L)	T-10 Flow (cfs)	T-10 Load (lbs/day)
10/18/12	2.3	0.16	0.002
3/12/13	1.8	0.13	0.001
3/22/13	1.5	0.16	0.001
4/5/13	3.1	0.20	0.003
4/19/13	2	0.45	0.005
5/3/13	2	0.45	0.005
9/30/13	2.6	0.45	0.006
3/20/14	1.9	0.2	0.002
4/3/14	1.7	1.45	0.013
4/17/14	1.4	1.0	0.008
9/24/14	2.5	0.45	0.006
3/13/15	1.4	0.55	0.004
3/19/15	2.2	1.25	0.015
3/27/15	1.4	0.95	0.007
4/13/15	1	0.71	0.004
4/27/15	1.1	0.71	0.004
10/19/15	2	0.22	0.002
Average			**0.005**

3.2 Belden Groundwater Arsenic Load

The chemistry of Belden groundwater is represented by samples from three wells listed in Table 3. Pump tests carried out on April 15, 2010 and April 4, 2012 indicated that the three wells together could produce 7 to 34 gpm. In the FFS (Section 4.2.1) 21 gpm is used to estimate the zinc load that could be captured by a system operating during the spring. Similar methodology is used here to estimate the arsenic load, wherein, the load is the sum of three flow-weighted components totaling 21 gpm:

BW-10 - 6 gpm x 0.0116 (units conversion) x 0.56 mg/L (Table 3) = 0.039 lbs/day

BW-9R - 5 gpm x 0.0116 (units conversion) x 0.0025 mg/L (Table 3) = 0.0001 lbs/day

BTS-1 - 10 gpm x 0.0116 (units conversion) x 0.078 mg/L (Table 3) = 0.009 lbs/day

Total 21 gpm **0.048 lbs/day**

3.3 Rock Creek Groundwater Arsenic Load

Well EDS-3 is completed in the colluvium, waste rock, and alluvium at the confluence of Rock Creek and the Eagle River. The EDS-3 well yields 10 gpm in the spring. The well is expected to yield an arsenic load of around 0.0002 lbs/day when pumping.

EDS-3 - 10 gpm x 0.0116 (units conversion) x 0.002 mg/L (Table 3) = 0.00023 lbs/day

3.4 Mill Level Arsenic Load

A dedicated sump pump is used to dewater the Mill Level. In 2016, 45,900 gallons of mine water were pumped out of the Mill Level to the main pipeline in Belden. The annual volume of Mill Level water represents a one-time arsenic load of 0.00014 lbs.

45,900 gallons x 0.0014 mg/L (Table 3) x 1 gram/1000 mg x1 lb/453.6 grams = 0.00014 lbs

3.5 Summary

The data from Tables 3 through 5 were used to estimate arsenic loading from selected sources, following the methodology for estimating zinc loading in the FFS. The results of this analysis are summarized in Table 6. These loading estimates are used later in the report to evaluate each alternative as to its effectiveness in diverting or capturing arsenic.

Table 6 Summary of Arsenic Load Estimates

Source and Text Reference	Sample Sites and Sample Events	Estimated Load (lbs/day)	FFS Text Reference and Method Notes
Rock Creek surface water; waste rock piles Section 3.1	Average Rock Creek load at T-10 for 2012 - 2015 sampled events	0.005	FFS Section 4.4, assumes all T-10 load is attributable to waste rock
Belden groundwater Section 3.2	Belden Wells BW-10, BW-9R, and BTS-1	0.048	FFS Section 4.2.1, flow-weighted average arsenic concentration from three wells producing 21 gpm during Spring
Rock Creek groundwater Section 3.3	EDS-3 Well, Average of 3 sampled events	0.00023	FFS Section 4.4, used 10 gpm. Periodic, well yields only during Spring
Mill Level, Belden Section 3.4	Average of 2 sampled events in 2015	0.00014 one-time load	FFS Section 4.2.3, one-time load based on 45,900 gallons/year

The load estimates point to groundwater in Belden as a primary source of arsenic, especially during the first flush of the snowmelt period (see the 3/7/2015 sample from BTS-1 in Table 3). Waste rock pile snowmelt to Rock Creek is the largest secondary source.

The FFS presents a comprehensive analysis of metals loading based on a large set of concentration data and years of stream flow data, focusing on mine-related sources of copper, cadmium, and zinc. Many of the conclusions in the FFS are relevant to arsenic as well, including the following.

- There is a relationship between snowpack and water quality. In years with higher snowpack, metal loading increases. The data set for arsenic is limited, but this relationship likely applies to arsenic.

- Upstream mine and waste rock sources in Segment 2 of the Eagle River contribute arsenic, cadmium, copper and zinc to the Eagle River. This background concentration is important to consider because the contribution from upstream will not be addressed by any of the remedial alternatives.

- The primary sources investigated in the FFS were waste rock piles and groundwater. The FFS concluded that groundwater in Belden is the primary source contributing copper, cadmium, and zinc to the Eagle River within Segment 5. It appears likely that Belden groundwater is also the primary source of arsenic.

4 IDENTIFICATION OF ARARS, RAOS, AND ARG

This section defines several key clean-up concepts common to all feasibility studies prepared in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The concepts included in this section are:

- Applicable or relevant and appropriate requirements (ARARs) and information that is “to be considered” (TBC) in the development of remedial alternatives,
- Remedial action objectives (RAOs), and
- Remedial action goals (RAGs) or for this report, alternate remedial goal (ARG) for arsenic.

ARARs and TBCs constitute the body of existing statutes, regulations, ordinances and guidance pertaining to any and all aspects of potential clean-up actions. This information influences the development of remedial alternatives by establishing numerical clean-up levels, permitting, siting, disposal, operating parameters, health and safety, and monitoring standards. The remedial alternatives selected to be evaluated must meet the substantive requirements of the ARARs and will consider those criteria, advisories, and guidance that are not ARARs but TBC. ARARs encompass all Federal and State regulatory environmental requirements that are to be considered and applied to implementation of the FFS. TBCs are criteria, advisories, guidance and proposed standards that are not legally binding and may provide useful information or recommended procedures for consideration in evaluating specific alternatives.

RAOs are general response clean-up objectives designed to protect human health and the environment.

4.1 Identification of ARARs

As part of the FFS and in accordance with the NCP [40 CFR 300.415(j)], ARARs were evaluated to ensure that all requirements are met for the scope of work to be performed. As specified in the NCP, an alternative must satisfy two "threshold" criteria specified in order to be eligible for selection: 1) the remedy must be protective of human health and the environment and 2) the remedy must meet (or provide the basis for waiving) the ARARs identified for the action.

Federal standards, requirements, criteria, or limitations that are determined to be ARARs must be met by remedial actions, as required by CERCLA (Section 121(d)(2)(A)). Also, State ARARs must be met if they are more stringent than Federal requirements. ARARs are designed to assure that potential remedial actions at a site are protective of human health and the environment; cost-effective; and use permanent solutions, alternative treatment technologies, or resource recovery technologies (EPA 1988a). The Superfund Amendments and Reauthorization Act (SARA) requires that any hazardous substance or pollutant remaining on a site must meet the level or standard of control that is established by the ARARs for that site, unless the ARAR is waived.

Applicable requirements are defined by the NCP as those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a site (40 CFR 300.5).

Although a requirement may not be applicable as a matter of law, it may still be relevant and appropriate. A requirement is deemed relevant and appropriate if it regulates or addresses problems or situations sufficiently similar to those encountered such that it is well suited to that particular site. Determination of whether a requirement is relevant and appropriate is site-specific and determined by professional judgment based on the characteristics of the remedial action, the hazardous substances present at the site, and the physical circumstances of the site and of the release. In addition, only a portion of a requirement may be deemed relevant and appropriate (EPA 1988b).

Compliance with all requirements found to be applicable or relevant and appropriate is required under SARA. A waiver from an ARAR may be obtained under certain circumstances (CERCLA Section 121(d)(4)). CERCLA Section 121(d)(2)(A) specifically limits the scope of State ARARs to standards, requirements, criteria, or limitations under environmental or facility siting laws that are promulgated and more stringent than Federal requirements.

The NCP identifies a category of information termed "to be considered" (TBC) when evaluating appropriate remedial action goals or approaches. TBC generally includes Federal and State advisories, criteria or guidance that are not ARARs, and while not legally binding may be useful in developing CERCLA remedies (see 40 CFR 300.400(g)(3)).

Refer to Section 4 of the FFS for a complete discussion of requirements that have significant potential to be ARARs and TBCs at the Eagle Mine Site.

4.2 Remedial Action Objective (RAO)

EPA guidance states that RAOs should be expressions of medium-specific risk prevention goals and must specify the following:

- The chemicals of concern (COCs) identified for the site,
- Exposure routes and receptors, and
- Acceptable COC levels for each identified exposure route.

EPA identified arsenic, cadmium, copper, lead, and zinc as the COCs in the Record of Decision (ROD) for the Operable Unit No. 1 at the Site (EPA 1993). For the former town of Gilman, or Operable Unit No. 2, human health risks were evaluated using arsenic, cadmium, chromium, and manganese (EPA 1998). Region VIII EPA, CDPHE, and a risk assessment for Operable Unit No. 3 (North Property Redevelopment for Ginn Resorts; ERM, 2007) have identified the following metals of concern at the Site: arsenic, cadmium, chromium, copper, lead, manganese and zinc.

Cadmium, copper, and zinc were previously identified as COCs in the many aquatic studies that have been performed at this Site. Subsequent studies have identified no unique characteristics that would warrant consideration of other metals for inclusion in the river COCs. The FFS is focused on the protection of aquatic receptors; therefore, cadmium, copper, and zinc make up the list of COCs. This COC list is a subset of those contained in the ROD for OU-1 and OU-2; however, it is specific to the FFS and does not imply that the COC list has been formally altered.

Aquatic receptors are exposed to the COCs through respiration, ingestion and dermal absorption. The acceptable COC level is the hardness-based WQS for Segment 5. Therefore, the RAO for the FFS is:

> **Prevent the exposure of biota in the Eagle River to cadmium, copper, and zinc concentrations that exceed Colorado Water Quality Standards by controlling the release and transport of these COCs from Site sources.**

Humans are potentially exposed to arsenic through ingestion of surface water and by consuming fish that may also have arsenic accumulated in the fish tissue. The alternate

remedial goal proposed by CDPHE (see Section 4.3 below) is protective of human health. Therefore, the RAO for arsenic is:

> **Prevent the exposure of humans to arsenic in surface water by controlling the release and transport of arsenic from Site sources to levels below the alternate remedial goal.**

The data and tables in the FFS indicate that in order to achieve the RAO, the remedial alternatives should be capable of removing at least 58 lbs/day of zinc loading to Segment 5a. The remedial action that reduces zinc concentrations will similarly reduce arsenic concentrations.

4.3 Alternate Remedial Goal for Arsenic (ARG)

Arsenic was not recognized as a COC for surface water in the 1993 Eagle Mine OU-1 ROD because arsenic was not detected in the Eagle River using the laboratory methods in effect at the time. Therefore, no ARAR for arsenic was selected in the ROD, and arsenic was not included in the on-going surface water monitoring program at the Site. However, sampling conducted by CBS in 2012 and 2013, using updated analytical methodologies with lower detection limits, confirmed that arsenic is present at the Site at concentrations that exceed the current arsenic standard of 0.02 µg/L (0.00002 mg/L). As a result, the EPA and CDPHE determined that the 0.02 µg/L arsenic standard is a potential ARAR for the Site. Nonetheless, it is technically impracticable to meet the 0.02 µg/L standard because:

- Background concentrations in the Eagle River are approximately 0.21 µg/L, (Leonard Rice Engineers, Inc. 2016a, 2016b) exceeding 0.02 µg/L by an order-of-magnitude,
- Analytical methods cannot measure to 0.02 µg/L, and
- No treatment technologies have been developed to effectively remove arsenic consistently to meet levels below 0.02 µg/L.

These issues are discussed in a Technical Impracticability (TI) Evaluation Report (CDPHE 2016) that provides the basis for a statutory waiver under CERCLA § 121(d)(4) of the 0.02 µg/L arsenic standard for Segments 5a, 5b, 5c and 7b of the Eagle River. As such, this addendum references an ARG for arsenic of 3 µg/L proposed by EPA and CDPHE in the TI Evaluation Report based on two findings of fact. First, 3 µg/L is the value selected by the Water Quality Control Commission as a Temporary Modification to the arsenic standard for new discharges (refer to Section 8.2 of the TI Evaluation Report). If a new water treatment plant were to apply for a permit to discharge into the Eagle River, the Temporary Modification for new discharges would apply, and that discharge would be granted an effluent limit of 3 µg/L. Second, based on a risk evaluation for the Site, prepared by an EPA Toxicologist, assuming a risk scenario of consuming water and fish from the Eagle River without prior treatment, 3 µg/L equates to $5x10^{-5}$ lifetime cancer risk. This goal is protective of human health and the environment, is within the acceptable risk

range, is attainable using available technologies, and is measurable using the available laboratory technologies. It is also lower than the current EPA Maximum Contaminant Level (10 µg/L) for drinking water for arsenic.

5 REMEDIAL ALTERNATIVES

The FFS remedial alternatives are listed in Table 7. This site-specific list was developed for the FFS in cooperation with the EPA and CDPHE and with input from local stakeholders.

Table 7 List of Alternatives

General Response Action	Description
No Action Alternative	
No added action	Treatment at WTP, surface ditches and runoff diversion at CTP and Gilman, collection of runoff at WP-8, mine pool regulation and MDD, Liberty well diversion, Copper Tipple Trench, groundwater and Eagle River Basin Segment 5a monitoring (Alternative 1)
Eagle Mine Seepage Alternatives	
Collection & Treatment	Groundwater collection in Belden and Rock Creek and treatment at WTP (Alternative 2A)
	In-mine precipitation in Bleakhouse mine pool (Alternative 2B)
	Iron-rich material (IRM) reaction wall in Belden, *in situ* treatment of Belden groundwater and Tip Top (Alternative 2C)
Waste Rock Alternatives	
Source Removal	Excavate, transport and dispose of onsite – only accessible acid-generating waste rock (Alternative 3A)
	Excavate, transport and dispose of onsite – all waste rock (Alternative 3B)
	Excavate, transport and dispose of offsite – all waste rock (Alternative 3C)
Collection & Treatment	Groundwater extraction at WRP-14 in Belden; convey to WTP (included in Alternative 2A)
Rex Flats and OTP Alternatives	
Collection & Treatment	Groundwater collection and treatment at new treatment plant (Alternative 4A)
	IRM reaction wall(s), *in situ* treatment (Alternative 4B)

The following provides a summary of each alternative and its method of meeting the RAO and the arsenic ARG. Detailed descriptions of each alternative and analysis of the alternatives' effectiveness at meeting the feasibility criteria are provided in the FFS.

5.1 Alternative 1 – No Added Action

Alternative 1 prescribes no new remedial actions but recognizes and takes into consideration the engineering actions, rules, regulations, and institutional controls (ICs) that have been previously implemented. The major components of Alternative 1 that would be operated and/or maintained include:

- Water Treatment Plant (WTP)
- Surface runon and runoff ditches at Gilman, Waste Pile-8, Old Tailing Pile, and the Consolidated Tailings Pile (CTP)
- Mine Draw Down (MDD) System
- Liberty well diversion
- CTP cap
- CTP groundwater extraction trenches
- Up-Gradient Diversion Trench (UGDT)
- Rock Creek Siphon.

5.2 Alternative 2A – Groundwater Collection and Treatment, Belden and Rock Creek

Alternative 2A is designed to achieve the RAO by collection of groundwater in Belden and Rock Creek with treatment at the WTP. Water that collects in the existing Copper Tipple Trench in Belden would be piped to a new deeper collection trench constructed in the railroad right-of-way. The new collection trench would be constructed with 700 feet of perforated pipe set between 7 feet and 15 feet below ground surface (bgs). The trench is designed to intercept groundwater along a line extending from the base of the Tramway Drainage downstream the full length of the Loading Dock. A diagram of the proposed collection trench is presented in the FFS. A non-perforated connecting pipeline would extend 1,100 feet downstream to Rock Creek where it would enter the existing pipeline. At Rock Creek, the existing, electrified pumping well EDS-3 would operate to capture and conventionally treat groundwater. To supplement the volume of groundwater captured by the Copper Tipple Trench and the new collection trench, water in the Mill Level of the underground mill would be pumped or gravity drained to the pipeline during the spring.

The Alternative 2A system would typically be operated continuously during March and April and is expected to yield on average:

- Copper Tipple Trench and Belden groundwater- 38 lbs/day zinc and 0.048 lbs/day arsenic (see Table 6)
- Rock Creek groundwater – 6 to 12 lbs/day zinc and 0.00023 lbs/day arsenic (see Table 6)
- Mill Level – One time load of 115 lbs zinc and 0.00014 lbs arsenic (see Table 6).

5.3 Alternative 2B – In-mine Precipitation

The proposed remediation system involves treating the water in the mine pool with lime or sodium hydroxide to raise the pH and cause metals to precipitate as insoluble oxyhydroxides. The WTP would be operated as a secondary treatment train, periodically adjusted to compensate for an influent from the mine with increasing pH and decreasing total dissolved solids. The long-term goal is to improve the water chemistry of the upper portion of the mine pool to the point where 1) Adit 5 water can be discharged with little or no treatment, and 2) metal loading to Rock Creek groundwater is negligible.

The final design of the full-scale in-mine treatment system will depend on the results of laboratory and pilot-scale testing; however, the full-scale built-out system would likely include the following.

- Use an existing sump at the base of Rock Creek (the Pumpback vault) as a collection point for water from Adit No. 6, WP-8, Tip Top mine, and Adit 5 seep.
- Construction of additional pumping and piping to deliver this sump water to a new slurry/solution system in Gilman.
- Delivery of lime or sodium hydroxide reagent from a new slurry/solution system in Gilman into the Bleakhouse mine pool.

The WTP would function as a backup, treating enough water drawn from Adit 5 to maintain a constant mine pool level and treating the groundwater collected in the CTP extraction trenches. With time, mine pool water would be directly discharged to the river. The system is expected to essentially eliminate zinc, cadmium, copper, and arsenic loading in Rock Creek groundwater resulting in a reduction of 0.00023 lbs/day arsenic (Table 6).

5.4 Alternative 2C – IRM Reaction Wall in Belden

The proposed remediation system involves passive *in situ* treatment of groundwater that has been shown to be a primary source of metals loading to Segment 5. Groundwater moving to the river from source areas in Belden would be treated *in situ* when passing through the iron-rich material (IRM). The remediation system is expected to remove 130 lbs/day zinc. The 130 lbs/day estimate is a design specification for 30 years; the IRM is capable of absorbing more than 130 lbs/day zinc over the short term. The pilot test results (Brown 2012) indicate that arsenic, iron, copper, and cadmium will also be sequestered in the IRM. While the system is designed to retain zinc, it is conservatively estimated that the arsenic load in Belden groundwater will be reduced by 50%:

Arsenic load est. of 0.048 lbs/day (Table 6) x 0.5 = 0.024 lbs/day.

The existing, electrified pumping well at the base of Rock Creek, EDS-3, would operate to capture and conventionally treat Rock Creek groundwater for another 6 to 12 lbs/day for a total of up to 142 lbs/day zinc and 0.00023 lbs/day arsenic (Table 6).

This alternative involves constructing a trench to bedrock in Belden containing 4,200 tons (2,900 CY) of IRM, roughly at the location of the proposed interceptor trench shown in the FFS. Materials excavated from the trench are a source of zinc and other metals and the rail ballast, debris, and waste rock will be hauled to the CTP for separation and disposal. Trash and debris (*e.g.,* rails, ties, pipes, and lumber) will be separated and taken to the municipal landfill or salvaged. Gravels and rock will be dumped at the Temp Cell or other CTP site designated by the landowners. Trench backfill above the IRM will consist of alkaline limestone and dolomite waste rock borrowed from WP-11 in Rock Creek canyon. Tip Top mine water (approx.10 gpm) will be conveyed in a new low-pressure pipe to the upgradient side of the IRM wall and treated *in situ*. Three existing wells, BW-5, 6 and 7, and two new wells will be used for monitoring wells on the downgradient (river) side of the wall.

The IRM wall is designed to have a 30-year life. After its lifetime, the “spent” wall will be excavated and replaced with fresh IRM or a second wall will be constructed.

If successfully implemented, the IRM wall would relieve the WTP of 5.8 million gallons of Tip Top mine water each year. The pipeline from the Belden to Rock Creek carrying Tip Top water would be abandoned, eliminating the possibility of a mine water release in that section. This buried *in situ* place-and-forget system does not require a power supply and has essentially no maintenance costs; however, it is inherently not receptive to modifications after installation. Some of the existing 10 monitoring wells in Belden could be converted to pumping wells for $150,000 to intercept additional groundwater if the RAO is not met. Permeability barriers could be installed to limit the amount of groundwater passing around the ends of the IRM wall.

5.5 Alternative 3A – Excavate, Transport and Dispose of Accessible and Acid-Generating Waste Rock Onsite

Acid-generating mine waste piles WP-8, WP-9, WP-10, and the remnants of WP-14 would be excavated and transported by off-road trucks and conveyor to an onsite repository at the CTP. The truck haul route would utilize the rail easement along the river from Belden to the repository site. Permission will be needed from the railroad and landowners. This alternative is focused on the waste rock piles that are accessible and that are potential sources for zinc loading based on the assessment of their acid-generating potential (see FFS Section 4.3). The removal of WP-9 and WP-10 would require partial removal of the concrete block crib wall installed by EPA in 2009. The removal of WP-9 and WP-10 would require federal funding because the piles resulted from early “orphan” mining operations.

To raise the soil pH, the excavated footprint of the waste rock piles would be limed with ground calcium carbonate, sugar beet precipitated calcium carbonate, or their equivalent. With the exception of WP-8, no other soil amendments are prescribed since the steep slopes will not be revegetated. The 4-acre footprint of WP-8 would receive lime, soil amendments, and seed for revegetation.

The source of some of the metals that impact Segment 5a would be eliminated by relocation and capping. The removal would eliminate a source of metal exposure to potential future residents of Gilman. The removal will eliminate most of the O&M currently committed to WP-8. With respect to loading to Segment 5a, the removal of the waste rock is expected to result in an 8 lbs/day decrease in zinc loading (see FFS Table 18) and a 0.005 lbs/day decrease in arsenic loading (Table 6).

5.6 Alternative 3B – Excavate, Transport and Dispose of All Waste Rock Onsite

This alternative will remove waste rock piles regardless of their acid-generating potential and will address piles that are not readily accessible. All mine waste piles (see FFS Figure 16) would be excavated and transported by off-road trucks and conveyed to an onsite repository at the CTP. The truck haul route would utilize the rail easement along the river from Belden to the repository site. Permission will be needed from the railroad and landowners.

Conventional open cut excavation with track excavators, wheel loaders, and scrapers is applicable to WP-7, WP-8, WP-9, WP-10, the top of WP-11, and a portion of WP-14. Removal of WP-1 through WP-6, the lower portion of WP-11, the top of WP-14, Adit 7, and Crossbeam piles on steep slopes is expected to require aerial trams and draglines. The removal of WP-9 and WP-10 would require the removal of the concrete block crib wall installed by EPA in 2009. The removal of WP-9 and WP-10 would require federal funding because the piles resulted from “orphan” mining operations.

WP-13 at the Rocky Point tunnel on the cliff below Gilman is not accessible with conventional equipment. Removal of this relatively inaccessible waste rock pile is considered to be impractical and not justified in terms of the added risk to workers and the small amount of metal load that could be removed from the system.

To raise the soil pH, the excavated footprint of the acid-generating waste rock piles would be limed with ground calcium carbonate, sugar beet precipitated calcium carbonate, or their equivalent. No other soil amendments are prescribed since the areas will not be revegetated. The 4-acre footprint of WP-8 would receive lime, soil amendments, and seed for revegetation.

The source of some of the metals that impact Segment 5a would be eliminated by relocation and capping. The removal would eliminate a source of metal exposure to

potential future residents of Gilman. The removal will eliminate the O&M currently committed to WP-8. The removal of the waste rock is expected to result in an 8 lbs/day decrease in zinc loading (see FFS Table 18) and a 0.005 lbs/day (Table 6) decrease in arsenic loading to Segment 5a.

5.7 Alternative 3C – Excavate, Transport and Dispose of All Waste Rock Offsite

This alternative is the same as Alternative 3B, except that all waste will be disposed of offsite. All waste rock piles would be excavated and transported to an offsite Subtitle D landfill capable of accepting the waste rock materials. The truck haul route would utilize Highway 24 and Interstate 70 with a staging area in Gilman.

Alternative 3C is similar to on-site disposal in that metal sources in the waste rock would be relocated and capped. The removal would eliminate a source of metal exposure to potential future residents of Gilman. The removal will eliminate the O&M currently committed to WP-8 thus O&M costs will be reduced slightly. The cost is significantly higher than on-site disposal due to transportation. The use of Highway 24 and Interstate 70 increases the risk of traffic accidents and road fatalities. As a stand-alone option, the removal of the waste rock is expected to result in an 8 lbs/day decrease in zinc loading (see FFS Table 18) and 0.005 lbs/day (Table 6) decrease in arsenic loading to Segment 5a.

5.8 Alternative 4A – Groundwater Collection and Treatment, OTP/Rex Flats

This alternative addresses metal loading within the lower reach of Segment 5a from the OTP/Rex Flats groundwater. Groundwater from two former tailings sites that would otherwise enter the river would be collected in groundwater interceptor trenches along the west bank of the river at the OTP and along the south bank of the river at Rex Flats. The interceptor pipes (see FFS Figure 21) would be installed approximately 3 feet bgs and vertical barrier walls of impermeable liner would be installed on the downgradient walls of the trench. Collected water would flow to sumps and duplex-pump lift stations. The existing WTP does not have the excess capacity to accept the water from the OTP/Rex collection thus the FFS included a new, separate water treatment facility at Rex Flats. For this Addendum, the treatment facility in the FFS was re-sized to treat 50 to 150 gpm and costs were updated. The construction and operation cost estimates for the new treatment plant were developed by NewFields (see Appendix A). The interceptor trench and pump station construction and operation costs, originally developed by ERM (2007), were taken from Table F-8 of the FFS.

This proven technology requires no innovative or non-standard equipment. Physical space for the trenches is readily available to allow installation. Because a new treatment facility is part of the alternative, the increased treatment requirement does not place a burden on the capabilities of the existing WTP. The visible OTP South Ditch seep along Tigwon Road would be captured and treated.

In the FFS, the Alternative 4A groundwater collection system at OTP/Rex Flats is expected to eliminate the OTP South Ditch seep and decrease zinc loading by up to 3 lbs/day during the spring (see FFS Section 4.5). The pump-and-treat system described above is expected to be equally effective. To estimate the arsenic load that would be intercepted, a zinc to arsenic load ratio (Zn load: As load) was developed using data from 2012 to 2016 for river station E-12A at the downstream end of the OTP/Rex Flats segment. The Zn load: As load ratio is 400:1; thus, 3 lbs/day zinc is proportional to approximately 0.0075 lbs/day arsenic.

3 lbs/day zinc /400 = 0.0075 lbs/day arsenic

5.9 Alternative 4B – IRM Reaction Wall at OTP/Rex Flats

This alternative is similar to Alternative 4A but instead of treating the groundwater in the OTP/Rex Flats area via a conventional pump and treat system, trenches will be filled with the *in situ* treatment material, IRM, to create a permeable reaction barrier (PRB). Tank pilot tests using IRM have proven effective at removing metals from Site waters. The proposed remediation system is similar to the Belden system described in Alternative 3C and involves constructing two, 100-foot-long, 15-foot-deep, 11-foot-wide PRBs, each containing 200 CY (290 tons) of IRM along the west bank of the river at the OTP and along the south bank of the river at Rex Flats, at roughly the same locations as the interceptor trenches in Alternative 4A, except that the IRM trench at the OTP would be on the south end to address the visible seep along Tigwon Road. Groundwater moving to the river from the OTP/Rex Flats area would be treated *in situ* when passing through the material. This system does not place a burden on the capabilities of the existing WTP by contributing additional flow.

Owing to the modest amount of zinc loading in the lower reach of Segment 5a, up to 3 lbs/day, the *in situ* IRM system at OTP/Rex Flats was designed to remove 10 lbs/day zinc for 30 years. The 10 lbs/day figure is a design specification; the IRM is capable of absorbing more than 10 lbs/day over the short term. Like zinc, arsenic loading to the river is small from OTP/Rex Flats (see estimate in Alternative 4A above). The IRM pilot tests (Brown 2012) indicate that an IRM *in situ* treatment system would be the equal of Alternative 4A and capable of eliminating an arsenic load of 0.0075 lbs/day.

6 COST COMPARISON

In the FFS, capital and O&M cost estimates were assembled for each alternative with an accuracy range of at least +50 to –30 percent. A present worth analysis discounting all costs to a common base year was performed. The present worth analysis is intended to facilitate a comparison of alternatives based on a single cost number, even when costs may be expended over different time periods.

In accordance with EPA guidance (EPA 1988a; EPA 2000), the cost criterion is comprised of the following cost analyses:

- Direct capital costs, including cost for construction; equipment, labor, and materials; site development and building; and disposal facility
- Indirect capital costs, including cost for engineering, construction oversight, start up and shakedown, and contingency allowances
- Annual O&M costs, including costs for post-construction labor, maintenance, administration, long-term monitoring, equipment replacement, and periodic reviews.

Detailed cost estimate tables are presented in Appendix F of the FFS. The tables present capital costs of constructing the Alternative followed by O&M costs, which include two parts; Alternative-required O&M and O&M of the existing remedial systems. The cost of the existing remedy includes annualized costs of surface water and groundwater monitoring, O&M of the treatment system and pipelines, and project management. On the reverse side of each table are 30-year non-discounted and present worth estimates. The net present worth of each alternative was calculated on the basis of a seven percent discount rate over 30 years.

For this Addendum, the O&M cost of the existing treatment plant and pipeline remedial systems has been updated to more accurately represent costs going forward. Updating the water treatment and pipeline maintenance costs changes the total 30-year non-discounted cost and the present worth for every alternative. The new totals are presented in Table 8 below; the Detailed Cost Estimate tables are presented in Appendix A to this Addendum.

Table 8 Estimated Costs

Alternative	Total Capital	Annual O&M	30-Year Non-Discounted	Present Worth
1	---	$ 713,000	$ 22,103,000	$ 9,561,000
2A	$ 389,789	727,460	22,926,589	10,130,000
2B	404,000	311,800	10,471,000	4,986,000
2C	634,910	713,000	22,737,910	10,196,000
3A	3,764,875	713,000	25,867,875	13,326,000
3B	5,057,675	682,000	26,236,675	14,068,000
3C	5,381,577	716,500	27,589,577	14,810,000
4A	3,259,593	1,336,235	44,059,643	20,554,000
4B	489,793	713,000	22,592,793	10,050,000

7 COMPARATIVE ANALYSIS SUMMARY

All the alternatives address the principal threat, impacts to surface water quality, to varying degrees and are implementable from an engineering perspective. The FFS comparative analysis summary is restated here, highlighting the key distinctions between the alternatives. A summary of the alternatives' abilities to meet the ARG is included.

Achievement of the Zinc RAO

The principal point of comparison in the FFS is the alternatives' abilities to achieve the RAO and the time required to meet that objective.

- Alternatives 2A and 2C are considered to be capable of achieving the RAO. The other alternatives are not expected to achieve the objective because they address secondary or minor sources of zinc.

- Only Alternatives 2A and 2C are expected to achieve the RAO in a reasonable timeframe, approximately 1 to 2 years.

Effectiveness and Cost

Depending on the setting, the alternatives differ with respect to their effectiveness and their cost.

- Alternative 2A and 2C are expected to be effective for a moderate cost.

- Alternative 2B, in-mine treatment, is designed to lower the zinc in the mine pool by precipitating metals directly in the mine. The long term cost of this alternative is substantially less than the others because in-mine treatment goes directly to reducing treatment costs which is the major component of the 30-year cost. While attractive from a cost perspective, in-mine treatment does not address the contaminated groundwater in Belden, thus there is no indication that it can independently achieve the RAO. A link between the mine pool and the seasonally present groundwater in Belden has not been established. Effectiveness of in-mine treatment by precipitation would not be known until completion of the initial pilot test phase thus its reliability and cost are speculative at this point.

- Waste rock removal under Alternatives 3A, 3B, and 3C has been shown to be costly and adds a degree of risk to the public and workers by excavation and transportation. Moreover, as a response action, it has not been shown to be effective in lowering the zinc load in the river to a point where the RAO will be achieved.

- It is expected that either of Alternatives 4A or 4B will be effective in controlling the small amount of zinc loading contributed by OTP/Rex Flats. However, the primary zinc loading occurs upstream and a remedy at OTP/Rex Flats will not lower the zinc concentration to a point where the RAO will be achieved.

Achievement of the Arsenic ARG

All the alternatives reduce arsenic loading to varying degrees. The ARG contains a goal for arsenic of 3 µg/L that is applicable to the Superfund remedies. It applies to the discharge from new treatment systems. Based on IRM pilot testing conducted thus far, it is doubtful that IRM alternatives 2C and 4B can meet this discharge standard. Similarly, the planned direct discharge of mine water associated with in-mine treatment Alternative 2B may not meet the ARG limit. Only conventional treatment associated with Alternatives 2A and 4A is expected to meet the ARG. Table 2 from the Technical Impracticability Evaluation Report showed that the existing water treatment plant at the site has an average influent concentration of 31.63 µg/L of arsenic and successfully treats that arsenic down to an average effluent concentration of 1.04 µg/L.

Preferred Remedy The preferred remedy is Alternative 2A because it is expected to control arsenic, cadmium, copper, and zinc loading in Belden and Rock Creek and achieve the RAO in a reasonable time frame at a moderate cost. Water collected under Alternative 2A would be treated at a conventional plant where the discharge from that plant meets the ARG.

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APPENDIX A

REVISED COST ESTIMATE TABLES

TABLE A-1

DETAILED COST ESTIMATE
Alternative 1 - No Added Action

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
CAPITAL COSTS					
None					
TOTAL CAPITAL COSTS					**$ -**
OPERATING AND MAINTENANCE (O&M) COSTS					
Groundwater and surface water sampling	a	1	year	$ 20,000.00	$ 20,000
Maintenance of Collection System	b	1	year	$ 40,000.00	$ 40,000
Water Treatment	c	1	year	$ 560,000.00	$ 560,000
Project Management	d	1	year	$ 93,000.00	$ 93,000
TOTAL ANNUAL O&M COSTS					**$ 713,000**
TOTAL 30-YEAR COSTS (non-discounted)					**$ 22,103,000**
Present Worth Value (see following table at 7% discount)					**$ 9,561,000**

Notes

Unless identified separately burden and profits are included in unit costs.

a Budget for 2016 monitoring; labor included with Project Management

b Pipeline maintenance and CTP pump replacement; reporting included with Project Management

c Cost estimate for operation of treatment system based on quotes for similar sized systems.

d 15% of annual costs

TABLE A-1 (cont.)

PRESENT WORTH ANALYSIS
Alternative 1 - No Further Action

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	Rate of Return = 3% Discount Factor	Rate of Return = 3% Present Worth	Rate of Return = 7% Discount Factor	Rate of Return = 7% Present Worth	Rate of Return = 10% Discount Factor	Rate of Return = 10% Present Worth
0	$0	$713,000	$713,000	1.0000	$713,000	1.0000	$713,000	1.0000	$713,000
1		$713,000	$713,000	0.9709	$692,233	0.9346	$666,355	0.9091	$648,182
2		$713,000	$713,000	0.9426	$672,071	0.8734	$622,762	0.8264	$589,256
3		$713,000	$713,000	0.9151	$652,496	0.8163	$582,020	0.7513	$535,687
4		$713,000	$713,000	0.8885	$633,491	0.7629	$543,944	0.6830	$486,989
5		$713,000	$713,000	0.8626	$615,040	0.7130	$508,359	0.6209	$442,717
6		$713,000	$713,000	0.8375	$597,126	0.6663	$475,102	0.5645	$402,470
7		$713,000	$713,000	0.8131	$579,734	0.6227	$444,021	0.5132	$365,882
8		$713,000	$713,000	0.7894	$562,849	0.5820	$414,972	0.4665	$332,620
9		$713,000	$713,000	0.7664	$546,455	0.5439	$387,825	0.4241	$302,382
10		$713,000	$713,000	0.7441	$530,539	0.5083	$362,453	0.3855	$274,892
11		$713,000	$713,000	0.7224	$515,086	0.4751	$338,741	0.3505	$249,902
12		$713,000	$713,000	0.7014	$500,084	0.4440	$316,581	0.3186	$227,184
13		$713,000	$713,000	0.6810	$485,518	0.4150	$295,870	0.2897	$206,531
14		$713,000	$713,000	0.6611	$471,377	0.3878	$276,514	0.2633	$187,755
15		$713,000	$713,000	0.6419	$457,648	0.3624	$258,424	0.2394	$170,687
16		$713,000	$713,000	0.6232	$444,318	0.3387	$241,518	0.2176	$155,170
17		$713,000	$713,000	0.6050	$431,377	0.3166	$225,718	0.1978	$141,063
18		$713,000	$713,000	0.5874	$418,812	0.2959	$210,951	0.1799	$128,239
19		$713,000	$713,000	0.5703	$406,614	0.2765	$197,150	0.1635	$116,581
20		$713,000	$713,000	0.5537	$394,771	0.2584	$184,253	0.1486	$105,983
21		$713,000	$713,000	0.5375	$383,273	0.2415	$172,199	0.1351	$96,348
22		$713,000	$713,000	0.5219	$372,109	0.2257	$160,933	0.1228	$87,589
23		$713,000	$713,000	0.5067	$361,271	0.2109	$150,405	0.1117	$79,627
24		$713,000	$713,000	0.4919	$350,749	0.1971	$140,566	0.1015	$72,388
25		$713,000	$713,000	0.4776	$340,533	0.1842	$131,370	0.0923	$65,807
26		$713,000	$713,000	0.4637	$330,614	0.1722	$122,775	0.0839	$59,825
27		$713,000	$713,000	0.4502	$320,985	0.1609	$114,743	0.0763	$54,386
28		$713,000	$713,000	0.4371	$311,636	0.1504	$107,237	0.0693	$49,442
29		$713,000	$713,000	0.4243	$302,559	0.1406	$100,221	0.0630	$44,947
30		$713,000	$713,000	0.4120	$293,747	0.1314	$93,665	0.0573	$40,861
			Non-discounted cost: $22,103,000						
TOTAL PRESENT WORTH				@ 3% $14,688,000		@ 7% $9,561,000		@ 10% $7,434,000	

Ongoing Costs include annual O&M costs and periodic costs

TABLE A-2

DETAILED COST ESTIMATE
Alternative 2A - Groundwater Collection and Treatment, Belden and Rock Creek

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
CAPITAL COSTS					
Direct Construction					
4" perforated HDPE pipe (installed)	a,b	700	lf	$ 8.00	$ 5,600
Cleanout (installed)	a,c	4	each	$ 100.00	$ 400
Trench excavation	a,d	1,800	lf	$ 65.00	$ 117,000
Trench membrane liner		1,166	sy	$ 5.00	$ 5,830
Place excess excavated soil in trench		11,000	cy	$ 3.50	$ 38,500
Geotextile filter around drainage rock	a	700	lf	$ 2.50	$ 1,750
Load Backfill	a	1,000	cy	$ 9.50	$ 9,500
Haul Backfill	a,e	1,000	cy	$ 4.50	$ 4,500
Place Backfill	a,f	1,000	cy	$ 3.50	$ 3,500
4" connecting surface pipe to existing pipeline at Rock Creek	a,g	1,100	lf	$ 3.50	$ 3,850
Remove and dispose of existing tracks	i	1,000	lf	$ 15.00	$ 15,000
Replace railroad tracks	i	1,000	lf	$ 75.00	$ 75,000
Dewatering	j	3	weeks	$ 500.00	$ 1,500
Excavate temporary sediment retention pond	a,k	1,000	cy	$ 2.50	$ 2,500
Line sediment retention pond	a	750	sy	$ 3.00	$ 2,250
Hookup to existing Pipeline at Rock Creek manhole	l	1	lump	$ 1,000.00	$ 1,000
Remove temporary sediment retention pond	l	1	lump	$ 2,000.00	$ 2,000
Mill Level dams with surface drain pipes to main pipeline	l	1	lump	$ 4,500.00	$ 4,500
Direct Construction Subtotal					**$ 294,180**
Indirect Construction					
Mobilization/Demobilization	l	6%			$ 17,651
Engineering Design	m	10%			$ 31,183
Project/Construction Management	m	15%			$ 46,775
Indirect Construction Subtotal					**$ 95,609**
TOTAL CAPITAL COSTS					**$ 389,789**
OPERATING AND MAINTENANCE (O&M) COSTS					
Alternative Required O&M					
Operation and Maintenance	l	1	year	$ 1,500.00	$ 1,500
Additional Water Treatment Costs, WTP	h	1	year	$ 12,960.00	$ 12,960
Alternative Required O&M					**$ 14,460**
O&M of Existing Remedial Systems					
Groundwater and surface water sampling	see Alt 1	1	year	$ 20,000.00	$ 20,000
Maintenance of Collection System	see Alt 1	1	year	$ 40,000.00	$ 40,000
Water Treatment	see Alt 1	1	year	$ 560,000.00	$ 560,000
Project Management	see Alt 1	1	year	$ 93,000.00	$ 93,000
Alternative 1 O&M					**$ 713,000**
TOTAL ANNUAL O&M COSTS					**$ 727,460**
TOTAL 30-YEAR COSTS (non-discounted)					**$ 22,926,589**
Present Worth Value (see following table at 7% discount)					**$ 10,130,000**

Notes

Unless identified separately burden and profits are included in unit costs.

a Cost from Means, 2005
b Standard HDPE pipe similar in cost to perforated PVC, used perforated PVC installation cost.
c Assume cleanout consists of t-joint with HDPE riser and end cap
d Cost assumes 3 foot bottom width of trench w/ vertical sides, 15 ft depth at Belden shallowing in downstream direction. Length includes Tramway extension of 50 ft.
e Assumes 1.5 mile round trip and 12 cy end dump; RT Rock Creek
f Price for bedding and backfill gravel is not included, uses WP-11 gravel from Rock Creek
g Assumes 4" HDPE non-perforated pipe. Pipe will transmit at least 60 gpm on a slope of .0136
h Cost estimate $0.006 per gallon at 25 gpm for 60 days = $12,960
i Costs based on Illinois Department of Transportation FY 1998 Proposed Rail Improvement Program Supplement
j Assumes use of 6" trash pump
k Size is adequate to store 2+ days dewatering @ 60gpm
l Estimate
m Based off direct construction costs and mob/demob costs

TABLE A-2 (cont.)

PRESENT WORTH ANALYSIS
Alternative 2A - Groundwater Collection and Treatment, Belden and Rock Creek

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	Rate of Return = 3% Discount Factor	Rate of Return = 3% Present Worth	Rate of Return = 7% Discount Factor	Rate of Return = 7% Present Worth	Rate of Return = 10% Discount Factor	Rate of Return = 10% Present Worth
0	$389,789	$713,000	$1,102,789	1.0000	$1,102,789	1.0000	$1,102,789	1.0000	$1,102,789
1		$727,460	$727,460	0.9709	$706,272	0.9346	$679,869	0.9091	$661,327
2		$727,460	$727,460	0.9426	$685,701	0.8734	$635,392	0.8264	$601,207
3		$727,460	$727,460	0.9151	$665,729	0.8163	$593,824	0.7513	$546,551
4		$727,460	$727,460	0.8885	$646,339	0.7629	$554,976	0.6830	$496,865
5		$727,460	$727,460	0.8626	$627,513	0.7130	$518,669	0.6209	$451,695
6		$727,460	$727,460	0.8375	$609,236	0.6663	$484,737	0.5645	$410,632
7		$727,460	$727,460	0.8131	$591,492	0.6227	$453,026	0.5132	$373,302
8		$727,460	$727,460	0.7894	$574,264	0.5820	$423,388	0.4665	$339,365
9		$727,460	$727,460	0.7664	$557,538	0.5439	$395,690	0.4241	$308,514
10		$727,460	$727,460	0.7441	$541,299	0.5083	$369,804	0.3855	$280,467
11		$727,460	$727,460	0.7224	$525,533	0.4751	$345,611	0.3505	$254,970
12		$727,460	$727,460	0.7014	$510,226	0.4440	$323,001	0.3186	$231,791
13		$727,460	$727,460	0.6810	$495,365	0.4150	$301,870	0.2897	$210,719
14		$727,460	$727,460	0.6611	$480,937	0.3878	$282,122	0.2633	$191,563
15		$727,460	$727,460	0.6419	$466,929	0.3624	$263,665	0.2394	$174,148
16		$727,460	$727,460	0.6232	$453,329	0.3387	$246,416	0.2176	$158,316
17		$727,460	$727,460	0.6050	$440,125	0.3166	$230,295	0.1978	$143,924
18		$727,460	$727,460	0.5874	$427,306	0.2959	$215,229	0.1799	$130,840
19		$727,460	$727,460	0.5703	$414,860	0.2765	$201,149	0.1635	$118,946
20		$727,460	$727,460	0.5537	$402,777	0.2584	$187,989	0.1486	$108,132
21		$727,460	$727,460	0.5375	$391,046	0.2415	$175,691	0.1351	$98,302
22		$727,460	$727,460	0.5219	$379,656	0.2257	$164,197	0.1228	$89,366
23		$727,460	$727,460	0.5067	$368,598	0.2109	$153,455	0.1117	$81,241
24		$727,460	$727,460	0.4919	$357,862	0.1971	$143,416	0.1015	$73,856
25		$727,460	$727,460	0.4776	$347,439	0.1842	$134,034	0.0923	$67,142
26		$727,460	$727,460	0.4637	$337,319	0.1722	$125,265	0.0839	$61,038
27		$727,460	$727,460	0.4502	$327,495	0.1609	$117,070	0.0763	$55,489
28		$727,460	$727,460	0.4371	$317,956	0.1504	$109,412	0.0693	$50,445
29		$727,460	$727,460	0.4243	$308,695	0.1406	$102,254	0.0630	$45,859
30		$727,460	$727,460	0.4120	$299,704	0.1314	$95,564	0.0573	$41,690
		Non-discounted cost:	$22,926,589						
TOTAL PRESENT WORTH				@ 3% $15,361,000		@ 7% $10,130,000		@ 10% $7,960,000	

Ongoing Costs include annual O&M costs and periodic costs

TABLE A-3

DETAILED COST ESTIMATE
Alternative 2B - In-mine Precipitation in Bleakhouse Mine Pool

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
CAPITAL COSTS					
Direct Construction					
Pilot testing	a	1	each	$ 265,000.00	$ 265,000
Upgrade to full scale treatment	a	1	each	$ 70,000.00	$ 70,000
Modify Pumpback sump and lime piping	a	1	each	$ 69,000.00	$ 69,000
Direct Construction Subtotal					**$ 404,000**
Indirect Construction					
Mobilization/Demobilization		0%			
Engineering Design	a	0%			$ -
Project/Construction Management	a	0%			$ -
Indirect Construction Subtotal					**$ -**
TOTAL CAPITAL COSTS					**$ 404,000**
OPERATING AND MAINTENANCE (O&M) COSTS					
Alternative Required O&M					
Operation and Maintenance	a	1	year	$ 160,000.00	$ 160,000
Alternative Required O&M					**$ 160,000**
O&M of Existing Remedial Systems					
Groundwater and surface water sampling	see Alt 1	1	year	$ 20,000.00	$ 20,000
Maintenance of Collection System	see Alt 1	1	year	$ 40,000.00	$ 40,000
Water Treatment	b	1	year	$ 72,000.00	$ 72,000
Project Management	see Alt 1	1	year	$ 19,800.00	$ 19,800
Alternative 1 O&M					**$ 151,800**
TOTAL ANNUAL O&M COSTS					**$ 311,800**
TOTAL 30-YEAR COSTS (non-discounted)					**$ 10,471,000**
Present Worth Value (see following table at 7% discount)					**$ 4,986,000**

Notes

Unless identified separately burden and profits are included in unit costs.

a Cost from *In-Mine Remediation Proposal, Eagle Mine* by Adrian Brown April 5, 2001.

b WTP functions as backup and treats CTP groundwater only; cost estimate $0.006 per gallon at 12,000,000 gallons/year

TABLE A-3 (cont.)

PRESENT WORTH ANALYSIS
Alternative 2B - In-mine Precipitation in Bleakhouse Mine Pool

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	Rate of Return = 3% Discount Factor	Rate of Return = 3% Present Worth	Rate of Return = 7% Discount Factor	Rate of Return = 7% Present Worth	Rate of Return = 10% Discount Factor	Rate of Return = 10% Present Worth
0	$404,000	$713,000	$1,117,000	1.0000	$1,117,000	1.0000	$1,117,000	1.0000	$1,117,000
1		$311,800	$311,800	0.9709	$302,718	0.9346	$291,402	0.9091	$283,455
2		$311,800	$311,800	0.9426	$293,901	0.8734	$272,338	0.8264	$257,686
3		$311,800	$311,800	0.9151	$285,341	0.8163	$254,522	0.7513	$234,260
4		$311,800	$311,800	0.8885	$277,030	0.7629	$237,871	0.6830	$212,964
5		$311,800	$311,800	0.8626	$268,961	0.7130	$222,309	0.6209	$193,603
6		$311,800	$311,800	0.8375	$261,128	0.6663	$207,766	0.5645	$176,003
7		$311,800	$311,800	0.8131	$253,522	0.6227	$194,173	0.5132	$160,003
8		$311,800	$311,800	0.7894	$246,138	0.5820	$181,470	0.4665	$145,457
9		$311,800	$311,800	0.7664	$238,969	0.5439	$169,599	0.4241	$132,234
10		$311,800	$311,800	0.7441	$232,008	0.5083	$158,503	0.3855	$120,212
11		$311,800	$311,800	0.7224	$225,251	0.4751	$148,134	0.3505	$109,284
12		$311,800	$311,800	0.7014	$218,690	0.4440	$138,443	0.3186	$99,349
13		$311,800	$311,800	0.6810	$212,321	0.4150	$129,386	0.2897	$90,317
14		$311,800	$311,800	0.6611	$206,137	0.3878	$120,921	0.2633	$82,107
15		$311,800	$311,800	0.6419	$200,133	0.3624	$113,011	0.2394	$74,642
16		$311,800	$311,800	0.6232	$194,303	0.3387	$105,617	0.2176	$67,857
17		$311,800	$311,800	0.6050	$188,644	0.3166	$98,708	0.1978	$61,688
18		$311,800	$311,800	0.5874	$183,150	0.2959	$92,250	0.1799	$56,080
19		$311,800	$311,800	0.5703	$177,815	0.2765	$86,215	0.1635	$50,982
20		$311,800	$311,800	0.5537	$172,636	0.2584	$80,575	0.1486	$46,347
21		$311,800	$311,800	0.5375	$167,608	0.2415	$75,304	0.1351	$42,134
22		$311,800	$311,800	0.5219	$162,726	0.2257	$70,377	0.1228	$38,303
23		$311,800	$311,800	0.5067	$157,986	0.2109	$65,773	0.1117	$34,821
24		$311,800	$311,800	0.4919	$153,385	0.1971	$61,470	0.1015	$31,656
25		$311,800	$311,800	0.4776	$148,917	0.1842	$57,449	0.0923	$28,778
26		$311,800	$311,800	0.4637	$144,580	0.1722	$53,691	0.0839	$26,162
27		$311,800	$311,800	0.4502	$140,369	0.1609	$50,178	0.0763	$23,783
28		$311,800	$311,800	0.4371	$136,281	0.1504	$46,895	0.0693	$21,621
29		$311,800	$311,800	0.4243	$132,311	0.1406	$43,827	0.0630	$19,656
30		$311,800	$311,800	0.4120	$128,457	0.1314	$40,960	0.0573	$17,869
		Non-discounted cost:	$10,471,000						
TOTAL PRESENT WORTH				@ 3% $7,228,000		@ 7% $4,986,000		@ 10% $4,056,000	

Ongoing Costs include annual O&M costs and periodic costs

TABLE A-4

DETAILED COST ESTIMATE
Alternative 2C - IRM Reaction Wall in Belden

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
CAPITAL COSTS					
Direct Construction					
Trench excavation	a	4,444	cy	$ 25.00	$ 111,100
Furnish and place IRM in excavated trench	a	4,200	tons	$ 84.00	$ 352,800
Haul excavated material to CTP for disposal	a	4,444	tons	$ 4.50	$ 19,998
Screen half of above and haul to landfill	h	2,222	tons	$ 5.00	$ 11,110
Load Backfill at WP-11	a	1,539	cy	$ 9.50	$ 14,621
Haul Backfill	b,c	1,539	cy	$ 4.50	$ 6,926
Place Backfill	b,d	1,539	cy	$ 3.50	$ 5,387
Remove and dispose of existing tracks	e	400	lf	$ 15.00	$ 6,000
Replace railroad tracks	e	400	lf	$ 75.00	$ 30,000
Dewatering	f	3	weeks	$ 500.00	$ 1,500
Excavate temporary sediment retention pond	b, g	1,000	cy	$ 2.50	$ 2,500
Line sediment retention pond	b	750	sy	$ 3.00	$ 2,250
Remove temporary sediment retention pond	h	1	lump	$ 2,000.00	$ 2,000
Install 2-inch HDPE line to Tip Top mine portal	h	1,000	ft	$ 6.00	$ 6,000
Install 2 monitoring wells		50	ft	$ 100.00	$ 5,000
Direct Construction Subtotal					**$ 577,191**
Indirect Construction					
Mobilization/Demobilization		0%			$ -
Engineering Design	i	5%			$ 28,860
Project/Construction Management	i	5%			$ 28,860
Indirect Construction Subtotal					**$ 57,719**
TOTAL CAPITAL COSTS					**$ 634,910**
OPERATING AND MAINTENANCE (O&M) COSTS					
O&M of Existing Remedial Systems					
Groundwater and surface water sampling	see Alt 1	1	year	$ 20,000.00	$ 20,000
Maintenance of Collection System	see Alt 1	1	year	$ 40,000.00	$ 40,000
Water Treatment	see Alt 1	1	year	$ 560,000.00	$ 560,000
Project Management	see Alt 1	1	year	$ 93,000.00	$ 93,000
Alternative 1 O&M					**$ 713,000**
TOTAL ANNUAL O&M COSTS					**$ 713,000**
TOTAL 30-YEAR COSTS (non-discounted)					**$ 22,737,910**
Present Worth Value (see following table at 7% discount)					**$ 10,196,000**

Notes

Unless identified separately burden and profits are included in unit costs.

a Cost from memorandum *Belden IRM Remediation Trench* Adrian Brown March 30, 2004
b Cost from Means, 2005
c Assumes 1.5 mile round trip and 12 cy end dump; RT Rock Creek
d Uses WP-11 gravel from Rock Creek as backfill
e Costs based on Illinois Department of Transportation FY 1998 Proposed Rail Improvement Program Supplement
f Assumes use of 6" trash pump
g Size is adequate to store 2+ days dewatering @ 60gpm
h Estimate
i Based off direct construction costs and mob/demob costs

TABLE A-4 (cont.)

PRESENT WORTH ANALYSIS
Alternative 2C - IRM Reaction Wall in Belden

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	**Rate of Return = 3%** Discount Factor	Present Worth	**Rate of Return = 7%** Discount Factor	Present Worth	**Rate of Return = 10%** Discount Factor	Present Worth
0	$634,910	$713,000	$1,347,910	1.0000	$1,347,910	1.0000	$1,347,910	1.0000	$1,347,910
1		$713,000	$713,000	0.9709	$692,233	0.9346	$666,355	0.9091	$648,182
2		$713,000	$713,000	0.9426	$672,071	0.8734	$622,762	0.8264	$589,256
3		$713,000	$713,000	0.9151	$652,496	0.8163	$582,020	0.7513	$535,687
4		$713,000	$713,000	0.8885	$633,491	0.7629	$543,944	0.6830	$486,989
5		$713,000	$713,000	0.8626	$615,040	0.7130	$508,359	0.6209	$442,717
6		$713,000	$713,000	0.8375	$597,126	0.6663	$475,102	0.5645	$402,470
7		$713,000	$713,000	0.8131	$579,734	0.6227	$444,021	0.5132	$365,882
8		$713,000	$713,000	0.7894	$562,849	0.5820	$414,972	0.4665	$332,620
9		$713,000	$713,000	0.7664	$546,455	0.5439	$387,825	0.4241	$302,382
10		$713,000	$713,000	0.7441	$530,539	0.5083	$362,453	0.3855	$274,892
11		$713,000	$713,000	0.7224	$515,086	0.4751	$338,741	0.3505	$249,902
12		$713,000	$713,000	0.7014	$500,084	0.4440	$316,581	0.3186	$227,184
13		$713,000	$713,000	0.6810	$485,518	0.4150	$295,870	0.2897	$206,531
14		$713,000	$713,000	0.6611	$471,377	0.3878	$276,514	0.2633	$187,755
15		$713,000	$713,000	0.6419	$457,648	0.3624	$258,424	0.2394	$170,687
16		$713,000	$713,000	0.6232	$444,318	0.3387	$241,518	0.2176	$155,170
17		$713,000	$713,000	0.6050	$431,377	0.3166	$225,718	0.1978	$141,063
18		$713,000	$713,000	0.5874	$418,812	0.2959	$210,951	0.1799	$128,239
19		$713,000	$713,000	0.5703	$406,614	0.2765	$197,150	0.1635	$116,581
20		$713,000	$713,000	0.5537	$394,771	0.2584	$184,253	0.1486	$105,983
21		$713,000	$713,000	0.5375	$383,273	0.2415	$172,199	0.1351	$96,348
22		$713,000	$713,000	0.5219	$372,109	0.2257	$160,933	0.1228	$87,589
23		$713,000	$713,000	0.5067	$361,271	0.2109	$150,405	0.1117	$79,627
24		$713,000	$713,000	0.4919	$350,749	0.1971	$140,566	0.1015	$72,388
25		$713,000	$713,000	0.4776	$340,533	0.1842	$131,370	0.0923	$65,807
26		$713,000	$713,000	0.4637	$330,614	0.1722	$122,775	0.0839	$59,825
27		$713,000	$713,000	0.4502	$320,985	0.1609	$114,743	0.0763	$54,386
28		$713,000	$713,000	0.4371	$311,636	0.1504	$107,237	0.0693	$49,442
29		$713,000	$713,000	0.4243	$302,559	0.1406	$100,221	0.0630	$44,947
30		$713,000	$713,000	0.4120	$293,747	0.1314	$93,665	0.0573	$40,861
		Non-discounted cost:	$22,737,910						
TOTAL PRESENT WORTH				@ 3% $15,323,000		@ 7% $10,196,000		@ 10% $8,069,000	

Ongoing Costs include annual O&M costs and periodic costs

TABLE A-5

DETAILED COST ESTIMATE
Alternative 3A - Excavate, Transport and Dispose of Accessible and Acid-Generating Waste Rock Onsite

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
CAPITAL COSTS					
Construction					
Excavate WP-8 and haul to CTP	a	1	lump	$ 1,850,000.00	$ 1,850,000
Demolish 350 feet of crib wall at WP-9 and WP-10		1	lump	$20,000.00	$ 20,000
Dispose crib wall at CTP		520	cy	$20.00	$ 10,400
Excavate and haul WP-9, WP-10 and remnants of WP-14 to CTP	b	40,000	cy	$ 12.00	$ 480,000
Cap and vegetate waste rock at CTP	c	25	acre	$ 26,000.00	$ 650,000
Lime application on waste rock pile footprints, WP-9, WP-10, and WP-14		1	acre	$ 1,500.00	$ 1,500
Lime, soil amendments and seeding, WP-8	d	4	acre	$ 8,000.00	$ 32,000
Direct Construction Subtotal					**$ 3,011,900**
Indirect Construction					
Mobilization/Demobilization	e				$ -
Engineering Design	f	10%			$ 301,190
Project/Construction Management	f	15%			$ 451,785
Indirect Construction Subtotal					**$ 752,975**
TOTAL CAPITAL COSTS					**$ 3,764,875**
OPERATING AND MAINTENANCE (O&M) COSTS					
O&M of Existing Remedial Systems					
Groundwater and surface water sampling	see Alt 1	1	years	$ 20,000.00	$ 20,000
Maintenance of Collection System	see Alt 1	1	years	$ 40,000.00	$ 40,000
Water Treatment	see Alt 1	1	years	$ 560,000.00	$ 560,000
Project Management	see Alt 1	1	years	$ 93,000.00	$ 93,000
Alternative 1 O&M					**$ 713,000**
TOTAL ANNUAL O&M COSTS					**$ 713,000**
TOTAL 30-YEAR COSTS (non-discounted)					**$ 25,867,875**
Present Worth Value (see following table at 7% discount)					**$ 13,326,000**

Notes

Unless identified separately burden and profits are included in unit costs.

a Preliminary cost from ERM Remediation & Construction Management (April 2008) includes erosion control, transportation, final grading and confirmation sampling

b Estimated volume of WP-9, WP-10 and WP-14 is 40,000 cy.

c Assumes repository covers 25 acres, is 5 feet thick with a vegetated cap composed of 24 inches of cap material borrowed from footprint of repository.

d USEPA, 2007

e Mobilization and demobilization costs are included in individual direct costs, as appropriate

f Based off direct construction costs and mob/demob costs

TABLE A-5 (cont.)

PRESENT WORTH ANALYSIS
Alternative 3A - Excavate, Transport and Dispose of Accessible and Acid-Generating Waste Rock Onsite

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	Rate of Return = 3% Discount Factor	Rate of Return = 3% Present Worth	Rate of Return = 7% Discount Factor	Rate of Return = 7% Present Worth	Rate of Return = 10% Discount Factor	Rate of Return = 10% Present Worth
0	$3,764,875	$713,000	$4,477,875	1.0000	$4,477,875	1.0000	$4,477,875	1.0000	$4,477,875
1		$713,000	$713,000	0.9709	$692,233	0.9346	$666,355	0.9091	$648,182
2		$713,000	$713,000	0.9426	$672,071	0.8734	$622,762	0.8264	$589,256
3		$713,000	$713,000	0.9151	$652,496	0.8163	$582,020	0.7513	$535,687
4		$713,000	$713,000	0.8885	$633,491	0.7629	$543,944	0.6830	$486,989
5		$713,000	$713,000	0.8626	$615,040	0.7130	$508,359	0.6209	$442,717
6		$713,000	$713,000	0.8375	$597,126	0.6663	$475,102	0.5645	$402,470
7		$713,000	$713,000	0.8131	$579,734	0.6227	$444,021	0.5132	$365,882
8		$713,000	$713,000	0.7894	$562,849	0.5820	$414,972	0.4665	$332,620
9		$713,000	$713,000	0.7664	$546,455	0.5439	$387,825	0.4241	$302,382
10		$713,000	$713,000	0.7441	$530,539	0.5083	$362,453	0.3855	$274,892
11		$713,000	$713,000	0.7224	$515,086	0.4751	$338,741	0.3505	$249,902
12		$713,000	$713,000	0.7014	$500,084	0.4440	$316,581	0.3186	$227,184
13		$713,000	$713,000	0.6810	$485,518	0.4150	$295,870	0.2897	$206,531
14		$713,000	$713,000	0.6611	$471,377	0.3878	$276,514	0.2633	$187,755
15		$713,000	$713,000	0.6419	$457,648	0.3624	$258,424	0.2394	$170,687
16		$713,000	$713,000	0.6232	$444,318	0.3387	$241,518	0.2176	$155,170
17		$713,000	$713,000	0.6050	$431,377	0.3166	$225,718	0.1978	$141,063
18		$713,000	$713,000	0.5874	$418,812	0.2959	$210,951	0.1799	$128,239
19		$713,000	$713,000	0.5703	$406,614	0.2765	$197,150	0.1635	$116,581
20		$713,000	$713,000	0.5537	$394,771	0.2584	$184,253	0.1486	$105,983
21		$713,000	$713,000	0.5375	$383,273	0.2415	$172,199	0.1351	$96,348
22		$713,000	$713,000	0.5219	$372,109	0.2257	$160,933	0.1228	$87,589
23		$713,000	$713,000	0.5067	$361,271	0.2109	$150,405	0.1117	$79,627
24		$713,000	$713,000	0.4919	$350,749	0.1971	$140,566	0.1015	$72,388
25		$713,000	$713,000	0.4776	$340,533	0.1842	$131,370	0.0923	$65,807
26		$713,000	$713,000	0.4637	$330,614	0.1722	$122,775	0.0839	$59,825
27		$713,000	$713,000	0.4502	$320,985	0.1609	$114,743	0.0763	$54,386
28		$713,000	$713,000	0.4371	$311,636	0.1504	$107,237	0.0693	$49,442
29		$713,000	$713,000	0.4243	$302,559	0.1406	$100,221	0.0630	$44,947
30		$713,000	$713,000	0.4120	$293,747	0.1314	$93,665	0.0573	$40,861
			Non-discounted cost: $25,867,875						
TOTAL PRESENT WORTH				@ 3% $18,453,000		@ 7% $13,326,000		@ 10% $11,199,000	

Ongoing Costs include annual O&M costs and periodic costs

TABLE A-6

DETAILED COST ESTIMATE
Alternative 3B - Excavate, Transport and Dispose of All Waste Rock Onsite

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
CAPITAL COSTS					
Construction					
Excavate WP-8 and haul to CTP	a	1	lump	$ 1,850,000.00	$ 1,850,000
Demolish 350 feet of crib wall at WP-9 and WP-10		1	lump	$20,000.00	$ 20,000
Dispose crib wall at CTP		520	cy	$20.00	$ 10,400
Excavate and haul WP-9, WP-10, and WP-14 to CTP		40,000	cy	$ 12.00	$ 480,000
Excavate and haul all other piles to CTP	b	82,395	cy	$ 12.00	$ 988,740
Lime application on waste rock pile footprints		10	acre	$ 1,500.00	$ 15,000
Lime, soil amendments and seeding, WP-8	c	4	acre	$ 8,000.00	$ 32,000
Cap and vegetate waste rock at CTP	d	25	acre	$ 26,000.00	$ 650,000
Direct Construction Subtotal					**$ 4,046,140**
Indirect Construction					
Mobilization/Demobilization	e				$ -
Engineering Design	f	10%			$ 404,614
Project/Construction Management	f	15%			$ 606,921
Indirect Construction Subtotal					**$ 1,011,535**
TOTAL CAPITAL COSTS					**$ 5,057,675**
OPERATING AND MAINTENANCE (O&M) COSTS					
O&M of Existing Remedial Systems					
Groundwater and surface water sampling	see Alt 1	1	years	$ 20,000.00	$ 20,000
Maintenance of Collection System	see Alt 1	1	years	$ 40,000.00	$ 40,000
Water Treatment	see Alt 1	1	years	$ 560,000.00	$ 560,000
Project Management	see Alt 1	1	years	$ 62,000.00	$ 62,000
Alternative 1 O&M					**$ 682,000**
TOTAL ANNUAL O&M COSTS					**$ 682,000**
TOTAL 30-YEAR COSTS (non-discounted)					**$ 26,230,675**
Present Worth Value (see following table at 7% discount)					**$ 14,068,000**

Notes

Unless identified separately burden and profits are included in unit costs.

a Preliminary cost from ERM Remediation & Construction Management (April 2008) includes erosion control, transportation, final grading and confirmation sampling

b Volume from Table 10, less WP-8, WP-9, WP-10, WP-13, and WP-14.

c USEPA 2007

d Assumes repository covers 25 acres, is 10 feet thick with a vegetated cap composed of 24 inches of cap material borrowed from footprint of repository.

e Mobilization and demobilization costs are included in individual direct costs, as appropriate

f Based off direct construction costs and mob/demob costs

TABLE A-6 (cont.)

PRESENT WORTH ANALYSIS
Alternative 3B - Excavate, Transport and Dispose of All Waste Rock Onsite

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	Rate of Return = 3% Discount Factor	Rate of Return = 3% Present Worth	Rate of Return = 7% Discount Factor	Rate of Return = 7% Present Worth	Rate of Return = 10% Discount Factor	Rate of Return = 10% Present Worth
0	$2,528,838	$713,000	$3,241,838	1.0000	$3,241,838	1.0000	$3,241,838	1.0000	$3,241,838
1	$2,528,838	$682,000	$3,210,838	0.9709	$3,117,318	0.9346	$3,000,783	0.9091	$2,918,943
2		$682,000	$682,000	0.9426	$642,850	0.8734	$595,685	0.8264	$563,636
3		$682,000	$682,000	0.9151	$624,127	0.8163	$556,715	0.7513	$512,397
4		$682,000	$682,000	0.8885	$605,948	0.7629	$520,295	0.6830	$465,815
5		$682,000	$682,000	0.8626	$588,299	0.7130	$486,257	0.6209	$423,468
6		$682,000	$682,000	0.8375	$571,164	0.6663	$454,445	0.5645	$384,971
7		$682,000	$682,000	0.8131	$554,528	0.6227	$424,715	0.5132	$349,974
8		$682,000	$682,000	0.7894	$538,377	0.5820	$396,930	0.4665	$318,158
9		$682,000	$682,000	0.7664	$522,696	0.5439	$370,963	0.4241	$289,235
10		$682,000	$682,000	0.7441	$507,472	0.5083	$346,694	0.3855	$262,941
11		$682,000	$682,000	0.7224	$492,691	0.4751	$324,013	0.3505	$239,037
12		$682,000	$682,000	0.7014	$478,341	0.4440	$302,816	0.3186	$217,306
13		$682,000	$682,000	0.6810	$464,409	0.4150	$283,006	0.2897	$197,551
14		$682,000	$682,000	0.6611	$450,882	0.3878	$264,491	0.2633	$179,592
15		$682,000	$682,000	0.6419	$437,750	0.3624	$247,188	0.2394	$163,265
16		$682,000	$682,000	0.6232	$425,000	0.3387	$231,017	0.2176	$148,423
17		$682,000	$682,000	0.6050	$412,621	0.3166	$215,904	0.1978	$134,930
18		$682,000	$682,000	0.5874	$400,603	0.2959	$201,779	0.1799	$122,664
19		$682,000	$682,000	0.5703	$388,935	0.2765	$188,579	0.1635	$111,512
20		$682,000	$682,000	0.5537	$377,607	0.2584	$176,242	0.1486	$101,375
21		$682,000	$682,000	0.5375	$366,609	0.2415	$164,712	0.1351	$92,159
22		$682,000	$682,000	0.5219	$355,931	0.2257	$153,936	0.1228	$83,781
23		$682,000	$682,000	0.5067	$345,564	0.2109	$143,866	0.1117	$76,165
24		$682,000	$682,000	0.4919	$335,499	0.1971	$134,454	0.1015	$69,240
25		$682,000	$682,000	0.4776	$325,727	0.1842	$125,658	0.0923	$62,946
26		$682,000	$682,000	0.4637	$316,240	0.1722	$117,437	0.0839	$57,224
27		$682,000	$682,000	0.4502	$307,029	0.1609	$109,755	0.0763	$52,021
28		$682,000	$682,000	0.4371	$298,086	0.1504	$102,574	0.0693	$47,292
29		$682,000	$682,000	0.4243	$289,404	0.1406	$95,864	0.0630	$42,993
30		$682,000	$682,000	0.4120	$280,975	0.1314	$89,592	0.0573	$39,084
			Non-discounted cost: $26,230,675						
TOTAL PRESENT WORTH				@ 3% $19,065,000		@ 7% $14,068,000		@ 10% $11,970,000	

Ongoing Costs include annual O&M costs and periodic costs

TABLE A-7

DETAILED COST ESTIMATE
Alternative 3C - Excavate, Transport and Dispose of All Waste Rock Offsite

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
CAPITAL COSTS					
Construction					
Excavate WP-8 and haul to offsite repository	a	1	lump	$ 1,850,000.00	$ 1,850,000
Demolish 350 feet of crib wall at WP-9 and WP-10		1	lump	$20,000.00	$ 20,000
Dispose crib wall at non-hazardous solid waste landfill		520	cy	$20.00	$ 10,400
Excavate WP-9, WP-10, and WP-14 and load		40,000	cy	$ 6.50	$ 260,000
Excavate all other piles and load	b	82,395	cy	$ 6.50	$ 535,568
Haul to offsite repository 4 hr RT	c	7,418	hr	$ 125.68	$ 932,294
Lime application on waste rock pile footprints		10	acre	$ 1,500.00	$ 15,000
Lime, soil amendments and seeding, WP-8	d	4	acre	$ 8,000.00	$ 32,000
Cap and vegetate waste rock repository	e	25	acre	$ 26,000.00	$ 650,000
Direct Construction Subtotal					**$ 4,305,262**
Indirect Construction					
Mobilization/Demobilization	f				$ -
Engineering Design	g	10%			$ 430,526
Project/Construction Management	g	15%			$ 645,789
Indirect Construction Subtotal					**$ 1,076,315**
TOTAL CAPITAL COSTS					**$ 5,381,577**
OPERATING AND MAINTENANCE (O&M) COSTS					
Alternative Required O&M					
O & M of repository		1	year	$ 3,500.00	$ 3,500
Alternative Required O&M					**$ 3,500**
O&M of Existing Remedial Systems					
Groundwater and surface water sampling	see Alt 1	1	years	$ 20,000.00	$ 20,000
Maintenance of Collection System	see Alt 1	1	years	$ 40,000.00	$ 40,000
Water Treatment	see Alt 1	1	years	$ 560,000.00	$ 560,000
Project Management	see Alt 1	1	years	$ 93,000.00	$ 93,000
Alternative 1 O&M					**$ 713,000**
TOTAL ANNUAL O&M COSTS					**$ 716,500**
TOTAL 30-YEAR COSTS (non-discounted)					**$ 27,589,577**
Present Worth Value (see following table at 7% discount)					**$ 14,810,000**

Notes

Unless identified separately burden and profits are included in unit costs.

a Preliminary cost from ERM Remediation & Construction Management (April 2008) includes erosion control, transportation, final grading and confirmation sampling

b Volume from Table 10, less WP-8, WP-9, WP-10, WP-13, and WP-14; transport cost on 200 mile RT.

c 16.5 cy dump truck, highway from Means 2005 (02225 3138)

d USEPA 2007

e Assumes repository covers 25 acres, is 10 feet thick with a vegetated cap composed of 24 inches of cap material borrowed from footprint of repository.

f Mobilization and demobilization costs are included in individual direct costs, as appropriate

g Based off direct construction costs and mob/demob costs

TABLE A-7 (cont.)

PRESENT WORTH ANALYSIS
Alternative 3C - Excavate, Transport and Dispose of All Waste Rock Offsite

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	Rate of Return = 3% Discount Factor	Rate of Return = 3% Present Worth	Rate of Return = 7% Discount Factor	Rate of Return = 7% Present Worth	Rate of Return = 10% Discount Factor	Rate of Return = 10% Present Worth
0	$2,690,789	$713,000	$3,403,789	1.0000	$3,403,789	1.0000	$3,403,789	1.0000	$3,403,789
1	$2,690,789	$716,500	$3,407,289	0.9709	$3,308,047	0.9346	$3,184,382	0.9091	$3,097,535
2		$716,500	$716,500	0.9426	$675,370	0.8734	$625,819	0.8264	$592,149
3		$716,500	$716,500	0.9151	$655,699	0.8163	$584,877	0.7513	$538,317
4		$716,500	$716,500	0.8885	$636,601	0.7629	$546,614	0.6830	$489,379
5		$716,500	$716,500	0.8626	$618,059	0.7130	$510,855	0.6209	$444,890
6		$716,500	$716,500	0.8375	$600,057	0.6663	$477,434	0.5645	$404,446
7		$716,500	$716,500	0.8131	$582,580	0.6227	$446,200	0.5132	$367,678
8		$716,500	$716,500	0.7894	$565,612	0.5820	$417,010	0.4665	$334,253
9		$716,500	$716,500	0.7664	$549,138	0.5439	$389,729	0.4241	$303,866
10		$716,500	$716,500	0.7441	$533,143	0.5083	$364,232	0.3855	$276,242
11		$716,500	$716,500	0.7224	$517,615	0.4751	$340,404	0.3505	$251,129
12		$716,500	$716,500	0.7014	$502,539	0.4440	$318,135	0.3186	$228,299
13		$716,500	$716,500	0.6810	$487,902	0.4150	$297,322	0.2897	$207,545
14		$716,500	$716,500	0.6611	$473,691	0.3878	$277,871	0.2633	$188,677
15		$716,500	$716,500	0.6419	$459,894	0.3624	$259,693	0.2394	$171,524
16		$716,500	$716,500	0.6232	$446,499	0.3387	$242,703	0.2176	$155,931
17		$716,500	$716,500	0.6050	$433,494	0.3166	$226,826	0.1978	$141,756
18		$716,500	$716,500	0.5874	$420,868	0.2959	$211,986	0.1799	$128,869
19		$716,500	$716,500	0.5703	$408,610	0.2765	$198,118	0.1635	$117,153
20		$716,500	$716,500	0.5537	$396,709	0.2584	$185,157	0.1486	$106,503
21		$716,500	$716,500	0.5375	$385,154	0.2415	$173,044	0.1351	$96,821
22		$716,500	$716,500	0.5219	$373,936	0.2257	$161,723	0.1228	$88,019
23		$716,500	$716,500	0.5067	$363,045	0.2109	$151,143	0.1117	$80,017
24		$716,500	$716,500	0.4919	$352,471	0.1971	$141,256	0.1015	$72,743
25		$716,500	$716,500	0.4776	$342,204	0.1842	$132,015	0.0923	$66,130
26		$716,500	$716,500	0.4637	$332,237	0.1722	$123,378	0.0839	$60,118
27		$716,500	$716,500	0.4502	$322,560	0.1609	$115,307	0.0763	$54,653
28		$716,500	$716,500	0.4371	$313,165	0.1504	$107,763	0.0693	$49,685
29		$716,500	$716,500	0.4243	$304,044	0.1406	$100,713	0.0630	$45,168
30		$716,500	$716,500	0.4120	$295,189	0.1314	$94,125	0.0573	$41,062
		Non-discounted cost:	$27,589,577						
TOTAL PRESENT WORTH				@ 3% $20,060,000		@ 7% $14,810,000		@ 10% $12,604,000	

Ongoing Costs include annual O&M costs and periodic costs

TABLE A-8

DETAILED COST ESTIMATE
Alternative 4A - Groundwater Collection and Treatment, OTP/Rex Flats

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
CAPITAL COSTS					
Construction					
OTP/Rex Flats interceptor trench/sump pumps, installed	a	1	lump	$ 388,711.00	$ 388,711
OTP/Rex Flats 50-150 gpm conventional lime precipitation treatment plant, installed	b	1	lump	$ 2,071,359.00	$ 2,071,359
Direct Construction Subtotal					**$ 2,460,070**
Indirect Construction					
Mobilization/Demobilization		6%			$ 147,604
Engineering Design	c	10%			$ 260,767
Project/Construction Management	c	15%			$ 391,151
Indirect Construction Subtotal					**$ 799,523**
TOTAL CAPITAL COSTS					**$ 3,259,593**
OPERATING AND MAINTENANCE (O&M) COSTS					
Alternative Required O&M					
OTP/Rex Flats interceptor trench	a	1	years	$ 63,235.00	$ 63,235
Water Treatment Plant	d	1	years	$ 560,000.00	$ 560,000
Alternative Required O&M					**$ 623,235**
O&M of Existing Remedial Systems					
Groundwater and surface water sampling	see Alt 1	1	years	$ 20,000.00	$ 20,000
Maintenance of Collection System	see Alt 1	1	years	$ 40,000.00	$ 40,000
Water Treatment	see Alt 1	1	years	$ 560,000.00	$ 560,000
Project Management	see Alt 1	1	years	$ 93,000.00	$ 93,000
Alternative 1 O&M					**$ 713,000**
TOTAL ANNUAL O&M COSTS					**$ 1,336,235**
TOTAL 30-YEAR COSTS (non-discounted)					**$ 44,059,643**
Present Worth Value (see following table at 7% discount)					**$ 20,554,000**

Notes

Unless identified separately burden and profits are included in unit costs.

a From ERM 2007 Table 14

b NewFields estimate for 50-150 gpm plant; installed

c Based off direct construction costs and mob/demob costs

d Based on comparison to similar sizes plants

TABLE A-8 (cont.)

PRESENT WORTH ANALYSIS
Alternative 4A - Groundwater Collection and Treatment, OTP/Rex Flats

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	Rate of Return = 3% Discount Factor	Rate of Return = 3% Present Worth	Rate of Return = 7% Discount Factor	Rate of Return = 7% Present Worth	Rate of Return = 10% Discount Factor	Rate of Return = 10% Present Worth
0	$3,259,593	$713,000	$3,972,593	1.0000	$3,972,593	1.0000	$3,972,593	1.0000	$3,972,593
1		$1,336,235	$1,336,235	0.9709	$1,297,316	0.9346	$1,248,818	0.9091	$1,214,759
2		$1,336,235	$1,336,235	0.9426	$1,259,530	0.8734	$1,167,119	0.8264	$1,104,326
3		$1,336,235	$1,336,235	0.9151	$1,222,844	0.8163	$1,090,766	0.7513	$1,003,933
4		$1,336,235	$1,336,235	0.8885	$1,187,227	0.7629	$1,019,407	0.6830	$912,666
5		$1,336,235	$1,336,235	0.8626	$1,152,648	0.7130	$952,717	0.6209	$829,697
6		$1,336,235	$1,336,235	0.8375	$1,119,076	0.6663	$890,390	0.5645	$754,270
7		$1,336,235	$1,336,235	0.8131	$1,086,481	0.6227	$832,140	0.5132	$685,700
8		$1,336,235	$1,336,235	0.7894	$1,054,836	0.5820	$777,701	0.4665	$623,363
9		$1,336,235	$1,336,235	0.7664	$1,024,113	0.5439	$726,823	0.4241	$566,694
10		$1,336,235	$1,336,235	0.7441	$994,284	0.5083	$679,274	0.3855	$515,176
11		$1,336,235	$1,336,235	0.7224	$965,325	0.4751	$634,836	0.3505	$468,342
12		$1,336,235	$1,336,235	0.7014	$937,208	0.4440	$593,304	0.3186	$425,766
13		$1,336,235	$1,336,235	0.6810	$909,911	0.4150	$554,490	0.2897	$387,060
14		$1,336,235	$1,336,235	0.6611	$883,409	0.3878	$518,215	0.2633	$351,872
15		$1,336,235	$1,336,235	0.6419	$857,678	0.3624	$484,313	0.2394	$319,884
16		$1,336,235	$1,336,235	0.6232	$832,697	0.3387	$452,629	0.2176	$290,804
17		$1,336,235	$1,336,235	0.6050	$808,444	0.3166	$423,018	0.1978	$264,367
18		$1,336,235	$1,336,235	0.5874	$784,897	0.2959	$395,344	0.1799	$240,334
19		$1,336,235	$1,336,235	0.5703	$762,036	0.2765	$369,480	0.1635	$218,485
20		$1,336,235	$1,336,235	0.5537	$739,841	0.2584	$345,309	0.1486	$198,623
21		$1,336,235	$1,336,235	0.5375	$718,292	0.2415	$322,718	0.1351	$180,566
22		$1,336,235	$1,336,235	0.5219	$697,371	0.2257	$301,606	0.1228	$164,151
23		$1,336,235	$1,336,235	0.5067	$677,059	0.2109	$281,875	0.1117	$149,228
24		$1,336,235	$1,336,235	0.4919	$657,339	0.1971	$263,434	0.1015	$135,662
25		$1,336,235	$1,336,235	0.4776	$638,193	0.1842	$246,200	0.0923	$123,329
26		$1,336,235	$1,336,235	0.4637	$619,605	0.1722	$230,094	0.0839	$112,117
27		$1,336,235	$1,336,235	0.4502	$601,558	0.1609	$215,041	0.0763	$101,925
28		$1,336,235	$1,336,235	0.4371	$584,037	0.1504	$200,973	0.0693	$92,659
29		$1,336,235	$1,336,235	0.4243	$567,026	0.1406	$187,825	0.0630	$84,235
30		$1,336,235	$1,336,235	0.4120	$550,511	0.1314	$175,537	0.0573	$76,578
		Non-discounted cost:	$44,059,643						
TOTAL PRESENT WORTH				@ 3% $30,163,000		@ 7% $20,554,000		@ 10% $16,569,000	

Ongoing Costs include annual O&M costs and periodic costs

TABLE A-9

DETAILED COST ESTIMATE
Alternative 4B - IRM Reaction Wall at OTP/Rex Flats

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
CAPITAL COSTS					
Direct Construction					
Trench excavation	a	1,666	cy	$ 20.00	$ 33,320
Haul excavated gravel to Temp Cell	d	1,666	cy	$ 4.50	$ 7,497
Furnish and place IRM in excavated trench	a	4,046	tons	$ 89.00	$ 360,094
Dewatering	b	1	week	$ 500.00	$ 500
Excavate temporary sediment retention pond	c	1,000	cy	$ 2.50	$ 2,500
Line sediment retention pond	d	750	sy	$ 3.00	$ 2,250
Remove temporary sediment retention pond	e	1	lump	$ 2,000.00	$ 2,000
Direct Construction Subtotal					**$ 408,161**
Indirect Construction					
Mobilization/Demobilization		0%			$ -
Engineering Design		5%			$ 20,408
Project/Construction Management		15%			$ 61,224
Indirect Construction Subtotal					**$ 81,632**
TOTAL CAPITAL COSTS					**$ 489,793**
OPERATING AND MAINTENANCE (O&M) COSTS					
O&M of Existing Remedial Systems					
Groundwater and surface water sampling	see Alt 1	1	year	$ 20,000.00	$ 20,000
Maintenance of Collection System	see Alt 1	1	year	$ 40,000.00	$ 40,000
Water Treatment	see Alt 1	1	year	$ 560,000.00	$ 560,000
Project Management	see Alt 1	1	year	$ 93,000.00	$ 93,000
Alternative 1 O&M					**$ 713,000**
TOTAL ANNUAL O&M COSTS					**$ 713,000**
TOTAL 30-YEAR COSTS (non-discounted)					**$ 22,592,793**
Present Worth Value (see following table at 7% discount)					**$ 10,050,000**

Notes

Unless identified separately burden and profits are included in unit costs.

a Cost from Brown 2012
b Assumes use of 6" trash pump
c Size is adequate to store 2+ days dewatering @ 60gpm
d Cost from Means 2005
e Estimate

TABLE A-9 (cont.)

PRESENT WORTH ANALYSIS
Alternative 4B - IRM Reaction Wall at OTP/Rex Flats

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	Rate of Return = 3% Discount Factor	Rate of Return = 3% Present Worth	Rate of Return = 7% Discount Factor	Rate of Return = 7% Present Worth	Rate of Return = 10% Discount Factor	Rate of Return = 10% Present Worth
0	$489,793	$713,000	$1,202,793	1.0000	$1,202,793	1.0000	$1,202,793	1.0000	$1,202,793
1		$713,000	$713,000	0.9709	$692,233	0.9346	$666,355	0.9091	$648,182
2		$713,000	$713,000	0.9426	$672,071	0.8734	$622,762	0.8264	$589,256
3		$713,000	$713,000	0.9151	$652,496	0.8163	$582,020	0.7513	$535,687
4		$713,000	$713,000	0.8885	$633,491	0.7629	$543,944	0.6830	$486,989
5		$713,000	$713,000	0.8626	$615,040	0.7130	$508,359	0.6209	$442,717
6		$713,000	$713,000	0.8375	$597,126	0.6663	$475,102	0.5645	$402,470
7		$713,000	$713,000	0.8131	$579,734	0.6227	$444,021	0.5132	$365,882
8		$713,000	$713,000	0.7894	$562,849	0.5820	$414,972	0.4665	$332,620
9		$713,000	$713,000	0.7664	$546,455	0.5439	$387,825	0.4241	$302,382
10		$713,000	$713,000	0.7441	$530,539	0.5083	$362,453	0.3855	$274,892
11		$713,000	$713,000	0.7224	$515,086	0.4751	$338,741	0.3505	$249,902
12		$713,000	$713,000	0.7014	$500,084	0.4440	$316,581	0.3186	$227,184
13		$713,000	$713,000	0.6810	$485,518	0.4150	$295,870	0.2897	$206,531
14		$713,000	$713,000	0.6611	$471,377	0.3878	$276,514	0.2633	$187,755
15		$713,000	$713,000	0.6419	$457,648	0.3624	$258,424	0.2394	$170,687
16		$713,000	$713,000	0.6232	$444,318	0.3387	$241,518	0.2176	$155,170
17		$713,000	$713,000	0.6050	$431,377	0.3166	$225,718	0.1978	$141,063
18		$713,000	$713,000	0.5874	$418,812	0.2959	$210,951	0.1799	$128,239
19		$713,000	$713,000	0.5703	$406,614	0.2765	$197,150	0.1635	$116,581
20		$713,000	$713,000	0.5537	$394,771	0.2584	$184,253	0.1486	$105,983
21		$713,000	$713,000	0.5375	$383,273	0.2415	$172,199	0.1351	$96,348
22		$713,000	$713,000	0.5219	$372,109	0.2257	$160,933	0.1228	$87,589
23		$713,000	$713,000	0.5067	$361,271	0.2109	$150,405	0.1117	$79,627
24		$713,000	$713,000	0.4919	$350,749	0.1971	$140,566	0.1015	$72,388
25		$713,000	$713,000	0.4776	$340,533	0.1842	$131,370	0.0923	$65,807
26		$713,000	$713,000	0.4637	$330,614	0.1722	$122,775	0.0839	$59,825
27		$713,000	$713,000	0.4502	$320,985	0.1609	$114,743	0.0763	$54,386
28		$713,000	$713,000	0.4371	$311,636	0.1504	$107,237	0.0693	$49,442
29		$713,000	$713,000	0.4243	$302,559	0.1406	$100,221	0.0630	$44,947
30		$713,000	$713,000	0.4120	$293,747	0.1314	$93,665	0.0573	$40,861
		Non-discounted cost:	$22,592,793						
TOTAL PRESENT WORTH				@ 3% $15,178,000		@ 7% $10,050,000		@ 10% $7,924,000	

Ongoing Costs include annual O&M costs and periodic costs