STATE OF COLORADO

Eschberger - DNR, Amy <amy.eschberger@state.co.us>

Schwartzwalder Mine Revised AM-06

Elizabeth Busby <ebusby@ensero.com> Wed, May 11, 2022 at 3:54 PM
To: "Amy Eschberger - CDRMS (amy.eschberger@state.co.us)" <amy.eschberger@state.co.us>
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Dear Ms. Eschberger,

Thank you for reviewing and providing comments on AM-06 for the Schwartzwalder Mine. I have sent two hard copies of the response to comments matric and revised document to your office (FedEx Tracking No. 7768 3027 7347). Additionally, those on this email will receive an invitation to download electronic copies of the submittal from an Ensero SharePoint site.

Here is a direct link: 2022-05-11-Schwartzwalder_AM-06

There is no password, you should be able to click and download the files directly. If you have any access issues please contact me directly, my information is below.

Elizabeth Busby, PE, PMP

Senior Project Manager

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May 11, 2022

Ms. Amy Eschberger
Division of Reclamation, Mining, and Safety
Department of Natural Resources
1313 Sherman Street, Room 215
Denver, CO 80203

Subject: Response to Secondary Adequacy Review
Application Amendment #6
Mine Land Reclamation Permit M-1977-300, Schwartzwalder Mine, Golden, Colorado

Dear Ms. Eschberger:

In response to comments received by DRMS, City of Arvada, and Denver Water, Colorado Legacy Land, LLC (CLL) has revised *Mine Land Reclamation Permit M-1977-300, Application Amendment #6* for the Schwartzwalder Mine, to address the reviewer's comments. Enclosed is a copy of the revised Application Amendment and comment summary table. If you have any questions regarding the subject document, please don't hesitate to contact me.

Sincerely,

Jim Harrington, Managing Director
COLORADO LEGACY LAND
Jim@ColoradoLegacy.Land

cc: Michael Cunningham - DRMS, Senior Environmental Protection Specialist, michaela.cunningham@state.co.us
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M-1977-300 APPLICATION AMENDMENT #6, COMMENT AND RESPONSE SUMMARY TABLE		
COMMENT NO.	COMMENT	RESPONSE TO COMMENT
COLORADO DIVISION OF RECLAMATION AND MINING SAFETY		
1	Exhibit E – Reclamation Plan (Rule 6.4.5): The operator has provided Figure E-2 to address the Division's adequacy item #3 (from the preliminary adequacy review letter). However, not all components requested were added to the map. Please revise Figure E-2 to include "any significant fracture/fault systems and other potential groundwater migration pathways that intersect the mine workings, and the point at which any such pathways intersect the creek system between the mine site and Ralston Reservoir".	Please note that in response to this adequacy review, figure numbers have changed, Figure E-2 is now Figure E-4. CLL has updated the map to show locations of the major fault systems as requested, however the groundwater gradients on this figure clearly show that a potential groundwater migration pathway does not exist when the mine pool is dewatered to 150 feet below Steve (or greater). CLL has maintained this dewatered mine pool condition since taking ownership of the site and intends to maintain a dewatered mine pool consistent with the reclamation plan described in Exhibit E. Please review responses to Comment #13 and Comment #14 below for additional discussion.
2	Exhibit E – Reclamation Plan (Rule 6.4.5): In its response to the Division's adequacy item #4, the operator stated the diversion pipeline and two bollards which hold the pipeline in place will be removed for reclamation. However, the operator did not describe how the upgradient cutoff wall and riprap/grouted boulder areas along the creek will be reclaimed. Is the operator proposing to leave these structures in place for final reclamation? If so, please describe how leaving these structures would be in compliance with county requirements and with the applicable regulatory agencies (e.g., CDPHE, USACE, USFWS). Additionally, please explain how leaving these structures would support the proposed plan to remove the bypass pipeline and re-establish creek flows across the mine site for final reclamation.	The operator is proposing to leave the cutoff wall, ripap/grouted boulder areas, and bypass pipeline in place. These structures were previously permitted by USACE as permanent features (USACE File # NOW-2011-1353 DEN) and constructed by the previous operator, Cotter Corporation (Cotter). After the alluvial valley exaction is complete and the corresponding disturbed areas are reclaimed, the bypass pipeline and sump system may be removed. CLL proposes allowing Ralston Creek to flow through the sluice gate at the cut off wall into its natural channel while the bypass pipeline infrastructure remains in place. This would allow CLL to monitor the water quality in Ralston Creek while the bypass pipeline infrastructure is still intact.
3	Exhibit E – Reclamation Plan (Rule 6.4.5): The operator is proposing to remove the bypass pipeline and re-establish creek flows across the mine site once the alluvial valley excavation project has been completed. Does this proposal include plans to keep the bypass system readily accessible, at least for a particular length of time after flows have been re-established, so the system could be reinstalled in the event that surface water monitoring at SW-BPL shows impacts from the mine site?	Revised as requested. The operator is proposing the leave the bypass pipeline in place. This allows CLL to reestablish flows in Ralston Creek with a readily accessible contingency system in place. Additional text has been added to the end of Section E.4 to describe CLL's proposed approach.
4	Exhibit E – Reclamation Plan (Rule 6.4.5): Please provide a detailed grading plan for the valley, showing how the valley floor will be reconfigured to establish positive drainage to the creek. (Please keep in mind, if the grading plan changes significantly from what is approved in this application, it can be updated through the Technical Revision process.) If on-site material will be used to fill/grade the valley for reclamation, please describe exactly where these materials will be derived from on site, and how the operator will confirm the materials are "clean" for use in reclamation.	Revised as requested. Additional information has been added to Exhibit E to discuss CLL's reclamation plans, however the full extent of the alluvial valley exaction is not currently known, therefore CLL cannot present a detail grading plan at this time. CLL is committed to reclaiming all disturbed areas in the permit boundary and shall prepare a site-specific planting and regrading plan once the excavation project is complete.
5	Exhibit E – Reclamation Plan (Rule 6.4.5): The operator is proposing to use on site materials for growth medium in reclamation, rather than importing this material. Please specify exactly where the growth medium will be derived from on site and how the operator will confirm this material is suitable for use in reclamation. Will any soil tests be conducted?	The text in Section E.4 has been revised to include language previously approved in Technical Revision #14 which permits CLL to stockpile 'clean' alluvial valley soils and use them as fill or growth media for reclamation. Soil testing is not required because these soils have been used as fill/growth media on the site previously (on both waste rock piles). Both waste rock piles are successfully reclaimed with a healthy vegetative cover.
6	Exhibit E – Reclamation Plan (Rule 6.4.5): Please include the proposed revegetation plan, including the specific seed/plant mixtures to be used for each area. Each seed mixture must include the plant species, the planting rate for each species (in pounds of pure live seed per acre or number of trees/shrubs per acre), and the application method.	The text in Section E.4 has been revised to include the previously approved seed mix from Technical Revision #23.
7	Exhibit E – Reclamation Plan (Rule 6.4.5): Please include a detailed plan for abandoning the 13 monitoring wells on site, which includes the diameter and depth of each well, a description of the proposed plugging materials to be used, and the type and quantity of equipment to be used. This information is needed in order for the Division to calculate the reclamation bond.	Revised as requested. Additional information has been added to Section E.6 of the document to discuss the well abandonment process. The diameter and total depth of each well is shown on Table E-3 of Amendment 05 and in each of CLL's quarterly environmental monitoring memos.

M-1977-300 APPLICATION AMENDMENT #6, COMMENT AND RESPONSE SUMMARY TABLE		
COMMENT NO.	COMMENT	RESPONSE TO COMMENT
8	Exhibit E – Reclamation Plan (Rule 6.4.5): Please provide a detailed plan for removing the master sump for reclamation, including the anticipated disposal location for the materials demolished/removed.	Revised as requested. Sump and well abandonment is discussed in Section E. 6
9	Exhibit E – Reclamation Plan (Rule 6.4.5): Please describe the existing mine closures (and/or provide photographs of each closure) installed in the following mine openings: Minnesota Adit, Sunshine Decline, Steve Adit, CV/Charlie Adit, and Pierce Adit.	Revised as requested. Photos of each mine opening closure have been added to Exhibit E as Figure E-1.
10	Exhibit E – Reclamation Plan (Rule 6.4.5): In comparing the recent mine pool chemistry (2018-present) to the mine pool chemistry during the period when the mine workings were flooded (2000-2007), the operator states that bulk TDS of the mine water has not changed, indicating the mine is chemically stable. Please provide a graph showing available TDS data compared with Uranium concentration data for these two periods. Additionally, please add TDS data on either the revised Figure E-4 or E-7.	Please note that in response to this adequacy review, figure numbers have changed, Figure E-4 is now Figure E-6 and Figure E-7 in now Figure E-9. Instead of creating another figure as requested, CLL has added the TDS data to Figure E-6 (formerly E-4) to respond to this request.
11	Exhibit E – Reclamation Plan (Rule 6.4.5): In its response to the Division's adequacy item #18(e), the operator states the location of return of the RO concentrate to the mine pre-2017 included a return injection port that included RO concentrate being added to the "open hole" adjacent to the Minnesota Adit (as shown in Figure E-3a). Figure E-3a depicts an "open hole" located in the Steve Adit (directly behind the concrete bulkhead). It is the Division's understanding the Minnesota Adit is located 3 levels higher than the Steve Adit, but does include a "glory hole", in which the operator placed contaminated alluvial material from the valley excavation project. However, this "glory hole" is not shown on Figure E-3a. Please clarify the location of the "open hole" referred to in this response.	Please note that in response to this adequacy review, figure numbers have changed, Figure E-3a is now Figure E-5a. The purpose of Figure E-3a is to show a schematic of the in-situ injections conducted in 2013/2015 not to show an overall view of the mine workings. As depicted, the 'open hole' is on the same level as the Steve Adit. However, the access for the open hole was by way of a temporary pipeline into the Sunshine adit, and this pipeline was removed in 2017 when the new water treatment plant was constructed and the RO concentrate was then injected through the Steve adit bulkhead penetrations into the shafts only. This "open hole" extends several levels from the Sunshine, and by way of personal conversation with the Schwartzwalder mine manager we understand that this "open hole" continued down to at least the 5 level. The Glory Hole was another "open hole" which has now been backfilled. The Glory Hole "open hole" stope was accessed through the Minnesota Adit for the placement of alluvial fill material beginning in 2018 and completed in 2021. This "open hole" i.e., the Glory Hole was not accessed for any in situ treatment at any time including the in situ treatment conducted prior to 2018.
12	Exhibit E – Reclamation Plan (Rule 6.4.5): On the revised Figure E-7, the operator has included the points in time in which RO reject was injected into the mine, the last of which occurred in 2017. It is the Division's understanding that RO reject is injected into the mine when the water treatment plant is in operation. If this is correct, there should be four additional times between 2018 and 2021 during which, RO reject was injected into the mine. Please provide clarification on this matter and add additional information to this figure, if needed.	Please note that in response to this adequacy review, figure numbers have changed, Figure E-7 is now Figure E-9. In the previous comments, the request was *"Please include available mine pool elevation data, dates for in-situ treatments, and* ***<u>the date the operation began injecting RO reject brine into the mine pool</u>****.(emphasis added)"* As requested, CLL added the 2 occasions (2012/2103 and 2016) that RO reject brine was injected into the mine pool and when the continuous operation and injections started in mid-2107. Rather than clogging up the figure with additional vertical lines, CLL has made a note on the figure to indicate that beginning in mid-2107 the RO reject brine has been continuously injected into the mine pool during operation of the treatment plant. Please note that the text already provided this explanation in the previous version.
13	Exhibit E – Reclamation Plan (Rule 6.4.5): Please describe how re-establishing creek flows across the mine site, as proposed, is expected to affect the mine pool management/water treatment plant operations, if at all.	In the current dewatered state (150 ft. below the Steve level or greater), hydraulic mechanisms do not exist whereby mine pool water can exit the workings and migrate towards Ralston Creek and Ralston Reservoir. Therefore, CLL does not expect the re-establishment of Ralston Creek to affect mine pool management or water treatment plant operations. It is possible that the reestablishment of flow in the mine area will allow limited recharge of surface water toward the mine workings, but studies shown during the mine operations showed only minor seasonal effects during the time that the creek had not yet been diverted so CLL expects that this additional surface recharge will similarly be minor when the creek flow is reestablished.
14	Exhibit E – Reclamation Plan (Rule 6.4.5):	

M-1977-300 Application Amendment #6, Comment and Response Summary Table

Comment No.	Comment	Response to Comment
	Please provide some additional discussion regarding the location at which the Schwartz Trend intersects the creek downgradient of the mine site, and whether this geologic feature might act as a migration corridor for mine water downgradient of the site (at mine pool levels at or below the regulatory limit of 150 feet below Steve Level). Please include in this discussion an evaluation of elevation differences between the mine pool and the creek bed at the location where the Schwartz Trend intersects the creek, as well as a discussion of how monitoring well MW-15 was installed to identify any offsite mine water flows through this feature.	Section 8(d) of the Schwartzwalder Mine Environmental Protection Plan (Whetstone Associates Inc., 2016) provides the following description of Fracture Systems near the Site: *"The area is characterized by extensive vertical fracturing, dominated by the West Rogers, East Rogers, and Illinois fault systems. The West Rogers Fault System extends from about 600 feet north of the main mine portal (Steve Adit) to about 1,100 feet south of the portal. The West Rogers Fault has not been mapped as intersecting Ralson Creek, but instead terminates in the upper reaches of a drainage, tributary to Ralston Creek. Therefore, the West Rogers Fault does not appear to directly connect to Ralston Creek, downstream (southeast) of the mine.* *The Schwartz Trend, however, intersects to Ralston Creek about 1,900 feet southeast of the mine (Figure 8-17). At the mine site, the Schwartz Trend is characterized by brittle fracturing and is the primary host for uranium. 1,900 feet southeast, where the creek flows over a 300-ft wide exposure of Schwartz Trend rocks, the Schwartz Trend has a measurable effect on electrical conductivity (E.C.) in Ralston Creek. E.C. is an indirect measurement of total dissolved solids (TDS). An E.C. survey, conducted by Whetstone and the Operator's personnel in November 2008, indicated that E.C. abruptly increased 21 µS/cm at the contact with the Schwartz trend rocks (Section 8(e)(ii)). Because no similar E.C. survey exists prior to mining or during mining operations, it is not known whether water in the flooded underground mine is influencing water quality in Ralston Creek at the Schwartz Trend intersection, or whether the Schwartz trend discharged water with higher TDS than the creek at this location."* Section 8(e) of the Schwartzwalder Mine Environmental Protection Plan (Whetstone Associates Inc., 2016) continues by describing: • the technical rationale for the location of MW-15 to monitor groundwater from the Schwartzwalder Trend near Ralston Creek, and • a series of environmental studies conducted to evaluate the potential connectivity of the Schwartzwalder Trend downgradient of the mine and Ralston Creek: ○ evaluation of stream flow rates and mine pumping rates, ○ an electrical conductivity, temperature, and pH profile of Ralston Creek, ○ a gamma survey across the Schwartzwalder Trend, ○ a water quality survey across the Schwartzwalder Trend and Ralston Creek, ○ Stable Isotopic Analysis of the Mine Water and Ralston Creek, and ○ Tritium Dating study of the Mine Water. The culmination of these investigations is provided Section 8(e)(i) of the Schwartzwalder Mine Environmental Protection Plan (Whetstone Associates Inc., 2016) which concludes the following: *"Summary of Hydraulic Connection. The available evidence indicates there is not a strong direct hydraulic connection between Ralston Creek and the Schwartzwalder Mine. However, a weak hydraulic connection may exist, so that while some water may have flowed from the creek into the mine during dewatering, flows from the creek to the mine were small and controlled by the inherent low permeability of the rock mass (2.8x10-7 cm/sec average bulk hydraulic conductivity). The low permeability of the bedrock limited flow from the creek into the mine, and dewatering the mine did not drain Ralston Creek."* This '*weak hydraulic connection*' has since been eliminated by CLL's commitment to maintain a dewatered mine pool below the regulatory limit (Figure E-3). The capture zone associated with the dewatered mine is illustrated on Figure E-4. The accompanying technical discussion in Appendix 3 of the AM-06 concludes: *"This technical memorandum presents solid evidence that the Schwartzwalder water management program, which uses pumping to depress the mine water level, has converted the mine workings to a large-scale groundwater sink. Hydraulic mechanisms do not exist whereby mine pool water can exit the workings and migrate towards Ralston Creek and Ralston Reservoir. This hydraulic behavior should continue as long as the water level in the mine is depressed below the regulatory level."*
15	Exhibit E – Reclamation Plan (Rule 6.4.5):	

M-1977-300 APPLICATION AMENDMENT #6, COMMENT AND RESPONSE SUMMARY TABLE		
COMMENT NO.	COMMENT	RESPONSE TO COMMENT
	The Division has the following comments regarding the revised Conceptual Site Model presented in Appendix 1: a. In its response to the Division's adequacy item #29(b), particularly to the question of whether sampling for tracers was conducted at any of the groundwater or surface water monitoring locations, the operator states "While tracer sampling was not performed in monitoring wells or surface water near the mine, the hydraulic head in the mine pool is lower than the hydraulic heads associated with these features, so it is highly unlikely that tracer would ever be found at these sampling locations". The Division understands the hydraulic head in the mine pool is lower than the hydraulic head at monitoring locations within the permit area. However, there are four surface water monitoring locations along the creek downstream of the mine site which could potentially be affected by water from the mine workings (if viable migration corridors exist). Given the known hydrogeology of the site, are there any tracer studies that could be performed specifically to investigate potential migration corridors in which water from the mine workings interacts with the creek downstream of the mine site?	The previous operator, Cotter, previously completed several environmental investigations to evaluate the potential connectivity of the Mine Pool and Ralston Creek. Please see previous response to Comment #14 and Section 8 of the Schwartzwalder Mine Environmental Protection Plan (Whetstone Associates Inc., 2016) for more detail. Additional tracer studies are not needed to determine if CLL has achieved physical and chemical stabilization of the mine pool. Data presented in AM-06 demonstrate that these objectives are met with CLL's current management approach. CLL has maintained a dewatered mine pool below the regulatory limit (Figure E-3) such that a hydraulic mechanism whereby mine pool water can exit the workings and migrate toward Ralston Creek and Ralston Reservoir does not exist (Appendix E and Figure E-4). Furthermore, CLL can maintain the physical and chemical stabilization of the mine pool by operating the existing water treatment plant facility 6 months a year, or less.
16	Exhibit F – Reclamation Plan Map (Rule 6.4.6): The Division has the following comments on the Figure F-1 Reclamation Plan map provided: a. Please explain the "diversion structure" shown to remain along the southern edge of the creek. Is this structure meant to represent the existing bypass pipeline? If so, please remove it from this map as the proposed reclamation plan includes removing this pipeline for reclamation. If this structure represents something else, additional clarification on the map is needed to differentiate it from the NWRP stormwater diversion channel (also identified on the map as "diversion structure") b. Please identify the areas to receive each of the revegetation plans proposed for reclamation. c. Please ensure all structures proposed to remain for reclamation (e.g., upgradient cutoff wall, riprap/grouted boulder areas, bridges, culverts, wells, buildings, powerlines, pipelines, roads, graveled or paved parking areas) are shown on this map. d. Please show the location of the Jeffrey Air Shaft and any structures currently installed at the surface of this shaft which are proposed to remain for reclamation.	a. Yes this "diversion structure" was the Ralston Creek bypass pipeline and North Waste Rock Pile channels. The legend of the figure has been revised for clarity. The text in AM-06 has been revised so it's clear that CLL intends to leave the bypass pipeline and associated infrastructure in place at least until it has been confirmed that surface water flow across the reclaimed site does not create an exceedance of uranium at BPL. b. At this time CLL cannot identify the exact area's that will receive each of the revegetation plans (seed mix, trees, and shrubs) because the extent of the alluvial valley reclamation project is not known. CLL shall prepare a site-specific planting plan in coordination with DRMS, USACE, and USFW once the excavation project is complete. Figure F-1 has been revised to illustrate the anticipated planting area, which corresponds to disturbed surface features at the site. CLL expects this disturbed area to receive the majority of the revegetation planting, however planting may extend to other areas along Ralston Creek within the Mine Permit Boundary. c. Revised as requested. d. Revised as requested. The insert showing the water treatment plant infrastructure has been updated to show the Winch and Cable Housing for the Dewatering Pump, which in installed in the Jeffery Air Shaft.
17	Exhibit F – Reclamation Plan Map (Rule 6.4.6): Please provide a separate reclamation plan map depicting a detailed grading plan for the valley floor. This map should show how the valley floor will be reconfigured to establish positive drainage to the creek. This map should also show any structures proposed to remain in the valley.	As described in Exhibit E, the extent of contamination in the alluvial valley is unknown, therefor CLL cannot provide a detailed grading plan for the valley floor at this time. The text in Exhibit E has been revised to: (1) affirm CLLs commitment to reclaiming all disturbed lands in accordance with all regulatory requirements and (2) commit to providing DRMS a detailed grading plant for the alluvial valley once excavation work is complete.
18	Exhibit L – Reclamation Costs (Rule 6.4.12): The Division has the following comments specific to the Water Treatment Plant Operations section: a. The operator has removed costs for demolishing the water treatment plant since the proposed reclamation plan includes continued operation of this plant. While the Division agrees that removing demolition of the water treatment plant is consistent with the proposed reclamation plan, the Division must continue to hold costs for this task until the operator has provided demonstration that leaving this	a. The costs to demolish the water treatment plant for $55,000 have been added back into Table L-1. CLL is also including a copy of this lump-sum bid in response to these comments.

M-1977-300 APPLICATION AMENDMENT #6, COMMENT AND RESPONSE SUMMARY TABLE		
COMMENT NO.	COMMENT	RESPONSE TO COMMENT
	building and associated structures for final reclamation is consistent with local land use and zoning laws. Therefore, please add these costs back to the bond estimate or provide the required demonstration. b. The costs for Caustic Soda (Sodium Hydroxide, Liquid 25%) is said to cover a total of 66,720 pounds (for 6 months of operation) at $0.30 per pound, for a total of $19,682.40. Based on the information provided, the Division estimates the total costs for this task are $20,016.00. Please correct this error in the total cost.	b. The excel version of Table L-1 was truncating the chemical costs and displaying it as $0.30/lb. The number of significant figures has been reformatted to show the correct pricing as $0.295/lb,
19	Exhibit L – Reclamation Costs (Rule 6.4.12): The Division has the following comments specific to the In-Situ Treatment section: a. The operator's initial bond estimate included costs for six months of Mine Pool Sampling following an injection, at $950.00 per month (for 5 additional injections over a 10 year period). The Division could not find this task in the revised estimate. Please explain why these costs were removed.	The current water quality monitoring plan stipulates that CLL will conduct quarterly monitoring of the mine pool along with other surface and groundwater locations in the monitoring network. Data from these samples shall be used to monitor in-situ treatment.
20	Exhibit L – Reclamation Costs (Rule 6.4.12): The Division has the following comments specific to the Alluvial Valley Excavation section: a. For the Excavate and Place Soil Onsite task, the operator did not provide the information requested in the Division's adequacy item #35(c). The Division had asked where exactly the fill material will be obtained from on site, whether the estimated 0.585 acre of disturbance requiring fill pertains only to the South Zone, and how the operator chose an average depth of 2 feet (for a total of 6,256 CY) when the excavation depth in the valley is said to vary from 0 to 10 feet. The operator's response states "suitable fill material shall be sourced from the alluvial valley itself" and "CLL intends to regrade the alluvial valley consistent with the surrounding slopes by pushing adjacent fill materials to fill in excavated pot holes". This response indicates the operator believes there is enough "clean" material available in the valley where the excavation project is occurring to merely regrade disturbed areas to achieve the final reclamation grade. Has the operator performed a survey of the excavation project area to confirm there will be enough "clean" soil available to regrade the valley in a manner that creates positive drainage to the creek? In order for the Division to calculate the bond estimate for regrading (rather than backfilling) the disturbed valley areas for reclamation, additional information is needed. Please provide an approximate total acreage that will require regrading and an average push distance for each of the two main excavation areas (north and south zones). b. The operator has added a line item in this section for Remove 18-in Bypass Pipeline, in accordance with the proposed reclamation plan. Because the operator provided a lump sum estimate of $8,000.00 for this task, it is not clear if this estimate includes demolition/removal costs for the two bollards or disposal costs for all of these materials. Please provide a breakdown of this estimate or submit a copy of the bid prepared by Kessler Reclamation and Construction. Where is the anticipated disposal location for these materials? c. The Division has requested additional information in Exhibit F regarding any additional structures associated with the creek (e.g., upgradient cutoff wall, riprap/grouted boulder areas) which will be removed for reclamation. Please be sure to add costs for reclaiming any such structures in this section, as needed. d. For the Top Soil/Plant Growth Medium task, the operator did not provide the information requested in the Division's adequacy item #35(d). The Division had asked where exactly the growth medium will be obtained from on site, whether any topsoil would need to be imported for reclamation, whether the estimated 0.585 acre of disturbance covers all disturbed areas in the valley which will require topsoil replacement, and how replacing only 3 inches of topsoil will be sufficient to achieve successful revegetation. The operator's response is exactly the same as its response to the Division's question regarding fill material, stating "suitable fill material shall be sourced from the alluvial valley itself" and "CLL intends to regrade the alluvial valley consistent with the surrounding slopes by pushing adjacent fill materials to fill in excavated pot holes". Is this an error? The operator also removed all costs from the bond	a. Correct, the operator believes there is enough "clean" material available in the valley where the excavation project is occurring to regrade disturbed areas and achieve the final reclamation grade. The operator performed a survey of the excavation project area to confirm that there will be enough "clean" soil available to regrade the valley in a manner that creates positive drainage to the creek. A map showing the anticipated horizontal extent of the valley is shown on Figure E-2 and additional text describing the alluvial valley excavation project has been added to Exhibit E. b. CLL intends to leave the bypass pipeline at the site, so costs for its removal have been deleted from Table L-1. c. Please see response to Comment #2. The cut-off wall and riprap/grouted boulder areas were permitted as permanent structures. CLL intends to leave them in place. d. The operator believes there is enough "clean" plant growth medium / topsoil material available in the valley where the excavation project is occurring to regrade disturbed areas, achieve the final reclamation grade, and support vegetative growth (e.g., seed mix/ trees / shrubs), therefor no imported topsoil is required for reclamation. These soils have successfully been used to support vegetative growth and cover at the site previously (e.g., the North and South Waste Rock Piles). The operator performed a survey of the excavation project area to confirm that there will be enough "clean" soil available to regrade the valley in a manner that creates positive drainage to the creek. A map showing the anticipated horizontal extent of the valley is shown on Figure E-2 and additional text describing the alluvial valley excavation project has been added to Exhibit E.

M-1977-300 APPLICATION AMENDMENT #6, COMMENT AND RESPONSE SUMMARY TABLE		
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	estimate for topsoil replacement. Please be advised, the reclamation bond must include costs for retopsoiling any areas to be revegetated for reclamation. Therefore, please add retopsoiling costs back to the bond estimate. In order for the Division to calculate the bond estimate for retopsoiling disturbed areas, additional information is needed. First, please clarify whether the operator intends to borrow topsoil from undisturbed areas within the permit area and/or create a growth medium from a combination of on-site materials. Second, please specify exactly where on site the operator intends to obtain the growth medium required for reclamation. Third, please describe how the operator will verify the on-site material is suitable for revegetation. Fourth, please provide an average depth of growth medium placement (that is no less than 6 inches). Lastly, please clarify the total amount of disturbed lands to be retopsoiled is 12.7 acres. e. The line item for Seed Mix covers seeding 12.7 acres with the grass/wildflower mixture approved in AM-5. Below this task, there are separate line items for planting trees and shrubs in disturbed areas above and below the cutoff wall. Please clarify the grass/wildflower mixture will be planted on all disturbed areas, and the tree and shrub mixtures would be planted in addition to the grass/wildflower mixture in the areas specified. f. The line items for Trees (planted above the cut-off wall) and Willow Stakes (planted above the cut-off wall) each state that approximately 4 acres will be planted with the species specified for that line item. Please clarify whether the same 4 acres will be planted with each of these mixtures or if 4 acres will receive the tree mixture and a separate 4 acres will receive the willow mixture. In other words, will a total of 4 or 8 acres above the cutoff wall be planted with these mixtures? (Note the Division is requesting the specific seed mixtures in Exhibit F, as the seed mixture approved in TR-23, which is referenced in this estimate, does not include trees and shrubs.) g. The line items for Trees (planted in reclaimed valley below cut off wall), Shrubs (planted in reclaimed valley below cut off wall) transported as 1 gallon pots, and Shrubs (planted in reclaimed valley below cut off wall) transported as 5-gallon pots each state approximately 6 acres will be planted with the species specified for that line item. Please clarify whether the same 6 acres will be planted with each of these mixtures. In other words, will a total of 6, 12, or 18 acres below the cutoff wall be planted with these mixtures? (Note the Division is requesting the specific seed mixtures in Exhibit F, as the seed mixture approved in TR-23, which is referenced in this estimate, does not include trees and shrubs.) h. Please explain why the total quantity of Trees (planted in reclaimed valley below cut off wall) went from 147 down to 89 in the revised estimate. i. The line item for Hydro mulching includes no costs, because it is "only required on 2H:1V and steeper slopes, which are not present in the valley". The Division understands the disturbed areas in the valley proposed for revegetation are flatter than 2H:1V. However, there are no costs included for conventional mulching in these flatter areas. Is the operator proposing to not apply mulch on areas in the valley that will be seeded/planted for reclamation? If a mulch will be applied, please add a line item for this task including the type of mulch, application rate per acre, and application method. j. If the operator intends to incorporate any amendments into the growth medium for reclamation, please include costs for this task. Additionally, please specify the type of amendment(s) to be used and the proposed application rate	e. Yes, the seed mix shall be planted on all disturbed areas. Please note the correct acreage is 12.5, not 12.7. This has been corrected on Figure F-1. f. CLL expects that the trees and willow steaks will be planted in the same 4-acre area. As described in Exhibit E, a site-specific planting plan shall be prepared after the alluvial valley excavation project is complete. This plan shall define the extent of disturbed lands that need to be reclaimed and specific exact quantities and locations for mitigation planting. The planting plan shall be submitted to USFW, USACE and DRMS to ensure all applicable regulatory requirements are satisfied. g. CLL expects these shall be planted over a 6-acre area. h. The previous version of this table inadvertently referenced an incorrect value. This error has been amended. The 89 trees shown in the Table L-1 match the maximum number of trees required for reclamation in the Biological Opinion that was submitted to USFW. A summary of this information has been added to Exhibit E for clarity. i. The operator is not proposing to apply any mulch. The approved language in Exhibit E does not require mulching in flatter (less and 2H:1V) areas. j. Previous on-site reclamation work has been successful without amendments and therefor the operator does not expect or intend to incorporate any amendments into the growth medium for reclamation.
21	Exhibit L – Reclamation Costs (Rule 6.4.12): The Division has the following comments specific to the Environmental Monitoring section: a. In its adequacy item #36(a), the Division required the operator to adjust the Surface Water Monitoring costs to cover quarterly sampling over a full 10-year period. In its response, the operator stated "revised as requested". However, the revised cost for this item does not cover	a. Revised as requested.

M-1977-300 APPLICATION AMENDMENT #6, COMMENT AND RESPONSE SUMMARY TABLE		
COMMENT NO.	COMMENT	RESPONSE TO COMMENT
	quarterly sampling over a 10 year period, which would include a total of 520 sampling events (not 260) for 13 monitoring locations. Given the operator's proposed plan to remove the bypass pipeline and re-establish creek flows across the mine site, it is especially important the Division continues to hold costs for sampling all surface water monitoring locations at the required quarterly frequency over the full 10 year period. Please adjust these costs accordingly. b. In its adequacy item #36(b), the Division required the operator to adjust the Groundwater Monitoring costs to cover quarterly sampling over a full 10-year period. In its response, the operator stated "revised as requested". However, the revised cost for this item does not cover quarterly sampling over a 10 year period, which would include a total of 560 sampling events (not 280) for 14 monitoring locations (12 wells with water quality sampling + 2 spigots). Please adjust these costs accordingly.	 b. Revised as requested.
22	Exhibit U – Designated Mining Operation Environmental Protection Plan (Rule 6.4.21): Under Section 7 of the revised EPP, please add a description of the bulkheads installed in the Steve and Pierce adits, which are considered Environmental Protection Facilities. If CLL has access to the as-built drawings for these bulkheads, please provide copies of these drawings.	Revised as requested. The text in Exhibit U has been updated to include a description of the bulk heads and CLL has included a copy of the As-Built Report provided in Technical Revision #9 with this submittal.
23	Exhibit U – Designated Mining Operation Environmental Protection Plan (Rule 6.4.21): Under Section 7, Table 7-1 provides a list of reclamation activities completed and in progress. The two items from this list shown to be "in progress" are the Fill Material Borrow Area and Ore Sorter Area Decommissioning. Please describe where these areas are located within the permit area and what reclamation activities remain in these areas.	These two areas are in the alluvial valley and are currently being reclaimed as part of the excavation project. The remaining reclamation activities in these areas include excavation of contaminated soils, regrading, replanting/reseeding in accordance with Exhibit E.
24	Exhibit U – Designated Mining Operation Environmental Protection Plan (Rule 6.4.21): Under Section 7.1, the operator provides a list of four chemicals used in the water treatment process. Please provide the maximum volume of each of these chemicals that is stored in the plant at any time.	Revised as requested.
25	Exhibit U – Designated Mining Operation Environmental Protection Plan (Rule 6.4.21): Under Section 7.1, the operator states "the plant floor was constructed with an 8-inch high berm to serve as secondary containment for all the structures in the building". Please provide additional details on the secondary containment system installed inside the plant, including whether it was designed to contain at least 110 percent of the maximum storage capacity of all primary containers holding hazardous chemicals.	Revised as requested. The text has been updated to state that plant can contain up to 110% of the maximum storage capacity including hazardous chemicals. The containment inside the water treatment plant is capable of holding approximately 10,000 gallons. Primary containers inside the Water Treatment Plant include: IX Vessels, anti-scale tank, chemical tote - pH adjustment, chemical totes – Stock consumables. IX Vessels: 3 IX vessels are connected in series and each one can be isolated as required. 2 vessels are used in normal operation. Each vessel will contain resin and treated water. Each vessel will contain 50% resin and 50% water. IX-1 = 1,000 gallons IX-2 = 1,000 gallons IX-3 = 1,000 gallons Anti-scale Tank: 1 Tank used to supply anti-scale additive =900 gallons pH Adjustment – Standard Chemical Tote: 1 tote = 275 gallons Stock reagents – Standard Chemical totes: *(Varying quantities with a maximum of 10 totes)*

M-1977-300 APPLICATION AMENDMENT #6, COMMENT AND RESPONSE SUMMARY TABLE		
COMMENT NO.	**COMMENT**	**RESPONSE TO COMMENT**
		10 totes = 2,475 gallons Total primary chemical storage = 6,650 gallons Total secondary containment = 10,000 gallons 10,000/6,650 x 100%= 150.378%
26	Exhibit U – Designated Mining Operation Environmental Protection Plan (Rule 6.4.21): Under Section 7.1, the operator states "the tanks are located within a lined, bermed excavation that serves as secondary containment". Please provide additional details on the secondary containment located outside of the water treatment plant in which the backfill slurry tanks are stored, including whether it was designed to contain at least 110 percent of the maximum storage capacity of the tanks with sufficient freeboard for precipitation.	Revised as requested. The text has been updated to state that lined bermed area under the tanks can contain up to 110% of the maximum storage capacity of the tanks with additional freeboard for precipitation. The secondary containment outside the water treatment plant is capable of storing approximately 22,000 gallons. The primary storage units that are housed inside the containment are 2 tanks capable of holding 20,000 gallons each. Standard operation of the water treatment equipment requires only one tank be in service at a time. The second tank does not hold water and is a redundant piece of equipment that is isolated from the system. 25,000/20,000 x 100% = 125%
27	Emergency Response Plan (Rule 8.3): Rule 8.1 requires an operator to notify the Division, as soon as reasonably practicable, but no later than 24 hours, after the operator has knowledge of a failure or imminent failure of any impoundment, embankment, stockpile or slope that poses a reasonable potential for danger to human health, property, or the environment, or in the case of a designated mining operation, any EPF designed to contain or control designated chemicals or process solutions as identified in the permit. For the Schwartzwalder Mine, the Division would consider a failure or imminent failure of the waste rock piles, the water treatment plant (including the pump/treat regime that keeps the mine pool level below the regulatory limit or a loss of containment situation), or the bulkheads installed inside the Steve and Pierce adits a situation in which the operator would need to notify the Division in accordance with Rule 8.2. Please commit to providing the required emergency notification to the Division in accordance with Rule 8.2 in the event of a failure or imminent failure of the facilities listed above.	Revised as requested. The text in Rule 8 has been revised to include this notification procedure.
28	Additional Item(s): Please remember that, pursuant to Rule 1.6.2(1)(c), any changes or additions to the application on file in our office must also be reflected in the public review copy which was placed with the County Clerk and Recorder. Pursuant to Rule 6.4.18, you must provide our office with an affidavit or receipt indicating the date this was done. This "proof" should be submitted with your adequacy response.	Thank you, comment noted.
Denver Water		
1	Conclusions regarding the hydraulic gradient are based on few data points; there are only three wells across the entire site that are being used to monitor bedrock groundwater including one background well and two cross-gradient wells; we continue to recommend installation of an additional monitoring well.	CLL responded to this comment within the last RTC submitted, e.g., response to Denver Water #12.
2	CLL did not update climate data for the region or provide analyses on potential impacts from increased flooding or other climate changes such as wildfires; the CSM should account for the full range of potential natural conditions.	CLL responded to this comment within the last RTC submitted, e.g., response to Denver Water #4. AM-06 includes an updated Emergency Response Plan (Rule 8) which discusses response to fires. As previously discussed in response to DRMS's comments the plant can be monitored remotely and in the event that Glencoe Valley Road is not accessible (e.g. due to flooding or wildfires), there is another access point through White Ranch Open space. This access point was previously used in 2013 when the site experienced heavy rains and flooding. CLL believes the climate data provide in the CSM is appropriate for the site and consistent with current the National Oceanic and Atmospheric Administration's (NOAA) most recent data for Colorado. The following information from NOAA has been added to the CSM to discuss potential climate change impacts: "There is less agreement among the models about future precipitation change for Colorado, which is shown in the second row of images. The models are split on whether the future will bring increasing, decreasing, or similar-to-current

M-1977-300 APPLICATION AMENDMENT #6, COMMENT AND RESPONSE SUMMARY TABLE		
COMMENT NO.	**COMMENT**	**RESPONSE TO COMMENT**
		precipitation in Colorado. They show a range of possible outcomes from a 5 percent decrease to a 6 percent increase by mid-century (2050). The risk of decreasing precipitation appears to be higher for the southern parts of the state." Kennedy, Caitlyn. Future Temperature and Precipitation Change in Colorado. NOAA. Published August 9, 2014, Updated July 3, 2021. https://www.climate.gov/news-features/featured-images/future-temperature-and-precipitation-change-colorado Accessed May 2, 2022.
3	No contingency plans were offered if the current strategy were to fail, and CLL indicates that they will continue with their current approach through 20 years with no description of a plan beyond that time.	CLL notes that it has previously stated that it will operate the WTP so that the mine pool elevation remains below the regulatory limit. Within the 20-year period of operation, sufficient data will be collected to evaluate any contingency plan, if needed.
4	We appreciate the pumping groundwater contour figure that was provided with Revised Amendment 6. Please provide: ○ The basis for the assumption that the mine workings are a fully connected infinite hydraulic conductivity feature, and ○ Reasoning for selecting the elevation of 6,434 feet for water in the mine workings as a constant head feature.	○ The mine workings are a network of adits and shafts that can be viewed as interconnected "pipes." The shafts run vertically through the entire thickness of the mine workings, and to our knowledge, there are no installed bulkheads or seals to restrict vertical flow within the shafts. The diameter of the adits and shafts are typically greater than 6 feet, which means that water can flow through these features with very little hydraulic head variation. The consequence is that water within the workings will have a uniform hydraulic head that is controlled by the free surface (water table) elevation in the upper workings. It is not appropriate to describe the mine workings as an "infinite hydraulic conductivity feature" because the flow mechanism is more similar to pipe flow rather than fracture or porous media flow. ○ The mine workings are not a constant head feature. The mine is a "uniform" head feature that varies seasonally. The stipulated maximum allowable head in the mine is 6,452 ft amsl. However, seasonal pumping is typically initiated when the mine water level reaches about 20 ft below the allowable maximum. The assumed head of 6,434 ft msl is considered the operating maximum water level that will typically occur in late spring before the pumps are turned on. If we were to conservatively set this value to the maximum allowable water level, the contour map would change slightly, but the interpretation of a groundwater divide between the mine workings and Ralston Creek (to the southeast) would remain.
5	A stagnation zone in bedrock may exist between the downgradient end of the mine pool and the Creek such that a portion of impacted groundwater in bedrock (not necessarily the mine pool) could discharge to Ralston Creek; we continue to recommend an additional monitoring well and continued environmental monitoring (see CLL response to Denver Water Comment #15).	The feature discussed in this comment is better described as a "groundwater divide" rather than a stagnation zone. On the groundwater contour map (Figure E-4), this feature is located southeast of the mine workings and its interpretation is supported by the configuration of contours and measured water levels in wells MW-15 and MW-16. Groundwater northwest of the divide flows towards the workings, so there does not exist a hydraulic mechanism by which water in or near the mine workings can migrate southeast to Ralston Creek. This situation will be maintained as long as the water level in the mine is depressed by pumping.
6	CLL's argument on stable discharged uranium concentrations does not sufficiently address the overall increasing uranium concentrations in the mine pool over the past few years. See the graph and Mann-Kendall trends provided as Attachments A and B, respectively (see CLL response to Denver Water Comments #2a, 20, 21, 23).	Comment noted. However, at this time CLL has no further explanation to provide. CLL will continue with the in-situ injections and collection of data to evaluate future trends. The concentration of uranium in the mine pool is stable with respect to the current water treatment technology at the site. The RO-IX system can treat these concentrations and discharging water below the USEPA drinking water standard (0.03mg/L). Therefore, CLL has achieved the necessary physical and chemical stabilization requirements outlined in the succession of operator's letters.
7	CLL has not sufficiently addressed that the most recent in situ treatment did not decrease uranium concentrations (see CLL's response to Denver Water Comments #2a, 17, 18). CLL's response to Denver Water Comment #17 states that "CLL is not relying on in-situ treatment for the operations of the RO treatment systems" and that the mine pool is chemically stable. However, mine pool uranium concentration trends are increasing (Attachment A), despite increased frequencies of in situ treatments.	Comment noted. However, at this time CLL has no further explanation to provide. CLL will continue with the in-situ injections and collection of data to evaluate future trends. The concentration of uranium in the mine pool is stable with respect to the current water treatment technology at the site. The RO-IX system can treat these concentrations and discharging water below the USEPA drinking water standard (0.03mg/L). Therefore, CLL has achieved the necessary physical and chemical stabilization requirements outlined in the succession of operator's letter.
8	CLL argues that the bulk total dissolved solids (TDS) of the mine water has not changed, indicating that the RO reject is not impacting the concentrations within the mine and that the mine is chemically stable. TDS concentrations are not an indicator of uranium trends within the mine pool and this argument does not address the chemical stabilization of the mine pool for key constituents such as uranium.	Comment noted. However, at this time CLL has no further explanation to provide. CLL will continue with the in-situ injections and collection of data to evaluate future trends.
9	CLL has not established a contingency plan if uranium levels continue to rise in the mine pool and in situ treatments are no longer effective and/or the RO system is less effective (see CLL responses to Denver Water Comments #2a, 17, 18).	CLL notes that it has previously stated that it will operate the WTP so that the mine pool elevation remains below the regulatory limit. Within the 20-year period of operation, sufficient data will be collected to evaluate any contingency plan, if needed. At this juncture there is no evidence to suggest that either the in-situ treatments will no longer be effective or that the RO system will be less effective. In fact, as stated in the report (Section E.5.2.4), and provided in the revised Figure E-6 (formerly Figure E-4), the TDS concentrations have been generally stable, which supports CLL's assertion that the RO technology appears to remain viable as long as it can be projected by the current data set, and no trend of loss of use or efficiency of RO can be projected from these data.

M-1977-300 APPLICATION AMENDMENT #6, COMMENT AND RESPONSE SUMMARY TABLE		
COMMENT NO.	**COMMENT**	**RESPONSE TO COMMENT**
10	Costs were inaccurately calculated for caustic soda – the price listed by CLL is only enough for one year of caustic soda, resulting in a discrepancy of approximately $380,000 over the subsequent 19 years of WTP operation using CLL's calculation methodology for other annual costs such as barium chloride and antifoulant.	The calculation error in Table L-1 has been corrected.
11	More description of the assumptions for the "sustaining capital" line item is needed. Useful life of major assets is not factored into the CLL cost analysis; therefore, it underestimates asset replacement costs and sustaining capital needs at the WTP over the 20-year period. Examples of likely asset replacements include feed pumps, system pumps, filter housing, electrical components, etc.	The sustaining capital costs provided in the table may be applied to assess replacement costs as noted by the reviewer. The costs provided in Table L-1 are for a 20-year time period, however WTP operations are limited to 6-months or less. At the present time, the "run time" of the RO units is less than 3 years, and a there have been only a few minor repairs required, at less than $2,000 per year.
12	CLL's cost analysis does not account for rate increases or inflation for key line operational/maintenance cost categories such as labor, power, and chemicals.	Inflation is not a line item in Table L-1 because the total surety amount is adjusted each year for inflation on the previous year's value. This process is done outside of this Amendment comment / response process.
13	There is no contingency plan if uranium and other site contaminants of concern concentrations continue to rise, causing more frequent membrane change outs or start-up and operation/maintenance of an ion exchange treatment system.	Please see previous responses to comments regarding contingency planning.
14	No estimates of use or costs were provided for potable water.	As stated in the notes section of Table L-1. Potable water for the bathroom facilities is provided by the onsite water treatment plant.
15	Based on these items, the estimated increase in costs could be up to $2 million or more based on our preliminary review of CLL's cost estimate provided in Attachment C. Thus, the costs provided are not sufficient for operating the water treatment plant for 20 years. Furthermore, the long-term operating strategy requires pumping the mine pool indefinitely, therefore the costs should account for a longer assurance time than 20 years.	Comment noted. Please see response to Comments #10-13 for line-item responses.
16	Lastly, it is not clear why the updated schedule for remaining work or anticipated durations of the remaining work is different for operating the water treatment plant compared to other reclamation activities such as environmental monitoring or in-situ treatments. Data collection and other reclamation activities that support the long-term plan for operating the water treatment should be calculated for the full period of reclamation. If a reduction in time and/or money is being sought, the existing information does not support a conclusion that the "reclamation activities" will achieve a condition consistent with Rule 3.1 at the end of the reclamation period.	The initial surety bond was developed using a consistent 10-year time period. However, in response to previous concerns expressed by the City of Arvada and Denver Water, and at the direction of DRMS, CLL increased the active Water Treatment Plant Operations surety basis from 10-years to 20-years because 20-years is the maximum permitted time period for surety bonding. CLL also notes that this is a rolling 20-year time period meaning this money would remain in the surety bond as long as current active treatment methods are employed.
17	The cost analysis provided herein is not considered a calculation of financial warranty, and addressing the comments provided above should not result in a reduction in the financial warranty for water treatment plant operations in the future.	Comment noted.

APPLICATION AMENDMENT 6, MINE PERMIT M-1977-300
SCHWARTZWALDER MINE, GOLDEN, COLORADO

MAY 2022

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APPLICATION AMENDMENT 6, MINE PERMIT M-1977-300, SCHWARTZWALDER MINE, GOLDEN, COLORADO
MAY 2022

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXHIBIT A. LEGAL DESCRIPTION

This Exhibit has not changed from the 2021 Mine Plan Amendment 5.

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EXHIBIT B. INDEX MAP

This Exhibit has not changed from the 2021 Mine Plan Amendment 5.

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EXHIBIT C. PRE-MINING AND MINING PLAN MAP(S) OF AFFECTED LANDS

This Exhibit has not changed from the 2021 Mine Plan Amendment 5.

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EXHIBIT D. MINING PLAN

This exhibit has not changed from the 1983 and 2001 Mine Plan Amendments. Mineral extraction ceased in 2000.

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EXHIBIT E. RECLAMATION PLAN

The Schwartzwalder Mine (Site) is a former underground uranium mine located on Colorado Legacy Land, LLC (CLL) property in Jefferson County near Golden, Colorado (Exhibit B). The mine was operated by Cotter Corporation N.S.L. (Cotter) from 1966 until May 2000, when mining operations were permanently terminated, and Site decommissioning and reclamation activities began. In March of 2018, CLL purchased the Schwartzwalder Mine and surrounding property from Cotter, acquiring title to 559.20 acres of real property including underlying mineral rights, certain water rights, and responsibility for meeting regulatory requirements for environmental protection and eventual Site closure. CLL property encompasses approximately 87 percent (%) of Section 25, T2S, R71W, of which 76.22 acres are permitted for reclamation under Colorado Mine Land Reclamation Permit (MLRP) M-1977-300 (Exhibit F). Figure E-1 presents photos of each mine opening closure shown in Exhibit F.

E.1. CONCEPTUAL CONSIDERATION

In accordance with Condition #2 of the Succession of Operators Plan, (letter dated February 20, 2018), a conceptual site model (CSM) of the Schwartzwalder Mine was provided to Colorado Division of Reclamation, Mining and Safety (DRMS) on November 6, 2018. The CSM was updated in December 2021 and is provided in Appendix 1. The CSM defines and describes the key environmental features of the Schwartzwalder Mine site (Site), with particular focus on the hydrologic and geochemical mechanisms that are expected to influence/control the flow and chemistry of water in and around the Site. A summary of the CSM is provided below.

- Uranium mining of the Schwartz Trend occurred from 1953 to 2000. The Schwartz Trend is a thin band of brittle garnet biotite gneiss and quartzite between the East Rogers and West Rogers Faults that hosted uranium ore and surrounding sub-ore enriched mineral deposits.
- The Ralston Creek Alluvium is largely confined to stream deposits of limited thickness and extent along Ralston Creek which was present pre-mining and was affected by waste rock deposited during mining activities.
- Colluvium and weathered bedrock contain limited amounts of groundwater located in a thin veneer on hillsides and in drainages tributary to Ralston Creek, which are localized, of limited areal extent, and strongly affected by seasonality. Groundwater in low-permeability bedrock is associated with regional faults and associated fracture systems that contain the limited occurrences of groundwater, which either recharge the mine when pumped down or can act as conduits of groundwater away from the mine when it is not pumped down.
- Climate and hydrology play a key role in any hydraulic connections between the mine workings and Ralston Creek.
    - Average annual precipitation of 18.66 inches per year (in/yr) is offset by an average evaporation rate of 35 to 40 in/yr.
    - Excess precipitation flows as runoff or shallow groundwater towards Ralston Creek.
- Currently a pipeline diverts Ralston Creek from upstream of the mine area to below the mine area. This bypass pipeline prevents Ralston Creek from interacting with contaminated alluvial soil. The alluvial

soil was identified in Technical Revision 14 as having the potential to leach uranium to shallow groundwater and adversely affect Ralston Creek. Upon the completion of the alluvial valley excavation project, Ralston Creek will be allowed to flow through its natural channel (the bypass pipeline will remain adjacent to Ralston Creek as a contingency system).

- Historical sources, e.g., waste rock dumps and alluvial waste rock fill, have contributed to a limited amount of mass loading of Ralston Creek with uranium and metals, and has affected the alluvial groundwater quality.
    - Waste rock dumps: In 2020, CLL constructed a diversion channel on the North Waste Rock Pile (NWRP). This channel diverts run-on water around the NWRP. Subsequent to the installation of this diversion, mass loading from the NWRP into Ralston Creek is now considered de minimus as observed seeps in the area of the NWRP have been largely eliminated.
    - Alluvial waste rock: As described above, a bypass pipeline now prevents Ralston Creek from interacting with the contaminated alluvial valley soil. Similarly, alluvial groundwater in the permit area has historically been captured by a sump system and sent back into the mine. As alluvial waste rock has been removed throughout the valley, the alluvium around the sumps has been removed so that the sumps are now above the surrounding soil and are thereby becoming redundant. These engineering controls shall be removed once the onsite source is addressed.
    - The historical solid phase sources have largely been reclaimed with limited materials around the Site access road still in the process of being removed, and then the valley will be reclaimed by establishing native vegetation. The reclamation activities combined with the upstream diversion have essentially eliminated mass loading to Ralston Creek.
- The mine pool is seasonally pumped to a water treatment plant (WTP), treated, clean water is discharged to Ralston Creek, and reject brine is sent back to the mine. The WTP includes a reverse osmosis (RO) and ion exchange (IX) system that removes uranium and metals from the mine pool water.
- Since CLL purchased the Site in March 2018, pumping of the mine pool has consistently maintained the mine pool elevation below the regulatory limit of 150 feet (ft) below the Steve Level (hereafter referred to as the “regulatory limit”) even during consecutive months of no pumping.
    - Maintaining the mine pool below the regulatory limit has led to (i) establishing a hydraulic gradient away from Ralston Creek in the permit area, and (ii) closing the mine has resulted in reducing the exposure of wall rock to oxygen, which minimizes uranium oxidation in the workings and translates to less mobile uranium to treat.
    - The regulatory limit was established as the permit level in 2012 by the Mine Land Reclamation Board. This elevation is agreed to establish a hydraulic gradient away from Ralston Creek in the permit area.
- In-situ treatment of the mine pool with molasses and alcohol (carbon and nutrient sources for the indigenous population of sulfate reducing bacteria [SRB]), has shown promising results in reducing uranium concentrations to below 10 milligrams per liter (mg/L). These results indicate that in-situ treatment of the mine pool may be a viable feature of a long-term strategy to manage the mine pool.

The usefulness of in-situ treatment as a feature of this long term strategy is still under consideration and may be addressed in a subsequent permit revision.

E.2. INTERCEPTION AND TREATMENT OF ALLUVIAL GROUNDWATER

Although the ore sorter was removed in 1999, legacy contamination associated with the Ore Sorter Decommissioning Area and other mining-impacted areas remain in the alluvial valley at the site. Material associated with these mine disturbances is a mix of mine waste rock and naturally occurring soils, alluvial sands, and gravels. For the purposes of this discussion, these materials are collectively referred to as “alluvial fill”. (The word “pad” has historically been used in reference to these disturbed alluvial fill materials.) Construction of the pad was altered over the operational history of the Mine as needed to support changes in mining facilities and operations. Because seasonally varying amounts of groundwater associated with Ralston Creek inundate portions of subsurface alluvial fill materials, and some of these materials include mineralized waste rock, water quality in the creek is subject to seasonal impacts to water quality, namely uranium concentrations that under low streamflow conditions can exceed the applicable water quality standard (0.03 mg/L, which is the U.S. Environmental Protection Agency’s [USEPA] primary drinking water standard for uranium and the State of Colorado’s domestic water supply limit for uranium). Probable leaching mechanisms include variable cycles of oxidation and formation of soluble uranium salts on waste rock surfaces, combined with seasonally fluctuating alluvial groundwater tables. Since operational mine dewatering and treatment was terminated in 2000, water quality monitoring data have consistently demonstrated that uranium is the primary constituent of concern. Due to geomorphic valley features in the vicinity of the Site, surface water in the creek seeps into the alluvium in upper portions of the pad to become alluvial groundwater that flows back towards the creek in the lower portions of the alluvial pad. The surface water monitoring station just below CLL’s property line (SW-BPL) is situated just below a geologic constriction in the valley that forces most of the alluvial groundwater to the surface and into the creek channel to become surface water. Surface water monitoring station SW-BPL is considered a point of compliance for Ralston Creek. In 2010, the water treatment plant in the valley was refurbished with a new ion-exchange water treatment system, along with infrastructure to begin interception, pumping, and treatment of alluvial groundwater from existing sumps and monitoring wells across the alluvial pad. These systems were authorized under a Colorado wastewater treatment discharge permit (CO-0001244) with the Water Quality Control Division (WQCD) of CDPHE, along with an amendment to the Radioactive Materials License (RML CO-369-06) and technical revisions (Technical Revision-12, Technical Revision-15) to the Mine Permit (M-1997-300). All sumps and monitoring wells were individually permitted with the State Engineer’s Office, Division of Water Resources.

E.3. ISOLATION OF RALSTON CREEK FROM SOURCES OF IMPACTS

While the alluvial groundwater interception and treatment system resulted in dramatic reductions in uranium concentrations in Ralston Creek (2013 Mine Plan Amendment 4), it was not sufficient to eliminate seasonal low-flow (base groundwater flow) exceedances of water quality standards at SW-BPL, and in 2012 an engineered upper cut-off wall was constructed to direct up to 8 cubic feet per second (cfs) of unimpacted upgradient alluvial groundwater and surface water flowing above historic mine facilities into an 18-inch HDPE pipeline, convey this water past the Site, and release it back into the creek below the Site.

The pipeline diversion was conceived and designed to achieve two basic objectives: 1) prevent upgradient groundwater and surface water from becoming impacted as it flows past the Site, and 2) to help dewater the alluvial fill during low-flow conditions such that other remedial measures, such as excavation of contaminated materials within the alluvial pad, can be performed. To allow for access to the contaminated soils in the alluvial valley, the water treatment plant was relocated up to the Mesa in 2018. The previous water treatment plant was demolished, and debris were returned to the underground mine in accordance with the Mine Permit (M-1977-300).

E.4. MITIGATION PLAN FOR SOLID SOURCE TERM MATERIALS

Alluvial valley excavation began in 2018 and has progressed seasonally (late spring to early fall) to present day. In accordance with 2013 Mine Plan Amendment 4, contaminated alluvial fill materials excavated to date have been placed in an underground stope known as the "Glory Hole", which is accessed through the Minnesota Adit of the Schwartzwalder Mine on the hillside well above the elevation of Ralston Creek on the southern side of the valley. Because the Glory Hole has recently reached capacity, and in accordance with 2021 Mine Plan Amendment 5, additional contaminated materials have been placed in the open adit for the Black Forest Mine, a nearby former decorative rock mine that was only partially advanced before operations were permanently terminated. The true spatial extent of the alluvial excavation project is not fully known. As the excavation work processes, and in accordance with Technical Revision 14, gamma radiation surveys are completed to guide excavations such that material are efficiently and effectively removed based on real time measurements. Figure E-2 illustrates the potential horizontal extent of contamination from the most recent surface gamma radiation survey (Fall 2021) and shows the location of the Ore Sorter Decommissioning Area (also called RML Area #2). The vertical extent of contamination in this area may extend to bedrock (approximately 15 feet below ground surface or less) in some areas. As indicated in Technical Revision -14:

Alluvial materials with Radium-226 concentrations above 7 pCi/g shall be excavated and disposed of in the Minnesota Adit (2013 Mine Plan Amendment 4) or the Black Forest (2021 Mine Plan Amendment 5) to protect water quality in Ralston Creek. Alluvial materials with Radium-226 concentrations below 7 pCi/g are expected to meet the 17.2 mg/kg natural-uranium criterion, which in turn, should ensure that groundwater leachate from contact with alluvial fill materials will not exceed the applicable water quality standard of 0.03 mg/L. These soils may be used a fill materials or growth media for reclaiming the valley. Successful completion of alluvial fill excavation work (i.e. confirmation that all contaminated soils have been removed) shall be verified with soil sampling results and presented in a Final Status Survey Report, which shall be provided under separate over to DRMS and CDPHE to satisfy the following regulatory requirements:

- DRMS: Remove soil with the potential to leach uranium to surface water above the Colorado domestic water supply limit for uranium [0.03 mg/L]. The objective is to protect water quality in Ralston Creek and satisfy reclamation requirements under the Mine Permit (M-1977-300).

- CDPHE WQCD: Eliminate the discharge of uranium and other mine-related pollutants from "the Pad" to alluvial groundwater and surface water in Ralston Creek. The removal of contaminated alluvial fill materials is expected to eliminate the long-term need to operate the sump-capture system and bypass pipeline, and to eliminate the need for monthly monitoring of Ralston Creek as required by the NOV/CDO (CDPHE, 2010).

- CDPHE Radiation Control Program: Remove soil above CDPHE clean-up requirements for unrestricted release of RML Area #2 (also called the Ore Sorter Decommissioning Area in Exhibit U) from Radioactive Materials License CO-369-06.

CLL is committed to reclaiming all affected lands and proposed affected lands in Figure F-1 for wildlife habitat use. Any surficial areas that are disturbed, shall be reclaimed consistent with the current topography (approximately 15-30% slopes, as shown in Figure F-1), reseeded (seed mix shown below in Table E-1) and re-topsoiled consistent with Technical Revision 23, Attachment B *Schwartzwalder Mine Environmental Protection Plan* (Whetstone Associates Inc., 2016).

TABLE E-1. SEED MIX

Species	Scientific Name	Season	% in Mix	Seed / lb	lbs PLS*/AC
Native Grasses**					
Sand dropseed	Sporobolus cryptandrus	Warm	15	5,298,000	0.1
Sideoats grama	Bouteloua curtipendula	Warm	15	191,000	3.1
Streambank wheatgrass	Elymus lanceolatus spp. Psammophilus	Cool	15	156,000	3.8
Needle and thread	Hesperostipa comate spp. Comate	Cool	15	115,000	5.2
Thickspike wheatgrass	Elymus laneolatus spp. Lanceolatus	Cool	10	154,000	2.6
Blue grama	Bouteloua gracilis	Warm	10	825,000	0.5
Canada wildrye	Elymus Canadensis	Cool	10	115,000	3.5
Native Wildflowers***					
Black-eyed susan	Rudbeckia hirta	Native	1.5	1,710,000	0.04
Sulfur flower	Eriogonum umbellatum	Native	1.5	209,000	0.3
Prairie aster	Maceranthera tanacetifolia	Native	1.5	408,000	0.2
Purple prairie clover	Dalea purpureum	Native	1.5	210,000	0.3
Western yarrow	Achillea millefolium var. occidentalis	Native	1	2,770,000	0.02
Planic coreopsis	Coreopsis tinctoria	Native	1	1,400,000	0.04
Blanket flower	Gaillardia aristata	Native	1	132,000	0.3
Purple coneflower	Echinacea purpurea	Native	1	117,000	0.3
Total			**100**	**20.3 lbs PLS*/AC**	

Source:

Technical Revision 23, Attachment B *Schwartzwalder Mine Environmental Protection Plan*, Table 7-2 (Whetstone Associates Inc., 2016).

Notes:

This upland seed mix is also included in the mitigation description portion of the USACE Section 404 Permit application and associated Biological Assessment for USFWS. Figure F-1 shows the anticipated extent of disturbed acres that will need to be replanted.*PLS/AC = Pure Live Seed per pound, per acre. If broadcast seeding, double the rate applied.

** Colorado native grasses and wildflowers may be substituted with project ecologist approval only

*** Wildflowers may be eliminated based on availability

The soils and plant growth media used for reclamation are native soils from the alluvial valley excavation area. These soils are called Cryofluvents and Curecanti very stony sandy loam soils (Map Units 21 and 23 from Table 17-1 and Figure 17-1 of the *Schwartzwalder Mine Environmental Protection Plan* [Whetstone Associates Inc., 2016]). During the alluvial valley excavation project, un-impacted soils shall be stockpiled and set aside to be redistributed during final grading. Section 7(b)(ii) of the *Schwartzwalder Mine Environmental Protection Plan* (Whetstone Associates Inc., 2016) provides the following description of seed and topsoil placement:

> *"<u>Topsoil Placement:</u> Topsoil will be end-dumped on the crest of the slope and graded by dozers. Slopes will be graded to avoid concentrated water flow and subsequent erosion. Soil surfaces will be moderately*

roughened to allow the seeds to hold and some moisture to collect. Roughening can simply be the tracks of heavy equipment that has been used at the site for regrading.

Seeding: Seeding will be accomplished by broadcast seeding followed by hydromulching. Hydroseeding is not recommended as it is not typically successful in an arid climate. Table E-1 presents the seed mix to be used for the waste rock piles.

Mulching: For 2H:1V and steeper slopes, mulch is necessary to keep the seed and topsoil in place. Mulch can also provide shade to the seedlings and help the soil to retain moisture. Mulching will be accomplished by hydromulching with addition of a tackifier. Tackifier (Ecology Control MBinder) is a botanical glue made from Plantago insularis that can also be applied to the slope to prevent erosion. The hydromulch and tackifier should effectively stabilize the surface of the slope.

Soil Amendments: Soil amendments may be required to improve the performance of the vegetation. This could include composted biosolids or manufactured amendments such as Biosol."

The planting plan for the alluvial valley is based on the Biological Assessment [1]prepared for the U.S Fish and Wildlife (USFW) service, in consultation with the U.S. Army Corps of Engineers (USACE), which was submitted to DRMS with Technical Revision #23. This Biological Assessment identified two phases of the remediation project:

- Phase One discussed impacts from the installation of the cut-off wall and bypass pipeline, and
- Phase Two discussed impacts from the alluvial valley excavation.

The previous operator, Cotter, completed all of the necessary planting and mitigation for Phase One impacts, except for planting 174 riparian area trees (Ponderosa Pine, Juniper, Cottonwood & Peachleaf Willow) and 615 willow stakes. Since the alluvial valley excavation project is on-going, no planting or mitigation has been completed for Phase Two impacts. The excavation area shown in Figure E-2 corresponds to the Phase Two Upland Mitigation Area (also called Impact Area#3 in the Biological Assessment). Table E-2 below summarizes the tree and shrub mitigation requirements remaining at the Schwartzwalder Site. Once the alluvial valley excavation is complete, and the excavation impact extents are fully known, CLL will develop a specific planting and grading plan which shall be submitted to the appropriate Agencies (USACE, USFW, and DRMS) to review and confirm that all of CLL reclamation obligations under the various permits are satisfied.

[1] Schwartzwalder Mine – Phase 2, Biological Assessment, USACE File # NOW-2011-1353-DEN (IRIS Mitigation and Design Inc., 2016).

TABLE E-2. ESTIMATED REMAINING PLANTING QUANTITIES FOR TREES AND SHRUBS		
Item	**Description**	**Mitigation Quantity (Includes Corps Ratio)**
Phase One Impacts from Cut-off Wall and Bypass Pipeline Installation		
Trees, 10-gallon pots	Ponderosa Pine, Juniper, Cottonwood, Douglas Fir, Engelmann Spruce	174
Shrubs	Willow stakes	615
Phase Two Impacts from Alluvial Valley Excavation [1]		
Trees, 10-gallon pots	Ponderosa Pine, Juniper, Cottonwood, Douglas Fir, Engelmann Spruce	89
Shrubs, 1-gallon pots	Mountain Mahogany, Hawthorne, Willow, and Fringed Sage	65
Shrubs, 5-gallon pots	Mountain Mahogany, Hawthorne, Willow, and Fringed Sage	66

Source:

Schwartzwalder Mine – Phase 2, Biological Assessment, USACE File # NOW-2011-1353-DEN (IRIS Mitigation and Design Inc., 2016).

Notes:

Figure E-2 illustrates that the anticipated extent of alluvial valley excavation, which corresponds to Impact Area #3 of the Biological Assessment. The maximum planting quantities for Impact Area #3 are shown, a site-specific planting plan shall be developed after the excavation is complete with exact quantities. Figure F-1 shows the anticipated extent of disturbed acres that will need to be replanted.

After the alluvial valley exaction is complete and the corresponding disturbed areas are reclaimed, the bypass pipeline and sump system may be removed. CLL proposes allowing Ralston Creek to flow through the sluice gate at the cut off wall into its natural channel while the bypass pipeline infrastructure remains in place. This would allow CLL to monitor the water quality in Ralston Creek while the bypass pipeline infrastructure is still intact.

E.5. MINE POOL MITIGATION

The WTP operating strategy is considered in conjunction with in-situ treatment of the mine pool to provide physical and chemical stabilization of the mine pool. During the period in which the WTP is shut down, in-situ treatment of the mine pool may at times be conducted, as necessary, to maintain chemical stabilization. A demonstration of the physical and chemical stabilization of the mine pool, including previous in-situ treatments, is discussed below.

E.5.1. Physical Stabilization of the Mine Pool Demonstration

Physical stabilization of the mine pool began when a 10-horsepower (hp) pump was installed in the #2 Shaft behind the Steve bulkhead. The pump was capable of dewatering the mine pool at 100 gallons per minute (gpm). The 10-hp pump was replaced with a 25-hp pump in February 2017 to increase the mine dewatering rate and speed up the process of achieving the regulatory limit. The pump was installed in the #2 Shaft behind the Steve bulkhead at 210 ft below the Steve Level and was capable of dewatering the mine pool at 190 gpm. The 25-hp pump dewatered the mine pool to below the regulatory limit by November 2017. The WTP has been operating approximately 50% of the time for the last four consecutive years and as shown in Figure E-3, the mine pool has been consistently below the regulatory limit, with the possible exception of one instance in the Winter of 2019 (January 27-29, 2019).

In April 2019, a 60-hp pump was installed in the Jeffrey Air Shaft at 410 ft below the Steve Level. The pump is capable of dewatering the mine pool at approximately 300 gpm.

In April 2020, there was a malfunction with the 60-hp pump and the 25-hp pump was temporarily brought into operation to dewater the mine pool. Operation of just the 25-hp pump was sufficient to keep the mine pool below the regulatory limit.

In October 2020, a team entered the mine to verify the mine pool elevation and calibrate the transducer used to measure the mine pool elevation. The team measured that the mine pool had been dewatered to 22 feet lower than the elevation recorded by the transducer, which caused inaccurate and higher measurements to be recorded. The transducer was lowered from 294 ft to 354 ft below the Steve Level and calibrated to accurately measure the mine pool elevation. The steep drop in October 2020 shown on Figure E-3 reflects when the calibration was performed. The fact that the transducer had been providing shallower mine pool elevation measurements indicates that the exceedance of the mine pool elevation above the regulatory limit in the Winter of 2019 may not have been an actual exceedance, and also it is possible that the mine achieved the 150 foot below Steve level sooner than November 2017.

Operation of the 60-hp pump and the dewatering/treatment of the mine pool will continue to physically stabilize the water elevation in the mine pool below the regulatory limit. During the time in which the WTP is not in operation, the mine pool will be allowed to naturally recover as shown in Figure E-3. Projections based on historical mine pool elevation trends and calculations of mine recharge rates show that each year the WPT can be shut down for at least a 6-month period with little risk of exceeding the regulatory limit. The basis for a shut down of at least 6-months is provided in the following section.

Maintaining the mine pool elevation below the regulatory limit (150-feet below the Steve Level) has established a hydraulic gradient inward toward the mine pool and away from Ralston Creek. A summary of the observed quarterly groundwater elevations in bedrock wells MW-13, MW-15 and MW-18 with respect to the mine pool elevation is presented in Table E-2. MW-13 is the upgradient deep groundwater well. MW-15 was installed east of the Schwartzwalder Mine, targeting the Schwartz Trend geologic transition zone, and was installed at a location that was downgradient of the mine area relative to pre-mining static water levels. MW-18 as installed in the valley floor targeting the Illinois Fault in the area near where the Illinois Fault is adjacent to Ralston Creek. These data are used to calculate the hydraulic gradient between each well and the mine pool. Negative gradients indicate an inward gradient of groundwater around the mine as measured by the transducer (which is installed within the mine pool and measured in Shaft 2). Depending on the elevation of the mine pool, which since 2018 it was below the regulatory limit, the gradient from each well ranged from 0.014 to 0.304 feet per foot. This validates that the regulatory limit is set at an appropriate depth to protect Ralston Creek and the potential for groundwater to migrate along the recognized permeable features that intersect the mine. The strongest gradient (0.304 ft/ft) was observed in MW-13 during the fourth quarter of 2021, when the mine pool was dewatered to its deepest elevation. The data also indicate an anisotropic capture zone from pumping the mine pool.

A bedrock groundwater contour map is shown on Figure E-4 that illustrates the capture zone associated with the mine pool. The lateral extent of mine pool workings is shown as the red-shaded area. Groundwater elevation data from the second quarter 2020 are shown next to wells MW-13, MW-15, and MW-18. These monitoring well data, which are conservative, are provided in Table E-2 and used on Figure E-4. In the second quarter of 2020 the mine pool elevation ranged from ~158 – 178 feet below the Steve Level (Table E-2). CLL has further dewatered the mine pool to greater than 345 feet below the Steve Level. Additional discussion of this figure and the physical stabilization of the mine pool is provided in Appendix 3.

E.5.1.1. Physical Stabilization of the Mine Pool Conclusion

The changes in mine pool elevation during the non-pumping recovery period are historically steady and consistent. On the basis of historical refill trends, once the mine pool is dewatered at the end of the operating season, the natural groundwater recharge will take at least six to and up to eight months before the mine pool approaches the regulatory limit. Historical mine pool elevations are shown in conjunction with mine pool projections in Figure E-3. The projections made for the natural refill in the spring of 2022 in Figure E-3 are based on previous recovery trends through the same elevations in the mine. The green point at 6,432 feet above mean sea level (ft amsl) represents the projected plant start-up day, when the mine pool is estimated to still be at a conservative 20 ft below the regulatory limit. On the basis of empirical data collected, the physical stabilization of the mine pool has been achieved for the last four consecutive years (i.e., since fall of 2017) by this approximately 6-month seasonal pumping. On the basis of (i) calculations developed from the empirical data, (ii) the operational periods of the WTP over the last 4 years, (iii) observed gradients in monitoring wells, and (iv) active dewatering performed for ~6 months of the year, the result is a physically stable mine pool.

E.5.2. Chemical Stabilization of the Mine Pool Demonstration

The chemical stabilization of the mine pool water has been accomplished through a number of steps taken to optimize the management of the Site, including reducing mine recharge from sumps as reclamation has progressed, closure of mine openings, as well as in-situ treatments. Functionally, keeping the mine chemistry stable enough in its overall composition to allow the RO to be used to maintain the mine pool in its target dewatered range is how achieving and maintaining chemical stabilization should be evaluated.

The mine chemistry is in a “brackish” water chemistry designation, where dissolved solids are higher than the freshwater range, but not so saline that it cannot be readily treated to make fresh water acceptable for other uses. Limiting oxidation processes has been accomplished by decreasing oxygen flux into the mine by closing/filling the open hole and stopping active ventilation, as well as by adding microbial reagents in situ into the mine workings to consume oxygen and reverse historical oxidation that occurred when the mine was open, and air was blown through the mine to decrease radon exposure. The amount of in-situ treatment is expected to decline as ventilation has been stopped, the mine openings have been closed, and the oxidized rock in the saturated workings has now been flooded with biochemically reducing water. The water in the mine has been shifted from its oxidizing form (+200 millivolts when initially flooded) to now be consistently negative millivolts (from March 2019 to the present, the raw feed into the WTP has ranged from -80 millivolts to -157.9 millivolts). When the mine water is chemically reducing, fluctuating mine pool levels cannot cause leaching of mine rock by oxidative processes.

In addition to creating a bulk mine water chemistry that is chemically reducing to minimize oxidative leaching of mine rock, the in-situ treatment regimen is also designed to create a zone of sulfate-reducing conditions for the reduction of soluble uranium species to insoluble uranium species, e.g., from the hexavalent oxidation state (U[VI]) to the tetravalent oxidation state (U[IV]), with a focus on the upper mine workings. Numerous field-based studies have documented that a sulfate-reducing environment is conducive to the reduction of U(VI) to U(IV) resulting in the decline in observed uranium concentrations (e.g., Anderson et al., 2003; Watson et al., 2013)[2], and also sulfate-reducing environments consume oxygen that otherwise could lead to uranium oxidation. The reducing environment is essential for the reduction of U(VI) to U(IV) to immobilize uranium and the precipitation of iron sulfides. In addition to the formation of insoluble uranium species, trace metals may coprecipitate with or adsorb on the surfaces of the iron sulfides.

The in-situ treatment consists of injecting carbon sources, e.g., molasses, alcohols such as ethanol and methanol, to stimulate the activity of native SRB. Oxidized sulfur compounds can be used as terminal electron acceptors for the anaerobic respiration of organic matter by SRB. SRB obtain energy by coupling the oxidation of organic compounds to the reduction of sulfate or other sulfur compounds to sulfide. Soluble sulfides are produced that react with chalcophile metals (e.g., zinc, cadmium, lead, copper) to precipitate low solubility metal sulfide phases. A phosphate source such as phosphoric acid is also added, as necessary, as a nutrient for the microbes.

[2] Anderson, R.T., Vrionis, H.A., Ortiz-Bernad, I., Resch, C.T., Long, P.E., Dayvault, R., Karp, K., Marutzky, S., Metzler, D.R., Peacock, A., White, D.C., Lowe, M., Lovley, D.R. (2003) Stimulating the in situ activity of Geobacter species to remove uranium from the groundwater of a uranium-contaminated aquifer, Appl. Environ. Microbiol., 69, 5884-5891.

Watson, D.B., Wu, W., Mehlhorn, T., Tang, G., Earles, J., Lowe, K., Gihring, T.M., Zhang, G., Phillips, J., Boyanov, M.I., Spalding, B.P., Schadt, C., Kemner, K.M., Criddle, C.S., Jardine, P.M., Brooks, S.C. (2013) In situ bioremediation of uranium with emulsified vegetable oil as the electron donor, Environ. Sci. Technol., 47, 6440-6448.

TABLE E-3. OBSERVED GROUNDWATER GRADIENTS							
		Daily Average Mine Pool Elevation		Monitoring Well (MW) Elevation and Gradient Data			
Sampling Memo/Data Source	Sample Date	(feet below Steve Adit)	(ft amsl)	Groundwater Elevation (ft btoc)	Groundwater Elevation (ft amsl)	Head in Well Compared to Mine Pool (ft)	Gradient Toward Steve Adit Transducer (ft/ft)
MW-13							
Q1 2019	No access, winter conditions						
Q2 2019	No data, transducer malfunction						
Q3 2019	No data, transducer malfunction						
Q4 2019	No access, winter conditions						
Q1 2020	No access, winter conditions						
Q2 2020	6/17/2020	178.05	6,423.95	446.37	6,956.95	533.00	-0.228
Q3 2020	No sample, equipment malfunction						
Q4 2020	No sample, equipment malfunction						
Q1 2021	No access, winter conditions						
Q2 2021	6/9/2021	227.40	6,374.31	443.55	6,959.77	585.46	-0.250
Q3 2021	7/27/2021	284.69	6,317.02	442.72	6,960.60	643.58	-0.275
Q4 2021	10/13/2021	349.07	6,252.64	440.43	6,962.89	710.25	-0.304
MW-15							
Q1 2019	No access, winter conditions						
Q2 2019	No data transducer malfunction						
Q3 2019	No data transducer malfunction						
Q4 2019	No access, winter conditions						
Q1 2020	No access, winter conditions						
Q2 2020	6/17/2020	178.05	6,423.95	373.40	6,525.93	101.98	-0.098
Q3 2020	7/29/2020	198.21	6,403.79	336.10	6,563.23	159.44	-0.153
Q4 2020	11/12/2020	326.76	6,275.24	386.90	6,512.43	237.19	-0.228
Q1 2021	Dry						

TABLE E-3. OBSERVED GROUNDWATER GRADIENTS

Sampling Memo/Data Source	Sample Date	Daily Average Mine Pool Elevation		Monitoring Well (MW) Elevation and Gradient Data			
		(feet below Steve Adit)	(ft amsl)	Groundwater Elevation (ft btoc)	Groundwater Elevation (ft amsl)	Head in Well Compared to Mine Pool (ft)	Gradient Toward Steve Adit Transducer (ft/ft)
Q2 2021	6/9/2021	227.40	6,374.31	379.40	6,519.93	145.62	-0.140
Q3 2021	7/27/2021	284.69	6,317.02	386.30	6,513.03	196.01	-0.188
Q4 2021	10/12/2021	350.05	6,251.66	422.80	6,476.53	224.87	-0.216
MW-18							
Q1 2019	Dry						
Q2 2019	Dry						
Q3 2019	9/25/2019	191.62	6,410.38	159.70	6,417.18	6.80	-0.020
Q4 2019	10/23/2019	187.84	6,414.16	153.60	6,423.28	9.12	-0.026
Q1 2020	3/4/2020	192.84	6,409.16	162.77	6,414.11	4.95	-0.014
Q2 2020	6/4/2020	158.71	6,443.29	124.70	6,452.18	8.89	-0.026
Q3 2020	7/29/2020	198.21	6,403.79	162.30	6,452.18	48.39	-0.139
Q4 2020	Dry						
Q1 2021	1/29/2021	256.61	6,345.10	215.00	6,361.88	16.78	-0.048
Q2 2021	6/8/2021	226.03	6,375.68	182.13	6,394.75	19.07	-0.055
Q3 2021	Dry						
Q4 2021	Dry						

Notes:

The following table summarizes relevant information for the Steve Adit (where the mine pool transducer is located) and monitoring wells:

Location ID	***Northing***	***Easting***	***Ground Surface Elevation***	***Well Casing Elevation***	***Total Depth of Well***	***Distance to Steve Adit***
	(feet)	***(feet)***	***(ft amsl)***	***(ft amsl)***	***(ft bgs)***	***(Linear ft)***
Steve Adit	*1,732,700.61*	*3,061,558.53*	*6,602*	*N/A*	*N/A*	*N/A*
MW-13	*1,731,272.17*	*3,059,706.76*	*7,401.87*	*7,403.32*	*500.80*	*2,338.69*
MW-15	*1,731,742.41*	*3,061,962.60*	*6,897.53*	*6,899.33*	*1,007.13*	*1,039.91*
MW-18	*1,732,989.50*	*3,061,365.66*	*6,575.34*	*6,576.88*	*239.9*	*347.36*

Coordinate values are Colorado State Plane Central Zone (NAD83) Elevations are NADV88. Survey information provided by Lambert Land Consulting, LLC and were measured on 7/23/2020.

The total depth of the well was obtained from the well construction report.

The distance between the Steve Adit and each MW was calculated using the following formula: $d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$

The gradient (i) toward the mine pool was calculated using the following formula: $i = \frac{dh}{dl}$ where *dh* is the difference in head between the well and the mine pool and *dl* is the distance between them.

E.5.2.1. In-Situ Treatments

Prior to the in-situ treatment of the mine pool in 2020, there were three previous in-situ treatments in 2013, 2015, and 2017. What is known about these in-situ treatments is summarized in the following paragraphs. Note: while there has been some continuity of staff between the Cotter and CLL operating periods, a significant amount of information is not available anymore as Cotter personnel from 2013-2017 are no longer available, and some records of what was done from 2013-2018 is limited. What is summarized below is what was recorded by the Alexco/Ensero staff who are still part of the program.

The initial in-situ mine pool treatment was completed in May 2013 as a pre-treatment step to the RO system in which molasses and methanol were injected into the mine pool. Molasses was injected in the #1 Shaft (~800 ft deep), the #2 Shaft (~1,160 ft deep), and the open hole behind the bulkhead. The injection location points are shown on Figure E-5a. Three subsequent monthly injections of methanol followed, and a second injection of molasses and methanol was made six months after the start of treatment.

The in-situ treatment was interrupted by a 1,000-year rainfall event in September 2013 that prevented access to the Schwartzwalder Mine for large semi-trucks from September 2013 until the summer of 2015 when the road into Schwartzwalder mine started to be rebuilt. Although truck access to the Schwartzwalder Mine was still limited in 2015 and a tanker could not make it to the Site, totes of MicroC® (a carbon source) and molasses were brought to the Schwartzwalder Mine and injected into the mine pool in the same locations as in 2013 in June and September, respectively.

In December 2017, the in-situ treatment of the mine pool consisted of an injection of phosphoric acid and molasses into the #2 Shaft. The 25-hp pump was operating and the RO concentrate effluent was reinjected into the #2 Shaft with the in-situ reagents. The operation of the pump allowed for a mixing of the mine pool to distribute the molasses and phosphoric acid. The pump was shut down on December 22, 2017, and not restarted until January 15, 2018. The injection location points are shown on Figure E-5b.

In December 2019, the 60-hp was turned off and was not restarted until April 2020. On January 28, 2020, beet molasses, phosphoric acid, and the tracer Rhodamine WT were injected in the #2 Shaft at 410 ft below the Steve Level. On January 29, 2020, alcohol and the tracer Fluorescein were injected in the #2 Shaft at 1,100 ft below the Steve Level. The injection location points are shown on Figure E-5b. The alcohol was injected into the mine pool at a lower level of the workings to mix the mine pool water as the alcohol bubbled up. The tracers were used to evaluate the mixing of the mine pool. These tracers were water soluble, low toxicity, expected to be reasonably stable in normal water environments, and highly detectable. It is expected that the use of tracers will only be required once. A discussion on the conclusion of the tracer test is provided in Section E.5.4 and a complete discussion is provided in Appendix 2.

E.5.2.2. In-Situ Treatment Results

During the in-situ treatments, the water quality of the mine pool was frequently monitored at a sample port in the WTP just before the RO units. The effectiveness of the in-situ treatments is illustrated by a decrease in the uranium and molybdenum concentrations shown on Figures E-6 and E-7, respectively. As shown on Figure E-6, dissolved uranium concentrations decreased from approximately 23 mg/L before the first in-situ treatment in

2013 to a minimum of approximately 2 mg/L, an approximate 90% reduction in concentration. There was a rebound in dissolved uranium concentrations in 2014, which subsequently decreased again after the injections of MicroC® and molasses in 2015. The dissolved uranium concentrations again rebounded to a maximum of approximately 40 mg/L before the second in-situ treatment in 2017 followed by a decrease to a minimum of approximately 4 mg/L, an approximate 90% reduction in concentration. The decreasing uranium concentrations indicate that a biochemically reducing environment is being achieved to form some insoluble uranium species that precipitate out of the mine pool.

Also shown on Figure E-6 are the TDS concentrations. Except for the noted period of suspect data, the TDS concentrations have been generally stable. This stability supports the viability of the RO technology treatment system, which is discussed in Section E.5.2.4.

As shown on Figure E-7, dissolved molybdenum concentrations indicate a consistent pattern of several quarters of decreasing concentrations with the in-situ treatments followed by an increase in concentrations. The dissolved molybdenum concentrations decreased from approximately 1.5 mg/L before the first in-situ treatment in 2013 to a minimum of approximately 0.04 mg/L, an approximate 97% reduction in concentration. There was a rebound in dissolved molybdenum concentrations in 2014, which decreased again after the injections of MicroC® and molasses in 2015. The dissolved molybdenum concentrations again rebounded to a maximum of approximately 6 mg/L before the second in-situ treatment in 2017 followed by a decrease to a minimum of approximately 0.05 mg/L, an approximate 99% reduction in concentration, after which dissolved molybdenum concentrations started increasing. The decreasing dissolved molybdenum concentrations is another indication of a reducing environment.

As shown on Figure E-7, the molybdenum concentrations increased in 2018 following the in-situ treatment in 2017, decreased after the in-situ treatment in 2020, and started to increase until the last sampling event in September 2020. The pattern of increasing and decreasing molybdenum concentrations with in-situ treatments is consistent. As shown on Figure E-6, there was not a significant decrease in uranium concentrations after the 2020 in-situ treatment as was seen in the previous in-situ treatments. There may be several factors for the absence of the significant decrease, but whatever the cause was for this limited uranium reduction is speculative at this time. What is known is that the removal of alluvial waste rock was occurring in this time period, with the open hole being filled by this rock material. It is possible that this caused a temporary increase in mine uranium concentrations as uranium containing waste rock materials that had been oxidizing on surface were placed back into the mine workings, and some of them may have fallen into the mine pool and contributed to temporary leaching of uranium. In any case, the mine pool was maintained in a reducing condition as a result of this treatment and while uranium concentrations were not reduced as a result of the in-situ treatment in 2020, the molybdenum concentrations were reduced.

A red circle is shown on Figures E-6 and E-7 for data points that had a high degree of variability in the months preceding the 2017 in-situ treatment. These data are suspect because in the nearly 10 years of other data shown on these figures, uranium concentrations have not exceeded 25 mg/L and molybdenum concentrations have not exceeded 2 mg/L, with the possible exception of one sampling event in November 2017. This is also during the period that Cotter had new staff on site, and CLL believes that a consistent labeling of samples from the mine may not have been performed. The nomenclature used for the Site included the term "mine refill" which was originally used by Cotter to refer to mine pool samples removed by operating the pump in the mine to sample the mine pool as it filled. When the permanent WTP plant RO operations started in 2017, it is plausible to think that "mine refill" was taken from the RO concentrate that was being reinjected into the mine by the new plant. The sudden increase and decrease in uranium and molybdenum concentrations during this time period does not fit with historical data and there is no plausible explanation that CLL knows other than this mislabeling and poor nomenclature to explain this variability during this time. Regardless, the few months of variable data in 2017 do not alter the conclusion that the mine pool has been chemically stable for the last four years.

E.5.2.3. Chemical Stabilization of the Mine Pool Discussion

The concentrations and linear regressions for uranium and molybdenum over the last 3.5 consecutive years are shown on Figure E-8. The uranium concentrations (dissolved and total) have maintained an average of approximately 12 mg/L since March 2018 with a positive slope. The majority of the uranium concentrations are in the 10 to 15 mg/L range with more recent data at approximately 20 mg/L. The molybdenum concentrations (dissolved and total) have maintained an average of approximately 0.6 mg/L since March 2018 with a slight negative slope. These stable average concentrations indicates that the in-situ treatments have been effective in controlling the concentrations of these two metals that are particularly elevated in concentration in this mine pool environment. The January 2020 in-situ treatment did not show the dramatic decreases in dissolved uranium concentrations as during the first two in-situ treatments, which is likely an indication that an environment favorable to U(IV) has been achieved.

A figure that combines multiple parameters (dissolved) with the mine pool elevation, in-situ treatment periods, and when the RO reject was injected back into the mine is presented on Figure E-9. Note that RO reject was injected back into the mine on a continuous basis starting in mid-2017 and the two events before that, e.g., 2013 and 2015, were only temporary periods of injection. Also note that the dates for the mine pool elevation correspond to the sampling dates and CLL does not have mine pool elevation data before December 2016. There does not appear to be any correlation between the mine pool elevation and the parameter concentrations shown on Figure E-9. The observations from Figure E-9 follows:

- The uranium and molybdenum concentrations are directly affected by the in-situ treatments, e.g., decrease during treatment and generally staying low for several quarters, with a subsequent increase toward baseline conditions.

- The arsenic and iron concentrations follow a similar pattern as the uranium and molybdenum concentrations. The arsenic and iron concentrations also increase in the 2017 period of the suspect data and coincide with a time that some of the RO concentrate was returned into the mine pool through the "open hole". The increase in concentrations appears to have occurred during the time where the continuous injection of RO concentrate began and is interpreted to be a result of leaching from broken rock in the open hole. Other than during that period (2016-2017) arsenic and iron concentrations decrease as a result of in situ treatment and have remained in line with concentrations observed after the refilling and pre-dewatering period. Iron is typically insoluble in oxidized and neutral conditions observed when the mine initially filled and transitioned to slightly soluble conditions when the mine became mildly reducing from being filled and sealed and the introduction of in-situ treatments. This should be considered a positive development that is consistent with a lack of increase in sulfate as not iron increasing due to iron sulfide oxidation, but rather from reductive solubility increase. Arsenic concentrations generally follow this same trend—low solubility in oxidized conditions with iron present, and slightly more soluble in mildly reducing conditions. However, a change from 3.6 ppb mean arsenic after mine filling to 13 ppb mean arsenic now in no way affects the effectiveness of RO at being capable of producing clean water for discharge, as 4 years of successful dewater demonstrates.

- The chloride concentrations increased after the continuous injection of RO concentrate, which is amended with barium chloride prior to being returned to the mine pool.

Further demonstration of the chemical stabilization of the mine pool can be seen with a comparison of data collected in the past 3.5 years to historical data. A hydrologic evaluation was conducted in anticipation of mine closure, which included a table that summarized results from water quality samples collected from the mine pool from June 2000 to July 2007 (2007, Whetstone)[3]. A summary of results for water quality samples collected from the mine pool from March 2018 to July 2021 is provided in Table E-3. These data are comprised of the quarterly routine monitoring samples collected and provided to DRMS and the increased frequency of samples collected during the in-situ treatment in 2020. The mean concentrations from the historical hydrologic evaluation are provided in the last column in Table E-3. A comparison of historical mean concentrations to current mean concentrations indicates an overall decrease in concentrations with the exception of an increase in concentrations for the general parameters, which are most likely from the treatment process, and arsenic, copper, iron, and magnesium. A summary of these increases follows:

- The increase in arsenic and iron concentrations may be the result of either the in-situ treatments or natural variation in the water entering the mine. The 2007 data had 73% and 75% of non-detects for dissolved and total arsenic, respectfully, while the current data had 3% and 6%, respectfully. The 2007 data also had 80% non-detects for dissolved iron and the current data had 0%. Iron is typically insoluble in oxidized and neutral conditions observed when the mine initially filled and transitioned to slightly soluble conditions when the mine became mildly reducing from being sealed and the introduction of in situ treatment. This should be considered a positive development that is consistent with a lack of increase in sulfate as not iron increasing due to iron sulfide oxidation, but rather from reductive solubility increase. Arsenic concentrations generally follow this same trend—low solubility in oxidized conditions with iron present, and slightly more soluble in mildly reducing conditions. However, a change from 3.6 ppb mean arsenic after mine filling to 13 ppb mean arsenic now in no way affects the effectiveness of RO at being capable of producing clean water for discharge, as 4 years of successful dewater demonstrates.

- The increase in total copper concentrations may be the result of the large percentage of non-detects (68%) used in the calculation of the mean. The 2007 calculation of the mean only included 29% of non-detects.

- The increase in magnesium concentrations may not be an increase at all. For example, the 2007 data listed magnesium under the general parameters without differentiating total or dissolved. If the 2007 mean magnesium concentration is compared to the current mean dissolved magnesium concentration (as shown in Table E-3) there is an increase. However, if the 2007 mean magnesium concentration is compared to the current mean total magnesium concentration there is no increase.

[3] Whetstone Associates, Inc. Schwartzwalder Mine Hydrologic Evaluation of Mine Closure and Reclamation. (2007) November 7.

Table E-4: Comparison of Schwartzwalder Mine Pool Concentrations Pre and Post In-Situ Treatment

Variable	Units	Number of Samples	Number of Non-Detects	Percent of Non-Detects	Minimum[1]	Maximum	Mean[2]	Median[2]	Standard Deviation	June 2000 to July 2007 Sample Data – Mean[3]
		March 2018 to July 2021 Mine Pool Sample Data								
General Parameters										
Bicarbonate as CaCO3	mg/L	21	0	0%	491	950	790	846	128	374
Calcium	mg/L	22	0	0%	153	352	302	321	53	299
Chloride	mg/L	35	0	0%	8	55	43	43	9.2	31
Conductivity Field	µS/cm	9	0	0%	2,680	5,131	3,510	3,351	742	3,319
Oxidation Reduction Potential	mv	6	0	0%	-158	147	-84	-121	104	193
pH Field	s.u.	10	0	0%	6.8	7.6	7.3	7.4	0.24	7.19
Phosphorus	mg/L	11	3	27%	0.15	0.40	0.19	0.20	0.09	0.15
Potassium	mg/L	22	0	0%	15	31.7	27	28	4.5	17.2
Sodium	mg/L	22	0	0%	139	297	235	231	43	197
Sulfate	mg/L	35	0	0%	408	1,790	1,362	1,420	293	1,725
TDS - Total Dissolved Solids	mg/L	24	0	0%	960	3,470	2,850	2,960	535	2,917
Temperature	Deg C	9	0	0%	7.8	22	17	18	3.8	17.2
Dissolved Metals										
Aluminum	mg/L	22	21	95%	0.17	0.17	-	-	-	0.15
Antimony	mg/L	22	21	95%	0.0012	0.0012	-	-	-	0.014
Arsenic	mg/L	35	1	3%	0.002	0.0311	0.013	0.011	0.008	0.0036
Copper	mg/L	22	20	91%	0.021	0.021	-	-	-	0.010
Iron	mg/L	35	0	0%	0.090	11	4.1	3.7	3.1	0.020
Lead	mg/L	19	19	100%	-	-	-	-	-	0.00030
Magnesium[4]	mg/L	22	0	0%	112	280	236	247	45	224

Variable	Units	Number of Samples	Number of Non-Detects	Percent of Non-Detects	Minimum[1]	Maximum	Mean[2]	Median[2]	Standard Deviation	June 2000 to July 2007 Sample Data – Mean[3]
		March 2018 to July 2021 Mine Pool Sample Data								
Manganese	mg/L	35	0	0%	0.25	1.0	0.74	0.74	0.12	2.1
Mercury	mg/L	11	11	100%	-	-	-	-	-	0.00036
Molybdenum	mg/L	35	0	0%	0.0371	1.4	0.58	0.58	0.38	1.85
Silver	mg/L	22	22	100%	-	-	-	-	-	0.0034
Thallium	mg/L	22	21	95%	0.00030	0.00030	-	-	-	0.025
Uranium	mg/L	35	0	0%	3.95	21	12	12	3.2	41.14
Zinc	mg/L	22	20	91%	0.030	0.050	0.016	0.010	0.0096	0.38
Total Metals										
Aluminum	mg/L	22	22	100%	-	-	-	-	-	0.09
Antimony	mg/L	22	19	86%	0.0016	0.0034	0.00064	0.00040	0.00081	0.020
Arsenic	mg/L	33	2	6%	0.0026	0.034	0.016	0.017	0.0077	0.0058
Copper	mg/L	22	15	68%	0.010	0.10	0.016	0.010	0.020	0.008
Iron	mg/L	35	0	0%	0.80	11	5.7	6.2	2.9	0.62
Lead	mg/L	22	9	41%	0.00010	0.0044	0.00044	0.00015	0.00091	0.018
Magnesium[4]	mg/L	11	0	0%	117	327	255	257	52	224
Manganese	mg/L	35	0	0%	0.14	1.1	0.77	0.77	0.14	2.63
Mercury	mg/L	11	11	100%	-	-	-	-	-	0.0004
Molybdenum	mg/L	32	0	0%	0.081	1.3	0.60	0.59	0.36	1.39
Silver	mg/L	22	22	100%	-	-	-	-	-	0.0023
Thallium	mg/L	22	20	91%	0.00030	0.00070	0.00012	0.00010	0.00014	0.024
Uranium	mg/L	32	0	0%	2.9	23	13	12	4.1	34.37
Zinc	mg/L	22	20	91%	0.030	0.040	0.015	0.010	0.0078	0.366
Radionuclides										
Radium 226 - Dissolved	pCi/L	22.0	0	0%	73	180	127	125	30	178

Table: TABLE E-4: COMPARISON OF SCHWARTZWALDER MINE POOL CONCENTRATIONS PRE AND POST IN-SITU TREATMENT

Notes:

[1] Minimum value only includes detected concentrations.

[2] Mean and median statistics calculated using one-half the detection limit as was done in Whetstone report.

[3] Mean values from Table 37 in Whetstone Associates, Inc. Schwartzwalder Mine Hydrologic Evaluation of Mine Closure and Reclamation. (2007) November 7, which were calculated from results of mine pool samples collected from June 2000 to July 2007.

[4] The Whetstone report Table 37 only had magnesium with no differentiation between dissolved or total.

Deg C - Degrees Celsius

mg/L - Milligrams per liter

mv - Millivolts

pCi/l - picoCuries per liter

s.u. - Standard unit

µS/cm - microSiemens per centimeter

The main takeaway from Table E-3 is the significant decrease in the concentrations of total and dissolved uranium and molybdenum, approximately 60% to 70%. For example, the mean concentrations of total and dissolved uranium decreased from 34.37 mg/L and 41.14 mg/L, respectively, to 13 mg/L and 12 mg/L, respectively. The mean concentrations of total and dissolved molybdenum decreased from 1.39 mg/L and 1.85 mg/L, respectively, to 0.60 mg/L and 0.58 mg/L, respectively. Therefore, the overall decrease in constituent concentrations further demonstrate that chemical stabilization of the mine pool has been achieved for the last three plus consecutive years.

E.5.2.4. Chemical Stabilization Functional Definition

Since physical stabilization of the mine was achieved and is being maintained by RO technology, it is relevant to define what is meant functionally by “chemical stabilization”, not just on a constituent-by-constituent evaluation, as performed in the prior section, but also from a bulk chemistry perspective. As shown in the prior table, the mean total dissolved solids (TDS) concentrations have remained unchanged or slightly decreased in the last 4 years compared to the mine refill period (2,850 mg/L vs. 2,917 mg/L) and remains in a “brackish” water TDS range. This is important because RO technology effectiveness relies on bulk rejection of dissolved constituents, and the mine pool water chemistry as measured by this bulk parameter has not changed at all as a result of this combined seasonal RO treatment and occasional in-situ treatment. If the TDS concentrations had appreciably changed, some concern might be validated that a loss of treatment capacity of this core treatment technology, which forms the basis of the financial assurance, could be projected. However, as no increase of TDS concentrations has resulted, the RO technology appears to remain viable as long as it can be projected by this data set, and no trend of loss of use or efficiency of RO can be projected from this data.

What this indicates is that for the foreseeable future, RO technology can continue to create high quality, low dissolved solids discharge water that will continue to keep the mine pool dewatered and the Site in compliance with its discharge permit. (In fact, RO is commonly used in desalination plants to treat water with more than 10 times the concentration of TDS shown above without the loss of the treatment capacity.) When considered on this basis, the mine pool is chemically stable such that RO can be used to efficiently dewater the mine on a seasonal basis, and thus is definitionally demonstrated to be chemically stable.

E.5.2.5. Physical and Chemical Stabilization Conclusion

It is important to note that the regulatory limit of dewatering the mine pool to 150 ft below the Steve level was specifically chosen by the DRMS to (i) re-establish a hydraulic gradient away from Ralston Creek in the permit area, and (ii) reduce the exposure of wall rock to oxygen in order to minimize uranium oxidation in the workings (MLRB, 2012). The hydraulic gradient away from Ralston Creek means there is no connection between the mine workings and Ralston Creek, i.e., uranium concentrations and other analytes in the mine pool are not adversely affecting Ralston Creek. As discussed above, physical stability of the mine pool over the last three consecutive years has been demonstrated and physical stability will continue for the following reasons:

- The mine pool elevations over the past nearly 4 consecutive years shown on Figure E-3 are below the regulatory limit. The noted ‘exception’ on the chart during the winter of 2019 had been verified to be the results of the transducer below the mine pool and therefore not accurately measuring the depth of the mine pool.

- Actual groundwater inflow into the mine during the periods that active dewatering of the mine pool was not occurring did not raise the mine pool elevation above the regulatory limit.
- The natural recovery rate allows for more than six months before the regulatory limit is approached, based on a starting mine pool elevation of approximately 345 ft below the Steve Level.
- As shown on Figure E-4, water level measurements in bedrock wells MW-13, MW-15, and MW-18 at the Site demonstrate an inward gradient toward the mine pool and away from Ralston Creek.

Chemical stabilization of the mine pool has been demonstrated to occur as a result of CLL's management approach and reclamation at the Site and has also been benefited by in-situ treatments that have occurred since 2013. The stabilization is most notable in evaluating the bulk water chemistry parameter TDS, which remains generally unchanged since 2012, except for the noted period of suspect data. Further, a decrease in uranium and molybdenum concentrations and the overall decrease in concentrations for most of the analytes is observed, as shown in Table E-3, for the last four consecutive years as compared to the concentrations in the pre-2017 samples.

A summary of the WTP operations for the four consecutive years from 2018 through 2021 is provided in Table E-4. As shown, the mine pool has been consistently below the regulatory limit when only operating the WTP for approximately 50% of the time. The mean concentration of dissolved uranium prior to in-situ treatment (2000 – 2007) was 41.14 mg/L. (Source: Whetstone Associates. 2007) compared to the post in-situ treatment mean annual concentration range of 12.19 to 19.90 mg/L.

On the totality of evidence, the operating approach for the Schwartzwalder Mine that is being managed by CLL and is the basis for the financial assurance provided for the Site, shows that the mine pool is physically and chemically stable now, has been physically and chemically stable for the last 4 years, and with the future projections showing that operations of the Site can maintain the mine in a physically and chemically stable state for at least the next 20 years as is provided for in the financial assurance that CLL has posted.

TABLE E-5: SUMMARY OF WATER TREATMENT PLANT OPERATIONS FOR FOUR CONSECUTIVE OPERATING YEARS

Year	WTP Operations Summary	Dissolved Uranium[1] (mg/L)	Mine Pool Dewatering Summary [3]	Notes
2018	Operated 47% of the year. Online = 171 days. Offline = 194 days.	12.19	Feet Gained = 51 feet Max. Depth = 201 fbS (6,401 ft amsl)	In-situ injection in December 2017.
2019	Operated 66% of the year. Online = 241 days. Offline = 124 days.	13.73	Feet Gained = 46 feet Max. Depth = 246 fbS (6,356 ft amsl)	Installed new 60 hp dewatering pump at ~410 fbS.
2020	Operated 47% of the year. Online = 172 days. Offline = 194 days.	12.56	Feet Gained = 99 feet Max. Depth = 345 fbS (6,257ft amsl)	In-situ injection in January 2020.
2021	Operated 37% of the year. Online = 134 days. Offline = 231 days.	19.80 [2]	Feet Gained = ~20 feet Max. Depth > 345 fbS (>6,257 ft amsl)	In-situ injection in October 2021.

Notes:

[1] Mean concentration of mine pool sample results. For comparison, the mean concentration of dissolved uranium in the mine pool from 2000 - 2007 was 41.14 mg/L. (Source: Whetstone Associates. 2007.)
[2] The mean concentration of mine pool sample results for 2021 do not include data collected during the fourth quarter because this report was prepared concurrent with the sample analysis.
[3] "Feet gained" is a measure of the storage created in the mine pool, measured as feet below the regulatory level (150-feet below the Steve Adit).

~ - Approximately
amsl - Above mean sea level
fbS - Feet below Steve Level (6,602 ft amsl)
ft amsl - Feet above mean sea level
mg/L - milligrams per liter
WTP - Water Treatment Plant

E.5.3. Tracer Test

During 2020, a two-chemical tracer test was conducted in the mine to evaluate the system hydraulics and the degree that organic carbon placed underground would disperse within the mine workings to facilitate in-situ treatment. A complete description of the tracer test is provided in Appendix 2. During the duration of the tracer test, there was no flow leaving the mine as confirmed by the mine pool elevation being consistently below the regulatory limit and the demonstrated inward gradient shown toward the mine compared to surrounding groundwater monitoring wells. Based on the absence of tracer concentrations in the WTP discharge, the tracers remained in the mine. Therefore, the mine is a hydrologic sink, e.g., mine pool water is not exiting the mine.

E.5.4. Water Treatment Plant Operating Strategy

CLL is planning to operate the WTP seasonally for approximately six months or less to manage the mine pool. As described above, shutting the WTP down for at least six months each year is based on empirical data with a conservative factor included. However, as more data are collected and the mine pool level maximized below the regulatory limit, the shut down period may be extended beyond six months. Regardless of the shut down period, the mine pool level will be monitored to ensure the regulatory limit is not exceeded. The months of operating the WTP are anticipated to be during the time of year in which access to the Schwartzwalder Mine is generally not hampered by weather. During operations, the 60-hp pump shall be used to dewater the mine workings to approximately 400 ft below the Steve level. The pump will be shut down during those months the WTP is not operating and as described above, the last three years of operating this way has demonstrated that the mine pool level has remained stable below the regulatory limit.

The WTP operating strategy is considered in conjunction with in-situ treatment of the mine pool. During the period in which the WTP is shut down, in-situ treatment of the mine pool may at times be conducted, as needed, to maintain chemical stabilization. The criteria for in-situ treatment of the mine pool shall consist of the Mann-Kendall trend test to evaluate statically significant trends in the uranium concentrations.

E.6. WATER QUALITY MONITORING PLAN

This Exhibit has not changed from the 2021 Mine Plan Amendment 5.

All of the wells/sumps in CLL's water quality monitoring network are installed in unconfined aquifers. These wells/sumps shall be abandoned in accordance with Rule 16, Standards for Plugging, Sealing and Abandoning Wells and Boreholes of the Colorado Code of Regulations which states:

> "Abandonment of Wells or Boreholes in Type II (unconfined bedrock aquifers) and Type III Aquifers (unconsolidated aquifers) - Wells completed into unconfined bedrock aquifers and unconsolidated aquifers must be plugged, sealed, and abandoned by filling the well to the static water level with clean sand or clean gravel. Between the static water level and the ground surface, the borehole must be filled with clean native clays, cement, drill cuttings, or high solid bentonite grout to the ground surface. The uppermost five (5) feet of casing must be filled with grout or a permanent watertight cover must be installed at the top of the casing. If casing is removed, the hole must be filled as described above to within five (5) feet of the ground surface." [4]

Specific means and methods shall be determined by the well abandonment subcontractor, but CLL expects that each well be filled with sand from the bottom of the well to 5-feet above the screen, and then grounded with bentonite to ground surface. Any surface pads or bollards would be removed, disposed of offsite, and reclaimed consistent with the natural surroundings. All sumps and monitoring wells all be individually permitted for abandonment with the State Engineer's Office, Division of Water Resources.

[4] Rules and Regulations for Water Well Construction, Pump Installation Cistern Installation, and Monitoring and Observation Hole/Well Construction, Code of Colorado Regulations, division of Water Resources, 2 CCR 402-2.

FIGURE E-1: PHOTOS OF MINE OPENING CLOSURES

(A) CV / Charlie Adit, April 2022

(B) Minnesota Adit, April 2022

FIGURE E-1: PHOTOS OF MINE OPENING CLOSURES

(C) Pierce Adit, April 2022

(D) Steve Adit, April 2022

FIGURE E-1: PHOTOS OF MINE OPENING CLOSURES

(E) Sunshine Decline, April 2022

COLORADO LEGACY LAND
SCHWARTZWALDER MINE

FIGURE E-2

POTENTIAL EXTENT OF ALLUVIAL VALLEY EXCAVATION

APRIL 2022

COLORADO LEGACY LAND

Potential Horizontal Extent of Excavation Area (9.02 Acres)
RML Area 2
Glencoe Valley Road
Ralston Creek

1:4,000 ***when printed on 8x11 inch paper***

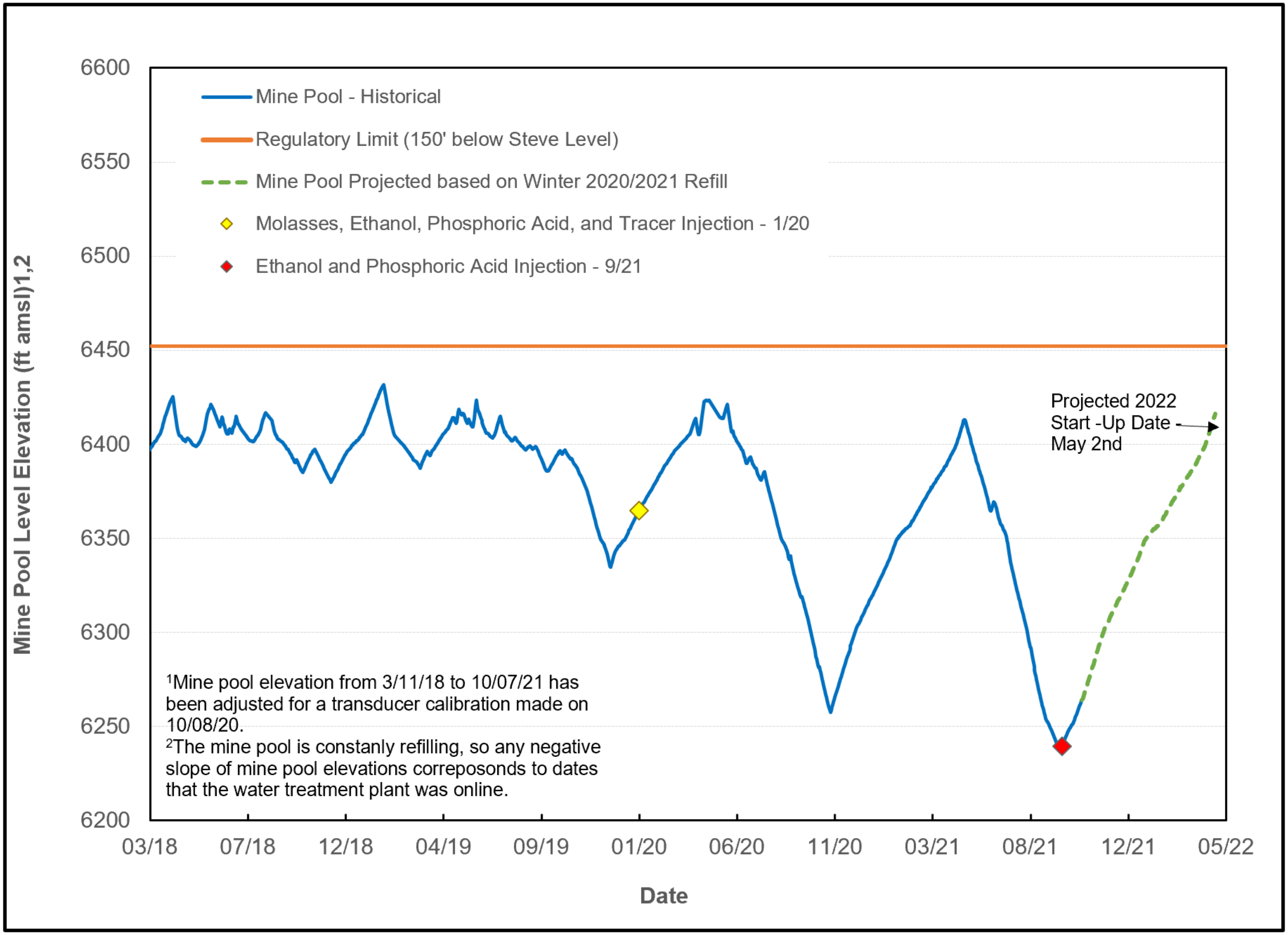
0 100 200 300 400 Feet

ENSERO solutions

Satelite imagery obtained from ArcGIS on services.arcgisonline.com on April 2022
Fault lines are manually digitized from Whetstone Associates Schwartzwalder Mine Environmental Protection Plan, 2016

Datum: NAD 1983 (CORS96) StatePlane Colorado Central FIPS 0502 (US Feet)

D:\Project\AllProjects\Schwartzwalder\Map\01-Overview\03-Overview\RML_Area2_20220426.mxd



COLORADO LEGACY LAND
SCHWARTZWALDER MINE

FIGURE E-3
SCHWARTZWALDER MINE POOL PROJECTED RECOVERY

MARCH 2021

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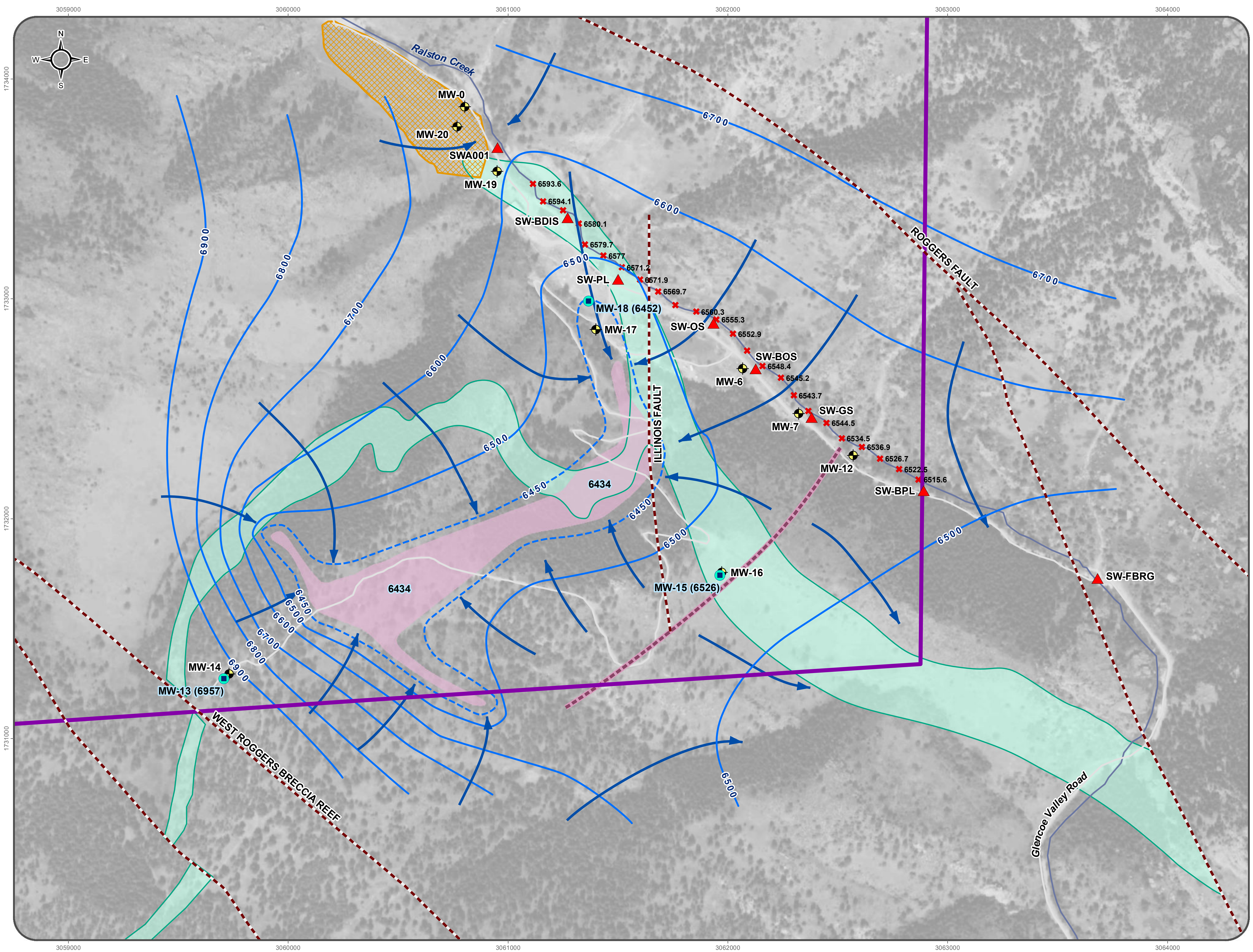
COLORADO LEGACY LAND
SCHWARTZWALDER MINE

FIGURE E-4

BEDROCK GROUNDWATER CONTOUR MAP

MAY 2022



Deep Bedrock Monitoring Well (6526) with Measured Q2-2020 Water Level (ft msl)

Alluvial or Shallow Bedrock Monitoring Well

Surface Water Quality Monitoring Station

100 foot Groundwater Contour (ft msl)

50 foot Groundwater Contour (ft msl)

Groundwater Flow Direction

Groundwater Divide

Fault

Ralston Creek Elevation Point (ft msl)

Underground Workings

Schwartz Trend

Waste Rock Dump

CLL Property Boundary

Ralston Creek

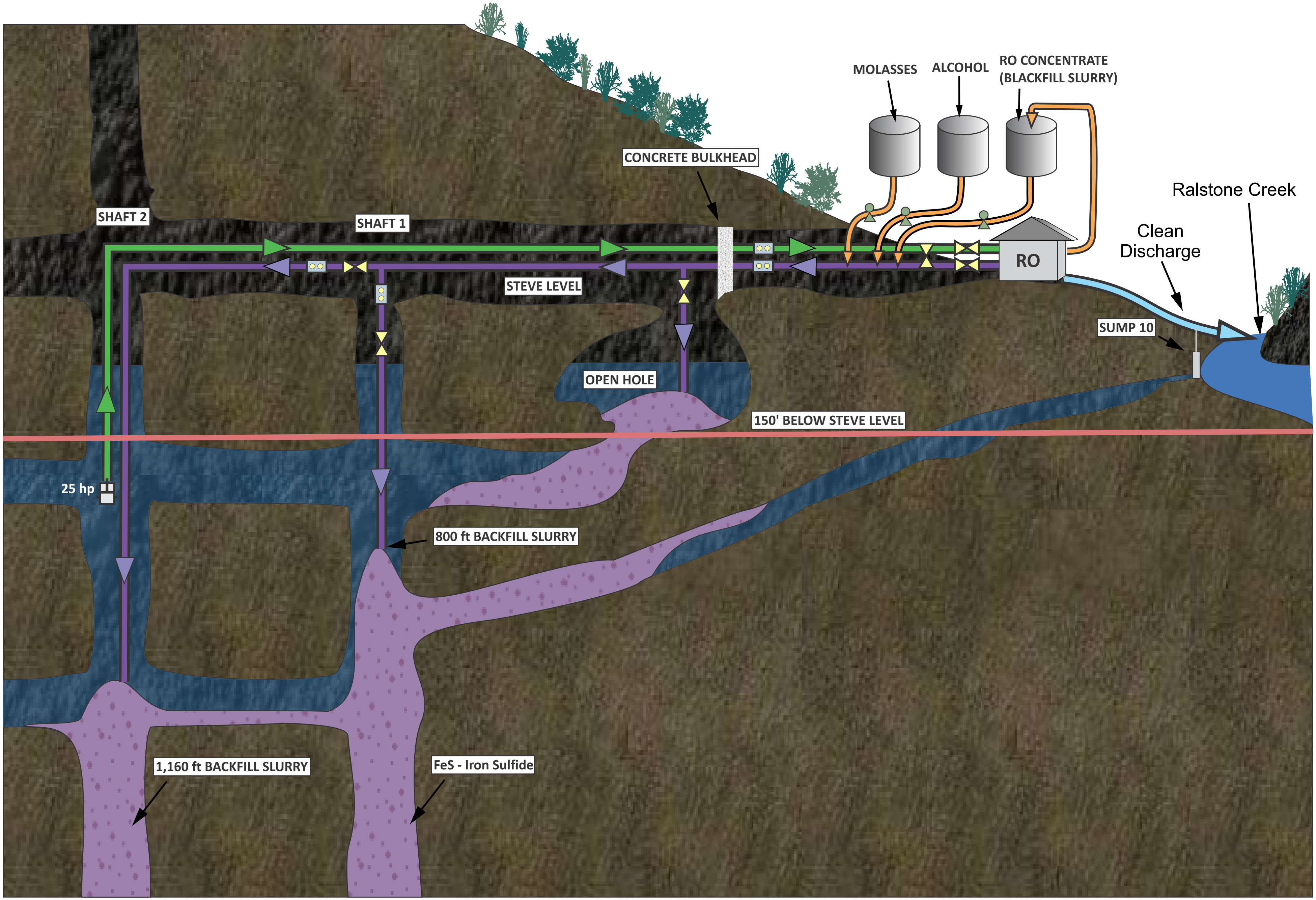
1 inch = 420 feet

0 250 500 750 ft

Satellite imagery obtained from ESRI ArcGIS map service https://services.arcgisonline.com/ArcGIS/rest/service on May 09 2022.

Datum: NAD_1983_StatePlane_Colorado_Central_FIPS_0502_Feet

D:\Project\AllProjects\Schwartzwalder\Map\02-Water_Quality\02-Groundwater\GW_Contours\GW_Contours_20211208.mxd
(*Last edited by: amatlashevska;2022-05-09/11:31 AM*)



FEATURES ARE NOT TO SCALE

Injected in-situ treatment material, e.g., molasses, alcohol, etc., and RO concentrate

Mine Pool Pumping

Gate Valve

Flow Meter

Pump

Submersible Pump

COLORADO LEGACY LAND

ENSERO solutions

COLORADO LEGACY LAND SCHWARTZWALDER MINE

FIGURE E-5a

SCHWARTZWALDER MINE IN-SITU TREATMENT INJECTION LOCATIONS - 2013/2015

JANUARY 2022

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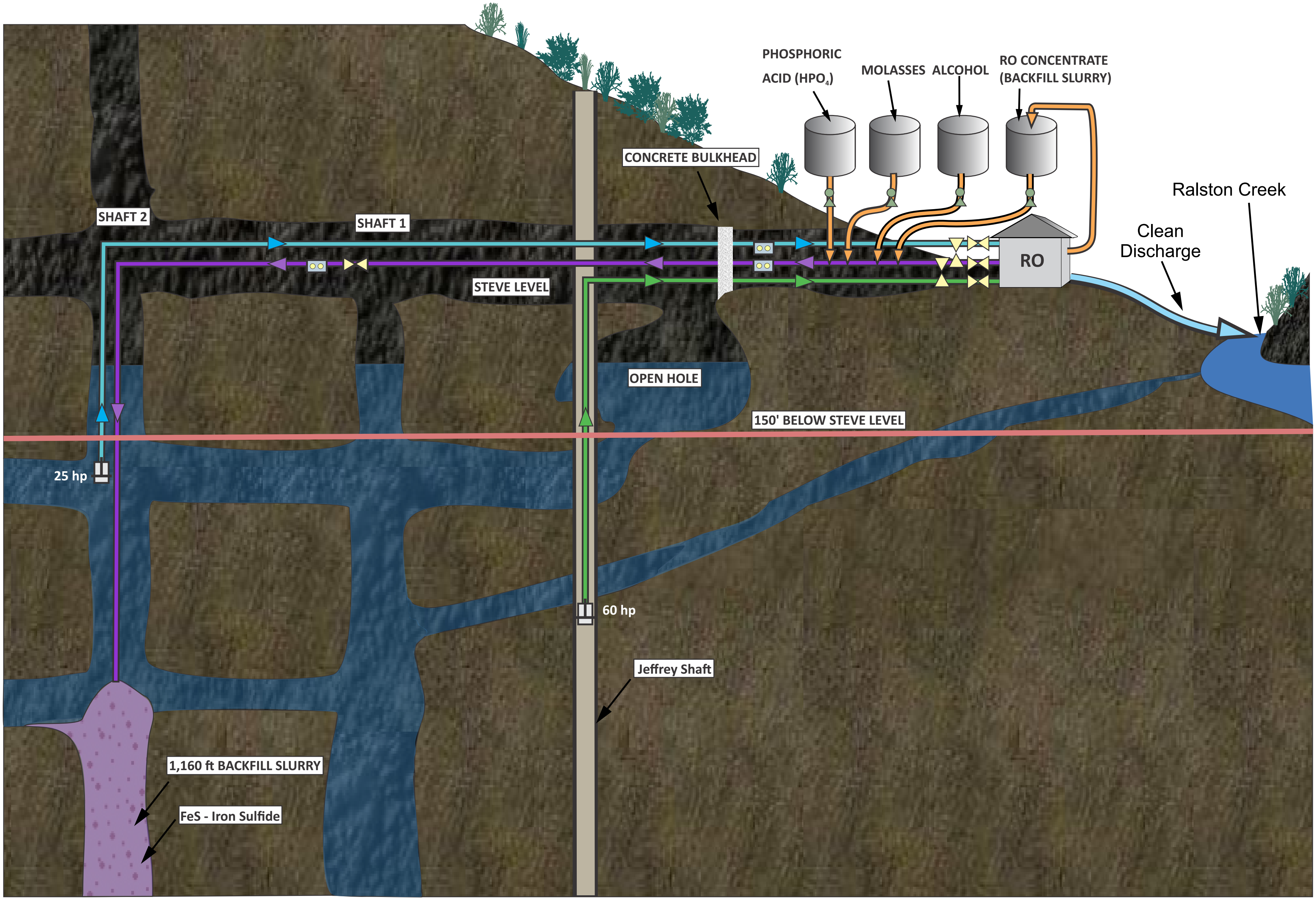

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FEATURES ARE NOT TO SCALE

The Jeffry Shaft is actually on a diagonal plane coming out of the figure

Injected in-situ treatment material, e.g., molasses, alcohol, etc., and RO concentrate

2020 Mine Pool Pumping

2017 Mine Pool Pumping

Pump

Gate Valve

Flow Meter

Submersible Pump

In 2017 molasses/HPO_4 were injected at 1,160' below the Steve Level

In 2020 molasses/HPO_4/ Rhodamine WT and alcohol/ Fluorescein were injected at 410' and 1,100' below the Steve Level, respectively

COLORADO LEGACY LAND

ENSERO solutions

COLORADO LEGACY LAND SCHWARTZWALDER MINE

FIGURE E-5b

SCHWARTZWALDER MINE IN-SITU TREATMENT INJECTION LOCATIONS - 2017/2020

JANUARY 2022

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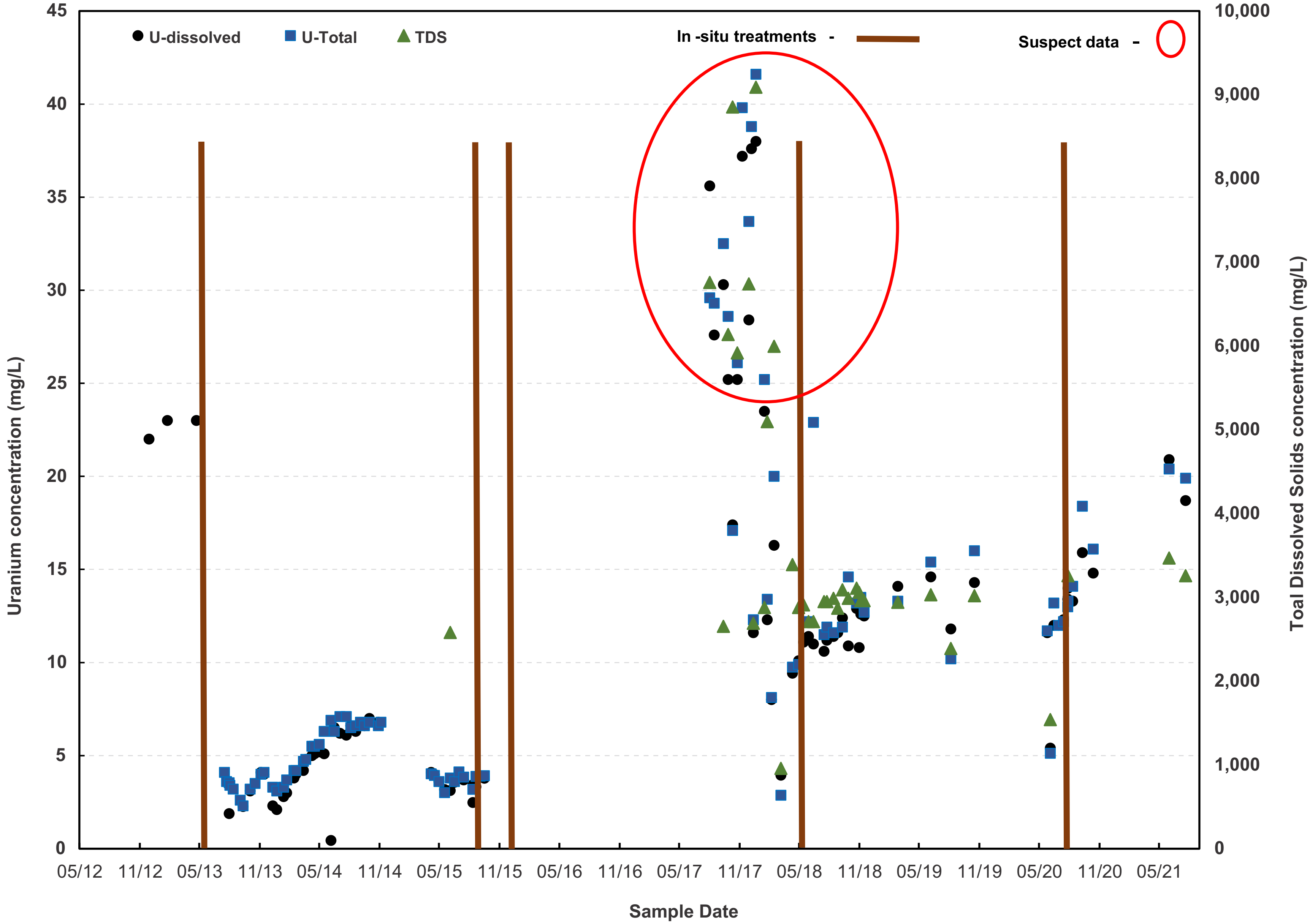

COLORADO LEGACY LAND

ENSERO solutions

COLORADO LEGACY LAND SCHWARTZWALDER MINE

FIGURE E-6
SCHWARTZWALDER MINE IN-SITU TREATMENT - URANIUM CONCENTRATIONS

MAY 2022

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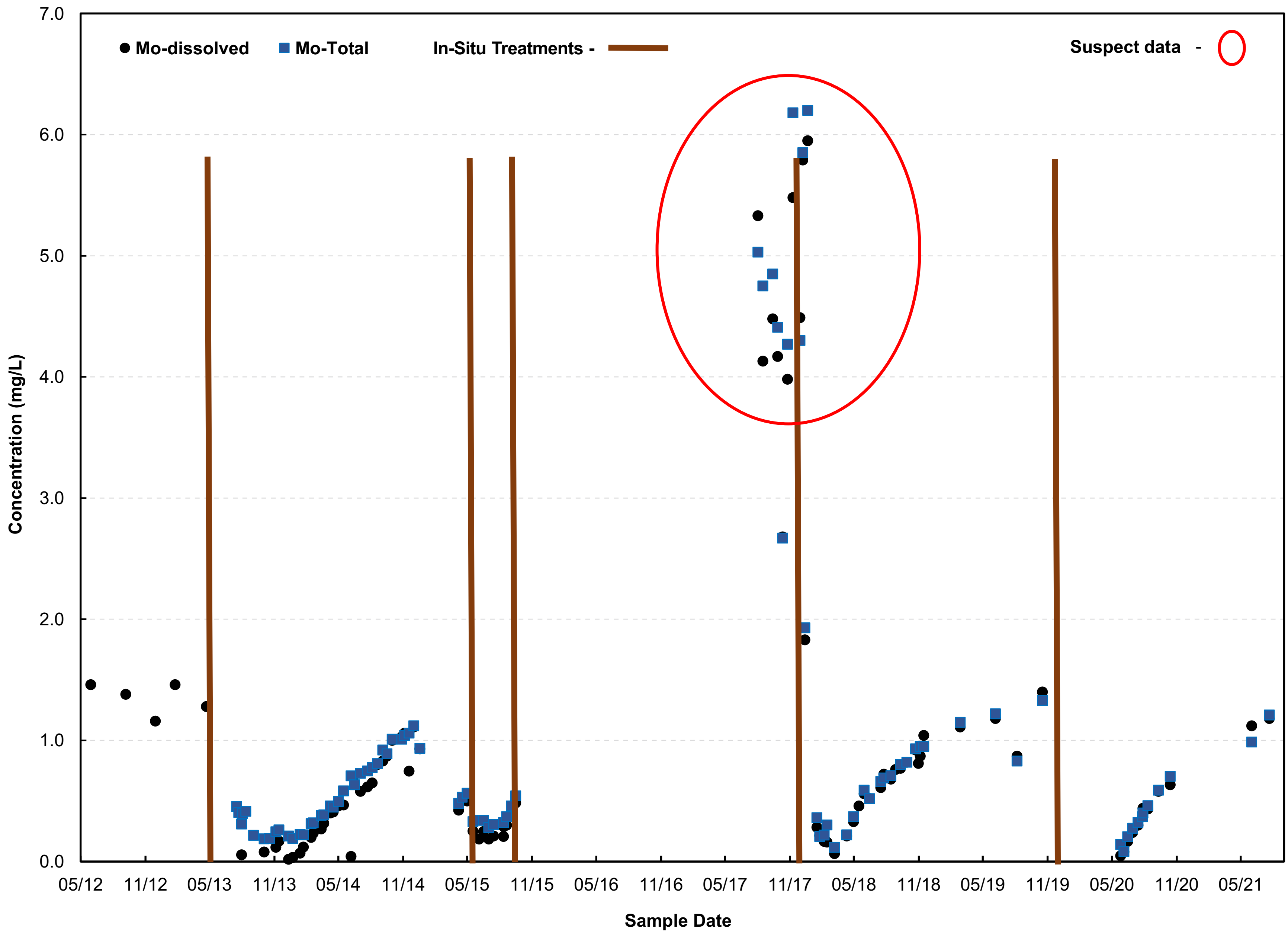

Colorado Legacy Land

ENSERO solutions

COLORADO LEGACY LAND SCHWARTZWALDER MINE

FIGURE E-7

SCHWARTZWALDER MINE IN-SITU TREATMENT - MOLYBDENUM CONCENTRATIONS

NOVEMBER 2021

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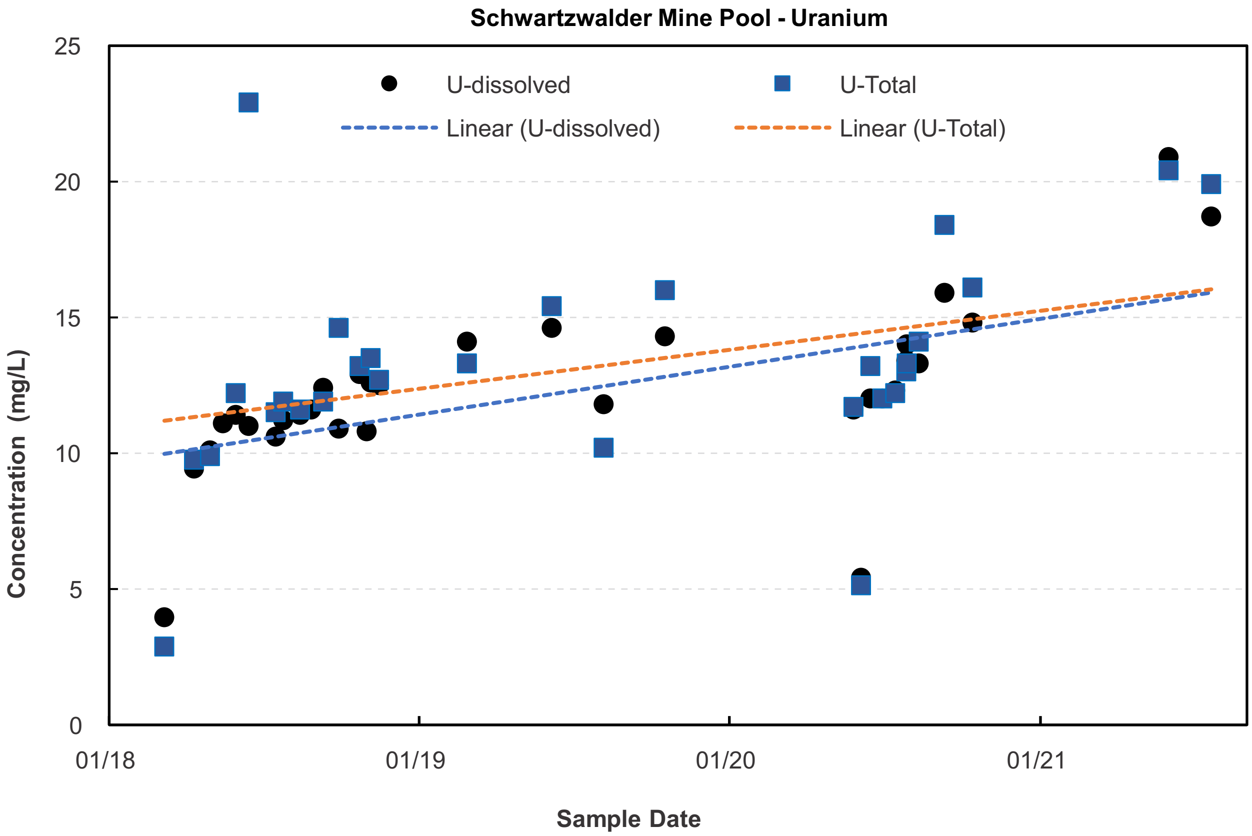

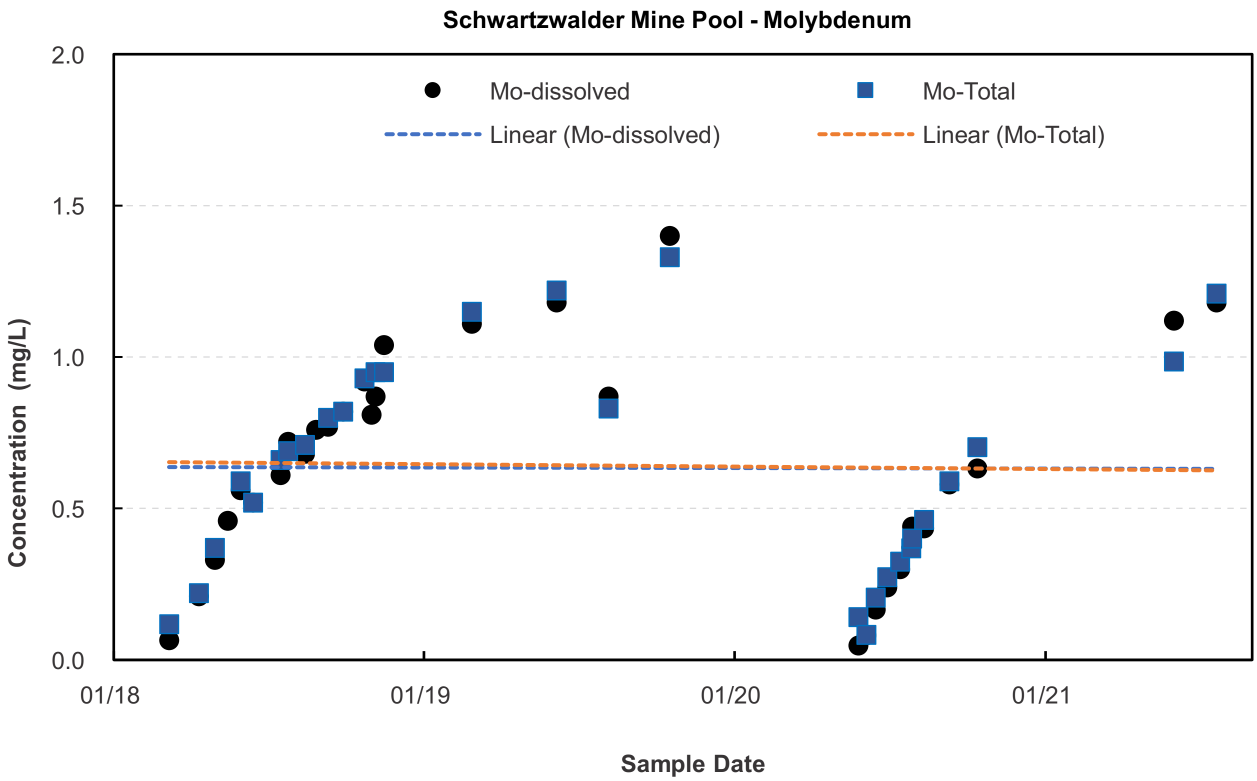

COLORADO LEGACY LAND

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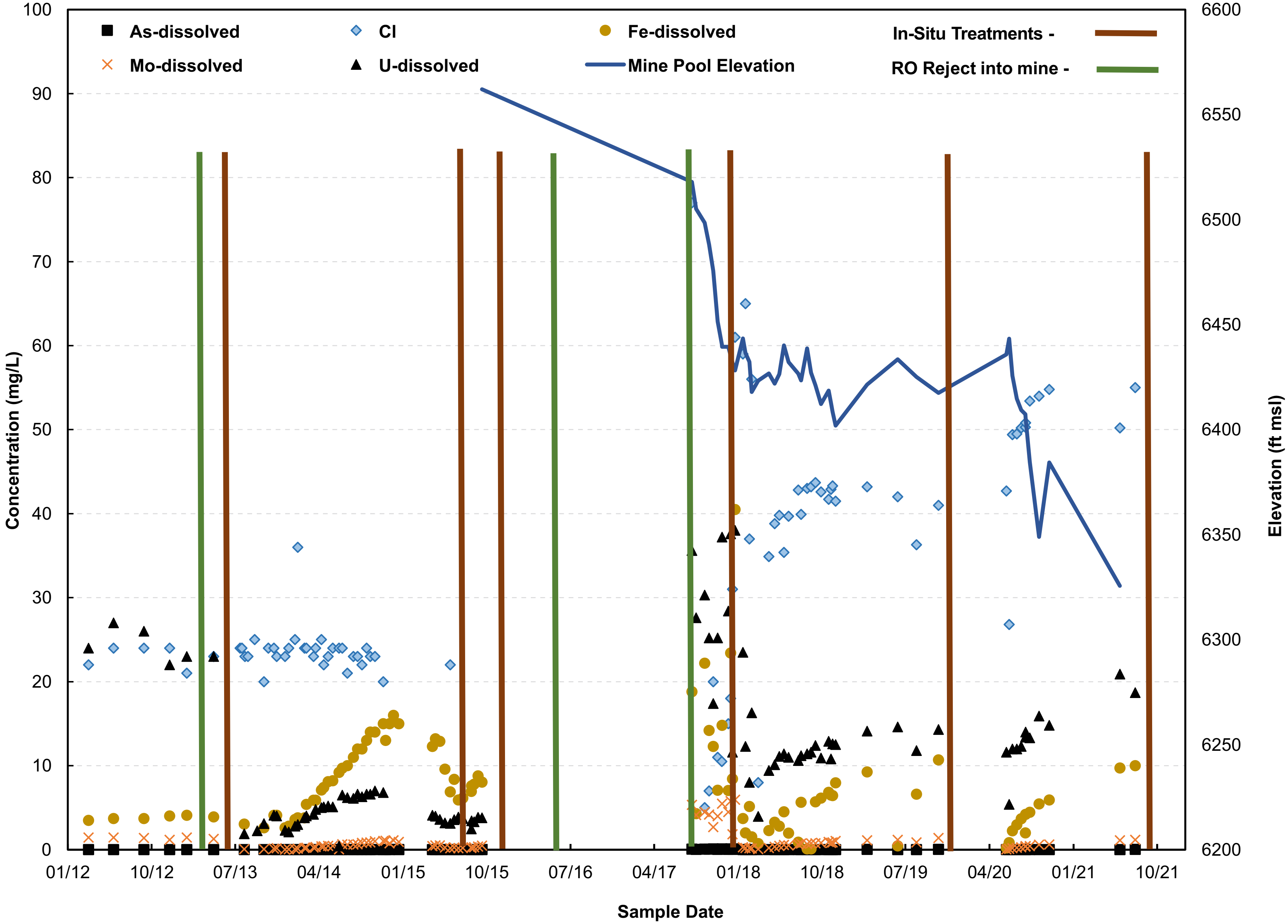
COLORADO LEGACY LAND SCHWARTZWALDER MINE

FIGURE E-8
SCHWARTZWALDER MINE
URANIUM AND MOLYBDENUM 3-YEAR TREND

NOVEMBER 2020

D:\Project\AllProjects\Schwartzwalder\Map\04-Report\DRMS_Schwartz_MLR_Permit_1977-300



Note: Beginning in mid-2017, the RO reject brine has been continuously injected back into the mine pool during operating periods of the treatment plant.

COLORADO LEGACY LAND
ENSERO solutions

COLORADO LEGACY LAND SCHWARTZWALDER MINE

FIGURE E-9
SCHWARTZWALDER MINE IN-SITU TREATMENT
CONSTITUENT CONCENTRATIONS

NOVEMBER 2021

D:\Project\AllProjects\Schwartzwalder\Map\04-Report\DRMS_Schwartz_MLR_Permit_1977-300

EXHIBIT F. RECLAMATION PLAN MAP

A reclamation plan map is shown on Figure F-1.

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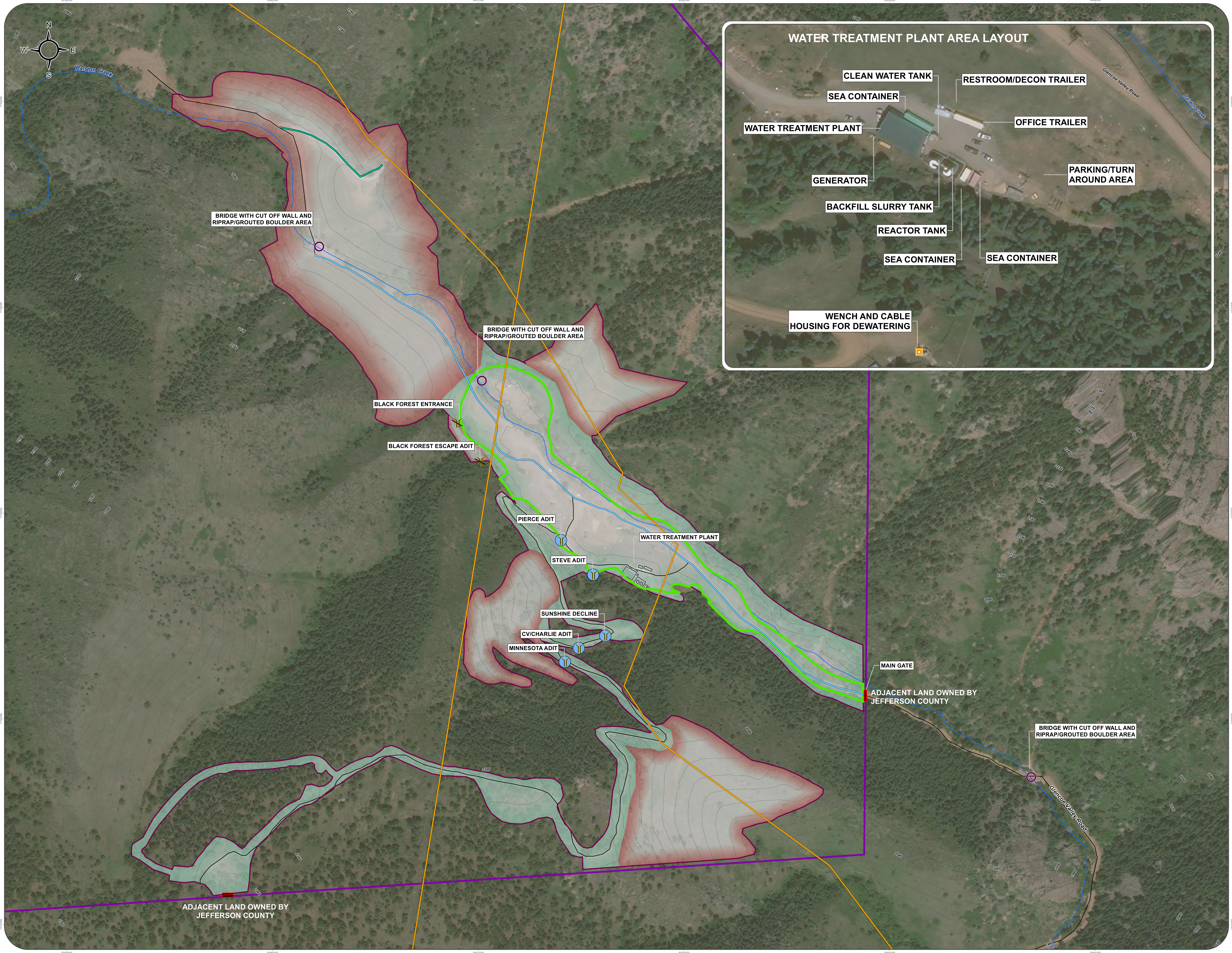

COLORADO LEGACY LAND
SCHWARTZWALDER MINE

FIGURE F-1
RECLAMATION PLAN MAP

MAY 2022

COLORADO LEGACY LAND

Sloped Areas

- 3H:1V or Flatter
- 3H:1V or Steeper
- Adit - Backfilled with Rockfill
- Adit - Closed with Gate
- Gate
- CLL Property Boundary (559.2 acres)
- Riprap / Grouted Boulder Area
- Anticipated Planting Area (12,5 acres)
- Permitted Boundary, Schwartzwalder Mine M-1977-300 (72.24 acres)
- Existing Mine Feature Footprint
- Power Line
- Bypass Pipeline
- North Waste Rock Pile Channel
- Ralston Creek
- Glencoe Valley Road
- Elevation Contour Lines (10-foot)

All disturbed areas within the Permitted Boundary for the Schwartzwalder Mine shall be retopsoiled (as needed) and revegetated to fully reclaim the land for wildlife habitat.

Wire Fence Varies Across Property Boundary

1 inch = 200 feet

0 200 400 600 800 ft

ENSERO solutions

Aerial imagery acquired from King Surveyors on December 10th, 2018

Datum: NAD_1983_StatePlane_Colorado_Central_FIPS_0502_Feet

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EXHIBIT G. WATER INFORMATION

This information is presented in Technical Revision 23, Attachment B *Schwartzwalder Mine Environmental Protection Plan* (Whetstone Associates Inc., 2016) and Exhibit E of this document, which provides an updated description of the current environmental monitoring program. Additional information regarding the Black Forest Mine is discussed below:

Disposal of radionuclide impacted alluvial valley soil in the Black Forest Mine is expected to improve the water quality in shallow groundwater and Ralston Creek. This is because Ralston Creek is in direct communication with the shallow alluvial aquifer and the contaminated alluvial soil is the primary source of metals loading to both surface water and groundwater at the Site (Whetstone Associates Inc., 2016). As described in Technical Revision #14, the scope of the alluvial valley excavation project is to remove any soil with the potential to leach uranium to groundwater above 0.03 mg/L (Colorado Groundwater Quality Standard and USEPA Drinking Water Standard). The Black Forest Mine is a dry mine and therefor is not hydraulically connected to the alluvial aquifer, bedrock aquifer, or Ralston Creek. This is because underground mining in the Black Forest occurred at elevations equal to or above 6,604 feet above mean sea level. The original Construction Materials 110 Permit (M-2001-036) for the Black Forest Mine states that the natural (pre-mining) depth to groundwater in the adjacent alluvium was approximately 9 feet below ground surface (ft bgs) (6,595 ft amsl). The current static water level (March 2020) in alluvial groundwater well MW-19 (total depth of 21.6 ft bgs) is approximately 15 ft bgs (6,625 ft amsl). The current static water level (March 2020) in nearby deep bedrock groundwater well MW-18 (total depth of 239.9 ft bgs) is approximately 120 ft bgs (6,484 ft amsl). These wells are part of the quarterly groundwater sampling network discussed in Section E.6. Heads in these wells are likely depressed due to the sump capture system, Ralston creek bypass pipeline, and the inward gradient created by dewatering the mine pool (the mine pool is required to be 150 feet below the Steve Level or 6,452 ft amsl). Following the alluvial valley reclamation, the heads in the shallow groundwater wells (e.g., MW-19) are expected to return to natural elevations. The head in MW-18 is expected to remain depressed, as the deep bedrock well is more indicative of the mine pool elevation. A cross section of the Schwartzwalder Mine workings is shown on Figure G-1 and Figure G-2. The Steve Adit elevation (6,602 ft amsl) is approximately the same as the Black Forest entrance adit (6,604 ft amsl). The maximum mine pool elevation is 150 feet below the Steve Adit (6,452 ft amsl). Additional surface water and alluvial groundwater data from 1998 to 2010 are presented and summarized in Sections 11 and 9 of the *Schwartzwalder Mine Environmental Protection Plan* (Whetstone Associates Inc., 2016). Removing soil from the alluvial valley and placing them inside the Former Black Forest Mine will prevent the soil from potentially leaching uranium to the surrounding waters.

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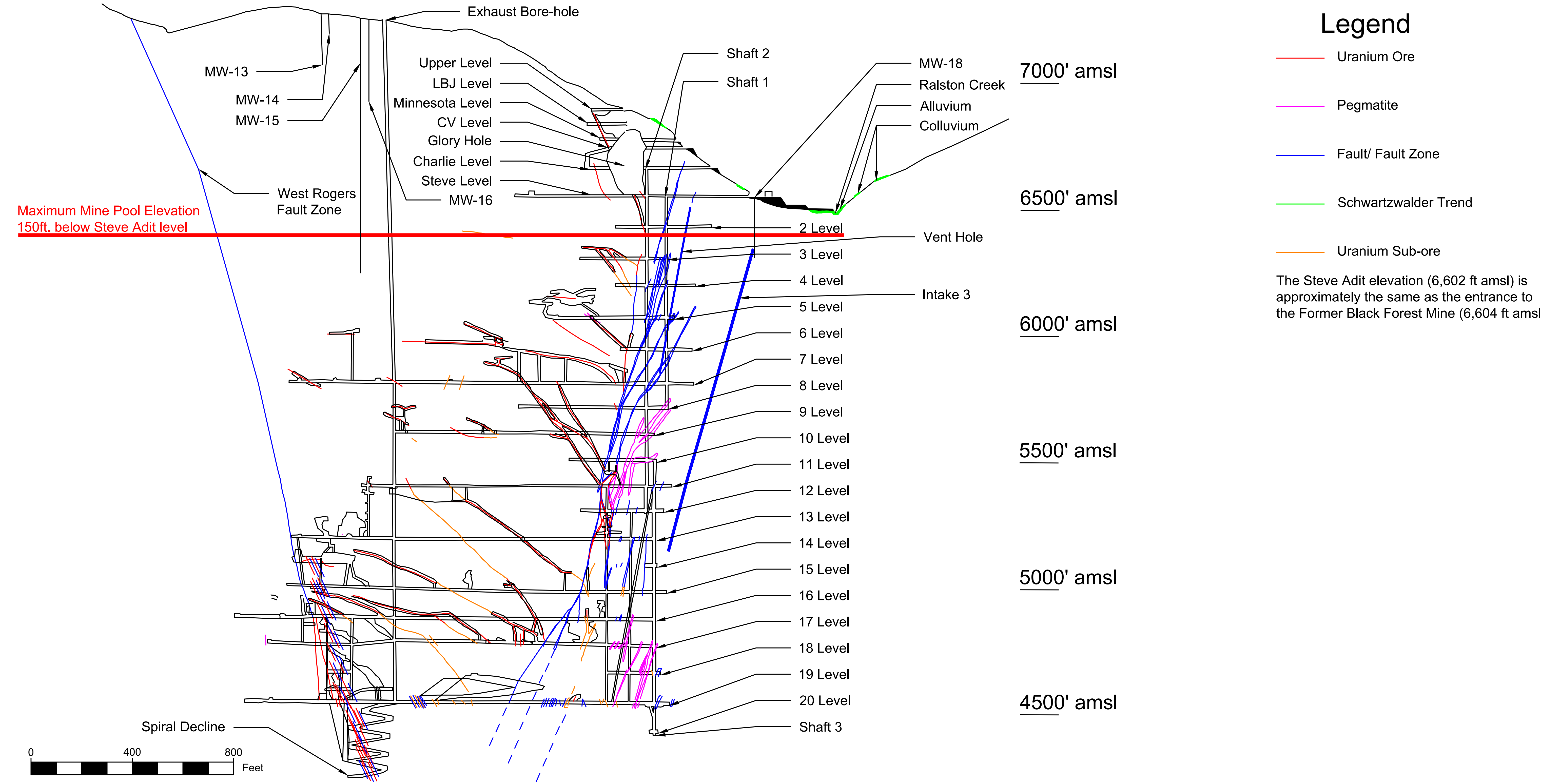

Revision History

Rev.	Description	Date
B	Added wells	01/06/2022
A	Initial Draft	11/05/2020

Engineer's Seal

	Name	Date
Design		
Drawn	N. Lambert	01/06/2022
Checked	E. Busby	01/06/2022
Approved		

Project/Drawing Information

Project Name	Former Schwartzwalder Mine
Project Number	EUS20CO00004
Project Location	Golden, Colorado

Drawing Name

Cross Section of Mine Workings
Figure G-1

Drawing Number

EUS20CO0004-C301

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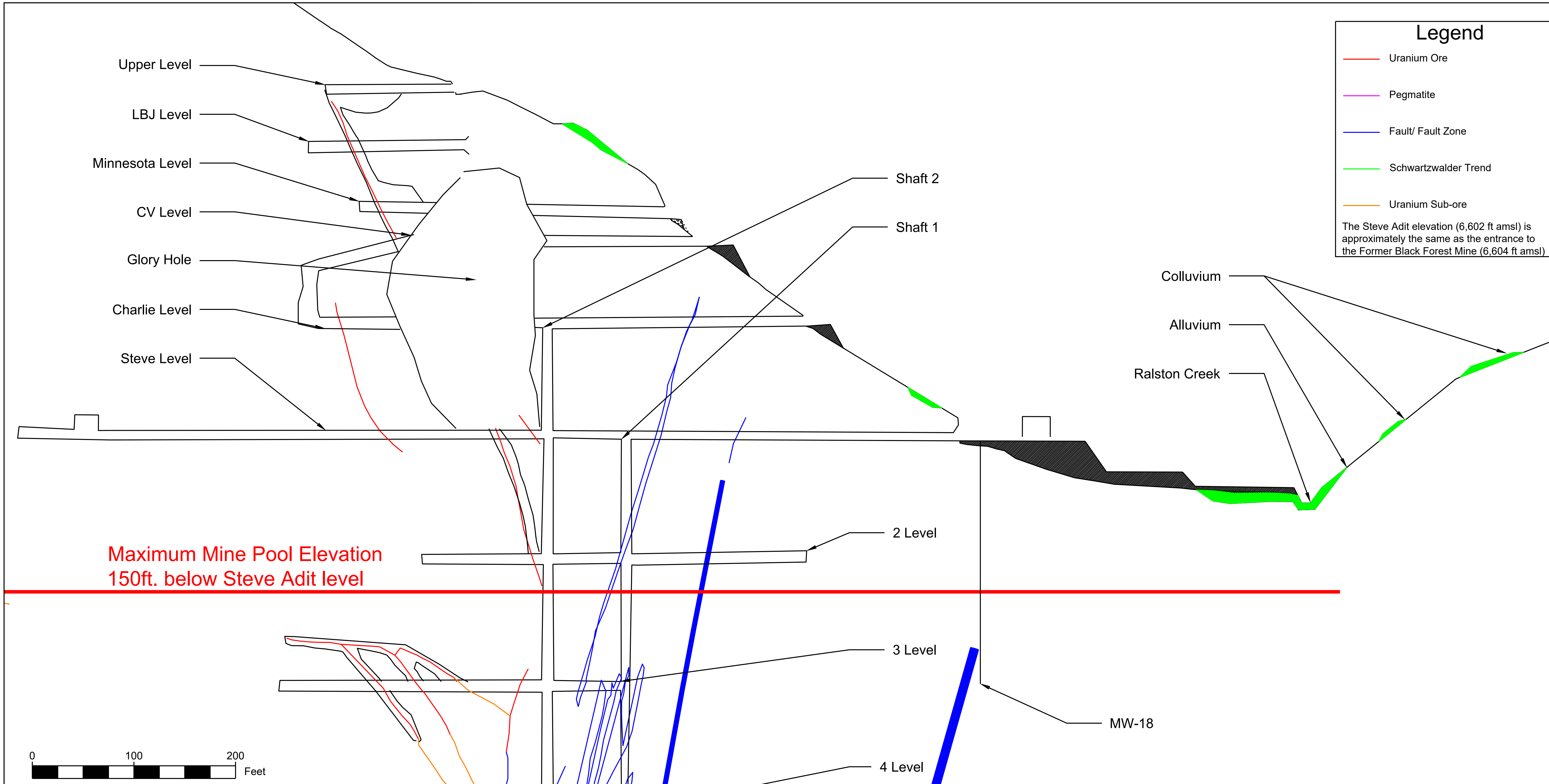
131 Lincoln Ave Suite 200
Ft. Collins, CO 80524

Colorado Legacy Land, LLC



Revision History		
B	Added wells	01/06/2022
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Rev.	Description	Date

Engineer's Seal

	Name	Date
Design		
Drawn	N. Lambert	01/06/2022
Checked	E. Busby	01/06/2022
Approved		

Project/Drawing Information	
Project Name	Former Schwartzwalder Mine
Project Number	EUS20CO00004
Project Location	Golden, Colorado
Drawing Name	
Detail Cross Section of Mine Workings Figure G-2	
Drawing Number	
EUS20CO0004-C302	

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131 Lincoln Ave Suite 200
Ft. Collins, CO 80524

Colorado Legacy Land, LLC

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EXHIBIT H. WILDLIFE INFORMATION

This information is presented in Technical Revision 23, Attachment B *Schwartzwalder Mine Environmental Protection Plan* (Whetstone Associates Inc., 2016). Section 18 of the *Schwartzwalder Mine Environmental Protection Plan* discusses soil.

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EXHIBIT I. SOILS INFORMATION

This information is presented in Technical Revision 23, Attachment B *Schwartzwalder Mine Environmental Protection Plan* (Whetstone Associates Inc., 2016). Section 17 of the *Schwartzwalder Mine Environmental Protection Plan* discusses soil.

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EXHIBIT J. VEGETATION INFORMATION

This exhibit has not changed from the 2012 Mine Plan Amendment 3.

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EXHIBIT K. CLIMATE INFORMATION

This information is presented in Technical Revision 23, Attachment B *Schwartzwalder Mine Environmental Protection Plan* (Whetstone Associates Inc., 2016). Section 13 of the *Schwartzwalder Mine Environmental Protection Plan* discusses climate.

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EXHIBIT L. RECLAMATION COSTS

The revisions in Table L-1 reflect the reclamation plan presented in Exhibit E of this document and are consistent with the remaining scope of work at the Site.

TABLE L-1. REVISED SCHWARTZWALDER MINE RECLAMATION COSTS					
Item	**Unit Cost**	**Quantity**	**Unit**	**Total Cost**	**Notes / Basis of Estimate**
Water Treatment Plant Operations (20-year time period)					
Water Treatment Plant Operator	$ 23.93	19,200	hour	$ 459,456.00	U.S. Department of Labor, Service Contract Act hourly wage for a Water Treatment Plant Operator (20 years *6 months*4 weeks *40 hours = 19,200 hours).
Controller	$ 8,982.90	2	controller	$ 17,965.80	Replacement for WTP controllers (remote monitoring of plant). Expected to be replaced once every 10 years. Quote from Tank Equipment.
Internet	$ 59.00	240	month	$ 14,160.00	Mountain Broadband monthly internet service
Electricity	$ 4,719.72	240	month	$ 1,132,732.80	United Power. Average monthly electric bill at the site.
Potable Water	$ -	0	gallon	$ -	Potable water for bathroom facilities provided by WTP.
Columbia Sanitary	$ 325.00	20	service	$ 6,500.00	Pump septic tank onsite once per operating year.
Waste Management	$ 164.00	60	month	$ 9,840.00	Bimonthly trash service (pickup 3 times per year).
Office Trailer	$ 18,500.00	1	trailer	$ 18,500.00	Office trailer for jobsite. Quote provided by JobBox for 40-foot standard office
Caustic Soda (Sodium Hydroxide, Liquid 25%)	$ 0.295	1,334,400	lbs	$ 393,648.00	Caustic soda is used for pH stablization and "Clean in Place, or CIP" washed of the membranes. Each chemical tote is 2,780-lbs. The WTP uses 1 tote per week during operations (6 months * 4 weeks = 24 totes / year).
Barium Chloride (55 lb bag of crystals)	$ 6.50	6,600	lbs	$ 42,900.00	Interstate Chemical Company. Crystals delivered in 55-lb bags/drums. The WTP uses 1 bag per month of operation.
Antifoulant or RO anti-scale (RO 1302 NSF)	$ 2.57	25,050	lbs	$ 64,378.50	Midsouth Chemical Company. Each chemical tote is 2,502 lbs. The WTP uses 1 tote every 2 years.
EDTA (39% solution)	$ 0.71	2,380	bs	$ 1,689.80	Interstate Chemical Company. Each drum is 595 lbs. The WTP uses 1 drum every 5 years.
RO Membranes (LG 400 Energy Saving Membranes)	$ 441.00	192	membrane	$ 84,672.00	Utilizing a 6-month or less operational period, RO membranes are expected to be replaced every 5 years. The WTP requires a total of 48 membranes (2 RO skids * 6 tubes per RO * 4 membranes per tube = 48 membranes). Unit price includes delivery fees. Costs provided by Consolidated Water Solutions.
Cannister filters (1 Micron 40")	$ 13.18	2,880	filter	$ 37,958.40	Cannister filters are replaced once every two months of operations. Unit price includes shipping. Optimum Filter.
Sustaining capital	$ 2,000.00	20	year	$ 40,000.00	Sustaining capital costs are for maintenance, repair, or replacement of WTP equipment.
Discharge permit sampling	$ 1,988.20	120	month	$ 238,584.00	Discharge sampling only occurs for 6 months of the year when the plant is operating (6 months * 20 years = 120 months). Unit costs for samples are provided by contract laboratories SeaCrest and ACZ.

TABLE L-1. REVISED SCHWARTZWALDER MINE RECLAMATION COSTS

Item	Unit Cost	Quantity	Unit	Total Cost	Notes / Basis of Estimate
Demolish water treatment plant	$ 55,000.00	1	lump sum	$ 55,000.00	Lump sum estimate to demolish and remove the Water Treatment Plant building and facilities. Bid provided by Kessler Reclamation and Construction.
In-situ Treatment (10-year time period)					
Ethanol	$ 4.70	33,655	gallon	$ 158,178.50	5 additional injections (1 injection every 2 years). One tanker (6,731 gallon) per injection. Bulk chemical costs are provided by Interstate Chemical Company.
Phosphoric Acid	$ 0.80	54,285	lbs	$ 43,428.00	5 additional injections (1 injection every 2 years). Each chemical tote is 3,619-lbs. 3 totes per inejction. Bulk chemical costs are provided by Interstate Chemical Company.
Alluvial Valley Excavation					
Mobilization	$ 17,000.00	1	event	$ 17,000.00	Heavy equipment already onsite. However in the event the State needs to perform the work , mobilization costs presented here are for a Dozer - John Deere 750, Haul Truck - Caterpillar D250E , Excavator -Caterpillar 320 , and Loader- Caterpillar 950G (or equivalent). These were mobilized from the nearest Wagner rental facility in Denver. Verbal quote provided by Wagner.
Demobilization	$ 17,000.00	1	event	$ 17,000.00	Demobilization of equipment expected to equal mobilization of equipment.
Excavate and place soil onsite	$ 5.33	6,256	CY	$ 33,344.48	South Zone Soils (identified in TR-14 and SR-9) are estimated with the following calculation: Overage Percent (15%) x Volume of Soils in South Zone (5,440 CY) = Estimated Overage Volume (6,256 CY) This unit rate per cubic yard includes labor and equipment (Dozer - John Deere 750 or equivalent, Haul Truck - Caterpillar D250E or equivalent, Excavator - Caterpillar 320 or equivalent, and Loader- Caterpillar 950G or equivalent) costs.
Confirmation sampling, soil analysis	$ 158.80	48	sample	$ 7,622.40	A total of 12 soil samples for each of the 4 survey units are proposed (4*12 = 48). Unit costs for samples are provided by contract laboratory ACZ. Exact sample quantities shall be presented in the Final Status Survey Work Plan document.
Fill Soil	$ -	0	CY	$ -	Sufficient quantities of suitable soil have been identified during the alluvial valley excavation. CLL intends to regrade the alluvial valley consistent with the surrounding slopes by pushing adjacent fill materials to fill in excavated pot-holes.

TABLE L-1. REVISED SCHWARTZWALDER MINE RECLAMATION COSTS

Item	Unit Cost	Quantity	Unit	Total Cost	Notes / Basis of Estimate
Top Soil / Plant Growth Medium	$ -	0	CY	$ -	Sufficient quantities of suitable soil have been identified during the alluvial valley excavation. CLL intends to regrade the alluvial valley consistent with the surrounding slopes by pushing adjacent fill materials to fill in excavated pot-holes.
Seed Mix	$ 450.00	12.5	acre	$ 5,625.00	Seed mix shown in Table E-1 of Application Amendment #5. Figure F-1 identifies the potential disturbed areas (12.5 acres) from mining operations that will likely be replanted, a site-specific planting plan shall be prepared following the alluvial valley excavation project.
Trees (planted above the cut-off wall)	$ 60.00	174	tree	$ 10,440.00	Transported in 10-gallon pots. Riparian Area trees (Ponderosa Pine, Juniper, Cottonwood & Peachleaf Willow) associated with habitat restoration above the cutoff wall and 18" creek bypass pipeline. Estimated quantities shown in Table E-2. Figure F-1 identifies the potential disturbed areas (12.5 acres) from mining operations that will likely be replanted, a site-specific planting plan shall be prepared following the alluvial valley excavation project.
Willow Stakes (planted above the cut-off wall)	$ 4.00	615	willow	$ 2,460.00	Transported as cuttings. Remaining habitat restoration above the cutoff wall and 18" creek bypass pipeline. Estimated quantities shown in Table E-2. Figure F-1 identifies the potential disturbed areas (12.5 acres) from mining operations that will likely be replanted, a site-specific planting plan shall be prepared following the alluvial valley excavation project.
Trees (planted in reclaimed valley below cut off wall)	$ 60.00	89	tree	$ 5,340.00	Transported as 10-gallon pots. Upland Area trees (Ponderosa Pine, Juniper, Cottonwood, Douglas Fir, Engelmann Spruce) associated with areas impacted by excavation below the cut off wall. Estimated quantities shown in Table E-2. Figure F-1 identifies the potential disturbed areas (12.5 acres) from mining operations that will likely be replanted, a site-specific planting plan shall be prepared following the alluvial valley excavation project.
Shrubs (planted in reclaimed valley below cut off wall)	$ 20.00	65	shrub	$ 1,300.00	Transported as 1-gallon pots. Upland Area shrubs (Mountain Mahogany, Hawthorne, Willow, and Fringed Sage) associated with areas impacted my excavation below the cut off wall. Planted over a 6-acre area. Estimated quantities shown in Table E-2. Figure F-1 identifies the potential disturbed areas (12.5 acres) from mining operations that will likely be replanted, a site-specific planting plan shall be prepared following the alluvial valley excavation project.

TABLE L-1. REVISED SCHWARTZWALDER MINE RECLAMATION COSTS					
Item	**Unit Cost**	**Quantity**	**Unit**	**Total Cost**	**Notes / Basis of Estimate**
Shrubs (planted in reclaimed valley below cut off wall)	$ 37.00	66	shrub	$ 2,442.00	Transported as 5-gallon pots. Upland Area shrubs (Mountain Mahogany, Hawthorne, Willow, and Fringed Sage) associated with areas impacted my excavation below the cut off wall. Estimated quantities shown in Table E-2. Figure F-1 identifies the potential disturbed areas (12.5 acres) from mining operations that will likely be replanted, a site-specific planting plan shall be prepared following the alluvial valley excavation project.
Hydromulching	$ 25.00	0	CY	$ -	Only required on 2H:1V and steeper slopes, which are not present in the valley.
Excavator	$ 120.00	0	hour	$ -	Excavator -Caterpillar 320 or equivalent, Loader- Caterpillar 950G or equivalent. Equipment costs included in unit cost ($/CY) for soils.
Dozer	$ 100.00	80	hour	$ 8,000.00	Dozer - John Deere 750 or equivalent. Regrading alluvial valley is expected to take 2 weeks (80-hours).
Labor	$ 42.00	80	hour	$ 3,360.00	Regrading the alluvial valley is expected to take one operator 2 weeks (80-hours).
Environmental Monitoring (10 year time period)					
Surface Water Monitoring	$ 722.40	520	sample	$ 375,648.00	Quarterly sampling of Ralston Creek at 13 stations.
Groundwater Monitoring	$ 722.40	560	sample	$ 404,544.00	Groundwater monitoring network includes 13 wells and 2 spigots (sumps and mine pool), however 1 well is only monitored for water levels.
Monitoring Well Abandonment	$ 20.00	2,511	well	$ 50,220.00	Typical unit rate ($20/foot) provided verbally by Drilling Engineers Inc. 13 monitoring wells onsite totaling 2,511 linear feet.
Sump Removal / Abandonment	$ 2,000.00	1	sump	$ 2,000.00	Abandon /remove the master sump.
Mine Opening Closure: Gate Closure					
Minnesota Adit, Sunshine Decline, Steve Adit, CV/ Charline, & Peirce Adit	$ -	1	gate	$ -	Gate closure already in place.
Mine Opening Closure: Black Forest Mine, Backfill Closure					
Fill Soil	$ 8.00	60	CY	$ 480.00	Sufficient quantities of fill soil have been identified during the alluvial valley excavation work. The haul / push distance for this material is estimated to be less than 1,000 feet.
Top Soil / Plant Growth Medium	$ 14.50	161	CY	$ 2,334.50	Sufficient quantities of top soil have been identified during the alluvial valley excavation work. The haul / push distance for this material is estimated to be less than 1,000 feet.

TABLE L-1. REVISED SCHWARTZWALDER MINE RECLAMATION COSTS					
Item	**Unit Cost**	**Quantity**	**Unit**	**Total Cost**	**Notes / Basis of Estimate**
Seed Mix	$ 450.00	0.1	acre	$ 45.00	Seed mix shown in Table E-1 of Application Amendment #5.
Hydromulching	$ 25.00	10	CY	$ 250.00	Unit rate includes costs for tackifier. Application rate is approximately 0.75 tons per acre (1,500 pound per acre).
Rock	$ 650.00	4	ton	$ 2,600.00	Sufficient quantities of large diameter rock (<1 foot) have been identified during the alluvial valley excavation work. The haul distance for this material is estimated to be less than 1,000 feet.
Excavator	$ 120.00	8	hour	$ 960.00	1 day. Caterpillar 320 or equivalent.
Loader	$ 120.00	8	hour	$ 960.00	1 day. Caterpillar 950G or equivalent.
Dozer	$ 100.00	8	hour	$ 800.00	1 day. John Deere 750 or equivalent.
Haul Truck	$ 115.00	8	hour	$ 920.00	1 day. Caterpillar D250E or equivalent.
Labor	$ 42.00	48	hour	$ 2,016.00	Team of three people for two 8-hour days.
Cost Total					
				$ 3,777,303.18	Subtotal of direct costs (equipment and materials)
	-			$ 160,535.39	Engineering Work &/or Contract/Bid Prep. (4.25% of direct costs)
	-			$ 188,865.16	Reclamation management &/or Admin. (5% of direct costs)
				$ 4,126,703.72	**Grand total**

EXHIBIT M. OTHER PERMITS AND LICENCES

This Exhibit has not changed from the 2021 Mine Plan Amendment 5.

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EXHIBIT N. SOURCE OF LEGAL RIGHT-TO-ENTER

This Exhibit has not changed from the 2021 Mine Plan Amendment 5.

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EXHIBIT O. OWNERS OF RECORD TO AFFECTED LAND (SURFACE AREA) AND OWNERS OF SUBSTANCE TO BE MINED

Colorado Legacy Land, LLC is the owner of record of affected land and has the following legal address:

Colorado Legacy Land, LLC
12150 E. Briarwood Ave., Suite 135
Centennial, CO 80112

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EXHIBIT P. MUNICIPALITIES WITHIN TWO MILES

No municipalities exist within two miles of the Schwartzwalder Mine.

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EXHIBIT Q. PROOF OF MAILING OF NOTICES TO COUNTY COMMISSIONERS AND CONSERVATION DISTRICT

COLORADO LEGACY LAND
12150 E. Briarwood Ave. Suite 135, Centennial, Colorado 80112
T. (303) 862-3928

June 21, 2021

Jefferson County
Board of County Commissioners
100 Jefferson County Pkwy.
Golden CO 80419

Subject: Notice of Filing an Amendment Application for Colorado Mine Land Reclamation Permit, Schwartzwalder Mine, Golden, Colorado

Colorado Legacy Land, LLC (CLL) has applied for an Amendment application to their 112d Designated Mining Reclamation Permit with the Colorado Mine Land Reclamation Board under provisions of the Colorado Mined Land Reclamation Act. This Amendment application is for the former Schwartzwalder Mine which is located at or near, Section 25, Township 2 South, Range 71 West of the 6th Prime Meridian. The entire application is on file with the Division of Reclamation, Mining and Safety (the "Division") and the Jefferson County Clerk and Recorders Office (100 Jefferson County Pkwy, Golden Colorado 80419).

The applicant/operator proposes to reclaim the affected land to Wildlife Habitat. Pursuant to Section 34-32-116(7)(j), C.R.S., the Board is required to confer with the local Board of County Commissioners before approving of the post-mining land use. Accordingly, the Board would appreciate your comments on the proposed operation. Please note that, in order to preserve your right to a hearing before the Board on this application, you must submit written comments on the application within twenty (20) days after the date of the applicant's newspaper publication.

If you would like to discuss the proposed post-mining land use, or any other issue regarding this application, please contact the Division of Reclamation, Mining and Safety, 1313 Sherman Street, Room 215, Denver, Colorado 80203, (303) 866-3567.

7020 3160 0001 2528 1600

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Golden, CO 80419
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☐ Return Receipt (hardcopy) $	$0.00
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☐ Certified Mail Restricted Delivery $	$0.00
☐ Adult Signature Required $	$0.00
☐ Adult Signature Restricted Delivery $	
Postage $	$0.55
Total Postage and Fees $	$4.15

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JUN 21 2021
06/21/2021
USPS

Sent To: Jefferson County Board of Commissioners
Street and Apt. No., or PO Box No.: 100 Jefferson County Pkwy.
City, State, ZIP+4®: Golden CO 80419

PS Form 3800, April 2015 PSN 7530-02-000-9047 See Reverse for Instructions

PAGE 1 OF 1

COLORADO LEGACY LAND

12150 E. Briarwood Ave. Suite 135, Centennial, Colorado 80112
T. (303) 862-3928

June 21, 2021

Jefferson Conservation District
10799 W. Alameda Ave. #261205
Lakewood, CO 80226

Subject: Notice of Filing an Amendment Application for Colorado Mine Land Reclamation Permit, Schwartzwalder Mine, Golden, Colorado

Colorado Legacy Land, LLC (CLL) has applied for an Amendment application to their 112d Designated Mining Reclamation Permit with the Colorado Mine Land Reclamation Board under provisions of the Colorado Mined Land Reclamation Act. This Amendment application is for the former Schwartzwalder Mine which is located at or near, Section 25, Township 2 South, Range 71 West of the 6th Prime Meridian. The entire application is on file with the Division of Reclamation, Mining and Safety (the "Division") and the Jefferson County Clerk and Recorders Office (100 Jefferson County Pkwy, Golden Colorado 80419).

The applicant/operator proposes to reclaim the affected land to Wildlife Habitat. Pursuant to Section 34-32-116(7)(j), C.R.S., the Board is required to confer with the local Board of County Commissioners before approving of the post-mining land use. Accordingly, the Board would appreciate your comments on the proposed operation. Please note that, in order to preserve your right to a hearing before the Board on this application, you must submit written comments on the application within twenty (20) days after the date of the applicant's newspaper publication.

If you would like to discuss the proposed post-mining land use, or any other issue regarding this application, please contact the Division of Reclamation, Mining and Safety, 1313 Sherman Street, Room 215, Denver, Colorado 80203, (303) 866-3567.

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Certified Mail Fee $	$3.60
Extra Services & Fees (check box, add fee as appropriate)	$0.00
☐ Return Receipt (hardcopy) $	$0.00
☒ Return Receipt (electronic) $	$0.00
☐ Certified Mail Restricted Delivery $	$0.00
☐ Adult Signature Required $	$0.00
☐ Adult Signature Restricted Delivery $	
Postage $	$0.55
Total Postage and Fees $	$4.15

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Postmark Here
JUN 21 2021
06/21/2021

Sent To: Jefferson Conservation District
Street and Apt. No., or PO Box No.: 10799 W. Alameda Ave. #261205
City, State, ZIP+4®: Lakewood CO 80226

PS Form 3800, April 2015 PSN 7530-02-000-9047 See Reverse for Instructions

PAGE 1 OF 1

EXHIBIT R. PROOF OF FILING WITH COUNTY CLERK AND RECORDER

On May 11 2022 (date) the Jefferson County Clerk and Recorder's Office received a copy of:

Application Amendment 6, Mine Permit M-1977-300
Schwartzwalder Mine, Golden, Colorado

This document is available for public review at:

Jefferson County Clerk & Recorder
100 Jefferson County Pkwy Suite 2560
Golden, CO 80401

Susan G Francis

(Signature from Clerk & Recorders Office)

5/11/22

(Date)

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EXHIBIT S. PERMANENT MAN-MADE STRUCTURES

This Exhibit has not changed from the 2021 Mine Plan Amendment 5.

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EXHIBIT U. DESIGNATED MINING OPERATION ENVIRONMENTAL PROTECTION PLAN

Please see the updated Environmental Protection Plan, provided under separate cover with this submission.

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RULE 6.5. GEOTECHNICAL STABILITY EXHIBIT

This exhibit has not changed from 2012 Mine Plan Amendment 3.

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RULE 8. EMERGENCY RESPONSE PLAN

Rule 8 requires CLL to notify DRMS, as soon as reasonably practicable, but no later than 24 hours, after CLL has knowledge of a failure or imminent failure of

- the waste rock piles,
- the water treatment plant (including the pump/treat regime that keeps the mine pool level below the regulatory limit or a loss of containment situation), or

the bulkheads installed inside the Steve and Pierce adits. If a failure or imminent failure situation arises, onsite personnel should contact the Project Manager, Elizabeth Busby, Ensero Solutions US Inc., Project Manager, 970-632-2240, as soon as it is safe to do so.

The Ensero Project Manager is responsible for notifying DRMS within 24-hours.

EMERGENCY RESPONSE PLAN SCOPE AND OBJECTIVES

The primary objectives of the emergency response plan at the Site are:

- Detail the procedures for use during any response to an emergency situation at the Site surface facilities. An emergency situation can include but is not limited to: Spills of hazardous materials, fires, accidents involving personnel and/or material transport, or any combination of the above. The emergency response procedures in text form are detailed in the following sections. A copy of the initial Site emergency response procedures is included in the Initial Response Guide. These procedures are not to be used for responding to alarms associated with routine operational problems that occur within the Site systems. Examples of routine problems include, but are not limited to, equipment breakdowns and water treatment system process alarms.
- List available equipment for response operations.
- Detail the training program for personnel who may be involved in an emergency situation at the Schwartzwalder Mine.

SURFACE FACILITY EMERGENCY RESPONSE PROCEDURES

These procedures have been developed for use by Colorado Legacy Land (CLL) personnel during any response to an emergency situation at the Site surface facilities. An emergency situation can include, but is not limited to, spills of hazardous materials (HazMat), fires, accidents involving personnel and/or material transport, or any combination of the above. Note that all CLL personnel located on the surface during an emergency situation are required to respond to the emergency. These procedures are not to be used for responding to alarms associated with routine operational problems that occur within the Site process and monitoring systems, unless those problems could result in an emergency situation. Examples of routine operational problems include routine process alarms at the water treatment facilities. Any emergency situation will be successfully resolved by a phased response consisting of notification, operations, and remediation. These three phases will be implemented in concert or sequentially depending upon the specific situation and available personnel.

- Phase One: Notification
- Phase Two: Operations
- Phase Three: Remediation

Phase One: Notification

The first person to arrive at the location of an emergency situation becomes the First Responder to the incident and assumes responsibility for the subsequent emergency response until they are relieved by an Incident Coordinator, or voluntarily relinquish their authority to a more qualified person. The First Responder can be any CLL employee or a contractor's employee (e.g., truck driver).

The primary responsibility of the First Responder in an emergency situation is the prompt notification of other Site personnel. The First Responder shall immediately relay an incident evaluation to at least one other person prior to initiating the operations phase during an emergency response. The incident evaluation must include the following information, at a minimum.

a) The location of the incident.
b) The nature of the incident.
c) The extent of injury, if applicable.
d) The type of material spilled, if known.
e) The physical extent of the spill area.
f) The First Responder=s intended course of action.
g) Available communication devices, if communication must be maintained.

Internal Notification

The first person contacted by a First Responder notes the information provided in the incident evaluation and is then responsible for notifying the Environmental Coordinator/ Radiation Safety Officer (EC/RSO). Notification procedures for work hours and off shift are detailed below.

Work Hours

During normal work hours internal notification by the First Responder shall be made verbally, or by utilizing the telephone in the job trailer. The first person contacted by the First Responder shall notify the EC/RSO and then notify all other personnel on the surface that an emergency situation exists.

Off Work Hours

Off-hours notification of response personnel is initiated by the First Responder, who notifies the Emergency Coordinator and any other available response personnel. Currently, the Site Environmental Coordinator/RSO carries a pager and is on call for responding to abnormal system conditions, A current list of on-call personnel is provided in the Access Numbers for Surface Facility Emergency Response List .

Incident Command

The first Incident Coordinator contacted shall assume the responsibility of Incident Command until officially relieved by someone of higher authority. The Incident Commander shall ensure that the Emergency Alarm Horn is sounded to alert all Site surface personnel that an emergency situation exists. The Incident Commander shall then proceed to the designated response assembly point to coordinate field operations.

Note: Once a response operation is underway, a change in Incident Command should only occur if the change would significantly improve the response to the emergency situation. Incident Coordinators must evaluate the situation on an ongoing basis to determine the best course of action to take during a response.

Emergency Coordinator

In coordination with the Radiation Safety Officer, the First Responder should act as the Emergency Coordinator during an emergency situation at the Schwartzwalder Mine surface facilities.

1. The Emergency Coordinator will perform the following duties:
2. Maintain contact with and coordinate Site operations and personnel with the incident response operation.
3. Evaluate the incident on an ongoing basis and coordinate the Site incident response operation with Corporate Management and any outside emergency response organizations, such as medical and fire services, responding to the Site.
4. Designate a suitable alternate during their absence.

Notification and Coordination with External Entities

Notification and coordination with external emergency response organizations, potentially affected off-site entities, and regulator/ agencies may be necessary during an emergency situation at the Schwartzwalder Mine.

External Emergency Response Organizations

The Emergency Coordinator will evaluate the need for assistance from external emergency response organizations, such as medical and fire services, at the earliest possible moment during an incident response. Notification of external response organizations must be done promptly, when necessary.

The current external medical and fire service organizations available for assistance during an emergency situation at the Schwartzwalder Mine are listed in the section below title, Access Numbers for Surface Facility Emergency Response List.Off-site Entities and Regulatory Agencies

The Emergency Coordinator will evaluate the emergency situation on an ongoing basis to determine whether the notification of off-site entities or regulatory agencies is necessary.

The Emergency Coordinator will be responsible for the notification of off-site entities or regulatory agencies, when necessary.

A list of off-site entities and regulatory agencies that may require notification during an emergency situation at the Schwartzwalder Mine is included below. Those agencies that must be notified within 24-Hours of the occurrence are noted as such.

For Reportable Quantity (RQ) spills:

- The State of Colorado Emergency Management Unit (24-our)
- The USEPA National Response Center (24-hour)
- The CDPHE Hazardous Materials and Waste Management Division Radiation Management Unit

For RQ spills involving Ralston Creek:

- The State of Colorado Emergency Management Unit (24-hour)
- The CDPHE Water Quality Control Division
- The Denver Water Board
- The North Table Mountain Water & Sanitation District

For a radioactive material spill outside of the restricted area:

- The State of Colorado Emergency Management Unit (24-hour)
- The CDPHE Hazardous Materials and Waste Management Division Radiation Management Unit (should notify within 24-Hour)

For any fire at the surface facilities:

- The Federal Mine Safety & Health Administration. (Within 2 Hours)

For any fire in the radioactive materials licensed facilities:

- The CDPHE Hazardous Materials and Waste Management Division

Radiation Management Unit

  - Note: The North Table Mountain Water and Sanitation District and the Denver Water Board must be notified immediately if any spill in Ralston Creek is a potential health risk.

Phase Two: Operations

The limiting factors of terrain and distance dictate that many emergency situations that occur at the surface facilities of the Schwartzwalder Mine will have to be successfully resolved or controlled by on-site personnel before external agencies or organizations will be able to mobilize and arrive on-site.

On-site personnel involved in responding to an emergency scene must carefully evaluate the situation prior to committing themselves and others to action. The severity of any injury, the quantity and concentration of any hazardous material released, the presence or absence of fire and/or energized electrical circuits, and the location of the incident are some of the primary factors used in determining an operations strategy both before and during an incident response. Responders should always perform a thorough initial and ongoing incident evaluation that accounts for these factors and adjust their actions accordingly. A thorough incident evaluation should include the following aspects:

1. The presence of physical and electrical hazards, or hazardous materials.
2. The physical layout of the incident area.
3. The extent of injury, if applicable.
4. The type and quantity of materials spilled, if any.
5. Any actions already taken.
6. The number and skills of available personnel.
7. The type and quantity of available equipment and supplies.
8. The type and availability of both internal and external support.
9. Alternate courses of action.

Response operations will usually occur in two distinct, but often overlapping, stages once the incident evaluation and subsequent notification is complete. The first stage consists of those actions taken by the First Responder immediately after the notification phase. The second stage of operations consists of coordinated site-wide actions taken to successfully resolve a situation by multiple response personnel or external support services. Actions taken by the First Responder may, or may not, successfully resolve the emergency at the Stage 1 level of operations. If the First Responder can successfully resolve the situation, then the second stage of operations will terminate with the mobilization of Site personnel during the notification phase. If the First Responder cannot successfully resolve the situation, or if the situation is beyond the First Respondents capabilities to resolve, then the second stage of response operations will continue through field response actions until a successful resolution of the emergency situation has occurred.

General guidelines for First Responder and multiple responder operations are provided below. Operational guidelines for specific types of incidents are attached as appendices to this section with HazMat response guidelines organized according to the respective USDOT hazard class of the material. The hazardous materials in use and stored on-site are listed in the Safety Data Sheets (SDSs) which are kept onsite in a binder the office trailer.

Responders should always attempt to de-energize electrical equipment and eliminate ongoing leak or spill sources (re. closing valves, etc.), both prior to and during operations, if the responder(s) will not be exposed to an unwarranted level of risk while doing so.

The prompt containment of spilled materials, or the containment of fires to a limited area, is a primary goal of any field response action during these types of emergency situations. Limiting the area impacted by a spill or a fire will significantly reduce the level of cleanup required after the response is over.

The use of proper personal protection equipment (PPE) is mandatory during response operations. The type of PPE used will depend on the type of HazMat involved and the potential for contact with a hazardous material.Stage 1 Operations- First Responder

The first person to arrive at the location of an emergency situation becomes the First Responder to the incident and assumes responsibility for the subsequent emergency response until they are relieved by a more qualified person. The First Responder can be any CLL employee or a contractor's employee (eg. truck driver).

Stage 1 response operations are coordinated individual operations undertaken by a single person upon encountering an emergency situation. The First Responder will proceed through the two distinct activity phases of Notification and Field Response Action when responding to an emergency situation.

Stage 1 Notification

The primary responsibility of the First Responder in an emergency situation is the prompt notification of other Site personnel. The First Responder shall immediately relay an incident evaluation to one additional person prior to taking any other action during an emergency response.

Stage 1 Field Action

After notification the First Responder will proceed to the Field Action Phase of response. The type of action taken by the First Responder during an emergency situation will depend on an ongoing evaluation of the incident and the First Responder's capability to respond.

First Responders should always make an initial response to incidents that are within the capabilities of a single person to correct, or control, until help arrives. Generally, a single person can successfully correct or control small fires, HazMat spills, and minor accidents that do not represent an unwarranted health hazard to a single responder. The First Responder must always be prepared to retreat and monitor the situation from a safe distance until help arrives if the initial incident evaluation, or the responders ongoing evaluation, indicate that an unwarranted hazard exists or may develop.

Stage 2 Operations – Multiple Responder

Stage 2 response operations are coordinated site-wide operations involving multiple personnel. Stage 2 response operations are initiated during the notification phase of any emergency response and proceed through the three distinct Stage 2 activity phases of Alert, Mobilization, and Field Actions.

Stage 2 Alert

Using radio communication to alert onsite workers to an emergency constitutes the Alert phase of a Stage 2 response operation and signals the beginning of a Stage 2 site response. All CLL and non-CLL personnel on the surface are to immediately proceed to a designated assembly point when the Emergency Alarm Horn (Fire Alarm) is sounded.

Stage 2 Mobilization

All emergency responses to an emergency situation at the Schwartzwalder Mine will progress through Stage 2 Mobilization. Mobilization for Stage 2 response operations consists of the assembly and organization of Site surface personnel for coordinated response operations. Stage 2 response activities will terminate at the end of mobilization if the emergency situation is successfully resolved at the First Responder level. The Site will demobilize and the Remediation Phase of the Emergency Response Plan will be executed if the situation is resolved at the First Responder level.

Mobilization: Assembly

All surface personnel are required to report to a designated assembly point when the alert signal is sounded. The primary assembly point for CLL personnel during a surface emergency situation is the Fire Alarm Control Panel located at the northeast corner of the Maintenance Building. The primary assembly point for non-CLL personnel is the Main Office Trailer. The Main Office Trailer is the alternative assembly area if the primary assembly points are inaccessible.

Mobilization: Basic PPE Requirements

All personnel reporting for Stage 2 response operations will first don hard hats, safety glasses, and steel-toed safety shoes. This is the minimum personnel protective equipment (PPE) required during response operations. CLL personnel who are not wearing the minimum PPE listed above will be restricted to support functions only during Stage 2 operations.

Mobilization: Specific Personnel Duties

The Radiation Safety Officer will:

- Provide an initial situation report to all response personnel at the primary assembly point.
- Review the incident evaluation, determine a preliminary course of action, and delegate specific duties to response personnel.
- Establish an incident command post at a secure location near the incident location.
- Establish a Site command post with secure communication links to off-site entities at a location unaffected by the incident. A mobile telephone and two hand-held radios are available to augment the telephone and mine-page phone communication systems.
- Ensure that communications with the incident command post and off-site entities are functional.
- Organize response personnel for deployment based upon the initial situation report and the projected course of action. Response organization will include the delineation of responsibilities or duties; the provision of proper PPE, including SCBA; the collection of specialized equipment; and the establishment of a support base, including communications
- Establish a preliminary field response plan based upon the initial situation report and the projected course of action.

Stage 2 Field Action

A Stage 2 Field Action is a coordinated field response to an emergency situation by multiple personnel. A Stage 2 Field Action occurs when an emergency situation cannot be successfully resolved at the First Responder level. Stage 2 field actions consist of operations undertaken in the field by multiple personnel that are designed and implemented in order to control or abate an emergency situation. A coordinated Stage 2 field response operation will continue until the situation has been successfully resolved.

Field Action: Operations

General guidelines for responding to incidents that involve specific hazardous materials classes or accident scenarios are provided under the Initial Response Guide to this procedure. The specific course of action taken during a Stage 2 Field Response Action will be determined by the ongoing incident evaluation. Rescue is the primary duty of any field response.

Field Action: Specific Personnel Duties

The Radiation Safety Officer (RSO), or RSO Designated Representative when the RSO is not present, shall:

- Act first and foremost to prevent unwarranted occupational and environmental exposures from occurring during emergency incidents involving radioactive materials.
- Monitor response activities and suspend any response activity that creates, or may create, an unwarranted exposure risk.
- Oversee and coordinate all field response actions until the emergency situation is successfully resolved.
- Perform an ongoing incident evaluation and determine an appropriate course of action for the response activity, in coordination with other relevant personnel.
- Coordinate incident response activities with external emergency responders when they are deployed in the field.
- Ensure that communications with the incident command post and off-site entities are maintained.
- Ensure that the incident response action is provided with resources that are adequate to sustain the response activity.
- Coordinate on-site response actions with off-site response activities.
- Ensure that Site response personnel are in a condition suitable for field operations, including the provision of proper PPE, sufficient quality and quantities of equipment, and adequate numbers of personnel for both operations and back-up.

Phase Three: Remediation

A successful resolution to the operations phase of an emergency situation at the surface facilities of the Schwartzwalder Mine will be followed by remediation actions designed to both mitigate the adverse effects of the emergency and reduce the potential for a recurrence of a similar situation. Remediation actions consist of clean-up activities at fire and spill locations, and formal and informal reviews of the emergency and the emergency response plan implementation.

Clean Up

General guidelines for clean-up activities at spill and fire locations are listed below. Specific clean-up guidelines for each material or incident type are included with the field response operational guidelines detailed in the Initial Response Guide.

Clean-Up: General

An evaluation for cleanup requirements at any fire or spill site will be performed by the Environmental Coordinator immediately upon the successful conclusion of field response operations. This evaluation will include the following considerations, at a minimum.

1) Type of material spilled.
2) Type of material(s) or structures affected by the incident.
3) Affected area (physical extent of contamination).
4) Physical configuration of the spill or fire area.
5) Personnel requirements and availability.
6) Equipment requirements and availability.
7) Disposal requirements.

Note: Radioactive materials will be promptly retrieved from unrestricted areas as soon as field response operations are terminated. The Environmental Coordinator will be responsible for coordinating cleanup activities in accordance with the post-field operations evaluation.

Review

The final stage in any emergency response activity is a complete review of the circumstances leading to the emergency, all response actions taken during the emergency, and post-response remediation activities.

The Environmental Coordinator will coordinate the requisite review and issue a report to corporate management summarizing the findings, including any necessary corrective actions. The Site Environmental Coordinator shall be responsible for preparing any requisite reports to the Federal Mine Safety and Health Administration. The Environmental Coordinator will prepare any necessary five or thirty day post-incident reviews for all relevant government agencies.

EMERGENCY RESPONSE EQUIPMENT

This list contains the equipment on site that may be used in responding to an emergency situation at the surface facilities of the Schwartzwalder Mine.

Emergency Response Equipment	Location
Chemical Handling Equipment	
Respirators {Half & Full-face)	Office Trailer Lockers
Rubber Gloves	Water Treatment Plant, Office Trailer and Work Truck
Eye Wash	Water Treatment Plant

Emergency Response Equipment	Location
Fire-fighting Equipment	
Fire Extinguishers	All Buildings, All Stationary and Work Truck
Earthmoving Equipment	
Ford 3550 Backhoe	Water Treatment Plant Mesa Area/Valley
Hand Tools	Water Treatment Plant
Other Equipment	
Link Belt YC-28 Crane (f 2'/2Ton)	Water Treatment Plant
Hyster P80-A Fork Lift (7300 lb)	Water Treatment Plant

EMERGENCY RESPONSE TRAINING

Response personnel have the following training:

- Forty (40) hour OSHA HAZWOPER with eight (8) hour annual refresher training
- Annual Radiation Safety Officer and radioactive materials user training for relevant personnel.
- Safety meetings as appropriate with discussion of work activities, hazardous material handling and safety.

EMERGENCY RESPONSE PLAN ~ INITIAL RESPONSE GUIDE

The initial Emergency Response Plan for the surface facilities at the Schwartzwalder Mine consists of two phases:

- Phase One: Notification
- Phase Two: Operations

Your primary responsibility as a First Responder in an emergency situation is the prompt notification of the Site Emergency Coordinator or 911, if the Emergency Coordinator cannot be contacted.

Phase One: Notification

- First Responder reports the following information to one other person immediately prior to starting any direct operations for an accident, spill, or fire,
  - The location of the incident.
  - The nature of the incident.
  - The extent of injury, if applicable.
  - The type of material spilled, if known,
  - The physical extent of the spill area.
  - The First Responder=s intended course of action.
  - Method of maintaining communication.

- The first person contacted by the First Responder notifies the Emergency Coordinator. The

Emergency Coordinator for the Schwartzwalder Mine is:

- Randy Whicker, Radiation Safety Officer Cell Phone: (970) 556-1174

Following initial notification Site personnel are mobilized for operations.

Phase Two: Operations

- The Emergency Coordinator becomes the Incident Commander and activates the Site Emergency Alarm Horn to mobilize the Site personnel.
- All surface personnel assemble at their designated assembly point.
- Onsite Personnel:
  - Primary Assembly Point: Water Treatment Plant
  - Back-up Assembly Points: Main Office Trailer
- Contractor and Visitor Personnel:
  - Assembly Point: Main Office Trailer

- The Incident Commander
  - Briefs the assembled response personnel.
  - Establishes a Site command post and communications links on-site and off-site (911, Corporate notification).
  - Reviews the situation and develops a plan of action for response operations.
  - Delegates support functions to other response personnel.

The Response Operations Plan is implemented.

Guidelines for Surface Emergency Response Operations

After notification the Responder will proceed to the Operations Phase of response. The type of action taken in the operations phase will depend on the incident and the Responder's capability. All other Site personnel have response training and should immediately begin Stage 2 operations when notification is complete. The quantity and concentration of hazardous material released, and the presence or absence of fire will be the primary factor in determining operations strategy. Proper personal protection equipment (PPE) is mandatory during response operations. Choice of PPE will depend on the type of material involved and the potential for contact with the material. A listing of available response equipment and its location is listed in the following section.

General operational strategies and PPE requirements are listed below for potential HazMat incidents involving Flammable materials. Every effort should be made, that does not involve an unwarranted risk to responders, to eliminate ongoing leak or spill sources (re. closing valves, etc.) prior to beginning operations.

Flammables

This category includes both flammable materials and some of the more volatile combustible materials such as diesel fuel. Flammable/Combustible materials stored onsite include small quantities contained in small appropriate containers as needed to fuel and maintain onsite equipment for immediate work activities only (no long-term storage of flammables is allowed):

- Gasoline (Site equipment, temporary containers)
- Various Lubricants (Site equipment, temporary containers)
- Diesel (Site equipment, temporary containers)

Spill - No Fire

PPE:

- Work clothes; rubber gloves; and rubber boots (chemical cartridge air-purifying respirator if available).

Response:

- Evaluate situation.
- Secure area.
- Rescue & First Aid, if necessary & possible.
- Remove ignition sources
- Locate fire extinguisher and keep near at hand,
- Dam or dike to contain material.
- Watch for flammable or explosive vapors.
- Coat surface of spilled liquid with dry chemical extinguishing agent, if enough is available. Save enough extinguishing agent for fire fighting.
- Do not add water.

Remediation:

- Evaluate situation.
- Do not add water.
- Pick up liquids if proper equipment is available, or absorb spilled materials with compatible material if liquid retrieval is not possible.
- Transport contaminated soil to the west waste Dump storage area for temporary storage until a permanent disposal site is determined.

Spill - Fire

PPE:

- Work clothes; self-contained breathing apparatus (alternatively, no respirator or full-face respirator for small fires that can be quickly knocked down); eye protection; gloves; and boots (rubber is best).

Response:

- Evaluate situation.
- Secure area.
- De-energize electrical equipment.
- Rescue & First Aid, if necessary & possible.
- For small fire use available dry-chemical and Halon fire extinguishers to knock down the fire as quickly as possible. Avoid water for small fires, if possible.
- Keep area well ventilated.
- For a large fire, protect adjacent structures, use water from a safe distance.
- Remember water can be used as a barrier.
- Direct extinguishing agent in a manner to avoid splashing spilled material.
- Dam and dike at a safe distance to control runoff.
- Contain collected runoff locally, when possible.
- Perform overhaul.

Remediation:

- Evaluate situation.
- Certify fire as extinguished.
- Absorb spilled materials, if possible, with earth or other suitable material.
- Transport contaminated soil to the West Waste Dump storage area for temporary storage until a permanent disposal site is determined

Radioactive Materials

This category includes all radioactive materials stored on-site. The radioactive materials stored at the Schwartzwalder Mine are low-toxicity alpha emitters. The responder must be aware that the radioactive materials may be contained within another hazardous material, such as sulfuric acid. The response should first address the material that is the more immediate health hazard.

Radioactive Materials stored on-site include:

- Large Quantities – (Storage Tanks, Emergency Pond, Building Sumps)
- Water Treatment Residues - (Surface Sumps)
- Water Treatment Plant - (Ion-Exchange Vessels, RO Membranes, and Filters)

Small Quantities:

- Radioactive Sources (Office Trailer)

Spill - No Fire

PPE:

- Protective clothing & respiratory protection appropriate to the most immediate health hazard; eye- protection; rubber gloves and boots.Note: Focus response on the most hazardous situation and material first.

Radioactive Materials Response:

- Evaluate situation.
- Secure area.
- Dam or dike to contain material.
- Do not add water.

Radioactive Materials Remediation:

- Evaluate situation.
- Do not add water.
- Pick up liquids if proper equipment is available, or absorb spilled materials with compatible material if liquid retrieval is not possible.
- Transport contaminated soil to the West Waste Dump storage area for temporary storage until a permanent disposal site is determined.

Spill - Fire

PPE:

- Protective clothing appropriate to the most immediate health hazard; self-contained breathing apparatus (alternately air-purifying respirator with at least HEPA cartridges for very small fires that can be quickly knocked down); eye-protection; rubber gloves and boots.
    - Note: Focus response on the most hazardous situation and material first.

Radioactive Materials Response:

- Evaluate situation.
- Secure area.
- Respond to fire and most immediately hazardous material present (see other *Guidelines).*
- Direct extinguishing agent in a manner to avoid splashing spilled material.
- Keep area well ventilated. Watch for airborne radioactive materials in smoke.
- Contain materials and runoff. Dam and dike at a safe distance to control runoff.
- Route collected runoff to the Emergency Storage Pond, if possible.
- Perform overhaul.

Radioactive Materials Remediation:

- Evaluate situation.
- Certify fire as extinguished.
- Absorb spilled materials, if possible, with earth or other suitable material.
- Transport contaminated soil to approved onsite storage location.

Main Access Road and Location Transport Responses

This category includes response operations to hazardous material transportation incidents on the Main Access Road (Glencoe Valley Road) and during transport on-site. In the event that Glencoe Valley Road is not accessible, there is another access point through White Ranch Open space. Materials transported at these locations include:

- Radioactive
- Flammable
- Combustible
    - Note that any radioactive materials transported are expected to be relatively low-activity alpha and gamma emitters.

The responder must be aware that the hazardous materials transported may fall under several different hazard classes with different reactions to extinguishing agents for fires or absorbent materials. The transporting vehicle may also constitute an additional hazard for responders. The response should first address the material that is the greatest immediate health hazard. Transported Materials May Include:

Radioactive

- Contaminated soil
- Loaded water treatment resin
- Small environmental samples

Flammable:

- Gasoline

Combustible

- Diesel fuel
- Oil/Lubricants

Spill - No Fire

PPE:

- Protective clothing & respiratory protection appropriate to the most immediate health hazard; eye-protection; rubber gloves and boots.
    - Note: Focus response on the most hazardous situation and material first. Radioactive material responses must be coordinated by authorized personnel only.

Response:

- Evaluate situation.
- Secure area.
- Rescue & First Aid, if necessary & possible.

- Remove ignition sources.
- Locate fire extinguisher and keep near at hand.
- Dam or dike to contain material. Prevent material from entering Ralston Creek.
- Watch for flammable or explosive vapors.

Remediation:
- Evaluate situation.
- Do not add water.
- Pick up liquids if proper equipment is available, or absorb spilled materials with compatible material if liquid retrieval is not possible.
- Recover as much material as is possible from Ralston Creek, if material was spilled into the creek.
- Transport contaminated soil to the storage area across the creek from the water treatment building for temporary (lined) storage until a permanent disposal site is determined.

Spill - Fire

PPE:

- Protective clothing appropriate to the most immediate health hazard; self-contained breathing apparatus (alternately air-purifying respirator with at least HEPA cartridges for very small fires that can be quickly knocked down); eye-protection; rubber gloves and boots.
    - Note: Focus response on the most hazardous situation and material first. Radioactive material responses must be coordinated by authorized personnel only. Generally, fire responses will involve monitoring the fire from a safe distance.

Response:
- Evaluate situation.
- Secure area.
- Rescue & First Aid, if necessary & possible.
- For small fire use available dry-chemical and Halon fire extinguishers to knock down the fire as quickly as possible. Avoid water for small fires, if possible.
- Remember water can be used as a barrier.
- Direct extinguishing agent in a manner to avoid splashing spilled material.
- Dam and dike at a safe distance to control runoff. Prevent material from entering Ralston Creek.
- Perform overhaul.

Remediation:
- Evaluate situation.
- Certify fire as extinguished.
- Absorb spilled materials, if possible, with earth or other suitable material.
- Transport contaminated soil to the storage area across the creek from the water treatment building for temporary (lined) storage until a permanent disposal site is determined.

ACCESS NUMBERS FOR SURFACE ACTIVITY EMERGENCY RESPONSE

Off-site Emergency Services Available to the Schwartzwalder Mine include:

Service	Organization	Phone
Fire and Rescue	Jefferson County Sheriff's Department	911 or 303-277-0211
	Coal Creek Canyon Fire Department	911 or 303-642-3121
Ambulance Services	Coal Creek Canyon Fire Department	911 or 303-642-3121
	Flight for Life Helicopter Landing Zone at Schwartzwalder: 39 50' 49"N 105 16'56"W	911 or 800-332-3123
Injuries (no ambulance required)	UCHealth Emergency Room 15240 W 64th Ave Arvada, CO 80007 Hours: Monday to Friday, 8am to 8pm Saturday and Sunday, 8 am to 6pm	303- 467-7185

Incident Coordinators for Surface Emergency Response

The following personnel are authorized to act as coordinators for emergency situations that occur at the surface facilities of the Schwartzwalder Mine. An emergency incident is defined as a spill of hazardous materials, a fire, an accident involving surface personnel. These personnel must be contacted during any emergency situation at the surface facilities of the Schwartzwalder Mine.

Name and Title	Telephone
Emergency Coordinator – Hazardous Materials, Fire, Radiation Protection	
Randy Whicker, Radiation Safety Officer Note: The RSO is authorized by the CDPHE to supervise the use of radioactive materials and must be notified.	970-556-1174 (cell) 505-298-4224 (office)
Corporate Management	
Jim Harrington, Colorado Legacy Land, Site Owner and Managing Partner	303-808-9101 (cell) 970-632-2239 (office)
Billy Ray, Sr Operations Manager	832-506-4433 (cell) 303-862-3928 (office)
Holli Merchant, Corporate Health and Safety Officer	303-668-0589 (cell) 303-986-1067 (office
State Agency Emergency Contacts	
Randy Whicker, Radiation Safety Officer, to notify CDPHE, Emergency Management Unit	Telephone: 1-877-756-4455 Telefax (303) 692-3683

ADDENDUM 1. NOTICE REQUIREMENTS [RULE 1.6.2(1)(B)]

NOTICE

This site is the location of a proposed mining operation. Colorado Legacy Land LLC, whose address and phone number is 12150 E. Briarwood Ave., Suite 135 Centennial, CO 80112, ph (303) 862-3938 has applied for an Amendment to their Reclamation Permit with the Colorado Mined Land Reclamation Board. Anyone wishing to comment on the application may view the application at the Jefferson County Clerk and Recorder's Office, 100 Jefferson County Parkway, Suite 2560 Golden, Colorado 80418, and should send comments prior to the end of the public comment period to the Division of Reclamation, Mining and Safety, 1313 Sherman St, Room 215, Denver, Colorado 80203.

CERTIFICATION

I Elizabeth Busby, hereby certify that I posed a sign containing the above notice for the proposed permit area known as the Schwartzwalder Mine. on June 22, 2021.

Signature: [signature]

Date: June 22, 2021

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Appendix 1. Conceptual Site Model

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CONCEPTUAL SITE MODEL

SCHWARTZWALDER MINE SITE
MAY 2022

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WHAT IS A CONCEPTUAL SITE MODEL?
SCHWARTZWALDER MINE SITE

- Conceptual Site Model (CSM) is the current Site narrative that explains:
  - Where does contamination exist and why?
  - How does contamination moves and/or change in the environment?
  - What risks do the various forms of contamination pose?
- What does a good CSM do?
  - Unifies all of the available data and information into a single narrative that makes sense and can be used to support a consensus path forward.
  - Points to gaps or weaknesses in understanding, helps to determine their significance.
- A CSM is:
  - The best available explanation of site conditions that considers all available information and data.
  - A living narrative that is updated as new data and information become available.
- A CSM is not:
  - Perfect– rather it is an informed interpretation that temporarily bridges data and information gaps. It identifies if there are key that affect making good site remedial decisions.
  - A comprehensive model – models may prove to be valuable pieces of a CSM but this site is too complex for any a single numerical model.

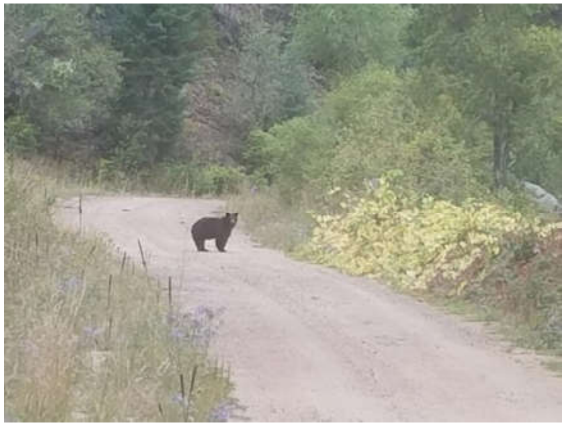
<u>Guidance documents used to develop this CSM:</u>

ASTM Standard E1689, 1995 (2014), "Standard Guide for Developing Conceptual Site Models for Contaminated Sites," ASTM International, West Conshohocken, PA, 2014, DOI: 10.1520/E1689-95R14 , www.astm.org.;

United States Environmental Protection Agency, 2011. "Effective Use of the Project Life Cycle Conceptual Site Model," Office of Solid Waste and Emergency Response. EPA 542-F-11-011, July.

WHAT IS A CONCEPTUAL SITE MODEL?
SCHWARTZWALDER MINE

- All CSMs have data gaps.
  - Data Gaps: information, details, data, facts, results, regulation, firsthand knowledge, interviews, etc.
- What is a data gap?
  - Something we don't fully understand that may be relevant to site remedial decision-making.
- Not all data gaps are created equal.
- When is a data gap important?
  - When it prevents us from making good decisions about the site.



CONCEPTUAL SITE MODEL: KEY UPDATES
SCHWARTZWALDER MINE SITE

- CSM: updated from 2018 Hydrogeologica version.
- New analytical data added from 2018 through 2021.
  - Recent surface water sampling.
  - Recent groundwater sampling.
  - Mine pool data.
  - In-situ injection data: 2020 & 2021
- Mine Reclamation
  - Water Treatment: Relocation of water treatment plant, new intake pump, updated operational strategy (4-6 month pump & treat, 6-8 months monitor mine pool's recovery).
  - North Waste Rock Pile Diversion Channel was constructed in 2020.
  - Alluvial valley reclamation progress updates.
  - Reclamation timeline added to slides (year and technical revision number).

Fall 2020: Water Treatment Plant

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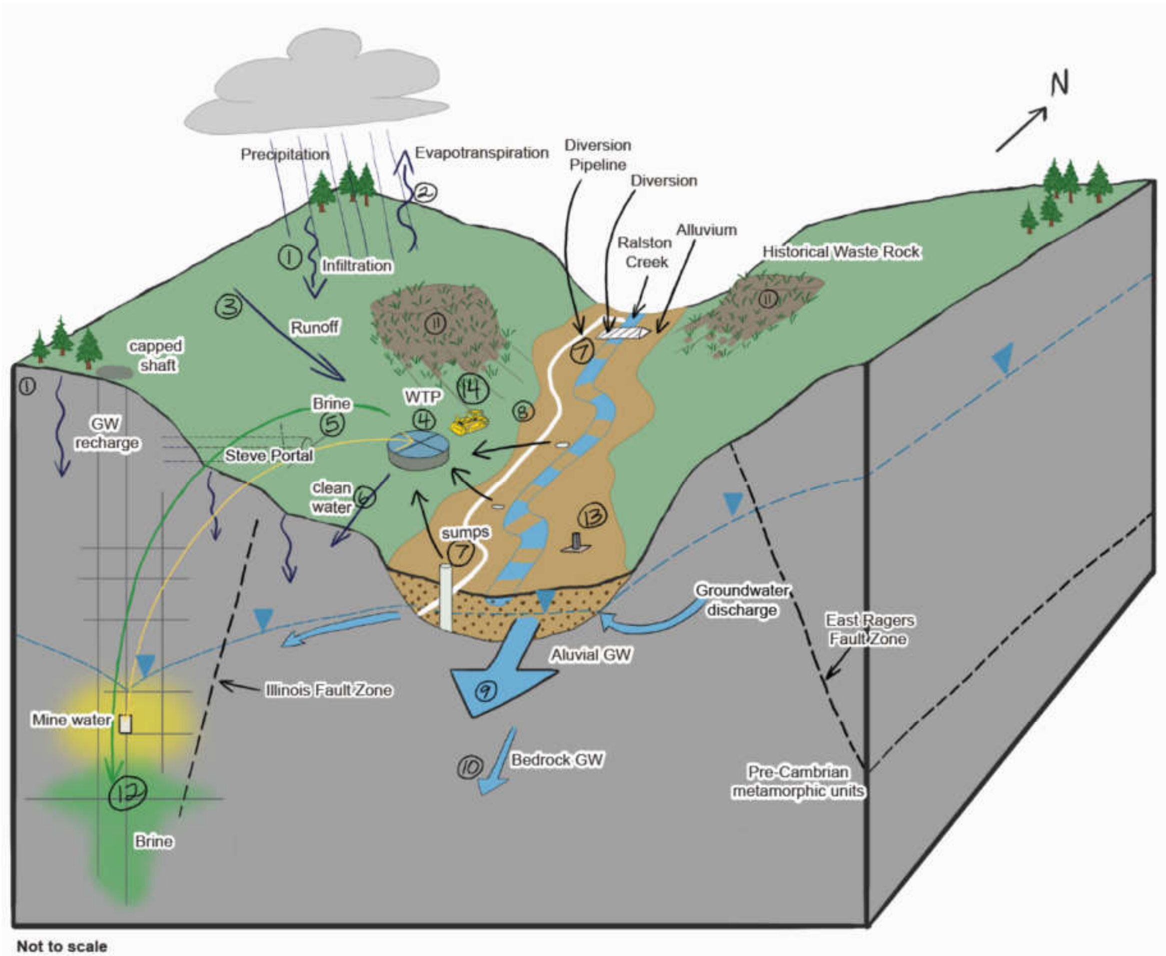
CONCEPTUAL SITE MODEL OBJECTIVES
SCHWARTZWALDER MINE SITE

- Overview of site history and mining operations that contributed to current setting.
- Define and describe the key hydrologic and geochemical mechanisms that are expected to influence/control the flow and chemistry of water in and around the Schwartzwalder Mine.
- Illustrate these mechanisms through a series of conceptual drawings and simple calculations.



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OPERATIONAL SITE HISTORY
SCHWARTZWALDER MINE SITE

Enhanced mineralization and erosion expose uranium ore at the surface

1953
Schwartzwalder Mine opens

Figure 9. Schwartzwalder Mine, 1993. (Photograph courtesy of Jim Paschis)

1998
Dewatering of sub-19 level ceases

2018
CLL acquires Schwartzwalder Mine; alluvial valley reclamation begins

Mine Operations

Pre-discovery → 1940s | 1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2010s

X Avg Crustal Abundance

U	70,700
Mo	4,800
Sb	2,200
W	1,150
Pb	600
Tl	400

1949
Ore deposit discovered by Fred Schwartzwalder by surface sampling

1966
Property sold to Cotter Corporation

2000
Mining ceases and upper mine begins to flood

2007
Mine pool elevation reaches Ralston Creek level

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MINING OPERATIONS (1978)
SCHWARTZWALDER MINE SITE

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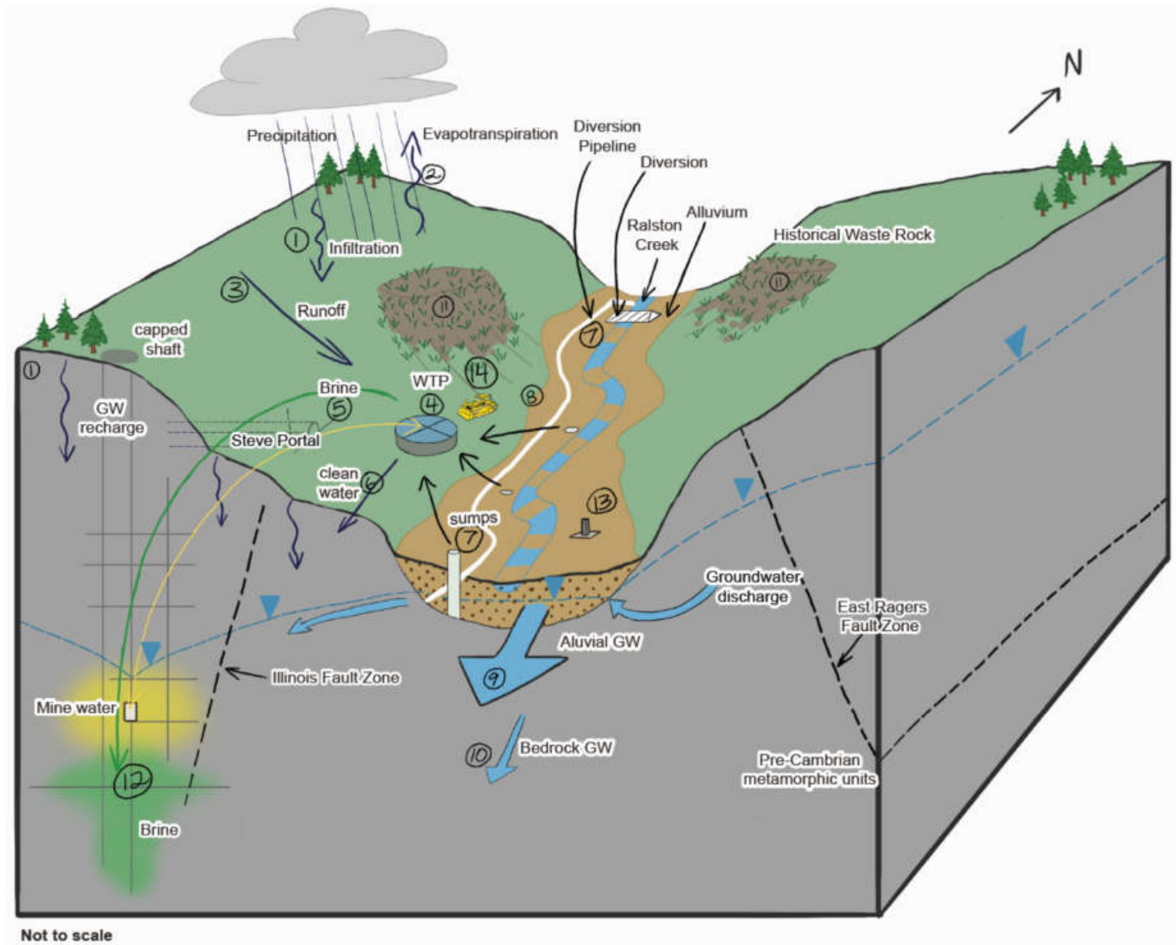
CONCEPTUAL SITE MODEL
SCHWARTZWALDER MINE SITE

2021 Current Conditions

- Ralston Creek diverted in bypass pipeline.
- Mine workings dewatered to below regulatory limit (6452 ft amsl = 150 feet below the Steve adit which is at 6602 ft amsl) annual range between >400 feet to 180 feet below Steve level.
- Seasonal operation of Water Treatment Plant 4.5 months active treatment season.
- Site reclamation in progress.



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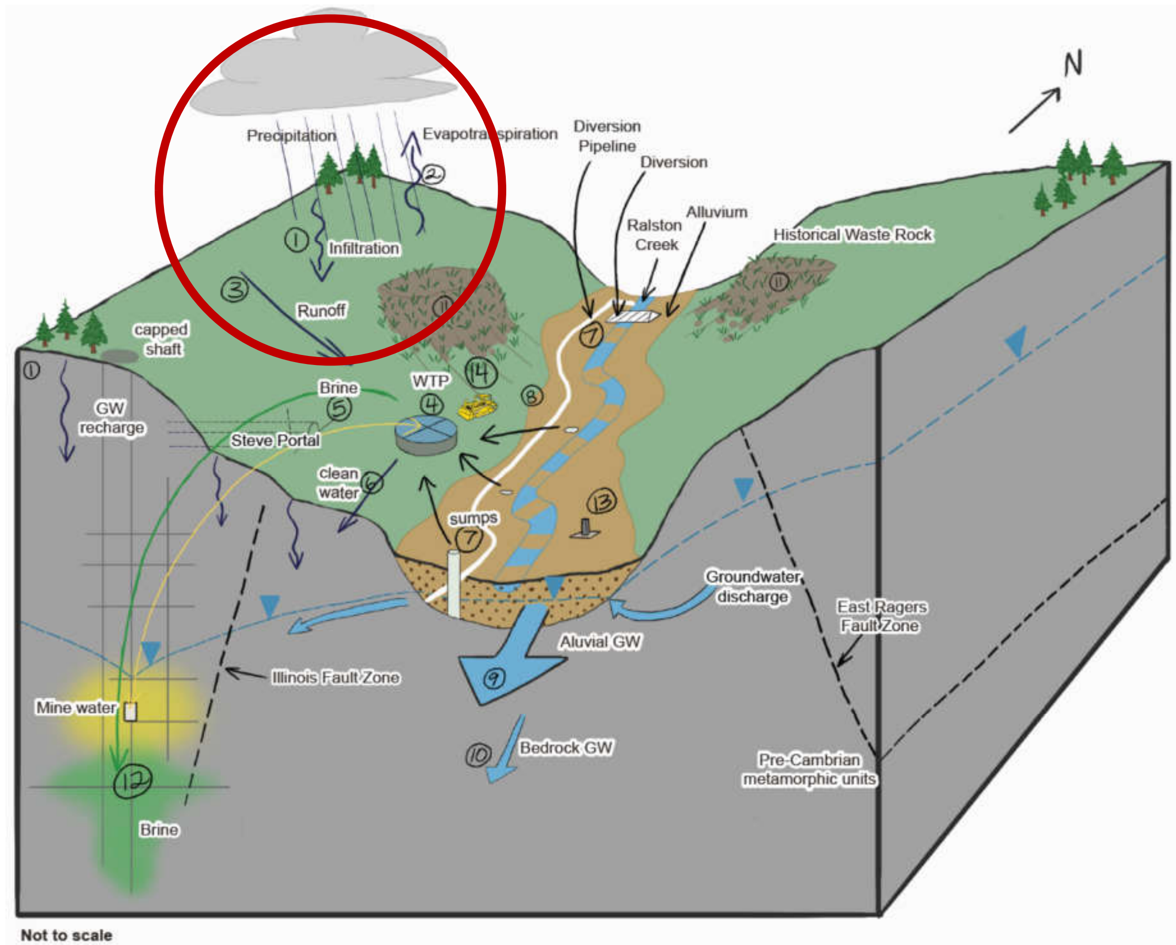
CLIMATE AND HYDROLOGY
SCHWARTZWALDER MINE SITE

- #1 - Infiltration
- #2 - Evapotranspiration
- #3 - Surface Runoff



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INFILTRATION
SCHWARTZWALDER MINE SITE

- Average annual precipitation at the site is 18.66 inches (WRCC, 1978 – 2005).
- Precipitation evaporates, transpires, and runs off. The remaining small percentage infiltrates through undisturbed, disturbed (e.g., roads and cleared areas), and reclaimed areas (e.g., waste rock facilities).
- Infiltration percolates to the water table and flows downgradient to Ralston Creek, mine workings, or flows along deeper flow paths to the west toward the Denver Basin.
- Infiltration through waste rock and impacted soils can transport metals and other mobile constituents.

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EVAPORATION AND EVAPOTRANSPIRATION
SCHWARTZWALDER MINE SITE

- Average evaporation at the site is 35 - 40 inches (CO DNR).
- Evaporation and transpiration limit the amount of precipitation that runs off or infiltrates, thereby limiting the long-term potential for dissolution and migration of metals and metalloids off site.
- Potential Climate Change Impacts:
  - There is less agreement among the models about future precipitation change for Colorado, which is shown in the second row of images. The models are split on whether the future will bring increasing, decreasing, or similar-to-current precipitation in Colorado. They show a range of possible outcomes from a 5 percent decrease to a 6 percent increase by mid-century (2050). The risk of decreasing precipitation appears to be higher for the southern parts of the state." - Kennedy, Caitlyn. Future Temperature and Precipitation Change in Colorado. NOAA. Published August 9, 2014, Updated July 3, 2021. https://www.climate.gov/news-features/featured-images/future-temperature-and-precipitation-change-colorado Accessed May 2, 2022.

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SURFACE RUNOFF
SCHWARTZWALDER MINE SITE

- Precipitation that does not evaporate, transpire, or infiltrate, flows by surface (or near-surface) flow toward Ralston Creek.
- Ralston Creek flows vary from less than 1 cfs to 80 cfs (May runoff) from the Schwartzwalder Mine site down to just upstream of the Ralston Reservoir.
- RC cannot be gaining in the mine area.
  - Ralston Creek currently diverted in pipeline – prevents conclusive assessment if RC is losing in mine area.
  - Mine level below 150 ft prevents mine water recharge to creek.

Fall 2020: NWRP channel during construction

SURFACE RUNOFF
SCHWARTZWALDER MINE SITE

- North Waste Rock Pile Construction Project was completed in 2020 (Technical Revision #28).
- Objective: Intercept and divert storm water around the North waste rock pile, prevent infiltration of runoff through the North waste rock pile, and avoid leaching of waste rock into Ralston Creek.
- Liner Materials: 4-inch thick Geoweb liner filled with concrete, underlain with impermeable geosynthetic liner (DuraSkrim), & non-woven geotextile.

Fall 2020: NWRP channel during construction

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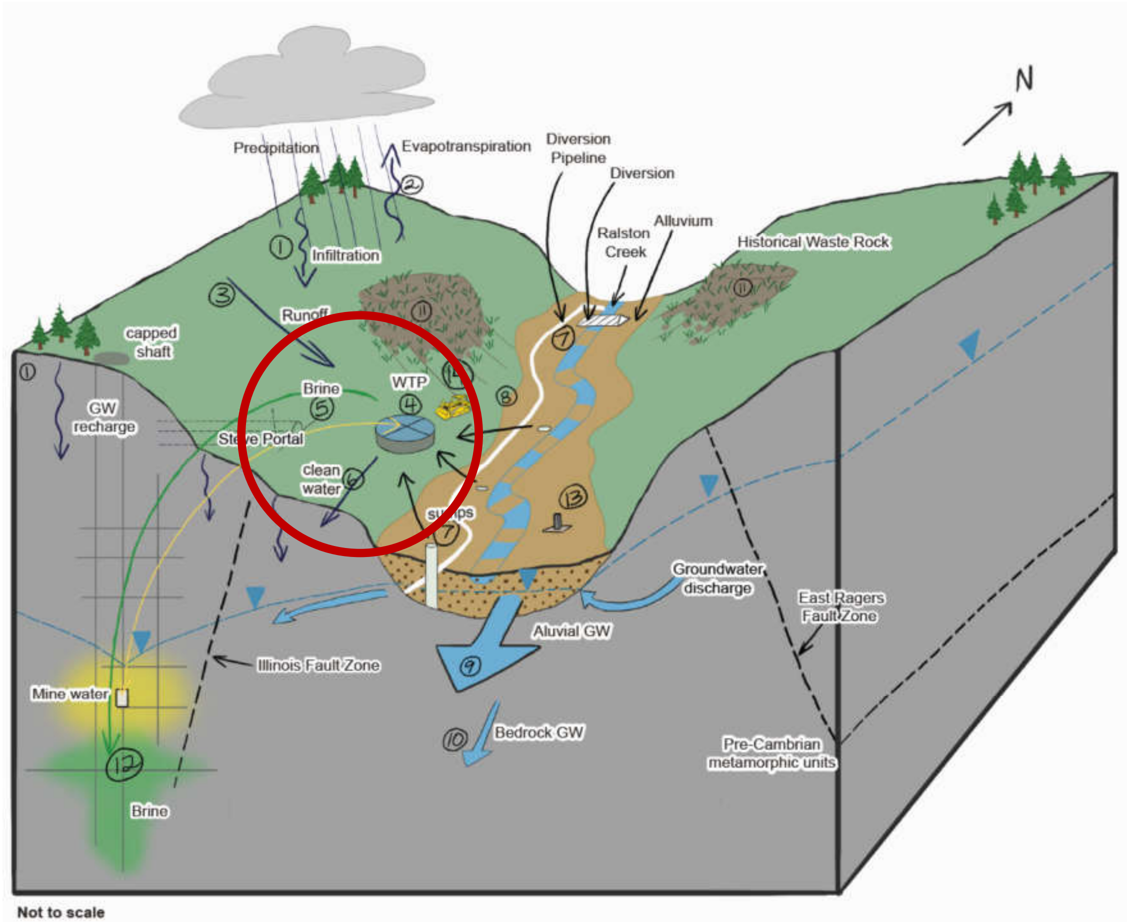
CONCEPTUAL SITE MODEL
SCHWARTZWALDER MINE SITE

- #4 - Water Treatment Plant (WTP)
- #5 - RO Concentrate Injection
- #6 - Clean Water Discharge



WATER TREATMENT PLANT
SCHWARTZWALDER MINE SITE

- Site water requiring treatment (e.g., groundwater recharge and alluvial water pulled from the mine workings during pump-down) is directed to the WTP. Treated water is discharged to Ralston Creek.
- RO concentrate from the R.O. treatment process is amended with barium chloride and injected into the deep mine workings for in-situ treatment and long-term storage.

Year	Operations Summary	Mean Influent Concentration, Dissolved Uranium [1]	Mine Pool Dewatering Summary	Notes
2018	Operated 47% of the year.	12.19 mg/L	Feet Gained[3] = 51 feet Max. Depth = 201 fbS (6,401 ft amsl)	In situ injection in December 2017.
2019	Operated 66% of the year.	13.73 mg/L	Feet Gained = 46 feet Max. Depth = 246 fbS (6,356 ft amsl)	Installed new 60hp pump at ~400 fbS.
2020	Operated 47% of the year.	12.56 mg/L	Feet Gained = 99 feet Max. Depth = 345 fbS (6,257 ft amsl)	In situ injection January 2020.
2021	Operated 37% of the year.	19.80 mg/L [2]	Feet Gained = ~20 feet Max. Depth > 345 fbS (>6,257 ft amsl)	In situ injection September 2021.

[1] Mean concentration of mine pool sample results. For comparison, the mean concentration of dissolved uranium in the mine pool from 2000 - 2007 was 41.14 mg/L. (Source: Whetstone Associates. 2007.)

[2] The mean concentration of mine pool sample results for 2021 do not include data collected during the fourth quarter because this report was prepared concurrent with the sample analysis.

[3] Feet gained is defined as compared to prior year end water level

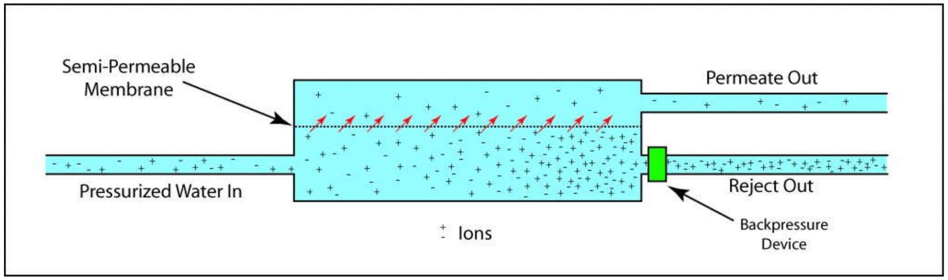
ENSERO solutions

REVERSE OSMOSIS AND RO CONCENTRATE RE-INJECTION

- RO concentrate is a higher-TDS solution generated in relatively low volumes (~30%) resulting from the reverse-osmosis treatment process.

Year	Discharge Total (MG)	RO Concentrate Total (MG)	Precent Recovery (Permeate)
2018	40.1	18.6	68%
2019	44.7	19.4	70%
2020	37.5	23.6	61%
2021	37.1	12.6	75%

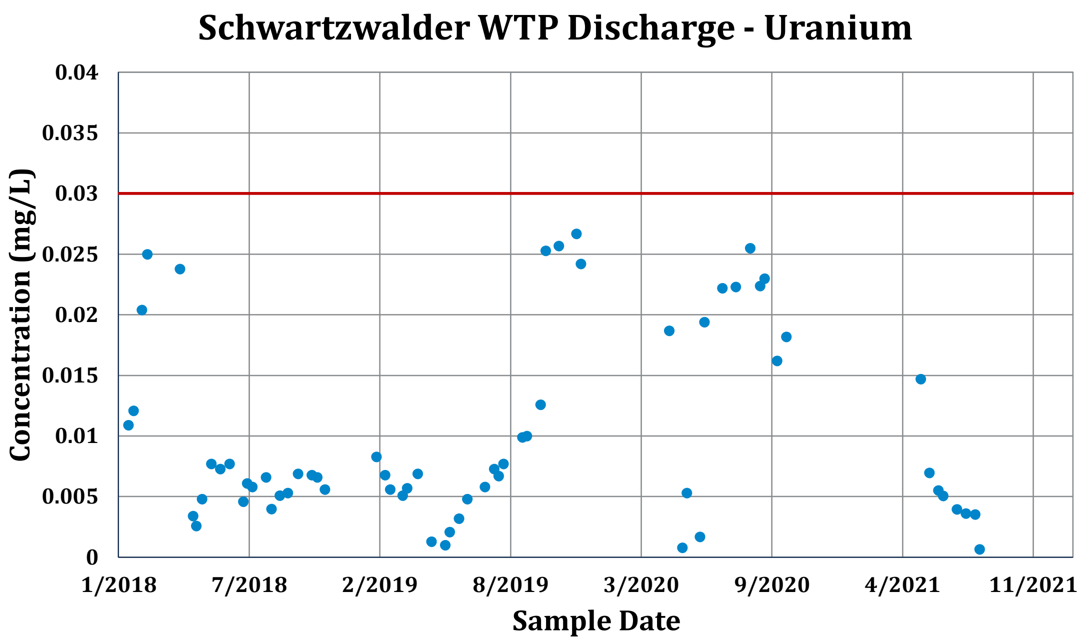
- The RO concentrate is injected into the deep mine workings through the Steve bulkhead into pipeline that discharges at the 1,100 level.
- The RO concentrate remains isolated in the deep workings because of inward hydraulic gradients.



Piping through Steve bulkhead

CLEAN WATER DISCHARGE
SCHWARTZWALDER MINE SITE

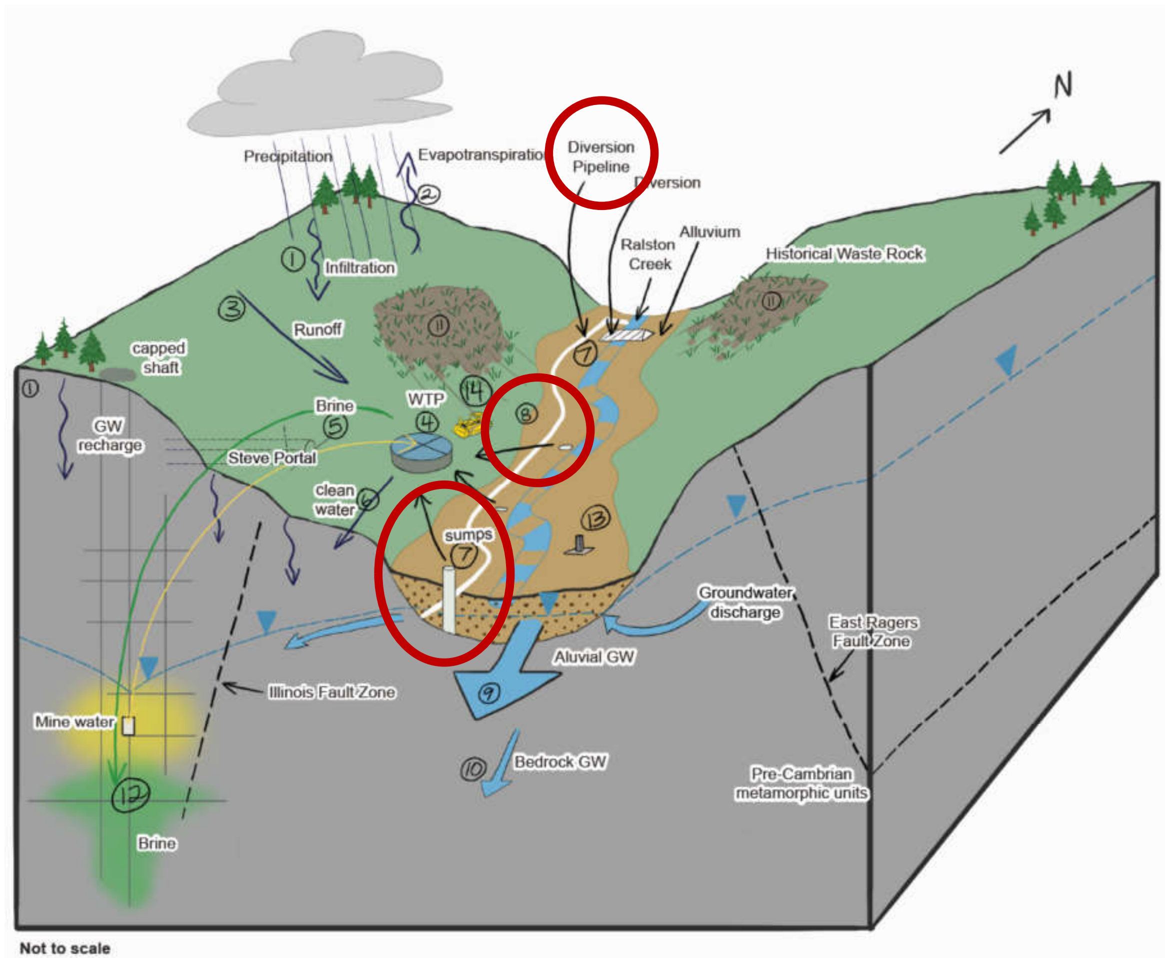
- Discharge to Ralston Creek at the property boundary is consistently below the USEPA MCL (0.03 mg/L).
  - Surface water sampling station: SW-BPL



Spring 2018: Surface Water Sampling Station (SW-BPL).

CONCEPTUAL SITE MODEL
SCHWARTZWALDER MINE SITE

- #7 – Sumps & Diversion (Bypass) Pipeline
- #8 - Mass Loading from Alluvium



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DIVERSION PIPELINE FOR RALSTON CREEK
SCHWARTZWALDER MINE SITE

- Upstream diversion (tied into bedrock) captures and directs Ralston Creek and alluvial water around the site. Piped and discharged downstream.
- Spring melt/large storms are not fully captured; ~2 week of flow per year water flows both in stream and pipeline.
- Diversion pipeline installed in 2011 (Technical Revision #18) to prevent unimpacted, upstream waters, from contacting recognized contamination in alluvium and minimize recharge into the mine pool.
  - Contaminated alluvium current being excavated. Earthwork is expected to be complete in 2022.
  - Mine pool currently dewatered below regulatory limit.

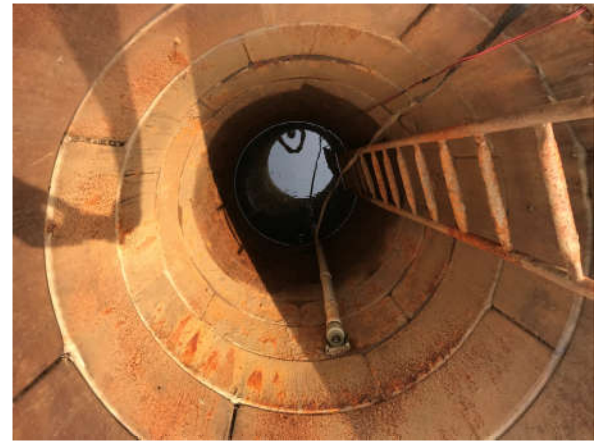
Spring 2018: Intake for Ralston Creek diversion across CLL property. Bypass pipeline and cutoff wall

ENSERO solutions

SUMPS
SCHWARTZWALDER MINE SITE

- Sumps were installed in 2011-2012 (Technical Revision #15) to prevent shallow alluvial water (from recognized contamination in alluvium and flooded mine pool) from leaving site.
- Sumps are large-diameter extraction wells installed in the alluvium and upper fractured bedrock.
  - CLL identified contaminated alluvium surrounding each sump and expects to remove all sumps to directly address source area contamination.
- 2021 Conditions: With the current dewatered mine pool, and bypass pipeline in place, sumps are typically dry. They only collect precipitation immediately following storm events.

Nov. 2021: Sump 1 near excavation area



Spring 2018: Sumps on grade and seasonally dry

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MASS LOADING TO RALSTON CREEK FROM ALLUVIUM
SCHWARTZWALDER MINE SITE

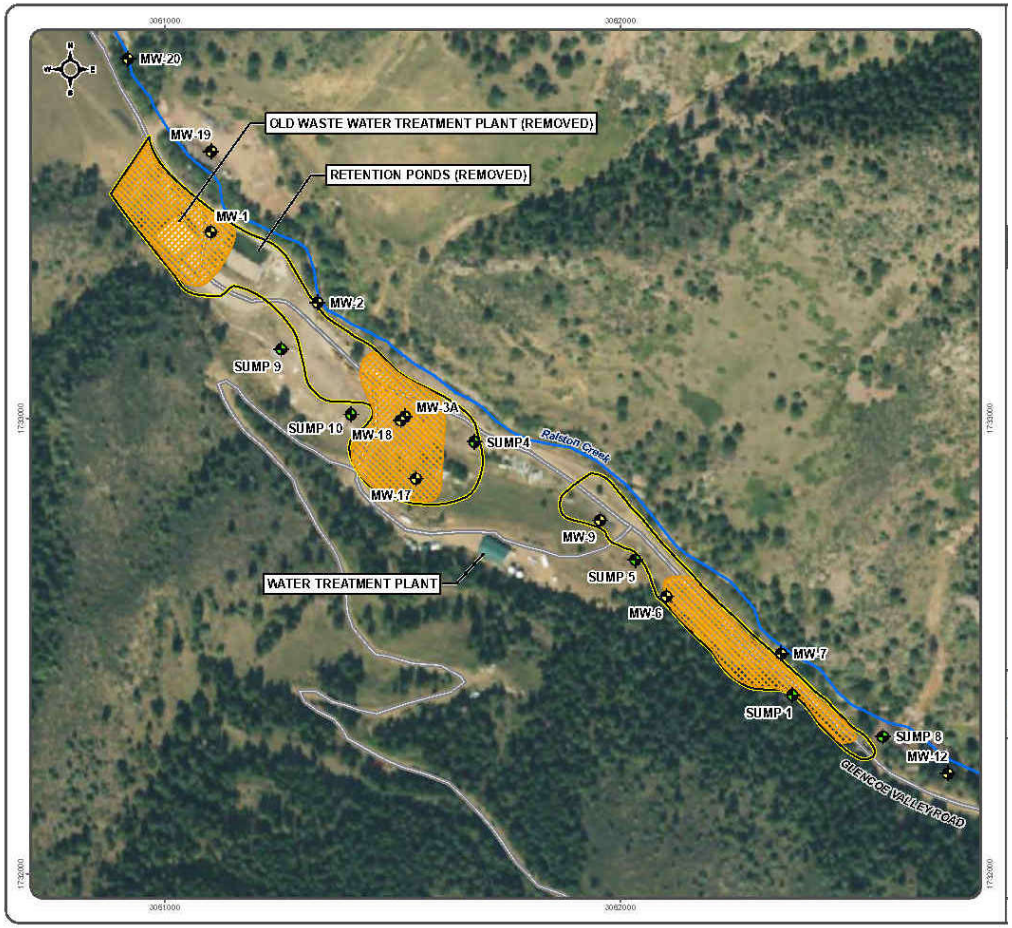
- Surface water and groundwater interact with natural and disturbed mineralized rock/soil and can result in transport of contaminant mass to the Ralston Creek system
- Likely sources include: former mining activities in alluvial valley, impacted soils/materials, and weathering of mineralized rock/soils.
- Mass loading has been ongoing since long before mining began but certainly increased as a result of mining.

Fall 2021: Alluvial valley excavation.

ENSERO solutions

MASS LOADING TO RALSTON CREEK FROM ALLUVIUM
SCHWARTZWALDER MINE SITE

- Alluvial valley excavation began in 2018 and is expected to finish in 2022. This work was originally scoped in 2011 (Technical Revision #14.)
- Objective: Remove any materials with the potential to leach uranium to groundwater above 0.03 mg/L.
  - Sumps and bypass pipeline have helped to dry out the alluvium for excavation work.
- Current excavation extents:
  - Yellow line = horizontal extent of contamination
  - Orange hatched area = vertical extent of excavation to bedrock.



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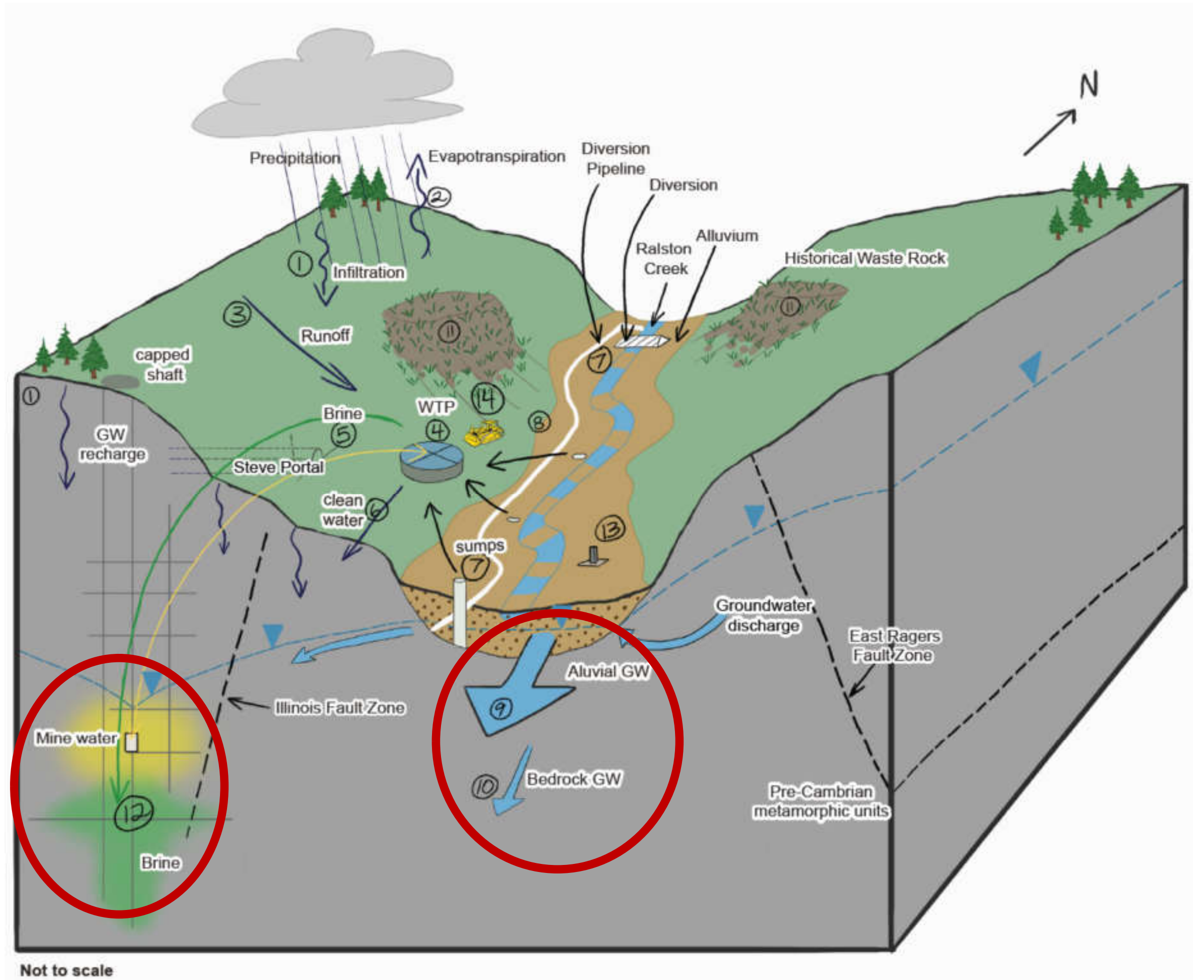
GROUNDWATER
SCHWARTZWALDER MINE SITE

- #9 - Alluvial groundwater.
- #10 - Bedrock groundwater.
- #12 - Mine water.



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ALLUVIAL GROUNDWATER
SCHWARTZWALDER MINE SITE

- Porous flow with relatively high hydraulic conductivity values; 10^{-4} cm/s – 10^{-2} cm/s
- Recharged by direct infiltration, runoff, and shallow groundwater discharge.
- All flows are diverted upstream of the site (except for highest flow conditions), into a pipe, or captured by the sump system, to limit interaction with site materials.
- Additional alluvial water is intercepted by the sumps and sent back to WTP/mine pool.
  - Sumps are typically dry expect following precipitation events.
  - As excavation progress has advanced less sump water is recovered.

Spring 2018: Dry Ralston Creek as it runs across site

ENSERO solutions

BEDROCK GROUNDWATER FLOW
SCHWARTZWALDER MINE SITE

- Dominated by fracture flow (Illinois Fault System) in Precambrian gneiss, schist, and pegmatite with potential connections to Ralston Creek via joints/fractures.
- Low hydraulic conductivity (10^{-8} – 10^{-5} cm/s).
- Low permeability of the bedrock limits flow from Ralston Creek into the mine. However, when mine pool was flooded (2000's), local/shallow interflow toward Ralston Creek was present.
- Regional (deeper) flow toward the Denver Basin.

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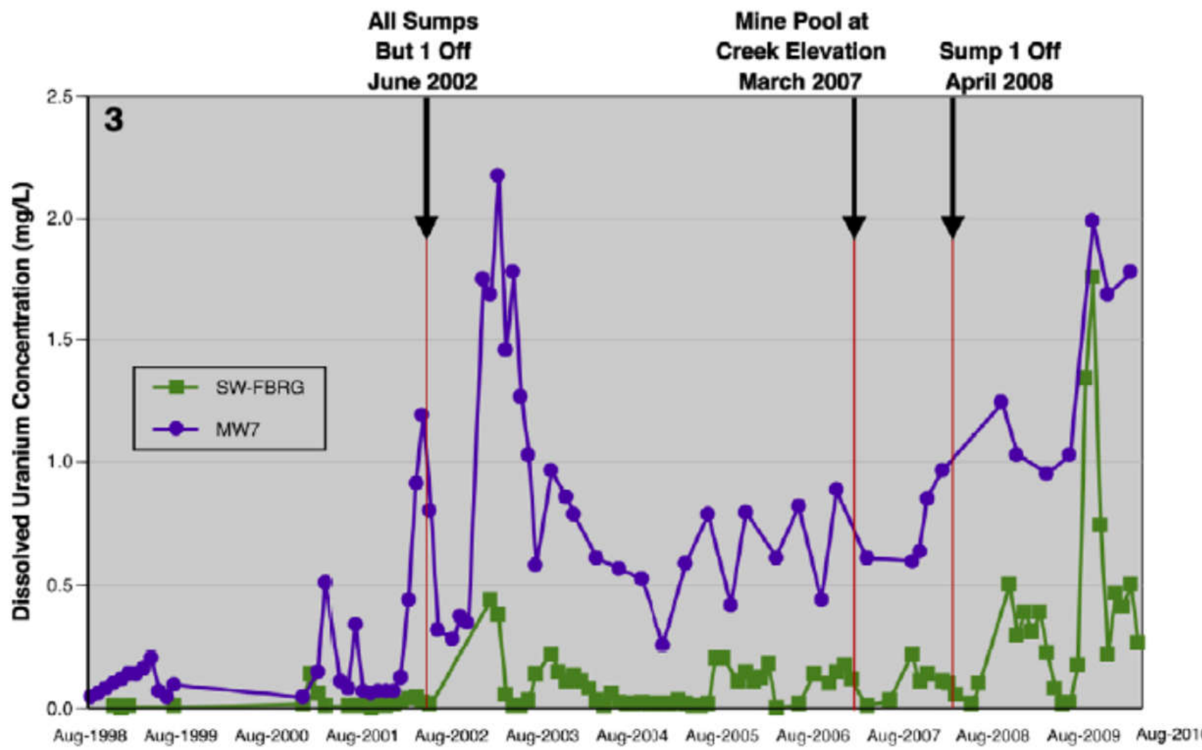
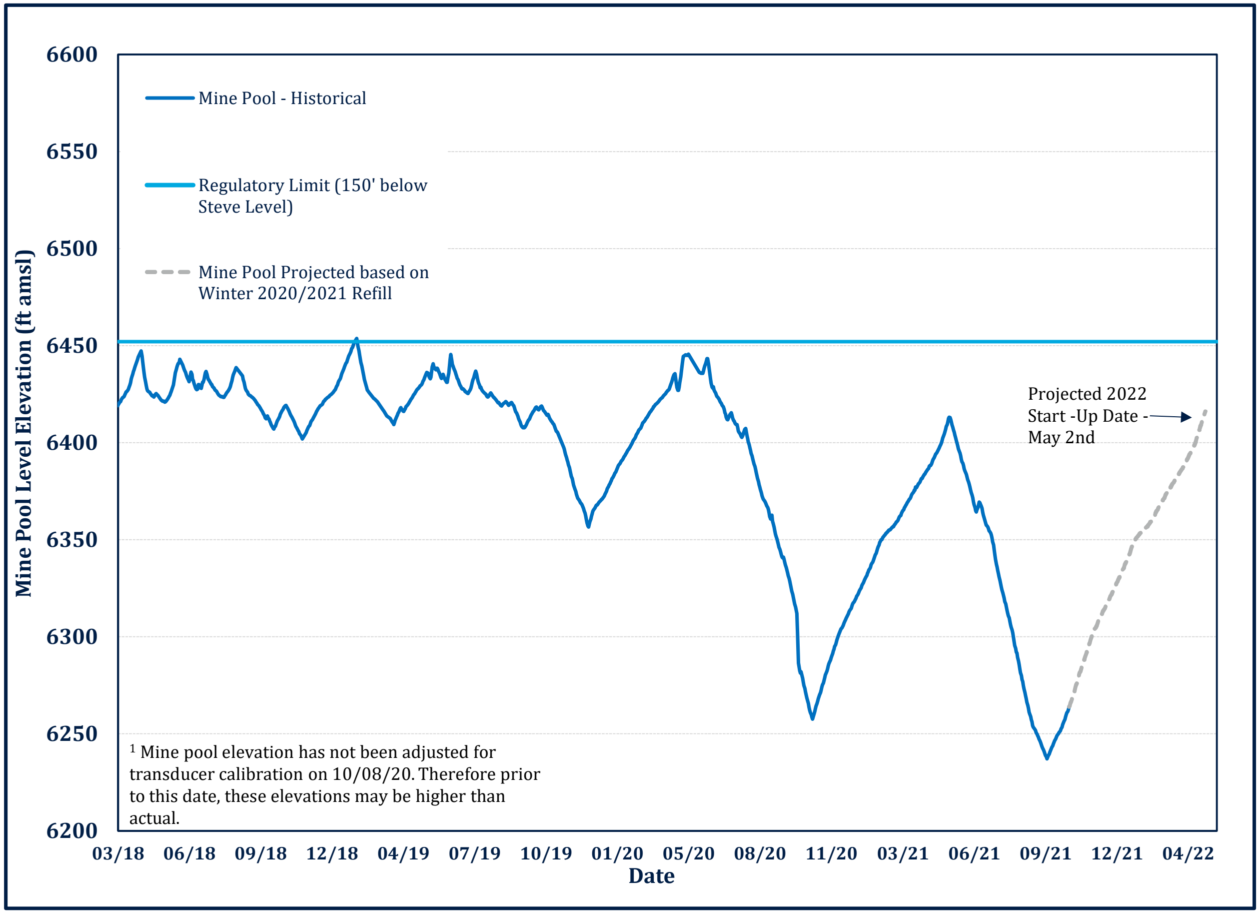
BEDROCK GROUNDWATER FLOW
SCHWARTZWALDER MINE SITE

- Ralston Creek does not appear to be in strong or direct hydraulic connection with the Schwartzwalder Mine based on stream flow rates / mine pool pumping rates, and isotopic comparison of mine water and surface water (performed by Cotter).
- Historical observed uranium concentrations suggest some hydraulic connection from the mine pool to Ralston Creek, when the mine pool was flooded (2000's) to creek elevation.
  - Flows from the creek to the mine are small and controlled by the inherent low permeability of the rock mass and the dry creek in the mine area.



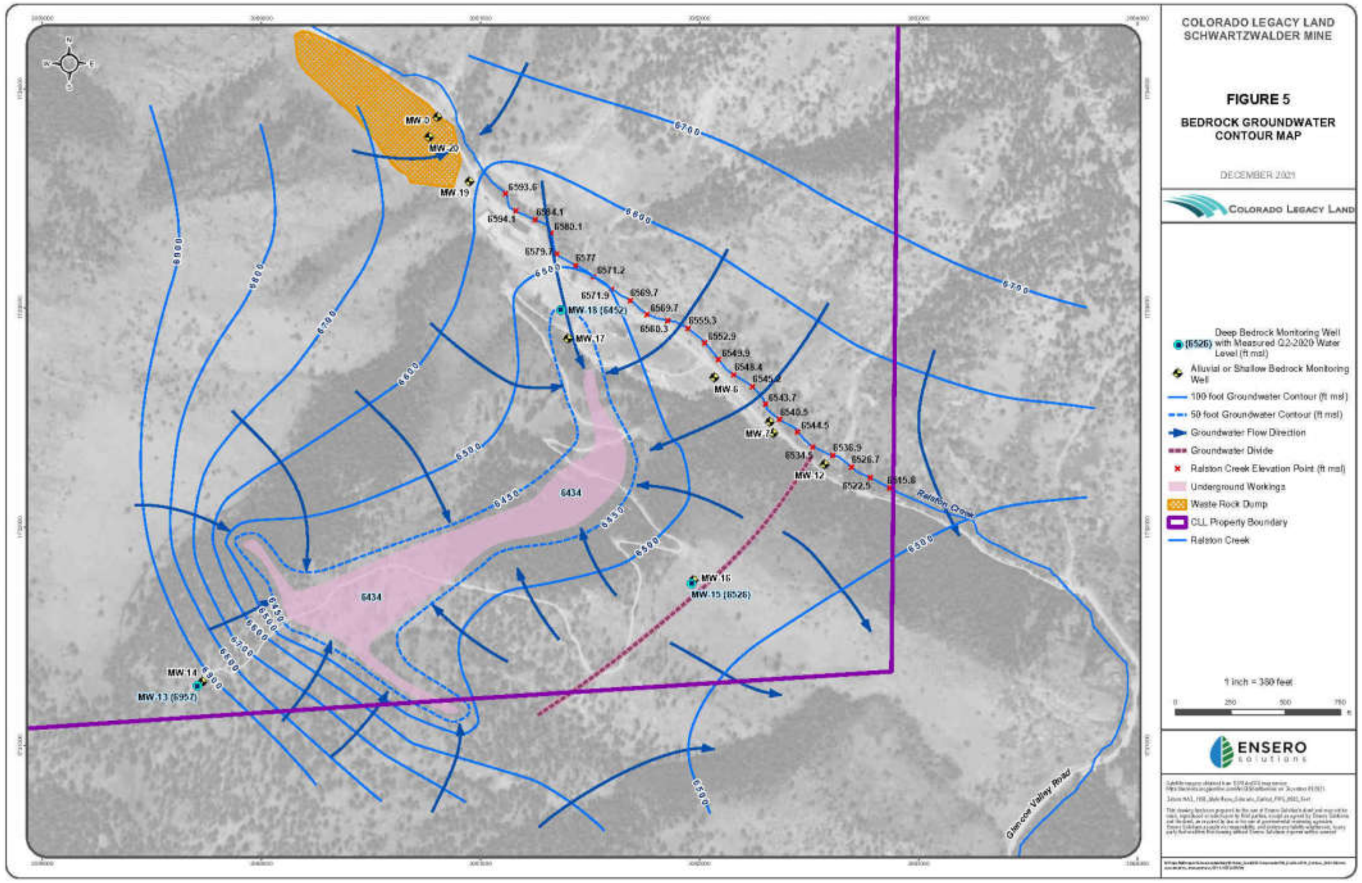
BEDROCK GROUNDWATER FLOW
SCHWARTZWALDER MINE SITE

- AM-06, Figure E-1. Mine Pool Projected Recovery.
  - Mine pool was first decreased to greater than regulatory limit November 2017.
  - CLL acquired the site from Cotter in March 2018.
  - Deep intake pump (60 HP pump) installed in January 2019.
  - Negative Slope = WTP in operation, actively dewatering the mine pool.
  - Positive Slope = WTP offline, mine pool refilling.



BEDROCK GROUNDWATER FLOW
SCHWARTZWALDER MINE SITE

- Maintaining a dewatered mine pool (150-feet or greater below the Steve level adit) has created an inward gradient in the bedrock groundwater.
- Groundwater in the permit area flows back toward the mine workings (shown with red-shaded area).



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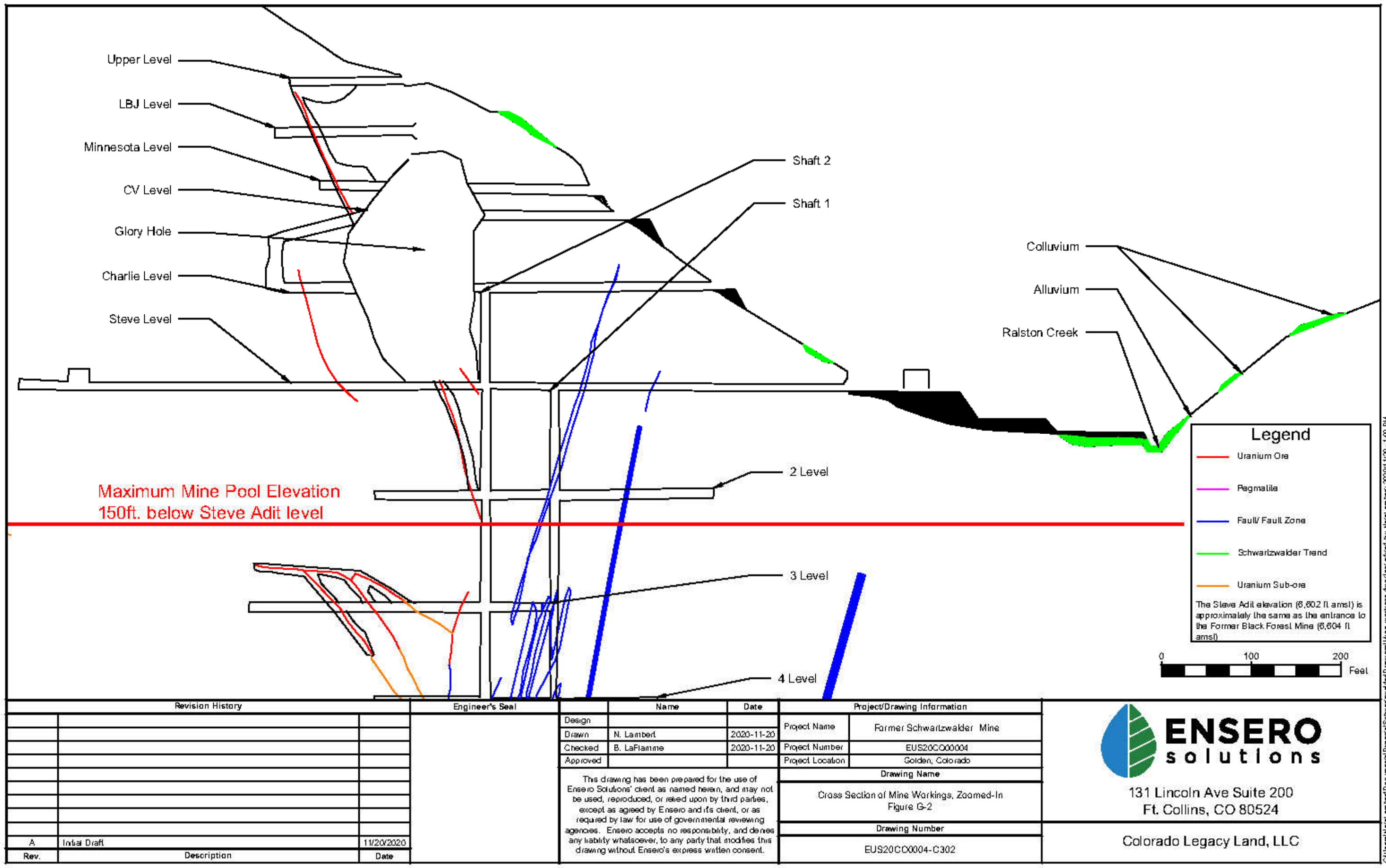
MINE WORKINGS AND GEOLOGICAL FEATURES
SCHWARTZWALDER MINE SITE



MINE WATER – IN-SITU TREATMENT
SCHWARTZWALDER MINE SITE

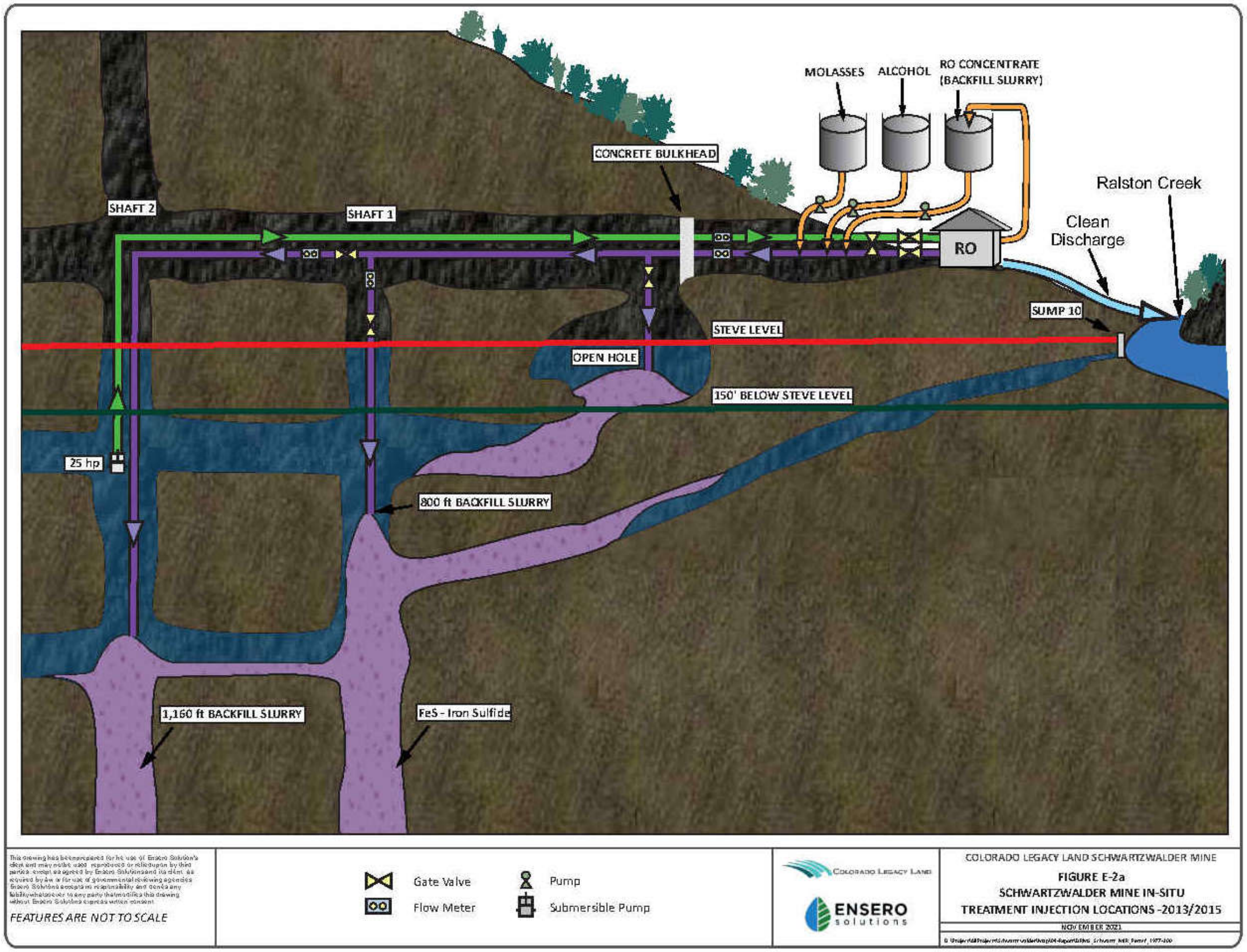
- Currently pumped down between 160 to >354 ft below the Steve-adit level.
  - Regulatory Level is 150 feet below the Steve-adit
- Contains water with elevated concentrations of uranium, molybdenum, and selenium.
- WTP returned constituents as RO concentrate to mine pool for long-term storage.
- In-situ treatment conducted during winter months when WTP is offline.

September 29, 2021. In-situ Injection Delivery

ENSERO solutions

MINE WATER – IN-SITU TREATMENT
SCHWARTZWALDER MINE SITE

- In-situ treatments: 2013, 2015, 2017, 2020, and 2021.
- The January 2020 in-situ treatment did not result in dramatic decreases in dissolved uranium concentrations as during the first two in-situ treatments.
  - May be an indication of a change in underground hydraulics during in-situ treatment.

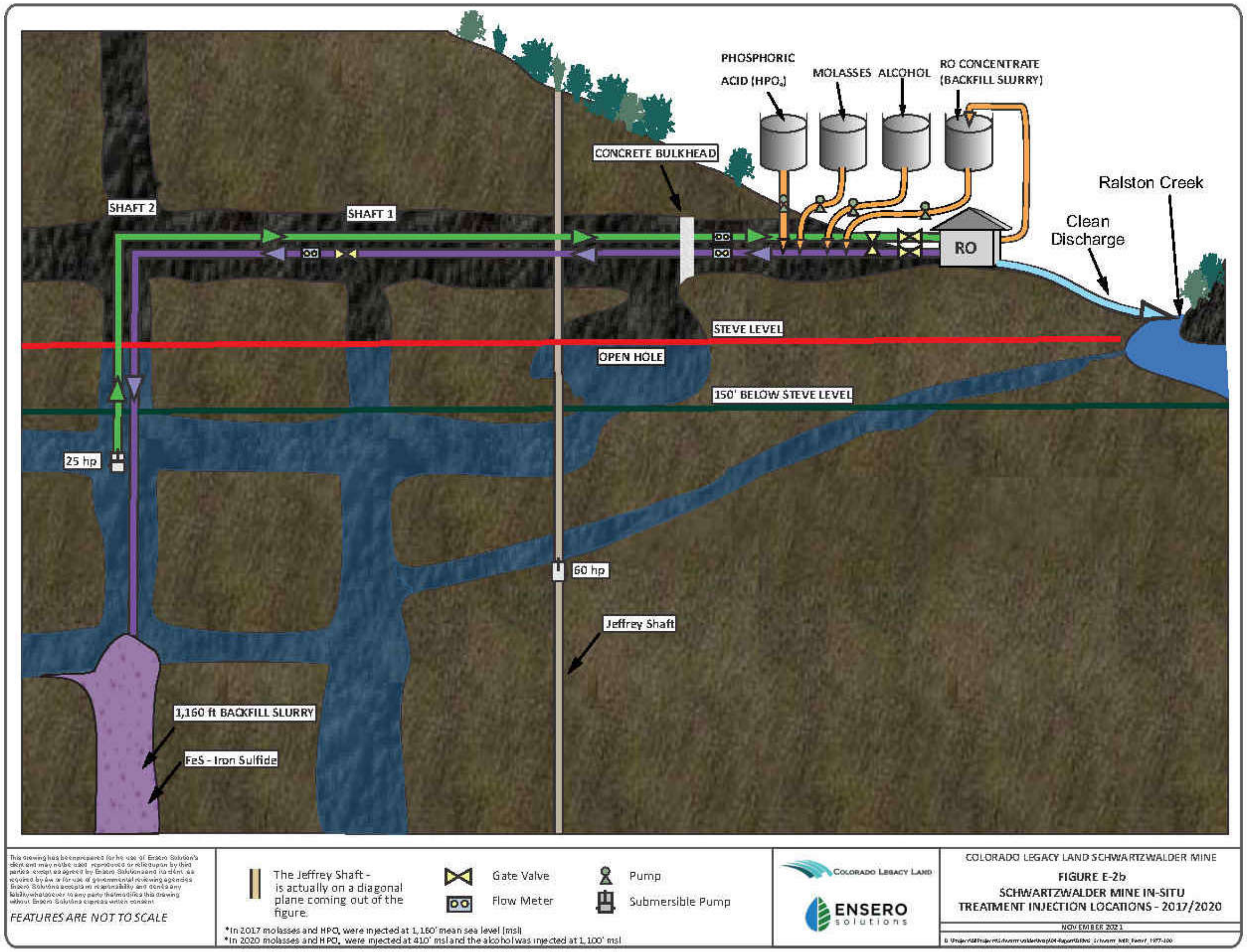


Schematic for 2013 and 2015 in-situ injection

ENSERO solutions

MINE WATER – IN SITU TREATMENT
SCHWARTZWALDER MINE SITE

- September 2021 injection:
  - WTP shut down for year 9/23/21.
  - Phosphoric nutrient: 10,857lbs on 9/24.
  - Ethanol: 6,700 gal on 9/29/21.
  - Pumps were recirculated after injection to promote mixing (~ 676,000 gal mixed).

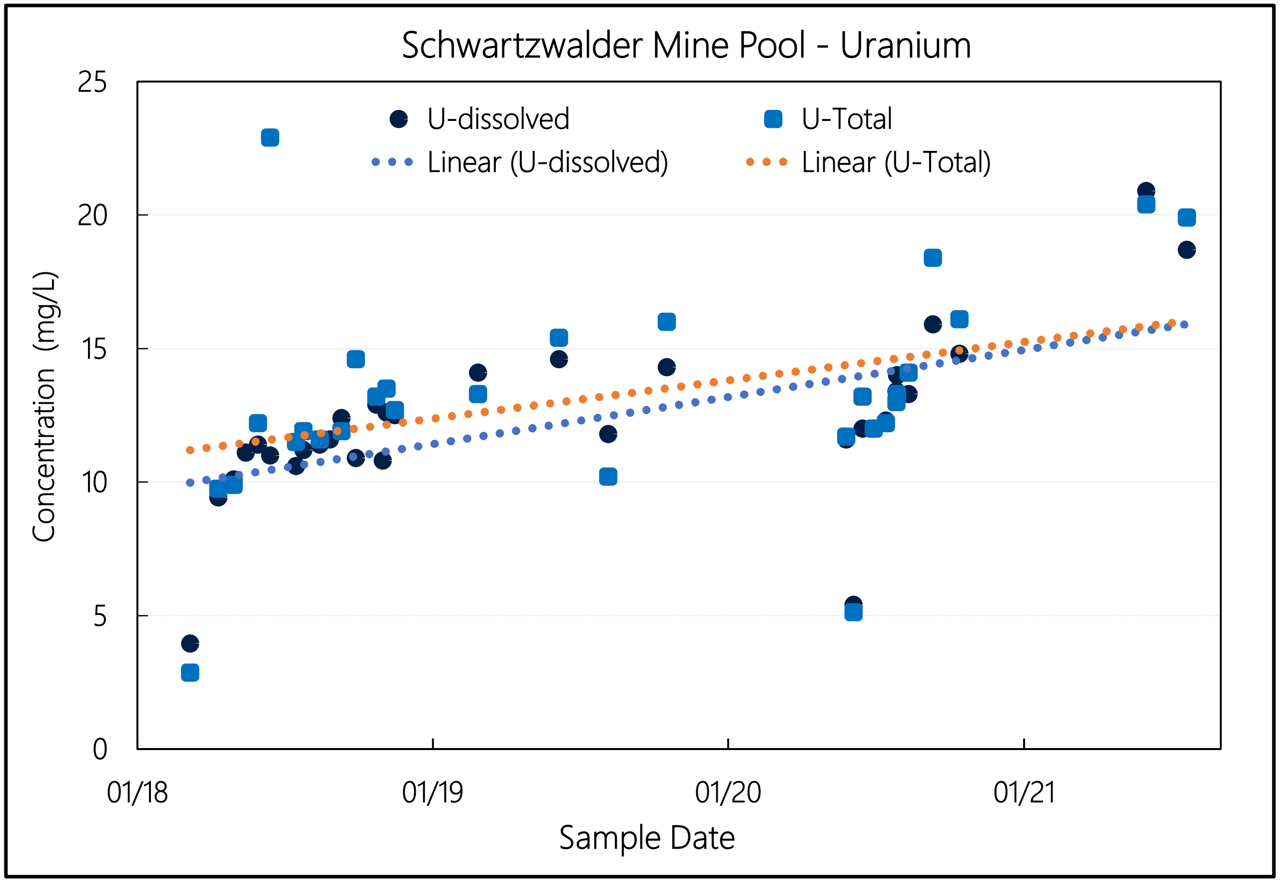


Schematic for 2017, 2020, and 2021 in-situ injection

ENSERO solutions

MINE WATER – IN-SITU TREATMENT
SCHWARTZWALDER MINE SITE

- Dissolved uranium concentrations in the mine pool:
  - Pre-treatment mean. (pre 2017). = 41.14 mg/L
  - Post treatment mean. = 12.75 mg/L
- CLL has successfully stabilized the mine pool to ~50% of pre-treatment concentrations.
  - Typical range (2018 to 2021) = 10 to 15 mg/L
- Cation/anion concentrations and ratios from pre-treatment vs. post treatment do not indicate degradation of general water quality parameters, overall TDS has remained unchanged.



MINE WATER – IN-SITU TREATMENT
SCHWARTZWALDER MINE SITE

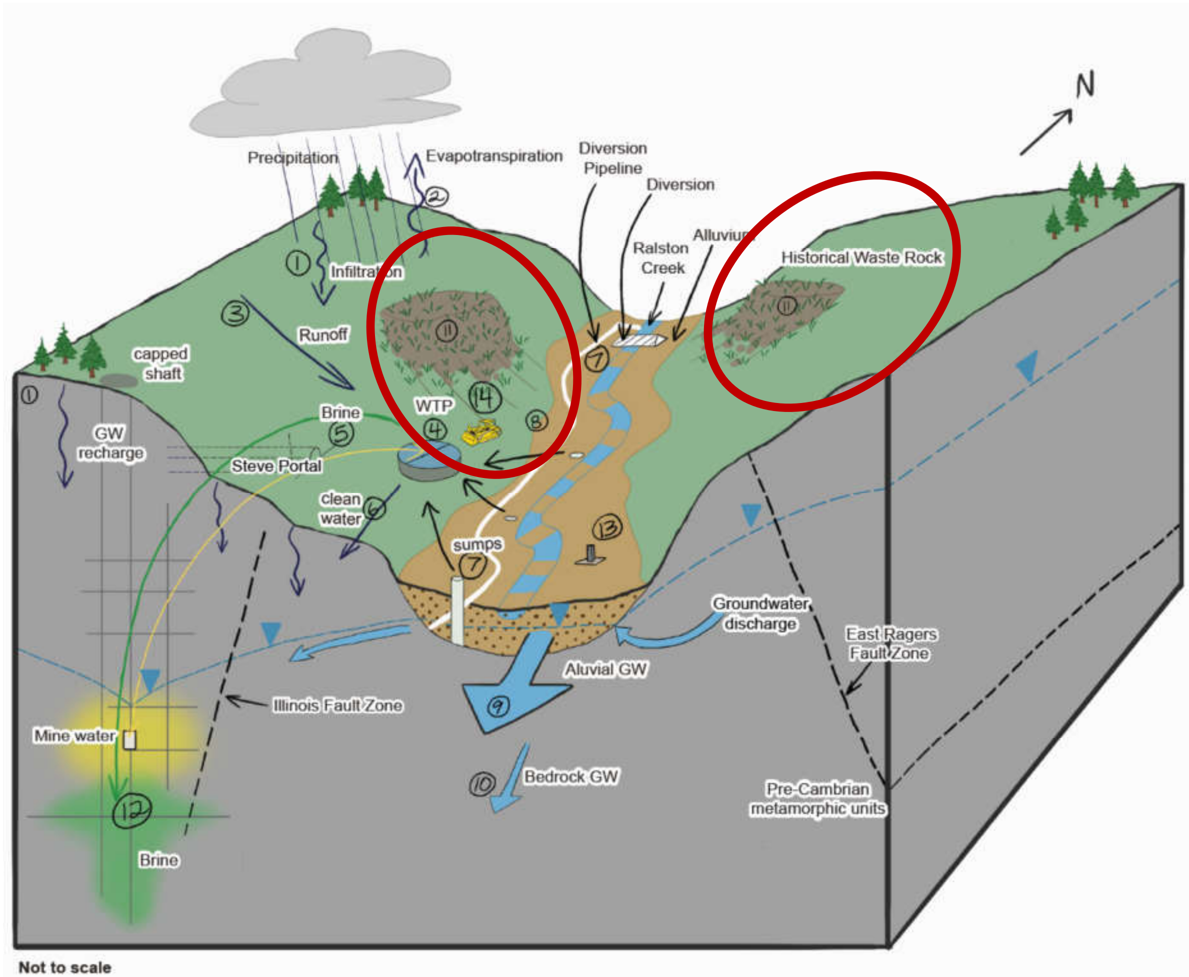
- Comparison of mine pool chemistry data indicates that general chemistry parameters are relatively stable while the concentration of uranium has decreased from 41 mg/L (Pre-treatment, 2000 to 2007) to 12 mg/L (Post-treatment, 2018 to 2021).

AM-06, Table E-2: Comparison of Schwartzwalder Mine Pool Concentrations pre-2017 and post-2017

Variable	Units	2018-2021	2000-2007
General Parameters			
Bicarbonate as $CaCO_3$	mg/L	790	374
Calcium	mg/L	302	299
Chloride	mg/L	43	31
Potassium	mg/L	27	17.2
Sodium	mg/L	235	197
Sulfate	mg/L	1,362	1,725
Total Dissolved Solids	mg/L	2,850	2,917
Dissolved Metals			
Antimony	mg/L	-	0.014
Arsenic	mg/L	0.013	0.0036
Iron	mg/L	4.1	0.020
Thallium	mg/L	-	0.025
Uranium -Dissolved	mg/L	12	41
Radionuclides			
Radium 226 - Dissolved	pCi/L	127	178

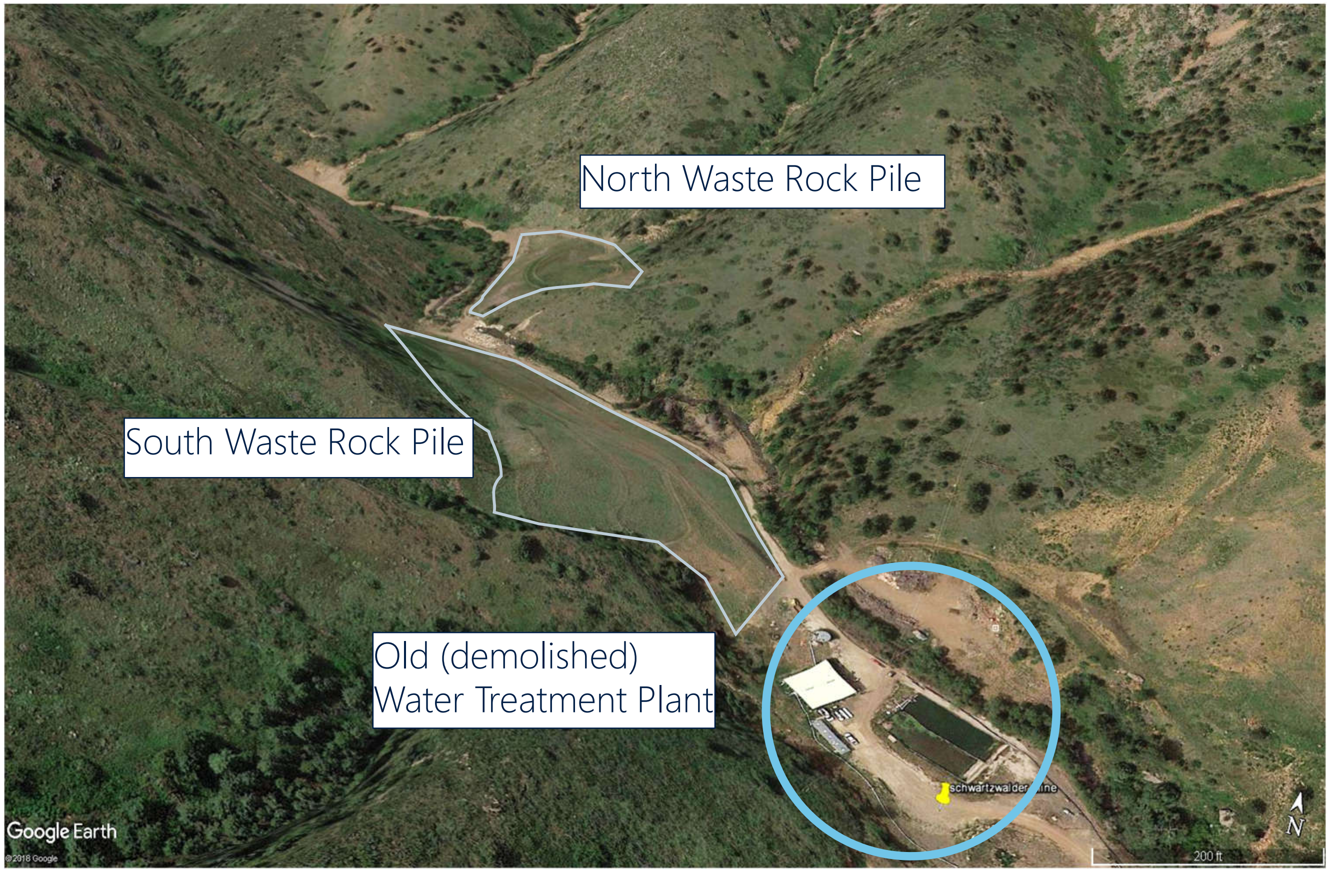
HISTORICAL FACILITIES
SCHWARTZWALDER MINE SITE

- #11 - Historical North and South Waste Rock Piles (Reclaimed)
- #14 – Mine Reclamation
  - Old (demolished) Water Treatment Plant
  - Mine Opening Closures



ENSERO solutions

RECLAIMED WASTE ROCK PILES
SCHWARTZWALDER MINE SITE



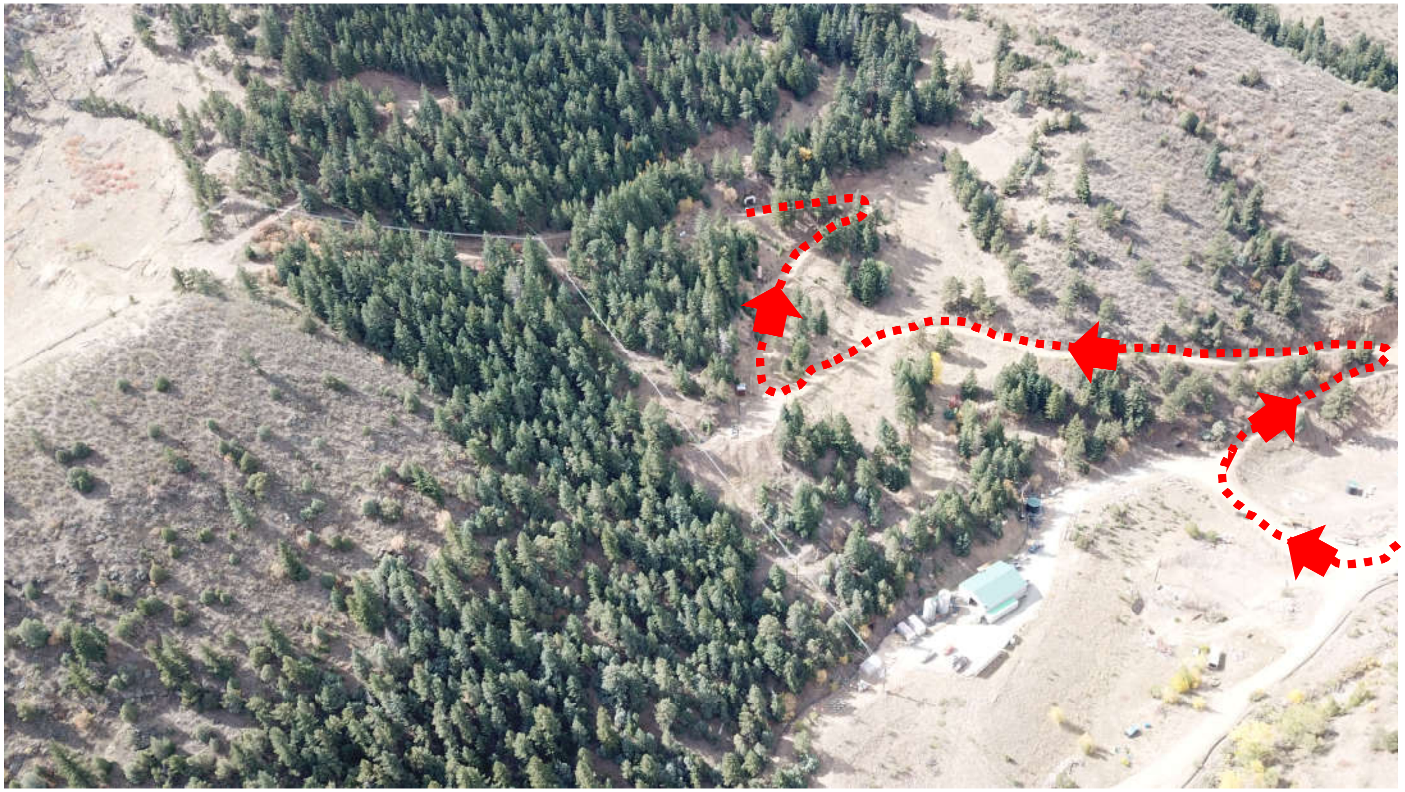
RECLAMATION: SITE PREPARATION (SPRING – SUMMER 2018)
SCHWARTZWALDER MINE SITE

- Regrade and widen haul road to Minnesota Adit. Prepare material staging area near Minnesota for underground disposal

Spring 2018: Haul road up to the Minnestoa Adit (left) and entrance to the Minnesota Adit (right).

RECLAMATION: SITE PREPARATION (SPRING – SUMMER 2018)
SCHWARTZWALDER MINE SITE

Haul Route to Glory Hole in Minnesota Adit



RECLAMATION: SITE PREPARATION (SPRING – SUMMER 2018)
SCHWARTZWALDER MINE SITE

- Reroute sump collection and relocate utilities.
- Demolish old water treatment plant, office trailer, concrete containment, parking apron

Spring 2018: Old Water Treatment Plant

Fall 2018: Demolished Old Water Treatment Plant

ENSERO solutions

RECLAMATION: SITE PREPARATION (SPRING – SUMMER 2018)
SCHWARTZWALDER MINE SITE

- Demolish old water treatment plant, office trailer, concrete containment, parking apron

Fall 2018: Demolished Old Water Treatment Plant

Fall 2018: Demolished Old Water Treatment Plant

ENSERO solutions

RECLAMATION: INSTALL 60 HP PUMP IN JEFFERY AIR SHAFT
SCHWARTZWALDER MINE SITE

- Winter 2018 – 2019. Began installation of 60 hp pump in Jeffery Air Shaft to allow for seasonal operation of WTP.
- Uncovered air shaft and performed down-hole camera inspection.
- Technical Revision #26.

Winter 2018-2019: 60HP Intake Pump

ENSERO solutions

RECLAMATION: INSTALL 60 HP PUMP IN JEFFERY AIR SHAFT
SCHWARTZWALDER MINE SITE

- Winter 2018 - 2019.
- Construct headframe, design pump & connect discharge line to WTP on mesa.
- Headframe / wench system allow CLL to service the pump without going underground.
- Intake at ~410 feet below the Steve Adit.
  - Jeffery Air Shaft is not perfectly straight.


Winter 2018-2019: 60HP Intake Pump

ENSERO solutions

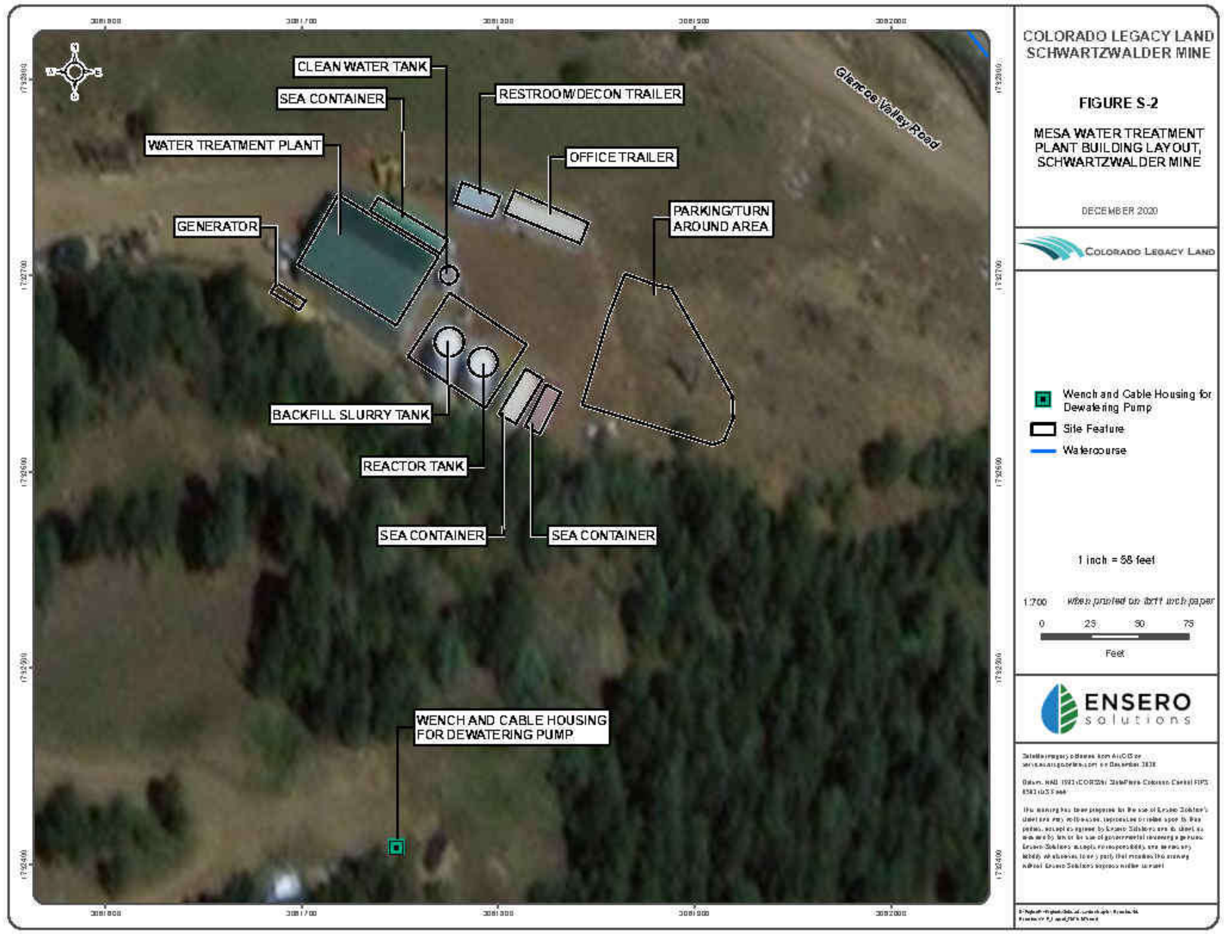
RECLAMATION: INSTALL 60 HP PUMP IN JEFFERY AIR SHAFT
SCHWARTZWALDER MINE SITE

- Winter 2018-2019: Lower new pump to depth and perform commissioning.



RECLAMATION: RELOCATE WATER TREATMENT PLANT
SCHWARTZWALDER MINE SITE

- AM-05, Figure S-2 Mesa Water Treatment Plant Building Layout



ENSERO solutions

RECLAMATION: ALLUVIAL VALLEY EXCAVATION
SCHWARTZWALDER MINE SITE

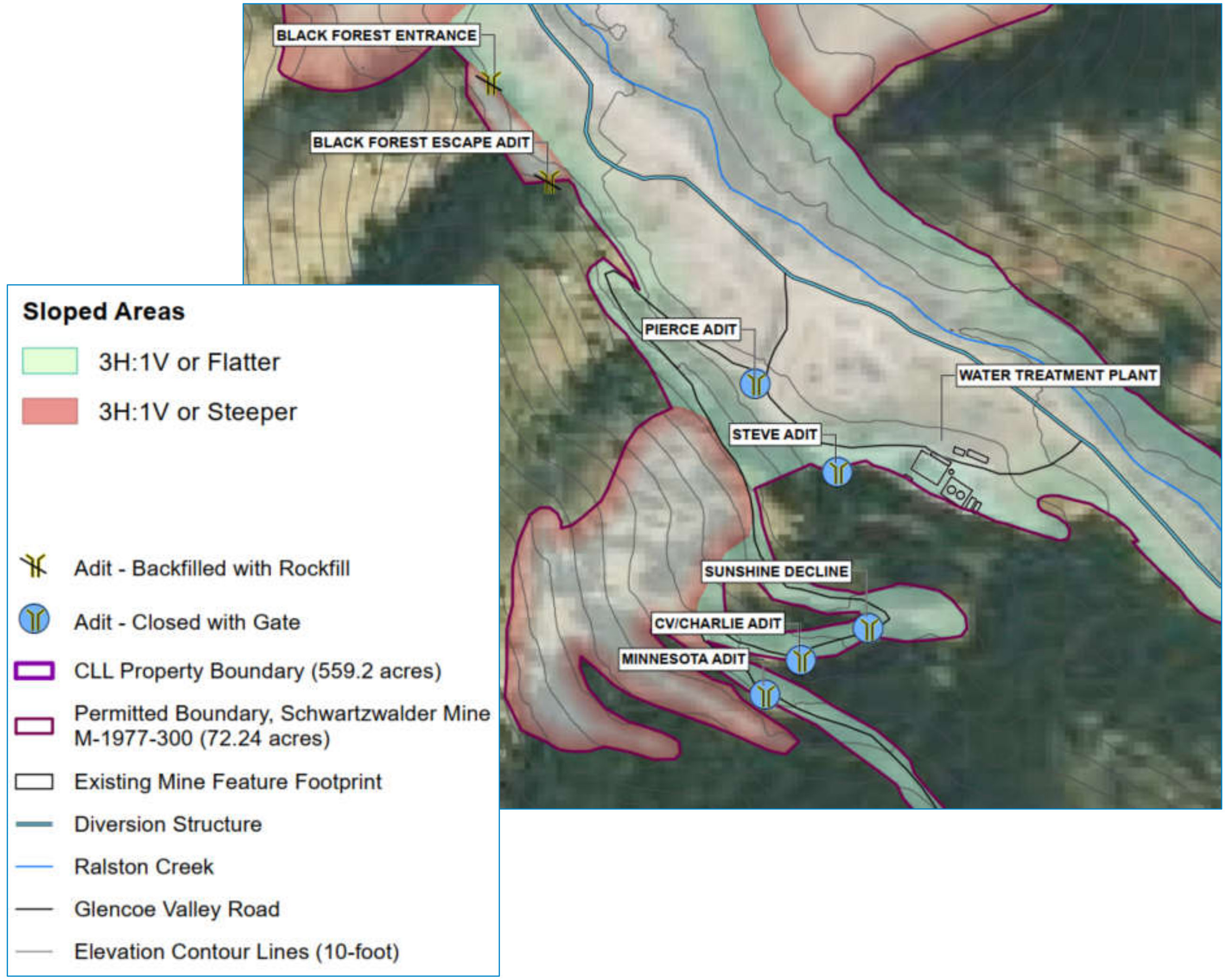
- Fall/Winter 2018 to present.
- Excavation work is seasonal. Expected completion, Spring 2022.

Winter 2018: Alluvial Valley Excavation

ENSERO solutions

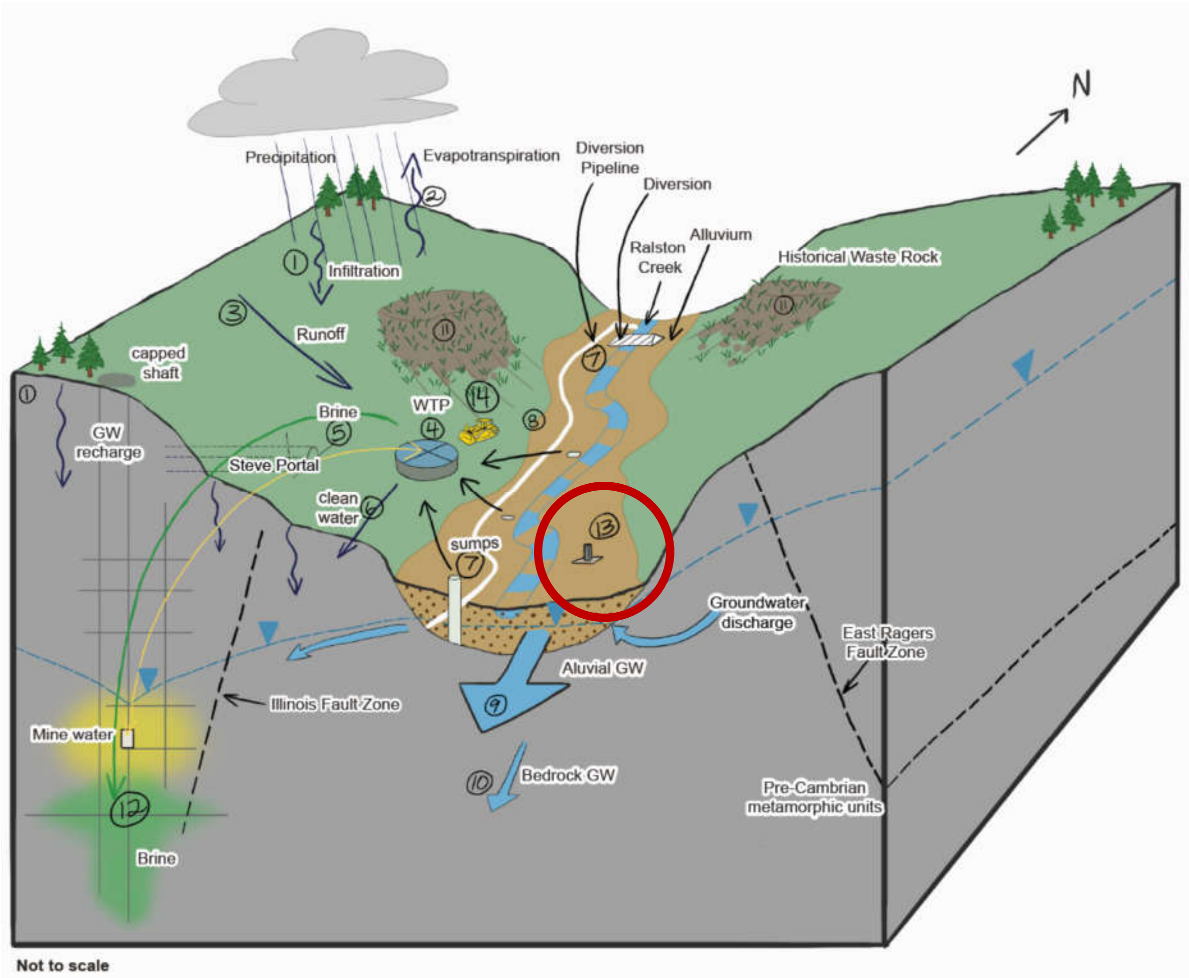
MINE OPENING CLOSURE
SCHWARTZWALDER MINE SITE

- Figure F-1 Reclamation Plan Map of AM-05 identifies adit closure types.
- Adits - Closed with gates by Cotter:
  - Minnesota
  - CV/Charlie
  - Sunshine
  - Steve
  - Pierce Adit
- Adits – Backfilled with Rockfill – 2022 Scope:
  - Black Forest Entrance
  - Black Forest Escape Adit



WATER QUALITY MONITORING
SCHWARTZWALDER MINE SITE

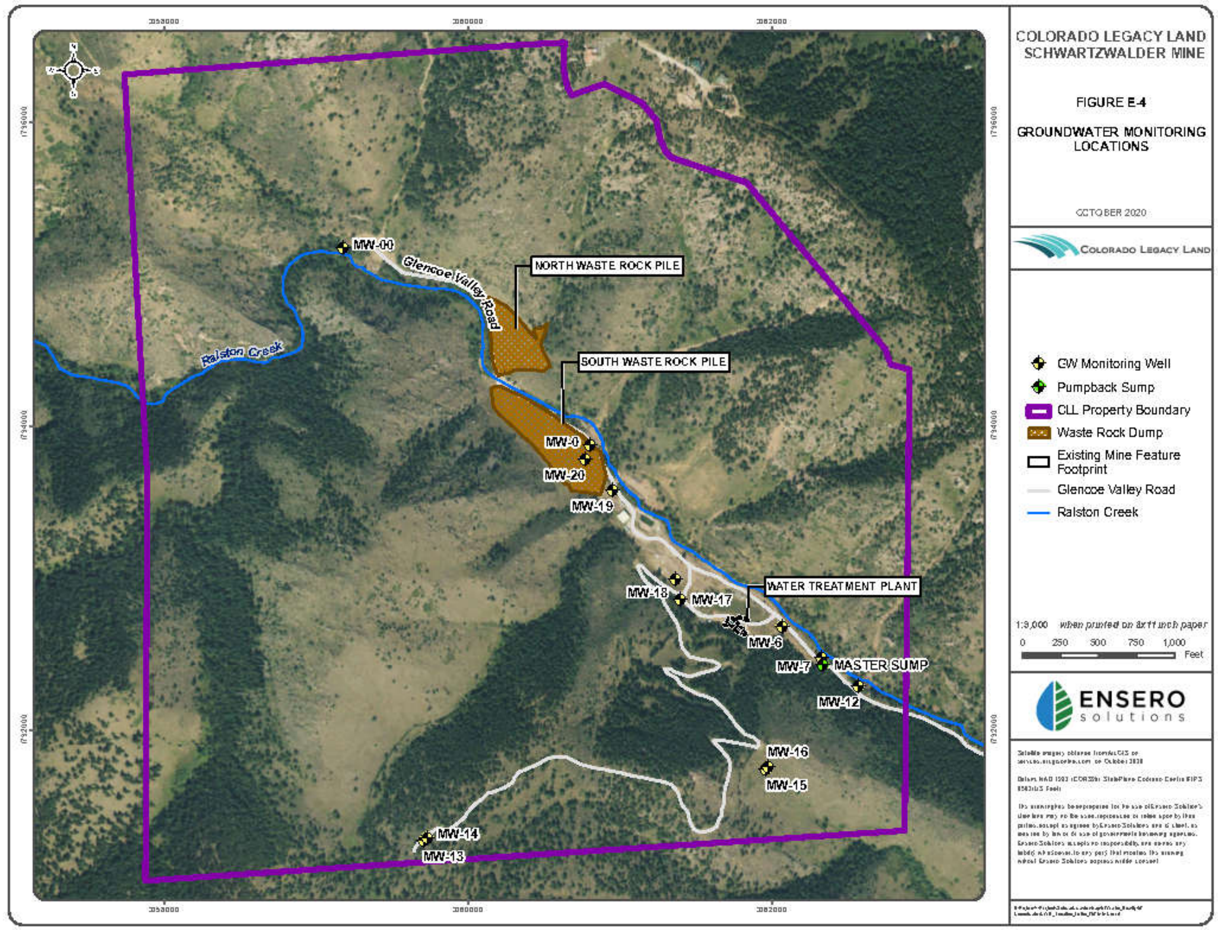
- #13 - Water Quality Monitoring
  - In addition to sampling for the discharge permit at the WTP, CLL performs quarterly surface water and groundwater monitoring for the Mine Land Reclamation Permit.



ENSERO solutions

GROUNDWATER MONITORING
SCHWARTZWALDER MINE SITE

- Quarterly monitoring of up to 13 wells.
  - Some alluvial wells were abandoned / removed during valley reclamation because the surrounding alluvium was removed.
- Upgradient, downgradient, and on-site adjacent to historical facilities and workings.
- Due to the dewatered condition of the mine and the bypass pipeline, many wells are dry.
- Deep Bedrock Monitoring Wells installed in 2012 to monitor the mine pool, Schwartz trend, and Illinois Fault zone.



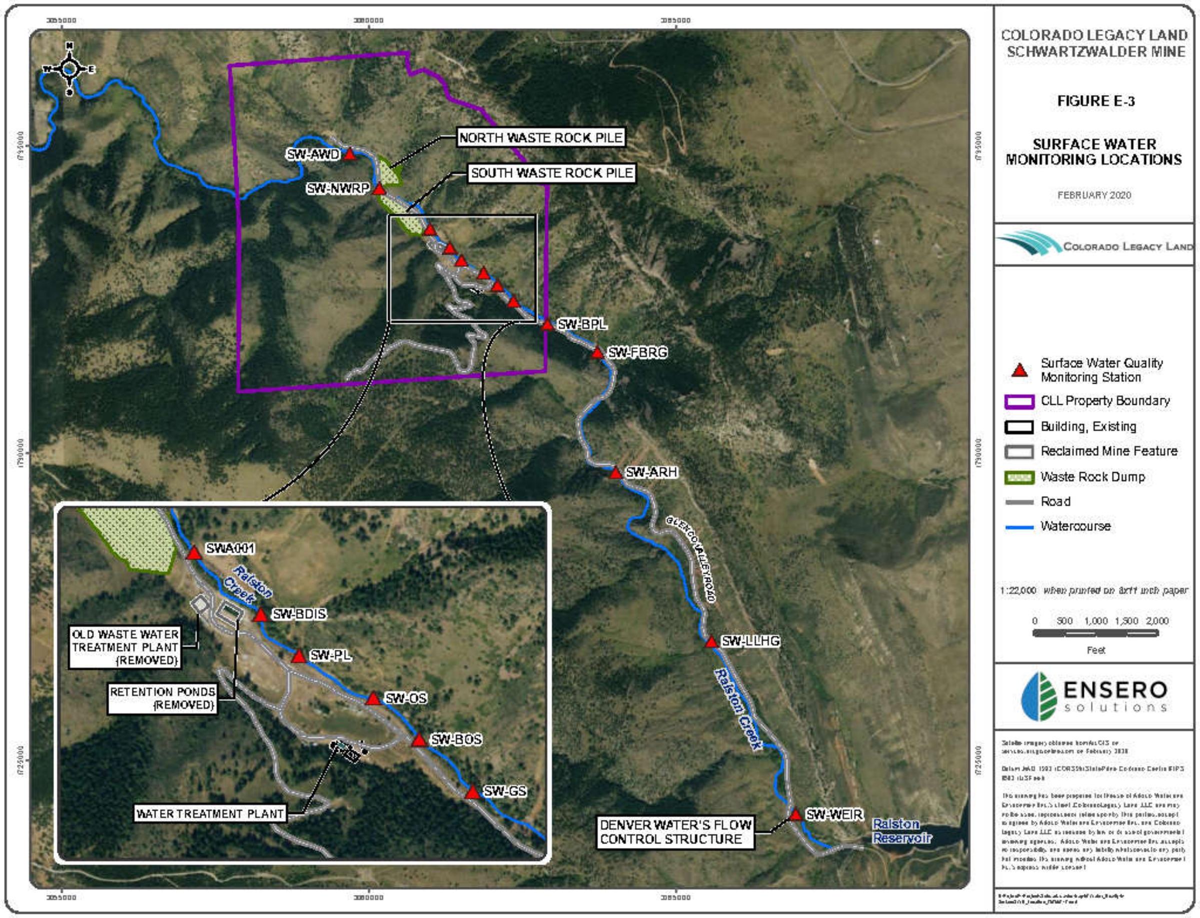
ENSERO solutions

GROUNDWATER MONITORING – DEEP MONITORING WELLS (2012)
SCHWARTZWALDER MINE SITE

Well ID	Location Description	Depth (feet bgs)	Purpose
MW-13	Upgradient – Deep	499.76	Background – replacement for MW-11
MW-14	Upgradient - Shallow	154.34	Background – replacement for MW-10
MW-15	East of Schwartzwalder Mine, targeting Schwartz Trend geologic transition zone, downgradient relative to pre-mining static water level - Deep	1,007.13	Determine vertical and horizontal gradient/directions; determine water quality in bedrock east of Schwartzwalder Mine
MW-16	East of Schwartzwalder Mines downgradient relative to pre-mining static waste level - Shallow	324.74	Determine vertical and horizontal gradients/directions; determine water quality in bedrock east of Schwartzwalder Mine
MW-17	Valley floor	119.00	Target Illinois Fault, determine alluvium/bedrock head differences, determine water quality in bedrock
MW-18	Valley floor	239.90	Target Illinois Fault, determine alluvium/bedrock head differences; determine water quality in bedrock

SURFACE WATER MONITORING
SCHWARTZWALDER MINE SITE

- 13 surface water monitoring locations on Ralston Creek.
- 1 upstream
- 5 downstream
- 7 adjacent to site facilities
- Ralston creek is seasonally dry and several onsite sample locations (shown in call out box of Figure E-3) are typically dry because Ralston Creek is diverted in a bypass pipeline.



ENSERO solutions

RECLAMATION SUMMARY
SCHWARTZWALDER MINE SITE

Remediation Priorities:

- Maintained dewatered mine pool.
- Excavate contaminated alluvium (source area).

Ongoing Environmental Operations:

- Seasonal operation of WTP (2018 – present).
- In-situ treatment (2013, 2015, 2017, 2020, & 2021).

Reclamation Timeline:

- Demolition and site prep (2018).
- Relocate Water Treatment Plant (2018).
- Install new intake pump (2018-2019).
- North waste rock pile diversion channel (2019- 2020).
- Alluvial valley excavation (2018 – present).
- Mine opening closure (2022).
- Excavation has removed alluvium around all sumps, except for Sump 1, eliminating their usefulness (2020-2021).

Summer 2019: Alluvial Valley Excavation Work

ENSERO solutions

2018 DATA ISSUES AND 2021 UPDATE: HYDROLOGY
SCHWARTZWALDER MINE SITE

- 2018: More accurate stream flow measurements to evaluate gaining/losing reaches with more confidence
  - 2021: CLL began collecting quarterly flow data in 2019. These data are reported with analytical results to all project stakeholders.
- 2018: Evaluation of future flood impacts on waste dumps and other facilities.
  - 2021: NWRP Channel was constructed in 2020. Onsite waste dumps and mesa were stable through 2013 flood.
- 2018: Additional evaluation of the Illinois Fault Zone, as it may be a significant connection between the mine area and Ralston Ck.
  - 2021: Currently N/A – CLL intends to maintain a dewatered mine pool to below required regulatory levels. Monitored by MW-15, MW-16, MW-17, and MW-18
- 2018: More robust infiltration/GW recharge evaluation
  - 2021: Provided in 2016 EPP and updated with new data in AM-06.
- 2018: More robust mine inflow analysis (in progress)
  - 2021: Provided in 2016 EPP and updated with new data in AM-06.
- 2018: Continued evaluation of mine pool geochemistry, inflows, in-situ treatment etc.
  - 2021: Provided in AM-06 & continued with quarterly monitoring program.

2018 DATA ISSUES AND 2021 UPDATE: CHEMISTRY
SCHWARTZWALDER MINE SITE

- Ongoing evaluation of contamination (mine, alluvium, bedrock, soils):
  - Surficial deposits (e.g., waste rock)
  - Soil/surface contamination from mining
  - Stored mass in alluvium (e.g., sorbed or labile phases like salts).
  - Mine pool connection to Ralston Creek and alluvium in dewatered condition.
  - Natural source from mineralized bedrock and secondary deposits in alluvium
- Ongoing monitoring of mine pool chemistry and groundwater quality in wells.

2018 DATA ISSUES AND 2021 UPDATE: NEXT STEPS
SCHWARTZWALDER MINE SITE

- 2018: Complete alluvial valley excavation of known contaminated soils (source materials).
  - Greater than 95% complete and expected to complete in 2022.
- 2018: Finish demolition of old WTP building in valley (concrete containment area, old WTP, old office trailer).
  - Completed in 2018
- 2018: Construct conveyance pipeline to prevent ephemeral SW drainage onto the North Waste Rock Facility.
  - Completed in 2020.
- 2018: Resume scheduled in-situ treatment of mine pool.
  - Completed in 2020 and 2021
- 2018: Lower WTP intake pump down in mine pool (60hp pump).
  - Completed in 2019.

2018 DATA ISSUES AND 2021 UPDATE: NEXT STEPS
SCHWARTZWALDER MINE SITE

- Continued environmental monitoring, reporting with Agencies and project stakeholders.
  - Application Amendment 05.
  - Application Amendment 06.
  - Technical Revisions 26, 27, 28, and 29.
  - Monthly surface water sampling report.
  - Monthly discharge report from water treatment plant.
  - Quarterly environmental monitoring (surface water and groundwater sampling) report.

2018 DATA ISSUES AND 2021 UPDATE: NEXT STEPS
SCHWARTZWALDER MINE SITE

- Communication with Agencies and project stakeholders:
  - May 2018: Meet & greet with Beartooth Ranch HOA.
  - July 2018: Meet & greet / site tour with Jefferson County Open Space. Open dialogue & access for wildlife biologists to study the site.
  - October 2018: Field trip for Colorado School of Mines students in "Mining & the Environmental Class".
  - November 2018: Presented initial Conceptual Site Model to DRMS, Denver Water & Geosyntec.
  - October 2019: Field trip for Colorado School of Mines students in "Mining & the Environmental Class".
  - June 2019: Site tour for DRMS, Denver Water & Geosyntec.
  - May – July, 2020: Correspondence with Denver Water on environmental monitoring data.
  - Summer 2020: Meet & greet / site tour with Conservation Land Trust(s).
  - October 2020: Site tour for DRMS, Denver Water & Geosyntec.
  - July – October 2020: Receive & respond to comments on AM-05.
  - January 2021: Virtual meeting with DRMS, Denver Water, Geosyntec, & City of Arvada to respond to comments on SR-9.
  - May 2021: Site tour with DRMS, Denver Water & Geosyntec.
  - May 2021: Virtual meeting with Denver Water, Geosyntec,
  - June 2021: Site tour with City of Arvada & DRMS.
  - July – December 2021: Receive and respond to comments on AM-06.
  - November 2021: Virtual meeting with City of Arvada, Denver Water, Geosyntec, and DRMS on AM-06 comments.

APPENDIX 2. TRACER TEST

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Tracer Test

During 2020, a two-chemical tracer test was conducted in the Schwartzwalder Mine to evaluate the system hydraulics and the degree that organic carbon placed underground would disperse within the mine workings to facilitate in-situ treatment. The tracer test setup is shown diagrammatically on Figure 1. Note that the Jeffrey Shaft connects to the #2 Shaft at about 1,100 ft below the Steve Level (bsl). After mine pool pumping was discontinued on December 20, 2019, the mine water level rose in response to groundwater inflows and sump water injected into the workings. On January 28, 2020, during the period of rising water level, 25 pounds (lbs) of Rhodamine WT dye was mixed with 49,400 lbs of beet molasses and gravity fed through a pipe in the #2 Shaft, discharging into the mine water at a depth of 410 ft bsl. On January 29, 2020, 6 lbs of Fluorescein dye was mixed with 44,800 lbs of ethanol and placed in a similar manner in the #2 Shaft at a depth of 1,110 ft bsl.

During the next three months, the fluorescent dyes dispersed within the mine workings as the mine water level continued to rise as shown on Figure 2. From April 19 to May 28, 2020, the mine pool was pumped using either the 60 horsepower (hp) pump set at 410 ft bsl in the Jeffrey Shaft or the 25 hp pump set at 210 ft bsl in the #2 Shaft. After seven days of non-operation, the system was then pumped starting on June 4, 2020, using the 60 hp pump. Pumping with the 60 hp pump was maintained until October 29, 2020, after which the mine water level again rose due to groundwater inflow and sump injection. During 2020, the highest mine water level was approximately 6,423 ft msl, which occurred during early May.

During mine pool pumping from May through October 2020, water samples were collected from the mine water (influent to the WTP) and sent to Ozark Underground Laboratory for analysis of Rhodamine WT and Fluorescein concentrations. Tracer sampling was discontinued on October 27, 2020, just before mine pool pumping was discontinued to initiate the winter shutdown. During the winter shutdown, the mine water level again rose due to groundwater inflows and sump water injection. Pumping with the 60 hp pump was resumed on June 4, 2021 and maintained into the fall. After 2021 pumping resumed, two additional samples of the WTP influent were obtained in mid-June and early August.

Tracer Test Concept

After injection, the tracers were expected to disperse within the mine workings by several mechanisms including advection and possible density variations. The Rhodamine WT/beet molasses mixture was used to create an injection mixture with a density greater than water and thus had the potential to sink downward within the #2 Shaft. Conversely the Fluorescein/ethanol mixture created an injection mixture with a density less than water and had the potential to rise upward in the #2 Shaft and possibly in the Jeffrey Shaft. In addition to density-related mechanisms, there was continuous upward advective flow in both the #2 Shaft and the Jeffrey Shaft, driven by deeper groundwater inflow to the mine and water going into storage within open voids at the rising water table.

When mine pool pumping was resumed, the tracers were expected to migrate to the pump and become part of the influent to the WTP. Because the WTP is based on reverse osmosis (RO), tracers entering the plant were retained and sent back into the mine via the RO reject. While a tracer could migrate vertically within the mine (e.g., due to density variations), it is unlikely that any tracer left the mine during the tracer test. In fact, no tracers left the mine/WTP system as confirmed by sampling the WTP treated-water discharge, which was non-detect for both Rhodamine WT and Fluorescein. The current water management strategy of depressing the mine water level by pumping ensures that water in the mine pool does not leave the mine and migrate into the outside groundwater flow system.

The interpreted flow conditions that occurred during early pumping (May 2020) using the 25 hp pump located in the #2 Shaft is shown on Figure 3. While there was a net water discharge from the mine (WTP treated discharge), the tracers in the WTP were returned to the #2 Shaft via the RO reject. Because there was upward flow from the lower mine workings, dissolved tracer would become "trapped" in an accumulation/recycle zone (ARZ) extending from the bottom of the return pipe at 1,100 ft bsl to the 25 hp pump intake at 210 ft bsl. New mine water would continuously pass through the ARZ, and if that water contained tracer, it would accumulate in the ARZ and one would expect to see systematically increasing tracer concentrations in the WTP influent. When mine pool pumping was transferred to the 60-hp pump, a new ARZ was established in the Jeffrey Shaft as shown on Figure 4. The tracer concentrations in the newly created Jeffrey Shaft ARZ would be expected to systematically increase over time as long as pumping was maintained. If the tracers were stable and chemically inert, and if the system had a high degree of collection efficiency, one would expect that after a long period of pumping, much of the originally injected tracer mass would end up recirculating in the prevailing ARZ

Groundwater Inflow Rates

An important component of the mine water balance is the rate of groundwater inflow into the mine, which should only depend on the mine pool elevation. For a given water level elevation in the mine, the inflow rate should be similar regardless of whether the mine is being pumped or is passively refilling.

Calculations were performed to estimate the mine inflow rate for two time periods shown as horizontal red lines on Figure 2. During the first period (December 1, 2019, to January 15, 2020), the mine water level ranged from 6,334 to 6,354 ft amsl and the computed total mine inflow rate was 60.6 gallons per minute (gpm). For the second period (October 7, 2020, to November 15, 2020), the mine water level ranged from 6,257 to 6,290 ft amsl and the computed inflow rate was 63.8 gpm. It is reasonable that the second inflow rate of 63.8 gpm is somewhat higher because the mine pool elevation was lower.

A separate calculation was performed to estimate the amount of inflow to the lower mine workings versus upper workings. For this analysis, "upper workings" were defined as those above 6,192 ft msl (or 410 ft bsl) and "lower workings" were those deeper than 6,192 ft msl. It was assumed that when the mine water level was 6,350 ft msl, the total mine inflow rate was 61 gpm. The calculations predict that for the mine water level at 6,350 ft msl, the inflow to upper workings would be 30 gpm and inflow to lower workings would be 31 gpm. The results suggest that during the entire tracer test, the continuous up flow from lower workings into the ARZ would be on the order of +/- 30 gpm.

When the mine was completely dewatered at full build-out, the reported inflow rate was 190 gpm. An additional calculation estimated that for this historical condition, inflow to the upper workings was 35 gpm and inflow to the lower workings was 155 gpm.

Tracer Concentrations

Tracer concentrations measured in the WTP influent are shown on Figure 5. Also shown on this figure are the periods when pumping was performed using the 60-hp pump located in the Jeffrey Shaft and the 25-hp pump in the #2 Shaft.

During early pumping with the 25-hp pump in the #2 Shaft, the Fluorescein concentration was at 13 to 16 micrograms per liter (µg/L), which may have resulted from density-driven upward migration of Fluorescein prior to pumping from its deep injection point in the #2 Shaft. In contrast, the Rhodamine WT concentration during early pumping was less than 3 µg/L. Although the Rhodamine WT/molasses mixture was placed at a shallower depth in the #2 Shaft, its higher density may have caused the mixture to migrate downward prior to pumping so that it only partially reached the pump. When the 60-hp pump was started in the Jeffrey Shaft in early June, there were marked changes in tracer concentrations. The Fluorescein concentration in the WTP influent dropped to less than 3 µg/L and the Rhodamine WT concentration increased to greater than 10 µg/L. The reasons for these concentration changes are unclear. While operating the 25 hp pump, an ARZ was set up in the #2 Shaft between the depths of 1,100 ft and 210 ft bls as shown on Figure 3. After 7 days of no pumping, the 60 hp pump was operated and a new ARZ was established in the Jeffrey Shaft between the depths of 1,100 ft and 410 ft bls as shown on Figure 4. It appears there was a loss of Fluorescein mass and an increase in Rhodamine WT mass in the WTP/mine recycle system when the ARZ shifted from the #2 Shaft to the Jeffrey Shaft.

After mid-June 2020, with continued pumping from the Jeffrey Shaft, the tracer concentrations were stable until pumping was discontinued at the end of October 2020. During this period, the Rhodamine WT concentrations ranged from 9 to 11 µg/L and the Fluorescein concentrations ranged from 2 to 3 µg/L. The systematic increase in tracer mass that was expected during continued operation of the Jeffrey Shaft ARZ was not observed in the tracer data. This observation suggests that nearly all available dissolved tracer had reached the ARZ and almost no additional dissolved tracer mass was migrating into the ARZ from other parts of the mine.

To investigate these observations further, a steady-state flow and Rhodamine WT mass balance was performed for the end of the pumping period (October 1 to October 28, 2020). These calculations are provided in Table 1 and flow/concentration values are shown graphically on Figure 6.

APPENDIX 2, TABLE 1: FLOW AND RHODAMINE WT MASS BALANCE FOR THE PERIOD 10/01/20 TO 10/28/20

$Q_{wt} := 270 \cdot gpm$	WTP influent	$\mu g := 10^{-6} \cdot gm$
$Q_{rj} := 106.9 \cdot gpm$	WTP reject	
$Q_{sp} := 20.1 \cdot gpm$	Sump	$\frac{Q_{rj}}{Q_{wt}} = 39.6 \cdot \%$
$Q_{gw} := 63.8 \cdot gpm$	Groundwater inflow	
$C_{wt} := 9.82 \cdot \frac{\mu g}{liter}$	Conc in WTP influent (average of 4 samples taken during October 2020)	
$C_{rj} := 27.25 \cdot \frac{\mu g}{liter}$	Conc in WTP reject (average of 2 samples taken during October 2020)	

WTP Balance

$M_{wt} := C_{wt} \cdot Q_{wt}$	Mass flux to WTP	$M_{wt} = 0.032 \cdot \frac{lb}{day}$
$M_{rj} := C_{rj} \cdot Q_{rj}$	Mass flux in WTP reject	$M_{rj} = 0.035 \cdot \frac{lb}{day}$

This is a tight chemical mass balance indcating that no tracer mass is lost from the WTP. This is verified by tracer mass not detected in the WTP *treated* discharge.

Mine Balance

$Q_{st} := Q_{wt} - Q_{rj} - Q_{sp} - Q_{gw}$	Water released from mine storage by the downward-moving water table	$Q_{st} = 79.2 \cdot gpm$
$M_m := M_{wt} - M_{rj}$	Tracer mass coming into the system from other parts of the mine	$M_m = -0.003 \cdot \frac{lb}{day}$

This result is within measurement error and suggests that there is no significant gain or loss of tracer mass in the recycle/mixing system.

Mixing zone (Jeffrey shaft from 1100' to 410')

$D := 8 \cdot ft$	Shaft diameter ***(assumed)***	
$L := (1100 - 410) \cdot ft$	Length of mixing zone	$L = 690 \cdot ft$
$V := L \cdot \frac{\pi}{4} \cdot D^2$	Water volume	$V = 9.821 \times 10^5 \cdot lite$
$M := V \cdot C_{wt}$	Mass of tracer in recycle/mixing zone	$M = 0.021 \cdot lb$
$t := \frac{V}{Q_{wt}}$	Residence time in mixing zone	$t = 0.667 \cdot day$

The mass of tracer in the recycle/mixing zone (0.021 lb) is very small compared to the original mass of injected tracer (25 lb). Nearly all the tracer originally placed is not migrating towards the 60 hp pump or has somehow degraded within the system.

The conclusions of the Rhodamine WT mass balance are summarized below:

- The Rhodamine WT mass flux leaving the WTP (via the RO reject) was essentially equal to the mass flux entering the WTP. There was no significant loss of tracer mass from the WTP, which was confirmed by no tracer being detected in WTP treated-water effluent.
- There appeared to be no significant loss or gain of Rhodamine WT mass in the Jeffrey Shaft ARZ, suggesting that essentially no additional dissolved tracer from other parts of the mine was entering or leaving the ARZ.
- The mass of accumulated Rhodamine WT in the ARZ (0.021 lbs) was very small compared to the original mass of injected Rhodamine WT (25 lbs).

A similar water/mass balance for Fluorescein in the Jeffrey Shaft ARZ is provided in Table 2. The result of this analysis leads to the same bulleted conclusions presented above.

Discussion

During the duration of the tracer test, there was no flow leaving the mine as confirmed by the mine pool elevation being consistently below the regulatory limit of 150 ft bsl. Based on the absence of detected tracer in the WTP treated discharge and the unlikelihood that mine pool water could leave the mine hydraulically, it is considered that virtually all the Rhodamine WT and Fluorescein mass originally injected into the underground workings remained in the mine. However, after months of pumping the mine pool with the 60-hp pump, only a small fraction of the originally injected tracers made their way into the ARZ. This suggests several possibilities:

1. The tracers were dispersed and diluted within a very large volume of mine water that did not have sufficient time to migrate into the ARZ,
2. The tracers rapidly degraded within the underground environment, and/or
3. The tracers absorbed onto solids (e.g., mine walls, particulates, timbers, etc.) and became immobile; that is, no longer dissolved in mine water.

The tracer test data indicate that nearly all of the originally injected tracer mass did ***not*** migrate into the Jeffrey Shaft ARZ during 5 months of nearly continuous pumping. Several possible explanations for this observation are proposed above, but the exact cause(s) cannot be definitively determined at this time.

APPENDIX 2, TABLE 2: FLOW AND FLUORESCEIN MASS BALANCE FOR THE PERIOD 10/01/20 TO 10/28/20

$Q_{wt} := 270 \cdot gpm$	WTP influent	$\mu g := 10^{-6} \cdot gm$
$Q_{rj} := 106.9 \cdot gpm$	WTP reject	
$Q_{sp} := 20.1 \cdot gpm$	Sump	$\frac{Q_{rj}}{Q_{wt}} = 39.6 \cdot \%$
$Q_{gw} := 63.9 \cdot gpm$	Groundwater inflow	
$C_{wt} := 2.89 \cdot \frac{\mu g}{liter}$	Conc in WTP influent (average of 4 samples taken during October 2020)	
$C_{rj} := 7.435 \cdot \frac{\mu g}{liter}$	Conc in WTP reject (average of 2 samples taken during October 2020)	

WTP Balance

$M_{wt} := C_{wt} \cdot Q_{wt}$	Mass flux to WTP	$M_{wt} = 0.00938 \cdot \frac{lb}{day}$
$M_{rj} := C_{rj} \cdot Q_{rj}$	Mass flux in reject from WTP	$M_{rj} = 0.00955 \cdot \frac{lb}{day}$

This is a tight chemical mass balance for the WTP indcating that no tracer mass is lost from the system. This is verified by tracer mass not detected in the WTP *treated* discharge.

Mine Balance

$Q_{st} := Q_{wt} - Q_{rj} - Q_{sp} - Q_{gw}$	Water released from mine storage by moving water table	$Q_{st} = 79.1 \cdot gpm$
$M_m := M_{wt} - M_{rj}$	Tracer mass coming into the system from other parts of the mine	$M_m = -0.00017 \cdot \frac{lb}{day}$

This result is within measurement error and suggests that there is no signficant gain or loss of tracer mass in the recycle/mixing system.

Mixing zone (Jefjrey shaft from 1100' to 410')

$D := 8 \cdot ft$	Shaft diameter ***(assumed)***	
$L := (1100 - 410) \cdot ft$	Length of mixing zone	$L = 690 \cdot ft$
$V := L \cdot \frac{\pi}{4} \cdot D^2$	Water volume	$V = 9.821 \times 10^5 \cdot liter$
$M := V \cdot C_{wt}$	Mass of tracer in recycle mixing zone	$M = 0.0063 \cdot lb$
$t := \frac{V}{Q_{wt}}$	Residence time in mixing zone	$t = 0.667 \cdot day$

The mass of tracer in the recycle/mixing zone (0.0063 lb) is very small compared to the original mass of injected tracer (6 lb). Nearly all the tracer originally placed is not migrating towards the 60 hp pump or has somehow degraded within the system.

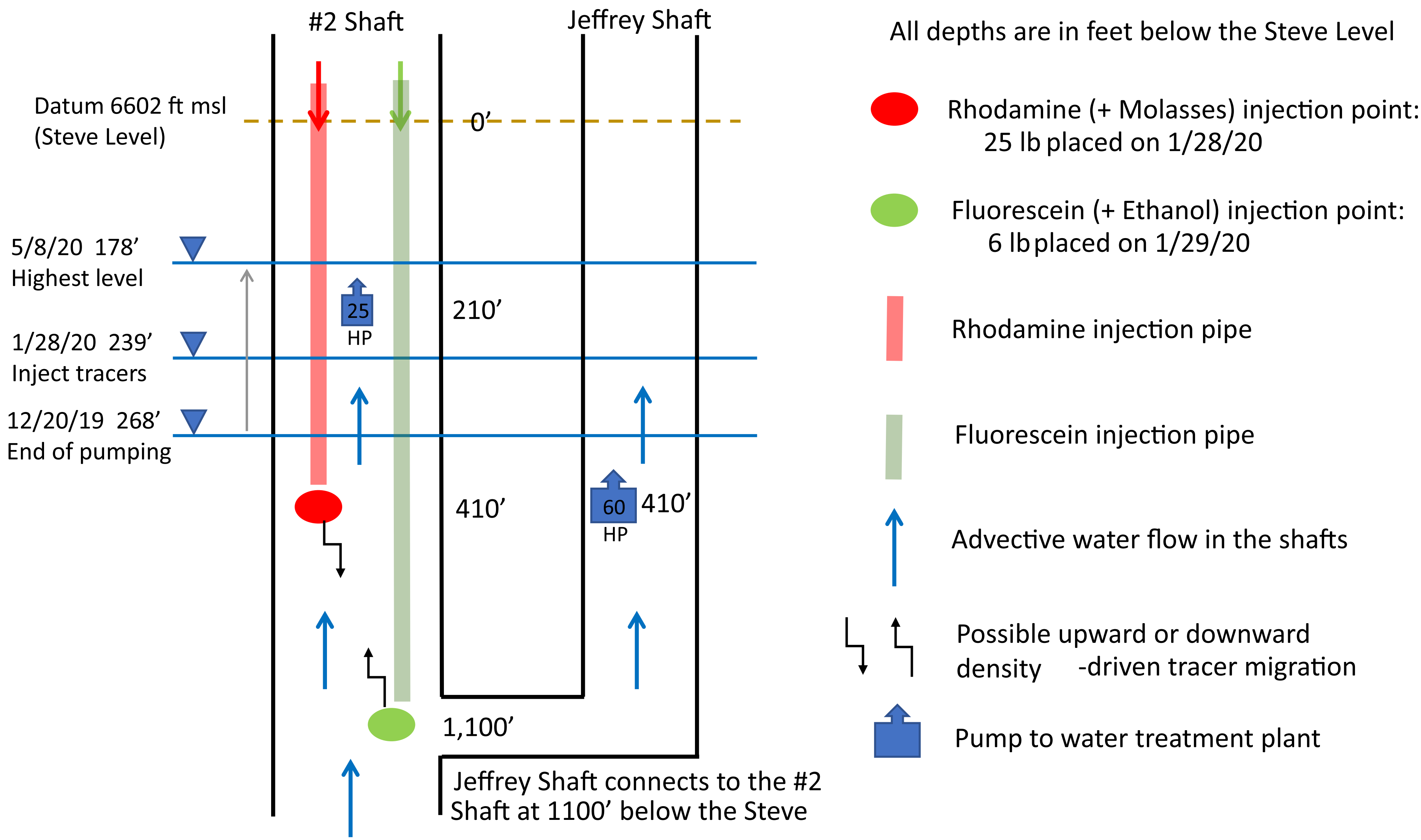

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FIGURE 1
TRACER TEST SETUP

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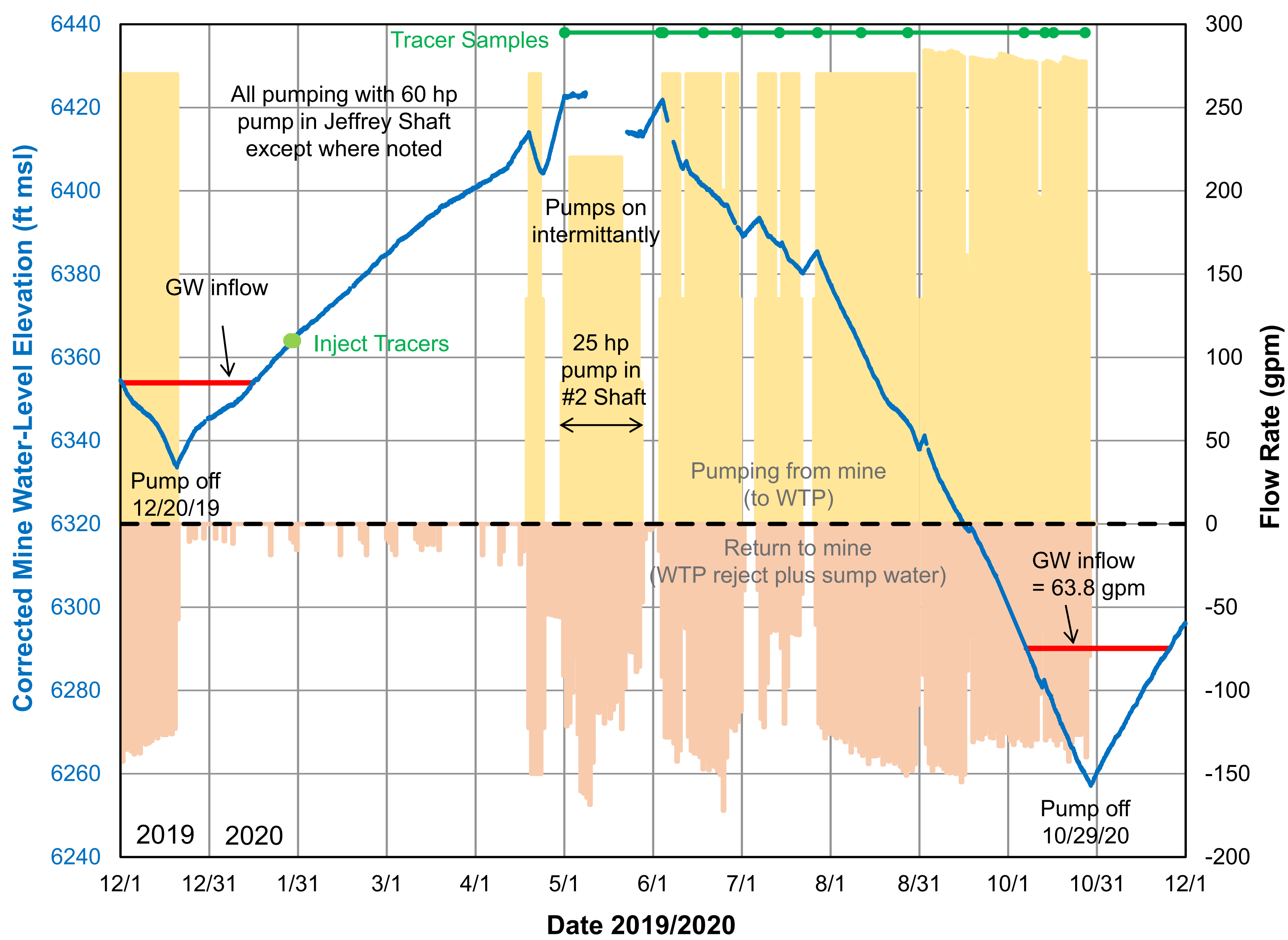

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FIGURE 2
FLOW AND WATER LEVELS
DURING TRACER TEST

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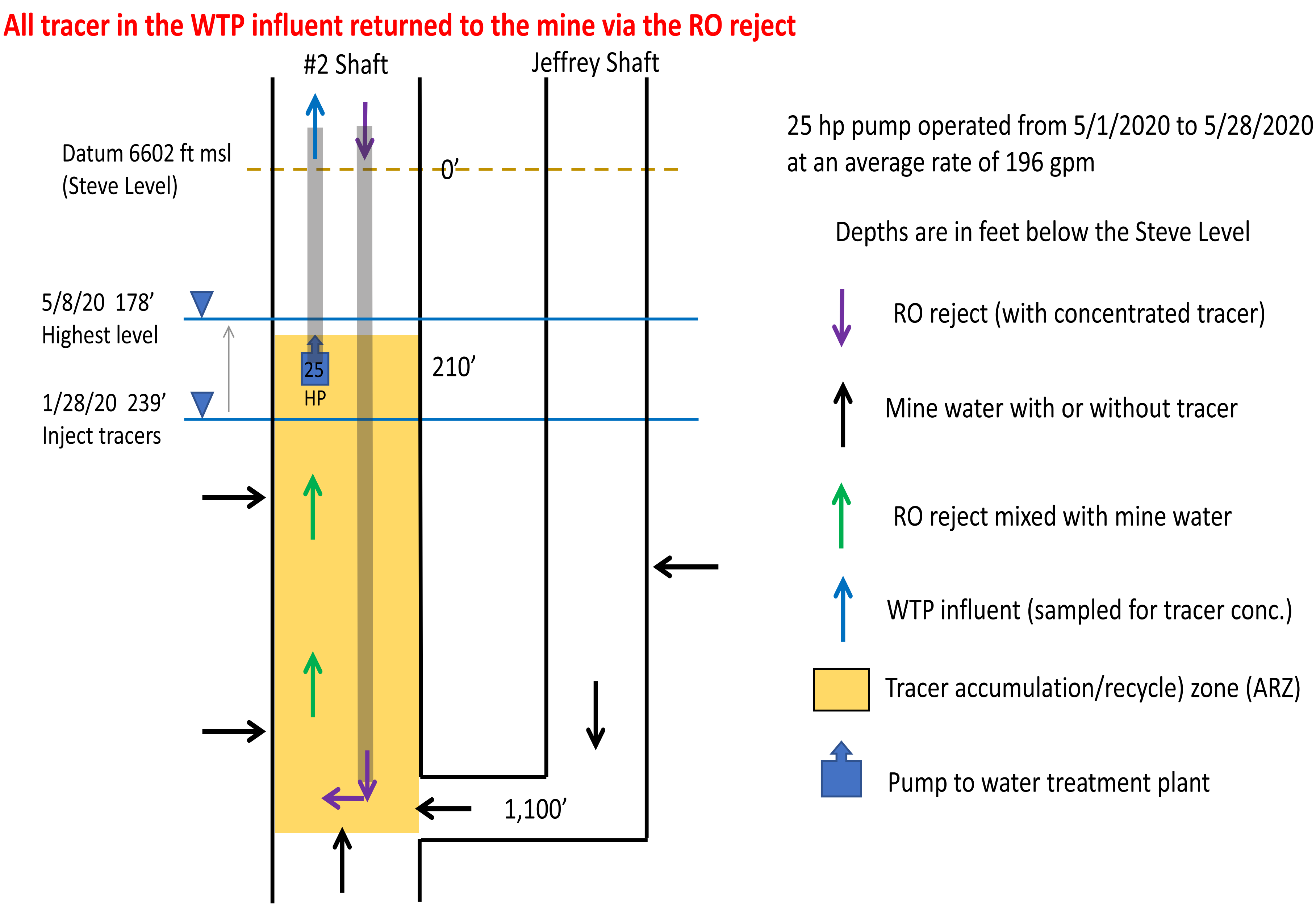

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FIGURE 3
EARLY PUMPING WITH 25HP PUMP

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All tracer in the WTP influent returned to the mine via the RO reject

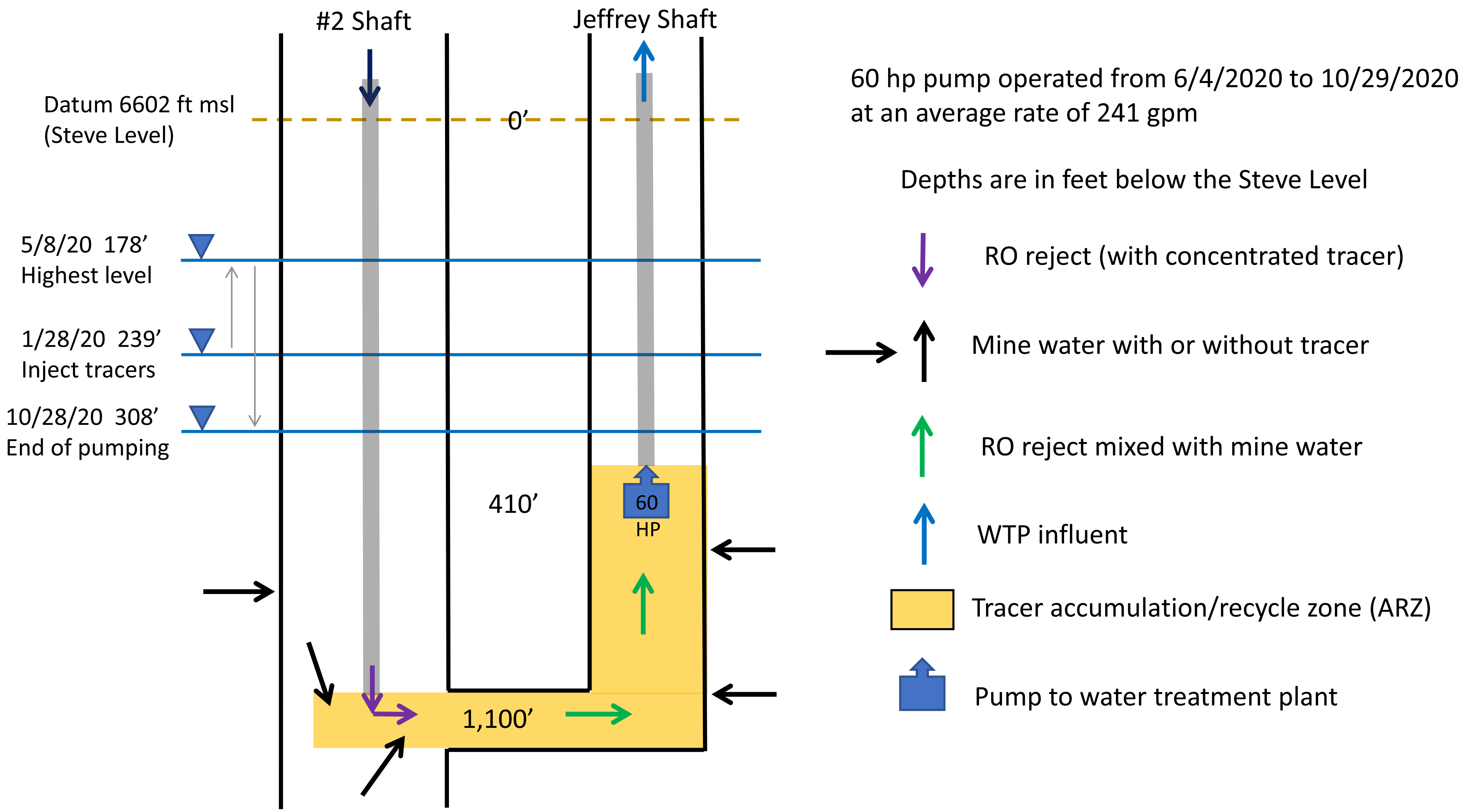

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FIGURE 4
SUBSEQUENT PUMPING WITH 60HP PUMP

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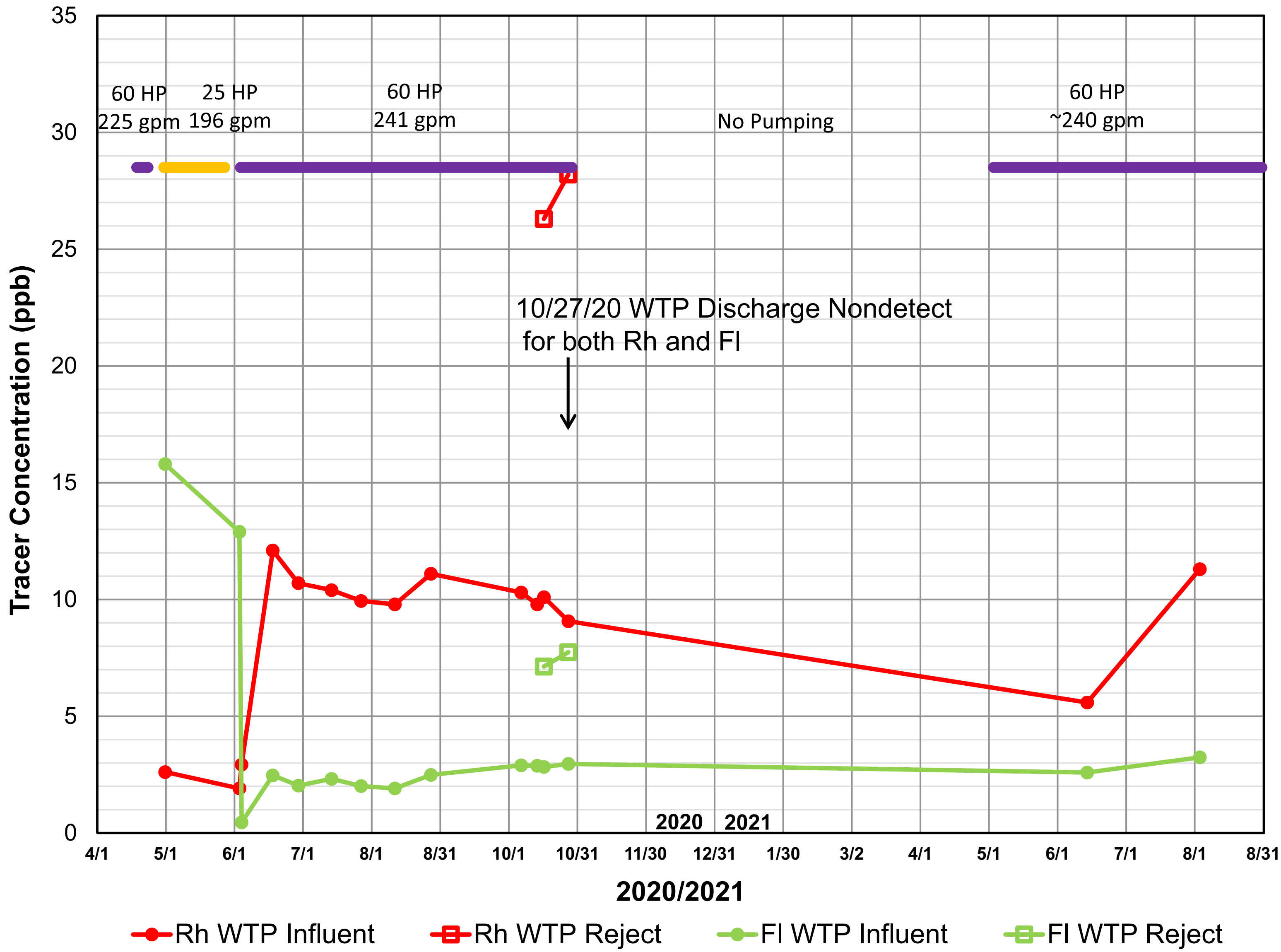

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FIGURE 5
MEASURED TRACER CONCENTRATIONS

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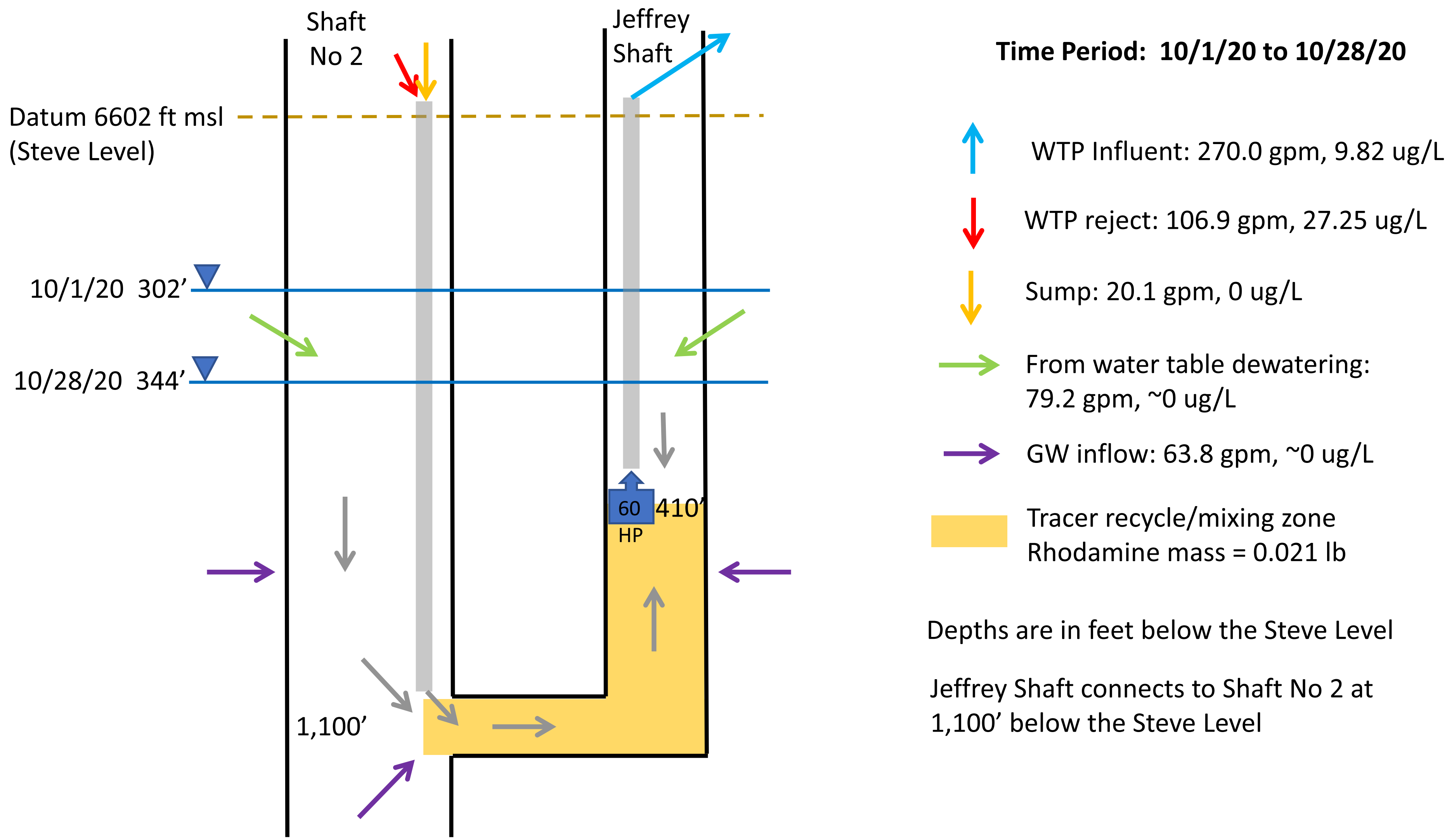

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FIGURE 6
RHODAMINE STEADY-STATE CONDITIONS

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APPENDIX 3. SCHWARTZWALDER MINE – HYDROGEOLOGY ASSOCIATED WITH THE CURRENT WATER MANAGEMENT PROGRAM

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Memorandum

To: Colorado Legacy Land, LLC

From: Ensero Solutions, Inc.

Date: December 1, 2021

Re: Schwartzwalder Mine – Hydrogeology Associated with the Current Water Management Program

1 INTRODUCTION

The current water management program at the Schwartzwalder Mine is to depress the mine water level by seasonal pumping. Per Agency agreement, the mine water level must be maintained lower than 6,452 feet mean sea level (ft msl), or greater than 150 feet (ft) below the Steve Level (collectively 'regulatory level'). From May through October, the mine is pumped at a relatively high rate, which causes the mine water level to drop well below the regulatory level. After pumping is discontinued (typically end of October), the mine passively refills via groundwater inflow and the mine water level rises during winter and spring. Pumping is resumed (typically beginning of May) before the rising water level reaches the regulatory level. The theoretical static water level for the mine is approximately 6,622 ft msl (20 ft above the Steve Level). Therefore, this water management strategy keeps the mine water level to be continuously depressed relative to both the theoretical static mine water level and the regulatory level.

Using this pumping strategy, the 2020 water level in the mine fluctuated between 6,260 and 6,420 ft msl (Figure 1), or 340 to 180 ft below the Steve Level. The hydraulic drawdown associated with this fluctuation range is estimated to have been 360 to 200 ft below the theoretical static (non-pumping) water level for the mine. The mine water level was maintained well below the elevation of the nearby Ralston Creek stream channel (6,540 to 6,590 ft msl).

The intent of the water management program is to sufficiently depress the mine water level, so the mine operates as a hydraulic sink and groundwater flows towards the mine from all directions. In this way, a hydraulic mechanism by which water in the mine pool can flow out of the workings and migrate away from the mine into the outside environment should not occur.

This memorandum evaluates the modified groundwater flow system that has evolved near the mine since initiation of the water management program. Of specific interest is the degree to which the current operation has transformed the mine workings into a permanent groundwater sink that would provide effective containment of the mine pool.

2 GROUNDWATER INFLOW RATES

An important component of the mine water balance is the rate of groundwater inflow into the mine, which as a first approximation should only depend on the mine water-level elevation. For a given mine pool elevation, the total inflow rate is the same regardless of whether the mine is being pumped or allowed to passively refill.

For an arbitrary time period, the mine water balance is given by:

net change in mine storage volume = groundwater inflow volume + water treatment plant (WTP) reject volume + sump water volume – mine pumping volume

Now if the time period is chosen so the begin time and end time correspond to the same water-level elevation, the net change in mine storage is zero and the groundwater inflow rate can be directly computed:

groundwater inflow rate = (mine pumping volume – WTP reject volume – sump water volume)/duration of the time interval

Using pumping and WTP return flow rates shown on Figure 1 to compute daily volumes, this calculation was performed for two time intervals shown as red horizontal lines on the figure. As shown in Table 1, the computed groundwater flow rate is 60.6 gpm for the time period of December 1, 2019, to January 15, 2021, when the water level ranged from 6,334 to 6,354 ft msl. For the period of October 7, 2020, to November 15, 2020, when the water level ranged from 6,257 to 6,290 ft msl, the computed inflow rate is 63.8 gpm. It is reasonable that the later inflow estimate is somewhat higher because the mine water level was lower, which would induce more groundwater flow into the mine.

Of interest is how the inflow to the mine is distributed vertically. As an approximation, the mine is divided into two zones designated as “Upper Workings” and “Lower Workings.” Upper Workings are taken to be those above 6,192 ft msl, which is the depth of the 60 hp pump (410 ft below the Steve Level). “Lower Workings” are those below 6192 ft msl. The “Nominal Pumping Condition” is a mine water level of 6,350 ft msl, which is approximately midway between the mine water level fluctuation that occurred during 2020. For this water level, the total groundwater inflow rate is estimated to have been approximately 61 gpm. The “Fully Dewatered Condition” is an historical condition when the mine was completely dewatered at full build-out. The reported dewatering rate for this historical condition was 190 gpm.

The delineation of the mine workings and hydraulic drawdowns for the Nominal Pumping Condition and Fully Dewatered Condition are shown diagrammatically on Figures 2 and 3, respectively. Note that when a vertical portion of the mine is dewatered, the average hydraulic drawdown within that zone is taken to be the static water level minus the average elevation of the dewatered interval. In saturated mine intervals, the hydraulic drawdown is equal to the static water level minus the mine water level. The drawdowns associated with saturated and dewatered intervals of the mine workings are shown on Figures 2 and 3.

The calculations that estimate groundwater inflow rates to the Upper and Lower Workings for different operating conditions are provided in Table 2. For the Nominal Pumping Condition, the estimated inflow rate to Upper Workings is 30 gpm and inflow to the Lower Workings is 31 gpm. It can be reasonably assumed that for the current water management program, approximately half of the mine inflow comes from workings above 6,192 ft msl and approximately half comes from workings below that elevation. Groundwater to the lower workings flows upward through the shafts and either (1) goes into the pump intake when the mine is being pumped or (2) goes into void storage at the rising water table when the mine is passively refilling.

For the historical condition when the mine was completely dewatered, the estimated inflow rate to the Upper Workings was approximately 35 gpm and inflow to Lower Workings was approximately 155 gpm.

3 GROUNDWATER FLOW NEAR THE MINE AREA

There are ten sets of contemporaneous bedrock water levels measured in the mine pool and three deeper monitoring wells (MW-13, MW-15, and MW-18) located near the mine. After initiation of the Schwartzwalder water management program, quarterly bedrock water levels were measured at these locations from September 2019 to October 2021. The measured groundwater levels along a northwest to southeast section through the mine workings and well MW-15 is shown on Figure 4. Water levels at MW-18 are also shown; however, this well is located off-section to the northeast. MW-15 is located southeast of the mine workings and is in an area of concern for potential southeast groundwater migration towards Ralston Creek and Ralston Reservoir. As shown on Figure 4, for all available data sets, there is a strong hydraulic gradient (+/- 0.25 ft/ft) indicating northwest groundwater flow from the area of concern towards the mine. As long as the mine water level is depressed by pumping, there should not be a hydraulic mechanism by which mine pool water could migrate in bedrock southeast of the mine area.

A bedrock water-level contour for the mine area based on June 2020 (second quarter) measurements is shown on Figure 5, which was constructed using the four bedrock water-level monitoring locations and reasonable hydrogeologic interpretation. To a certain degree, the contour map is conceptual; however, standard hydrogeologic interpretations were used to develop contours where data are sparse. The interpreted contours indicate the following:

- All groundwater near the mine flows towards the mine.
- Northeast of the mine, the bedrock water levels are below Ralston Creek.
- Southeast of the mine is a groundwater divide. North of the divide, groundwater flows into the mine. South of the divide, groundwater flows towards Ralston Creek.

For the current groundwater conditions, hydraulic mechanisms do not exist by which the mine pool water can exit the mine workings and discharge to Ralston Creek or into the surrounding bedrock groundwater system. This condition will persist as long as the mine water level is depressed by pumping.

4 DISCUSSION

This technical memorandum presents solid evidence that the Schwartzwalder water management program, which uses pumping to depress the mine water level, has converted the mine workings to a large-scale groundwater sink. Hydraulic mechanisms do not exist whereby mine pool water can exit the workings and migrate towards Ralston Creek and Ralston Reservoir. This hydraulic behavior should continue as long as the water level in the mine is depressed below the regulatory level.

Table 1. Total Groundwater Inflow Rates During 2020

$MG := 10^6 \cdot gal$

Period: 12/1/19 to 1/15/20

$t := 45.1 \cdot day$	Duration of time period where the water table elevation at the beginning and end is 6353.9 ft msl. For the period as a whole, the net change in storage is zero.	
$V_{wt} := 7.582 \cdot MG$	Total volume of water extracted from the mine	
$V_{bs} := 3.646 \cdot MG$	Total volume of water reinjected into mine (WTP reject + sump)	
$V_{gw} := V_{wt} - V_{bs}$	Total volume of groundwater inflow	$V_{gw} = 3.936 \cdot MG$
$Q_{gw} := \frac{V_{gw}}{t}$	Average groundwater inflow rate	$Q_{gw} = 60.6 \cdot gpm$

Period: 10/7/20 to 11/25/20

$t := 49.3 \cdot day$	Duration of time period where the water table elevation at the beginning and end is 6290.1 ft msl. For the period as a whole, the net change in storage is zero.	
$V_{wt} := 8.607 \cdot MG$	Total volume of water extracted from the mine	
$V_{bs} := 4.076 \cdot MG$	Total volume of water reinjected into mine (WTP reject + sump)	
$V_{gw} := V_{wt} - V_{bs}$	Total volume of groundwater inflow	$V_{gw} = 4.531 \cdot MG$
$Q_{gw} := \frac{V_{gw}}{t}$	Average groundwater inflow rate	$Q_{gw} = 63.8 \cdot gpm$

Table 2. Groundwater Inflow Rates to Upper and Lower Workings

Governing equation

$Q = \frac{2 \cdot \pi \cdot K \cdot b \cdot s}{F}$ General equation for steady-state radial flow to a sink (Theim equation)
where:
Q = flow rate
K = hydraulic conductivity
s = drawdown
F = shape factor

General inputs

$H_s := 6622 \cdot ft$	Static water-level elevation (assume 20 feet above Steve Level)	Elevations are NAD 27
$H_1 := 6350 \cdot ft$	Nominal pumping water-level elevation	
$H_2 := 6192 \cdot ft$	Elevation at bottom of Upper Workings (same as current pump set at 410 ft below Steve Level)	
$H_3 := 4306 \cdot ft$	Mine bottom elevation	
$F := 6.2$	Steady-state shape factor for essentually horizontal radial flow	

Nominal (current) pumping condition

$b_{c1} := H_s - H_1$	Thickness of Zone 1	$b_{c1} = 272 \cdot ft$
$b_{c2} := H_1 - H_2$	Thickness of Zone 2	$b_{c2} = 158 \cdot ft$
$b_{c3} := H_2 - H_3$	Thickness of Zone 3	$b_{c3} = 1886 \cdot ft$
	Note: Zones 1 and 2 constitute "Upper Workings"; Zone 3 constitutes "Lower Workings"	
$s_{c1} := \frac{H_s - H_1}{2}$	Average drawdown in Zone 1 (dewatered seepage face)	$s_{c1} = 136 \cdot ft$
$s_{c2} := H_s - H_1$	Drawdown in Zone 2 (saturated)	$s_{c2} = 272 \cdot ft$
$s_{c3} := H_s - H_1$	Drawdown in Zone 3 (saturated)	$s_{c3} = 272 \cdot ft$

$$Q_c(K_u, K_l) := \frac{2 \cdot \pi \cdot K_u \cdot b_{c1} \cdot s_{c1}}{F} + \frac{2 \cdot \pi \cdot K_u \cdot b_{c2} \cdot s_{c2}}{F} + \frac{2 \cdot \pi \cdot K_l \cdot b_{c3} \cdot s_{c3}}{F}$$

Total mine inflow for current conditions where the mine is partially dewatered. K_u is the average hydraulic conductivity of the upper workings and K_l is the conductivity of the lower workings.

Historical (fully dewatered) condition

All of Zone 1 is dewatered
There is no Zone 2
All of Zone 3 is dewatered

$b_{h1} := H_s - H_2$	Thickness of Zone 1	$b_{h1} = 430 \cdot ft$
$b_{h3} := H_2 - H_3$	Thickness of Zone 3	$b_{h3} = 1886 \cdot ft$
	Note: Zone 1 constitues "Upper Workings"; Zone 3 constitutes "Lower Workings"	
$s_{h1} := \frac{H_s - H_2}{2}$	Average drawdown in Zone 1 (seepage face)	$s_{h1} = 215 \cdot ft$
$s_{h3} := \frac{(H_s - H_2) + (H_s - H_3)}{2}$	Average drawdown in Zone 3 (seepage face)	$s_{h3} = 1373 \cdot ft$

$$Q_h(K_u, K_l) := \frac{2 \cdot \pi K_u \cdot b_{h1} \cdot s_{h1}}{F} + \frac{2 \cdot \pi \cdot K_l \cdot b_{h3} \cdot s_{h3}}{F}$$

Total mine inflow for historical condition when the mine was fully dewatered. K_u is the average hydraulic conductivity of the upper workings and K_l is the conductivity of the lower workings.

Table 2 (cont.)

Solution

We now have two equations (Q_c and Q_h) and two unknowns (K_u and K_l)

Iterate on the two unknowns until current inflow rate (Q_c) is 61 gpm and historical inflow rate (Q_h) is 190 gpm

$K_u := 2.54 \cdot 10^{-5} \cdot \frac{cm}{sec}$

$K_l := 4.01 \cdot 10^{-6} \cdot \frac{cm}{sec}$

These hydraulic conductivities are calibrated by iteration

$Q_c(K_u, K_l) = 61.01 \cdot gpm$ **This should be 61 gpm**

$Q_h(K_u, K_l) = 190.00 \cdot gpm$ **This should be 190 gpm**

Inflow distribution for nominal (current) water level condition

$$Q_{upperzone1} := \frac{2 \cdot \pi \cdot K_u \cdot b_{c1} \cdot s_{c1}}{F} \qquad Q_{upperzone1} = 14.02 \cdot gpm$$

$$Q_{upperzone2} := \frac{2 \cdot \pi \cdot K_u \cdot b_{c2} \cdot s_{c2}}{F} \qquad Q_{upperzone2} = 16.29 \cdot gpm$$

$$Q_{upper} := Q_{upperzone1} + Q_{upperzone2}$$

Inflow from Upper Workings; above elevation 6192 ft msl $Q_{upper} = 30.31 \cdot gpm$

$$Q_{lower} := \frac{2 \cdot \pi \cdot K_l \cdot b_{c3} \cdot s_{c3}}{F}$$

Inflow from Lower Workings; below elevation 6192 ft msl $Q_{lower} = 30.70 \cdot gpm$

$$Q_{upper} + Q_{lower} = 61.01 \cdot gpm$$

Inflow distribution for historical water level condition

$$Q_{upper} := \frac{2 \cdot \pi \cdot K_u \cdot b_{h1} \cdot s_{h1}}{F}$$

Inflow from Upper Workings; above elevation 6192 ft msl $Q_{upper} = 35.04 \cdot gpm$

$$Q_{lower} := \frac{2 \cdot \pi \cdot K_l \cdot b_{h3} \cdot s_{h3}}{F}$$

Inflow from Lower Workings; below elevation 6192 ft msl $Q_{lower} = 154.96 \cdot gpm$

$$Q_{upper} + Q_{lower} = 190 \cdot gpm$$

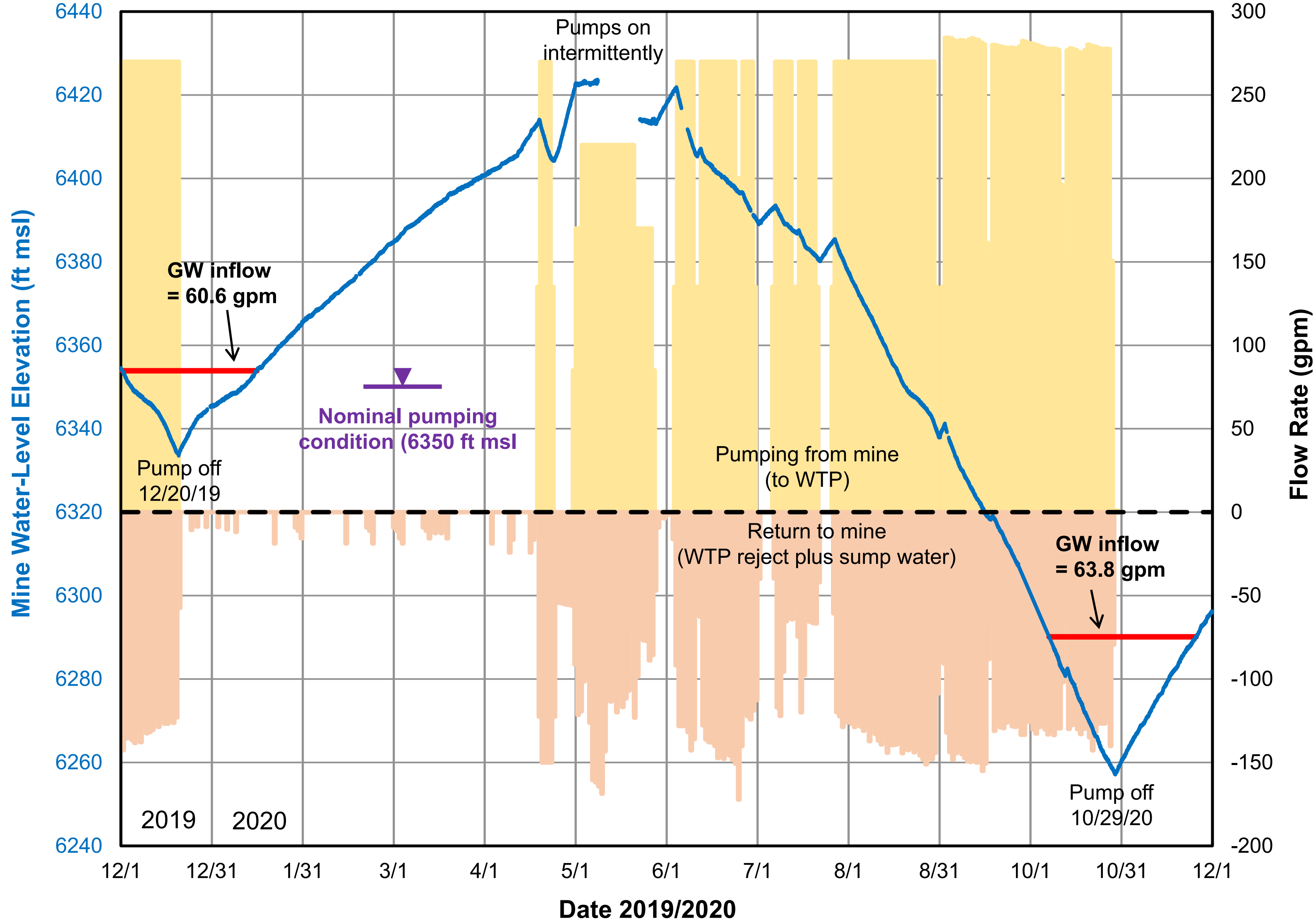

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FIGURE 1
MINE WATER-LEVEL ELEVATION
AND FLOW RATE

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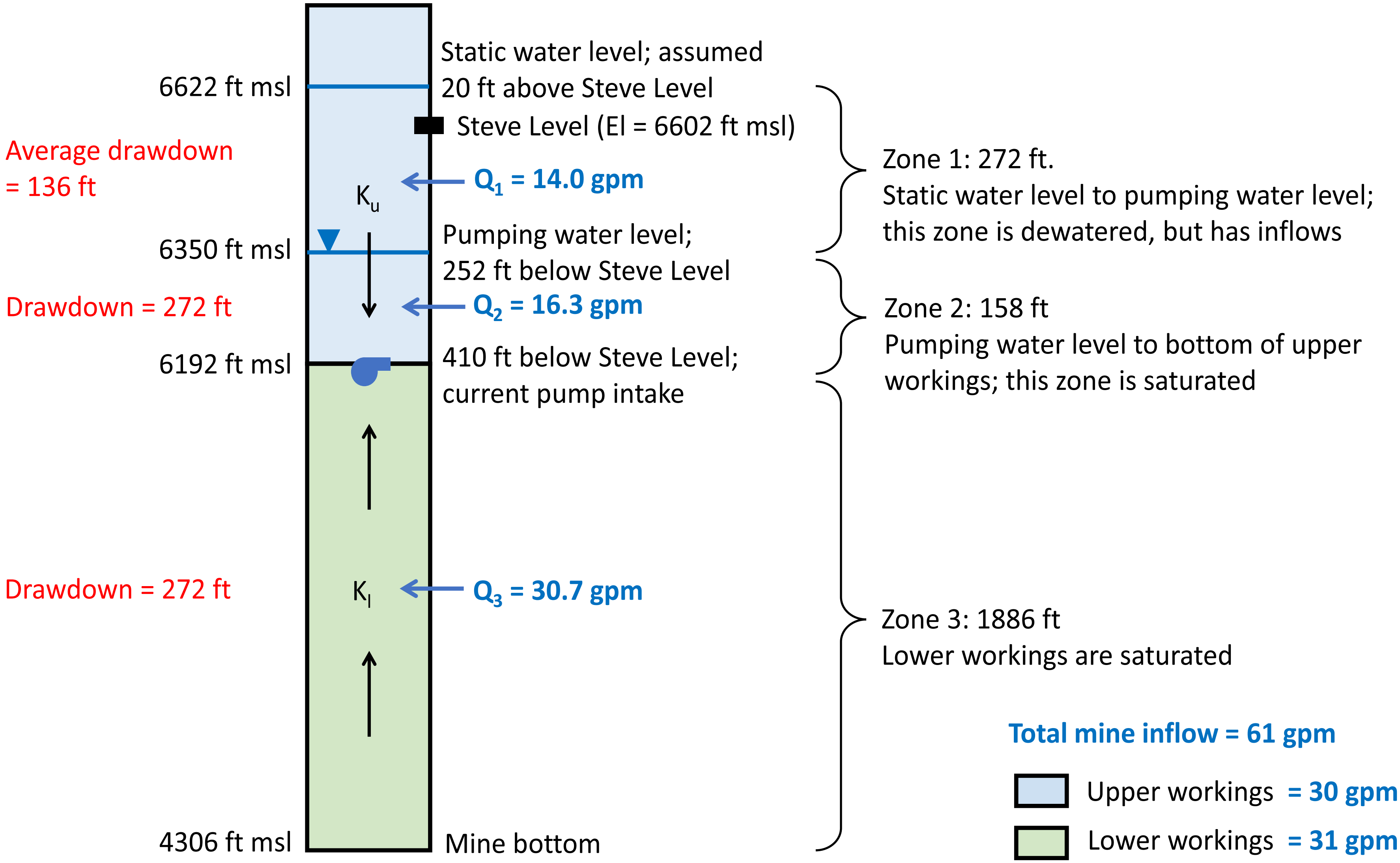

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FIGURE 2
NOMINAL PUMPING CONDITION

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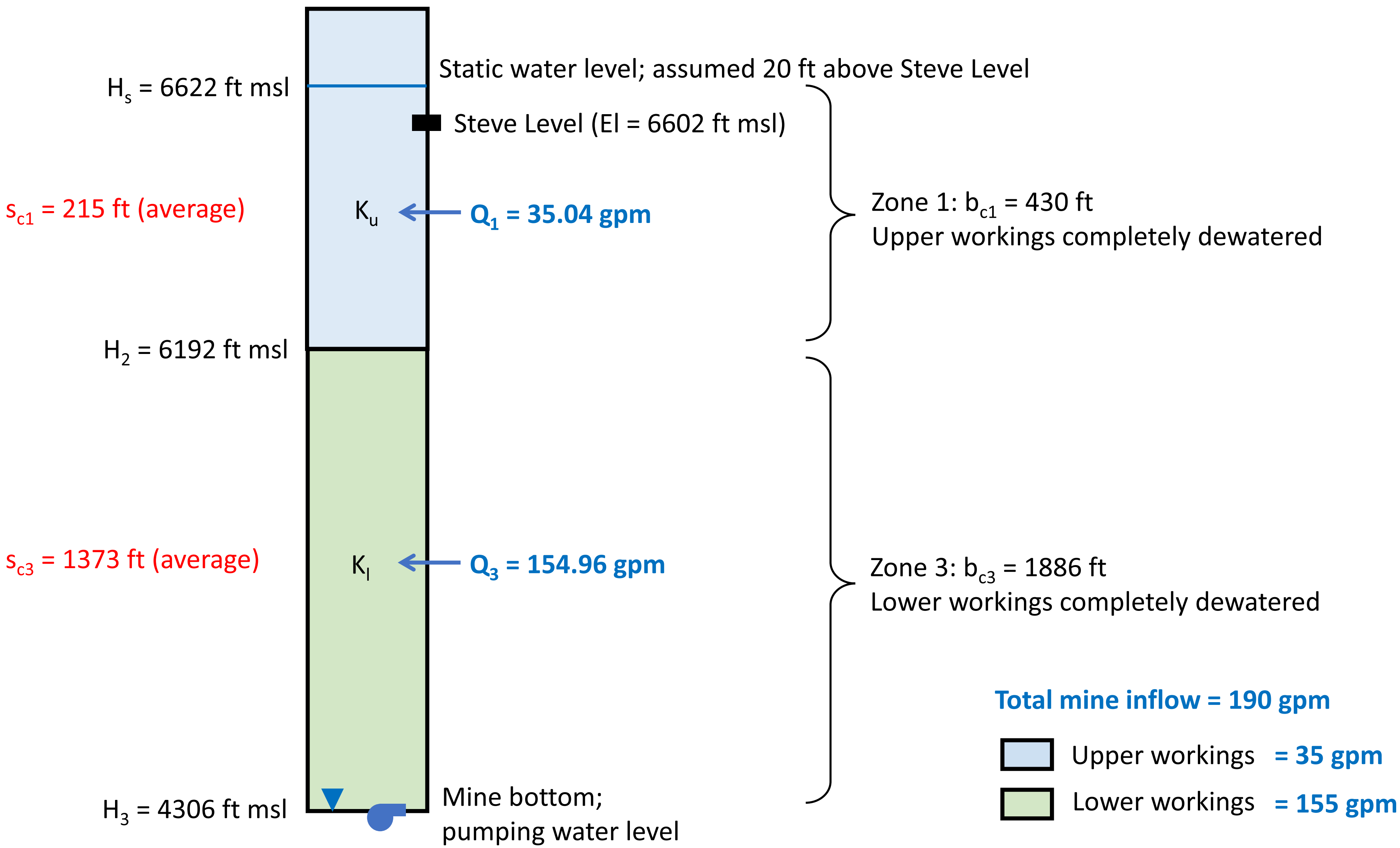

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FIGURE 3
FULLY DEWATERED CONDITION

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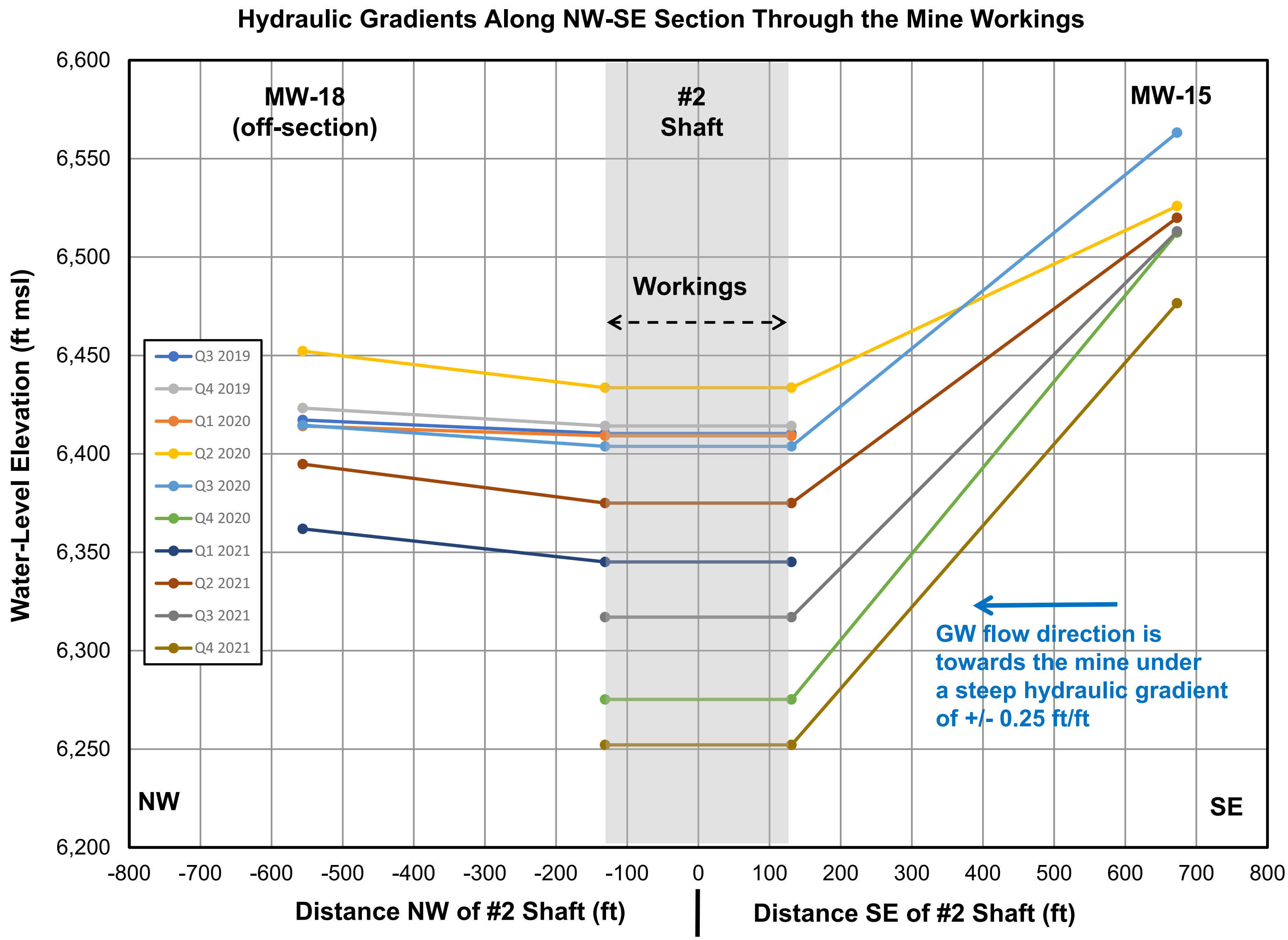

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FIGURE 4
HYDRAULIC GRADIENTS ALONG NW-NE SECTION
THROUGH THE MINE WORKINGS

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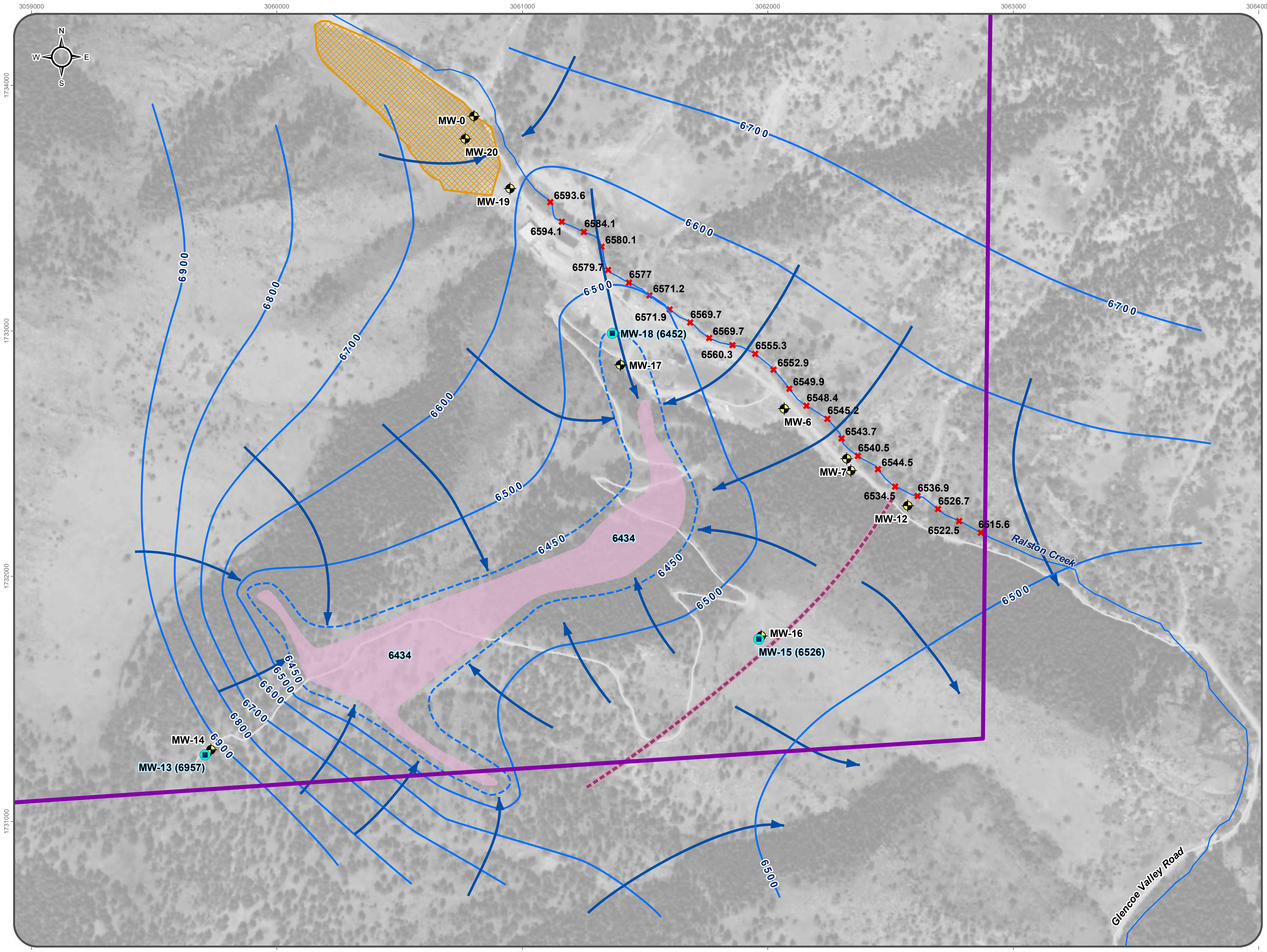

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FIGURE 5

BEDROCK GROUNDWATER CONTOUR MAP

DECEMBER 2021

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(6526) Deep Bedrock Monitoring Well with Measured Q2-2020 Water Level (ft msl)
Alluvial or Shallow Bedrock Monitoring Well
100 foot Groundwater Contour (ft msl)
50 foot Groundwater Contour (ft msl)
Groundwater Flow Direction
Groundwater Divide
Ralston Creek Elevation Point (ft msl)
Underground Workings
Waste Rock Dump
CLL Property Boundary
Ralston Creek

1 inch = 380 feet

0 250 500 750 ft

ENSERO solutions

Satellite imagery obtained from ESRI ArcGIS map service https://services.arcgisonline.com/ArcGIS/rest/service on December 09 2021.

Datum: NAD_1983_StatePlane_Colorado_Central_FIPS_0502_Feet

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from: cotter

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Division of Reclamation, Mining and Safety

David Bird
Senior Geochemist
To Division of Reclamation, Mining & Safety
1313 Sherman Street, Rm 215
Denver, CO 80203
Tel: 303-866-3927
Fax: 303-832-8106

November 13, 2007

TR 09

Subject: Schwartzwalder Technical Revision Application, Permit No. M-77-300

Dear Mr. Bird:

This is request for a Technical Revision (TR) to Cotter Corporation's Schwartzwalder Reclamation Plan (File No. 77-700) in accordance with Rule 1.8.4. A check in the amount of $173.00 is provided herewith in accordance with SB 07-185. The TR request pertains to revision of one section of Appendices E-3 (Adit Closures) of the existing Plan.

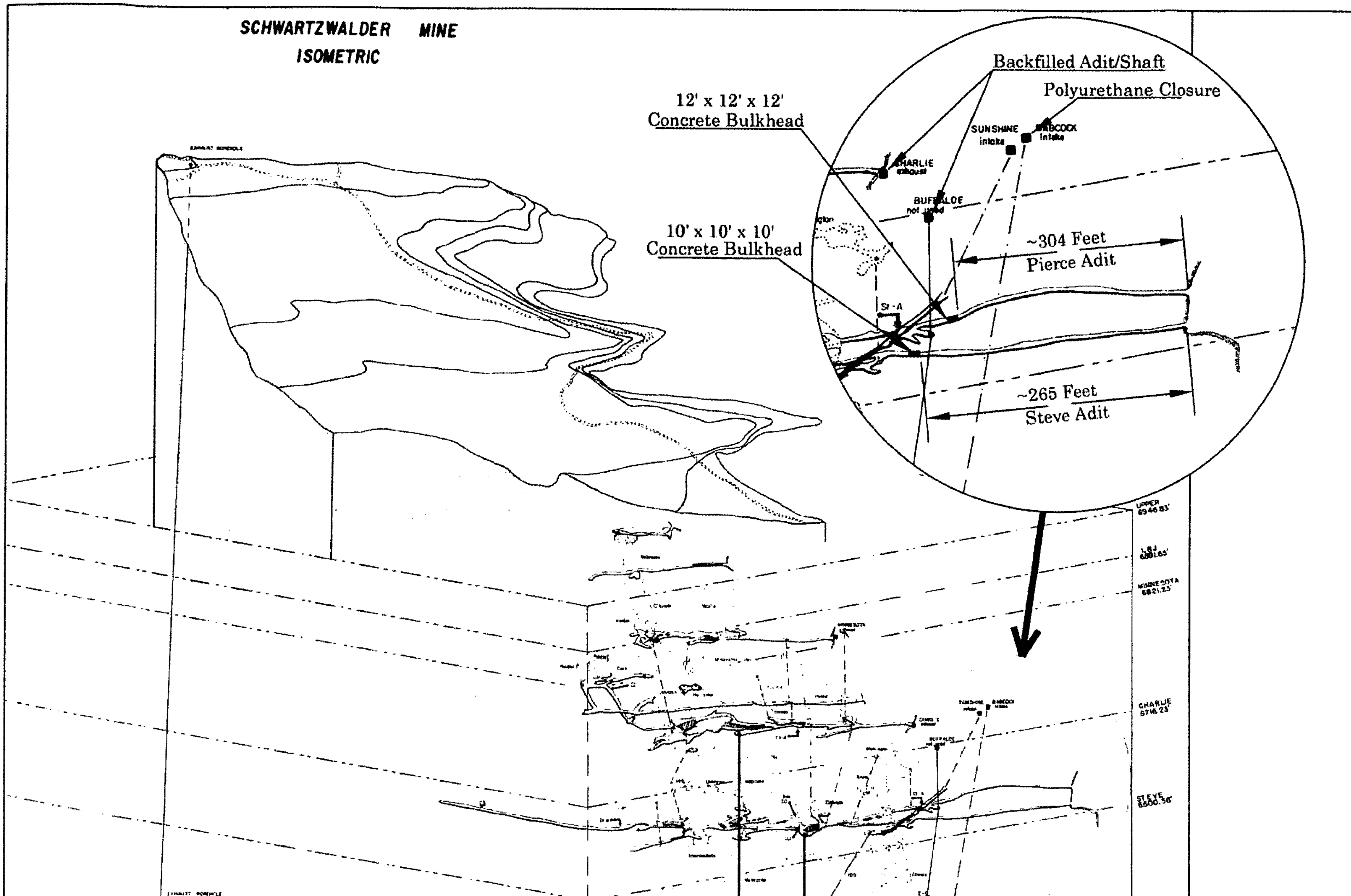
The current reclamation plan provides for the hydrologic sealing of the Steve Level adits using bulkheads constructed using sprayed gunite concrete. This TR request is to upgrade the bulkhead seals from sprayed gunite concrete to a formed and pumped concrete, with additional post-shrinkage grouting. Enclosed are preliminary drawings and calculations for the upgraded bulkheads, which were presented previously at the November 8th meeting.

Should you have any questions or comments regarding this request for a Technical Revision or need additional information, please do not hesitate to contact me at 361-318-1622 cell or 720-554-6205 office.

Respectfully,

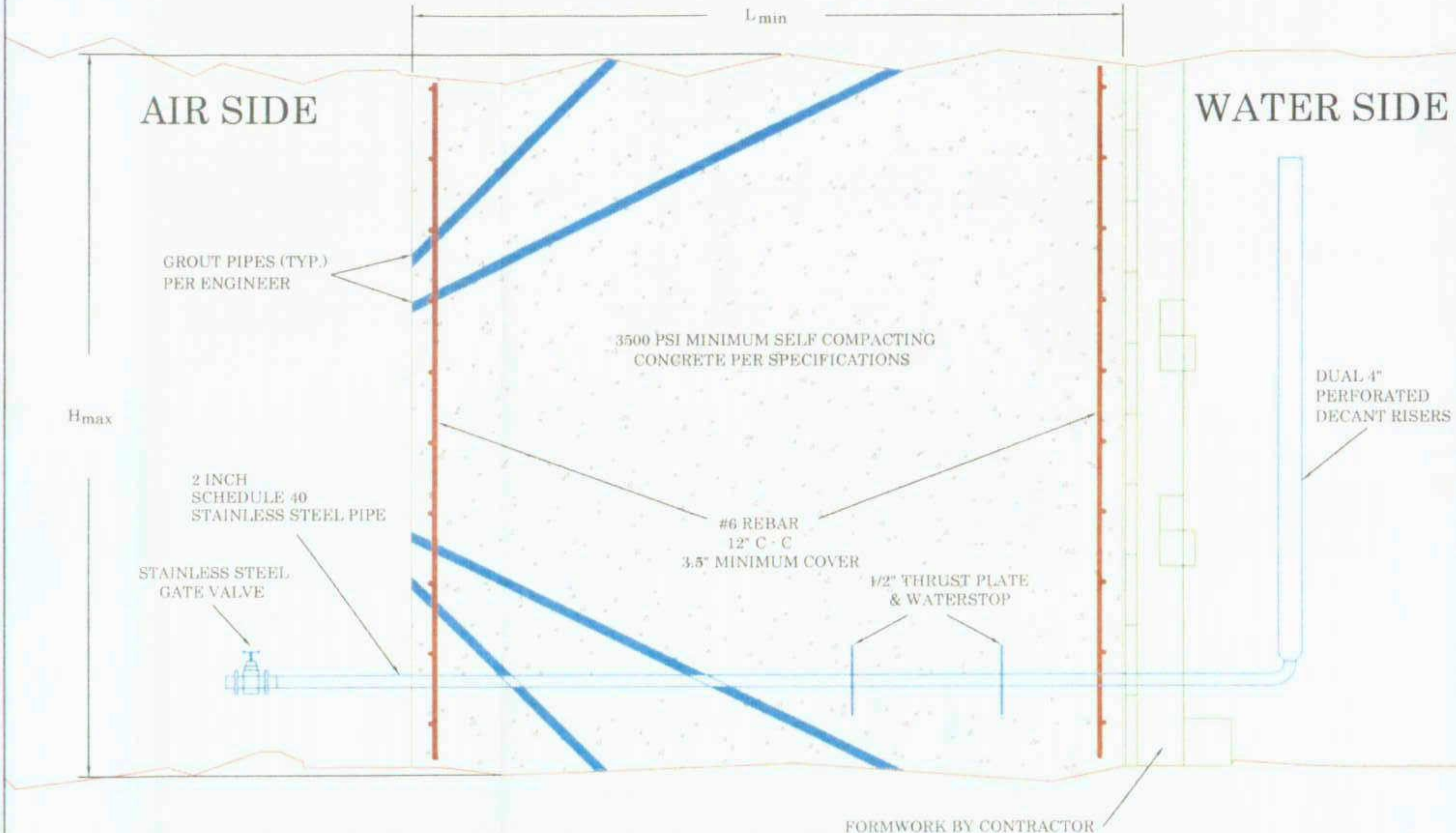
Amy L. Thurlkill

Amy Thurlkill
EH&S Manager
Cotter Corporation
Enclosures (3)
AT
cc: DTC File



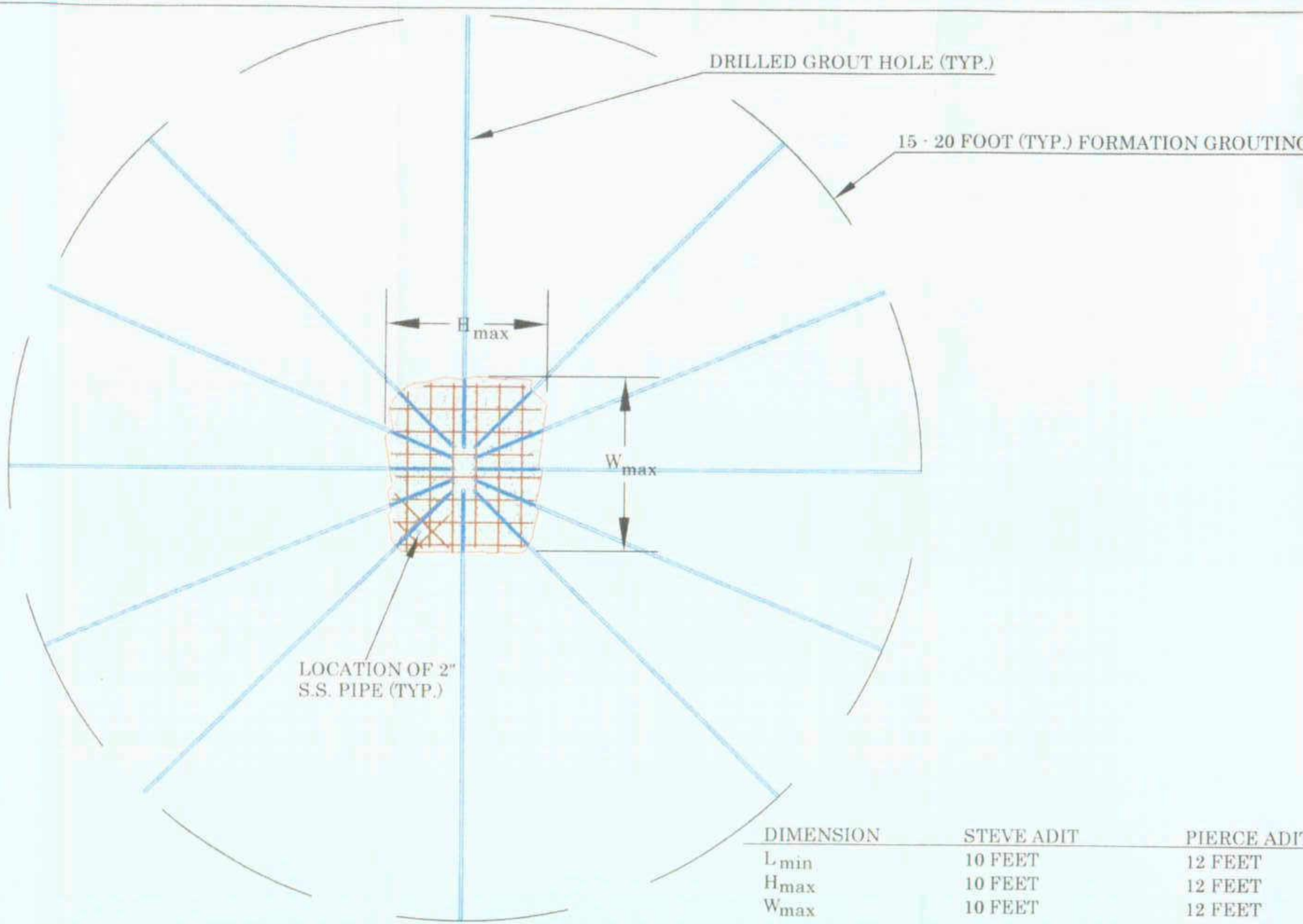
Revision: Rev. Date:	Date: 11/5/07	Steve Level - Bulkhead Closures Cotter Corp. - Schwartzwalder Mine	
PRELIMINARY DRAWINGS ONLY	Drawn By: M. Collins		
NOT FOR CONSTRUCTION	Engineer: M. Levin/J.F. Abel	General Location Steve (6600') Level Isometric	Revision 0
	Approved By:		
	Approval Date:		
Drawing File: Cotter\Steve Level Bulkhead Closures <Location>	Scale: NOT TO SCALE	Mining and Environmental Services, LLC Post Office Box 1511 - Idaho Springs, CO - 80452 - (303)567-4174	

MINING & ENVIRONMENTAL SERVICES



DIMENSION	STEVE ADIT	PIERCE ADIT
L_{min}	10 FEET	12 FEET
H_{max}	10 FEET	12 FEET
W_{max}	10 FEET	12 FEET

Revision:	Rev. Date:	Date: 11/5/07	**Steve Level - Bulkhead Closures** Cotter Corp. - Schwartzwalder Mine
PRELIMINARY DRAWINGS ONLY		Drawn By: M. Collins	
NOT FOR CONSTRUCTION		Engineer: M. Levin/J.F. Abel	Concrete Bulkhead Side View Longitudinal Section Elevation — Revision 0
		Approved By:	
		Approval Date:	
Drawing File: Cotter\Steve Level Bulkhead Closures <Long Section>		Scale: 1 inch = 2 Feet	Mining and Environmental Services, LLC Post Office Box 1511 - Idaho Springs, CO - 80452 - (303)567-4174



DIMENSION	STEVE ADIT	PIERCE ADIT
L_{min}	10 FEET	12 FEET
H_{max}	10 FEET	12 FEET
W_{max}	10 FEET	12 FEET

Revision: Rev. Date:

PRELIMINARY DRAWINGS ONLY
NOT FOR CONSTRUCTION

Date: 11/5/07
Drawn By: M. Collins
Engineer: M. Levin/J.F. Abel
Approved By:
Approval Date:
Scale: 1 inch = 6 Feet

Drawing File: Cotter\Steve Level Bulkhead Closures <Cross Section>

Steve Level - Bulkhead Closures

Cotter Corp. - Schwartzwalder Mine

Concrete Bulkhead End View
Formation Grouting and Re-bar
Elevation

Revision 0

Mining and Environmental Services, LLC
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Project, Pierce Adit Bulkhead, Sta. 3+04
12' Thick, 12' Wide, 12' High, #6 Rebar

By MEL/JFA Date 10/30/07
Sheet 1 of 8

References Used:

Calculations are based on:

Abel, J.F., Jr. Bulkhead design for acid mine drainage: 1998, in Proc Western U.S. Mining-Impacted Watersheds, Joint Conf on Remediation and Ecological Risk Assessment Technologies, Denver, CO, 36 p

American Concrete Institute, 2002. Building code requirements for structural concrete (ACI 318-02) and commentary - ACI 318R-02: 369 p

Wang, C.K. & C.G. Salmon, 1985, Reinforced concrete design: 4th ed., Harper & Rowe Publishers, Inc.

Notation:

a = minimum concrete compression zone depth (in) to balance rebar tension

A_s = area of rebar (in^2)

b_w = beam width (ft)

B_p = allowable breakdown pressure (psi)

d = max distance, compressed concrete to center of tensile rebar (in)

E_{bm} = earthquake bulkhead load (lb)

E_{fm} = earthquake static fluid load (lb)

f_{ct} = concrete tensile strength $[3(f_c)^{1/2}]$

f_{cs} = concrete shear strength $[2(f_c)^{1/2}]$

FS = factor of safety

L = bulkhead (beam) thickness (ft)

Ls = bulkhead shear thickness (ft)

I = moment of inertia (in^4)

K = $[3.5 - 2.5(M_u/d)]$

M = beam bending moment (ft-lb)

M_u = factored bending moment (ft-lb)

M_n = nominal bending moment (ft-lb)

M_{ua} = earthquake bending moment (ft-lb)

p = max hydraulic pressure head (psi)

p_w = ratio rebar to concrete areas = $A_s/(w_b d)$

S = section modulus (in^3)

T = tensile bending unit force (lb/ft)

U = factored unit strength required (lb/ft)

U_a = earthquake unit strength required (lb/ft)

V = concrete shear strength required (lb/ft)

Inputs:

Beam width, $b_w := 1$ ft (12 in)

Bulkhead depth below surface, $B_w := 125$ ft

Maximum bulkhead height, $h_b := 12$ ft

Maximum bulkhead width, $w_b := 12$ ft

Current tunnel height, $h_t := 11$ ft

Current tunnel width, $w_t := 11$ ft

Design water head, $H := 120$ ft

Concrete compressive strength, $f_c := 3000$ psi

Inbye line-of-sight water distance, $S_{ls} := 313$ ft

Overburden rock density, $\gamma_r := 163$ pcf

Concrete density, $\gamma_c := 151$ pcf

Water density, $\gamma_w := 62.4$ pcf

Minimum concrete rebar cover, $m_c := 3.5$ in

Rebar yield strength, $f_y := 60000$ psi

Pressure gradient with low-pressure concrete/rock contact grouting, $p_{ag} := 41$ psi

Gravity acceleration, $g := 32.2$ ft/sec^2

Maximum earthquake acceleration, $\alpha := 0.239 \cdot g$

Bulkhead trial thickness, $L_t := 12$ ft

Strength reduction factors

Rebar flexure (tensile) strength, $\phi_{rt} := 0.90$

Reinforced concrete shear strength, $\phi_{rs} := 0.75$

Plain concrete flexure strength, $\phi_{pc} := 0.55$

Reinforced concrete flexure strength $\phi_{rc} := 0.90$

Project, **Pierce Adit Tunnel Bulkhead, Sta. 3+04**
12' Thick, 12' Wide, 12' High, #6 Rebar

By **MEL/JFA** Date **10/30/07**

Notation continued:

V_n = nominal concrete shear strength (lb/ft)

V_u = factored concrete shear strength (lb/ft)

v_s = rebar shear stress (psi)

W = total bulkhead load (lb)

Z = height of rock to prevent hydrofrac (ft)

Δ_{ovb} = overburden rock stress per ft depth (ft)

ω_{fs} = factored static fluid bulkhead load (psf)

ω_{fsc} = factored static fluid bulkhead earthquake load (psf)

ω_{fle} = factored line-of-sight fluid earthquake bulkhead load (psf)

ω_{fbe} = factored concrete bulkhead earthquake load (psf)

Inputs continued:

Load increase design factors

Fluid static load, $\phi_{fs} := 1.40$

Earthquake acceleration of static fluid load, $\phi_{fe} := 1.05$

Earthquake acceleration of line-of-sight impounded fluid and bulkhead loads, $\phi_{ea} := 1.40$

v_{n1} = nominal limiting shear stress, $w_b/L_t<2$ (psi)

v_{n2} = nominal limiting shear stress, $w_b/L_t = 2\text{-}5$ (psi)

σ_s = flexural stress (psi)

σ_{mingp} = minimum contact grout pressure (psi)

σ_{maxgp} = maximum contact grout pressure (psi)

Bulkhead length for allowable hydraulic pressure gradient:

Maximum (design) hydraulic pressure, $p := \frac{H \cdot \gamma_w}{144}$ psi $\quad p = 52$ psi

Minimum contact grout pressure, $\sigma_{mingp} := \frac{B_w \cdot \gamma_w}{144}$ psi $\quad \sigma_{mingp} = 54.2$ psi

Maximum contact grout pressure, $\sigma_{maxgp} := \frac{2 \cdot B_w \cdot \gamma_r}{144}$ psi $\quad \sigma_{maxgp} = 283$ psi

Allowable 41 psi/ft pressure gradient for low-pressure grouting of upper part of concrete/rock contact:

Required bulkhead thickness for low-pressure contact grouting, $L_{hp} := \frac{p}{41}$ ft $\quad L_{hp} = 1.27$ ft

Depth below surface to prevent hydrofrac of rock around tunnel:

Available formation breakdown pressure, $B_p := p$ $\quad B_p = 52$ psi

Overburden pressure, per ft of depth, $\Delta_{ovb} := \frac{\gamma_r}{144}$ $\quad \Delta_{ovb} = 1.132$ psi/ft

Height of rock to prevent hydrofrac, $Z := \frac{B_p}{2 \cdot \Delta_{ovb}}$ $\quad Z = 23$ ft

Project, **Pierce Adit Bulkhead, Sta. 3+04** **12' Thick, 12' Wide, 12' High, #6 Rebar** By **MEL/JFA** Date **10/30/07**
Sheet **3** of **8**

Bulkhead thickness (length) to resist concrete shear from static fluid load on upstream face:

Factored static fluid load on bulkhead face. $F_s := 144 \cdot \phi_{fs} \cdot p \cdot h_b \cdot w_b$ $F_s = 1509581$ lb

Factored static fluid load/sq ft of face, $\omega_{fs} := \dfrac{F_s}{h_b \cdot w_b}$ $\omega_{fs} = 10483$ psf

Concrete shear strength, $f_{cs} := 2\sqrt{f_c}$ $f_{cs} = 109.5$ psi

Bulkhead thickness to resist factored shear load, $L_s := \dfrac{F_s}{2 \cdot (h_b + w_b) \cdot 144 \cdot f_{cs}}$ $L_s = 1.99$ ft

Plain concrete deep-beam bending stress design for static fluid load on upstream face:

Deep-beam defined as Wb/Lt < 4 (ACI 318-02, Sec 10-7).

$\dfrac{w_b}{L_t} = 1.0$ which is less than 4. Therefore, this is a deep beam for design.

Factored static fluid load on bulkhead face, $F_s := 144 \cdot \phi_{fs} \cdot p \cdot h_b \cdot w_b$ $F_s = 1509581$ lb

Uniform factored static fluid load on bulkhead, $f_s := \dfrac{F_s}{h_b \cdot w_b}$ $f_s = 10483$ psf

Nominal static fluid bending moment, $M_n := f_s \cdot \dfrac{w_b^2}{8}$ $M_n = 188698$ ft-lb

Factored static fluid bending moment, $M_u := \dfrac{M_n}{\phi_{pc}}$ $M_u = 343087$ ft-lb

Bulkhead section modulus, $S := \dfrac{144 \cdot L_t^2}{6}$ $S = 3456$ in³

Concrete flexural (tensile) design stress, $f_{cl} := 3\sqrt{f_c}$ $f_{cl} = 164.3$ psi

$$\sigma_s := \frac{M_u}{S} \qquad \sigma_s := \frac{M_u}{\frac{144 \cdot L_t^2}{6}} \qquad \sigma_s := \frac{M_u}{24 \cdot L_t^2}$$

$$\sigma_s := f_{cl} \qquad L_{st} := \sqrt{\frac{M_u}{24 \cdot \sigma_s}} \qquad L_{st} = 9.33 \text{ ft}$$

Project, **Pierce Adit Bulkhead, Sta. 3+04**
12' Thick, 12' Wide, 12' High, #6 Rebar

By **MEL/JFA** Date **10/30/07**

Sheet **4** of **8**

Reinforced concrete deep-beam bending stress design for static fluid load on upstream face

$C = \phi_{rc} f_c b_w a = 0.85(3000)12a = 30600a$ $T = A_s f_y = 60000A_s$

$C = T$ $30600a = 60000A_s$ $a = (60000\ A_s)/30600 = 1.961\ A_s$

Factored static fluid bending moment, $M_u := \dfrac{M_n}{\phi_{rc}}$ $M_u = 209664$ ft-lb

$M_{uin} := 12 \cdot M_u$ $M_{uin} = 2515968$ in-lb

Maximum concrete rebar cover, $d := 12 \cdot L_t - m_c$ $d = 140.500$ in

$M_u = A_s f_c (d - a/2) = 60000 A_s (116.5 - 1.961\ A_s/2) = 60000\ A_s d - 58830\ A_s^2$

$58830\ A_s^2 - 60000\ A_s d + M_{uin} = 0$ $C_1 := 58830$ $C_2 := -60000 \cdot d$ $C_3 := M_{uin}$

$$A_s := \frac{-C_2 - \sqrt{C_2^2 - 4 \cdot C_1 \cdot C_3}}{2 \cdot C_1}$$ $A_s = 0.299$ in^2

One cage of #6 bars (0.44 in² per bar, 0.750-in nominal diameter, 1.502 lb/ft) on 12.00-in c-c (11.250-in between bars) provides 0.44 in²/ft of steel area.

Therefore, $A_s := 0.44$ in^2

Check for adequacy,

Allowable factored bending moment, $A_u := -C_1 \cdot \left(A_s^2\right) - C_2 \cdot A_s$ $A_u = 3697811$ in-lb

Design factored bending moment, $M_{uin} = 2515968$ in-lb

Factor of safety, $FS := \dfrac{A_u}{M_{uin}}$ $FS = 1.470$

Project, **Pierce Adit Bulkhead, Sta. 3+04**
12' Thick, 12' Wide, 12' High, #6 Rebar

By **MEL/JFA** Date **10/30/07**
Sheet **5** of **8**

Plain concrete deep-beam bending stress design for earthquake acceleration:

Factored earthquake accelerated static fluid load, $E_{fe} := 144 \cdot \phi_{fe} \cdot p \cdot h_b \cdot w_b$ $E_{fe} = 1132186$ lb

Factored earthquake accelerated line-of-sight fluid load, $E_{fm} := \dfrac{\phi_{ea} \cdot S_{ls} \cdot \gamma_w \cdot h_t \cdot w_t \cdot \alpha}{g}$

$E_{fm} = 790752$ lb

Factored earthquake accelerated bulkhead load, $E_{bm} := \dfrac{\phi_{ea} \cdot L_t \cdot h_b \cdot w_b \cdot \gamma_c \cdot \alpha}{g}$

$E_{bm} = 87307$ lb

Total factored earthquake load on bulkhead, $U_\alpha := E_{fe} + E_{fm} + E_{bm}$ $U_\alpha = 2010244$ lb

Uniform factored earthquake load on bulkhead, $u := \dfrac{U_\alpha}{h_b \cdot w_b}$ $u = 13960$ psf

Nominal earthquake bending moment, $M_n := u \cdot \dfrac{w_b^{\,2}}{8}$ $M_n = 251280$ ft-lb

Factored earthquake bending moment, $M_u := \dfrac{M_n}{\phi_{pc}}$ $M_u = 456874$ ft-lb

Bulkhead section modulus, $S := \dfrac{144 \cdot L_t^{\,2}}{6}$ $S = 3456$ in^3

Concrete flexural (tensile) design stress, $f_{cl} := 3\sqrt{f_c}$ $f_{cl} = 164.3$ psi

$\sigma_s := \dfrac{M_u}{S}$ $\sigma_s := \dfrac{M_u}{\dfrac{144 \cdot L_{fc}}{6}}$ $\sigma_s := \dfrac{M_u}{24 \cdot L_{fc}}$

$\sigma_s := f_{cl}$ $L_{fc} := \sqrt{\dfrac{M_u}{24 \cdot \sigma_s}}$ $L_{fc} = 10.76$ ft

Project, **Pierce Adit Bulkhead, Sta. 3+04**
12' Thick, 12' Wide, 12' High, #6 Rebar

By **MEL/JFA** Date **10/30/07**
Sheet **6** of **8**

Reinforced concrete deep-beam bending stress design for earthquake acceleration

$C = \phi_{rc} f_c b_w a = 0.85(3000)12a = 30600a$ $T = A_s f_y = 60000 A_s$

$C = T$ $30600a = 60000 A_s$ $a = (60000\ A_s)/30600 = 1.961\ A_s$

Factored earthquake bending moment, $M_u := \frac{M_n}{\phi_{rt}}$ $M_u = 279201$ ft-lb

$M_{uin} := 12 \cdot M_u$ $M_{uin} = 3350407$ in-lb

Maximum concrete rebar cover, $d := 12 \cdot L_t - m_c$ $d = 140.500$ in

$M_u = A_s f_c (d - a/2) = 60000 A_s (116.5 - 1.961\ A_s/2) = 60000\ A_s d - 58830\ A_s^2$

$58830\ A_s^2 - 60000\ A_s d + M_{uin} = 0$ $C_1 := 58830$ $C_2 := -60000 \cdot d$ $C_3 := M_{uin}$

$$A_s := \frac{-C_2 - \sqrt{C_2^{\,2} - 4 \cdot C_1 \cdot C_3}}{2 \cdot C_1}$$ $A_s = 0.399$ in^2

One cage of #6 bars (0.44 in^2 per bar, 0.750-in nominal diameter, 1.502 lb/ft) on 12.00-in c-c (11.250-in between bars) provides 0.44 in^2/ft of steel area.

Therefore, $A_s := 0.440$ in^2

Check for adequacy,

Allowable factored bending moment, $A_u := -C_1 \cdot \left(A_s^{\,2}\right) - C_2 \cdot A_s$ $A_u = 3697811$ in-lb

Design factored bending moment, $M_{uin} = 3350407$ in-lb

Factor of safety, $FS := \frac{A_u}{M_{uin}}$ $FS = 1.104$

Project, **Pierce Adit Bulkhead, Sta. 3+04**
12' Thick, 12' Wide, 12' High, #6 Rebar

By **MEL/JFA** Date **10/30/07**
Sheet **7** of **8**

Critical section shear strength for 12-ft thick reinforced deep-beam concrete bulkhead subjected to maximum credible earthquake:

Deep-beam bulkhead defined as wb/Lt < 4 (ACI 318-02, Sec 10.7). The critical shear section is 0.15 times the maximum bulkhead width (2.25 ft) from the ribside (ACI 318-02, Sec 11.8.5).

$\frac{w_b}{L_t} = 1.0$ which is less than 4. Therefore, this is a deep beam for design.

When wb/Lt < 4, the limiting nominal shear stress (v_n) cannot exceed 10 times the sq rt of f_c (ACI 318-02, Sec11.8.3).

$v_n := 10 \cdot \sqrt{f_c}$ $v_n = 548$ psi

Therefore, the maximum allowable nominal shear force per foot of beam width is:

$V_{na} := v_n \cdot 12 \cdot b_w \cdot d$ $V_{na} = 923460$ lb per 1-ft wide horizontal deep beam

Nominal developed shear force at critical section per foot of horizontal deep beam width

$V_{nd} := 0.35 \cdot u \cdot w_b$ $V_{nd} = 58632$ lb per 1-ft wide horizontal deep beam

Factored nominal developed shear force at critical section per foot of horizontal deep beam width

$V_u := \frac{V_{nd}}{\phi_{rs}}$ $V_u = 78176$ lb per 1-ft wide horizontal deep beam

Nominal developed moment at critical section per foot of horizontal deep beam width

$M_n := 0.06375 \cdot \frac{u \cdot \left(w_b^{\,2}\right)}{2}$ $M_n = 64077$ ft-lb per 1-ft wide horizontal deep beam

Factored nominal developed moment at critical section per foot of horizontal deep-beam width

$M_u := \frac{M_n}{\phi_{rt}}$ $M_u = 71196$ ft-lb per 1-ft wide horizontal deep beam

Project, **Pierce Adit Bulkhead, Sta. 3+04**
12' Thick, 12' Wide, 12' High, #6 Rebar

By MEL/JFA Date 10/29/07
Sheet 8 of 8

Calculation equation for allowable shear strength (V_c) at critical section of deep beam, including rebar tensile reinforcement,

$$V_c := K \cdot \left(1.9 \cdot \sqrt{f_c} + 2500 \cdot p_w \cdot \frac{V_u}{M_u} \cdot \frac{d}{12}\right) \cdot 12 \cdot b_w \cdot d$$

Maximum permitted calculated concrete shear strength (v_c): (ACI 318-02, Sec 11.8.3)

$v_c := 6 \cdot \sqrt{f_c}$ $v_c = 329$ psi

Ratio of rebar reinforcement area to concrete area (p_w), $p_w := \frac{A_s}{b_w \cdot 12 \cdot d}$ $p_w = 0.000261$

Limiting value for term $K = [3.5 - 2.5(M_u/V_u d)] = 2.5$

$K := 3.5 - 2.5 \cdot \frac{M_u}{\frac{V_u \cdot d}{12}}$ $K = 3.306$ Therefore, $K := 2.5$

Allowable shear strength (V_c) at critical section of deep beam,

$$V_c := K \cdot \left(1.9 \cdot \sqrt{f_c} + 2500 \cdot p_w \cdot \frac{V_u}{M_u} \cdot \frac{d}{12}\right) \cdot 12 \cdot b_w \cdot d$$

$V_c = 473998$ lb per 1-ft wide horizontal deep beam

Limiting allowable shear force cannot exceed:

$V_{max} := v_c \cdot b_w \cdot 12 \cdot d$ $V_{max} = 554076$

Factor of safety using the lower of calculated V_c or V_{max} in relation to maximum credible earthquake loading induced factored nominal developed shear force (V_u) at critical section,

$FS := \frac{V_{max}}{V_u}$ $FS = 7.088$

Project, **Steve Adit Bulkhead, Sta. 2+65**
10' Thick, 10' Wide, 10' High, #6 Rebar

By **MEL/JFA** Date **10/30/07**
Sheet **1** of **8**

References Used:

Calculations are based on:
Abel, J.F., Jr. Bulkhead design for acid mine drainage: 1998, in Proc Western U.S. Mining-Impacted Watersheds, Joint Conf on Remediation and Ecological Risk Assessment Technologies, Denver, CO, 36 p
American Concrete Institute, 2002, Building code requirements for structural concrete (ACI 318-02) and commentary - ACI 318R-02: 369 p
Wang, C.K. & C.G. Salmon, 1985, Reinforced concrete design: 4th ed., Harper & Rowe Publishers, Inc.

Notation:

a = minimum concrete compression zone depth (in) to balance rebar tension
A_s = area of rebar (in^2)
b_w = beam width (ft)
B_p = allowable breakdown pressure (psi)
d = max distance, compressed concrete to center of tensile rebar (in)
E_{bm} = earthquake bulkhead load (lb)
E_{fm} = earthquake static fluid load (lb)
f_{cl} = concrete tensile strength $[3(f_c)^{1/2}]$
f_{cs} = concrete shear strength $[2(f_c)^{1/2}]$
FS = factor of safety
L = bulkhead (beam) thickness (ft)
Ls = bulkhead shear thickness (ft)
I = moment of inertia (in^4)
K = $[3.5 - 2.5(M_u/d)]$
M = beam bending moment (ft-lb)
M_u = factored bending moment (ft-lb)
M_n = nominal bending moment (ft-lb)
M_{ua} = earthquake bending moment (ft-lb)
p = max hydraulic pressure head (psi)
p_w = ratio rebar to concrete areas = $A_s/(w_b d)$
S = section modulus (in^3)
T = tensile bending unit force (lb/ft)
U = factored unit strength required (lb/ft)
U_a = earthquake unit strength required (lb/ft)
V = concrete shear strength required (lb/ft)

Inputs:

Beam width, $b_w := 1$ ft (12 in)
Bulkhead depth below surface, $B_w := 115$ ft
Maximum bulkhead height, $h_b := 10$ ft
Maximum bulkhead width, $w_b := 10$ ft
Current tunnel height, $h_t := 9$ ft
Current tunnel width, $w_t := 8.5$ ft
Design water head, $H := 120$ ft
Concrete compressive strength, $f_c := 3000$ psi
Inbye line-of-sight water distance, $S_{ls} := 280$ ft
Overburden rock density, $\gamma_r := 163$ pcf
Concrete density, $\gamma_c := 151$ pcf
Water density, $\gamma_w := 62.4$ pcf
Minimum concrete rebar cover, $m_c := 3.5$ in
Rebar yield strength, $f_y := 60000$ psi
Pressure gradient with low-pressure concrete/rock contact grouting, $p_{ag} := 41$ psi
Gravity acceleration, $g := 32.2$ ft/sec^2
Maximum earthquake acceleration, $\alpha := 0.239 \cdot g$
Bulkhead trial thickness, $L_t := 10$ ft

Strength reduction factors

Rebar flexure (tensile) strength, $\phi_{rt} := 0.90$
Reinforced concrete shear strength, $\phi_{rs} := 0.75$
Plain concrete flexure strength, $\phi_{pc} := 0.55$
Reinforced concrete flexure strength $\phi_{rc} := 0.90$

Project, **Steve Adit Tunnel Bulkhead, Sta. 2+65**
10' Thick, 10' Wide, 10' High, #6 Rebar

By MEL/JFA Date 10/30/07
Sheet 2 of 8

Notation continued:

V_n = nominal concrete shear strength (lb/ft)
V_u = factored concrete shear strength (lb/ft)
v_s = rebar shear stress (psi)
W = total bulkhead load (lb)
Z = height of rock to prevent hydrofrac (ft)
Δ_{ovb} = overburden rock stress per ft depth (ft)
ω_{fs} = factored static fluid bulkhead load (psf)
ω_{fse} = factored static fluid bulkhead earthquake load (psf)
ω_{flc} = factored line-of-sight fluid earthquake bulkhead load (psf)
ω_{fbe} = factored concrete bulkhead earthquake load (psf)

Inputs continued:

Load increase design factors

Fluid static load, $\phi_{fs} := 1.40$

Earthquake acceleration of static fluid load, $\phi_{fc} := 1.05$

Earthquake acceleration of line-of-sight impounded fluid and bulkhead loads, $\phi_{ea} := 1.40$

v_{n1} = nominal limiting shear stress, $w_b/L_t<2$ (psi)

v_{n2} = nominal limiting shear stress, $w_b/L_t = 2\text{-}5$ (psi)

σ_s = flexural stress (psi)

σ_{mingp} = minimum contact grout pressure (psi)

σ_{maxgp} = maximum contact grout pressure (psi)

Bulkhead length for allowable hydraulic pressure gradient:

Maximum (design) hydraulic pressure, $p := \frac{H \cdot \gamma_w}{144}$ psi $p = 52$ psi

Minimum contact grout pressure, $\sigma_{mingp} := \frac{B_w \cdot \gamma_w}{144}$ psi $\sigma_{mingp} = 49.8$ psi

Maximum contact grout pressure, $\sigma_{maxgp} := \frac{2 \cdot B_w \cdot \gamma_r}{144}$ psi $\sigma_{maxgp} = 260$ psi

Allowable 41 psi/ft pressure gradient for low-pressure grouting of upper part of concrete/rock contact:

Required bulkhead thickness for low-pressure contact grouting, $L_{hp} := \frac{p}{41}$ ft $L_{hp} = 1.27$ ft

Depth below surface to prevent hydrofrac of rock around tunnel:

Available formation breakdown pressure, $B_p := p$ $B_p = 52$ psi

Overburden pressure, per ft of depth, $\Delta_{ovb} := \frac{\gamma_r}{144}$ $\Delta_{ovb} = 1.132$ psi/ft

Height of rock to prevent hydrofrac, $Z := \frac{B_p}{2 \cdot \Delta_{ovb}}$ $Z = 23$ ft

Project, **Steve Adit Bulkhead, Sta. 2+65** By **MEL/JFA** Date **10/30/07**
10' Thick, 10' Wide, 10' High, #6 Rebar Sheet **3** of **8**

Bulkhead thickness (length) to resist concrete shear from static fluid load on upstream face:

Factored static fluid load on bulkhead face, $F_s := 144 \cdot \phi_{fs} \cdot p \cdot h_b \cdot w_b$ $F_s = 1048320$ lb

Factored static fluid load/sq ft of face, $\omega_{fs} := \frac{F_s}{h_b \cdot w_b}$ $\omega_{fs} = 10483$ psf

Concrete shear strength, $f_{cs} := 2\sqrt{f_c}$ $f_{cs} = 109.5$ psi

Bulkhead thickness to resist factored shear load, $L_s := \frac{F_s}{2 \cdot (h_b + w_b) \cdot 144 \cdot f_{cs}}$ $L_s = 1.66$ ft

Plain concrete deep-beam bending stress design for static fluid load on upstream face:

Deep-beam defined as Wb/Lt < 4 (ACI 318-02, Sec 10-7).

$\frac{w_b}{L_t} = 1.0$ which is less than 4. Therefore, this is a deep beam for design.

Factored static fluid load on bulkhead face, $F_s := 144 \cdot \phi_{fs} \cdot p \cdot h_b \cdot w_b$ $F_s = 1048320$ lb

Uniform factored static fluid load on bulkhead, $f_s := \frac{F_s}{h_b \cdot w_b}$ $f_s = 10483$ psf

Nominal static fluid bending moment, $M_n := f_s \cdot \frac{w_b^2}{8}$ $M_n = 131040$ ft-lb

Factored static fluid bending moment, $M_u := \frac{M_n}{\phi_{pc}}$ $M_u = 238255$ ft-lb

Bulkhead section modulus, $S := \frac{144 \cdot L_t^2}{6}$ $S = 2400$ in^3

Concrete flexural (tensile) design stress, $f_{cl} := 3\sqrt{f_c}$ $f_{cl} = 164.3$ psi

$\sigma_s := \frac{M_u}{S}$ $\sigma_s := \frac{M_u}{\frac{144 \cdot L_t^2}{6}}$ $\sigma_s := \frac{M_u}{24 \cdot L_t^2}$

$\sigma_s := f_{cl}$ $L_{st} := \sqrt{\frac{M_u}{24 \cdot \sigma_s}}$ $L_{st} = 7.77$ ft

Project, **Steve Adit Bulkhead, Sta. 2+65**
10' Thick, 10' Wide, 10' High, #6 Rebar

By **MEL/JFA** Date **10/30/07**

Sheet 4 of 8

Reinforced concrete deep-beam bending stress design for static fluid load on upstream face

$C = \phi_{rc} f_c b_w a = 0.85(3000)12a = 30600a$ $T = A_s f_y = 60000A_s$

$C = T$ $30600a = 60000A_s$ $a = (60000\ A_s)/30600 = 1.961\ A_s$

Factored static fluid bending moment, $M_u := \dfrac{M_n}{\phi_{rc}}$ $M_u = 145600$ ft-lb

$M_{uin} := 12 \cdot M_u$ $M_{uin} = 1747200$ in-lb

Maximum concrete rebar cover, $d := 12 \cdot L_t - m_c$ $d = 116.500$ in

$M_u = A_s f_c (d-a/2) = 60000A_s(116.5 - 1.961\ A_s/2) = 60000\ A_s d - 58830\ A_s^2$

$58830\ A_s^2 - 60000\ A_s d + M_{uin} = 0$ $C_1 := 58830$ $C_2 := -60000 \cdot d$ $C_3 := M_{uin}$

$$A_s := \frac{-C_2 - \sqrt{C_2^2 - 4 \cdot C_1 \cdot C_3}}{2 \cdot C_1}$$ $A_s = 0.25$ in^2

One cage of #6 bars (0.44 in² per bar, 0.750-in nominal diameter, 1.502 lb/ft) on 12.00-in c-c (11.25-in between bars) provides 0.44 in²/ft of steel area.

Therefore, $A_s := 0.44$ in^2

Check for adequacy,

Allowable factored bending moment, $A_u := -C_1 \cdot \left(A_s^2\right) - C_2 \cdot A_s$ $A_u = 3064211$ in-lb

Design factored bending moment, $M_{uin} = 1747200$ in-lb

Factor of safety, $FS := \dfrac{A_u}{M_{uin}}$ $FS = 1.754$

Project, **Steve Adit Bulkhead, Sta. 2+65** By **MEL/JFA** Date **10/30/07**
10' Thick, 10' Wide, 10' High, #6 Rebar Sheet 5 of 8

Plain concrete deep-beam bending stress design for earthquake acceleration:

Factored earthquake accelerated static fluid load, $E_{fe} := 144 \cdot \phi_{fe} \cdot p \cdot h_b \cdot w_b$ $E_{fe} = 786240$ lb

Factored earthquake accelerated line-of-sight fluid load, $E_{fm} := \dfrac{\phi_{ea} \cdot S_{ls} \cdot \gamma_w \cdot h_t \cdot w_t \cdot \alpha}{g}$

$E_{fm} = 447229$ lb

Factored earthquake accelerated bulkhead load, $E_{bm} := \dfrac{\phi_{ea} \cdot L_t \cdot h_b \cdot w_b \cdot \gamma_c \cdot \alpha}{g}$

$E_{bm} = 50525$ lb

Total factored earthquake load on bulkhead, $U_\alpha := E_{fe} + E_{fm} + E_{bm}$ $U_\alpha = 1283994$ lb

Uniform factored earthquake load on bulkhead, $u := \dfrac{U_\alpha}{h_b \cdot w_b}$ $u = 12840$ psf

Nominal earthquake bending moment, $M_n := u \cdot \dfrac{w_b^{\,2}}{8}$ $M_n = 160499$ ft-lb

Factored earthquake bending moment, $M_u := \dfrac{M_n}{\phi_{pc}}$ $M_u = 291817$ ft-lb

Bulkhead section modulus, $S := \dfrac{144 \cdot L_t^{\,2}}{6}$ $S = 2400$ in^3

Concrete flexural (tensile) design stress, $f_{cl} := 3\sqrt{f_c}$ $f_{cl} = 164.3$ psi

$\sigma_s := \dfrac{M_u}{S}$ $\sigma_s := \dfrac{M_u}{\frac{144 \cdot L_{fc}}{6}}$ $\sigma_s := \dfrac{M_u}{24 \cdot L_{fc}}$

$\sigma_s := f_{cl}$ $L_{fc} := \sqrt{\dfrac{M_u}{24 \cdot \sigma_s}}$ $L_{fc} = 8.60$ ft

Project, Steve Adit Bulkhead, Sta. 2+65
10' Thick, 10' Wide, 10' High, #6 Rebar

By MEL/JFA Date 10/30/07
Sheet 6 of 8

Reinforced concrete deep-beam bending stress design for earthquake acceleration

$C = \phi_{rc} f_c b_w a = 0.85(3000)12a = 30600a$ $\quad T = A_s f_y = 60000A_s$

$C = T$ $\quad 30600a = 60000A_s$ $\quad a = (60000\ A_s)/30600 = 1.961\ A_s$

Factored earthquake bending moment, $M_u := \frac{M_n}{\Phi_{rt}}$ $\quad M_u = 178332$ ft-lb

$M_{uin} := 12 \cdot M_u$ $\quad M_{uin} = 2139989$ in-lb

Maximum concrete rebar cover, $d := 12 \cdot L_t - m_c$ $\quad d = 116.500$ in

$M_u = A_s f_c (d\text{-}a/2) = 60000A_s(116.5 - 1.961\ A_s/2) = 60000\ A_s d - 58830\ A_s^2$

$58830\ A_s^2 - 60000\ A_s d + M_{uin} = 0$ $\quad C_1 := 58830$ $\quad C_2 := -60000 \cdot d$ $\quad C_3 := M_{uin}$

$$A_s := \frac{-C_2 - \sqrt{C_2^{\,2} - 4 \cdot C_1 \cdot C_3}}{2 \cdot C_1} \qquad A_s = 0.307 \quad in^2$$

One cage of #6 bars (0.44 in² per bar, 0.750-in nominal diameter, 1.502 lb/ft) on 12.00-in c-c (11.25-in between bars) provides 0.44 in²/ft of steel area.

Therefore, $A_s := 0.44$ in²

Check for adequacy,

Allowable factored bending moment, $A_u := -C_1 \cdot \left(A_s^{\,2}\right) - C_2 \cdot A_s$ $\quad A_u = 3064211$ in-lb

Design factored bending moment, $M_{uin} = 2139989$ in-lb

Factor of safety, $FS := \frac{A_u}{M_{uin}}$ $\quad FS = 1.432$

Project, **Steve Adit Bulkhead, Sta. 2+65**
10' Thick, 10' Wide, 10' High, #6 Rebar

By **MEL/JFA** Date **10/30/07**
Sheet **7** of **8**

Critical section shear strength for 12-ft thick reinforced deep-beam concrete bulkhead subjected to maximum credible earthquake:

Deep-beam bulkhead defined as wb/Lt < 4 (ACI 318-02, Sec 10.7). The critical shear section is 0.15 times the maximum bulkhead width (2.25 ft) from the ribside (ACI 318-02, Sec 11.8.5).

$\frac{w_b}{L_t} = 1.0$ which is less than 4. Therefore, this is a deep beam for design.

When wb/Lt < 4, the limiting nominal shear stress (v_n) cannot exceed 10 times the sq rt of f_c (ACI 318-02, Sec11.8.3).

$v_n := 10 \cdot \sqrt{f_c}$ $v_n = 548$ psi

Therefore, the maximum allowable nominal shear force per foot of beam width is:

$V_{na} := v_n \cdot 12 \cdot b_w \cdot d$ $V_{na} = 765716$ lb per 1-ft wide horizontal deep beam

Nominal developed shear force at critical section per foot of horizontal deep beam width

$V_{nd} := 0.35 \cdot u \cdot w_b$ $V_{nd} = 44940$ lb per 1-ft wide horizontal deep beam

Factored nominal developed shear force at critical section per foot of horizontal deep beam width

$V_u := \frac{V_{nd}}{\phi_{rs}}$ $V_u = 59920$ lb per 1-ft wide horizontal deep beam

Nominal developed moment at critical section per foot of horizontal deep beam width

$M_n := 0.06375 \cdot \frac{u \cdot \left(w_b^2\right)}{2}$ $M_n = 40927$ ft-lb per 1-ft wide horizontal deep beam

Factored nominal developed moment at critical section per foot of horizontal deep-beam width

$M_u := \frac{M_n}{\phi_{rt}}$ $M_u = 45475$ ft-lb per 1-ft wide horizontal deep beam

Project, **Steve Adit Bulkhead, Sta. 2+65**
10' Thick, 10' Wide, 10' High, #6 Rebar

By **MEL/JFA** Date **10/30/07**
Sheet **8** of **8**

Calculation equation for allowable shear strength (V_c) at critical section of deep beam, including rebar tensile reinforcement,

$$V_c := K \cdot \left(1.9 \cdot \sqrt{f_c} + 2500 \cdot p_w \cdot \frac{V_u}{M_u} \cdot \frac{d}{12}\right) \cdot 12 \cdot b_w \cdot d$$

Maximum permitted calculated concrete shear strength (v_c): (ACI 318-02, Sec 11.8.3)

$v_c := 6 \cdot \sqrt{f_c}$ $\quad v_c = 329$ psi

Ratio of rebar reinforcement area to concrete area (p_w), $p_w := \frac{A_s}{b_w \cdot 12 \cdot d}$ $\quad p_w = 0.0003147$

Limiting value for term K = [3.5-2.5(M_u/V_ud)] = 2.5

$K := 3.5 - 2.5 \cdot \frac{M_u}{\frac{V_u \cdot d}{12}}$ $\quad K = 3.305$ Therefore, $K := 2.5$

Allowable shear strength (V_c) at critical section of deep beam,

$$V_c := K \cdot \left(1.9 \cdot \sqrt{f_c} + 2500 \cdot p_w \cdot \frac{V_u}{M_u} \cdot \frac{d}{12}\right) \cdot 12 \cdot b_w \cdot d$$

$V_c = 398894$ lb per 1-ft wide horizontal deep beam

Limiting allowable shear force cannot exceed:

$V_{max} := v_c \cdot b_w \cdot 12 \cdot d$ $\quad V_{max} = 459430$

Factor of safety using the lower of calculated V_c or V_{max} in relation to maximum credible earthquake loading induced factored nominal developed shear force (V_u) at critical section,

$FS := \frac{V_{max}}{V_u}$ $\quad FS = 7.667$

Division of Reclamation, Mining, and Safety

Fee Receipt for M1977300

Cotter Corporation

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Receipt #: 1971

Date: 11/16/2007

Permit: M1977300

Payment Method	Revenue Code	Fee Description/Notes	Amount
226699	4300-11	Minerals Technical Revision M-1977-300	$173.00
		Receipt Total:	**$173.00**

M-1977-300

TR10

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4-21-08

to: DRMS

Schwartzwalder Mine
Steve Level Adit Bulkheads

As-Built Documentation Package

Prepared for:

Amy Thurkill
Manager of Environmental, Health and Safety
Cotter Corporation
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Englewood, CO 80111

By:

MINING & ENVIRONMENTAL SERVICES LLC
P.O. Box 1511, Idaho Springs, CO 80452
March 16, 2008

RECEIVED
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Division of Reclamation,
Mining and Safety

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Steve Level Adit Bulkheads

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Schwartzwalder Mine
Steve Level Adit Closures

As-Built Documentation

Table of Contents

1.0 Project Summary

In the fall of 2007, the Cotter Corporation ("Cotter") engaged Mining & Environmental Services LLC ("MES") to design and construct two adit bulkheads at the idle Schwartzwalder underground uranium mine, located in the Ralston Creek drainage in northwestern Jefferson County, Colorado.

On the MES team was Project Manager / Mining Engineer, Mark Levin, who led the design and planning effort, and the Superintendent / Mining Engineer Willis "Will" Beach, P.E., who was responsible for all phases of construction.

Subconsultants to MES included Mining Engineers Dr. John F. Abel, P.E., in charge of overall review and direction of structural design, and Stephen Phillips, P.E., of Phillilps Mining, Geotechnical and Grouting, Inc.("PMGG"), who was responsible for providing input on the grouting and concrete plans and specifications. Additional engineering support was provided by subconsultant Mining Engineer Matt Collins, EI, who developed the preliminary and as-built design drawings.

MES utilized Advanced Terra Testing, Inc. to perform compressive strength testing of the adit rock samples taken by MES at the design phase, and CTL Thompson, Inc. as an independent Quality Assurance inspector to sample and test the concrete used in the bulkheads during construction.

2.0 Design

This section discusses the highlights of the design.

Detailed calculations, drawings, specifications, and test results appear in the tabbed sections which follow.

2.1 Location

The bulkhead locations are constrained by the fact that stopes are farther inby, rendering bulkheading any farther in impracticable. (See Drawing Sheet 2).

The Steve location at approximately 265 feet in from the portal (to the inby side of the bulkhead) was selected to avoid the timbered area just outby the vein / stope intersection, and also to incorporate a visibly iron stained seepage point source on the south rib within the bulkhead. Additionally, this location had favorable geometry, with a natural "keyway" with an enlarged area bounded by smaller cross sections inby and outby.

Figure 1: Steve adit bulkhead location, showing seep on rib.

The original Pierce adit bulkhead location was constrained by a weak altered zone on the south rib, which terminates about 35 feet outby from the stope intersection. Placement of a bulkhead within that alteration affected zone would have at a higher risk of perimeter leakage, and therefore the bulkhead was located outby from that altered zone, and also outby any areas of the sill (floor) being undermined significantly. Thus, in the original calculations, a tentative location (inby side) of 304 feet from the portal was selected.

It was noted on an examination from the bridge over the stope area farther inby in the Pierce adit that there was a possible stope area under the adit.

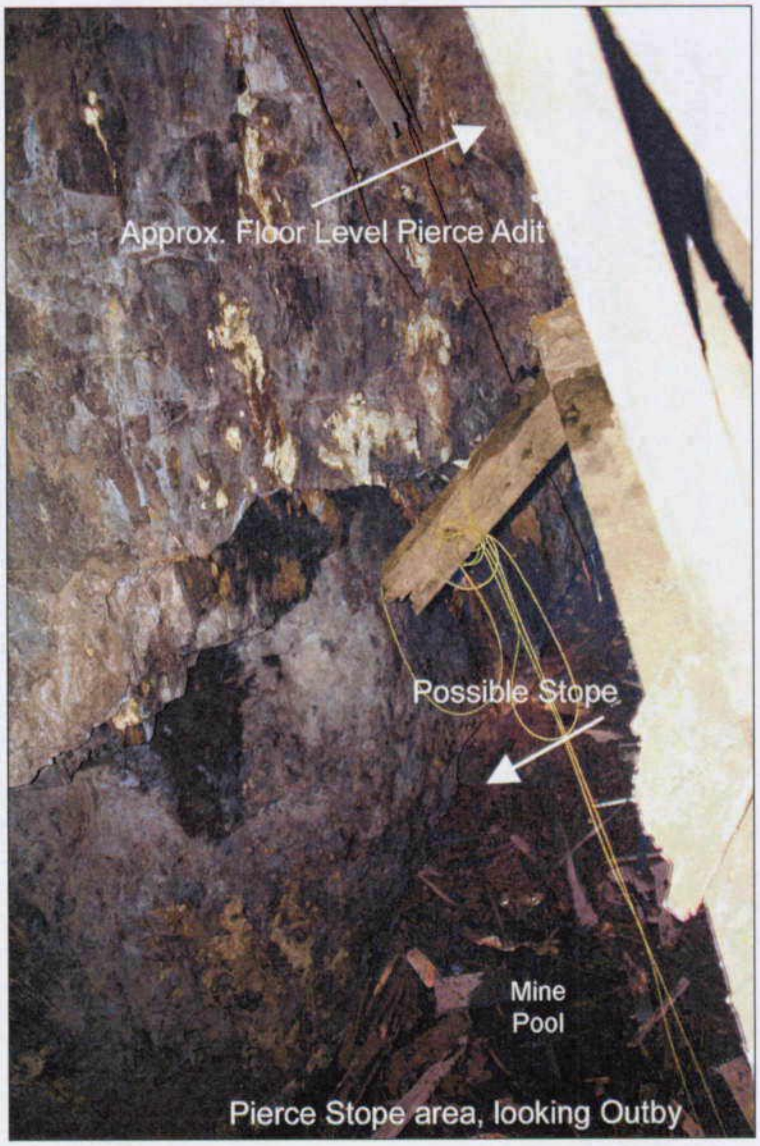

Figure 2: Area of possible stope

To investigate the thickness of the sill pillar (adit floor) above the suspected stope area, probe hole drilling was conducted to verify that there was adequate sill thickness. The probe hole drilling verified that there was at least 30 feet of rock pillar, however there was a fractured and rubbellized zone encountered below the north edge of the adit. As a result, it was decided to move the final bulkhead location outby another 20 feet.

Figure 3: Probe hole drilling in Pierce adit floor

Drawing sheet 6 shows the locations of these probe holes.

At this new location, an additional advantage was that the bulkhead closure could take in the 6-inch borehole to the next level up, resulting in sealing that potential water infiltration pathway from above as well.

Figure 4: Borehole in Pierce adit roof

2.2 Rock Strength

The rock strength of the adit ribs and roof in the bulkhead areas was tested to determine whether the rock strength would be a constraint on bulkhead design. The results are included at Tab #4. In all cases, for 3 samples each of the Steve and Pierce, the rock compressive strength exceeded the design concrete strength of 3000 psi used in the preliminary calculations, which means that the concrete strength was the governing constraint with respect to shear at the bulkhead perimeter.

2.3 Mine Water

Mine water quality data was provided to MES by Whetstone Associates, and is summarized at Tab 15. The mine shaft water quality data were judged to be representative of the expected water quality in a scenario where water was being impounded by the bulkheads.

Two parameters which are typically of concern in the design of mine bulkheads are acidity and sulfates, both of which can attack concrete.

A review of this data indicates that the mine shaft water is alkaline, approximately a pH of 7.5 and has a sulfate concentration of about 2000 mg/l. Acidity is thus not an issue. While the sulfate concentration is not high compared to many metal mine pools, any sulfate is adverse to concrete. Additionally, some individual samples of small pools on the mine floor showed sulfate concentrations as high as 7190 mg/l.

As a result, a highly sulfate resistant concrete mix specification, using a flyash addition, was provided (see specification at Tab 7). The specified Sulfate Resistance Factor of 0.75 required the importation of a railcar of a special fly ash from the Bridger plant (see mix data at Tab 9). This highly sulfate resistant flyash was used for both the bulkhead concrete and the portland-flyash grout mix.

2.4 Design Head

The design maximum head for the bulkheads was conservatively set at 120 feet. This is greater than the elevation approximately 116 foot difference between the Steve level (6600.56') and the open Charlie level (6716.23'). If the mine filled above the Steve level, water would run out the Charlie level before the design maximum head was reached. Additionally, were the mine to fill significantly above the Steve level, there is at least one adit between the Steve and the Charlie which has been backfilled with rock and soil, which would likely begin to seep before the mine pool reached the Charlie level.

Per e-mail correspondence from Susan Wyman at Whetstone Associates, they have determined that the mine pool is not expected to reach the Steve level, except possibly from infiltration in very wet years. A copy of this communication is included at the back of the Structural Calculations section under Tab 3.

2.5 Hydrofracturing Potential at Maximum Head

Hydrofracturing potential is the possible fracturing and failure of the rockmass above a bulkhead, as a result of the uplift force from the water head pressure exceeding the downward overburden force of the rockmass.

The potential for hydrofracturing was checked using previous rock density data that Dr. John Abel, P.E. had for the Schwartzwalder mine, of 163 pounds per cubic foot (PCF). Based on the weight of water at 62.4 PCF, it was determined that a minimum height of about 46 feet of rock would need to be above each bulkhead for resistance to hydrofracturing , assuming that the rock has zero tensile strength.

A review of the cross-section mine maps provided by Cotter indicates that rock depth above the bulkhead locations are well over 100 feet, and the more recent rock test results (Tab 4) indicate that the lowest measured rock density in the immediate area of the bulkheads was 173.8 PCF, thus providing even more resistance to uplift.

2.6 Earthquake

An important factor in the design of a water impoundment such as a dam or a mine bulkhead is the determination of the integrity of the structure under possible earthquake conditions. This calculation considers the effect of the water impounded in a direct line of sight behind the bulkhead being accelerated under conditions of the design basis earthquake.

Design basis earthquake accelerations for use in the calculations were obtained in accordance with the 2003 National Earthquake Hazards Reduction Program (NEHRP) Seismic Design Provisions, using the United States Geological Survey Java Ground Motion Parameter Calculator, Version 5.0.8. The results of this computer run are documented near the end of the Structural Calculations, under Tab 3.

The acceleration used was 0.239 g, corresponding to the expected maximum earthquake acceleration under a 0.2 second interval.

2.7 Concrete specifications and mix design

The Concrete specification is located at Tab 7. The concrete specified for the project was intended to meet several constraints:

- Self-compacting characteristics, to eliminate the need for vibration of the mass pour;
- Low heat of hydration;
- High sulfate resistance;
- Good pumpability.

Concrete mix design data is included at Tab 9.

The formwork specifications and shop drawings are included at Tab 8. In general, the critical issue with the formwork is that it must withstand the forces of the concrete (full hydrostatic head for self compacting concrete) plus the forces imposed by the pump overpressure, assumed to be 50 psi at the delivery point.

2.8 Grouting plan and specifications

The MES proposal to Cotter identified two options: contact grouting only, or an enhanced grouting program, intended to pressure-grout the blast-shattered, jointed rock of the adit perimeter.

To maximize protection of the environment, Cotter elected to have MES implement the more advanced grouting program alternative, to further reduce the potential leakage flow around the bulkheads.

The grouting plan calls for the use of two kinds of grout: one is a portland cement / flyash mixture, and the other is a superfine (typically 3 micron) particle size grout which is intended to permeate into very small fractures and joints in the rockmass. Additional data about this product is under Tab 13.

The general grouting plan appears under Tab 11, and the grouting specification at Tab 12.

2.9 Additional Monitoring pipes

On December 7th, MES was requested by Cotter to modify the Steve bulkhead to incorporate two additional stainless steel pipes, to be designed and provided and installed by Frontier Environmental Services, Inc. ("FESI") for the purpose of providing a method of obtaining water level measurements and samples from the mine shaft remotely.

MES personnel delayed closure of the Steve Adit forms for 3 days, in order to accommodate the new piping and the associated HDPE lines. MES personnel assisted Frontier in the installation of the pipes, and then worked over the weekend in an attempt to recover schedule. A sketch, provided by FESI, illustrates the placement of these pipes, and is included at Tab 6.

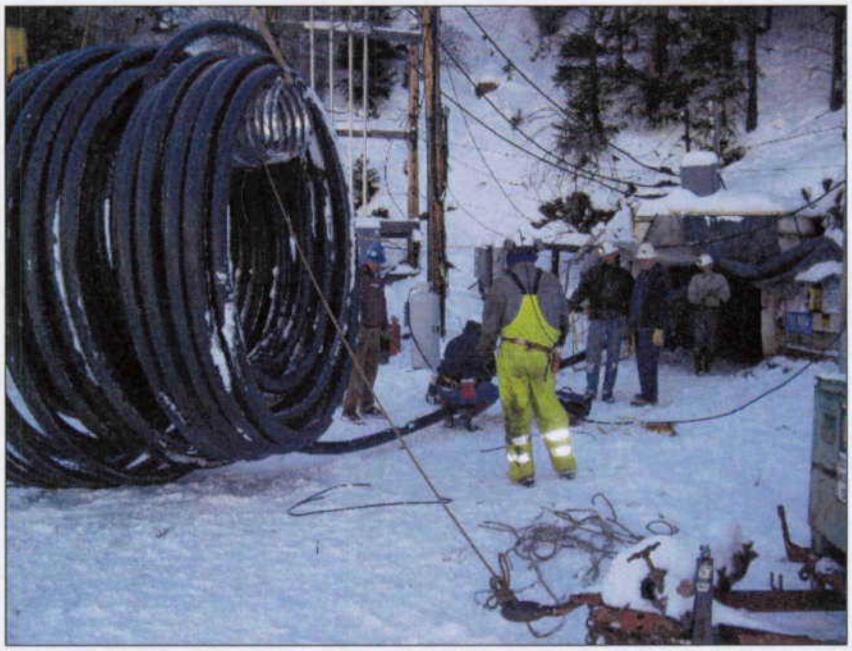

Figure 5: HDPE monitoring pipe installation

3.0 Construction

3.1 Preparation and Forming

MES performed the stripout of piping and electrical utilities in Steve level, in the vicinity of the bulkhead. The additional task of assisting in the removal of certain items of mining equipment, old explosives, and other items prior to the closure of the adits was also performed. MES then secured the top of the Sunshine winze on the Steve level with chain link mesh for the safety of persons who might be going down the Sunshine decline from the surface.

Probe hole drilling was conducted in the Pierce to validate the integrity of the sill pillar prior to bulkhead construction (see Drawing sheet 6).

Preparation of the bulkhead locations included thorough scaling, excavating the adit floor to bare rock, and cleaning all the rock surfaces with water and compressed air for a good bond with the concrete.

Forms were constructed of horizontal 2" x 4" laminae, with vertical walers of laminated 2" x 10" timber, backed up by horizontal walers of 4" x 13 #/ ft or 6" x 20 #/ft wide flange steel beams, secured by 6"x 4" x 1/2" angle iron brackets anchored into the rock by resin-grouted #8 Williams rockbolts. The formwork specification, typical formwork loads and construction details are under Tab 8.

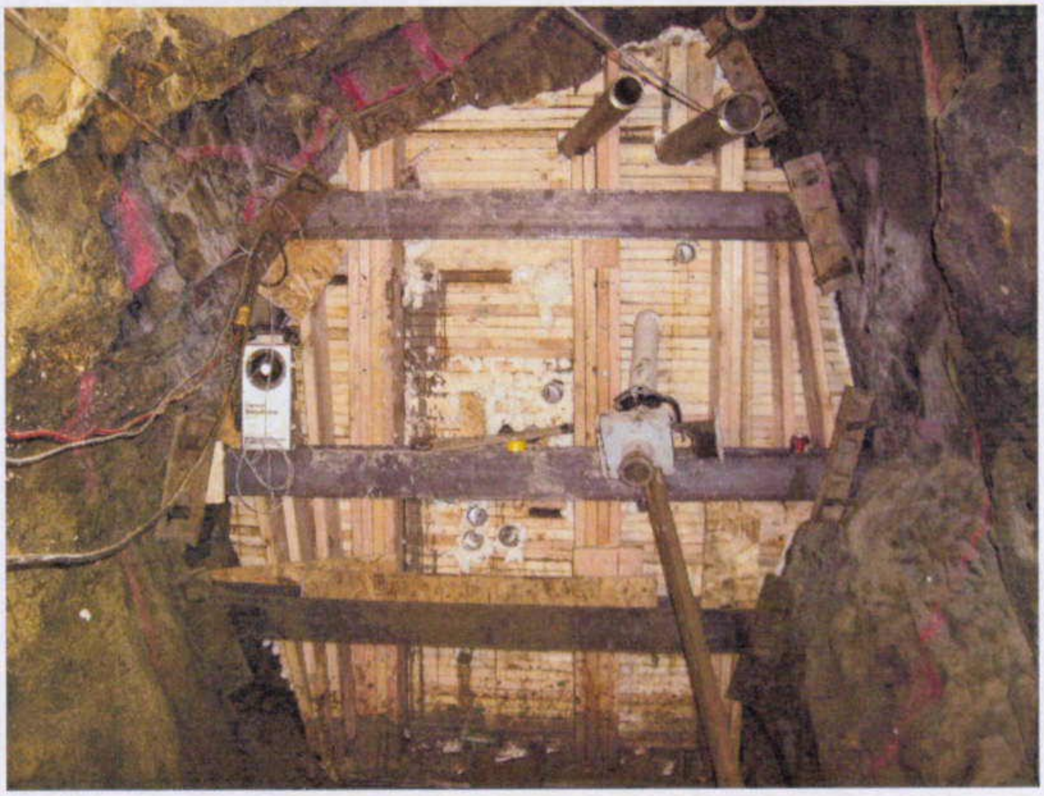

Figure 6: Steve adit bulkhead forms, showing contact grout pipes, concrete injection line, and additional pipes for remote shaft water monitoring (above)

3.2 Pumping

Concrete was pumped into the adits using a Schwing piston pump, at a nominal pressure at the pump of 250-300 bar (3675 – 4410 psi).

Figure 7: Concrete pumping operations

Some pumpability problems were encountered on the first day, as the concrete mix with the specially imported flyash was behaving differently than the vendor expected. The first two "test" truckloads did not meet an acceptable spread index, and there were persistent problems pumping the mixture.

After consultation between the vendor, MES superintending engineer Willis Beach, P.E. and Stephen Phillips, P.E., the proportion of cementitious materials was raised, improving pumpability and allowing the work to progress normally.

Compressive strength samples were taken by CTL Thompson, and appear under Tab 10. For the Steve Adit, the actual minimum 28-day compressive strength achieved was 6390 psi, vs. a design strength in the initial calculations of 3000 psi.

For the Pierce adit, the actual minimum 28-day compressive strength achieved was 5330 psi, versus a design strength in the initial calculations of 3000 psi.

3.3 Curing and Shrinkage

The MES construction specifications and plans followed the recommendations of PMGG in that there was a minimum 28-day lag period between the pumping of the concrete and the inception of the contact grouting, to allow the concrete to be past the majority of its shrinkage curve before the grout injection.

The Steve adit bulkhead was pumped on December 19th, 2007 and the Pierce adit bulkhead was pumped on December 20, 2007. Contact grouting began at the Steve adit on January 22, 2008, and at the Pierce adit on January 29th, 2008.

3.4 Contact grouting

Grouting was performed in general accordance with the grouting plan (Tab 11) and grouting specification (Tab 12). This grouting was performed using both cement-flyash mixtures and with Nittetsu superfine grouts. Additional information about the Nittetsu superfine grout is located at Tab 13.

Figure 8: Typical array of contact grouting pipes

Contact grouting is the grouting of the space left between the concrete bulkhead and the adjacent rock surfaces after the concrete shrinkage period.

Grouts were mixed using a high-shear "colloidal" mixer, and then transferred to a paddle mix tank. The grouting system was a recirculating type, where the grout is pumped from a constant displacement progressive cavity pump, through to a grouting "T", where there is an inlet connection, grout injection connection, and a connection for a return line to the paddle mix agitator tank. By varying a valve on the return line, a constant pressure can be maintained on the grout injection pipe.

This system was used to effect progressive stage grouting where each grout pipe is drilled to a depth, pumped to a set pressure, then closed off. On subsequent grouting stages, the pipe is drilled out, and the drilling continues several feet deeper into the rock.

Figure 9: Grout hole drilling

Typical layout of grouting pipes is shown in the drawing sets under Tab 5.

Detailed daily grouting logs can be found at Tab 14. Grout takes were minimal, which indicates that the contact between the concrete and the rockmass was generally low permeability, which is very favorable.

3.5 Formation grouting

Formation grouting is the grouting of the rockmass itself. For this project, it consists of grout injection of pressurized grout through drillholes in a fan pattern, which are intended to intersect open joint systems in the rockmass immediately adjacent to the adit.

A portion of the boreholes used for contact grouting also served as formation grout holes in later drilling stages.

An additional "ring" of formation-only grout holes was added to each location after the preliminary design, to further reduce the probability of significant leakage.

Typical layout of grouting pipes is shown in the drawing sets under Tab 5.

Detailed daily grouting logs can be found at Tab 14. Grout takes were minimal, which indicates that the joints in the rockmass were generally low permeability, which is very favorable.

3.6 Borehole grouting

For the Pierce adit, additional grout pipes were placed to effect the abandonment of a 6-inch diameter borehole going to an upper level, and to fill the 4-inch HDPE pipe located in the borehole. This borehole was grouted on January 29, 2008. Field calculations based on pressure head indicate that the borehole was grouted to approximately 71 feet of elevation above the injection point, midway in the adit.

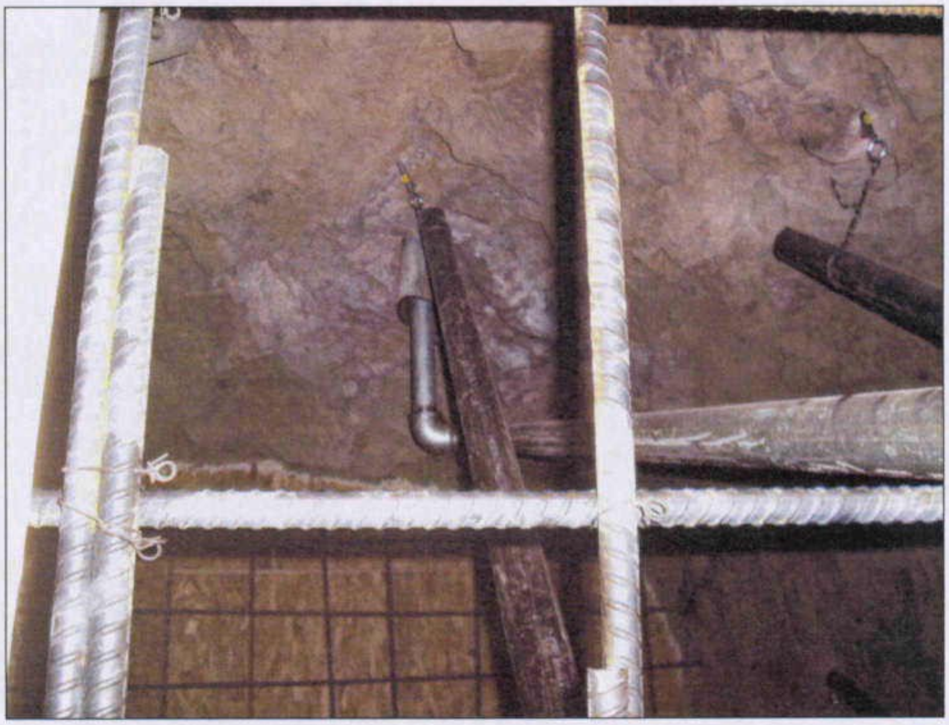

Figure 10: Placement of grout pipes for borehole abandonment

3.7 Water Drain Valves

At each bulkhead, a 2" stainless steel ball valve was placed as the primary shutoff mechanism, with an ancillary 1" ball valve to allow a pressure gauge reading to be taken.

Figure 11: Typical drain valve assembly

3.8 Decant risers

Each of the bulkhead drain pipes included dual vertical decant risers on the inby (wet) side, to prevent clogging of the drain pipe in the event that it becomes desirable to drain water from behind the bulkhead in the future.

These inlets were constructed of 4-inch Schedule 40 PVC pipe, connected to the 2-inch diameter stainless steel pipe via ells and reducers, and secured to the bulkhead form beams. The pipes were slotted with 1/8 inch kerf width slots, on ½ inch centers, to provide filtration of water passing into the drain line.

3.9 Completed adit bulkheads

Inspection of the bulkheads after the front forms were stripped showed a good homogenous pour, with no areas of aggregate separation, voids or other defects. The concrete was in very tight contact with the rock on all sides.

Figure 13: Completed bulkhead – Steve adit

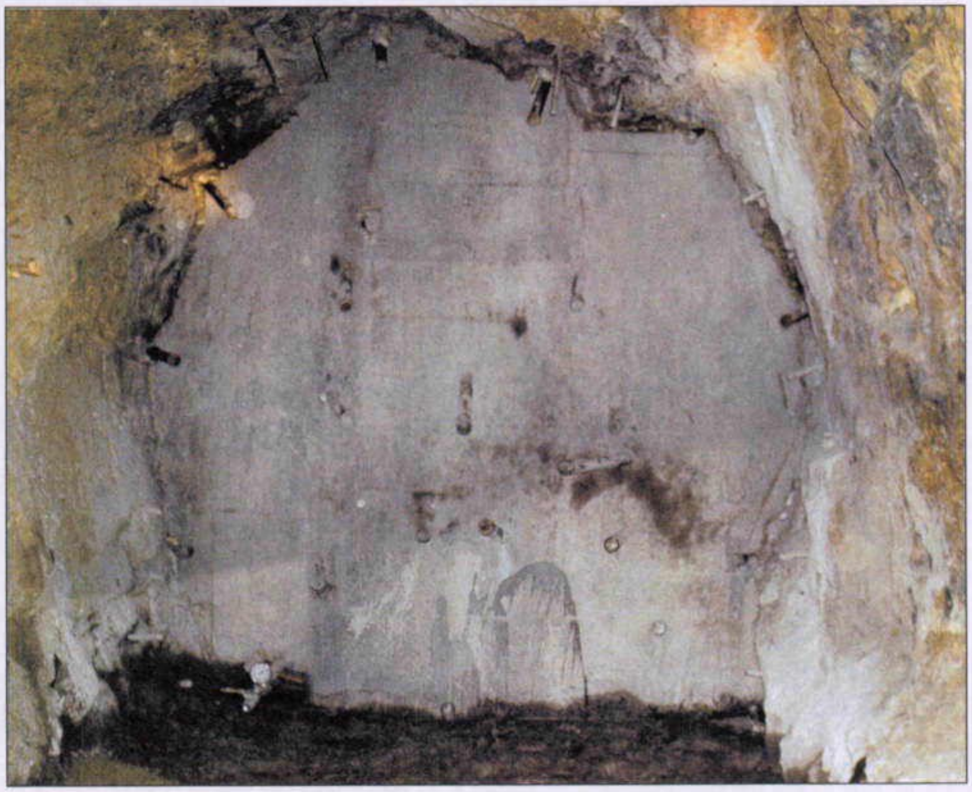

Figure 14: Completed bulkhead – Pierce adit

JOHN F. ABEL, JR.
MINING ENGINEER

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February 29,2008

Mark Levin
Mining & Environmental Services LLC
P.O. Box 1511
Idaho Springs, CO 80452

Reference: "As Built' bulkhead review

Dear Mark:

The "As Built" Pierce Adit and Steve Adit reinforced concrete bulkheads constructed by MES at the Schwartzwalder Mine are strong enough to support all potential anticipated loads, including the maximum static water head of 120 feet and the predicted peak 0.239 g earthquake acceleration of the impounded line-of-sight water. The initial bulkhead design calculations had to be rerun after the adit profiles for the bulkhead sites were scaled, cleaned and measured. The calculations for the "As Built" bulkhead dimensions were checked and verified. The low-pressure grouting of the rock/concrete contact and the formation grouting that was being performed during our inspection on January 24th was designed to further seal the bulkhead and provide additional protection against leakage along and around the bulkheads.

The "As Built" strength of the bulkheads exceeds all American Concrete Institute requirements for structural concrete. In addition, the compressive strength of every sample of the "As Built" concrete collected during filling of the forms and measured by CTL Thompson, Inc. exceeded the specified 28-day 3,000 psi design concrete compressive strength in the initial design calculations.

Sincerely,

COLORADO REGISTERED PROFESSIONAL ENGINEER
JOHN F. ABEL, JR.
5642

John F. Abel, Jr.
Colorado P.E. 5642

Structural Calculations

Project, **Steve Adit Bulkhead, As-Built**
Sta. 2+65
10' Thick, 7'-7" Wide, 8'-2" High,
#6 Rebar

By **MEL/JFA** Date **3/28/08**
Sheet **1** of **8**

References Used:

Calculations are based on:

Abel, J.F., Jr. Bulkhead design for acid mine drainage: 1998, in Proc Western U.S. Mining-Impacted Watersheds, Joint Conf on Remediation and Ecological Risk Assessment Technologies, Denver, CO, 36 p

American Concrete Institute, 2002, Building code requirements for structural concrete (ACI 318-02) and commentary - ACI 318R-02: 369 p

Wang, C.K. & C.G. Salmon, 1985, Reinforced concrete design: 4th ed., Harper & Rowe Publishers, Inc.

Notation:

a = minimum concrete compression zone depth (in) to balance rebar tension

A_s = area of rebar (in^2)

b_w = beam width (ft)

B_p = allowable breakdown pressure (psi)

d = max distance, compressed concrete to center of tensile rebar (in)

E_{bm} = earthquake bulkhead load (lb)

E_{fm} = earthquake static fluid load (lb)

f_{cl} = concrete tensile strength $[3(f_c)^{1/2}]$

f_{cs} = concrete shear strength $[2(f_c)^{1/2}]$

FS = factor of safety

L = bulkhead (beam) thickness (ft)

Ls = bulkhead shear thickness (ft)

I = moment of inertia (in^4)

K = $[3.5 - 2.5(M_u/d)]$

M = beam bending moment (ft-lb)

M_u = factored bending moment (ft-lb)

M_n = nominal bending moment (ft-lb)

M_{ua} = earthquake bending moment (ft-lb)

p = max hydraulic pressure head (psi)

p_w = ratio rebar to concrete areas = $A_s/(w_b d)$

S = section modulus (in^3)

T = tensile bending unit force (lb/ft)

U = factored unit strength required (lb/ft)

U_a = earthquake unit strength required (lb/ft)

V = concrete shear strength required (lb/ft)

Inputs:

Beam width, $b_w := 1$ ft (12 in)

Bulkhead depth below surface, $B_w := 115$ ft

Maximum bulkhead height, $h_b := 8.167$ ft

Maximum bulkhead width, $w_b := 7.59$ ft

Current tunnel height, $h_t := 8.167$ ft

Current tunnel width, $w_t := 7.59$ ft

Design water head, $H := 120$ ft

Concrete compressive strength, $f_c := 6390$ psi

Inbye line-of-sight water distance, $S_{ls} := 280$ ft

Overburden rock density, $\gamma_r := 163$ pcf

Concrete density, $\gamma_c := 151$ pcf

Water density, $\gamma_w := 62.4$ pcf

Minimum concrete rebar cover, $m_c := 3.5$ in

Rebar yield strength, $f_y := 60000$ psi

Pressure gradient with low-pressure concrete/rock contact grouting, $p_{ag} := 41$ psi

Gravity acceleration, $g := 32.2$ ft/sec^2

Maximum earthquake acceleration, $\alpha := 0.239 \cdot g$

Bulkhead trial thickness, $L_t := 10$ ft

Strength reduction factors

Rebar flexure (tensile) strength, $\phi_{rt} := 0.90$

Reinforced concrete shear strength, $\phi_{rs} := 0.75$

Plain concrete flexure strength, $\phi_{pc} := 0.55$

Reinforced concrete flexure strength $\phi_{rc} := 0.90$

Notation continued:

V_n = nominal concrete shear strength (lb/ft)

V_u = factored concrete shear strength (lb/ft)

v_s = rebar shear stress (psi)

W = total bulkhead load (lb)

Z = height of rock to prevent hydrofrac (ft)

Δ_{ovb} = overburden rock stress per ft depth (ft)

ω_{fs} = factored static fluid bulkhead load (psf)

ω_{fse} = factored static fluid bulkhead earthquake load (psf)

ω_{fle} = factored line-of-sight fluid earthquake bulkhead load (psf)

ω_{fbe} = factored concrete bulkhead earthquake load (psf)

Inputs continued:

Load increase design factors

Fluid static load, $\phi_{fs} := 1.40$

Earthquake acceleration of static fluid load, $\phi_{fe} := 1.05$

Earthquake acceleration of line-of-sight impounded fluid and bulkhead loads, $\phi_{ea} := 1.40$

v_{n1} = nominal limiting shear stress, $w_b/L_t<2$ (psi)

v_{n2} = nominal limiting shear stress, $w_b/L_t = 2\text{-}5$ (psi)

σ_s = flexural stress (psi)

σ_{mingp} = minimum contact grout pressure (psi)

σ_{maxgp} = maximum contact grout pressure (psi)

Bulkhead length for allowable hydraulic pressure gradient:

Maximum (design) hydraulic pressure, $p := \frac{H\cdot\gamma_w}{144}$ psi $p = 52$ psi

Minimum contact grout pressure, $\sigma_{mingp} := \frac{B_w\cdot\gamma_w}{144}$ psi $\sigma_{mingp} = 49.8$ psi

Maximum contact grout pressure, $\sigma_{maxgp} := \frac{2\cdot B_w\cdot\gamma_r}{144}$ psi $\sigma_{maxgp} = 260$ psi

Allowable 41 psi/ft pressure gradient for low-pressure grouting of upper part of concrete/rock contact:

Required bulkhead thickness for low-pressure contact grouting, $L_{hp} := \frac{p}{41}$ ft $L_{hp} = 1.27$ ft

Depth below surface to prevent hydrofrac of rock around tunnel:

Available formation breakdown pressure, $B_p := p$ $B_p = 52$ psi

Overburden pressure, per ft of depth, $\Delta_{ovb} := \frac{\gamma_r}{144}$ $\Delta_{ovb} = 1.132$ psi/ft

Height of rock to prevent hydrofrac, $Z := \frac{B_p}{2\cdot\Delta_{ovb}}$ $Z = 23$ ft

Bulkhead thickness (length) to resist concrete shear from static fluid load on upstream face:

Factored static fluid load on bulkhead face, $F_s := 144 \cdot \phi_{fs} \cdot p \cdot h_b \cdot w_b$ $F_s = 649828$ lb

Factored static fluid load/sq ft of face, $\omega_{fs} := \dfrac{F_s}{h_b \cdot w_b}$ $\omega_{fs} = 10483$ psf

Concrete shear strength, $f_{cs} := 2\sqrt{f_c}$ $f_{cs} = 159.9$ psi

Bulkhead thickness to resist factored shear load, $L_s := \dfrac{F_s}{2 \cdot (h_b + w_b) \cdot 144 \cdot f_{cs}}$ $L_s = 0.9$ ft

Plain concrete deep-beam bending stress design for static fluid load on upstream face:

Deep-beam defined as Wb/Lt < 4 (ACI 318-02, Sec 10-7).

$\dfrac{w_b}{L_t} = 0.8$ which is less than 4. Therefore, this is a deep beam for design.

Factored static fluid load on bulkhead face, $F_s := 144 \cdot \phi_{fs} \cdot p \cdot h_b \cdot w_b$ $F_s = 649828$ lb

Uniform factored static fluid load on bulkhead, $f_s := \dfrac{F_s}{h_b \cdot w_b}$ $f_s = 10483$ psf

Nominal static fluid bending moment, $M_n := f_s \cdot \dfrac{{w_b}^2}{8}$ $M_n = 75490$ ft-lb

Factored static fluid bending moment, $M_u := \dfrac{M_n}{\phi_{pc}}$ $M_u = 137254$ ft-lb

Bulkhead section modulus, $S := \dfrac{144 \cdot {L_t}^2}{6}$ $S = 2400$ in^3

Concrete flexural (tensile) design stress, $f_{cl} := 3\sqrt{f_c}$ $f_{cl} = 239.8$ psi

$\sigma_s := \dfrac{M_u}{S}$ $\sigma_s := \dfrac{M_u}{\dfrac{144 \cdot {L_t}^2}{6}}$ $\sigma_s := \dfrac{M_u}{24 \cdot {L_t}^2}$

$\sigma_s := f_{cl}$ $L_{st} := \sqrt{\dfrac{M_u}{24 \cdot \sigma_s}}$ $L_{st} = 4.88$ ft

Reinforced concrete deep-beam bending stress design for static fluid load on upstream face

$C = \phi_{rc} f_c b_w a = 0.85(3000)12a = 30600a$ $T = A_s f_y = 60000A_s$

$C = T$ $30600a = 60000A_s$ $a = (60000\ A_s)/30600 = 1.961\ A_s$

Factored static fluid bending moment, $M_u := \dfrac{M_n}{\phi_{rc}}$ $M_u = 83877$ ft-lb

$M_{uin} := 12 \cdot M_u$ $M_{uin} = 1006529$ in-lb

Maximum concrete rebar cover, $d := 12 \cdot L_t - m_c$ $d = 116.500$ in

$M_u = A_s f_c (d - a/2) = 60000A_s(116.5 - 1.961\ A_s/2) = 60000\ A_s d - 58830\ A_s^2$

$58830\ A_s^2 - 60000\ A_s d + M_{uin} = 0$ $C_1 := 58830$ $C_2 := -60000 \cdot d$ $C_3 := M_{uin}$

$$A_s := \frac{-C_2 - \sqrt{C_2^2 - 4 \cdot C_1 \cdot C_3}}{2 \cdot C_1}$$ $A_s = 0.144$ in^2

One cage of #6 bars (0.44 in² per bar, 0.750-in nominal diameter, 1.502 lb/ft) on 12.00-in c-c (11.25-in between bars) provides 0.44 in²/ft of steel area.

Therefore, $A_s := 0.44$ in^2

Check for adequacy,

Allowable factored bending moment, $A_u := -C_1 \cdot \left(A_s^2\right) - C_2 \cdot A_s$ $A_u = 3064211$ in-lb

Design factored bending moment, $M_{uin} = 1006529$ in-lb

Factor of safety, $FS := \dfrac{A_u}{M_{uin}}$ $FS = 3.044$

Plain concrete deep-beam bending stress design for earthquake acceleration:

Factored earthquake accelerated static fluid load, $E_{fe} := 144 \cdot \phi_{fe} \cdot p \cdot h_b \cdot w_b$ $E_{fe} = 487371$ lb

Factored earthquake accelerated line-of-sight fluid load, $E_{fm} := \dfrac{\phi_{ea} \cdot S_{ls} \cdot \gamma_w \cdot h_t \cdot w_t \cdot \alpha}{g}$

$E_{fm} = 362387$ lb

Factored earthquake accelerated bulkhead load, $E_{bm} := \dfrac{\phi_{ea} \cdot L_t \cdot h_b \cdot w_b \cdot \gamma_c \cdot \alpha}{g}$

$E_{bm} = 31319$ lb

Total factored earthquake load on bulkhead, $U_\alpha := E_{fe} + E_{fm} + E_{bm}$ $U_\alpha = 881077$ lb

Uniform factored earthquake load on bulkhead, $u := \dfrac{U_\alpha}{h_b \cdot w_b}$ $u = 14214$ psf

Nominal earthquake bending moment, $M_n := u \cdot \dfrac{w_b^2}{8}$ $M_n = 102354$ ft-lb

Factored earthquake bending moment, $M_u := \dfrac{M_n}{\phi_{pc}}$ $M_u = 186097$ ft-lb

Bulkhead section modulus, $S := \dfrac{144 \cdot L_t^2}{6}$ $S = 2400$ in^3

Concrete flexural (tensile) design stress, $f_{cl} := 3\sqrt{f_c}$ $f_{cl} = 239.8$ psi

$\sigma_s := \dfrac{M_u}{S}$ $\sigma_s := \dfrac{M_u}{\dfrac{144 \cdot L_{fc}}{6}}$ $\sigma_s := \dfrac{M_u}{24 \cdot L_{fc}}$

$\sigma_s := f_{cl}$ $L_{fc} := \sqrt{\dfrac{M_u}{24 \cdot \sigma_s}}$ $L_{fc} = 5.69$ ft

Reinforced concrete deep-beam bending stress design for earthquake acceleration

$C = \phi_{rc}f_cb_wa = 0.85(3000)12a = 30600a$ $T = A_sf_y = 60000A_s$

$C = T$ $30600a = 60000A_s$ $a = (60000\ A_s)/30600 = 1.961\ A_s$

Factored earthquake bending moment, $M_u := \frac{M_n}{\phi_{rt}}$ $M_u = 113726$ ft-lb

$M_{uin} := 12 \cdot M_u$ $M_{uin} = 1364714$ in-lb

Maximum concrete rebar cover, $d := 12 \cdot L_t - m_c$ $d = 116.500$ in

$M_u = A_sf_c(d-a/2) = 60000A_s(116.5 - 1.961\ A_s/2) = 60000\ A_sd - 58830\ A_s^2$

$58830\ A_s^2 - 60000\ A_sd + M_{uin} = 0$ $C_1 := 58830$ $C_2 := -60000 \cdot d$ $C_3 := M_{uin}$

$$A_s := \frac{-C_2 - \sqrt{C_2^2 - 4 \cdot C_1 \cdot C_3}}{2 \cdot C_1}$$ $A_s = 0.196$ in^2

One cage of #6 bars (0.44 in² per bar, 0.750-in nominal diameter, 1.502 lb/ft) on 12.00-in c-c (11.25-in between bars) provides 0.44 in²/ft of steel area.

Therefore, $A_s := 0.44$ in^2

Check for adequacy,

Allowable factored bending moment, $A_u := -C_1 \cdot \left(A_s^2\right) - C_2 \cdot A_s$ $A_u = 3064211$ in-lb

Design factored bending moment, $M_{uin} = 1364714$ in-lb

Factor of safety, $FS := \frac{A_u}{M_{uin}}$ $FS = 2.245$

Critical section shear strength for 10-ft thick reinforced deep-beam concrete bulkhead subjected to maximum credible earthquake:

Deep-beam bulkhead defined as wb/Lt < 4 (ACI 318-02, Sec 10.7). The critical shear section is 0.15 times the maximum bulkhead width (2.25 ft) from the ribside (ACI 318-02, Sec 11.8.5).

$\frac{w_b}{L_t} = 0.8$ which is less than 4. Therefore, this is a deep beam for design.

When wb/Lt < 4, the limiting nominal shear stress (v_n) cannot exceed 10 times the sq rt of f_c (ACI 318-02, Sec11.8.3).

$v_n := 10 \cdot \sqrt{f_c}$ $v_n = 799$ psi

Therefore, the maximum allowable nominal shear force per foot of beam width is:

$V_{na} := v_n \cdot 12 \cdot b_w \cdot d$ $V_{na} = 1117526$ lb per 1-ft wide horizontal deep beam

Nominal developed shear force at critical section per foot of horizontal deep beam width

$V_{nd} := 0.35 \cdot u \cdot w_b$ $V_{nd} = 37759$ lb per 1-ft wide horizontal deep beam

Factored nominal developed shear force at critical section per foot of horizontal deep beam width

$V_u := \frac{V_{nd}}{\phi_{rs}}$ $V_u = 50345$ lb per 1-ft wide horizontal deep beam

Nominal developed moment at critical section per foot of horizontal deep beam width

$M_n := 0.06375 \cdot \frac{u \cdot \left(w_b^{\,2}\right)}{2}$ $M_n = 26100$ ft-lb per 1-ft wide horizontal deep beam

Factored nominal developed moment at critical section per foot of horizontal deep-beam width

$M_u := \frac{M_n}{\phi_{rt}}$ $M_u = 29000$ ft-lb per 1-ft wide horizontal deep beam

Calculation equation for allowable shear strength (V_c) at critical section of deep beam, including rebar tensile reinforcement,

$$V_c := K \cdot \left(1.9 \cdot \sqrt{f_c} + 2500 \cdot p_w \cdot \frac{V_u}{M_u} \cdot \frac{d}{12} \right) \cdot 12 \cdot b_w \cdot d$$

Maximum permitted calculated concrete shear strength (v_c): (ACI 318-02, Sec 11.8.3)

$v_c := 6 \cdot \sqrt{f_c}$ $\quad v_c = 480$ psi

Ratio of rebar reinforcement area to concrete area (p_w), $p_w := \frac{A_s}{b_w \cdot 12 \cdot d}$ $\quad p_w = 0.0003147$

Limiting value for term K = [3.5-2.5(M_u/V_ud)] = 2.5

$K := 3.5 - 2.5 \cdot \frac{M_u}{\frac{V_u \cdot d}{12}}$ $\quad K = 3.352$ Therefore, $K := 2.5$

Allowable shear strength (V_c) at critical section of deep beam,

$$V_c := K \cdot \left(1.9 \cdot \sqrt{f_c} + 2500 \cdot p_w \cdot \frac{V_u}{M_u} \cdot \frac{d}{12} \right) \cdot 12 \cdot b_w \cdot d$$

$V_c = 577173$ lb per 1-ft wide horizontal deep beam

Limiting allowable shear force cannot exceed:

$V_{max} := v_c \cdot b_w \cdot 12 \cdot d$ $\quad V_{max} = 670516$

Factor of safety using the lower of calculated V_c or V_{max} in relation to maximum credible earthquake loading induced factored nominal developed shear force (V_u) at critical section,

$FS := \frac{V_{max}}{V_u}$ $\quad FS = 13.318$

Project, **Pierce Adit Bulkhead - As Built**
Sta. 2 + 84
12' Thick, 11'-7" Wide, 11'-8" High,
#6 Rebar

By **MEL/JFA** Date **3/28/08**

References Used:

Calculations are based on:

Abel, J.F., Jr. Bulkhead design for acid mine drainage: 1998, in Proc Western U.S. Mining-Impacted Watersheds, Joint Conf on Remediation and Ecological Risk Assessment Technologies, Denver, CO, 36 p

American Concrete Institute, 2002, Building code requirements for structural concrete (ACI 318-02) and commentary - ACI 318R-02: 369 p

Wang, C.K. & C.G. Salmon, 1985, Reinforced concrete design: 4th ed., Harper & Rowe Publishers, Inc.

Notation:

a = minimum concrete compression zone depth (in) to balance rebar tension

A_s = area of rebar (in^2)

b_w = beam width (ft)

B_p = allowable breakdown pressure (psi)

d = max distance, compressed concrete to center of tensile rebar (in)

E_{bm} = earthquake bulkhead load (lb)

E_{fm} = earthquake static fluid load (lb)

f_{cl} = concrete tensile strength $[3(f_c)^{1/2}]$

f_{cs} = concrete shear strength $[2(f_c)^{1/2}]$

FS = factor of safety

L = bulkhead (beam) thickness (ft)

Ls = bulkhead shear thickness (ft)

I = moment of inertia (in^4)

K = $[3.5 - 2.5(M_u/d)]$

M = beam bending moment (ft-lb)

M_u = factored bending moment (ft-lb)

M_n = nominal bending moment (ft-lb)

M_{ua} = earthquake bending moment (ft-lb)

p = max hydraulic pressure head (psi)

p_w = ratio rebar to concrete areas = $A_s/(w_b d)$

S = section modulus (in^3)

T = tensile bending unit force (lb/ft)

U = factored unit strength required (lb/ft)

U_a = earthquake unit strength required (lb/ft)

V = concrete shear strength required (lb/ft)

Inputs:

Beam width, $b_w := 1$ ft (12 in)

Bulkhead depth below surface, $B_w := 125$ ft

Maximum bulkhead height, $h_b := 11.67$ ft

Maximum bulkhead width, $w_b := 11.59$ ft

Current tunnel height, $h_t := 11.67$ ft

Current tunnel width, $w_t := 11.59$ ft

Design water head, $H := 120$ ft

Concrete compressive strength, $f_c := 5330$ psi

Inbye line-of-sight water distance, $S_{ls} := 333$ ft

Overburden rock density, $\gamma_r := 163$ pcf

Concrete density, $\gamma_c := 151$ pcf

Water density, $\gamma_w := 62.4$ pcf

Minimum concrete rebar cover, $m_c := 3.5$ in

Rebar yield strength, $f_y := 60000$ psi

Pressure gradient with low-pressure concrete/rock contact grouting, $p_{ag} := 41$ psi

Gravity acceleration, $g := 32.2$ ft/sec^2

Maximum earthquake acceleration, $\alpha := 0.239 \cdot g$

Bulkhead trial thickness, $L_t := 12$ ft

Strength reduction factors

Rebar flexure (tensile) strength, $\phi_{rt} := 0.90$

Reinforced concrete shear strength, $\phi_{rs} := 0.75$

Plain concrete flexure strength, $\phi_{pc} := 0.55$

Reinforced concrete flexure strength $\phi_{rc} := 0.90$

Notation continued:

V_n = nominal concrete shear strength (lb/ft)

V_u = factored concrete shear strength (lb/ft)

v_s = rebar shear stress (psi)

W = total bulkhead load (lb)

Z = height of rock to prevent hydrofrac (ft)

Δ_{ovb} = overburden rock stress per ft depth (ft)

ω_{fs} = factored static fluid bulkhead load (psf)

ω_{fse} = factored static fluid bulkhead earthquake load (psf)

ω_{fle} = factored line-of-sight fluid earthquake bulkhead load (psf)

ω_{fbe} = factored concrete bulkhead earthquake load (psf)

Inputs continued:

Load increase design factors

Fluid static load, $\phi_{fs} := 1.40$

Earthquake acceleration of static fluid load, $\phi_{fe} := 1.05$

Earthquake acceleration of line-of-sight impounded fluid and bulkhead loads, $\phi_{ea} := 1.40$

v_{n1} = nominal limiting shear stress, $w_b/L_t<2$ (psi)

v_{n2} = nominal limiting shear stress, $w_b/L_t = 2\text{-}5$ (psi)

σ_s = flexural stress (psi)

σ_{mingp} = minimum contact grout pressure (psi)

σ_{maxgp} = maximum contact grout pressure (psi)

Bulkhead length for allowable hydraulic pressure gradient:

Maximum (design) hydraulic pressure, $p := \frac{H \cdot \gamma_w}{144}$ psi $\quad p = 52$ psi

Minimum contact grout pressure, $\sigma_{mingp} := \frac{B_w \cdot \gamma_w}{144}$ psi $\quad \sigma_{mingp} = 54.2$ psi

Maximum contact grout pressure, $\sigma_{maxgp} := \frac{2 \cdot B_w \cdot \gamma_r}{144}$ psi $\quad \sigma_{maxgp} = 283$ psi

Allowable 41 psi/ft pressure gradient for low-pressure grouting of upper part of concrete/rock contact:

Required bulkhead thickness for low-pressure contact grouting, $L_{hp} := \frac{p}{41}$ ft $\quad L_{hp} = 1.27$ ft

Depth below surface to prevent hydrofrac of rock around tunnel:

Available formation breakdown pressure, $B_p := p$ $\quad B_p = 52$ psi

Overburden pressure, per ft of depth, $\Delta_{ovb} := \frac{\gamma_r}{144}$ $\quad \Delta_{ovb} = 1.132$ psi/ft

Height of rock to prevent hydrofrac, $Z := \frac{B_p}{2 \cdot \Delta_{ovb}}$ $\quad Z = 23$ ft

Bulkhead thickness (length) to resist concrete shear from static fluid load on upstream face:

Factored static fluid load on bulkhead face, $F_s := 144 \cdot \phi_{fs} \cdot p \cdot h_b \cdot w_b$ $\quad F_s = 1417908$ lb

Factored static fluid load/sq ft of face, $\omega_{fs} := \dfrac{F_s}{h_b \cdot w_b}$ $\quad \omega_{fs} = 10483$ psf

Concrete shear strength, $f_{cs} := 2\sqrt{f_c}$ $\quad f_{cs} = 146$ psi

Bulkhead thickness to resist factored shear load, $L_s := \dfrac{F_s}{2 \cdot (h_b + w_b) \cdot 144 \cdot f_{cs}}$ $\quad L_s = 1.45$ ft

Plain concrete deep-beam bending stress design for static fluid load on upstream face:

Deep-beam defined as Wb/Lt < 4 (ACI 318-02, Sec 10-7).

$\dfrac{w_b}{L_t} = 1.0$ which is less than 4. Therefore, this is a deep beam for design.

Factored static fluid load on bulkhead face, $F_s := 144 \cdot \phi_{fs} \cdot p \cdot h_b \cdot w_b$ $\quad F_s = 1417908$ lb

Uniform factored static fluid load on bulkhead, $f_s := \dfrac{F_s}{h_b \cdot w_b}$ $\quad f_s = 10483$ psf

Nominal static fluid bending moment, $M_n := f_s \cdot \dfrac{{w_b}^2}{8}$ $\quad M_n = 176024$ ft-lb

Factored static fluid bending moment, $M_u := \dfrac{M_n}{\phi_{pc}}$ $\quad M_u = 320043$ ft-lb

Bulkhead section modulus, $S := \dfrac{144 \cdot {L_t}^2}{6}$ $\quad S = 3456$ in^3

Concrete flexural (tensile) design stress, $f_{cl} := 3\sqrt{f_c}$ $\quad f_{cl} = 219$ psi

$\sigma_s := \dfrac{M_u}{S}$ $\qquad \sigma_s := \dfrac{M_u}{\dfrac{144 \cdot {L_t}^2}{6}}$ $\qquad \sigma_s := \dfrac{M_u}{24 \cdot {L_t}^2}$

$\sigma_s := f_{cl}$ $\qquad L_{st} := \sqrt{\dfrac{M_u}{24 \cdot \sigma_s}}$ $\qquad L_{st} = 7.80$ ft

Reinforced concrete deep-beam bending stress design for static fluid load on upstream face

$C = \phi_{rc} f_c b_w a = 0.85(3000)12a = 30600a$ $T = A_s f_y = 60000A_s$

$C = T$ $30600a = 60000A_s$ $a = (60000\ A_s)/30600 = 1.961\ A_s$

Factored static fluid bending moment, $M_u := \dfrac{M_n}{\phi_{rc}}$ $M_u = 195582$ ft-lb

$M_{uin} := 12 \cdot M_u$ $M_{uin} = 2346981$ in-lb

Maximum concrete rebar cover, $d := 12 \cdot L_t - m_c$ $d = 140.500$ in

$M_u = A_s f_c (d - a/2) = 60000A_s(116.5 - 1.961\ A_s/2) = 60000\ A_s d - 58830\ A_s^2$

$58830\ A_s^2 - 60000\ A_s d + M_{uin} = 0$ $C_1 := 58830$ $C_2 := -60000 \cdot d$ $C_3 := M_{uin}$

$$A_s := \frac{-C_2 - \sqrt{C_2^{\ 2} - 4 \cdot C_1 \cdot C_3}}{2 \cdot C_1}$$ $A_s = 0.279$ in^2

One cage of #6 bars (0.44 in² per bar, 0.750-in nominal diameter, 1.502 lb/ft) on 12.00-in c-c (11.250-in between bars) provides 0.44 in²/ft of steel area.

Therefore, $A_s := 0.44$ in^2

Check for adequacy,

Allowable factored bending moment, $A_u := -C_1 \cdot \left(A_s^{\ 2}\right) - C_2 \cdot A_s$ $A_u = 3697811$ in-lb

Design factored bending moment, $M_{uin} = 2346981$ in-lb

Factor of safety, $FS := \dfrac{A_u}{M_{uin}}$ $FS = 1.576$

Project, **Pierce Adit Bulkhead, As-Built**
Sta. 2+84
12' Thick, 11'-7" Wide, 11'-8" High,
#6 Rebar

By **MEL/JFA** Date **3/28/08**
Sheet **5** of **8**

Plain concrete deep-beam bending stress design for earthquake acceleration:

Factored earthquake accelerated static fluid load, $E_{fe} := 144 \cdot \phi_{fe} \cdot p \cdot h_b \cdot w_b$ $E_{fe} = 1063431$ lb

Factored earthquake accelerated line-of-sight fluid load, $E_{fm} := \dfrac{\phi_{ea} \cdot S_{ls} \cdot \gamma_w \cdot h_t \cdot w_t \cdot \alpha}{g}$

$E_{fm} = 940392$ lb

Factored earthquake accelerated bulkhead load, $E_{bm} := \dfrac{\phi_{ea} \cdot L_t \cdot h_b \cdot w_b \cdot \gamma_c \cdot \alpha}{g}$

$E_{bm} = 82005$ lb

Total factored earthquake load on bulkhead, $U_\alpha := E_{fe} + E_{fm} + E_{bm}$ $U_\alpha = 2085828$ lb

Uniform factored earthquake load on bulkhead, $u := \dfrac{U_\alpha}{h_b \cdot w_b}$ $u = 15421$ psf

Nominal earthquake bending moment, $M_n := u \cdot \dfrac{w_b^2}{8}$ $M_n = 258941$ ft-lb

Factored earthquake bending moment, $M_u := \dfrac{M_n}{\phi_{pc}}$ $M_u = 470802$ ft-lb

Bulkhead section modulus, $S := \dfrac{144 \cdot L_t^2}{6}$ $S = 3456$ in^3

Concrete flexural (tensile) design stress, $f_{cl} := 3\sqrt{f_c}$ $f_{cl} = 219$ psi

$\sigma_s := \dfrac{M_u}{S}$ $\sigma_s := \dfrac{M_u}{\dfrac{144 \cdot L_{fc}}{6}}$ $\sigma_s := \dfrac{M_u}{24 \cdot L_{fc}}$

$\sigma_s := f_{cl}$ $L_{fc} := \sqrt{\dfrac{M_u}{24 \cdot \sigma_s}}$ $L_{fc} = 9.46$ ft

Project,	**Pierce Adit Bulkhead, As-Built** **Sta. 2+84** **12' Thick, 11'-7" Wide, 11'-8" High,** **#6 Rebar**	By **MEL/JFA** Date **3/28/08** Sheet **6** of **8**

Reinforced concrete deep-beam bending stress design for earthquake acceleration

$C = \phi_{rc} f_c b_w a = 0.85(3000)12a = 30600a$ $\qquad T = A_s f_y = 60000A_s$

$C = T$ $\qquad 30600a = 60000A_s$ $\qquad a = (60000\ A_s)/30600 = 1.961\ A_s$

Factored earthquake bending moment, $M_u := \frac{M_n}{\phi_{rt}}$ $\qquad M_u = 287712$ ft-lb

$M_{uin} := 12 \cdot M_u$ $\qquad M_{uin} = 3452549$ in-lb

Maximum concrete rebar cover, $d := 12 \cdot L_t - m_c$ $\qquad d = 140.500$ in

$M_u = A_s f_c(d\text{-}a/2) = 60000A_s(116.5 - 1.961\ A_s/2) = 60000\ A_s d - 58830\ A_s^2$

$58830\ A_s^2 - 60000\ A_s d + M_{uin} = 0$ $\qquad C_1 := 58830$ $\qquad C_2 := -60000 \cdot d$ $\qquad C_3 := M_{uin}$

$$A_s := \frac{-C_2 - \sqrt{C_2^{\,2} - 4 \cdot C_1 \cdot C_3}}{2 \cdot C_1} \qquad A_s = 0.411 \quad in^2$$

One cage of #6 bars (0.44 in² per bar, 0.750-in nominal diameter, 1.502 lb/ft) on 12.00-in c-c (11.250-in between bars) provides 0.44 in²/ft of steel area.

Therefore, $A_s := 0.440$ in²

Check for adequacy,

Allowable factored bending moment, $A_u := -C_1 \cdot \left(A_s^{\,2}\right) - C_2 \cdot A_s$ $\qquad A_u = 3697811$ in-lb

Design factored bending moment, $M_{uin} = 3452549$ in-lb

Factor of safety, $FS := \frac{A_u}{M_{uin}}$ $\qquad FS = 1.071$

Critical section shear strength for 12-ft thick reinforced deep-beam concrete bulkhead subjected to maximum credible earthquake:

Deep-beam bulkhead defined as wb/Lt < 4 (ACI 318-02, Sec 10.7). The critical shear section is 0.15 times the maximum bulkhead width (2.25 ft) from the ribside (ACI 318-02, Sec 11.8.5).

$\frac{w_b}{L_t} = 1.0$ which is less than 4. Therefore, this is a deep beam for design.

When wb/Lt < 4, the limiting nominal shear stress (v_n) cannot exceed 10 times the sq rt of f_c (ACI 318-02, Sec11.8.3).

$v_n := 10 \cdot \sqrt{f_c}$ $v_n = 730$ psi

Therefore, the maximum allowable nominal shear force per foot of beam width is:

$V_{na} := v_n \cdot 12 \cdot b_w \cdot d$ $V_{na} = 1230895$ lb per 1-ft wide horizontal deep beam

Nominal developed shear force at critical section per foot of horizontal deep beam width

$V_{nd} := 0.35 \cdot u \cdot w_b$ $V_{nd} = 62557$ lb per 1-ft wide horizontal deep beam

Factored nominal developed shear force at critical section per foot of horizontal deep beam width

$V_u := \frac{V_{nd}}{\phi_{rs}}$ $V_u = 83409$ lb per 1-ft wide horizontal deep beam

Nominal developed moment at critical section per foot of horizontal deep beam width

$M_n := 0.06375 \cdot \frac{u \cdot \left(w_b^2\right)}{2}$ $M_n = 66030$ ft-lb per 1-ft wide horizontal deep beam

Factored nominal developed moment at critical section per foot of horizontal deep-beam width

$M_u := \frac{M_n}{\phi_{rt}}$ $M_u = 73367$ ft-lb per 1-ft wide horizontal deep beam

Calculation equation for allowable shear strength (V_c) at critical section of deep beam, including rebar tensile reinforcement,

$$V_c := K\cdot\left(1.9\cdot\sqrt{f_c} + 2500\cdot p_w\cdot\frac{V_u}{M_u}\cdot\frac{d}{12}\right)\cdot 12\cdot b_w\cdot d$$

Maximum permitted calculated concrete shear strength (v_c): (ACI 318-02, Sec 11.8.3)

$v_c := 6\cdot\sqrt{f_c}$ $\quad v_c = 438$ psi

Ratio of rebar reinforcement area to concrete area (p_w), $p_w := \dfrac{A_s}{b_w\cdot 12\cdot d}$ $\quad p_w = 0.000261$

Limiting value for term $K = [3.5-2.5(M_u/V_ud)] = 2.5$

$K := 3.5 - 2.5\cdot\dfrac{M_u}{\frac{V_u\cdot d}{12}}$ $\quad K = 3.312$ Therefore, $K := 2.5$

Allowable shear strength (V_c) at critical section of deep beam,

$$V_c := K\cdot\left(1.9\cdot\sqrt{f_c} + 2500\cdot p_w\cdot\frac{V_u}{M_u}\cdot\frac{d}{12}\right)\cdot 12\cdot b_w\cdot d$$

$V_c = 621281$ lb per 1-ft wide horizontal deep beam

Limiting allowable shear force cannot exceed:

$V_{max} := v_c\cdot b_w\cdot 12\cdot d$ $\quad V_{max} = 738537$

Factor of safety using the lower of calculated V_c or V_{max} in relation to maximum credible earthquake loading induced factored nominal developed shear force (V_u) at critical section,

$FS := \dfrac{V_{max}}{V_u}$ $\quad FS = 8.854$

Project Name = Schwartzwalder Mine
Conterminous 48 States
2003 NEHRP Seismic Design Provisions
Latitude = 39.845
Longitude = -105.2808
Spectral Response Accelerations Ss and S1
Ss and S1 = Mapped Spectral Acceleration Values
Site Class B - Fa = 1.0 ,Fv = 1.0
Data are based on a 0.05 deg grid spacing

Period (sec)	Sa (g)
0.2	0.239 (Ss, Site Class B)
1.0	0.059 (S1, Site Class B)

Conterminous 48 States
2003 NEHRP Seismic Design Provisions
Latitude = 39.845
Longitude = -105.2808
Spectral Response Accelerations SMs and SM1
SMs = FaSs and SM1 = FvS1
Site Class B - Fa = 1.0 ,Fv = 1.0

Period (sec)	Sa (g)
0.2	0.239 (SMs, Site Class B)
1.0	0.059 (SM1, Site Class B)

Conterminous 48 States
2003 NEHRP Seismic Design Provisions
Latitude = 39.845
Longitude = -105.2808
SDs = 2/3 x SMs and SD1 = 2/3 x SM1
Site Class B - Fa = 1.0 ,Fv = 1.0

Period (sec)	Sa (g)
0.2	0.159 (SDs, Site Class B)

Qwest Mail
by Windows Live

RE: Bulkhead Design Criteria

From: **Susan Wyman** (swyman@whetstone-associates.com)
Sent: Thu 10/25/07 12:01 PM
To: 'mark levin' (engmines@hotmail.com)
Cc: 'john abel' (jfabel2@comcast.net); 'steve phillipps' (shep@pmgg.com); 'steve phillips' (shep_pmgg@mac.com); 'amy thurlkill' (amy.thurlkill@cottercc.com); 'Scott Effner' (seffner@whetstone-associates.com)

Hi Mark,
I started an e-mail to you yesterday, but did not get it sent. We have evaluated the refilling hydrology using several methods, and have concluded that the water level will not rise to the Steve level as a result of deep groundwater inflow (from bedrock). However, the bulkhead is a prudent measure in the event that water from the upper workings temporarily pools in the Steve Level during and after the rainy season in very wet years.

A low pressure bulkhead will be adequate.

We are in the process of writing up the hydrologeologic analysis. Please call to discuss, if you have questions.

Regards,

Susan

From: mark levin [mailto:engmines@hotmail.com]
Sent: Thursday, October 25, 2007 10:36 AM
To: swyman@whetstone-associates.com
Cc: john abel; steve phillipps; steve phillips; amy thurlkill
Subject: RE: Bulkhead Design Criteria

Hi Susan:

Just checking in - when do you think you might have an estimate of the post-bulkheading mine pool elevation?

Thanks,

Mark Levin
Mining & Environmental Services LLC
303.567.4174

From: swyman@whetstone-associates.com
To: engmines@hotmail.com
Subject: RE: Bulkhead Design Criteria
Date: Tue, 2 Oct 2007 06:31:42 -0600

Hi Mark,
Thanks for your e-mail. I'm working out in the field on Monday and Tuesday of this week, but will call you on Wednesday to discuss the Schwartzwalder bulkheading.

Also, can you give me the general elevation (or location) of the Sunshine adit? I have detailed drawings of the underground workings, but don't recall that level. I'll try to be more knowledgable when we talk on Wednesday.

Regards,

Adit Rock Testing

UNCONFINED COMPRESSIVE STRENGTH

ASTM D 7012 METHOD C

UNCONFINED COMPRESSIVE STRENGTH
ASTM D 7012; Method C (Previously ASTM D 2938)

CLIENT: Mining & Environmental Service, LLC.

JOB NO.: 2721-01

LOCATION:

DATE TESTED: 10/31-11/01/07 HN

PROJECT: Schwartzwalder

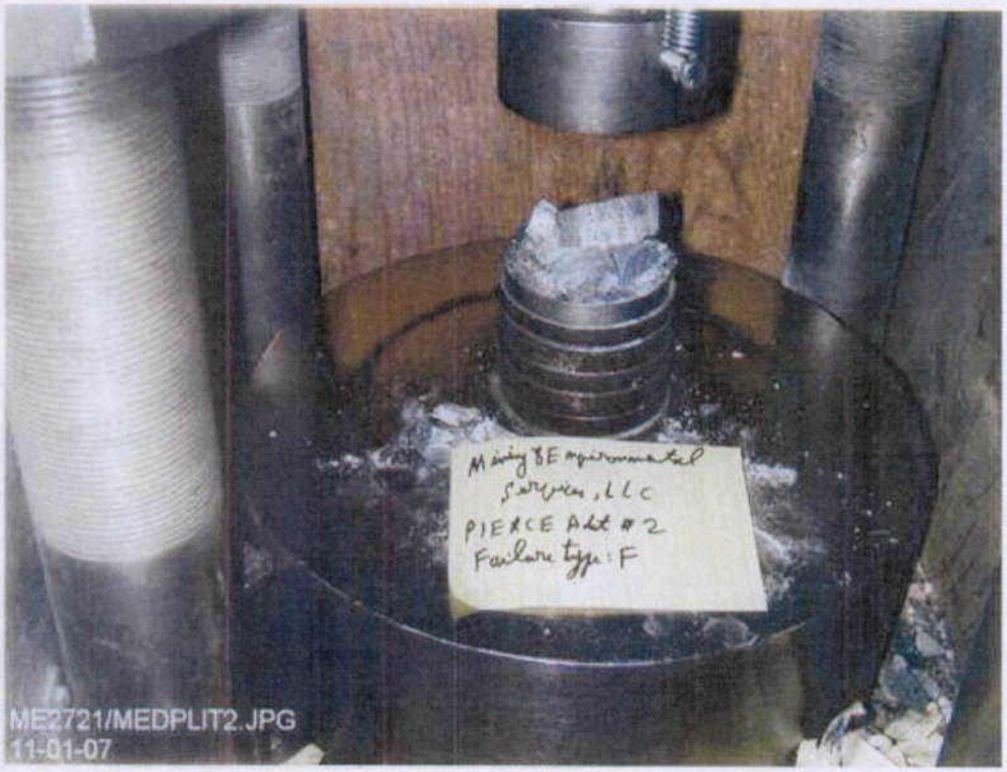
Specimen ID Boring, Sample #	Diameter (in.)	Length (in.)	Mass (gms)	Wet Density (pcf)	Failure Load (lb)	Failure Types *	Compressive Strength (psi)
Pierce Adit-1	1.478	3.278	263.40	178.4	22,184	F/S	12,930
Pierce Adit-2	1.477	3.144	246.90	174.6	15,628	F	9,120
Pierce Adit-3	1.487	3.356	265.90	173.8	10,721	F	6,170
Steve Adit-1	1.477	3.357	271.50	179.8	18,771	F/S	10,960
Steve Adit-2	1.483	3.287	271.20	182.0	7,940	F/S	4,600
Steve Adit-3	1.482	3.545	288.50	179.7	19,915	F/S	11,550

Notes and Comments: * Failure types S: Shear Failure, M: Matrix Failure, F: Failure due to Fracture/Bedding, V: Void Failure, C: Combination

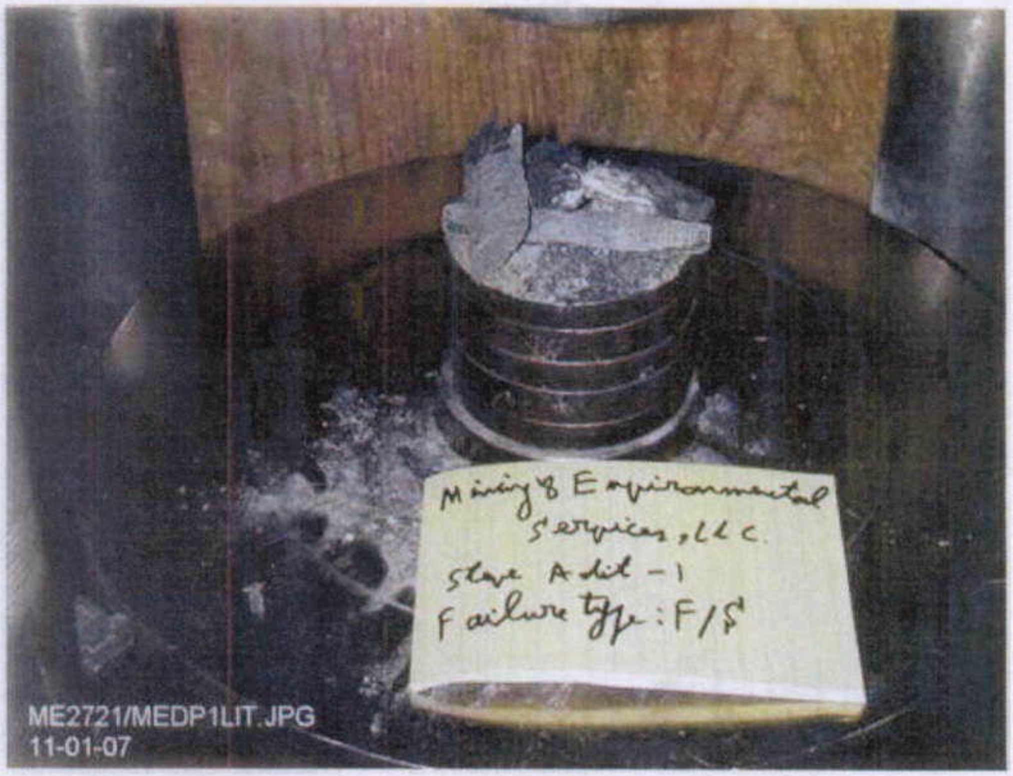
Data Entered By: HN Date: 11/01/2007
Data Checked By: RS Date: 11/1/07
Filename: MEUCSRCK

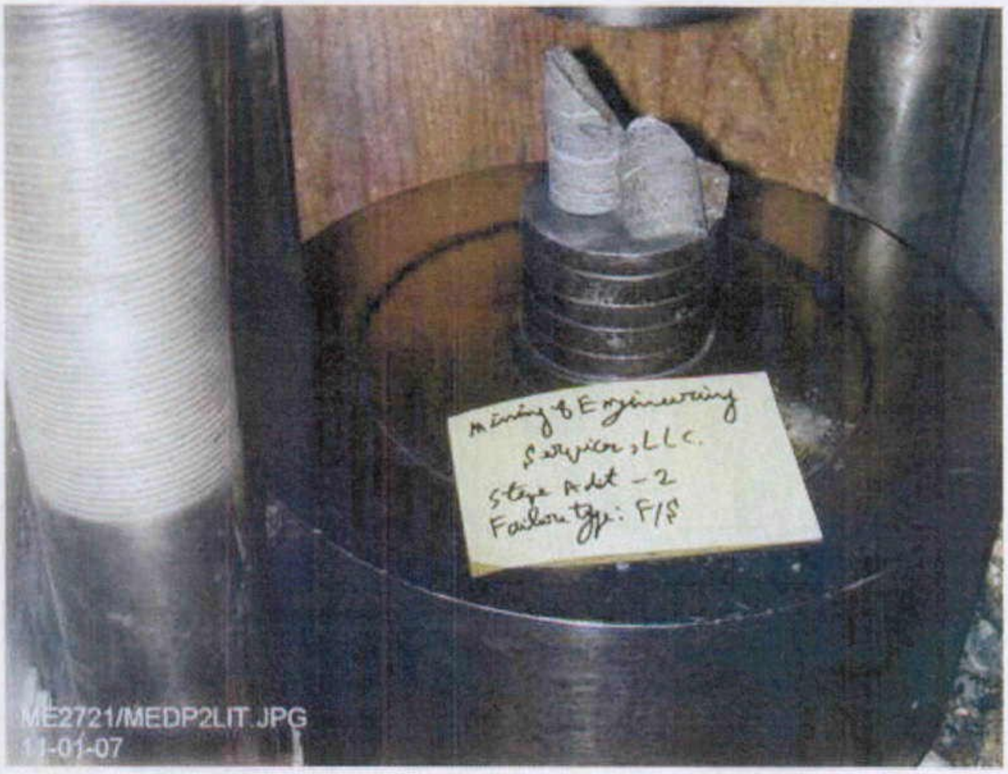
ADVANCED TERRA TESTING, Inc.


ME2721/MEDPLIT1.JPG
11-01-07


Mining & Environmental
Services, LLC
PIERCE Alt #2
Failure type: F
ME2721/MEDPLIT2.JPG
11-01-07


Mining & Environmental
LLC.
PIERCE Add-3
Failure type: F
ME2721/MEDPLIT3.JPG
11-01-07

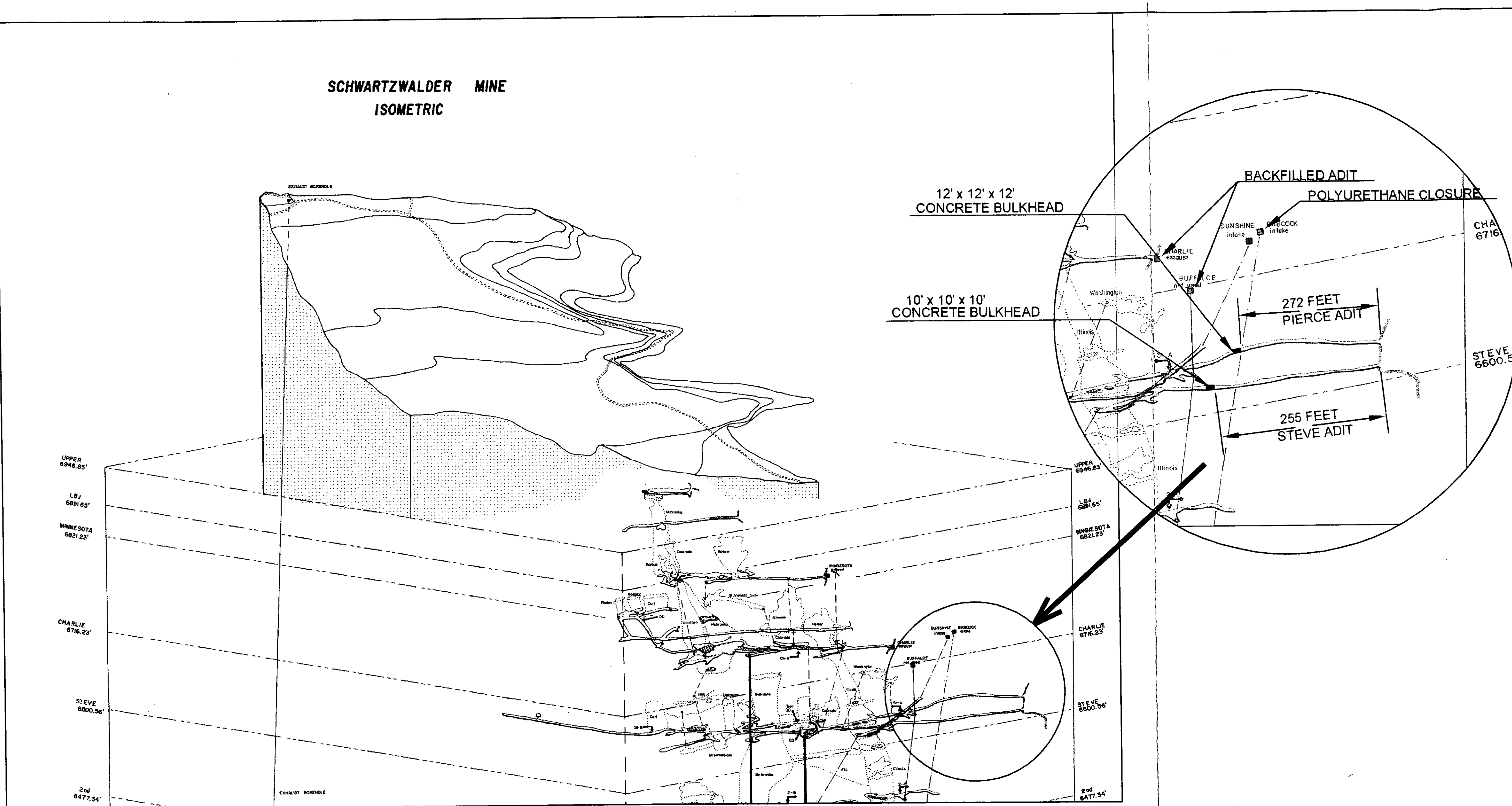

Mining & Environmental
Services, LLC
Stave Adit - 1
Failure type: F/S
ME2721/MEDP1LIT.JPG
11-01-07


Mining & Engineering
Services, LLC.
Stope Adit - 2
Failure type: F/S
ME2721/MEDP2LIT.JPG
11-01-07


ME2721/MEDP3LIT.JPG
11-01-07

Schwartzwalder Mine
Steve Level Adit Closures

As-Built Drawings



Notes: Schwartzwalder Mine Isometric raster image provided by Cotter Corp.

Drawing File: Mining & Environmental Services/Cotter/BulkheadAsBuilt <Location>

Date:	03/09/08
Drawn By:	M.C.C.
Engineer:	M. Levin/J.F. Abel
Approved By:	
Approval Date:	
Scale:	NOT TO SCALE

Steve Level - Bulkhead Closures

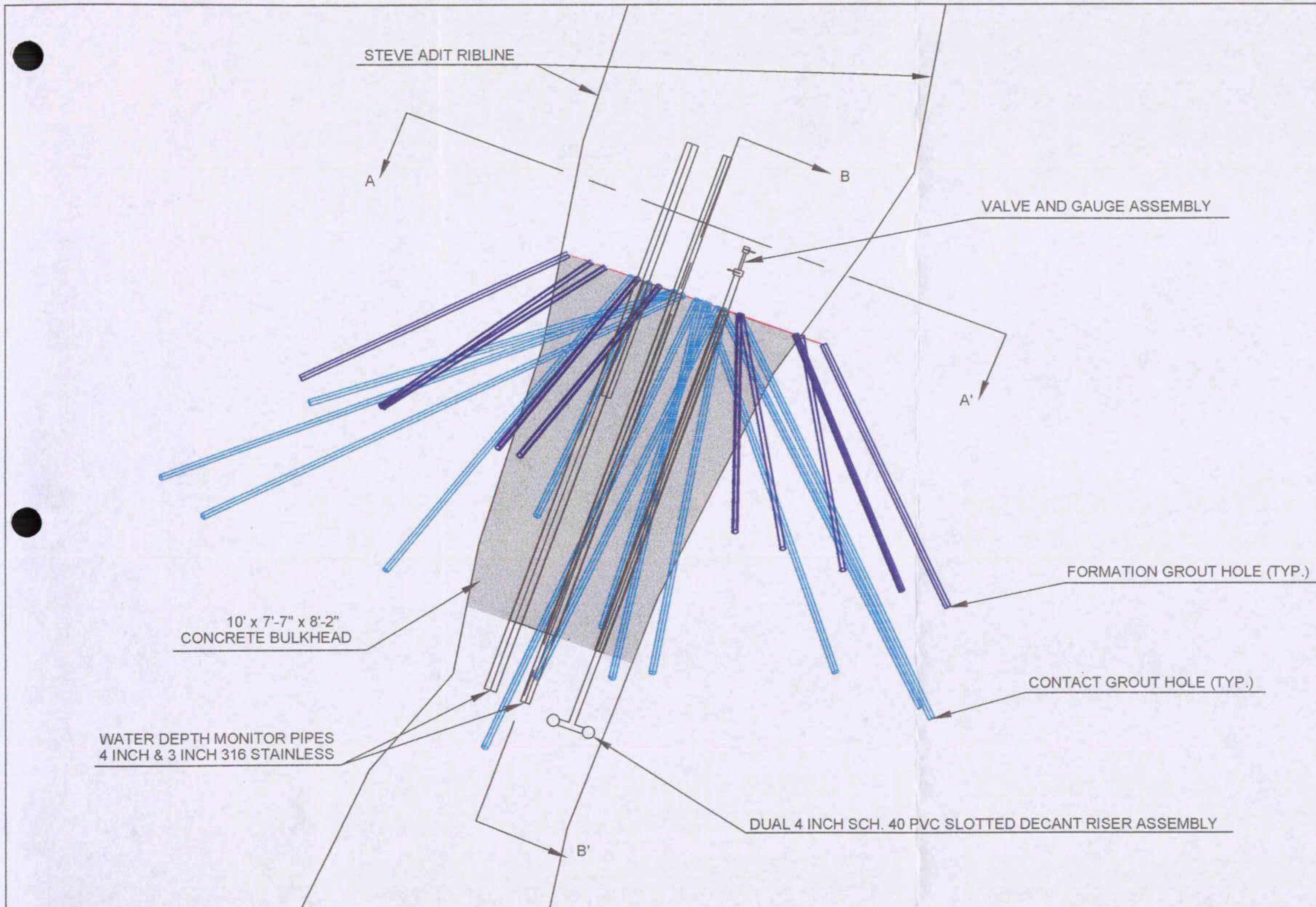
Cotter Corp. - Schwartzwalder Mine

General Location - As Built
Steve (6600') Level
Isometric

Sheet 1 — Revision 0

Mining and Environmental Services, LLC
Post Office Box 1511 - Idaho Springs, CO - 80452 - (303)567-4174

Schwartzwalder Mine -Steve Letie_I_
Scale: finch = 60 feet
12' x 11'-7" x 11'-8"
PROBE HOLES
SUSPECTED STOPING
UNDERNEATH ADIT
wl HDPE PIPE
x 8'-2"
Level Base Map provided by Cotter Corp
03x09108
M.C.C.
M Levlrti'J F Abel
General Location - As Built """ "`""""
Steve (6600') Level 2O
Plan View
Drawing File: Mining 8 Environmental ServiceslCotter/BulkheadAsBuitt <Lacation • Plan> I Scale: As Noted
~chwartzwalder Mine -Steve Level
Scale: finch =120 feet



STEVE ADIT BULKHEAD

GROUT PIPE DATA

CONTACT GROUT HOLES

Pipe No.	Pipe Length (Inches)	Hole Length O.A. (Inches)	Distance to back of Bulkhead (Feet)	Vertical Angle
1	129	196.8	3	+34º
2	126	195	3	+28º
3	120	126	3	+10º
4	102	150	4	-25º
5	108	148	4	-05º
6	114	151.2	4	+36º
7	84	141	6	+27º
8	96	198	6.5	+26º
9	90	103.9	6.5	-35º
10	78	145	7	-28º
11	96	147.6	5	-12º
12	102	147.6	6	+42º
13	102	144	5	+26º

FORMATION GROUT HOLES

Note: All Formation Grout Holes Are Minimum 8 Foot Length - Arranged as Shown

Notes: Steve Level Base Map provided by Cotter Corp.

Grout Data and Field Measurements Provided by Will Beach, P.E.

Drawing File: Mining & Environmental Services/Cotter/BulkheadAsBuilt <Steve Adit - Plan>

Date:	03/09/08
Drawn By:	M.C.C.
Engineer:	M. Levin/J.F. Abel
Approved By:	
Approval Date:	
Scale:	1 Inch = 3 Feet

Steve Level - Bulkhead Closures

Cotter Corp. - Schwartzwalder Mine

Steve Adit Bulkhead - As Built
w/ Grout Holes & Data
Plan View

Sheet 3 | Revision 0

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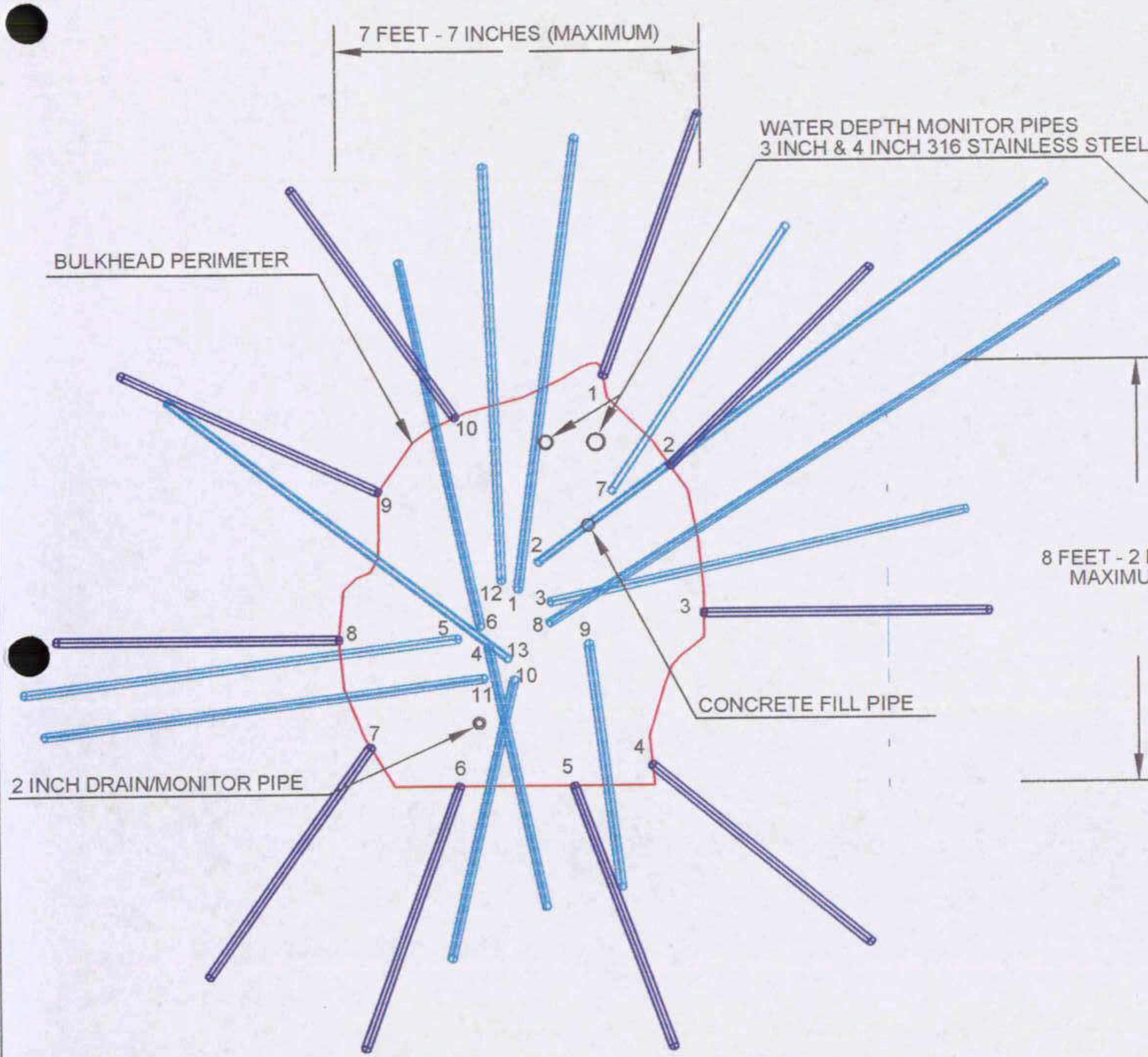
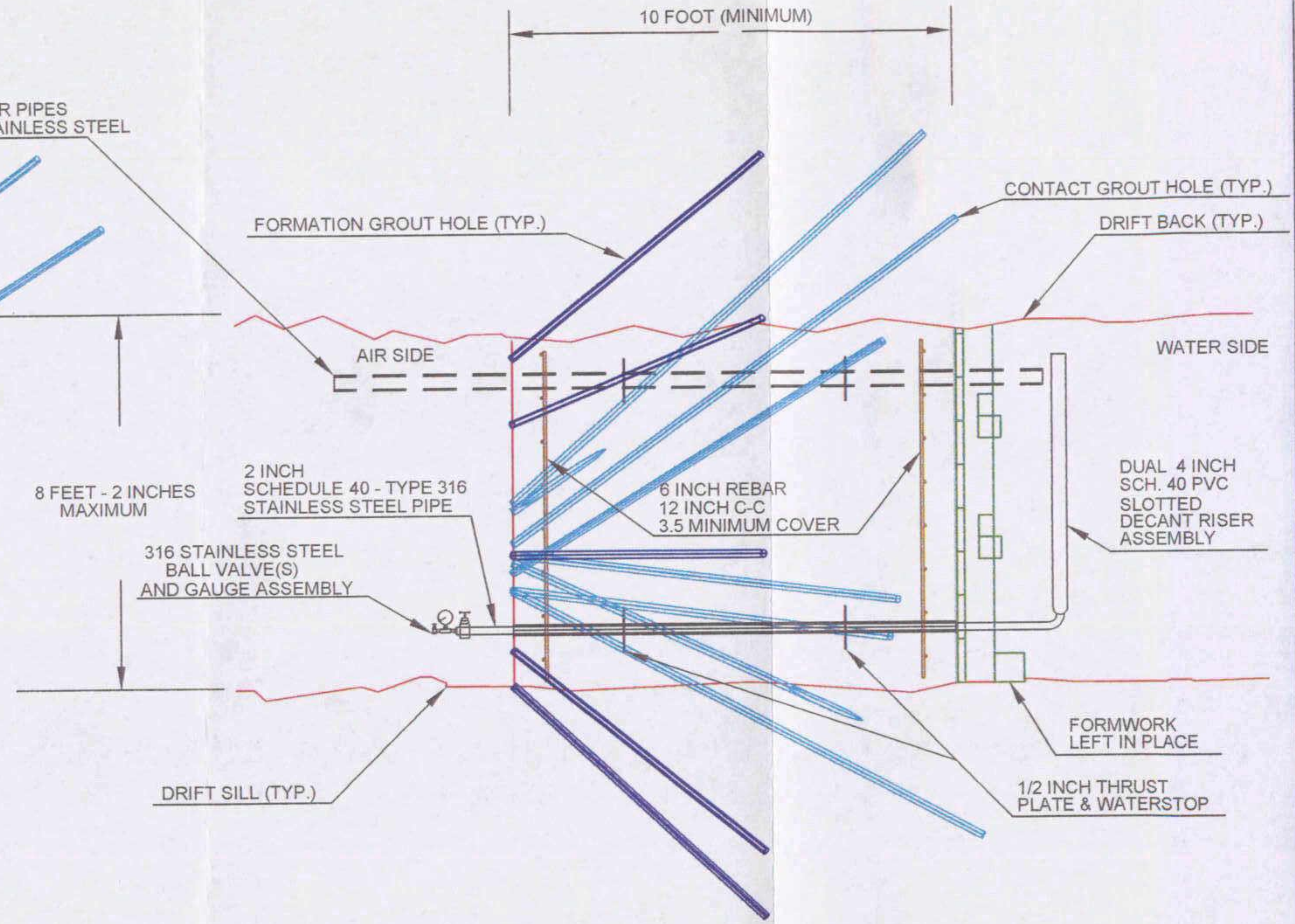


Section A-A' - Bulkhead Elevation



Section B-B' - Longitudinal Section - Elevation

Notes: Field Measurements by Will Beach, P.E.
Water Depth Monitoring Pipes (3 inch & 4 inch Stainless) Projected onto Section B-B'

Drawing File: Mining & Environmental Services/Cotter/BulkheadAsBuilt <Sections - Steve>

Date:	03/09/08
Drawn By:	M.C.C.
Engineer:	M. Levin/J.F. Abel
Approved By:	
Approval Date:	
Scale:	1 Inch = 3 Feet

Steve Level - Bulkhead Closures
Cotter Corp. - Schwartzwalder Mine

Steve Adit Bulkhead - As Built
Section A-A' - Elevation
Section B-B' - Elevation

Sheet 4
Revision 0

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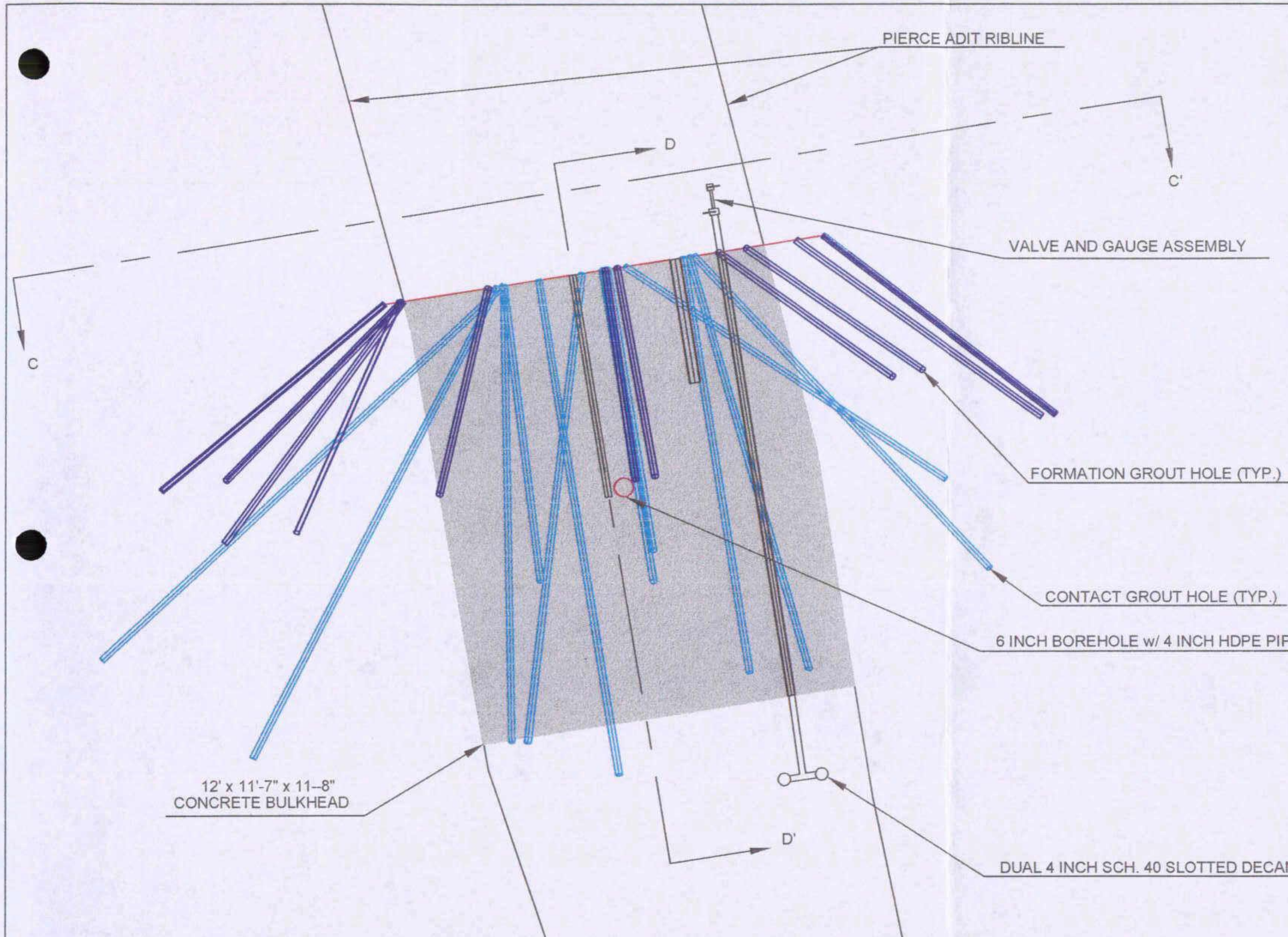

PIERCE ADIT BULKHEAD

GROUT PIPE DATA

CONTACT GROUT HOLES

Pipe No,	Pipe Length (Inches)	Hole Length O.A. (Inches)	Distance to back of Bulkhead (Feet)	Vertical Angle
1	123	171	4	+20°
2	118	157	4	+21°
3	132	157	4	-15°
4	120	126	4	-15°
5	117	151	4	+25°
6	80	168	6	+35°
7	107	170	6	+03°
8	67	175	8	+10°
9	72	164	8	-23°
10	51	126	8	-51°
11	72	170	8	-21°
12	68	116	8	+48°

FORMATION GROUT HOLES

Note: All Formation Grout Holes Are Minimum 8 Foot Length - Arranged as Shown

Notes: Steve Level Base Map provided by Cotter Corp.
Grout Data and Field Measurements Provided by Will Beach, P.E.

Drawing File: Mining & Environmental Services/Cotter/BulkheadAsBuilt <Pierce Adit - Plan>

Date:	03/09/08
Drawn By:	M.C.C.
Engineer:	M. Levin/J.F. Abel
Approved By:	
Approval Date:	
Scale:	1 Inch = 3 Feet

Steve Level - Bulkhead Closures

Cotter Corp. - Schwartzwalder Mine

Pierce Adit Bulkhead - As Built
w/ Grout Holes & Data
Plan View

Sheet 5 | Revision 0

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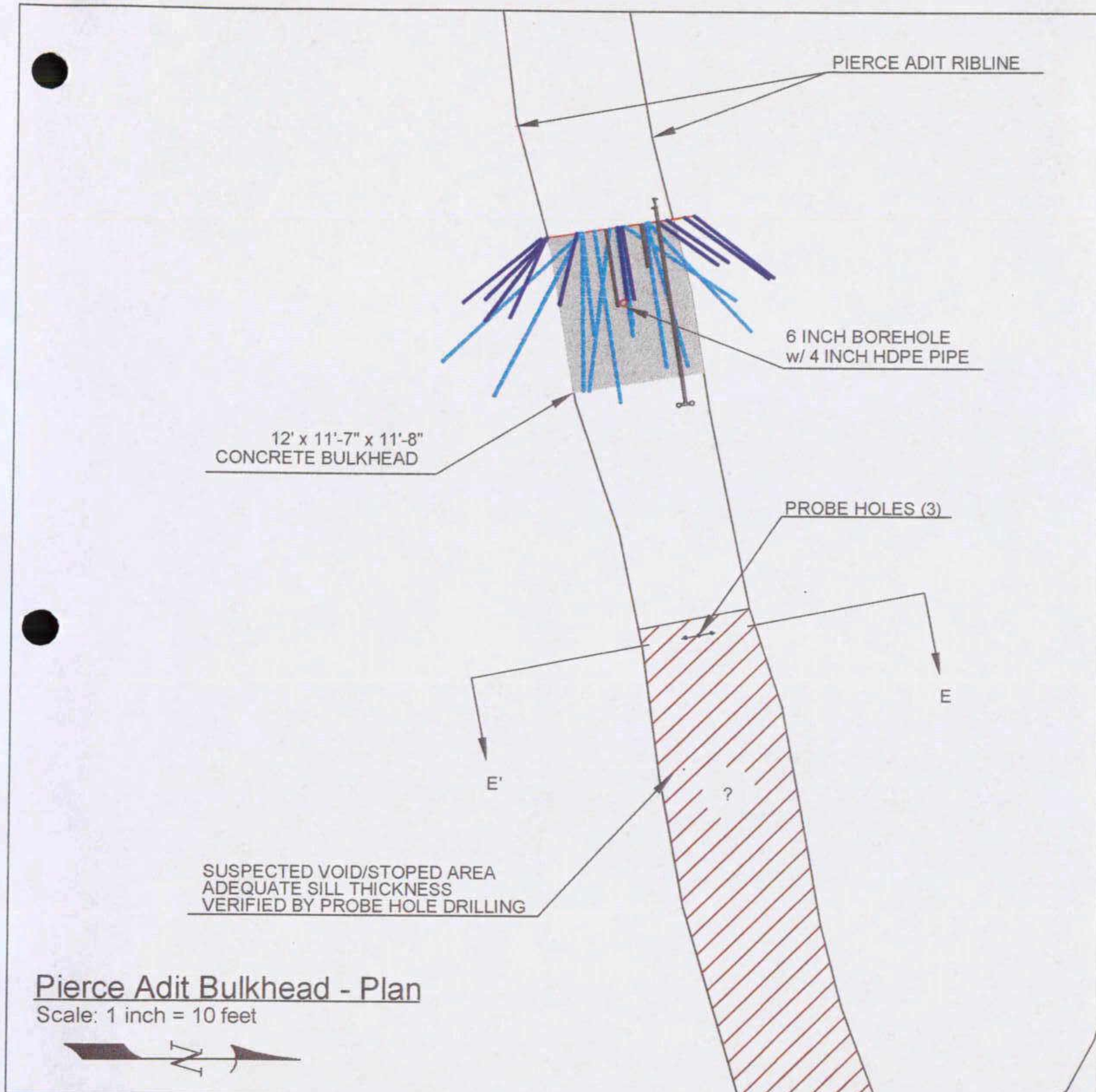
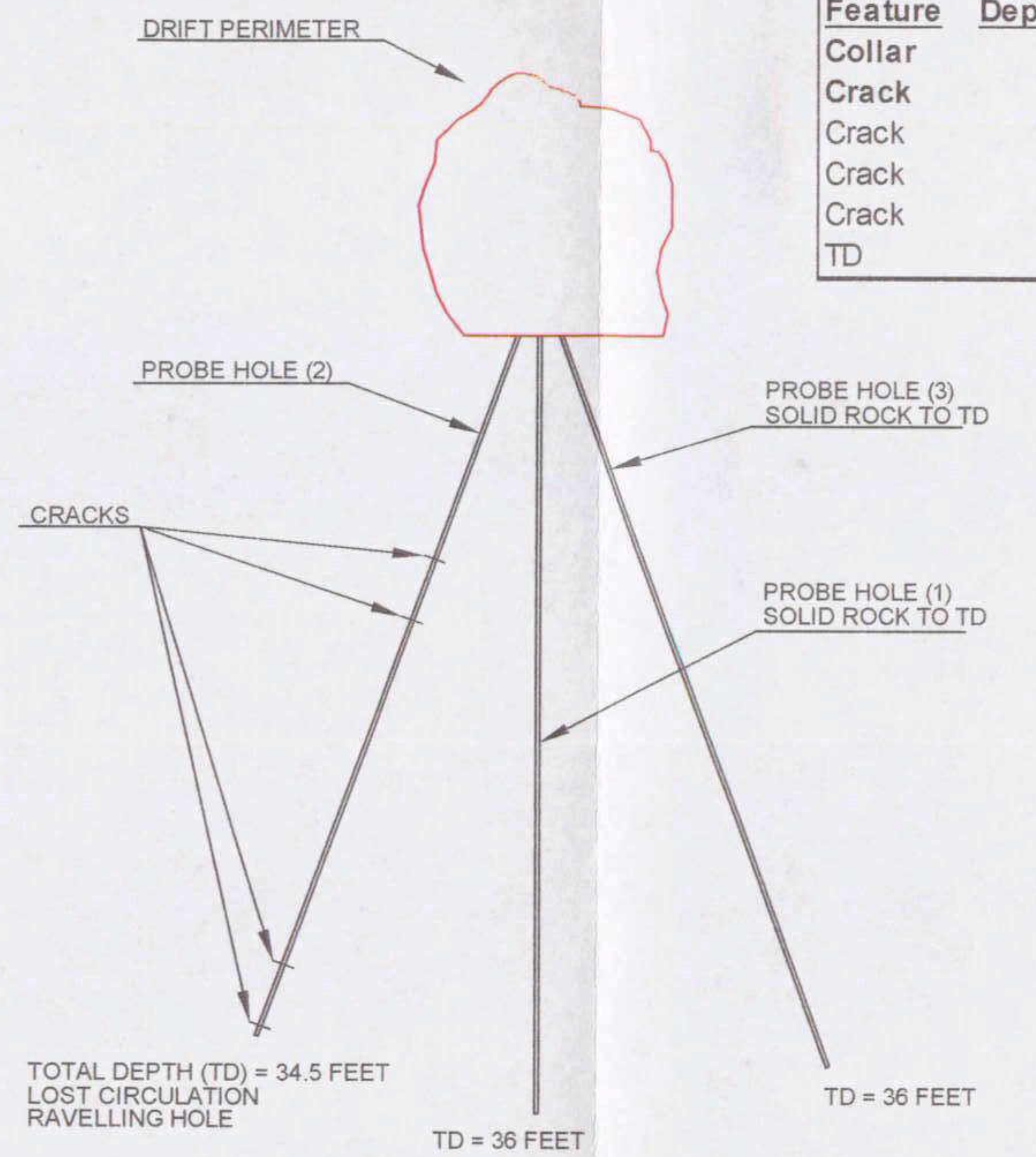


Pierce Adit Bulkhead - Plan

Scale: 1 inch = 10 feet



PIERCE ADIT
PROBE HOLE #2

Feature	Depth (Feet)
Collar	0
Crack	11
Crack	14
Crack	31
Crack	34
TD	34.5

Pierce Adit - Section E-E'

Scale: 1 inch = 8 feet

Notes: Steve Level Base Map provided by Cotter Corp.
Grout Data and Field Measurements Provided by Will Beach, P.E.

Drawing File: Mining & Environmental Services/Cotter/BulkheadAsBuilt <Pierce Void Probing>

Date: 03/09/08
Drawn By: M.C.C.
Engineer: M. Levin/J.F. Abel
Approved By:
Approval Date:
Scale: As Shown

Steve Level - Bulkhead Closures

Cotter Corp. - Schwartzwalder Mine

Pierce Adit Bulkhead - As Built
Void Probing
Plan & Section

Sheet 6 Revision 0

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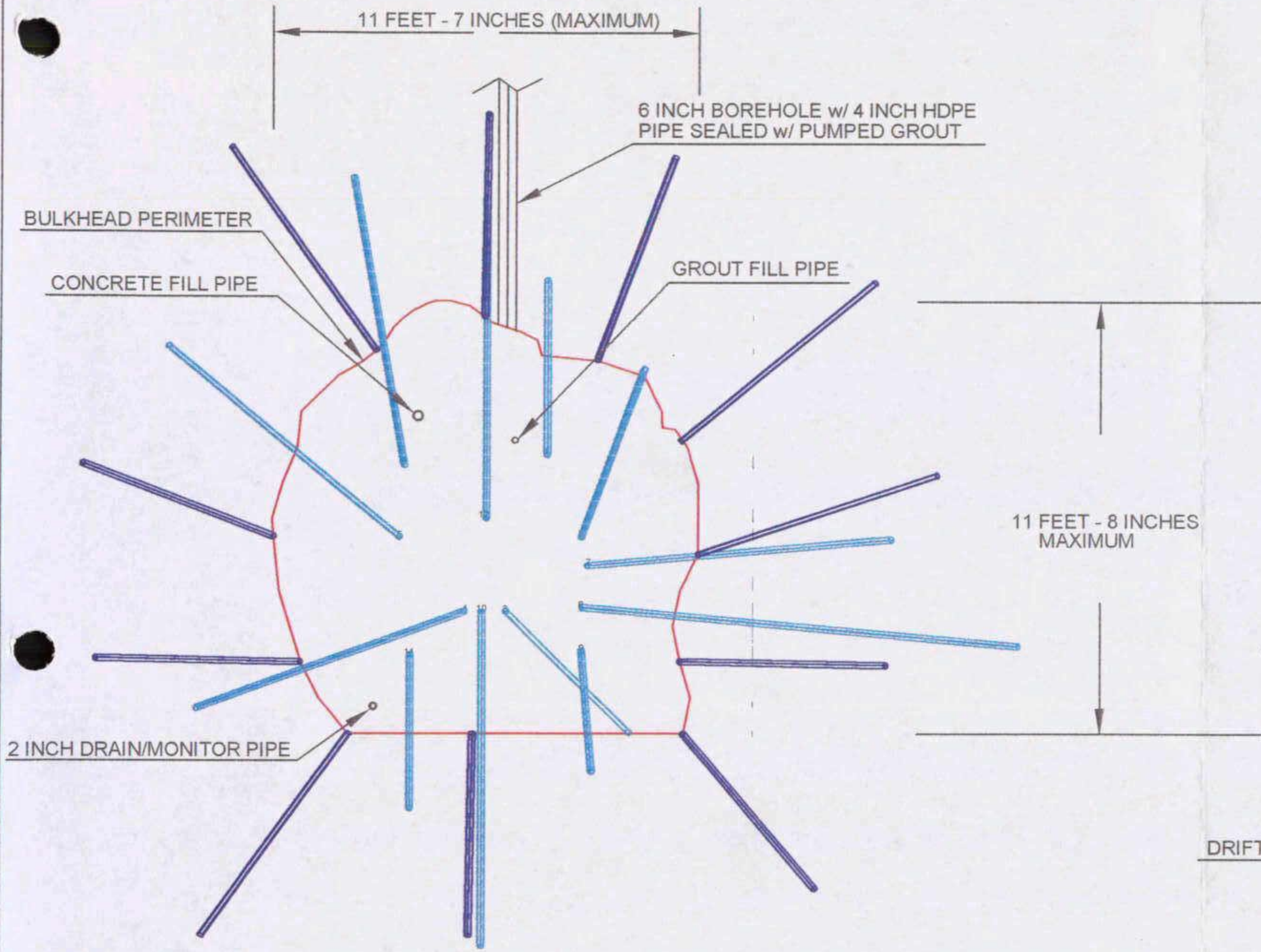
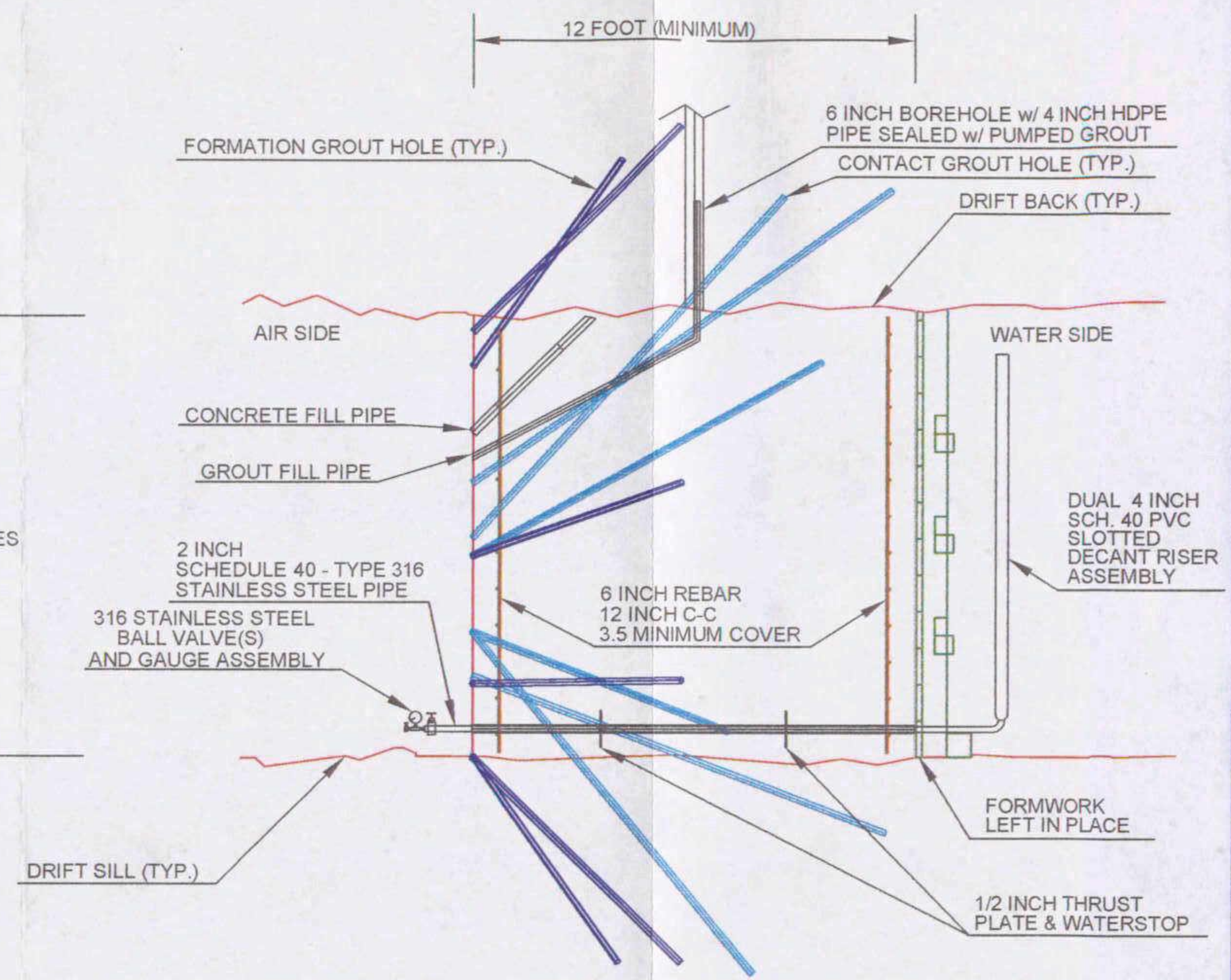


Section C-C' - Bulkhead Elevation



Section D-D' - Longitudinal Section - Elevation

Notes: Field Measurements by Will Beach, P.E.
6 Inch Borehole w/ HDPE Pipe Sealed by Pumped Grout via Drillhole in Annulus and by Placed Grout Pipe in HDPE Pipe

Drawing File: Mining & Environmental Services/Cotter/BulkheadAsBuilt <Sections - Pierce>

Date:	03/09/08
Drawn By:	M.C.C.
Engineer:	M. Levin/J.F. Abel
Approved By:	
Approval Date:	
Scale:	1 Inch = 4 Feet

Steve Level - Bulkhead Closures
Cotter Corp. - Schwartzwalder Mine

Pierce Adit Bulkhead - As Built
Section C-C' - Elevation
Section D-D' - Elevation

Sheet 7
Revision 0

Mining and Environmental Services, LLC
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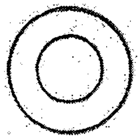
MINING & ENVIRONMENTAL SERVICES

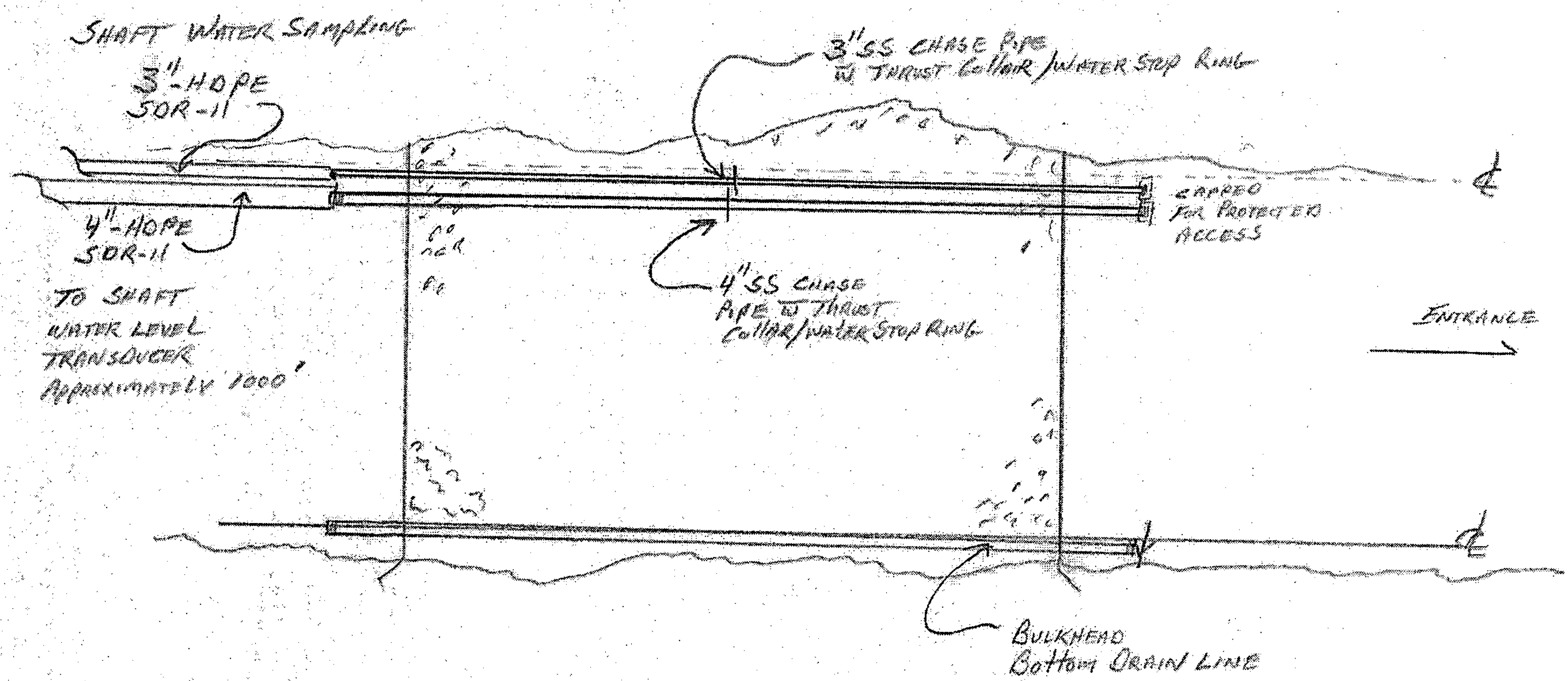
SCHWARTZWALDER MINE

SECTION DETAIL



4" SS CHASE PIPE — WATER LEVEL TRANSDUCER
+ THRUST / WATER STOP RING

3" SS CHASE PIPE — SHAFT WATER SAMPLE RETRIEVAL
+ THRUST / WATER STOP RING



STEVE TUNNEL BULKHEAD
CROSS SECTION
WITH CHASE PIPE EMBEDMENT

SECTION 03300

CONCRETE FOR BULKHEAD.

PART I - GENERAL

1.1 Scope

This section includes:

- The concrete for the bulkhead in the Steve and Pierce Levels.
- Requirements of concrete mix design.
- Sampling and testing of concrete components and set concrete.

1.2 Related Sections

Not applicable

1.3 References

The Contractor shall in all cases use the latest revision of the applicable Standard.

The Standards relevant to this Section are as follows:

ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavy Weight and Mass Concrete.
ACI 318.1	Building Code Requirements for Structural Plain Concrete.
ACI 304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete.
ACI 304 2R	Placing Concrete by Pumping Methods.
ACI 308	Curing Concrete.
ASTM C 31	Making and Curing Concrete Test Specimens in the Field.
ASTM C 33	Standard Specification for Concrete Aggregates.
ASTM C 39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
ASTM C 94	Standard Specification for Ready-Mixed Concrete.
ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

ASTM C 138	Unit Weight, Yield and Air Content (Gravimetric) of Concrete.
ASTM C 143	Standard Specification for Slump of Hydraulic Cement Concrete.
ASTM C 150	Standard Specification for Portland Cement.
ASTM C 172	Method of Sampling Freshly Mixed Concrete.
ASTM C 186	Standard Test Method for Heat of Hydration of Hydraulic Cement.
ASTM C 231	Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
ASTM C 403/ C 403M	Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance.
ASTM C 494	Standard Specification for Chemical Admixtures for Concrete.
ASTM C 566	Test Method for Total Moisture Content of Aggregate by Drying
ASTM C 618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as an Admixture in Portland Cement Concrete.

1.4 Submittals.

The Contractor shall submit the proposed concrete mix design, including proportions, source and identification of all materials used in the concrete mix for approval by the Engineer. This shall include the sources, product data and specifications of any proposed admixtures, together with certification of compatibility of all the concrete mix components, including the water that will be used. These same components shall be used during construction of the bulkhead.

The Contractor shall also provide in this submittal, laboratory test data and trial mix data from a qualified Testing Facility approved by the Engineer for the proposed concrete to be utilized for the bulkhead, including, but not limited to;

- Compressive strengths at 7 and 28 calendar days respectively. Perform at least three tests for each time increment.
- Slump Flow Value for each mix.
- Air Content. Perform at least three tests.
- Density. Perform at least three tests.
- Perform all tests at 70° F.
- Test data confirming the sulfate resisting properties of the concrete and its ability to contain the mine water without significant degradation.

This submittal shall be made in a timely manner to suit the Contractor's overall construction schedule, but no later than 21 days prior to placing the concrete.

1.5 Quality Assurance

Perform the work in accordance with the referenced ACI and ASTM standards.

The aggregate sources chosen shall be capable of producing materials of the quality and quantity required for this project provided suitable processing is performed. Samples from any source selected consisting of not less than 150 pounds of each size of coarse aggregate and 75 pounds of fine aggregate, taken under the supervision of the approved Testing Facility in accordance with CRD-C 100. The Testing Facility shall be responsible for sampling, shipment and testing of the samples at the Contractor's expense.

The evaluation of the aggregates shall be completed within 14 calendar days of receiving the samples. Testing shall be performed in accordance with the applicable CRD or ASTM test methods. Tests to which aggregate shall be subjected are listed in the paragraph in Part 2 entitled "Quality". The material from the proposed source shall meet the requirements of that paragraph in order to qualify for use on this project.

Prior to commencing concrete mix design, the Contractor shall notify the Engineer of the source and brand name, and supply the mill certificates and analyses of each cementitious material to be used in the manufacture of the concrete. All specified sampling and testing shall be performed at the expense of the Contractor.

PART 2 - PRODUCTS

2.1 Cement

Portland cement shall conform to ASTM C150 Type I/II, Type II or Type V, depending upon the requirement for sulfate resistance of the mix. The source of the cement to be used shall be indicated and manufacturer's certification that it complies with the applicable standard shall be provided with each shipment. Only one brand of cement shall be used for all the work, unless otherwise approved by the Engineer.

2.2 Fly ash.

Fly ash shall be Type F and conform to ASTM C 618-94a with the additional requirements that the percent of CaO shall not exceed 10 percent and the Loss on Ignition shall not exceed 6 percent. In addition, the Sulfate Resistance Factor R, equal to (CaO% - 5%) ÷ (Fe_2O_3 %), shall be less than 0.75.

The source of the fly ash to be used shall be indicated and the manufacturer's certification that it complies with the applicable standard shall be provided with each shipment. Only one brand of fly ash shall be used for all work, unless otherwise approved by the Engineer.

2.3 Aggregates

Fine and Coarse aggregates shall at all times conform to ASTM C 33 and the following requirements.

	Test Limits	
Property Aggregate	Fine Aggregate	Coarse
Specific Gravity (ASTM C 127, ASTM C 128)	2.65 max	2.80 max
Absorption (ASTM C 127, ASTM C 128)	1.5 % max	3.5 % max
Clay Lumps and Friable Particles (ASTM C 142)	3.0 %	3.0 % max
Material Finer than 75 microns (No. 200) Sieve (ASTM C 117)	3.0 % max	1.0 % max

Fine aggregate shall consist of clean, sharp, washed natural or washed crushed sand of uniform gradation.

The maximum size of the coarse aggregate shall be $^{3}/_{4}$ inch, and it shall be clean, washed, naturally siliceous gravel. It shall have hard, strong, durable pieces, free of deleterious substances and adherent coatings and shall not contain flat or elongated particles in excess of 15% by weight.

2.4 Water

Water used in mixing concrete shall be fit for human consumption, free of injurious amounts of oil, acid, alkali, organic matter or other deleterious substances.

Water shall conform to the provisions in ASTM C 94, and in addition, shall conform to the following:

- pH not less than 6.0 or greater than 8.0.
- Carbonates and/or bicarbonates of sodium and potassium: 1000 ppm maximum.
- Chloride ions (Cl): 250 ppm maximum.
- Sulfate ions (SO4): 1000 ppm maximum.

- Iron content: 0.3 ppm maximum.
- Total solids: 2000 ppm maximum.

If ice is used in the concrete mix to replace water, ice shall be made from water that meets all of the above requirements.

2.5 Admixtures

All admixtures shall conform to ASTM C494, where applicable.

The Contractor shall use admixtures to produce a self-compacting concrete that is pumpable, essentially self-leveling, requires no vibration and resists segregation. The admixtures required to produce this type of concrete are consistent with the required properties of workability, volume stability and low water-cement ratio. The Contractor shall use admixtures manufactured by Master Builders Technologies or approved equal.

2.6 Target Properties of the Concrete Mix

The Contractor shall develop and proportion a cement/fly ash concrete mix for use in constructing the plug. Fly ash shall be added to the mix to minimize the heat of hydration produced by the resultant mix.

The Contractor shall demonstrate by trial mix that the proposed concrete meets the following properties:

Target properties for Plug Concrete

Property	Comment
Workability.	Range of Slump Flow Value 26 to 30 inches at delivery to the concrete pump. This value must not vary by more than 2 inches over the following 60 minutes. The Slump Flow Test must result in a flat, approximately circular shaped mass of concrete that shows no sign of segregation, having a uniform distribution of coarse aggregate within the mortar matrix. There shall be no sign of any halo of mortar around the outside of the resulting disc of plastic concrete.
Self-compacting.	Use appropriate additives (see Section 2.5 Admixtures).
Less than 25 °F heat rise prior to placement.	Difference between initial condition and temperature after 4 hrs.

3,500 psi compressive strength (f'_c).	At 28 calendar days after casting (ASTM C 39)
Volume stability.	Length change between +/- 0.05 percent (ASTM C 157). Minimize the volume of water used.
Minimal entrained air.	2 to 4 percent air.
Minimum water/cement ratio.	Use appropriate admixtures to achieve the minimum water/cement ratio.
Minimal evolution of heat of hydration.	Minimize the Portland cement content by maximizing the fly ash replacement while also achieving the required strength.

The Contractor shall provide certified copies of test data from an approved laboratory demonstrating compliance with the above target properties.

PART 3 - EXECUTION

3.1 General

The Contractor shall provide all labor, materials, equipment and tools necessary to design, mix and test mass concrete as called for in these specifications. All work shall be according to the Standard References in Paragraph 1.3 of this Section.

3.2 Quality Control

The Contractor shall employ a qualified Testing Facility approved by the Engineer throughout the concrete design and testing process and shall ensure that accurate records are kept of the various potential mix designs and test results. See Paragraph 1.4 of this Section for the required tests and submittals.

End of section.

SECTION 03100

CONCRETE FORMWORK

PART I-GENERAL

1.1 Scope

This section includes:

- Formwork for cast-in-place concrete for the plug and for containment of cellular concrete, complete with shoring, bracing d anchorages.
- Accessory items, water pipe, grout pipes, concrete delivery pipes.

1.2 Related Sections

- 02722 -Grouting.
- 03300- Concrete for Plug.

1.3 References

The Contractor shall in all cases use the latest revision of the applicable Standard.

The standards relevant to this Section are as follows:

ACI 301	Specifications for Structural Concrete for Buildings.
ACI 347	Recommended Practice for Concrete Formwork.
ASTM A-36/ A36M.	Standard Specification for Structural Steel
ASTM A-53	Standard Specification for Pipe, Steel, Black and Hot-Dipped Zinc Coated Welded and Seamless.
ASTM A-325	Standard Specification for Structural Bolts, Steel, Heat- Treated 120/105 ksi Minimum Tensile Strength.
ASTM A-615	Standard Specifications for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
AWS A3.0	Welding Terms and Definitions.
AWS A5.1	Specifications for Mild Steel Covered Arc Welding Electrodes.
AWS D 1.1	Structural Welding Code-Steel.
AISC	Manual of Steel Construction, Latest Edition.

AITC	Manual of Timber Construction, Latest Edition.
30 CFR 57	Safety and Health Standards -Underground Metal and Nonmetal Mines
CRD-C-94	Construction Joints.

1.4 Submittals

The Contractor shall submit the following supporting documentation for the adequacy of the formwork, in a timely manner that suits the Contractors overall Schedule, but no later than 14 days prior to the scheduled commencement of forming of the concrete plug or cellular concrete containment barriers:

- Shop detail drawings with appropriate calculations to support the adequacy of the formwork with regard to such parameters as placement rate, slump and assumed set time. This shall also include the details of the components to be used and method of construction.
- Manufacturer's specification sheets for any manufactured items utilized in construction of the formwork and for materials used for surface treatments.
- Details of proposed installation procedure, including the method to be adopted for sealing the forms to the rock surface to produce a mortar-tight joint.

1.5 Quality Assurance

The design and detail of the formwork shall be conducted under direct supervision of a Professional Engineer experienced in design of this work.

Contractor must ensure that the formwork is fabricated in accordance with the approved shop drawings and the work is performed in accordance with the referenced Standards.

PART 2-PRODUCTS

2.1 Form Materials

Main Forming Materials

Forms to contain the plug concrete or cellular concrete may be constructed of steel, timber or a combination thereof: as approved by the Engineer in the Shop Drawing Submittal. For the appropriate concrete finish, if wood is used, it shall be "Standard" plywood, shiplap or square-edged boards.

Miscellaneous Hardware

Bolts shall be as specified in the shop detailed drawings.

Grout pipes and water pipe shall be ASTM A-53 stainless steel, standard weight pipe.

Rock anchors shall develop strength equal to, or greater than, ASTM A-36 round stock.

Welding electrodes shall conform to AWS A5.1.

Form Surface Treatments

Apply form oil or other release agent to minimize the bond between the forms and the concrete to ease stripping those forms that must be removed as part of this project.

PART 3-EXECUTION

3.1 General

The Contractor shall furnish all labor, materials, equipment and tools to perform all operations in connection with the design, detailing, fabrication and erection of the formwork and the fabrication and installation of grout pipes for the cast-in-place concrete plug and for the cellular concrete containment barriers. All work shall be performed according to the relevant Standards.

All designs must be supported by design calculations stamped and sealed by a Registered Professional Engineer.

The Contractor shall furnish, fabricate and install all concrete placement, grout and air relief pipes for the cast-in-place concrete plug and for the barriers to contain the cellular concrete.

3.2 Shop Drawings

The Contractor shall design and detail all formwork tor the plug or the cellular concrete barriers, complete with any required bracing and shoring, in accordance with ACI 318 and 347 and the AISC Manual of Steel Construction and/or AITC Manual of Timber Construction.

The formwork must be capable of conforming to, and sealing against the irregular profile of the excavation, or to the profile of the existing adit tunnel support (concrete or timber sets and lagging).

The Contractor shall be responsible for verifying the dimensions of the opening into which the formwork or barrier must fit.

3.3 Fabrication

The Contractor shall fabricate all formwork and ancillary items in accordance with the latest edition of the AISC Manual of Steel Construction, AITC Manual of Timber

Construction and the approved detail drawing. All welding shall be in accordance with AWS Dl.l structural welding code including operator and procedure certifications.

Formwork shall contain all inserts, pipes, anchors and cut-outs for grouting and pumping concrete.

3.4 Installation

3.4.1 Grout Pipes and Water Pipe

The Contractor shall furnish, fabricate and install all grout pipes in the cast-in-place plug as approved by the Engineer. One end of the grout pipe shall be attached to the rock wall using masonry anchors and the other threaded end hall be securely fastened to the formwork. Other air relief pipes, as necessary shall be attached to the rock in the same manner while the other end extends through the forms, Grout and air relief pipes shall be temporarily capped or plugged to prevent entry of foreign matter until ready for grouting.

In addition, the Contractor shall furnish, fabricate and install the water pipe through the cast-in-place concrete plug to conduct the water being produced upstream through the construction area. This pipe shall be as shown on the Drawings, complete with seal rings, inlet decant risers, etc.

3.4.2 Formwork

The Contractor shall install formwork at the locations shown on the drawings. Forms are to be mortar tight. The Contractor shall construct the formwork to suit the contour of the excavation or the surrounding adit tunnel support. Any existing adit tunnel support shall not be significantly modified to suit the forms, however, rock may be trimmed or chipped to suit where interferences are encountered. The installation of the formwork shall be reviewed and approved by the Engineer prior to proceeding with concrete or cellular concrete placement.

The forms on the upstream side of the cast-in place concrete plug remain permanently in place while the formwork on the downstream side shall be oiled or receive an application of release agent.

Temporary openings/holes in the forms shall be provided where required to facilitate access for cleaning of the rock surfaces inside the forms and for inspection and installing grout pipes and concrete placement pipes. Small holes shall be made in the top of the accessible side of the forms to allow visual observation of the progress of the concrete placement. These holes will be plugged as the concrete or cellular concrete level reaches them.

Form ties that extend completely through the plug from one side to the other shall not be used.

The forms shall be installed vertically. The deviation from vertical shall not exceed one (1) inch.

3.4.3 Embedded Items.

Portions of items embedded in concrete shall e free of oil, dirt, loose mill scale, rust and debris at the time the concrete is placed. Such material shall be removed by rubbing with burlap.

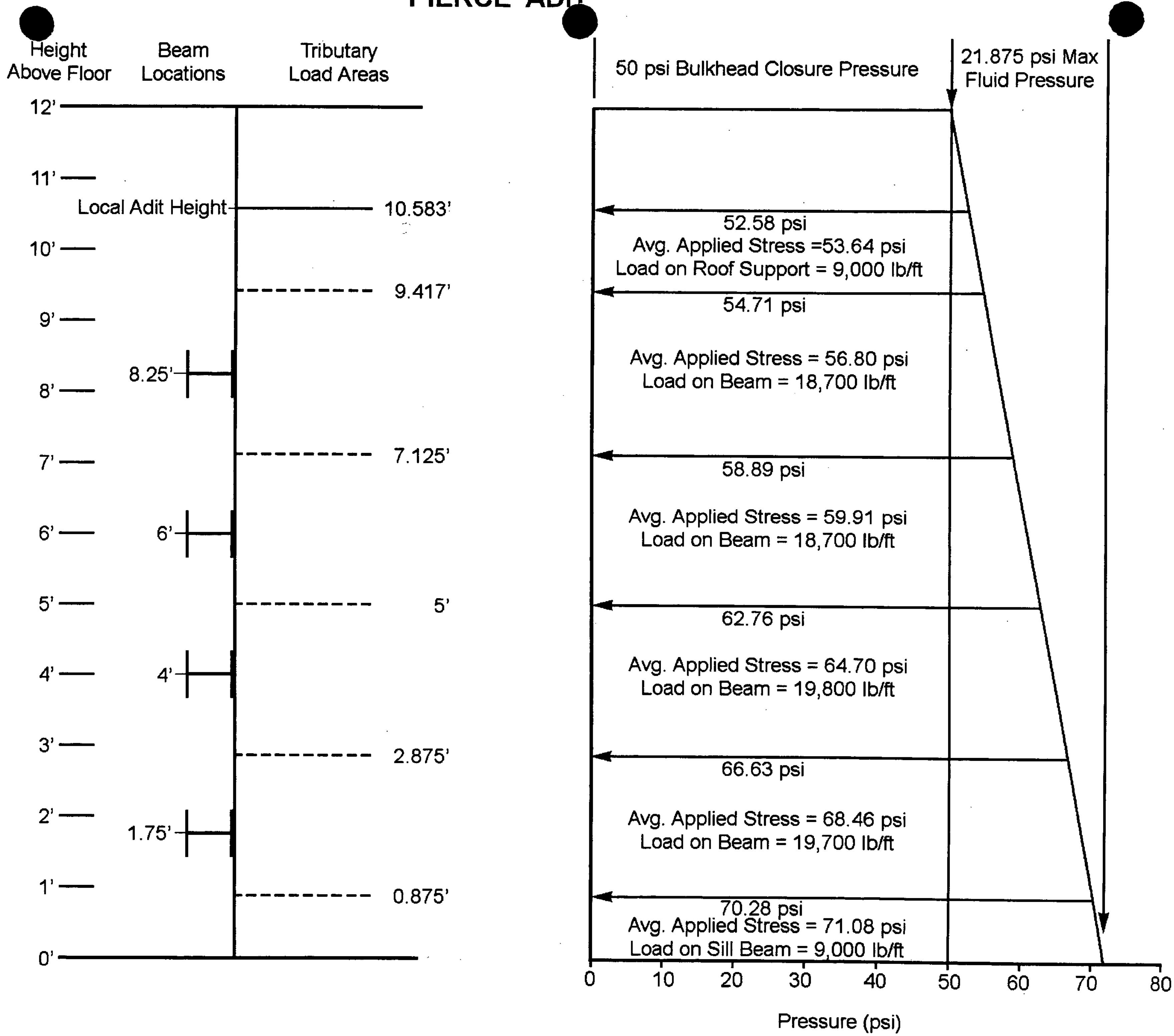
3.5 Quality Control

The Engineer shall visually inspect the formwork installation for fit-up and dimensionally for location, together with any embedded items prior to placement of concrete.

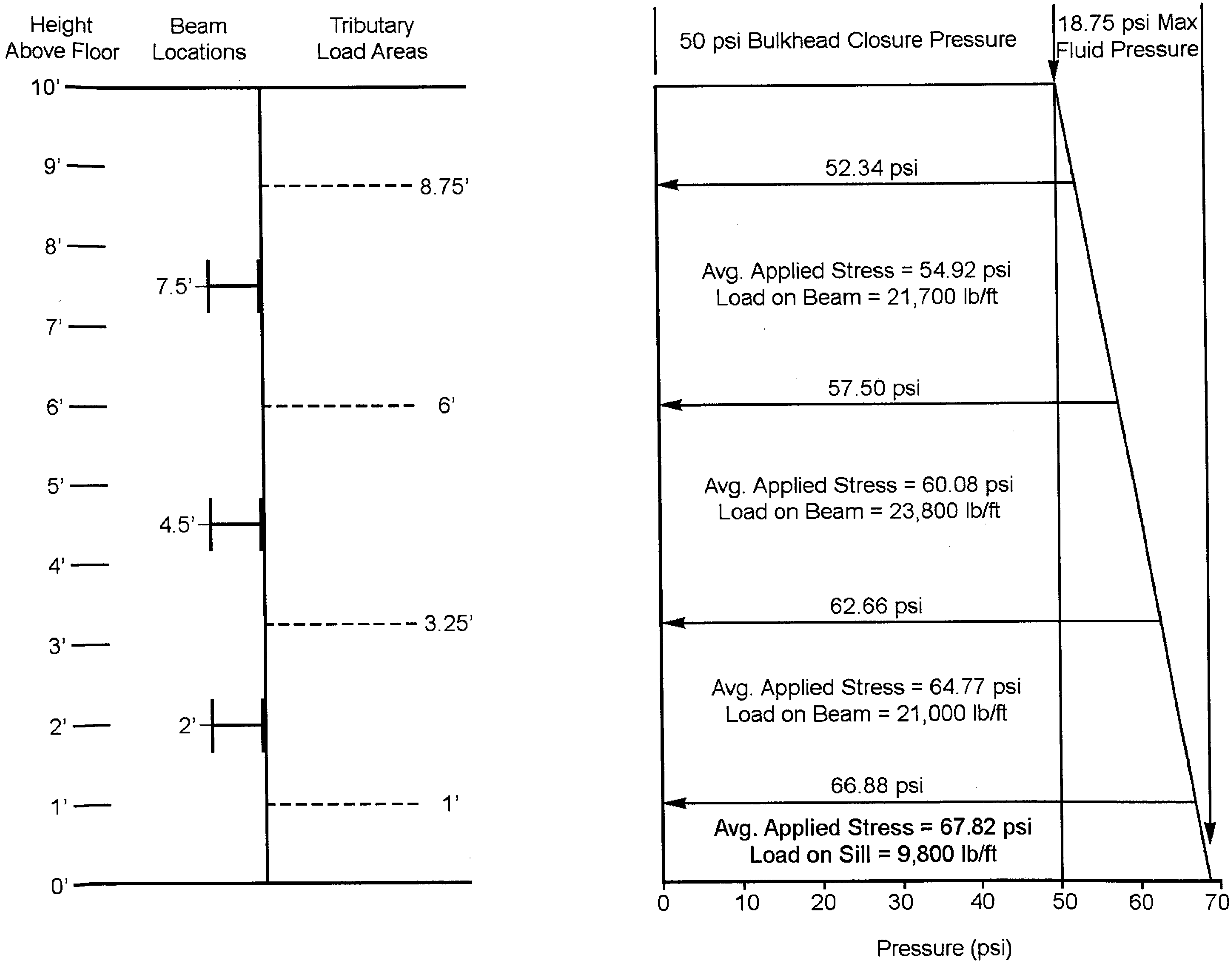
End of section

PIERCE ADIT

TYPICAL FORMWORK LOADING

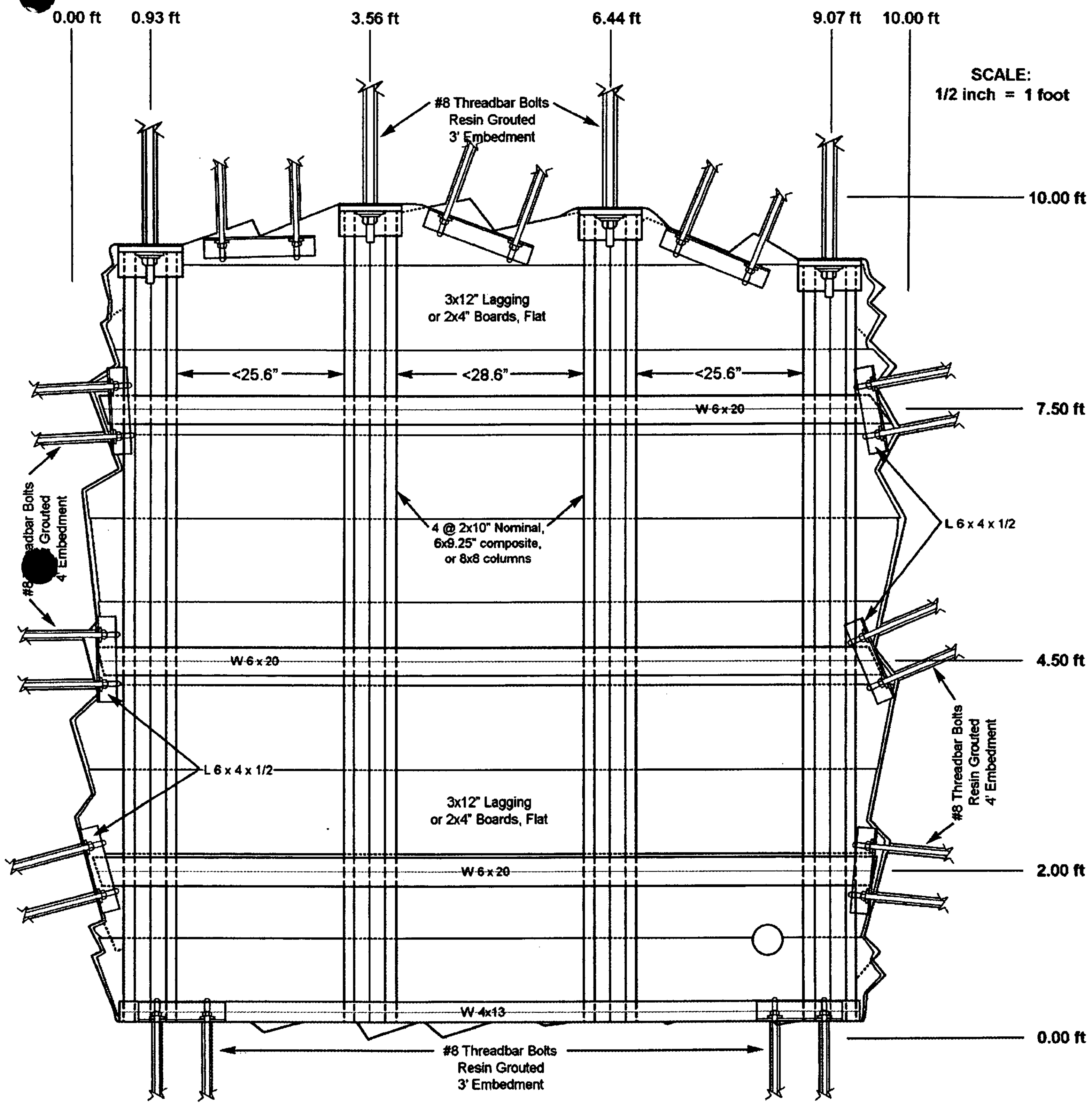


STEVE AD



Height Above Floor
Beam Locations
Tributary Load Areas
10'
9'
8.75'
8'
7.5'
7'
6'
6'
5'
4.5'
4'
3.25'
3'
2'
2'
1'
1'
0'
50 psi Bulkhead Closure Pressure
18.75 psi Max Fluid Pressure
52.34 psi
Avg. Applied Stress = 54.92 psi
Load on Beam = 21,700 lb/ft
57.50 psi
Avg. Applied Stress = 60.08 psi
Load on Beam = 23,800 lb/ft
62.66 psi
Avg. Applied Stress = 64.77 psi
Load on Beam = 21,000 lb/ft
66.88 psi
Avg. Applied Stress = 67.82 psi
Load on Sill = 9,800 lb/ft
0
10
20
30
40
50
60
70
Pressure (psi)

STEVE ADIT



TYPICAL FORMWORK DETAIL

Concrete Mix Data

Everist Materials, LLC

PO Box 1150
28755 Hwy #9
Silverthorne, CO 80498
Phone 970•468•2521
Fax 970•468•2756

December 12, 2007

Mining and Environmental Services
PO Box 1511,
Idaho Springs, Co. 80452
Ph: 303-567-4174
Fx: 303-567-1006
lbennetts@minenv.com

Attn: Will Beach
Re: Bulkhead Concrete

Dear Will,

Enclosed is the submittal package for approval of our concrete mix design requested of us from Section 03300 in the designs for your project. The mix design specified is a Self Consolidating Concrete and is as follows:

Everist ID	PSI	Slump	Air	W/C Ratio
340300SCC	3500	25 – 29	1 – 4	N/A

Also attached are our certification on our aggregate for concrete, and the required certification for our admixtures, cement, and flyash. For your convenience please order using the Everist mix ID numbers. Thank you for doing business with Everist Materials, LLC and please don't hesitate to call if you need any further assistance.

Sincerely,

Nate Thomas
Everist Materials
Quality Control

Everist Materials, LLC

PO Box 1150
28755 Hwy #9
Silverthorne, CO 80498
Phone 970•468•2521
Fax 970•468•2756

Cement:	Type I-II
Fly Ash:	Class F
Admixtures:	Type F
	Viscosity Modifying Admixture
Aggregates:	Coarse Aggregate – No. 8
	Fine Aggregate – Washed Concrete Sand

CONCRETE MIX INFORMATION

Identification No: 340300SCC

MIX PROPORTIONS (Per one cubic yard of Concrete)

Cement	428 lbs.
Fly-ash	183 lbs.
Coarse Agg.	1630 lbs.
Fine Agg.	1370 lbs.
Type F	10oz/cwt to 15oz/cwt
VMA	3oz/cwt to 5oz/cwt
Water	275 lbs. (33 gal.)

These weights are based on S.S.D. condition and will be adjusted accordingly as the moisture varies in the aggregates.

PHYSICAL PROPERTIES OF CONCRETE

Unit Wt. Of fresh Concrete, (ASTM C 138), pcf:	142.0 to 150.0
Slump, (ASTM C143), inches spread:	25" – 29"
Air Content, (ASTM C 231, Pressure Method), %:	1% - 4%
Water/Cementations Materials Ratio:	0.47

COMPRESSIVE STRENGTH

<u>28-DAY</u>

3500 PSI

ATTACHMENT A

AGGREGATE TEST RESULTS

CTL | THOMPSON
MATERIALS ENGINEERS, INC.

June 1, 2006

Everist Materials
PO BOX 1150
Silverthorne, Colorado 80498

Attention: Mr. Nate Thomas

Subject: Physical Properties Testing
Fine Aggregate, Empire Pit
Project No. CT13,613-400

Dear Mr. Thomas:

This report presents results of physical properties tests performed on material delivered to our laboratory in May, 2006. Representative samples delivered were identified as Fine Aggregate from the Empire Pit. Testing was performed to determine the materials compliance with Colorado Department of Transportation (CDOT) specifications. Testing was performed in general conformance with the applicable AASHTO and ASTM test methods. A summary of test results is presented below. Complete test results are presented in Attachment A.

Summary Table
Fine Aggregate, Empire Pit

Test	Fine Aggregate	ASTM C 33 Specifications	CDOT Specifications (AASHTO M 80)
Sieve Analysis (ASTM C 33, AASHTO M 43)	See Table 1	See Table 1	See Table 1
Passing No. 200 Sieve (ASTM C 117, AASHTO T 11)	1.1%	1% max	1% max
Specific Gravity (SSD) Fine Fraction (ASTM C 127, AASHTO T 85)	2.62	NA	NA
Absorption (ASTM C 127, AASHTO T 85)	1.2%	NA	NA
Sand Equivalent (ASTM D 2419, AASHTO T 176)	89%	NA	80% min
Sodium Soundness Fine Fraction (ASTM C 88, AASHTO T 104) Weighted Loss	3.5%	12.0% max	12.0% max
Clay Lumps and Friable Particles Fine Fraction (ASTM C 142, AASHTO T 112) Weighted Average	0.2%	2% max	2% max

Rodded Unit Weight & Voids (ASTM C 29, AASHTO T 19)	106 pcf 1.43 tons/yd^3 35% Voids	NA	NA
Loose Unit Weight & Voids (ASTM C 29, AASHTO T 19)	96 pcf 1.30 tons/yd^3 41% Voids	NA	NA
Lightweight Particles, 2.0 Sp. G. (ASTM C 123, AASHTO T 113)	< 0.1%	0.5% max	0.5% max
Organic Impurities (ASTM C 40, AASHTO T 21)	Plate 2	< Plate 3	< Plate 3
Potential Reactivity of Aggregates (Mortar-bar method) (ASTM C 1260) 14-day expansion	0.12%	Inconclusive	Inconlusive
Potential Reactivity of Aggregates (Mortar-bar method) (ASTM C 1260) 30 % fly Ash 14-day expansion	0.03%	Innocuous	Innocuous
Potential Reactivity of Aggregates (Mortar-bar method) (ASTM C 1260) 25 % Fly Ash 14-day expansion	0.03%	Innocuous	Innocuous

If you have any questions regarding this report, please call.

Very truly yours,

CTL | THOMPSON MATERIALS ENGINEERS, INC.

Matthew A. Best
Materials Lab Manager

Reviewed by:

Damon B. Thomas, P.E.
Division Manager / Associate

MAB:DBT/klb
Enclosures
(2 copies sent)

ATTACHMENT A

LABORATORY TEST RESULTS

TABLE 1
PHYSICAL PROPERTIES OF AGGREGATES

Client: Everist Materials
Sample: Fine Aggregate, Empire Pit
Date Submitted: May, 2006

Sieve Analysis of Fine Aggregate
(ASTM C 136, AASHTO T 27)

Sieve Size	Percent Passing Fine Aggregate	Percent Passing (ASTM C 33)	Percent Passing (AASHTO M 6)
⅜ inch (9.5 mm)	100	100	100
No. 4 (4.75 mm)	96	95-100	95-100
No. 8 (2.36 mm)	83	80-100	80-100
No. 16 (1.18 mm)	68	50-85	50-85
No. 30 (600 μm)	43	25-65	25-60
No. 50 (300 μm)	18	5-30	10-30
No. 100 (150 μm)	5	0-10	2-10

Fineness Modulus: 2.88

Material Finer Than No. 200 Sieve by Washing
Fine Aggregate
(ASTM C 117, AASHTO T 11)

Sample ID	Initial Dry Weight	Final Dry Weight	Percent of Material Finer than No. 200 Sieve
Fine Aggregate	616.0	609.2	1.1

Specific Gravity and Absorption of Fine Aggregate
(ASTM C 127)

Sample ID	Pycnometer Weight with Water	SSD in Air Weight (g)	Pycnometer Weight with Sample	Bulk Volume	Oven Dry Weight	Bulk (SSD) Specific Gravity	Absorption (%)
Fine Aggregate	663.1	500.1	972.1	191.1	494.0	2.62	1.2

Sand Equivalent Value of Soils and Fine Aggregate
(AASHTO T 176, ASTM D 2419)

Tube No.	Clay Reading	Sand Reading	Sand Equivalent
No. 1	4.5	4.0	89
No. 2	4.6	4.0	89
No. 3	4.5	4.0	89

Average Sand Equivalent: 89

TABLE 1
PHYSICAL PROPERTIES OF AGGREGATES

Client: Everist Materials
Sample: Fine Aggregate, Empire Pit
Date Submitted: May, 2006

Soundness of Fine Aggregates by Use of Sodium Sulfate
(ASTM C 88, AASHTO T 104)

Sieve Size		Percent Grading of Sample	Weight Before (g)	Weight After (g)	Percent Loss	Weighted Percent Loss
No. 4	No. 8	13	100.0	92.8	7.2	0.9
No. 8	No. 16	15	99.9	94.3	5.6	0.8
No. 16	No. 30	25	100.0	98.0	2.0	0.5
No. 30	No. 50	25	100.0	95.0	5.0	1.3

Weighted Total Percent Loss: 3.5%

Clay Lumps and Friable Particles in Fine Aggregate
(ASTM C 142, AASHTO T 112)

Sieve Size		Percent Grading of Sample	Weight Before (g)	Weight After (g)	Percent Loss	Weighted Percent Loss
No. 4	No. 16	29	55.0	54.6	0.7	0.2

Weighted Total Percent Loss: 0.2%

Bulk Density ("Unit Weight") and Voids in Aggregates (Rodded Method)
(ASTM C 29, AASHTO T 19)

Sample Weight (lbs)	Bucket Volume (ft^3)	Unit Weight (pcf)
10.34	0.098	105.5
10.36	0.098	105.7
10.37	0.098	105.8

Average: 106 pcf

Bulk Specific Gravity (OD) = 2.59
Voids in aggregate compacted by rodding = 35%

TABLE 1
PHYSICAL PROPERTIES OF AGGREGATES

Client: Everist Materials
Sample: Fine Aggregate, Empire Pit
Date Submitted: May, 2006

Bulk Density ("Unit Weight") and Voids in Aggregates (Loose Method)
(ASTM C 29, AASHTO T 19)

Sample Weight (lbs)	Bucket Volume (ft^3)	Unit Weight (pcf)
9.33	0.098	95.2
9.50	0.098	96.9
9.34	0.098	95.3

Average: 96 pcf

Bulk Specific Gravity (OD) = 2.59
Voids in loose aggregate = 41%

Organic Impurities in Fine Aggregate
(ASTM C 40, AASHTO T 21)

Sample ID	Organic Plate Number	Specified Organic Plate Number
Fine Aggregate	Plate 2	Less Than Plate 3

CTL | THOMPSON
MATERIALS ENGINEERS, INC.

April 4, 2006

Albert Frei & Sons
P.O. Box 700
Henderson, Colorado 80640

Attention: Mr. Rick Foster

Subject: Physical Properties Testing
Pit 6, No. 7 Crushed Rock (ASTM)
Project No. CT13,440-400

Dear Mr. Foster:

This report presents results of physical properties testing performed on material designated as "No. 7 Crushed Rock" from Pit 6. A representative sample was delivered to our laboratory in January of 2006. Testing was performed in general conformance with the applicable ASTM test methods. A summary of test results is presented below. Complete test results are presented in Attachment A.

Summary Table
Pit 6, No. 7 Crushed Rock

Test	Pit 6 No. 7 Crushed Rock	ASTM C 33 Specifications
Sieve Analysis (ASTM C 136)	Meets Specifications	See Table 1
Passing No. 200 (75 µm) Sieve (ASTM C 117)	0.5%	1% max
Specific Gravity (SSD) (ASTM C 127)	2.76	NA
Absorption (ASTM C 127)	1.7%	NA
L.A. Abrasion, Grading C (ASTM C 131)	32%	50% max
Sodium Soundness (ASTM C 88) Weighted Loss	2.2%	12.0% max
Magnesium Soundness (ASTM C 88) Weighted Loss	3.8%	18.0% max
Clay Lumps and Friable Particles (ASTM C 142) Weighted Average	0.1%	2% max
Rodded Unit Weight & Voids (ASTM C 29)	100 pcf 1.35 tons/yd^3 41% Voids	NA
Loose Unit Weight & Voids (ASTM C 29)	90 pcf 1.22 tons/yd^3 47% Voids	NA

Percentage of Fractured Particles of Coarse Aggregate (ASTM D 5821) Minimum 2 Faces Fractured	Average (by weight): 100% Fractured faces per size by mass	NA
Lightweight Particles, 2.4 Sp. G. (ASTM C 123)	0.0%	3% max
Lightweight Particles, 2.0 Sp. G. (ASTM C 123)	0.0%	0.5% max
Weighted Percentage of Flat Particles and Elongated Particles (ASTM D 4791)	1.4% (by mass)	NA
Potential Reactivity of Aggregates (Mortar-bar method) (ASTM C 1260) 14-day expansion	0.03%	Innocuous

The material identified as "No. 7 Crushed Rock" from Pit 6 was prepared for testing in general conformance with ASTM C 1260, *"Potential Alkali Reactivity of Aggregates (Mortar Bar Method)"*. The 14-day expansion for the mix was 0.03%. Results are shown in Attachment A.

The ASTM C 1260 test method defines the potential of an aggregate for deleterious expansion as follows:

Test Expansion	Classification	Potential for Deleterious ASR
< 0.1%	Innocuous	Low
> 0.1% to < 0.2%	Inconclusive	Not Predictable
> 0.2%	Deleterious	High

Based on these results, the potential for deleterious alkali-silica behavior of the aggregate is classified as "Innocuous".

Laboratory test results indicate the aggregate tested meets ASTM requirements for the properties tested. If you have any questions regarding this report, please call.

Very truly yours,

CTL|Thompson Materials Engineers Inc.

Reviewed by:

Matthew A. Best
Materials Lab Manager

Damon B. Thomas, P.E.
Division Manager / Associate

MAB:DBT/mab

Enclosures
(2 copies sent)

ATTACHMENT A
LABORATORY TEST RESULTS

TABLE 1
PHYSICAL PROPERTIES OF AGGREGATES

Client: Albert Frei & Sons
Sample: Pit 6, No. 7 Crushed Rock
Date Submitted: January 2006

Sieve Analysis of Coarse Aggregate
(ASTM C 136)

Sieve Size	No. 7 Crushed Rock Percent Passing	Percent Passing (ASTM C 33)
¾ inch (19.0 mm)	100	100
½ inch (12.5 mm)	98	90-100
⅜ inch (9.5 mm)	62	40-70
No. 4 (4.75 mm)	2	0-15
No. 8 (2.36 mm)	1	0-5

Material Finer Than No. 200 Sieve by Washing
Coarse Aggregate
(ASTM C 117)

Sample ID	Initial Dry Weight	Final Dry Weight	Percent of Material Finer than No. 200 Sieve
No. 7 Crushed Rock	2020.5	2011.0	0.5

Specific Gravity and Absorption of Coarse Aggregate
(ASTM C 127)

Sample ID	Oven Dry Weight (g)	SSD in Air Weight (g)	Submerged Weight (g)	Bulk Volume	Bulk (SSD) Specific Gravity	Absorption (%)
No. 7	4772	4851	3092	1759	2.76	1.7

Resistance to Degradation of Small-size Coarse Aggregate by abrasion and Impact in the Los Angeles Machine
(ASTM C 131)

Sample ID	Grading	Initial Weight	Final Weight	Percent Loss
No. 7	C	5000.5	3393.6	32

TABLE 1
PHYSICAL PROPERTIES OF AGGREGATES

Client: Albert Frei & Sons
Sample: Pit 6, No. 7 Crushed Rock
Date Submitted: January 2006

Soundness of Coarse Aggregates by Use of Sodium Sulfate (ASTM C 88)

Sieve Size		Percent Grading of Sample	Weight Before (g)	Weight After (g)	Percent Loss	Weighted Percent Loss
½ inch	⅜ inch	25	331.0	321.6	2.8	0.7
⅜ inch	No. 4	70	299.7	293.3	2.1	1.5

Weighted Total Percent Loss: 2.2%

Soundness of Coarse Aggregates by Use of Magnesium Sulfate (ASTM C 88)

Sieve Size		Percent Grading of Sample	Weight Before (g)	Weight After (g)	Percent Loss	Weighted Percent Loss
½ inch	⅜ inch	25	330.2	315.1	4.6	1.1
⅜ inch	No. 4	70	301.3	289.8	3.8	2.7

Weighted Total Percent Loss: 3.8%

Clay Lumps and Friable Particles in Coarse Aggregate (ASTM C 142)

Sieve Size		Percent Grading of Sample	Weight Before (g)	Weight After (g)	Percent Loss	Weighted Percent Loss
¾ inch	⅜ inch	25	2307.1	2304.3	0.1	0.0
⅜ inch	No. 4	70	1422.6	1419.9	0.2	0.1

Weighted Total Percent Loss: 0.1%

Bulk Density ("Unit Weight") and Voids in Aggregates (Rodded Method) (ASTM C29)

Sample Weight (lbs)	Bucket Volume (ft^3)	Unit Weight (pcf)
9.765	0.098	99.6
9.780	0.098	99.8
9.730	0.098	99.3

Average: 100 pcf

Bulk Specific Gravity (OD) = 2.71
Voids in aggregate compacted by rodding = 41%

TABLE 1
PHYSICAL PROPERTIES OF AGGREGATES

Client: Albert Frei & Sons
Sample: Pit 6, No. 7 Crushed Rock
Date Submitted: January 2006

Bulk Density ("Unit Weight") and Voids in Aggregates (Loose Method)
(ASTM C29)

Sample Weight (lbs)	Bucket Volume (ft^3)	Unit Weight (pcf)
8.900	0.098	90.8
8.775	0.098	89.5
8.790	0.098	89.7

Average: 90 pcf

Bulk Specific Gravity (OD) = 2.71
Voids in loose aggregate = 47%

Determining the Percentage of Fractured Particles in Coarse Aggregate
(ASTM D 5821)

Sample ID	Initial Weight (g)	Weight of Fractured Particles (g)	Percent of Fractured Particles (minimum 2 faces)
No. 7 Crushed Rock	508.6	508.5	100

Lightweight Particles in Aggregate
(ASTM C 123)

Sample ID	Sample Weight (g)	Specific Gravity of Liquid	Percentage by Mass of Lightweight Particles
No. 7 Crushed Rock	5020	2.0	0.0
No. 7 Crushed Rock	5020	2.4	0.0

Flat Particles and Elongated Particles in Coarse Aggregate
(ASTM D 4791)

Sieve Size	Percent Grading of Sample	Mass of Particles Tested (g)	Mass of Flat Particles (g)	Mass of Elongated Particles (g)	Percentage of Flat Particles and Elongated Particles (% by mass)	Weighted Percentage of Flat Particles and Elongated Particles (% by mass)
⅜-inch	26	191.9	8.8	1.8	5.5	1.4

Weighted Total Percent (by mass) Flat Particles and Elongated Particles: 1.4%

ASH GROVE CEMENT COMPANY

ASH GROVE CEMENT COMPANY

ASH GROVE

Lot Number: 2220
Quantity (tons):
Trailer/Car:
Shipped:

Consigned to:

1801 North Santa Fe
Post Office Box 519
Chanute, Kansas 66720
Phone: 620-431-4500
Fax: 620-431-4552

Silo 30

Cement Type: I/II

Production Period: September 2 - September 30, 2007

Date: 10/26/2007

STANDARD REQUIREMENTS
ASTM C150

CHEMICAL

Item	Spec. Limit	Test Result
SiO_2 (%)	20.0 min	20.85
Al_2O_3 (%)	6.0 max	4.18
Fe_2O_3 (%)	6.0 max	3.41
CaO (%)	*A*	63.00
MgO (%)	6.0 max	2.02
SO_3 (%)	3.0 max	2.50
Loss on ignition (%)	3.0 max	1.49
Na_2O (%)	*A*	0.17
K_2O (%)	*A*	0.51
Insoluble Residue (%)	0.75 max	0.24
CO_2 Content (%)		0.90
LS Content (Calculated %)	3.0 max	2.27
Potential compounds (%)		
C_3S (CO2 corrected)	*A*	47
C2S (CO2 corrected)	*A*	24
C_3A	*A*	5
C_4AF	*A*	10
C_3S+4(C_3A)		83

PHYSICAL

Item	Spec. Limit	Test Result
Air content of mortar (volume %)	12 max	7.3
Fineness (cm^2/g)		
(Air permeability)	2800 min	4490
Autoclave expansion (%)	0.80 max	0.05
Compressive strength (psi)	Min:	
1 Day	*A*	2530
3 Days	1740	3880
7 Days	2760	4790
28 Days	*A*	
Time of setting (minutes)		
(Vicat)		
Initial	Not less than 45	111
Final	Not more than 375	243
Specific Gravity		3.15

OPTIONAL REQUIREMENTS
ASTM C150 Tables 2 and 4

CHEMICAL

Item	Spec. Limit	Test Result
C_3S + C_3A (%)	*A*	
Equivalent alkalies (%)	0.60	0.50

A = Not applicable.
B = Limit not specified by purchaser, test result provided for information only.
C = Test results for this period not available.

PHYSICAL

Item	Spec. Limit	Test Result
False set (%)	*A*	90.8
Heat of hydration (kJ /kg)		
7 days	*A*	*A*
Compressive strength (Mpa)		
28 Days	*A*	

We certify that the above described cement, at the time of shipment, meets the chemical and physical requirement of the ASTM C150-04 and AASHTO M85, or (other) ________________ specification.

Signature: Marc D. Melton
Marc D. Melton

Title: Chief Chemist

Prepared on 10/28/2007

CTL | THOMPSON
MATERIALS ENGINEERS, INC.

Chemical and Physical Analysis of Fly Ash

Developed For: *Headwaters Resources*
16817 - 155th Pl SE
Renton, WA 98058

Ticket: *7420*	**Plant of Origin:** *Bridger*	**Sample Date Range:** *08/25/2007*
Job: *13968*	**Sample ID:** *Br-126-07*	**to:** *08/29/2007*
Report Date: *10/31/2007*	**Docket:** *10021766 - 10021848*	**Date Received:** *09/06/2007*

Chemical Composition (%)

(by Wyoming Analytical Laboratories, Inc.)

			ASTM C 618-05 Specifications Class F	ASTM C 618-05 Specifications Class C
Total Silica, Aluminum, Iron:	*82.7*		70.0 Min	50.0 Min
Silicon Dioxide:		*60.5*		
Aluminum Oxide:		*17.2*		
Iron Oxide:		*5.0*		
Sulfur Trioxide:	*0.7*		5.0 Max	5.0 Max
Calcium Oxide:	*6.7*			
Moisture Content:	*0.0*		3.0 Max	3.0 Max
Loss on Ignition:	*0.3*		6.0 Max	6.0 Max

Physical Test Results

		ASTM C 618-05 Specifications Class F	ASTM C 618-05 Specifications Class C
Fineness, Retained on #325 Sieve (%):	*18.1*	34 Max	34 Max
Strength Activity Index (%)			
Ratio to Control @ 7 Days:	*87.6*		
Ratio to Control @ 28 Days:	*93.1*	75 Min	75 Min
Water Requirement, % of Control:	*95.0*	105 Max	105 Max
Soundness, Autoclave Expansion (%):	*0.05*	0.8 Max	0.8 Max
Density Mg/m^3:	*2.36*		

Comments:

CTL | Thompson Materials Engineers, Inc.

Orville R. Werner II, P.E.

COLORADO REGISTERED ORVILLE R. WERNER II 14540 10/31/2007 PROFESSIONAL ENGINEER

22 Lipan Street | Denver, Colorado 80223 | Telephone: 303-825-0777 Fax: 303-893-1568

BASF

The Chemical Company

3	03 30 00	Product Data
	03 40 00	Cast-in-Place Concrete
	03 70 00	Precast Concrete
4	04 05 16	Mass Concrete
		Masonry Grouting

GLENIUM® 3030 NS

Full-Range Water-Reducing Admixture

Description

Glenium 3030 NS ready-to-use full-range water-reducing admixture is a patented new generation of admixture based on polycarboxylate chemistry. Glenium 3030 NS admixture is very effective in producing concretes with different levels of workability including applications that require the use of Rheodynamic® Self-Consolidating Concrete (SCC). Glenium 3030 NS admixture meets ASTM C 494/C 494M requirements for Type A, water-reducing, and Type F, high-range water-reducing, admixtures.

Applications

Recommended for use in:

- Concrete where high flowability, high-early and ultimate strengths and increased durability are needed
- Self-consolidating concrete
- Concrete where normal, mid-range, or high-range water-reduction is desired
- Concrete where normal setting times are required
- 4x4™ Concrete for fast track construction
- Pervious Concrete
- Self-consolidating grout

Features

- Reduced water content for a given slump
- Dosage flexibility for normal, mid and high-range water reduction
- Produces cohesive and non-segregating concrete mixture
- Increased compressive strength and flexural strength performance at all ages
- Providing faster setting times and strength development
- Enhanced finishability and pumpability

Benefits

- Providing economic benefits to the entire construction team through higher productivity and reduced variable costs

Performance Characteristics

Mixture Data: 600 lb/yd^3 of Type I cement (360 kg/m^3); slump, 8.5-9.25 in. (210-235 mm); non-air-entrained concrete; dosage rate adjusted to obtain 25-30% water reduction.

Setting Time

Mixture	Initial Set (h:min)	Difference (h:min)
Plain	4:24	–
Conventional Superplasticizer	6:00	+ 1.36
Glenium 3030 NS admixture	5:00	+0.36

Compressive Strength

Mixture	1 day		7 days	
psi	MPa	psi	MPa	
Plain	1700	12	4040	28
Conventional Superplasticizer	3460	24	6380	44
Glenium 3030 NS admixture	4120	28	7580	52

Slump Retention - in. (mm)

Mixture	Minutes		
	15	30	45
Plain	8.5 (215)	8.5 (215)	7.5 (200)
Conventional Superplasticizer	8.5 (215)	4.25 (110)	3.5 (90)
Glenium 3030 NS admixture	9.25 (235)	9.25 (235)	8.25 (210)

Master Builders

Product Data: GLENIUM® 3030 NS

Rate of Hardening: Glenium 3030 NS admixture is formulated to produce normal setting characteristics throughout its recommended dosage range. Setting time of concrete is influenced by the chemical and physical composition of the basic ingredients of the concrete, temperature of the concrete and ambient conditions. Trial mixtures should be made with actual job materials to determine the dosage required for a specified setting time and a given strength requirement.

Guidelines for Use

Dosage: Glenium 3030 NS admixture has a recommended dosage range of up to 3 fl oz/cwt (195 mL/100 kg) for Type A applications, 3-6 fl oz/cwt (195-390 mL/100 kg) for mid-range use and up to 18 fl oz/cwt (1,170 mL/100 kg) for Type F applications. The dosage range is applicable to most concrete mixtures using typical concrete ingredients. However, variations in job conditions and concrete materials, such as silica fume, may require dosages outside the recommended range. In such cases, contact your local BASF Admixtures, Inc. representative.

Mixing: Glenium 3030 NS admixture can be batched with the initial mixing water or as a delayed addition. However, optimum water reduction is generally obtained with a delayed addition.

Product Notes

Corrosivity – Non-Chloride, Non-Corrosive: Glenium 3030 NS admixture will neither initiate nor promote corrosion of reinforcing steel embedded in concrete, prestressed concrete or of galvanized steel floor and roof systems. Neither calcium chloride nor other chloride-based ingredients are used in the manufacture of Glenium 3030 NS admixture.

Compatibility: Glenium 3030 NS admixture is compatible with most admixtures used in the production of quality concrete, including normal, mid-range and high-range water-reducing admixtures, air-entrainers, accelerators, retarders, extended set control admixtures, corrosion inhibitors, and shrinkage reducers.

Do not use Glenium 3030 NS admixture with admixtures containing beta-napthalene-sulfonate. Erratic behaviors in slump, slump flow, and pumpability may be experienced.

For directions on the proper evaluation of Glenium 3030 NS admixture in specific applications, contact your BASF Admixtures, Inc. representative.

Storage and Handling

Storage Temperature: If Glenium 3030 NS admixture freezes, thaw at 45 °F (7 °C) or above and completely reconstitute by mild mechanical agitation. ***Do not use pressurized air for agitation.***

Shelf Life: Glenium 3030 NS admixture has a minimum shelf life of 12 months. Depending on storage conditions, the shelf life may be greater than stated. Please contact your BASF Admixtures, Inc. representative regarding suitability for use and dosage recommendations if the shelf life of Glenium 3030 NS admixture has been exceeded.

Packaging

Glenium 3030 NS admixture is supplied in 55 gal (208 L) drums, 275 gal (1040 L) totes and by bulk delivery.

Related Documents

Material Safety Data Sheets: Glenium 3030 NS admixture.

Additional Information

For additional information on Glenium 3030 NS admixture or its use in developing concrete mixes with special performance characteristics, contact your BASF Admixtures, Inc. representative.

BASF Admixtures, Inc. is a leading provider of innovative chemical admixtures and silica fume for specialty concrete used in the ready mix, precast, manufactured concrete products, underground construction and paving markets in the United States and Canada. The Company's respected Master Builders brand products are used to improve the placing, pumping, finishing, appearance and performance characteristics of concrete.

NSF
Certified to NSF/ANSI 61

www.basf-admixtures.com
United States 23700 Chagrin Boulevard, Cleveland, Ohio 44122-5544 ■ Tel: 800 628-9990 ■ Fax: 216 839-8821
Canada 1800 Clark Boulevard, Brampton, Ontario L6T 4M7 ■ Tel: 800 387-5862 ■ Fax: 905 792-0651

Master Builders

degussa.

creating essentials

RHEOMAC® VMA 362

Viscosity-Modifying Admixture

3/4	Product Data
03 30 00	Cast-in-Place Concrete
03 40 00	Precast Concrete
03 70 00	Mass Concrete
04 05 16	Masonry Grouting

Description

Rheomac VMA 362 viscosity-modifying admixture (VMA) is a ready-to-use, liquid admixture that is specially developed for producing concrete with enhanced viscosity and controlled rheological properties. Concrete containing Rheomac VMA 362 admixture exhibits superior stability, thus increasing resistance to segregation and facilitating placement and consolidation.

Applications

Recommended for use in:

- Concrete containing "gap-graded" aggregates
- Lean concrete mixtures
- Concrete containing manufactured sand
- Concrete as a pumping aid
- Concrete as a finishing aid
- Concrete mixtures requiring "more body"
- Rheodynamic® Self-Consolidating Concrete (SCC)
- Liquid Sand™

Features

- Modifies viscosity of concrete
- Easy to dispense

Benefits

- Controls bleeding
- Modifies rheological properties
- Provides flexibility in mixture proportioning and batching
- Provides concrete stability during transport and placement
- Reduces segregation, even with highly-fluid concrete mixtures
- Enhances pumping and finishing
- Enhances surface appearance
- Provides superior and predictable in-place concrete properties
- Facilitates production of highly-fluid concrete mixtures such as Rheodynamic Self-Consolidating Concrete (SCC)

Performance Characteristics

Mixture Data: Non-air-entrained Rheodynamic SCC; 750 lb/yd³ (445 kg/m³) Type I cement; Glenium 3200 HES admixture @ 8.0 fl oz/cwt (520 mL/100 kg); w/cm = 0.35; s/a = 0.42; slump flow 20-27 in. (510-685 mm).

Setting Time: Rheomac VMA 362 admixture has little to no impact on concrete setting time within the recommended dosage range of 2-14 fl oz/cwt (130-920 mL/100 kg) of cementitious materials.

Compressive Strength: Rheomac VMA 362 admixture does not affect the compressive strength of concrete.

Viscosity: Concrete containing Rheomac VMA 362 admixture will exhibit an increase in viscosity with increasing dosage of the admixture. This desirable characteristic facilitates concrete placement, consolidation and finishing and provides stability to very fluid concrete mixtures.

Workability: Rheomac VMA 362 admixture enhances workability.

Air Content: Rheomac VMA 362 admixture does not affect the air content in either air-entrained or non-air-entrained concrete. Typical dosages of air-entraining admixtures may be used to achieve the desired air content.

Construction Chemicals
Degussa Admixtures, Inc.

Master Builders

Guidelines for Use

Dosage: The recommended dosage range for Rheomac VMA 362 admixture is 2-14 fl oz/cwt (130-920 mL/100 kg) of cementitious materials. A dosage of 2-6 fl oz/cwt (130-390 mL/100 kg) is recommended for typical concrete mixtures requiring "more body" to facilitate pumping and finishing procedures. A dosage of up to 14 fl oz/cwt (920 mL/100 kg) is recommended to provide stability in self-consolidating concrete mixtures. Because of variations in concrete materials, job site conditions and/or applications dosages outside of the suggested range may be required.

Mixing: Rheomac VMA 362 admixture is typically added with the initial mix water. Alternately, Rheomac VMA 362 admixture may be added after all other concreting ingredients have been batched and thoroughly mixed, either at the batch plant or at the jobsite.

Product Notes

Compatibility: Rheomac VMA 362 admixture is compatible with most admixtures used in the production of quality concrete including normal, mid-range and high-range water-reducing admixtures and air entrainers. Rheomac VMA 362 admixture is also compatible with typical accelerators, retarders, extended set-control admixtures, corrosion inhibitors, and shrinkage reducers. However, a field trial mixture is recommended to ensure appropriate performance.

Storage and Handling

Storage Temperature: Rheomac VMA 362 admixture must be stored at temperatures above 32 °F (0 °C) and below 130 °F (54 °C). Protect Rheomac VMA 362 admixture from freezing because it cannot be reconstituted after thawing.

Shelf Life: A product stability evaluation has shown that Rheomac VMA 362 admixture has a shelf life of 8 months. Please contact your Degussa Admixtures, Inc. representative regarding suitability for use and dosage recommendations if the stated minimum shelf life of Rheomac VMA 362 admixture has been exceeded.

Dispensing: Rheomac VMA 362 admixture should be dispensed using direct-feed dispensing systems. It is recommended that fail-safe features must be included in this dispenser application for potential meter malfunctions. Consult your local Degussa Admixtures, Inc. sales representative for the proper dispensing equipment for Rheomac VMA 362 admixture.

Packaging

Rheomac VMA 362 admixture is supplied in 55 gal (208 L) drums, 275 gal (1040 L) totes, and by bulk delivery.

Related Documents

Material Safety Data Sheets: Rheomac VMA 362 admixture.

Additional Information

For additional information on Rheomac VMA 362 admixture or on its use in developing concrete mixtures with special performance characteristics, contact your Degussa Admixtures, Inc. representative.

Degussa Admixtures, Inc. is a leading provider of innovative chemical admixtures and silica fume for specialty concrete used in the ready mix, precast, manufactured concrete products, underground construction and paving markets in the United States and Canada. The Company's respected Master Builders brand products are used to improve the placing, pumping, finishing, appearance and performance characteristics of concrete.

Master Builders
Construction Chemicals
Degussa Admixtures, Inc.

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Canada *1800 Clark Boulevard, Brampton, Ontario L6T 4M7 · Tel: 800-387-5862 · Fax: 905-792-0651*

BASF
The Chemical Company

3	03 30 00 03 40 00	Product Data Cast-in-Place Concrete Precast Concrete

POZZOLITH® NC 534

Accelerating Admixture

Description

Pozzolith NC 534 patented, ready-to-use, liquid admixture is formulated to accelerate time of setting and to increase early concrete strengths. Pozzolith NC 534 admixture does not contain calcium chloride and is formulated to comply with ASTM C 494/C 494M Type C, accelerating, admixture requirements.

Applications

Recommended for use in:

- Reinforced, precast, pumped, flowable, lightweight or normal weight concrete and shotcrete (wet mix)
- Concrete placed on galvanized steel floor and roof systems which are left in place
- Prestressed concrete
- Fast-track concrete construction
- Concrete subject to chloride ion constraints
- 4x4™ Concrete
- Rheodynamic® Self-Consolidating Concrete (SCC)
- Pervious Concrete

Features

- Accelerated setting time across a wide range of temperatures
- Increased early compressive and flexural strength

Benefits

- Earlier finishing of slabs — reduced labor costs
- Reduced in-place concrete costs
- Reduced or eliminated heating and protection time in cold weather
- Earlier stripping and reuse of forms
- Superior finishing characteristics for flatwork and cast surfaces

Performance Characteristics

Mix Data: 453 lb/yd^3 (269 kg/m^3) of Type I cement; 3-4 in. ; (75-100 mm) slump; concrete temperature 74 °F (23 °C); ambient temperature 50 and 75 °F (10 and 24 °C); Non-air-entrained concrete.

Setting time

Mix @ 50 °F (10 °C)	Initial Set (h:min)	Difference (h:min))
Plain	13:44	REF
Pozzolith NC 534 admixture @		
20 fl oz/cwt (1300 mL/100 kg)	7:11	– 6:33
40 fl oz/cwt (2600 mL/100 kg)	6:05	– 7:39
Mix @ 75 °F (24 °C)		
Plain	8:18	REF
Pozzolith NC 534 admixture @		
20 fl oz/cwt (1300 mL/100 kg)	4:59	– 3:19
40 fl oz/cwt (2600 mL/100 kg)	4:18	– 4:00

Guidelines for Use

Dosage: The recommended dosage range for Pozzolith NC 534 admixture is 10-45 fl oz/cwt (0.65 – 2.9 L/100 kg) of cementitious materials for most concrete mixtures using average concrete ingredients. Because of variations in job conditions and concrete materials, dosage rates other than the recommended amounts may be required. In such cases, contact your BASF Admixtures, Inc. representative.

For specialty concrete mixtures such as 4x4™ Concrete, dosages up to 100 fl oz/cwt (6.5 L/100 kg) may be required.

Master Builders

Product Data: POZZOLITH® NC 534

Product Notes

Corrosivity – Non-Chloride, Non-Corrosive: Pozzolith NC 534 admixture will neither initiate nor promote corrosion of reinforcing steel in concrete.

Compatibility: Pozzolith NC 534 admixture may be used in combination with any BASF Admixtures, Inc. admixture. When used in conjunction with other admixtures, each admixture must be dispensed separately into the mix.

Storage and Handling

Storage Temperature: Store at 5 °F (-15 °C) or above. If Pozzolith NC 534 admixture freezes, thaw at 35 °F (2 °C) or above and completely reconstitute by mild mechanical agitation. ***Do not use pressurized air for agitation.***

Shelf Life: Pozzolith NC 534 admixture has a minimum shelf life of 18 months. Depending on storage conditions, the shelf life may be greater than stated. Please contact your BASF Admixtures, Inc. representative regarding suitability for use and dosage recommendations if the shelf life of Pozzolith NC 534 admixture has been exceeded.

Packaging

This product is supplied in 55 gal (208 L) drums, 275 gal (1040 L) totes and by bulk delivery.

Related Documents

Material Safety Data Sheets: Pozzolith NC 534 admixture.

Additional Information

For additional information on Pozzolith NC 534 admixture or its use in developing a concrete mixture with special performance characteristics, contact your BASF Admixtures, Inc. representative.

BASF Admixtures, Inc. is a leading provider of innovative chemical admixtures and silica fume for specialty concrete used in the ready mix, precast, manufactured concrete products, underground construction and paving markets in the United States and Canada. The Company's respected Master Builders brand products are used to improve the placing, pumping, finishing, appearance and performance characteristics of concrete.

www.basf-admixtures.com
United States 23700 Chagrin Boulevard, Cleveland, Ohio 44122-5544 ■ Tel: 800 628-9990 ■ Fax: 216 839-8821
Canada 1800 Clark Boulevard, Brampton, Ontario L6T 4M7 ■ Tel: 800 387-5862 ■ Fax: 905 792-0651

Master Builders

DELVO® STABILIZER

Hydration Controlling Admixture

Description

Delvo Stabilizer ready-to-use, liquid admixture is used for making more uniform and predictable high-performance concrete. Delvo Stabilizer admixture retards setting time by controlling the hydration of portland cement and other cementitious materials while facilitating placing and finishing operations. It can be used to stabilize returned plastic concrete and concrete washwater to reduce waste and increase profits. Delvo Stabilizer admixture meets ASTM C 494/C 494M requirements for Type B, retarding, and Type D, water-reducing and retarding, admixtures.

Applications

Recommended for use in:

- Stabilization of concrete washwater
- Stabilization of returned plastic concrete
- Stabilization of freshly batched concrete for long hauls
- 4x4™ Concrete
- Pumped concrete, shotcrete (wet mix) and conventionally-placed concrete
- Plain, reinforced, precast, prestressed, lightweight and normal weight concrete
- Pervious concrete

Features

- Reduced water content required for a given workability
- Retarded setting time characteristics
- Improved workability
- Reduced segregation

Benefits

- Provides flexibility in the scheduling of placing and finishing operations
- Offsets the effects of slump loss during extended delays between mixing and placing
- Reduces waste associated with concrete washwater and returned concrete
- Increased strength – compressive and flexural

Performance Characteristics

Rate of Hardening: The temperature of a concrete mixture and the ambient temperature (forms, earth, air, etc.) affect the hardening rate of concrete. At higher temperatures, concrete hardens more rapidly which may cause problems with placing and finishing.

One of the functions of Delvo Stabilizer admixture is to retard the set of concrete. Within the normal dosage range, it will generally extend the working and setting times of concrete containing normal portland cement, fly ash, slag cement and silica fume approximately 1 hour to 5 hours compared to a plain concrete mixture. This depends on job materials and temperatures. Trial mixes should be made under approximate job conditions to determine the dosage required.

Compressive Strength: Concrete produced with Delvo Stabilizer admixture will develop higher early (within 24 hours) and higher ultimate strengths than plain concrete when used within the recommended dosage range and under normal, comparable curing conditions. When Delvo Stabilizer admixture is used in heat-cured concrete, the length of the preheating period should be increased until the initial set of the concrete is achieved. The actual heat-curing period is then reduced accordingly to maintain existing production cycles without sacrificing early or ultimate strengths.

Guidelines for Use

Dosage: Delvo Stabilizer admixture is recommended for use at a dosage of 4 ± 1 fl oz/cwt (260 ± 65 mL/100 kg) of cementitious materials for most concrete mixtures using average concrete ingredients. Because of variations in job conditions and concrete materials, dosages other than the recommended amounts may be required. In such cases, contact your BASF Admixtures, Inc. representative. For concrete washwater and returned concrete stabilization, utilize Delvo charts or the Delvomatic™ software to determine the appropriate dosage rates.

Product Data: DELVO® STABILIZER

Product Notes

Corrosivity – Non-Chloride, Non-Corrosive: Delvo Stabilizer admixture will neither initiate nor promote corrosion of reinforcing steel in concrete. This admixture does not contain intentionally-added calcium chloride or other chloride-based ingredients.

Compatibility: Delvo Stabilizer admixture may be used in combination with any BASF Admixtures, Inc. admixture. When used in conjunction with another admixture, each admixture must be dispensed separately into the mix.

Storage and Handling

Storage Temperature: If Delvo Stabilizer admixture freezes, thaw at 35 °F (2 °C) or above and completely reconstitute by mild mechanical agitation. **Do not use pressurized air for agitation**.

Shelf Life: Delvo Stabilizer admixture has a minimum shelf life of 12 months. Depending on storage conditions, the shelf life may be greater than stated. Please contact your BASF Admixtures, Inc. representative regarding suitability for use and dosage recommendations if the shelf life of Delvo Stabilizer admixture has been exceeded.

Packaging

Delvo Stabilizer admixture is supplied in specially designed 55 gal (208 L) drums, 275 gal (1040 L) totes and by bulk delivery.

Related Documents

Material Safety Data Sheets: Delvo Stabilizer admixture.

Additional Information

For more information on Delvo Stabilizer admixture, contact your BASF Admixtures, Inc. representative.

BASF Admixtures, Inc. is a leading provider of innovative chemical admixtures and silica fume for specialty concrete used in the ready mix, precast, manufactured concrete products, underground construction and paving markets in the United States and Canada. The Company's respected Master Builders brand products are used to improve the placing, pumping, finishing, appearance and performance characteristics of concrete.

NSF Certified to NSF/ANSI 61

www.basf-admixtures.com
United States 23700 Chagrin Boulevard, Cleveland, Ohio 44122-5544 ■ Tel: 800 628-9990 ■ Fax: 216 839-8821
Canada 1800 Clark Boulevard, Brampton, Ontario L6T 4M7 ■ Tel: 800 387-5862 ■ Fax: 905 792-0651

Master Builders

MATERIAL SAFETY DATA SHEET
For
CONCRETE/CONCRETE PRODUCTS*

(wet unhardened concrete and dry hardened concrete products such as block, pipe, and precast concrete)

Section I-Product and Company Identification

Material Identity (Trade Names): Concrete/Concrete Products

Manufacturer's Name: Everist Materials LLC.	Emergency Telephone Number: 911
Address: 28755 Hwy #9 Silverthorne, Co. 80498	Telephone Number for Information: 970-468-2521
PO Box 1150 Silverthorne, Co. 80498	Preparer: Nathaniel Thomas

Section II-Hazardous Ingredients/Identity Information

Hazardous Components (Chemical Identity/Common Names)	**CASE No.**	**OSHA PEL**	**ACGIH TLV**	**MSHA PEL**	**%**
Portland Cement	65997-15-1 (Total) 5mg/m^3 (Respirable)	15mg/m^3 (Total)	10mg/m^3 (Total)	10mg/m^3 (Total)	10-30%
Limestone ($CaCo_3$) (Calcium carbonate, present, if limestone aggregates are used)	1317-65-3 (Total)	15mg/m^3 (Total)	10 mg/m^3 (Total)	10mg/m^3	0-65%
Crystalline Silica (Quartz) (Concrete aggregates may contain silica)	14808-60-7	30 / (%SiO_2+2)mg/m^3 (Total particulate) 10/(%SiO_2+2)mg/m^3 (Respirable particulate)	0.05 mg/m^3 (Total) (Respirable quartz)	30 / (%SiO_2+2)mg/m^3 (Total) 10/(%SiO_2+2)mg/m_3 (Respirable)	0.5-80%
Particulates not otherwise Classified		15 mg/m^3 (Total) 5mg/m^3 (Respirable)	10mg/m^3 (Inhalable) 3mg/m^3 (Respirable)	10mg/m^3 (Total)	0-100%
Fly Ash which contains:	68131-74-8	N/A	N/A	N/A	1-4%
Aluminum Oxide (Al_2O_3)	1344-28-1	15mg/m^3 (Total) 5mg/m^3 (Respirable)	10mg/m^3	10mg/m^3	0.1-2%
Amorphous Silica	61790-53-2	80mg/m^3 /(%SiO_2)	10mg/m^3 (Total) 3mg/m^3 (Respirable)	20mppcf	0.01-3%
Calcium Oxide (CaO)	1305-78-8	5mg/m^3	2mg/m^3	5mg/m^3	0-1%
Iron Oxide (as Fe_2O_3)	1309-37-1	10mg/m^3	10mg/m^3	10mg/m^3	0.1-2%
Note: Chemical admixtures may be present in quantities less than 1%.					

Section III-Physical/Chemical Characteristics

Boiling Point	Not Applicable	**Specific Gravity (H_2O=1)**	Wet Concrete 1.9 to 2.4
Vapor Pressure (mm Hg)	Not Applicable	**Melting Point**	Not Applicable
Vapor Density (Air = 1)	Not Applicable	**Evaporation Rate (Butyl Acetate = 1)**	Not Applicable

Solubility in Water: not soluble

Appearance and Odor: Hardened concrete products are odorless solid materials. Unhardened wet concrete is an odorless gray, plastic, flowable, granular mud of varying color and texture.

Section IV-Fire and Explosion Hazard Data

Flash Point: Not Combustible	**Flammable Limits**: Not flammable	**LEL**: N/A	**UEL**: N/A

Extinguishing Media: This material is noncombustible. Use extinguishing media appropriate to surrounding fire.

Unusual Fire and Explosion Hazards: None reported.

Section V-Reactivity Data

Stability: Wet unhardened concrete sets and hardens in 2-8 hours and is no longer hazardous.

Hardened concrete is stable. Conditions to avoid: Do not allow wet unhardened concrete to harden on tools or surfaces. Product hardens in 2–8 hrs.

Incompatibility (Materials to avoid): Stable under expected conditions of use. Under unanticipated conditions of use, crystalline silica may react with hydrofluoric acid to produce a corrosive gas (silicon tetrafluoride). Aluminum powder and other alkali and alkaline earth metals will react in wet mortar or concrete, liberating hydrogen gas.

Hazardous Decomposition or Byproducts: Thermal oxidative decomposition of $CaCO_3$ (limestone) can produce lime (CaO). The lime does not add to the hazards associated with the use of the product. **Note: Hazardous Polymerization will not occur.**

Section VI-Health Hazard Data

Route(s) of Entry: **Inhalation**? Yes **Skin**? No **Ingestion**? Unlikely

Health Hazards:
Acute Effects: Skin contact with wet concrete can dry the skin and cause alkali burns. Within 12 to 48 hours after skin contact (after one to six-hour exposures), first, second, or third degree burns may occur. There may be no obvious pain at the time of exposure. Eye contact with wet unhardened concrete may cause burning and possible corneal edema. Ingestion of concrete dust may cause esophagus and stomach burns.

Cutting, grinding, crushing, or drilling hardened concrete or concrete products may generate dust containing crystalline silica. Acute effects of exposure to such dust may include:

EYE CONTACT: Direct contact with dust may cause irritation by mechanical abrasion.

SKIN CONTACT: Direct contact may cause irritation by mechanical abrasion.

SKIN ABSORPTION: Not expected to be a significant route of exposure.

INGESTION: Expected to be practically non-toxic. Ingestion of large amounts may cause gastrointestinal irritation and blockage.

INHALATION: Dusts will irritate the nose, throat, and respiratory tract by mechanical abrasion. Coughing, sneezing, and shortness of breath may occur following exposures in excess of recommended exposure limits. Use of concrete products for construction purposes is not believed to cause additional acute toxic effects. However, repeated

Section VI-Health Hazard Data – (continued)

overexposures to very high levels of crystalline silica (quartz, cristobalite, tridymite) for periods as short as six months have caused acute silicosis. Acute silicosis is a rapidly progressive, incurable lung disease that is typically fatal. Symptoms include (but are not limited to): shortness of breath, cough, fever, weight loss, and chest pain.

Chronic Effects: Continued exposure of the skin to wet unhardened concrete may cause chronic dermatitis.

Chronic bronchitis may result from chronic exposure to dust generated from cutting, grinding, crushing, or drilling hardened concrete. Chronic exposure to respirable limestone dust in excess of the ACGIH TLV has caused pneumoconiosis (Dusty Lung). Concrete dust may contain more than 0.1% crystalline silica, which is a cancer hazard if inhaled. Cancer risk depends on duration and level of exposure. Prolonged exposure to crystalline silica will cause silicosis, a progressive pnemoconisis (lung disease). Respirable dust containing newly broken silica particles has been shown to be more hazardous to animals in laboratory tests than respirable dust containing older silica particles of similar size. Respirable silica particles which had aged for sixty days or more showed less lung injury in animals than equal exposures of respirable dust containing newly broken particles of silica.

There are reports in the literature suggesting that excessive crystalline silica exposure may be associated with adverse health effects involving the kidney, scleroderma (thickening of the skin caused by swelling and thickening of fibrous tissue) and other autoimmune disorders. However, this evidence has been obtained primarily from case reports involving individuals working in high exposure situations or those who have already developed silicosis; and therefore, this evidence does not conclusively prove a causal relationship between silica and these adverse health effects. Several studies of persons with silicosis also indicate an increased risk in developing lung cancer, a risk that increases with duration of exposure. Many of these studies of silicosis do not account for lung cancer confounders, especially smoking.

Carcinogenicity: Concrete products are not listed on the NTP, IARC, or OSHA list of carcinogens. However, in October 1996, IARC classified respirable crystalline silica from occupational sources as a known human carcinogen (Group 1). The NTP indicates that crystalline silica is reasonably anticipated to be a carcinogen (Group 2). These classifications are based on sufficient evidence of carcinogenicity in certain experimental animals and on selected epidemiological studies of workers exposed to crystalline silica. Concrete may contain crystalline silica in concentrations greater than 0.1%, principally contributed by the aggregates. Crystalline silica in wet concrete is not respirable and does not pose a hazard when the concrete is in its plastic or unhardened state. Once concrete has hardened, airborne dust generated by grinding, sawing, drilling, breaking, etc. will lead to potentially hazardous exposures to workers and appropriate respiratory protection precautions must be taken.

Iron oxide is listed by IARC as exhibiting evidence of carcinogenicity in experimental animals.

Signs and Symptoms of Exposure: Freshly mixed concrete is irritating to the eyes and skin. It can dry the skin and can cause alkaline burns to the skin and eyes. Hypersensitive individuals may develop an allergic dermatitis.

Chronic exposure to respirable dust containing crystalline silica in excess of applicable OSHA PELs, MSHA PELs, and ACGIH TLVs has caused silicosis, a progressive lung disease. Symptoms of silicosis may include (but are not limited to): shortness of breath, difficulty breathing with or without exertion, coughing, diminished work capacity, diminished chest expansion, reduction of lung volume, right heart enlargement and/or failure. Persons with silicosis have an increased risk of pulmonary tuberculosis infection.

Medical Conditions Generally Aggravated by Exposure

Individuals with chronic respiratory disorders should minimize inhalation of dust generated from cutting, grinding, crushing, or drilling hardened concrete. Individuals with skin diseases should minimize skin contact with the dust , and with wet unhardened concrete.

Physicians Note: Ingestion of large amounts of wet unhardened concrete is unlikely. However, if wet concrete is swallowed, to prevent re-exposing the esophagus and stomach, do not induce emesis or perform gastric lavage. Immediate dilution may prevent esophageal burns. For severe burns, consider esophogoscopy within the first 24 hours. Washing with a pH neutral soap and water may aid in removing hardened concrete from the skin.

Section VI-Health Hazard Data – (continued)

Emergency and First Aid Procedures

Wet unhardened concrete or hardened concrete dust in the eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water for a minimum fifteen minutes. Consult a physician immediately if irritation persists or later develops.

Wet unhardened concrete on skin: Quickly remove contaminated clothing. Wash affected areas thoroughly with a pH neutral soap and water. Consult a physician immediately if irritation persists.

Inhalation of hardened concrete dust: Remove exposed person to fresh air and support breathing as needed. Encourage victim to cough, spit out, and blow nose to remove dust. Consult a physician immediately. See physician's note in section VI.

Section VII-Precautions for Safe Handling and Use

Steps to be taken in Case Material is Released or Spilled: Personnel involved with the handling of wet unhardened concrete should take steps to avoid contact with the eyes and skin, through the use of gloves and suitable clothing. Wet unhardened concrete should be recycled or allowed to harden and disposed.

Waste Disposal Method: Allow wet unhardened concrete to harden and dispose in a landfill as common solid waste. Follow applicable Federal, State, and local regulations for disposal. The material is not listed as hazardous waste under designations by the EPA or DOT.

Precautions to Be Taken in Handling and Storing: Silica-containing respirable dust particles may be generated by crushing, cutting, grinding, or drilling hardened concrete or concrete products. Follow protective controls defined in Section VIII when handling these products.

Section VIII-Control Measures

Respiratory Protection: When exposed to dust from cutting, grinding, crushing, or drilling hardened concrete or concrete products above recommended limits, wear a suitable NIOSH –approved respirator with protection factor appropriate for the level of exposure. For emergency or nonroutine operations (e.g., confined spaces), additional precautions or equipment may be required. Respirator use must comply with applicable MSHA or OSHA standards.

Ventilation
Local Exhaust: When cutting, grinding, crushing, or drilling hardened concrete, provide general or local ventilation systems, as needed, to maintain airborne dust concentrations below the OSHA PELs, MSHA PELs, and ACGIH TLVs. Local exhaust ventilation is preferred since it prevents release of contaminants into the work area by controlling it at the source.

Other: Respirable dust and quartz levels from hardened concrete cutting, grinding, crushing or drilling operations should be monitored regularly. Dust and quartz levels in excess of applicable.

OSHA PELs, MSHA PELs, and ACGIH TLVs should be reduced by all feasible engineering controls including (but not limited to) wet suppression, ventilation, process enclosure, and enclosed employee work stations.

Mechanical (General): See above recommendations. **Special**: None reported.

Protective Gloves: When handling wet unhardened concrete, wear chemical resistant gloves to prevent skin contact. Wash thoroughly after handling.

Eye Protection: When cutting, grinding, crushing, or drilling hardened concrete wear safety glasses with side shields or dust goggles in dusty environments. When there is a splash hazard working with wet unhardened concrete, wear safety glasses with side shields or goggles.

Section VIII-Control Measures – (continued)

Other Protective Clothing or Equipment: Wear suitable protective clothing, as needed, to prevent skin contact with unhardened concrete.

Work/Hygienic Practices: Contact with wet unhardened concrete, mortar, cement or cement mixtures can cause skin irritation, severe chemical burns, or serious eye damage. Avoid contact with eyes and skin. Wear waterproof gloves, a fully buttoned long-sleeved shirt, full-length trousers, and tight fitting eye protection when working with these materials. If you have to stand in wet concrete, use waterproof boots that are tight at tops and high enough to keep concrete from flowing into them. If you are finishing concrete, wear knee pads to protect knees. Wash wet concrete, mortar, cement, or cement mixtures from your skin with fresh, clean water immediately after contact. Indirect contact through clothing can be as serious as direct contact, so promptly rinse out wet concrete, mortar, cement or cement mixtures from clothing, Seek immediate medical attention if you have persistent or severe discomfort. In case of eye contact, flush with plenty of water for at least 15 minutes. Consult a physician immediately. **KEEP OUT OF REACH OF CHILDREN** Avoid dust inhalation and direct contact with skin and eyes. Wash contaminated skin before eating, drinking, smoking, lavatory use and before applying cosmetics.

*Disclaimer:

This Material Safety Data Sheet is intended as a sample. While it represents ingredients and values typical for portland cement concrete, concrete and its constituent ingredients vary in composition. Information on specific aggregates, cementitious materials, water and admixtures should be provided by the supplier upon request.

The information contained in this Material Safety Data Sheet relates only to the specific material designated herein and does not relate to use in combination with any other material or in any process.

The information set forth herein is intended for use by persons having technical skill and at their own discretion and risk. Since conditions of use are outside the concrete/concrete products producer's control, the producer makes no warranties, expressed or implied, and assumes no liability in connection with any use of this information.

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MINING AND ENVIRONMENTAL SERVICES, LLC
P.O. BOX 1511
IDAHO SPRINGS CO 80452

Date: *01/18/2008*
Report ID: *K34794 - DN43360.000*

Report of Concrete Compressive Strength Tests

Project: *SCHWARTZWALDER MINE*
8200 GLENCOE VALLEY ROAD

Supplier: *EVERIST*

Location: *REPORT 2. BULKHEAD NO. 1, FIRST LIFT.*

Cast Date: *12/19/2007*	Ticket: *451664*	Batch Time: *08:46*	Concrete Mix: *340300SCC*
In-Lab Date: *12/20/2007*	Truck Number: *110*	Test Time: *13:55*	Specimens Made By: *TRUJILLO*

Initial Curing			Final Curing
Curing Method:	Min. Temp:	Max Temp:	Curing Method:
IN MINE	° F	° F	*Fog Room*

Physical Properties of Concrete (ASTM C143, C231, C138, C1064)

Specified Strength (f'c)	Slump	Air Content	Density	Temperature
3500 psi @ 28 days		*2.0%*	*145.2 pcf.*	*50 deg. F*

Compressive Strengths (ASTM C39)

Specimen Number	Age in Days	Diameter (inches)	Area (sq. inches)	Max. Load (lbs.)	Compressive Strength (psi)	Percent of f'c	Type of Fracture
1	7	6.00	28.27	136,000	4810		
2	7	6.00	28.27	138,500	4900		
				Average:	4860	139	
3	28	6.00	28.27	206,500	7300		
4	28	6.00	28.27	205,000	7250		
				Average:	7280	208	

cc: *EVERIST*

Comments: NOTIFIED MINING AND ENVIRONMENTAL OF PHYSICAL PROPERTY RESULTS. SPREAD WAS 22 INCHES. THE AVERAGE 28 DAY COMPRESSIVE STRENGTH ACHIEVED SPECIFIED STRENGTH.

CTL | THOMPSON
INCORPORATED

MINING AND ENVIRONMENTAL SERVICES, LLC
P.O. BOX 1511
IDAHO SPRINGS CO 80452

Date: *01/18/2008*
Report ID: *K34795 - DN43360.000*

Report of Concrete Compressive Strength Tests

Project: *SCHWARTZWALDER MINE*
8200 GLENCOE VALLEY ROAD

Supplier: *EVERIST*

Location: *REPORT 3. BULKHEAD NO. 1, SECOND LIFT.*

Cast Date: *12/19/2007*	Ticket: *451670*	Batch Time: *12:48*	Concrete Mix: *340300SCC*
In-Lab Date: *12/20/2007*	Truck Number: *110*	Test Time: *15:15*	Specimens Made By: *TRUJILLO*

Initial Curing			Final Curing
Curing Method:	Min. Temp:	Max Temp:	Curing Method:
IN MINE	°F	°F	*Fog Room*

Physical Properties of Concrete (ASTM C143, C231, C138, C1064)

Specified Strength (f'c)	Slump	Air Content	Density	Temperature
3500 psi @ 28 days		*2.0%*	*144.0 pcf.*	*52 deg. F*

Compressive Strengths (ASTM C39)

Specimen Number	Age in Days	Diameter (inches)	Area (sq. inches)	Max. Load (lbs.)	Compressive Strength (psi)	Percent of f'c	Type of Fracture
1	*7*	*6.00*	*28.27*	*137,750*	*4870*		
2	*7*	*6.00*	*28.27*	*135,250*	*4780*		
				Average:	*4820*	*138*	
3	*28*	*6.00*	*28.27*	*180,750*	*6390*		
4	*28*	*6.00*	*28.27*	*181,500*	*6420*		
				Average:	*6400*	*183*	

cc: *EVERIST*

Comments: NOTIFIED MINING AND ENVIRONMENTAL OF PHYSICAL PROPERTY RESULTS. SPREAD WAS 28 INCHES. THE AVERAGE 28 DAY COMPRESSIVE STRENGTH ACHIEVED SPECIFIED STRENGTH.

CTL | THOMPSON
INCORPORATED

MINING AND ENVIRONMENTAL SERVICES, LLC
P.O. BOX 1511
IDAHO SPRINGS CO 80452

Date: *01/18/2008*
Report ID: *K34796 - DN43360.000*

Report of Concrete Compressive Strength Tests

Project: *SCHWARTZWALDER MINE*
8200 GLENCOE VALLEY ROAD

Supplier: *EVERIST*

Location: *REPORT 4. BULKHEAD NO. 2, FIRST LIFT.*

Cast Date: *12/20/2007*	Ticket: *451693*	Batch Time: *10:01*	Concrete Mix: *3403005CC*
In-Lab Date: *12/24/2007*	Truck Number: *108*	Test Time: *11:30*	Specimens Made By: *TRUJILLO*

Initial Curing			Final Curing
Curing Method:	Min. Temp:	Max Temp:	Curing Method:
IN MINE	°F	°F	*Fog Room*

Physical Properties of Concrete (ASTM C143, C231, C138, C1064)

Specified Strength (f'c)	Slump	Air Content	Density	Temperature
3500 psi @ 28 days		*1.6%*	*141.6 pcf.*	*50 deg. F*

Compressive Strengths (ASTM C39)

Specimen Number	Age in Days	Diameter (inches)	Area (sq. inches)	Max. Load (lbs.)	Compressive Strength (psi)	Percent of f'c	Type of Fracture
1	*7*	*6.00*	*28.27*	*106,500*	*3770*		
2	*7*	*6.00*	*28.27*	*105,250*	*3720*		
				Average:	*3740*	*107*	
3	*28*	*6.00*	*28.27*	*152,000*	*5380*		
4	*28*	*6.00*	*28.27*	*150,750*	*5330*		
				Average:	*5360*	*153*	

cc: *EVERIST*

Comments: NOTIFIED MINING AND ENVIRONMENTAL SERVICES OF PHYSICAL PROPERTY RESULTS. SPREAD WAS 21 INCHES. THE AVERAGE 28 DAY COMPRESSIVE STRENGTH ACHIEVED SPECIFIED STRENGTH.

CTL | THOMPSON
INCORPORATED

MINING AND ENVIRONMENTAL SERVICES, LLC
P.O. BOX 1511
IDAHO SPRINGS CO 80452

Date: *01/18/2008*
Report ID: *K34797 - DN43360.000*

Report of Concrete Compressive Strength Tests

Project: *SCHWARTZWALDER MINE*
8200 GLENCOE VALLEY ROAD

Supplier: *EVERIST*

Location: *REPORT 5. BULKHEAD NO. 2, SECOND LIFT.*

Cast Date: *12/20/2007*	Ticket: *451698*	Batch Time: *12:45*	Concrete Mix: *3403005CC*
In-Lab Date: *12/24/2007*	Truck Number: *112*	Test Time: *15:05*	Specimens Made By: *TRUJILLO*

Initial Curing

Curing Method:	Min. Temp:	Max Temp:
IN MINE	°F	°F

Final Curing

Curing Method: *Fog Room*

Physical Properties of Concrete (ASTM C143, C231, C138, C1064)

Specified Strength (f'c)	Slump	Air Content	Density	Temperature
3500 psi @ 28 days		*2.9%*	*141.6 pcf.*	*54 deg. F*

Compressive Strengths (ASTM C39)

Specimen Number	Age in Days	Diameter (inches)	Area (sq. inches)	Max. Load (lbs.)	Compressive Strength (psi)	Percent of f'c	Type of Fracture
1	*7*	*6.00*	*28.27*	*116,500*	*4120*		
2	*7*	*6.00*	*28.27*	*117,250*	*4150*		
				Average:	*4140*	*118*	
3	*28*	*6.00*	*28.27*	*178,500*	*6310*		
4	*28*	*6.00*	*28.27*	*178,500*	*6310*		
				Average:	*6310*	*180*	

cc: *EVERIST*

Comments: NOTIFIED MINING AND ENVIRONMENTAL SERVICES OF PHYSICAL PROPERTY RESULTS. SPREAD WAS 18 INCHES. THE AVERAGE 28 DAY COMPRESSIVE STRENGTH ACHIEVED SPECIFIED STRENGTH.

Grouting Plan

CONSTRUCTION OF THE BULKHEADS FOR THE CLOSURE OF THE SCHWARTZWALDER MINE.

Prepared for:

MINING & ENVIRONMENTAL SERVICES LLC
IDAHO SPRINGS, COLORADO.

NOVEMBER 2007

By:

Phillips Mining Geotechnical & Grouting Inc.
8640 North Glenhurst Place
Tucson, Arizona 85704

TABLE OF CONTENTS

1.0 PREPARATION FOR BULKHEAD CONSTRUCTION

In preparation for the bulkhead construction at each site, safe access must be provided up to its location, together with the appropriate services required for construction. It is not anticipated that any additional support of the back and ribs will be required in any of the areas in which bulkheads are to be constructed.

Water collected behind the bulkhead will be piped through the bulkhead via a 2 inch diameter Schedule 40 pipe, which will ordinarily be kept closed with valves. This pipe will also serve as the means whereby the samples of the impounded water may be obtained and also for treating the impounded water, should this become necessary. This pipe must be 316 stainless steel. Downstream of the bulkhead the pipe would be fitted with a stainless steel tee (fitted with a pressure gauge), and a 2 inch stainless steel valve. The upstream end of the 2 inch drain pipe should be fitted with a 90° elbow and decant risers, which may be constructed with slotted 4" PVC pipe. This will prevent the pipe from being plugged with debris that may accumulate in the water behind the upstream dam, should it ever become necessary to drain the water from behind the bulkhead.

Two stainless steel seal rings must be attached around the outside of the stainless steel drain pipe at locations that are about 2 ft and 6 ft from the wet end of the bulkhead. These $^{1}/_{2}$ inch thick stainless steel rings, must be fully welded around the complete perimeter of the pipe, and should form a solid collar extending about 4 inches outside the exterior surface of the pipe. Eventually these seal rings will be completely embedded in the bulkhead concrete to prevent any leakage along the outside of the pipe.

Additional preparation for constructing all the bulkheads includes the removal of all old pipes, cables, brackets and other materials etc., so that the area to be filled with concrete is free of any loose, rusty and unnecessary debris.

It will be imperative that the bulkhead concrete be cast directly against clean, competent rock in the back, walls and floor of the drift. Therefore, the portion of the drift in which the bulkhead will be constructed must be scaled and thoroughly washed with high-pressure water and blown clean with air around its complete perimeter and length, to expose a clean rock surface.

Concrete forms for each bulkhead site must be designed by a Professional Engineer to withstand the appropriate height of fluid concrete. The completed forms must be essentially vertical and mortar tight, following the contours of the excavation. Temporary openings/holes will be located in the forms to allow access to the inside of the forms during the final phases of construction leading up to the concrete placement. In addition, these holes will also be used for visual observation of the concrete being placed inside the forms.

Prior to concrete placement, steel grout pipes (2 inch diameter, sch 80) will be accurately located and oriented inside the forms. These pipes will extend from the rear of the downstream forms (this end of the pipe is threaded) to the rock at the floor, ribs and back, to act as guides through which the grout holes would be subsequently drilled, and to contain the injected grout. The planned locations of the grout pipes in the bulkheads are shown in Drawings.

The bulkheads at each site should be constructed with a Self Compacting Concrete (SCC). Other sections of this report describe this type of concrete and outline the various advantages of using this type of concrete for this application.

To prepare for the concrete placement, a steel pipe with a minimum diameter of 3 inches should be hung on brackets so that it is aligned approximately along the centerline of the drift. The concrete placement pipe will be located as close to the back of the drift as can be practically achieved. Arrangements will be made to allow the concrete placement pipe to be retracted during the bulkhead construction, to ensure that the concrete completely fills the space immediately up to the rear of the front timber forms.

Several of the upper grout pipes can be left open to be used as air relief pipes if they happen to be located in the highest points in the back of the drift. Otherwise, additional pipes will be installed to allow air to escape that would otherwise be trapped by the concrete in the highest portions in the back of the drift.

2.0 CONCRETE MIX DESIGN.

A Self-Compacting Concrete (SCC) mix with the required properties will be developed and tested for the project. This mix is especially suitable for use in the bulkhead construction.

The SCC mix must utilize the minimum amount of Ordinary Portland Cement Type I/II (preferably, but Type V, sulfate resisting cement, if necessary because the water is particularly aggressive) to achieve the necessary unconfined compressive strength of 4000 psi. The remainder of the cementitious content of the mix comprises fly ash. The use of fly ash firstly minimizes the total quantity and rate of generation of the heat of hydration that is produced in the concrete and thus avoids the potentially detrimental thermal effects that may be produced during setting, thus also minimizing any thermal shrinkage. The high percentage of fly ash with the cement used will produce a very durable cementitious paste that is resistant to any potentially acidic water retained behind the bulkhead.

The water:cement ratio of the basic concrete mix must also be kept to a minimum to achieve the necessary strength with the minimum amount of cement (and therefore minimum heat generation) and reduce the shrinkage of the concrete due to the loss of water during curing. The required pumpability, workability and the properties of SCC are achieved by the use of appropriately sized aggregate and concrete admixtures.

The resulting mix will be a good quality, durable, Self-Compacting Concrete that is pumpable, essentially self-leveling, requires no vibration and resists segregation. The admixtures required to produce this type of concrete are consistent with the required properties of workability, volume stability and low water-cement ratio. To help ensure the maximum durability of the concrete, the fine and coarse aggregates comprising the concrete must be chosen for their resistance to long-term degradation.

To summarize, the properties and the materials in the concrete mix should be as follows:

- Workability; Range of Slump Flow Value - 28 to 29 inches at the concrete pump.
- Self-compacting.
- Unconfined compressive strength of 4000 psi in 28 days.
- Volume stability will be achieved by minimizing the volume of water required using water reducing agents.
- Entrained air; minimal, 1 to 2 percent.
- Minimal evolution of heat of hydration.
- The Portland cement used in the mix will be Type I/II.
- The fly ash used in the mix will be Class F with the requirements that the CaO content will not exceed 10 percent and the Loss on Ignition will not exceed 6 percent. In addition the Sulfate Resistance Factor R of the fly ash must be less than 0.75, where $R = \frac{CaO\% - 5\%}{Fe_2O_3\%}$.
- The fine aggregate will consist of clean, washed, siliceous sand of uniform gradation.

- The coarse aggregate will be, clean, washed, crushed gravel with a maximum size of $^{3}/_{4}$ inch. It must comprise hard, strong, durable pieces, free of deleterious substances and adherent coatings containing no flat or elongated particles in excess of 15% by weight.
- Water used in mixing concrete will be potable quality, free of injurious amounts of oil, acid, alkali, organic matter and other deleterious substances.

3.0 CONCRETE PLACEMENT.

The Self-Compacting Concrete mix specified for the construction of the water retention bulkheads does not suffer from segregation. Therefore, techniques used for placing conventional concrete may be modified to reflect this property. For this application, a Self-Compacting Concrete may be allowed to free fall through a longer vertical drop and to flow greater lateral distances from its point of deposition to its final location, without segregation of the coarse aggregate, mortar or water from the concrete mass, than would be possible with a conventional concrete mix (Reference 1).

Using the Self-Compacting Concrete, it will be possible to construct the bulkheads with one placement pipe located at the highest point against the rock back of the drift. Further benefits are realized by the use of a self-compacting concrete mix; i.e., the elimination of the requirement for mechanical vibration and the need for additional personnel inside the formwork during concrete placement to perform this task.

In preparation for this concrete placement, every effort will be expended to ensure that the total concrete placement for the entire bulkhead is completed without interruption, to avoid the potential formation of horizontal cold joints. Ready-mix concrete trucks will transport the concrete from the batch plant to a concrete pump from where it will be pumped into the forms. Prior to discharge from the ready-mix concrete trucks, the slump of the concrete will be tested and any necessary adjustments made to the quantity of water in the mix. Concrete admixtures will then be added to produce the SCC with the appropriate slump flow value and therefore, workability. When the required workability is achieved, the concrete will be discharged into the hopper of the concrete pump. From here, the concrete will be pumped through a 5 inch (minimum) pipe to discharge directly into the forms.

A reliable, audible communication system will be installed where necessary between the bulkhead and the person operating the concrete pump to allow the rate of pumping to be slowed down or stopped at critical phases of the work. As noted earlier, every effort must be made to complete each concrete placement as a monolithic pour. However, if some event occurs that makes this impossible, the surface of the concrete at any unplanned construction joint must be treated with a surface retarder. Spraying on this product permits the production of a rough exposed aggregate surface on the surface of recently placed concrete by brushing away and cleaning the retarded cement paste from the set base concrete. This allows the subsequently placed concrete to develop the maximum bond to the concrete that was previously placed. The concrete will be discharged from the placement pipe (that is installed at the highest point in the adit) at a location approximately 2 to 3 feet from the front face of the rear forms. Pumping will continue until it is in contact with the back of the drift over the rear several feet of the bulkhead. At this time, the concrete placement pipe in the forms will be partially submerged in concrete. Pumping will then be stopped and the guillotine concrete valve on the end of the placement pipe will be closed. A section of concrete pipe will be removed from immediately behind the guillotine valve, the placement pipe will be retracted inside the forms by the length of the removed pipe, the pipes reconnected, the guillotine valve opened and pumping will recommence.

After the concrete has reached the back of the drift at the front forms, pumping must continue slowly and carefully, as there are only the high zones in the back of the drift left to be filled. During this portion of the concrete pumping, the return of air or concrete from the air relief (grout pipes) must be carefully noted. Finally, when concrete return has been achieved from all the air relief pipes, usually accompanied by creaking of the forms, pumping should cease, as the forms will be essentially full.

The concrete guillotine valve on the placement pipe in the forms will then be closed and the concrete left to set, while the concrete pump and pipes between it and the guillotine valve are cleaned out. Subsequently, when the concrete has set, the placement pipe will be cut off flush with the face of the bulkhead.

During the concrete placement at each of the bulkheads, test cylinders (6 inches diameter, 12 inches long) must be taken from the trucks to determine the unconfined compression strength of the concrete. The samples will be taken in sets of 6 cylinders for each 25 cu yds, or part thereof, of concrete placed. Cylinders will be sealed with polyethylene and taped and field cured at ambient temperatures in an appropriate location near the bulkhead for a period of three calendar days. Following this, they will be transported to a testing laboratory for further curing at 70 degrees F. Two of each set of six (6) samples will be tested at 7 and 28 calendar days respectively. The third pair of cylinders of each set will be tested if either of the other two pairs of cylinders in the same set is determined to be excessively weak.

4.0 GROUTING

An integral part of the successful installation of an underground bulkhead for the impoundment of water is the grouting program that is performed around the bulkhead. This procedure will be carried out to ensure that intimate contact is achieved between concrete and rock for the uniform transfer of stress, and that the resulting bulkhead will exhibit the minimum of leakage.

Any potential seepage that might occur is likely to be associated with any gap that may exist at the bulkhead concrete/rock contact, or with any open fractures that may be present in the rock around the bulkhead. The grout hole locations and the grouting program around the bulkhead is planned to seal these potential leakage paths.

Grouting of a bulkhead is usually deferred until the concrete has achieved the majority of its strength, has cooled down and most of the concrete shrinkage has taken place. This is normally about 4 weeks after concrete placement.

Grouting Approach and Sequence.

The grouting will be performed from the dry end of the completed bulkheads. The grout hole layout for each bulkhead is given in Drawings. A very conservative approach has been adopted to maintain any potential water leakage around the bulkhead to a minimum.

Grouting will be performed through the 2 inch standpipes that were previously cast into the concrete and are fitted with suitable valves. The depth to which these holes are drilled and grouted will depend upon the actual rock conditions encountered, but the drilling equipment must be available and capable of drilling $1^1/_2$ to $1^7/_8$ inch diameter holes to a minimum of 20 feet at an acceptable rate of penetration.

The initial grouting phase in each bulkhead will extend the holes through the standpipes out to about 6 to 9 inches beyond the concrete/rock interface. This joint will then be grouted with cement to completely fill any voids or cracks that may exist at the interface and form a tight bond between the concrete and rock along and around the total length and perimeter of the bulkhead.

After this area has been grouted, the holes will be extended out in stages into the surrounding rock. The rock will then be grouted progressively out from the bulkhead until the holes penetrate the rock remote from the excavation that has not been subject to blast damage, stress relief and relaxation, or influenced by the presence of the mined opening. This is anticipated to be up to about 7 to 8 feet from the original excavation, depending upon the bulkhead being considered. In this way a zone of grouted rock is formed that extends out around the bulkhead. The rock is re-stressed by the pressure grouting, creating a state of confinement on the bulkhead that increases its resistance to movement and to leakage.

Primary and secondary grouting procedures will be used in each ring of holes in all stages of the grouting. The primary holes, i.e., every other one in the same ring around the periphery of the bulkhead, will be drilled and grouted first, followed by the remaining secondary holes. The holes in the rear ring should be completed first, followed by those in the front ring. Thus the grout cover will proceed in a series of drilled stages in each of the primary or secondary holes down to its final depth. After the completion of the initial stage comprising the grouting of the concrete/rock contact, the length of the remaining stages is anticipated to range from about 3 feet to 5 feet.

It is anticipated that grouting of the concrete/rock interface, especially at the top of the bulkhead, will be performed initially with Type III Portland cement/fly ash (mixed in the ratio 2:1) grout. This type of cement may also be required to grout the wider fractures that are intercepted in the rock itself. Thus Type III cement/fly ash will probably be adequate for the first round of grouting and will eliminate the majority of any potential leakage around the bulkhead. To further reduce leakage, and to seal the finer fractures, an ultrafine cement (such as Nittetsu

Super Fine or equivalent) will be required. The small size of the particles in this latter cement allows it to penetrate much smaller fractures than can be sealed by the Type III cement/fly ash grout with its larger particles.

The choice between the two types of cement will be determined by the size of the fracture/opening to be grouted. This can be determined by water injection testing or by observation of actual grout takes. However to save time when both grouts are available, it is usual to start grouting with the ultrafine cement and to change over to Type III cement/fly ash if this grout is found to be appropriate. Both grouts are recommended, as they will be durable over the long term.

Grouting each stage should commence with a mix with a water:cement ratio of 3:1 by weight (Type III/fly ash) or 2:1 by weight (ultrafine), unless it is positively known that a thicker mix can be accepted. The mix should be thickened gradually, as appropriate, to ensure that the thickest mix possible is placed in the fractures and voids. Grout pressures up to 125 psi will be utilized for the grouting procedures in the Pierce Level Bulkhead and the Steve Level Bulkhead respectively.

During some of the stages of injection, grout leakage will likely occur between the concrete and rock or even through the rock around the bulkhead. If the leak does not stop even after thickening the grout mix and (where possible) caulking the leaking crack with burlap and wedges, the grout setting time should be accelerated and the grout further thickened by adding a viscosity modifier. Appropriate products for this application are Diutan Gum, manufactured by Kelco or Rheocem UW450, manufactured by Degussa.

At the completion of grouting, all the holes should be filled and plugged with an anti-bleed, anti-shrink cement grout with a water:cement ratio not greater than 0.7:1 by weight and the standpipes capped.

The grouting equipment will consist of a high shear colloidal mixer, such as a Colcrete mixer or equivalent, a paddle type holding tank and a progressive cavity grout pump, such as a Moyno pump or equivalent. The pump must be capable of pumping cement grouts with water:cement ratios down to 0.6:1 by weight, at a rate of at least 10 gpm at 200 psi. The mixing and holding tanks must be sized to adequately supply the pump at its maximum pumping rate.

5.0 CONCLUSIONS

The most appropriate techniques and durable products that are in current use must be utilized for their construction to minimize their potential degradation in the environment in which they have to function.

Apart from using the most appropriate techniques and materials for this particular application, great care must be taken in the construction of the bulkheads. The completed bulkhead must be a competent unit that is capable of withstanding the applied hydrostatic head with the minimum of leakage. To achieve this goal, particular care must be taken in its construction, especially in the following areas;

- All the water in the immediate area of the bulkhead construction must be completely controlled during the concrete placement;
- The entire rock surface around the complete bulkhead perimeter must be thoroughly cleaned prior to the placement of concrete against it;
- The concrete must be placed in one monolithic pour (if possible);
- There must be adequate preparation for the concrete pours, including the provision of a suitable concrete mix design and the necessary back up equipment and/or spare parts, to ensure that the pours can be completed without a major delay;
- The grout pipes must be carefully and accurately located;
- The materials comprising the concrete must be chosen to be suitable to the environment in which they will be placed;

- The grouting of the holes around the bulkhead must be appropriately sequenced, using primary and secondary holes and advancing from the rear of the bulkheads towards the front;
- Inject the appropriate cement type and grout mix ratio into each grout stage to be compatible with the conditions encountered.
- The supervisor for the construction of the bulkhead must have had prior experience in this type of work including form construction, concrete placement and grouting.

REFERENCE

1. Daczko, J. A. and Phillips S. H. E. (2001). Self-Compacting Concrete in Underground and Mining Applications. Second International Symposium on Self-Compacting Concrete, Tokyo.

Mark Levin

From: Stephen Phillips [SHEP_PMGG@mac.com]
Sent: Tuesday, November 13, 2007 4:46 PM
To: Mark Levin; Will Beach; John Abel
Subject: Bulkhead Drawings
Attachments: Pierce Adit Grout Holes.pdf; ATT00706.txt; ATT00709.txt; Steve Adit Grout Holes.pdf; ATT00712.txt; ATT00715.txt

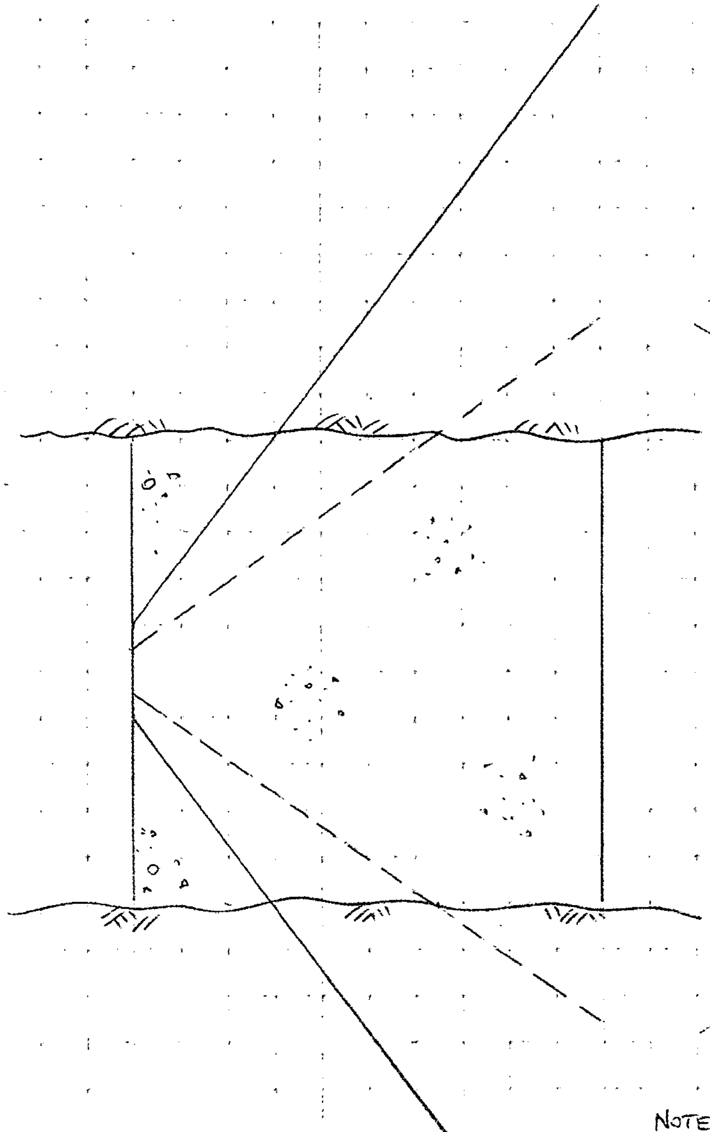
Mark, John, Will,

Attached are the grout hole layouts suggested for the Steve and the Pierce Adits. These holes concentrate on grouting the ground that is anticipated to be most permeable around the bulkhead.

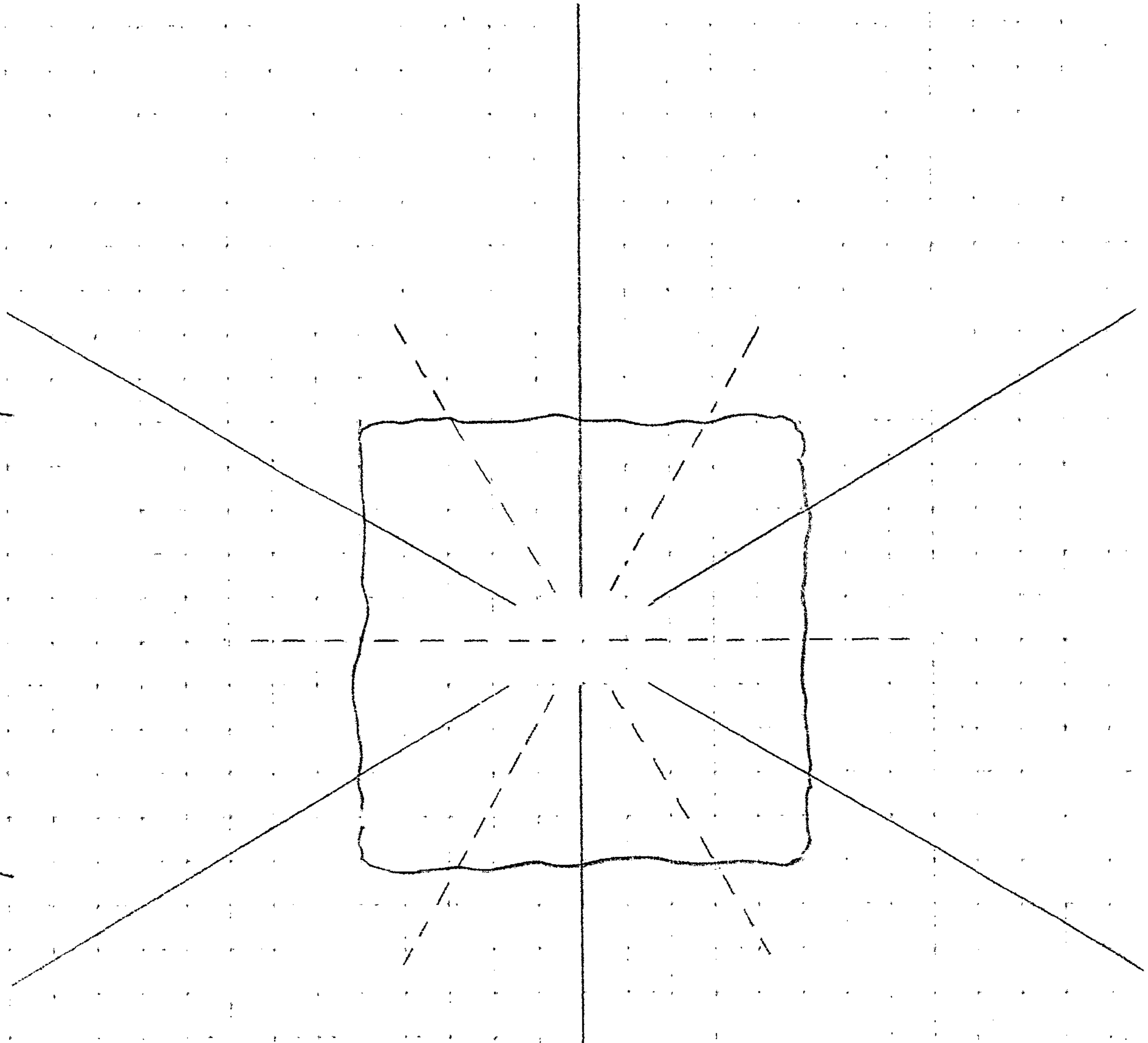
If grout takes are not as anticipated/expected and takes in the deeper stages of the holes in the outer ring do not indicate that the rock is becoming more competent and impermeable, additional holes will be required. These could include holes drilled from from the corner between the rock and concrete at the front face, out around the bulkhead at an angle of about 35 degrees to the plane of the front face over the bulkhead as indicated in Will's fax and as outlined in my email of Nov 6, 07 (attached). Personally I would only put in these additional holes if I knew that the ground was permeable outside the zone covered by the grout holes shown, as would be indicated by high takes in the deeper stages of the outer ring of holes. At this time I anticipate that the rock outside the immediate area of the bulkhead is fairly competent and tight; do any of you have other expectations?

I would appreciate any comments.

Regards,
Steve.



SIDE VIEW.



FACE VIEW.

NOTE: SOME SLIGHT MODIFICATIONS MAY BE NECESSARY IN THE FIELD TO SUIT EXISTING CONDITIONS.

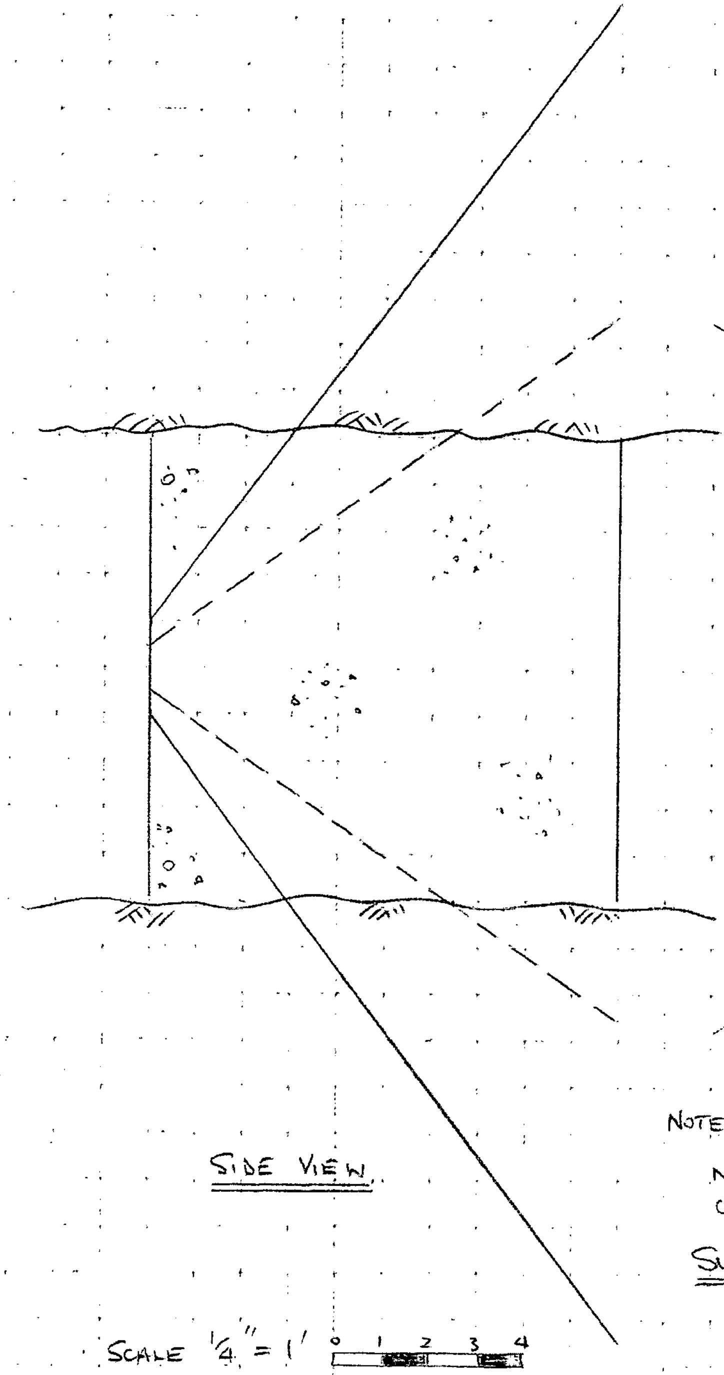
SUGGESTED GROUT HOLE CONFIGURATION.

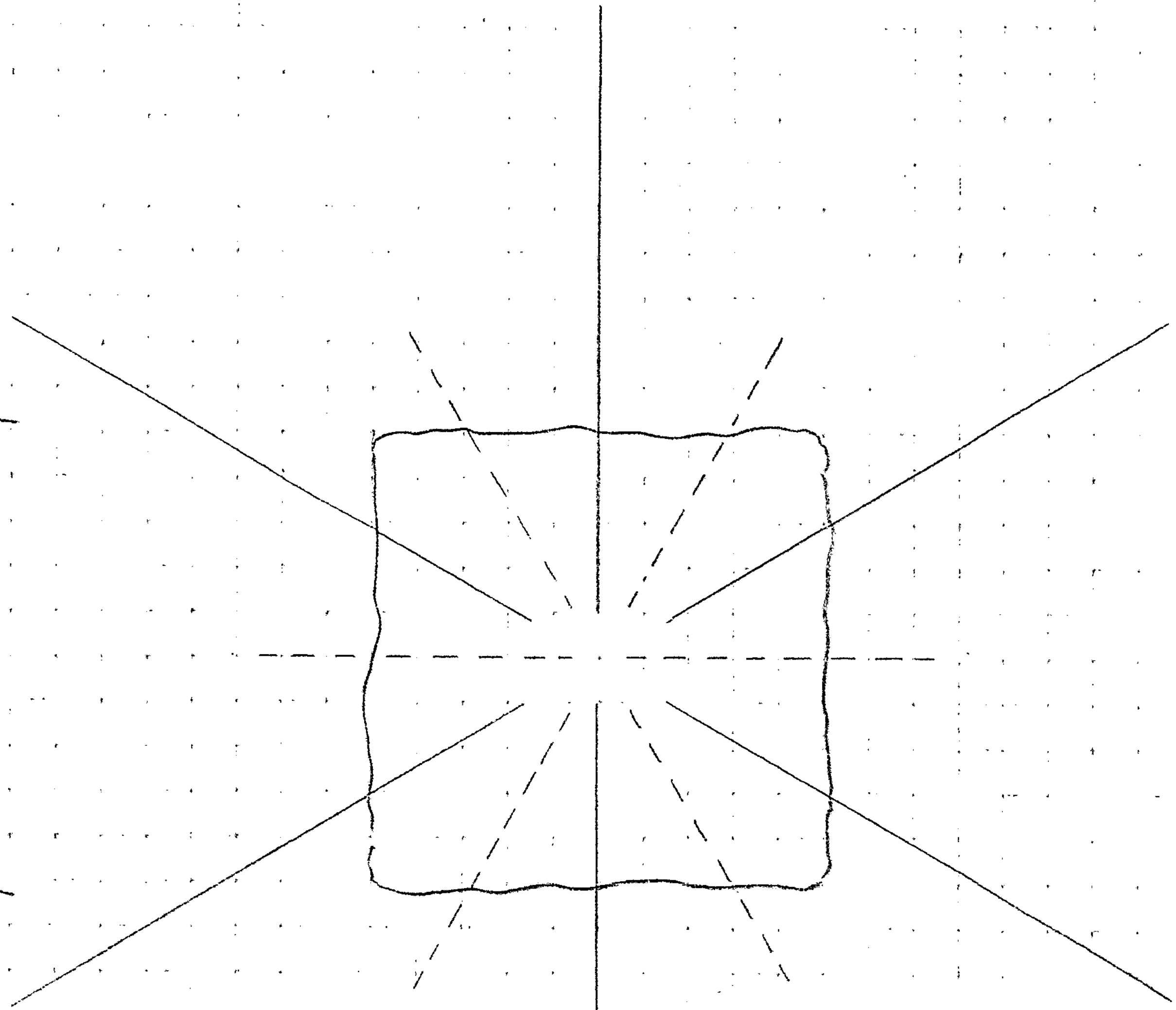
STEVE ADIT BULKHEAD

COTTER CORP- SCHWARTZWALDER MINE

SHEP 11.13.07

SCALE 1/4" = 1' 0 1 2 3 4





NOTE: SOME SLIGHT MODIFICATIONS MAY BE NECESSARY IN THE FIELD TO SUIT EXISTING CONDITIONS.

SUGGESTED GROUT HOLE CONFIGURATION.

STEVE ADIT BULKHEAD

COTTER CORP. - SCHWARTZWALDER MINE

SHEP 11.13.07

SECTION 02722

GROUTING - Specs

PART 1-GENERAL

1.1 Scope

This section includes:

- Drilling grout holes.
- Furnishing, transporting, storing and mixing grout material-
- Injecting grout.
- Clean up of areas after the completion of grouting.
- All other operations that are incidental to grouting the concrete/rock contact and the surrounding rock.

1.2 Related Sections

- 03100 -Concrete Form Work.
- 03300- Concrete for Plug.

1.3 References

The Contractor shall in all cases use the latest revision of the applicable Standard.

The Standards relevant to this Section are as follows:

ASTM C 109 Test Method for Compressive Strength of Hydraulic Cement

30 CFR 57 Safety and Health Standards -Underground Metal and Nonmetal Mines.

1.4 Submittals

Daily grouting reports indicating the day, date, holes drilled and their depth, time of mixing and delivery of grout, quantity of grout placed, water:cement ratio, pressure used, problems encountered, action taken, etc., shall be submitted no later than 24 hours following construction.

1.5 Quality Assurance.

Perform the work in accordance with these specifications and drawings, the submittals and the referenced standards.

The Contractor's Supervisor of the grouting operation shall have at least 2 years technical experience in similar grouting applications, or be under the technical direction of an Engineer with appropriate underground grouting experience.

All personnel involved with the grouting shall be trained in the use of personal safety equipment and the safe handling procedures of the products on hand and be aware of the potential hazards involved.

PART 2-PRODUCTS

2.1 General

Contractor shall provide product data sheets for the individual grout components and other materials as listed in this Section.

2.2 Cement for Grouting

The cement used for grouting shall be either a Type III Portland cement/Class F fly ash or an ultrafine cement grout.

The Portland cement shall conform to ASTM C 150 Type III. The source of the cement to be used shall be indicated and a manufacturer's certification that it complies with the applicable standard shall be provided with each shipment. Only one brand of cement shall be used for all the work, unless otherwise approved by the Engineer.

In lieu of Type III cement, Type I/II cement fly ash mix may be used for the initial stage grouting of areas to fill any large fissures or joints, provided that it is followed by re-grouting in a second stage in the same location with an ultrafine cement grout.

The fly ash shall be as specified for concrete, Section 03300-2.2.

Ultrafine cement such as Nittetsu Super Fine cement, or equivalent, shall be used, having all the particles smaller than 10 microns, 95 percent of the particles smaller than 8 microns and an average particle size less than 4 microns. Additives such as “Mighty 150” shall be used per the manufacturer’s instructions.

2.3 Water

Water for mixing grout shall be of potable quality as specified in Section 03300-2.4.

2.4 Standpipes

Standpipes shall be furnished by the Contractor and cast into the plug concrete at the appropriate orientation. They shall consist of 2 inch, schedule 40 stainless steel pipe. The standpipes will extend from the rear of the forms to the rock at the floor, ribs and back to act as guides through which the grout holes will subsequently be drilled and grout injected.

The approximate locations of the grout pipes are shown in the Drawings. However, the final location of these pipes and their length shall be determined in the field to best suit the final contour of the rock surface. It is anticipated that two rings of 6 grout pipes each will be required for each bulkhead . Additional pipes may need to be placed into the highest locations in the back of the drift to allow trapped air to escape during concrete placement.

Where the mine adit dimensions limit the angle of drilling, additional grout pipes may need to be set into the rock outby the bulkhead in order to provide farther penetration into the rockmass to achieve the desired grouting distance.

2.5 Caulking materials and Additives

If needed, caulking materials to stop leaks of grout to the free face of the plug shall consist of burlap, polyurethane foam sealant, and/or wooden wedges. Suitable caulking materials shall be on hand at the commencement of grouting operations.

The use of a viscosity modifier such as Rheomac UW 450, as manufactured by Master Builders Technologies, or equivalent, shall be permitted to help retain the grout in the interface. The addition of an accelerator to the grout shall also be permitted. The specifications of the grout viscosity modifier and accelerator shall be approved by the Engineer.

PART 3-EXECUTION

3.1 General

The Contractor shall furnish all labor, materials, equipment and tools to perform all operations in connection with the grouting.

Grouting shall not commence sooner than 28 days after the completion of the plug concrete placement to allow the concrete to gain strength, cool and dimensionally stabilize.

The order in which the holes are drilled, and the depth to which they are drilled and grouted, the type of cement and the grout used, the time of grouting, the pressures used in, grouting, and all other details of the grouting operations shall be directed by the Engineer. Sufficient quantities of grout components and additives shall be stockpiled prior to initiation of the grouting to perform the work so as not to result in delays during the mixing/placing sequence.

3.2 Drilling

Drilling grout holes shall be accomplished with rotary or percussion-type drills. If a jackleg drill is used, external flushing equipment shall be utilized to adequately flush the cuttings from the holes, especially the down-dipping holes.

The depth to which the holes are drilled and grouted will depend upon the actual site conditions encountered, but the drilling equipment must be available and capable of drilling the allowable range of hole size (1 1/2 to 1 7/8 inch diameter holes) to a minimum depth of 15 feet, at an acceptable rate of penetration. The Contractor should be prepared to drill holes up to a maximum length of 20 feet. Sufficient quantities of drill steel and bits shall be supplied to allow for breakage and loss of steel without delaying the progress of the work.

3.3 Mixing and Pumping Equipment

The Contractor shall make provisions to accurately proportion the components. All mixing and measuring equipment shall be sufficiently accurate and sensitive to provide proper control of the grout mixes.

Mixers shall be high shear "colloidal" type with a rotary speed of 1,700 to 1,800 rpm. Grout shall be mixed as per the manufacturer's recommendations and Engineer's instructions. Each of the components of the grout shall be accurately metered into the mixer to control the consistency of the grout.

The grout mixed in the high shear mixer shall be transferred into a mechanical paddle type agitator tank(s) that directly feeds the suction of the pump(s). This agitator tank shall be equipped with a suitable screen to prevent the entry of oversized foreign material.
The grout pump(s) shall be variable speed, progressive cavity type, designed for grouting service and capable of continuously developing an uninterrupted flow of between 1 and 30 gpm at any specified pressure up to 100 psi. Grout pressures and flows shall be controlled by a valve that allows some of the grout to return to the grout holding tank from the high-pressure grout line. The Contractor shall supply a second pump with the same specifications that shall be utilized in the event of a breakdown of the primary unit.

Flow meters or other acceptable means to reliably measure grout acceptance rate and total volume shall be provided with each pump that is used. Pressure gauges have a minimum diameter of 3 inches and shall be accurately calibrated, with a range of zero to 100 psi. They shall be liquid filled and fitted with appropriate gauge protectors.

Grout pipes, hoses and header assemblies shall have a nominal diameter of 1 inch and shall be capable of withstanding a minimum pressure of 250 psi greater than the achievable pump pressure.

A reliable, audible communication system shall be provided between the grout plant and the grouting location in the adit.

Equipment and lines shall be capable of being cleaned out by periodic flushing with clean water. The arrangement shall be such that flushing may be accomplished with the grout hole intake valve closed, the brine supply valve open and the grout pump running at full speed.

Each grout hole, during grouting, shall be fitted with a valve capable of withstanding a minimum pressure of 250 psi which can be closed after grouting is completed and maintained that way until the grout has set.

3.4 Grouting Around the Concrete Plug

Following drilling, each of the holes will be thoroughly washed with clean water introduced through a hose that extends to the extremity of the hole. Subsequently, all the down-dipping holes will also be purged with compressed air, also introduced into the hole through a hose that extends to the bottom of the hole.

When the drilling of each hole has been completed, the hole shall be temporarily capped or otherwise suitably protected to prevent the hole from becoming clogged or obstructed until it is grouted. Any pipe/hole that becomes clogged or obstructed from any cause shall be cleaned satisfactorily or replaced prior to grouting.

Grouting shall be performed through the 2 inch standpipes that were previously cast into the concrete (and if necessary, the rock), and fitted with suitable valves.

The Contractor shall initially drill about 6 inches beyond the concrete/rock interface so that the contact between the concrete and the rock surrounding the plug is subsequently grouted.

Upon completion of grouting this contact area, the holes shall be extended out in stages into the surrounding rock. The length of these stages shall be about 2 to 3 feet. The total distance drilled and grouted will depend upon the ring of holes being drilled and the conditions encountered, but may be up to 15 feet.

Primary and secondary grouting procedures shall be used in each ring of holes in all stages of the grouting. The primary holes, i.e., every other one in the same ring around the periphery of the plug, shall be drilled and grouted first, followed by the remaining secondary holes. Grouting in the holes in the back ring shall be completed first, followed by those in the front ring.

Grouting shall be performed with either or both the coarser Portland cement/Class F flyash and ultrafine cement grout, depending upon the conditions encountered.

The choice between the two types of cement shall be determined by the size of the fracture/opening to be grouted, as determined by drilling and/or water injection testing.

The water:cement ratio shall be modified to suit the injection conditions ranging from 3:1 to 0.6:1 by weight.

Grouting each stage shall commence with a mix with a water:cement ratio of 3:1 by weight, unless it is positively known that a thicker mix can be accepted. The grout mix shall be thickened gradually, as appropriate, to ensure that the thickest mix that can be accepted is injected into the fractures and voids.

After the grouting is complete, the grout pressure shall be maintained by means of suitable valves attached to the standpipes of the holes that have been grouted.

All holes to which grout connects from another hole shall be pumped before the grout has set. Grouting shall not be considered complete until all stages in all holes have been injected with grout.

Grout pressures up to 75 psi shall be utilized for the grouting procedures.

At the completion of grouting, all the holes shall be filled and plugged with an anti-bleed, anti-shrink cement grout with a water:cementitious materials ratio not exceeding 0.6: 1 by weight.

If a leak of grout occurs to the free face, the leak shall be caulked as per Section 2.5 herein. Other techniques for stopping leaks of grout, such as slowing down or stopping the grout pump shall also be used, as required. The addition of an accelerator and/or a viscosity modifier to the grout mix at the point of injection shall also be permitted.

3.5 Clean Up

Washout and cleanup must be properly contained. The Contractor shall provide measures to contain and store all waste grout and wash water before removal from the grouting location, if required.

End of section.

NITTETSU SUPERFINE

Nittetsu Cement Co.,Ltd
Bansei-Muromachi Bldg,5F,4-3-12
Nihonbashi-Muromachi,Chuo-Ku,Tokyo
103-0022 Japan
Tel.81-3-3279-0581／Fax.81-3-3245-1335
URL／http//:www.nittetsu-cement.co.jp
E-mail／tokyo@nittetsu-cement.co.jp

Introduction of Nittetsu Cement

Nittetsu Cement Co.,Ltd. was founded through a joint capital investment between Nippon Steel Corporation and Sumitomo Osaka Cement Co.,Ltd. in June of 1954. It mainly produces and merchandises Portland cement,Blast-furnace slag cement and other cement related products. A variety of Nittetsu Cement products have been used in the construction of large-sized dams,bridges and tunnels and the others.
Our technology and quality has been highly evaluated.

Outline of SuperFine

◇ The longevity of grouting strength is excellent.
◇ When hardend,it displays high durability and excellent water cut off properties.
◇ Gelation time is controllable by using a hardener,if required.

Physical properties

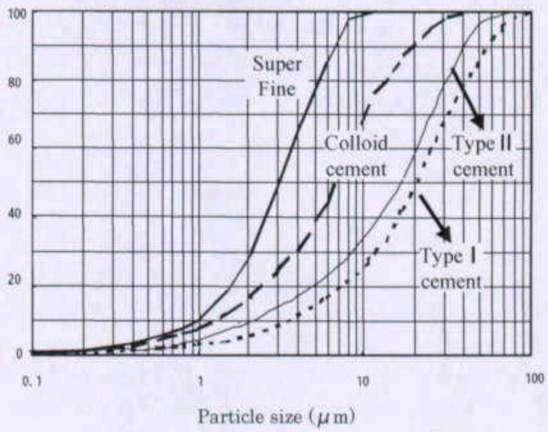
◇ Specific gravity 3.00g/cm^3

◇ Medium particle size $\leqq 3\mu m$

Chemical analysis results

SiO_2	Al_2O_3	CaO	SO_3
29	11	51	1

Gradation curves of SuperFine and other grouting materials



Application of SuperFine

◇ Foundation and consolidation grouting of dams and embankments.
◇ Water cut-off grouting and pre-excavation grouting in tunnel construction.
◇ Maintenance grouting of existing dams and tunnels.
◇ Consolidation of poor soils.
◇ Foundation stabilization of new and existing structures.
◇ Consolidation of soils to prevent liquefaction

Package of SuperFine

◇ 20kg bag (into the covering bag)
◇ 1.0mt flexible-container bag

Nittetsu Super Fine Cement
Partial Project List

- Barrick Gold, Complex Bousquet
  Tunnel plug grouting - Preissac, PQ, Canada
- Cameco Corp.
  Tunnel plug grouting / water cut-off grouting
  McArther River and Cigar Lake Mines - Saskatchewan, Canada
- Flour Daniel Argentina
  Tailings pond dam grouting / Minera Alumbrera Ltd. - Belen, Argentina
- Coastal Drilling West
  East Valley Lateral Tunnel, pre-excavation grouting Southern Nevada Water Authority
  Henderson, NV
- GeoGrout
  Civic Center soil stabilization grouting, San Francisco State Building Authority
  San Francisco, CA
- GeoGrout / Power Engineering
  M.H. de Young Museum, soil stabilization grouting, FAMSF - San Francisco, CA
- Homestake Mining Co.
  Tunnel plug grouting - Homestake Mine - Lead, SD
- Kiewit Construction
  Lake Mead Intake No. 2, water cut-off and soil stabilization grouting for shaft and tunnel
  Henderson, NV
- Layne Christensen / Fonditek
  Soil stabilization for shaft excavation, MetroWest Water District - Weston, MA
- Moore & Taber
  Stabilization of dune sand at private residence - Dana Point, CA
- Obayashi Corp
  Soil stabilization and water cut-off grouting, MetroWest Water District - Framingham, MA
- Atkinson Construction
  Pre-excavation and water cut-off grouting, Tenn. Valley Authority - Blue Ridge Dam, GA
- Shank Balfour Beatty
  Pre-excavation grouting - Riverside Badlands Tunnel, Metropolitan Water District
  Moreno Valley, CA
- Stimpel Wiebelhaus Associates
  Dam Foundation Grouting - Slickrock Dam, Iron Mountain Mine CH2M Hill / EPA
  Redding, CA
- Teck / Sumitomo
  Water Cut-off and pre-excavation grouting - Pogo Mine - Delta Junction, AK
- The Judy Company
  Dam foundation grouting US Corps of Engineers, Red Rock Dam - Pella, IA
- US Corps of Engineers
  Portugues Dam pre-construction grouting - Ponce, Puerto Rico
- INCO Ltd.
  Water cut-off grouting INCO mines - Thompson, MB, Canada
- Gilbert Healy J.V.
  Chattahoochee CSO Tunnel post excavation water cut-off grouting, Dept. of Water
  Management - Atlanta, GA
- Shea Kenny J.V.
  Pre-excavation grouting, Arrowhead Tunnels Project, Metropolitan Water District
  San Bernardino, CA

07/07

Test report of chemical admixture for concrete July to September 2007

Type	JIS A 6204, High Range Water Reducing Agent, normal I ASTM C494-92, A and F
Commodity	MIGHTY 150

1. Concrete Test Results

Item			JIS A 6204 : 2006 Requirement	Test Result	
				Initial type testing	Factory production control testing
Fresh concrete	Water content %		Not more than 88	88	88
	Bleeding ratio %		Not specified	—	—
	Setting time difference min	Initial	Not more than +90	+25	+25
		Final	Not more than +90	+20	+25
Hardened concrete	Compressive strength, % of control	At 7 days	Not less than 115	133	132
		At 28 days	Not less than 110	121	120
	Length change, % of control		Not more than 110	98	—
	Relative durability factor		Not specified	—	—

Remark 1. Dosage of chemical admixtures per 1 m^3,

Initial type testing 4.20 kg/m^3, Factory production control testing 4.20 kg/m^3.

2. Factory production control testing of fresh concrete shall be done four times a year every three months. The concrete test of this report was done on June 2007. Factory production control testing of hardened concrete shall be done once a year. The concrete test of this report was done on June 2007

3. Initial type testing of this report was done on September 2005 at Kao Corporation.

2. Chloride (Cl^-) content and total alkaline content

Item	JIS A 6204 Requirement	Initial quality test	Routinely control test		
			Content in the chemical admixures	Dosage of chemical admixtures per $1m^3$ concrete	Test Result
Chloride ion content	Not more than $0.02kg/m^3$	$0.00kg/m^3$	0.00 %	4.20 kg/m^3	0.00 kg/m^3
Total alkaline content	Not more than $0.30kg/m^3$	$0.20kg/m^3$	4.6 %	4.20 kg/m^3	0.19 kg/m^3

Remark 1. Factory production control testing shall be done four times a year every three months. This test was done on June 2007.

2. Initial type testing of this report was done on September 2005 at Kao Corporation.

3. Others

Item	Value Specified	Test Result
Density (g/cm^3、20℃)	1.190 ～ 1.210	1.201

Remark This test was done on June 2007.

Respectfully submitted,
for Kao Corporation

Inspector Tatsuya Mizunuma

NITTETSU CEMENT CO.,LTD
64 NAKAMACHI, MURORAN
HOKKAIDO, JAPAN 050-8510
TEL (81143)44-2618
FAX (81143)45-3923

Date: July 2007

NITTETSU SUPER FINE
CERTIFICATE OF ANALYSIS

CHEMICAL COMPOSITION

Test Method JIS R 5202

Ignition loss	0.0	%
SiO_2	29.8	%
Al_2O_3	11.4	%
Fe_2O_3	1.1	%
CaO	49.8	%
MgO	5.1	%
SO_3	0.9	%

PHYSICAL PROPERTIES

Specific Gravity 3.01

Fineness*

10% Grain Size	1.0	μm
20% Grain Size	1.7	μm
50% Grain Size	3.0	μm
85% Grain Size	7.2	μm
95% Grain Size	9.4	μm

* Measured by Laser Micron Sizer PRO-7000S,Seishin Co.

石谷清

KIYOSHI ISHITANI
Group Leader of Manufacturing Technique Group

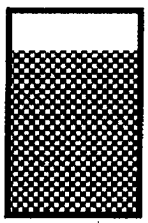
Nittetsu Super Fine
Yield Chart

Water cement ratio by weight or by volume.

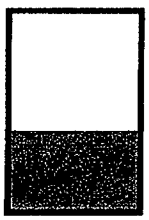
Material packaged 50 - 20 kg (44 lb.) bags per pallet (1 metric ton per pallet)
Mighty 150R superplasticizer included at 1% by weight of cement

Water : Cement	Water per 20 Kg Bag			Superplasticizer	Yield Per 20 Kg Bag		
Ratio	Gallons /	Cubic Feet	Liters	Required Per Bag	Gallons	Cubic Feet	Liters
0.5 : 1	2.65	0.35	10.03	5 fluid oz.	4.41	0.59	16.71
0.75 : 1	3.97	0.53	15.03	5 fluid oz.	5.76	0.77	21.81
1 : 1	5.29	0.71	20.03	5 fluid oz.	7.03	0.94	26.62
1.5 : 1	7.94	1.06	30.06	5 fluid oz.	9.65	1.29	36.53
2 : 1	10.58	1.41	40.05	5 fluid oz.	12.34	1.65	46.73
2.5 : 1	13.23	1.77	50.09	5 fluid oz.	14.96	2.00	56.64
3 : 1	15.87	2.12	60.08	5 fluid oz.	17.58	2.35	66.55
3.5 : 1	18.52	2.48	70.11	5 fluid oz.	20.27	2.71	76.75
4 : 1	21.17	2.83	80.15	5 fluid oz.	22.89	3.06	86.66
4.5 : 1	23.81	3.18	90.14	5 fluid oz.	25.51	3.41	96.57
5 : 1	26.46	3.54	100.17	5 fluid oz.	28.20	3.77	106.77
5.5 : 1	29.10	3.89	110.17	5 fluid oz.	30.82	4.12	116.68
6 : 1	31.75	4.24	120.20	5 fluid oz.	33.44	4.47	126.59
6.5 : 1	34.39	4.60	130.19	5 fluid oz.	36.13	4.83	136.79
7 : 1	37.04	4.95	140.23	5 fluid oz.	38.75	5.18	146.70
7.5 : 1	39.68	5.30	150.22	5 fluid oz.	41.36	5.53	156.61
8 : 1	42.33	5.66	160.25	5 fluid oz.	44.06	5.89	166.80

Apparent Bulk Density:
1g/cm^3 (62.5 lbs. / ft.^{3})



Absolute Density:
3g/cm^3 (187.5 lbs./ft^3)



Water: 1kg / liter (62.5 lbs./ft^3)

Conversions:
1 cubic foot = 7.48 gallons (U.S.)
1 cubic foot = 28.32 liters
1 gallon (U.S.) = 3.7854 liters

GROUTING LOG

Date: 22 JAN 2008 **Shift:** DAY

JASON + DOUG + ROLAND

CLEAR ~ 30°F HIGH

Location: SWARTZ = STEVE **Report by:** [illegible]

HOLE #	DEPTH	GROUT TYPE	W/C RA TIO	GROUT TAKE	NOTES (Admixture(s), problems, etc.)
1	~10'	CEMENT/FLY ASH	3/1	NIL	30 GAL WATER
2	~10'	"	3/1	NIL	92 LB I/II CEMENT
3	~10'	"	3/1	NIL	~50 LB FLY ASH
4	~10'	"	3/1	NIL	
5	~10'	"	3/1	NIL	
6					COTTER GROUP VISITED
					GROUTED INSIDE RING OF
					CONTACT HOLES
					GROUTED IN COLLAR PIPES
					FOR FORMATION GROUTING
					10 PIPES 2.5 SAC/20 GAL

GROUTING LOG

CLEAR & ~~COOL~~ COLD WINDY

Date: 23 JAN 08 **Shift:** DAY

JASON + DOUG + ROLAND

Location: **Report by:**

HOLE #	DEPTH	GROUT TYPE	W/C RA TIO	GROUT TAKE	NOTES (Admixture(s), problems, etc.)
1	~10	I/II w/FA	0.6/1	NIL	20 GAL WATER = 166 LB
2	~10	"	0.6/1	NIL	~~3 CEMENT @ 92 = 186 LB~~
3	~10	"	0.6	NIL	~~2 FLASH @ 54 LB = 108 LB~~
4	~10	"	0.6	NIL	3 CEMENT = 278 LB
5	~10	"	0.6	NIL	3 FLY ASH @ 54 = 162 LB
7	~8	"	0.6	NIL	5 OZ MIGHTY 150
					10:00 START GROUTING
					11:30 FINISH GROUTING

12/19 18/20 9/10

GROUTING LOG

Date: 25 JAN 2008 **Shift:** DAY CLEAR & COOL

JASON + ROLAND

Location: STEELE **Report by:** WGB

HOLE #	DEPTH	GROUT TYPE	W/C RA TIO	GROUT TAKE	NOTES (Admixture(s), problems, etc.)
3	~10	I/II + FLY ASH	0.67	~ ~~8~~ 15 GAL	~~8~~ 15 GAL WATER ~~[illegible]~~ 125 Lb
7	~10	"	0.67	NCL	2 SAC CEMENT = 185 Lb
8	~10	"	0.67	NCL	FLY ASH = 104 Lb
11	~9	"	0.67	NCL	5 OZ MIGHTY 150
					#3 HOLE IS BOTTOM HOLE
					POSSIBLE LIFTER FRACTURING
					12:00 START GROUT
					13:00 FINISH GROUT
					GROUT PRESSURE 100 PSI

GROUTING LOG

Date: 28 JAN 2002 Shift: DAY

JASON & DOUG

Location: STEVE - SCHWARTZ Report by: WEB

HOLE #	DEPTH	GROUT TYPE	W/C RA TIO	GROUT TAKE	NOTES (Admixture(s), problems, etc.)
3	120"	I/II + FLYASH	0.45	NIL	5 GAL WATER = 42 LB
4	102"	"	0.45	NIL	1 SAC CEMENT = 94 LB
					FLY ASH = 50 LB

GROUTING LOG

Date: 29 JAN 2008 Shift: DAY

JASON + DOUG + ROLAND

Location: SWARTZ PIERCE Report by: WLB

START 09:30
FINISH 10:50

HOLE #	DEPTH	GROUT TYPE	W/C RA TIO	GROUT TAKE	NOTES (Admixture(s), problems, etc.)
1	149"	1/11 + FLYASH	0.6	NIL	20 GAL WATER @ 8.34 167 Lb
2	143"		"	NIL	3 SAC CEMENT @ 92.6 278 Lb
3	147"		"	NIL	FLY ASH 162 Lb
4	126"		"	NIL	MIGHTY 150 - 5 OZ
5	129"		"	NIL	~ 17 GAL CONSUMED
6	100"		"	NIL	11:00 START = FINISH 12:10
7	116"		"	NIL	PUMPED 36 GALLONS
8	95"		"	NIL	INTO 3" Ø HOPE VERT
9	95"		"	NIL	PIPE ~ 63 FT OF HOLE
10	92"		"	NIL	FILL: IF BOTH INSIDE &
11	86"		"	NIL	OUTSIDE ARE FILLED
12	88"		"	NIL	INSIDE ~ 0.3 GAL/FT
					OUTSIDE ~ 0.6 GAL/FT
			0.57		35 GAL WATER (292 Lb) / 5.5 SAC = 509 Lb / 250 Lb FLYASH
					S.G. ~ 1.68
					@ 120 PSI ~ 71 FT HEAD

GROUTING LOG

Date: 01 FEB 08 Shift: Swing

Jason & Will

Location: SCHWARTZ-STEVE Report by: [illegible]

HOLE #	DEPTH	GROUT TYPE	W/C RA TIO	GROUT TAKE	NOTES (Admixture(s), problems, etc.)
F-1	47 inch	SUPER FINE	1.04	NIL	55 GAL WATER 459 LB
F-2	47 inch	"	"	NIL	10 SAC SUPER FINE 440 LB
F-3	54 inch	"	"	NIL	FLY ASH 216 LB
F-4	54 inch	"	"	NIL	
F-5	52 inch	"	"	NIL	MINIMUM BATCH SIZE IN
F-6	49 inch	"	"	1 GAL	COLLOIDAL MIXER IS 50 GAL
F-7	48 inch	"	"	NIL	~ 400 LB CEMENT
F-8	51 inch	"	"	NIL	MUCH WASTE
F-9	50 inch	"	"	NIL	
F-10	45 inch	"	"	NIL	

1.04

GROUTING LOG

Date: 01 FEB 02 Shift: SWING
JASON & WILL
Location: SWARTZ STEVE Report by: CWB

HOLE #	DEPTH ~~FEET~~	GROUT TYPE	W/C RA TIO	GROUT TAKE	NOTES (Admixture(s), problems, etc.)
1	16 40	SUPERFINE	1.04	NIL	55 GAL WATER 459 LB
2	16 25	"	"	NIL	10 SAC SUPERFINE 440 LB
3	10 50	"	"	NIL	FLY ASH 216 LB
4	12 50	"	"	NIL	
5	12 33	"	"	NIL	MINIMUM BATCH SIZE IN
6	12 60	"	"	NIL	COLLOIDAL MIXER IS 50 GAL
7	11 25	"	"	NIL	~ 400 LB CEMENT
8	16 50	"	"	NIL	MUCH WASTE
9	8 66	"	"	NIL	
10	12 08	"	"	NIL	
11	12 30	"	"	NIL	
12	12 60	"	"	NIL	
~~13~~	FEET				
~~F-2~~					
~~F-3~~					
~~F-4~~					
~~F-5~~					
~~F-6~~					

8

GROUTING LOG

SNOWING ALL DAY

Date: 04 FEB 08 Shift: DAY

JASON + ROLAND + WILL

Location: SWARTZ - STEVE Report by: WKB

START 10:00
FINISH 11:30

HOLE #	DEPTH	GROUT TYPE	W/C RA TIO	GROUT TAKE	NOTES (Admixture(s), problems, etc.)
SF-1	8'	SUPERFINE	0.95	NIL	50 GAL WATER = 415 LB
SF-2	8'	"	0.95	NIL	10 SAC SUPERFINE = 440 LB
SF-3	8'	"	0.95	NIL	FLY ASH 216 LB
SF-4	8'	"	0.95	NIL	5 OZ MIGHTY 150
SF-5	8'	"	0.95	NIL	
SF-6	8'	"	0.95	NIL =	< LEAKS AROUND PIPE AT DRIFT FLOOR
SF-7	8'	"	0.95	NIL	
SF-8	8'	"	0.95	NIL	
SF-9	8'	"	0.95	NIL	
SF-10	8'	"	0.95	NIL	

GROUTING LOG

SNOWING ALL DAY

Date: 04 FEB 2008 Shift: DAY

START 13:45

FINISH 15:00

JASON + ROLAND + WILL

Location: SWARTZ - PIERCE Report by: CORB

HOLE #	DEPTH	GROUT TYPE	W/C RA TIO	GROUT TAKE	NOTES (Admixture(s), problems, etc.)
PF-1	4º	SUPERFINE	0.75	NIL	40 GAL WATER 334 Lb
PF-2	4º	"	"	NIL	10 SAC SUPERFINE 440 Lb
PF-3	4º	"	"	NIL	FLY ASH 216 Lb
PF-4	4º	"	"	NIL	5 OZ MIGHTY 150
PF-5	4º	"	"	NIL	SMALL LEAK @ COLLAR
PF-6	4º	"	"	NIL	SMALL LEAK @ COLLAR
PF-7	4º	"	"	NIL	SMALL LEAK @ COLLAR
PF-8	4º	"	"	NIL	
PF9	4º	"	"	NIL	~ GROUT PRESSURE 125 PSI
PF-10	4º	"	"	NIL	
PF-11	4º	"	"	NIL	BEAR MINIMUM BATCH SIZE
					IN COLLOIDAL MIXER

GROUTING LOG

CLOUDY - SNOW - AM
CLEARING - PM
14:30 START
15:30 FINISH

Date: 05 FEBRUARY 08 Shift: DAY
JASON & WILL
Location: SCHWARTZ - PIERCE Report by: WB

HOLE #	DEPTH	GROUT TYPE	W/C RA TIO	GROUT TAKE	NOTES (Admixture(s), problems, etc.)
PF-1	8.0	SUPERFINE	0.76	NIL	40 GAL WATER 384 LB
PF-2	8.0	"	"	NIL	10 SAC. SUPERFINE 440 LB
PF-3	8.0	"	"	NIL	FLY ASH 216 LB
PF-4	8.0	"	"	NIL	MIGHTY 150 5 OZ
PF-5	8.0	"	"	NIL	
PF-6	8.0	"	"	NIL	GROUT PRESSURE ~ 125 PSI
PF-7	8.0	"	"	NIL	
PF-8	8.0	"	"	NIL	
PF-9	8.0	"	"	NIL	
PF-10	8.0	"	"	NIL	
PF-11	8.0	"	"	NIL	

GROUTING LOG

Date: 05 FEBRUARY 08 Shift: DAY

CLOUDY - SNOW AM
CLEARING PM
14:30 START
15:30 FINISH

JASON & WILL

Location: SCHWARTZ - PIERCE Report by: LWKB

HOLE #	DEPTH	GROUT TYPE	W/C RA TIO	GROUT TAKE	NOTES (Admixture(s), problems, etc.)
P-1	14 25	SUPERFINE	0.76	NIL	40 GAL WATER 333Lb
P-2	13 08	"	"	NIL	10 SAC SUPERFINE 440Lb
P-3	13 08	"	"	NIL	FLY ASH 216Lb
P-4	10 5	"	"	NIL	MIGHTY 150 5OZ
P-5	12 58	"	"	NIL	
P-6	14 00	"	"	NIL	GROUT PRESSURE ~ 125PSI
P-7	14 17	"	"	NIL	
P-8	14 58	"	"	NIL	
P-9	13 67	"	"	NIL	
P-10	10 50	"	"	NIL	
P-11	14 17	"	"	NIL	
P-12	9 67				B.T. TO VERT 6"Ø HOLE ABOVE BULKHEAD

GROUTING LOG

CLEAR / COLD / WINDY

Date: 06 FEB 08 Shift: DAY

WILL & JEROMEY

Location: PIERCIE-SCHWARTZ Report by: WCB

HOLE #	DEPTH	GROUT TYPE	W/C RA TIO	GROUT TAKE	NOTES (Admixture(s), problems, etc.)	
P-12		I/II w/FLYASH	0.45	NIL	15 GAL WATER	125 Lb
					3 SAC I/II	278 Lb
					54 Lb FLYASH	54 Lb
					5 OZ MIGHTY 150	

Schwartzwalder Mine Underground Water Quality -

Representative mine pool samples from shaft

Water Quality Parameter	Location Shaft 4/21/05	Shaft 4/19/07	Shaft 6/27/07
pH (Std. Units)		7.52	7.53
Bicarbonate (mg/L)	476	482	481
Alkalinity, total (mg/L)	390	395	394
Conductivity, specific (uS/cm)		3560	3580
Total dissolved solids (mg/L)	3420	3430	3320
Sulfate (mg/L)	1850	2060	2020
Calcium, dissolved (mg/L)	366	387	396
Calcium, total (mg/L)		413	
Sodium, dissolved (mg/L)	175	159	169
Sodium, total (mg/L)		182	
Potassium, dissolved (mg/L)	22.2	21.3	21.6
Chloride (mg/L)	30	30	27
Aluminum, dissolved (mg/L)	<0.2	<0.2	<0.2
Aluminum, total (mg/L)		<0.2	<0.2
Antimony, dissolved (mg/L)	0.001	0.001	<0.001
Antimony, total (mg/L)	<0.05	0.002	0.001
Arsenic, dissolved (mg/L)		0.002	0.003
Arsenic, total (mg/L)	0.006	<0.1	<0.1
Barium, total (mg/L)		0.02	0.019
Copper, dissolved (mg/L)	<0.005	<0.005	<0.005
Copper, total (mg/L)	<0.01	0.005	<0.005
Iron, dissolved (mg/L)	<0.03	<0.03	<0.03
Iron, total (mg/L)	3.42	3.34	1.52
Lead, dissolved (mg/L)		<0.05	<0.05
Lead, total (mg/L)	<0.05	<0.005	<0.005
Magnesium, dissolved (mg/L)	226	237	254
Manganese, dissolved (mg/L)	5.15	5.59	5.58
Mercury, dissolved (mg/L)		<0.001	<0.001
Mercury, total (mg/L)	<0.001	<0.0001	<0.0001
Molybdenum, dissolved (mg/L)	1.95	1.56	1.62
Silver, dissolved (mg/L)		<0.01	<0.01
Silver, total (mg/L)	<0.01	<0.001	<0.001
Thallium, dissolved (mg/L)	0.002	0.004	0.004
Thallium, total (mg/L)	<0.1	0.005	0.005
Zinc, dissolved (mg/L)		0.05	0.06
Zinc, total (mg/L)	0.11	0.092	0.085
Uranium, dissolved (pCi/L)	46	44.1	44.7
Radium-226, dissolved (pCi/L)	219	0.2	208

Notes:

1) Data provided to MES by Whetstone Associates, Inc.

2) "Shaft" samples represent mixed water in shaft during refilling, and were judged to be representative of expected bulk chemistry of underground water against bulkhead Other samples of localized pools and seeps were in some cases of worse quality