BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Suite 200 - 1121 Centre St. NW, Calgary, AB Canada T2E 7K6
Telephone (403) 250-5185 Fax (403) 250-5330

# Project Memorandum

| | | | |
|---|---|---|---|
| **To:** | **Kitikmeot Inuit Association** | **Doc. No.:** | |
| **Attention:** | **Mr. John Roesch** | **cc:** | |
| **From:** | **Geoff Claypool** | **Date:** | **July 27, 2016** |
| **Subject:** | **DRAFT - Review of Interim Closure Cost Estimate for the Doris North Mine** | | |
| **Project No.:** | **0454-004-08** | | |

## 1.0 INTRODUCTION

The Doris North Mine, owned and operated by TMAC Resources Inc. (TMAC), is located on Inuit Owned Land (IOL) administered by the Kitikmeot Inuit Association (KIA). The project is located approximately 120 km southwest of Cambridge Bay, NU. In May 2015, SRK produced an updated interim closure plan and associated closure cost estimate for the Doris North Mine. The 2015 closure plan was updated from previous versions, also authored by SRK, to reflect recent project changes. A third-party review of the interim closure cost estimate has also been completed by Indigenous and Northern Affairs Canada (INAC).

Since the KIA administers the land on which the project is located, the KIA requires a technical review of the adequacy of the current interim closure cost estimate. The KIA requested that BGC undertake this technical review of the Doris North interim closure plan.

## 2.0 SCOPE OF WORK

As outlined in BGC's proposal to KIA dated July 12, 2016, the scope of work for BGC's technical review of the Doris North interim closure cost estimate consisted of the following:

- Review of the current interim closure cost estimate provided by SRK and associated documents provided by the KIA.
- Following the review, prepare a summary memorandum that addresses the following questions, as noted by the KIA:
    - Is the overall cost estimate considered adequate?
    - Is the division of costs between land and water related issues appropriate?
    - Is more detailed review of the closure plan, including interactions with TMAC and/or SRK required prior to the public hearings currently schedules in early September?

In addition to the questions noted above, the following additional guidance was requested by KIA following submission of the original proposal:

- Are the methods chosen for land related reclamation on IOL:
    - optimal for physical and chemical stability,
    - optimal for safety of wildlife and people, and
    - involve no perpetual care.

As part of the scope of work, the following documents were provided to BGC by KIA for review:

- TMAC Resources Inc. June 2015. Doris North Mine Interim Closure and Reclamation Plan.
- SRK Consulting (Canada) Inc. June 2015. Costing assumptions summary for Doris North Mine Interim Closure and Reclamation Plan. Submitted to TMAC Resources Inc. June 11, 2015.
- SRK Consulting (Canada) Inc. December 2015. Response to IR AANDC TC10- Closure Cost Estimate. Memorandum submitted to TMAC Resources Inc. December 18, 2015.
- TMAC Resources Inc. December 2015 TMAC Resources Inc.'s Revision to Amendment Application No. 1 of Project Certification No. 003 and Water License No. 2AM-DOH1323: Proponent's Response to NWB Technical Comments. Letter submitted to Nunavut Water Board December 21, 2015. (Note this document was not reviewed as part of this scope due to scheduling constraints.)
- SRK Consulting (Canada) Inc. February 2016. Addendum to Document P5-2 – Interim Closure and Reclamation Plan. Submitted to TMAC Resources Inc. February 3, 2016.

Due to scheduling constraints, KIA requested that this current review be completed in a preliminary manner and that initial results be provided as soon as possible. As noted in the proposal, pending the results of the preliminary review, additional review and interaction may be required.

## 3.0 GENERAL SUMMARY OF CLOSURE PLAN

Based on BGC's review of the documents listed in Section 2, the following summarizes our understanding of the closure plan for the Doris North Mine Project:

- The stated closure objectives include the following:
  - Establish stable chemical and physical conditions; and
  - Ensure the future use and aesthetics of the project site, following reclamation activities, meets the requirements of Aboriginal, Federal and Territorial governments, landowners, local communities and regulatory authorities.
- Progressive reclamation is planned throughout mining operations, including the underground disposal of mineralized waste rock and detoxified cyanide leach tailings. At the end of mining operations, only non-mineralized waste rock and flotation tailings will be exposed at surface, both of which are suggested to be geochemically benign by TMAC and SRK.
- All building infrastructure is to be dismantled. Non-hazardous materials will be placed in an engineered landfill in Quarry #3. Hazardous materials will be transported off site.
- Building pads constructed of non-mineralized rockfill will be left in place and graded to prevent ponding and to blend into the natural landscape. Similarly roads and other rockfill structures will be graded to prevent ponding and breached in select locations to restore natural drainage pathways. Any culverts or bridges will be removed.
- Fuel storage facilities will be decommissioned and dismantled. All liners will be removed, decontaminated and disposed of in the non-hazardous waste landfill. Containment berms will be graded to blend into the natural topography and breached to prevent ponding. Any hydrocarbon contamination encountered during decommissioning of the fuel storage facilities will be remediated in-situ or removed off-site for remediation.
- The Tailings Impoundment Area (TIA) consists of the North Dam, South Dam, and Interim Dike and Reclaim Pond. The aerially exposed tailings will be contained between the south dam and interim dike. At closure, the tailings will be covered with a single layer (0.3 m thick, total cover material volume of ~135,000 $m^3$) of non-acid generating quarry rock. The reclaim pond water will be pumped through the Roberts Bay Discharge System for undersea discharge. The pond will refill naturally to pre-disturbance levels. Once the water in the pond is confirmed to meet water quality objectives, the North Dam will be breached to re-establish the natural drainage path through an engineered spillway structure. The South Dam and Interim Dike will be left in place.
- As part of operations, the reclaim pond water level will be at a higher elevation than the pre-mining water level. Following decommissioning of the TIA and breaching of the North Dam, the water level will return to lower, pre-mining elevations. Following restoration of the pre-mining water levels in the reclaim pond, a portion of the shoreline will be armoured

with rip rap to limit erosion of the portion of the shoreline deemed to be susceptible to permafrost degradation associated with higher water levels during operation (0.5 m layer thickness, rip rap volume ~24,700 $m^3$). The rip rap will be separated from natural ground subgrade with a geotextile fabric.

- Access to the underground mine workings will be closed off. The entrance to the decline portal will be backfilled with quarry rock and vent raises will be sealed with a reinforced concrete cap.
- With the exception of Quarry #3, the only reclamation activity planned for the quarries is scaling of the vertical faces. At Quarry #3, a non-hazardous waste landfill will be constructed by placing waste on two lifts of approximately 0.85 m thickness. Following placement of the waste materials, an isolation cover consisting of a single layer of compacted crushed quarry rock will be constructed (layer thickness of 1 m, total rockfill cover volume of ~19,500 $m^3$).
- The majority of the reclamation is intended to be completed in one construction season. The transfer of the reclaim pond water to Roberts Bay is expected to take approximately 2.5 years. The breaching of the North Dam is expected to take place in year 8 of the reclamation schedule, following natural refilling of the reclaim pond area and confirmation that the pond water meets water quality objectives.
- Reclamation will be undertaken using equipment mobilized to site specifically for the reclamation activities by a third party contractor.
- A camp will be mobilized to site specifically for reclamation activities, a portion of which will remain on site until the active management of water in the reclaim pond is completed.
- A separate mobilization of equipment and a camp will be undertaken for the breach of the North Dam, anticipated to be in year 8 of the reclamation schedule.

## 4.0 CLOSURE COST REVIEW

As noted in Section 1, the interim closure cost estimate prepared by SRK was originally submitted by TMAC in June 2015 with a revised version submitted in December 2015 addressing some of the review comments provided by INAC following completion of their review of the closure costs by a third party. Both the June and December 2015 closure cost estimates were reviewed by BGC as part of this current scope and the closure cost amounts to $28.94 million.

BGC's comments following our review of the closure cost estimates are summarized by the following:

- The cost estimate is separated into direct costs (~$19.8M) and indirect costs (~$9.2M).
- The direct costs and indirect costs are summarized in Tables 1 and 2, respectively.

**Table 1. Summary of Direct Costs (from SRK December 2015)**

| Mine Area | Estimated Costs |
|---|---|
| Roberts Bay Area / Airstrip | $768,158 |
| U/G Workings and Reagent Pads | $144,561 |
| North and South Dams / Interim Dyke | $8,655,951 |
| Doris Windy Road / Secondary Road | $547,927 |
| Doris Camp | $2,996,446 |
| Quarry #2, Doris Mtn. / Quarry #3 Waste Area / Ocean Discharge System | $372,923 |
| Surface Water Management | $3,361,200 |
| Interim Care and Maintenance | $2,408,390 |
| Off-Site Disposal of Hazardous Waste | $491,960 |
| **Subtotal Direct Costs** | **$19,747,514** |

**Table 2. Summary of Indirect Costs (from SRK December 2015)**

| Mine Area | Estimated Costs |
|---|---|
| Mobilization and Demobilization | $2,865,058 |
| Post Closure Monitoring | $868,500 |
| Engineering (1% of Direct Costs) | $197,475 |
| Field Support (2% of Direct Costs) | $394,950 |
| Health and Safety Plans/Monitoring and QA/QC | $394,950 |
| General Administration | $618,571 |
| Contingency (20% of Direct Costs) | $3,851,111 |
| **Subtotal Indirect Costs** | **$9,190,615** |

- The unit rates used by SKR/TMAC to prepare the closure cost estimate were derived from contractor supplied rates, site experience from recent construction activities and first principle derivations. Based on BGC's review of the unit rates used in the development closure cost estimate, the unit rates appear to be reasonable for use in a closure project of this scale in a remote northern setting. Some of the more pertinent unit rates used in the cost analysis include the following:
    - Drill and blast rock for construction purposes: $31.99/m$^3$
    - Load/Haul/Dump/Place Run of Quarry rockfill: $16.35/m$^3$
    - Geotextile (material and placement): $28.27/m$^2$
    - Load/Haul/Dump Rip Rap: $8.82/m$^3$
    - Hauling Demo material: $4.17/m$^3$ to $5.99/m$^3$ (depending on haul distance)
    - Building Demolition: $12.90/m$^3$

The rational for the unit rates and general costing presented in the June 2015 and December 2015 was reviewed. No significant concerns were noted during this review. Though there are uncertainties noted within the proposed reclamation plan, the potential implications of which on the closure cost estimate are discussed later in this document.

# 5.0 RESPONSE TO SPECIFIC KIA QUESTIONS

## 5.1. Adequacy of closure cost estimate

Based on BGC's review of the information provided, the closure costs appear to be reasonable for a project of this scale in a remote northern setting, especially given the limited amount of required earth works and lack of water treatment requirements. However, this is dependent on a number of assumptions noted within the TMAC closure costing document and summarized below:

- It is currently projected that the flotation tailings will have limited impact on the long term water quality in the TIA reclaim pond. If this is not the case, either water treatment and / or a more sophisticated cover system may be required to meet the long term water quality objectives in the reclaim pond and associated discharge. Either of these would have significant impact on the closure cost requirements. It is understood that the current water quality projections support the concept that limited water quality impacts will be realized and that the water quality model will continue to be reviewed and updated as water quality measurements are made during operations.
- Similarly, it is not anticipated that the reclaim water will require treatment prior to discharge to Roberts Bay. It this is not the case and water treatment is required, additional costs would be incurred.
- If the final landfill volume is larger than what is currently assumed in the closure plan, the cover may be more expansive than currently planned. If this ends up being the case, additional rockfill volumes would be required at increased cost.
- Depending on the thermal state of the tailings at closure and the observed run off water quality, a more intensive performance monitoring program may be required. If this is the case, additional costs could be incurred under the post closure monitoring program item.

The costs will also be sensitive to the reclamation schedule. If the work cannot be completed in one season as anticipated, additional costs associated with this delay could be significant, including indirect costs for power, fuel, management, camps and engineering support.

The inclusion of a contingency amount addresses some of the uncertainty noted above, but will need to be reviewed as part of any future updates to the interim closure plan cost estimate and modified according to observed performance.

## 5.2. Division of costs between land and water

During BGC's review of the closure cost estimates, an explicit separation of water and land related costs was not observed. However, based on BGC's review of the information provided, the majority of the direct costs are thought to be associated with reclamation of land and only the costs associated with the transfer of reclaim water to Robert's Bay and likely to be considered water related reclamation costs. Reclamation of the Robert's Bay jetty could also be considered a water related reclamation cost.

A portion of the indirect costs will be related to reclamation of water including mobilization of equipment required for the water transfer activities, accommodation for staff required for the duration of water transfer activities and water quality monitoring components of the post closure monitoring program. This was subjectively estimated by BGC to be approximately 15% of the indirect costs included in the closure cost estimate.

Based on the above, the proportion of costs association with reclamation of land and water is summarized in Table 3.

**Table 3. Estimate of Division between Land and Water Related Reclamation Costs.**

| | Land | Water | Total |
|---|---|---|---|
| **Direct Costs** | $16,390,000 | $3,360,000 | $19,750,000 |
| **Indirect Costs** | $7,811,500 | $1,378,500 | $9,190,000 |
| **Subtotal** | $24,201,500 | $4,738,500 | $28,940,000 |

### 5.3. Physical and chemical stability

From a physical stability perspective, the main aspects of the reclamation plan include the stability of the tailings cover, landfill cover, perimeter of the reclaim pond, South Dam, Interim Dike, North Dam (until breaching) and the North Dam spillway (following breaching). The reclamation measures currently planned for each facility, should result in long term physical stability of the site. The final closure design of each facility will need to ensure the physical stability of each of the noted structures.

Given the plan to disposed of mineralized waste rock and detoxified cyanide leach tailings in the underground mine workings, most risks associated with the chemical stability of the reclaimed mine site should be minimized. This will be dependent on the observed behavior of the flotation tailings and the resultant run off and seepage water quality observed during operations. The ability to separate mineralized waste rock and subsequent disposal of this rock in the underground mine workings will also be critical to ensuring the long term chemical stability of the site.

### 5.4. Safety of wildlife and people

The risk to wildlife and people at the site following closure will be dependent on the physical and chemical stability of the reclamation measures discussed in Section 5.3.

If the chemical stability of the site is realized as per the proposed reclamation plan, limited residual risk to the safety of wildlife and people will exist.

The reclamation plan for the quarries is noted to only involve scaling of the vertical faces within the quarry walls. Depending on the height of the highwall, some long term risk to human and wildlife may be realized.

The openings to the underground will be closed as part of site reclamation activities. This includes backfilling of the decline portal and construction of concrete seals over the vent raises. The concrete seals will have a finite life and the concrete will degrade over time. This may pose a limited risk to wildlife and people, if access to the underground is re-established over time.

### 5.5. Perpetual care

Facilities requiring perpetual care in closure are undesirable due to the residual risk they may pose and the costs associated with ongoing care and maintenance activities, especially in remote settings. There are no structures proposed to require perpetual care in the current closure plan, but there are facilities that pose some amount of residual risk and potential for care requirements over the long term, pending the final closure design of each facility.

The South Dam will remain in place retaining tailings solids in perpetuity. Depending on the configuration of the dam and TIA at closure, some residual risk may be associated with this structure, though care may be minimal pending the closure design of the dam.

The Interim Dike will also remain in place, retaining tailings solids in perpetuity. The crest of the dike is to be graded at closure to prevent water from ponding on the covered tailings surface behind the dam. Similar to the South Dam, depending on the configuration of the dike and TIA at closure, some residual risk may be associated with this structure, though care may be minimal pending the closure design of the dike.

The North Dam will be breached once the north half of the lake returns to pre-disturbance levels and the water quality is demonstrated to meet site objectives. The breach in the North Dam will act as a spillway to allow natural discharge of the lake to the surrounding environment, similar to the natural drainage conditions prior to mining disturbance. Depending on the closure design, there is some residual risk and potential for care with the spillway, which will be an engineered structure.

The current tailings cover design is a relatively simple single layer design with modest performance objectives of physical isolation and dust suppression. Should the surface of the cover system settle or heave over time, disturbing the drainage characteristics of the cover system, some care and maintenance may be required.

The concrete seals over the vent raises may also poses a long term care and maintenance issue for the site as the concrete is expected to have a finite life span. For northern mine sites that included concrete seals over mine opens, a replacement frequency of 50 years is typically anticipated. Enhanced design may potentially extend the design life.

## 6.0 REQUEST FOR ADDITIONAL CLARIFICATIONS

As part of BGC's review of the interim closure plan, and number of items requiring additional clarification were noted. These requested clarifications are summarized by the following:

- The largest cost component of the closure cost estimate is associated with the tailings cover. Hence, the closure cost will be sensitive to the thickness of the cover material. Does the tailings cover volume only consider a 0.3 m thickness over the footprint of the area between the Interim Dike and the South Dam? Or is there a contingency volume included that would account for some topographic variation in the tailings surface at closure? Alternatively, some allowance for grading of the tailings surface could be allotted for therein.
- How will the surface water flow from the covered tailings area to the residual process water pond? If this is to be sheet flow over the interim dike, are there any enhancements required to the dike to ensure long term stability?
- What is the thermal state of tailings expected to be at closure? Is freezeback of the tailings anticipated? Will this have any impacts on the stability of the Interim Dyke or the South Dam?
- Are there any concerns with respect to long term consolidation or frost heave of the tailings? If so, how will the cover system be designed to accommodate this deformation and still be effective in shedding water?
- Are there any impacts on the groundwater quality beneath Tails Lake expected in operations or in closure?
- Is the rockfill required for construction of the tailings and landfill cover systems already stockpiled at site? If so, is it anticipated that permafrost will have aggraded into the stockpiles requiring them to be drilled and blasted prior to use.
- Is there any processing of cover materials or rip rap planned?
- Is the cost of a second camp and equipment mobilization for the breach of the North Dam included in the December 2015 cost estimate?
- The closure plan notes that certain sumps and other surface water collection ponds will remain in-place for a period of time following closure to ensure quality of surface water run-off prior to breaching these facilities. Will equipment remain on site during active water treatment to complete these activities?
- Can the timing of the mobilization of equipment be clarified? The reclamation schedule included in the June 2015 interim closure and reclamation plan notes a start of reclamation activities in Q1. Is the equipment barged to site the fall before reclamation is to begin? Are there standby charges included in the cost estimate to accommodate this period of inactivity?

## 7.0 SUMMARY

Based on BGC's review of the interim reclamation plan, the proposed measures appear to be designed to achieve the site reclamation goals noted in Section 2. The adequacy of the proposed measures will need to be further evaluated during operation of the mine site. This ongoing evaluation will also aid in assessing the residual risks associated with the closure facilities and the potential for future care and maintenance requirements.

The closure cost estimate developed in consideration of the proposed interim reclamation plan appears to be reasonable for a project of this scale in a remote northern setting. The cost was developed using contractor provided unit rates and site experience from construction. This likely presents the most accurate method of developing a reclamation cost estimate at this time.

BGC's review of the interim closure plan and associated cost estimate was conducted at a high level given the compressed time frame in which to complete the review and was limited to the documents listed in Section 2. Many of the clarifications requested in Section 6 may be addressed in other project documentation not reviewed as part of this scope. If desired by KIA, BGC would be pleased to review these items with KIA, TMAC and SRK, as required.

## 8.0 CLOSURE

BGC Engineering Inc. (BGC) prepared this document for the account of the Kitikmeot Inuit Association. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

As a mutual protection to our client, the public, and ourselves all documents and drawings are submitted for the confidential information of our client for a specific project. Authorization for any use and/or publication of this document or any data, statements, conclusions or abstracts from or regarding our documents and drawings, through any form of print or electronic media, including without limitation, posting or reproduction of same on any website, is reserved pending BGC's written approval. A record copy of this document is on file at BGC. That copy takes precedence over any other copy or reproduction of this document.

We trust the information presented herein meets your current requirements. Should you wish to discuss any of the information provided, feel free to contact either of the undersigned at your earliest convenience.

Yours sincerely,

**BGC ENGINEERING INC.**
**per:**

Geoff Claypool, M.Eng., P.Eng.
Senior Geological Engineer

Reviewed by:

James W. Cassie, M.Sc., P.Eng.
Principal Geotechnical Engineer

APEGA Permit to Practice: P5366

GC/JWC/vc /cs

# REFERENCES

SRK Consulting (Canada) Inc. June 2015. Costing assumptions summary for Doris North Mine Interim Closure and Reclamation Plan. Submitted to TMAC Resources Inc. June 11, 2015.

SRK Consulting (Canada) Inc. December 2015. Response to IR AANDC TC10- Closure Cost Estimate. Memorandum submitted to TMAC Resources Inc. December 18, 2015.

SRK Consulting (Canada) Inc. February 2016. Addendum to Document P5-2 – Interim Closure and Reclamation Plan. Submitted to TMAC Resources Inc. February 3, 2016.

TMAC Resources Inc. June 2015. Doris North Mine Interim Closure and Reclamation Plan.

TMAC Resources Inc. December 2015 TMAC Resources Inc.'s Revision to Amendment Application No. 1 of Project Certification No. 003 and Water License No. 2AM-DOH1323: Proponent's Response to NWB Technical Comments. Letter submitted to Nunavut Water Board December 21, 2015.