Hope Bay Project, Waste Rock, Ore and Mine Backfill Management Plan

Hope Bay, Nunavut

January 2019

Hope Bay Project, Waste Rock, Ore and Mine Backfill Management Plan

Plain Language Overview:

This Plan describes how rock that is brought to the ground surface during mining and mine backfill materials are handled to minimize impacts to water quality. The rock brought to surface from the underground mine includes ore (rock that contains economic quantities of gold) and waste rock (rock that does not contain economic quantities of gold). When ore is brought out of the mine, it is placed in stock piles until it is processed to extract the gold. As much waste rock as possible is left underground to fill voids created by mining and thus stabilize the ground. However, some of the waste rock may be brought to surface during mining and temporarily stockpiled separate from the ore. The rock will be taken back underground on an ongoing basis as underground void space becomes available however where suitable some may be used for construction.

Mine backfill is required for structural purposes and includes waste rock from the underground mine (all mines), rock extracted from quarries on surface (Madrid North and Boston) and/or detoxified tailings from the mill (Doris, Madrid North and Boston). Detoxified tailings are classified as potentially acid generating (PAG). Rock quarried on surface is used for construction or underground backfill. All quarry rock geochemically characterized as having a high risk for acid rock drainage (ARD) will be used as mine backfill only. All backfill is placed on the waste rock stockpile prior to transfer underground.

A secondary objective of the plan is to implement a monitoring program that will support mitigative action, as required, in the event that unanticipated changes to water quality are observed in drainage from the surface stockpiles or underground.

Hope Bay, Nunavut

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Revisions

Revision #	Date	Section	Changes Summary	Author	Approver
1	2010		Approved Plan under 2AM-DOH1323	SRK	HBML
2	April 2015	Throughout	TMAC as current licensee for the Hope Bay region.	SRK	TMAC
		Throughout	Addition of Pad T for waste rock storage		
		Sec 3.3	Introduction of the low salt drilling procedure		
		Throughout	Update classification of Gabbro as Low NP basalt		
3	June 2015	Throughout	Changes to document structure for operational suitability and efficiency	TMAC with contributions from SRK	TMAC
		Sec 1	Addition of Glossary and list of List of Acronyms, related TMAC documents, revised Plan Management responsibilities		
		Sec 2	Revised waste rock classification and segregation		
		Module A	Concordance with 2AM-DOH1323, revised Mine development plan to include placement of waste rock on Pad T, Ore storage on Pad U		
4	August 2016	Sec 2.4	Limiting backfill of ANFO spill impacted material to permafrost zones of the underground mine	TMAC with contributions from SRK	TMAC
		Sec 2.6	Limiting backfill of hydrocarbon impacted material to permafrost zones of the underground mine		
		Sec 2.1 and Sec 3.2	Monitoring of the available mine void space and backfill volumes being placed underground		
		Sec 2.3	New section pertaining to detoxified tailings		
		Sec 2.1	Inclusion of monitoring for Total Cyanide as part of the surface water monitoring program		
		Sec 5	References updated		
		Sec 2.1.1	Removal of segregation into mineralized and non-mineralized		
			Approved Plan under 2AM-DOH1323 Amendment No.1		

Revision #	Date	Section	Changes Summary	Author	Approver
5	December 2017	Throughout	Replaces the plan for waste rock from Doris (Phase 1). Now includes waste rock from Madrid North, Madrid South and Boston (Phase 2) and Doris.	TMAC with contributions from SRK	TMAC
		Sec 1.2	Change in overall management of waste rock explained		
6	January 2019	Throughout	Updates to conform to amended water license	TMAC	TMAC

Conformity Table

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<tr><th>Licence</th><th>Part</th><th>Item</th><th>Topic</th><th>Report Section</th></tr>
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<tr><td>18</td><td>Quarry rock monitoring</td><td>Sec 3.1.6</td></tr>
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<tr><td>19</td><td>Surface seepage collection</td><td>Sec 2.1.1</td></tr>
<tr><td rowspan="4">F</td><td>13,14,15,</td><td>Waste rock and quarry monitoring and management</td><td>Sec 2.1, Sec 3.1, Sec 3.2 and Sec 3.3</td></tr>
<tr><td>19j</td><td>Use of detoxified tails as backfill in permafrost</td><td>Table 1-3 and Sec 2.2</td></tr>
<tr><td>15</td><td>Manage underground backfill and placement</td><td>Table 1-3, Table 3-2, and Sec 3.1</td></tr>
<tr><td>12</td><td>Waste rock segregation</td><td>Sec 3.2 and Appendix A</td></tr>
<tr><td>I</td><td>5d, 5e</td><td>Monthly volumes</td><td>Table 1-3 , Sec 3.1 and Table 3-2</td></tr>
<tr><td>I</td><td>6b</td><td>tonnage of tails placed underground</td><td>Table 1-3, Sec 3.1, Table 3-1 and Table 3-2</td></tr>
<tr><td colspan="2">Provisions in Schedule B</td><td>Annual reporting</td><td>Sec 3.3</td></tr>
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<tr><td rowspan="13">2AM-BOS1835</td><td rowspan="5">D</td><td>1</td><td>Waste rock and quarry monitoring and management</td><td>Sec 2.1, Sec 3.1, Sec 3.2 and Sec 3.3</td></tr>
<tr><td>2</td><td>Rock for construction</td><td>Sec 3.2 and Sec 4.2</td></tr>
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<tr><td>20</td><td>Quarry rock monitoring</td><td>Sec 3.1.6</td></tr>
<tr><td rowspan="4">F</td><td>13</td><td>Waste rock segregation</td><td>Sec 3.2 and Appendix A</td></tr>
<tr><td>14</td><td>Waste rock and quarry monitoring and management</td><td>Sec 3.1.6, Sec 2.1, Sec 3.1, Sec 3.2 and Sec 3.3</td></tr>
<tr><td>16</td><td>Manage underground backfill and placement</td><td>Table 1-3, Table 3-2, and Sec 3.1</td></tr>
<tr><td>23</td><td>Use of waste rock for construction</td><td>Sec 3.2 and Appendix A</td></tr>
<tr><td rowspan="2">I</td><td>6b</td><td>tonnage of detoxified tailings placed underground</td><td>Table 1-3, Sec 3.1, Table 3-1 and Table 3-2</td></tr>
<tr><td>5f</td><td>Monthly Tonnes of Waste Rock</td><td>Table 1-3 , Sec 3.1 and Table 3-2</td></tr>
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<tr><td rowspan="2">2BB-MAE1727 Amendment No.2</td><td rowspan="2">G</td><td>1,4</td><td>Construction Summary Report</td><td>Sec 3.3</td></tr>
<tr><td>5</td><td>Quarry rock monitoring</td><td>Sec 3.1.6</td></tr>
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		13	Rock for construction	Sec 3.2 and Sec 4.2
		13	Use of waste rock for construction	Sec 3.2
		5	Waste rock and quarry monitoring and management	Sec 2.1, Sec 3.1, Sec 3.2 and Sec 3.3
	E	13	Surface seepage collection	Sec 2.1.1
	B	2	Annual reporting	Sec 3.3

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Glossary

Term	Definition
ABA	Acid base accounting
ANFO	Ammonium nitrate – fuel oil mixture
AP	Acid potential
ARD	Acid rock drainage
EC	Electrical conductivity
FOS	Factor of safety
GPS	Global positioning system
HBML	Hope Bay Mining Ltd.
ICP-MS	Inductively coupled plasma – mass spectrometry
ML	Metal leaching
NiAsS	Sulphide mineral gersdorffite
Non-PAG	Non-potentially acid generating
NP	Neutralization potential
NWB	Nunavut Water Board
ORP	Oxidation-reduction potential
PAG	Potentially acid generating
PCP	Pollution control pond
pH	Hydrogen ion concentration
QMP	Quarry Management Plan
SNP	Surveillance Network Program
TDS	Total dissolved solids
TIA	Tailings Impoundment Area
TIC	Total inorganic carbon
TMAC	TMAC Resources Inc.

1 Introduction

The Plan is intended primarily for use by TMAC and its contractors to ensure that best practices for minimizing potential environmental impacts and potential environmental liabilities associated with waste rock, ore and mine backfill storage are understood and managed.

The document outlines TMAC's approach to waste rock, ore and mine backfill management as it pertains to all TMAC Hope Bay developments.The Plan is structured in a manner such that one document pertaining to waste rock, ore and mine backfill management is approved and implemented across all TMAC Hope Bay project sites, while still addressing site- and licence-specific needs.

1.1 Objectives

The objective of the Plan is to provide guidance and procedures required to deposit, manage and monitor waste rock, ore and mine backfill stored on-site in accordance with the current mine and closure plans for Doris, Madrid North, Madrid South and Boston and licences associated with development of the Hope Bay Project.

A secondary objective of the plan is to implement a monitoring plan that will support mitigative action, as required, in the unanticipated event that deleterious water quality is observed in drainage from the surface stockpiles or underground.

The third objective is to outline the process for establishing suitable waste rock for use in the construction of pads, roads or other construction uses consistent with the flexibility authorized under TMAC's Type A and B licences. Waste rock that is determined suitable for construction is not considered waste rock once utilized as such.

1.2 Scope of the Plan

The design of the management plan is consistent with TMAC's current mine and closure plans. Specifically:

- Waste rock brought to surface will ultimately be placed as structural backfill in an underground mine. At closure, no waste rock will remain on surface, except for rock that has been characterised as suitable and utilized for construction of surface infrastructure.
- The waste rock will not be segregated on surface based on geological management units.
- The management and monitoring of detoxified tailings from the both Doris and Boston processing plants.
- Management of quarry rock that is placed on the waste rock stockpile for its intended use as mine backfill.
- The geochemical requirements to demonstrate the geochemical suitability of waste rock for use as construction material.

Furthermore, this plan:

- Supercedes TMAC's *Waste Rock and Ore Management Plan, Hope Bay Project, Nunavut* (TMAC 2016) dated August 2016, which was approved under 2AM-DOH1323 Amendment No.1 Water Licence.
- Updates and supercedes the *Overview of Madrid North and Madrid South Bulk Sample ML/ARD Characterization Programs and Conceptual Waste Rock Management Plan*, dated December 2014 (SRK 2014) as required under the Madrid Advanced Exploration Project 2BB-MAE1727 Water Licence.
- Does not address the waste rock and ore currently on surface at Boston camp as part of underground exploration carried out in 1996/97. The management plan for these materials is documented in the *Water and Ore/Waste Rock Management Plan for the Boston Site, Hope Bay Project, Nunavut* (TMAC 2017a) dated January 2017 as part of the Boston Advanced Exploration Project 2BB-BOS1727 Water Licence.
- Supercedes TMAC's Waste Rock, Ore and Mine Backfill Management Plan (December 2017) which was submitted and reviewed for permitting of the Phase 2 Madrid-Boston Project.

1.3 Background

The Hope Bay Project is a gold mining and milling undertaking of TMAC. 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.

In 2010 and 2011, approximately 2,670 m of lateral and 76 m of vertical underground development were completed at the Doris Mine by HBML. This development resulted in production of approximately 183,000 t of waste rock, including 86% non-mineralized and 14% mineralized waste rock. Additionally, 329 m of ore development occurred resulting in the production of 9,400 t of ore (HBML 2012).

Throughout this period, HBML placed the rock according to the approved interim management plans described in Revision 01 of the Waste Rock Management Plan (SRK 2010), which included segregation of mineralized and non-mineralized waste rock within the footprint of the Temporary Waste Rock Pad (on Pad I; Pads F and G were temporarily used as laydown areas), and placement of ore on Pads Q and H/J). HBML's waste rock program included segregation of waste rock based on lithology and sulphide content to create a stockpile of waste rock with low risk of ML/ARD. The segregation program was designed to meet the objectives of the HBML mine plan and closure objectives, specifically using the segregated stockpile of low risk ML/ARD waste rock as construction material and/or leaving this stockpile on surface at closure.

No underground development occurred during 2012-2014. TMAC re-opened the Doris mine in 2015 and constructed Pad I for waste rock storage. Consistent with TMAC's mine plan (TMAC 2015) and revised waste rock management plan (SRK 2015), waste rock was not segregated on Pad I and a new pad (Pad T) was constructed. Pad T is currently the main Temporary Waste Rock pad and ore is being stockpiled around the perimeter of Pad T according to the approved Revision 4 of the Waste Rock and Ore Management Plan (TMAC 2016).

Waste rock stockpile material are maintained, including volumes of:

- Waste rock placed on the stockpile, according to deposit;
- Detoxified tailings placed on the stockpile;
- Quarry rock placed on the pad, according to source Quarry;
- Backfill, as either rock or detoxified tailings, returned to the mine; and
- Voids created in the mine.

1.4 Relevant Legislation and Guidance

The following table lists federal and territorial regulations governing the management of waste rock and ore and associated guidelines.

Table 1-1. Regulations and guidelines pertinent to the Hope Bay Project, Waste Rock, Ore and Mine Backfill Management Plan

Regulation	Year	Governing Body	Relevance
Nunavut Waters Regulation (NWB 2013)	2013	Nunavut Water Board (NWB)	License for mining and milling undertaking to use water and deposit of waste in relation to the construction, operation, closure and reclamation.
Mine Health and Safety Act and Regulations (WSCC 2011)	2011	Workers' Safety and Compensation Commission (WSCC)	Waste dump design and operations safety requirements. Designs to be approved by Chief Inspector.
Guideline	**Year**	**Issued by**	**Relevance**
Prediction Manual for Drainage Chemistry for Sulphidic Geologic Materials, Report 1.20.1 (MEND 2009)	2009	Mine Environmental Neutral Drainage (MEND)	Guidance on determining the type, magnitude, location and timing of measures required to prevent significant environmental impacts by drainage from disturbed rock.
Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories (MVLWB/AANDC 2013)	2013	Aboriginal Affairs and Northern Development Canada (AANDC) and the Mackenzie Valley Land and Water Boards (MVLWB)	Guidance on closure and reclamation expectations.

1.5 Related Documents

Table 1-2 provides a list of documents to be considered in conjunction with this Plan.

Table 1-2. List of documents related to the Hope Bay Project, Waste Rock, Ore and Mine Backfill Management Plan

<table>
<tr><th>Document Title</th><th>Year</th><th>Relevance</th></tr>
<tr><td>Hope Bay Project Boston Water Management Plan (TMAC 2017b)</td><td>2017</td><td>Identifies water management areas, facilities and procedures</td></tr>
<tr><td>Hope Bay Project, Quarry Management and Monitoring Plan (TMAC 2017c)</td><td>2017</td><td>Describes management of rock for all Phase 1 and Phase 2 quarries, including identification of quarry rock suitable for use as construction material and/or mine backfill. Monitoring programs for quarry rock is outlined.</td></tr>
<tr><td>Hope Bay Spill Contingency Plan (TMAC 2017d)</td><td>2017</td><td>Spill response procedure</td></tr>
<tr><td>Air Quality Management Plan (TMAC 2017e)</td><td>2017</td><td>Outlines how fugitive dust, associated with blasting, hauling and end dumping is managed and monitored.</td></tr>
<tr><td>Hope Bay, Explosives Management Plan (TMAC 2017f)</td><td>2017</td><td>Contingency procedure for disposal of spilled ANFO</td></tr>
<tr><td>Kinetic Testing of Waste Rock and Ore from the Doris Deposits, Hope Bay (SRK 2015b) and Supporting Data (SRK 2015c)</td><td>2015</td><td rowspan="2">Geochemical characterization of waste rock, ore, quarry rock and detoxified tailings.

Source term estimates for rock stockpiles and underground mines containing backfill.</td></tr>
<tr><td>Static Testing and Mineralogical Characterization of Waste Rock and Ore from the Doris Deposit, Hope Bay (SRK 2015d) and Supporting Data (SRK 2015e)</td><td>2015</td></tr>
<tr><td>Doris Madrid Water Management Plan (TMAC 2017g)</td><td>2017</td><td>Identifies water management areas, facilities, procedures and SNP monitoring for contact water from surface stockpiles and underground mine.</td></tr>
<tr><td>Groundwater Management Plan (TMAC 2017h)</td><td>2017</td><td>Identifies underground sump water monitoring procedures.</td></tr>
</table>

1.6 Plan Management

This Plan is reviewed annually and updated as necessary. Revisions to the Plan will be submitted as necessary to address future water licence conditions. Personnel responsible for implementing and updating the Plan identified in Table 1-3.

Table 1-3. Roles and Responsibilities

Role	Responsibility
Mine General Manager	• Overall responsibility for implementation of this management plan • Provide the on-site resources to operate, manage, and maintain waste rock and ore management infrastructure such as pads, stockpiles and ponds • Ensure underground practices are continually improved to reduce brine and blast residues in waste rock • Provide input on modifications to handling and operational procedures to improve operational performance
Surface Manager	• Conduct regular inspections of the pads, stockpiles and containment ponds • Facilitate Geotechnical Inspection, when required
Environmental Manager	• Updating the Plan; • Providing the necessary resources for completing the water sampling programs; • Coordinate: - Waste Rock and Quarry Monitoring Report; and - Monthly Monitoring Report.
Environment Supervisor	• Ensure water sampling programs are completed as needed; • Keeping records of onsite analysis, observations, photographs, and laboratory analysis; • Conduct or facilitate seep sampling program on surface and underground as required; and • Conduct monthly and annual regulatory reporting as required
Mine Geologist	• Execute construction qualification sampling program and assisting with any underground seepage monitoring; • Inspect the working face on a regular basis to confirm geology • Instruct the mucking crew regarding waste rock and ore placement on surface
Mucking crew	• Place waste rock and ore in the intended and designated location
Mine Engineer	• Record quantity of material sent to each of the stockpiles in daily record • Record quantity, source and destination of backfill material sent to underground in daily record • Provide waste rock and backfill movement totals to Environment Manager monthly
Blaster	• Inspect blasted area • Make note of and mark blast holes with paint that may not have been completely detonated

2 Waste Rock, Ore and Backfill Management Issues

2.1 Waste Rock Stockpile – Metal Leaching and Acid Rock Drainage (ML/ARD) Potential

The mine plans for all Hope Bay mines includes placement of structural backfill in the underground. Backfill material types include waste rock, detoxified tailings and/or quarry rock, depending on the specific mine (Table 2.1). On surface, all backfill materials will be placed on the waste rock stockpile prior to placement in the underground stopes. At closure, there will be no waste rock and detoxified tailings remaining on surface pads.

Contact water chemistry from waste rock stockpile materials will be a result of metal leaching and/or acid rock drainage (ML/ARD) due to the weathering of sulphide minerals. Due to the high carbonate content of rock at Hope Bay, the risk of ARD for the waste rock stockpile is low however, neutral pH drainage issues can occur, depending on the mine, as discussed below.

Table 2.1. Sources of structural backfill

Mine	Backfill Source
Doris	• Doris waste rock • Detoxified tailings from Doris processing plant
Madrid North	• Madrid North waste rock • Doris waste rock • Madrid South waste rock • Detoxified tailings from Doris processing plant • Quarry rock
Madrid South	• Madrid South waste rock
Boston	• Boston waste rock • Detoxified tailings • Quarry rock (including all rock from Quarry AD)

2.2 Geochemical Characterization of Mine Backfill

This section discusses the geochemistry of waste rock, quarry rock and detoxified tailings. For context, the geochemistry of ore is also presented. Contact water from the temporary waste rock stockpile pad is projected to remain pH neutral. At closure, there will be no materials on the waste rock stockpile as all material will be placed as backfill underground.

2.2.1 Waste Rock

The geochemistry of waste rock varies according to geological deposit and is therefore discussed according to each mine. The geochemical characterization program for waste rock is documented in SRK (2015b, 2015c, 2015d, 2015e, 2017a, 2017b and 2017c). The results of operational monitoring of Doris waste rock are also documented (e.g. SRK 2017j). This section presents a summary of the geochemistry of waste rock from each mine.

Doris

The baseline geochemical characterization program indicated that the majority of the samples were classified as non-potentially acid generating (non-PAG). Most of the samples classified as PAG or uncertain were classified as ore or as a mixture of ore and waste rock. Diabase and some of the hornfelsed basalt had low sulphide, NP and TIC content, and were classified as PAG or uncertain on the basis of low NP/TIC ratios, but contained such low concentrations of sulphide that buffering by silicate minerals is likely to be sufficient to maintain neutral pH conditions in these rocks. The risk of ARD/ML from Doris waste rock is low and demonstrated by operational monitoring of waste rock and associated seepage (e.g. SRK 2017j).

Madrid North

The most volumetrically significant waste rock lithology is mafic metavolcanics (1)[1]. The ore is also hosted in the mafic metavolcanics (1). Mafic volcanics with sediments (1oj, 1aj or 1aj), intermediate volcanics (2p, 2pg), sedimentary units (5) and the deformation zone (13a) are volumetrically less significant waste lithologies that are projected to be intersected by the mine workings based on the geological logging. Additional volumetrically minor units include mafic volcanics with sediments (1oj, 1aj), intermediate volcanics (2p, 2pg), early gabbro (7a), late mafic intrusive rocks (10b), diabase (11c) and quartz veins (12q).

The waste rock sample set was typically characterized by low sulphur levels, with 90% of samples having total sulphur contents less than 0.43%. Carbonate minerals were generally ubiquitous and abundant. Ferroan dolomite was the dominant carbonate mineral though calcite was the dominant carbonate mineral in selected rock types. Median levels of NP and TIC for mafic metavolcanics is greater than 240 kg$CaCO_3$/t. All other rock types except mafic intrusives and diabase, had median NP and TIC levels greater than 100 kg $CaCO_3$/t.

Samples of ore contained the highest median total sulphur levels, which included rock types mafic metavolcanics (1 ore and 1 ore/waste), mixed mafic metavolcanics (1 mixed) and mixed sedimentary units (5 mixed). These gold-bearing samples had median values of NP and TIC of 120 and 140 $CaCO_3$/t, respectively.

The acid-base accounts ($TIC_{(Ca+Mg)}$/AP) resulted in more than 95% of samples classified as non-PAG, where $TIC_{(Ca+Mg)}$ is the effective TIC and addresses the potential overestimation of neutralization potential due to the presence of NP-neutral iron carbonates. The rock types classified as PAG (sedimentary units and early gabbro) are projected to represent less than 4% of the volume of waste rock. Kinetic test work indicates arsenic, antimony, cobalt, molybdenum and nickel leaching are potential issues at neutral to alkaline pH values.

[1] Denotes TMAC lithological codes

Madrid South

The most volumetrically significant rock types for the Madrid South deposit include mafic to ultramafic metavolcanics (1), intermediate volcanics (2), and late porphyry granitoids (9). Less significant rock types characterized include quartz veining (12q), which is associated with gold mineralization, intermediate to felsic volcanics (3ao), early gabbro intrusives (7), late gabbro intrusive (10a), late mafic dykes (10b), and carbonate vein (12c).

The waste rock and ore samples were characterized by low sulphur content, with 95% of samples containing less than 0.5% total sulphur. Levels of NP and TIC were high (median values for all rock types greater than 75 kg$CaCO_3$/t). All samples were classified as non-PAG.

The potential for ARD from Madrid South waste rock is low. Neutral pH metal leaching from the relatively small proportion of samples that contain higher sulphur concentrations is of concern, specifically related to arsenic and, to a lesser extent, cobalt, copper, nickel, molybdenum and uranium.

Boston

The most volumetrically significant waste rock lithologies are mafic metavolcanics (1) and sedimentary units (5). The ore is hosted in quartz veins (12q), mafic metavolcanics with sediments (1oj) and mafic metavolcanics (1). Mafic metavolcanics with sediments (1oj), late intermediate dyke (9n) and late gabbro (10a) are volumetrically less significant waste lithologies.

Sulphur levels for Boston (75^{th} percentiles of 0.38%) were higher than Doris, Madrid North, and Madrid South (0.26, 0.28 and 0.11%, respectively). NP and TIC values were high (median values for all rock types greater than 85 kg $CaCO_3$/t).

The risk of ARD for Boston is low, with approximately 95% of the overall sample set classified as non-PAG. Boston ore samples were characterized by higher levels of total sulphur compared to waste. The humidity cell tests data indicated that arsenic leaching is related to solid-phase arsenic content, and arsenic, antimony, cobalt and nickel leaching are potential issues at neutral to alkaline pH values. Compared to the other Hope Bay deposits, arsenic content for mafic metavolcanics from Boston were higher than Madrid South and generally comparable to Madrid North.

2.2.2 Quarry Rock

Quarry rock typically has a low risk for ARD/ML and is suitable for use as construction material. It is anticipated that the majority of quarry rock backfill will have a low risk for ARD/ML. Quarries containing PAG rock that would be developed (e.g. Quarry AD where the Boston mill pad will be developed) will be used as mine backfill only. The *Hope Bay Quarry Management Plan* outlines management of quarry rock (TMAC 2017c).

2.2.3 Detoxified Tailings

Detoxified tailings have high sulphide content and are classified as PAG (SRK 2015f and 2017d). Kinetic testing indicated that sulphate, cobalt, manganese, nickel and selenium leaching at neutral to alkaline pH conditions. The projected onset to acidity for detoxified tailings is 20 years (SRK 2015f). The residence time of detoxified tailings on surface will be less than this period, therefore drainage from detoxified tailings is expected to be neutral to alkaline pH during operations.

2.2.4 Management Response

Backfill Materials Management on Surface

Backfill material types include waste rock, detoxified tailings and/or quarry rock, depending on the specific mine (Table 2-1). On surface, all backfill materials will be placed on the waste rock stockpile prior to placement in the underground stopes. Backfill use and available mine void space will continuously be monitored to ensure that the all backfill materials can be placed underground as proposed. At closure, there will be no mineralized waste rock and detoxified tailings on surface. The management of each backfill type is discussed below.

Waste Rock

All mineralized waste rock from Doris, Madrid South, Madrid North and Boston will be placed as backfill in the underground stopes. At each mine, over 50% of the waste rock will remain underground and never brought to surface. Waste rock on surface will be placed on the waste rock stockpile pad.

Quarry Rock

Waste rock volumes from Doris and Madrid South are sufficient to meet structural backfill requirements, however Madrid North and Boston require imported sources. Once all mine waste rock has been exhausted, quarry rock will be developed and used for structural backfill underground.

As stated in the *Hope Bay Quarry Management Plan* (TMAC 2017c), all quarry rock classified as PAG will be placed on the waste rock stockpile for placement as underground backfill. This includes all quarry rock from Quarry AD during the construction of the mill pad at Boston. The rock will be stockpiled in the waste rock storage area prior to placement underground.

Detoxified Tailings

Detoxified tailings from the Doris processing plant are transferred underground in the Doris mine on a daily basis as they are generated. Later in the mine life, detoxified tailings from the Doris processing plant will be placed as backfill in the Madrid North mine. Detoxified tailings from the Boston processing plant will be placed as mine backfill in the Boston mine. Once all mine waste rock has been exhausted, detoxified tailings will be mixed with quarry rock during this period.

Detoxified tailings will be filtered in the plant with free water recirculated as a closed loop within the facility. Once filtered, the dry “filter cake”, which has a saturation of about 80%, has no free water. The dry filter cake can be handled with conventional earthmoving equipment. This filter cake will be trucked from the filter belt stockpile within the plant to underground workings or the waste rock storage area as needed. It will be placed immediately adjacent to, or on top of, waste rock material that is designated for backhaul to the mine as underground backfill. As waste rock material is loaded for use as underground backfill, detoxified tailings (when available) will be included in appropriate proportions to ensure the structural backfill requirements continue to be met. These tailings will be moved underground into voids that will remain frozen within permafrost on a daily basis. Due to the inherent moisture content in the material there will be no requirement for dust suppression.

Designated Surface Facilities and Water Management

All seepage and runoff from the waste rock stockpile pads are directed to downstream lined collection ponds and managed according to the water management plans (TMAC 2017b, 2017g). Contact Water Ponds are monitored as part of the Surveillance Network Program (SNP) monitoring network.

Doris

The permitted surface facilities in the Doris camp and processing plant area are shown in Figure 2.1. The site is currently divided into a series of adjoining rock pads that provide a foundation for all of the facilities in this area. The pads on the eastern half of this area (Pads D, F, G, H/J, I, Q and T) are located within the Pollution Containment System, which drains to a Pollution Control Pond (PCP) at the southern edge of the pad complex and collection sumps located at the southeast corner of the pad area. The processing plant is located on Pad D. Pad U has a dedicated PCP as it is located adjacent to the existing Pollution Containment System. Pad T is the current main Temporary Waste Rock Pad. Pads I, F and G have been and may continue to be utilized for temporary waste rock storage. Water collected at the PCPs and collections sumps is discharged to the Doris Tailings Impoundment Area (TIA).

Madrid North

The proposed surface facilities for Madrid North mine and concentrator plant are shown on Figure 2.2. The concentrator will process the Madrid North ore through a flotation circuit. The resulting flotation tailings will be pumped via pipeline and deposited in the Doris TIA. The Madrid North Contact Water Pond (CWP) will capture contact water from the Madrid North concentrator area, ore stockpile, and waste rock stockpile. The Madrid North (CWP) will be dewatered to the Doris TIA.

Madrid South

Madrid South surface facilities are shown on Figure 2.3. The Madrid South Primary CWP captures contact water within the Madrid South ore stockpile and waste rock stockpile. The Madrid South Primary CWP will be dewatered to the Doris TIA. All ore from Madrid South will be trucked to Doris for processing.

Boston

Waste rock and ore stockpile contact water at the Boston mine site will be collected in two CWPs (Figure 2.4). CWP #1 will collect runoff from the waste rock pile. The outflow from contact water pond #1 will be a pumping station directing contact water to CWP #2, and ultimately the Boston water treatment plant. CWP #2 will capture runoff from the infrastructure pads containing the process plant, ore stockpile and camp. Excess water from CWP #2 will flow over a spillway into the connected surge pond. The surge pond will be a lined facility, which will have a pipeline directly to water treatment plant.

Volume Tracking and Mine Void Space

Backfill volumes will be tracked together with the mine plan, which contains available mine void space at any given time in the mine life. This record indicates progress towards ensuring that all mine waste is placed underground prior to the completion of mining. Backfill volume tracking will include tracking of waste rock, detoxified tailings and quarry rock placement underground.

Monitoring

All monitoring of backfill materials temporarily stored on the waste rock stockpile pad is discussed in Section 3.1.

2.3 Underground Mine Backfill - Metal Leaching and Acid Rock Drainage (ML/ARD) Potential

Section 2.1 summarizes the geochemical properties of all backfill materials.

Mining of the Doris, Madrid North and Madrid South deposits is within permafrost but selected areas of the mine will intersect talik resulting in intercepted groundwater. The Boston mine is entirely within permafrost and accordingly, there will be no management of source load (water chemistry) resulting from mine backfill.

SRK (2017e) presents operational source term drainage chemistry estimates for the underground mine backfill based on the interaction of mine backfill with intercepted groundwater. At closure, all mine workings will be allowed to flood. When the mine is reflooded, all backfill will be either submerged or within permafrost, and therefore not oxidizing. The reflooded mine backfill source terms represent pore water chemistry in the mine "pool" or flooded portion of the mine workings when the water level is first allowed to recover, and oxidation products that have accumulated on the backfill material are released into the porewater. These source loads are considered backfill contact water and do not include the water chemistry of groundwater. The site-wide water and load balance combines the loads from mine backfill and groundwater sources (SRK 2017f). The source terms indicate that for operations and closure, backfill contact water chemistry at each mine will be pH neutral.

2.3.1 Management Response

Backfill

Backfill materials management is described in Section 2.1.1. The mine plans for all Hope Bay mines includes progressive placement of structural backfill in the underground during operations. Backfill material types include waste rock, detoxified tailings and/or quarry rock, depending on the specific mine. At closure, there will be no all waste rock and detoxified tailings remaining on surface.

Water Management

The management of groundwater is presented in the Hope Bay Groundwater Management Plan (TMAC 2017h). A synopsis for each mine is presented.

Doris, Madrid North and Madrid South

Intercepted groundwater will be collected in underground sumps and pumped to surface, from where it will be discharged to the marine mixing box in Roberts Bay.

Boston

The Boston Mine will be completely within permafrost, and no groundwater interception is anticipated (SRK, 2017g). The management of any unplanned groundwater interception is presented in the Hope Bay Groundwater Management Plan (TMAC 2017h).

Monitoring

The monitoring of mine backfill and underground mine drainage is discussed in Section 3.1.

2.4 ORE STOCKPILE - Metal Leaching and Acid Rock Drainage (ML/ARD) Potential

The material from the stopes is classified as ore, and will be processed in the mill. The ML/ARD potential of ore from each deposit is summarized in Section 2.1. This material tends to have a higher sulphide content and lower NP and TIC. Ore is more likely to be classified as uncertain or PAG. However, there is sufficient NP present that the development of acidic conditions is unlikely to occur during the short time that this material will be stockpiled on surface.

2.4.1 Management Response

Ore is temporarily stockpiled on surface prior to being processed in the mill to extract the gold. The ore stockpiles locations and associated water management are discussion in Section 2.1.1 (Designated Surface Facilities and Water Management).

There are no separate monitoring requirements for the ore stockpile.

2.5 Nutrient Release from Explosives

The majority of waste rock is blasted using a bulk form of ammonium nitrate and fuel oil mixture (ANFO). Nutrients may be released during mining from ANFO residue on rocks, packaging or ANFO spills. ANFO can be highly water soluble, with runoff able to release ammonia, nitrate and nitrite to the receiving environment.

2.5.1 Management Response

Surface Water Management

Water flows and seepage from waste rock and ore piles are captured in a series of ponds designed to prevent direct discharge of potentially contaminated water to the environment. All waste rock and ANFO-contaminated material will routinely be placed underground throughout operations and completely at closure.

Drainage collected in the Doris and Madrid ponds are transferred to the Doris Tailings Impoundment Area (TIA) whereas drainage in the Boston ponds will be transferred to the surge pond for treatment to the Boston water treatment plant.

Groundwater Management

Material from clean-up of ANFO spills will only be placed in permafrost areas of the mine to limit mobility of nutrients.

Minimization of Residual ANFO during Detonation

Any wet holes will be evident at the time of drilling and during the cleaning of each blast hole. The blaster, being responsible for the loading and firing of the holes, begins the loading process by checking the actual depth of each hole and records unusual conditions, such as water in the blast-holes. The inadvertent loading of ANFO into a wet blast hole could result in residual from an incomplete detonation of the product. In the event a wet hole is encountered, one of two charging methods is employed to ensure complete detonation of the explosives:

- The hole is dewatered using compressed air. This is common on the bottom (lifter) holes in underground mining.
- If the hole cannot be dewatered, or if it is seeping water, the hole will be loaded with an alternative explosive that is effective under wet conditions.

After blasting, the blaster is required by regulations to inspect the blasted area, make note of blast holes that may have experienced incomplete detonation, and mark those locations with paint. Information from the blaster’s inspection will be noted in the daily operations shift log and will be communicated to all underground supervision personnel.

Material considered un-detonated or high in ANFO residue, which will contain potentially elevated level of nutrients (primarily ammonia), will be used for backfill of permafrost areas of the mine.

Minimization of ANFO Spills

To minimize the risk of spills during loading, the loader hose is pushed to the end of the hole and is slowly withdrawn as the ANFO is blown into the hole, thereby filling the hole. Once the end of the loading hose is near the top (collar) of the hole, the loader is stopped to prevent spillage of ANFO.

In the unlikely event that a spill of ANFO occurs during charging of the blast holes, the ANFO will be cleaned-up immediately upon the completion of all loading operations, in accordance with the Spill Contingency Plan (TMAC 2017d). Spilled ANFO will be reused where possible, or deposited in a designated areas for use in backfill of permafrost areas of the mine only.

2.6 Underground Brine Water

Water is used as a lubricant for drilling, as a means of cleaning off the face and walls for geological mapping, and for dust suppression in the underground mine. Salt is added to the make-up water to lower the freeze point and thereby keep the water supply lines from freezing. This water is called underground brine water. Any excess brine water that ends up at the mine face is pumped to a settling sump and is recycled for use at the face. However, some of the water is absorbed by the blasted rock, which is hauled to the surface stockpiles.

Excessive use of salt can result in impacts to the structural integrity of infrastructure components arising from ground thaw, increased or alternative requirements for wastewater treatment and disposal, increased challenges associated with waste rock and tailings disposal and stabilization, and limitations on using the waste rock for construction.

TMAC has procedures for reducing the concentration and amount of brine that is used in the underground mine. These procedures are outlined below. The *Hope Bay Groundwater Management Plan (2017h)* provides details on the collection and fate of underground sump water management.

2.6.1 Management Response

TMAC follows a Low Salt Underground Brine Water Use Procedure to minimize the amount of calcium chloride use in the mine, and therefore minimize the amount of salt that is entrained in waste rock and ore. The procedure includes:

- locating brine mixing tanks in the mine or within an enclosure to control temperatures, and thereby limit the amount of salt used in the brine;
- using hose nozzle atomizers and/or foggers to reduce the amount of water used for dust suppression; and
- recycling brine water during drilling activities, bolt inflation, and washing activities.

2.7 Fuel and Lubricants

Any fuel or lubricant spills, including leaks from mobile equipment, have the potential to become mixed with the waste rock; and therefore, effect the quality of water entrained in the waste rock. Therefore, prevention and management of spills is particularly important for ensuring that the waste rock can be used for construction activities outside of the Pollution Containment System.

2.7.1 Management Response

If re-fuelling of mobile equipment is required in the mining or waste deposition areas, it will be conducted at a location and time that will ensure that any spill of fuel or lubricants will be effectively contained and clean-up can be easily accomplished.

Every operator is required to inspect their light or heavy equipment at the beginning of every shift. In the event that leaks are detected, the vehicle will be taken out of service and must be repaired prior to resuming use.

In the unlikely event that a spill occurs, clean-up of the spilled material will be initiated immediately as per the requirements specified in the Spill Contingency Plan.

Hydrocarbon contaminated rock will be placed in a designated area of the mineralized waste rock piles, for use in backfill of permafrost areas of the mine only.

2.8 Dust

Fugitive dust can arise from blasting, haul traffic and end dumping. Fugitive dust poses a potential risk to human and ecological health through both ingestion and deposition.

2.8.1 Management Response

The Air Quality Management Plan (TMAC 2017e) outlines procedures for managing fugitive dust including:

- Watering traffic surfaces and active end dumping areas;
- Controlling vehicle speeds; and
- Applying approved dust suppressants to high traffic areas.

2.9 Geotechnical Stability

The stability of the waste rock piles is an important consideration for traffic safety and for containment of the waste rock.

The waste rock piles are designed such that the foundation pad extends 2.5 to 3 m beyond the toe of the waste rock pile. The outer edge of the pads also have a safety berm that will prevent any large boulders from rolling off of the pad during construction. The waste rock piles have been designed with slopes of 2H:1V, and will be constructed in lifts, which will result in a configuration that provides a high degree of geotechnical stability. Stability calculations confirm that there are no stability concerns associated with stockpile design.

2.9.1 Management Response

Based on a factor of safety (FOS) of 1.0, a minimum safe distance from the crest of the waste rock pile (1.2 m) should be maintained for haul trucks dumping waste rock close to the crest of the waste rock pile.

3 Monitoring and Evaluation

3.1 Mine Backfill Monitoring

As previously discussed, drainage from all surface stockpiles (ore and waste rock) and from the Doris, Madrid North and Madrid South underground mines are expected to be pH neutral with potential metal leaching, particularly arsenic. The water management plan is designed to address understood issues related to water quality and associated water treatment. As such, the monitoring program for mine backfill materials (waste rock, quarry rock and detoxified tailings) was designed to generate the required data set to support any unanticipated drainage quality and associated mitigative measure in consideration that characterization of mine backfill materials is more practical before placement underground. The objectives of the geochemical monitoring plan are described as follows:

- Monitor water quality from waste rock stockpiles and the underground monitor as an indicator of the geochemical performance of backfill materials with respect to ML/ARD;
- Monitor the geochemical properties (ML/ARD) of the waste rock, quarry rock and/or detoxified tailings placed underground in each mine; and
- Inventory quantities of each material type placed as backfill according to mine;

Table 3-2 summarizes the operational monitoring programs, including program objectives and monitoring. An overview of the programs includes:

- Inventory of available backfill
- Maintaining records of backfill volumes according to material type (waste rock, detoxified tailings and quarry rock);
- Geological mapping inventory of waste rock from the underground workings;
- Annual inspections of the waste rock stockpile, including a freshet seepage survey and waste rock sampling program;
- Geochemical monitoring of detoxified tailings and quarry rock backfill; and
- Routine water quality monitoring of contact water quality from surface stockpiles and underground mine sumps.

Table 3-1. Overview of Mine Backfill Monitoring Programs and Objectives for Doris, Madrid North, Madrid South and Boston

Component	Report Section	Monitoring Program	Objective	Frequency
Waste Rock	3.1.1	Material handling records	• Inventory of waste rock backfill, including source mine.	• Reported monthly
	3.1.2	Routine geological mapping of blast round face and back[2]	• The geochemical characterization of waste rock for each mine was determined according to rock type therefore, the operational inventory of waste rock geology also provides an inventory of baseline ML/ARD potential of waste rock backfill, e.g. SRK 2017a.	• As determined by TMAC geology
	3.1.3	Annual inspection of waste rock stockpile and geochemical characterization of waste rock	• Visual inspection of waste rock stockpile and sampling and geochemical characterization of waste rock for comparison with baseline geochemical characterization, e.g. SRK 2017a.	• Annually
	3.1.4	Annual seepage monitoring	• Monitor stockpile contact geochemistry and confirm appropriate capture of contact water	• Annually at spring freshet
Detoxified Tailings	3.1.1	Material handling records	• Inventory of tailings placed as backfill	• Daily
	3.1.5	Geochemical characterization of detoxified tailings	• Geochemical characterization of detoxified tailings for ML/ARD potential.	• Monthly
Quarry Rock	3.1.1	Material handling records	• Inventory of quarry rock placed underground, including source quarry.	• Reported monthly
	3.1.6	Geochemical characterization of quarry rock (as backfill)	• Geochemical characterization of quarry rock used as backfill.	• Two samples per year when quarry active.
Waste rock stockpile	3.1.7	Water quality monitoring of contact water in downstream collection ponds.	• Monitor water chemistry from waste rock stockpiles	• Monthly
Ore stockpile	3.1.7	Water quality monitoring of contact water in downstream collection ponds.	• Monitor water chemistry of waste rock and ore stockpiles.	• Monthly
	3.1.4	Annual seepage monitoring	• Confirm appropriate capture of contact water	• Annually at spring freshet
Underground mine	3.1.2	Mine void space	• Inventory of available mine void space for backfill	• Reported monthly
	3.1.7	Water quality monitoring of mine sumps	• Monitor water chemistry of underground mine (mine backfill, blast residues and drilling brines)	• Monthly

[2] Conducted as part of the mine geological mapping program

3.1.1 Backfill Volume Tracking and Mine Void Space

Backfill volumes will be tracked together with each mine plan, which contains available mine void space at any given time in the mine life. This record indicates progress towards ensuring that all mine waste is placed underground prior to the completion of mining. Backfill volume tracking will include tracking of waste rock, detoxified tailings and quarry rock placement underground. As discussed in Section 3.1, waste rock geochemistry varies by mine and quarry rock geochemistry can vary by quarry. Accordingly, the volumes of waste rock and quarry rock backfill will also be traced according to source location to allow for geochemical tracking of backfill. This is in relation to Madrid North, which has waste rock backfill also sourced from the Doris and Madrid South mines. Quarry rock from multiple sources may also be placed as backfill at Madrid North and Boston.

3.1.2 Geological Mapping of Mine Workings

TMAC routinely conducts geological mapping of each blast round within the underground workings. This program includes logging of the waste rock lithology, thereby allowing the tracking of waste rock according the ML/ARD potential, as established by the geochemical characterization program of waste rock and ore, e.g. SRK 2017x. The operational geochemical monitoring of waste rock is discussed in Section 3.1.3

3.1.3 Annual Inspections and Geochemical Characterization of Waste Rock

Material in the waste rock stockpiles is inspected by a qualified geochemist on an annual basis. The purpose is to examine the waste rock for signs of sulphide oxidation and weathering, and conduct the operational waste rock geochemical monitoring program.

A representative sample set of the waste rock in the stockpile will be collected (approximately 5 to 20 samples based on volume and geology. Both location of origin and the location where the material is placed in the dump will be established and recorded. The samples will be submitted to a commercial testing laboratory for full ABA (including total sulphur, sulphur speciation, inorganic carbon, and modified Sobek NP), TIC and trace metals by ICP digestion. The -2 mm fraction of a subset of samples will be submitted for shake flask extractions to assess the soluble content, including residues from blasting and drilling brines.

Samples will be approximately 1 to 2 kg in size. The following information will be recorded at the time of sampling:

- GPS coordinates of the sample location;
- Approximate location of where the associated waste rock was deposited (location in the pile);
- The name of the person who collected the sample;
- Date and time of sampling; and
- Geological description, including rock type, estimated sulphide and carbonate content.

Data from confirmatory testing and geological inspections would be compared to the baseline ML/ARD characterization of waste rock. Results of the inspections and waste rock geochemical characterization are provided in the annual report to the NWB.

In addition, annual visual inspections of all pads, berms and containment ponds by TMAC geotechnical engineer are to be completed to determine if the facilities are operating as designed and to assess maintenance requirements.

3.1.4 Seep Survey

Spring seep surveys are conducted to characterise metal leaching and confirm appropriate capture of mine backfill runoff. Areas include the down-gradient toe of the waste rock pile, and below the contact water ponds and associated pads.

Seep surveys are completed annually during freshet each year while mine backfill and material is stored on a surface pad. Seep surveys are completed along all safely accessible areas along the down-gradient toe of the mine backfill piles and pads below the PCPs and CWPs and access roads to the pads that contain mine backfill. The surveys are completed during the latter part of the spring freshet, concurrent with other seep surveys completed elsewhere on-site.

Seeps are identified by walking along the down-gradient toe of the roads, piles and pads looking and listening for signs of flowing water. Samples of seepage water are collected for analysis where seepage flow exits the pads to the surface. A survey stake is installed to mark the location of each seep sampled and the following information is recorded:

- Description of the seep location;
- Global positioning system (GPS) location of the seep;
- A photographic record of the seep;
- A description of the flow pattern and magnitude of flow; and
- Field pH, Chloride, Electrical Conductivity (EC), Oxidation reduction potential (ORP) and temperature readings.

Field pH, Chloride, EC, ORP and temperature measurements are also to be established at reference sites located in a similar geological, and physiographic setting, but away from the influence of mine related activities. These reference stations may also be shared with the quarry monitoring programs.

In the immediate area of the waste rock pile, water samples are collected from all distinct seepage locations. Where there are clusters of seeps within 50 m of each other, the one with the dominant flow will be sampled, appropriately preserved, labelled, and submitted to an accredited laboratory for analysis. The following information is recorded per sample:

- The name of the person who collected the sample;
- Date and time of sampling; and
- Date of analysis.

Following receipt of analytical results, the following are maintained on-site to support annual Water Licence reporting and record keeping:

- Name of person who completed the analysis;
- Analytical methods or techniques used; and
- Results of the analyses, including pH, total dissolved solids (TDS), acidity and/or alkalinity, sulphate, total ammonia, nitrate, total cyanide, and a full suite of metals by ICP-MS.

3.1.5 Geochemical Monitoring of Detoxified Tailings

Confirmatory monitoring of detoxified tailings includes weekly sample collection for the preparation of a monthly composite sample to be analysed for total metals by aqua regia digestion, total sulphur by Leco furnace and direct measurement of total inorganic carbon.

Results of the monitoring are provided in the annual report to the NWB.

3.1.6 Geochemical Monitoring of Quarry Rock Backfill

The geochemical monitoring of quarry rock backfill is outlined in Section 3.1 of the Quarry Management plan. In brief, the geochemical characterization program includes collection and analysis of two samples per year when the quarry is operating.

Results of the monitoring program are provided in the annual report to the NWB.

3.1.7 Water Quality Monitoring

The water quality monitoring program includes the following:

- Monthly sampling of contact water ponds downstream of all waste rock and ore stockpiles for parameters indicative of ML/ARD, blast residues and drilling brine;
- Monthly sampling of underground mine sump water at Doris, Madrid North and Madrid South for parameters indicative of ML/ARD, blast residues and drilling brine;
- Monthly sampling of underground mine sump water at Boston for parameters indicative of blast residues and drilling brine;

Results of the monitoring program are provided in the annual report to the NWB.

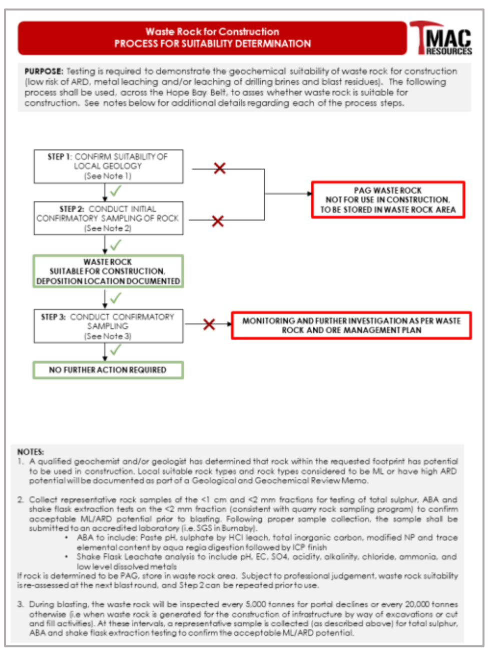
3.1.8 Ore Stockpile

There are no specific monitoring requirements for the ore stockpile. The seepage and water quality monitoring programs also address the monitoring of contact water from this area.

3.2 Use of Waste Rock for Construction

Testing is required to demonstrate the geochemical suitability of waste rock for construction, including having a low risk of ARD, metal leaching and/or leaching of drilling brines and blast residues. Given the potential variability of waste rock within a given mine and between different mines (Section 2.1), each potential source needs to be assessed on a case-by-case basis. A process flow diagram titled 'Waste Rock for Construction, Process for Suitability Determination' (Appendix A), has been developed for use across the Hope Bay Belt to determine if a specific waste rock source is suitable for construction.

The process flow diagram provides the steps to determine if waste rock is suitable for construction. After the initial confirmation of suitability of the local geology and rock type, rock samples are submitted for testing prior to the onset of blasting at a frequency of one composite sample for every 5,000 tonnes for portal declines or every 20,000 tonnes otherwise (I.e. when waste rock is generated for the construction of infrastructure by way of excavations or cut and fill activities). At these intervals, a representative sample is collected (as described in Appendix A) and testing is to include an assessment of ML/ARD potential by acid-base accounting (ABA), total sulphur and trace element content to assess the ML/ARD potential of the rock of the <1 cm and <2 mm fractions and shake flask extraction tests on the <2 mm fraction to assess the amount of soluble salt, nutrients and metals present in the rock. The monitored parameters are consistent with the quarry rock sampling program which TMAC has performed successfully for many years. See Appendix A for complete diagram and details.



Waste Rock for Construction
PROCESS FOR SUITABILITY DETERMINATION

PURPOSE: Testing is required to demonstrate the geochemical suitability of waste rock for construction (low risk of ARD, metal leaching and/or leaching of drilling brines and blast residues). The following process shall be used, across the Hope Bay Belt, to asses whether waste rock is suitable for construction. See notes below for additional details regarding each of the process steps.

STEP 1: CONFIRM SUITABILITY OF LOCAL GEOLOGY (See Note 1)

STEP 2: CONDUCT INITIAL CONFIRMATORY SAMPLING OF ROCK (See Note 2)

PAG WASTE ROCK
NOT FOR USE IN CONSTRUCTION.
TO BE STORED IN WASTE ROCK AREA

WASTE ROCK
SUITABLE FOR CONSTRUCTION,
DEPOSITION LOCATION DOCUMENTED

STEP 3: CONDUCT CONFIRMATORY SAMPLING (See Note 3)

MONITORING AND FURTHER INVESTIGATION AS PER WASTE ROCK AND ORE MANAGEMENT PLAN

NO FURTHER ACTION REQUIRED

NOTES:

1. A qualified geochemist and/or geologist has determined that rock within the requested footprint has potential to be used in construction. Local suitable rock types and rock types considered to be ML or have high ARD potential will be documented as part of a Geological and Geochemical Review Memo.

2. Collect representative rock samples of the <1 cm and <2 mm fractions for testing of total sulphur, ABA and shake flask extraction tests on the <2 mm fraction (consistent with quarry rock sampling program) to confirm acceptable ML/ARD potential prior to blasting. Following proper sample collection, the sample shall be submitted to an accredited laboratory (i.e. SGS in Burnaby).
    - ABA to include: Paste pH, sulphate by HCl leach, total inorganic carbon, modified NP and trace elemental content by aqua regia digestion followed by ICP finish
    - Shake Flask Leachate analysis to include pH, EC, SO4, acidity, alkalinity, chloride, ammonia, and low level dissolved metals

If rock is determined to be PAG, store in waste rock area. Subject to professional judgement, waste rock suitability is re-assessed at the next blast round, and Step 2 can be repeated prior to use.

3. During blasting, the waste rock will be inspected every 5,000 tonnes for portal declines or every 20,000 tonnes otherwise (i.e when waste rock is generated for the construction of infrastructure by way of excavations or cut and fill activities). At these intervals, a representative sample is collected (as described above) for total sulphur, ABA and shake flask extraction testing to confirm the acceptable ML/ARD potential.

Figure 1. Image of Waste Rock for Construction Process Flow Diagram. See Appendix A for actual document.

3.2.1 Post-Construction

If qualified waste rock is used for construction outside of the water control area, the following post-construction inspections of infrastructure are to be conducted:

- An annual seep survey during spring freshet, as outlined in the Quarry Management Plan, will be carried out in the first 3 years following construction;
- Visual inspection of infrastructure with an emphasis on geology (lithology and sulphides); and
- ABA and trace element content (aqua regia digestion) test work on the -1 cm fraction collected from the infraction. Samples are to be collected at a frequency of 1 samples per 50,000 tonnes of rock or for a linear corridor, one sample every 500 m at pre-determined locations. The -2 mm fraction of a subset of samples will be tested by SFE to assess the soluble load of the construction material.

All results will be reported to the Board in the annual report. Should the material show evidence of acid rock drainage, the Board and TMAC will determine the best course of action.

Table 3-2. Hope Bay Waste Rock, Ore and Backfill Management Plan and Monitoring Summary

Aspect	Monitoring Activity	Monitoring Type	Data Management and Reporting
Mining Operations, including Waste Rock Deposition and Backfill	Pre-blast inspection by blaster	Identify "wet holes" and clean spilled ANFO	Maintain field notes
	Post-blast inspection by blaster	Confirm there were no misfires	Maintain field notes
	Visual inspection of blast face by mine geologist	Geological mapping of map faces and backs of accessible mine workings	Maintain field notes and internal record.
	Inventory of available mine void space and waste rock mined; amount waste rock and quarry rock stockpiled on surface and location; Amount of material used for backfill (source and final location) is recorded by the mine engineer.	Material quantities (cubic m and tonnes) summarized on a monthly basis	Maintain record for Annual Reporting
	Amount of detoxified tailings used for backfill is recorded by the mine engineer.	Material quantities (cubic m and tonnes) summarized on a daily basis	Maintain record for Annual Reporting
	Waste rock stockpile inspection and monitoring	Visual inspection and geochemical monitoring.	Maintain field notes. Discuss findings with site geologists. Report findings in Annual Report
	Annual seep survey of materials on surface by Environmental personnel	Water samples submitted for pH, total sulphate, total ammonia, nitrate, alkalinity, and metals by ICP-MS	Maintain field notes. Report findings in Annual Report
	Monthly Water Licence monitoring by Environmental personnel	Water samples and samples of detoxified tailings submitted for analysis of parameters specified in the Water Licence	Maintain field notes. Report findings in Monthly or Annual Reports to NWB as required
	Twice annually survey by Environmental personnel	Visual inspections for seepage and if present water samples submitted for analysis of parameters specified in the Water Licence	Maintain field notes. Report findings in Monthly or Annual Reports to NWB as required
Infrastructure Construction and Post-Construction	Amount of waste rock used for construction, and location of placement tracked by Surface Manager	Material quantities (tonnes) and geochemical monitoring	Maintain records for Annual Reporting
	Geochemical inspections and sampling of infrastructure areas constructed using waste rock by Environmental personnel	As per Quarry Management and Monitoring Plan (TMAC 2017c)	As per Quarry Management and Monitoring Plan (TMAC 2017a)
	Annual seep survey by Environmental personnel	As per Quarry Management and Monitoring Plan (TMAC 2017c)	As per Quarry Management and Monitoring Plan (TMAC 2017a)

3.3 Documentation and Reporting

All documentation related to waste rock and ore classification, sampling, material hauled from underground, material hauled underground for backfill and waste rock, ore and mine backfill storage facility inspection records are maintained on-site.

Annual reporting required under the water licence will include reporting of waste rock, quarry and detoxified tailings tonnages placed on the designated waste rock storage areas as part of the annual report to the Board. Tonnages of waste rock both above and returned to underground are tracked and reported, together with the available void space in the mine. Annual geochemical monitoring of backfill and waste rock storage assessment is included in the annual report.

TMAC will combine all other results from the inspections and monitoring programs related to waste rock and quarry rock in an annual "Waste Rock and Mine Backfill Monitoring Report". The monitoring report would be prepared and submitted no later than March 31 of the year following the monitoring activities, and would include all data collected prior to December 31 of the preceding year.

This brief factual report will address the requirements specified in the Water Licenses and Quarry Permit Agreements. The report will include, but not necessarily be limited to:

- A summary of the geochemical inspections;
- Results of the seep surveys;
- Results of geochemical sampling and analysis, if any;
- A summary of all mitigation activities undertaken as a result of monitoring; and
- A summary of the backfill volumes and available mine void space.

4 Contingencies

4.1 Drainage with ML/ARD Issues in Underground Sumps or Rock Stockpile Collection Ponds

In the unlikely event that the results of the underground seepage monitoring program indicate an elevated potential for ML/ARD, further investigations will be undertaken to define the contributing backfill sources from the geological and material handling records maintained during operations. If warranted, and after discussion with the appropriate regulatory agencies, water treatment measures may be implemented prior to discharge of underground water. The underground water monitoring program is described in the TMAC Groundwater Management Plan (2017g).

4.2 Inappropriate Construction Material Identified

In the unlikely event that the results of the seep monitoring program or the confirmatory sampling program (Section 3.2) indicate the presence of material with an elevated potential for ML/ARD has been used in construction, further investigations will be undertaken to define the extent and assess the potential impacts of the material. If warranted, and after discussion with the appropriate regulatory agencies, the material may be mitigated in place or excavated and hauled to the waste rock stockpile for eventual disposal underground.

4.3 Permanent Storage of Waste Rock Stockpiles on Surface Required

While it is expected that all waste rock will be placed underground by the time of closure, if for some reason waste rock was to remain on surface it would be managed on existing pads consistent with principles of this Plan and the site relevant Closure and Reclamation Plans (SRK 2017h, SRK 2017i). Several alternatives were considered as contingency for any ore and/or mineralized waste rock left on surface. One option is moving the piles to Doris TIA and/or Boston TMA for placement in the tailings area or in the case of the Doris TIA, sub-aqueous disposal in the Reclaim Pond. Another option is consolidating, contouring and covering the piles with an impermeable liner and a 0.3 m thick protective layer of crushed rock. Additional options may also be considered. All above ground storage options are subject to approval by NWB.

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Figures

LEGEND

- New Infrastructure Pads
- Safety Berms

NOTES

1. The co-ordinate system is UTM NAD 83, Zone 13.
2. All dimensions are in metric units, unless specifically mentioned.

srk consulting

SRK JOB NO.: 1CT022.002.200.1600

FILE NAME: 1CT022.001_PadU&T Fig 1.dwg

TMAC RESOURCES

Hope Bay Project

Waste Rock & Ore Management Plan

Plan of Surface Infrastructure Facilities, Current Configuration at Doris

DATE:	APPROVED:	FIGURE:
June 2015	LW	2.1

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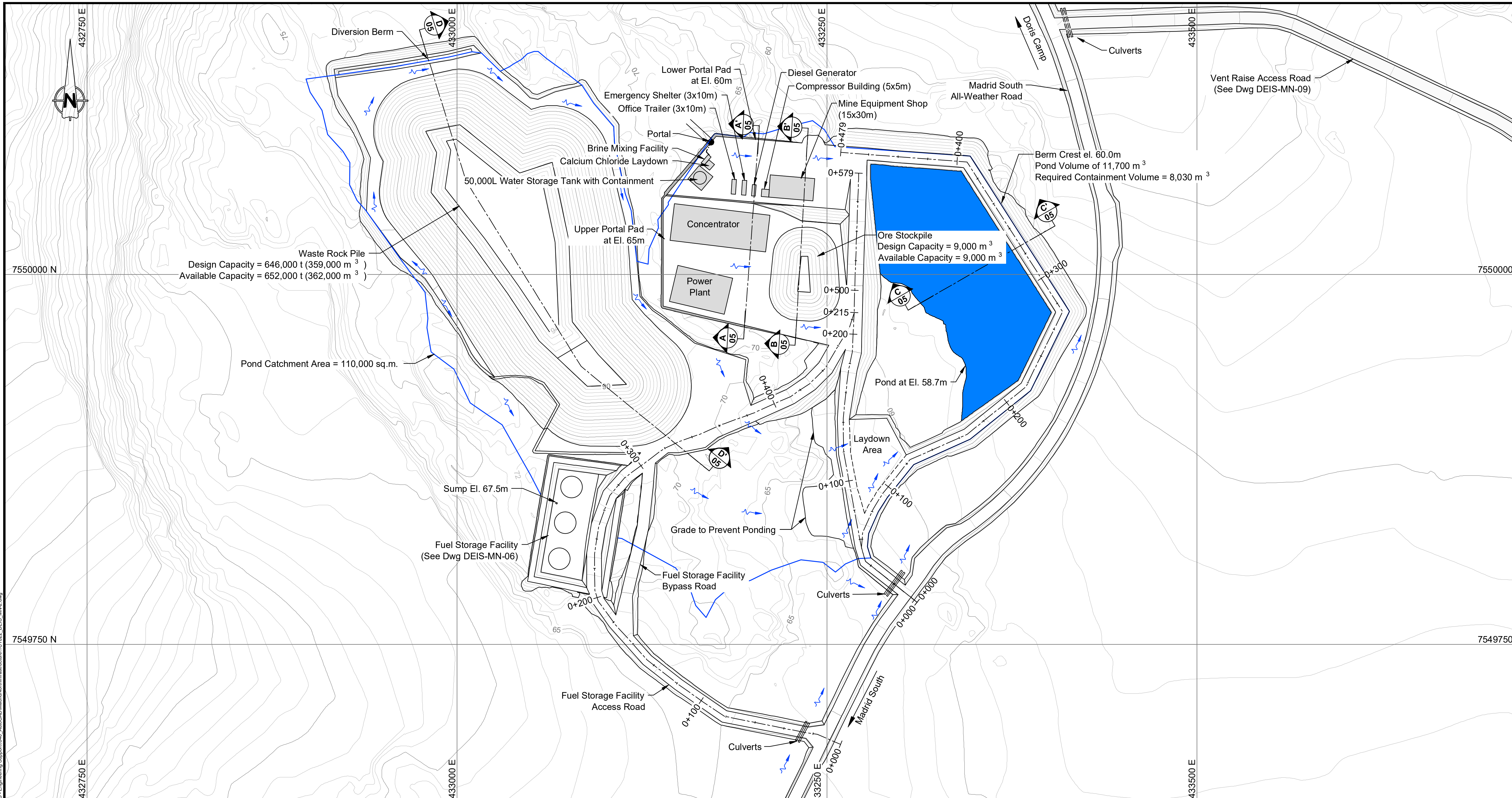

NOTES

1. All dimensions in metres unless noted otherwise.
2. Notes in this drawing apply to all other active drawings.

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE
REFERENCE DRAWINGS			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
B	Issued for Discussion	CH	EMR	16Nov17
A	Issued for Discussion	MMM	EMR	9Nov16

REVISIONS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN: CH | DRAWN: NV | REVIEWED: CH
CHECKED: CH | APPROVED: EMR | DATE: Nov. 2017
FILE NAME: 1CT022.013_DEIS_MN-2.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.013

Madrid North DEIS Surface Infrastructure

DRAWING TITLE:

Plan of Surface Infrastructure Facilities, Proposed Configuration at Madrid North

DRAWING NO.: DEIS-MN-03 | SHEET: 3 of 14 | REVISION NO.: B

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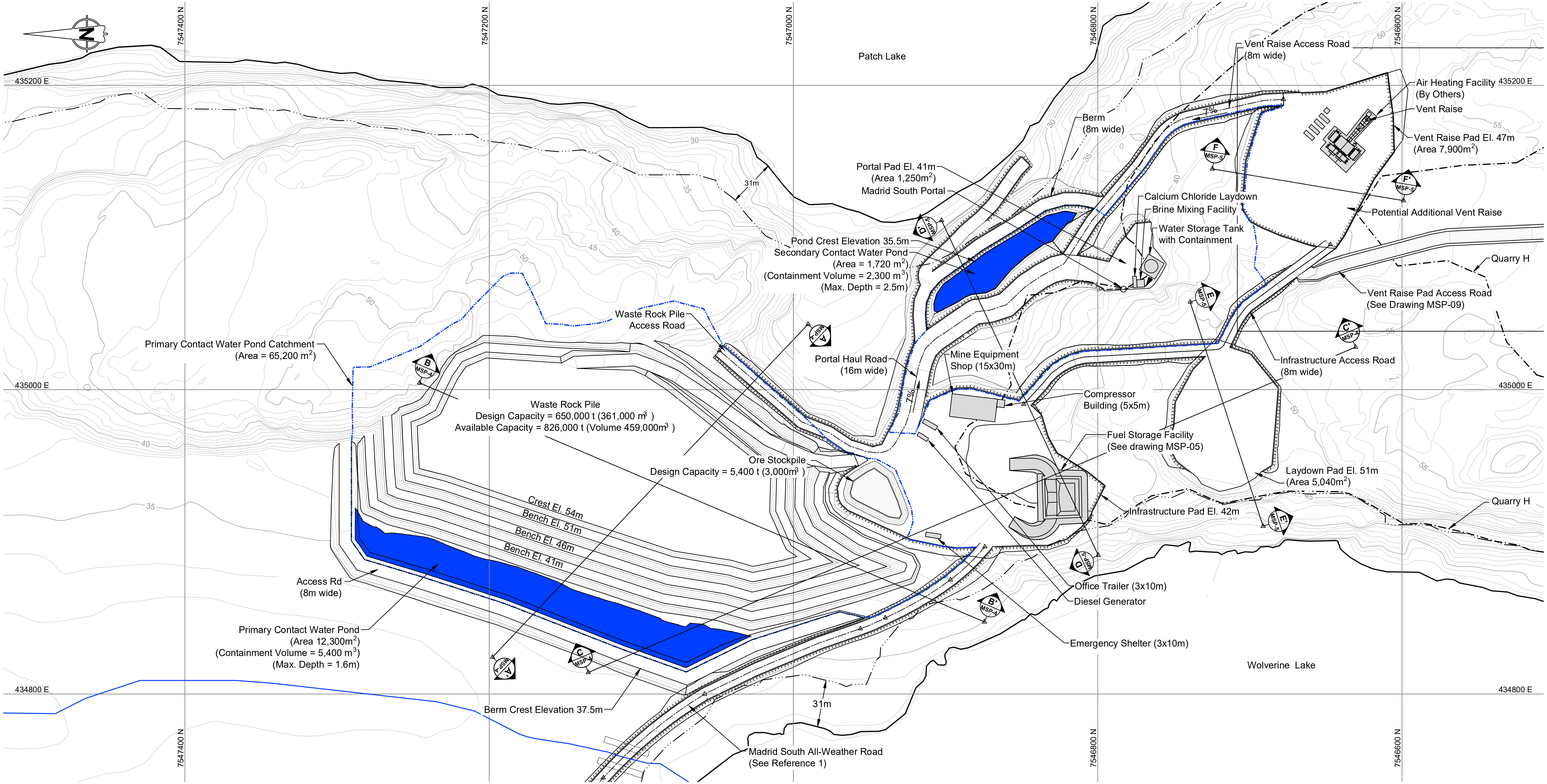

LEGEND

- Proposed Quarry Boundary
- Water Line
- Pollution Pond Catchment
- 31m Lake Buffer

NOTES

1. The design of the Madrid South Portal and Vent Raise is based on topographic contour information provided by HBML and is derived by 2007 aerial photography.
2. Contours are shown in 1m intervals.
3. The co-ordinate system is UTM NAD 83, Zone 13.
4. Madrid south portal is located at 435,066 E, 7,546,783 N, 41.0m elevation, and the vent raise is located at 435,177 E, 7,546,623 N.
5. All dimensions are in metric units, unless specifically mentioned.
6. Notes in this drawing apply to all other active drawings.

REFERENCE

1. Engineering drawings for the Madrid South All-Weather Road, Hope Bay Project, Nunavut, Canada. Issued for Discussion. Revision D. Project No. 1CT022.001. October 31, 2014.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
J	Issued for Discussion	CH	EMR	23Oct17
I	Minor Edits	CH	EMR	21Nov16
H	Issued for Discussion	MMM	EMR	30Jun16
G	Minor Edits	LW	EMR	31Oct14
F	Minor Edits	LW	EMR	17Sep14
E	Liner Added to Ponds	LW	EMR	7Aug14
D	New Portal Location	LW	EMR	27June14
C	Minor Edits	LW	EMR	12June14

REVISIONS

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN: JK | DRAWN: NV | REVIEWED: CH
CHECKED: CH | APPROVED: EMR | DATE: October 2017

FILE NAME: 1CT022.004_Madrid_South_Pads RevJ.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.013

Madrid South Surface Infrastructure

DRAWING TITLE:
Plan of Surface Infrastructure Facilities, Proposed Configuration at Madrid South

DRAWING NO. MSP-02 | SHEET 3 OF 12 | REVISION NO. J

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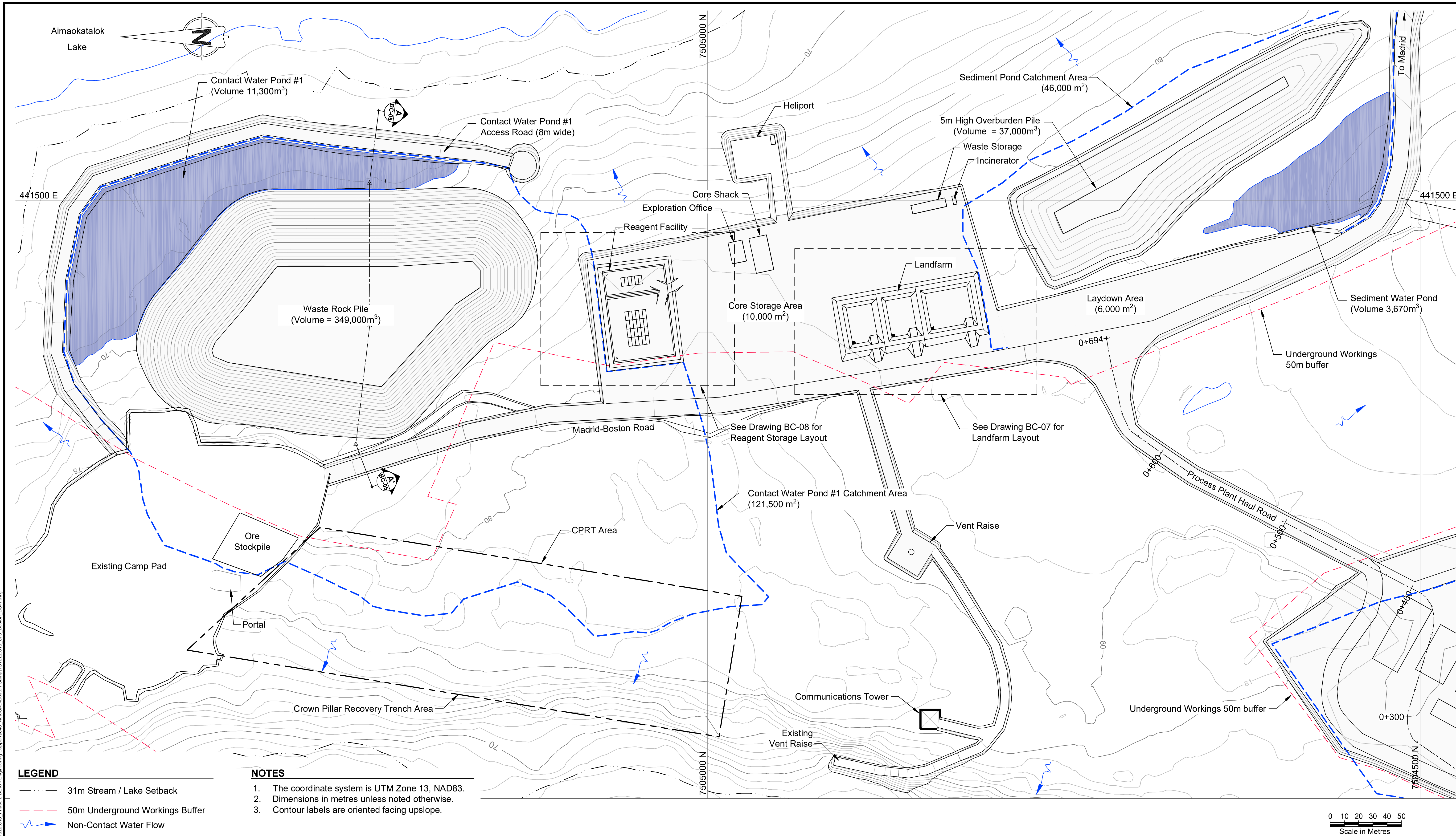

LEGEND

- 31m Stream / Lake Setback
- 50m Underground Workings Buffer
- Non-Contact Water Flow

NOTES

1. The coordinate system is UTM Zone 13, NAD83.
2. Dimensions in metres unless noted otherwise.
3. Contour labels are oriented facing upslope.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
C	Issued for Discussion	KK	EMR	7Dec17
B	Issued for Discussion	MMM	EMR	16Nov16
A	Issued for Discussion	MMM	EMR	8Jul16

REVISIONS

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN: TSF | DRAWN: NV | REVIEWED: TSF
CHECKED: MMM | APPROVED: EMR | DATE: Dec. 2017

FILE NAME: 1CT022.013_670_Boston_BC-1.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.013

Boston Surface Infrastructure

DRAWING TITLE: Boston Waste Rock and Overburden Piles

DRAWING NO.: BC-02 | SHEET: 3 of 18 | REVISION NO.: C

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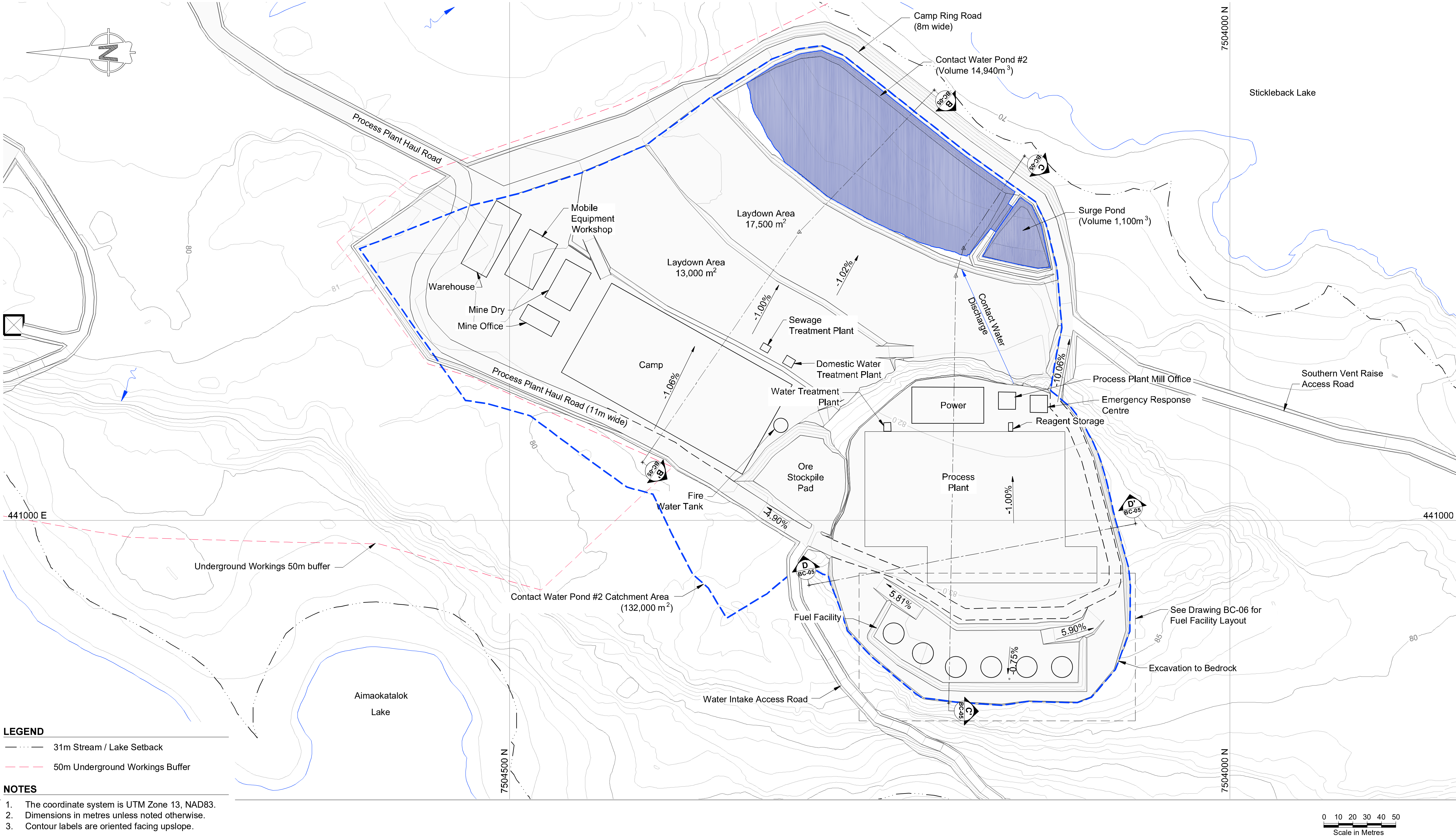

LEGEND

31m Stream / Lake Setback

50m Underground Workings Buffer

NOTES

1. The coordinate system is UTM Zone 13, NAD83.
2. Dimensions in metres unless noted otherwise.
3. Contour labels are oriented facing upslope.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
C	Issued for Discussion	KK	EMR	7Dec17
B	Issued for Discussion	MMM	EMR	16Nov16
A	Issued for Discussion	MMM	EMR	8Jul16

REVISIONS

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN: TSF | DRAWN: NV | REVIEWED: TSF
CHECKED: MMM | APPROVED: EMR | DATE: Dec. 2017

FILE NAME: 1CT022.013_670_Boston_BC-1.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.013

Boston Surface Infrastructure

DRAWING TITLE:

Boston Camp Infrastructure Layout

DRAWING NO.: BC-03 | SHEET 4 of 18 | REVISION NO. C

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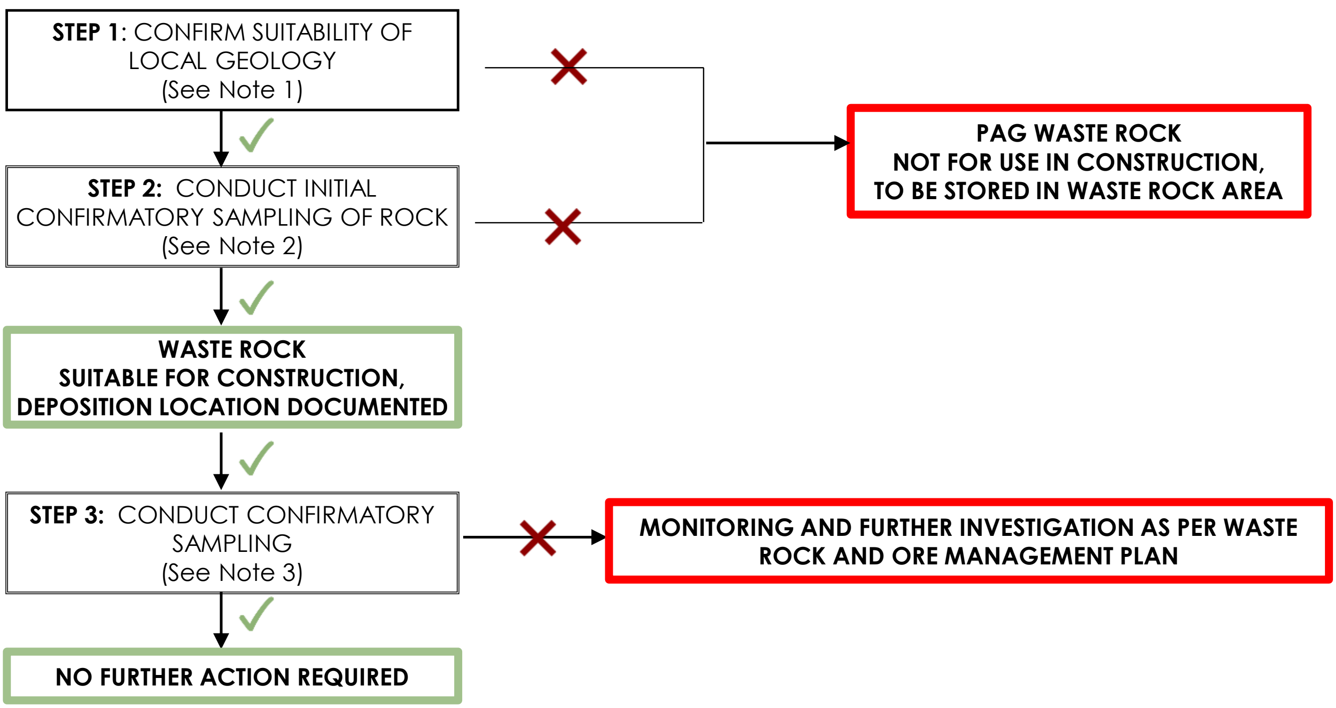
Appendix - A

Waste Rock for Construction
PROCESS FOR SUITABILITY DETERMINATION

PURPOSE: Testing is required to demonstrate the geochemical suitability of waste rock for construction (low risk of ARD, metal leaching and/or leaching of drilling brines and blast residues). The following process shall be used, across the Hope Bay Belt, to asses whether waste rock is suitable for construction. See notes below for additional details regarding each of the process steps.



NOTES:

1. A qualified geochemist and/or geologist has determined that rock within the requested footprint has potential to be used in construction. Local suitable rock types and rock types considered to be ML or have high ARD potential will be documented as part of a Geological and Geochemical Review Memo.

2. Collect representative rock samples of the <1 cm and <2 mm fractions for testing of total sulphur, ABA and shake flask extraction tests on the <2 mm fraction (consistent with quarry rock sampling program) to confirm acceptable ML/ARD potential prior to blasting. Following proper sample collection, the sample shall be submitted to an accredited laboratory (i.e. SGS in Burnaby).
   - ABA to include: Paste pH, sulphate by HCl leach, total inorganic carbon, modified NP and trace elemental content by aqua regia digestion followed by ICP finish
   - Shake Flask Leachate analysis to include pH, EC, SO4, acidity, alkalinity, chloride, ammonia, and low level dissolved metals

If rock is determined to be PAG, store in waste rock area. Subject to professional judgement, waste rock suitability is re-assessed at the next blast round, and Step 2 can be repeated prior to use.

3. During blasting, the waste rock will be inspected every 5,000 tonnes for portal declines or every 20,000 tonnes otherwise (i.e when waste rock is generated for the construction of infrastructure by way of excavations or cut and fill activities). At these intervals, a representative sample is collected (as described above) for total sulphur, ABA and shake flask extraction testing to confirm the acceptable ML/ARD potential.