RED MOUNTAIN UNDERGROUND GOLD PROJECT

VOLUME 2 | CHAPTER 4

ALTERNATIVE MEANS OF UNDERTAKING THE PROJECT

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4 ALTERNATIVES MEANS OF UNDERTAKING THE PROJECT

4.1 Introduction

Various mining, processing, and site development alternatives have been developed and analyzed by past proponents of the Red Mountain Underground Gold Project (the Project) and by IDM Mining Ltd. (IDM, the Proponent). This section presents the analysis of the range of alternative means of carrying out the proposed Project. It includes the following:

- An assessment of the alternative means of carrying out the proposed Project that are technically and economically feasible, including the alternatives identified in the Application Information Requirements (AIR) issued for the Project by the BC Environmental Assessment Office (EAO) in March 2017;
- The rationale and criteria used to select the proposed means of undertaking the proposed Project; and
- The methodology and criteria used in the assessment of alternatives.

The alternatives assessment has been completed as per guidance provided in the Operational Policy Statement Addressing “Purpose of” and “Alternative Means” under the *Canadian Environmental Assessment Act, 2012* (2012; Agency 2013).

4.2 Method of Assessing Alternatives

Alternatives means are defined by the Canadian Environmental Assessment Agency (the Agency; 2013) as “the various technically and economically feasible ways under consideration by the proponent that would allow a designated project to be carried out.” For the Project assessment of alternative means, two tiers of alternatives have been identified:

- Tier one alternatives are related to executing the Project and consist of options evaluated that would shape the overall development of the Project; and
- Once the decisions have been made related to the above alternatives, a second tier of alternatives consist of trade-off analysis for executing various key components of the Project.

An analysis of alternative means was carried out by undertaking the following steps (as per the Agency (2013)):

1. Identify technically and economically feasible alternative means;
2. Analyze potential effects of technically and economically feasible alternative means; and
3. Select preferred alternative means.

Where final decisions concern the placement of Project infrastructure, the technologies to be used, or where several options may exist for certain Project components, consideration was given through the environmental effects analysis to the various options available (alternative means) within the Application for an Environmental Assessment Certificate / Environmental Impact Statement (Application/EIS). For the Project, this primarily related to optimizing the location of Project infrastructure and was addressed in the effects assessment through the establishment of disturbance limits that extend beyond the Project footprint boundary.

4.2.1 Alternative Assessment Methodology

The identification of technically and economically feasible alternative means was carried out using the following criteria:

1. **Technical Suitability** – Although the technical feasibility for various alternatives may have been previously demonstrated at other mine sites, this criterion relates to the viability or applicability of a technology in the context of the Project, which considers:

    a. Size of the operation;
    b. Climatic conditions and geographic setting of the Project;
    c. Proven technology;
    d. Ability to meet Project design criteria and operational complexity;
    e. Constructability; and
    f. Project schedule considerations.

2. **Economic Feasibility –** Relates to a comparison of costs against forecasted revenues. An alternative is considered uneconomic if its use or implementation poses a significant risk to return on investment; that is, its use is cost prohibitive considering the climatic and geographical context of the Project site. Where an alternative was deemed to be prohibitive in terms of capital expenditure, it was rejected.

Once technically and economically feasible alternative means have been identified, they are evaluated per one or more of the following criteria:

1. **Cost Implications** relates to the overall Project costs including capital, operating and maintenance, and closure/reclamation costs of an alternative.

2. **Potential Residual Effects on the Environment** look at the expected severity of residual effects on the environment of one alternative relative to the other. The “environment” in this context refers to both the bio-physical and socio-economic environment, focusing on the valued components (VCs) and intermediate components (ICs) identified in the effects assessment.

3. **Amenability to Reclamation** is also taken into consideration. This objective relates to the decommissioning or reclamation of various aspects at eventual Project closure. It is relevant to those aspects of the Project that alter the landscape (i.e., road and stockpiles) and/or require dismantling and either removal from site or disposal on site (e.g., buildings).

4. **Community Acceptability**, which is a subjective criterion both in terms of the community perspectives that have been expressed as well as the interpretation and weighing of those perspectives. However, effort has been given to synthesizing and incorporating viewpoints and desires expressed to IDM through its consultation efforts with Aboriginal Groups, communities, stakeholders, and the public. For alternatives where feedback has not been obtained, this criterion is not included in the evaluation.

   Over the course of IDM's consultation efforts, communities have expressed the need for the Project to be developed in a manner that is safe for both people and the environment. Concern has been expressed about potential long-term effects on mountain goat, fish, other wildlife resources, water quality, and from mine tailings and other potential contaminants. As such, IDM has gone through extensive efforts to select alternatives that minimize potential negative socio-economic and environmental effects in these topic areas. Management and monitoring plans have been developed that address key areas of concern for local communities identified during consultation. More details on IDM's commitments to addressing community-identified issues are provided in Volume 4, Chapters 25, 26, 27, and 28 of the Application/EIS.

5. **Aboriginal Interests and Treaty Rights:** IDM is required to consider the opinions and preferences of Aboriginal Groups, communities, stakeholders, and the public as a criterion in the assessment for Project alternatives, as well as the potential effects of the Projects on the relevant Aboriginal Interests and Treaty Rights. IDM has been conducting Aboriginal and community engagement and consultation activities since it acquired the Project in 2014. During this time, several meetings have been held with the public and Aboriginal Groups. Numerous questions, issues, and suggestions have been raised. IDM has documented this information its consultation and engagement records, available Chapters 25, 26, 27, and 28 and in the Public and Aboriginal Consultation Reports. Where IDM has received feedback on potential Project alternatives, IDM has incorporated this feedback into various aspects of Project design and management.

6. **Other Socio-economic Considerations**: With respect to enhancing socio-economic effects, it is recognized that some alternatives may provide tangible and intangible benefits to local communities and the region. Since this objective is focused on enhancement of positive benefits, and negative socio-economic effects are addressed in the preceding objective, there is no unacceptable rating.

Any considerations of potential environmental effects, for example effects of terrestrial VCs (e.g., Wildlife, Vegetation, and Ecosystems), aquatic VCs, or water quality, have the potential to affect Aboriginal Interests and Treaty rights through pathway effects to water quality, fish, and game. Where a preferred alternative was selected and brought forward into the Project's design, an assessment of the potential effects of that Project component or activity was conducted in Volume 4, Chapters 25, 26, and 27.

4.3 Discussion of Major (Tier One) Alternatives within the Project

The alternatives that shaped the overall development of the Project include the following:

- Mine rate;
- Access and transportation alternatives for the movement of ore, freight, and personnel;
- Underground mining operations;
- Waste rock management;
- Mineral processing technology;
- Tailings management and location; and
- Power supply.

Decisions were made based on the feasibility and selection criteria presented in Section 4.2.

A summary of the tier one alternatives analysis is provided in Table 4.3-2 at the end of this section.

4.3.1 Mine Rate

4.3.1.1 Mine Rate Alternatives

There are two options for the rate of mining. They are:

- Option 1: year-round mining operation at 1,000 tonnes per day (tpd); and
- Option 2: 8-month mining operation at 1,500 tpd.

For Option 1, the Access Road and Haul Road from Highway 37A to the Mine Site would have to be maintained throughout the year. Terrain stability and geohazard mapping for the entire Project footprint is provided in Appendix 9-A. In addition, Appendix 9-C provides a section by section description of terrain characteristics, geohazard risk, as well as prescriptions and management strategies for addressing these risks, for the Project footprint.

4.3.1.2 Feasibility of Alternatives

Criteria for assessing the feasibility of mine rate alternatives were:

- Technical suitability, in consideration of topographic and climatic constraints (related to road use / maintenance); and

- Economic feasibility.

Both options were considered technically suitable and economically feasible and were carried forward for further analysis.

4.3.1.3 Selection of Alternative(s)

Selection criteria for transportation of equipment and supplies to and from Stewart, BC, were:

- Cost implications;
- Health and safety concerns;
- Residual environmental effects related to the following VCs:
    - Air Quality and potential effects from dust generation;
    - Noise and potential effects from mining operations;
    - Terrestrial VCs and potential effects from the disturbance footprint size;
    - Aquatic VCs and potential effects from water quality interactions with the Run of Mine (ROM) Stockpile; and
- Enhancement of socio-economic effects (related to employment and workforce requirements from mining operations).

Option 1 would expose the Project to some weather-related risk and safety concerns, although these risks and concerns can be managed by implementing operational controls. This scenario would also increase road maintenance operating costs, since the portal would have to be accessed for twelve months of the year. However, Option 1 has a lower potential for mechanical and operational issues associated with closing and restarting the underground mining operation.

Option 2 would process ore from a ROM Stockpile (120,000 tonne capacity) at Bromley Humps, from November to February, while temporarily closing the mining operation for the winter months. This would eliminate hauling and mining during the most challenging weather conditions encountered at the Project (and associated geohazards and health and safety concerns). From an economic perspective, the two options compared fairly closely on a Project net present value (NPV) basis, with Option 2 having an advantage of $4.2 million, or about 3% addition to the NPV.

4.3.1.4 Environmental and Social Considerations

The primary environmental and social criteria that would indicate differential potential effects from the Project mine rate alternatives have been identified and are listed above. A summary of the potential differential effects on these environmental and social aspects from the mine rate alternatives is provided in Table 4.3-2 and in the discussion below.

4.3.1.4.1 Terrestrial VCs

With Option 1, a smaller ROM Stockpile would be required at Bromley Humps (10,000 tonne capacity for Option 1 vs 120,000 tonne capacity for Option 2). The Process Plant will run year-round regardless of the mine rate option; however, a smaller ROM Stockpile, and therefore smaller disturbance footprint, is required since material will be delivered to the Process Plant site on an ongoing basis.

4.3.1.4.2 Aquatic VCs

Drainage that contacts site infrastructure, particularly from ore stockpiles, has the potential to contain dissolved metals. This contact water must be managed (i.e., intercepted, contained, and treated if required) to avoid adverse effects to the aquatic receiving environment. Option 2 is therefore less desirable than Option 1 when considering Aquatic VCs given the smaller ROM Stockpile required at Bromley Humps compared to Option 1.

4.3.1.4.3 Socio-economic VCs

Option 1 would result in an enhancement of socio-economic benefits as a result of the Project, given year-round rather than seasonal employment opportunities during the Operation Phase.

4.3.1.4.4 Air Quality and Noise

Some additional noise and dust generation during the winter months would be anticipated with Option 1 as a result of year-round operations.

4.3.1.5 Preferred Alternative

Option 1 (mining year-round at 1,000 tonnes per day) was ultimately selected as the preferred option. Although Option 2 was found to have a slight advantage from an economic perspective, Option 1 was considered preferable, mainly as a result of the enhanced benefits a year-round operation provides in relation to employment (full-time vs seasonal) and employee retention. Option 1 also has a lower potential for mechanical and operational issues associated with closing and restarting the underground mining operation.

4.3.2 Access and Transportation Alternatives

4.3.2.1 Transportation of Personnel, Equipment, and Supplies

The Project requires a means for transporting equipment, supplies, personnel, and ore on and/or off the site.

Access to the Red Mountain Property for exploration purposes is currently by helicopter. Road access up the Bitter Creek valley from Highway 37A was partially developed for 13 kilometres (km) by Lac Minerals in 1994 to the Hartley Gulch-Otter Creek area. Currently this road is passable for only a few kilometres from the highway. The remainder is not passable and has been subjected to washout or landslide activity.

Alternatives for the transportation of equipment and supplies to and from Stewart, and transportation of ore between the Mine Site and Bromley Humps, are discussed further below.

4.3.2.1.1 Alternatives for the Transportation of Personnel, Equipment, and Supplies

There are two options for the transportation of personnel, equipment, and supplies to and from Stewart, BC, over the Project life. They are:

- Option 1: road access; and
- Option 2: air / helicopter access.

Road access (Option 1) construction would be undertaken between Highway 37A and Bromley Humps through the rehabilitation of an existing road within the narrow Bitter Creek valley. No alternative options for routing of the road are available given the narrowness and steepness of the valley.

4.3.2.1.2 Feasibility of Alternatives

The feasibility of options for transportation of personnel, equipment, and supplies to and from Stewart were assess based on the following:

- Technical suitability, in consideration of ability to transport all required equipment and materials; and

- Economic feasibility.

Option 2 (air / helicopter access) was not considered to be a feasible option given the need to transport large equipment to the site and the very high costs associated with this. Option 2 is only practical for the transportation of personnel and smaller equipment / materials.

4.3.2.1.3 Selection of Alternatives

Road access (Option 1) is the only feasible option for transportation of personnel, equipment, and supplies to and from the site.

An Access Road approximately 13 km long will be constructed from Highway 37A along the North / North-East side of Bitter Creek to Bromley Humps, following the pre-existing resource road through the valley bottom. There are no viable alternatives for routing of the Access Road between Highway 37A and Bromley Humps given the existence of the historical access route and terrain limitations.

4.3.2.2 Transportation of Ore (On-Site)

4.3.2.2.1 Alternatives for Transportation of Materials on Site

There are two options in relation to transportation of ore between Bromley Humps and the Mine Site during the Operation Phase. They are:

- Option 1: tram from Bromley Humps to the Mine Site; and
- Option 2: road only.

For Option 1, a permanent road would still be required during the Operation Phase for the transportation of personnel, equipment, and supplies to the Mine Site.

4.3.2.2.2 Feasibility of Alternatives

Criteria for assessing the feasibility of on-site transportation alternatives were:

- Technical suitability, in consideration of constructability and design criteria; and
- Economic feasibility.

The design basis for on-site transportation is to maximize user safety, minimize use of undulating topography and steep slopes, and avoid culturally and environmentally sensitive areas.

Both options were considered technically suitable and were carried forward for further analysis.

4.3.2.2.3 Selection of Alternatives

The primary selection criteria for an analysis of alternatives for the on-site transportation of ore were:

- Cost implications; and
- Residual environmental effects, in particular residual effects to Air Quality.

Trams offer good material movement capacity, the ability to operate in adverse weather conditions (which are common at the Project site), and provide a safe alternative to hauling ore down the road in trucks during inclement weather. An advantage to the tram would be that, because it is hauling ore down and not up, it would actually generate power that could supplement power to the Mine Site or Process Plant when the tram is operating. Using a tram system (Option 1) would however increase capital costs significantly.

Advantages of a road are that it is a proven method for ore transportation, and that it has lower capital and operating costs when compared to the tram. Using a road transport provides the opportunity to backhaul fill material back up to the portal and underground.

4.3.2.2.4 Environmental and Social Considerations

The primary environmental and social criteria which would indicate differential potential effects from the on-site transportation of ore alternatives have been identified and are listed above. A summary of the potential differential effects on these environmental and social aspects from the on-site transportation of ore alternatives is provided in Table 4.3-2 and in the discussion below.

There are few differential considerations regarding environmental and social aspects. Option 1 (tram) would not eliminate the need for a road, as access will still be required to transport labour, equipment, and materials to the underground workings and maintenance facilities. However, less vehicle movement on the Haul Road would be anticipated, resulting in lower dust and greenhouse gas emissions. Best management practices would be applied for either method that would bring levels within BC air quality guidelines.

4.3.2.2.5 Preferred Alternative

Ultimately, Option 2 was selected as the preferred option due to the significantly lower capital costs, the relatively simple engineering involved, and lower operating costs. While additional vehicle movement on the Haul Road as a result of ore hauling would generate additional dust and greenhouse gases, it is assumed these effects can be mitigated through the adoption of best management practices.

4.3.3 Underground Mining Operations

4.3.3.1 Underground Mining Access

The Project has one existing portal that was previously established, which provides access to the ore body. However, the mine plan and future exploration potential would benefit from a primary access portal at a lower elevation. In addition, a secondary portal is required during operations to provide secondary emergency egress and dewatering. Alternatives were evaluated for the preferred primary access portal, taking the existing and potential future locations into consideration.

A ventilation portal is also required for mining operations in addition to the access portals.

4.3.3.1.1 Alternative Mine Portal Locations

There are three options for the primary mine access portal locations. They are:

- Option 1: Upper Portal: An existing portal at the top of the mountain at 1,890 metres above sea level (masl) elevation;
- Option 2: Lower Portal: The portal proposed in the Preliminary Economic Assessment (PEA; JDS 2016) at 1,650 masl elevation; and
- Option 3: The hump portal location at Bromley Humps.

Figure 4.3-1 shows the location of the three alternative access portals.

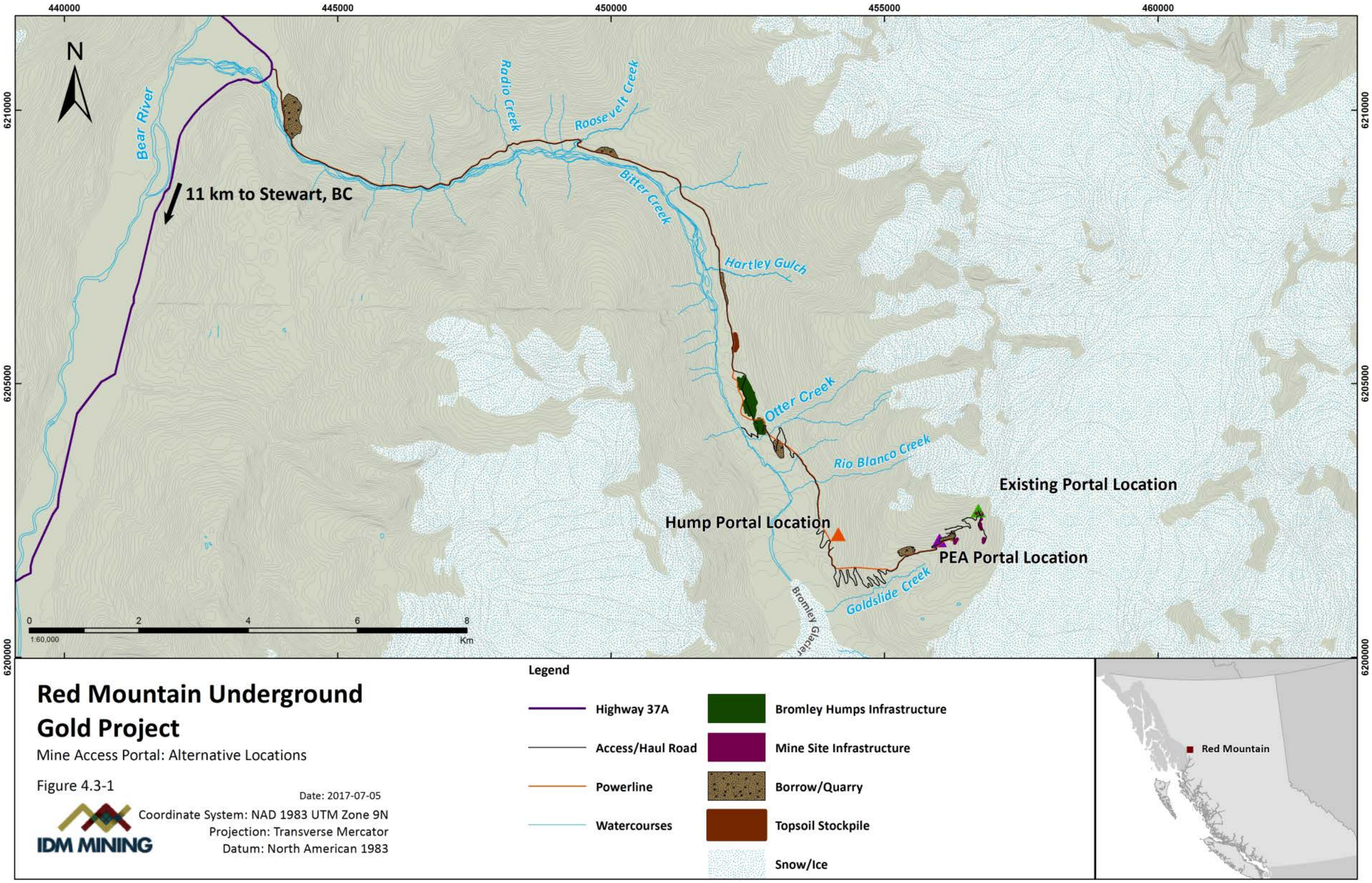
4.3.3.1.2 Feasibility of Alternatives

Criteria for assessing the feasibility of access portal location alternatives were:

- Technical suitability in consideration of implications to Project schedule, site conditions, and operational complexity; and
- Economic feasibility.

Based on the abovementioned criteria, Option 3 was not considered technically suitable nor economically feasible. Option 3 would require an enormous amount of underground development. The resulting costs associated with this development and delay to the Project schedule due to the required development time made this option unfeasible.

Figure 4.3-1: Mine Access Portal: Alternative Locations



4.3.3.1.3 Selection of Alternatives

Cost implications were the primary criteria for selection of a primary access portal location.

Option 1 (the Upper Portal) had advantages in that it requires the least capital spending and allows for a short start-up schedule. Disadvantages of having the portal in this location include having the most exposure to weather, the longest Haul Road, and an uphill haul to the underground mine.

Some minor drawbacks to Option 2 (the Lower Portal) are its location (relatively high up the mountain compared to Option 3), and the fact that it will generate a fair amount of waste rock to develop. However, the waste rock will be needed to backfill underground stopes later in the mine life.

Option 2 (the Lower Portal) was selected as the preferred option for primary access. This option significantly reduces: ore haul distance; ore haul elevation; and dewatering / pumping requirements. In addition, the Lower Portal doubles as an exploration drift, intersecting a sizeable portion of the 141 Zone, which is currently an inferred resource and has extension potential.

The Upper Portal will be used to initially support mining while the Lower Portal is being developed. The Upper Portal will also be used as a secondary access location. As a result, Option 1 is also carried forward in the Project effects assessment.

Given that both the Lower Portal and Upper Portal are scoped into the Project design, further analysis comparing these alternatives (e.g., environmental and social considerations) is not required.

4.3.3.2 Underground Mining Method

Mineralized zones consist of tabular, northwesterly trending, moderate to steeply dipping gold and silver-bearing iron sulphide stockworks. The zones range from 1 m to 40 m in width, 70 m to 200 m in strike length, and 60 m to 100 m in height.

4.3.3.2.1 Alternative Mining Methods

There are two options in relation to underground mining methods. They are:

- Option 1: longhole stoping; and
- Option 2: drift and fill.

4.3.3.2.2 Feasibility of Alternatives

Criteria for assessing the feasibility of the underground mining method were:

- Technical suitability in consideration of the orientation and location of the deposit / mineralized zones; and
- Economic feasibility.

Both options were considered technically suitable and economically feasible and were carried forward for further analysis.

4.3.3.2.3 Selection of Alternatives

Cost implications were the primary selection criteria for underground mining method.

The geometry of the deposit is amenable to sub-level longhole (LH) stoping, which has been selected as the principle mining method. Longhole stoping is a semi-selective and productive underground mining method that has a successful history of application for similar deposits with relatively low costs. Where conditions are not suitable for longhole stoping (generally this is when the dip of the deposit is shallow), drift and fill (D&F) mining will be used.

Given that both LH and D&F mining methods are scoped into the Project design, further analysis comparing these alternatives (e.g., environmental and social considerations) is not required.

Other mining methods, or combinations of methods, may be used to safely and efficiently extract resources taking into consideration geometry, dip angle, continuity and grade distribution, rock mass strength and competency, and in-situ value of mineralized material. In addition to providing access to mineralized zones, development will provide ventilation, communications and other mine services, and emergency egress. Underground mining alternatives include access and mining methods. Access to the mineralized zones could be via shaft, decline, or some combination of the two. Given the geometry of the deposits, depth and location of mineralized zones, proposed mining method, and mine life the preferred access method for underground Operation Phase will be by decline.

4.3.4 Waste Rock Management

Waste rock will be excavated to develop the underground mine at the Mine Site. The current mine production schedule produces approximately 719,000 tonnes of waste rock. Geochemical study and monitoring have indicated that all mine rock will be potentially acid generating (PAG). However, there is a long lag time to the onset of acidic conditions; more than 20 years. PAG rock at Red Mountain is known to be stable in the short- to medium-term (approximately 20 years) and is not anticipated to become acidic during the short timeframe during which waste rock will be stored at surface (less than 2 years).

The classification of excavated rock as waste may change over the life of the Project, depending on metal concentrations in the waste rock and metal prices.

4.3.4.1 Alternatives for Managing Waste Rock

There are two options in relation to storage of waste rock. They are:

- Option 1: storage on surface; and
- Option 2: placement of waste rock underground as backfill.

For Option 2, a temporary waste rock storage area would be required on surface. During the preproduction stage of operations, waste rock from mine development (approximately

52,000 tonnes) would be stored in a temporary waste rock storage area located adjacent to the Upper Portal. This temporary pile would be reclaimed within a year and placed underground as backfill.

4.3.4.2 Feasibility of Alternatives

Criteria for assessing the feasibility of waste rock storage alternatives were:

- Technical suitability in consideration of waste rock characterization and volumes, Project scheduling, and site conditions / capacity; and
- Economic feasibility.

Both options were considered technically suitable and economically feasible and were carried forward for further analysis

4.3.4.3 Selection of Alternatives

The selection criteria for waste rock storage alternatives were as follows:

- Cost implications;
- Residual environmental effects related to the following VCs:
  - Terrestrial VCs (e.g., Wildlife, Vegetation, and Ecosystems), specifically in relation to disturbance footprint;
  - Aquatic VCs and potential effects associated with the surface storage of waste rock and potential seepage on Water Quality;
- Community acceptability; and
- Amenability to reclamation.

The current mine plan exhibits a large deficit of stope backfill material, hence backfill requirements can be cost-effectively and partially satisfied by all waste rock generated during the current mine plan, as well as historic waste rock from previous underground exploration programs. Additional backfill material will be quarried from nearby sources of talus.

4.3.4.4 Environmental and Social Considerations

The primary environmental and social criteria which would indicate differential potential effects from the waste rock management alternatives have been identified and are listed above. A summary of the potential differential effects on these environmental and social aspects from the waste rock management alternatives is provided in Table 4.3-2 and in the discussion below.

4.3.4.4.1 Option 1 (Storage on Surface)

4.3.4.4.2 Terrestrial VCs

Option 1 is not considered a desirable option given the larger surface disturbance footprint associated with long-term storage of waste rock at surface.

4.3.4.4.3 Aquatic VCs

Water quality issues associated with potential seepage would require management in perpetuity should waste rock be stored on surface.

4.3.4.4.4 Community Acceptability

Concerns from the community and Aboriginal Groups are anticipated given potential environmental issues to be managed and monitored through the Closure and Reclamation and Post-Closure Phases.

4.3.4.4.5 Amenability to Reclamation

The long-term storage of waste rock at surface would substantially increase reclamation requirements.

4.3.4.4.6 Option 2 (Placement of Waste Rock Underground as Backfill)

Backfilling of waste rock into the underground workings will greatly limit the size and duration of the disturbance footprint on surface, given that a much smaller and temporary Waste Rock Storage Area would be required. Moving the waste rock underground also serves to reduce the generation of contact water that must be managed (i.e., intercepted, contained, and treated if required) to avoid adverse effects to the aquatic receiving environment.

4.3.4.4.7 Preferred Alternative

Option 2, the temporary storage of 52,000 tonnes of waste rock on surface followed by backfilling of waste rock into the underground workings, was selected as the preferred alternative. No waste rock is planned to be permanently storaged on the surface.

4.3.5 Mineral Processing Technology

There has been a significant amount of metallurgical testing conducted on samples from the Project. Three basic process options were explored to extract gold and silver: production of gold- and silver-bearing flotation concentrates for sale to a smelter; direct whole mineralized material cyanidation for doré production; and a hybrid flotation process with cyanide leaching of the flotation concentrate to produce doré.

4.3.5.1 Alternative Processing Technologies

The results from previously reported metallurgical test work were used to consider three potential process options:

- Option 1: Whole Ore Leach (WOL);
- Option 2: Flotation, Re-grind, and Leaching (FRL) of a concentrate finely ground to approximately 90% passing 37 micrometres (µm); and
- Option 3: Floatation to produce gold-silver concentrate for sale to an offsite smelter.

4.3.5.2 Feasibility of Alternatives

The feasibility of processing technology alternatives was assessed based on economic feasibility and the recovery performance of gold and silver.

Producing a gold- and silver-bearing floatation concentrate (Option 3) requires securing a favourable smelter contract, as this concentrate would be viewed as “low grade”, which limits marketability. This adds significant risk to the economic viability of the Project. Compared to the other alternatives, this option would also incur increased transportation costs. Thus, Option 3 was not considered economically feasible.

The trade-off study between Option 1 and Option 2 assesses the expected recovery and capital and operating costs for both circuit configurations. Selection criteria for processing technology alternatives is therefore focused on cost implications.

The crushing and grinding circuits for both options utilize similar equipment, including tertiary crushing due to material hardness, feeding into a ball mill in open circuit, and a second ball mill in closed circuit. In WOL, larger mills will be required due to the finer grind size targeted for whole ore leach.

With WOL (Option 1), the grinding circuit product will be thickened and leached followed by Counter Current Decantation (CCD) washing, Merrill Crowe (MC), cyanide destruction, and disposal in the tailings management facility (TMF).

FRL incorporates rougher flotation before leaching to separate the gold-bearing concentrate from the tailings. The flotation concentrate, approximately 30% of the feed tonnage, will report to pre-leach thickening, regrind, leaching, CCD washing, and gold recovery by MC. The concentrate tailings will undergo cyanide destruction and disposal in the TMF.

Based on the analysis completed by IDM, WOL without gravity (Option 1), at a P80 primary grind size of 40 to 50 µm, was identified as the technically suitable alternative. The following are key factors that led to selecting the WOL option:

- Pyrrhotite levels varied significantly in the deposit for some samples representing most of the sulphide mineral mass. Pyrrhotite is very reactive and oxidizes rapidly, degrading flotation performance. Stockpiling ores containing pyrrhotite would likely have a significant negative effect on flotation performance;

- Total organic carbon (TOC) has more influence at ultrafine grind sizes. The projected recovery for the FRL at 20 µm could therefore be higher than the actual recovery;
- Preliminary evaluations of key flotation test conditions have indicated recoveries have little room for improvement;
- Variability flotation testing has identified several areas within the deposit that produce poor, rougher flotation recovery. These areas are associated with lower sulphur grades and relatively high iron content; and
- The fine grind associated with WOL may affect the consolidation rate of the tailings and may result in slightly lower densities, particularly in earlier years. The final settled dry density will not change, but the length of time to achieve this may change. This will be mitigated using underdrains and wick drains.

4.3.5.3 Selection of Alternatives

WOL without gravity (Option 1) is the preferred option on the basis of technical suitability and economic feasibility. In addition, Options 1 and 2 are comparable from an environmental perspective, including any consideration for water treatment and discharge to the receiving environment.

Following the trade-off study between WOL and FRL, additional test work and design work was performed to further optimize the recovery. The final flowsheet included two stages of grinding to target a product size of 80% passing (P_{80}) 25 µm, followed by carbon-in-leach (CIL), acid wash, stripping, and electrowinning for the recovery of gold and silver.

4.3.6 Tailings Management

The management of tailings and the tailings technologies utilized depends on multiple specific considerations, such as location, climate, topography, environment, tailings geochemistry, processing requirements, and throughput. Information presented below regarding TMF location alternatives was obtained from the technical memorandum *Red Mountain Gold Project – Tailings and Water Management*, provided in Appendix A of the Tailings Best Available Technology (BAT) Assessment (Volume 7, Appendix 1-J). Information presented in Section 4.3.6.3 (Tailings Technology) was summarized based on information contained in the Tailings BAT Assessment (Appendix 1-J).

4.3.6.1 Tailings Disposal Location

4.3.6.1.1 Alternatives for the Tailings Management Location

Two options for a tailings disposal location were considered. They are:

- Option 1: surface disposal of tailings in the Tailings Management Facility (TMF); and
- Option 2: Underground disposal of tailings as backfill, including the potential for co-mingling tailings with waste rock

For Option 2, a temporary storage area for filtered or paste tailings would be required.

4.3.6.1.2 Feasibility of Alternatives

Criteria for assessing the feasibility of tailings management location alternatives were:

- Technical suitability in consideration of tailings characterization and volumes, Project scheduling, and site conditions / capacity; and
- Economic feasibility.

Option 2 (underground disposal of tailings as backfill, including the potential for co-mingling tailings with waste rock) was not considered to be a technically suitable or economically feasible option. This option is incompatible with the mine development schedule and requires extensive temporary storage of filtered or paste tailings on surface for 2 to 3 years. This option would also require infrastructure for reprocessing / dewatering of tailings to generate a suitable material for backfill.

4.3.6.1.3 Selection of Alternatives

IDM has produced a Technical Decision Memo to support the conclusions reached for this design consideration (Volume 7, Appendix 1-J (Appendix D)). The conclusion of this analysis indicates that Option 1 is the only technically suitable and economically feasible option for the disposal of tailings.

4.3.6.2 Surface TMF Facility Location

Heavy snowfall, steep terrain, and frequently windy conditions are important considerations for tailings and water management. Blizzard conditions are frequent in the immediate vicinity of Red Mountain during winter, and avalanches pose a significant threat in the Bitter Creek valley.

Terrain stability and geohazard mapping for the entire Project footprint, including the TMF, is provided in Appendix 9-A. In addition, Appendix 9-C provides a section-by-section description of terrain characteristics, geohazard risk, as well as prescriptions and management strategies for addressing these risks for the Project footprint.

4.3.6.2.1 Alternatives for Locating the TMF

Several sites were identified as potential locations for surface storage of tailings. The locations are summarized in Table 4.3-1 and shown on Figure 4.3-2.

Table 4.3-1: Alternative Tailings Management Facility Locations

Option	Name	Location
1	Cirque TMF (JDS PEA)	Base of Red Mountain Cirque (described in 2014 PEA)
2	Top of Cirque	Located above the Cirque TMF
3	SRK Side Cirque	Side Cut facility in Cirque proposed by SRK Consulting
4	Lower Cirque	Located downstream of Bromley Glacier
5A	Upper Bromley Humps (formerly Otter Creek Upper)	Adjacent to where Otter Creek meets Bitter Creek
5B	Lower Bromley Humps (formerly Otter Creek Lower)	Downstream of Otter Creek Upper
6	Roosevelt Creek	Terrace where Roosevelt Creek meets Bitter Creek
7	Highway	Confluence of Bitter Creek and Bear River adjacent to Clements Lake
8	Top of Mountain	Top of Red Mountain

4.3.6.2.2 Feasibility of Alternatives

Criteria for assessing the feasibility of the surface TMF location were:

- Technical suitability, in consideration of topographic and climatic constraints, and site conditions / capacity; and
- Economic feasibility.

Option 3 (SRK Side Cirque TMF) was proposed by SRK Consulting in 2004. The side valley impoundment is in the Red Mountain Cirque at approximate 1,500 masl and consists of five separate impoundments terraced along the north and south cirque slopes. The dam is constructed using the upstream method of construction. The Project is located in an area of high seismicity where the upstream method of embankment construction is not recommended. Thus, this option is not considered to be technically suitable.

Option 4 (Lower Cirque TMF) is situated at the junction of the lower tongue of the Cambria Glacier and the tongue of the Bromley Glacier at approximate 800 masl. The steep terrain is located on the right bank of Bitter Creek and provides little to no impoundment capacity. The storage efficiency is extremely poor. Thus, this option is not considered as technically suitable for tailings storage.

Option 8 (Top of Mountain TMF) is located on top of Red Mountain and does not provide any area suitable to store the volume of tailings required. Option 8 is therefore not considered to be technically suitable.

Option 5B (Lower Bromley Humps) does not provide the design storage capacity but was considered for further analysis as a potential location for expansion of Option 5A.

4.3.6.2.3 Selection of Alternatives

The options that are being considered for tailings and water management are as follows:

- Option 1 – Cirque TMF (JDS PEA)
- Option 2 – Top of Cirque TMF
- Option 5A – Bromley Humps Upper TMF
- Option 5B – Bromley Humps Lower TMF
- Option 6 – Roosevelt Creek TMF
- Option 7 – Highway TMF

The selection of a preferred TMF location was primarily based upon the following criteria:

- Cost implications; and
- Environmental effects, specifically in relation to:
  - Terrestrial VCs and potential effects from geohazards and the disturbance footprint size; and
  - Aquatic VCs and potential effects from geohazards and water quality interactions.

The Cirque TMF (Option 1) is located in the Red Mountain Cirque between the Cambria Ice fields and the Bromley Glacier. The area has an average elevation of approximately 1,500 masl and has little vegetation. Foundation conditions consist mainly of talus deposits overlying fractured bedrock. Due to the relatively poor topographical conditions for impoundment capacity and dam construction, a large dam is required to provide sufficient storage, increasing costs and environmental risk (due to larger disturbance footprint and potential for accidents and malfunctions associated with poor topographic conditions and geohazard risks).

The Top of Cirque TMF (Option 2) is also located in the Red Mountain Cirque and has the advantage of being near the portals. The facility is located at approximate 1,700 masl, above the Cirque TMF. The steep topographical grade requires an extremely large dam with very poor storage efficiency for tailings, increasing costs and environmental effects (due to a larger disturbance footprint and the potential for accidents and malfunctions associated with poor topographic conditions and geohazard risks).

Upper and Lower Bromley Humps TMF (Options 5A and 5B) are located along the north bank of Bitter Creek adjacent to where Otter Creek meets Bitter Creek. The elevated deposit is at an approximate elevation of 450 masl.

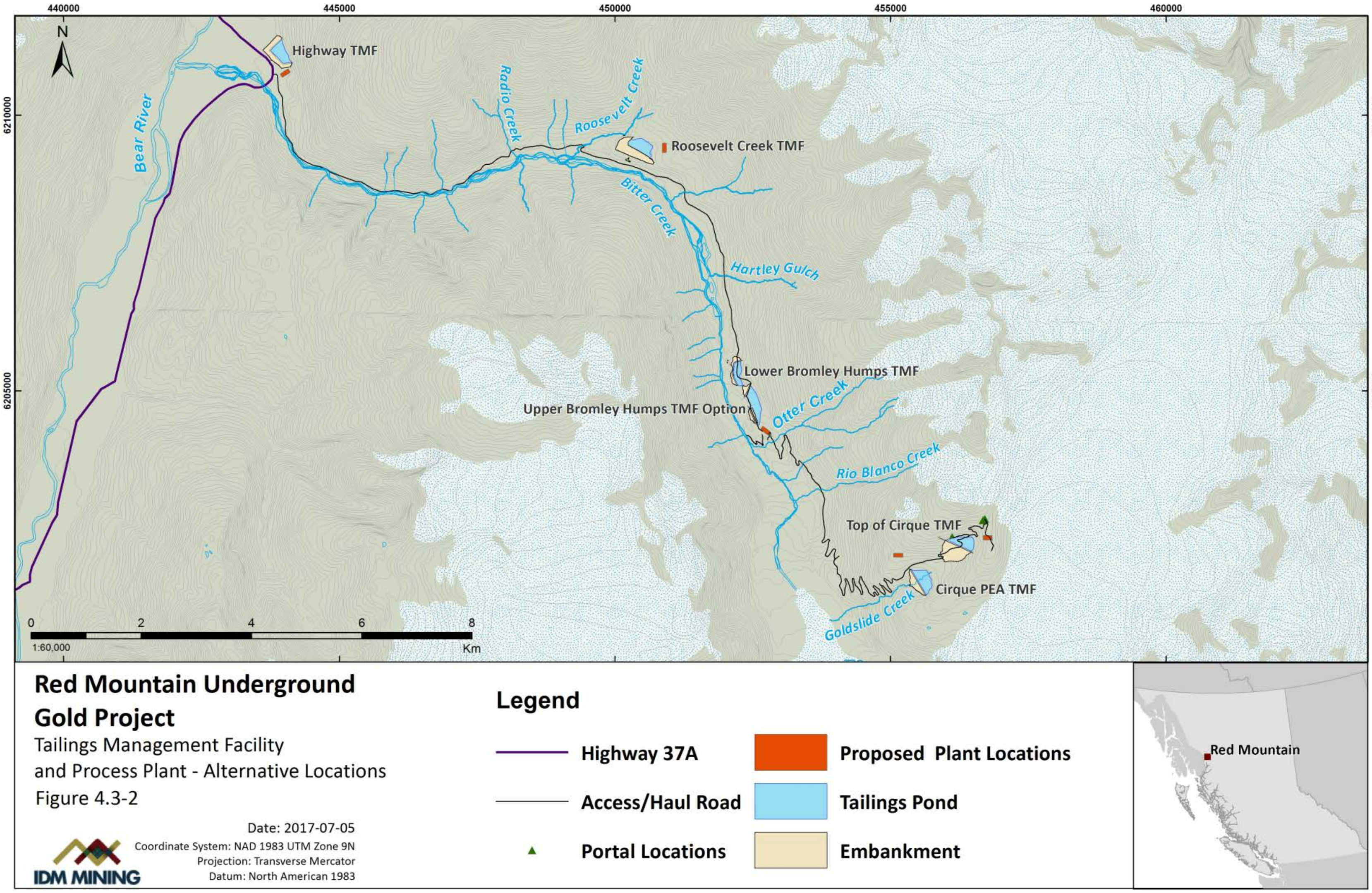
The Roosevelt Creek TMF (Option 6) is located on a terrace along the north bank of Bitter Creek at approximately 350 m. The topography has a grade of approximately 20-25% and would require a large dam associated disturbance footprint to provide storage. The terrace consists of an outwash deposit of permeable sandy gravel with cobbles and boulders. The site has a potential for geohazards (avalanches and debris slides), increasing environmental risk. Further, this area is considered to have ecological value and the impacts described above would represent a much larger impact and higher degree of risk than other alternatives.

The Highway TMF (Option 7) is located where Bitter Creek merges with Bear River and is adjacent to Clements Lake. Clements Lake is a provincially maintained recreation area. The distance from the mine site plus the proximity to the Bear River and Clements Lake make this area an unsuitable location for a TMF.

Option 5A (Upper Bromley Humps) is the preferred location from a technical, cost, and environmental perspective. This option is advantageous for the following reasons:

- Located at a lower elevation, therefore more favourable climatic conditions. Winter operations are expected to be safer and more reliable at a lower elevation;
- Clear from the Otter Creek avalanche path;
- Provides the best storage efficiency of the alternatives;
- More favourable water management strategies compared to other options (deep groundwater levels, favourable topography for non-contact water diversion, etc.);
- Could be developed in combination with Option 5B, the lower TMF impoundment, for additional capacity;
- Geotechnical and Hydrogeological Site Investigations were completed in 2016 by KP and in 1996 by Golder Associates in this area;
- TMF and Mill locations are advantageous from a construction schedule and Project execution standpoint. Construction could begin on the Mill and TMF while the road between Otter Creek and the mine is being constructed; and
- Lower capital, sustaining and operating costs than other options.

Figure 4.3-2: Tailings Management Facility and Process Plant – Alternative Locations



4.3.6.3 Tailings Technology

This section summarizes the Best Available Technology (BAT) assessment for tailings management at Bromley Humps TMF location (as described in detail in Volume 7, Appendix 1-J). The BAT can be defined as the most suitable, site-specific tailings technology and management strategy for the Project based on the tailings characteristics and the TMF location. The overall objective of the BAT Assessment is to identify the alternatives for tailings disposal that pose the lowest risk to the Project. The assessment includes a consideration of environmental, technical, social, and economic implications.

4.3.6.3.1 Alternatives for Tailings Technology

There are five options in relation to tailings technology. They are:

- Option 1: Conventional Slurry Tailings;
- Option 2: Thickened Slurry Tailings;
- Option 3: Ultra-Thickened (Paste) Tailings;
- Option 4: Ultra-Thickened Cemented Tailings; and
- Option 5: Filtered Tailings.

4.3.6.3.2 Conventional Slurry Tailings

Conventional slurry tailings are discharged from the mill at about 20 to 35% solids (by weight). The tailings may be pumped by centrifugal pumps, flow by gravity, or a combination thereof. Slurry is discharged through off-takes along the embankments or around the perimeter of the TMF to optimize basin filling and control the location of the supernatant pond. Segregation occurs in the tailings, with coarser particles settling out near the discharge points to form tailings beaches, while the fines are transported further. Supernatant water and runoff are reclaimed for processing.

Conventional slurry tailings disposal is well suited to project sites that operate with a surplus water balance and for facilities that contain PAG or ML waste materials that require saturation to prevent adverse chemical reactions. Although conventional slurry is the most water intensive tailings disposal option, it is operationally the simplest method provided water management is addressed adequately.

4.3.6.3.3 Conventional Thickened Tailings

Thickening is used to increase the solids content to a solids content of approximately 40 to 55% by weight. The excess process water generated during the thickening process is typically reused in the mill. Thickened tailings can be transported in smaller diameter pipelines for the equivalent mill throughput, but may require greater pumping pressures. Centrifugal pumps are typically used; however, booster pump stations may be required with higher densities and longer pipelines. Tailings deposition is similar to conventional slurry tailings. Supernatant water and runoff is reclaimed from the TMF supernatant pond for processing. Thickened slurry tailings are appropriate for sites that require extensive pumping or sites that require more water conservation.

4.3.6.3.4 Ultra-Thickened (Paste) Tailings

The ultra-thickened tailings technology requires additional thickening or additives to increase the solids content to about 60 to 75% by weight. Ultra-thickening results in greater water recovery at the mill and less water delivered to the TMF. The tailings flowrate is less and therefore conveyed in smaller pipeline sizes, however greater pumping pressures may be required and positive displacement (PD) pumps are typically used. Reclaim pumping requirements are usually low because less water is delivered to the TMF with the tailings. A separate water management pond is likely required for an ultra-thickened tailings facility for management of storm water from the TMF.

Ultra-thickened tailings are most appropriate for sites that operate in a significant water deficit and require a high level of water conservation, i.e. where water supply is significantly limited or prohibitively expensive.

4.3.6.3.5 Ultra-Thickened Cemented Tailings

A variation of ultra-thickened tailings is cemented tailings, which utilize cement, fly ash, or slag additives to create a non-flowable, low permeability tailings mass once the tailings are deposited and have settled. Cemented tailings are typically deposited as underground backfill for mining stopes and voids.

4.3.6.3.6 Filtered Tailings

Mechanical dewatering of tailings can be used to remove process water to a point at which the tailings behave like a soil. A partially saturated filter cake is developed for disposal in a filtered tailings stack. Mechanical dewatering of the tailings can be achieved through a variety of technologies, including vacuum and pressure filtration processes. Filtered tailings are typically dewatered to a moisture content of approximately 15% and placed and compacted in thin lifts. Filtering and transport of dewatered tailings by conveyor or haul truck can be costly in comparison to pipeline disposal of tailings slurry. In addition, a contingency alternative method for tailings discharge is required (i.e., pipeline system and/or emergency dump pond in the event of a filter system failure).

Depending on the angle of repose of the final filtered tailings, confining berms and buttresses may be required to construct the filtered tailings stack. In some cases, full TMF embankments may be required to contain the filtered tailings in a safe and efficient manner.

A separate water management pond is required to store process water and storm water runoff from the surface of the TMF as the water cannot be stored on the filtered tailings in order to maintain the mass in an unsaturated condition.

A key requirement for filtered tailings is maintaining the stack in a relatively dry (unsaturated) condition, which is a challenge in wet environments.

4.3.6.3.7 Feasibility of Alternatives

Criteria for assessing the feasibility of alternatives in relation to tailings technology were:

- Technical suitability, in consideration of climatic and topographic conditions, tailings properties, and operational efficiencies; and
- Economic feasibility.

In terms of technical feasibility, all the above alternatives are technically feasible and have been demonstrated at various mining operations. However, regional considerations, such as precipitation and topographic conditions, greatly influence the technical suitability and economic viability of each option for the Project. Therefore, the selection of a tailings disposal technology is largely dependent on the selection of the tailing disposal site, the Project location, and the associated geohazards and terrain challenges associated with the site selection.

Option 1 (conventional slurry tailings) was not considered technically suitable and therefore not carried forward for further analysis. This option was excluded as the mill process design optimization work completed for the Project identified a tailings solids content of 50% (thickened slurry) could be achieved using the regular mill process. Pumping tailings at a lower solids content and higher flowrate was therefore considered inefficient.

Option 3 (ultra-thickened tailings (without cement)) was also not considered further due to the operating and processing similarities with the ultra-thickened cemented tailings alternative. Between the two options (Options 3 and 4), ultra-thickened cemented tailings (Option 4) was preferred for inclusion in the assessment due to its increased performance as a non-flowable, non-segregating mass.

4.3.6.3.8 Selection of Alternatives

Criteria for selecting a preferred alternative, as outlined in the Tailings BAT Assessment are as follows:

- Environmental effects, specifically considering the disturbance footprint area, effects to water quality, flora and fauna, chemical stability of the stored tailings, and reclamation. Alternatives that are easier to reclaim minimize the need for active management in closure and can achieve a suitable final land use are preferred;
- Technical suitability in consideration of constructability, long-term operational viability, operational complexity, and potential for future expansion. This criterion considers potential concerns relating to permitting as candidates that are uncommon or unconventional may be more difficult to permit and can result in extended permitting timelines;
- Social effects in consideration of safety characteristics of tailings storage and the ability to limit the effect of the proposed technology on the community. It also includes the safety of workers on site; and

- Cost implications. Higher costs may be considered acceptable if the expenditure improves the performance in other categories. Alternatives that have the potential to significantly affect profitability or viability of the operation are less preferable.

Further information regarding criteria, ratings and descriptions can be found in Appendix 1-J.

Option 2 (thickened slurry tailings) was identified as the preferred option. The main factors for this determination are as follows:

- The tailings deposition and water management strategy is simple relative to the other candidates;
- The process water is contained within the same facility and used for mill reclaim;
- No additional mill processes are required;
- There is a lower risk of operational problems (complications due to climactic conditions, etc.); and
- There is a greater ability to maintain a degree of saturation within the tailings mass to reduce exposure of the tailings to oxidation and to limit ARD/ML generation potential.

4.3.7 Power Supply

Total maximum power requirements for the Project are 9.5 megawatts (MW): 6 MW for the Mine Site and 3.5 MW for the Process Plant.

4.3.7.1 Power Supply Alternatives

There are five power supply alternatives for the Project. They are:

- Option 1: Diesel;
- Option 2: Liquefied Natural Gas (LNG);
- Option 3: Transmission line tying into the BC Hydro grid;
- Option 4: Wind; and
- Option 5: Solar.

The transmission line (Option 3) would be constructed within the Access Road right-of-way, within the narrow Bitter Creek Valley. As such no alternative options for routing of the transmission line were available.

4.3.7.2 Feasibility of Alternatives

Criteria for assessing the feasibility of power supply alternatives were:

- Technical suitability, in consideration of the ability to supply the required amount of power on a consistent basis; and

- Economic feasibility.

Option 5 (solar power) is not yet a proven technology for large commercial or industrial use. There are advantages of longer days in summer (offset by less sunlight in winter) and increased efficiency of photovoltaic modules in low temperatures and snow reflection. At this time, solar cannot be the primary power source, but it is a possible supplemental supply.

Option 4 (wind) is not considered technical suitable as a secondary power source as it would be required to ensure continuity of supply. Both wind and solar power are intermittent energy sources at best in this area.

Diesel (Option 1), LNG (Option 2), and the construction of a transmission line (Option 3) are considered technically suitable and economically feasible power supply options.

4.3.7.3 Selection of Alternatives

Criteria for selecting a preferred source of power were:

- Cost implications; and
- Residual environmental effects related to the following VCs:
  - Terrestrial VCs;
  - Air Quality; and
  - Aquatic VCs, in particular Groundwater Quality and Surface Water Quality.

The Project has an estimated operating life of 6 years. For this relatively short Project life cycle and having the Mine Site and Process Plant at separate locations, grid power offers the most flexibility at the lowest cost. Grid power supply will provide the required capacity to meet power demands of the Project at the lowest cost.

Diesel or LNG power generation are technically feasible power supply alternatives. However, these options have a higher unit cost compared to grid power.

4.3.7.4 Environmental Considerations

The primary environmental and social criteria which would indicate differential potential effects from the power supply alternatives have been identified and are listed above. A summary of the potential differential effects on these environmental and social aspects from the power supply alternatives is provided in Table 4.3-2 and in the discussion below.

4.3.7.4.1 Option 1 (Diesel)

4.3.7.4.2 Terrestrial VCs

The disturbance footprint associated with LNG and diesel power supply options would be comparable but smaller than that associated with grid power and the establishment of a transmission line.

4.3.7.4.3 Aquatic VCs

Diesel would require additional fuel capacity on-site, increasing the risk of fuel spills and associated effects to the aquatic environment. The transportation of fuel would also generate additional environmental hazards and risks when compared to grid power (Option 3).

4.3.7.4.4 Air Quality

Diesel produces the highest amounts of greenhouse gas emissions when compared to the other two options.

4.3.7.4.5 Option 2 (LNG)

4.3.7.4.6 Terrestrial VCs

The disturbance footprint associated with LNG and diesel power supply options would be comparable but smaller than that associated with grid power and the establishment of a transmission line.

4.3.7.4.7 Aquatic VCs

LNG would require additional fuel capacity on-site, increasing the risk of fuel spills and associated effects to the aquatic environment. The transportation of fuel would also generate additional environmental hazards and risks when compared to grid power (Option 3).

4.3.7.4.8 Air Quality

LNG produces higher amounts of greenhouse gas emissions when compared to grid power (Option 3).

4.3.7.4.9 Option 3 (Transmission Line)

4.3.7.4.10 Terrestrial VCs

Construction of a transmission line creates a larger disturbance footprint than other power supply alternatives; however, effects can be mitigated through establishment of the Powerline in the Access and Haul Road rights of way to the greatest extent possible and through implementation of standard best practices.

4.3.7.5 Preferred Alternative

In consideration of the abovementioned factors, grid power and construction of a transmission line to the Project site (Option 3) is selected as the preferred alternative.

4.3.8 Summary of Tier One Alternatives

Table 4.3-2 summarizes the analyses of tier one alternatives.

Table 4.3-2: Summary of Tier One Alternatives Analysis

Tier 1 Alternatives	Pre-screening Criteria		Advantages/Disadvantages/Constraints	Evaluation Criteria for the Project						IDM Decision
	Technical Suitability	Economic Feasibility		Project Cost Implication	Potential Environmental Effects	Amenability to Reclamation	Community Acceptability	Aboriginal Interests and Treaty Rights	Other Socio-Economic Factors	
Mining Rate										
Year-round mining at 1,000 tpd	YES	YES	Advantages: year-round rather than seasonal employment opportunities Disadvantages: weather-related risks and safety concerns in relation to winter access. Increased road maintenance operating costs. Some additional dust generation and noise during winter months.	Retained as base case option	Smaller disturbance footprint, lower volume of ROM Stockpile contact water to be managed, and slightly higher dust generation and noise given year-round operations	No advantage	Provide year-round employment	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Not applicable	Preferred option for the Project as it is preferred by the community
Seasonal (8 months/year) at 1,500 tpd	YES	YES	Advantages: eliminate hauling and mining during the most challenging weather conditions. Disadvantages: larger disturbance footprint for ROM Stockpile.	Higher operational cost due to need to shut down operation annually and maintain “care and maintenance” mode during these shutdown periods.	Larger disturbance footprint, higher volume of ROM Stockpile contact water to be managed, but slightly lower dust generation and noise given shut-down period during the winter	No advantage	Seasonal employment	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Improve transportation safety due to winter month shutdown	No significant economic benefits over the preferred option
Transportation of Personnel, Equipment, and Supplies										
Surface Road from Highway 37A	YES	YES	Transportation represents a significant contributor to capital and operating costs. Overland access is therefore the only option considered viable for transportation of gold doré. It is also the primary option for transportation of equipment and supplies to the site.	This is the only feasible option.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Preferred Option This is the only cost-effective mean of accessing the site during construction and operations
Air/Helicopter	Not Practical for large equipment	NO	Only practical for personnel and smaller equipment and supplies.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not technically suitable or economically feasible

Tier 1 Alternatives	Pre-screening Criteria		Advantages/Disadvantages/Constraints	Evaluation Criteria for the Project						IDM Decision
	Technical Suitability	Economic Feasibility		Project Cost Implication	Potential Environmental Effects	Amenability to Reclamation	Community Acceptability	Aboriginal Interests and Treaty Rights	Other Socio-Economic Factors	
Transportation of Ore (On-Site)										
Haul road	YES	YES	Advantage – reliable access to the portal year-round.	Requires construction of haul road	Some additional dust and greenhouse gas emissions (air quality)	No advantage	Not applicable	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Not applicable	Preferred option due to lower capital cost
Tram	YES	YES	Disadvantage – road access to the portal is required for mine supplies and equipment. An access road is required for the tram option for maintenance of the tram and transportation of equipment and consumables to the mine thus it does not eliminate the need for a Haul Road.	Higher cost since access road to the mine portal is required for equipment and supplies as well as the construction of a service road for the tram line	Eliminates the need for truck transportation of ore hence reduces potential effects on air quality and air emission (dust, greenhouse gases)	No advantage	Not applicable	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Not applicable	Rejected on the basis of higher capital and operating costs as well as marginal environmental benefits
Underground Mining Access										
Upper Portal (Top of the Mountain Portal)	YES	YES	Already present, no development required, least capital spending. Most exposed to weather. There should be two portals for safety reasons and ventilation, so will act as a secondary portal.	Marginal cost implication	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Preferred option (initial / secondary access)
Lower Portal (PEA Portal)	YES	YES	This option significantly reduces ore haul distance, reduces ore haul elevation, reduces dewatering/pumping requirements, doubles as exploration development as intersects Zone 141. Preferred option due to exploration duality, use of existing portal as secondary option.	Marginal cost implication	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Preferred option (primary access)
Hump Portal	NO	Not applicable	Significant underground development that would be required was not considered technically feasibly due to resulting delays in project schedule.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not technically feasible as excessive mining is required to access ore body
Underground Mining Method										
Longhole stoping	YES	YES	Semi-selective and productive underground mining method which has a successful history of application for similar deposits with relatively low costs.	Cost effective primary option	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Preferred Options Both methods will be used where appropriate
Drift and fill	YES	YES	Preferred method where the dip of the deposit is shallow.	Cost effect option for shallow deposits	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	

Tier 1 Alternatives	Pre-screening Criteria		Advantages/Disadvantages/Constraints	Evaluation Criteria for the Project						IDM Decision
	Technical Suitability	Economic Feasibility		Project Cost Implication	Potential Environmental Effects	Amenability to Reclamation	Community Acceptability	Aboriginal Interests and Treaty Rights	Other Socio-Economic Factors	
Waste Rock Management										
Above ground	YES	YES	Not a desirable option given the large deficit of stope backfill, and given the need for management of water quality issues in perpetuity.	Higher cost as backfill must be provided entirely from quarries	Larger disturbance footprint and increased volume of contact water to be managed	Extensive reclamation requirement	Community concern over long term runoff water quality (ML/ARD)	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Not applicable	Waste rock is used to backfill the mine as mining proceeds. Would necessitate additional quarries for the supply of backfill material.
Underground, with temporary storage on the surface	YES	YES	The current mine plan exhibits a large deficit of stope backfill material, hence backfill requirements will be partially satisfied by all waste rock generated during the current mine plan. Backfilling of waste rock material will also minimize potential adverse effects as a result of ML / ARD and water quality issues	Lower cost as waste rock is utilized as backfill – reduces the need for quarried rock	Smaller disturbance footprint and lower volume of contact water to be managed	Minimal reclamation requirement	Preferred due to esthetic and environmental concerns with runoff quality	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Not applicable	Preferred option
Mineral Processing										
Whole Ore Leach (WOL)	YES	YES	Considered the preferred alternative based on cost implications and the ability to mitigate issues associated with this option in relation to consolidation rate of the tailings (using underdrains and wick drains). Following the trade-off study between WOL and FRL, additional test work and design work was performed to further optimize the recovery with the final flowsheet including two stages of grinding to target a product size of 80% passing (P80) 25 µm, followed by carbon-in-leach (CIL), acid wash, stripping and electrowinning for the recovery of gold and silver.	Not Applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Preferred option
Flotation, RE-grind and Leaching (FRL) of a concentrate finely ground to approximately 90% passing 37 µm	NO	Not applicable	Not selected based on the following key factors: • Stockpiling ore containing pyrrhotite would likely have a significant negative effect on flotation performance • The projected recovery for FRL could be higher than actual recovery (given total organic carbon has more influence at ultrafine grind sizes) • Key flotation test conditions indicate recoveries have little room for improvement • Variability flotation testing has identified several areas within the deposit that produce poor rough flotation recovery	Not Applicable	Not Applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected on basis of non-technical suitability for this site.

Tier 1 Alternatives	Pre-screening Criteria		Advantages/Disadvantages/Constraints	Evaluation Criteria for the Project						IDM Decision
	Technical Suitability	Economic Feasibility		Project Cost Implication	Potential Environmental Effects	Amenability to Reclamation	Community Acceptability	Aboriginal Interests and Treaty Rights	Other Socio-Economic Factors	
Flotation to produce a potentially saleable gold and silver-bearing flotation concentrate	YES	NO	Requires securing a favorable smelter contract as this concentrate would be viewed as "low grade" which limits marketability. This adds significant risk to the economic viability of the Project. Compared to alternatives, this option would also incur increased transportation costs.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected based on economic considerations of being tied to one client smelter and increased costs associated with transportation and handling.
Underground vs Surface Tailings Disposal										
Underground disposal as backfill, including potential for co-mingling of tailings with waste rock	NO	NO	Incompatible with mine development schedule. Requires extensive temporary storage of filtered or paste tailings on surface for 2 to 3 years in addition to reprocessing/dewatering of tailings to generate suitable paste for backfill.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected based on non-technical suitability, cost, and, incompatibility with mine development schedule.
Surface disposal of tailings	YES	YES	Only technical suitable and economically feasible option based on the mine development schedule.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Preferred Option
TMF Location on Surface										
Cirque – JDS PEA	YES	YES	Advantages: Proximity to the PEA portal. Disadvantages: Due to the relatively poor topographical conditions for impoundment capacity and dam construction, a large dam is required to provide sufficient storage (increased costs and larger disturbance footprint).	Higher construction cost and operation cost as a secondary site would be required to provide sufficient capacity for 2 Mt of tailings. No expandability.	Larger footprint and higher environmental risk due to accident and malfunctions	Not applicable	Not applicable	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Not applicable	Rejected based on poor topographic conditions, accessibility and insufficient storage space for 2 Mt of tailings.
Top of Cirque	YES	YES	Advantages: Proximity to the existing portal. Disadvantages: The steep topographical grade requires an extremely large dam (increased costs and larger disturbance footprint) and results in very poor storage efficiency for tailings.	Higher construction cost and operation cost due to difficult terrain.	Larger footprint and higher environmental risk due to accident and malfunctions	Not applicable	Not applicable	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Not applicable	Rejected based on poor topographic conditions, accessibility and insufficient storage space for 2 Mt of tailings.
SRK Side Cirque	NO	Not applicable	This option utilizes an upstream method of dam construction. The project is in an area of high seismicity where the upstream method of embankment construction is not recommended.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected based on terrain characteristics and non-technical suitability for this site.

Tier 1 Alternatives	Pre-screening Criteria		Advantages/Disadvantages/Constraints	Evaluation Criteria for the Project						IDM Decision
	Technical Suitability	Economic Feasibility		Project Cost Implication	Potential Environmental Effects	Amenability to Reclamation	Community Acceptability	Aboriginal Interests and Treaty Rights	Other Socio-Economic Factors	
Lower Cirque	NO	Not applicable	This option is in extremely steep terrain and does not provide the design storage capacity of 1.2 Mm^3. The storage efficiency is extremely poor and is not considered as a viable option for tailings storage.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected based on terrain characteristics and non-technical suitability for this site.
A- Bromley Humps	YES	YES	Advantages: Efficient TMF site, not steep in the area. "B – Bromley Humps Lower" is proximal and could provide additional storage. Least CAPEX and OPEX/sustaining costs, favourably located in the valley (nearly equi-distant from portal and highway) and provides best efficiency.	Preferred site as it meets all Project requirement	Preferred site	Not applicable	Not applicable	Not applicable	Not applicable	Preferred option as this site satisfies all Project requirement
B- Bromley Humps Lower	YES	YES	This option does not provide the design storage capacity but was advanced to the cost estimate stage as a potential location for expansion of "A – Bromley Humps" option. Requires additional storage facility.	Higher construction cost and operation cost as a secondary site would be required to provide sufficient capacity for 2 Mt of tailings. No expandability.	Comparable to preferred site	Not applicable	Not applicable	Not applicable	Not applicable	Limited storage capacity for tailings produced
Roosevelt Creek	YES	YES	Advantages: Relatively easy access as not too far along the valley road Disadvantages: The topography has a grade of approximately 20-25% and would require a large dam to provide storage (increased costs and larger disturbance footprint). The site also has a potential for avalanches and debris slides.	Higher construction cost and operation cost due to difficult terrain.	Larger footprint and higher environmental risk due to accident and malfunctions	Not applicable	Not applicable	Not applicable	Not applicable	Rejected based on suitability of terrain and cost of developing this site for TMF
Highway	YES	YES	Advantages: Proximity to highway and infrastructure, flat area Disadvantages: Adjacent to Clements Lake, which is a Provincial Park, and sensitivity of Bear River and Clements Lake.	Higher construction cost and operation cost due to distance from Plant site.	Comparable to preferred site	Not applicable	Not applicable	Not applicable	Not applicable	Rejected based on distance to the mining operation and transportation costs for materials and water/slurry pipelines
Top of Mountain	NO	Not applicable	This option is located on Top of Red Mountain and does not provide any area suitable to store the volume of tailings required.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Site has insufficient storage capacity and difficult terrain

Tier 1 Alternatives	Pre-screening Criteria		Advantages/Disadvantages/Constraints	Evaluation Criteria for the Project						IDM Decision
	Technical Suitability	Economic Feasibility		Project Cost Implication	Potential Environmental Effects	Amenability to Reclamation	Community Acceptability	Aboriginal Interests and Treaty Rights	Other Socio-Economic Factors	
Tailings Disposal Technology										
Conventional slurry tailing	NO	Not applicable	No – option excluded as the mill process design optimization work completed for the Project identified a tailings solids content of 50% (thickened slurry) could be achieved using the regular mill process. Pumping tailings at a lower solids content and higher flowrate was therefore considered inefficient.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected based on non-technical suitability and cost associated with larger requirements for effluent treatment.
Thickened slurry tailings	YES	YES	Option 2 (thickened slurry tailings) was identified as the preferred option. The main factors for this determination are as follows: The tailings deposition and water management strategy is simple relative to the other candidates. The process water is contained within the same facility and used for mill reclaim. No additional mill processes are required. There is a lower risk of operational problems (complications due to climactic conditions, etc.). There is a greater ability to maintain a degree of saturation within the tailings mass to reduce exposure of the tailings to oxidation and to limit ARD/ML generation potential.	Most favorable cost option for the TMF site retained	Operability and ease of water management	Lowest cost option for reclamation	Not applicable	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Not applicable	Preferred option
Ultra-thickened tailings (paste)	YES	Not applicable	Like ultra-thickened cemented tailings alternative. Ultra-thickened cemented tailings were preferred for inclusion in the assessment due to its increased performance as a non-flowable, non-segregating mass.	Significantly higher capital costs	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected on the basis that this option offered no technical or environmental advantages over thickened tailings and incurs high capital and operating costs for the Project.

Tier 1 Alternatives	Pre-screening Criteria		Advantages/Disadvantages/Constraints	Evaluation Criteria for the Project						IDM Decision
	Technical Suitability	Economic Feasibility		Project Cost Implication	Potential Environmental Effects	Amenability to Reclamation	Community Acceptability	Aboriginal Interests and Treaty Rights	Other Socio-Economic Factors	
Ultra-thickened cemented tailings	YES	YES	Advantages: TMF storage capacity is increased given higher average dry density, and low risk of mobilization in the event of a dam failure (given non-segregating nature of tailings). In addition, all available process water recovered in the Process Plant. Disadvantages: The overall tailings management cost is higher than managing a thickened slurry tailings. There is additional complexity and cost associated with a paste plant. A separate process water pond is likely required. In addition, positive displacement pumping is required to discharge thickened and cemented tailings a distance of 400 m from the Process Plant to the TMF.	Significantly higher capital costs	Not environmental advantage over thickened tailings disposal (lowest cost alternative)	No advantage in reclamation costs over thickened tailings disposal (lowest cost alternative)	No esthetic or visual advantage over thickened tailings disposal (lowest cost alternative)	No esthetic or visual advantage over thickened tailings disposal (lowest cost alternative) No effects on Treaty Rights	No esthetic or visual advantage over thickened tailings disposal (lowest cost alternative)	Rejected on the basis that this option offered no technical or environmental advantages over thickened tailings and incurs high capital and operating costs for the Project.
Filtered tailings	YES	YES	Advantages: no mobilization in the event of a buttress or embankment failure Disadvantages: The overall tailings management cost is higher than managing a thickened slurry tailings. The additional capital cost of paste and filter plants and the increased operating cost associated with filtering and transporting tailings would increase the overall cost further. Aggressive water management and a separate water management pond are required. In addition, ML / ARD potential is greater given increased rates of oxidation, and additional challenges exist when placing and compacting filtered tailings in an area with cold temperatures and high precipitation and snowfall.	Significantly higher capital cost due to filtration equipment	Not environmental advantage over thickened tailings disposal (lowest cost alternative)	No advantage in reclamation costs over thickened tailings disposal (lowest cost alternative)	No esthetic or visual advantage over thickened tailings disposal (lowest cost alternative)	No esthetic or visual advantage over thickened tailings disposal (lowest cost alternative) No effects on Treaty Rights	No esthetic or visual advantage over thickened tailings disposal (lowest cost alternative)	Rejected on the basis that this option offered no technical or environmental advantages over thickened tailings and incurs high capital and operating costs for the Project.
Power Supply										
Diesel	YES	YES	Diesel has a higher unit cost compared to grid power. Diesel would also require additional fuel capacity on-site (increased costs and risks of spills and other accidents / malfunctions) and produce higher amounts of greenhouse gases.	Higher energy cost and additional site infrastructure required (power plant and fuel storage)	Compared to Transmission Line: Smaller disturbance footprint, increased risk associated with transportation of fuel, and higher GHG emissions	Not applicable	Not applicable	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Increase hazard risk with road transportation of fuel	Rejected as it is not as favorable as Powerline option. Higher CAPEX and OPEX.

Tier 1 Alternatives	Pre-screening Criteria		Advantages/Disadvantages/Constraints	Evaluation Criteria for the Project						IDM Decision
	Technical Suitability	Economic Feasibility		Project Cost Implication	Potential Environmental Effects	Amenability to Reclamation	Community Acceptability	Aboriginal Interests and Treaty Rights	Other Socio-Economic Factors	
LNG	YES	YES	LNG has a higher unit cost compared to grid power. LNG also would require additional fuel capacity on-site (increased costs and risks of spills and other accidents / malfunctions) and produce higher amounts of greenhouse gases.	Higher energy cost and additional site infrastructure required (power plant and fuel storage)	Compared to Transmission Line: Smaller disturbance footprint, increased risk associated with transportation of fuel, and higher GHG emissions	Not applicable	Not applicable	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Increase hazard risk with road transportation of fuel	Rejected as it is not as favorable as Powerline option. Higher CAPEX and OPEX.
Solar	NO	NO	Although the technology is proven, a primary power supply is required to ensure reliability of energy supply for the operation of the Project. For a longer Project life, solar could be considered as a supplemental power supply.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected as this option requires an additional power supply.
Wind	NO	NO	Although the technology is proven, a primary power supply is required to ensure reliability of energy supply for the operation of the Project. For a longer Project life, solar could be considered as a supplemental power supply.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected as this option requires an additional power supply.
Transmission Line	YES	YES	Grid power provides the required capacity to meet power demands of the Project at the lowest cost.	Lower capital and operating costs	Compared to Diesel or LNG: Larger disturbance footprint, lower risk associated with transportation of fuel, and lower GHG emissions	Not applicable	Not applicable	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Not applicable	Preferred option. Lowest OPEX and CAPEX.

4.4 Discussion of Tier Two Alternatives within the Project

Once tier one alternatives decisions have been made, a second tier of alternatives are considered as means of executing components of the Project and evaluated. These tier two alternatives support optimization of the configuration of the site during the preliminary and detailed design phases of the Project. Optimization focuses on:

- Location of infrastructure;
- Laydown areas within the Project area;
- Type of explosives and storage locations;
- Location of quarry and borrow sites;
- Water management approaches within the Project Area; and
- Waste and wastewater management.

A summary of the tier two alternatives analysis is provided in Table 4.4-2.

4.4.1 Site Selection for Buildings, Ancillary Facilities, and Laydown Areas

Selecting a suitable location for buildings and structures is primarily dictated by proximity to the Mine Site and/or Bromley Humps (and the Process Plant and TMF). The following is a list of on- and off-site infrastructure for which no viable alternatives or options were available:

Bromley Humps

- Administration Office / Mine Dry
- Warehouse
- Hazardous Materials Storage
- Waste Storage Area
- ROM Stockpile
- Water Treatment Plant
- 100,000 L fuel tank

Mine Site

- Offices (Lower and Upper Portal)
- Fuel Tank (Lower Portal)
- Fuel Tank (Upper Portal)
- Explosives Magazine[1]
- Maintenance shop (Lower Portal)
- Maintenance shop (Upper Portal)

Offsite

- Project office in Stewart
- Warehouse in Stewart

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[1] No options beyond ANFO (Construction Phase) and bulk emulsion (Operation Phase) were considered about the type of explosives to be used. Both options were carried forward in the effects analysis.

4.4.2 Alternatives for Process Plant Location

Several options for a Process Plant location were initially considered and are shown on Figure 4.3-2. Initial consideration was also given to establishing the Process Plant and TMF facilities in different locations, however the engineering design of a pipeline for tailings in the Bitter Creek valley was found to be costly and inefficient. As well, consequences of a pipeline failure due to seismicity, avalanches, or debris flows would be an additional risk to manage. Thus, it was determined that there was only one suitable location for the Process Plant and associated facilities: the site in closest proximity to the TMF at Bromley Humps. This site is also in reasonable proximity to the Mine Site.

Given that only one economically feasible and technically suitable location for the Process Plant was identified, no further analysis of other criteria, including environmental and social considerations, was undertaken.

4.4.3 Borrow Sites

Quarry and borrow material will be needed for the early development of roads and laydown areas. Quarry material will also be needed for the construction, operation, and maintenance of infrastructure required throughout the life of the Project as well as material for mine backfill.

Options for quarry and borrow material include:

- Talus deposits (to be used as backfill);
- Local aggregate sources near the access road;
- local bedrock locations within proposed infrastructure footprint; and
- Underground non-mineralized development rock within current mine operations plan.

Suitable material locations need to be physically stable, aim to minimize use of PAG material, minimize transport distances, and avoid culturally and environmentally sensitive areas. Locations can be new areas outside the proposed mine workings or be areas that are accessed during regular mining operations.

Due to the spread-out nature of the sites, several local quarries and borrow pits along the Access Road alignment have been identified to minimize total disturbance and reduce transportation of material (Figure 4.4-1). An assessment of quarry material needs for construction has currently identified six areas that may be suitable sources for rock and aggregate for construction purposes and mine backfill. Two potential gravel borrow areas near Roosevelt Creek and Hartley Gulch have been identified for construction material needs. Two rock quarry sources have been identified: one within 1 km of the Highway 37A intersection and the other approximately 500 metres (m) south of Otter Creek. Rock quarries will be used when gravel material is not suitable for construction purposes. Two talus material sources have been identified along the Haul Road. Talus material will only be used for mine backfill purposes. Most quarry material will be used for the staged construction of the TMF. Initial material requirements will be sourced from the borrow location near Hartley Gulch with future material coming from the borrow source at Roosevelt Creek. The Bromley Humps site has been designed to be primarily in cut with the excess material being used for the initial construction of the TMF. This will minimize the requirement for borrow material.

4.4.3.1 Environmental and Social Considerations

As noted above, multiple suitable locations for quarry and borrow materials along the Access Road and Haul Road alignments were selected and carried forward in the Project effects assessment. Criteria used in this selection process of relevance to environmental and social considerations included avoidance of culturally and environmentally sensitive areas (related to terrestrial and aquatic VCs), minimizing the use of PAG material (related primarily to aquatic VCs), and minimizing transport distances (related primarily to air quality and dust generation).

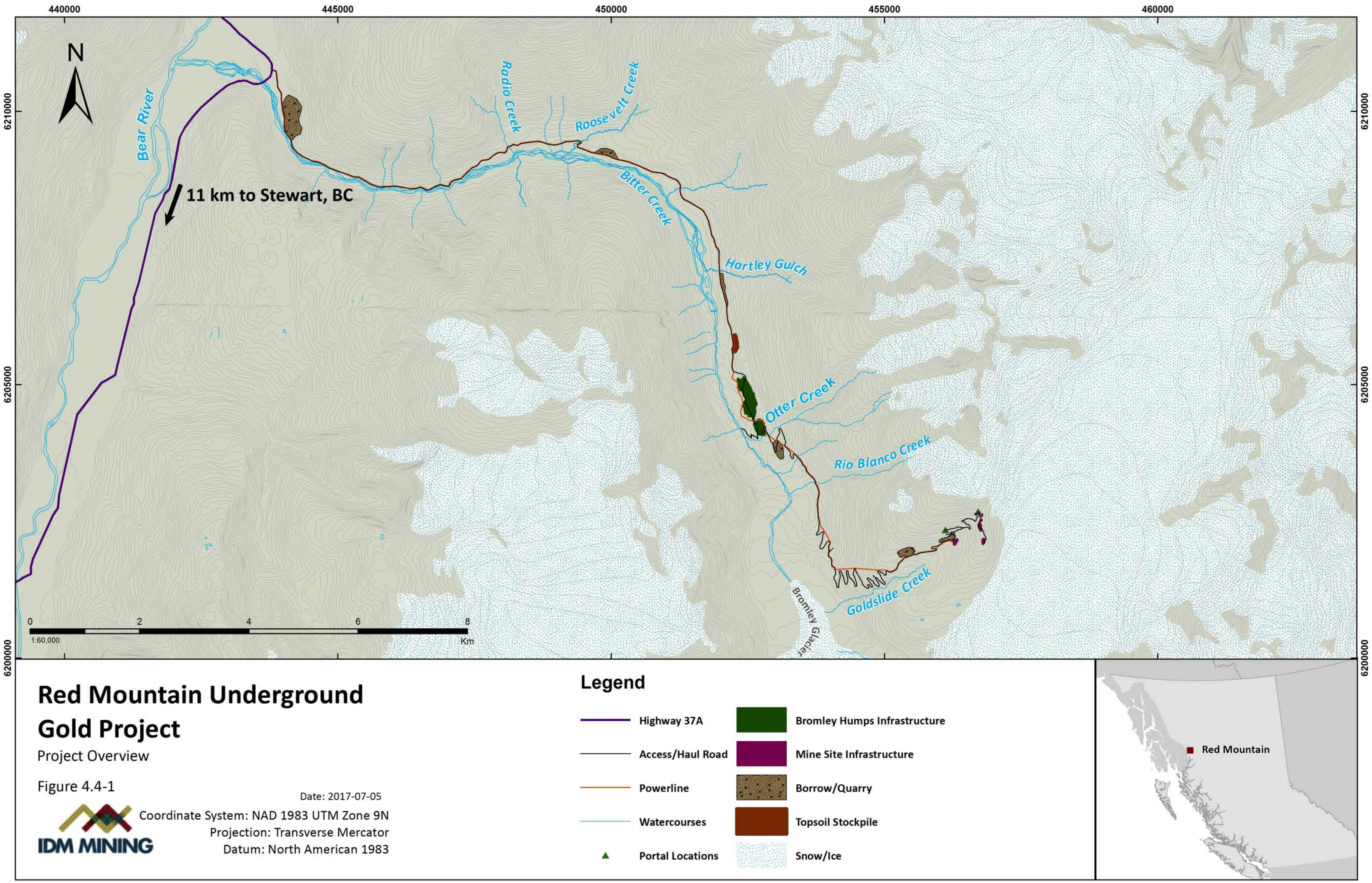
More detailed information on borrow sites is provide in the Project Overview (Volume 2, Chapter 1).

Prior to construction, further geochemical analysis for ML/ARD potential will be undertaken for borrow sites, large cuts, and along the road alignment. If concerns are encountered, management strategies, as outlined in the Materials Handling and ML/ARD Management Plan (Volume 5, Chapter 29), will be implemented. Management options include but are not limited to:

- Geochemical testing to further delineate and characterize materials;
- Minimizing the use of PAG material for construction;
- Reducing cut and fill to the extent practicable;
- Optimizing cut and fill angles (i.e. minimizing exposed surfaces);
- Isolating PAG material from air and water to prevent the onset of ARD;
- Optimizing mass haul (i.e. management of material movement along the Access and Haul Roads); and
- Design adjustments, where possible, when PAG materials are encountered during construction.

The location of quarry and borrow sites will be confirmed through detailed design.

Figure 4.4-1: Project Overview with Borrow and Quarry Site Locations



4.4.4 Water Management

Water management includes: water supply, process water management, and surface water management.

Once the Process Plant, waste rock storage, ROM stockpile, and TMF were located, other Project components, including water management infrastructure, were situated based on the following factors: proximity to major Project infrastructure, suitable ground conditions, minimizing Project footprint, and avoidance of culturally and environmentally sensitive areas, where possible.

4.4.4.1 Mine Dewatering Water Management

Surplus groundwater will be generated from the underground mine during operations, and groundwater controls include either physical barriers to cut-off inflow or an array of pumps and sumps to dewater. Due to technical and cost considerations, physical barriers will be used locally to cut-off groundwater inflow from distinct sources to limit the volume of inflow. Options to discharge excess groundwater are limited by water quality and discharge criteria.

Two options were considered management of water from the underground workings:

- Option 1: Discharge to the environment; and
- Option 2: Use as process water at the Process Plant.

Discharge to the environment is associated with additional cost due to the need for a pipeline to transport the mine water to the Process Plant.

4.4.4.1.1 Environmental and Social Considerations

Option 2 will have a slightly larger disturbance footprint than Option 1, given the preferred location of the Process Plant at Bromley Humps and Option 1’s need for a pipeline to transport the mine water from the Mine Site to the Process Plant.

Discharge to the environment (Option 1) of the water from the underground workings has the potential for adverse effects to water quality and aquatics VCs. However, with the implementation of best practices (i.e. interception, containment, and treatment if required), adverse effects to the aquatic receiving environment can be managed such that permitted discharge criteria are achieved.

4.4.4.1.2 Preferred Alternative

Discharge to the environment (Option 1) was selected as the preferred option given the additional cost of a pipeline and the limited potential for any negative effects to the receiving environment.

Water will be reused as necessary in the mine, and excess water will be treated and discharged.

Dewatering of the underground mine workings will be directed to the upper reaches of Bitter Creek via the Bromley Glacier or Goldslide Creek. Specifically, dewatering of the Upper Portal will be achieved from start of operations to Year 1.5 via pumping and discharging to Bromley Glacier.

The Upper and Lower Portals will be physically connected after Year 1.5 through to closure and therefore there will be no more surplus water from the Upper Mine Portal after Year 1.5. Dewatering of the Lower Portal will be achieved by routing surplus water to the Portal Collection Pond and discharging to Goldslide Creek.

4.4.4.2 Potable, Process, and Industrial Water Supply

Two options were considered for the supply of potable water during construction and operations:

- Option 1: Obtain and treat water from Bitter Creek; or
- Option 2: Haul potable water to the site from Stewart.

Treating water from Bitter Creek for potable water was selected as the preferred option based on the costs associated with trucking potable water to site from Stewart.

Options 1 and 2 are comparable when considering potential environmental and social effects. While Option 1 is associated with water taking from Bitter Creek, no adverse effect is anticipated given the small volume of potable water (7.5 m^3/day during the Operation Phase) required.

With regards to other water supply needs during construction and operations, the proximity to the water source is the primary selection criteria. However, the source must provide sufficient volumes to satisfy the Project needs while respecting drawdown criteria. In determining water needs, water balance calculations were modelled and the following determinations were made:

- Bitter Creek, Otter Creek, and Goldslide Creek have sufficient capacity to supply the domestic freshwater needs of the Project during construction and operations.

- With regards to dust suppression (construction and operations) and water supply for other uses during construction, the following options are considered, in order of priority:
    - Contact water management ponds;
    - Bitter Creek (Bromley Humps);
    - Otter Creek (Bromley Humps); and
    - Goldslide Creek (Mine Site).

All options identified above are considered feasible. Contact water management ponds are a preferred source of water. However, an alternative source is required during construction start-up (until ponds are built) and during the remainder of the Project life given the limited reliability of water availability in the ponds. As a result, permitting will be sought for Bitter Creek, Otter Creek, and Goldslide Creek as backup sources of water.

Minimizing use of freshwater is an important design criterion for Process Plant operations. For this reason, the water balance incorporates maximizing the use of recycled water from the TMF for use in the Process Plant while maintaining an adequate water cover on the tailings. Even with recycling, the Process Plant will likely require additional freshwater for operations. This fresh make-up water will be sourced from Bitter Creek to provide additional water resources during operations and/or for closure activities. Alternative water sources for water supply throughout the Project life will be based on technical feasibility, costs, proximity to infrastructure, and environmental considerations.

Given that all identified options for process and industrial water use are scoped into the Project as noted above, further analysis comparing these alternatives (e.g. environmental and social considerations) is not required.

4.4.4.3 Surface Water Management

Water management includes options for surface water control and groundwater control. In both situations, water can either be diverted/excluded or collected and pumped to treatment if needed, disposed of, or put to beneficial use on site. A discussion of alternatives for the management of groundwater from the underground mine is presented in Section 4.4.4.1.

Surface water management at the Mine Site and at Bromley Humps will include a network of diversion channels to direct surface water flow away from the Project footprint as well as a network of collection channels and sumps to collect contact water. Contact water will include water from mine workings and surface water flow/stormwater from the individual Project areas.

Options to manage the surface water at Bromley Humps include discharge to the environment or directing to a temporary retention area. Due to operational water requirements at the Process Plant, surface contact water will be directed to the TMF. Surplus water will be treated and discharged to Bitter Creek.

Given that only one economically feasible and technically suitable option for surface water management at Bromley Humps was identified, no further analysis of other criteria, including environmental and social considerations, was undertaken.

4.4.4.4 Site Water Treatment

4.4.4.4.1 Process Plant Water and Tailings Treatment

A site-wide water quality prediction model was developed to determine mine water management and effluent treatment requirements for the Red Mountain Project (Volume 8, Appendix 14-C). The results of the water quality prediction model indicated that concentrations of ammonia, total suspended solids (TSS), copper, and iron in the tailings pond water could exceed discharge concentration limits proposed for the Project. Therefore, excess water collected in the tailings facility would require treatment before water can be discharged to Bitter Creek.

Water treatment for removal of dissolved metals and TSS is typically done with some version of lime water treatment. Lime treatment is relatively low cost, reliable, and a ubiquitous water treatment method in the mining industry and at industrial sites.

The treatment process works by increasing the pH of the process water by adding hydrated lime ($Ca(OH)_2$). At pH values above 9 or so, many metals, such as copper, lead, cadmium, and zinc, precipitate as hydroxide solids. The precipitated solids are subsequently removed by settling and filtration after adding coagulants and flocculants. The settling and filtration step also removes any TSS in the process water.

Although lime water treatment can be implemented in several different ways, and additional reagents can be introduced to improve the removal of specific metals, the treatment process can be considered to be the best available technology for metal removal in all but a few specialized cases.

Treatment options considered for removal of ammonia included the following:

Chemical / Physical Treatment

- Ammonia stripping;
- Ion exchange (zeolite water treatment);
- Reverse Osmosis (RO) and ammonia stripping; and
- Breakpoint chlorination.

Biological Treatment

- Rotating Disk Reactor (RBC);
- Moving Bed Biofilm Reactor (MBBR); and
- In-Pond biological treatment;
  - Submerged attached growth reactor; and
  - Floating island.

A screening of the above commercially available water treatment technologies for ammonia was undertaken, the results of which are presented in Table 4.4-1 (extracted from Appendix G of the Water and Load Balance Model Report (Volume 8, Appendix 14-C)). Based on experience with the treatment of similar mine contact water at other projects, the following two stage water treatment process is proposed for the Project:

- Stage 1 – Chemical Treatment: Lime precipitation and ferric coagulation followed by clarification for the removal of dissolved metals (including copper, cadmium, and iron) and TSS.

- Stage 2 – Biological Treatment: MBBR treatment system for the removal of ammonia.

Table 4.4-1: Summary of Water Treatment Technologies for Removal of Ammonia

Name of Technology	Description of Technology	Advantages	Disadvantages
Chemical/Physical Treatment			
Ammonia Stripping	• pH dependent conversion of dissolved ammonium (NH $^+$) to dissolved ammonia (NH) by increasing the pH to 11. • At this pH, nearly all ammonium is converted to ammonia gas, and the water is sent through gas stripping units (columns) to remove the dissolved ammonia gas with counter-current air flow. • Stripped ammonia gas vented to atmosphere or into a scrubber at the top of the column.	• Proven process • Relies solely on chemical reagents and conventional stripping	• Volatilization process requires clarification and filtration pre-treatment step to remove TSS. • High calcium concentrations can form calcium carbonate scaling in column • Air must be heated during winter to prevent column freezing and ensure adequate gas transfer. • Effluent must be neutralized to pH 7 using CO_2 or sulphuric acid. • High concentrations of salts are added to effluent. • Potentially generates ammonia air emissions.
Ion Exchange (Zeolite Water Treatment)	• Uses synthetic resin beads or natural zeolite minerals to capture ammonium ions by passing ammonium rich water through a bed of positively charged resin beads. • Ammonium ions are exchanged for sodium or potassium ions present on the resin/zeolite media. • Ion exchange media regenerated or replaced once majority of sodium or potassium ions have been replaced by ammonium ions. • Regeneration accomplished by passing concentrated sodium chloride or potassium sulphate solution through the media, displacing the ammonium ions attached to the resin. • The regeneration solution will have a high concentration of ammonium and will require disposal.	• Proven process • Relies on adsorption, which is a reliable mechanism	• High cost of zeolite and zeolite disposal if single-pass configuration is used, OR • Regenerant disposal is a major issue if zeolite is regenerated using nitric acid. • Adds salt (sodium or potassium) to effluent. • Potential scaling issues. • Can perform poorly at cold water temperatures.
Reverse Osmosis (RO) and Ammonia Stripping	• Similar to ammonia stripping process described above. • In this system, RO unit inserted upstream of air stripper. • RO uses high pressure to force water through membrane that prevents most ions from passing, and therefore produces two waste streams: a very clean water stream (permeate), and a concentrated brine (retentate) that contains most of the contaminants from the mine water. • Retentate sent to softening step and pH adjustment to pH 11, then through ammonia stripping process.	• Proven technology	• Volatilization process requires clarification and filtration pre-treatment step to remove TSS. • Combination of two physical treatment processes. • Generates ammonia air emissions. • Complicated operation.
Breakpoint Chlorination	• Destruction of ammonium by chlorine gas. • Only practical as effluent polishing technique, and not for removing high levels of influent nitrogen. • Reactions between chlorine and ammonia produce monochloramines (NH_2Cl), dichloamines ($NHCl_2$), and nitrogen trichloride (NCl_3).	• Proven technology	• Only practical as polishing step. • Difficult to control process. • Potential for toxic residual chlorine in effluent. • Hazardous reagents.
Biological Treatment			
Rotating Disk Reactor (RBC)	• Consists of large wheel of stacked disks partially submerged in water to be treated. • Disks provide fixed growth media for biofilms of nitrifying bacteria. • Rotation of wheel aerates and mixes water to ensure that feed water comes into contact with the biofilm, and the aeration rate is controlled by adjusting the wheel speed.	• Simple operation • No by-products generated • No salt added to effluent • Proven technology	• Reliance on biological system. • Potentially challenging start up.
Moving Bed Biofilm Reactor (MBBR)	• Operates similar to RBC but in different configuration • Instead of disks mounted on a wheel, MBBR uses hollow, plastic media as growth media for nitrifying bacteria. • Aeration and mixing accomplished by bubbling air through the MBBR tank.	• Proven technology • Simple operation • No by-products generated	• Reliance on biological system. • Potentially challenging start up.

Name of Technology	Description of Technology	Advantages	Disadvantages
In-Pond Biological Treatment			
Submerged Attached Growth Reactor	• In situ variation of biological treatment, where fixed film media (crushed rock) is placed in a lined pond. • Crushed rock covered with insulating layer of peat, and aeration is provided by a manifold of perforated pipes.	• Simple process • Inexpensive to implement	• Uncertain treatment effectiveness. • Lack of process control.
Floating Island	• Another variation of biological treatment, in which engineered floating islands installed in a pond containing the water requiring treatment. • Island material and vegetation roots populating island serve as fixed film media for nitrifying bacteria. • Additionally, vegetation growing on islands assimilates ammonia during the open water season.	• Simple process • Inexpensive to implement	• Not suitable for cold climate. • Lack of process control.

4.4.4.4.2 Environmental and Social Considerations

Environmental considerations are integrated into Table 4.4-1 above and are discussed in further detail in Appendix 14-C.

4.4.4.4.3 Grey Water and Sewage Treatment

Two options were considered for grey water and sewage treatment. These alternatives included:

- Option 1: Treat using a membrane bioreactor or similar biological process; and
- Option 2: Offsite disposal at an approved facility.

Ultimately, the option of offsite disposal was found to be the most cost effective option and was therefore selected as the preferred option for the Project.

4.4.4.4.4 Environmental and Social Considerations

There are few differential considerations between Option 1 and Option 2 regarding environmental and social aspects. Option 1 is associated with on-site treatment and would result in some discharge to the receiving environment. However, it is assumed that treatment technologies, best practices, and regulatory requirements are well established to address all potential residual effects. For example: in BC, sewerage system design and management for handling less than 22,700 litres per day of sewage flow to ground falls under the Sewerage System Regulation (BC Reg. 326/2004) as per the *BC Health Act* (1996). Systems exceeding this flow rate, and all discharge to surface water, are regulated by the Municipal Wastewater Regulation (BC Reg. 87/2012) as per the *Environmental Management Act* (2003).

4.4.5 Flooding of the Underground Workings

Baseline water levels in the area of the Mine Site have been measured at a maximum of 1,875 masl in the summer months (Volume 8, Appendix 10-A), which is higher than the elevation of each of the three mine portals:

- Existing Portal (Upper Portal): 1870 masl
- Ventilation Portal (New): 1861 masl
- Lower Portal (New): 1720 masl

Water and load balance results, as presented in the Water and Load Balance Model Report (Appendix 14-C), have shown post-closure exceedances in groundwater of MMER guidelines under a worst-case scenario. However, the use of both the cemented rock backfill (CRF) in the primary stopes and lime that will have been mixed with the talus quarry rock also used as backfill (Appendix 14-C) is expected to address this issue. Further modelling work will be completed during detailed design to refine water quality predictions and management strategies.

IDM considered the following alternatives in relation to flooding of the underground workings:

- Option 1: Not flooding underground workings at closure;
- Option 2: No Lower Portal location;
- Option 3: Installation of hydraulic plugs at the Lower Portal, Upper Portal, and Ventilation Portal;
- Option 4: Altering Lower Portal location to allow for flooding of underground workings without hydrostatic plugs; and
- Option 5: No hydrostatic plug at the Upper Portal, and either:
    - Allow seasonal flows from Upper Portals to discharge to Goldslide Creek; or
    - Install system of ditches to allow seasonal flows from Upper Portal to flow to Cambria Icefield.

Not flooding the underground workings (Option 1) at closure is not a viable option, as mine water potentially exceeding MMER discharge limits would be discharged from the Lower Portal and report to Goldslide Creek. Additionally, the underground would remain exposed to oxygen over the long-term, possibly inducing acid mine drainage and further metal leaching once the alkaline CRF has been exhausted.

Having no Lower Portal location (Option 2) is not a viable option as discussed in Section 4.3.3.1. The Lower Portal provides a more economical point of access by reducing haul distances, reducing weather exposure, and reducing uphill hauls.

Further discussion comparing the remaining alternatives (Options 3, 4, and 5) is presented below.

Flooding of the underground workings without the installation of a hydrostatic plug (Option 4) would require a new portal at a higher elevation than the maximum groundwater elevation of 1,875 masl. An Upper Portal (1,861 masl) already exists and, regardless of any new portal being created above this, mine water would still discharge seasonally. Further, in addition to the significant cost of installing a new portal, it would also require the construction and maintenance of several diversion ditches to channel seasonal flows, adding long-term liability in terms of maintenance and possible water treatment

Installing a hydrostatic plug in only the Lower Portal (Option 5) would result in seasonal discharges of mine water from both the Ventilation Portal (1,870 masl) and the Upper Portal (1,861 masl). Similar to the option of not flooding the underground workings, this option is not considered viable, as mine water exceeding MMER discharge limits would be discharged from the Upper Portal and report to Goldslide Creek. In consideration of this, not plugging the Upper Portal would require the construction and maintenance of diversion ditches to channel seasonal flows, adding long-term liability in terms of maintenance and water treatment.

The preferred option is therefore sealing each of the three portals (Upper Portal, Lower Portal, and Ventilation Portal) with hydrostatic plugs during the Closure and Reclamation Phase. It will take an estimated 20 to 40 years for groundwater levels to reach near baseline levels in the underground workings (Appendix 10-A).

4.4.5.1 Environmental and Social Considerations

There are few differential considerations between flooding of the underground workings alternatives regarding environmental and social aspects. Effects to the aquatic environment from the mine water discharge would be managed through the implementation of standard best practices and as per regulatory requirements, regardless of the option ultimately selected.

4.4.5.2 Preferred Alternative

Option 4 and 5 are less desirable than Option 3, given the need for additional infrastructure (and associated disturbance footprint) to manage mine water over the long-term, prior to discharge.

Ultimately, with Option 3 (the preferred alternative), the hydrostatic plugs will:

- Restrict the discharge of mine water from the underground workings;
- Prevent the infiltration of surface water into the underground workings;
- Allow the mine to passively flood to minimize development of ARD/ML; and
- Prevent unauthorized access.

4.4.6 Summary of Tier Two Alternatives Analysis

Table 4.4-2 summarizes the tier two alternatives analysis.

Table 4.4-2: Summary of Tier Two Alternatives Analysis

Tier 2 Alternatives	Pre-screening Criteria		Advantages/Disadvantages/Constraints	Evaluation Criteria for the Project						IDM Decision
	Technical Feasibility	Economic Feasibility		Project Cost Implication	Potential Environmental Effects	Amenability to Reclamation	Community Acceptability	Aboriginal Groups and Treaty Rights	Other Socio-Economic Factors	
Process Plant Location (Suitable location must be in proximity to the Mine Site and to the selected TMF site at Bromley Hump)										
Bromley Humps	YES	YES	Efficiently located in proximity to Mine Site (minimize haulage distance of ore) and the TMF (minimize pumping distance for tailing slurry and TMF recycled water). Least CAPEX and OPEX/sustaining costs, and favourable location from geohazard (avalanche path and landslides) perspective given location in the valley.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Preferred option as the site is optimal with respect to mine portal and TMF.
Highway	YES	NO	Advantages: Proximal to grid, highway and infrastructure – would allow year-round operation with very little maintenance. Disadvantages: With preferred location of the TMF at Bromley Humps Upper, a pipeline would be required for transport of tailings.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected site is not proximal to TMF or Mine Site, resulting in higher CAPEX/OPEX.
Roosevelt Creek	YES	NO	Advantages: Relatively easy access as not too far along the valley road. Disadvantages: With preferred location of the TMF at Bromley Humps Upper, a pipeline would be required for transport of tailings. This location is also far from the Mine Site, and has a potential for avalanches and debris slides.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected site is not proximal to TMF or Mine Site, resulting in higher CAPEX/OPEX.
Cirque PEA	YES	NO	Advantages: Located proximal to the Mine Site and prior to steep section of the Haul Road Disadvantages: Relatively poor topographical conditions and associated geohazard risks. With preferred location of the TMF at Bromley Humps Upper, a pipeline would be required for transport of tailings.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected as TMF is in a different location, resulting in higher CAPEX/OPEX.
Top of Cirque	YES	NO	Advantages: Located proximal to the Mine Site Disadvantages: This site is most exposed from a weather / climate perspective. With preferred location of the TMF at Bromley Humps Upper, a pipeline would be required for transport of tailings.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected as TMF is in a different location, resulting in higher CAPEX/OPEX.

Tier 2 Alternatives	Pre-screening Criteria		Advantages/Disadvantages/Constraints	Evaluation Criteria for the Project						IDM Decision
	Technical Feasibility	Economic Feasibility		Project Cost Implication	Potential Environmental Effects	Amenability to Reclamation	Community Acceptability	Aboriginal Groups and Treaty Rights	Other Socio-Economic Factors	
Mine Dewatering Water Management										
Discharge to environment	YES	YES	Discharge mine water to the Cambria Icefield (from the Upper Portal) and then to Goldslide Creek via the Portal Collection Pond (from the Lower Portal).	Lower cost option	Potential adverse effects to aquatic environment associated with discharge can be managed through BMP implementation	Not applicable	Not applicable	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Not applicable	Preferred option – least cost and environmentally benign
Use as process water in the Mill	YES	YES	Requires construction of a pipeline to the Process Plant. Higher risk due to potential landslide and geohazards.	Additional costs due to pipeline requirement	Slightly larger disturbance footprint due to construction of pipeline, no surface water discharge	Not applicable	Not applicable	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Not applicable	Rejected due to higher cost with no additional environmental benefits
Potable Water Supply										
Bitter Creek	YES	YES	On-site year-round source of water	Preferred option	No adverse environmental effects given small quantity of potable water required	Not applicable	Not applicable	Not applicable	Not applicable	Preferred option due to proximity to the mill
Haulage from Stewart	YES	YES	Disadvantage: reliability of daily supply due to site access hazards (road wash out, avalanches, etc.)	Higher cost for transportation equipment	No adverse environmental effects	Not applicable	Not applicable	Not applicable	Not applicable	Rejected based on reliability concerns, increase CAPEX and OPEX for transportation equipment
Water Treatment Options for Removal of Ammonia										
Refer to Table 4.4-1										
Grey Water and Sewage Disposal										
Treatment on site	YES	YES	Construct and operate a grey water/sewage treatment plant on site.	Higher cost associated with construction and operation of a treatment facility	Treatment technologies, BMPs, and regulatory requirements well established. No residual effects anticipated.	Not applicable	Not applicable	Not applicable	Not applicable	Rejected based on higher costs
Off-site disposal at approved facility	YES	YES	Truck sewage/grey water to treatment plant in Stewart.	Base case option	No significant environmental benefits	Not applicable	Not applicable	Not applicable	Not applicable	Preferred option

Tier 2 Alternatives	Pre-screening Criteria		Advantages/Disadvantages/Constraints	Evaluation Criteria for the Project						IDM Decision
	Technical Feasibility	Economic Feasibility		Project Cost Implication	Potential Environmental Effects	Amenability to Reclamation	Community Acceptability	Aboriginal Groups and Treaty Rights	Other Socio-Economic Factors	
Flooding of the Underground Workings										
Do not flooding underground workings	NO	NO	Not a viable option as mine water exceeding MMER discharge limits would be discharged from the Lower Portal and report to Goldslide Creek. Not economical considering water management infrastructure (including treatment) that would be required.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected as technically unsuitable and economically unfeasible
No Lower Portal location	NO	NO	Not a viable option as the Lower Portal provides a more economical point of access by reducing haul distances, reducing weather exposure, and reducing uphill hauls.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Rejected as technically unsuitable and economically unfeasible
Installation of hydrostatic plugs at three portal locations	YES	YES	Sealing each of the three portals (Upper Portal, Lower Portal, and Ventilation Portal) with a hydrostatic plug during the Closure and Reclamation Phase. It will take an estimated 20 to 40 years for groundwater levels to reach near baseline levels in the underground workings.	Base case option	Base case option	Not applicable	Not applicable	Not applicable	Not applicable	Preferred option
Altering Lower Portal location to avoid installation of a hydrostatic plugs	YES	YES	Mine water potentially exceeding MMER discharge limits would be discharged seasonally from the Upper Portal and report to Goldslide Creek. Not plugging the Upper Portal would require the construction and maintenance of diversion ditches to channel seasonal flows, adding long-term liability in terms of maintenance and water treatment.	Higher costs and long-term liability associated with diversion ditches and water treatment	Discharge to surface would be required over the long-term. However, environmental effects anticipated to be similar to base case with water management.	Not applicable	Not applicable	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Not applicable	Rejected based on higher costs when compared to base case
No hydrostatic plug at the Upper Portal	YES	YES	Mine water potentially exceeding MMER discharge limits would be discharged seasonally from the Upper Portal and report to Goldslide Creek. Not plugging the Upper Portal would require the construction and maintenance of diversion ditches to channel seasonal flows, adding long-term liability in terms of maintenance and water treatment.	Higher costs and long-term liability associated with diversion ditches and water treatment	Discharge to surface would be required over the long-term. However, environmental effects anticipated to be similar to base case with water management	Not applicable	Not applicable	Potential indirect effects to Aboriginal Interests and Treaty rights due to potential environmental effects.	Not applicable	Rejected based on higher costs when compared to base case

4.5 References

Canadian Environmental Assessment Agency. 2013. *Addressing "Purpose of" and "Alternative Means" under the Canadian Environmental Assessment Act, 2012*. Operational Policy Statement. Updated March, 2015. http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=1B095C22-1&pedisable=true.

JDS Energy and Mining Inc. 2016. NI 43-101 Preliminary Economic Assessment Technical Report for the Red Mountain Project, British Columbia, Canada. August 2016.