Application for Waste Management Permit for the Palmer Phase II Exploration Project

Haines, Alaska

Upland Mining Lease No. 9100759

Prepared for:
Alaska Department of Environmental Conservation

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March 2019, Revised April 2022 to Incorporate Updates to Appendix A.

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1.0 INTRODUCTION

This document has been updated and is being submitted by Constantine Mining LLC. (Constantine) to the Alaska Department of Environmental Conservation (ADEC) in support of Waste Management Permit 2019DB0001. This document has been updated to reflect new information that has been incorporated into a modified design for the Land Application Disposal System (LAD) that was originally described in the March 2019 version of this document for the Palmer exploration project (Project). The Revised LAD Design Report is available in Appendix A with additional water management details available in Appendix B and C.

Since 2019 Constantine has completed several field studies and computer modeling mostly related to the hydrogeology of the Glacier Creek Valley and the modifications to the LAD design were made in response to the information generated by these studies. The results of field studies are available in Appendix D and E.

The more significant modifications to the LAD include:

- Adding active water treatment.
- Elimination of the Upper Diffuser.
- The lower LAD diffuser trench location, spacing and length are modified to mitigate potential surface discharge and optimize groundwater flow paths in the overburden, based on recent site investigation results. The lower diffuser trench depth, width or materials are not changed from the 2018 design.
- A slightly revised configuration of the 2018 design for the liner footprint for temporary PAG storage is proposed adjacent to the sediment ponds to accommodate for settled solids management activities, if required. No change is being proposed to the overall PAG storage capacity.
- A pumping system is included and the conceptual design of a pumphouse is presented to pump water from the sediment ponds to the LAD diffuser as a contingency, following temporary water storage in the sediment ponds.
- The LAD pipe connections are revised to consider the updated design intent to treat adit discharge water at the adit portal, thereby enabling gravity drainage directly from the adit portal to the diffuser.
- The design for the settling ponds has not changed but they have been repurposed. The sediment ponds will be used for continency storage and total suspended solids (TSS) treatment of discharge water only during periods of high flow, or malfunction or maintenance of the water treatment infrastructure at the portal. One pond will also be used for settled solids storage in winter months, then emptied during the following summer.

- An additional pipeline is included to allow pump-back capacity from the sediment ponds to the adit portal, if required (i.e., if treatment of potentially acid generating (PAG) runoff or additional water treatment is required prior to discharge).

Where elements of the original LAD design remain unchanged the narrative in the 2019 version of this document also remains unchanged. As such this document reflects the most current and complete description of the LAD system proposed for the Palmer Project.

This document contains:

- Updated narrative that describes component parts, including modifications to the original design, and the functionality of the LAD system,
- Updated engineered plans of the entire LAD system comprising the water treatment plant, settling ponds, diffuser and the piping that connects them,
- An updated tentative schedule for construction of the LAD,
- Updated statements identifying who will own and operate the proposed LAD system,
- Updated description of the proposed wastewater discharge including,
    - An updated prediction of the water quality of the wastewater discharge comprised of underground seepage water that has been in contact with the wallrock and blasting residues underground,
    - A comparison of predicted discharge water quality with background shallow groundwater quality and Alaska water quality guidelines.
    - Background water quality for groundwater monitoring wells near the lower LAD diffuser,
    - Baseline water quality data for Waterfall Creek, Hangover Creek and Glacier Creek are presented.
- Narrative tables and graphs that describe the acid generating potential of 101 background rock samples, humidity cell and barrel tests. This information is unchanged from the 2019 application,
- Narrative describing the management of non-PAG development rock on the surface the same as in the 2019 application,
- Narrative describing the proposed identification, segregation, storage, and permanent disposal of PAG development rock, as a contingency in the very unlikely situation where PAG rock is encountered in the ramp as it was originally described in the 2019 application.

2.0 WASTEWATER DISPOSAL

This section provides information regarding the proposed wastewater discharge, including a description of the water disposal system, the characteristics of the proposed discharge and the background water quality of surface and ground waters.

2.1 Wastewater Disposal System and Disposal Location

2.1.1 Description of Disposal System

The wastewater disposal system is intended to provide a means of treating and disposing of underground seepage water in a simple manner that is protective of the environment while complying with applicable regulations. The system is basically a land application disposal (LAD) of wastewater, with the diffuser buried in the ground deep enough to protect it from freezing and allow year-round discharge.

Discharge water will originate as seepage into the underground exploration ramp. Seepage water will be collected and stored temporarily in underground sumps before being directed to a water treatment plant near the portal and then be directed to the diffuser for discharge.

Constantine has incorporated two ponds into the LAD system as illustrated in Figure 1. The ponds were originally intended to provide time and space for settleable solids to settle prior to discharging the water through the lower buried diffuser. However, with the addition of a water treatment plant the ponds have been repurposed; one pond will remain available as a settling pond to accommodate any unanticipated seepage flow rates that overwhelm the water treatment plant or when the water treatment plant is not operating, and the other pond will be used to manage water treatment settled solids. The removal of settleable solids prior to discharge is intended to minimize clogging of the diffuser and the permeable gravels receiving the discharge downgradient of the diffusers.

Settleable solids will include drill cuttings (from blast holes), fines from blasting and those generated by driving on the roadbed underground. They may also include Portland cement during and after grouting operations underground. Some solids will settle as the water resides in the underground sumps prior to being directed to the water treatment plant. The water treatment plant will also produce a stream of inert settled solids that Constantine will manage. Core drills will use centrifuges at each drill location to collect cuttings for disposal.

The diffuser will consist of 12 in.-diameter perforated pipes that will be buried in bedded gravels approximately 6 feet below the surface in two trenches. Burying the diffuser serves to protect it from seasonal frost and allow year-round discharge. Several valves will effectively create four zones within the two perforated pipes allowing the discharge to be directed to any combination of them to manage flows.

The diffuser site is in an aerially extensive alluvial fan composed of permeable gravels. The diffuser is now designed to accommodate a steady state flow of 700 gpm and temporary flows of 900 gpm (Appendix A, KCB, 2022a). This provided a 1.9 factor of safety of above the anticipated base-case flows of 360 gpm as well as accommodating the unlikely flows up to 700 gpm (Tundra, 2022). The pipes from the portal to the settling ponds and from the settling ponds to the diffuser are designed to accommodate more than 900 gpm.

The upper diffuser portion of the LAD system has been eliminated.

Constantine has completed hydrogeologic tests in the upper Glacier Creek Valley as well as 3-D groundwater modelling. The updated LAD design considered base-flow and high-flow scenarios for underground seepage inflows based on the results of groundwater modelling by Tundra (2022). The base-flow scenario assumes inflows start at 0 and gradually increase to a maximum flow of 362 gpm (23 L/s) at the end of Year 1, then fluctuating seasonally between 355 gpm (22 L/s) and 325 gpm (20 L/s) from Year 2 to 5. A constant flow of 350 gpm (22 L/s) was assumed from Year 5 onward in the computer modelling. The high-flow scenario begins from 0 and gradually increases to a maximum flow of 900 GPM (57 L/s) at the end of Year 1, then fluctuates seasonally between 815 GPM (51 L/s) and 680 GPM (43 L/s) from Years 2 to 5. A constant flow of 700 GPM (44 L/s) is assumed from Year 5 onward. The updated design of the LAD accommodates both scenarios.

Constantine has developed an adaptive management strategy for seepage water that will allow them to minimize seepage inflows. Part of that strategy is using probe holes to identify seepage zones ahead of the development ramp and using pressure grouting to form a cement grout curtain stemming the flows before the ramp advanced to the zones with higher seepage rates. The adaptive water management strategy is discussed in Section 2.2.

In the remainder of this section the design of the major component parts of the LAD system are described, including water treatment. Portions of the following sections are summarized from the KCB (2022a) LAD Revised Design report and the Veolia (2022) water treatment report. The complete reports are included as Appendix A and B.

2.1.1.1 Water Treatment

Constantine has added active water treatment for suspended solids to the overall LAD system rather than relying solely on passive settling pond treatment. The water treatment plant will be located underground near the portal or at the portal pad. The design of the plant is detailed in Appendix B (Veolia, 2022). The plant will be capable of treating at least 700 gpm continuously. Treatment will include pH adjustment, coagulation followed by flocculation, and settling/clarification. Microsand is added in the flocculation step to enhance effectiveness and allows the plant to perform well under dramatically changing flow rates. The clarified water will be directed to the LAD diffuser for discharge to the environment and the settled solids are directed to the hydrocyclone to recycle the microsand and generate the inert solids slurry which is directed to geotubes for dewatering or to the settling pond (winter only). The use of active solids removal will prolong the useful life of the LAD diffuser and the permeability of the overburden receiving environment and relieve the reliance on the settling ponds for routine solids settling.

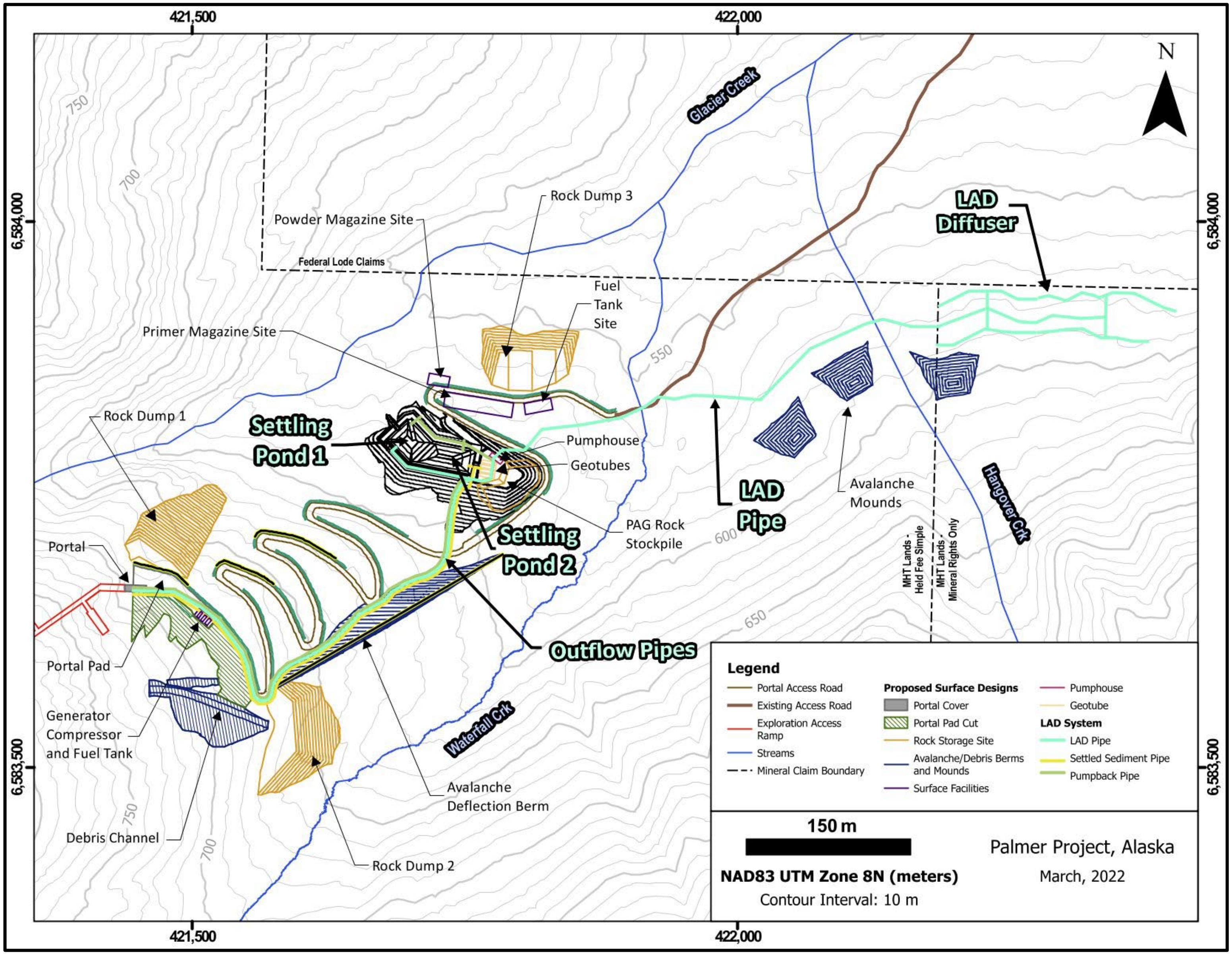


Figure 1. Surface Facility Layout – Palmer Project – Emphasis on LAD System

2.1.1.2 Settling Ponds

The settling ponds have been repurposed from their original 2019 purpose. One pond will now be used to accommodate solid settling of seepage water only when the water treatment plant is inoperative or when the seepage inflows exceed the 900 gpm design capacity of the water treatment plant (extremely unlikely). The second pond will be used to store and otherwise manage settled solids that will be a waste product of the water treatment plant. Settled solids will be stored in this pond during winter operations and then removed during the following summer. The design of the ponds remains unchanged from the original design (BGC, 2018) except a pumping facility (pump, housing, piping) has been added adjacent to the ponds to accommodate pumping untreated water from a pond back up to the water treatment plant (described in Appendix A, KCB, 2022a). The design capacity for each pond is 1,360 m^3 (1.1 acre-feet). The ponds are illustrated on Figure 2 and Figure 3.

The upstream embankment of the ponds is designed to slope at a ratio of 2 horizontal to 1 vertical (2H:1V), except for the upstream embankment adjacent to the temporary rock storage pad, which slopes at 3H:1V to allow access between Sediment Pond 2 and the temporary rock storage pad. Similarly, an internal ramp at 4H:1V is included within each pond to support maintenance activities, including removal of accumulated sediments. Upgradient of the ponds, the cut slope is designed at a grade of 1.9H:1V. The downstream embankment fill is designed at a grade of 2H:1V.

Stability of the sedimentation ponds was assessed using GeoStudio's 2018 Slope/W software, version 9.0.4.15639. The stability analyses indicate that the settling ponds design will meet the recommended minimum factor of safety of 1.3 and 1.1 for end-of-construction and earthquake loading conditions, respectively.

An emergency spillway is designed for the northwest end of Sediment Pond 1, with an invert 0.5 m (1.6 ft) below the crest of the ponds (elevation 578.5 m). The spillway is a mechanism to have a controlled release of excess water while still maintaining the integrity of the pond embankment. The spillway will be lined with a HDPE geomembrane through the embankment and will discharge into a riprap lined channel to prevent erosion of the downstream face, ultimately spilling toward Glacier Creek. This spillway would only operate if there was an event larger than the 100 year 24-hr event, and the diffuser was inoperable.

A separation berm 1.0 m (3.3 ft) below crest level (elevation 578 m) divides the two ponds, allowing them to equalize prior to any discharge through the emergency spillway. The elevation of this separation berm is above the invert elevation of the pipes discharging from the ponds to allow for them to operate independently of each other, if necessary. The pumps at the pond area would first be used to direct excess water to the LAD diffuser. Space is available in several locations adjacent to the ponds that is large enough for a flocculent system, if required to further reduce settlement, and/or water treatment equipment.

A practical method (BCME, 2015) for sizing settling ponds for mine-related applications is presented in the box below that shows that the proposed LAD ponds are each of sufficient size to provide adequate retention time to settle the anticipated solids suspended in the underground seepage water. The method is acceptable for ponds where the finest suspended particles will be present, thus requiring the maximum retention time.

Assumptions:

- particle size of 5 to 10 micron (and coarser)
- settling velocity (V) of 2×10^{-5} m/s
- pond outflow rate (Q) of 500 gpm ($0.031545 \text{ m}^3/\text{s}$)

Sediment Pond Area (m^2): A = (Q/V)
A = ($0.031545 \text{ m}^3/\text{s}$) / (0.00002 m/s)
<u>A = 1,577 m^2</u>

Retention time (hours): Tr = d/(3600*V)
<u>Tr = 21 hours</u>

This method utilizes standard assumptions on particle size and settling velocity and is appropriate for projects where no site-specific sediment is available for testing. This design approach has been used to design many settling ponds at currently operating mines.

Given a minimum pond depth (d) of 1.5 m, defined as the difference in vertical elevation between the inlet water level and the bottom of the pond adjacent to the outlet, and a settling velocity of 2 x 10-5 m/s for fine silt, a total retention time of approximately 21 hours is required to treat 500 gpm using both ponds and one pond will provide 24 hours of retention time at flows of 250 gpm.

This analysis indicates that settling of suspended solids in untreated seepage water could take place in one settling pond if seepage water is required to bypass the water treatment facility at the portal. Using a single pond, 250 gpm could be treated continuously. This would allow the site to treat up to 700 gpm through the water treatment plant and an additional 250 gpm through one of the settling ponds simultaneously. Combined, the 950 gpm treatment capacity exceeds any flows that might be realized even in the most conservative scenario. Also, the pond retention time could be decreased if a flow curtain is installed in the pond to increase retention time for the settling of solids (KCB, personal communications).

2.1.1.3 Diffuser

The purpose of the buried diffuser is to discharge water intercepted by the exploration ramp into the shallow subsurface, below the seasonal depth of frost. The pipe flow to the diffuser originates at the water treatment plant, and then discharges through the diffuser pipes into the ground, like a shallow septic system drain field. KCB incorporates some elements of the 2018 design by BGC but developed an updated design for the diffuser (Figure 4) which consists of 12-inch perforated HDPE pipe in two trenches, with valves to create four “zones”. Some elements including the depth of emplacement and specifications for the bedding and trench fill material remain unchanged from the 2019 design.

The diffuser pipe will be buried approximately 2 m (6.6 ft) below ground surface (bgs) to prevent pipe freezing. The steady state design for the diffuser is 700 gpm with the capacity for temporary flows on 900 gpm. Groundwater flow modelling was completed by iteratively testing various diffuser trench configurations under both base-flow and high-flow conditions, until a configuration that achieved the design criteria was established. Results indicate that the optimal diffuser trench configuration is located east of Hangover Creek, as shown on Drawing D07-01 (Appendix A; KCB, 2022a). This configuration comprises two trenches along the 576 masl (1,890 ft) and 588 masl (1,929 ft) elevation contours, extending from the MHT State land boundary to approximately 220 m east and 195 m east, respectively. The diffuser pipes in these trenches are separated by valves such that the pipes in the eastern portion of the trenches can be isolated from the western portion as well as from each other using isolation/flow control valves. This will enable discharge to be directed to either arm of the east diffuser or west diffuser independently, allowing a degree of flexibility in managing the diffuser discharge and controlling groundwater mound development, if required. Segmentation of the diffuser will also allow operation to continue during maintenance if required (such as excavation and replacement of a segment of drain gravel and pipe).

Each diffuser infiltration trench will consist of a clean base of gravel approximately 0.3 m (1 ft) thick. A 300 mm (12-in) perforated PVC or HDPE pipe will be placed on the gravel bedding layer, and then covered with approximately 1.2 m (3.9 ft) layer of clean gravel. Due to expected freezing conditions during the winter months, an additional 2.0 m (6.6 ft) of engineered fill will be placed on top of the geotextile.

An inverted siphon will be utilized to maintain adequate flow in the pipeline where it crosses low points at both Waterfall and Hangover creeks. A pipe crossing at this location minimizes disturbance to the drainage, but also reduces the gradient for pipe flow to the diffuser. A low-point drain will be installed at the bottom of the inverted siphons with an isolation butterfly valve to allow for complete drainage of the system, if necessary.

The diffuser is located to the southeast of the avalanche mounds, which will be designed for saturated foundation conditions. The mounds are designed to protect the road from avalanches. The LAD diffuser will not be subject to avalanche damage because it will be buried.

2.1.1.4 Supporting Pipework

The purpose of the pipe network is to convey flow from the portal to the settling ponds and the diffuser. The pipeline network design layout and corresponding profiles are represented on Drawings D07-001 through 004 in Appendix A (KCB, 2022*a*).

The piping is designed to meet the following design criteria.

- The design steady state flowrate to the settling ponds and LAD diffuser is 700 gpm
- The design temporary flowrate to the LAD diffuser is 900 gpm
- Gravity drainage will be provided where possible and supported by pumps when necessary.
- Pipe for the pipeline network will be HDPE.

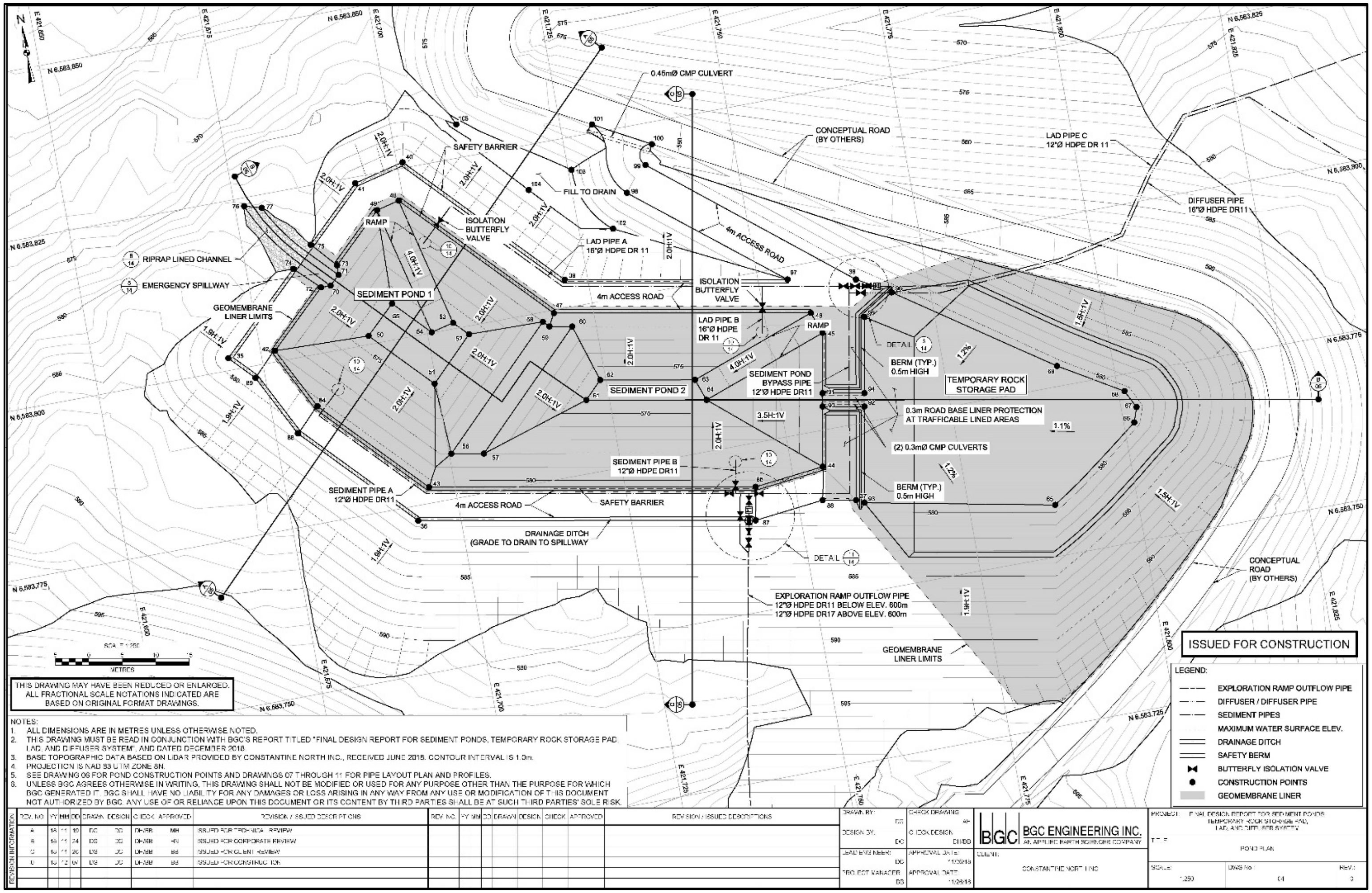
- Pipe will be buried a minimum of 2 m (6.6 ft) bgs to avoid freezing.

The LAD pipes will extend from the adit portal and will convey water directly to either the diffuser or the sediment control ponds. It is expected that under normal operations flow will be discharged directly from the adit portal to the diffuser; water will only be directed to the ponds when water discharged from the adit cannot be treated at the portal (i.e., when the water treatment infrastructure is offline, either due to malfunction or maintenance, or when seepage flows exceed the capacity of the treatment infrastructure). In this scenario, water will be stored in the sediment ponds for TSS treatment (as described in the 2018 design report by BGC) and pumped from the ponds to the diffuser. An additional inverted siphon will be required at the low point in the pipe where it crosses Hangover Creek. The proposed extended LAD pipe will follow existing roads or existing disturbed areas where possible.

LAD diffuser performance and operational life will be contingent on the degree of clogging of the trench drain gravel and surrounding overburden due to residual TSS in the discharge water. Pressure transducers installed in the diffuser area will measure water levels that, when compared to the discharge rate, will provide an indication of the degree of clogging that has occurred. If the diffuser performance decreases such that typical discharge rates cannot be maintained without risking ponding at the ground surface, the trenches may be excavated, and the drain gravel and pipe may be cleaned or replaced.

The steep grades above the ponds for this section of the piping network and potential accumulated head pressure allows for the use of PE 4710 HDPE pipe with an IPS nominal diameter of 12". Discharge from the ponds will be managed by a piping network designed to accommodate design flows to the buried diffuser. There will be minimal potential for accumulated head pressure in this section of the piping network, resulting from the differences in inlet and outlet elevation, as well as the pipe grades. Therefore, PE 4710 HDPE pipe with an IPS nominal diameter of 12" can still be used for the design flow to the diffuser.

While there are no manually induced pressures introduced into the piping network, if flow through the piping network is inhibited or shut off entirely, water could backfill into the entirety of its length. This would allow head pressure to build, with the maximum condition corresponding to the difference in the highest and lowest elevations of the system (approximate elevation 680 m (2,231 ft) to elevation 552 m (1,811 ft)). Therefore, the pressure rating of the pipes above elevation 600 m (1,969 ft) is required to be DR17 and the pressure rating of the pipes below elevation 600 (1,969 ft) m is required to be DR11. In general, pipes will be placed in a trench on 0.3 m (1 ft) of engineered fill pipe bedding and covered with engineered fill to a minimum of approximately 2.0 m (6.6 ft) above the pipe.



THIS DRAWING MAY HAVE BEEN REDUCED OR ENLARGED. ALL FRACTIONAL SCALE NOTATIONS INDICATED ARE BASED ON ORIGINAL FORMAT DRAWINGS.

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING MUST BE READ IN CONJUNCTION WITH BGC'S REPORT TITLED "FINAL DESIGN REPORT FOR SEDIMENT PONDS, TEMPORARY ROCK STORAGE PAD, LAD, AND DIFFUSER SYSTEM", AND DATED DECEMBER 2018.
3. BASE TOPOGRAPHIC DATA BASED ON LIDAR PROVIDED BY CONSTANTINE NORTH INC., RECEIVED JUNE 2018. CONTOUR INTERVAL IS 1.0m.
4. PROJECTION IS NAD 83 UTM ZONE 8N.
5. SEE DRAWING 06 FOR POND CONSTRUCTION POINTS AND DRAWINGS 07 THROUGH 11 FOR PIPE LAYOUT PLAN AND PROFILES.
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REV. NO	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS
A	18	11	19	DC	DC	DH/BB	MH	ISSUED FOR TECHNICAL REVIEW
B	18	11	24	DG	DC	DH/BB	HN	ISSUED FOR CORPORATE REVIEW
C	18	11	26	DG	DC	DH/BB	BB	ISSUED FOR CLIENT REVIEW
0	18	12	07	DG	DC	DH/BB	BB	ISSUED FOR CONSTRUCTION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS

DRAWN BY: DG
CHECK DRAWING: AF
DESIGN BY: DC
CHECK DESIGN: DH/DD
LEAD ENGINEER: DC
APPROVAL DATE: 11/30/18
PROJECT MANAGER: BB
APPROVAL DATE: 11/28/18

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: CONSTANTINE NORTH INC.

PROJECT: FINAL DESIGN REPORT FOR SEDIMENT PONDS, TEMPORARY ROCK STORAGE PAD, LAD, AND DIFFUSER SYSTEM

TITLE: POND PLAN

SCALE: 1:250
DWG No: 04
REV: 0

Figure 2. Engineered Drawings of Settling Ponds – Plan View

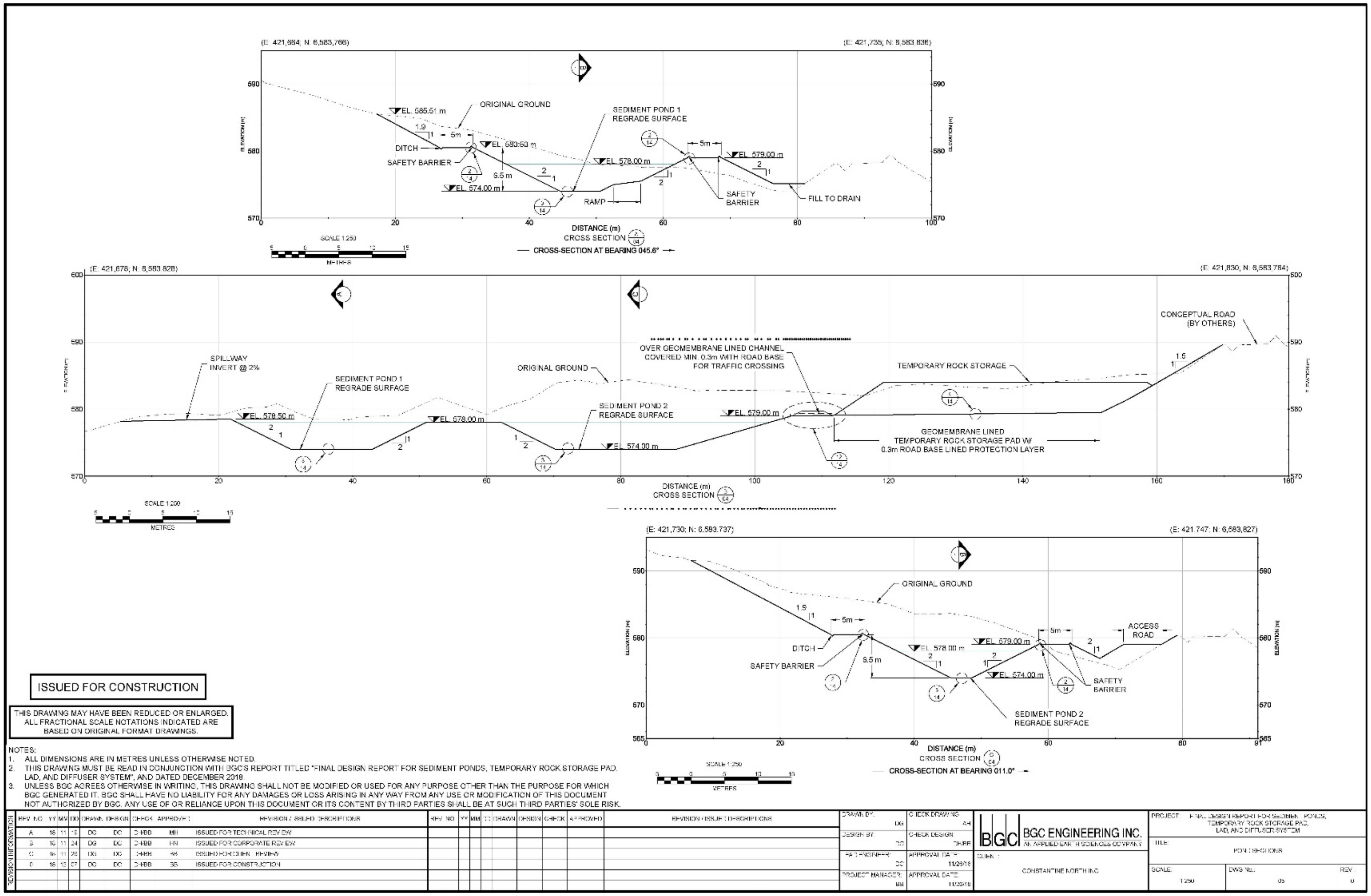
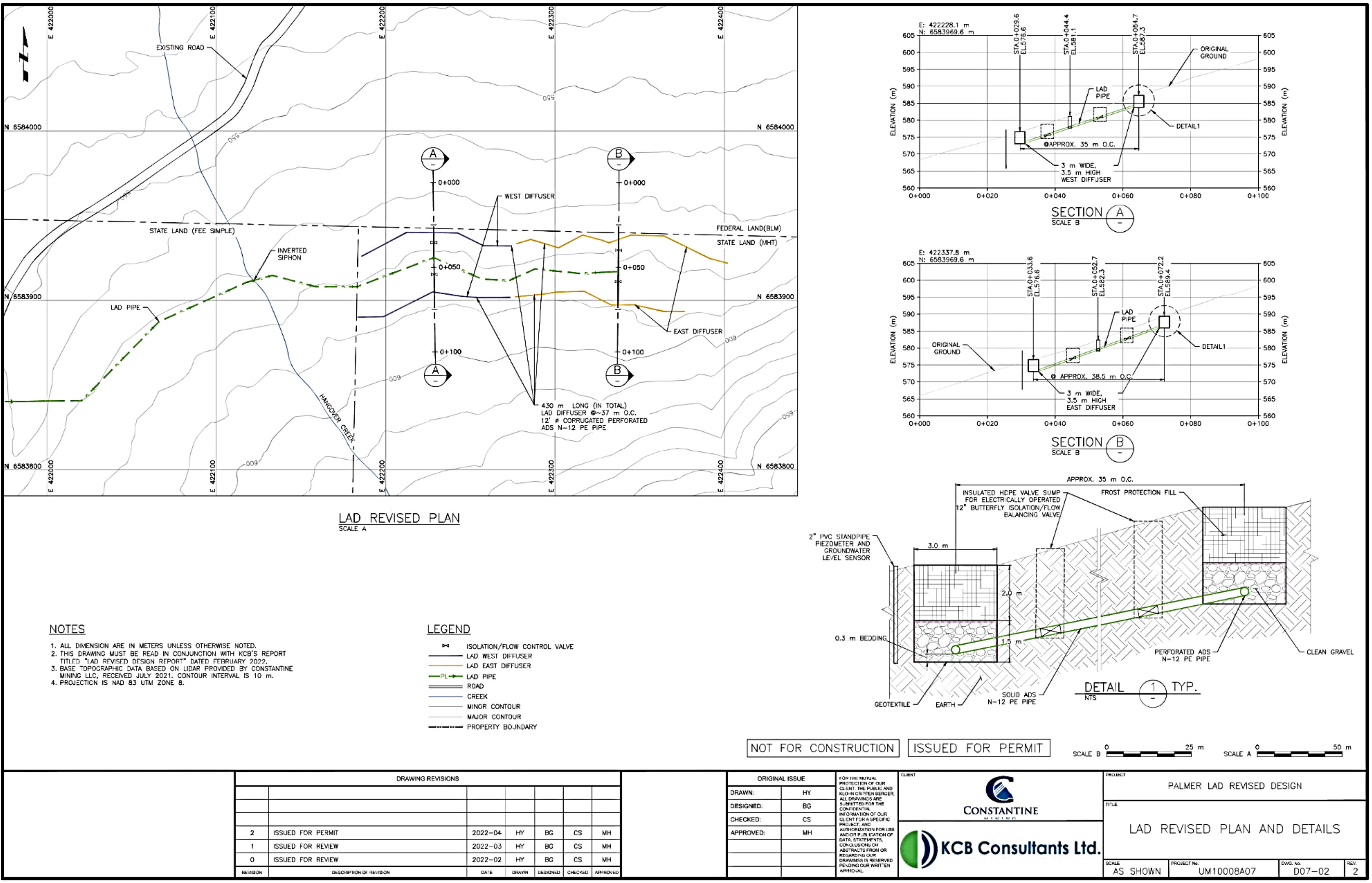


Figure 3. Engineered Drawings of Settling Ponds – Sectional View



NOTES

1. ALL DIMENSION ARE IN METERS UNLESS OTHERWISE NOTED.
2. THIS DRAWING MUST BE READ IN CONJUNCTION WITH KCB'S REPORT TITLED "LAD REVISED DESIGN REPORT" DATED FEBRUARY 2022.
3. BASE TOPOGRAPHIC DATA BASED ON LIDAR PROVIDED BY CONSTANTINE MINING LLC, RECEIVED JULY 2021. CONTOUR INTERVAL IS 10 m.
4. PROJECTION IS NAD 83 UTM ZONE 8.

LEGEND

⋈	ISOLATION/FLOW CONTROL VALVE
—	LAD WEST DIFFUSER
—	LAD EAST DIFFUSER
—PL→—	LAD PIPE
═	ROAD
—	CREEK
—	MINOR CONTOUR
—	MAJOR CONTOUR
—·—·—	PROPERTY BOUNDARY

NOT FOR CONSTRUCTION

ISSUED FOR PERMIT

DRAWING REVISIONS

REVISION	DESCRIPTION OF REVISION	DATE	DRAWN	DESIGNED	CHECKED	APPROVED
2	ISSUED FOR PERMIT	2022-04	HY	BG	CS	MH
1	ISSUED FOR REVIEW	2022-03	HY	BG	CS	MH
0	ISSUED FOR REVIEW	2022-02	HY	BG	CS	MH

ORIGINAL ISSUE	
DRAWN:	HY
DESIGNED:	BG
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PALMER LAD REVISED DESIGN

TITLE
LAD REVISED PLAN AND DETAILS

SCALE AS SHOWN
PROJECT No. UM10008A07
DWG. No. D07-02
REV. 2

Figure 4. Engineered Drawings of LAD Diffuser

2.1.2 Chemical Composition of the Wastewater

There is no pre-existing wastewater to sample to establish the exact chemical composition of the proposed wastewater discharge. Constantine's consultant pHase Geochemistry did a prediction of the discharge wastewater chemistry. The predicted wastewater chemistry is shown in Table 1 where it is compared to Alaska Water Quality guidelines and background water quality at groundwater well P29. The prediction was based on the assumptions that: 1) the seepage inflows into the exploration ramp will consist of groundwater and will be geochemically like the groundwater quality in groundwater well P29, 2) this seepage would encounter wallrock in the ramp, 3) this seepage would also come in contact with blasting residues in the ramp, and 4) these interactions would contribute to the chemistry of the wastewater discharge. PHase considered two other variables in the development of the water quality prediction, including the results of the humidity cell and barrel tests, because these were illustrative of the geochemical interaction of water with wallrock in an oxidizing environment.

PHase (2022) developed 3 predictions of discharge water quality. The first utilizes the laboratory-based humidity cell data which is scaled-up to anticipated field conditions. The second utilizes the field barrel data representing leachate from rock exposed to site climate conditions. The third is their "conservative" discharge water quality prediction using an empirical approach based on both data sets from 40 week humidity cell tests and from the field barrel tests conducted since 2017. This is considered the best prediction of water quality for the discharge as it leaves the portal.

In addition to the above, nitrogen species, resulting from explosives use, were predicted using methods provided in Ferguson & Leask (1998) and Morin & Hutt (2008). Nitrates and nitrate source control are described in more detail in Section 2.1.3.

Humidity cell data used in calculations are represented as release rates from the samples in units of mg/kg/week. Samples representing each of the three main lithological units expected in ramp development (Jasper Mountain Basalt, Limey Argillite and Hanging Wall Basalt) were tested for 40 weeks. Weekly release rates were averaged for two time periods representing the initial flush (first 10 weeks of testing) and the steady-state stable rates (cycles 11 through 40) which were then scaled.

Field barrel data were also used as a separate method of assessing potential source chemistry. Four field barrels are currently being monitored at the Palmer site, including one each for the three main rock units in the proposed exploration ramp and a fourth barrel that is collecting rainwater.

Table 1. Predicted Discharge Wastewater Chemistry Compared to Alaska Water Quality Guidelines and Background Groundwater at Station P29

		Alaska WQ Guidelines				Discharge Wastewater Chemistry (Predicted)		
Parameter	as	Acute Guideline (mg/L)	Chronic Guideline (mg/L)	*as*	Background Groundwater (GW) at Station P29	GW + Scaled Humidity Cell Concentration	GW + Field Barrel Concentration	Conservative Predicted Discharge Wastewater Chemistry
Hard as $CaCO^3$	t	—	—	—	255	907	258	907
pH	-	—	—	—	8.6	7.9	8	7.9
NH^3 as N	t	8.4	—	t	0.027	n.d.	n.d.	0.79
NO^3 as N	t	10*	—	t	0.005	n.d.	n.d.	1.1
NO^2 as N	t	1*	—	t	0.001	n.d.	n.d.	0.08
Al	d	0.75	0.75	t	0.0039	0.00024	0.0039	0.0039
As	d	0.34	0.15	d	0.00019	0.0034	0.00019	0.003
Cd	d	0.00299	0.00033	d	0.0000065	0.00015	0.0000065	0.00015
Cr-III	d	0.7942	0.1033	d	0.0002	0.0076	0.0002	0.0076
Cr-IV	d	0.0160	0.0110	d	0.0002	0.0076	0.0002	0.0076
Cu	d	0.0197	0.0127	d	0.0005	0.0079	0.0005	0.0079
Fe	d	—	1	t	0.24	0.24	0.24	0.24
Pb	d	0.10013	0.00390	d	0.000058	0.0008	0.000058	0.0008
Mn	d	0.05**	—	t	0.076	0.33	0.076	0.33
Hg	d	0.001400	0.000770	d	0.000017	0.0001	0.000017	0.0001
Ni	d	0.6598	0.0733	d	0.0005	0.0079	0.0005	0.0079
Se	d	—	0.0046	d	0.00005	0.0028	0.00005	0.0028
Ag	d	0.00646	—	d	0.00001	0.00016	0.00001	0.00016
V	d	0.1***	—	t	0.0005	0.11	0.0005	0.11
Zn	d	0.1652	0.1666	d	0.00087	0.045	0.00087	0.045
Notes:		Note: Data is presented as dissolved metals (d) or total metals (t) in mg/L						
		n.d. is non detectable						
		Guidelines were taken from: *Alaska Water Quality Criteria Manual for Toxic And Other Deleterious Organic and Inorganic Substances (DEC, 2008)*; guidelines for dissolved metals are presented						
		Acute and Chronic guidelines for Freshwater Aquatic Life are presented, unless more stringent guidelines were available; * = drinking water; ** = human health for the consumption of water and aquatic organisms; *** = irrigation water						
		If parameters of interest are not presented, no exceedance was observed						
		For calculation of hardness-dependent guidelines, an assumed hardness of 150 mg/L as CaCO3 was used; pH was assumed to be ≥8						

2.1.3 Nitrates and Nitrate Source Control

As described in Section 2.1.2 underground seepage water will encounter blasting residues in the underground ramp and this will likely result in the contribution of nitrate compounds to the wastewater discharge. PHase (2022) considered this in their wastewater prediction work and the predicted concentrations of these nitrate compounds (NH^3, NO^3 and NO^2) are shown in Table 1 and Table 2. Constantine will monitor nitrate concentrations through water quality sampling and explosives handling procedures (below) will be adjusted accordingly.

The generally accepted best practice for minimizing nitrate concentrations in mine drainage water is nitrate source control. Nitrate source controls are BMP's designed to minimize the amount of nitrate generated underground by strictly controlling the handling of explosives underground. Constantine will implement several nitrate source control BMP's to minimize nitrates in the wastewater discharge as described in Appendix C.

2.2 Adaptive Water Management Strategies

There is typically a degree of uncertainty, or a lack of precision, in the prediction of seepage rates of groundwater into any underground excavation, including the ramp system proposed by Constantine. With a robust data set supported by field investigations and computer modeling, the seepage estimate can still have a range that is as large as an order of magnitude (i.e., 50 to 500 gpm, or 10 to 100 gpm).

To address this uncertainty Constantine has thoroughly considered a range of options for managing water, including options for managing the unlikelihood of unanticipated high seepage rates. Constantine also discusses water management in its Water Management Plan included as Appendix C with this application.

Constantine will use an adaptive management strategy for managing seepage inflows. It will be prepared to implement several different operating procedures in response to changing conditions to reduce or minimize seepage rates into the ramp system. It is important to note that Constantine will be advancing the ramp at an average rate of approximately 12 ft/day and will be probing (with a drill hole) in front of that, to detect any new significant water inflows before the ramp advanced into these zones of higher seepage. Constantine has the flexibility to stop the ramp at any time before it intersects unanticipated large volumes of water once they are identified out "in front" of the ramp in a probe hole. This greatly minimizes the likelihood of any sudden unanticipated inflows into the ramp from the start, and as a result the strategy is to identify these and then takes step to minimizes seepage before piercing these zones with the ramp itself.

Constantine may implement one or more of the following adaptive strategies in response to conditions underground with the objective of minimizing seepage inflows into the ramp.

- Drill probe holes in front of the advancing ramp to identify fracture zones, perform hydrogeology testing, and define seepage rates in advance of intersecting them with the ramp.
- Use pressure grouting techniques to create a grout curtain around the ramp to minimize the seepage inflows when they are identified in the probe holes, prior to intersecting them with the ramp.
- Plug and cement all exploration drill holes unless required to be left open for hydrogeology or other surveys.

- Install pressure transducers in underground artesian drillholes or perform other hydrogeologic tests underground to contribute to the understanding and characterization of the groundwater in the area.
- Modify or add additional underground sumps to encourage settling of solids before water is pumped to settling ponds.

2.3 Background Groundwater Quality in the Project Area

Characterizing the background groundwater quality in the project area is fundamental to predicting the quality of groundwater seepage that will be encountered in the proposed underground ramp.

Constantine has been monitoring groundwater quality and/or water levels in 29 monitoring wells in the project area (Figure 5). The background water quality in the general vicinity of the proposed underground ramp is generally represented by wells P29, P17 and possibly spring P19. However, sample location P29 is in closest proximity to the proposed underground ramp and interpreted to be the most representative sample of seepage water that will report to the ramp. As a result, pHase (2022) used this background water quality to predict the discharge water quality, after considering some chemical interactions with the wall rock and blasting compounds as discussed in Section 2.1.2.

Groundwater quality data for sample sites P17, P19 and P29 are summarized in Table 2 and compared to Alaska Chronic, Acute and Human Health Guidelines. The Table illustrates that P29 exceeded the Human Health criteria for Mn, and the spring at P19 exceeded chronic aquatic life standards for Al, Cd, and Fe, and the Human Health criteria for Mn. There are additional monitoring data for sample sites since 2019 and ADEC is in receipt of the data for groundwater monitoring wells MW-01 and MW-02.

Integral Consulting (2018*a*) evaluated the groundwater sampling data for P29, P17 and P19 and concluded the following.

- Station P19 (spring) sample results exceeded the chronic and acute aquatic life standard (0.75 mg/L) for total aluminum in August 2015 and August 2016,
- Station P19 (spring) sample results exceeded the chronic standard (1 mg/L) for total iron in August 2015, August 2016, and July 2017, and
- Station P19 (spring) dissolved cadmium concentration was above the hardness- based chronic aquatic life standard for one event. This sample, collected on August 5, 2015, was slightly above the calculated hardness-based standard of 0.35 µg/L, with a measured concentration of 0.64 µg/L.

No exceedances of the chronic or acute aquatic life standards were observed for any of the groundwater samples collected from drillhole locations P17 or P29. When compared to standards for human health consumption of water and aquatic organisms, concentrations of manganese for all three samples from station P29 and 1 sample from station P19 (spring) were above the consumption standard of 50 µg/L for manganese.

Constantine has also been monitoring two additional groundwater wells located west of the proposed diffuser since 2018. These are wells MW-01 and MW-02 and are also illustrated on Figure 5. ADEC is in receipt of all monitoring data for these wells. In addition, Constantine developed additional groundwater monitoring wells in 2021. Two of those wells are specifically located to provide ground water monitoring up- and down-gradient of the new location of the LAD diffuser (see Figure 5). Those wells were sampled once in 2021 and will be sampled as many as three times in 2022. Constantine will provide all these data to ADEC for their consideration as they consider establishing monitoring requirements for the new LAD diffuser location prior to commissioning the LAD system.

Constantine engaged HDR Consultants in 2021 to review groundwater information for the Project. The following is modified from HDR (2022*a*) final report.

Total metal concentrations in groundwater are typically similar across the valley-fill, bedrock, and spring sampling locations. However, the spring (P19) does have higher concentrations of cadmium, selenium, and zinc than the other sample locations. Groundwater measured at the spring exhibits higher concentrations of total metals than the bedrock wells on two dates in particular, August 2015 and August 2016. This likely results from those sample events more closely following a precipitation event, since shallow groundwater expressing from the spring is fed by infiltration of rainfall through soil and fractured rock, causing solids to become entrained in the groundwater.

Dissolved metal concentrations are typically much lower than the total metal concentrations except for selenium for most sampling events and occasionally for manganese. In some cases, these trends could be linked with high turbidity readings caused by particulate matter. Samples have typically been taken during the second and third quarter, with only a few wells having a sample collected during the first and fourth quarters. Based on current results, it is difficult to determine if seasonal variation exists among metal concentrations at the different sample locations. The data show that, except for aluminum and manganese, the metals concentrations were generally lower than the AWQS in all of the groundwater monitored.

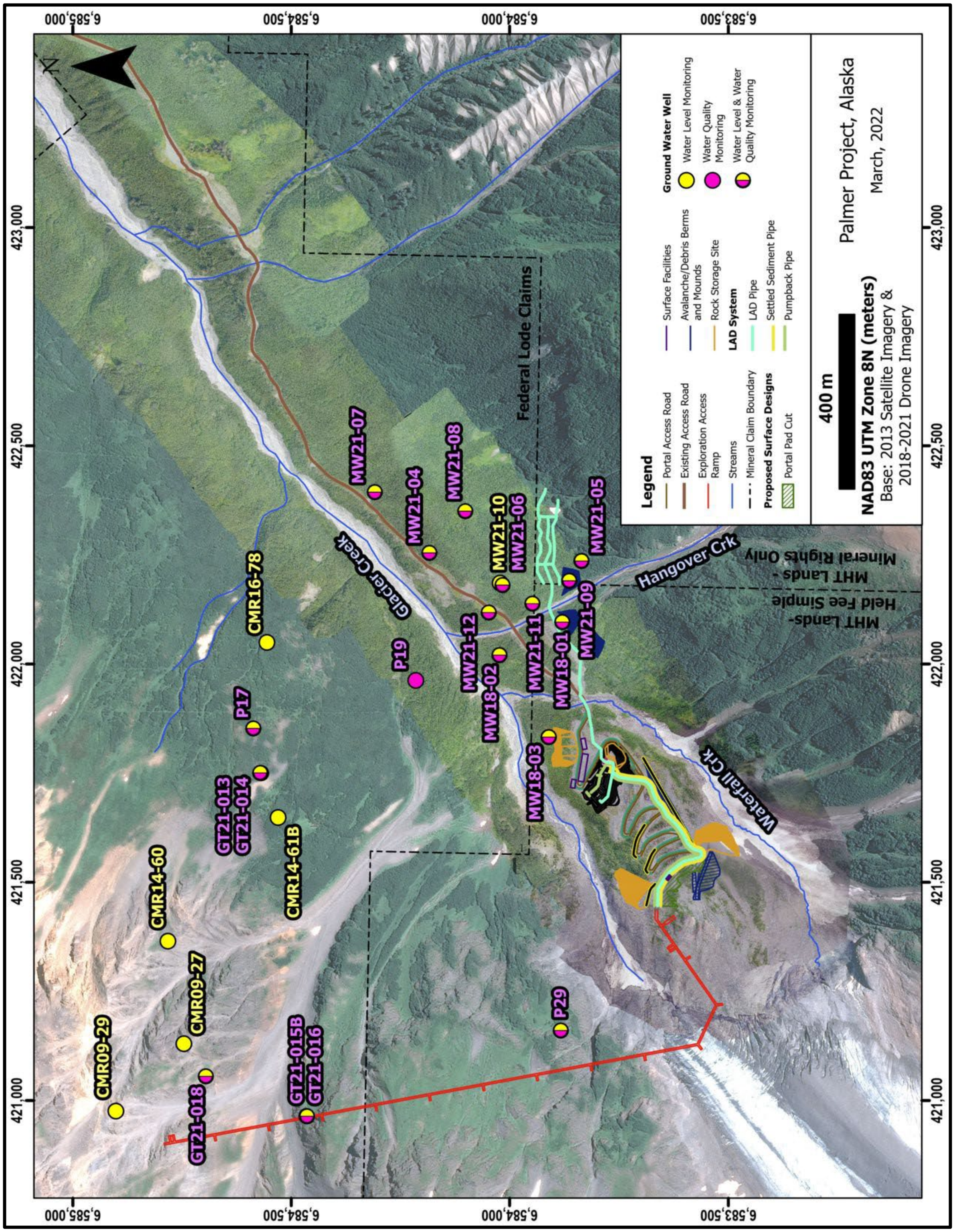
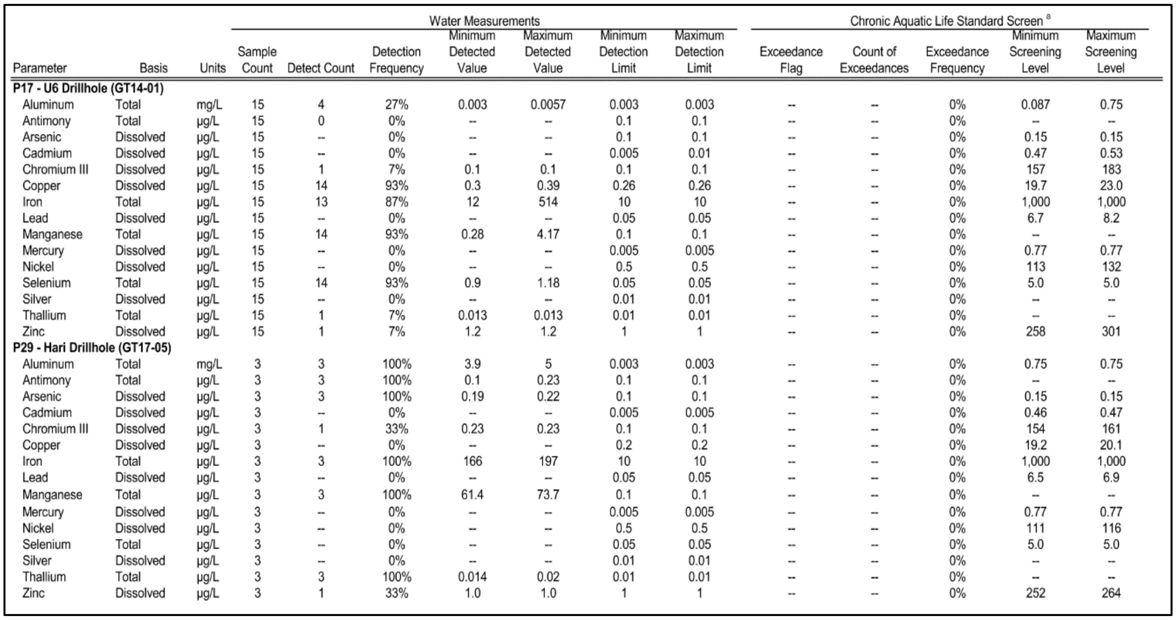
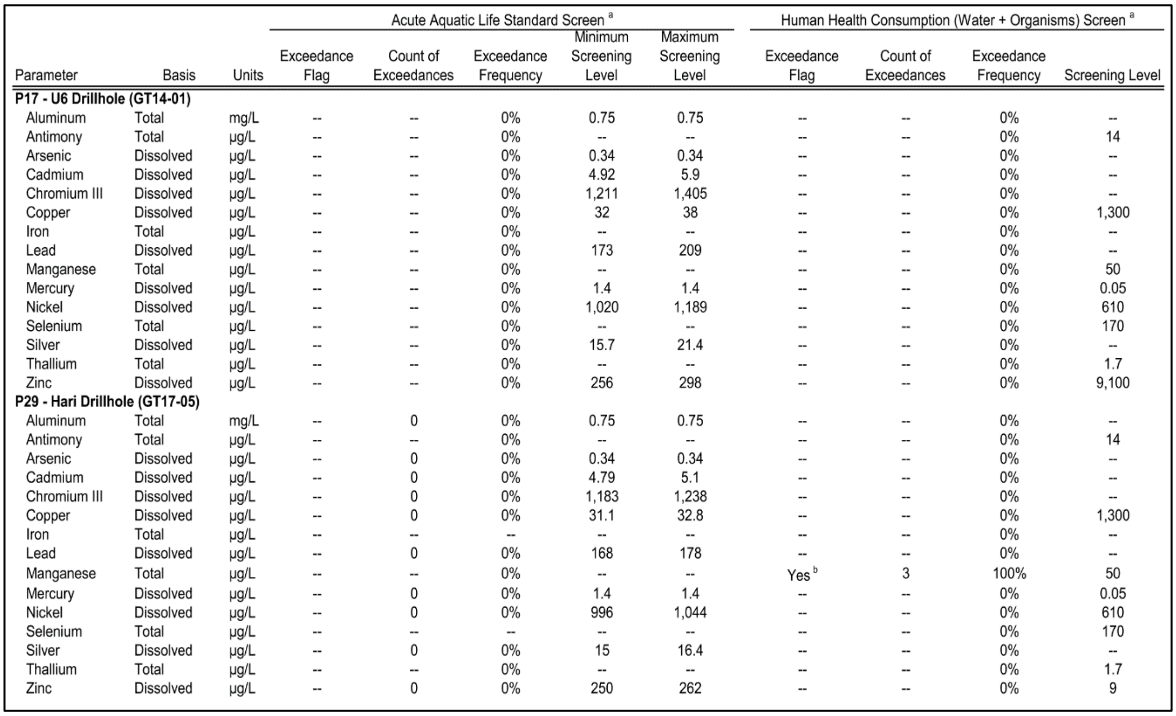


Figure 5. Groundwater Monitoring Sites

Table 2. Predicted Groundwater Quality in Wells and Springs Near Proposed Underground Ramp (Integral 2018*a*)

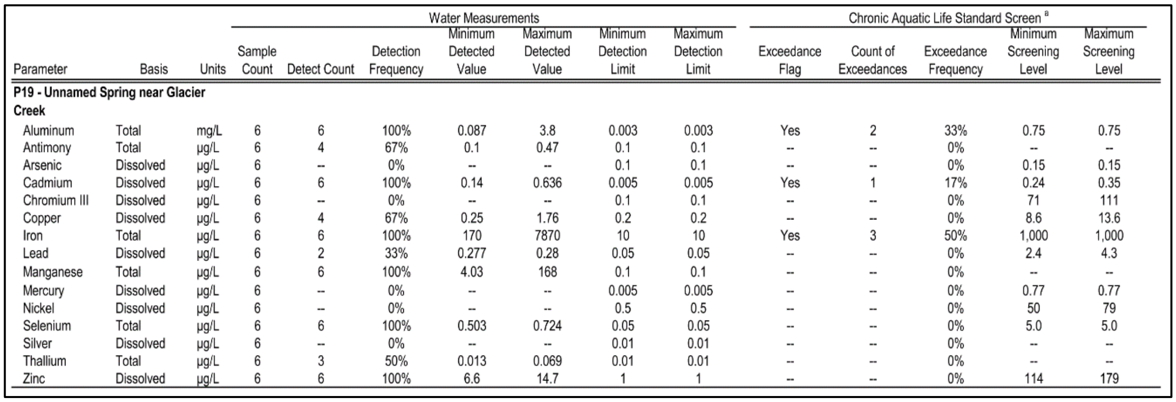


			Water Measurements							Chronic Aquatic Life Standard Screen [a]				
Parameter	Basis	Units	Sample Count	Detect Count	Detection Frequency	Minimum Detected Value	Maximum Detected Value	Minimum Detection Limit	Maximum Detection Limit	Exceedance Flag	Count of Exceedances	Exceedance Frequency	Minimum Screening Level	Maximum Screening Level
P17 - U6 Drillhole (GT14-01)														
Aluminum	Total	mg/L	15	4	27%	0.003	0.0057	0.003	0.003	--	--	0%	0.087	0.75
Antimony	Total	µg/L	15	0	0%	--	--	0.1	0.1	--	--	0%	--	--
Arsenic	Dissolved	µg/L	15	--	0%	--	--	0.1	0.1	--	--	0%	0.15	0.15
Cadmium	Dissolved	µg/L	15	--	0%	--	--	0.005	0.01	--	--	0%	0.47	0.53
Chromium III	Dissolved	µg/L	15	1	7%	0.1	0.1	0.1	0.1	--	--	0%	157	183
Copper	Dissolved	µg/L	15	14	93%	0.3	0.39	0.26	0.26	--	--	0%	19.7	23.0
Iron	Total	µg/L	15	13	87%	12	514	10	10	--	--	0%	1,000	1,000
Lead	Dissolved	µg/L	15	--	0%	--	--	0.05	0.05	--	--	0%	6.7	8.2
Manganese	Total	µg/L	15	14	93%	0.28	4.17	0.1	0.1	--	--	0%	--	--
Mercury	Dissolved	µg/L	15	--	0%	--	--	0.005	0.005	--	--	0%	0.77	0.77
Nickel	Dissolved	µg/L	15	--	0%	--	--	0.5	0.5	--	--	0%	113	132
Selenium	Total	µg/L	15	14	93%	0.9	1.18	0.05	0.05	--	--	0%	5.0	5.0
Silver	Dissolved	µg/L	15	--	0%	--	--	0.01	0.01	--	--	0%	--	--
Thallium	Total	µg/L	15	1	7%	0.013	0.013	0.01	0.01	--	--	0%	--	--
Zinc	Dissolved	µg/L	15	1	7%	1.2	1.2	1	1	--	--	0%	258	301
P29 - Hari Drillhole (GT17-05)														
Aluminum	Total	mg/L	3	3	100%	3.9	5	0.003	0.003	--	--	0%	0.75	0.75
Antimony	Total	µg/L	3	3	100%	0.1	0.23	0.1	0.1	--	--	0%	--	--
Arsenic	Dissolved	µg/L	3	3	100%	0.19	0.22	0.1	0.1	--	--	0%	0.15	0.15
Cadmium	Dissolved	µg/L	3	--	0%	--	--	0.005	0.005	--	--	0%	0.46	0.47
Chromium III	Dissolved	µg/L	3	1	33%	0.23	0.23	0.1	0.1	--	--	0%	154	161
Copper	Dissolved	µg/L	3	--	0%	--	--	0.2	0.2	--	--	0%	19.2	20.1
Iron	Total	µg/L	3	3	100%	166	197	10	10	--	--	0%	1,000	1,000
Lead	Dissolved	µg/L	3	--	0%	--	--	0.05	0.05	--	--	0%	6.5	6.9
Manganese	Total	µg/L	3	3	100%	61.4	73.7	0.1	0.1	--	--	0%	--	--
Mercury	Dissolved	µg/L	3	--	0%	--	--	0.005	0.005	--	--	0%	0.77	0.77
Nickel	Dissolved	µg/L	3	--	0%	--	--	0.5	0.5	--	--	0%	111	116
Selenium	Total	µg/L	3	--	0%	--	--	0.05	0.05	--	--	0%	5.0	5.0
Silver	Dissolved	µg/L	3	--	0%	--	--	0.01	0.01	--	--	0%	--	--
Thallium	Total	µg/L	3	3	100%	0.014	0.02	0.01	0.01	--	--	0%	--	--
Zinc	Dissolved	µg/L	3	1	33%	1.0	1.0	1	1	--	--	0%	252	264

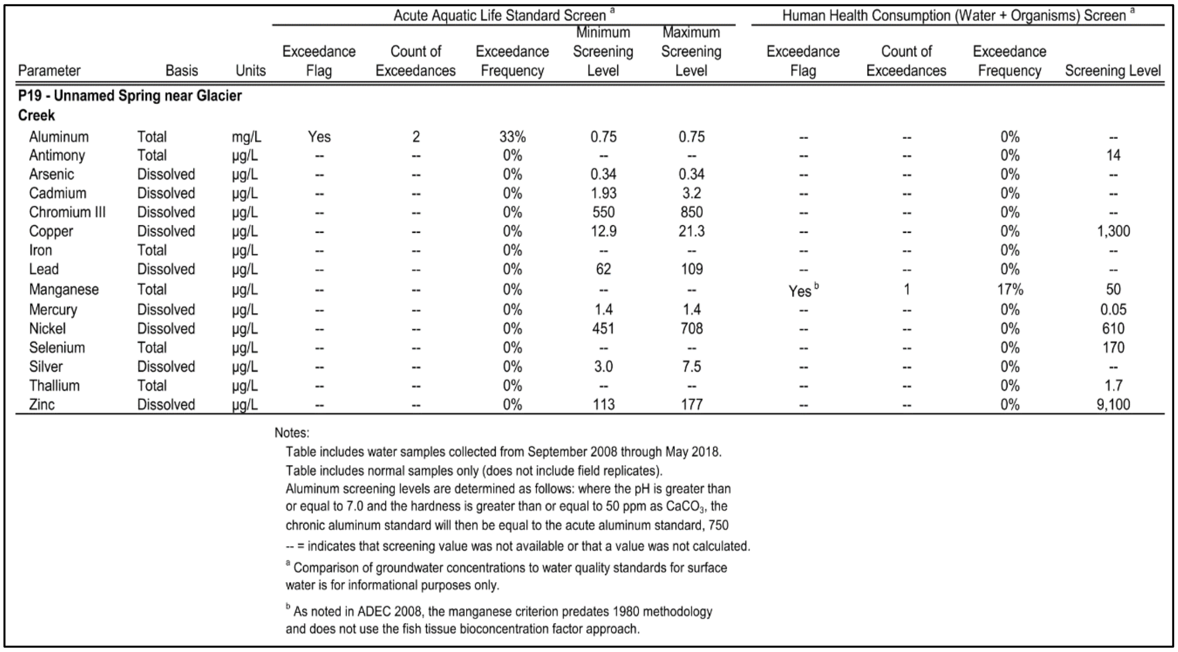


			Acute Aquatic Life Standard Screen [a]					Human Health Consumption (Water + Organisms) Screen [a]			
Parameter	Basis	Units	Exceedance Flag	Count of Exceedances	Exceedance Frequency	Minimum Screening Level	Maximum Screening Level	Exceedance Flag	Count of Exceedances	Exceedance Frequency	Screening Level
P17 - U6 Drillhole (GT14-01)											
Aluminum	Total	mg/L	--	--	0%	0.75	0.75	--	--	0%	--
Antimony	Total	µg/L	--	--	0%	--	--	--	--	0%	14
Arsenic	Dissolved	µg/L	--	--	0%	0.34	0.34	--	--	0%	--
Cadmium	Dissolved	µg/L	--	--	0%	4.92	5.9	--	--	0%	--
Chromium III	Dissolved	µg/L	--	--	0%	1,211	1,405	--	--	0%	--
Copper	Dissolved	µg/L	--	--	0%	32	38	--	--	0%	1,300
Iron	Total	µg/L	--	--	0%	--	--	--	--	0%	--
Lead	Dissolved	µg/L	--	--	0%	173	209	--	--	0%	--
Manganese	Total	µg/L	--	--	0%	--	--	--	--	0%	50
Mercury	Dissolved	µg/L	--	--	0%	1.4	1.4	--	--	0%	0.05
Nickel	Dissolved	µg/L	--	--	0%	1,020	1,189	--	--	0%	610
Selenium	Total	µg/L	--	--	0%	--	--	--	--	0%	170
Silver	Dissolved	µg/L	--	--	0%	15.7	21.4	--	--	0%	--
Thallium	Total	µg/L	--	--	0%	--	--	--	--	0%	1.7
Zinc	Dissolved	µg/L	--	--	0%	256	298	--	--	0%	9,100
P29 - Hari Drillhole (GT17-05)											
Aluminum	Total	mg/L	--	0	0%	0.75	0.75	--	--	0%	--
Antimony	Total	µg/L	--	--	0%	--	--	--	--	0%	14
Arsenic	Dissolved	µg/L	--	0	0%	0.34	0.34	--	--	0%	--
Cadmium	Dissolved	µg/L	--	0	0%	4.79	5.1	--	--	0%	--
Chromium III	Dissolved	µg/L	--	0	0%	1,183	1,238	--	--	0%	--
Copper	Dissolved	µg/L	--	0	0%	31.1	32.8	--	--	0%	1,300
Iron	Total	µg/L	--	--	--	--	--	--	--	0%	--
Lead	Dissolved	µg/L	--	0	0%	168	178	--	--	0%	--
Manganese	Total	µg/L	--	--	0%	--	--	Yes [b]	3	100%	50
Mercury	Dissolved	µg/L	--	0	0%	1.4	1.4	--	--	0%	0.05
Nickel	Dissolved	µg/L	--	0	0%	996	1,044	--	--	0%	610
Selenium	Total	µg/L	--	--	--	--	--	--	--	0%	170
Silver	Dissolved	µg/L	--	0	0%	15	16.4	--	--	0%	--
Thallium	Total	µg/L	--	--	0%	--	--	--	--	0%	1.7
Zinc	Dissolved	µg/L	--	0	0%	250	262	--	--	0%	9

Table 2 cont'd. Groundwater Quality in Wells and Springs Near Proposed Underground Ramp (Integral. 2018*a*)



			Water Measurements							Chronic Aquatic Life Standard Screen [a]				
Parameter	Basis	Units	Sample Count	Detect Count	Detection Frequency	Minimum Detected Value	Maximum Detected Value	Minimum Detection Limit	Maximum Detection Limit	Exceedance Flag	Count of Exceedances	Exceedance Frequency	Minimum Screening Level	Maximum Screening Level
P19 - Unnamed Spring near Glacier Creek														
Aluminum	Total	mg/L	6	6	100%	0.087	3.8	0.003	0.003	Yes	2	33%	0.75	0.75
Antimony	Total	µg/L	6	4	67%	0.1	0.47	0.1	0.1	--	--	0%	--	--
Arsenic	Dissolved	µg/L	6	--	0%	--	--	0.1	0.1	--	--	0%	0.15	0.15
Cadmium	Dissolved	µg/L	6	6	100%	0.14	0.636	0.005	0.005	Yes	1	17%	0.24	0.35
Chromium III	Dissolved	µg/L	6	--	0%	--	--	0.1	0.1	--	--	0%	71	111
Copper	Dissolved	µg/L	6	4	67%	0.25	1.76	0.2	0.2	--	--	0%	8.6	13.6
Iron	Total	µg/L	6	6	100%	170	7870	10	10	Yes	3	50%	1,000	1,000
Lead	Dissolved	µg/L	6	2	33%	0.277	0.28	0.05	0.05	--	--	0%	2.4	4.3
Manganese	Total	µg/L	6	6	100%	4.03	168	0.1	0.1	--	--	0%	--	--
Mercury	Dissolved	µg/L	6	--	0%	--	--	0.005	0.005	--	--	0%	0.77	0.77
Nickel	Dissolved	µg/L	6	--	0%	--	--	0.5	0.5	--	--	0%	50	79
Selenium	Total	µg/L	6	6	100%	0.503	0.724	0.05	0.05	--	--	0%	5.0	5.0
Silver	Dissolved	µg/L	6	--	0%	--	--	0.01	0.01	--	--	0%	--	--
Thallium	Total	µg/L	6	3	50%	0.013	0.069	0.01	0.01	--	--	0%	--	--
Zinc	Dissolved	µg/L	6	6	100%	6.6	14.7	1	1	--	--	0%	114	179



			Acute Aquatic Life Standard Screen [a]					Human Health Consumption (Water + Organisms) Screen [a]			
Parameter	Basis	Units	Exceedance Flag	Count of Exceedances	Exceedance Frequency	Minimum Screening Level	Maximum Screening Level	Exceedance Flag	Count of Exceedances	Exceedance Frequency	Screening Level
P19 - Unnamed Spring near Glacier Creek											
Aluminum	Total	mg/L	Yes	2	33%	0.75	0.75	--	--	0%	--
Antimony	Total	µg/L	--	--	0%	--	--	--	--	0%	14
Arsenic	Dissolved	µg/L	--	--	0%	0.34	0.34	--	--	0%	--
Cadmium	Dissolved	µg/L	--	--	0%	1.93	3.2	--	--	0%	--
Chromium III	Dissolved	µg/L	--	--	0%	550	850	--	--	0%	--
Copper	Dissolved	µg/L	--	--	0%	12.9	21.3	--	--	0%	1,300
Iron	Total	µg/L	--	--	0%	--	--	--	--	0%	--
Lead	Dissolved	µg/L	--	--	0%	62	109	--	--	0%	--
Manganese	Total	µg/L	--	--	0%	--	--	Yes [b]	1	17%	50
Mercury	Dissolved	µg/L	--	--	0%	1.4	1.4	--	--	0%	0.05
Nickel	Dissolved	µg/L	--	--	0%	451	708	--	--	0%	610
Selenium	Total	µg/L	--	--	0%	--	--	--	--	0%	170
Silver	Dissolved	µg/L	--	--	0%	3.0	7.5	--	--	0%	--
Thallium	Total	µg/L	--	--	0%	--	--	--	--	0%	1.7
Zinc	Dissolved	µg/L	--	--	0%	113	177	--	--	0%	9,100

Notes:

Table includes water samples collected from September 2008 through May 2018.

Table includes normal samples only (does not include field replicates).

Aluminum screening levels are determined as follows: where the pH is greater than or equal to 7.0 and the hardness is greater than or equal to 50 ppm as $CaCO_3$, the chronic aluminum standard will then be equal to the acute aluminum standard, 750

-- = indicates that screening value was not available or that a value was not calculated.

[a] Comparison of groundwater concentrations to water quality standards for surface water is for informational purposes only.

[b] As noted in ADEC 2008, the manganese criterion predates 1980 methodology and does not use the fish tissue bioconcentration factor approach.

2.4 Background Surface Water Quality in the Project Area

Constantine has been characterizing surface water quality by collecting samples from up to 27 stations since 2008 including samples in lower Waterfall and Hangover creeks and Glacier Creek above the confluence with Waterfall Creek (Figure 6). The project area where the surface proposed project disturbance activities and wastewater discharges will occur are drained by Waterfall Creek, Hangover Creek and Glacier Creek.

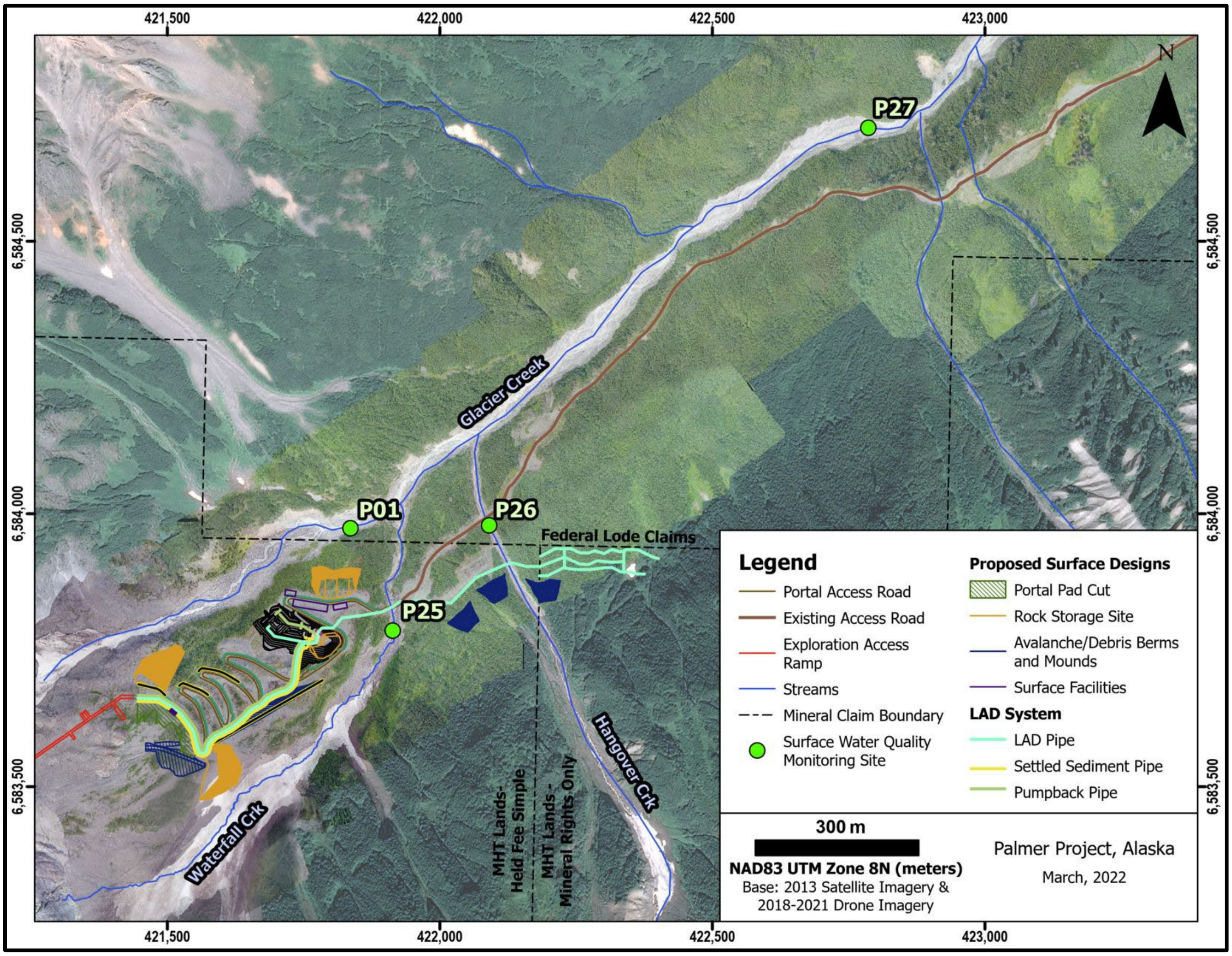


Figure 6. Surface Water Quality Sample Location Map Near the Confluences of Glacier, Waterfall and Hangover Creeks

Constantine's consultant Integral (2018*b*) observed a large variability in the concentrations of many water quality parameters between locations and at different times of year. Differences in local geology and mineralization, as well as the variable proportion of glacial melt/surface runoff and base flow comprising streamflow, are expected to influence water quality and drive variations in conventional, major ion, and metal concentrations between sampling locations. Larger, glacier fed streams (the Klehini River and Glacier Creek) tend to carry higher amounts of suspended solids during periods of snowmelt (late spring through summer) and during precipitation events. Smaller tributaries generally have lower suspended solid loads, clearer waters, and lower flow volume; water chemistry in these streams may be more heavily influenced by groundwater and local geology.

Integral (2018*b*) summarized that the surface waters in the immediate project area and surrounding areas (not shown in Figures) generally exhibit high quality water. However, some natural surface water concentrations measured were above the chronic and acute water quality standards for the following metals (as summarized in Table 3):

- Chronic and acute standards were widely exceeded for total aluminum in Glacier Creek and its tributaries, Waterfall Creek, Hangover Creek, Oxide Creek and Argillite Creek.
- Chronic standard for dissolved cadmium exceeded at sites in Oxide Creek
- Chronic standard for total Iron extensively exceeded (Klehini River, Glacier Creek, Waterfall Creek, Hangover Creek, Oxide Creek, Argillite Creek)
- Total selenium above chronic life standard in Argillite Creek
- Dissolved zinc exceeded acute standards in lower Oxide Creek
- Concentrations of total manganese were above the human health consumption (water + organisms) standard at multiple stations (Klehini River, Glacier Creek, Waterfall Creek, Hangover Creek, Oxide Creek, Argillite Creek)
- Note that elevated aluminum, iron and manganese concentrations were associated with particulates suspended in the water (TSS)

For all metals except cadmium, the laboratory reports and/or validator-assigned concentration detection limits are below the Alaska water quality standards. This indicates that the analytical methods used meet the DQO outlined in the project QAPP are appropriate, and that the baseline data set is acceptable for comparison to Alaska water quality guidelines.

In 2021 Constantine engaged HDR Consultants to review the surface water quality data monitoring for the project for the period 2008 – 2021. In part this was a repeat of Integral’s 2018 work but the more recent HDR (2022) work included an additional 4 years of data and reached many of the same observations and conclusions.

Table 3. Comparison of Surface Water Quality to Freshwater Aquatic Life and Human Health Criteria for Metals (Integral 2018b)

		Chronic Aquatic Life					Acute Aquatic Life		Human Health
		Aluminum	Cadmium	Iron	Selenium	Zinc	Aluminum	Zinc	Manganese
Station ID	Location Description	Total	Dissolved	Total	Total	Dissolved	Total	Dissolved	Total
Klehini River									
P14	Klehini River Upstream of Glacier Creek	11	-	11	-	-	11	-	11
P14B	Klehini River HWY Mile 36	4	-	4	-	-	4	-	4
P28	Klehini River HWY Mile 26 at bridge	3	-	3	-	-	3	-	3
Glacier Creek									
P1	Glacier Creek (Saksai) upper station	12	-	12	-	-	11	-	11
P27	Glacier Creek mid station	3	-	3	-	-	2	-	2
P6	Glacier Creek lower station	11	-	11	-	-	11	-	11
Tributaries to Glacier Creek									
P25	Waterfall Creek	2	-	2	-	-	2	-	2
P26	Hangover Creek	2	-	2	-	-	2	-	1
P11	Oxide Creek upper station	-	10		-	-	-	-	
P2	Oxide Creek lower station (lower branch of split channel)	1	-	1	-	1	1	1	1
P2A	Oxide Creek lower station (upper branch of split channel)	-	5	-	-	8	-	8	-
P4	Argillite Creek	3	-	3	8	-	3	-	3
Total, All Stations		52	15	52	8	9	50	9	49

Notes:
Table includes water samples collected from September 2008 through May 2018.
Table includes the following stations: P1, P1B, P6, P27, P28, P14, P14B, P25, P26, P4, P5, P11, P2, and P2A.
Table includes normal samples only (does not include field replicates).
- = indicates that screening level was not exceeded

2.5 LAD Construction Schedule and Disposal Timeline

Constantine intends to initiate construction of the LAD system as early as possible after spring thaw in 2022 and continue construction through the summer of 2022 until the LAD is complete, assuming this LAD design review is concluded positively. Table 4 illustrates the tentative construction schedule. Note that even through the construction schedule in the table ends in October 2023, underground ramp construction will continue for approximately 1 year.

Constantine will bury the LAD pipes concurrent with the road construction in June 2022. They will construct the LAD diffuser concurrent with the pond construction starting in August 2022.

Constantine will install the water treatment plant underground after the space for the plant is excavated in summer 2023. Water treatment operations will begin as soon as the need for seepage water treatment is required.

Table 4. Tentative Construction Schedule for Wastewater Disposal System

Construction Component	2022					2023				
	June '22	July '22	Aug '22	Sept '22	Oct '22	June '23	July '23	Aug '23	Sept '23	Oct '23
Road Construction	▨	▨								
LAD Pipe Installation	▨	▨								
Diffuser Installation			▨	▨	▨					
Pond Construction			▨	▨	▨					
Pump Installation & Instrumentation						▨	▨	▨		
Water Treatment Plant Install/Commission						▨	▨	▨		
Underground Ramp Construction						▨	▨	▨	▨	▨

Wastewater discharge will begin as soon as measurable seepage inflows are encountered in the advancing exploration ramp, expected in late July or August 2023. Wastewater discharge will continue for the life of the underground exploration program which is anticipated to last approximately 3-4 years from the start of the ramp development. As a result, the wastewater discharge is temporary in the sense that it will end at a point in time following the underground exploration program when decisions are made about the future path for the project. If the decision is made not to advance the project, then a hydraulic portal plug will be installed in the ramp. If the project is going to advance, then Constantine will approach ADEC to discuss options for managing the discharge or closing the portal. In any case Constantine has included the estimated cost for the portal plug design and installation in their reclamation cost estimate and will include it in their financial assurance.

2.6 Responsible Persons

The Palmer Project is owned and operated by Constantine Mining LLC, a Joint Venture company controlled by Constantine North Inc (44.9%) and Dowa Metals & Mining Alaska Ltd. (55.1%), both of which are incorporated under the laws of the State of Alaska. The Palmer Project operations manager is Michael Vande Guchte and Allegra Cairns is the environmental manager, and the technical lead for operating the proposed wastewater disposal system is too be determined. Contact information is as follows:

Constantine Mining LLC	Haines, AK	
Michael Vande Guchte	Operations Manager	907-766-2057
Allegra Cairns	Environmental Manager	907-766-2057
TBD	Facilities Manager	907-

2.7 Water Monitoring

Constantine will perform a range of monitoring activities during the proposed underground program. These monitoring efforts are fully described in the Monitoring Plan Phase II - Underground Exploration, Upland Mining Lease No. 9100759.

Water quality monitoring that Constantine will perform during the Phase II program is excerpted from the monitoring plan and included below. There may be additional monitoring requirements in a future waste management permit amendment from ADEC. Constantine will update its monitoring plan to reflect any changes in monitoring requirements.

2.7.1 Surface Water Quality Monitoring

Constantine will continue water quality sampling at sites P01 and P27 in upper and mid-Glacier Creek, respectively and P25 in Waterfall Creek, and P26 in Hangover Creek. These sites are the most relevant sites for detecting any significant change in water quality, over time, that may coincide with Constantine's underground exploration activities which are restricted to the upper Glacier Creek area. Sampling frequency will generally be 4x/year in the ice-free months. Water quality sampling and analytical procedures will remain unchanged and be performed in accordance with Constantine's QAPP. Other surface water sampling sites are sampled opportunistically.

2.7.2 Groundwater Quality Monitoring

Constantine has been performing groundwater quality sampling since 2014. Objectives of the sampling were to characterize groundwater as a step in predicting the quality of seepage water inflows into any future underground ramp and to characterize groundwater in the overburden where the LAD diffuser will be constructed. Transducers have been installed in all suitable groundwater wells to monitor groundwater levels. Water quality sampling was performed in accordance with Constantine's QAPP.

Constantine has several groundwater wells proximal to the alignment of the underground drift, including site P17 at drillhole GT14-01, and site P29 at drill hole GT17-05, which continue to be sampled during the snow-free season.

In 2018 Constantine developed two groundwater monitoring wells above and below the proposed 2018 LAD lower diffuser site (MW-01 and MW-02, respectively). The results of the sampling are being used to characterize the natural groundwater conditions for the area and in part to predict the water quality of the anticipated underground seepage water. In 2021 Constantine also developed a pair of monitoring wells up and down-gradient of the new diffuser location (MW21-05 and MW21-04; Figure 5). It will continue to monitor these wells through the 2022 field season and then provide that data to ADEC for consideration.

2.7.3 Underground Seepage Monitoring

After Constantine begins excavating the exploration ramp it will collect seepage water quality samples on an opportunistic basis. For example, when there is enough seepage inflow to provide a sample, samples will be collected on a quarterly basis.

Constantine may have opportunities to sample pristine seepage water (i.e., from pilot or exploration drillholes). If artesian drillholes are encountered Constantine will have an opportunity for collecting additional water quality and hydrogeological data.

Finally, Constantine will monitor the area below the diffuser for signs of new seeps that might result from the discharge.

3.0 DEVELOPMENT ROCK MANAGEMENT

This Section is unchanged from the 2019 version and describes how Constantine will manage all development rock that is generated from the proposed underground ramp including visual and geochemical monitoring, segregating and final disposal of the rock. This information is being included to support a waste management permit application and a permit that will authorize the disposal of PAG waste rock.

The results of all the analytical work performed to date show that the development rock intersected by the ramp will not generate acid or leach metals; based on the geological information acquired to date, Constantine does not expect to intersect any PAG during the underground development program. In 2019 Constantine applied for inclusion of development rock in the waste management permit as a contingency to cover the situation where PAG material is unexpectedly intersected with the ramp development.

The underground ramp development will include collaring a portal at the portal pad and excavating a cumulative length of approximately 2,012 meters underground. The ramp development will be performed by a specialized contractor. The excavation of the ramp will yield approximately 70,000 m^3 of waste rock equivalent to approximately 170,000 tonnes assuming 10% overbreak and 15% swell factor. Starting at the portal, the ramp will consist of the following major segments, with the length and grades as described below and illustrated in Figure 7:

0 meters = Portal
Portal – 13 m, 13 m-long segment, +2.5% grade
13 m – 270 m, 257 m-long segment, +2.5% grade
270 m – 370 m, 100 m-long segment, +2.5% grade
370 m – 1,612 m, 1,242 m-long segment, +12.4% grade
1,612 m, – 2,012 m, 400 m-long segment, +2.5% grade (drill ramp)

The cross-sectional dimensions of the ramp would be approximately 5 m by 5 m (16 ft. by 16 ft.). The last 400 meters of ramp will serve as a platform for drilling. Excavating the ramp will be accomplished with a typical drill-blast-muck cycle, which will operate on a 24-hr basis using two 12-hour shifts. We anticipate the ramp to advance an average of 12 feet per 24-hr day, until the target length is achieved, over an anticipated period of at least months, although the schedule is subject to modification due to ground conditions, amount of grouting that is done and equipment availability. Development rock will generally be permanently disposed in one of several facilities on the surface as illustrated in Figure 8 including rock dumps 1,2 and 3, a lined storage pad adjacent to pond #2, avalanche deflection mounds located on the uphill side of the Glacier Creek access road and the avalanche deflection berm located adjacent to the portal road switchbacks.

Constantine has previously performed ABA studies of a suite of more than 100 samples from drill core and surface outcrops that are representative of the rocks that will be cut by the development ramp. The results of that work suggest that these rocks will all be non-PAG and non-metal-leaching as discussed below in Section 3.1.

While the ABA data show that all the development rock will be non-PAG, Constantine are applying for a waste management permit that authorizes the disposal of PAG development rock, as described below, in the situation that PAG development rock is identified.

Throughout the underground ramp development Constantine will monitor every blast round to confirm the geologic character of that round and segregate any rounds that are suspect of being PAG and subject those rounds to geochemical analyses. These and additional monitoring steps are described more fully in Section 3.2.

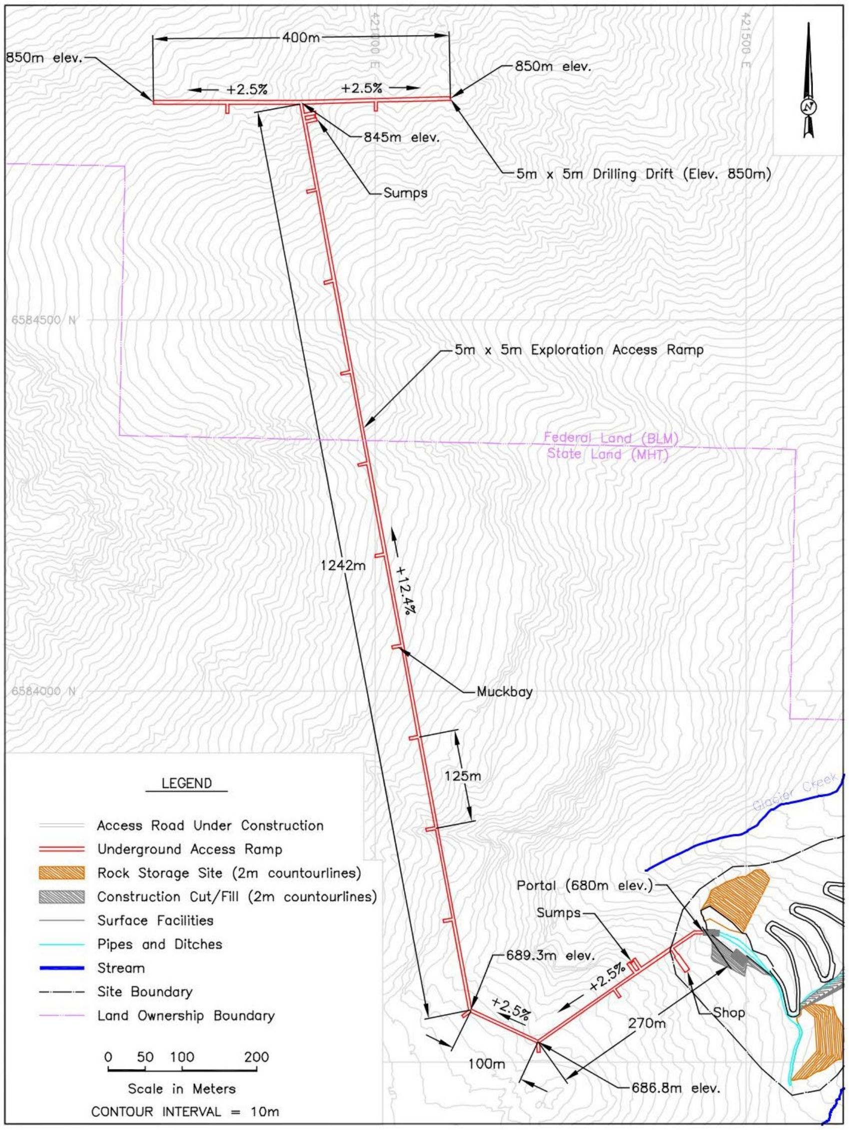


Figure 7. Proposed Underground Ramp - Plan View

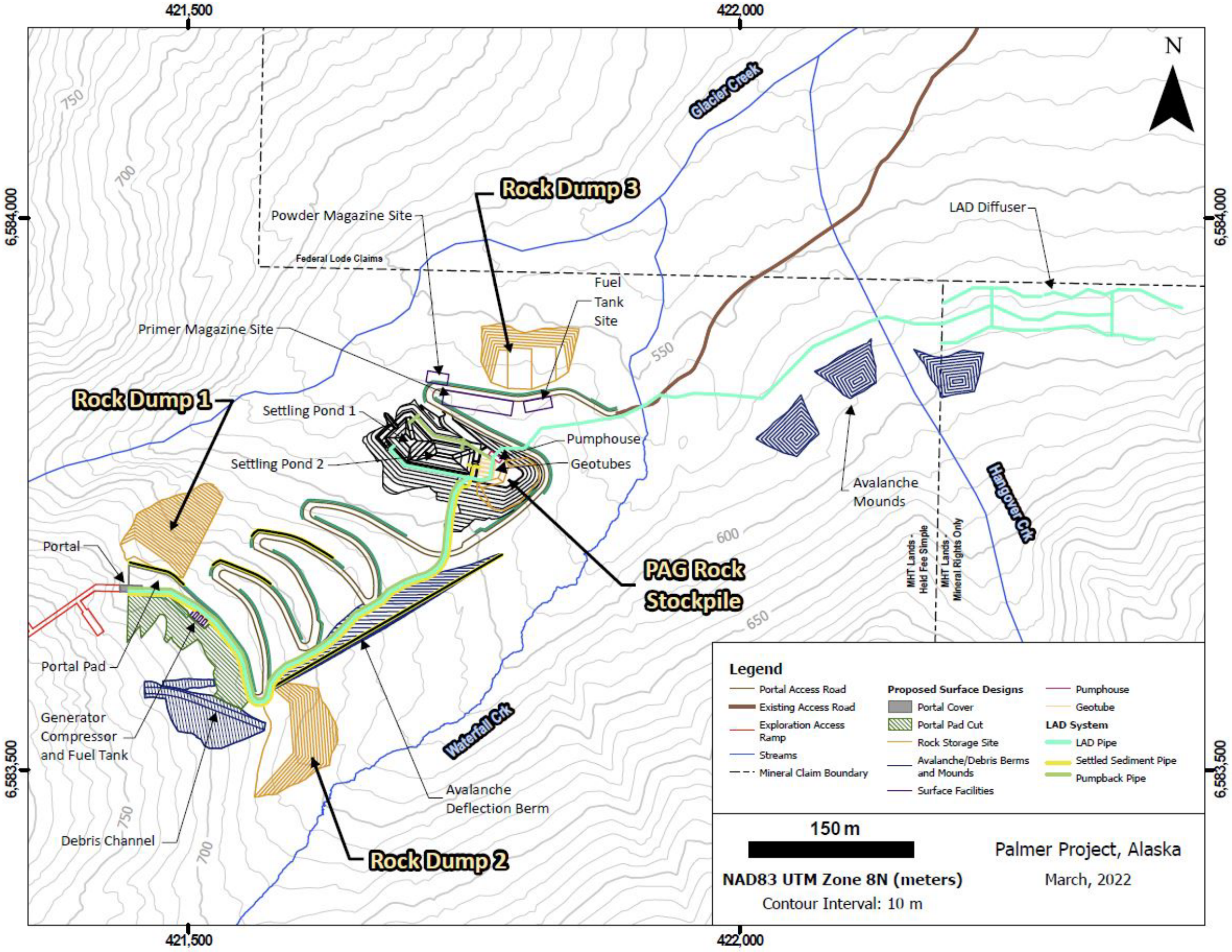


Figure 8. Surface Facilities including Waste Rock Disposal Sites (Rock Dumps 1,2,3, Avalanche Berm and Avalanche Mounds)

3.1 Background Geochemistry of the Exploration Ramp Development Rock

This section is unchanged from the 2019 Application. Constantine has performed considerable work to characterize the rock it will intersect with the proposed exploration ramp. The work has included analyzing 101 rock samples specifically selected from drill core or collected from surface outcrops to be representative of all lithologies represented in the proposed ramp. In addition to acid-base accounting geochemical analyses on all these samples, select samples were used to set up kinetic humidity cell test and others were composited to set up a series of 3 field barrel tests at the Palmer site. All this information is discussed by pHase Geochemistry (2018*a*). The results of that work show that these rocks will not generate acid or leach metals; Constantine does not expect to intersect any PAG during the underground development program. In 2018 Constantine applied for inclusion of development rock in the waste management permit as a contingency to cover the situation where PAG material is unexpectedly intersected with the ramp development.

A total of 101 representative samples were collected by Constantine from 2014 through 2017 and tested as part of the ARD/ML characterization program. These samples, including I7 surface outcrop samples and 84 diamond drill core samples, comprise the three main rock types that will be intersected along the access ramp: Jasper Mountain basalt (most volumetrically significant), limey argillite, and hanging wall basalt in the South Wall area, as well as minor units such as mafic dikes, gabbro, faults etc. Figure 9 illustrates where these samples were collected relative to the proposed exploration ramp.

Laboratory static tests included acid-base accounting, total inorganic carbon and trace element analyses on all samples. In addition, field barrel kinetic tests and parallel laboratory humidity cell leach tests are done or continue to be in progress (barrel tests) on three composite samples representing the three main rock types expected in ramp development. Additional analyses on the three composite samples have included particle size analyses and mineralogical analysis via QEMSCAN.

The results of the acid-base-accounting for samples geologically representative of the exploration ramp are included in Table 5. Results indicate that rock expected to be encountered in exploration ramp development has abundant neutralization potential and thus buffering capacity, primarily in the form of calcite. Sulfur content was generally low and typical of trace to minor amounts of sulfide mineralization in the rock, primarily as pyrite. However, sulfur content was typically higher in the limey argillite unit than the Jasper Mountain basalt and hanging wall basalt units. All rock samples of relevance to the proposed exploration ramp classified as non-potentially acid generating (non- PAG) (Figure 10). Thus, waste rock encountered during underground ramp development is not expected to generate acid rock drainage

Results of the kinetic testing of drill core in the three field barrels have yielded leachates with alkaline pH and are not expected to generate acid. The potential for metal leaching from the Jasper Mountain and hanging wall basalts is likely to be low. Leach tests on limey argillite have indicated an initial flush of soluble selenium from the rock at neutral pH. However, selenium in the humidity cell test steadily declined to lower levels as testing has progressed (Figure 11).

Table 5. Summary of Acid Base Accounting Results by Rock Type for the Samples that are Representative of Geologic Units Anticipated in the Proposed Exploration Ramp.

Rock Type	Statistic	Paste pH	Total S	Sulfate S	Sulfide S	MPA	Modified NP	CO_3 NP	NNP	NPR
			wt. %			kgCaCO$_3$/t				
All Rock (n = 101)	Min	7.5	0.01	0.01	0.01	0.3	6	4	5	2.5
	Median	8.8	0.13	0.01	0.12	4	100	89	96	33
	Max	9.8	1.09	0.19	1.05	34	651	647	634	381
Jasper Mtn Basalt (n=38)	Min	8.1	0.01	0.01	0.01	0.3	17	4	10	2.5
	Median	8.8	0.12	0.01	0.11	4	93	78	88	31
	Max	9.2	0.32	0.19	0.26	10	617	622	607	219
Limey Argillite (n = 14)	Min	7.5	0.04	0.01	0.03	1	114	110	96	6.3
	Median	8.6	0.57	0.02	0.55	18	435	457	414	27
	Max	8.9	1.09	0.04	1.05	34	651	647	634	235
HW Basalt (n=37)	Min	8.0	0.01	0.01	0.01	0.3	28	13	28	7.9
	Median	8.8	0.05	0.01	0.04	2	91	82	89	80
	Max	9.7	0.44	0.03	0.41	14	381	381	379	381
Mafic Dyke (n = 8)	Min	8.2	0.13	0.01	0.12	4	46	37	40	4.9
	Median	9.0	0.28	0.01	0.28	9	74	62	61	7.0
	Max	9.8	1.06	0.01	1.05	33	201	211	196	43
Gabbro (n = 2)	Min	8.8	0.03	0.01	0.03	1	40	26	39	13
	Max	9.0	0.22	0.01	0.21	7	88	74	81	43
Fault (n = 1)		8.4	0.23	0.01	0.23	7	245	237	238	34
Cap Intrusive (n=1)		8.9	0.03	0.02	0.01	1	6	4	5	6

Notes:
Full ABA results provided in Appendix D.
Sulfate-sulfur (by Na_2CO_3 leach)
Sulfide-Sulfur: Total-Sulfur - Sulfate-Sulfur
MPA (Maximum Potential Acidity): Total-Sulfur x 31.25
CO_3 NP (Carbonate NP): Equivalents: based on CO_2 (Carbonate Carbon)
NNP (Net Neutralization Potential): Calculated as Mod. NP - MPA
NPR (Neutralization to Acid Potential Ratio): Calculated as Mod.NP / MPA

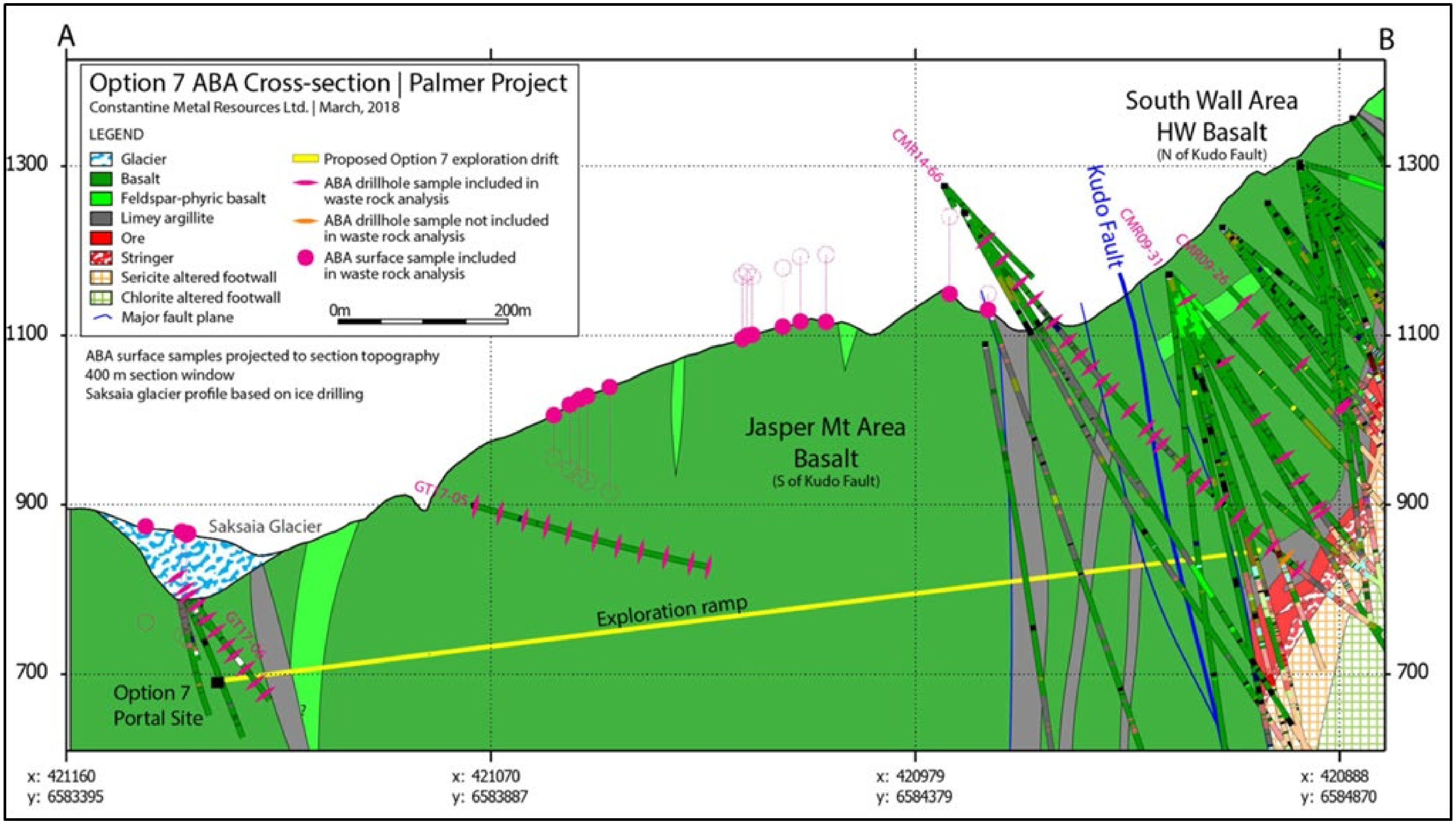


Figure 9. Geologic Crossection in Plane of Proposed Exploration Ramp Showing ABA Sample Locations

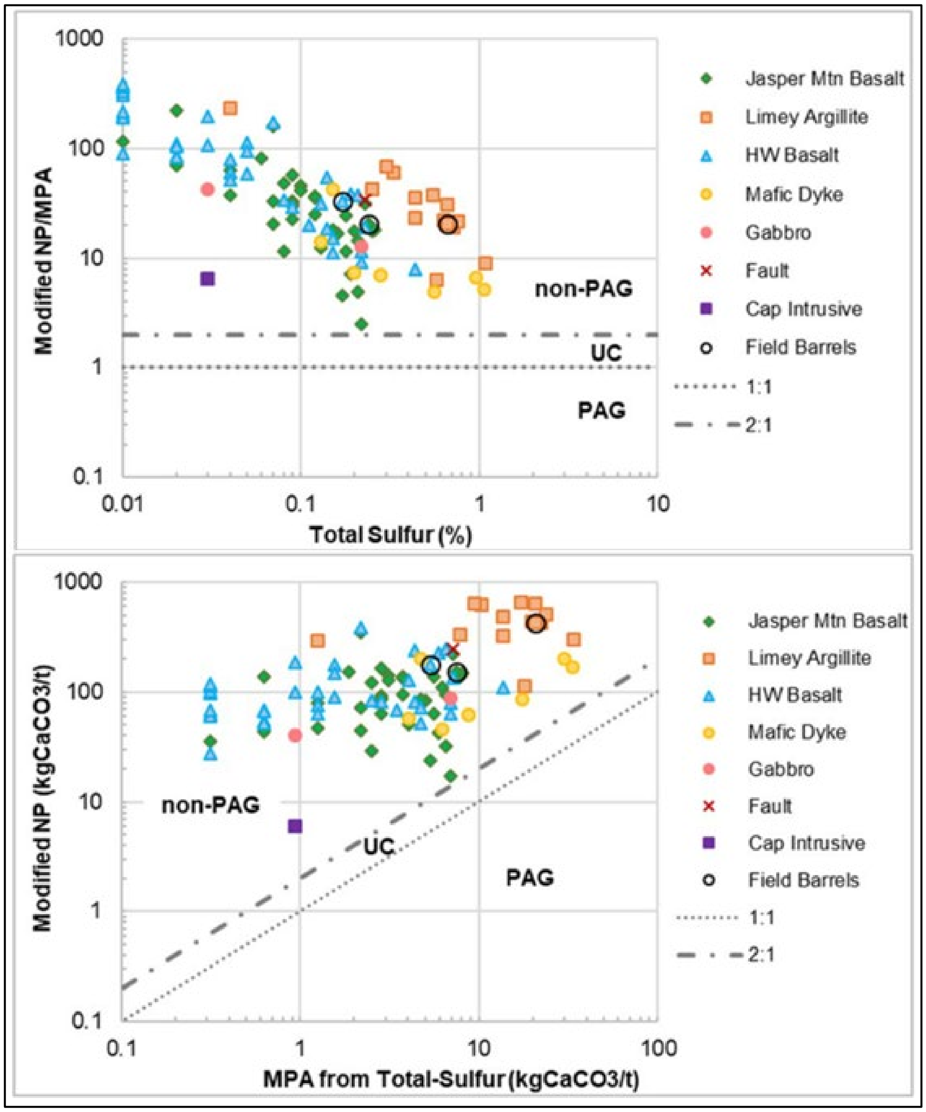
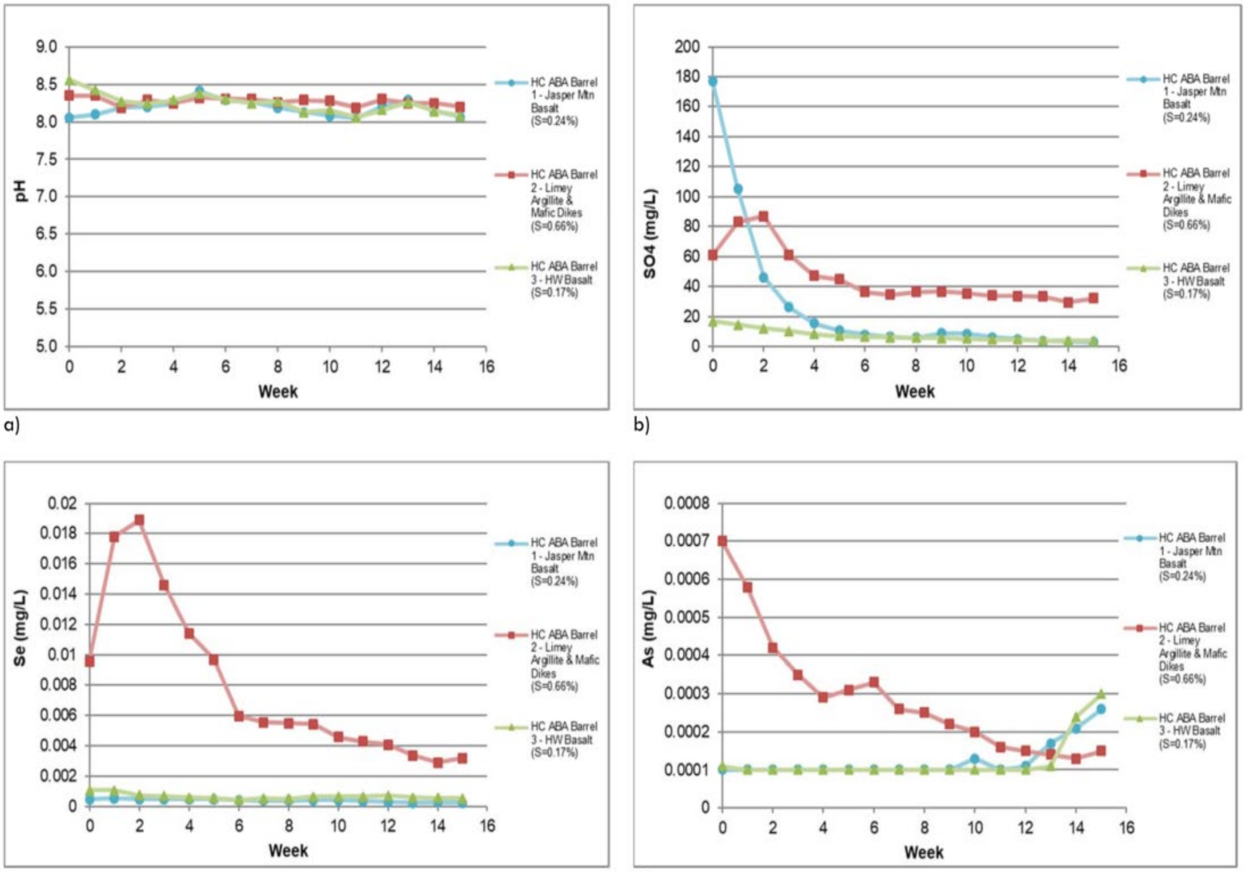


Figure 10. Classification of 101 Representative Samples of the Proposed Exploration Ramp



a)

b)

Figure 11. Barrel Leachate Results for Samples of Jasper Mtn. Basalt, Hangingwall Basalt and Limey Argillite Rock Units

3.2 Development Rock Monitoring, Handling and Disposal

Constantine will perform the following activities as part of its development rock management during the development of the underground ramp. This monitoring is partly modeled after suggestions made by pHase (2018*b*).

- Assign a unique identifier to each round of development rock.
- Monitor each blast round by performing a visual geologic examination of each round as it is delivered to the portal pad. Geologist will record - rock lithology, sulfide species and concentration, intensity of effervescence using dilute HCl.
- Permanently dispose of all muck rounds with less than 2% sulfide in one of the three rock dumps, the avalanche berm or the avalanche deflection mounds.

- Collect a grab sample of muck from each round with greater than 2% sulfide and submit the sample for ABA analysis and temporarily store the muck on the lined storage pad adjacent to settling pond #2, pending results of ABA analyses of that round.
- Continue to store confirmed PAG rounds on the lined storage pad for rounds where the ABA analysis indicates a net neutralizing potential (NP:AP) less than 2.
- Haul the confirmed PAG rounds back underground for permanent disposal at the end of exploration program.
- Monitor active development rock disposal sites (rock dumps 1,2 and 3, avalanche deflection mounds and berms) by collect quarterly composite grab samples from and submit those samples for ABA analyses.
- Maintain records that describe where each round originated underground, the details the visual geologic inspection results and describe where each round was disposed on the surface, which rounds were tentatively identified as PAG and subject to ABA analyses. These records will also include the results of the ABA analyses. Finally, the records will describe where quarterly samples are collected and the results of the ABA analyses for those samples.

These are described in more detail below.

Assign Unique Designation to Each Round

Underground ramp development will proceed utilizing a typical drill-blast-muck cycle. Each round will consist of the blast rock (muck) from a single blast and represent approximately 10 feet of ramp advancement. Constantine will develop a system of uniquely identifying each round of muck. Typical approaches include the date and shift (night vs. day) or date and distance from an underground survey monument.

Monitor Each Blast Round - Perform Geologic Examination

Depending on the selection haul trucks for the project, muck from each round either be hauled to the surface and placed in a discrete pile on the portal pad or hauled directly from underground to a rock storage pile on the surface. While each round is on the portal pad, or while it is still underground a geologist will examine the characteristics of each round. The geologists will determine 1) the basic lithology (Jasper Mtn basalt, Hanging wall basalt, Argillite, Mafic dike, or a mix, etc.), 2) the average sulfide content as a percentage of the volume of the rock in each round, 3) the types of sulfides (pyrite, pyrrhotite etc.). 4) The geologist will also apply dilute HCl to the rock and establish the amount of effervescence (strong, moderate, or weak) to determine the potential neutralizing effect on the waste rock.

Permanently Dispose of Rounds with 2% or Less Sulfide

Once the geologist has examined the round and established that the total average sulfide content for the round is 2% or less, he will release the round to surface operations and it will be permanently disposed of in one of the three surface rock dumps, the avalanche berm or the avalanche deflection mounds, or a combination of these sites. The final disposal site will be recorded.

Segregate and Sample Rounds with Greater than 2% Sulfide

If the geologic examination of any round establishes the presence of more than 2% average sulfide content by volume, the geologist will collect a random grab sample of the round. The sample will weigh at least 4 kilograms and the geologist will sample randomly from the entire muck pile to collect a representative sample of that round. The sample will be sent to a certified laboratory and subject to acid base accounting procedures appropriate to establish the ratio of neutralizing potential to the acid potential. The muck pile will be moved to the lined temporary storage site, adjacent to the settling ponds, and stored there pending the results of the ABA analyses. If the ABA analyses indicates an NP:AP ratio of 2 or more (i.e., non-PAG) then the muck pile may be moved to any other location for permanent disposal. If the NP:AP ratio is less than 2 then the muck pile will remain on a lined pad until it is placed back underground permanently.

Monitor Active Development Rock Disposal Sites by Collecting Quarterly Grab Samples

Following the visual geologic inspection non-PAG rounds will be routinely and permanently disposed on the surface in any of the following: rock dumps 1, 2 and 3, avalanche mounds or avalanche deflection berms. At the beginning of each quarter, Constantine will employ a geologist to collect a random grab sample from each of the disposal sites where muck was placed in the previous quarter and subject those samples to ABA procedures appropriate to establish the NP:AP ratio. This is being done to confirm the non-PAG nature of the muck piles.

Maintain Records

During the entire underground development program Constantine will maintain records that include the information generated by the implementation of this development rock handling plan including:

- Record the unique identifying number/name for every underground round including sufficient information to establish the original location of that round underground.
- Record the observations of the geologist for each round including at least the lithology, sulfide concentration and types, and results of the HCl fizz test.
- Record the ABA sample number for any rounds with greater than 2% sulfide and the ABA analytical results once they are received from the lab
- Record the final disposal location for each round including the date it was hauled to that location
- Record a description of quarterly ABA samples including lithology, sulfide content and results of dilute HCl test and a description of the approximate location of the sample and identification of the sample disposal site (i.e., upper half of avalanche berm or southernmost avalanche mound or portal disposal site) and the ABA analytical results once they are received from the lab.

4.0 RECLAMATION AND CLOSURE

Constantine updated the Reclamation Plan and cost estimate in 2022 and these changes are summarized here.

Reclamation and Closure of the site is included in this application because certain aspects of reclamation apply to removal of the wastewater discharge system (ponds, surface piping, etc.) and includes the contingency costs to haul PAG development rock back underground if PAG is encountered during development of the exploration ramp.

This reclamation plan is designed to meet the State of Alaska regulatory requirements for a reclamation plan. Constantine has prepared plans for both temporary closure and permanent closure scenarios. This reclamation plan and reclamation cost estimate information supersede the reclamation plan and cost estimate included in Constantine's Phase II Plan of Operations and approved under by ADNR Reclamation Plan Approval #J20185690RPA Amendment #1. This reclamation plan and cost estimate has been modified to incorporate minor LAD changes and modifications to the road design, including the debris channel. Costs have been increased to reflect inflation between 2019 and 2022.

4.1 Care and Maintenance Plan for Temporary Closure

There are some situations where Constantine may elect to suspend its activities proposed under the Plan of Operations for periods longer than the seasonal interruptions that are common to mineral exploration. Under any situation where activities at the site will cease for more than 1 year and for up to 3 years Constantine would take the steps necessary to put the site on a care and maintenance status and continue to perform all maintenance, monitoring and reporting tasks that are necessary to protect public health and the environment during the temporary closure. Should Constantine decide to suspend activities for more than 1 year it will notify the Trust, ADNR and ADEC within 45 days of making that decision. The Care and Maintenance Plan for the temporary closure scenario includes the following key components:

- Continuation of baseline water quality monitoring at select sites,
- Installation of a gate to discourage public vehicular access onto Trust lands.
- Continuation of seasonal water quality monitoring at the monitoring wells up- and down-gradient of the LAD diffuser, as long as water is being discharged through the LAD diffuser,
- Continuation of discharge of underground seepage water through the LAD disposal system,
- Compliance with the SWPPP, including visual inspections and maintenance of stormwater BMP's during the ice-free months,

- Installing a barrier at the portal to restrict public access to the underground development ramp,

- Compliance with the SPCC Plan including visual monitoring and management of fuel storage facilities including maintenance of secondary containment vessels when fuel is stored on site during Care & Maintenance.

- Monthly visual monitoring of site roads, laydown areas and portal pad areas during ice-free months for any conditions that warrant repair or other response.

4.2 Reclamation Plan for Permanent Closure

If Constantine decides to cease activities at the site permanently, it will perform the activities prescribed in the Reclamation Plan for Permanent Closure. Those activities are summarized below:

- Constantine will update its water management plan incorporating underground seepage water quality and quantity data and confirm the need for installation of a hydraulic portal plug in the development ramp to minimize the flow of underground seepage water to the surface at the portal. Constantine's base assumption is that it will install a hydraulic portal plug in the development ramp at closure. Constantine has included the estimated costs for the portal plug design and installation in the reclamation cost estimate. In the absence of a need to install a hydraulic plug, Constantine will install a barricade on the portal that will provide a barrier to protect public safety and keep out the public and wildlife.

- Constantine will consult with the Mental Health Trust to identify any surface infrastructure that the Trust wants left in place at final closure. Presently Constantine understands the Trust prefers that the access road up to the portal pad remain in place for the long term. Accordingly, costs for reclaiming the access road on MHT lands are not included in the reclamation cost estimate

- Constantine will remove all surface facilities and appurtenances (buildings, ponds, exposed piping, secondary roads, fuel storage facilities, etc.) and materials (supplies, fuel, tanks, debris, explosives, chemicals, etc.), except those that the Trust requests to be left in-place or that are required for long-term monitoring and maintenance. Presently Constantine anticipates that there will not be any facilities required for long-term water management and has not included any costs associated with operating or maintaining any facilities following reclamation of the site in accordance with the Reclamation Plan.

- Constantine will reclaim the disturbed areas by recontouring as necessary, distributing any salvaged soil and reseeding, to provide short-term stability from erosion and encourage long-term re-establishment of native plant species. Constantine will consult with the Alaska Plant Materials Research Center to develop a strategy for revegetation including identifying the appropriate seed mix to use for revegetation disturbed areas.

There will not be an effort to place topsoil on the development rock or reseed it. As a practical matter, the glaciofluvial material that overlies bedrock in most of upper Glacier Creek is too immature to have developed a salvageable organic topsoil horizon. As a result, little topsoil has been salvaged and Constantine anticipates that it will be reseeding directly onto this glaciofluvial material during reclamation. Undisturbed glaciofluvial material in upper Glacier Creek currently supports predominantly alder and subordinate devils club.

- Constantine has included the costs for monthly site inspections and reporting during the snow-free months for a two-year period following completion of the reclamation activities described above. The principal purpose of the monitoring is to monitor seepage from the portal as a measure of the efficacy of the portal plug in reducing seepage to de-minimis levels.

- In the event any PAG material is identified by Constantine during the underground development program, that material will be placed back underground prior to installing the hydraulic portal plug. Constantine has included the cost for hauling PAG development rock back underground as a contingency, even though current data indicates no PAG development rock will be encountered.

4.3 Financial Assurance and Estimated Costs for Reclamation and Care and Maintenance

Constantine has calculated estimated costs for both the care and maintenance under a 3-year temporary closure scenario, and permanent closure scenario. Constantine intends to post a financial assurance in a form acceptable to the State regulatory agencies prior to initiating construction activities after the MHTLO approves the Plan of Operations Amendment, ADNR approves the Reclamation Plan Amendment, and ADEC approves the revised LAD design.

Constantine's estimated cost for the temporary closure scenario is: 1) $34,974 to stabilize the site and make it ready for Care and Maintenance and install an access road gate, plus 2) $15,969/year for twice-monthly inspections and monthly reporting for each year that it remains in Care and Maintenance status. Assuming a 3-year duration on Care & Maintenance status, the total cost is estimated to be $110,937 including indirect costs per ADNR guidance. At the end of 3 years Constantine must either request an extension of the Care and Maintenance status from ADNR or permanently close the site in accordance with the Reclamation Plan for permanent closure.

Constantine's estimated reclamation cost for the permanent closure of the site is $1,073,970. This includes $549,334 to design and construct a hydraulic portal plug in the development ramp to reduce flows from the portal to de minimis levels. The cost estimate includes indirect costs per ADNR guidance.

The permanent closure cost estimate includes indirect costs in accordance with ADNR guidance. In determining the Indirect rate for each of the 7 categories of Indirect Costs, we referred to the

DOWL (2015) report for the discussion of factors affecting the range of indirect costs in each category. In general owing to the low risk (no PAG, good water quality predicted, low project uncertainty, good access, the lack of project complexity, fact that equipment rates already include contractor profit, history of civil contractor experience on site, and the low overall direct cost of the reclamation, and manageable climate the guidance suggests using the lower range of indirect costs, with some exceptions. The following is a discussion of the factors Constantine considered in selecting the indirect costs.

Contractor Profit – ADNR guidelines (DOWL, 2015) recommend a range of 6-10% of direct costs. Much of the reclamation costs for the project are civil works costs and the cost estimate is based on quotes from a local contractor who has performed years of civil work on the project and for Alaska Department of Transportation and Public Facilities. Contractor profit is already included in the contractor's hourly equipment rates used for the cost estimate. As a result, Constantine concluded the low end (6%) of the indirect range is appropriate for contractor profit.

Contractor Overhead – ADNR guidelines (DOWL, 2015) recommend a range of 4-8% of direct costs. As with contractor profit, contractor overhead is already built into the contractor's hourly rates for equipment, including the equipment operator, fuel, and repairs. While the guidelines point out that there are often higher overhead costs for smaller projects, our use of local contractor rates negates this idea for the Palmer project. Nonetheless Constantine did not choose the lowest value but used 5% for contractor overhead in the cost estimate.

Performance and Payment Bonds - ADNR guidelines (DOWL, 2015) recommend a range of 2.5-3.5% of direct costs. Constantine concluded that the low end of the range was appropriate owing to the low overall cost of reclamation, the simplicity of the project, past performance of local contractors and the few contractors/subcontractors required to perform the reclamation.

Liability Insurance - ADNR guidelines (DOWL, 2015) recommend 1.5% of labor costs. This is a fixed percentage according to the guidelines.

Contract Administration - ADNR guidelines (DOWL, 2015) recommend a range of 5-9% of direct costs. According to the guidelines this category of indirect costs is to cover the cost of hiring a project management firm to inspect and supervise the reclamation work. The guidelines go on to state that the contract administration amount accepted be the state will be based on size of the bond, project closure complexity and duration of the active reclamation phase. The guidelines also describe factors like access, climate, and mine maturity. On one hand the guidelines say that in general larger projects may require a lower percentage of contract administration costs compared to small or mid-size projects. But on the other hand, the guidelines offer that while scale may warrant lower contract administration costs, project complexity may push these costs to the top of the range. In addition, Constantine already has a project lead (supervisor) built into each of the tasks that comprise the entire reclamation project, including meals and accommodations for the lead. Constantine also included engineering supervision costs in the direct costs for the portal plug. This is the single component of the reclamation activities that requires engineering support and inspecting. Constantine considered all these factors and concluded that the inclusion of supervision (including support costs) in the cost estimate, lack of project complexity, ease of access, moderate weather, and the general lack of the requirement for inspections of engineered facilities (lack of engineered covers, engineered water management components) all justify using a contract administration value in the lower half of the range (5-9%). Constantine used 6% in the cost estimate

Engineering Redesign - ADNR guidelines (DOWL, 2015) recommend a range of 3-7% of direct costs. Engineering redesign costs are meant to bring conceptual closure plan designs to ready-for construction designs. The guidelines use scale to mean that bigger mines often have performed more closure design work by the time closure occurs. This is true for more mature mines but not necessarily for immature, complex mines. Reclamation at Palmer is mostly simplistic recontouring operations and removal of pipe. The only required complicated engineering design is for the portal plug and the direct cost estimate includes $113,000 specifically for geotechnical studies, engineering design (conceptual to final) and professional engineering management/oversight during entire construction of the portal plug. Owing to the inclusion of geotechnical work, engineering design and professional engineering supervision costs in the direct cost for the portal plug and the otherwise simplistic nature of the reclamation itself, Constantine concluded that 3% is sufficient for engineering redesign component of indirect costs.

Scope Contingency - ADNR guidelines (DOWL, 2015) recommend a range of 6-11% of direct costs. Owing to the narrow scope and simplicity of the reclamation work, and familiarity that local contractors have with the site, Constantine chose 6% for scope contingency.

Bid Contingency - ADNR guidelines (DOWL, 2015) recommend a range of 4-9% of direct costs. The guidelines offer that this contingency might be lower for larger projects there would be project efficiencies realized over the life of the reclamation project. Constantine believes that the years of experience gained at the site by the few civil contractors in Haines has the same effect. Namely that any of those contractors know how to bid any work at Palmer and make it cost effective for them. Constantine did not choose the lowest in the range but chose 5% for bid contingency.

5.0 REFERENCES

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APPENDICES

Appendix A	2022 LAD Revised Design Report by KCB Consultants Ltd.
Appendix B	2022 Water Treatment Report by Veolia Water Technologies Canada
Appendix C	2022 Palmer Project Water Management Plan
Appendix D	2022 Palmer Project Tracer Study Final Report by Ozark Underground Laboratory Inc.
Appendix E	2022 Site Investigation Report by KCB Consultants Ltd.