Figure 3.8-1
Boston Layout

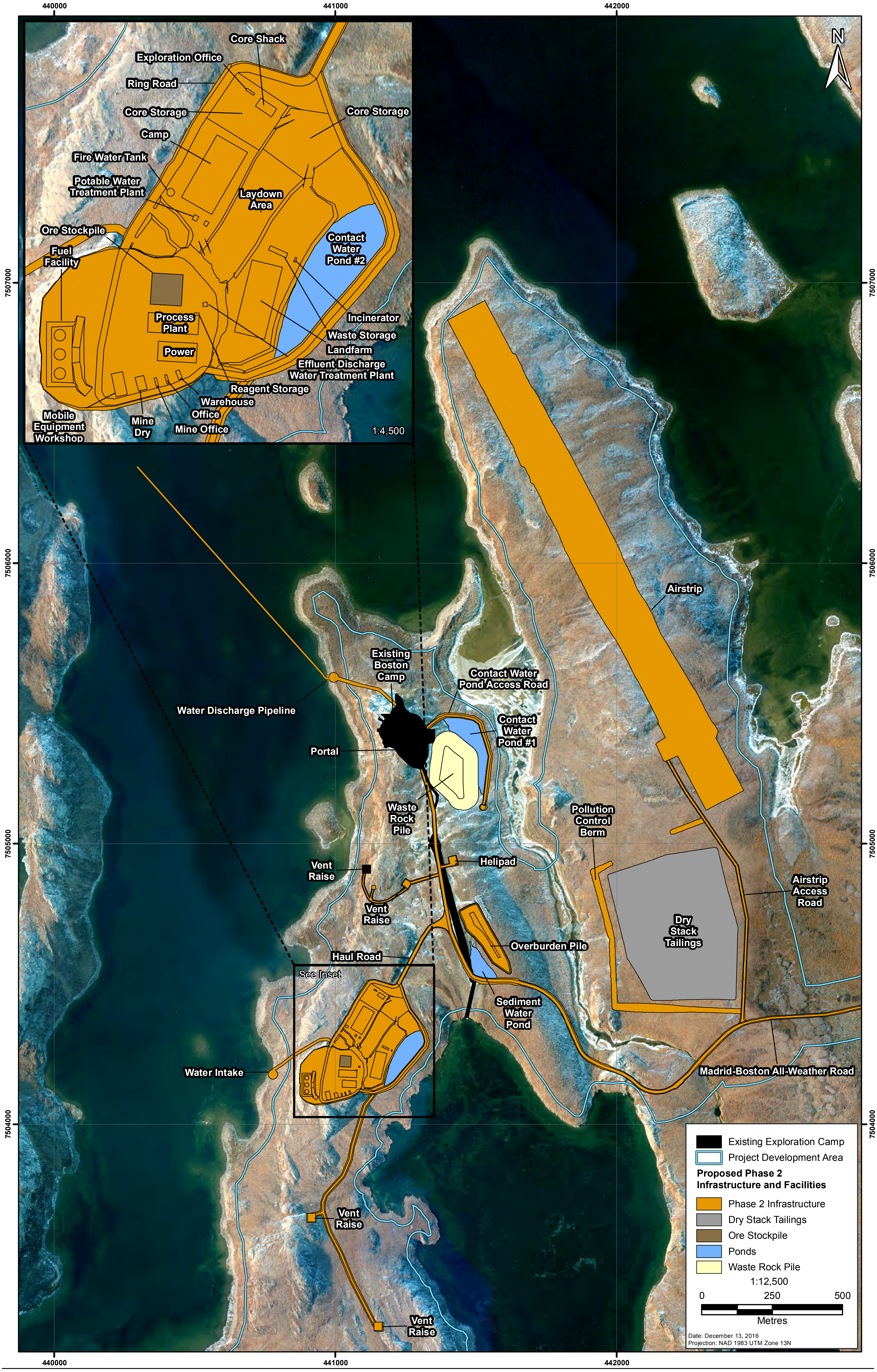


Table 3.8-1. Summary of Expected Infrastructure Associated with Operations at Boston

Zone	Infrastructure Component	Surface Area	Limitations and Comments
Accommodations and facilities (Camp)	Accommodations building	4,140 m² (45 × 92 m)	Minimum 10 m offset from other buildings
	Sewage Treatment Plant	29.89 m² (6.1 × 4.9 m)	Minimum 10 m offset from other buildings
	Potable Water Treatment Plant	44.53 m² (6.1 × 7.3 m)	Minimum 10 m offset from other buildings
	Fire Water tank	78.54 m² (10 m diameter)	Minimum 10 m offset from other buildings
	Incinerator		
Geology	Heliport	729 m² (27 × 27 m)	Requires 27 m clearance distance
	Heliport Shack	14.64 m² (6.1 × 2.4 m)	Shack at edge of 27 m heliport clearance
	Exploration Office	29.28 m² (12.2 × 2.4 m)	Minimum 10 m offset from other buildings
	Core Storage	10,000 m²	
Process Plant Area	Power Station	575 m² (25 × 23 m)	Minimum 10 m offset from other buildings; founded on bedrock or thin overburden
	Office	29.28 m² (12.2 × 2.4 m)	Minimum 10 m offset from other buildings
	Effluent Discharge Water Treatment Plant	29.89 m² (6.1 × 4.9 m)	Minimum 10 m offset from other buildings
	Ore Stockpile	1,600 m² (40 × 40 m)	Minimum 10 m offset from other buildings; should drain towards a contact water pond
	Warehouse	58.56 m² (12.2 × 4.8 m)	Minimum 10 m offset from other buildings
	Concentrator	1,625 m² (25 × 65 m)	Minimum 10 m offset from other buildings; founded on bedrock or thin overburden
	Reagent Storage	14.64 m² (6.1 × 2.4 m)	Immediately adjacent to the processing plant
Mine	Portal Access Clearance	36 m² (6 × 6 m)	
	Vent Raise	625 m² (25 × 25 m)	
	Mine Office	29.28 m² (12.2 × 2.4 m)	Minimum 10 m offset from other buildings
	Mine Dry	198 m² (18 × 11 m)	Minimum 10 m offset from other buildings
	Mobile Equipment Workshop	450 m² (30 × 15 m)	Minimum 10 m offset from other buildings
	Waste Rock Pile	As required for 349,000 m³	Minimum 10 m offset from other buildings; should drain to a contact water pond

Zone	Infrastructure Component	Surface Area	Limitations and Comments
Others	Water Supply Pump House	14.64 m^2 (6.1 × 2.4 m)	Minimum 10 m offset from other buildings
	Landfarm	3,800 m^2 (95 × 40 m)	Minimum 10 m offset from other buildings
	Fuel Facility	3,320 m^2 (83 × 40 m)	Minimum 10 m offset from other buildings; founded on bedrock or thin overburden
	Laydown Areas	10,000 m^2	
	Overburden Pile	As required for 54,100 m^3	
	Contact Water Pond	As required	Needed downstream of ore, waste rock and mill pads

3.8.4 Waste Rock and Ore Stockpile

3.8.4.1 Design Criteria

The waste rock pile is to be a temporary pile. The waste rock is used as backfill for the underground mine as an integral part of the mining method. Prior to closure, it is expected that all waste rock will have been utilized for underground backfill. The waste rock and ore stockpile design criteria are listed below:

- minimum waste rock storage capacity of 628,000 tonnes (349,000 m^3);
- minimum ore storage capacity of 7,000 tonnes (3,900 m^3);
- maximum overall slope angle of 2H:1V;
- maximum height of waste rock pile of 100 m;
- factors of safety of:
  - 1.0 for pile surface during construction,
  - 1.3 for short and long-term deep seated stability,
  - 1.1 for pseudo-static deep seated stability; and
- seismic parameter for event with 10% probability of exceedance in 50 years (1:500 year return period).

3.8.4.2 Design

The Boston waste rock pile has a maximum available capacity of 349,000 m^3 (628,000 tonnes), and a maximum height of approximately 23 m. The waste rock pile is located on a 1 m thick runoff-quarry material pad.

The Boston waste rock pile has a pile stability rating of “LOW” according to the classification standards outlined by the *Mined Rock and Overburden Piles Interim Guidelines* (Piteau 1991). This rating is due to the shallow foundation slopes, low seismicity, side hill design, thin lifts, and slow dumping rate. Stability analysis performed on a general waste rock pile under site conditions indicates that applying the design criteria listed above should be stable under static and pseudo-static conditions. Appendix V3-2E details stability analysis including material properties, and seismic parameters used in this evaluation.

3.8.5 Contact Water Ponds

3.8.5.1 Design Criteria

The contact water ponds will intercept all contact water runoff from the waste rock pile, ore pad, mine and mill pads, and portal pads. Specific design criteria are:

- the design life is 20 years;
- effects of climate change during the 2011 to 2040 timeframe have been considered;
- the ponds have the capacity to contain at a minimum the contact water from the 1:100 year, 24 hour storm event, and the maximum daily snowmelt (73 mm/m^2 of catchment area);
- freeboard is 1.3 m;
- the maximum geomembrane slopes is 2H:1V;
- the berms that make up the ponds will be used as an access road;
- the berms will be constructed of locally available quarried rock; and
- permafrost damage within the ponds will be minimized.

3.8.5.2 Design

There will be two unlined contact water ponds at Boston. These ponds will be located downstream of the waste rock pile and ore pads, as well as the mine and mill infrastructure. The unlined pond design uses the permafrost and naturally low permeability of the foundation materials to contain the contact water on the bottom of the pond and a geomembrane acts as the impermeable layer within the berm. This design requires the contact between the geomembrane and permafrost soil remaining frozen.

The key features of the contact water berm design are:

- 8 m wide crest;
- side slopes of 2H:1V;
- 2.5 m minimum thickness to ensure the contact between the geomembrane and permafrost soils remains frozen, additional thickness, if required;
- two thermistors to monitor thermal performance of the berm;
- minimum of 1 m cover between the top of the geomembrane and the driving surface;
- geomembrane slope of 2H:1V;
- high density polyethylene (HDPE) liner sandwiched between two layers of non-woven geotextile, except at the liner tie-in;
- two 0.3 m thick layers of bedding material surrounding the HDPE liner.

Thermal modelling has indicated water accumulating in the pond for up to one week does not degrade the permafrost.

3.8.6 Overburden Pile

3.8.6.1 Design Criteria

The design criteria for the overburden are:

- maximum height of 10 m;
- 5H:1V side slopes; and
- capacity for overburden removal during the construction of the mill pad and the contact water pond berms.

3.8.6.2 Design

The Boston overburden pile has a maximum available capacity of 37,000 m^3 and a maximum height of approximately 5 m. The overburden pile is located on a 1 m thick ROQ material pad and located within the Stickleback Lake watershed. The Madrid-Boston AWR will act as a sedimentation berm for the overburden stockpile.

3.8.7 Infrastructure Pads

3.8.7.1 Design Criteria

The design criteria for the pads are:

- minimum fill thickness is 1 m;
- side slopes are 1.5H:1V when fill thickness is less than 2 m;
- side slopes are 2H:1V when fill thicknesses is greater than 2 m;
- no cut is allowed in overburden; and
- the floor of bedrock cuts should slope at 1% to shed water.

3.8.7.2 Design

The pads are designed with a minimum 1 m fill thickness, which consists of a minimum of 0.85 m of ROQ material overlain by 0.15 m of surfacing material.

The mill area is to be excavated to bedrock, with the blasted material expected to be suitable for construction of the accommodations area pads. The mill area will have a 0.15 m layer of surfacing material. The terraced accommodations area pads and mill area pads are sloped at 1% towards the contact water pond, so contact water and sediments are collected.

There is no sediment or contact water pond associated with the vent raise pad; therefore, a silt fence may be required the first spring after construction.

3.8.8 Access and Haul Roads

The Project requires eight access roads in the Boston mine site, excluding the Madrid-Boston AWR:

- an access road to the contact water pond 1 berm;
- an access road to the vent raise;
- an access road to the heliport;
- a haul road to the process plant;
- an access road to the TMA;
- the water intake;

- the water discharge; and
- the ring road.

The design criteria for the access and haul roads is similar to that used on other roads on-site:

- haul roads have a maximum grade of 7% while access roads shall have a maximum grade of 10%;
- the roadway are crowned at 0.5% to promote drainage;
- side slopes are 2H:1V when fill thickness is greater than 2 m and 5H:1V when fill thickness is less than 2 m; and
- no cut is allowed into overburden.

3.8.9 Fuel Facility

The fuel facility will include three 1,500 m^3 fuel storage tanks and a fuel transfer station for refueling of vehicles.

3.8.9.1 Design Criteria

Design criteria are:

- fuel storage tanks and transfer station are within a lined facility to provide secondary containment, should leaks occur;
- the design vehicles for the facility are crew cab trucks and Super B train fuel trucks (60,000 L capacity);
- the secondary containment facility is designed to contain 110% of the fuel tank volume, 10% of the fuel transport truck volume, all the rainfall from the 1:100 year, 24-hour storm runoff, and the average maximum daily snowmelt; and
- the containment area has a minimum slope of 1% towards a sump.

In addition, the fuel facility meets the following codes and guidelines:

- NFPA (2014) 30, Flammable and Combustible Liquids Code, 2015 Edition;
- Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products (CCME 2015); and
- ORD-C58.9-1997, Secondary Containment Liners for Underground or Aboveground Tanks.

3.8.9.2 Design

The fuel tanks will be located in a row in the center of the facility, a minimum of 3.0 m from the base of the containment area berms, and 9.8 m between tanks to allow access. The containment berms will be constructed of transition material overlain by the geomembrane and bedding layers. To reduce the amount of construction material required and the height of the containment berms, the base of the fuel facility will be cut into bedrock. The berms will have interior slopes of 2H:1V to allow for geomembrane placement and will have exterior slopes of 1.5H:1V. The secondary containment facility will have a surface area of 6,800 m^2 and a minimum containment capacity of 5,500 m^3.

There will be a 6 m wide ramp allowing vehicles to drive through the fuel facility. Ramps sloping at 5 to 6% enter and exit the facility. A flat area within the facility is where the fuel transfer module will be set up and where refueling will occur.

3.8.10 Process Plant

TMAC proposes to carry out crushing, milling and concentration of ore at Boston. The concentrate will correspond to less than 10% of the ore milled, and will be transported to the Doris mill for gold extraction. Hence, the Boston process plant (mill) does not require the use of hazardous chemicals in the extraction process.

Ground preparation and construction of the foundation for the mill will begin in the spring and concrete pads for the mill building and crushing/mill equipment will occur during the summer months. A concrete batch plant will be transported to Boston prior to commencing construction. To the extent practicable, the mill building will be prefabricated in modular sections, transported to site, and assembled on the prepared foundation pads. Crushers and milling equipment will be shipped to Roberts Bay during the open water season, transported to the Boston Site on the AWR, and placed on the prepared foundations within the mill building. Filtration equipment will be incorporated into the mill building as this mill will generate a low moisture content tailing. The filtered tailings will be transported to the tailings management area (TMA) by trucks.

Construction of the mill building is expected to be completed within one year.

3.8.11 Tailings Management Area

A filtered tailings disposal facility will be constructed (typically referred to as “dry stack”) approximately 1 km east of the mill (Appendix V3-2F). The facility occupies a flat area just east of the Aimaokatalok Lake extension, and south of the proposed airstrip (Figure 3.8-1).

For the purpose of this TMA design, the tailings quantity is assumed to be produced at a nominal rate of 2,000 tpd for the duration of active processing (11 years), resulting in a theoretical total quantity of tailings of about 5.1 million tonnes for the life of mine. This is a conservative approach since the initial ore mined is planned to be trucked to the Doris process plant.

The footprint of the dry stack facility is in the shape of an irregular heptagon. The approximate size of the facility is 400 m in east-west direction and 450 m in north-south direction. Proximity to the proposed airstrip limits the height of the dry stack facility to 26 m, while expansion to the east would impinge on the airstrip exclusion zone.

The dry stack facility will be built progressively during mine operations entirely of the filtered tailings. The facility will be constructed during Boston operations in thin lifts, 0.3 to 0.5 m, built successively to achieve the final height of the facility. Intermediate benches will be constructed at 5 m interbench height, with a width of 5 m. These benches will facilitate placement of the geomembrane and of the final cover at closure. The slope of the benches will be 3H:1V, while the overall slope of the facility will be approximately 3.9H:1V. The top off of the lift will be graded at 2% toward the perimeter of the facility, to promote run-off. A summary of the dry stack design parameters is listed in (Appendix V3-2F).

The contact water containment berms will be constructed of run of quarry (ROQ) fill and incorporate a geomembrane protected by bedding material. Construction of the containment berms must be done in the winter to protect the permafrost.

Access to the facility will be gained via the Madrid-Boston AWR, then following the airstrip access road. Finally, to reach the top of the facility a ramp will be constructed at a grade of maximum 8%.

Tailings are expected to freeze completely during the first winter season following placement, therefore a tailings freeze-back model was not completed. Seasonal thaw of the upper-most layers of tailings will however create an active layer of variable thickness, which was assessed in a detailed thermal model taking into account climate change effects. The dry stack active layer thickness has been estimated for the period of operation and following placement of a ROQ cover, with consideration for climate change. Active layer thickness of exposed tailings located outside of areas of active material placement is estimate to average 2.5 m. Once the 1 m thick closure cover is constructed, active layer thickness is predicted to be between 2.7 m and 3.2 m depending on tailings saturation.

3.8.11.1 Construction Methodology

Geochemically suitable, permitted quarries provide all construction fill materials. Management and monitoring of these quarries will be according to the Quarry Management and Monitoring Plan (Volume 8, Annex 17). The construction materials for Boston will be sourced from Quarry AD, which coincides with the excavation of the mill area. Surfacing (32 mm minus), bedding (19 mm minus), and transition (150 mm minus) materials will be produced at an on-site crusher located within one of the permitted quarries.

Wherever possible, winter construction of pads and roads ensures the foundation materials remain frozen. Summer construction may be required to meet development schedules. Winter and summer construction techniques will be identical; however, summer construction will result in the use of more construction material as greater imbedding of material into the active layer will occur. Summer construction will also require careful screening of the site for nesting birds. Modifications to the construction schedule may be required to avoid disturbing nesting populations.

3.9 BOSTON AIRSTRIP CONSTRUCTION ACTIVITIES

The design of the Boston airstrip is described in *Hope Bay Project – Boston Airstrip Preliminary Design* (Appendix V3-3K). The airstrip will be a new facility constructed for the Project and, therefore, its construction is attributable to the Project. The Project construction activities include:

- development and use of quarries to produce construction bulk rock fill and aggregate; and
- construction of the airstrip, access road and associated facilities per design.

The Boston mine site requires reliable year-round air access that cannot be achieved with the existing 500 m STOL airstrip. A new 1,524 m (5,000') long gravel airstrip has been designed for Dash 8 sized and Boeing 737-200 aircraft as well as an optional 450 m extension, which would allow for larger aircraft such as Hercules C-130 aircraft. The EIS considers the longer airstrip in all assessments.

The airstrip is intended for private use to support year-round operations of the Boston mining area. Normal use includes; routine crew changes and cargo transfers. The airstrip is also used for emergency medical evacuation. The airstrip will be a non-precision approach runway in accordance with the Aerodrome Standards and Recommended Practices (Transport Canada 2015).

The location of the Boston airstrip is illustrated on Figure 3.8-1.

3.9.1 Design Criteria

3.9.1.1 Primary Airstrip

The primary airstrip is designed for the Dash 8 and Boeing 737-200 aircrafts. The Dash 8 has a length of 22.25 m, a wing span of 25.9 m, and a maximum weight of 16,465 kg for takeoff. The Boeing 737-200 has a length of 30.53 m, a wing span of 28.35 m, and a maximum weight of 45,722 kg for takeoff. The design length for the airstrip is 1,524 m (5,000 ft). The Dash 8 requires a category IIIA airstrip and the Boeing 737 requires a category IIIB airstrip (Transport Canada 2015). However, as the landing of Hercules C-130 is being considered the design will meet the requirements of a category IV airstrip in all aspects except length and width (Transport Canada 2015).

3.9.1.2 Airstrip Extension

To retain the flexibility of allowing larger aircraft to land at the Boson airstrip, a potential extension of 450 m has been selected for the Phase 2 proposal. The design aircraft for the extended airstrip is the Hercules C-130 with a length of 29.3 m, a wing span of 39.7 m, and a maximum weight of 69,750 kg for takeoff.

The Hercules C-130 requires a category IV airstrip (Transport Canada 2015). Since the Hercules C-130 has more stringent design requirements than the Dash 8 and Boeing 737-200 series, the Hercules C-130 will be adopted as the design aircraft for the primary 1,524 m airstrip (Section 3.9.1.2) for all criteria excluding runway length. This will allow the airstrip to be upgraded by extending the airstrip length without having to redesign and reconstruct the existing airstrip. A summary of the design criteria of the Boston airstrip is provided in Table 3.9-1.

Table 3.9-1. Boston Airstrip Design Criteria

Design Component	Design Criteria
Design Aircraft	Primary Airstrip: Boeing 737-200 Airstrip Expansion: Hercules C-130
Category	Boeing 737-200: Category IIIB Hercules C-130: Category IV
Runway Orientation	Between bearings 280° and 350° or between 100° and 170° in the other direction (SRK 2008)
Runway Length	1524 m (5,000 ft) plus 450 m (1,477 ft) extension for Category IV aircraft
Runway Width	40 m (98 ft)
Approach Type	Non-Precision Approach
Taxiway	A taxiway is not required.
Ramp/Apron	Apron located at the south end of the airstrip with dimensions of 60 m x 100 m.
Runway Slope	Maximum longitudinal slope of the runway of 1.25% up or down. Maximum longitudinal slope change of 1.25%. Vertical slope changes are joined with a curved surface with a maximum rate of change per 30 m of 0.1%. Symmetrical 1.0% crown for drainage. 3H:1V side slopes.
Runway safety Area	Minimum distance of 75 m each side of the runway centreline and extended centreline with a maximum transverse slope of 2.5% down from the runway edge. Minimum length of runway end safety area is 150 m with a maximum slope of 1.5% up or down.
Waviness	The runway is designed so that no undulations occur, if undulations occur over time they should be filled in during regular maintenance.
Obstacle Clearance Requirements	No buildings, cargo or other obstructions shall be within 61 m of the runway centerline. Beyond that, any object must be below the obstacle limitation surface which arises with a slope of 25% to 23 m above the runway reference point and continues to rise with a slope of 14.3% to an outer surface 45 m above the runway reference point. The outer surface of the obstacle limitation surface extends in a circle with a radius of 4,000 m from the centerline of the runway.
End Clearance Requirements	At the end of each runway there is 61 m of level surface beyond which the end clearance surface of the runway rises with a slope 2.5% to a distance of 720 m, then for another 4,280 m with a slope of 2.9%. The end clearance surface extends for 5,000 m either end of the runway. The end clearance surface diverges from the 150 m clearance area centered on the runway centerline by 15% on either side.

Note: Runway refers to the actual surface available for landing aircraft while the airstrip includes the runway and 150 m safety areas at either end of the runway.

3.9.1.3 Environmental Setbacks

Environmental setbacks for infrastructure are listed in Section 2.4.

3.9.1.4 Access Road

The Boston airstrip will be access by a road connecting the south apron of the airstrip and the Madrid-Boston AWR. The southern portion of the access road will double as a contact water pond berm for the Boston TIA. To meet the design requirements of the contact water pond, this section the road will be constructed using design criteria (Section 3.8.5.1) and design (Section 3.8.5.2) for contact water ponds.

3.9.1.5 Visual Aids for Navigation

Wind Direction Indicators

In accordance with the Aerodrome Standards and Recommended Practices (Transport Canada 2015), a wind direction indicator will be positioned near each end of the runway a minimum of 60 m from the runway edge. The wind direction indicator will have a maximum height of 7.5 m above grade and must be clear of the obstacle limitation surface. It must be visible from aircraft in flight and should be positioned in such a way as to be unaffected by air disturbances caused by nearby objects.

Lighting

The following lighting elements will be required for the Boston airstrip:

- two sets of omnidirectional approach lighting systems extending 450 m beyond the ends of the runway;
- two wind direction indicator lighting systems;
- runway edge lights;
- runway end and threshold lights;
- one aerodrome beacon; and
- two apron floodlights.

The omnidirectional approach lighting systems north of the airstrip will extend into Aimaokatalock Lake and will use a floating, anchored lighting system.

3.9.2 Design

3.9.2.1 Quarries and Construction Material

Three quarries were identified as potential ROQ sources for the construction of the Boston airstrip. The locations of the potential quarries are shown in Drawing BAS-04 (Attachment A) of Appendix V3-3K.

Crushed rock materials for airstrip and road construction will be produced from a crusher located within one of the quarries (location to be determined). Estimated material requirements are summarized in Table 3.9-2.

Table 3.9-2. Estimated Material Requirements for Boston Airstrip Construction

Item	Quantity
Culverts (1 m diameter)	2
Run of Quarry Material	769,800 m^3
Surfacing Material – 32 mm Minus	11,250 m^3
Finishing Material – 19 mm Minus	10,050 m^3

3.9.2.2 Construction

<u>Construction Schedule</u>

Wherever possible, the airstrip and access road will be constructed in the winter to ensure the integrity of the permafrost. Nonetheless, construction during the summer may be required to realize the benefits of the proposed airstrip. Winter and summer construction techniques will be identical; however, summer construction will result in the use of more construction material as greater imbedding of material into the active zone will occur. It is recognized that summer construction will require careful screening of the site for nesting birds and it may be necessary to modify construction schedules to avoid the disturbance of nesting populations.

<u>Construction Method</u>

Construction of the airstrip and access road will consist of:

- snow and ice will be cleared off the alignment immediately prior to fill placement;
- construction fill will be placed by end-dumping along an advancing access road then airstrip surface. After end-dumping, the fill will be levelled with a bulldozer and compacted with a packer;
- surfacing and finishing material will not be placed until the run of quarry layer has been completed to design grade and level and a topographic survey has been performed;
- temporary rock fill turnouts to facilitate construction and meet safe pullouts for emergencies will be constructed; and
- where necessary, rock drains or culverts will be installed at topographic lows to ensure no standing water is created on or near the airstrip and road.

4. Operational Phase

4.1 OPERATING STRATEGY

TMAC views the Doris Project (NIRB Project Certificate No. 003 [the Doris Project Certificate]; NWB Type A Licence 2AM-DOH1323 [Type A Water Licence]) as Phase 1 for the development of the Hope Bay Belt. The Doris Project is designed to operate as a stand-alone operation, and will remain a central part of belt-wide development for the foreseeable future. The port at Roberts Bay and the Doris Site will continue to support other developments as required for gold processing, accommodations, staging for equipment and supplies. Furthermore, the Doris TIA will be expanded to store additional tailings for the Project.

The Phase 2 Project is intended to cover the reasonable and foreseeable proposed incremental development of the Belt. The operation phase of the Project includes:

- mining of the Madrid North, Madrid South, and, Boston deposits;
- operation of a concentrator at Madrid North;
- transportation of ore from Madrid North, Madrid South and Boston to the Doris mill, and transportation of concentrate from the Madrid North concentrator and Boston concentrator to Doris for final gold refining;
- extending the operation at Roberts Bay and Doris;
- processing the ore and/or concentrate from Madrid North, Madrid South and Boston at the Doris mill with disposal of the detoxified leach tailings underground. The tailing are pumped to the expanded Doris TIA, and discharge of the TIA effluent to the marine environment;
- operation of a process plant at Madrid North and disposal of tailings at the Doris TIA;
- operation of a process plant and wastewater treatment plant at Boston and disposal of tailings to the Boston tailings management facility (TMA); and
- on-going maintenance of transportation infrastructure (cargo dock, jetty, roads, and quarries).

Most of the facilities and the activities occurring at Roberts Bay and Doris are authorized under the Doris Project Certificate and Type A Licence. As part of Phase 2, a cargo dock and a tank farm will be constructed and operated at Roberts Bay.

The use of existing infrastructure at Doris enables TMAC to minimize adverse potential effects on the receiving environment. TMAC intends to extend the operating life of the Roberts Bay and Doris facilities. All environmental and monitoring management plans approved under the Type A Water Licence to support the Doris Project remain in effect. Required revisions to these plans will support the approval of the Project and applicable permits and licences.

Madrid North and Boston are large deposits with significant potential. TMAC's expectation is that ongoing exploration activities will increase the proven reserves at Madrid North and Boston. Hence, TMAC proposes to construct and operate a concentrator at Madrid North and a concentrator at Boston. The concentrator at Madrid North will be sized to process up to 1,200 tpd of ore, with excess ore mined trucked to the existing Doris mill for processing. For the initial years (two years), ore mined from Boston will be trucked and processed at the Doris mill. However, TMAC anticipates that a concentrator will be constructed and operated at Boston by 2023. For the purpose of this EIS, it is assumed that the Boston process plant will be constructed and operational by Year 5 of the Project (2024). Thus, for two years, ore mined at Boston will be trucked to Doris and subsequently, a concentrate produced at the Boston process plant will be trucked to the Doris mill for gold extraction. The tailings produced from the Boston concentrator will be dry stacked in a tailing management area (TMA) adjacent to the Boston process plant.

Mitigation of potential effects during the Operation phase is incorporated into the Project design (Volume 3, Section 2) and the mitigation measures are summarized in each assessment chapter of this EIS (Volumes 4 to 7). Management plans and monitoring programs are described in Volume 8.

4.2 MINING METHODS

4.2.1 Overview

Mining will incorporate several methods that address the deposit geometry and anticipated ground conditions. Mining will take place under permafrost conditions where the mineralization is located away from any water bodies and also under non-permafrost conditions in talik zones. The Madrid North (Naartok) and the Madrid South deposits (Patch 14 and Wolverine) are situated partially beneath the lakes, therefore will not be entirely under permafrost conditions. The Boston mine is situated entirely in permafrost conditions.

The deposits will be accessed and services will be provided by ramp declines from surface. The ramps will also be used for ore and waste haulage from the underground operations. Mining methods will generally minimize waste rock material brought to surface thereby reducing mine contact water potential at surface and also minimizing blasting and fuel requirements for haulage out of the mine. All waste rock will be consumed as backfill prior to closure.

To optimize extraction of the mineral reserves, backfill consisting of cemented rock fill (CRF) may be used. Backfill consisting of unconsolidated fill (UCF) will be used where. The CRF backfill system would consist of adding the required amount of cement (4 to 7%) to a truck load of aggregate of waste rock or quarry mined rock crushed to six inches. A small mix plant comprising a cement hopper with knife splitter, feeder, mixing tank, and slurry pump located on surface at each mine site. Cement would be delivered in the yearly sealift in tote bags and delivered to the sites for use.

The mining plan does not incorporate permanent pillars in ore, however, if required for ground support, lower grade pillars will be considered. Detailed definition diamond drilling prior to stope development will permit determination of such potential areas.

4.2.1.1 Rock Properties

In the past, mining activity has taken place in the Hope Bay camp with mine development at both Doris (2011) and Boston (1995). These programs included development via ramp access and drifting on ore for bulk sample testing. TMAC is not aware of any major incidents that occurred during these programs. The ground conditions at Doris feature very good rock quality and industry standard ground support techniques have been applied. Mining at the Hope Bay mines will be to a depth of approximately 450 m making it accessible throughout the mine life by ramp access. Ground stress is not considered a major issue.

4.2.1.2 Regional Geology

The Project is a greenstone belt that is located in the northeast portion of the Slave Structural Province. The geology is mafic volcanic-dominated, typified by massive to pillowed tholeiitic flows interbedded with calc-alkaline felsic volcanic and volcanoclastic rocks, clastic sedimentary rocks, and rarely synvolcanic conglomerate and carbonates.

Multiple Quaternary Ice Ages produced an extensive glaciated landscape that was covered by successive Laurentide ice sheets. The last ice sheet started receding about 8,800 years ago leaving an extensive blanket of basal till. Immediately following the de-glaciation, the entire Hope Bay region was submerged approximately 200 metres below present mean sea level. Fine sediment derived from meltwater (rock flour), was deposited onto the submerged Hope Bay shelf as marine clays and silts onto the basal tills. The greatest thicknesses accumulated in the deeper water zones are now represented by valleys.

Isostatic rebound after the de-glaciation, resulted in emergent landforms and reworking of the unconsolidated marine sediments and tills along the prograding shoreface. Sediments were easily stripped off the uplands and redeposited in valleys, leaving relatively continuous north-northwest trending bedrock ridges and elongate lakes. The unconsolidated overburden, now up to 30 m in thickness, comprises locally and regionally derived tills and boulder tills with lacustrine and marine sediments and clay up to 15 m thick in the larger valleys.

A detailed description of regional geology is provided in Volume 4, Section 5.

4.2.1.3 Local Geology

Gold mineralization varies depending on mineralization style and relationship to the host volcanic sequences. The Boston deposit is located near the south end of the belt and is associated with a flexure in the Hope Bay regional structure. The Madrid deposit consists of three styles of veining and brecciation.

The Boston gold deposit is situated in an area dominated by mafic metavolcanics rocks, metasedimentary rock and minor amounts of felsic metavolcanics. The strata are folded and form a large south-plunging synformal anticline. The mafic metavolcanics form the interior of the fold, while synvolcanic metasediments flank the east and the west sides. The transition between the metasediment and metavolcanic packages is variable, with interbedded units of metasediments and metavolcanics. Gold mineralization is associated primarily with steep deformed quartz veins at the contact between mafic metavolcanics and metasedimentary rocks. Four brittle faults have been modeled to crosscut the Boston area. Additional fault lineaments have been observed in airborne geophysics.

The general stratigraphy of the Madrid area is composed of three major volcanic packages: the Wolverine group basalts (C-type rocks), the Patch Group basalts (A-type rocks), and the pale green pillow basalts. Metasedimentary rocks often occur in the Patch Group metavolcanics. The western and southern portions of the Madrid area are characterized by a wide package of variably deformed and altered rocks collectively referred as the Deformation Zone (DEFZ), about 100 to 140 m thick. The DEFZ is typically comprised of chlorite schist with a strong overprinting (regional) foliation. Diabase dykes are the youngest rocks. Two dykes occur in the vicinity of the Naartok. No dykes have been identified in proximity to Suluk. Gold mineralization occurs within the proximity to the DEFZ, which is not a single planar structure, but a complicated anastomosing feature with several splays and local pinch-and-swell textures. Its orientation varies from east-west in the Naartok area to north-south at Suluk. The dip of the zone at Naartok is approximately 75° to the north and is vertical at Suluk. Five distinct faults have been interpreted in the Naartok area and two in the Suluk area. Apparent discontinuities in alteration, mineralization and lithological units generally define a set of northwest trending steep structures.

The overburden can be described as ice-rich (10 to 30% by volume on average, but occasionally as high as 50%) marine silty clay and clayey silt. The onshore profile consists generally of a thin veneer of hummocky organic soil covered by tundra heath vegetation. Under this organic zone is a layer of marine clay (silty clay and clayey silt) typically between 5 and 20 m thick; however, since the terrain is glaciated with significant bedrock control, there are areas where overburden is less than 5 m thick as well as areas where the overburden exceeds 30 m in thickness. In areas where the overburden exceeds 20 m in thickness, it appears to be underlain by clayey morainal till, which contains moderate amounts of cobbles and boulders. The overburden soils under the lakes are of the same origin as the onshore overburden soils, i.e. silty clays and clayey silts. There is a layer of limnic sediments ranging between a few centimetres to as much as 2 m thick, under which is a normally consolidated layer of marine silty clay and clayey silts between 10 and 20 m thick.

A detailed description of local geology is provided in Volume 4, Section 5.

4.2.2 Mining Methods

The mining methods that will be used for the Hope Bay project include a bulk method consisting of sublevel long-hole retreat (SLR) and a more conventional method of drift and fill in narrow and more difficult ground conditions. The large widths are made up of several veins with sufficient separation between them to allow for longitudinal long-hole mining. The drift and fill method will be used for all of the Madrid South (Patch 14 and Wolverine) zones and the Hinge portion of the Doris zone while the Hinge limbs will be mined by SLR. All of Madrid North (including Naartok, Rand, Suluk) as well as the Boston zones will be mined using SLR.

4.2.2.1 Sublevel Long-hole Retreat

The stoping method for the bulk of the mining at Hope Bay will be the SLR method followed by a combination of CRF (where required) and UCF made up of the mine waste rock and surface quarry rock as makeup.

The undercut drift and overcut drift are driven on ore and mining would start from the lower access retreating out towards the main access drift. Stope strike lengths can vary from 20 to 35 m. Once a stope block is finished, backfill can be introduced to fill and stabilise the area.

4.2.2.2 Drift and Fill

The drift and fill method will be used at Madrid South for the Patch 14 and Wolverine veins The access drift will be offset about 50 m from the vein and an attack ramp driven at -20% gradient to intercept the vein and driven through to the hanging wall contact. Subsequent cuts will be taken at 4 m heights with a total of five cuts and an approximate 2 m backslash taken on retreat. The veins will be accessed at about 150 m centres and the cuts driven in both directions to provide two working faces. This will be repeated on several levels to enable achieving the production levels.

4.2.2.3 Pre-Production Development

Development of Madrid North and South will commence with the approval of the Advanced Exploration Program (TMAC 2014). Initial development will commence in Year 1 at Madrid North for the Naartok vein. Development of the Madrid South Wolverine vein is schedule to begin in Year 11 while development of the Boston mine will begin in Year 4. Boston mine underwent a development program in

1995 with about 3,000 m of development completed including development on veins for bulk sampling and a considerable bulk sample remains available on surface (see Table 1.3-1). The bulk sample at Boston will be transported to and processed at the Doris mill after the completion of the AWR.

4.2.2.4 Access

All of the accesses (portals) required to mine the Hope Bay deposits will be via ramps from the surface. This will account for equipment clearances and ventilation ducting currently under consideration for the Construction phase of each operation. This will also facilitate operation at the required ventilation air velocity for ramps which will be upcasting ventilation air from the mine workings. Ramp accesses are appropriate given that the ore depths are all basically within 500 m of the surface. Surficial ore (crown pillar) will be removed where possible as part of access development.

In addition, where ore is found close to the surface, stopes may extend to surface and break through the surface. Where this is the case, surface overburden will be removed prior to the removal of the ore and the box cut created by the stope will be backfilled with waste rock to approximately the original ground profile.

4.2.2.5 Lateral

Lateral development will typically be 5 m high by 5 m wide for the main ramps and reduced to 4.5 m high by 4.5 m wide for the level accesses and other openings. Drives on ore will vary from 3 m high by 3 m wide to 4.5 m high by 4.5 m wide, where possible. The mine inspector responsible for the Nunavut Territory will be engaged for permissions in advance of any heading sizes under the regulation to ensure safe procedures are being followed.

4.2.2.6 Vertical

For vertical openings such as ventilation raises and service raises both raise bore and alimak systems will be utilized, as required. For the operations, slot raises will be bored or drilled off with the longhole drill and completed as a “drop raise” to provide the slot for initial blasting of the stope tonnage. For the raise boring and alimak raises this will required specialised labour as these are specialized methods.

4.2.3 Ore and Waste Handling

Ore and waste will be mucked from the development faces with Cat R1600 or similar scoops at 6 m^3 capacity while the stopes will be mucked using Car R1300 or similar scoops at 2.4 m^3 capacity as these will be SLR stopes requiring use of smaller scoops. All of the ore from the stopes will be loaded in Cat AD30 or similar haul trucks and loaded at the load-out situated within about 50 m of the entry to the ore drifts. Ore and waste will be dumped on surface in a stockpile and re-handled by a front end loader into the mill grizzly and ore chute for the Boston mill (Year 7 onwards) or loaded into the ore haulage trucks at Madrid North and South and Boston (until Year 6) for transport to the Doris mill.

4.2.3.1 Backfill

Backfill will be placed after each stope is completed. This will permit extraction of the whole vein and avoid the requirement of leaving any permanent pillars within the ore. Consequently, the SLR stopes will be filled with backfill for the stope length. For the Madrid North and Boston mines, there are multiple veins running parallel to each other requiring careful consideration of backfilling methods (CRF or UCF) to allow for effective stoping sequencing and grade maintenance.

The backfill plant (2 × 12 m) will operate based on the level of CRF required during a particular period. The backfill system consists of a hopper with knife bade to break open the cement tote bags which feeds into a mixing tank and then pumps into the AD30 truck carrying the load of waste rock. The system is enclosed to protect the components from the elements and provide for smooth loading of cement unto the truck load.

4.2.3.2 System Capacity

The average backfill requirement over life of mine (LOM) is estimated at about 1,150 tpd which would require a maximum of 15 truckloads on average based on the estimate of 40% requirement of CRF backfill, (with a range of 25% to 48%). Whenever possible and practical, waste rock will be taken from the face and sent directly to the stope. From an economic standpoint, CRF will be minimized and becomes more important when simultaneous mining of adjacent ore veins is occurring. UCF will be used where possible.

4.2.3.3 Source Material

Over the LOM (including all earlier mining), an estimated total of 10 million tonnes waste rock will be produced while the backfill required amounts to 14 million tonnes. This leaves a deficit of 4 million tonnes which will be made up through using surface quarry rock. An active quarry exists at Doris and additional quarries will be developed during the AWR construction (Section 3.7). Additional quarries may be required and will be permitted as required.

Temporary waste rock storage areas will be developed at each site to enable underground mine development. Refer to site layouts presented in Sections 3.5, 3.6, and 3.8 for Madrid North, Madrid South, and Boston, respectively.

4.2.3.4 Cement Slurry

If it is decided to make use of cement for backfill, cement will be shipped to site during the annual sealifts. A total of 265 kt of cement binder may be required over the LOM with an average of 20 kt per year where cemented backfill is used in preference over unconsolidated backfill.

4.2.4 Ore Production

Four mines including Doris (already approved under the Doris Project Certificate and Type A Water Licence), the Madrid North, the Madrid South and Boston deposits make up the sources of ore that will be extracted during the LOM. Production of ore over the LOM amount to 21 million tonnes of ore produced (including Doris and Phase 2), the estimated distribution by mine is 13% from Doris, 60% from Madrid North, 5% from Madrid South, and 24% from Boston. Details of the operational timelines for the Madrid North, Madrid South and Boston mines, including total volumes of ore, waste rock and tailings are presented in Table 2.1 of Appendix V3-4F. Additional details of mine plan development are described in Volume 8, Annex 27, Section 2.1.

4.2.5 Cut-off Grade

The cut-off grade for mineral reserves is estimated at 4.5 g/t Au.

4.2.6 Surficial Mining

The drilling program at Madrid North and Boston has focused on continuing to define the spatial extent and the controls of near-surface gold mineralization. The near-surface mineralization is positioned vertically above the mineral resource. The grade, geological controls, and near-surface extent of the gold mineralization will be amenable for extraction using multiple box cuts. At Boston and Madrid deposits, box cuts will be utilized for establishing declines to underground mine workings, or in other locations where subsequent infrastructure could be placed, thereby minimizing surface disturbance of non-gold bearing land.

Another extraction method that may be utilized for accessing surficial mineralization at Madrid and Boston would be to remove the mineralization into the mine development. This technique, referred to as stoping is how some underground mineralization is mined at the Doris deposit, where ore is dropped into lower mine developments and later trucked to surface via the underground mine. The stoping method, when applied to surficial mineralization results in temporary “daylighting” to surface. The void is then backfilled with waste rock and or quarried material to stabilize the location, similar to how other underground mined areas will be closed off and stabilized.

Extracting surficial resources at Boston and Madrid has several environmental advantages including incorporating infrastructure development (i.e., portals)in mine development to minimize disturbing land elsewhere and also ensure efficient utilization of a resource within the development area. Removing the narrow crown pillar by box cutting allows the underground resource to be mined in a safer manner and avoids possibility of surface collapse or longer term subsistence of surface land after closure.

Since there are several of these smaller high grade surficial deposits, TMAC will develop a management plan to guide box cutting and daylighting mining activities. The box cut management plan will contain the following elements:

- delineation of the surficial ore body;
- characterization of the waste rock for acid rock drainage (ARD)/metal leaching (ML) properties;
- timeline for box cutting activities from site preparation to closure;
- quantification of expected tonnage of ore and waste rock to be extracted including identification of disposal method/location for each material;
- a proposed layout for the box mining area which will identify:
  - temporary facilities and equipment required for the undertaking,
  - drainage plan for the site and surface water management,
  - identification of temporary stockpiling areas for overburden and waste rock;
- safety precautions at the box cut site;
- wildlife management; and
- site closure and reclamation

4.3 UNDERGROUND INFRASTRUCTURE AND SERVICES

4.3.1 Underground Ventilation

Ventilation of the underground mines for the Project follows (but not restricted to) Sections 1.47 to 1.64 of the Consolidation of Mine Health and Safety Regulations. Ventilation will be provided by ventilation raises that will be driven from the underground or surface accesses through to the surface. The locations of vent raises are illustrated in Figures 3.6-1, 3.7-1, and 3.8-1 for Madrid North, Madrid South, and Boston, respectively.

4.3.1.1 Air Volume Requirements

The air volume requirements of each of the mines are the same. The mine air volume is based on the CANMET rating for the equipment engines and the estimated underground mining equipment. The estimated air volume requirement are 17,000 Nm^3/min for the Madrid North mine, 6,000 Nm^3/min for the Madrid South mine and 9,600 Nm^3/min for the Boston mine.

4.3.1.2 Ventilation Equipment

The mine ventilation systems will consist of a push pull system featuring a 250 HP fan main fan pushing the required volume into the mine workings and exhaust fans strategically located providing the pull for the system. Each system will have its own variation of the arrangement given the various geometries encountered in each case. Also a variety of auxiliary ventilation fans will be required to adequately service the development headings both driven in waste (for capital development) and development on ore (operating development) until breakthroughs have been completed to allow tie in with the main mine circuit. These auxiliary fans will consist vary from 50 to 100 HP to permit reasonable lengths of ramps/drifts to be driven prior to the need for a booster fan. The air will be moved via flexible ventilation ducting that can be advanced from time to time as the main circuit is tied in. The ventilation fans will be fed from the underground substations located on approximately every 100 m vertically throughout the mine.

The main ventilation raises will also serve as escape-ways to surface, in case of a fire underground during the mining operations. A mobile refuge station will be advanced with the headings to ensure the crews have a safe place in the case of an incident early in mine development or if they are away from the main access.

The surface ventilation installations will be carried out by experienced contractors and suppliers to ensure an adequate installation that meets all of the territorial regulations and laws. Underground ventilation installation will be completed by the mining crews who are experienced in this type of installations and supported by mechanical and electrical tradesman who are equally qualified.

4.3.1.3 Mine Air Heating

A 30 million BTU/hr diesel fired mine air heating unit will provide mine air heating in all three mines. The mine air will be heated to about -8°C to provide for an adequate work environment both for the mine personnel and the equipment hydraulics. On average two million liters of diesel fuel will be required annually (from October to May) for the mine air heating.

4.3.2 Mine Dewatering

The hydrogeological conditions at the Madrid North, Madrid South and Boston mines and the predictive numerical groundwater models for these mines are described in Appendix V3-4B. The resultant groundwater quality and inflow rates at each of these mines are presented during all phases of the Project, including Construction, Operation, Closure and Post-closure. This information serves as a basis to assess the effect of the mines to the groundwater environment and is used as input to the Project water and load balance (Appendix V3-2D).

For mine works where permafrost is present; the anticipated inflows will be negligible. Boston underground mine workings are all contained within permafrost and therefore the inflow of water is expected to be negligible. In contrast, for the mines located beneath lakes (Madrid North and Madrid South), there will be some inflow dependent on the ground conditions. These mines will be dewatered by two main sumps located at 375 m vertical intervals with pumps capable of pumping 800 L/min with a 375 m head. These sumps would be set up as close to the main ventilation raise as possible in order to carry the dewatering line down the raise thereby reducing the amount of resistance in the pumping circuit. Water pumped from the mine will be conveyed to a contact water pond.

4.3.3 Underground Mine Equipment

Expansion of the Project to the development of underground mining at Madrid and Boston will require additional underground equipment due to the simultaneous operation of all three underground mines (Figure 3.1-1). The expected and typical underground mobile equipment needs are captured in Table 4.3-1.

Table 4.3-1. Estimated Underground Mine Equipment for all Phase 2 Mines in Operating Year 12

Unit Description	Quantity Required
Aerial lift truck	20
ANFO Loader Truck	6
Compressors (1,500 cfm)	6
Crane Truck	6
Grader	6
Jumbo Drills, 1 Boom	16
Jumbo Drills, 2 Boom	14
Kubota Utility Transport	8
Load-haul-dump, CAT R1300	36
Load-haul-dump, CAT R1600	22
Long Tom	12
Lube Truck	6
MacLean Rock bolter	12
Misc. Pumps	30
Personnel Carrier	34
Production Drill	12
Service Truck, flat deck	6
Transmixers	6
Underground mine truck, CAT AD30 30T	36

4.3.4 Stationary Equipment

Mine compressors will be located at the ventilation raises as is the current installation at the Doris mine. Compressed air will be required to feed the long-hole pneumatic drills, Longtom mini jumbo drills and airlegs, stopper drills, and other equipment.

4.3.5 Compressed Air

Each site will have a 1,500 cfm compressor located on surface that will deliver compressed air via a 150 mm diameter line to the underground via the main ventilation raise or alternate access. A portable compressor will be used initially to commence the portal development at new sites and can serve later as backup.

4.3.6 Refuge Stations

Refuge stations will be cut underground in strategic locations and within a one kilometer distance or 15 minutes walking time to comply with mine health and safety regulations (Section 1.64 Consolidation of

Mine Health and Safety Regulations). As well portable refuge chambers will be provided and located strategically in areas of mine development.

4.3.7 Mine Rescue Equipment and Supplies

Mine rescue facilities including a training room are located at the Doris mine site which can service all of the operations. This includes the required number of BG4 rescue apparatus and all the accessories including an oxygen system for recharging the oxygen bottles. Given the remote locations it is estimated that three crews of six persons will be required to provide an initial response to an emergency situation.

4.4 SURFACE INFRASTRUCTURE AND SERVICES

4.4.1 Waste Rock

Each of the mine sites have a waste rock piles (WRP). Generally WRPs are located as close as practical to the mine openings for economic reasons. All WRPs are well within the Project Development Area (PDA). Sections 7.3.2, 7.3.3, and 7.3.4 discuss layouts for the infrastructure including WRPs for Madrid North, Madrid South, and Boston, respectively.

4.4.1.1 Geochemical Characterization of the Waste Rock

Geochemical characterization of the waste rock produced at each site has been completed. Refer to Appendices V3-4C (Madrid North), V3-4D (Madrid South), and V3-4E (Boston) for the detailed reports. Waste rock generated by the Project does not pose a risk of ARD. A risk of neutral ML does however exist for select material.

4.4.1.2 Waste Rock Deposition Strategies

Waste rock deposition strategies include:

- use as underground backfill;
- sub-aqueous deposition in the Doris TIA; and
- on-land storage.

Waste rock will be used as underground backfill to the maximum extent possible and is predicted to consume all of the Project waste rock with the makeup underground backfill coming from quarries, as required. Sub-aqueous deposition is not expected to be necessary given the geochemical composition of the rock. Therefore, the preferred method is on-land deposition on engineered waste rock pads until placement as backfill in the closed mine workings.

4.4.1.3 Operations

Temporary storage requirements for waste rock are as follows:

- Madrid North: 646,000 tonnes (359,000 m^3);
- Madrid South: 826,000 tonnes (459,000 m^3);
- Boston: 628,000 tonnes (349,000 m^3).

WRPs will be constructed over the Operation phase as conventional bottom up benched piles with overall final compound slopes of 2H:1V to 3H:1V. All waste rock piles will be engineered structures to ensure geotechnical stability. Waste rock will be transported to the piles using underground mine trucks and be placed at its natural angle of repose with safety berms spaced at regular vertical intervals. The WRPs will be contoured using bulldozers. The material in the piles will generally remain in place temporarily after which it is returned underground for use as backfill.

4.4.1.4 Water Management

Downstream of all WRPs, contact water ponds will be constructed to ensure containment of potential mine contact water, surface runoff and melt water. Berms will be strategically constructed to ensure complete containment of runoff water and seepage, as well as prevent any clean water run-off of surface waters to the waste rock. As appropriate, upstream surface water diversion structures will be constructed to minimize contact water.

4.4.2 Ore Stockpiles

Over the LOM for both Doris, Madrid and Boston, a total 21 Mt of ore will be extracted. The ore stockpile area at Doris will continue to be utilized for Phase 2 for Madrid and Boston ores. Ore stockpiles will also be located at Madrid North, Madrid South and Boston (Sections 3.4.6.1, 3.5.6.1, and 3.7.6.1). Ore stockpiles at all mine sites will be continually drawn down and replenished as ore is processed at Doris, Madrid North, and Boston.

4.4.2.1 Geochemical Characterization of the Ore

Geochemical characterization of the ore produced at each site has been completed (Appendices V3-4C, V3-4D, and V3-4E).

4.4.2.2 Ore Haulage to Doris Mill

A 1,200 tpd concentrator will be built at Madrid North. Since the mining rate will exceed the concentrator capacity, excess ore mined at Madrid North will be transported to Doris for processing. The concentrate produced by the Madrid North concentrator will be transported to Doris for gold extraction.

All of the ore mined from Madrid South will be hauled by truck to the Doris or Madrid North mill for processing.

Boston mining operations will begin by Year 4. The ore will be trucked to the Doris mill until the Boston concentrator is operational in Year 6. The Boston concentrator will produce gold concentrate which will be trucked to the Doris mill for gold recovery. This concentrate corresponds to approximately 10% of the ore processed at Boston. A summary of the estimated ore production and transportation requirements for the ore is presented in Table 4.4-1.

Table 4.4-1. Ore Production and Haulage for the Project

	Peak Years	No. of Return Trips/Day	Type	Frequency
Madrid North to Doris - 2019 to 2031				
Transport of ore	Year 2 to Year 13	53	40-t haul truck	Daily
Transport of concentrate	Year 5 to Year 13	3	40-t haul truck	Daily
Boston to Doris				
Transport of ore	Year 5 to Year 14	10	40-t haul truck	Daily
Transport of concentrate	Year 7 to Year 14	4	40-t haul truck	Daily

4.4.3 Processing Method

For the Doris mill, ore will initially be sourced from the Doris underground mine (as currently permitted), followed by Madrid and Boston mines. A 1,200 tpd mill will be constructed at Madrid North and a 2,400 tpd mill will be constructed at Boston.

The mining rate at Madrid North is expected to peak at 3,200 tpd which exceeds the processing capacity of the Madrid North concentrator. The excess ore will be trucked to the Doris mill for processing. The concentrate produced by the Madrid North mill will also be trucked to the Doris mill for gold recovery.

The Boston concentrator will come into operations two years after the mine is in production. Hence, for the initial two years, ore from Boston will be trucked to the Doris mill for processing. Once the Boston mill is operational (Year 5), the concentrate produced by the Boston mill will be trucked to the Doris mill for gold recovery.

The Doris mill is operational and authorized under the Doris Project Certificate and Type A Water Licence. The tailings generated at the Doris mill will be disposed of at the expanded Doris TIA.

Cyanide is already in use and authorized at the Doris process plant. The new process plants at Madrid North and Boston are concentrators that do not utilize cyanide. In this way, the use of cyanide is maintained only at the established location (Doris).

The final gold product will continue to be flown off site.

4.4.3.1 Madrid North and Boston Process Plants

The ore processing at Madrid North and Boston are identical in design. The Madrid North mill will be designed for a 1,200 tpd plant capacity while the Boston mill will be designed for a capacity of 2,400 tpd. The concentrating process consists of:

- crushing;
- continuous gravity concentration;
- grinding of gravity tails;
- flotation;
- tails thickening; and
- concentrate filtering, storage and reclaim.

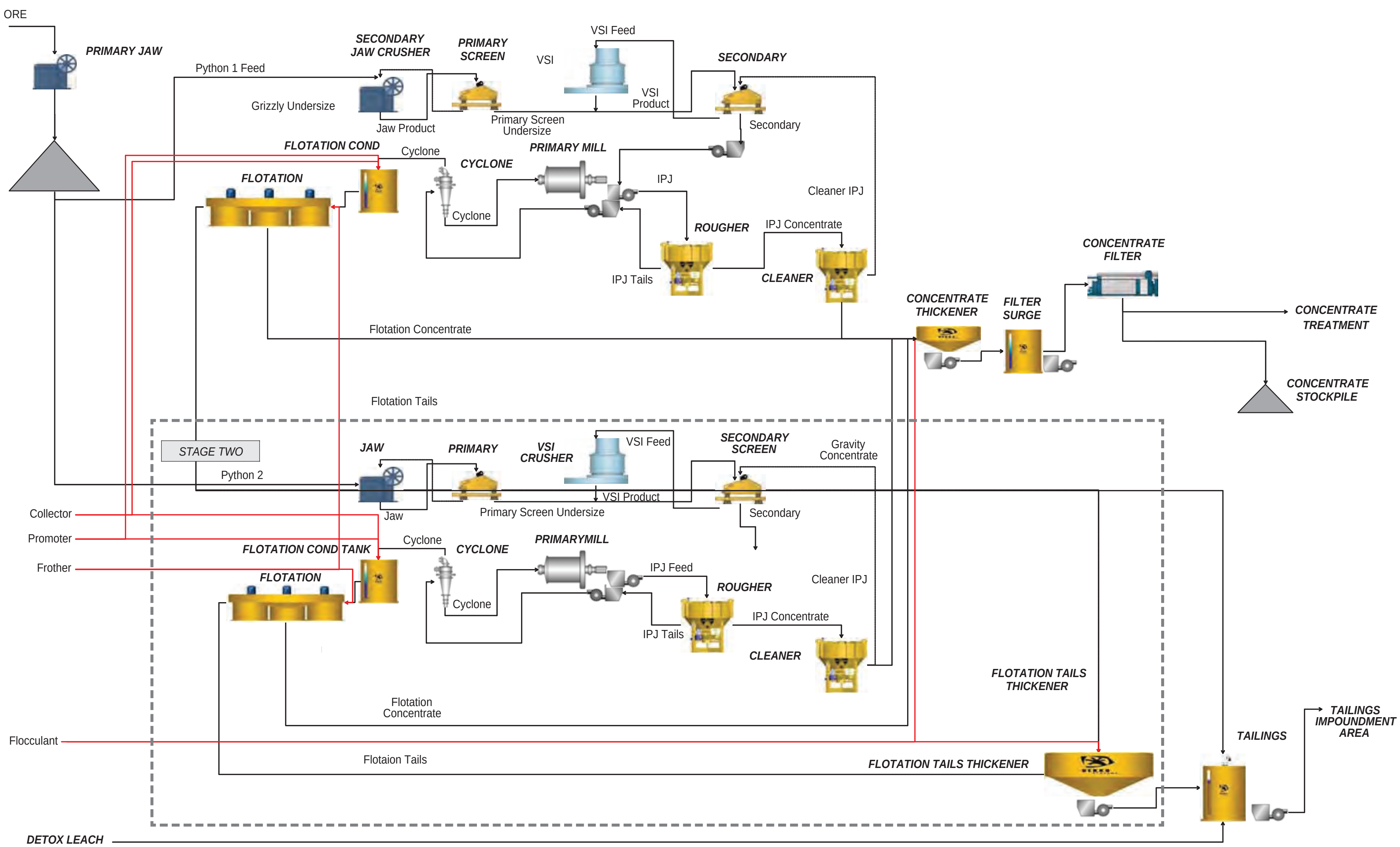
The tonnage of concentrate produced at Madrid North and Boston represents approximately 10% of the incoming ore. The tailings produced at Madrid North will be pumped to the Doris TIA. The tailings produced by the milling operation at Boston are dry-stacked and stockpiled at Boston (Section 4.4.4). A simplified flowsheet for the Madrid North and Boston mill is presented in Figure 4.4-1.

4.4.3.2 Crushing, Stockpiling and Screening

Run of mine (ROM) material is trucked from the ore stockpile to the ROM pad in preparation for processing. A front end loader recovers the ore from the ROM pad and tips onto the primary grizzly to scalp out +600 mm materials. The +600 mm materials are presented to the rock breaker to be broken and stockpiled for reclaim, while the -600 mm materials flow onto the vibrating grizzly.

Figure 4.4-1

Processing Plant Simplified Flowsheet



Source: Gekko Systems Pty Ltd., 2014.

The vibrating grizzly scalps out -100 mm ore and feeds the oversize into the primary jaw crusher to be crushed to P_{95} 125 mm. The vibrating grizzly undersized ore and crusher discharge are conveyed by the primary crusher discharge conveyor under a belt magnet to the stockpile feed conveyor for transfer to the stockpile. A metal detector is installed on the stockpile feed conveyor. A weightometer is installed on the stockpile feed conveyor for primary crushing circuit control.

Crushed ore is reclaimed to feed each Python train via the reclaim tunnel for each train using two apron feeders discharging onto two plant feed conveyors. A weightometer is installed on each plant feed conveyor for python feed rate control.

The plant feed conveyor discharges into a secondary jaw crusher via the grizzly feeder, scalping out minus 50 mm material. The jaw crusher crushes the oversize to a P_{95} 75 mm. The combined grizzly undersize and jaw crusher discharge are then transferred to the primary screen for sizing. The oversize is returned to the secondary jaw crusher for further crushing; while the undersize is sent to the secondary screen. Secondary screening is a wet process.

The oversize from the secondary screen reports to a vertical shaft impactor, for further crushing. The vertical shaft impactor discharges crushed ore to the secondary screen for re-sizing.

The P_{80}~1.7mm undersize slurry from the secondary screen reports to the secondary screen undersize sump; from which it is pumped to the gravity/grinding circuit.

4.4.3.3 Gravity and Grinding

The secondary screen underflow pump delivers slurry to one side of the primary mill discharge sump, where it is mixed with the discharge from the primary mill to the rougher inline pressure jig (IPJ). The concentrate from the rougher IPJ is sent to the cleaner IPJs (IPJ 1000), while the tails report to the other side of the primary mill discharge sump, where it is combined with excess mill discharge slurry and is pumped to the cyclone cluster. The cyclone clusters are banks of 6 Cavex 250CVX20, with 4 operating and 2 standbys. The underflow slurry from the cyclones return to the primary mill for grinding while the overflow reports to the agitated rougher flotation conditioning tank.

The cleaner IPJ tail returns to the secondary screen and the cleaner IPJ concentrate is pumped to the concentrate thickener.

4.4.3.4 Flotation

The cyclone overflow reports to the agitated rougher flotation conditioning tank. Process water is added to reach the required %w/w solids and reagents (collector, promoter and frother) are also added. The slurry overflows from the conditioning tank to the rougher flotation cells. The rougher flotation tails are pumped to the plant tails thickener, while the rougher flotation concentrate is to the cleaner flotation cells.

The tailings thickener underflow is pumped to the agitated tailings transfer tank from where they are pumped to the TIA. Thickener overflow reports to the process water tank.

The cleaner flotation tails flow by gravity to the rougher flotation cells for re-processing, while the cleaner concentrate is pumped to the concentrate thickener.

4.4.3.5 Concentrate Thickening and Filtering

The flow from the pythons recombines in the concentrate thickener feed. Concentrate from the cleaner jigs and cleaner flotation circuits are pumped to the concentrate thickener to recover excess water before the combined materials are sent to the concentrate filter for filtering. The concentrate thickener overflow and the concentrate filter filtrate report to the process water tank for re-use, while the filter cake materials are discharged onto a transfer conveyor, from where they either report to the regrind mill discharge sump via a slew conveyor for immediate processing, or stockpiled in the concentrate bunker to be reclaimed at a later time for processing.

The tonnage of concentrate produced is approximately 10% of the ore tonnage processed by the mill. This concentrate will be trucked to the Doris mill for final treatment and gold recovery.

4.4.3.6 Reagents

The reagents module consists of the tanks, mixers and pumps required for the following reagents:

- collector: Potassium Amyl Xanthate (PAX);
- frother: DSF002A;
- promoter: DSP002P;
- high pH Flocculant - SNF AN977SH; and
- low pH Flocculant- Anionic Polyacrylamide - High MW.

4.4.3.7 Utilities

The process plant module includes:

- low pressure (LP) process air system;
- high pressure (HP) air system;
- mine water;
- process water;
- gland water;
- potable water; and
- safety shower water.

4.4.4 Tailings Management

Geochemical characterization of tailings from processing Madrid North, Madrid South and Boston ore is described in Appendix V3-4A.

4.4.4.1 Expansion of Doris TIA

The operation of the Doris TIA will continue as currently authorized under the Type A Water Licence. Details of the TIA management are described in *Hope Bay Project – Doris Tailings Impoundment Area Phase 2 Design* (Appendix V3-3F).

The tailings deposition plan ensures that the supernatant pond will be located away from the South and West Dams. Deposition will be started from the crest of the South and West Dams, to create beaches that would push the supernatant water away from these structures. Once these beaches are created, the spigot points will be moved to the east side of the TIA. This will create a long and even tailings surface sloping toward the North Dam and ensuring that the water in the original Tail Lake is displaced and pushed away from the south end of the facility.

A plan view and two sections that illustrate the typical surface profile of the preferred tailings deposition plan are illustrated on Figures 4.4-2 and 4.4-3. Cross section A-A' which is a North-South section, shows that the overall tailings surface generally slopes from the South Dam towards the North Dam. Similarly, section B-B' which is an East-West section, shows that the final drainage swale will be along the western flank of the TIA.

Tailings deposition will minimize the area of exposed inactive tailings surface that might be prone to dusting. Beyond such mitigation by design, the primary dust control measure of the project site TIA will be the use of environmentally suitable chemical dust suppressants. The application of these suppressants will be reviewed on an ongoing basis to ensure that any areas that may be at risk will be adequately covered. In addition to chemical dust suppressants, natural dust control in the form of packed snow when available will be used as far as practical. In addition, a suitable water cannon will be available for dust suppression by wetting the areas of concern, if required.

Throughout the operational phase of the Project, the containment structures (North, South and West dams) will be subject to monitoring to evaluate their performance. This will include thermal, settlement and deformation monitoring. All TIA components and activities will be subject to annual inspections by a qualified engineer. The frequency of these inspections may be reduced as time progresses in accordance with the qualified engineer's recommendations.

4.4.4.2 Madrid North

The tailings produced at the Madrid concentrator will be pumped to the Doris TIA along the access road to be constructed from Madrid North to the south end of the TIA.

4.4.4.3 Boston

The Boston mill will produce dry tailings. Details of the Boston TIA are described in *Hope Bay Project – Phase 2: Boston Tailings Management Area Preliminary Design* (Appendix V3-2F).

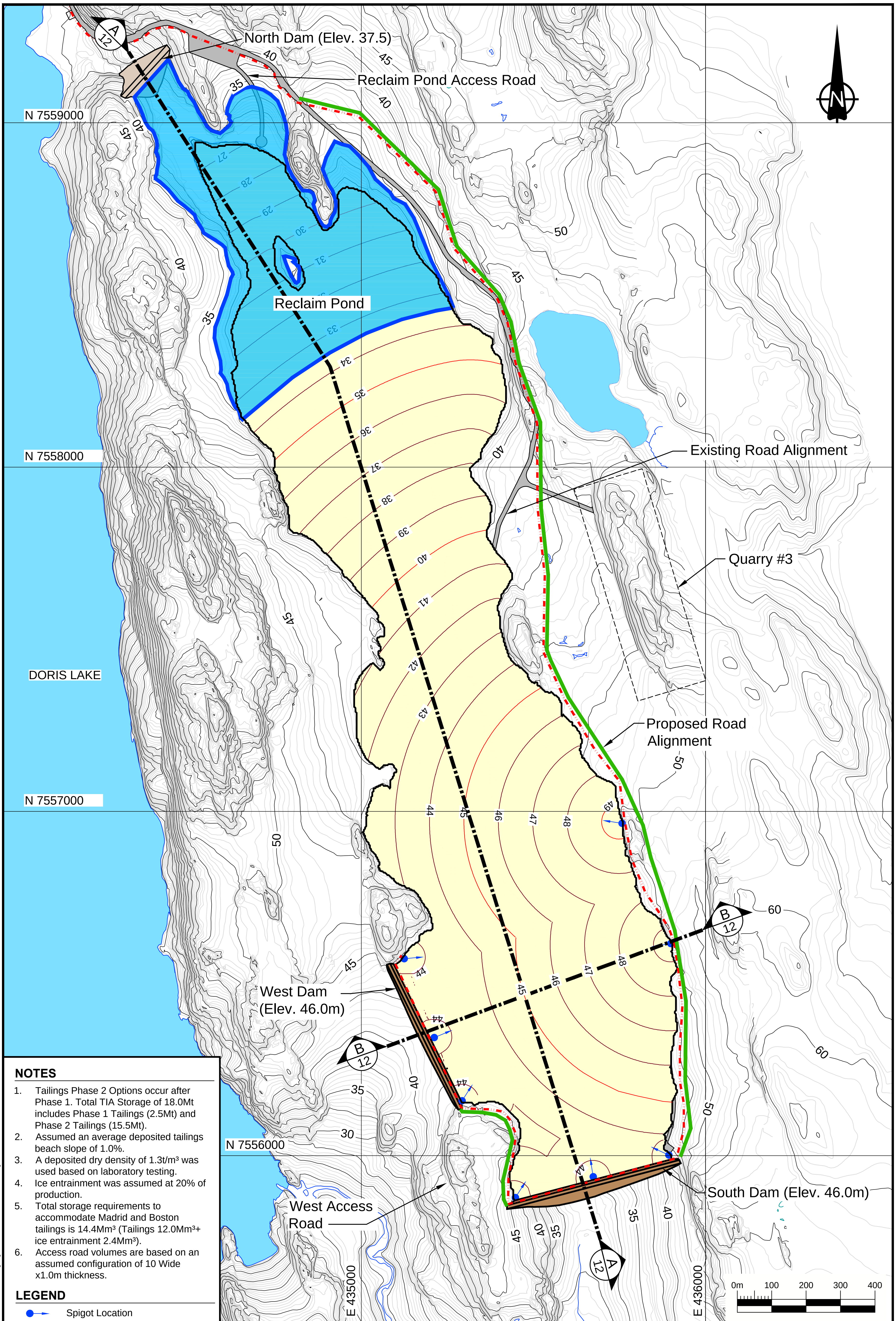
The tailings will be dry stacked on the designated site located near the Boston mine which has a design capacity to hold 5.1 Mt of tailings (Appendix V3-2F). Runoff from the active storage area will be collected in a dedicated contact water collection pond and returned to the mill as process water. If runoff water quality meets discharge criteria established by the Type A Water Licence, the excess runoff will be discharged to the industrial waste water treatment plant.

The tailings produced by the Boston Mill will be filtered to a water content amenable to handling by typical earth moving equipment (loaders, trucks, bulldozers) and hauled to the TMA for disposal. A filtered tailings disposal facility will be constructed (typically referred to as dry stack) approximately 1 km east of the mill by spreading the tailings in thin lifts (0.3 m) and compacting to a density as high as practicable. The facility is built up in this fashion to reach a maximum height of about 26 m, with 5 m intermediate benches. The inter-bench slope will be 3H:1V, with the overall slope of about 3.9H:1V.

The footprint occupied by the TMA is about 17.5 ha, but the location offers the possibility of expanding this area to the north in the future.

The dry stack tailings material will be placed directly on the tundra, with no excavation of vegetation or overburden prior to tailings placement. To ensure the permafrost foundations remain frozen, the first lift of filtered tailings should be placed in the winter when the ground is frozen. If tailings placement must start when the ground is thawed, a layer of ROQ material will be placed to protect the ground from traffic, if required.

Figure 4.4-2
Doris Tailings Impoundment Area
Plane View of Tailings Surface



NOTES

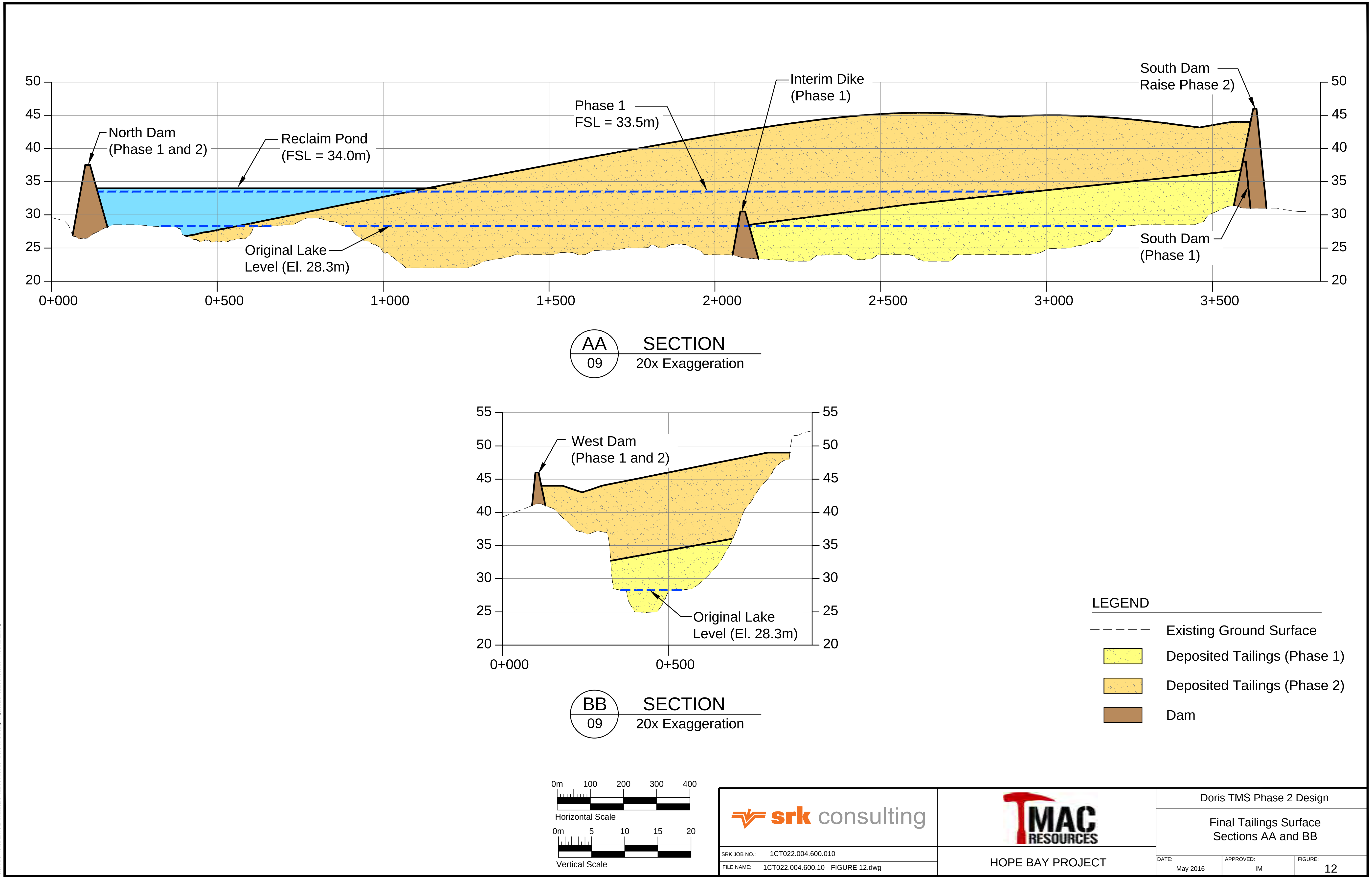
1. Tailings Phase 2 Options occur after Phase 1. Total TIA Storage of 18.0Mt includes Phase 1 Tailings (2.5Mt) and Phase 2 Tailings (15.5Mt).
2. Assumed an average deposited tailings beach slope of 1.0%.
3. A deposited dry density of 1.3t/m³ was used based on laboratory testing.
4. Ice entrainment was assumed at 20% of production.
5. Total storage requirements to accommodate Madrid and Boston tailings is 14.4Mm³ (Tailings 12.0Mm³+ ice entrainment 2.4Mm³).
6. Access road volumes are based on an assumed configuration of 10 Wide x1.0m thickness.

LEGEND

- Spigot Location
- Deposited Tailings
- Dam/Dike
- Proposed Road Realignment
- Proposed Tailings Line
- Final Tailings Topography

srk consulting | TMAC RESOURCES | Doris TMS Phase 2 Design
SRK JOB NO.: 1CT022.004.600.010
FILE NAME: 1CT022.004.600.10 - FIGURE 9.dwg
HOPE BAY PROJECT
Final Tailings Surface
DATE: May 2016 | APPROVED: IM | FIGURE: 09

Figure 4.4-3
Doris Tailings Impoundment Area Section A and Section B View of Tailings Surface



Contact water from the TMA will be retained by a series of containment berms, surrounding the facility on three sides. The east side berm will double as the access road to the Boston airstrip. The north side is open as the topography slopes back to the TMA and a containment berm is not necessary.

The contact water pond berms surrounding the tailings will also be placed directly on the tundra with no excavation of vegetation or organic material, except for the key trench portion of the berm. Overburden materials and vegetation excavated from the key trench should be placed on the overburden pile.

The volume of contact water running off the TMA was calculated based on a catchment area of 28.0 ha including the dry stack footprint and the bounded area within the contact water berms. A conservative run-off factor of 1 was applied, meaning all precipitation will be accounted for as run-off, with no losses to storage or evaporation. The run-off volume to be temporarily retained was based on the 1:100 years return 24 hours rainfall (55 mm) plus the maximum daily snowmelt of 18 mm, for a total of 73 mm. The 1:100 years 24 hour rainfall includes the climate change predictions extended to 2040. The computed volume of run-off to be retained is about 20,500 m^3, split between three ponding areas on the south, west, and northeast sides of the dry stack. This water will be retained temporarily by the contact water containment berms and pumped to the mill for treatment and release to the environment.

Deformation of the crest and slopes of the TMA will be monitored during construction and into the initial Post-closure phase to provide an early indication of possible instability. Monitoring will be performed through a network of survey prisms placed at appropriate intervals along the inter-bench berms and the crest of the facility. The prisms will be installed in large boulders imbedded within the final ROQ cover.

4.4.5 Water Management

4.4.5.1 Overview

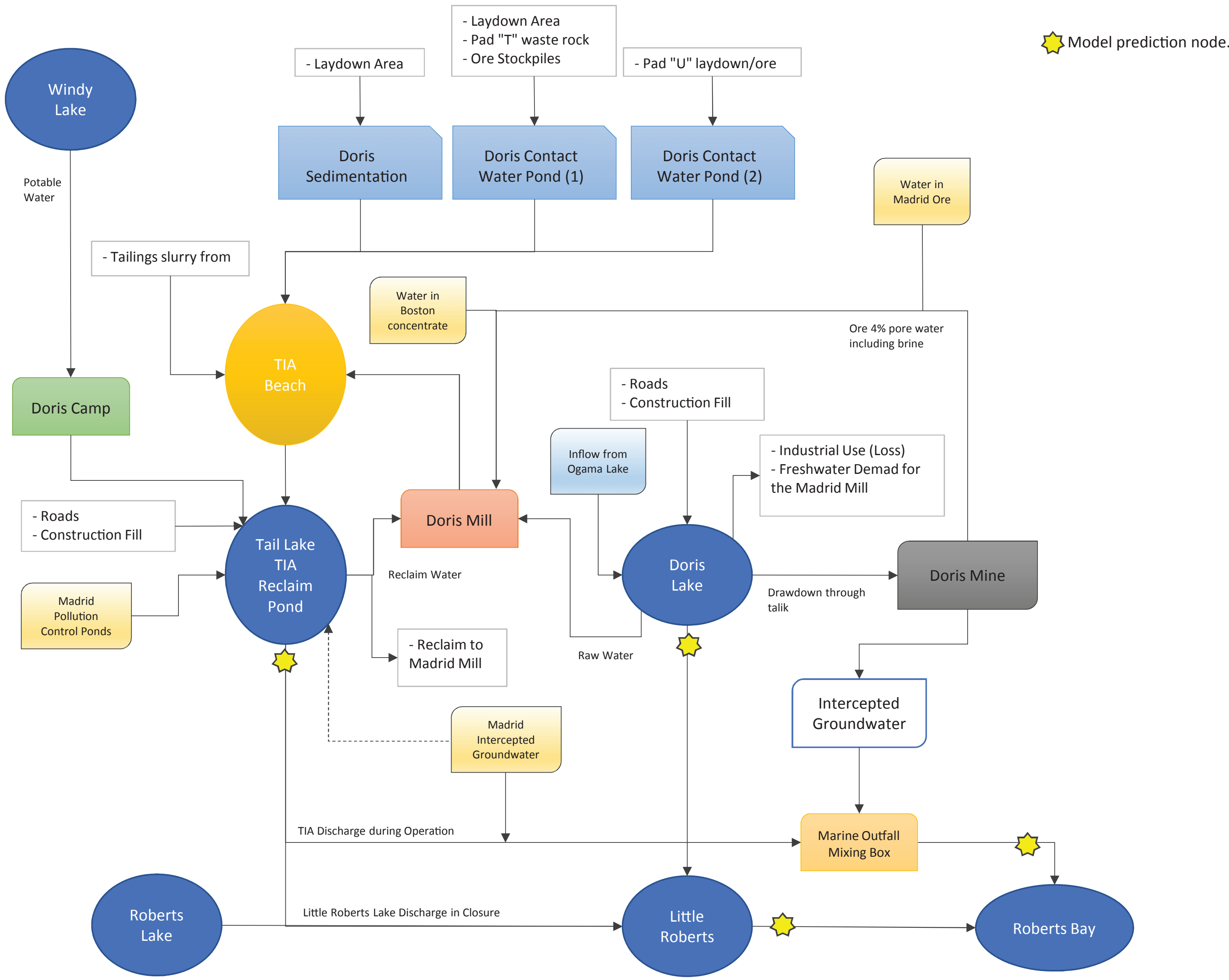
Detailed water management plans for the Project (Doris, Madrid and Boston) is described in *Hope Bay Project – Water and Load Balance* (Appendix V3-2D). Geochemistry source terms for input to the *Hope Bay Project – Water and Load Balance* (Appendix V3-2D) is provided in Source Term Predictions for the Proposed Madrid North, Madrid South and Boston Mines Report (Appendix V3-4F).

4.4.5.2 Doris

The flowsheet for water management at Doris is presented in Figure 4.4-4. Water management for Doris follows the authorizations under the Project Certificate and the Type A Water License. Water management is modified at Doris to include the following connections between the other mining areas:

- water collected in the Madrid North and Madrid South CWPs may be deposited in the Doris TIA;
- Madrid North ore and concentrate, Madrid South ore, and Boston ore (Year 3 and 4) and concentrate (Year 4 onwards) will be processed at the Doris mill with flotation tailings deposited in the Doris TIA;
- concentrate tailings will be placed underground with waste rock; and
- intercepted groundwater from Madrid mines will be discharged to the Doris TIA or marine outfall mixing box.

Figure 4.4-4
Doris Conceptual Water Balance



During the Operation phase, all site surface and underground mine water that does not meet discharge criteria will be redirected to the TIA. Reclaim water from the TIA will be pumped to the Doris mill. The reclaim volume will be maximized so as to minimize the need for freshwater make-up from Doris Lake. A reclaim barge on the reclaim pond in the TIA will house the reclaim pump. The reclaim barge will be equipped with a bubbler system to ensure it remains functional during winter months.

Water that meets discharge criteria set forth in the Metal Mining Effluent Regulation (MMER) will be discharged to the approved and engineered outfall in Roberts Bay. Since the TIA is located in a small isolated headwaters catchment, there is no diversion of non-contact water. All precipitation and runoff that fall within the catchment area of the TIA reports to the TIA.

At the Closure and Post-closure phases, the Doris Site will be reclaimed with restoration of natural flow. Water withdrawal and drawdown from Doris Lake will cease. Doris CWPs will be decommissioned and the flow previously reporting to these ponds will flow to Doris Lake. The Doris TIA will be pumped empty and a rock cover placed on the beaches. Lastly, the North dam will be breached to restore the natural Tail Lake catchment flow.

4.4.5.3 Madrid North and South

The flowsheet for water management at Madrid North and South is presented in Figure 4.4-5. Madrid North is located in the Doris and Windy watersheds. The Windy Lake watershed flows through Windy Lake to Glenn Lake to Roberts Bay.

Madrid South is located within the Doris Watershed. The Doris watershed flows through Imniagut and Wolverine Lakes to Patch Lake, PO Lake, Ogama Lake and eventually to Doris Lake.

Mine Water

The Madrid North mine will intercept the talik below Patch, Windy, and Imniagut lakes. Mining at the Madrid South mine is expected to intercept the talik below Wolverine and Patch Lakes. This intercepted ground water is expected to be high in salinity. The goal of the water management system will be to use underground mine water within the underground workings. Mine water collected in underground settling sumps (this includes groundwater seepage into the workings and drilling wastewater) will recycled for underground use. Underground mine water will also be transferred to the tank to be used as water supply for the Brine Mixing Facility. Excess groundwater will be pumped or hauled to Doris for transfer to the TIA or discharge via the marine outfall mixing box and discharge to the ocean.

Domestic Water

Domestic water for the Madrid North and South comes from the potable water drawn from Windy Lake under the Type A Water Licence for the Doris Mine. The total volume allocated under the authorization is 22,995 m^3/year for Doris, Phase 2 will make use of this allocation in addition to a further 20,805 m^3/year. Water will be trucked to the Madrid North and South and Doris.

Industrial Water

Industrial water (dust suppression, wash bays, and machine shops) is sourced from Doris Lake. The total volume currently allocated for industrial use under the Type A Water Licence is 480,000 m^3/year. Phase 2 will increase this water demand as indicated in Table 4.4-2.

Figure 4.4-5
Madrid Conceptual Water Balance

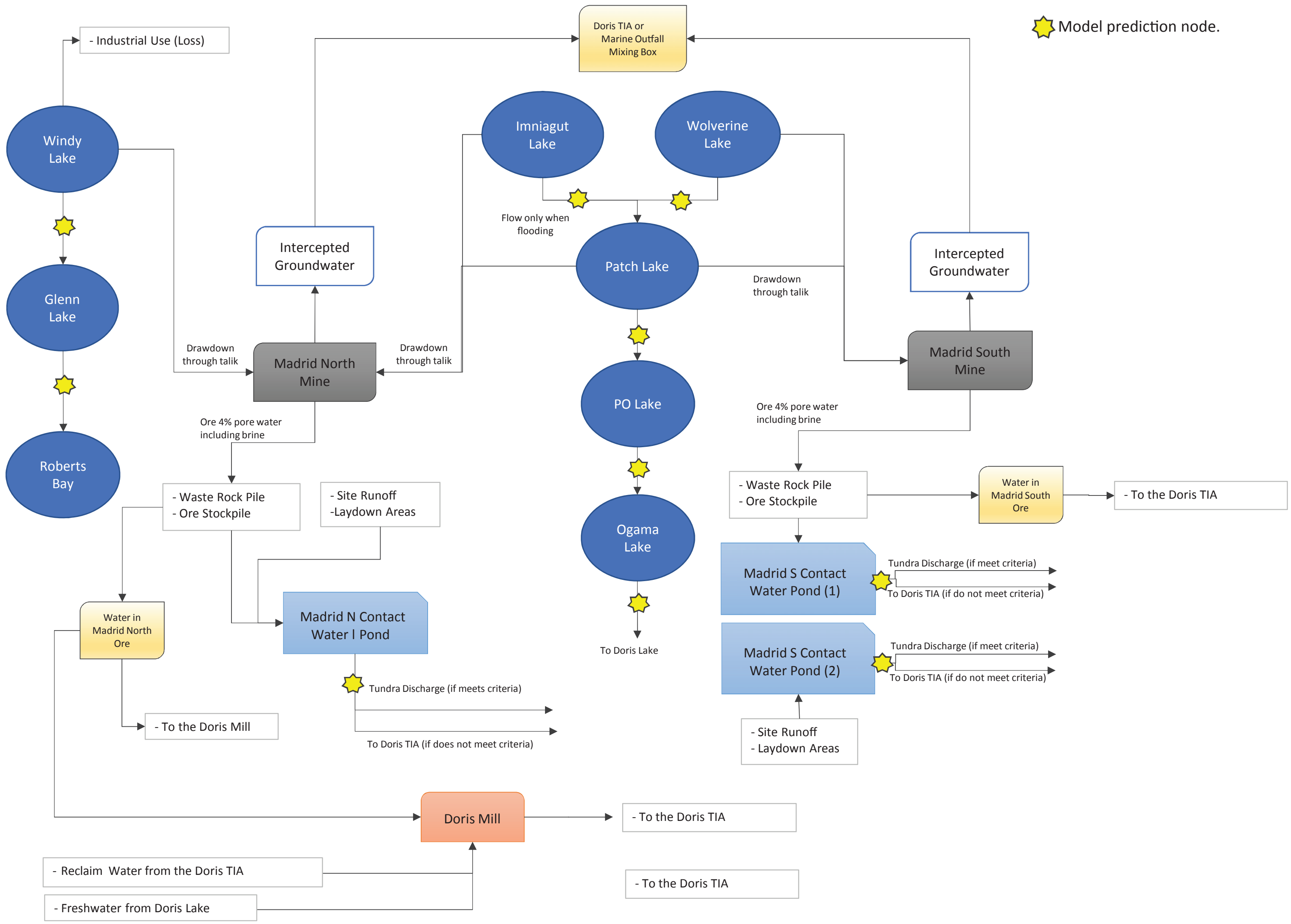


Table 4.4-2. Industrial Water Use for Doris Mill and Madrid Processing Plant

Source	Uses	Expected m^3/year	Peak m^3/year
Doris lake	Doris mill	266,450	980,000
	Madrid processing plant	135,050	844,000
	Doris and Madrid other industrial uses	365,000	365,000
Total draw - Doris Lake		**766,500**	**2,190,000**
TIA	Doris mill recycled water	1,065,800	0
	Madrid processing plant	532,900	0
Total draw - TIA		**1,598,700**	**0**
	Percent of recycled water	80%	No recycling

The water balance (Appendix V3-4F) indicates that for most of the operating period, the total water drawn from Doris Lake is expected to be 766,000 m^3/year. Over 80% of the process water used at the mill is sourced from recycled TIA water. Towards the end of the Project life (Year 10), due to the increased footprint of tailings and a smaller reclaim pond and due to ice formation in the TIA, it is likely that less water will be available from the TIA for reuse at the Doris mill. For the purpose of this assessment, an extreme scenario assume that all of the process water required by the Doris mill would be drawn from Doris Lake, which represents up to 2,190,000 m^3/year (no TIA water recycled for reuse in the mill). This is an unlikely scenario since the conceptual design of the TIA incorporates conservative assumptions that result in an underestimation of the volume of water contained within the TIA and available for recycling to the Doris mill. The maximum withdrawal of 2,190,000 m^3/year from Doris Lake would result in a reduction of up to 18% of the flow in Little Roberts Creek during the August and September period. This reduction in flow can be mitigated by the removal of obstacles (boulders) within section of the creek that could result in barriers to fish movement.

<u>Contact Water</u>

Contact water (surface water runoff) from the waste rock piles, ore stockpiles, and all other surface infrastructure pads will be collected in CWPs, one CWP at Madrid North and two CWPs at Madrid South. In order to maximize mine water reuse, runoff collected in CWPs will be transferred by truck or pumped to the tank to be used as water supply for the Brine Mixing Facility. Make-up water will only be drawn from the freshwater sources when it cannot be drawn from the CWPs. These event ponds will normally be maintained empty. Excess contact water will be sent to the Doris TIA or discharged onto the tundra if water meets discharge criteria.

Water accumulated in the containment berms for the fuel storage facilities will be deposited in the TIA, used as mill make-up water, or tested for discharge criteria and used for dust suppression or discharged to the tundra.

<u>Sewage Treatment</u>

There will not be a camp at the Madrid North or South sites. A portable wash car containing toilets, washbasins and showers will be equipped with heated black and gray water day tanks (Pacto unit). These tanks will be emptied via a vacuum sewage truck and transported to a holding tank at the Doris Site for blending into the Doris Site sewage treatment facility.

4.4.5.4 Boston

The flowsheet for water management at Boston presented in Figure 4.4-6. Boston is located on the southern end of Aimaokatalok Lake. Aimaokatalok Lake flows into the Koignuk River, which flows into

Hope Bay. The Aimaokatalok watershed is a large watershed separate from the Doris or Windy watershed systems.

Mine Water

The Boston mine will be completely within permafrost, and no groundwater interception is anticipated. Starting Year 7, Boston ore will be processed at a mill in Boston. The flotation tails (94% of ore stream) will be dewatered via a filter press and deposited in the Boston TIA dry stack facility. The flotation concentrate will be trucked to the Doris mill for final processing. Filter press water is internally recycled in the Boston mill.

Domestic Water

At the Boston, potable water for human use and raw water for industrial use (brine mixing, dust suppressant, and mill makeup water) will be sourced from Aimaokatalok Lake. Potable water will be used at the Boston Site (initially 65 persons and increasing to 200 persons for the Operation phase). A volume of 22,000 m^3/year of potable water are anticipated to be required during the Operation phase. The domestic wastewater will be treated prior to discharge to the tundra.

Industrial and Processing Water

Raw water will be used in processing at the Boston mill, for surface and underground exploration, and for equipment washing. A volume of 290,000 m^3/year of water will be used during the Operation phase. Purge water from the mill will be sent to the water treatment plant (WTP) prior to discharge to Aimaokatalok Lake.

Contact Water

Contact water from the waste rock pile, ore stockpile, and other mine surface infrastructure pads will be collected at Contact Water Pond No. 1 (CWP 1). CWP 1 will send makeup water back to the mill for processing or to the WTP for eventual discharge to Aimaokatalok Lake. Contact water from the mine portal area, laydown areas and general site run-off will be collected at Contact Water Pond No. 2 (CWP 2). CWP 2 will send water to the WTP for eventual discharge to Aimaokatalok Lake. Contact water from the Boston TMA will be collected at Contact Water Pond No. 3 (CWP 3). CWP 3 will send makeup water back to the mill for processing or to the WTP for eventual discharge to Aimaokatalok Lake.

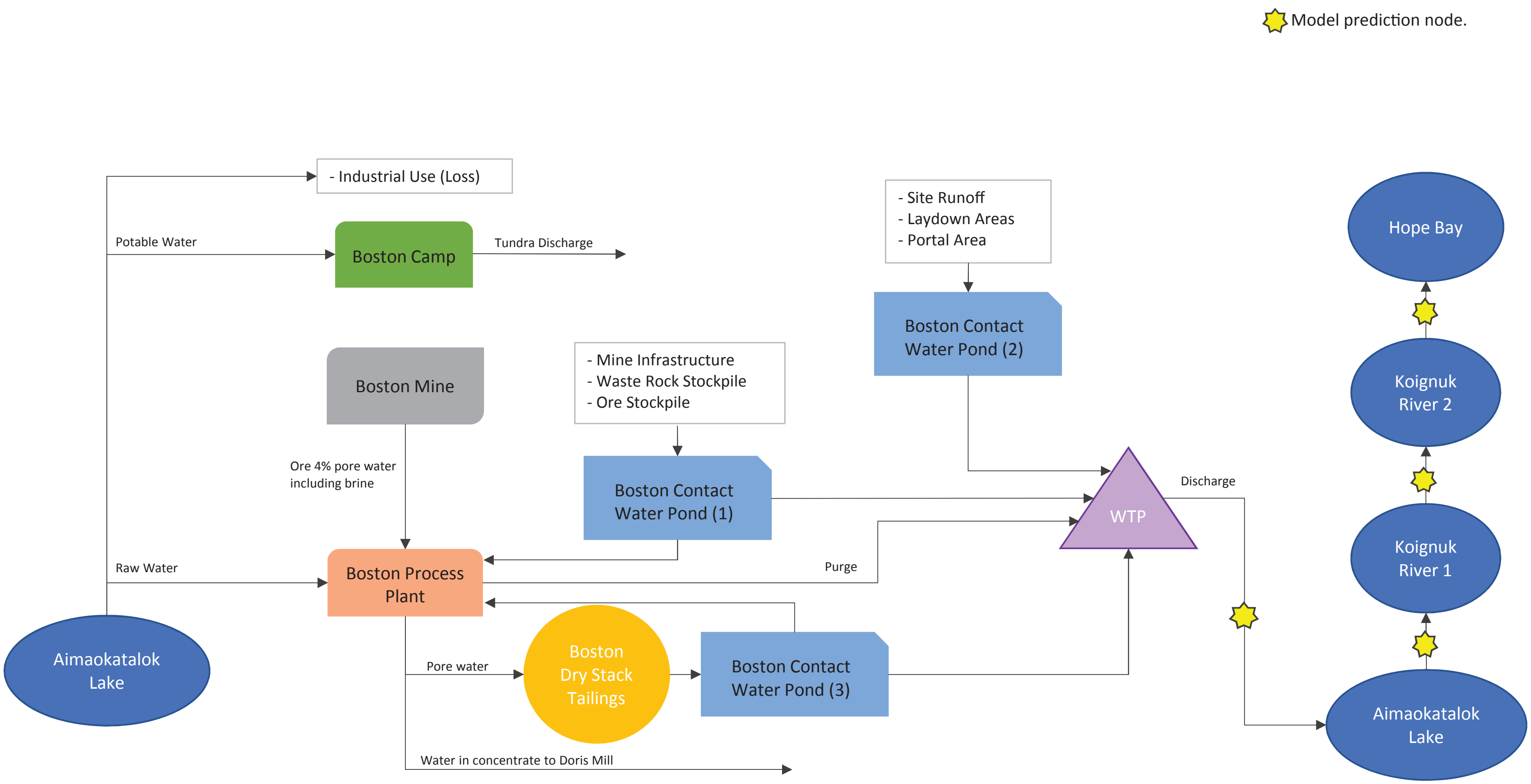
Water accumulated in the containment berms for the fuel storage facilities will either be deposited in the Doris TIA, used as mill make-up water, or tested for discharge criteria and used for dust suppression or discharged to the tundra.

Industrial Waste Water Treatment Plant

An industrial waste water treatment plant (WTP) will be required at Boston. Based on predicted elevated levels of arsenic and cadmium in Boston contact water, a two stage treatment process will be utilized.

The first stage targets arsenic removal with a ferric co-precipitation process. Arsenic co-precipitates with iron to lower the arsenic concentration to acceptable discharge limits. A second lime neutralization stage is also required for cadmium levels to meet acceptable discharge limits. In order to remove cadmium, the solution pH must be raised to 10 with the addition of lime. Ferric sulphate may be required as a coagulant. In addition to cadmium removal, lime neutralization also targets the precipitation of other metals with predicted increasing pH such as nickel, copper and zinc. The effluent produced by this waste water treatment will comply with discharge criteria established under the Type A Water Licence.

Figure 4.4-6
Boston Conceptual Water Balance



Both processes produce sludge containing precipitated metals and arsenic. Since the Boston mine is located within permafrost, it was assumed that any sludge produced will be placed underground where it will freeze and remain immobilized. The WTP will be initiated at the start of the Operations phase at Boston and remain in place through the Closure phase to treat any water collected in the site ponds. Once Boston enters the Post-Closure phase, the WTP will no longer be required and will be decommissioned.

Sewage Treatment

Boston will have a fully functional accommodations facility complete with packaged biological sewage and gray water treatment plant. Discharge of the treated effluent will be to the tundra via a diffuser or into Aimaokatalok Lake with other site discharges. The sludge will either be incinerated or trucked underground for disposal with the backfill waste. The capacity of the treatment plant is predicted to be an average of 60 m^3/day during the Operation phase. Treated effluent for the Sewage treatment plant discharged to tundra will meet criteria outlined in the Doris Type A Water licence (Part G, Article 3b).

4.4.5.5 Quarry Contact Water Management

The development of each quarry will proceed in a manner that, to the extent possible, all water generated as a result of precipitation or snow melt is retained within the quarry boundaries. This will be accomplished by sloping and contouring quarry floors toward the natural low area and, if required the creation of a pit and installation of a quarry sump to collect the waters and settle out suspended solids.

Quarry sumps will be inspected and emptied as required. Prior to discharge water will be sampled to confirm compliance with discharge criteria. Compliant water will be discharged to the tundra or used for dust suppression. Non-compliant water may be treated on site or trucked to Boston for treatment or disposed of in the Doris TIA. Discharge compliance criteria are expected to be aligned with those outlined in Part D Item 18 Type B Water Licence 2BE-HOP1222. Sampling results will be reported as part of the monthly monitoring reporting.

Additionally, notification will be provided to the Inspector, at least fifteen (10) days prior to the planned pumping. The notification will include the volume proposed for discharge and the discharge location.

Care will be taken not to disturb settled solids in the bottom of the sump and pumping of the sump will only take place when conditions are suitable. Care will also be taken to discharge water such that it does not enter fish bearing waters and that the pump discharge is positioned in a manner that minimizes erosion and siltation of the area downstream of the discharge.

4.4.6 Waste Management

Waste management activities, including training of employees in waste handling and minimization of waste generation, will continue to be undertaken in accordance with existing management plans for the Doris Project (Volume 8, Annex 15).

4.4.6.1 Non-Hazardous Waste

Non-Hazardous waste will be segregated and disposed of either in the in an incinerator, landfill, or will be open burnt. Incinerators will comply with appropriate Environment Canada (*Canadian Environmental Protection Act*) and Government of Nunavut (GN) legislation (*Consolidation of Environmental Protection Act*) and guidelines (Department of the Environment 2012) as well as TMAC's own Incinerator Management Plan, (Volume 8, Annex 16). Incinerated wastes will include food waste, sewage sludge, and limited portions of paper products and/or oily rags. Where practical, waste oil will be used to fuel these incinerators. Incinerators are permitted under both the existing Boston Type B Water Licence 2BB-BOS1712 and the Doris Project Certificate and the Type A Water Licence 2AM-DOH1323, and an incinerator will be located at Boston. Domestic waste generated at Madrid will be trucked to Doris and integrated with the Doris waste stream for handling and disposal.

A non-hazardous landfill to contain generally dry, non-leachable waste materials will be constructed at Boston. Similar waste from Madrid North and South will be trucked to the Doris Site for disposal. The landfill at Doris is authorized under the Project Certificate and the Type A Water Licence, and demonstrates that current procedures are appropriate.

A Boston landfill will be developed within the designated rock quarry immediately behind the portal. The general landfill development concept will be identical to the Doris Site. The base of quarry will be designed to slope at 1%, so surface water runoff is directed towards a low point (sump pit) in the quarry. The landfill containment berms will be constructed from crushed compacted quarry rock and are designed so that any discharge from the landfill will accumulate in the sump pit of the landfill.

Once completed the landfill will be capped with a 1 m thick rock fill cover of 150 mm minus (6 inch) clean compacted quarry rock material. The final surface of the landfill will be graded similar to the foundation base grade, of 1%, to shed water and minimize infiltration. The capping material will move the active thaw layer away from the stored waste so it is expected that permafrost will partially aggrade into the landfill waste over time.

Landfill sump discharge water quality criteria are listed the same as criteria for the Type A Water Licence (Table 4.4-3).

Table 4.4-3. Landfill Sump Water Quality Criteria for Discharge to Receiving Environment

Parameter	Maximum Average Concentration (mg/L)	Maximum Allowable Grab Sample Concentration (mg/L)
pH	6 – 9	9
Total Suspended Solids (TSS)	15	30
Total Oil and Grease	5 no visible sheen	10 no visible sheen
Total Ammonia-N	2.0	4.0
Total Cyanide (CN)	1.0	2.0
Total Aluminium (Al)	1.0	2.0
Total Arsenic (As)	0.05	0.10
Total Copper (Cu)	0.02	0.04
Total Iron (Fe)	0.3	0.6
Total Lead (Pb)	0.01	0.02
Total Nickel (Ni)	0.05	0.10
Total Zinc (Zn)	0.01	0.02

Source: Type A Licence 2AM-DOH1323, Part G, Article 24a

Prior to landfill development, or to reduce the quantity of material landfilled, clean wood and cardboard will be open burnt within the landfill at Boston or at the existing Doris burn pan.

Bottom ash generated from open burning and incineration will be characterized, and ash which conforms with criteria outlined in the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* (GN 2011) will be disposed of in the landfill, and ash which does not meet these criteria will be placed underground with backfill material or shipped off site for disposal.

4.4.6.2 Hazardous Waste Disposal

There will be no hazardous waste disposal facilities on site. All hazardous waste will be stored using standard industry best practice methods and shipped off site, either via sealift or airlift backhaul as the opportunities arise. Final disposal will be under contract at a designated licenced hazardous waste disposal site close to the designated port or airport. Hydrocarbon and ammonium nitrate fuel oil contaminated solids will be placed underground as backfill.

4.4.6.3 Other Wastes

Contaminated Soils

Hydrocarbon and ammonium nitrate fuel oil contaminated solids will be placed underground as backfill. Hydrocarbon contaminated snow and ice will be treated within properly designed landfarms. A landfarm is currently located at Doris and one will be constructed at Boston. The landfarms will be in use for the LOM and the Boston landfarm will be located adjacent to waste management facilities (e.g., waste rock storage areas; see Figure 3.8-1). Smaller quantities of hydrocarbon contaminated snow or ice may be melted in barrels and the oil fraction decanted for reuse of disposal and the remaining water fraction returned to the landfarm. Water pooling within the landfarm will be managed similarly to contact pond water, with water directed to the Doris TIA or the Boston WTP, or discharged to the tundra if it meets discharge criteria (Table 4.4-4).

Table 4.4-4. Proposed Landfarm Pooling Water Quality Discharge Criteria

Parameter	Maximum Average Concentration (mg/L)	Maximum Allowable Grab Sample Concentration (mg/L)
pH	6 – 9	9
Total Suspended Solids (TSS)	15	30
Total Oil and Grease	5 no visible sheen	10 no visible sheen
Total Ammonia-N	2.0	4.0
Total Lead (Pb)	0.01	0.02
Benzene	0.37	-
Toluene	0.002	-
Ethyl benzene	0.09	-

Source: Type A Water Licence, Part G, Article 24c

Waste Oil and Lubricants

Waste oil and lubricants will be managed and disposed of in accordance with existing management plans for the Doris Project (Volume 8, Annex 15). As far as practical, waste oil will be re-used as fuel for the garbage incinerator or as a heat source in non-inhabited areas. If necessary, excess waste oil and lubricants will be collected and disposed of off-site, at a designated and licenced disposal site. Transport of these products will be by either sea or air backhaul.

4.4.6.4 Anticipated Waste Quantities

A summary of expected waste types and quantities is presented in Table 4.4-5 for Madrid North and Madrid South, and Table 4.4-6 for Boston.

Table 4.4-5. Expected Types and Quantities of Solid Waste for Madrid North and Madrid South

Type of Waste	Composition	Quantity Generated	Treatment Method	Disposal Method
Solid Waste	Mixed non-hazardous waste typically generated at a work site	< 5 m^3/d	Collected for transport to the Doris Site	Disposal as per approved 2AM-DOH1323 waste management plan.
Waste Oil	Waste oil generated from mining equipment (electrical generators, trucks, drills)	< 1 m^3/d	Collected for transport to the Doris Site	Disposal as per approved 2AM-DOH1323 waste management plan.
Waste, Scrap metal, and Contaminated sludges	Waste generated from drilling activities and accidents	Unknown	Collected for transport to the Doris Site	Disposal as per approved 2AM-DOH1323 waste management plan and Spill Contingency Plan.
Drill Cuttings	Drill waste, including water, chips, muds and salts ($CaCl_2$) from land-based and on-ice diamond drilling.	Unknown	Cuttings are dewatered, and the separated water or brine is recycled back into the drilling process.	Saline cuttings: removed from the drill site and deposited in a contained location (i.e., designated sump, waste rock pile) where runoff is captured for treatment or disposal to an appropriate facility (i.e., TIA, TMA). Non-saline cuttings: disposed in a sump or natural depression proximal to the drill where direct flow into a water body is not possible and no additional impacts are created. May be used for reclamation purposes. Excess Brine: removed from the drill site and deposited onto waste rock piles, into Pollution Control Ponds, or discharged to the TIA.

Table 4.4-6. Expected Types and Quantities of Solid Waste for Boston

Type of Waste	Composition	Quantity Generated	Treatment Method	Disposal Method
Solid Waste	Mixed non-hazardous waste typically generated at a work site	< 10 m^3/d	Collected for transport to the Doris Site	Disposal as per approved 2AM-DOH1323 waste management plan.
Waste Oil	Waste oil generated from mining equipment (electrical generators, trucks, drills)	< 2 m^3/d	Collected for transport to the Doris Site	Disposal as per approved 2AM-DOH1323 waste management plan.
Waste, Scrap metal, and Contaminated sludge	Waste generated from drilling activities and accidents	Unknown	Collected for transport to the Doris Site	Disposal as per approved 2AM-DOH1323 waste management plan and Spill Contingency Plan.
Drill Cuttings	Drill waste, including water, chips, muds and salts (CaCl2) from land-based and on-ice diamond drilling.	Unknown	Cuttings are dewatered, and the separated water or brine is recycled back into the drilling process.	Saline cuttings: removed from the drill site and deposited in a contained location (i.e., designated sump or waste rock pile) where runoff is captured for treatment or disposal to an appropriate facility (i.e., TIA). Non-saline cuttings: disposed in a sump or natural depression proximal to the drill where direct flow into a water body is not possible and no additional impacts are created. May be used for reclamation purposes. Excess Brine: removed from the drill site and deposited onto waste rock piles, into Pollution Control Ponds, or discharged to the Doris TIA.

4.4.7 Surface Mine Equipment

Expansion of the Project to the development of underground mining at Madrid and Boston will require additional mine equipment. The anticipated and typical surface mobile equipment needs for the project are captured in Table 4.4-7.

Table 4.4-7. Phase 2 Surface Mobile Equipment

Unit Description	Total Requisite
45 tonne Super B Train Haul Truck	1
Batch truck	1
Cement Mixer	3
Compressor	4
Crew Bus	3
Dozer	5
Drill Rig	14
Elevated Work Platform	22
Excavator	6
Fuel truck	18
Gator Utility Transport	3
Grader	4
Light vehicle (e.g., pickup trucks)	66
Lighting Tower	28
Loader (Large, e.g., Cat 980H)	6
Loader (Small, e.g., Cat 930H)	14
Mobile Crane (130 t)	1
Mobile Crane (30 t)	4
Mobile crusher	1
Other heavy vehicles	10
Pump	12
Rock haul trucks	3
Roller	2
Shredder	2
Snow Cat	4
Telehandler/Zoom Boom	4
Tractor	2
Tundra Hauler	1
Vacuum Truck	1
Water Truck	2
Welder	6
Yard Forklift	1

4.4.8 Explosives and Cap Magazines

Explosives will be used on-site for blasting of the underground mine development and at quarries. The Project will utilize only pre-packaged explosives. Due to the volume and nature of explosives, facilities meeting specific safety and regulatory conditions are required (i.e., adequate separation between storage magazines and facilities). All staff accessing the explosives storage must be trained in the safe handling of the materials.

On average, access to the ore vein will require between six and seven blasts per day, while mining of the ore will require two to three blasts per day. Expected usage of explosives is listed in Table 4.4-8.

Table 4.4-8. Anticipated Explosives Usage for Operation

Extraction (based on peak mining rates)	Madrid North	Madrid South	Boston
Ore (tpd)	3,200	2,415	1,600
Waste Rock (tpd)	690	2,300	710
Total (tpd)	3,890	3,726	2,310
Projected Explosives Consumption (kg/day)	4,670	4,470	2,770

Explosives will be stored in magazines as authorized by a permit obtained under the Nunavut *Explosives Uses Act*. The uses of explosives falls within the regulatory purview of the Inspector of Mines and explosives storage facilities are subject to detailed and frequent inspection. As required, detonators and dynamite will be stored in steel Type 4 magazines or better (NFPA 495, 2006, Sect. 9.2). The detonators must be housed separately from the explosives in their own magazine(s). The current explosives and detonator storage magazines are located to the east of the Doris TIA at an acceptable distance from the nearest occupied structure and shielded as required by regulations. It is anticipated that this current location will suffice for Project operations with campaigned delivery to a smaller magazine and storage areas near Boston.

The current capacity of the explosives magazines is 40 t which is sufficient for over 30 days' production at 2,000 tpd. Magazines for detonators, properly separated from explosives, are approved by NRCan and have sufficient storage capacity for several months of supply on surface and underground. Underground storage of explosives within approved magazines is only limited by practical transport distances and currently stands at 20 t.

4.4.9 Fuel Storage and Distribution

Fuel will be transported via the Mackenzie River, east or west coast by double-hull tankers to the port at Roberts Bay. Fuel will be delivered to land-based fuel storage via floating line to a tanker moored in Roberts Bay to the Dock with land lines.

Primary fuel storage will be at Roberts Bay with supplemental storage at the Doris tank farm, the Madrid North tank farm and the Boston tank farm to ensure continuous supplies at the generator sets.

Bulk fuel trucks are used to transport fuel supply to tanks. The bulk fuel trucks are filled and unloaded in a lined fuel transfer pad. The majority of the heavy equipment will be refueled by smaller fuel trucks. The smaller fuel trucks and lightweight vehicles will refuel at the Roberts Bay, Doris, Madrid and Boston refueling stations. Refueling stations draw directly from storage tanks via modularized container systems containing pumps, meters and necessary flow control and emergency stop valves.

The installed (existing) and future diesel fuel storage summary is provided in Table 4.4-9. Site wide fuel consumption is expected to peak at 40 ML during the peak mining years at Madrid North and Boston.

Table 4.4-9. Existing Diesel Fuel Storage Summary

Area	Existing Diesel Storage	Phase 2 Fuel Diesel Storage
Roberts Bay[1]	4 @ 5 ML existing	5 @ 5 ML (existing) 2 @ 5 ML Total storage of 65 ML
Doris[1]	5 @ 1.5 ML	No additional fuel storage
Madrid North	None	Three tanks at 1.5 ML each Total of 4.5 ML
Madrid South	None	0.75 ML Enviro tank
Boston[2]	6 @ 0.77ML 2 @ 0.330 ML	Three tanks at 1.5 ML each Total of 4.5 ML

[1] Authorized under the Doris Project Certificate and Type A Licence.
[2] Authorized under the Boston Bulk Sample Type "B" Water Licence 2BB-BOS1217.

4.4.9.1 Roberts Bay

Total storage at Roberts Bay is currently permitted for 25 ML, and comprises the following:

- one existing diesel fuel storage tank with 5,000 m^3 working capacity. The tank is located in a lined containment area at Quarry 1;
- three existing diesel tanks, each with 5,000 m^3 working capacity. Tanks are located in a separately lined containment area east of Quarry 1. All tanks have interconnecting piping;
- the tank farm has been designed to accommodate one additional 5,000 m^3 diesel storage tank and 500 m^3 of jet fuel; and
- fuel offloading and transfer module and piping network for offloading diesel fuel from fuel tanker truck to diesel fuel tanks.

An additional 10 ML of storage will be constructed at Roberts Bay for Phase 2.

4.4.9.2 Doris

Total storage at Doris is currently permitted for 7.5 ML:

- five diesel fuel tanks, each with 1,500 m^3 working storage capacity;
- fuel offloading and transfer module and piping network for:
  - distributing fuel to generator day tanks and potentially for fuel storage at Doris mine portal,
  - fuel dispensing module which is equipped with a fuelling station for light vehicles, and a fuelling station for heavy vehicles; and
- fuel supply piping between permanent generators and the fuel tank farm and the above distribution points is operational.

4.4.9.3 Madrid Fuel Storage

A tank farm consisting of 3 tanks of 1.5 ML capacity will be constructed at the Madrid North site. Madrid South will have fuel a transfer station containing a 75 m^3 Enviro Tank.

4.4.9.4 Boston Fuel Storage

The tank farm at Boston will have three tanks each with a capacity of 1,500 m^3. These tanks will be re-supplied from Doris by road, as required. The tanks hold sufficient fuel for more than two weeks consumption at full production providing an adequate buffer against delivery interruptions.

4.4.9.5 Fuel Consumption

The primary uses of diesel at site include the various power plants, mine mobile equipment, surface mobile equipment, and ventilation burners. Most of fuel is consumed by power generation. The type of diesel selected for Hope Bay is Ultra Low Sulphur Diesel (ULSD) No. 1. The annual consumption of fuel is expected to peak at 40 ML per year during the peak mining period at Madrid North and Boston.

Fuel consumption at each site for mining activities is presented in Table 4.4-10 and fuel consumption for power generation is described in Section 4.4.10.

Table 4.4-10. Expected Fuel Consumption over the Life of Mine

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Year	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Doris mining	4.1	2.9	1.8	-	-	-	-	-	-	-	-	-	-	-
Doris mill	4.8	4.7	4.7	4.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	3.8
Doris accommodations and facilities	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Madrid North mining	0.2	4.8	6.0	5.8	6.1	6.1	7.2	8.4	7.3	9.6	6.5	6.5	6.1	-
Madrid North mill	-	2.5	2.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	-
Madrid South mining	-	-	-	-	-	-	-	-	-	-	0.7	3.6	3.3	2.3
Boston accommodations and facilities, mill	-	-	-	1.5	6.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	1.4
Boston mining	-	-	-	0.5	1.9	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	0.4
Total	**15.6**	**21.4**	**21.5**	**22.0**	**29.2**	**37.1**	**38.1**	**39.4**	**38.3**	**10.5**	**38.1**	**41.1**	**40.3**	**14.3**

As mining winds down at Doris, the Madrid North mine will come on stream and by Year 4, the Boston mine will be in production. The Madrid South mine will not be developed until the later stage of the Project when ore production at Madrid North and Boston begin to decline.

4.4.10 Power

Power demand is estimated by analysing consumption in four activities: mining, processing, surface operations, and general and administrative buildings. The most significant consumers of power are the processing plant and mine operations. Mine operations include all mobile equipment and all support infrastructure such as surface fans, compressors, underground heading fans, and dewatering pumps that require power. The limited power generation requirements at the Roberts Bay site are provided through small generators.

Due to the substantial existing diesel power generation equipment and associated infrastructure at the Hope Bay Property, alternatives to diesel power generation are not considered practicable at this time. However, TMAC is reviewing the feasibility of wind power generation (refer to Section 7 discussion on alternatives).

4.4.10.1 Doris

The approved Doris power plant currently supplies power to the entire Doris Site. Power load requirement for the mine, mill and site related facilities, will range from approximately 40,000 MWh/year usage initially up to approximately 85,000 MWh/yr.

4.4.10.2 Madrid

Madrid North will be serviced by dedicated power generation plant (3 units at 1.2 MW) located next to the processing plant. For Madrid South demand will be limited to mining operations and related office space. Madrid South will utilize two 600 V, 725 KW generators in a N+1 configuration for 1,000 tpd operations with a 600 V, 350 KW generator for emergency standby power.

4.4.10.3 Boston

Boston, due to its distance from Doris, will have mining operations and associated support infrastructure and a 200 person accommodations facility. Boston will also be supported by a dedicated power generation plant consisting of eight 1.2 MW generators with a 725 KW standby generator. TMAC is proposing to build a power line (aerial or on ground) from Doris to Boston as a means of centralizing long-term power generation. A power line would also provide site independent power supplies in case of a local outage. However, startup operations at Boston will rely on local power generation described above. A power line to Boston would also support future development of wind power which could be tied into the power grid.

Power distribution feeders will be required at each mine site. Each site will require five feeders protected by disconnects; two underground feeders, a separate feeder for the ventilation fan, a surface facilities feeder and a spare with cross ties for availability in the event of failure of one of the feeder switches.

4.4.11 Hazardous Material Management

All hazardous materials received, handled and stored on site will be managed in accordance with TMAC's Hazardous Material Management Plan already approved under Type A Water Licence. A list of chemicals stored on site is presented in Table 4.4-11.

Table 4.4-11. Hazardous Chemicals On-site

Material	Tonnes
Collector	468
Promoter	156
Frother	83
Flocculant Low pH	83
Sodium Cyanide	1,248
Caustic Soda	2,340
Flocculant High pH	10
Sodium Metabisulphite	1,248
Copper Sulphate	650
Hydrochloric Acid	21
Sodium Benzoate	104
Soda Ash	46

Material	Tonnes
Potassium Nitrate	26
Calcium Chloride	57

4.4.12 Safety, Security, and Fire Control

Site Security is achieved primarily by location and limited access points. All persons entering and leaving the site are tracked by passenger manifest and approved for entry prior to boarding aircraft. All persons entering site for a visit or work will receive an orientation on site safety rules, relevant regulations, evacuation procedures, and occupancy rules. Violation of rules can lead to immediate revocation of the privilege to be on site and transport off site.

Site safety will follow best practices with oversight by site safety coordinators ensuring site rules, procedures and regulations are followed. Safety coordinator will audit employees and contractors for conformance. Failure to follow safety criteria can lead to immediate revocation of the privilege to be on site and transport off site. Contractors with repeated problems will be removed from site and not eligible for future tenders.

Fire control will generally be managed by training and vigilance of the workforce in identifying fire hazards and responding with hand held equipment. In addition, automatic detection and suppression systems are deployed for high risk and/or high value installations. The site offices and sleeping quarters are protected by automatic fire sprinkler systems with alarms to provide immediate suppression and alert surrounding occupants. The site sleeping quarters are further protected by firewalls with automatic closing doors to prevent a rapid spread of fire. High value equipment such as the power generators are protected by automatic inert chemical fire suppression systems with integral alarms. Large underground mobile equipment is protected with manually actuated dry chemical fire suppression systems limit risk an equipment fire can lead to entrapment of mine employees. Mill equipment with flammable liquids will be protected by automatic dry chemical fire suppression systems in addition to hand held equipment.

Fire evacuation plans for all areas are formal and include designated muster points and identification of potentially missing persons. The Doris Site has an emergency shelter capable of sustaining site occupants until site evacuation should there be a catastrophic loss of site facilities. Underground operations will be provided with two means of escape and refuge chambers utilized for areas beyond access to a second escape way or where escape would take longer than 40 minutes. All persons entering and leaving site are informed they are subject to search at any time to reduce the opportunity for theft. The gold room will be a secure facility requiring restricted access

The Hope Bay site is a dry camp – there is zero tolerance for alcohol or drug use. Pre-employment screening and testing for cause will be utilized to ensure the site remains free of the hazard of drugs and alcohol.

Site emergency response will be achieved through the training and equipping of an emergency response team. The emergency response team (ERT) will be trained in surface and underground rescue to maximize the number of available responders among the relatively small site population. The site currently has a mine rescue station with sufficient apparatus and most support equipment required to make it operation on recertification by manufacturers' representatives.

4.4.13 Auxiliary Services

4.4.13.1 Maintenance Facilities

Underground primary service and lubrication will be carried out underground to minimize the transit of equipment and exposure to cold weather. Underground service bays are served by two modular fuel and lube storage unit equipped with automatic fire suppression and fire doors to comply with mining regulations for underground flammable storage.

For equipment maintenance, each mine site will have a maintenance facility of approximately 15 × 30 m in area providing two service bays and a wash bay for the major equipment. The shops at Madrid and Boston will carry out minor repairs and major repairs will be carried out at the Doris facility. A low-boy will be available to transport equipment from the remote sites to the main mine.

Major repairs will be carried out in the main maintenance facility at Doris which consists of a high bay shop sufficient for six pieces of mobile equipment to be under repair at any one time. In addition, a satellite facility is also available for storage and service of equipment. The primary maintenance shop has seacan storage and office spaces attached to allow for ready access to consumable supplies and to organize work.

4.4.13.2 Office Facilities

The Doris facilities are in good shape, and provide adequate space for ongoing production and support of the Madrid North and South. There will be a need for office space at Madrid North and South and, Boston to support the mining teams and site support supervision at Boston. Atco office trailers will be installed at the Madrid sites as well as the Boston where a 200-person dry accommodations facility will also be installed. Arctic corridors will be installed to provide covered access to the mill and related facilities.

4.4.13.3 Employee Accommodations

It is anticipated that up to 700 beds (i.e., including on-going Doris operations) may be on the Hope Bay property during the peak Construction phase, and up to 600 beds during the peak Operation phase.

The existing Doris Site can house approximately 280 persons under current authorizations and the Boston Site approximately 120 persons, which could accommodate the early Construction phase.

For the Operation phase, the Doris Site accommodations will be expanded to accommodate 400 persons and the Boston Site accommodations will be expanded to 200-person capacity.

4.4.13.4 Communications

The site has established adequate satellite support infrastructure and site based server capacity to support modern mining operations. The site wireless fidelity (Wi-Fi) system is fully functional in all office and dormitory spaces.

A voice over IP (VoIP) based phone system is operational and allows for over 100 extensions are available for business and personal communications. Phone booths are provided for free calling to home via this system.

The site radio system communicates across all active areas of the belt from Windy Lake to Roberts Bay by means of a series of repeaters. The underground radio communications are operating for the Doris underground mine workings and will be expanded to include Madrid and Boston.

4.5 ROADS AND VEHICLE TRAFFIC

4.5.1 Road Network and Maintenance

The Project and the Doris Project will have a total of 90.5 km of roads during the Operation phase.

Existing, well maintained roads lead from Roberts Bay through the Doris airstrip to the Doris mine site and further south to Windy Lake (see Figure 3.7-1). As well there is a winter road route from Doris to Boston and portage access routes established for winter access to Roberts Bay and Doris Lake (Figure 3.7-1). Windy Road from Doris south to the Madrid North site is in place.

An extension of the AWR from Madrid North site to the Madrid South site is planned to be constructed as part of the Madrid Advanced Exploration Program and will be in place for the Project.

An AWR will connect Madrid to Boston (Section 3.7), and an AWR will connect the proposed marine dock at Roberts Bay to the laydown area at Roberts Bay. An access road will connect the southern end of the TIA with the Madrid North Infrastructure (Madrid North to TIA Road Preliminary Design Memo, Appendix V3-4G). Approximately 3.6, 2.3, and 4.5 km of access and haul roads will be operational at Madrid North, Madrid South, and Boston, respectively.

Road maintenance will be required weekly during the busy period around the annual sea lift. When the road is used less frequently, maintenance is expected to only be required monthly during the snow free months. During the winter months it is expected that some level of snow clearing will be required daily; and additional clearing may be required in stormy or windy weather.

The all-weather road will be periodically maintained using a conventional road grader, following standard road grading procedures for gravel topped roads. The surface will be roughened up, the crown reshaped, ruts, potholes and areas of settlement will be filled.

Periodically new surfacing material will be required to fill in settlements, potholes or to reshape the road crown. Stockpiles of crushed quarried rock will be maintained at the site quarries for this purpose. If dust suppression is required, water will be sprayed from a truck mounted tank used solely for this purpose. The truck will be filled from existing or planned freshwater supply systems, no chemical suppressants are planned for or thought necessary. Speed control is the main mechanism for dust suppression. The maximum speed on-site is 50 km/hr. At low speed, less dust is generated.

4.5.2 Vehicle Traffic

Table 4.5-1 summarizes the expected vehicle traffic for the Project.

Table 4.5-1. Project Vehicle Traffic Roberts Bay, Doris, Madrid, and Windy Lake

	Peak Vehicle Traffic Expected for Phase 2			
	Peak Years	**No. of Return Trips**	**Type**	**Frequency**
Madrid North to Doris - Year1 to Year 13				
Transport of ore and concentrate	Year 5 to Year 13	53	40-t haul truck	Daily
Transport of leach tailings to Madrid North	Year 5 to Year 12	3	40-t haul truck	Daily
Transport of fuel	Year 4 to Year 13	1	60 m^3 tanker	Every 2 days
Transport of supplies	Year 1 to Year 13	1	Flatbed truck	Daily

	Peak Vehicle Traffic Expected for Phase 2			
	Peak Years	No. of Return Trips	Type	Frequency
(assume 500 seacans/year for 1,000 tpd mill and mine; 2 × 20t seacan per truck)				
Transport of employees	Year 1 to Year 13	8	40 person bus	Daily
(assume 120 workers for mill and mine at Madrid North – 2 × 12 hours shift per day)				
Service vehicle	Year 1 to Year 13	20	Misc vehicles	Daily
Windy Lake to Doris – Year 1 to Year 4				
Transport of water	Year 1 to Year 13	6	20 m^3 tanker	Daily
Boston to Doris – Year 4 to Year 13				
Transport of ore	Year 5 to Year 6	42	40-t haul truck	Daily
Transport of concentrate	Year 6 to Year 13	4	40-t haul truck	Daily
Transport of fuel	Year 5 to Year 13	1	60 m^3 tanker	Every 3 days
Transport of supplies	Year 4 to Year 13	2	Flatbed truck	Daily
(assume 1,000 seacans/year for 2,000 tpd mill and mine; 2 × 20t seacan per truck)				
Service vehicle	Year 4 to Year 13	20	Misc vehicles	Daily

4.6 AIR TRANSPORT

4.6.1 Roberts Bay/Doris Airstrip

The all-weather airstrip (length ~ 1,525 m) located between Roberts Bay and the main Doris Site is capable of landing aircraft up to a Hercules C-130. The runway can also accommodate Bombardier Q400 aircraft. It is constructed with ROQ rock topped with a crush layer for durability. Dust suppression is managed through the use of water trucks or environmentally safe chemical dust suppressants, as required.

4.6.2 Boston Airstrip

Construction of the new airstrip at Boston is described in detail in Volume 2, Section 3.9 and Appendix V3-3K. The airstrip is assumed to be constructed to the extended design length of 1,974 m such that it is capable of landing aircraft up to Hercules C-130.

The airstrip will be regularly inspected, and airstrip maintenance will occur as necessary. Maintenance is expected to consist of reshaping the crown and filling ruts, potholes, and areas of settlement. Periodically, new surfacing and/or finishing material will be required. Stockpiles of crushed quarried rock will be maintained at the site quarries for this purpose.

During the winter months, it is expected that snow clearing of the airstrip and access road will be required prior to any incoming flights. If dust suppression is required, water will be sprayed from a truck mounted tank used solely for this purpose. The truck will be filled from existing or planned fresh water supply systems; no chemical suppressants are planned for or thought necessary.

4.6.3 Winter Airstrips

In the past there has been a certified and Transport Canada registered ice airstrip on Doris Lake. This ice strip is normally operational from February to mid-April when ice thicknesses and surface conditions permit larger aircraft operations including heavy lift air transports, direct to Hope Bay and return.

An ice airstrip has also been utilized in the past on Aimaokatalok Lake at the Boston Site and Windy Lake near Madrid. These strips will be constructed as required each winter for the Project.

4.6.4 Air Freight for Construction and Operations

Air freight service to Hope Bay is accomplished on regularly scheduled crew transports which typically accommodate 900 kg of cargo each trip out of the 2,550 kg payload capacity. An additional 680 kg payload capacity per trip will be achieved by on-site refueling operations via refueling tanker truck stocked with bulk Jet A fuel. Appropriate quantities of Jet A fuel will be sealifted each year. In addition to the available payload on crew rotation charters, the Project will make use of freight aircraft.

4.6.5 Personnel Transport

Personnel transport services are based on charter aircraft from Edmonton, Yellowknife, or Kitikmeot communities. Southbound (Edmonton and Yellowknife) passenger flights will occur 2 times a week, and will make use of aircraft sized to optimize transportation costs, these may include Dash 8s, Dorniers, ATR72, 737s or similar aircraft. Nunavut residents are transported via Dornier's, twin otters or other similar aircraft to site.

As the permanent operational workforce is hired, the routing of employees will be examined to optimize transportation costs. TMAC will specify a few regional hubs as points of hire for transportation of employees to limit costs and complexity of travel.

4.7 MARINE TRANSPORT

4.7.1 Marine Facilities

Roberts Bay is located approximately five kilometres from Doris and is the main port entry point to the Belt. The facility provides a marine dock, cargo offloading jetty, a diesel fuel offloading facility, and additional fuel storage facility.

An approximately 65 m long, 30 m wide jetty was constructed in the summer of 2007 and improved in 2013 and 2014 at the south end of Roberts Bay for the Doris Project. Water depth at the jetty head is approximately three metres. Five land-based mooring points were installed in the summer of 2010 to provide fixed points for vessel moorage. They are located on rock outcrops near the Roberts Bay shore, one on either side of the jetty, one near the existing Roberts Bay fuel tank, and two approximately one kilometre northwest on the west shore of the loading facility. Each mooring point consists of steel anchor rods grouted into solid rock to a depth of ten metres, attached to a steel superstructure with a shackle to attach a mooring line from a vessel.

The jetty has been enhanced to safely support cargo loads that are anticipated to cross the structure during construction of the process plant. The jetty was improved in accordance with the existing Doris Fisheries Authorization, Federal Land Lease, and Navigable Waters Approval (Table 1.3-1). The improvements included widening and armouring the jetty as well as creation of fish breeding habitat to replace habitat lost in the development of the jetty.

To support the safe and efficient offloading of fuel, equipment and supplies, a marine dock will be constructed (Figure 3.3-1; Section 3.3) and utilized for the Project. The marine dock will have a 9 m water depth at the dock face (compared to the Jetty's 3 m depth), so it will be able to support cargo ships as well as large ocean-going barges. Cargo ships used will have self-loading capabilities and store cargo both in secured hatches and in containers stowed on deck. Goods received at the dock would be transferred to vehicles for transport to the marine laydown area for further storage or sorting, and processing prior distribution to the Project sites.

The proposed dock, although allowing much deeper drafts than the existing Jetty, will still require that large fuel vessels moor offshore. Large fuel ocean going vessels such as the Handi Max tankers require a minimum depth of 12 m. Offshore mooring for these ocean going vessels will include attachment to two fixed mooring points onshore and using the ship's anchor to hold the ship in place during fuel transfer activities. A work boat will ferry a floating hose (300 to 400 m) to connect the tanker manifold to a shore manifold and pipeline which leads to the fuel tank farm. The fuel off load facilities will be separated from cargo handling operations to prevent any interference. Appropriate emergency/spill response equipment will be on hand during these fuel transfer events and offload will be undertaken as outlined in an Oil Prevention Emergency Plan/Oil Prevention Pollution Plan prepared in advance of each years offload events. Additionally, the manifold will have an associated sump to collect any spills. Pipeline connections for fuel transfer to the Roberts Bay fuel tank farm will allow for immediate offloading to these facilities.

4.7.2 Annual Sealift for Operations

In order to provide for the economic supply of material, equipment, etc., into the Hope Bay site, an annual sealift is required. This sealift generally occurs in the August to October period, when the ships and barges can access the site.

The main sealift will use the ports of Montreal and/or Vancouver as the embarkation point. There is also the capability to use the Mackenzie River system, and having Hay River as the embarkation point. Freight will move to site along the least cost route with emphasis on reducing risk by splitting key deliverables such as fuel to two or more routes. Annual sealifts have been estimated at approximately 10,000 tonnes of material. This includes all mine, mill and surface supplies.

Logistics surrounding the sealift are planned in advance and booked early in each year to maximize supply of material, equipment, etc. during the short shipping season to Hope Bay. An office is maintained in Yellowknife, in order to provide logistical assistance.

The expected annual deliveries of fuel and cargo are summarized in Table 3.3-1

4.8 EXPLORATION ACTIVITIES

Exploration activities related to the Phase 2 project will continue throughout the Project life. Geological and geophysical mapping, diamond drilling, and sampling provide data for statistically robust estimates of the extent and quality of deposits and an improved geological knowledge of the area. The surface drilling at Madrid North and South, in combination with underground drilling, and the bulk sample program, will collectively provide information that will support a potential upgrade to the mineral resource classification.

All surface exploration activities will occur in consultation with the project archaeologist, and exploration personnel will be trained in archaeological site recognition and reporting. Land-based drilling will be > 31 m from water bodies. Drill inspections will be routinely conducted to ensure impacts from exploration are minimized. A program of progressive reclamation will be undertaken for all surface drilling. Immediately upon completion of drilling, all casings and collars will be removed to ground level and sealed, and other materials will be removed, and any depressions which may have formed around the drill collar will be filled to the extent practicable to prevent future pooling of water.

4.8.1 Diamond Drilling

The diamond core drilling uses a core barrel and bit with a hollow diamond drill bit to collect a continuous sample of rock. These samples will be transported to Doris or Boston for processing in the core logging and sampling facilities and sampled core will be stored on site for future reference.

Surface land-based drilling makes use of light heli-portable shacks which are transported by helicopter or moved by heavy machinery along existing all weather road routes. Winter surface drills are generally steel enclosed structures transported on skids between drill locations, often on ice. Surface drill rig fuel will be stored in small double-walled fuel tanks at each drill site. Quantities will vary, but should not exceed ~1,500 L at a time, and will have spill containment protection. Underground diamond drills are powered off of electricity sourced from surface generators.

Chemicals used during drilling activities include calcium chloride (salt) used to prevent freezing of the water in the hole, Visco which is used as a lubricant in the hole, linseed soap for cleaning of drill string components, and heavy grease to prevent seizure of drill rods to each other. Salt will be stored in containment as appropriate, while the other materials are stored within the drillers' seacans located on site. Small quantities of each material are also located with each drill. No salts or drilling lubricants are used for on-ice drilling, where unfrozen taliks surrounding the lakes reduce the need for these substances.

In Arctic permafrost drilling conditions, diamond drilling requires a drilling fluid that uses water that is either heated and/or salinated to maintain the sample and drill efficiency. To maintain a properly conditioned drill hole, drilling fluids are added to drill water and injected down the hole. Additives, such as polymers, assist in lubrication, wall cake suspension, and other functions needed for different drilling conditions. Flocculent agents are used to assist in removing drill cuttings from the drill water supply in the event that recirculation and containment of fluids/spoils are required. Calcium chloride is used to lower the freezing point of drill fluids to allow them to remain in liquid form while drilling in freezing subsurface conditions.

4.8.2 Water Use

Water supply for the individual drill sites will be provided by a nearby lake that has a surface area of at least 15,000 m^2 and, if drawing water from under ice, complies with Department of Fisheries and Oceans's (DFO) *Water Withdrawal under Ice Guidelines* (DFO 2010). Intake screens will also consider DFO's measures to reduce serious harm for water intakes[2]. For Madrid drill locations, Patch, Windy and Wolverine Lakes will serve as the sources of water. For Boston drill locations, Aimokatalok Lake, and possibly Trout and Stickleback lakes will provide drill water. Water is metered and recorded daily as consumed by each drill, or tracked by delivered truckload to temporary water supply tanks when drills are located adjacent to the road system. Anticipated water needs have been included in the water usage summarized in Section 4.4.5.

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[2] http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/measures-mesures-eng.html

4.8.3 Waste Management

Water from the drill will be recycled to minimize the quantity of freshwater used, and to reduce salt use. Excess brine remaining following drill completion will be disposed of with salt-containing drill cuttings.

Drill cuttings are pumped to a cuttings management containment system that allows the cuttings to settle and separate from the drill water. The clarified water is re-circulated through the system. If cuttings are brine free (where not generated while added salt was used), cuttings sludge may be deposited in a natural depression in the vicinity of the drillhole, or transported by helicopter to a central cuttings management area where direct flow into a water body is not possible and no additional impacts are created. If the cuttings are contaminated with brine, they are transported to a containment facility where runoff is captured for treatment or transfered to an appropriate wastewater disposal facility (e.g., Doris TIA, or Boston TMA).

4.8.4 Airborne, Surficial, and Downhole Geophysics

Geophysical methods are used to describe the magnetic and gravity properties of the geologic material. No water is used and no wastewater is produced and this activity is included to provide a comprehensive list of activities that may occur as part of exploration activities.

4.8.5 Prospecting, Trenching, Mapping, and Sampling

Prospecting and mapping typically involve surficial investigations to systematically identify the underlying geologic material and mineralization. This program also involves the collection of samples collected by hammer from outcrops or from shallow depths using mechanical methods such as channel saws and portable/back-pack diamond drills. Water needed for the mechanical methods would be provided by local nearby lakes.

Trenching involves the use of heavier equipment to excavate the underlying material to access areas to sample. No trenching is planned at this time in the Madrid Area; however, if needed to improve geologic understanding or inform ongoing feasibility studies.

5. Closure and Reclamation

The Interim Mine Closure and Reclamation Plan (ICRP) submitted in support of the Type A Water Licence will be updated to take into consideration the additional facilities for the Project. The Project Closure and Reclamation Plan is provided in Annex 27 of Volume 8. The Project Closure and Reclamation Plan Bonding Costing Basis is provided in Annex 28 of Volume 8 (Phase 2 Mine Closure and Reclamation Plan Bonding Costing Basis memo) The following section describes TMAC's approach for closure and reclamation.

5.1 INTERIM MINE SITE CLOSURE OBJECTIVES

Over the life of the Project, it is expected that techniques and methodology for mine site reclamation will continue to evolve with changes to our understanding of the Project site, stakeholder's views and technologies for cost effective and practical reclamation in northern conditions. Planning for the mine site reclamation will be risk based and remain dynamic in order to take into account results of on-going studies and identified best practices for the site specific conditions as this knowledge base is expanded over time.

The site has been designed with closure in mind and throughout operations every effort to apply progressive reclamation will be evaluated and implemented where practical to do so. The overall objectives of the closure and reclamation plan are to establish stable chemical and physical conditions and ensure the future use and aesthetics of the site following reclamation, and meet the requirements of Aboriginal, Federal and Territorial governments, landowners, local communities and regulatory authorities. These objectives and the closure and reclamation criteria and strategies presented have been developed in accordance with the Nunavut Mine Site Reclamation Policy (DIAND 2010) and the 2*007 Northwest Territories Mine Site Reclamation Guidelines* (INAC 2007).

In terms of future land use, some infrastructure at the site is a substantial contribution to the development of Nunavut and could be left in place after closure following consultation with all interested parties. For example, the fuel storage, airstrip, port/jetty, roads and rock pads can be used as a base for other projects in the area. However the EIS assumes these structures and facilities will all be removed and/or reclaimed to acceptable standards.

5.1.1 Goals for Final Closure

The goals for the Final Closure are to:

- apply the principles of pollution prevention and continuous improvement to minimize ecosystem impacts, and facilitate biodiversity conservation;
- use energy resources, raw materials and natural resources efficiently and effectively;
- engage with governments, local communities and the public to create a shared understanding of closure and reclamation issues and take their views into consideration in making decisions;
- return the Project affected and viable sites to "wherever practicable, self-sustaining ecosystems that are compatible with a healthy environment and human activities" (NRCan 1994);
- where practicable, undertake reclamation of affected areas as soon as practical in an on-going and progressive manner to reduce the environmental risk once the mine ceases operation (INAC 2002, 2007);

- provide for the reclamation of affected sites and areas to a stable and safe condition and restore altered water courses to near their original alignment and cross-section, and where practical, affected areas will be returned to a state compatible with the original undisturbed area (Territorial Land Use Regulations);
- reduce the need for long-term monitoring and maintenance by designing for closure and instituting progressive reclamation, when possible;
- provide for mine closure using the current available proven technologies in a manner consistent with sustainable development; and
- provide sufficient detail such that adequate scopes of work can be developed for the execution of reclamation work, and where insufficient details exist, monetary allowances should be included in the cost estimate to account for additional engineering and planning.

5.1.2 Post Closure Goal

The goal of the Final Closure activities as outlined in the ICRP is to abandon the Project sites and achieve the "Recognized Closed Mine" status (Section 1 Metal Mining Effluent Regulations) as rapidly as practicable.

The primary objectives that will enable TMAC to obtain the Recognized Closed Mine status are:

1. Ensure the safety of the abandoned sites for wildlife and human users;
2. Ensure physical stability of abandoned Project sites and remaining physical features (road embankments, infrastructure pads and stream crossings);
3. Ensure chemical stability of the mine and other Project disturbed areas; and
4. Incorporate considerations for future land use of Project sites in Final Closure planning.

Secondary objectives are:

- Where practical, promote and enhance natural re-vegetation and recovery of disturbed areas that is compatible with the surrounding natural environment and to allow for the future use by people and wildlife.
- Implement reclamation in a progressive on-going manner during the life of the Project and restore sites as soon as an area is no-longer required to limit the need for long-term maintenance and monitoring.

5.2 PROGRESSIVE RECLAMATION

Most of the Project areas will be actively used during the construction and operation phases of the Project, although where practical, areas which are no longer needed to carry out Project activities will be progressively reclaimed during construction and operations. Where practicable, progressive rehabilitation will be implemented to achieve the Projects site abandonment goal and closure principles.

The general progressive rehabilitation measures for each Project component is provided in the subsections below.

5.2.1 Laydown Areas

Laydown areas no longer required will be re-graded to ensure physical and geotechnical stability and promote free-drainage, and, any obstructed drainage patterns will be re-established. Surface runoff and seepage water quality will be safe for humans and wildlife, and the area will not inhibit wildlife movement.

5.2.2 Quarries

Quarries no longer required will be made physical and geotechnically stable by scaling high walls and constructing barrier berms upstream of the high walls. The quarry floor will be regraded to ensure free drainage, while maintaining water quality safe for humans and wildlife. Closure and reclamation of these sites may be carried out in accordance the site specific permits.

5.2.3 Non-hazardous Landfill

Non-hazardous landfills will be progressively covered with quarry rock, as cells are completed. At final closure, the facility will receive a final quarry rock cover which will ensure physical and geotechnical stability. Surface runoff and seepage water quality will be safe for humans and wildlife, and the area will not inhibit wildlife movement.

5.2.4 Landfarms

Hydrocarbon-contaminated materials may be temporarily stored in lined landfarms prior to permanent relocation underground. Hydrocarbon-contaminated materials may be stored throughout the life of the Project in landfarms to maintain the chemical stability of the site. When no longer required, landfarms will be closed by removing and disposing of the liner, and re-grading the berms to ensure the area is physically and geotechnically stable. Surface runoff and seepage water quality will be safe for humans and wildlife, and the area will not inhibit wildlife movement.

5.2.5 Camps and Associated Infrastructure

Non-hazardous components of construction camps and associated infrastructure no longer required for operations will be demolished and/or disposed of in approved non-hazardous site landfills. Rockfill pads occupied by construction camps and associated infrastructure, no longer required for operations will be re-graded to ensure physical and geotechnical stability and promote free-drainage, and, any obstructed drainage patterns will be re-established. Surface runoff and seepage water quality will be safe for humans and wildlife, and the area will not inhibit wildlife movement.

5.2.6 Waste Rock Pile

All mine waste rock will be used as structural mine backfill. There is predicted to be a deficit of backfill material. In the later stages of the mine life backfill will be supplemented from surface rock quarries. As a result, there will be no mine WRPs at the end of the Project life requiring reclamation.

5.3 TEMPORARY MINE CLOSURE AND SUSPENSION OF ACTIVITIES

The *Mine Site Reclamation Policy for Nunavut* (INAC 2002) and the *Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories* (MVLWB/AANDC 2013) require that contingency measures be established in the ICRP for temporary closure of a mine site. Temporary closure is defined as the planned shutdown of a mine site for a period of less than one (1) year. This section of the report presents the plans for suspension of activities of less than one (1) year. Section 5.4 below covers Long-term Temporary Closure beyond one year.

Short-term Temporary Mine Closure will occur when the Project ceases operations for a period of less than one (1) year with the intent of resuming operational activities or final closure activities. When this occurs, the Project enters a "Care and Maintenance" phase, the main objective of which is to maintain all equipment and facilities in a state of readiness to resume operation with minimal delay or have project components at the ready for use to support closure activities while ensuring appropriate environmental protection measures or activities continue.

Care and maintenance preparation will be implemented and executed by operational maintenance staff and other support personnel on site and will be carried out within approximately six (6) months of the initiation of the Temporary Closure Care and Maintenance phase based on the level of effort required. Access to the Project sites, buildings and structures will be restricted to authorized persons only. Buildings where potential hazards exist will be locked or otherwise secured.

5.3.1 Health and Safety of Workers and the Public during Temporary Closure

The health and safety of workers and the Public will be ensured during Temporary Closure Care and Maintenance. Infrastructure will be kept secure by routine maintenance and inspections to eliminate any hazard to the public health and safety. Access to buildings and infrastructure will be restricted to authorized personnel only. Water management and environmental protection measures will continue as required to ensure environmental protection.

Employees on site will be trained in site-specific health and safety requirements. TMAC will abide by all applicable *NWT/Nunavut Mines Safety Act* and Regulations, and the *Explosives Use Act*. TMAC will ensure that emergency procedures are updated, if required, and implemented and that all equipment necessary to properly carry out these procedures will be accessible and kept in good working condition.

5.3.2 Restriction of Access and Site Security

During Temporary Closure Care and Maintenance, the Project sites will be maintained in a secure condition through the provision of appropriate measures. Mine dewatering, where required, will continue. As a result, a number of operational maintenance staff, environmental personnel and other support personnel will be onsite when needed. Access to buildings, structures, and storage compounds will be restricted to authorized persons. Buildings where potential hazards exist will be locked or otherwise secured with signed fences and/or barriers.

Qualified personnel will carry out routine inspections of security, safety and environmental measures and maintain a record of these inspections. Contact information will be provided to pertinent government agencies and the landowner, to facilitate their communication and potential access to the Project sites, if and when necessary.

During Temporary Closure Care and Maintenance, reclamation activities such as re-grading may continue as per the progressive reclamation plan (Section 5.2). Site discharge streams will be controlled as part of regular maintenance activities, and all unused pipelines will be maintained in a state that prevents freezing and/or other damage.

5.3.3 Security of Mine Openings

The entrance ramps to the underground mine portals, and vent raises will be barricaded and signs posted to prevent inadvertent access.

5.3.4 Security of Mechanical, Hydraulic Systems and Electrical Systems

During Temporary Closure Care and Maintenance, equipment required for the security and safety of the infrastructure systems, including environmental aspects, will be maintained in working condition. Buildings will be locked or otherwise secured to prevent inadvertent access once the Project sites are evacuated by the majority of the personnel, except as required by the onsite staff for site maintenance and security. Non-essential machinery, equipment and systems will be left in a no-load condition, or removed from site. Live electrical systems will be fenced, locked, or otherwise secured against inadvertent entry or contact, and appropriate signs will be placed to warn of potential hazards.

5.3.5 Hazardous Materials and Waste Management Sites

During or prior to Temporary Closure Care and Maintenance, an inventory of all hydrocarbon products, chemicals, explosives and hazardous wastes/materials (e.g., used oils, ammonium nitrate and greases) will be updated and the materials stored in a secure and environmentally sound manner. All storage facilities that contain any such materials will be secured and monitored. Inert waste will be disposed of in the landfill sites.

During Temporary Closure Care and Maintenance, the non-hazardous waste management facilities at the Project will continue as in normal operations on an as-required basis.

5.3.6 Roberts Bay Jetty and Airstrip

During Temporary Closure Care and Maintenance activities, the all-weather airstrips, jetty and cargo dock infrastructure at Roberts Bay will be left in place. All non-essential airstrip and dock machinery, equipment and systems will be left in a no-load condition. Live electrical systems will be fenced, locked, or otherwise secured against inadvertent entry or contact, and appropriate signs will be placed to warn of potential hazards.

5.3.7 Control of Effluents

The water management requirements at the sites during Temporary Closure Care and Maintenance will include:

- domestic sewage treatment at the Doris and Boston sites; and
- surface/discharge waters, as per applicable regulatory requirements.

The drainage system established during operations will be retained and surface water will continue to collect in existing contact water ponds and, where required by the Water Licence, waters will be treated prior to discharge to the receiving environment.

5.3.8 Stabilization of Stockpiles

Ore and waste rock stockpiles will be visually assessed for stability at the start of the Temporary Closure Care and Maintenance period and stabilized if required. The stockpiles will be periodically inspected.

5.3.9 Site Inspection Program

The Project sites will be periodically visually inspected for physical stability by onsite qualified personnel. The environmental management and monitoring plans implemented during the Project operation phase will remain effective and in use for the Temporary Closure Care and Maintenance period.

5.3.10 Notification of Temporary Closure

Employees, local communities, and the public will be notified in advance of any scheduled short term temporary closure activities.

5.3.11 Environmental Management and Monitoring

During the Temporary Closure Care and Maintenance period, all terms and conditions of the Project Certificates and Water Licences will remain in force. Throughout the Temporary Closure Care and Maintenance period, TMAC will continue to report on its activities on an annual basis to the NIRB (as per Project Certificate requirements), the NWB (as per Type A Water Licence requirements). If a Care and Maintenance monitoring schedule is required differing from Operations, it will be established in compliance with the Aquatic Effects Monitoring Plan (AEMP) and other applicable management plans in consultation with applicable regulators.

5.4 LONG-TERM TEMPORARY MINE CLOSURE CARE AND MAINTENANCE

A “Long-term Care and Maintenance Plan” would be submitted to the NWB and the Land Owner at least 60 days prior to entering the Long-term Mine Closure period. Site personnel will conduct general inspections periodically and may decrease that frequency if the site inspections indicate that the site infrastructure is stable. A record of these inspections will be maintained. The names of contact persons will be provided to the pertinent regulators and government agencies such as INAC and Landlord for their information, and to facilitate their access to the site, if and when necessary. The Project could reopen when the circumstances requiring the Long-term Temporary Closure change (e.g., when economic or other conditions that caused the temporary cessation of operations is no longer of concern).

The following sub-sections describe the detailed activities that would be undertaken to secure the Project components in the event of Long-Term Temporary Mine Closure.

Once these measures have been implemented, the labour force on site is reduced to the minimum required to ensure security of the site and on-going monitoring requirements. It is expected the following activities will be carried out within approximately six (6) months of the initiation of Long-term Temporary Closure based on the level of effort required.

5.4.1 Health and Safety of Workers and the Public during Long-term Temporary Closure

Health and safety of workers and the public will be ensured during Long-term Temporary Closure. Infrastructure will be kept secure by routine maintenance and inspections to eliminate any hazard to the public health and safety, or to the terrestrial or aquatic receiving environment.

Access to buildings and infrastructures will be restricted to authorized personnel only. Safety will be reinforced by an inspection program. It will be ensured that emergency procedures will be applicable and that all equipment necessary for these procedures will be accessible and kept in good working condition.

5.4.2 Restriction of Access and Site Security

During Long-term Temporary Closure, the Project sites will be maintained in a secure condition. Access to the buildings, structures and storage compounds will be locked and/or fenced/gated. Potentially unsafe areas will be posted with appropriate signage. Unused machinery and equipment will be removed, where practical.

On commencement of Long-term Temporary Closure, explosives will be either removed from the Project or/and detonated or burnt in a controlled and safe fashion by experienced and licensed personnel at appropriate locations away from sensitive receptors.

During Long-term Temporary Closure, reclamation activities such as re-grading will continue as per the progressive reclamation plan. Discharge management will be maintained as part of regular maintenance activities. Additionally, care will be taken that lines and pipes do not freeze and break.

5.4.3 Security of Underground Mines

In addition to the measures outlined in Section 5.3.4, during Long-term Temporary Closure dewatering of the underground mines may cease and the underground workings allowed to naturally flood.

5.4.4 Security of Mechanical, Hydraulic, and Electrical Systems

All buildings will be locked and/or otherwise secured to prevent inadvertent access once the Project is evacuated by the majority of the personnel, except as required by the onsite staff for site maintenance and security. All non-essential machinery, equipment and systems will be left in a no-load condition. Live electrical systems will be fenced, locked, or otherwise secured against inadvertent entry or contact, and appropriate signs will be placed to warn of potential hazards.

5.4.5 Hazardous Materials and Waste Management Sites

Non-hazardous waste will first be disposed of in the landfill sites. During or prior to the Long-term Temporary Closure an inventory of all hydrocarbon products, chemicals, explosives and hazardous wastes (e.g., used oils and greases, reagents) will be updated and all materials placed in secondary containment or shipped south to the appropriate hazardous waste disposal facility via sealift. All storage facilities that contain any such materials will be secured and monitored routinely.

5.4.6 Stabilization of Stockpiles

At the onset of Long-term Temporary Closure the waste rock stockpiles may undergo minor re-contouring and the physical and chemical stability of the waste rock stockpiles will be assessed. Following this investigation and according to the stockpile geometry at the time of Long-term Temporary Closure, aspects related to erosion, runoff control, slopes, benches, and discharges will be addressed.

Ore stockpiles are expected to be depleted prior to Long-term Temporary Closure. In the event the ore stockpiles remain during Long-term Temporary Closure, they will be monitored.

5.4.7 Roberts Bay Jetty and Doris Airstrip

During Long-term Temporary Closure activities, the airstrips and dock and jetty infrastructure at Roberts Bay will be left in place. All non-essential machinery, equipment and systems will be left in a no-load condition. Live electrical systems will be fenced, locked, or otherwise secured against inadvertent entry or contact, and appropriate signs will be placed to warn of potential hazards.

5.4.8 Control of Effluents

Water management at Project sites will be required during Long-term Temporary Closure, including:

- domestic sewage treatment at Doris and Boston; and
- surface/discharge waters, as per applicable regulatory requirements.

The drainage system established during operations will be retained and surface water will continue to collect in existing CWPs and be managed as required by the Water Licence and/or the Metal Mining Effluent Regulations.

5.4.9 Site Inspection Program

The Project sites will be periodically visually inspected for safety and environmental concerns by qualified personnel.

5.4.10 Environmental Management and Monitoring

During Long-term Temporary Closure, an application for a licence amendment would identify the changes proposed for the facilities required to be shutdown, the location of new discharges (if any), updates to any management plans and/or the AEMP (if required), and an indication of sites to be permanently rehabilitated. A monitoring schedule, if differing from the Operation phase, will be established as part of the Long-Term Care and Maintenance Plan in compliance with the AEMP and other applicable management plans in consultation with applicable regulators.

Routine inspection, monitoring and reporting as required by the Type A Water Licence and the applicable management plans will remain applicable.

TMAC will continue to report on its activities throughout the Long-term Temporary Closure period on an annual basis to the NIRB (as per Project Certificate requirements), the NWB (as per Type A Water Licence requirements).

5.5 FINAL MINE CLOSURE AND RECLAMATION ACTIVITIES

5.5.1 Buildings, Pads, and Infrastructure

Final closure activities for the specific project components such as laydown area, buildings, process plant, power plant, fuel tank farms, mine portals, vent raises, ore pads, reagent pads, equipment and machinery, are described in the approved ICRP and Doris Mine Closure and Reclamation Plan (TMAC 2014). These methods will be followed for closure of the Project components as described in Annex 27 of Volume 8.

5.5.2 Doris Tailings Impoundment Area

The closure concept for the Doris TIA is established in the approved Doris Mine Closure and Reclamation Plan. Upon closure, the tailings surface will be covered with a nominal waste rock cover of 0.3 m thickness. The function of the cover is to prevent dust and to minimize direct contact by terrestrial animals. Once the water quality in the Reclaim Pond has reached the required discharge criteria, the North Dam will be breached as originally intended. The updated closure and reclamation measures for the Doris TIA are described in Appendix A of Appendix V3-3F.

5.5.3 Madrid-Boston All-Weather Road

The all-weather road will remain in place after closure. Peripheral equipment such as sign posts will be removed. Where rock drains, culverts, or bridges have been installed, the roadway will be breached and the element removed. The breached opening will be sloped and armoured with rock to ensure that natural drainage can pass without the need for long-term maintenance.

5.5.4 Boston Tailings Management Area

At closure, a low permeability cover will be constructed to reduce the amount of seepage expected. The geomembrane will be placed in direct contact with the tailings and will be protected by a granular cover consisting of 0.3 m of crushed rock and 0.7 m of ROQ. Construction of the cover will be done in stages or at the end of the active deposition.

The contact water containment berms will be breached and the liner will be cut to prevent collecting any water. Several breaches may be required and will be done at the topographic lows. The balance of the berms will be left in place, as removal of the ROQ fill could result in localised permafrost degradation.

In the Post-closure phase, no seepage is expected, as an infiltration reduction cover incorporating a low-permeability geomembrane will be constructed. A long-term seepage collection system is therefore not required.

The closure and reclamation measures for the Boston TMA are described in Appendix V3-2F and Annex 27 of Volume 8.

5.5.6 Boston Airstrip

The airstrip and access road fill will remain in place after closure. Peripheral equipment such as lighting and sign posts will be removed. Where rock drains or culverts have been installed, the airstrip or roadway will be breached and the element removed. The breached opening will be sloped and armoured with rock to ensure natural drainage can pass without the need for long-term maintenance.

5.6 EXPECTED CONDITIONS – POST FINAL CLOSURE

The site abandonment goal of the final closure activities is to return project sites and affected areas to viable and, wherever practicable, self-sustaining ecosystems that are compatible with a healthy environment and with human activities. TMAC’s closure principles, objectives and criteria have been developed to achieve this future land use goal in as short of duration as reasonably practical.

The airstrip and all-weather roads built using rock fill will be left in place as a permafrost protection measure. The surface will be crowned or graded to prevent permanent ponding. The bridges and the arch culverts will be removed for safety and to restore natural drainage. Roads will be breached in areas where their presence has blocked natural drainage allowing the natural drainage paths to be re-established. When appropriate based on milling rates, TMAC will also apply for Recognized Closed Mine Status and undertake the biological monitoring study prescribed under the MMER.

5.7 POST-CLOSURE MONITORING AND REPORTING

Post-closure monitoring will take place at the site until such time that the objectives of the closure and remediation activities have been met to the satisfaction of the regulatory authorities and all affected parties. Coupled with the proper implementation of best practice closure and remediation activities, the following Post-closure monitoring will support TMAC in meeting closure and remediation objectives:

- The site will be visually inspected by a Professional Engineer annually for three consecutive years to ensure that permafrost degradation areas have stabilized.

- Post-closure monitoring of all covers will be performed every two years for a ten-year period or until it is confirmed the areas are physically stable. These inspections will be completed by a qualified inspector to ensure the physical integrity of the cover is maintained. Maintenance will be performed on areas that monitoring identifies as needing repairs.
- The annual seep sampling program carried out in accordance with Type A Water Licence will be continued to detect any changes in the leachate chemistry downstream of the remediated areas for a period of five years or until the leachate is confirmed to be chemically stable and consistent with the site specific closure criteria.

The Post-closure monitoring may require additional activities following the implementation of the project's final closure and remediation plan and the subsequent Reclamation Completion Report.

In addition, the monitoring requirements may again change as a result of the Performance Assessment Report which will be prepared and submitted to the NWB for their review following the initial Post-closure monitoring period which will be defined in consultation with NWB as part of the final closure and remediation plan.

6. Economic and Operating Environment

6.1 PROJECT EXPENDITURES

6.1.1 Construction

During the Construction phase of the Project, capital expenditures (CAPEX), including labour, is estimated at $367.0 million. This CAPEX is to be spent over a four year period, from 2019 (Year 1) to 2022 (Year 4). Capital is expected to be sourced primarily from within Alberta and Ontario. Some expenses are also expected in British Columbia, Quebec and the Northwest Territories. Further, it is expected that all of process equipment and at least a half of infrastructure purchases will be via direct import. In addition to CAPEX, from 2019 to 2022 there will be operating expenditures (OPEX) incurred as mining at Madrid begins (Table 2.3-1). Total expenditures for the Construction phase are estimated at $809.3 million, including $367.0 million in CAPEX and $442.3 million in OPEX.

The Construction phase will bring GDP impacts estimated at $727.4 million for Canada. The Project will also contribute to tax revenue of approximately $81.2 million to the federal and $62.7 million to the provincial and territorial governments across Canada; this revenue will primarily come from personal income tax, indirect corporate tax and sales tax. For Nunavut, Project benefits to the territorial GDP are estimated at $58.1 million, whereas the territorial tax revenue is expected to increase by as much as $3.6 million. Most Project impacts in Nunavut are predicted for the Kitikmeot region that benefits from the location of the Project in the region.

6.1.2 Operation

The Operation phase, as defined for the EIS, is set to start in 2023 (Year 5) and end in 2032 (Year 14). The total OPEX for the Operation phase is estimated at $2,723.0 million. In addition, CAPEX during this phase is estimated to be $144.8 million, mainly for sustaining capital (capital investments required to sustain production). All expenditures during the Operation phase total $2,867.8 million.

Total Canadian GDP impacts of the Project for the Operation phase are predicted at $3,073.7 million, of which $229.8 million will benefit Nunavut. The total tax revenue for governments across Canada during operation is estimated at $528.7 million, consisting of $286.4 million in federal and $242.1 million in provincial/territorial tax revenue; tax revenues for Nunavut are estimated at $12.2 million.

Additionally, based on the results of the Prefeasibility Study (RPA 2015), royalties, exploration and production lease rents, land tenure payments, water compensation, and IIBA implementation payments are estimated at $144.3 million for the Phase 2 Project. This is in addition to payments made during the production at Doris. The Phase 2 Project will also pay an estimated $256.6 million in corporate tax payments to the federal and provincial/territorial governments as well as $32.7 million in non-production based royalties to the federal government. TMAC will allocate corporate taxable income in accordance with the *Federal Income Tax Act* (Canada) and its regulations. Corporate taxable income is allocated to the relevant jurisdictions using the required standard formula that allocates based on salaries and wages earned per jurisdiction and revenues earned per jurisdiction.

For the Hope Bay Project as a whole, including development at Doris and the Phase 2 Project, TMAC expects to begin making initial corporate income tax payments (i.e., have taxable income) by 2020 (Year 2 of the Phase 2 Project). This estimate is based on the financial model developed as part of the

Prefeasibility Study (RPA 2015) and assumes initial production starting at Doris in 2017 and a gold price of US$1,250 per ounce. Estimates of royalty payments, taxes and other sums are prospective and are based on assumptions of gold price, foreign exchange rates, tax rates, and various other economic factors. Should these factors change, the amounts could differ from those estimated here.

6.2 EMPLOYMENT

6.2.1 Manpower Requirements

In total, over the life-of-mine (LOM), an estimated 10,470 person-years of direct employment will be created at the Phase 2 Project, including 1,353 person-years for the CAPEX workforce and 9,117 for the OPEX workforce. This includes both on-site TMAC employees and contractors.

6.2.2 Construction

During the Construction phase, the Project is estimated to result in a total of 6,685 person-years of direct, indirect and induced employment across Canada. Direct Construction phase employment is estimated at 2,308 person-years, with 411 person-years created in 2019, 465 person-years created in 2020, 808 person-years in 2021, and 624 person-years in 2022. It is further estimated that of the total direct employment, the Kitikmeot Region will benefit in 57 person-years of employment in 2019, 61 person-years in 2020, 109 person-years in 2021, and 84 person-years in 2022, for a total of 312 person-years over the Construction phase. Overall, it is estimated that approximately 90% of all direct employment opportunities in Nunavut (a total of 346 person-years) are expected to take place in the Kitikmeot Region. As residents of Nunavut, it is expected that these workers will file taxes in Nunavut.

The economic model estimates that the Phase 2 Project will create 2,817 person-years in indirect and 1,561 person-years in induced employment opportunities across Canada with the Construction phase. In Nunavut, the Project will provide 89 person-years of indirect and 38 person-years of induced employment with impacts felt in the three regions of Nunavut (Qikiqtaaluk, Kivalliq, and Kitikmeot). A total of 46 person-years of indirect and induced employment is predicted for the Kitikmeot Region.

6.2.3 Operation Employment Impacts

During the Operation phase, the Project is expected to create 27,245 person-years of direct, indirect and induced employment for Canada. Total direct employment is estimated at 8,162 person-years for Canada with up to 865 positions created annually; of that total, an estimated 960 person-years of direct employment is predicted for Nunavut with all of the employment created in the Kitikmeot Region. As residents of Nunavut, it is expected that these workers will file taxes in Nunavut.

The Project is also expected to contribute in 11,715 person-years in indirect and 7,369 person-years in induced employment across Canada. In Nunavut, indirect and induced employment are expected to benefit all three regions, including 413 person-years in indirect and 46 person-years in induced employment being created in the Kitikmeot Region.

6.3 ORIGIN OF WORKFORCE

The estimate for the sourcing of labour is based on the experience of the Doris Project to date, the achievements reported by other projects in Nunavut and the Northwest Territories, and professional opinion of TMAC and ERM. Current estimates indicate that approximately 15% of Construction workforce and up to 30% of Operation workforce will be sourced from Nunavut. These estimates may vary depending on numerous external factors. Employment opportunities will focus on hires from the Kitikmeot communities of Cambridge Bay, Kugluktuk, Gjoa Haven, Taloyoak, and Kugaaruk. Under the IIBA signed in

March of 2015, TMAC highlights Inuit employment preference which means that if there are two or more equally matched Inuit and non-Inuit candidates, TMAC will hire Inuit candidates (KIA and TMAC 2015). As outlined in the IIBA, priority to hiring employees at the Project is in the following order:

1. Kitikmeot Inuit and other Nunavut Inuit resident in the Kitikmeot Region
2. All other Kitikmeot and Nunavut Inuit
3. Residents of the Kitikmeot Region, and
4. All others.

TMAC will also utilize other locations such as Yellowknife and other cities in Southern Canada as and when needed.

6.4 LABOUR INCOME

For the Construction phase, total (direct, indirect and induced) employment opportunities are expected to contribute $526.6 million in personal income benefits in Canada, of which $287.1 million will be attributed to direct employment. In Nunavut, total personal income benefits are estimated at $50.3 million, with $42.8 million resulting from direct employment at the Project. For direct workers in Nunavut, this is an average earning (including benefits) during the Construction phase of approximately $124,000 per year.

For the Operation phase, total (direct, indirect and induced) employment opportunities are expected to contribute $2,236.7 million in personal income benefits in Canada, of which $1,248.2 million will be attributed to direct employment. In Nunavut, total personal income benefits for the phase are estimated at $192.1 million, with $147.1 million resulting from direct employment at the Project. For direct workers in Nunavut, this is an average earning (including benefits) during the Operation phase of approximately $153,000 per year.

6.5 CONTRACTING

Through the IIBA, TMAC is committed to promoting and maximizing opportunities for the engagement of Kitikmeot Qualified Businesses in the development and operation of the Hope Bay Project (KIA and TMAC 2015). As outlined in the IIBA, Kitikmeot Qualified Business Contracts represent contracts for goods and services only open to bids from Kitikmeot Qualified Businesses, whereas Open Contracts are for the provision of goods and services not provided by Kitikmeot Qualified Businesses. TMAC, in collaboration with the KIA and other appropriate agencies, will work to establish bid preparation training program for Inuit. Contracts open only to bids from Kitikmeot Qualified Businesses will include the following categories:

- Air regional and site specific services;
- Expediting;
- Freight shipping;
- Infrastructure planning, financing and related advisory (other than engineering, procurement and construction management services);
- Catering and housekeeping;
- Drilling – surface and subsurface;

- Blasting services;
- Earthworks and earthworks construction;
- Surface mining;
- Underground mining;
- Environmental services;
- Tire services (but not including supply of tires);
- Medical and first aid;
- Translation and cultural services; and
- Heavy equipment maintenance.

Other contracting opportunities related to the development and production activities at the Hope Bay Project may be open to both the Kitikmeot Qualified Businesses and other northern and/or Canadian businesses.

6.6 WORK SCHEDULE, TRANSPORTATION AND HOUSING

The Project will be a fly in/fly out operation from Yellowknife for non-Nunavut based employees chartered to site four times per week. Nunavut residents are to be transported from local communities through Cambridge Bay to site. The Project will operate on a mix of two weeks on and two weeks off, or three weeks on three weeks off basis for all personnel (RPA 2015).

Housing for workers includes existing infrastructure at the Doris Site and the Boston Site. Madrid North and South are greenfield sites. It is anticipated that approximately 600 people will be at the Hope Bay Project during peak operations, including the Boston Site. The Doris Site includes a kitchen and dining facility, sleeping facilities for approximately 280 personnel, medical, small suite of offices, recreational and meeting facilities; another sleeping facility is available that could house approximately 60 personnel. In addition, a 120 person accommodations facility will be added to the Doris Site to accommodate full production and exploration. Mine crews and surface support staff would be bussed to the Madrid Site (approximately eight kilometres) for work and returned to the Doris Site. Further, the Boston Site has an existing capacity of 65 persons, which could be utilized initially and replaced with a 200 man accommodations facility for full operations. The Doris Site will house miners for the Doris and Madrid operations and a secondary accommodations facility at Boston will house personnel for all Boston mining operations (RPA 2015).

6.7 TRAINING AND BENEFIT PROGRAMS

The Project, through the provision of employment opportunities, has the potential to change the skills and experience of the territorial and regional labour force and contribute to building labour force capacity. TMAC, under the IIBA, is committed to supporting training opportunities for Inuit (KIA and TMAC 2015). TMAC's human resources strategy will contain talent management initiatives such as training, career planning and advancement. The strategy will also contain specific measures to maximize Inuit employment, training and advancement and meeting or exceeding Inuit Training Targets. The IIBA specifies that TMAC may include on-the-job technical training and skills development in a variety of areas including underground mining, surface operations, mill processing, geotechnical and environmental. Career development plans will also be developed for all Inuit employees. TMAC and the KIA will encourage the government and local agencies to develop and provide training related to trades within the Kitikmeot high school system and off-site education and training programs aimed at preparing Inuit for employment in mining and related fields (KIA and TMAC 2015). Additionally, a Training and Development Fund will be developed to promote relevant post-secondary education to which TMAC will contribute $15,000 initially followed by yearly contributions of up to $100,000 (KIA and TMAC 2015). Additionally, those employed by the Project will gain years of work related experience that will help them obtain other jobs once the Project ceases operations.

Other potential benefits to employees hired at the Project include annual bonuses, registered retirement savings plan (RRSP) matching, transportation premiums, and health and dental insurance.

6.8 INUIT IMPACT AND BENEFIT AGREEMENT

The KIA and TMAC signed the Hope Bay Project IIBA on March 30, 2015 (KIA and TMAC 2015). The agreement details training and education, employment, as well as business and contracting opportunities for the Inuit people and Inuit owned businesses. In general, through the IIBA, TMAC is committed to promoting and maximizing opportunities for the employment of Inuit and the engagement of Kitikmeot Qualified Businesses in the development and operation of the Hope Bay Project. These benefits can include supporting training opportunities for Inuit, providing on-the-job training, contributing to the Training and Development Fund, giving priority to hiring Inuit employees at the Project, and offering contracts for goods and services (Kitikmeot Qualified Business Contracts) to the Kitikmeot Qualified Businesses. The IIBA also details other items including access to facilities and roads and the roles and responsibilities of the Inuit Environmental Advisory Committee.

6.9 GOVERNANCE AND LEADERSHIP

Nunavut Tunngavik Inc. (NTI), the organization which coordinates and manages Inuit responsibilities set out in the Nunavut Agreement, holds the surface title and mineral rights to IOLs in the Kitikmeot Region of Nunavut, including the surface rights over the entire Hope Bay Project area and mineral rights over selected portions of the Project (RPA 2015). With the exception of the Roberts Bay jetty (which is located on federal lands) and mining leases PJ1 through PJ-7, Heku 4, 6, 7, and small portions of Boston 4, 18-20, surface lands at Hope Bay are on IOLs (RPA 2015). The KIA administers the surface rights and the IIBA associated with the Project (KIA and TMAC 2015; RPA 2015). Royalty rates for NTI mineral rights are governed by Production Leases granted by NTI (RPA 2015). In March of 2015, a 20-year Framework Agreement (the Mineral Exploration Agreement) has been signed between TMAC and the KIA with respect to the Inuit owned surface rights. As part of this agreement, TMAC issued 3,400,000 Common Shares to the KIA and granted a 1% NSR royalty on future production from the Hope Bay Project (RPA 2015).

Because the Project lies on IOL, it can only proceed with the consent of the Inuit as provided by the KIA. In addition, the communities of Cambridge Bay, Kugluktuk, Gjoa Haven, Taloyoak, and Kugaaruk, and groups within these communities play an important part in the advancement of the Project.

Three institutions of public government created under the Nunavut Agreement will play a key role in deciding whether the Project can be developed and under what conditions. These include:

- The Nunavut Planning Commission (NPC) – responsible to ensure that the proposed development meets concordance of existing land use plans.
- The Nunavut Impact Review Board (NIRB) – responsible to screen and review the environmental and socio-economic impact of the proposed Project in a public setting to determine whether a recommendation should be made to the Federal Minister of Aboriginal Affairs and Northern Development on whether the Project should proceed or not and under what conditions. If the

Project is approved to proceed, the NIRB also plays a role in monitoring that the Project is constructed, operated and ultimately closed in accordance with the commitments made and conditions applied during the review process.

- The Nunavut Water Board (NWB) – responsible for issuing the required water licences for the Project should it proceed. The water licence addresses all water use at the Project including diversions and all deposition of waste to water generated as a result of mining, including ultimate closure and reclamation.

TMAC will work with other Federal and Territorial government agencies to address their areas of focus and authorization. These include, but are not limited to, the Government of Nunavut, Canadian Northern Development Agency, Indigenous and Aboriginal Affairs Canada, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada, Transport Canada, and the Government of the Northwest Territories.

Applicability of Transport Canada's Navigable Waters Protection Program for the navigability and safety of watercourses, as regulated under the *Navigation Protection Act*, including consideration of the construction and operation of Project components that may affect scheduled navigable waters, will be addressed through applicable Navigable Waters Approval(s) or Exemption(s) during the permitting process.TMAC will endeavor to avoid potential conflicts of interest that may arise in current governance regimes during the Project development by bringing all of the parties together in an open and transparent manner and working in a cooperative manner to seek accommodation that will avoid such conflicts.

7. Alternatives for Project Design

7.1 CRITERIA AND METHODOLOGY FOR ASSESSING ALTERNATIVE PROJECT DESIGNS

As appropriate and where applicable, for each alternative investigated, the following criteria were considered in evaluating the feasibility of the alternatives for the Phase 2 Project:

- technical feasibility;
- economic feasibility;
- environmental acceptability;
- amenability to reclamation;
- community acceptability or preference; and
- socio-economic effects and benefits.

Health and safety considerations also formed part of the evaluation of alternatives where these were most applicable to distinguish between alternatives, and are noted throughout Section 7.3.

7.1.1 Technical Feasibility

Technical feasibility relates to the engineering or operational appropriateness of a design in meeting the performance objectives for the Project. These can include but are not limited to production levels, reliability, ease of maintenance, compatibility with other components and activities, and operational ease in northern climates and remote areas.

7.1.2 Economic Viability

Economic viability refers to the capital, operating and maintenance, and closure/reclamation costs of an alternative design.

7.1.3 Environmental Acceptability

Environmental acceptability refers to the potential for adverse effects on the environment (short-term and long-term). The design of the Project avoids potentially negative effects on VECs. Potential environmental sensitivities were mapped (Section 2) and included in the design of the Project areas.

7.1.4 Amenability for Closure/Reclamation

Amenability for closure/reclamation refers to the potential long-term footprint and residual effects, and costs for decommissioning, closure, and reclamation (if appropriate) of Project components. Decommissioning may include recontouring landscape changing components (e.g., roads) that require disassembly and disposal, and structures that may require removal from site.

7.1.5 Community Acceptability or Preference

Community acceptability or preference refers to the expressions of approval or preference in local communities described in the Social Economics Assessment (Volume 6 Section 4). Project alternatives have been presented and feedback has been received through a number of consultation methods.

Traditional Knowledge (Volume 2 Section 2), Public Consultation and Engagement (Volume 2 Section 3) chapters detail the methods and results of community engagement. These have been applied to the evaluation of Project alternatives.

7.1.6 Socio-economic Effects and Benefits

Socio-economic effects refer to the potential for adverse effects on the VSECs of the Project. The design of the Project avoids potentially negative effects on VSECs. Socio-economic benefits refer to potential tangible positive effects to local communities and the region provided by alternatives and measured through VSECs.

7.2 ALTERNATIVES TO THE PROJECT – GO / NO GO DECISION

Section 6.4 of the Guidelines requires TMAC to presents an explicit analysis of alternative means of carrying out the Project components including a “no go” alternative. There are two possible outcomes for a go/no-go decision for Phase 2 Project:

1. Proceed with the Phase 2 Project, as proposed within this Application, or
2. Abandon the Phase 2 Project until such time that risks identified through analyses could be reduced or mitigated so as to enhance the Project feasibility.

Based on a Preliminary Feasibility Study (PFS, RPA 2015) completed in 2015, TMAC concludes that Phase 2 Project as proposed in the EIS application, should proceed (i.e., outcome 1). The rationale provided in the PFS is as follows:

> *The outcome for PFS is that the Project represents a significant opportunity for the development of a new mining camp in the Canadian Arctic. The property encompasses an area of significant exploration potential. The Project assets are well advanced and there has been significant derisking through the expenditures both on site and off site, including construction of significant on-site infrastructure. The development plan has been designed to minimize capital investment and build on the existing assets to generate cash flow that can sustain expansion and exploration. The property encompasses an area of significant exploration potential.*

If the Project does not proceed or is delayed until such time that issues can be derisked, the mineral resource will not be developed, and the potential effects and benefits predicted in this Application will not be realized. In the absence of the Phase 2 Project, existing conditions are predicted to continue barring other projects within the described LSAs and RSAs for the VECs and trends created by non-Project effects such as climate change. Similarly, socio-economic effects and benefits will not accrue. These effects and benefits are described in Volume 6, Section 3. Predicted benefits of the Project to local communities include the support of both traditional lifestyles and pursuits, and lifestyles that integrate wage-based employment in local communities.

7.3 ALTERNATIVE MEANS OF CARRYING OUT THE PROJECT

The physical location of the deposits somewhat reduces the number of potential alternatives for the development of Phase 2 Project components. The key drivers for the development of the site layouts at each mining site are:

- access to identified ore bodies;

- mining method (open pit, box cutting versus underground or a combination of methods);
- location of the processing plant; and
- mine waste disposal alternatives for tailings and waste rock.

The development of each site requires a minimum amount of infrastructure such as a mine portal (to access the underground mines, ore and waste rock areas, laydown areas, power supplies, fuel supplies, and, supporting facilities. Once the mining method is selected and a preferred mine waste alternative is identified, the design for each site focuses on optimizing the layout of this infrastructure at each of the Project sites where mining occurs, and therefore, a wide range of options have been considered during the conceptual design phase in order to achieve an optimal layout of facilities at each site. Alternative means of executing the Phase 2 Project must consider the infrastructure already developed to service the larger development of the Hope Bay Belt.

As appropriate and where applicable, for each alternative investigated, the evaluation criteria identified in Section 7.1 (technical feasibility, economic feasibility, environmental acceptability, amenability to reclamation, community acceptability or preference, and, socio-economic effects and benefits) were considered (Appendix V3-7A).

7.3.1 Access to Gold Bearing Ore

Access to the ore bodies includes both the land access (by road) and the physical location of the mine portal. For each deposit, the siting of the mine portal is based on configuration of the ore body and economic consideration which consist of the minimal amount of tunneling and extraction of waste rock required to gain access to the mineralized zone of the ore body and extract the ore.

The alignment of surface roads to gain access to the mine portal is mainly driven by site topography, terrain, number of water crossings and economic considerations for the construction of all-weather access road. The alignment of the access roads is established during site reconnaissance and conceptual engineering design.

7.3.1.1 Access to Madrid North and Madrid South Mines

Access to both Madrid North and Madrid South have been addressed under the *Request for Approval under Advanced Exploration Madrid Bulk Sample* currently under NIRB review. The proposed access roads described under that application are adequate for Phase 2 Project. Utilizing existing infrastructure applied for, approved and built in advance of Phase 2 construction will greatly reduce environmental footprint for required infrastructure and also minimize the capital investment required to further develop Phase 2.

7.3.1.2 Access to Boston Site – All-Weather Road and Boston Airstrip

The Boston deposit is located approximately 55 km from the Doris Site. Access to Boston is currently by winter road and by airplane. To minimize footprint of facilities at Boston, the development of the Boston mine site requires reliable year-round access, from Roberts Bay/Doris Site, for the resupply of fuel, mining equipment and supplies. This can only be accomplished with the construction of an all-weather road as described in the Phase 2 Project.

Three alternative methods were considered for access to Boston from Roberts Bay, Doris, and Madrid (Appendix V3-3I):

- **Winter Road Access** – Consideration was given to access of the Boston area using only seasonal winter roads. Seasonal access will significantly limit development of the Boston requiring complex annual shut-downs, and excessive seasonal manpower loads. For these reasons, winter road access was not pursued further, although a winter road may be required to access Boston and the quarries until the Madrid-Boston AWR has been constructed.
- **Air Access** – A temporary airstrip has been constructed at Boston and a permanent airstrip design is proposed for Phase 2, but is not intended to be the sole method of access to Boston. Road access is needed for transport of ore, concentrates, fuel, supplies and equipment, some of which would be delivered to the Project via the annual sea-lift at Roberts Bay.
- **All-weather Road Access** – The Boston Mine can be linked to the rest of the Hope Bay development by extending the Madrid South AWR to the Boston mining area. In the event of an emergency, an all-weather road provides more reliable access to Boston and also acts as a service road for a potential power line connecting Madrid and Boston and wind generation being linked into a power grid for the Hope Bay belt.

An AWR would allow year-round vehicle access to Boston and provide maximum flexibility. Therefore, an AWR is the preferred alternative.

7.3.1.3 All-weather Road

Several alignment options have been considered for the all-weather road. These options are described in Appendix V3-3I Madrid-Boston All-Weather Road Design. The alignment retained is described in Section 3.7. Based on the results of Section 7.3.3-6: Access to Boston Mining Area, two alternative all-weather road alignments were considered (Appendix V3-3I):

- EBA 1997 Route – This route was first proposed by EBA in 1993 and refined in 1997. It extends south from the Madrid South AWR following topographic lows until terminating at Boston. The topographic lows also correspond to wet areas and permafrost polygons, which make construction and surface water drainage for this alignment difficult. Therefore, this alternative was not selected as the preferred alternative.
- PND/SRK Route – This route was first developed SRK in 2006 to minimize areas with unfavorable foundations conditions (wet areas and permafrost polygons). The route was further refined by PND Engineers in 2009 and again by EBA (2011). It extends south from the Madrid South all-weather road to the west of the EBA (1997) route.

The PND/SRK route avoids environmentally sensitive areas and unfavourable foundation. Thus, it is the preferred route.

7.3.1.4 Boston Airstrip

A larger and more reliable airstrip is also required for the Boston Site. Seven alternative airstrip locations were identified. These locations were assessed for the current project description and design aircraft as described in Appendix V3-3K. Of the alternatives identified, Airstrip alternative 1 is the preferred airstrip alternative because it is located near Boston Site, it is oriented favorably with respect to the wind, and it does not cross streams.

7.3.2 Mining Methods

For each ore deposit, an assessment is made on the feasibility of underground mining versus open pit mining or other surface mining methods. Underground mining is generally preferable where high grade veins of ore can be mined with minimal removal of waste rock. By contrast, open pit mining involves a larger stripping ratio of waste rock to ore depending on the configuration of the ore body.

For the Madrid North and South deposits as well as the Boston deposits, the PFS 2015 established that underground mining methods were economically feasible. Ongoing exploration and economic evaluations will continue to evaluate and consider the feasibility of surface mining methods, open pits or a combination of surface and underground methods. For both Madrid North and Madrid South mines, Phase 2 Project builds on the development of the mine portals described under TMAC's *Request for Approval under Advanced Exploration Madrid Bulk Sample* currently under NIRB review.

7.3.3 Ore Processing Alternatives

Phase 2 Project proposes to process a nominal 5000 tpd of gold bearing ore mined from three mine sites (Madrid North, Madrid South and Boston). Project Certificate 003 authorizes TMAC to construct and operate a nominal 2,000 tpd mill at the Doris Site. This mill consists of a gravity concentration circuit (Python plant), a cyanide leach circuit, and a gold recovery circuit. This Doris process plant/mill is expected to begin operations in Q1 of 2017.

7.3.3.1 Cyanide leach and Gold Extraction

The Doris mill has excess capacity for the cyanide leach and gold recovery processes. The intent of Phase 2 Project is to fully utilize the capacity of all circuits of the Doris mill while installing additional 3,000 tpd of ore processing capacity belt-wide (at Madrid North and Boston).

Based on environmental, health and safety considerations, design and cost considerations, it is preferable to maintain and expand existing gold extraction processes at the Doris Site. The Doris mill/ site already has the facilities required to handle, store and manage the hazardous chemicals/reagents required for the cyanide leach and gold extraction operations. Hence, based on the evaluation factors itemized in Section 7.1, an expansion of the Doris mill cyanide leach and gold extraction circuits is preferable to any other potential alternatives from an environmental, health and safety, and, economics considerations.

7.3.3.2 Processing Plants at Madrid North and Boston

The shorter life of mine of Madrid South (2 to 3 years) does not justify the construction of a processing facility at Madrid South. However, both the Madrid North and the Boston ore bodies are large deposits with significant upside potential in terms of ore resources. TMAC anticipates that on-going exploration activities will significantly increase the ore reserves and thus increase the life of mine for both of these sites.

The ore processing plant essentially consists of the Python gravity concentration circuit which does not utilise hazardous chemicals for gravity concentration of the gold bearing material. The Python process utilised crushing, grinding, spiral concentration, flotation, thickening, and filtration for concentration of the gold bearing content of the ore (refer to flowsheet presented in Figure 4.4-1).

The Python line of the Doris mill will be fully utilized until the Doris mine is exhausted, which is expected to occur by Year 3 of the Phase 2 Project (2022). Since the Madrid North mine is expected to ramp up to full ore production of 3,300 tpd of ore by Year 3, ore mined at the Madrid North site will be used to supplements the Doris mine ore production in order to maintain the Doris mill operation at its full design capacity. However, mining at Madrid North is expected to exceed the Doris mill capacity by up to 1,300 tpd. Hence an additional Python processing line will be required for the treatment of all the ore mined from Madrid North.

Boston is also a large mineral deposit and on-going exploration activities are likely to increase mineral reserves significantly. Once Boston mining production ramps up, it will surpass processing capacity at both Doris and Madrid, requiring a process plant at Boston. A process plant at Boston centralizes ore transport from the Boston mine in the Boston area, while small amounts of concentrates will utilize the cyanide process and final gold recovery process at Doris.

Two alternative have been considered for the processing of ore mined at Madrid North and Boston:

1. Expansion of the Doris mill Python circuit, or
2. Construction of a new Python plant to process up to 1,200 tpd of ore at Madrid North and 2,400 tpd at Boston.

The advantages of each alternative with the considerations identified above are summarized below in Table 7.3-1.

Table 7.3-1. Ore Processing Alternatives

Considerations	Expansion of Doris Processing	Processing Plant at Madrid North	Processing Plant at Boston
Capacity	3,600 tpd	1,200 tpd	1,200 tpd
Technical feasibility	Yes Expanded building footprint would be required. Modification of processes to address different metallurgical characteristics of the ore may be required	Yes Process design can be adapted for specific ore metallurgy at Madrid	Yes Process design can be adapted for specific ore metallurgy at Boston
Economic feasibility	Favorable	More costly than Doris expansion due to required support infrastructure (power, water, supplies)	More costly than Doris expansion due to required support infrastructure (power, water, supplies)
Environmental	Requires trucking of ore to Doris	Requires trucking of concentrate which is 10% of the ore tonnage to Doris for final gold extraction. Significant reduction in traffic volume and greenhouse gas emissions	Requires trucking of concentrate which is 10% of the ore tonnage to Doris for final gold extraction. Significant reduction in traffic volume and greenhouse gas emissions
Amenability to reclamation	No significant advantages over other alternatives	No significant advantages over other alternatives	No significant advantages over other alternatives
Community acceptability/Socio-economic effects	No significant advantages over other alternatives	No significant advantages over other alternatives	No significant advantages over other alternatives

On the basis of:

1. the existing reserves, potential resources and significant upside potential at both Madrid North and Boston; and
2. the environmental advantages introduced by operating a processing plant at Madrid North and at Boston,

the preferred alternative is to construct and operate a 1,200 tpd ore processing facility at Madrid North, and, a 1,200 tpd ore processing facility at Boston. The purpose of these processing facilities is to produce a concentrate from the ore mined at each site. The concentrate is then trucked to the Doris process facility for gold recovery.

The main technical, economic, and environmental advantages of this approach are:

- The processing facility is adapted to the specific characteristics of the ore mined at each deposit, based on the specific mineralogy of the deposit which may require specific enhancements to the processing facility in order to maximize gold recovery;
- It minimizes the capital investment and maximizes use of existing facilities at Doris; and
- It reduces transportation requirements for ore and hence fuel consumption and greenhouse gas emissions for the entire site.

7.3.4 Tailings and Rock Disposal Alternatives

The alternatives for tailings disposal include:

1. Optimizing the use of the Doris TIA.
2. Construct and operate tailings impoundment area for each processing facility.

7.3.4.1 Tailings Disposal for Madrid Mine

A primary consideration for the site selection of the Doris TIA during Phase 1 of the Hope Belt development was the potential for expansion of the TIA. The existing Doris TIA has more than sufficient capacity to safely contain the additional Phase 2 tailings volume, as well as a significant additional capacity to accommodate further expansion without additional encroachment on water bodies. Furthermore, the TIA is already approved for the water recirculation/recycling and effluent discharge infrastructure. The construction activities required for this expansion are described in Section 3.4 of Volume 3, and described in Appendix V3-3F.

The alternatives evaluation for this Project considered variations to the current tailings deposition plan to maximise the storage capacity while minimising additional construction. Five tailings deposition options were considered for Project tailings disposal into the Doris TIA (Appendix V3-3F).

Based on the evaluation, tailings deposition Option 5 is the preferred solution. Option 5 allows for creation of the desired landform using a number of spigot points that enables operational flexibility, while avoiding the need to raise the North Dam and construct a new Interim Dike. Furthermore, less discharge pipeline and surface infrastructure is required for Option 5. Option 5 is illustrated on Figures 4.4-2 and 4.4-3.

The ore processing alternatives described in Section 7.2.4.1 maximizes the use of the Doris TIA. The tailings generated by the Madrid processing plant will be pumped to the Doris TIA for disposal (6 km pipeline).

7.3.4.2 Tailings Disposal Alternatives at Boston

Since Boston consists of the development of a new site, an evaluation of the alternatives for disposal of tailings was undertaken in accordance with *Environment Canada's Guidelines for the Assessment of Alternatives for Mine Waste Disposal* (September 2011). Five tailings containment technologies and 35 alternative disposal sites were considered for disposal of the Boston tailings. The report is presented in Appendix V3-2F. This evaluation concluded that dry-stacked tailings is the optimal tailing disposal technology for the Boston processing facility, and the optimal disposal location is close to the processing plant complex as shown on Figure 3.8-1.

7.3.4.3 Retained Alternatives for Tailings Disposal

The Phase 2 Project adopts a hybrid of these two alternatives. It maximizes the use of the Doris TIA which can readily be expanded to accept additional tailings produced from the Madrid processing facility, thus eliminating the need for a dedicated TIA for Madrid. Tailings produced at Madrid will be pumped to the Doris TIA (distance of 6 km).

The physical distance separating the Boston Site from Doris is over 55 km. Transportation of tailings generated at Boston to Doris would result in increased traffic on the all-weather road, and hence increased greenhouse gas emissions and cost. Furthermore, the dry-stack tailings produced by the Boston processing plant eliminate the need for a tailings embankment. The tailings are dry-stacked on a prepared pad and do not require containment structures. Furthermore, the proposed TMA site does not impact on a waterbody frequented by fish.

7.3.4.4 Waste Rock Management

As all the waste rock excavated from all three mines will be re-used as backfill in the underground mine, there will be no permanent waste rock stockpiles at Madrid North, Madrid South, and Boston sites. At each mine site, the location of the temporary waste rock stockpiles was selected on the basis of minimal driving distance from the mine portal. This approach minimizes the required footprint area, emissions due to transport distance and allows all rock hauled to surface to be returned underground.

<u>Madrid North Waste Rock Stockpile</u>

Three alternative waste rock piles were considered for Madrid North (Appendix V3-3G).

- **South Waste Rock Pile -** The south waste rock pile would be located in a gully to the southwest of the portal. The contact water berm would be located on ground that has permafrost degradation, and the berm would tie-in to the Doris-Windy all-weather road. The waste rock foundation slopes steeply, which may reduce the pile safety rating, and require high contact water pond berms.
- **East Waste Rock Pile -** The east waste rock pile would be located in the gully to the southeast of the portal. The ground in this area slopes steeply towards the south, which may reduce the pile safety rating, and require thick contact water pond berms.
- **North Waste Rock Pile -** The north waste rock pile would be located in the large open area north of the portal. This alternative would have smallest contact water berms, and most efficient storage area

The north waste rock pile is the preferred waste rock pile location because of its shallower foundation slopes and more efficient contact water pond berms.

7.3.5 Madrid South Surface Development

Three alternative levels of surface infrastructure development were considered for the Madrid South location (Appendix V3-3H).

- **No Surface Infrastructure, access via Doris Portal** - Access to Madrid South deposits would be underground via the Doris Connector and Central underground workings, with no surface infrastructure, and no portal. This alternative would result in large underground haul distances for ore and waste rock.

- **Minimal Development** - Only the vent raise and portal would be constructed, all waste rock and ore would be hauled to Doris via a winter road. Ore and waste rock would be stockpiled on surface for a portion of the year, therefore waste pads and pollution control pond(s) would be required.
- **Full Development** - Vent raise, portal, and infrastructure pads with all-weather road access to Doris. All waste rock would be stored on-site until final deposition underground. Infrastructure pad footprint is not much larger than the minimal development option.

The full development alternative is the preferred alternative since it has shorter haul distances than the no surface development option, and less re-handling of waste rock than the minimal development option. All-weather road access also simplifies logistics and could speed up medical attention if necessary.

7.3.6 Boston Site Layout

Three alternative layouts were prepared based on the location and size of watersheds, overburden thickness, and the location of the 50 m crown pillar which influences the current mine plan and future development (Table 7.3-2). Details of the layouts are presented in Appendix V3-3J. Components that take priority in analyzing the alternatives include the mill, the power plant, and the fuel facility. These critical components are to be built on bedrock and thus should be located where overburden thickness is less than 3 m. Mine and mill zones were contained to as few watershed areas as possible to reduce the footprint of CWPs.

Table 7.3-2. Boston Infrastructure Layout Alternatives

Alternative	Details	Advantages	Disadvantages
1	The camp and geology zone buildings would be located ~200 m north of the current portal. The mine and mill infrastructure would be placed ~50 m east of the portal, close to the planned waste rock pile. Laydown areas, fuel facility, and the landfarm would be placed ~700 m south of the portal.	There is a short hauling distance between the portal and the mill. The camp is situated close to the mine and mill infrastructure. Contact water from the mine and mill are contained within the same contact water pond as the waste rock pile.	There is increased distance between all three areas.
2	The camp and geology zone buildings would be located ~200 m north of the current portal. The mine and mill infrastructure as well as the infrastructure within the other zone would be placed ~700 m east of the portal.	The camp is close to the portal.	Both the mine and mill infrastructure are distant from the camp and the portal.
3	All infrastructure excluding the waste rock pile and overburden pile would be located ~700 m south of the portal.	The majority of the infrastructure is contained within one location. There is greater access to areas with shallow bedrock.	There is a relatively long distance from the mill and the addition of a second ore storage pile is required.

Components in the camp zone should be relatively close to the mine and mill infrastructure, while the geology zone, landfarm, overburden storage area, and laydown area were assumed to be the least critical infrastructure in terms of constraints on placement.

Alternative 3 is preferred as it is the most practical of the options by having space for all infrastructure and more suitable foundation conditions.

7.3.7 Roberts Bay Cargo Dock

The primary resupply method for the Project is via sealift. The existing jetty was designed to accommodate the shallow-draft Hay River, 1500 series barges and is too shallow to accommodate deeper draft ocean going vessels (OGVs). The increased shipping traffic and a desire for a lower risk and more efficient procedure for handling fuel and goods for the Project has led to consider building a marine dock at Roberts Bay. An alternatives analysis considered two alternative construction methods. Open cell reinforced construction method was selected over the gravity fill caissons due its simplicity, greater flexibility to ground conditions, and the poor foundation soils within Roberts Bay.

Based on the evaluation of typical OGV for docking including tanker class, approach/berthing requirements, environmental conditions, surface infrastructure requirements, and costs, a location was selected that could accommodate Handi Max tankers for offshore mooring and medium-draft cargo ships (less than 9 m draft, e.g., *Rosaire Desgagnés* 12,000 DWT; see Figure 3.3-1).

7.3.8 Sourcing of Aggregate

Sourcing of aggregate is primarily driven by the geochemistry of the rock to ensure that quarried material does not result in acid drainage. TMAC has a Quarry Management Plan (refer to EMS, Volume 8) that outlines screening methods for quarry sites.

At the conceptual design stage of the Project, TMAC has identified several quarry sites with suitable geochemical properties. These quarry sites are identified in Section 3.2 of this Volume.

7.3.9 Water Supply

TMAC has authorizations and infrastructure in place for drawing water from Windy Lake (potable water) and from Doris Lake (for industrial water). This existing infrastructure will satisfy the requirements for Phase 2 Project for the Madrid North and Madrid South mines.

For Boston, the water supply will be drawn from Aimaokatalok Lake as this is the closest and largest water body to the Boston Site. No alternative has been considered.

7.3.10 Water Management Alternatives

7.3.10.1 Surface Runoff

At all three mine sites, the water management strategy focuses on the capture of surface runoff from the mine surface facilities (contact water) and the reuse of this surface runoff as mine process water. This approach enables TMAC to reduce the amount of freshwater required for its mining and processing operation. As this approach is environmental sound and desirable, no alternative have been evaluated.

7.3.10.2 Mine Dewatering and Disposal of Saline Water

As mining at Madrid extends into a talik zone, the mine water captured at Madrid North and Madrid South is expected to be saline. To the extent practicable, the mine water will be re-used for the mining operation, with the excess water being trucked to the existing Doris outfall mixing box for discharge to the ocean via the Roberts Bay outfall. The alternative to this approach would be to provide a desalination plant or evaporation plant for the treatment of the saline mine water. Such treatment facilities require 1) large amount of energy to operate, 2) offer no environmental benefits (need for disposal of a concentrated waste), 3) are complex to operate, and, 4) increases capital and operating costs.

For Boston, thermal modelling indicates that the mine workings will remain in the permafrost and that mine water will not be saline. Therefore, all mine water will be pumped to the processing plant for use as process water.

7.3.10.3 Madrid North Contact Water Pond

Two contact water pond designs were considered for Madrid North (Appendix V3-3G).

- **Line Pond (geomembrane)** – The pond is fully lined with a geomembrane. The advantages of this design is it is a conventional lined pond that will not be affected by climate change, it is also the less complex alternative. The disadvantage of this design is that the geomembrane and bedding layers on the pond floor will thaw the permafrost, which may create a depression resulting in water accumulation and more thaw after the geomembrane is removed at closure. Additionally, placement of the liner could be challenging depending of the terrain.
- **Unlined Pond (permafrost)** – Water is contained within the unlined pond by permafrost on the bottom of the pond and a geomembrane within the berm. This design is dependent on the base of the berm remaining frozen. The advantages of this design are that, provided the pond is properly managed, the permafrost on the pond floor should not be degraded, reducing potential issues at closure. The disadvantages of this design are that thick berms are required to ensure the geomembrane tie-in remains frozen. This design is also dependant on the expected temperatures changes due to climate change, higher than expected temperature increases would require modification of the berms to ensure the liner tie-in remains frozen.

The unlined pond is the preferred alternative. The advantage of not placing a geomembrane on the floor of the pond should overcome the disadvantages of thicker berms. Uncertainties in thermal performance of the berms can be addressed by placing additional material if deemed necessary to protect the thermal integrity of the liner tie-in.

7.3.10.4 Madrid South Contact Water Pond

Two pollution control pond designs were considered (Appendix V3-3H).

- **Lined Pond (geomembrane)** - The pond is fully lined with a geomembrane. The advantages of this design is it is a conventional lined pond that will not be affected by climate change, it is also the less complex alternative. The disadvantage of this design is that the geomembrane and bedding layers on the pond floor will thaw the permafrost, which may create a depression resulting, in water accumulation and more thaw after the geomembrane is removed at closure. Additionally, placement of the liner could be challenging depending of the terrain.
- **Unlined Pond (permafrost) -** Water is contained within the unlined pond by permafrost on the bottom of the pond and a geomembrane within the berm. This design is dependent on the base of the berm remaining frozen. The advantages of this design are that provided the pond is properly managed, the permafrost and vegetation on the pond floor should not be degraded, reducing potential issues at closure. The disadvantage of this design is that thick berms are required to ensure the geomembrane tie-in remains frozen. This design is also dependant on the expected temperatures changes due to climate change, higher than expected temperature increases would require modification of the berms to ensure the liner tie-in remains frozen.

The unlined pond is the preferred alternative. The advantage of not placing a geomembrane on the floor of the pond should overcome the disadvantages of thicker berms. Uncertainties in thermal performance of the berms can be addressed by placing additional material if deemed necessary to protect the thermal integrity of the liner tie-in.

7.3.11 Power Generation and Distribution for Hope Bay Belt

The alternatives considered for power generation include:

- Stand-alone generation at each mine site;
- Centralized power plant with transmission lines;
- Wind turbines to supplement power generation.

TMAC will continue to develop strategies for power generation and supply of the entire Hope Bay Belt. The long-term strategy includes potential integration of wind turbines for power generation and the construction of a power distribution grid for the entire Hope Bay Belt. Baseline wind information is currently being collected in order to assess the technical feasibility of this option at Doris. It is expected that wind turbines could eventually supply a portion of the power requirements of the Hope Bay Belt. However, to ensure safe and reliable power generation, diesel generators will remain an integral part of the power generation system, and, stand-by diesel generation will be required at each Project site.

Phase 2 Project proposes to build stand-alone power generation facilities at Madrid North, Madrid South and Boston sites. The construction of these components fit within the overall power generation and distribution strategy envisioned for the Hope Bay Belt. It is proposed that power lines will connect the sites to enable wind turbines to tie into the Hope Bay grid and at the same time, provide electrical supply reliability across the belt in the event that power generation at one site is unavailable.

7.3.12 Fuel Storage Alternatives

The location of the fuel storage is primarily driven by the location of the power generation facilities. Sufficient storage is required at each site to ensure reliable operation of the power generation system. The largest storage capacity is needed at Roberts Bay in order for annual resupply and offloading. The design proposed for Phase 2 achieves a balance with respect to fuel storage requirements at each mine site.

7.3.13 Closure and Reclamation Alternatives

The closure and reclamation concepts proposed for Phase 2 consist of dismantling and removal of all surface infrastructure, removal of equipment and shipping any hazardous materials off site. Non-hazardous materials will be landfilled at closure. Once buildings are dismantled and removed, surfaces will be scoured to promote natural rehabilitation. The all-weather road and the cargo dock will remain in place. Since closure and reclamation are required under a Type A Water Licence, no alternatives have been evaluated.

8. Future Development

8.1 BACKGROUND TO STAGED DEVELOPMENT OF THE HOPE BAY GREENSTONE BELT

Regional geological and exploration investigations have been completed within the Hope Bay Greenstone Belt since the mid-1990s, with early work focused on the Boston area and its commercial development potential. Ongoing exploration and development studies identified that the Doris area had a higher ore grade than the Boston or Madrid areas and it became the focus of advanced development into an operating project. Since 2012, when TMAC acquired the Hope Bay Project, ongoing exploration and feasibility work have better defined the geology and reserves of the Doris area and outlined additional resources associated with the known deposits.

Development of the resources within the Belt is planned as a series of phases to maintain producing mines over a longer period of time. The benefits of a staged development approach include:

- cashflow generated from one phase supports the development of the subsequent phases;
- overall footprint is minimized by consolidating, to the extent practicable, waste management and support infrastructure in previously developed areas;
- benefits to Inuit, local communities and governments are extended; and
- potential negative economic and social impacts of mine closures on TMAC, its workers, Inuit, the Kitikmeot Region, and Nunavut are reduced.

The first stage of TMAC's approach to development of the Belt is underway, through operation of the Doris Mine. The Phase 2 Project represents the next stage of development, enabling transition to mining at Madrid and Boston.

8.2 POTENTIAL FOR EXTENSION OF THE PROJECT

The Phase 2 Project provides for mining at the Madrid North, Madrid South and Boston.

TMAC's exploration on the Belt will continue in much the same way it has been undertaken for the past several years. The exploration program consists of mapping and drilling programs aimed at discovering potential mineralized zones in the Belt. These activities are supplemented with ground and aerial geophysical programs. The majority of drilling is focused on known deposits with the goal of better defining the resources at Doris, Madrid, and Boston. Underground exploration diamond drilling will be performed to explore deposits at depth and TMAC plans to proceed with underground advanced exploration and bulk sample testing at Madrid and Boston.

It is expected that planned exploration drilling and bulk sampling will enhance the economic viability of the Madrid and Boston deposits. If additional resources/reserves are identified through this work, TMAC anticipates that additional infrastructure may not be needed beyond what is presented within this Project Description, in which case mine life and activities would be extended along with extension of the associated local and regional benefits of a long-term sustained mining operation.

Given the staged development of the Belt, the infrastructure at Roberts Bay, Doris, Madrid and Boston will be able to accommodate mine life extensions.

8.3 POTENTIAL FOR DEVELOPMENT OF ADDITIONAL ORE DEPOSITS

Mining operations and benefits may be extended should additional mineral reserves, resources and or deposits become economical to develop. As exploration is a Life of Project activity, it is possible that additional deposits will be delineated within the Belt and become economically feasible to develop. Should additional deposits be identified that are beyond the scope of the authorizations and approvals held, TMAC will enter into the appropriate permitting processes. The presence of existing infrastructure would be of environmental and economic value to future projects, just as it is for this current Project.

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