Appendix V3-7A

Hope Bay Project Boston Tailings Disposal Alternatives Assessment, Hope Bay, Nunavut

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Prepared for

TMAC Resources Inc.

Prepared by

SRK Consulting (Canada) Inc.
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Prepared for

TMAC Resources Inc.
PO Box 44
Suite 1010-95 Wellington St. W
Toronto, ON M5J 2N7
Canada

Tel: +1 867 873 4767
Web: www.tmacresources.com

Prepared by

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2
Canada

Tel: +1 604 681 4196
Web: www.srk.com

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srk consulting

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1 Introduction

The Hope Bay Project (the Project) is a gold mining and milling undertaking of TMAC Resources Inc. The Project is located 705 km northeast of Yellowknife and 153 km southwest of Cambridge Bay in Nunavut Territory, and is situated east of Bathurst Inlet. The Project comprises three distinct areas of known mineralization plus extensive exploration potential and targets. The three areas that host mineral resources are Doris, Madrid, and Boston.

The Project consists of two phases: Phase 1 (Doris project), which is currently being carried out under an existing water licence, and Phase 2 which is in the environmental assessment stage. Phase 1 includes mining and infrastructure at Doris only, while Phase 2 includes additional mining and infrastructure at Madrid and Boston located approximately 10 and 60 km due south from Doris, respectively.

The Madrid Mine will be operated as satellite facilities to Doris, with the majority of Madrid ore being trucked to the Doris mill, safe for a small concentrate plant at Madrid North. However, all of the Madrid tailings will be deposited in the Doris Tailings Impoundment Area (TIA). Boston; however, is sufficiently far from Doris that deposition of Boston tailings at the Doris TIA is impractical. Therefore, Boston is to be a self-sufficient mining complex that will include a processing facility and a new tailings management area (TMA).

This report presents a comprehensive tailings disposal alternatives assessment for the Boston deposit in the form of a multiple accounts analysis (MAA). It was prepared in accordance with the Environment Canada guideline for disposal of mine waste (EC 2011). This assessment takes into consideration technical, operational, environmental, socio-economic, and project economic factors. It also considers tailings disposal technologies, containment dam technologies, and tailings disposal sites.

2 Multiple Accounts Analysis Process

MAA is a tool for performing detailed analyses that allows the direct comparison of various alternatives on an objective basis. The MAA, as defined by EC (2011) for mine waste facilities, is a seven-step process where the first six steps pertain to the analysis, while the seventh step is documenting the analysis and reporting the findings, i.e. this report.

Step 1: Accounts and Subaccounts (Section 4). This step entails documenting a comprehensive list of subaccounts (or criteria) organized by accounts (or general categories) pertinent to the evaluation of each alternative. The four accounts are technical/operational, environmental, project economics, and socio-economic. Using these accounts and the subaccounts, the alternatives are presented in the form of concise summary tables to allow direct comparison.

Step 2: Pre-screening Assessment (Section 5). This assessment typically uses a subset of conditional evaluation criteria that allows any alternatives identified as potentially “fatally flawed” to be rejected from further detailed assessment. The reasons for removal of any of the alternatives are clearly identified as part of this step.

Step 3: Detailed Analysis (Section 6.1). This step comprises a detailed evaluation of the alternatives that remain after the pre-screening assessment. Each alternative is evaluated based on all accounts and the complete set of subaccounts. Data to support each sub-account is collected, processed, and summarized, complete with engineering evaluations as required.

Step 4: Scoring (Section 6.2). Each subaccount receives a score in this step. The scores are tallied and the alternatives are ranked on the total score basis, with the highest score usually becoming the preferred alternatives.

Step 5: Weighting (Section 6.3). Apply a weight to the accounts. Each account is given a relative weight based on its level of importance compared to the other accounts. These weight create a fixed-value bias that should reflect site specific factors and stakeholder input. EC (2011) recommends assigning the following weights to each of the accounts: Technical/Operational (3), Environmental (6), Project Economics (1.5), and Socio-Economics (3).

Step 6: Sensitivity Analysis (Section 7). Assigning of weighting factors to the various accounts provides the greatest opportunity for imposing user bias into the analysis (such as the weighting imposed by EC (2011)). Therefore, the MAA must be accompanied by a rigorous sensitivity analysis to ensure that the bias of the assessor is not impacting the outcome.

These six steps of the analysis are documented within this report, followed by discussions and conclusions (Section 8).

3 Selecting Alternatives

3.1 Tailings Technologies

3.1.1 General

Technologies commonly used for tailings management and deposition include conventional low solids content slurry tailings, thickened tailings, paste tailings, and filtered (i.e. dry-stack) tailings. The primary differences between these technologies relate to the amount of water that is associated with the tailings deposition. Different definitions exist for different tailings technologies depending on the literature cited. The sections below provide descriptions of each of these technologies in the context of this Project, complete with a discussion of their advantages and disadvantages.

There are also technologies where tailings and waste rock are managed as a combined stream (i.e. co-disposal and co-mixing). Underground mining at the Project requires the use of structural backfill; therefore, all waste rock will be hauled back underground for use as backfill over the life of the Project. As a result, combined tailings and waste rock technologies were not considered in this alternatives assessment.

3.1.2 Tailings Management Technologies

Conventional Low Solids Content Slurry Tailings

Conventional low solids content slurry tailings are the most widely used tailings technology throughout the world including the Canadian arctic. It is the technology used for Doris and Madrid within the Doris TIA. Other examples of its use in an arctic climate setting include the closed Lupin and Nanisivik mines, as well as the operating mines of Meadowbank, Diavik, and Ekati to name just a few.

The technology consists of pumping a slurry with a solids content of typically between 30 and 50%. The solids content is sufficiently low that conventional centrifugal pumps can be used, making it a very economical disposal technology. Tailings are deposited using spigots and depending on the deposition plan, there could be any number of active spigots operating at any time. Once the slurry exits the spigot, material segregation takes place. The larger (i.e. coarser) and heavier (i.e. sulfate minerals) particles settle out first, and the smallest and lightest particles settle out last with significant free water liberated in this process typically collected in a reclaim pond. The result is that a tailings beach is developed, which for gold tailings is typically about 1% in grade from the discharge location to the reclaim pond. The upper part of the beach is more permeable and contains much of the sulfate bearing minerals (if present), while the lower part of the beach is less permeable as it contains most of the fines (also known as slimes).

This technology is naturally associated with a large volume of free water (which can be recycled to the processing facility), and therefore requires environmental containment in the form of containment dams. Due to the low solids content, the settled dry density of the tailings is typically quite low, in the range of 1.3 tonnes per m^3. As a result, this is a less efficient storage technology compared to other tailings technologies and requires the largest containment structures (and typically overall footprint). This storage efficiency is often further reduced in an arctic climate where a significant proportion (approximately 20%) of the storage capacity can be lost to ice entrainment; however, the ice entrainment can be managed if careful winter tailings deposition strategies are adopted. The low settled dry density and large volume of free water being retained also presents the highest operational (and subsequent environmental and economic) risk of any of the technologies due to unforeseen events such as a dam breach.

The capital costs associated with containment dams can be high, but this if often mitigated by constructing the dams in stages over the life of the Project. The operational costs of this technology are typically the lowest of all the technologies, as it is limited to predominantly tailings discharge and reclaim water pumping, which even at increased distances from the processing plant is relatively economical.

Two primary deposition strategies for conventional low solids content slurry are typically considered: subaqueous deposition and subaerial deposition. Subaqueous deposition entails complete submergence of the tailings stream, which is considered to be the best long-term closure strategy for acid generating tailings and also mitigates against tailings dust and excess ice entrainment during the operational period. If a permanent water cover can be maintained at closure, with appropriate depth taking into consideration wave action and ice scour, the material would not oxidize, and therefore the ultimate long-term environmental containment could be provided. However, if this water cover requires permanent water retaining containment dams, it cannot be a walk-away closure strategy.

Subaerial tailings means the tailings beaches are not covered by water and the closure strategy would entail some form of engineered dry cover. This offers the advantage of allowing for decommissioning of the containment dams and facilitates a walk-away closure strategy. Dust management is however a concern that requires management over the life of the Project. Cover placement over the often very soft tailings can be challenging; however, this is to some extent mitigated by the ability to construct covers in the winter and early spring when the tailings are sufficiently frozen to provide a trafficable surface.

Thickened Tailings

Thickened tailings in the context of this discussion is simply a higher solids content slurry, typically higher than 50% for gold tailings. However, what makes this technology different is that the thickening is done to specifically preclude tailings segregation once discharged, which means that the tailings beach is a more uniform product. This is done by using high rate thickeners (and chemical flocculants as required) that alter the rheological properties of the tailings stream. However, the viscosity of the thickened tailings must remain low enough to allow pumping using conventional centrifugal pumps.

The resultant tailings beach has an increased slope, typically between 1 and 4%, and the settled dry density of the tailings is slightly higher than that of conventional low solids content slurry. This deposition strategy still results in liberation of a fair amount of free water, and therefore containment dams are still required, but relative to the low solids content slurry technology the dams are smaller and the overall footprint required is reduced. At higher beach angles, thickened tailings can be deposited from a single central raised discharge structure to develop a self-draining cone shaped tailings facility.

The bulk of water can be recycled at the thickener, which provides opportunities for water circuit optimizations and ultimately a lower fresh make-up water draw for the processing plant. Since considerable effort and expense is undertaken to dewater the tailings, it typically does not make sense to do subaqueous placement of thickened tailings.

The capital cost of this technology can be significantly greater than conventional low solids content slurry due to the need for a thickening plant. The need for slightly smaller containment dams could however offset those costs. Increased thickening and pumping costs do result in increased overall operating costs. Closure costs may be lower compared to the low solids content slurry method due to the slightly smaller surface area and possibly improved tailings access from a trafficability perspective.

Thickened tailings are commonly preferred in arid parts of the world where maximizing recycled water close to the processing facility is of great value. There are no known thickened tailings facilities in the Canadian arctic, but the Kidd Creek Mine in Ontario does use this technology successfully under typical Canadian winter conditions.

Paste Tailings

Paste tailings are like thickened tailings, but a greater degree of thickening is targeted using specialized deep cone or paste thickeners to get the tailings consistency to that of toothpaste. The goal is to produce a non-segregating pumpable tailings (albeit with costly positive displacement pumps) with a very small amount of free water liberated after deposition. This technology was initially developed to use tailings as an underground structural backfill material by adding binders, predominantly cement, to the thickened paste.

When applied as a primary surface tailings disposal technology, cement binders are not added because they are not required and doing so would be cost prohibitive. Paste tailings have steeper beach angles than thickened tailings, typically upwards of 6%, and have even greater settled dry density than thickened tailings. In addition, since there is very little free water liberated, the containment dams and overall footprint required for this tailings technology is markedly smaller than the previous two technologies. In addition, the tailings surface is trafficable very soon after placement.

Like thickened tailings, it does not make sense to go through the expense of paste thickening if the disposal strategy is subaqueous, due to the fact that mixing of the tailings with the water in the pond will add back much of the water that was previously removed at great expense. Therefore, this technology is only applied subaerially. Dust management and cover placement is however comparatively easier due to the increased trafficability.

Capital and operating costs associated with paste production and pumping is very high compared to thickened tailings, but substantially reduced containment dams and water management costs do offset those costs to some degree.

Although paste tailings technology is common for mine backfill purposes, including the Canadian arctic, its use as full scale surface tailings disposal technology is limited worldwide and there are no Canadian arctic case studies.

Filtered Tailings

Filtered tailings are on the opposite end of the tailings dewatering spectrum compared to low solids content tailings slurry. The technology entails dewatering the tailings by mechanical means through either filter presses (lower production rates) or belt filters (higher production rates). The dewatered tailings, which typically have a gravimetric moisture content of about 10 to 15% after filtration, can then be transported to the deposition site by either conventional truck-and-shovel methods or by belt conveyors and stackers. At the deposition site, relatively thin lifts of tailings are “stacked” and in most cases (but not always) compacted using conventional earthworks techniques. This technology is therefore often referred to as dry-stack tailings.

Since there is no free water liberated from these tailings and the tailings are considered a structural component if properly compacted, no containment dams are required. It is however best practice to construct downstream water containment structures to retain any surface water runoff that does come into contact with the filtered tailings.

The tailings grind needs to be sufficiently coarse for this technology to be cost effective, but typical gold tailings, such as planned for at Boston, would be suitable.

Compared to the other tailings technologies, filtered tailings typically have the highest equipment capital and operating costs. This is due to the very high capital cost of the filter plant, which may not necessarily be offset by the savings of not requiring containment dams. The operating cost is high because of the energy demands for filtering, and the placement cost of using earthmoving equipment as opposed to hydraulic placement by pumps.

Once again, filtered tailings are only placed sub-aerially as it would be counterproductive to go through the expense of dewatering the tailings only to submerge it afterwards. Closure cover placement and dust management is however simple compared to the other technologies as the material is completely trafficable and the facility can be shaped to accommodate any required landform.

Filtered tailings are routinely used worldwide and are rapidly becoming the preferred technology due to the belief that it is best practice in tailings management available. This technology has been used in the Canadian arctic at the Raglan Mine. Other examples of filtered tailings used in very cold climates include the Minto Mine in Yukon, as well as Red Dog and Pogo mines in Alaska.

3.1.3 Tailings Technologies Assessment

A qualitative assessment of the tailings technologies described above was completed, considering the advantages and disadvantages in the context of the proposed Boston Mine project (Table 1).

Table 1: Details of Tailings Technology Assessment

Technology	Advantages	Disadvantages	Conclusion
Conventional Low Solids Content Slurry Tailings	• Most commonly used technology, including in cold climates; • Simple technology, well understood by operators; • Most operationally flexible technology under upset or changing conditions; and • Generally lowest operating cost.	• Lowest storage efficiency due to low settled dry density, high water content and ice entrainment; • Typically requires largest footprint; • Potentially highest up-front and sustaining capital for containment dams; • Requires management of the largest volumes of supernatant water; • Perceived to be the highest risk tailings technology; • Lowest trafficability makes dust management and closure cover construction most challenging; • Least efficient use of water; and • Tailings segregation makes closure more challenging.	• Although there are considerable disadvantages, the technology was considered for Boston since it is a well understood and proven technology in cold climates, and is the preferred strategy for the Doris TIA.
Thickened Tailings	• Non segregating tailings; • Slightly reduced footprint compared to low solids content slurry tailings due to slightly greater settled dry density, steeper beach angle and lower water content; • Lower water use than for low solids content slurry tailings; and • Improved tailings trafficability allowing for possible year-round tailings access for dust management and construction of closure covers.	• Increased capital cost for thickening plant (may be offset by savings offered by requirement for smaller containment dams); • Large containment dams still necessary (albeit smaller than for low solids content slurry tailings; • Limited flexibility to handle upset or changing conditions; and • Less commonly used in cold regions.	• This technology has definite advantages over low solids content slurry tailings; however, the benefits would be hard to accurately quantify at a conceptual design level. Therefore low solids content slurry was deemed a conservative bookend for the alternatives assessment and thickened tailings technology was not assessed further.
Paste Tailings	• Non-segregating tailings; • Slightly reduced footprint compared to thickened tailings due to slightly greater settled dry density, steeper beach angle and lower water content; • Markedly smaller containment dams due to minimal water management requirements; • Lower water use than for thickened tailings; and • Vastly Improved tailings trafficability allowing for year-round tailings access for dust management and construction of closure covers.	• Vastly increased capital cost for paste plant and positive displacement pumps compared to thickened tailings; • High operating cost; • Minimal flexibility to handle upset or changing conditions; • Highly complex operation; and • No precedent in cold regions.	• There are no documented case studies of full scale paste tailings technology in an arctic setting, and therefore it is deemed an unproven technology and was not considered further.

Technology	Advantages	Disadvantages	Conclusion
Filtered Tailings	• Proven technology in cold climates; • Most efficient use of water as all water is recycled in the processing plant; • No need for containment dams; • Smallest footprint; • Perceived to be best practice and the safest tailings technology.	• Sensitive to upset conditions, requiring provisions for temporary tailings storage in a separate facility; • Tight quality control of the deposition sequence is required; • Very high capital and operating cost.	• Notwithstanding the fact that this technology is considered best practice, the clear operational and environmental advantages offered by this technology makes it worthy of further consideration. It also offers the opposite bookend of available tailings technologies to consider.

3.2 Containment Dam Technologies

3.2.1 General

For low solids content slurry tailings containment dams are required. Foundation conditions at Boston are described in SRK (2016), and can be summarized as moderately thick, often ice rich permafrost soils. The soils range from sandy gravels to silty clays, and the active layer is typically about 1 m thick. Construction borrow materials are limited to geochemically suitable quarry rock crushed and screened to the required size fractions.

3.2.2 Containment Technologies

Containment dam technologies that were considered for the Project including cyclone tailings dams, conventional low permeability core dams, frozen core dams, conventional (unfrozen) upstream geosynthetic lined dams, and frozen foundation dams with upstream geosynthetic liner. The sections below provide a more detailed discussion of these technologies.

Cyclone Tailings Dam

A cost-effective tailings containment dam technology that is commonly used worldwide is to construct dams with cyclone tailings. The tailings slurry is passed through cyclones and the coarser underflow consisting predominantly of sand is used to construct the walls using conventional earthmoving equipment. The finer overflow tailings are deposited upstream of the cycloned sand walls together with the supernatant water.

Although there are examples of this technology being used in areas that experience seasonally cold conditions such as in interior British Columbia, there are no arctic case studies of this technology in use. The primary reason is due to the operational challenges of managing cyclones under freezing conditions and the strict quality control required for constructing the sand walls. Ice entrainment would be extremely detrimental to the stability of the structure and precluding that from occurring in an arctic setting would be challenging. As a result, the use of this technology is not considered appropriate for the Project.

Low Permeability Core Dam

Conventional low permeability core dams rely on a low permeability material, typically a material of moderate to high clay content, to provide the necessary water retention ability of the structure. The core material must be carefully placed using strict quality control procedures and needs to be keyed into bedrock or other suitable low permeability foundation materials.

Low permeability cores cannot be constructed under winter conditions (i.e. frozen) as the appropriate material moisture conditioning and compaction cannot be done. Also, all construction material needs to be completely thawed. There is no suitable low permeability borrow sources available at the Project site and, should any be found, the material would be completely frozen. Therefore, the use of this containment dam technology is not considered viable for the Project.

Frozen Core Dam

A frozen core dam consists of an engineered saturated frozen core, completely bonded to the underlying permafrost foundation. This technology was used to construct the North Dam at the Doris TIA (SRK 2012) and has been demonstrated to work very effectively at the Project site. Construction of a frozen core dam is complex, time consuming and expensive. Very strict quality control is required to ensure suitable core material is produced, while construction of the core requires rigorous production, placement and testing procedures. In addition, a frozen core dam can only be constructed in the winter when air temperatures are colder than −15°C.

If water retention is required for prolonged periods of time, this dam construction technology would undoubtedly be the most viable technology for the Project site. However, if the tailings deposition plan was designed to progressively develop tailings beaches against the dams and thereby move the pond away from the wall, then a less complex technology such as the frozen foundation dam (see sub-section below) would be more suitable.

Unfrozen Upstream Geosynthetic Lined Dam

If suitable low permeability core material is not available or if site conditions do not allow for construction with low permeability material (e.g. at the Project site), a viable alternative would be to construct a rockfill dam with an upstream liner providing the water retention layer. The liner; however, needs to be tied into suitable low permeability foundation soils or bedrock.

Even though this dam construction technology is often used in arctic settings, it is not a viable technology for this Project. Although permafrost conditions ensure that foundation soils are currently frozen, if the dam foundation is not engineered to remain frozen it would eventually thaw and the soils are seldom of sufficiently low permeability when unfrozen. Tying the liner into intact bedrock is not viable either because foundation soils at the Project site are typically too thick making excavation of the key trench to bedrock impractical.

Frozen Foundation Dams with Upstream Geosynthetic Liner

The frozen foundation dam combines the frozen core and unfrozen upstream geosynthetic dam concepts. The primary water retention component is an upstream geomembrane liner; however, the liner is keyed into the permafrost and the dam is engineered to ensure that the liner remains tied into permafrost for its design life. This is achieved by providing appropriate thermal insulation in critical areas. If this dam is subject to prolonged water ponding, it has a limited practical design life; however, if the pond is progressively moved away from the dam by beaching tailings adjacent to the dam, this containment structure becomes part of the permafrost landscape and is considered a very effective containment technology.

3.2.3 Containment Dam Technology Assessment

Based on the summaries of containment dam technologies in the preceding section, it can readily be concluded that cyclone tailings dams, conventional low permeability core dams, and conventional unfrozen upstream geosynthetic lined dams are not suitable technologies for the Project site, and therefore were not further evaluated in this alternatives assessment.

Frozen core and frozen foundation dams are viable and appropriate containment dam technologies for the Project site; however, frozen core dams are complex and expensive structures, and that degree of rigour is only warranted if long-term water retention is required. It is preferable from an overall environmental risk perspective to minimize the load on containment dams; therefore, as far as practical, tailings beaches will be developed upstream of all containment dams which makes frozen foundation dams the preferred containment dam technology for the Project site. In this alternatives assessment, all containment dams are therefore considered to be frozen foundation dams with upstream geosynthetic liners.

3.3 Tailings Disposal Sites

Taking into consideration the tailings and containment dam technologies suitable for the Project site, several tailings disposal sites were considered for evaluation in the alternatives assessment. As an initial starting point the following siting rationale was selected for finding candidate sites:

- Slurry tailings sites had to have sufficient storage capacity for at least 5.1 million tonnes of tailings at an assumed settled dry density of 1.3 t/m^3, for a minimum storage volume of 3.9 million m^3 plus a 1 million m^3 allowance for reclaim water and freeboard. Initially the tailings quantity considered was 4.5 million tonnes (3.5 million m^3), but as the project planning progressed, the ore reserves included in this study were increased to 5.1 Mt, resulting in an increase in required storage capacity. Storage capacity evaluation was based on the available regional topographical data (5 m contour intervals).
- Dry stack tailings sites had to have sufficient storage capacity for storage for at 2.8 million m^3 of tailings, i.e. 5.1 million tonnes at 1.8 t/m^3 density. No allowance for water storage is required. As in the case of the slurry tailings sites, the initial storage requirement was lower (2.3 million m^3) and had to be increased as the project planning progressed, and larger ore quantities were included.
- A maximum straight line distance of 15 km as measured form the existing Boston portal.
- No locations west of Aimaokatalok Lake.

- Use of water bodies, possibly requiring listing on Schedule 2 of the Metal Mining Effluent Regulations (MMER 2015) was not specifically excluded.
- As far as practical, sites with natural containment offered by topographical features such as valleys or gently sloping terrain are preferred over large man-made containment.

A total of 35 tailings disposal alternatives were identified and are illustrated in Figure 2. Two of these locations are different tailings disposal technologies (conventional low solids content slurry, #08 (B3a), and filtered tailings, #09 (B3b), at the same site. Three alternatives were evaluated only for filtered tailings technology (Alt. #03 (A3a), Alt. #04 (A3b), and Alt. #10 (B4)) and the remaining sites only considered conventional low solids slurry tailings.

Table A-1 (Appendix A) contains a comprehensive summary describing each of the 35 tailings disposal sites. Each site is identified by an alternative number and a site descriptor. Table A-1 also references figures associated with each alternative. For each alternative, Table A-1 provides a concise description of the site location, the tailings deposition method, the tailings deposition type, the straight-line distance from the Boston portal, the tailings management area footprint, the proposed containment dam and/or dry-stack height, the maximum tailings storage volume, the containment dam type (dam descriptor), and whether or not the proposed tailings management area are within the proposed project development area (PDA) or not.

4 Step 1: Accounts and Subaccounts

4.1 Accounts

In accordance with the MAA guideline published by EC (2011) for disposal of mine waste, the four accounts assessed includes technical/operational, project economic, environmental, and socio-economic criteria (Table 2).

4.2 Subaccounts

Subaccounts selected for the MAA are listed in Table 2. The subaccounts follow the recommended list in the MAA guideline published by EC (2011) for disposal of mine waste, but were modified slightly considering site specific conditions. Specifically, environmental and socio-economic subaccounts are based on the identified valued ecosystem components (VECs), valued socio-economic components (VSECs), and subjects of note for the Project.

Care was taken to avoid “double counting” of criteria. For example, although distance from the mill site can be a subaccount for the environmental (land disturbance) and engineering categories (fill quantity), it was evaluated under the technical/operational account only.

Table 2: Summary of Accounts and Subaccounts

Account	Subaccount
Technical/Operational	Deposition Method
	Distance from Mill
	Dam Volume
	Total Dam Fill
	Engineering Complexity
	Storage Factor
	Pumping Distance
	Head Difference
	Flexibility with Respect to Deposition Method
	Height/Footprint Trade-off
	Opportunity for Progressive Reclamation
	Favourable Topography
	Dam Height (qualitative)
	Volume of Water Stored
	Consequence of Dam/Dry Stack Failure
	Water Management Add-on
Project Economic	Total Cost
	Economic Risks
	Construction Risks

Account	Subaccount
Environmental	Air Quality
	Surface Water Quantity and Quality
	Fish and Fish Habitat
	Terrestrial Ecology, Vegetation and Landforms
	Caribou
	Wolverine
	Grizzly Bear
	Migratory Birds
	Raptors
Socio-Economic	Archaeological Sites
	Inuit Employment and Training
	Inuit Economic Opportunities
	Traditional Land Use
	Community Response
	Regulatory Response

5 Step 2: Pre-Screening Assessment

5.1 Primary Pre-Screening Criteria

The first step of the MAA is to conduct a pre-screening assessment. The objective of this step is to conduct a high level “fatal flaw” analysis of all the tailings disposal alternatives identified in Table A-1 (Appendix A) to develop a more practical and reasonable short list from which to conduct the more rigorous quantitative MAA. The primary pre-screening criteria selected for the Boston tailings alternatives assessment were as follows:

- **Location relative to the potential development area (PDA) boundary.** Considerable project baseline data has been collected within an extensive PDA and any tailings alternative within that area would allow for seamless transitioning into the environmental assessment phase. However, alternatives outside of the PDA may require up to two years of additional baseline data collection which would result in unacceptable project delays.
- **Practical distance from mill.** Transport of tailings must be within 10 km (road distance) from the Boston processing plant**.** The tailings volume is low requiring a small diameter pipeline. The friction and heat loss through such a pipeline is significant and pumping further than 10 km is not deemed economically feasible. Likewise trucking filtered tailings that distance will result in tailing freezing in the truck, which would make dry stack construction impossible.

These disposal criteria were applied sequentially. The first criterion above was applied to the whole of 35 alternatives, resulting in 18 alternatives being eliminated. Preliminary road alignments were then created for the remaining 17 alternatives. The second criterion was subsequently applied resulting in an additional 3 alternatives being eliminated, leaving 14 alternatives worthy of further consideration (Table A-2, Appendix A).

5.2 Secondary Pre-Screening Criteria

Due to the large number of alternatives that had not been screened out as part of the primary pre-screening process, a decision was made to subject those alternatives to a secondary pre-screening phase. The rationale behind selection of these criteria was to eliminate alternatives that might have very material environmental impacts associated with them, which when evaluated by stakeholders could constitute “fatal flaws”. The secondary pre-screening criteria selected for the Boston tailings alternatives assessment were as follows:

- **Major Stream Diversion.** Construction, operation, and maintenance of major stream diversions in an arctic setting is technically challenging and can have significant long-term environmental effects associated with permafrost degradation and habitat loss. As a result, alternatives that would require this feature were not carried forward in the assessment.
- **Complex Contact Water Management.** Contact water needs to be effectively managed during construction, operations and closure. A failure of the contact water collection and management system could lead to significant environmental effects if an uncontrolled discharge were to occur to streams and/or lakes. Alternatives that require very complex contact water management strategies were therefore not preferred.

- **Listing on Schedule 2 of MMER.** Discharge of a deleterious substance (including tailings) into a water body that would impact fish habitat requires delisting under Schedule 2 of the MMER (MMER 2015). This process is onerous and could have material impacts on timelines for regulatory approvals. As a result, alternatives where this may be a requirement were not carried forward in the assessment.
- **Capacity for Expansion.** The alternatives were compared based on conceptual engineering that considered storage capacity as described in Section 3.3. However, this is an early development stage of the Project and the selected disposal site must allow for increases in ore reserves.

Just as for the primary pre-screening criteria, these secondary pre-screening criteria were also applied sequentially. A further ten alternatives were eliminated, leaving four alternatives for detailed evaluation in the MAA (Table A-2, Appendix A). Complete details of the four shortlisted alternatives are provided in Table A-3 (Appendix A). Figures 4 through 7 provide general arrangements for each of these alternatives.

6 Analysis, Scoring, and Weighting

6.1 Step 3: Detailed Analysis

Comprehensive conceptual designs of each of the four shortlisted alternatives described in Table A-3 (Appendix A) were developed. The designs were carried out using 3-D modelling software Muck3D (MineBridge 2015), and the resultant design layouts are presented in Figures 4 through 7. Tables A-4 through A-7 (Appendix A) provide complete details of these shortlisted alternatives in the context of the accounts and subaccounts selected for the Project (i.e. technical/operational, economic, environmental, and socio-economic), with each table representing one of the accounts above.

6.2 Step 4: Scoring

The scoring criteria for each of the subaccounts selected for the Project are summarized in Table A-8 through A-11 (Appendix A). All scoring was based on a point scale from 0 to 5. In cases where a binary rating was required (yes/no type of questions) the full range was not applied, but a score of 4 or 5 was assigned to differentiate between alternatives.

Two of the socio-economic subaccounts (community response and regulatory response) could not be used in the ranking process because community consultation was still in progress at time of writing and, as a result, factual data was not yet available.

Table A-12 (Appendix A) provides the compiled accounts ledger for the alternatives. This ledger documents the score assigned to each alternative for each subaccount. No weighting is assigned to any of the scores in Table A-12, i.e., all subaccounts are considered equal.

6.3 Step 5: Weighting

Weighting of the accounts for the base case analysis was done in accordance with the MAA guideline published by EC (2011) for disposal of mine waste. The guideline recommends a weight of 3 for technical/operational, 1.5 for project economics, 6 for environmental, and 3 for socio-economic. This assessment has considered various weightings as part of the Step 6: Sensitivity Analysis.

The base case MAA results are presented Table 3. The account merit rating is calculated by scoring each of the subaccounts as presented in Table A12 (accounts ledger). The total merit score of each account is the sum of all the subaccount scores.

For any given subaccount in the table, the maximum merit rating (and merit score in this case) that an alternative can achieve is five, which implies the alternative is considered to have the best performance in that given subaccount. The merit scores for each subaccount are then added to determine the total merit score of the account.

To avoid unintentionally increasing the importance of an account with many subaccounts relative to an account with few subaccounts, each account merit score is normalized by the number of subaccounts it contains. For example, the technical/operational account has 15 subaccounts while the project economics account only has 3 subaccounts. Without the normalization, the maximum merit score that can be achieved by an alternative is the product of five times the number of subaccounts within that account. The technical/operational account could receive a maximum merit score of 75, while the economic account could only receive a maximum merit score of 15. To avoid this bias, the account merit scores are normalized by dividing by the sum of the subaccounts of 15 and 3, respectively. This normalized account merit score is called the account merit rating.

Finally, the total overall score of an alternative consists of the sum of the four proportionate account scores. The highest proportionate number in any given account implies the most desirable alternative with respect to that account. The tailings alternative that has the largest overall merit rating is considered to be the best overall alternative.

Each account was given the weight as recommended by the EC (2011) guidelines. The effect of assigning weights to the accounts was determined by conducting a sensitivity analysis as discussed in the next section. Figure 9 displays the account merit scores in radar charts. The best alternative would have the largest area.

Table 3: Alternatives Ranking

		Weight	Alternatives			
			B3a	**B3b**	**B4**	**G1**
Account Merit Rating	Technical / Operational	**3**	2.93	3.93	3.87	2.33
	Project Economics	**1.5**	3.00	3.67	3.67	2.67
	Environmental	**6**	2.22	2.78	3.44	2.78
	Socio-Economics	**3**	1.83	1.67	1.83	1.67
Account Merit Score (Account Merit Rating x Weight)	Technical / Operational		8.80	11.80	11.60	7.00
	Project Economics		4.50	5.50	5.50	4.00
	Environmental		13.33	16.67	20.67	16.67
	Socio-Economics		5.50	5.00	5.50	5.00
Alternative Merit Score			32.13	38.97	43.27	32.67
Alternative Merit Rating			**2.38**	**2.89**	**3.20**	**2.42**
Account Rank	Technical / Operational		3	1	2	4
	Project Economics		3	1	1	4
	Environmental		4	2	1	2
	Socio-Economics		1	3	1	3
Overall Alternative Rank			4	2	1	3

Source: \\van-svr0\Projects\01_SITES\Hope.Bay\1CT022.004_Phase 2 DEIS - Engineering Support\Task 620_Tailings Boston\BostonTIA_MAA_SummarySheets_1CT022.004 _Rev11_IM_KK_EMR.xlsx

7 Step 6: Sensitivity Analysis

A sensitivity analysis was conducted by assigning different weightings to the accounts and the results are summarized in Table 4. Weighting of zero was assigned to the accounts one-by-one while maintaining the other account unchanged (scenarios 1 through 4), followed by assigning zero weighting to all but one account (scenarios 5 through 8). An equal weighting of 1 was also tested (scenario 9), followed by assigning a weighting of zero to the account one-by-one while all other accounts had a weighting of 1 (scenarios 10 through 13).

It was found that Alternative B4 remained the preferred option in all but one of the weighting scenarios. The overall ranking was largely maintained, with filtered tailings (B3b and B4) ranking consistently higher than slurry tailing alternatives (B3a and G1).

Table 4: Sensitivity Analysis Results

Scenario	Account Weights				Overall Ranking			
	Technical/ Operational	Project Economics	Environmental	Socio-economic	B3a	B3b	B4	G1
Base	3	1.5	6	3	4	2	1	3
1	0	1.5	6	3	4	2	1	3
2	3	0	6	3	4	2	1	3
3	3	1.5	0	3	3	2	1	4
4	3	1.5	6	0	4	2	1	3
5	3	0	0	0	3	1	2	4
6	0	1.5	0	0	3	1	1	4
7	0	0	6	0	4	2	1	2
8	0	0	0	3	1	3	1	3
9	1	1	1	1	3	2	1	4
10	0	1	1	1	4	2	1	3
11	1	0	1	1	3	2	1	4
12	1	1	0	1	3	2	1	4
13	1	1	1	0	3	2	1	4

Source: \\van-svr0\Projects\01_SITES\Hope.Bay\1CT022.004_Phase 2 DEIS - Engineering Support\Task 620_Tailings Boston\BostonTIA_MAA_SummarySheets_1CT022.004 _Rev10_IM_KK_EMR.xlsx

8 Discussion and Conclusion

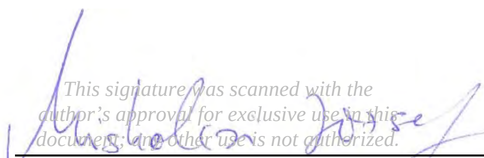
An MAA, in accordance with the EC (2011) guidelines for MAA for mine waste disposal, was completed to determine which of 35 tailings disposal alternatives would be the preferred option for the Boston TMA. Following a two-stage pre-screening evaluation, four sites were shortlisted for detailed evaluation. Comprehensive conceptual designs of each of the shortlisted options were developed and subsequently scored in terms of technical/operational, project economic, environmental and socio-economic criteria (accounts). Each account was further broken down into subaccounts (33 in total).

The base case analysis assumed weighting in accordance with the EC (2011) guideline, and a series of sensitivity analysis was completed to test for any bias in the analysis.

The analysis concluded that the preferred tailings management system at Boston would be to place filtered tailings into a free-standing dry stack facility in close proximity to the proposed processing facility on favourable ground. B4 was the only site to meet this criteria; therefore, it was ranked at the top as the most viable alternative.

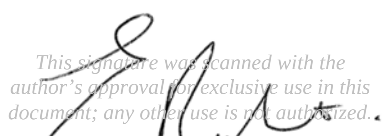
This report, Hope Bay Project Boston Tailings Disposal Alternatives Assessment, was prepared by SRK Consulting (Canada) Inc.

Kaitlyn Kooy, EIT
Staff Consultant



Iozsef Miskolczi, PEng
Senior Consultant

and reviewed by



Maritz Rykaart, PhD, PEng
Practice Leader

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

9 References

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Figures

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TMAC RESOURCES

Boston Tailings Disposal Alternatives Assessment

Site Location Plan

SRK JOB NO.: 1CT022.004.600.20

FILE NAME: 1CT022.004T600-FIGURE 1.dwg

HOPE BAY PROJECT

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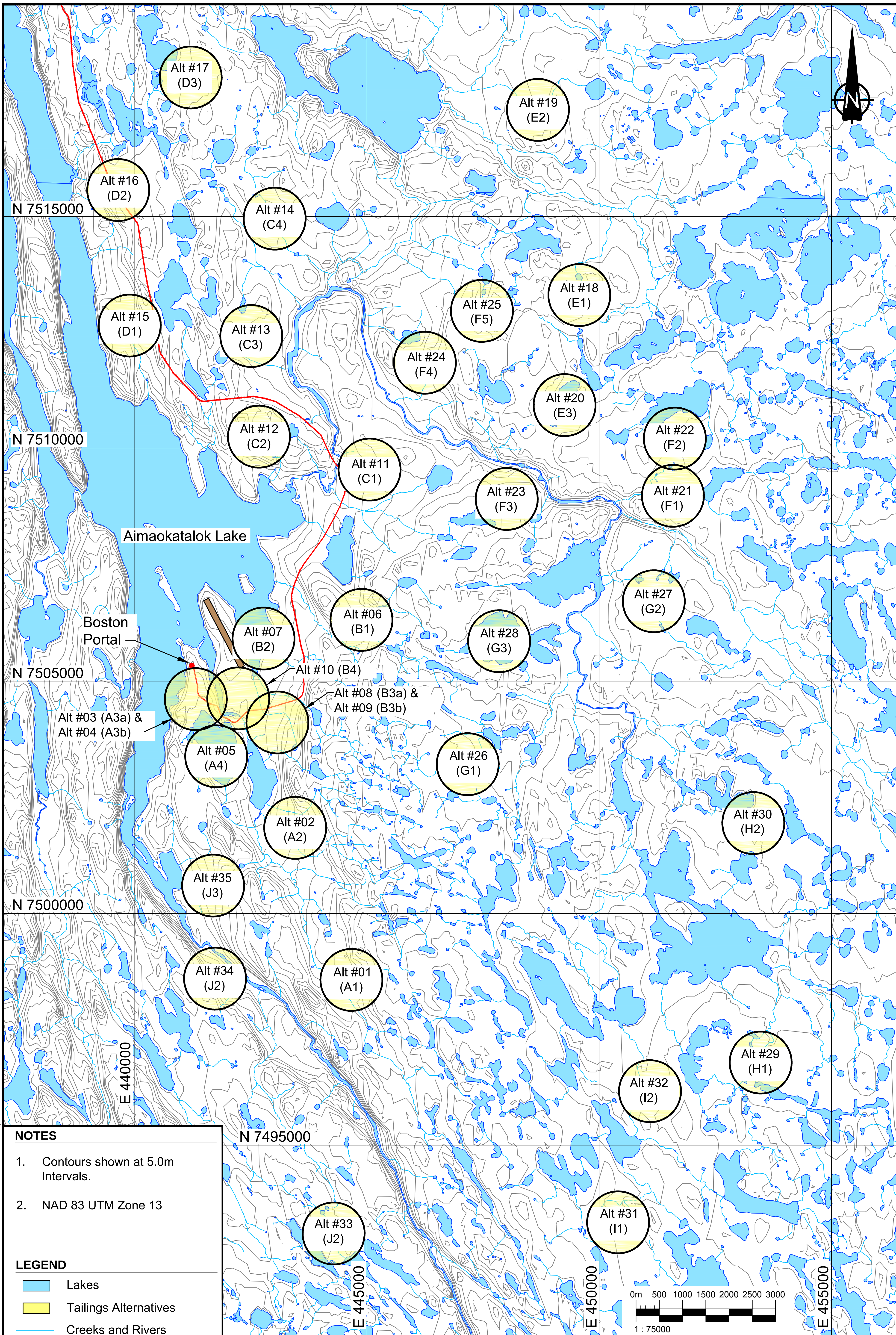
Nov. 2016	IM	01



NOTES

1. Contours shown at 5.0m Intervals.
2. NAD 83 UTM Zone 13

LEGEND

- Lakes
- Tailings Alternatives
- Creeks and Rivers
- Madrid-Boston Road

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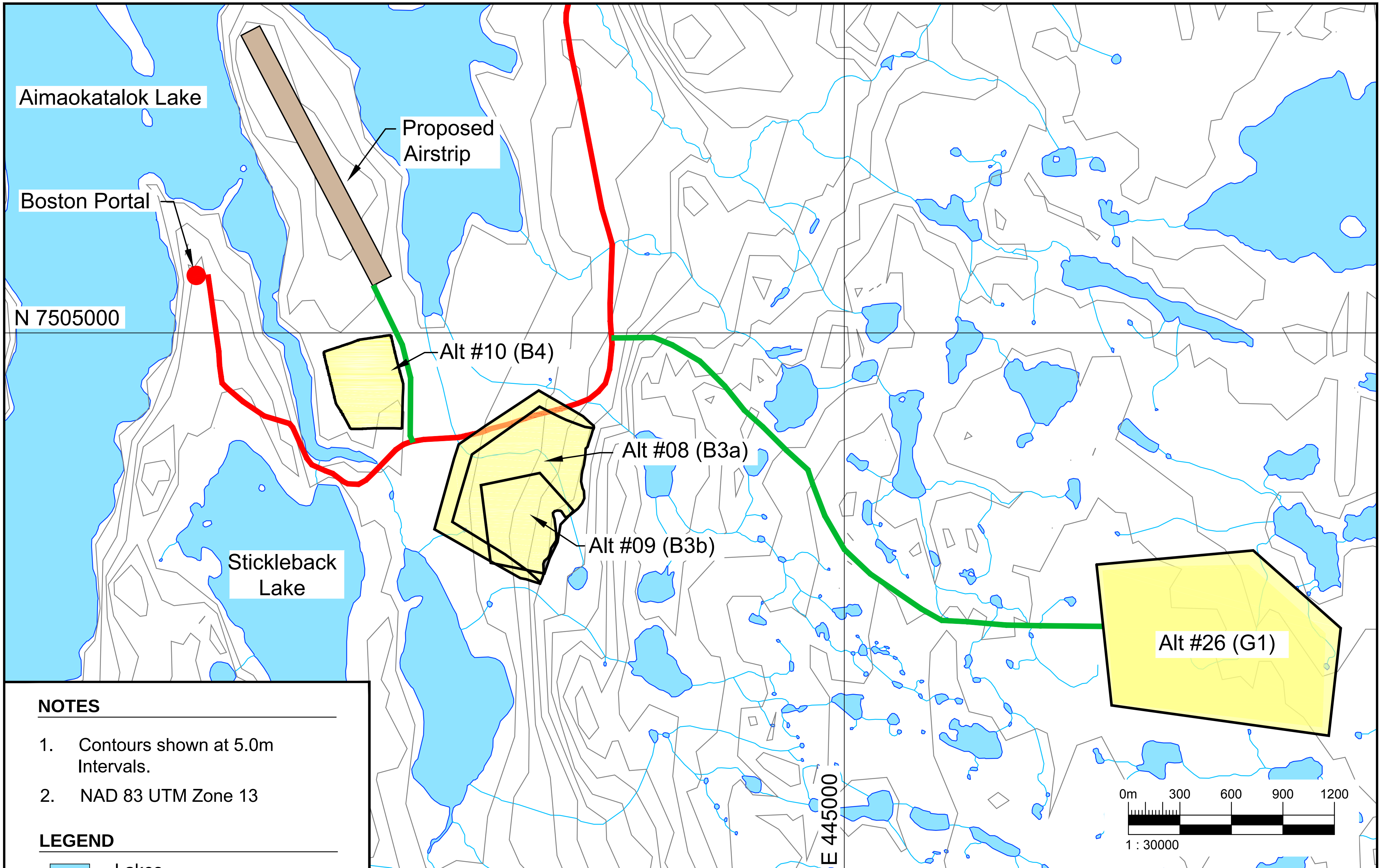
Boston Tailings Diposal Alternatives Assessment

Tailings Disposal Alternatives

SRK JOB NO.: 1CT022.004.600.20	DATE: Nov. 2016	APPROVED: IM	FIGURE: 02
FILE NAME: 1CT022.004T600-FIGURE 2.dwg			



NOTES

1. Contours shown at 5.0m Intervals.
2. NAD 83 UTM Zone 13

LEGEND

- Lakes
- Tailings Alternatives
- Creeks and Rivers
- Proposed Access Road
- Madrid-Boston Road

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SRK JOB NO.: 1CT022.004.600.20

FILE NAME: 1CT022.004T600-FIGURE 3.dwg

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Boston Tailings Disposal Alternatives Assessment

Shortlisted Tailings Disposal Alternatives

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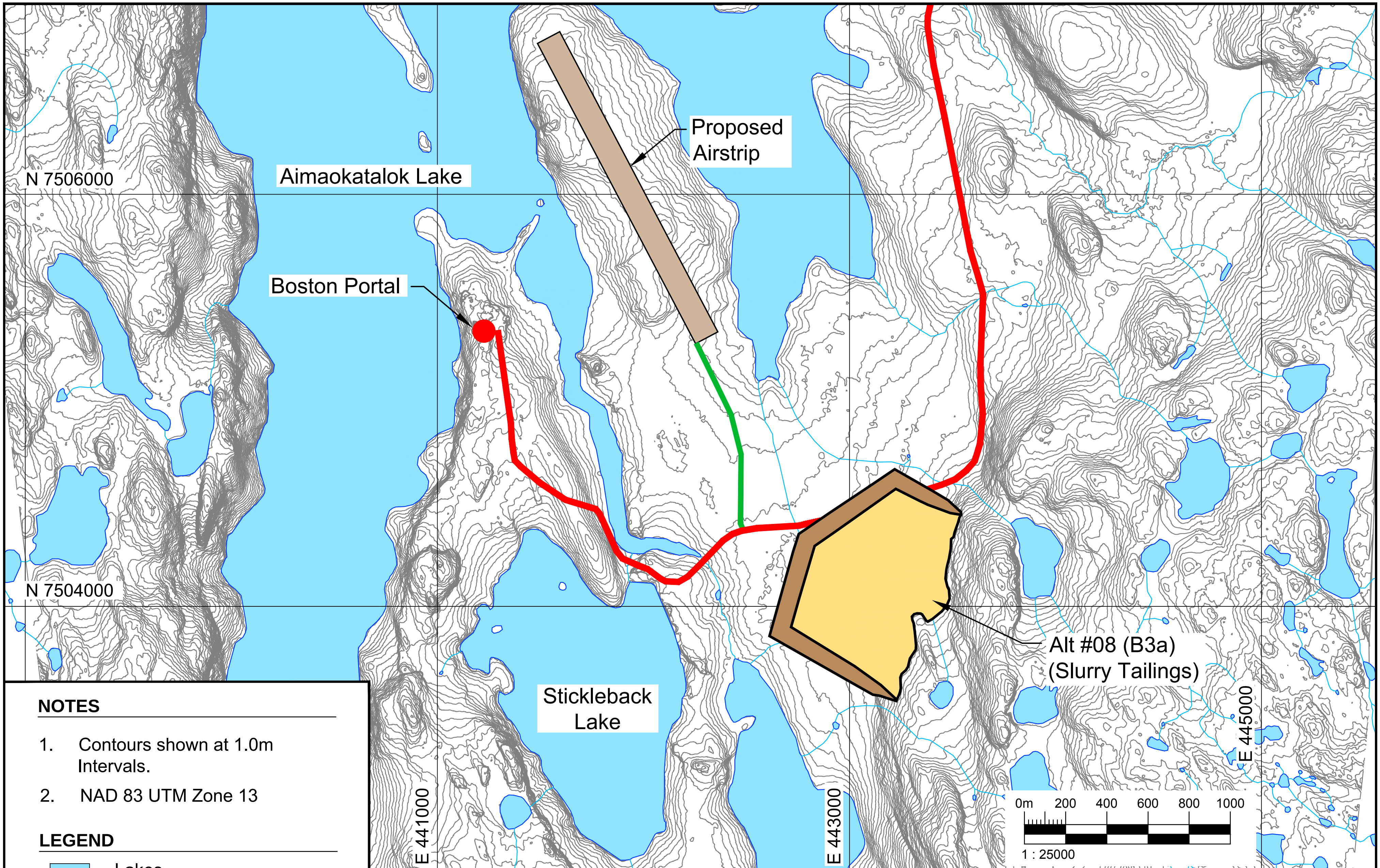

NOTES

1. Contours shown at 1.0m Intervals.
2. NAD 83 UTM Zone 13

LEGEND

- Lakes
- Tailings Area
- Creeks and Rivers
- Proposed Access Road
- Madrid-Boston Road

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SRK JOB NO.: 1CT022.004.600.20

FILE NAME: 1CT022.004T600-FIGURE 5 B3a.dwg

HOPE BAY PROJECT

Boston Tailings Disposal Alternatives Assessment

Alternative #08 (B3a) (Slurry Tailings)

DATE:	APPROVED:	FIGURE:
Nov. 2016	IM	04