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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Application Statement

This document is an application for a waste management permit to dispose of non-domestic wastewater and waste rock at the Palmer Project located north of Haines, Alaska. The facility is owned and operated by Constantine Mining LLC (Constantine), a joint venture company between the US subsidiaries of Dowa Metals and Mining Co. Ltd., of Japan and Constantine Metal Resources Ltd., of Vancouver, Canada (Constantine North Inc.). The lands are owned by the Alaska Mental Health Land Trust (Trust). Constantine has an upland mining lease for these lands from the Trust. The source of the excess wastewater is from underground seepage into the exploration ramp. The proposed wastewater discharge would occur under the provisions outlined in 18 AAC 72.500 for the disposal of non-domestic wastewater.

Studies predict development waste rock generated during the Phase II underground program will not present a public health, safety, or welfare threat or environmental problem (i.e. waste rock is non-acid generating/non-metals leaching) and therefore its management is considered exempt from the requirements of 18 AAC 60.005. However, to ensure these criteria are met prior to permanent surface disposal, Constantine will implement monitoring procedures to verify the character of each round of development rock. A contingency plan has been developed for the unlikely event that potentially acid generating (PAG) is encountered. Constantine is formally requesting permit approval under 18 AAC 60.005 to store and manage any potential PAG material temporarily on the surface and permanently dispose of PAG material back underground.

March 27, 2019

Darwin Green
Member Representative
Constantine Mining LLC

Date

1.0 INTRODUCTION

This document is being submitted by Constantine Mining LLC. (Constantine) to the Alaska Department of Environmental Conservation (ADEC) for a permit to construct and operate a Land Application Disposal System (LAD) to discharge underground seepage water at the Palmer exploration project and to manage potentially acid generating (PAG) development rock in the very unlikely event that any is intersected underground. The project is located north of Haines, Alaska, The LAD system and other surface development will be located on Mental Health Trust land, but it will be built, operated and maintained by Constantine Mining LLC. This submittal is intended to meet the requirements of an application for a permit to discharge non-domestic wastewater under 18 AAC 72 and dispose of solid waste under 18 AAC 60.005

This permit application contains:

- Narrative that describes component parts and the functionality of the LAD system,
- Engineered plans of the entire LAD system comprising the settling ponds, lower buried diffuser, upper buried diffuser and the piping that connects them,
- A tentative schedule for construction of the LAD,
- Statements identifying who will own and operate the proposed LAD system,
- Description of the proposed wastewater discharge including,
    - A 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 monitoring wells up- and down-gradient of 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.
- Narrative describing the management of non-PAG development rock on the surface,
- 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.

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 Locations

2.1.1 Description of Disposal System

The wastewater disposal system, including two separate diffuser discharge locations, 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. However, the diffusers at the two discharge points will be buried in the soil deep enough to protect them 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 pumped to the portal and either: 1) directed to the upper diffuser for discharge, or 2) directed to the two settling ponds and from the ponds to the lower buried diffuser for discharge.

Constantine has incorporated two settling ponds into the LAD system as illustrated in Figure1. The ponds are primarily intended to provide enough time and surface area for settleable solids to settle prior to discharging the water through the lower buried diffuser. The removal of settleable solids in the settling ponds and underground sumps prior to discharge should minimize clogging of the diffuser and the permeable gravels receiving the discharge downgradient of the diffusers.

Settleable solids will include drill cuttings (from core and 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. Solids will settle as the water resides in the underground sumps prior to being pumped to the surface. The combined settling time in the ponds is 24 hours at a flow rate of 500 gpm which is enough to allow even fine solids to settle as discussed later.

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

The lower diffuser site is in an aerially extensive alluvial fan composed of permeable gravels. Infiltration field tests and computer modelling completed for the LAD system design simulated a total infiltration capacity of 800 gpm (BGC, 2018) for the lower diffuser. This is 1.6 times the original planned design capacity of 500 gpm. The pipes from the portal to the settling ponds and from the settling ponds to the lower diffuser are designed to accommodate at least 800 gpm.

In addition to directing underground seepage water to the settling ponds and discharging it through the lower buried diffuser, Constantine will also direct water to the upper diffuser. Previous infiltration tests completed in 2017 indicate that infiltration rates and hydraulic conductivity in the upper Waterfall Creek area, composed of a mix of glacial outwash and debris flow material, are much higher than rates in the lower LAD diffuser area, at least 25 m/hr. (980 in/hr.) (BGC, 2018).

The upper diffuser portion of the LAD system will consist of a buried 12-inch pipe that will convey water from the portal, along the upper portal road, to a talus slope where the diffuser pipe will be perforated and buried where it passes along the top of the talus slope. The diffuser will allow water to discharge into the talus. The upper diffuser will accommodate a discharge of 50 gpm. The discharge water is expected to flow directly into the talus and percolate into the ground under the talus. The upper diffuser is intended for temporary use, early in the development of the underground ramp system until the lower diffuser is fully operational. The Constantine will limit discharge to the upper diffuser to a level that will avoid any new seeps downgradient.

Constantine has completed several hydrogeologic tests in drillholes as well as modelling and estimates underground seepage inflows of up to approximately 160 – 200 gpm for the first 1250m (4,100 ft) of the ramp, with higher flows likely for the remaining 760m (2,500 ft) (Tundra, 2018), unless steps are taken to minimize flows. 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. Constantine has also completed infiltration tests in pits on the property as illustrated in Figure 6 to aid in the siting of the diffusers.

In the remainder of this section the design of the major component parts of the LAD system are described. Much of the following sections is excerpted/modified from the BGC (2018) LAD design report. The complete report is included as Appendix A.

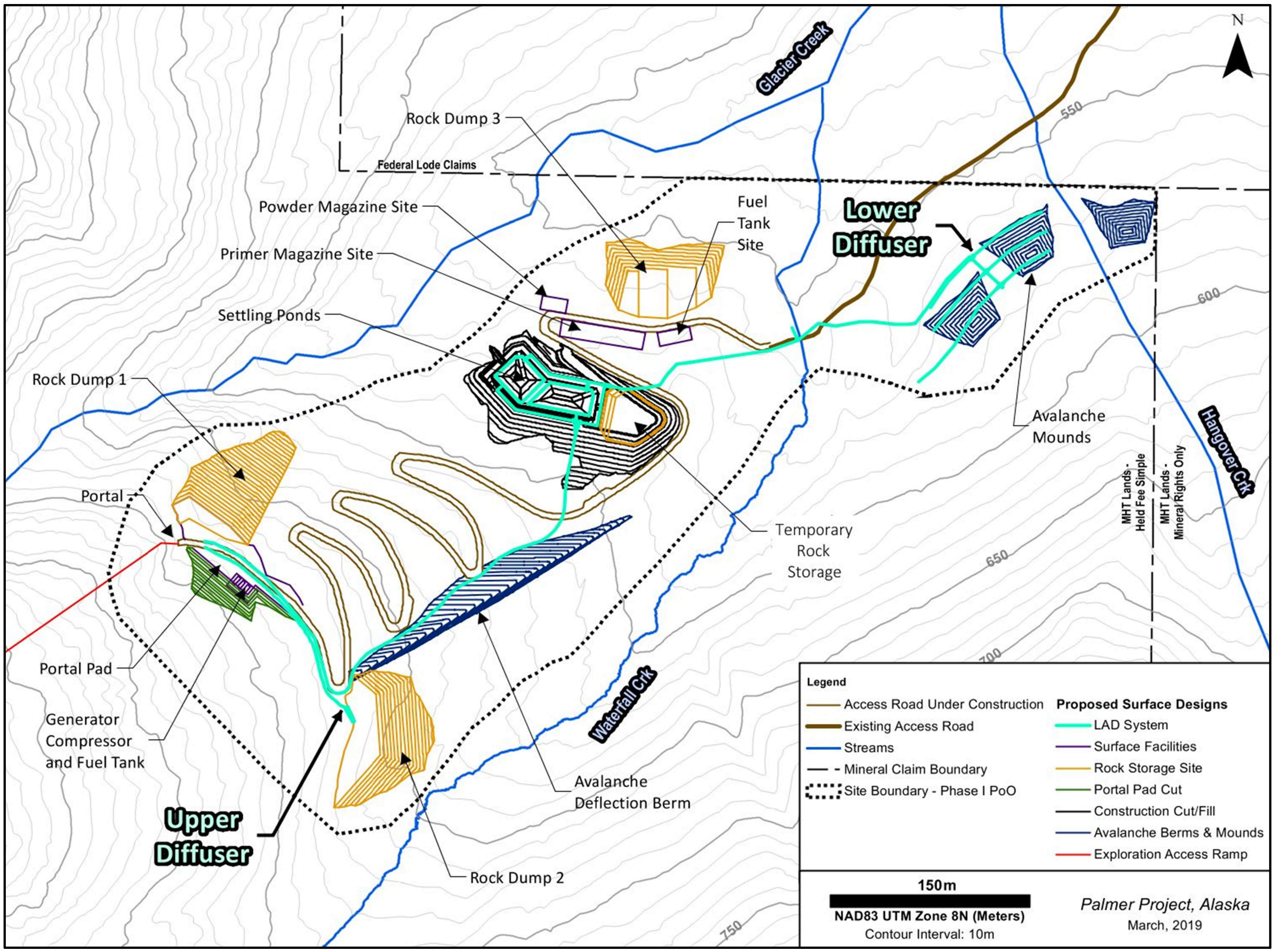

Figure 1. Surface Facility Layout – Palmer Project – Emphasis on LAD System

2.1.1.1 Settling Ponds

The primary purpose of the two settling ponds is to reduce suspended solids in the underground seepage water prior to piping the water to the buried lower diffuser for discharge. The ponds are illustrated on Figures 2 and 3. The design criteria, final facility geometry, and supporting geotechnical and hydrological engineering analyses are described below.

The following criteria are specific to the final design of the two settling ponds:

- The total design inflow is 32 l/s (500 gpm).
- The design capacity for each pond is 1,360 cubic-meters (m3) (1.1 acre-feet), which equates to 12 hours of storage per pond at 500gpm inflow rate, for a total retention time of 24 hours.
- 1 m (3.3 ft) of freeboard is provided for each sediment pond; this is considered a conservative assumption to account for wave action and storm routing.
- The ponds will maintain an operational volume and contain the 100-year 24-hr storm event.
- The ponds will be hydraulically connected above elevation 498.0 m to allow flow from one to the other over the separator berm.
- An emergency outfall (spillway) will be incorporated into the pond design to allow for a controlled release up to 190 l/s (3,000 gpm), should the ponds overflow due to pipe plugging or rupture from outside influence.
- The pond embankments will be constructed using native materials from the site.
- The ponds will be lined with a 60-mil geomembrane synthetic liner.
- The ponds should be of sufficient size to allow settling of expected solids
- The embankment crest width should be at least 5 m (16.4 ft) for access; this includes a 4 m (13 ft) wide road for vehicles and equipment access during operations, with another 0.5 m (1.6 ft) for safety berms and/or a drainage ditch, on each side. Safety berms as outlined herein are to accommodate light vehicle traffic; if access is required for larger vehicles, the safety berms should be sized according to MSHA 30 CFR requirements (mid- axle of largest equipment on the road).

To meet the design criteria listed above, the ponds will be constructed to elevation 579 m. A 4 m (13 ft) wide access road forms the crest, along the perimeter of the two ponds. A drainage ditch is provided on the outer edge of the crest road on the upgradient side; all other crest road edges are bounded by safety berms. 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, the lower and upper diffusers were both inoperable, or the amount of water coming from the portal exceeded the combined discharge capacities of the buried lower and upper diffusers.

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. Submersible pumps may be used in the case that water in the ponds cannot be gravity-drained to the lower diffuser. As noted previously, the LAD system is necessary to dispose of water during development of an exploration ramp and is not planned for long-term use. 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 of sufficient size to provide adequate retention time to settle the anticipated solids suspended in the underground

Assumptions:

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

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

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

seepage water. The method is acceptable for ponds where the finest suspended particles will be present, thus requiring the maximum retention time.

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 ponds 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 and as designed, they will provide 24 hours of retention time at flows of 500 gpm. If one of the settling ponds is taken off line the remaining pond would still provide sufficient settling time at total flows of 500gpm assuming 250 gpm of that total was directed at the upper diffuser.

2.1.1.2 Lower Diffuser

The purpose of the buried lower 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 lower diffuser originates at the settling ponds, and then discharges through the diffuser pipes into the ground, like a shallow septic system drain field. BGC developed a final design for the lower diffuser (Figure 4) which consists of perforated pipes in three trenches, with valves to create six "zones". The lower diffuser site has higher infiltration rates than most other locations on site, as discussed in BGC's report (2018) except for test pit ITP-18 (Figure 6) in upper Waterfall Creek.

The lower diffuser pipe will be buried approximately 2 m (6.6 ft) below ground surface (bgs) to prevent pipe freezing. The minimum design flowrate to the buried lower diffuser is 32 l/s (500 gpm). The minimum gradient for the lower diffuser area is 2%.

The design flow rate from the sedimentation ponds of 32 l/s (500 gpm) was combined with a factor of safety to calculate a total required trench length of 400 m (1,300 ft). Each trench is 3 m (9.8 ft) wide and offset by 15 m (50 ft). Given the available space, the trench designs vary in length (Figure 4).

For final design, two-dimensional (2D) numerical infiltration models were run, at two seepage cross sections that explicitly consider topography in the lower diffuser area, both vertical and lateral flow, and interference between parallel lower diffuser trenches. The purpose of the modeling was to estimate the lower diffuser infiltration rate, potential groundwater mounding, and potential seepage below the lower diffuser. Development of the models was completed by BGC (2018) using the commercially available 2D finite element modelling software Seep/W (GeoStudio, 2016). Seep/W is designed to analyze groundwater flow, seepage and pore-water pressure dissipation in porous media.

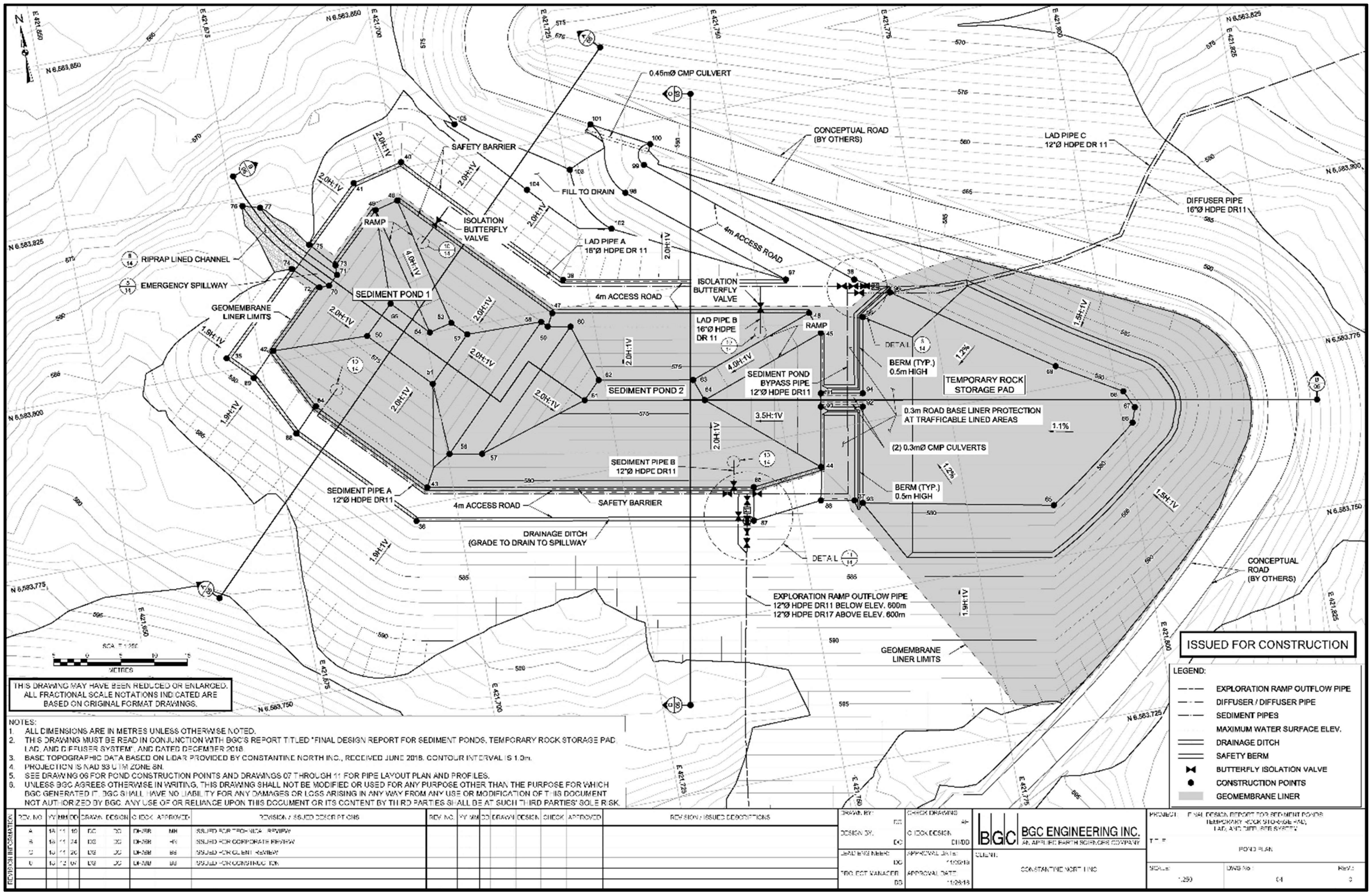

Figure 2. Engineered Drawings of Settling Ponds – Plan View

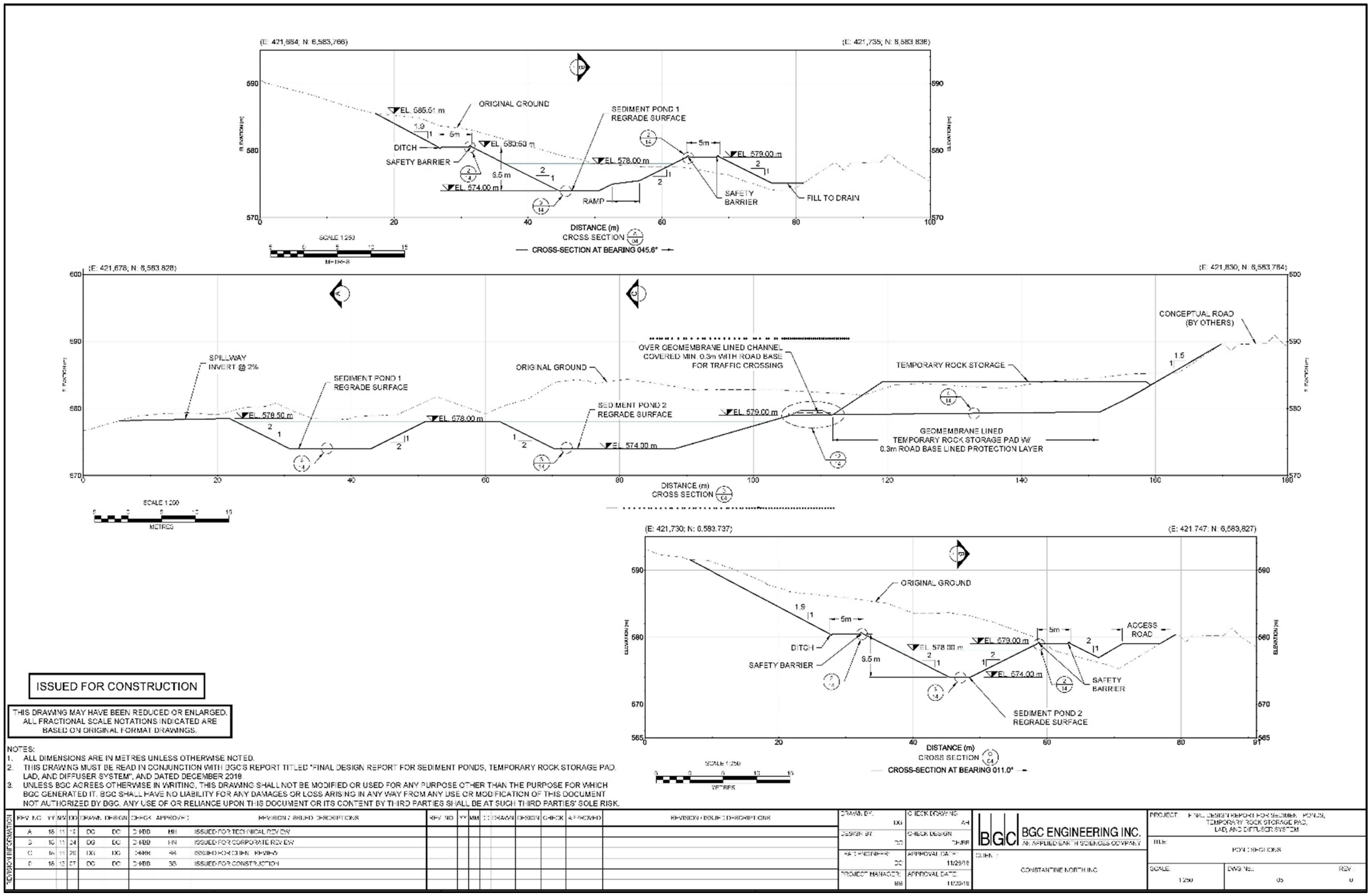

Figure 3. Engineered Drawings of Settling Ponds – Sectional View

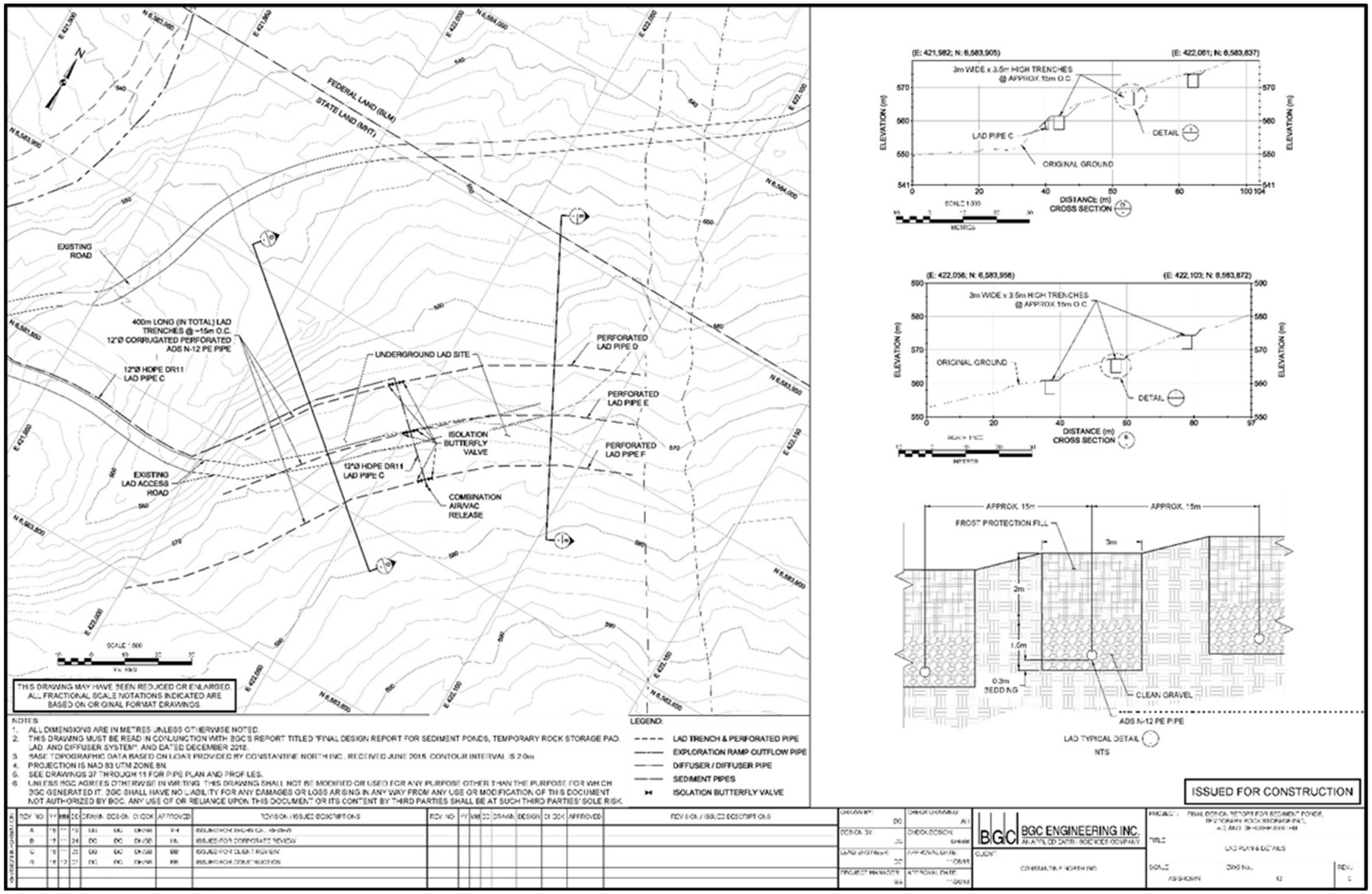

Figure 4. Engineered Drawings of Lower Diffuser

The infiltration modeling completed for the lower diffuser resulted in an average infiltration rate for of approximately 1.2 x 10-4 m3/sec per linear meter of trench. The rate varies based on trench location and elevation. The higher elevation trenches were simulated to have increased infiltration rates as there was no interference from adjacent upgradient seepage. Furthermore, the infiltration trench extending to the southwest is simulated to have an increased infiltration rate due to the absence of additional downgradient infiltration trenches. Based on a total infiltration trench system length of 400 m (1,300 ft), the infiltration models simulated a total infiltration capacity of 0.05 m3/sec (800 gpm). The calculated factor of safety compared to the design flow rate of 500 gpm is 1.6. This factor of safety is considered reasonable, based on using a 2D infiltration analysis. The infiltration capacity of the lower diffuser system was found to be limited by the hydraulic conductivity of the alluvium. To quantify the influence of the alluvium hydraulic conductivity on the infiltration rates, two sensitivity scenarios were completed; the hydraulic conductivity of the alluvium was increased and decreased by a factor of 2. Based on the sensitivity scenarios, an increased hydraulic conductivity of the alluvium resulted in an increase infiltration rate of 0.10 m3/sec (1,600 gpm). Conversely, a decreased hydraulic conductivity of the alluvium resulted in a decreased infiltration rate of 0.025 m3/sec (400 gpm).

Each lower 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 a low point at Waterfall Creek. A pipe crossing at this location minimizes disturbance to the Waterfall Creek drainage, but also reduces the gradient for pipe flow to the lower diffuser. A low point drain will be installed at the bottom of the inverted siphon with an isolation butterfly valve to allow for complete drainage of the system, if necessary. The lower diffuser is located below avalanche berms, which are being designed by others. The design of the avalanche berms should account for saturated foundation conditions.

2.1.1.3 Upper Diffuser

An additional LAD discharge point will be constructed near the upper segment of the portal pad road and is illustrated as the Upper Diffuser on Figure 1. This will consist of a diffuser buried in a trench that will accommodate the discharge of wastewater to coarse talus material. This upper diffuser is illustrated in more detail in Figure 5. Its purpose is to accommodate wastewater discharges of seepage water in the underground ramp during the initial underground development stage while the settling ponds and lower diffuser are being constructed. The upper diffuser will accommodate flows of 50 gpm and is being buried to protect it from seasonal frost, like the lower diffuser. It will be constructed approximately 228m (750 ft) south of the portal at a slightly lower elevation to allow gravity flow and discharge.

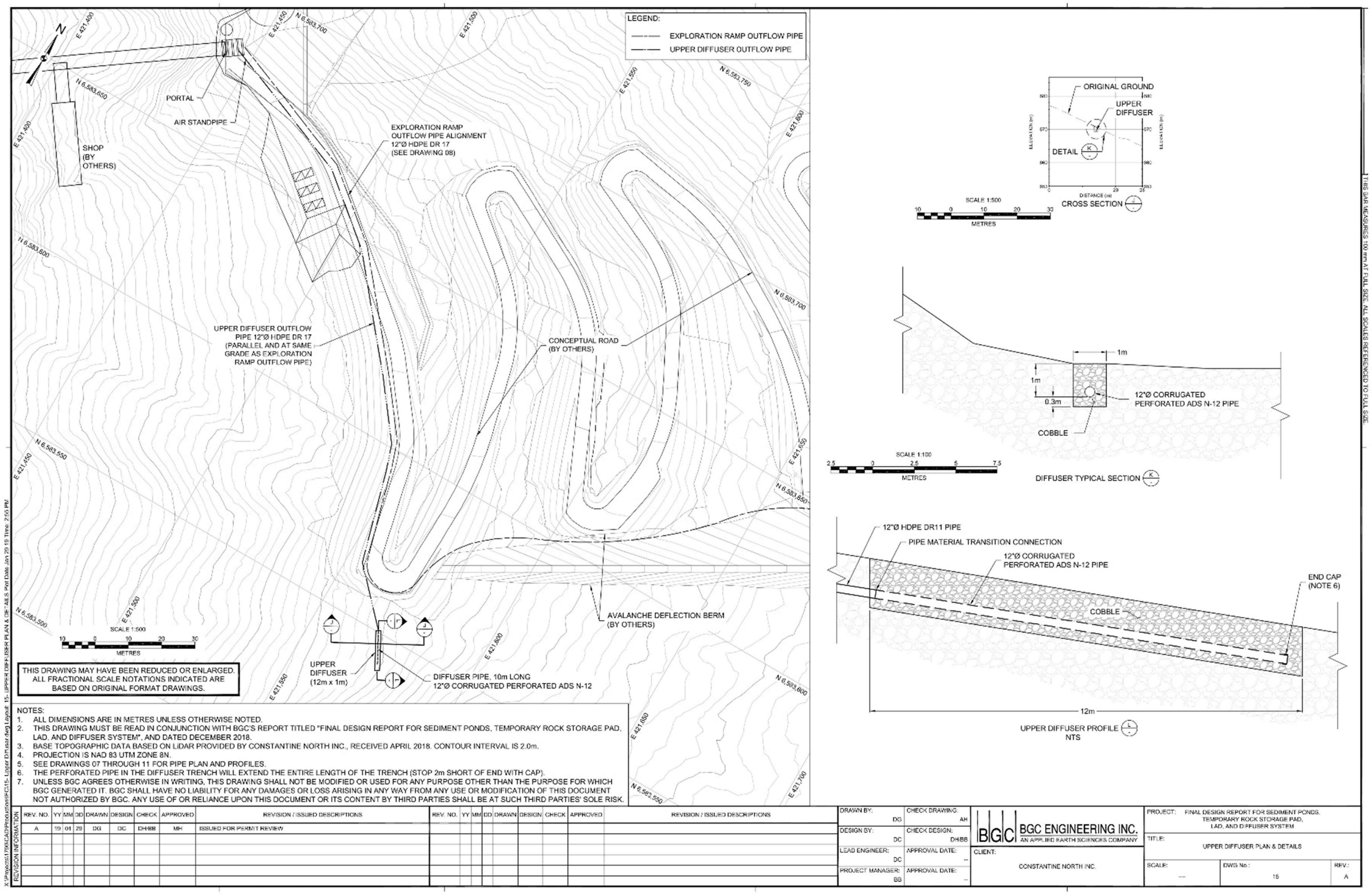

Figure 5. Engineered Drawings of Upper Diffuser

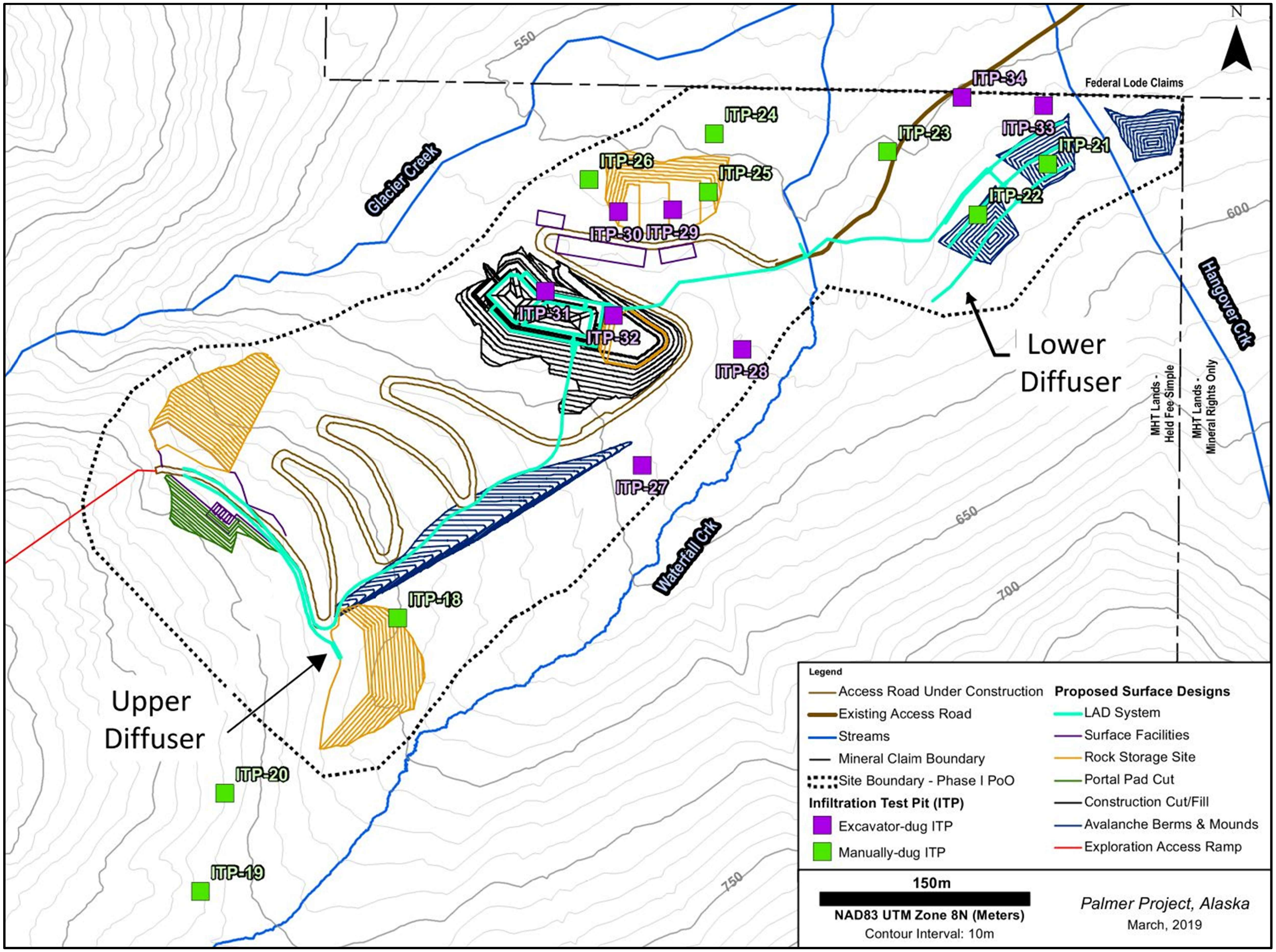

Figure 6. Location of Infiltration Test Pits

Figure 6 illustrates the location of the upper diffuser and the water will be conveyed to the upper diffuser by PVC or HDPE pipe buried along the portal access road between the portal and the talus slope, where the pipe will be perforated for a length of 40 feet (12m), and the water will discharge directly into the poorly consolidated talus.

The infiltration test data (infiltration test pit locations illustrated in Figure 6) indicate that the upper diffuser area will very easily accommodate 50 gpm. The diffuser will be installed with a downslope gradient toward the end of the pipe to ensure that the discharge is evenly distributed along the length of the diffuser avoiding any focused discharge at any point along the pipe. Constantine will monitor the talus slope daily for signs of new seeps that might result from the upper diffuser. Constantine will also monitor the water quality in a new shallow groundwater monitoring well to be installed in 2019, down-gradient of the upper diffuser.

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 upper and lower diffusers. The pipeline network design layout and corresponding profiles are represented on Drawings 07 through 13 in Appendix A.

The piping is designed to meet the following design criteria.

- The design flowrate to the settling ponds is 32 l/s (500 gpm).
- The design flowrate to the LAD is 32 l/s (500 gpm), with a maximum infiltration capacity of 50 l/s (800 gpm).
- A peak flowrate of 190 l/s (3,000 gpm) for the pipelines from the portal to the ponds.
- Gravity drainage must be provided where possible.
- Pipe for the pipeline network will be PVC or HDPE.
- Pipe will be buried a minimum of 2 m (6.6 ft) bgs.

Water from the portal will be conveyed by gravity flow via pipeline to a junction point adjacent to the southeast portion of the settling ponds. Flow through this section of the pipeline will be maintained in a mostly pressurized condition to reduce the potential for jumping, cavitation, and/or suction in the line. This will be controlled by a proportional pressure reducing valve and a pressure sustaining valve in series, pre-configured to allow flow in incrementally increasing amounts as additional head builds above it in the pipeline. Flow through this junction can be directed to each of the settling ponds individually or jointly, by way of isolation butterfly valves, to allow for full operational flexibility. Flow can be directed into one pond, be allowed to spill over the separating berm, and then discharge from the other pond to maximize retention time and therefore the settling of suspended solids. Flow can also be directed through each pond individually to accommodate taking either pond offline for maintenance and/or for sediment removal.

The invert elevations of pipes discharging into the ponds are situated near the top (elevation 578.2 m) to allow for visual confirmation of inflows and prevent backup due to sediment accumulation in the pond bottoms. Alternatively, flow though this junction can be routed to a by-pass line, by way of an isolation butterfly valve, that diverts water around the ponds directly to the buried lower diffuser pipes. This configuration provides the ability to operate the ponds in tandem, individually during maintenance scenarios, or by-pass them altogether if necessary or desired.

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 at least 50 l/s (800 gpm) to the buried lower 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 50 l/s (800 gpm) flow to the buried lower 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 (approximately elevation 680 m to elevation 552 m). Therefore, the pressure rating of the pipes above elevation 600 m is required to be DR17 and the pressure rating of the pipes below elevation 600 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.

2.1.2 Physical and 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 from monitoring wells adjacent to the proposed lower diffuser location. The prediction was based on the assumptions that: 1) the seepage inflows into the exploration ramp will consist of groundwater and will be geochemically similar to the groundwater quality in groundwater well P29, 2) this seepage would come in contact with 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 (2018) developed what they term as a "conservative" discharge water quality prediction using an empirical approach based on two data sets. 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.

In addition to the above, nitrogen species, resulting from explosives use, were predicted using methods provided in Ferguson and Leask (1998) and MDAG (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. Results are provided in Appendix D. 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 rain water. Data is provided in pHase's report in Appendix C.

Table 2 makes a similar comparison as Table 1 but in Table 2 the background water chemistry for the two sampling events and for both wells MW-01 and MW-02 are averaged and then compared with AWQ guidelines and the predicted wastewater discharge chemistry (aka LAD discharge). The Table illustrates that predicted LAD discharge exceeds the average background concentrations for many parameters but for all but two of these the predicted discharge will still meet AWQ guidelines. The predicted discharge exceeds AWQ guidelines for dissolved and total Al, dissolved Mn (and arguably dissolved V). However, even though the predicted discharge concentrations for Al and Mn exceeds AWQ guidelines, the Al concentration in the wastewater discharge is still lower than background Al concentrations measured as total aluminum. All other parameters that were analyzed but don't appear in the Table meet AWQ guidelines. All baseline water quality data for Glacier Creek, Waterfall Creek, Hangover Creek and monitoring wells MW-01, 02 and 03 are being provided to ADEC in electronic form as part of this permit application.

Table 1. Predicted Discharge Wastewater Chemistry Compared to Alaska Water Quality Guidelines and Background Groundwater Quality in MW-01 and MW-02

Parameter	as	Alaska Guidelines			Discharge Wastewater Chemistry (Predicted)				Groundwater Chemistry from Monitoring Wells (actual)			
		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	MW-02 (below LAD) sampled 9/17/2018	MW-01 (above LAD) sampled 9/17/2018	MW-02 (below LAD) sampled 9/28/2018	MW-01 (above LAD) sampled 9/28/2018
Hard as $CaCO^3$	t	—	—	—	255	109	255	255	167	151	151	154
pH	-	—	—	—	8.8	8.9	8.2	8.9	8.20	8.21	8.18	8.17
NH3 as N	t	8.4	—	t	0.03	n.d.	n.d.	0.8	0.0052	0.005	0.005	0.005
NO3 as N	t	10*	—	t	0.005	n.d.	n.d.	1.1	0.216	0.191	0.414	0.188
NO2 as N	t	1*	—	t	0.001	n.d.	n.d.	0.08	0.001	0.001	0.001	0.001
Al	t	0.75	0.75	t					**4.51**	**1.13**	**6.55**	0.043
Al	d	0.75	0.75	t	0.004	**2.9**	0.004	**2.9**	0.0076	0.0103	0.0131	0.0022
As	t	0.34	0.15	t					0.00044	0.00024	0.00055	0.0001
As	d	0.34	0.15	d	0.0002	0.003	0.0002	0.003	0.0001	0.0001	0.0001	0.0001
Cd	t	0.00322	0.00037	t					0.0000709	0.0000573	0.000106	0.000008
Cd	d	0.00299	0.00033	d	0.00001	0.00016	0.00001	0.00016	0.0000071	0.0000093	0.0000073	0.0000091
Cr	t	2.5132	0.1201	t Cr-III					0.0102	0.0022	0.0165	0.0004
Cr	d	0.7942	0.1033	d Cr-III	0.0001	0.008	0.0001	0.008	0.0001	0.00012	0.00027	0.00014
Cr	t	0.0160	0.0110	d Cr-IV					0.0102	0.0022	**0.0165**	0.0004
Cr	d	0.0160	0.0110	d Cr-IV	0.0001	0.008	0.0001	0.008	0.0001	0.00012	0.00027	0.00014
Cu	t	0.0205	0.0132	t					**0.0153**	0.00361	**0.0218**	0.0005
Cu	d	0.0197	0.0127	d	0.0005	0.008	0.0005	0.008	0.0002	0.0002	0.0002	0.0002
Fe	t	—	1	t					**8.59**	**2.21**	**12.1**	0.077
Fe	d	—	1	t	0.23	0.68	0.23	0.68	0.012	0.018	0.022	0.01
Pb	t	0.13680	0.00533	t					0.00138	0.000229	0.00183	0.00005
Pb	d	0.10013	0.00390	d	0.00006	0.0008	0.0001	0.0008	0.00005	0.00005	0.00005	0.00005
Mn	t	0.05**	—	t					**0.198**	0.0428	**0.273**	0.00154
Mn	d	0.05**	—	t	**0.08**	**0.33**	**0.08**	**0.33**	0.0136	0.00067	0.00482	0.00030
Hg	t	0.001400	0.000770	d					0.000005	0.000025	0.00005	0.000005
Hg	d	0.001400	0.000770	d	0.000005	0.00009	0.000005	0.00009	0.000005	0.000005	0.000005	0.000005
Ni	t	0.6612	0.0735	t					0.00557	0.00242	0.00916	0.0015
Ni	d	0.6598	0.0733	d	0.0005	0.008	0.001	0.008	0.0005	0.0005	0.0005	0.0005
Se	t	—	0.005	t					0.00163	0.00172	0.00196	0.00184
Se	d	—	0.0046	d	0.00005	0.0028	0.0001	0.0028	0.00162	0.00158	0.00203	0.00199
Ag	t	0.00760	—	t					0.000021	0.00001	0.000028	0.00001
Ag	d	0.00646	—	d	0.00001	0.00016	0.00001	0.00016	0.00001	0.00001	0.00001	0.00001
V	t	0.1***	—	t					0.0234	0.00600	0.0325	0.0005
V	d	0.1***	—	t	0.0005	**0.11**	0.0005	**0.11**	0.0005	0.0005	0.0005	0.0005
Zn	t	0.1689	0.1689	t					0.0275	0.0063	0.0376	0.003
Zn	d	0.1652	0.1666	d	0.0006	0.05	0.0006	0.05	0.001	0.001	0.0018	0.001

Notes: Note modelled data is presented as dissolved metals and groundwater data is presented as both the total recoverable fraction and dissolved metals (mg/L)

Detection limit presented for values under detection limit; groundwater data has not undergone full QA/QC process

Guidelines were taken from: *Alaska Water Quality Criteria Manual for Toxic And Other Deleterious Organic and Inorganic Substances (DEC, 2008)* ; guidelines for total recoverable and 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

chronic exceedance | acute exceedance

Table 2. Predicted Wastewater Discharge Chemistry Compared to Alaska Water Quality Guidelines and Average Background Groundwater Quality in MW-01 and MW-02

Parameter	as	Alaska Water Quality Guidelines (AWQG)			Conservatively Predicted Wastewater Discharge Chemistry	Background Groundwater Chemistry (Average MW-01 and 02)	Predicted Wastewater Chemistry Exceeds Background	Predicted Wastewater Chemistry Exceeds AWQG
		ACUTE Guideline (mg/L)	CHRONIC Guideline (mg/L)	*as*				
Hard as CaCO3	t	—	—	—	255	156		
pH	-	—	—	—	8.90	8.19000	✓	
NH3 as N	t	8.4	—	t	0.8	0.00505	✓	
NO3 as N	t	10*	—	t	1.100	0.25225	✓	
NO2 as N	t	1*	—	t	0.08	0.00100	✓	
Al	t	0.75	0.75	t		3.05825		
Al	d	0.75	0.75	t	2.9000	0.00830	✓	✓
As	t	0.34	0.15	t		0.00033		
As	d	0.34	0.15	d	0.003	0.00010	✓	
Cd	t	0.00322	0.00037	t		0.00006		
Cd	d	0.00299	0.00033	d	0.0001600	0.00001	✓	
Cr	t	2.5132	0.1201	t Cr-III		0.00733		
Cr	d	0.7942	0.1033	d Cr-III	0.00800	0.00016	✓	
Cr	t	0.0160	0.0110	d Cr-IV		0.00733		
Cr	d	0.0160	0.0110	d Cr-IV	0.00800	0.00016	✓	
Cu	t	0.0205	0.0132	t		0.01030		
Cu	d	0.0197	0.0127	d	0.008	0.00020	✓	
Fe	t	—	1	t		5.74425		
Fe	d	—	1	t	0.68	0.01550	✓	
Pb	t	0.13680	0.00533	t		0.00087		
Pb	d	0.10013	0.00390	d	0.0008	0.00005	✓	
Mn	t	0.05**	—	t		0.12884		
Mn	d	0.05**	—	t	0.33000	0.00485	✓	✓
Hg	t	0.001400	0.000770	d		0.00002		
Hg	d	0.001400	0.000770	d	0.00009	0.00001	✓	
Ni	t	0.6612	0.0735	t		0.00466		
Ni	d	0.6598	0.0733	d	0.008	0.00050	✓	
Se	t	—	0.005	t		0.00179		
Se	d	—	0.0046	d	0.0028	0.00181	✓	
Ag	t	0.00760	—	t		0.00002	✓	
Ag	d	0.00646	—	d	0.00016	0.00001	✓	
V	t	0.1***	—	t		0.01560		
V	d	0.1***	—	t	0.11	0.00050	✓	✓
Zn	t	0.1689	0.1689	t		0.01860		
Zn	d	0.1652	0.1666	d	0.05	0.00120	✓	

Notes:

Note modelled data is presented as dissolved metals and groundwater data is presented as both the total recoverable fraction and dissolved metals (mg/L)

Detection limit presented for values under detection limit; groundwater data has not undergone full QA/QC process

Guidelines were taken from: *Alaska Water Quality Criteria Manual for Toxic And Other Deleterious Organic and Inorganic Substances (DEC, 2008)* ; guidelines for total recoverable and 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 consuption of water and aquatic organisms; *** = irrigaiton 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 (2018) considered this in their wastewater prediction work (Appendix C) and the predicted concentrations of these nitrate compounds (NH^3, NO^3 and NO^2) are shown in Tables 1 and 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 the following nitrate source control BMP's to minimize nitrates in the wastewater discharge:

- **Explosive product selection**
    - Constantine has chosen to use packaged emulsion as the primary blasting agent for the program.
- **Powder factor optimization**
    - With ramping rounds, once the contractor finds a drill/blast pattern that works well in the rock they are ramping in, they will use it routinely. In the interest of drilling efficiency, they will keep the number of holes to a minimum, which means the powder usage will also be efficient.
- **Practices for explosive storage (preventing contact with water/moisture)**
    - Packaged emulsion will be stored in weatherproof magazines separate from blasting caps to prevent contact with water and for safety. The magazines will be provided by the explosives vendor, thus the magazine size is not currently known. After the development contract has been awarded, the contractor will inform Constantine of the number of magazines and the magazine storage capacity. At that time safety berms will be designed to comply with Bureau of Alcohol, Tobacco, and Firearms (BATF) regulations and to provide avalanche protection.
- **Practices to prevent water contacting explosive in blast holes (i.e., blast hole liners, bench dewatering)**
    - Grades in the underground ramp access at the Palmer Project vary from +2.5% to +12%. Ground water and drill water will drain away from the face, thus there will be no ponding at the face. Holes will be blown clean of debris and water before loading.

- **Drill pattern optimization**
  - Drill pattern density and drillhole depth will be optimized to attain the desired break using the minimum amount of explosive.
- **Explosive loading**
  - The blasts at Palmer will be small (5m x 5m x ~3m), so the explosives loading process will be fast. Excess explosives brought to the face, but not used, will be returned to the magazines.
- **Spill response/reporting**
  - This would apply to bulk loaded explosives, which will not be used at Palmer. Any sticks of emulsion that are dropped will be picked up and used or returned to storage.
- **Incident management/investigation**
  - Incidents will be investigated by the Contractor (who will hold the BATF license) and Constantine. Reports will be made to the proper authorities (BATF and/or MSHA).
- **Training and inspection**
  - Only trained personnel will be allowed to handle, load, and detonate explosives. All shipments of explosives will be inspected and inventoried upon arrival.
- **Dealing with misfires**
  - After blasting and after mucking, the face will be inspected for misfires. Misfires will be detonated by inserting a new cap and firing after the face has been safely cleared of personnel.
- **Handling and disposal of waste explosive products**
  - Defective or excess explosive products will be returned to the vendor.

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 Attachment 2 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 a 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.
- Use approved settling additives (flocculants) in underground sumps to encourage settling of suspended solids underground prior to pumping it to the settling ponds or the upper diffuser.

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 13 monitoring wells in the project area (Figure 7; Integral, 2018, Tundra, 2018). 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 (2018) used this is the background water quality for use in predicting the discharge water quality after considering some interaction with 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 3 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.

Integral Consulting (2018, and Appendix B) 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 up-gradient and downgradient of the proposed lower diffuser since 2018. These are wells MW-01 and MW-02 and are also illustrated on Figure 7. The background water quality in these wells is important because it is against these background values that any future change in water quality, after the lower diffuser discharge is initiated, will be compared. The water quality data for two sampling events for these wells is provided in Table 1. In that Table the background water quality data are compared to acute and chronic water quality guidelines. This is also illustrated in Table 2, but in Table 2 the groundwater quality data for MW-01 and MW-02 are averaged for a simpler comparison. Table 2 shows that natural background groundwater quality exceeds chronic and acute guidelines for Al, and chronic guidelines for Fe. In addition, MW-02 exceeds acute guidelines for Mn.

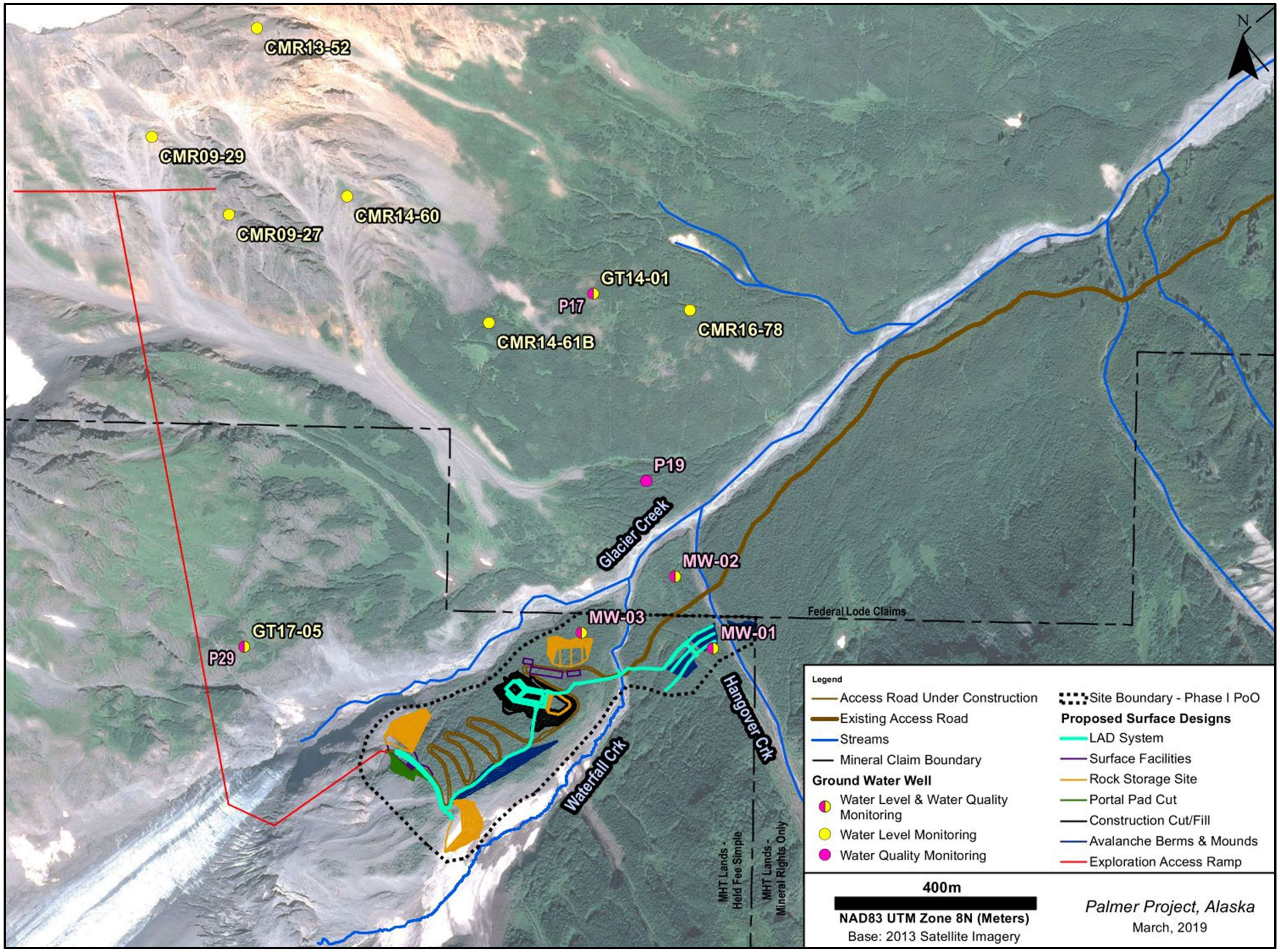

Figure 7. Groundwater Monitoring Sites

Table 3. Groundwater Quality in Wells and Springs Near Proposed Underground Ramp

			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 3 cont'd. Groundwater Quality in Wells and Springs Near Proposed Underground Ramp

			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 8). 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.

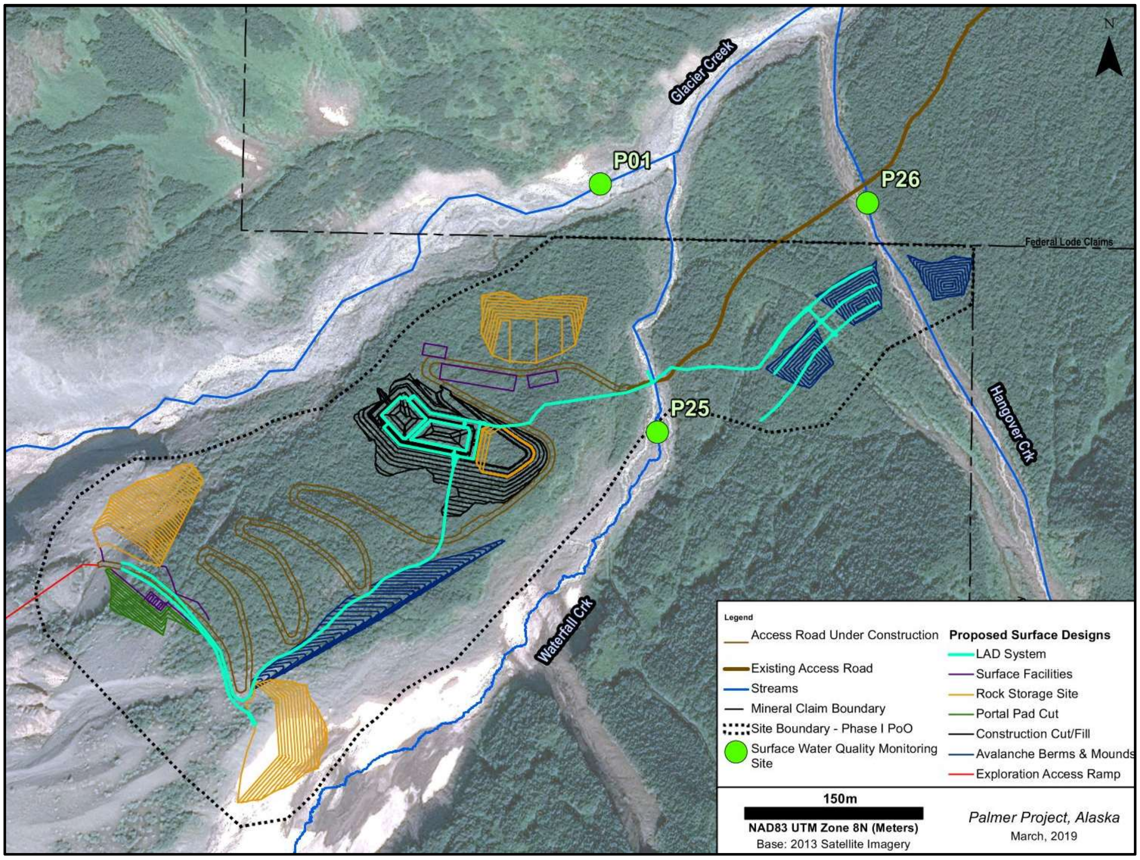

Figure 8. Surface Water Quality Sample Location Map Near the Confluences of Glacier, Waterfall and Hangover Creeks

Constantine's consultant Integral 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 stream may be more heavily influenced by groundwater and local geology.

Integral (2018, and Appendix B) summarized that the surface waters in the project area 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 4):

- Chronic and acute standards 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) (Integral, 2018)

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.

Constantine will continue monitoring at sites P1 and P27 in upper and mid-Glacier Creek, respectively, 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 be concomitant with Constantine’s underground exploration activities which are restricted to the upper Glacier Creek area.

Table 4. Comparison of Surface Water Quality to Freshwater Aquatic Life and Human Health Criteria for Metals

		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 2019 and continue construction through the summer of 2019 until the LAD is complete. Table 5 illustrates the tentative construction schedule.

Initial focus will be to construct the upper diffuser and pipe connecting it to the portal so that it can be used as soon as necessary to manage water after the start of underground activities. Constantine will also construct a new monitoring well down-gradient of the upper diffuser.

Some ground-clearing and initial earth moving was completed in 2018 in the vicinity of the settling ponds so the work in 2019 will move directly into excavating the ponds and creating the impoundments to the ponds prior to installing the 60mil HDPE liner.

Excavation of the lower diffuser trenches will likely overlap with pond construction.

Pipe installation between the portal and ponds and between ponds and buried lower diffuser will lag a bit behind the construction of these facilities.

Construction will end with some functional testing of the overall LAD system.

Table 5. Tentative Construction Schedule for Wastewater Disposal System

Construction Component	May'19		June'19				July '19	
	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2
Upper Diffuser Trench								
Sediment Ponds								
Lower Diffuser Trenches								
Pipe Installation								
Testing								

Wastewater discharge will begin as soon as measurable seepage inflows are encountered in the advancing exploration ramp, likely in late July or August 2019. 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 (51%) and Dowa Metals & Mining Alaska Ltd. (49%), both of which are incorporated under the laws of the State of Alaska. The Palmer Project operations manager is Darwin Green 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	
Darwin Green	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 included as Attachment 1 with this application.

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 the forthcoming waste management permit from ADEC.

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.

2.7.2 Groundwater Quality Monitoring

Constantine has been performing groundwater quality sampling since 2014. A primary objective of the sampling was to characterize groundwater as a step in predicting the quality of seepage water inflows into any future underground ramp. Sampling was performed in accordance with Constantine's QAPP.

Two drillholes with artesian flow (site P17 at drillhole GT14-01, and site P29 at drill hole GT17-05) are routinely sampled, during the snow-free season. Site P17 is a horizontal hole at the South Wall prospect, which can be used to characterize subsurface drainage associated with the hanging wall basaltic rocks of the mineralized South Wall zone and site P29 is also a horizontal hole characterizing subsurface drainage associated with the Jasper Mountain basalts. In addition to the drillholes, Constantine also samples a spring at the base of Paddys Pocket referred to as site P19.

In 2018 Constantine developed two groundwater monitoring wells above and below the proposed LAD diffuser site (MW01 and MW02, 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. The monitoring wells above and below the LAD have only been sampled three times so far but they are being used to characterize the shallow groundwater in the vicinity of the LAD and to provide a basis for comparison after Constantine starts discharging water through the buried LAD diffuser.

Constantine intends to continue groundwater sampling, including sampling select underground seepage water inflows. Constantine will continue to sample groundwater at the two lower diffuser wells (MW-01 and MW-02). Constantine will also develop a new groundwater monitoring well downgradient of the upper diffuser and begin background groundwater quality sampling there in 2019. These samples will be collected quarterly and in accordance with the QAPP.

Constantine also has transducers in MW-01 and MW-02 above and below the LAD diffuser site and will monitor groundwater levels in these wells.

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 install a valve in at least one of these holes to provide opportunities for quarterly sampling.

Constantine will also monitor the quantity of underground seepage water inflows underground by measuring the flow in the water discharge pipe at the portal, as the water is conveyed to the settling ponds and or the upper diffuser.

Finally, Constantine will monitor the area below the upper and the lower diffusers for signs of new seeps that might result from the discharges.

3.0 DEVELOPMENT ROCK MANAGEMENT

This Section 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; Constantine does not expect to intersect any PAG during the underground development program. Constantine is applying for inclusion of development rock in the waste management permit as a contingency to cover the very unlikely 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 9:

0 meters = Portal
Portal – 13m, 13 m-long segment, +2.5% grade
13m – 270m, 257 m-long segment, +2.5% grade
270 – 370 m, 100 m-long segment, +2.5% grade
370 – 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 5m by 5m (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 10 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 rock 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 unlikely 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.

Constantine will perform the following activities as part of its development rock handling plan during the development of the underground ramp at Palmer.

- Assign a unique identifier to each round of development rock.
- Perform a 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 (Figure 10).
- Collect a grab sample of muck from each round with greater than 2% sulfide and submit sample for ABA analysis and temporarily segregate the muck on the lined storage pad next to the settling ponds (Figure 10) pending results of ABA analyses of that round.
- Segregate all rounds for which the ABA analysis indicates a net neutralizing potential (NP:AP) less than 2 on the lined stockpile pad located adjacent to settling pond 2 (Figure 10)
- Place all rounds designated as PAG (NP:AP less than 2) back underground at end of exploration program.
- Collect quarterly composite grab samples from active development rock disposal sites (rock dumps, avalanche deflection mounds and berms) 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, including 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.

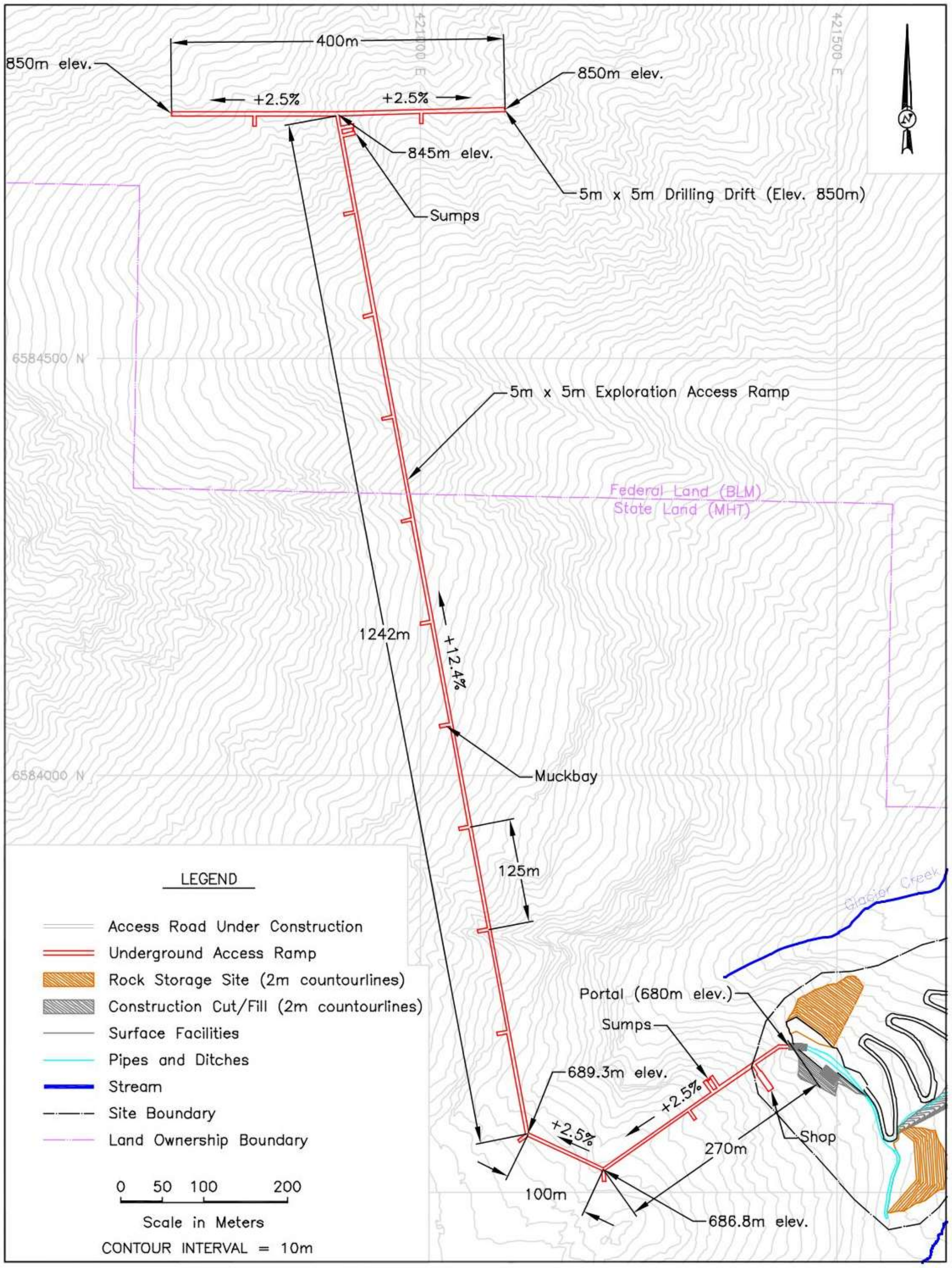

Figure 9. Proposed Underground Ramp - Plan View

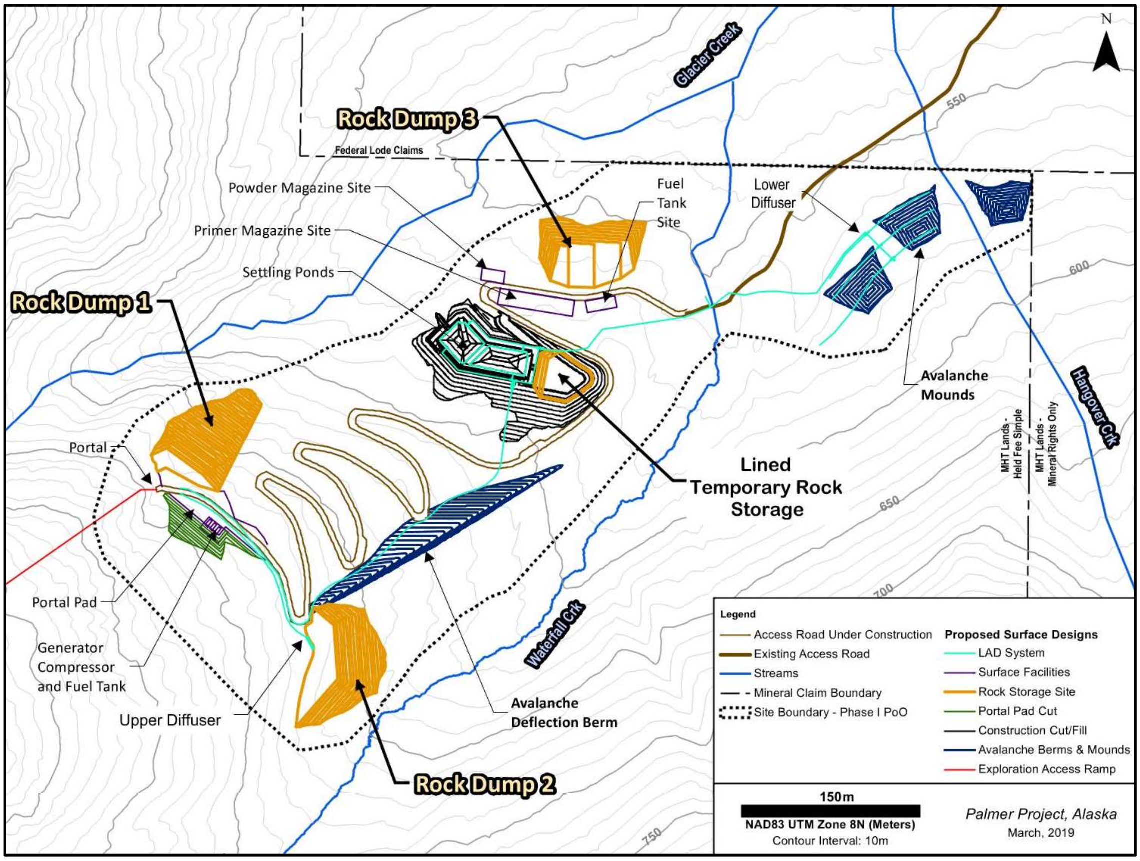

Figure 10. Surface Facilities including Waste Rock Disposal Sites (Rock Dumps 1,2,3, Avalanche Berm and Avalanche Mounds)

3.1 Background Geochemistry of the Exploration Ramp Development Rock

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 all of the 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, Appendix D). 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. Constantine is applying for inclusion of development rock in the waste management permit as a contingency to cover the very unlikely situation where PAG material is unexpectedly intersected with the ramp development.

A total of 101 representative samples were collected by Constantine from 20l4 through 2017and tested as part of the ARD/ML characterization program. These samples, including l7 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 dykes, gabbro, faults etc. Figure 11 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 has 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 6. 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 12). 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 13).

Table 6. 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

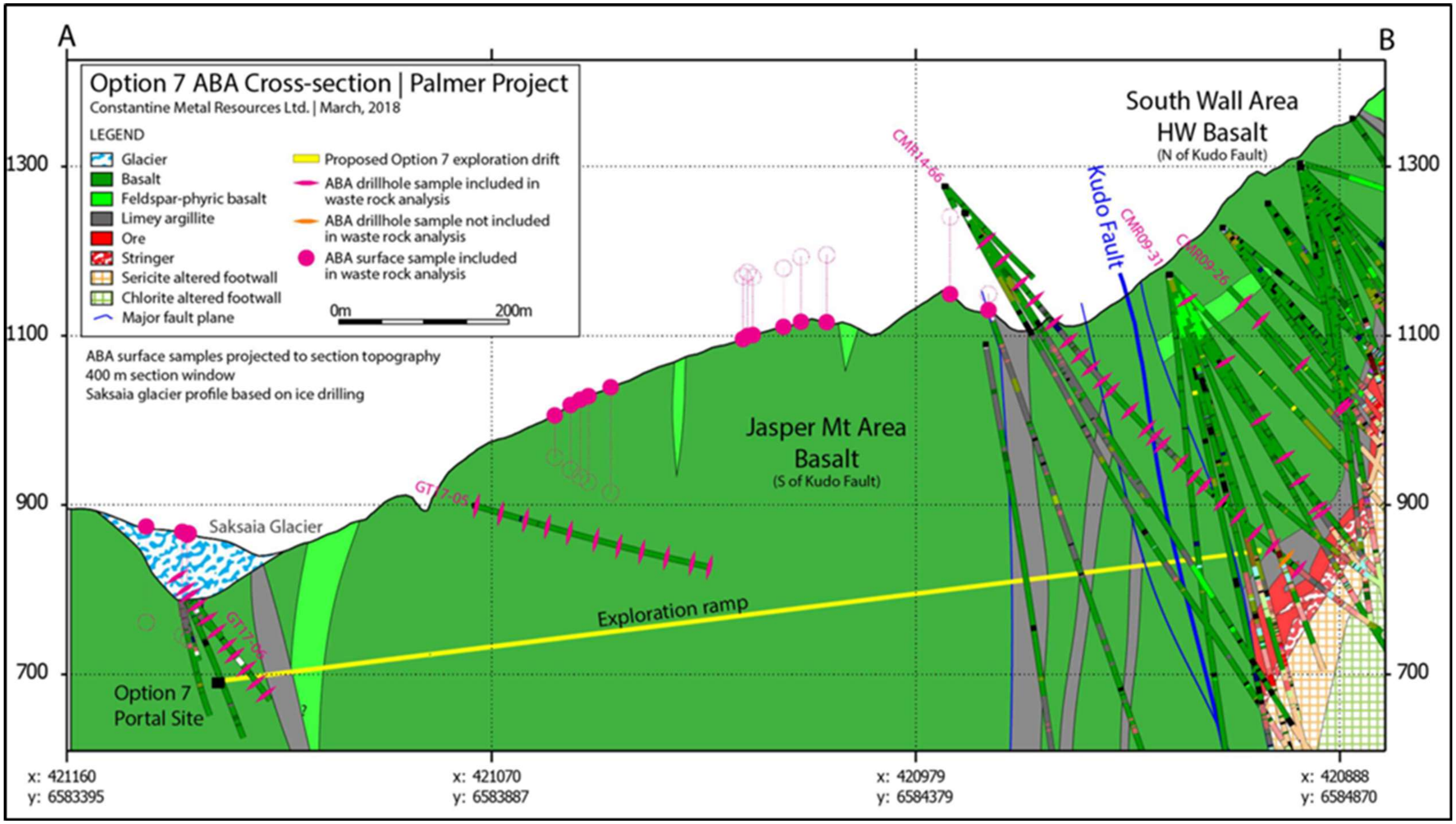

Figure 11. Geologic Crossection in Plane of Proposed Exploration Ramp Showing ABA Sample Locations

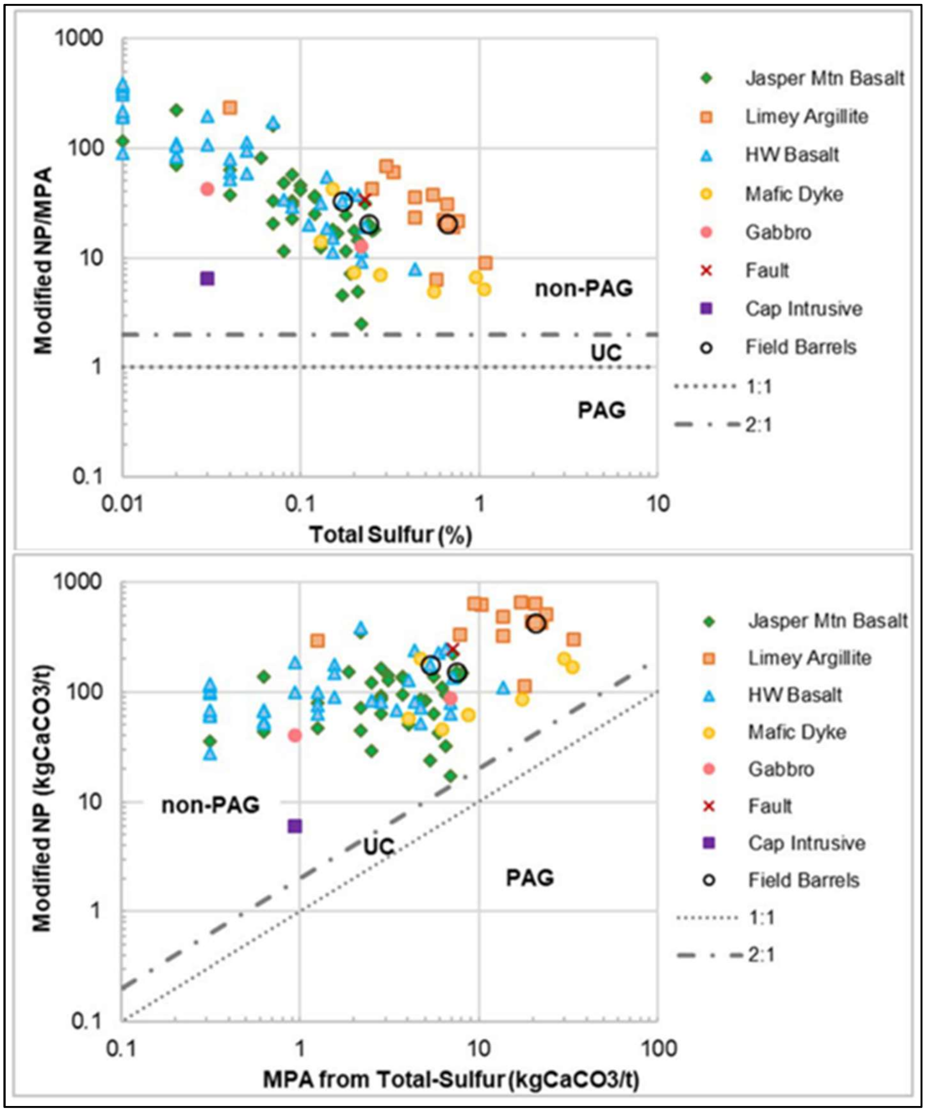

Figure 12. Classification of 101 Representative Samples of the Proposed Exploration Ramp

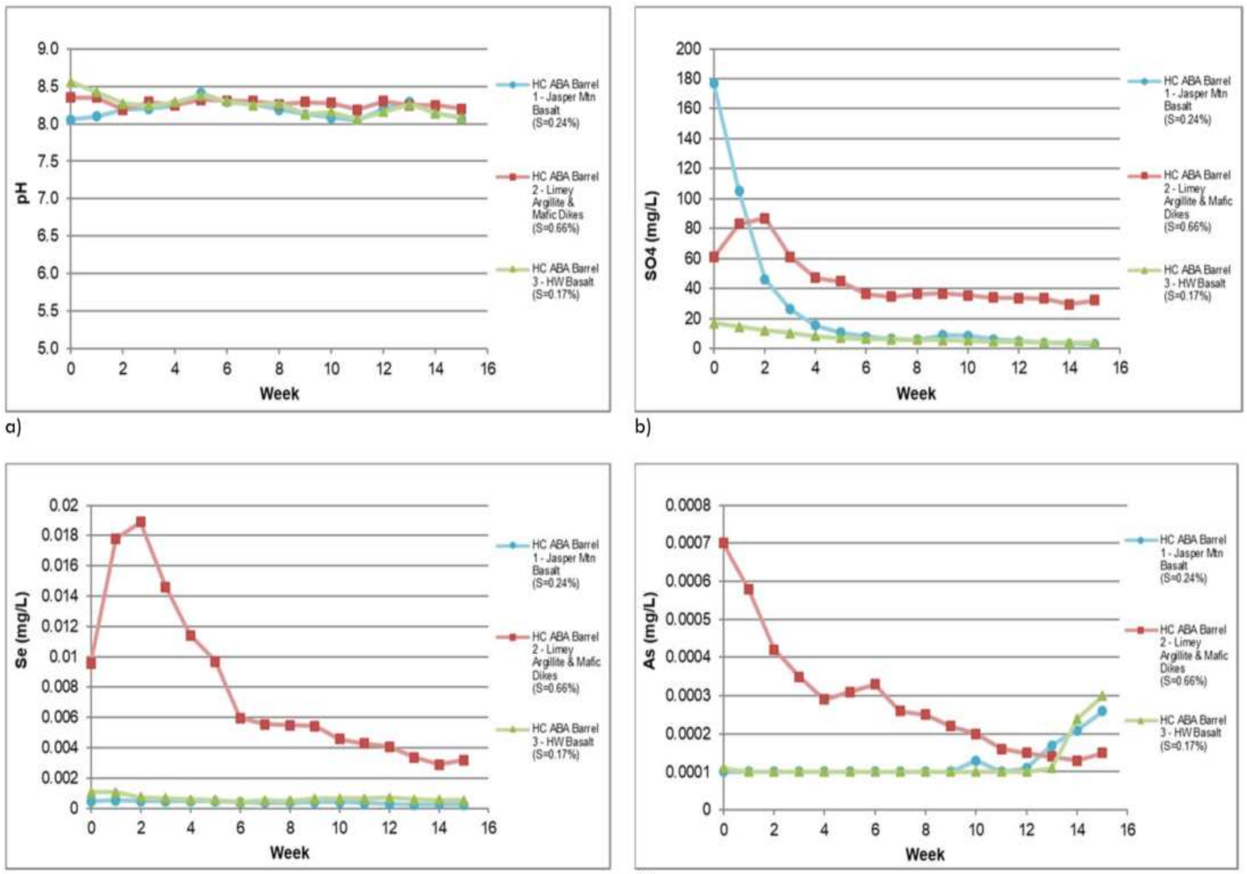

Figure 13. Barrel Leachate Results for Samples of Jasper Mtn. Basalt, Hangingwall Basalt and Limey Argillite Rock Units

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).

- 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, Hangingwall basalt, Argillite, Mafic dike, or a mix, etc.), 2) the average sulfide content as a percentage of the volume of the rock, 3) the types of sulfides (pyrite, pyrrhotite etc.). The geologist will also apply dilute HCl to the rock and establish the amount of effervescence (strong, moderate or weak).

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 (Figure 10), or a combination of these sites. The geologist will track and record the site used for final disposal

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 from

Following the visual geologic inspection non-PAG rounds will be routinely and permanently disposed on the surface in any of: rock dumps 1, 2 and 3, avalanche mounds or avalanche deflection berm. 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 acid base accounting 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 as a result of 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 fizz 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

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 in the very unlikely situation where PAG is encountered during development of the exploration ramp.

This Phase II 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 which are described below with additional details in Attachment 3. This reclamation plan and reclamation cost estimate supersede the reclamation plan and cost estimate included in Constantine's Phase I Plan of Operations and approved under by ADNR Reclamation Plan Approval #J20185690RPA. This Phase II reclamation plan and cost estimate includes all the reclamation activities from the Phase I reclamation plan but has been expanded to include reclamation activities required for the additional impacts of the proposed underground program (Phase II) as well.

4.1 Care and Maintenance Plan for Temporary Closure

There are some situations where Constantine may elect to suspend its activities proposed under this Phase II 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 is included in Appendix C and 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 area 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 included in Appendix C. 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 principle 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 unlikely event that any confirmed PAG material is identified 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 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 the temporary closure scenario and reclamation for permanent closure. Temporary and permanent closure scenarios are also described in Appendix C. Constantine intends to post a financial assurance in a form acceptable to the State regulatory agencies prior to initiating any work under this Plan of Operations, once the Plan of Operations is approved by the MHT and the Reclamation Plan is approved by ADNR.

Constantine's estimated cost for the care and maintenance under the temporary closure scenario is: 1) $33,245 to stabilize the site and make it ready for Care and Maintenance and install an access road gate and portal barrier, plus 2) $15,180/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 $103,090 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 permanent closure of the site is $1,011,542. This includes $522,181 in direct costs to design and construct a hydraulic portal plug in the development ramp to reduce surface flows at the portal to de minimis levels.

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 predicted water quality, 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. Most 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. Contractor profit is already included in the contractor's hourly equipment rates used for the cost estimate. As a result, Constantine feels that 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 for the Palmer project owing to the low overall cost of reclamation, the simplicity of the project, past performance of local contractors and relatively few number of 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. Arguably 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 essentially 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