DORIS NORTH PROJECT
"NO NET LOSS" PLAN

- REVISION 6 -
December 2007

FINAL REPORT

Golder Associates

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- Revision 6 -
20 December 2007

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Prepared For:

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Cover Photo: Downstream view of Roberts Outflow showing dense boulder garden (proposed enhancement site) in foreground and Little Roberts Lake in the background, August 2002.

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EXECUTIVE SUMMARY

Miramar Hope Bay Ltd. has proposed an underground gold mining project (Doris North Project), which is located in the Canadian Arctic to the east of Bathurst Inlet, approximately 75 km northeast of the community of Umingmaktok and approximately 125 km southwest of Cambridge Bay, Nunavut. This document outlines the potential adverse environmental effects from the Doris North Project on fish resources and provides a conceptual “No Net Loss” Plan to meet the requirements of the federal Department of Fisheries and Oceans.

Based on our evaluation of the potential losses, the mitigation incorporated into the project, and the proposed compensation activities, it is expected that there will be a “No Net Loss” of fish habitat, as outlined by the following:

Tail Lake will be taken out of biological production, as this lake is the recipient water body for all process tailings and treated sewage. The quantity and quality of fish habitat in Tail Lake was quantified using a modified Habitat Evaluation Procedure (HEP). The results indicated that 34.8 Habitat Units (HUs) of fish habitat will be lost in Tail Lake. Compensation includes increasing accessibility to Roberts Lake through stream channel enhancement in Roberts Outflow, which will potentially provide 132.18 HUs. This will result in a 1:3.8 ratio of habitat loss to habitat gain. Additional compensation includes the creation of rearing habitat in Doris Lake and stream habitat enhancement in a tributary to Roberts Lake.

The natural water flow in Tail Outflow will be disrupted by the tailings dam. Approximately 0.027 ha of fish habitat will be compensated by enhancement (0.153 ha) of rearing habitat in Doris Lake. This will result in a net gain of 0.126 ha of fish habitat.

The proposed jetty in Roberts Bay will adversely affect approximately 0.176 ha of marine fish habitat. Compensation will be four shoals located west of the jetty (equivalent to 0.150 ha of fish habitat). In combination with the below high-water sideslope area of the jetty, this results in a net gain of 0.138 ha of higher complexity fish habitat. The interstitial spaces of the riprap will serve to create a diverse three-dimensional structure, in an area of limited habitat complexity, which will provide habitat for fish.

Project activities where fish habitats are not expected to be negatively affected included the water intake barge, the floating boat and float plane dock, tailings pond discharges, the Doris Outflow bridge, watercourse crossings, blasting, and dust deposition.

Key to the compensation of HADD during the proposed project will be improvements for Arctic char migration and reduction in high mortality of adults and subadults due to stranding in the shallow boulder area of Roberts Outflow. This will provide greater access to overwintering, spawning, and rearing habitats. Increasing production of Arctic char in the Roberts Lake system will allow larger numbers of fish to take advantage of productive ocean habitats, thereby greatly increasing biomass subsequently returning to Roberts Lake. We feel that the compensation proposed will increase the productive capacity of Roberts Lake, thereby replacing the loss of productive capacity of Tail Lake due to the project. Arctic char are culturally, recreationally and ecologically important to people of the Canadian north. Since Arctic char in this system are anadromous, this species is able to attain a much larger size in a shorter time period than landlocked lake trout (particularly such as those in Tail Lake, which have a very limited forage base). In addition, other species, such as broad whitefish, lake whitefish, cisco, least cisco, and lake trout, may also benefit through improvements in migration habitat and access to additional stream habitat.

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1.0 INTRODUCTION

Miramar Hope Bay Limited (MHBL) proposes to construct and operate a new underground gold mine ("Doris North Project") in the West Kitikmeot Region of Nunavut. The project is located 685 km northeast of Yellowknife and 125 km southwest of Cambridge Bay. The mine is on Inuit owned land, approximately 5 km south of the Arctic Ocean. The nearest communities are Umingmaktok, located 75 km to the southwest, and Bathurst Inlet located about 160 km to the southwest. Activities associated with construction, operation and reclamation of the mine may potentially affect existing fisheries resources within local and regional surface water bodies. The overall site infrastructure layout is provided in Appendix A1.

Under Section 35(2) of the *Fisheries Act*, an authorization from the Minister is required for any undertakings that may result in the harmful alteration, disruption or destruction (HADD) of fish habitat. As well, in order to maintain the productive capacity of fish habitats, Department of Fisheries and Oceans (DFO) has adopted a "No Net Loss" policy (DFO 1986; 1998a). Under the *Fisheries Act*, fish habitat is defined as "spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly in order to carry out their life processes." To further the "No Net Loss" principle, DFO has also published a document on "Decision Framework for the Determination and Authorization of Harmful Alteration, Disruption or Destruction (HADD) of Fish Habitat" (DFO 1998b), with respect to the *Fisheries Act*, Section 35. This publication outlines the decision processes for authorization of HADD. Within the initial application process, DFO habitat biologists determine if the proposed project could result in HADD. If a HADD could occur as a result of the proposed activities, the next step is to assess if the adverse effects could be fully mitigated. If the adverse effects could be fully mitigated, then a Letter of Advice specifying mitigation would be issued; however, if the potential effects cannot be fully mitigated, then a decision will be made as to whether or not compensation is possible and an Authorization for the HADD may be issued.

The present document is Revision 6 of the "No Net Loss" Plan (NNLP). The original NNLP was completed in January 2003. Following that, a revised NNLP was completed in November 2003, which incorporated additional field data collected during 2003. Revision 3 was completed in May 2004, which incorporated information requests from Fisheries and Oceans Canada (DFO) dated 30 January 2004 and 10 May 2004 (NIRB Files 130 and 151e, respectively) prior to the Nunavut Impact Review Board (NIRB) hearings in July 2004. Revision 4 incorporated additional information requests from DFO dated June 2004 (NIRB File 177b) and requests stated at the NIRB hearings. Revision 5, dated October 2005, incorporated minor revisions or additions in response to information requests or technical reviews following the submission of the Draft EIS in June 2005. An "Update and Detailed Design Drawings" document was submitted to DFO and the Nunavut Water Board in May 2007. This document outlined changes to the project infrastructure and detailed design drawings for the various compensation structures. The current revision, Revision 6, addresses changes to the project presented to the NWB and NIRB in June of 2007 that resulted from detailed engineering, changes in habitat compensation structures for the as-built jetty (completed in July 2007), as well as fulfilling subsequent DFO requests that were made during the Nunavut Water Board Licensing process. Revision 6 also includes the re-designed rearing shoals in Doris Lake (i.e., moved into deeper water) to address concerns regarding potential effects on navigation in the lake.

This document outlines the potential adverse effects on fisheries resources associated with the Doris North Project, and provides a "No Net Loss" Plan to meet the requirements of DFO. Overall, seven pathways of potential effects on fish resources were identified for the Doris North Project; these include habitat alteration/loss, reduced water quality, blasting, fish harvesting, water withdrawal, impediment of fish passage, and the inadvertent release of deleterious substances. Each potential effect is discussed in detail below in relation to the project design features and mitigation measures (Section 2.0). Where residual or non-mitigable adverse effects remain, habitat alterations/losses are quantified in the effects analysis section (Section 3.0). To ensure that "No Net Loss" in fish habitat productive capacity is achieved as it relates to the DFO policy for the management of fish habitat, proposed detailed compensation plans are presented in Section 4.0. As part of the authorization process, there will be a monitoring requirement to ensure that the compensation is functional as predicted. Therefore, specific monitoring measures have been identified in Section 5.0. In response to a request by DFO at the Nunavut Water License Hearings, a proposed Fish-Out Plan (Section 6) has been developed for the removal of fish from Tail Lake prior to using it as a tailings impoundment area.

2.0 OVERVIEW OF PROJECT DESIGN FEATURES AND MITIGATION MEASURES

The following outlines an overview of the project design features, potential adverse effects to the aquatic environment and measures that will be implemented to mitigate or reduce adverse effects.

2.1 Habitat Alteration/Loss

2.1.1 Tailings Dam

Tail Lake will be the recipient water body for all process tailings and treated sewage during the operation of the mine. To adequately isolate this lake, two containment dams will be constructed. Since the South Dam does not interfere with any watercourses, this dam was not included in further discussions of the NNLP. However, the North Dam will be constructed at the upstream end of Tail Outflow; thus, during construction and operation of the mine, the water flow in Tail Outflow, which enters Doris Lake near Doris Outflow, will be disrupted due to the presence of the tailings dam. Construction of the dams will be conducted during winter when Tail Outflow is dry or frozen to the bottom. The North Dam will be approximately 11.4 m in height and 190 m in length, with a minimum freeboard of 1 m above the full supply water elevation of 33.5 m (SRK 2005a). Upon mine closure when the water quality in Tail Lake meets the federal water quality guidelines (CCME 1999) or an ecological risk assessment indicates the water can be discharged without harming aquatic biota, the dam will be breached and the water flow in Tail Outflow will then be restored.

During the Nunavut Water License Hearings, DFO requested more details on the design, construction methods and costs of breaching the north Dam. These details have been provided in Appendix A2. Restoration details for the Tail Outflow channel are based on channel geomorphology measured downstream at Hydrometric Station H76 and derived from aerial photography of the area. The existing channel is a narrow, U-shaped channel with a low sinuosity and a low width-to-depth ratio. Its bankfull depth is approximately 0.25 m and bankfull width is approximately 0.95 m. The channel bed comprises sand and fine gravel and its banks consist of organics and root mass. Discharge at bankfull is approximately 0.05 m^3/s. The reconstructed channel mimics the channel geometry, but also incorporates rock armour features for grade control to prevent erosion that could affect the restored Tail Lake water level regime. The restored channel is slightly oversized, with shallower bank slopes than the natural channel, to allow for sediment deposition and revegetation over time. Figure D12 details the incorporation of the natural stream characteristics into the dam breach outflow channel.

The tailings dam at the outlet of Tail Lake will cause a loss of fish habitat directly at its footprint, as well as a loss in habitat downstream in Tail Outflow as the result of the disruption of the natural flow path. Although Tail Outflow will be affected by the dam, this stream has low quality fish habitat (Rescan 2001). It is a small and narrow stream, with a length of approximately 600 m and a mean width of approximately 0.45 m. Discharge was low when measured during summer 2003; a point discharge on 30 June 2003 was 0.045 m^3/s and point discharges in August ranged from 0.007 m^3/s (8 Aug) to 0.018 m^3/s (18 Aug) (RL&L/Golder 2003a). The streambed material is composed predominantly of organic matter (Rescan 2001). Ninespine stickleback was the only fish species captured during baseline studies (n=1, Rescan 2001 and n=10, RL&L/Golder 2003a). During the initial Nunavut Impact Review Board hearings in July 2004, concerns were raised regarding the potential loss of wetland habitat in Tail Outflow. As a result, detailed habitat mapping of Tail Outflow was conducted in August 2004 (Golder 2005a). Habitat categories included bog, grass channel, grass bog, and willow. Fish habitat for ninespine stickleback was only present in the grass channel.

Upon mine closure and after the water quality in Tail Lake meets the federal water quality guidelines or an ecological risk assessment indicates the water can be discharged without harming aquatic biota, the dam will be breached and the water flow in Tail Outflow will be restored. The tailings containment area could not be relocated or redesigned to avoid adverse effects on the outflow stream, thus compensation for the disruption of fish habitat in Tail Outflow during the operation of the mine is required.

Since the flow in Tail Outflow will be disrupted during operation of the mine, a change in water levels in Doris Lake and a change in Doris Outflow flows will result. Water balance modelling was conducted to predict the combined effects of water withdrawal from Doris Lake and the dewatering of Tail Outflow on the water levels of Doris Lake, as well as predict the changes in flow in Doris Outflow. The water balance simulation predicted that under mean conditions, mean monthly lake drawdown from natural conditions will vary from 5 mm to 70 mm (includes Tail Outflow and Project water withdrawal requirements). The most extreme monthly lake drawdowns from natural conditions calculated by the model varied from 5 mm to 93 mm over the course of the year. These values are within the natural annual variations in lake water level of approximately 500 mm (Golder 2005b). The model also predicted the effects of dewatering Tail Outflow on Doris Outflow. Predictions ranged from a 5% reduction during spring flood flows (June) below the tailings pond discharge pipe outlet to a <0.1% reduction during the low base flow period (October) (Golder 2005b).

The water levels and velocities in Doris Outflow between Doris Lake and the falls (where the Tail Lake discharge point will be located) will decrease slightly during the life of the

Project (i.e., up to nine years), due to water withdrawal from Doris Lake and close-circuiting of Tail Lake outflow. Estimates of water level change in this section of Doris Outflow during the low flow months of August to October ranged from 1 mm to 10 mm (see Appendix 1 in Golder 2005b). There were no instances during the water balance simulation that would suggest the Project would result in Doris Outflow within the section above the falls becoming dry.

Based on the water balance modelling, the disruption of Tail Outflow is not expected to adversely affect fish habitat in Doris Lake or in Doris Outflow.

2.1.2 Water Intake Structure

The preliminary water intake design included two project specific water intake structures that would be installed at the northwest end of Doris Lake for process water and potable water supply. The intakes were to be constructed on a floating pumphouse, which would have no in-lake footprint associated with this structure. During the design sequence, this was subsequently changed to on-shore pumphouse with a water intake pipe sited on the bottom of Doris Lake.

Based on recommendations from SNC-Lavalin, the current engineering design involving a 10 m^2 floating pump-house barge, which would be easier to install and maintain for the small water volumes required for the project. The floating barge will be equipped with an aerator bubble system to keep the barge from freezing solidly in place; this bubble system would only affect ice within 15 cm of the barge, so would not create any new hazards to wildlife or humans traveling on the frozen lake.

The proposed floating pump house location is shown in Appendix A3-a. The barge will be anchored in Doris Lake at a point approximately 25 m to the east of the proposed boat and float plane dock. The pump house will be connected to shore by a 15 m long by 1.5 m wide pre-fabricated clear span walkway that ties the pump hose to shore (Appendix A3-b). The fresh-water pipeline will be cantilevered along the side of this walkway, and then travel along the road right-of-way back to the camp.

The lake depth at the proposed pump barge site is 5 m, and the water would be withdrawn from a depth of approximately 3 m. The pump barge is a floating steel box with a submerged tunnel running down the centre of the barge through the long dimension. The tunnel open to the lake at one end, and will be equipped with a removable #60 wedge wire stainless steel screen with a minimum surface area of 2 m^2. The intake screen has been designed to meet the DFO guidelines for intake screening and velocities (DFO 1995). The mesh opening would have an estimated width of 2.54 mm, and a wire thickness of 1.5 mm. The estimated approach velocity for a flow rate of 24 L/s would be well below the 0.038 m/s DFO guideline (DFO 1995) for fish that use anguilliform swimming mode (e.g. burbot). It should be noted that in Doris Lake, fish species collected to date have only been fish species that use the subcarangiform swimming mode (DFO guideline of 0.11 m/s approach velocities), so the screen design proposed for the Doris Lake water intake will be highly protective in preventing impingement or entrainment of fish at the water intake.

As part of the mitigation measures, installation of the water intake structures will be conducted in a manner to minimize the release of sediment to Doris Lake. Minimal near shore and in-water activities are expected; however, silt curtains or other sediment control technology will be implemented as needed. Total suspended solids (TSS) levels will be monitored during the construction and removal of the water intake structures to ensure that the federal water quality guidelines for TSS are met (CCME 1999).

Fish habitat in the vicinity of the water intake structure was rated as poor quality based on substrate type (100% bedrock; Rescan 2001). Additional fish sampling during 2003 indicated that few fish were utilizing the area near the proposed water intake structures (RL&L/Golder 2003a). After mitigation has been implemented (e.g., intake screening, and sediment control during construction and removal), the construction, operation, and removal of the water intake structures will not adversely affect fish habitat.

2.1.3 Float Plane and Boat Dock

The previous design of the float plane and boat dock was a rock-filled structure that was to be installed at the northwest end of Doris Lake. The in-lake section of the dock would have protruded approximately 10 m into the lake to a water depth of approximately 3 m, and the dock would have been approximately 40 m in length along the shoreline. Construction of the structure would have required blasting to remove bedrock within Doris Lake.

The rock-filled dock design would have resulted in the loss of aquatic habitat within the filled footprint of the dock that is out of the water; also, there was some risk to fish due to blasting within the lake bed, although MHBL committed to following DFO blasting guidelines (Wright and Hopky 1998) as modified for use in Nunavut. The overall fish habitat loss was estimated to be 0.04 ha.

Based in part on concerns raised by DFO regarding habitat loss and alteration associated with the rockfill design, the current engineering design for the float plane and boat dock is a floating structure, located in a small bay of Doris Lake immediately southeast of the proposed mill (MHBL 2007). The dock portion will be a pre-fabricated modular unit, approximately 25 m long and about 4 m wide, and will be held in place by six permanently installed bollards (Appendix A4).

The implication of the current dock design to the NNLP is that the habitat loss of 0.04 ha associated with the rockfill design will not occur. In addition, the floating structure may provide a limited amount of overhead cover for fish in Doris Lake; however, the extent to which fish will use the overhead cover is unknown. Based on the current design and proposed mitigation to prevent high TSS concentrations during installation and removal, and for the removal of the bollard anchors at the lake bed during decommissioning, the float plane and boat dock is not expected to result in any adverse impacts to fish and fish habitat in Doris Lake.

2.1.4 Watercourse Crossings

An all-weather access road (4.8 km in length) will be constructed from the south end of Roberts Bay to the Doris North Project site (main road) and another all-weather road (5.6 km in length) will be constructed from camp to the south end of Tail Lake (Tailings Service Road). The Main Road and the Tailings Service Road cross nine intermittent/ephemeral streams. In the preliminary designs, culverts were to be installed at all of these crossings; however, based on a recommendation from SNC-Lavalin, MHBL plans to install coarse rock drains on all of the low flow (less than 0.25 m^3/s) ephemeral drainages that have no fish access potential. The SNC-Lavalin recommendation was based on experience at other northern sites where typically the culverts remain frozen after the freshet flow commences in the spring, turning the culvers into flow obstructions until they can be thawed using applied heat. The rock drains (see Appendix A5) will consist of coarse rock that has been screened to remove fines. Additional rock drains may be installed along the road to ensure proper cross-ditch drainage during periods of snowmelt. In addition to these main roads, there will also be two additional short sections of road required; these include the road from the main Tailings Service road to the discharge release point just above the falls on Doris Creek, and an 800 m long service road to allow installation and maintenance of two ventilation raises for the underground mine. The locations of these roads are shown in Figure A6. There are no stream crossings along the road to the discharge release point, but there are three small, ephemeral runoff paths identified along the ventilation raise service road. MHBL proposes to install rock drains at these three points to allow unimpeded passage of surface runoff through these drainage pathways. Due to the ephemeral nature of these drainage paths, they would not provide fish habitat upstream of the road crossings.

The Tailings Service Road also crosses Doris Outflow at the north end of Doris Lake. This crossing will incorporate a clear-span bridge that does not encroach within the normal high flow channel.

The all-weather road will remain in place after post-closure; however, road sections with rock drains will be breached to provide unrestricted drainage. Stream banks will be stabilized by armouring with riprap to ensure that sedimentation issues from erosion do not occur. The bridge crossing will be removed during post-closure of the mine, once water quality in Tail Lake has reached the licensed discharge criteria.

Bridge

Doris Outflow will be crossed by a single-span bridge. No in-stream activity will be associated with the bridge design or construction of this crossing. A pre-fabricated modular steel bridge structure will be assembled on two rock-fill abutments The bridge deck will provide about 2.1 m of clearance above the ordinary high water mark, and the toes of the bridge abutments will be a minimum distance of 15 m apart (MHBL 2007, Supporting Document S4, Drawing S12).

Figures 1 to 3 are photographs of Doris Outflow taken during the field visit between 30 June and 1 July 2003, and provide an overview of the morphology of the outlet channel. A stream discharge measurement was also undertaken on 30 June and a channel cross-section (below the water surface elevation) is provided in Figure 4.

The following are stream habitat characteristics observed during 2003:

- Water depth: During discharge transect measurements in August and September 2003, the maximum-recorded depth was 0.38 m, with a mean depth of 0.26 m.
- River width in June was approximately 12 m. During discharge transects in August and September 2003, river width ranged from 2.8 to 4.7 m.
- The high water mark during the June site visit was approximately 1 m above existing conditions.
- The bank-full distance at this location during the June site visit was approximately 14 m across the river channel.

Figure 1 **Doris Lake outlet gauging station, looking south (upstream) from right downstream bank.**

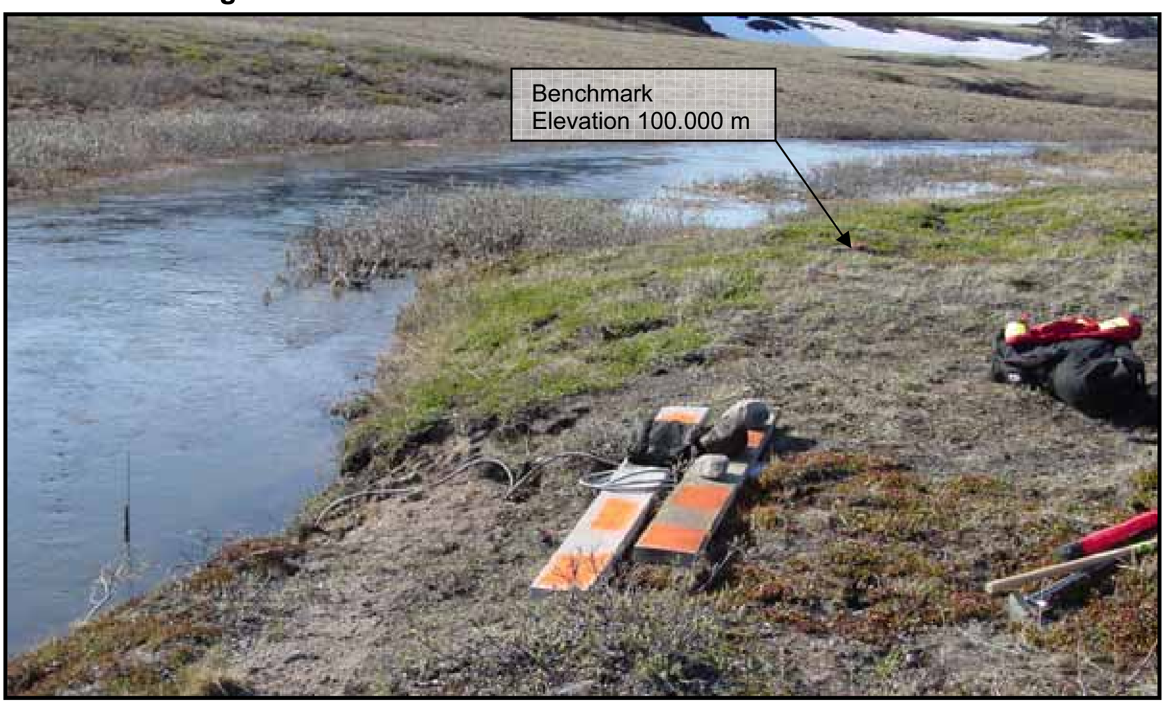


Figure 2 **Doris Lake outlet gauging station, looking north (downstream) from right downstream bank.**

Figure 3 **Aerial view of Doris Lake outlet gauging station, looking north (downstream).**

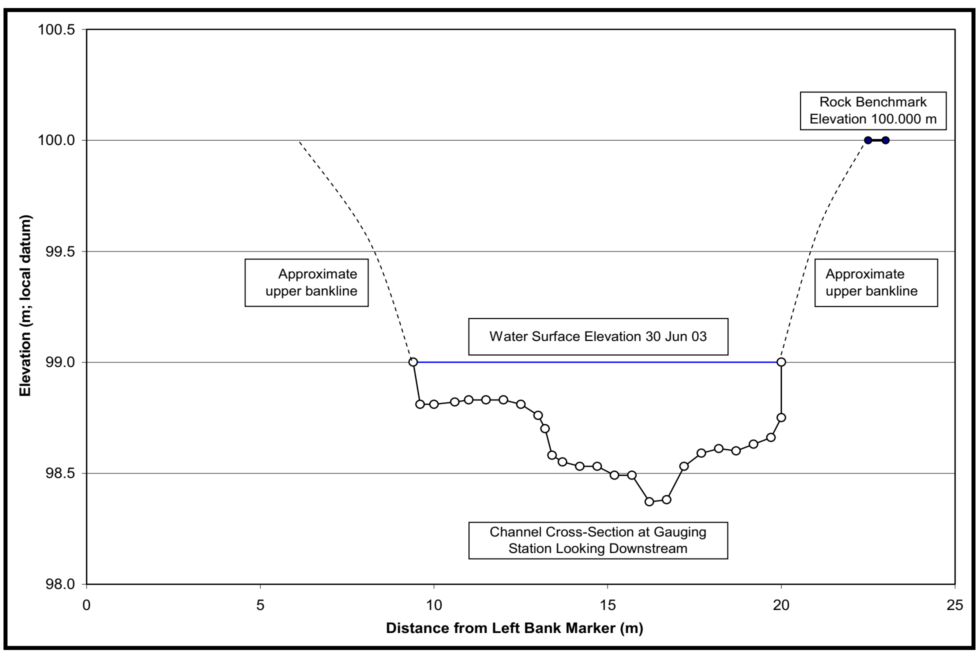


Figure 4 **Cross-section and water surface elevation at Doris Lake outlet gauging station, looking downstream. Upper banklines are approximate; lower cross-section and benchmark elevation were measured.**

Rock Drains

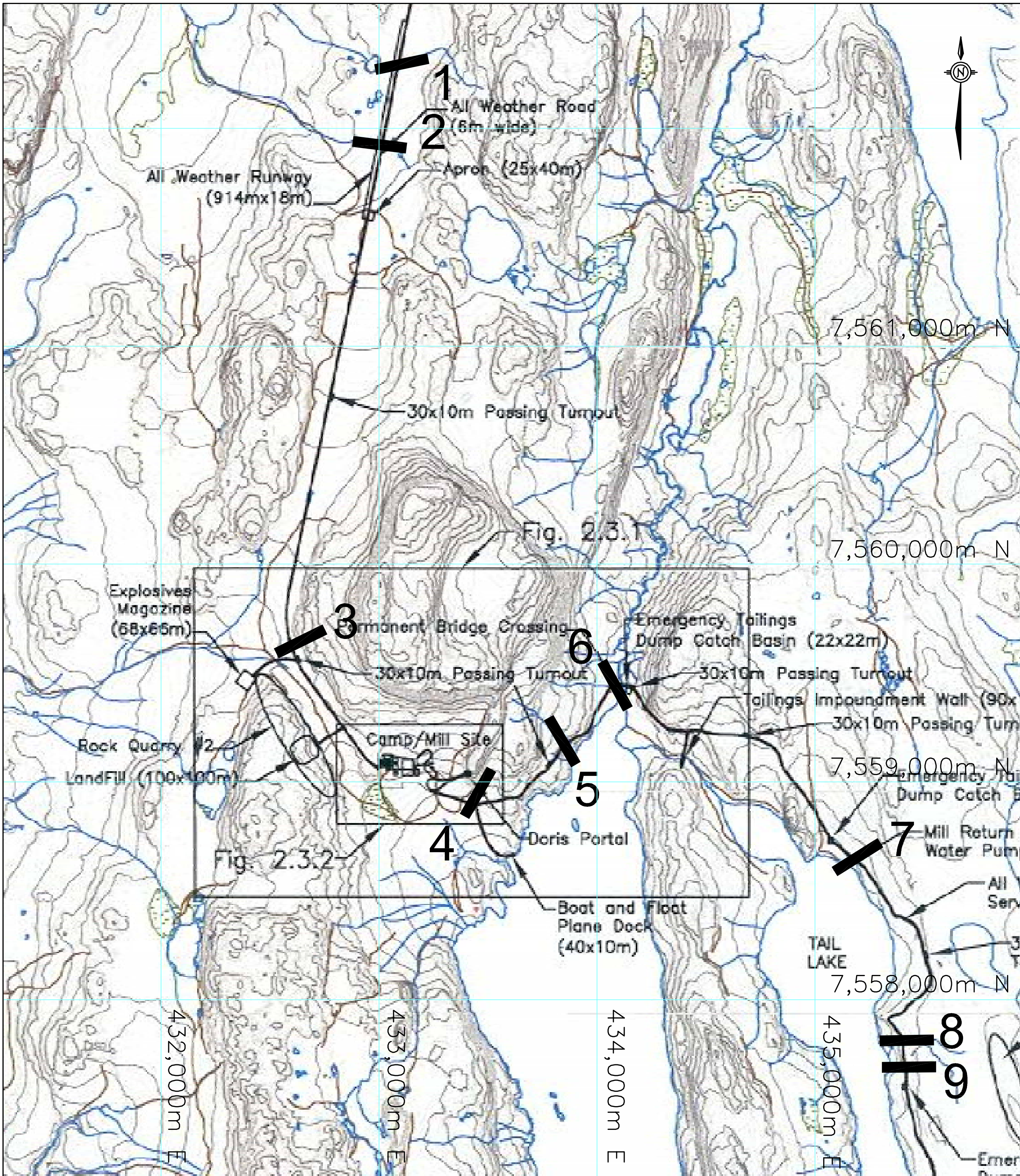
In total, there are nine watercourse locations identified along the Main Road and the Tailings Service Road that will require rock drains (Figure 5). Representative photos of each of the crossings were taken during the 2004 field season (Appendix B). All streams with proposed crossings have narrow channels and are shallow; they are approximately 20 to 30 cm wide and approximately 5 to 10 cm deep (when water was present). Most of the streams did not have flowing water in July or August. Similarly, the three runoff drainages crossed by the ventilation service raise road are also ephemeral drainages (see photos B19 to B21 in Appendix B).

The stream crossings assessed did not provide suitable habitat for fish, and, therefore, no additional compensation should be required. However, mitigation measures will be taken to avoid downstream effects. Mitigation measures will include:

- constructing the rock drains of suitable material and size to accommodate high flows during the spring melt period;
- avoiding in-stream activities whenever possible during construction;
- monitoring sediment concentrations during rock drain installation and removal if flowing water is present; and
- all activities, including maintenance procedures, will be controlled to prevent the entry of petroleum products, or other deleterious substances into the watercourse. Vehicular refueling and maintenance will be conducted away from the watercourses.

2.1.5 Roberts Bay Jetty

A rockfill jetty was constructed during early July of 2007 at the south end of Roberts Bay for barge loading and off-loading. Over the course of the regulatory review process, additional studies were conducted to develop a single preferred design for the jetty (SRK 2005b and Golder 2005c). These studies included a shoreline processes study and characterization of the jetty foundation conditions. The preferred jetty design was a complete rock-filled jetty. Alternative jetty designs that were considered included: (1) conventional piling with a bridge deck structure or floating pontoons, (2) sheet piling filled with rock-fill, (3) simple rock-fill combined with partial dredging, and (4) foundation freezing combined with simple rock-fill. The alternative jetty designs were not selected because the cost of specialized equipment required for construction could not be economically justified for this project. Thus the proposed final jetty design was a complete rock-filled jetty.



LEGEND

▬ CULVERT LOCATION

REFERENCE

DRAWING PROVIDED BY SRK CONSULTING.

Miramar MINING CORPORATION

PROJECT

MIRAMAR HOPE BAY LTD.
DORIS NORTH PROJECT

TITLE

CULVERT LOCATIONS

Golder Associates
Edmonton, Alberta

PROJECT 05-1373-008.1500			FILE No. Culvert Locations	
DESIGN	AS	26/05/05	SCALE 1:25000	REV. 0
CADD	MWL	26/05/05	**FIGURE: 5**	
CHECK	AS	26/05/05		
REVIEW				

R:\CAD\2005\1370-Edmonton\1373-ES\05-1373-008\1500\Fig 5 CULVERT LOCATIONS.dwg May 26, 2005 - 2:19pm

The proposed design for the jetty was a rock-fill structure situated perpendicular to shore, and 103 m in length and 6 m in width, with a 25 m long mooring face. The side-slopes were originally designed be at the angle of repose for the quarry rock; however, subsequent design modifications that took settlement of the rockfill into consideration suggested a 3:1 sideslope would be more likely after settlement. The jetty area above the normal high water level would be 0.1584 ha (MHBL 2007b).

The first 55 m of the jetty from shore would cover a substrate consisting of frozen marine silt and clay (this section freezes to the bottom in winter). The remainder of the jetty would cover unfrozen marine silt and clay (Golder 2005c; SRK 2005b).

Construction of the jetty began once the ice had melted off the shore of Roberts Bay in early July of 2007, and was completed by 15 July. During the construction of the jetty, technical difficulties were encountered in the deeper sections that resulted in a slightly shorter length for the jetty (i.e., approximately 96 m long), but a larger turn-around area on the left side near the end of the jetty. A drawing of the “as-built” surface area, as well as estimated areas along the side slope of the jetty, is provided in Appendix A7.

Although rock spurs were to be constructed off the sides of the jetty as fish compensation for the fish habitat lost under the out-of-water footprint of the jetty, these were not completed due to problems associated with the constructability of the rock spurs. This will be addressed in greater detail in the compensation design section.

The jetty will remain in place during the period of mine construction and operation, and for the first two years of active decommissioning after mine closure, at which time the portion of the jetty seaward of the 1.0 m depth contour will be graded to a minimum of 1.0 m below mean water level, as required in the Navigable Waters Protection Act approval for the project.

Mitigation measures implemented during the construction of the jetty included:

- constructing the jetty of run-of-quarry rock that has been certified as having low acid generation potential and low metal leaching potential;
- timing of construction (i.e., early July) to avoid spawning migrations of capelin (*Mallotus villosus*) during end of July; and
- use of silt curtains enclosing the in-water construction area to reduce suspended sediment to a level to meet the federal CCME (1999) water quality guidelines.

The fish habitat in the vicinity of the jetty was rated as good quality by Rescan (2001), based on assessments of nearshore areas and shoreline conditions. They indicated the substrate in this area was composed predominately of sand, with some cobble, boulder, and bedrock (primarily nearshore); however, more recent studies specific to the jetty area (Golder 2005c; SRK 2005b) suggest the habitat would be of poorer quality, with substrates over most of the length of the jetty consisting of marine silts and clays, with only small patches of fine sand or rock (rocks likely moved off the shoreline by ice).

Over half of the section affected by the jetty is shallow nearshore habitat that would freeze to the bottom throughout the winter. A limited netting program was conducted in Roberts Bay by Golder in 2003 to assess fish resources in the near-shore marine environment (RL&L/Golder 2003a). Results indicated that both marine benthic and pelagic species and anadromous species (Arctic char [*Salvelinus alpinus*] and several species of coregonids) utilized the bay. There were also four species that are typically found only in freshwater (lake trout [*Salvelinus namaycush*], lake whitefish [*Coregonus clupeaformis*], cisco [*Coregonus artedi*], and least cisco [*Coregonus sardinella*]) present in the catch (RL&L/Golder 2003a). Fish sampling of the area near the jetty with a fyke net during the construction period in 2007 caught six species of fish, including Arctic char, lake trout, Arctic flounder (*Pleuronectes glacialis*), Pacific herring (*Clupea pallasii*), saffron cod (*Eleginus gracilis*) and fourhorn sculpin (*Myoxocephalus quadricornis*).

2.1.5.1 Habitat Alteration

It is difficult to quantitatively assess the effects of construction of the jetty, as the jetty would result in a habitat alteration as opposed to out-right habitat loss (with the exception of the above-water footprint). There are also differing views in the scientific literature as to whether this type of habitat alteration (i.e., sand/silt to rockfill) is harmful or not. There have been few studies of the effect of alteration of fish habitat through the use of riprap and no studies could be located in the scientific literature that examined the effects of riprap in Arctic marine environment. The following is a brief summary of several studies that have examined the effects of riprap on fish and fish habitat.

Golder (2002) examined the potential effects that the construction of a larger off loading facility at Kugluktuk, Nunavut, would have on fish and fish habitat. An examination of the results of the Golder (2002) fish sampling program suggested that catches of adult Arctic char were slightly higher in areas of rocky shoreline. Golder (2002) also provided some anecdotal information that indicated that fish numbers have been observed to increase in the immediate area of several recently constructed breakwaters in Nunavut. Golder (2002) did caution that no scientific studies of these breakwaters have been carried out. Therefore, it is possible that there will be an increase in habitat for Arctic char and other salmonid species in the immediate vicinity of the jetty constructed in

Roberts Bay. Species such as starry flounder may be displaced from the immediate jetty area.

Fisheries and Oceans (1990) indicated that artificial reefs composed of rock are an effective fishery enhancement tool in marine waters, and that reefs constructed of rock will last indefinitely. It is further stated that "an artificial reef enhances fish aggregation and production habitat required by various invertebrates and fishes. Increased habitat complexity and heterogeneity of habitats created by the artificial reef provide a multitude of microhabitats for many invertebrates. These in turn provide food for fishes and many invertebrates. The reef also provides shelter for many fishes and motile invertebrates."

2.1.5.2 Foraging Opportunities

The loss of sand dwelling invertebrates within the footprint of the jetty is not considered to be significant. The invertebrate sampling results show that invertebrate numbers were lowest in shallow water (i.e., <1.5 m), similar to conditions in which much of the jetty is located, and showed a trend of increasing density with increased water depth (e.g., 1700 animals/m^2 at the 1.5 m station and >30 000 animals/m^2 at the 15 m station; RL&L/Golder 2002). This is likely due to the influence of ice action on the nearshore habitat. Polychaetes were the predominate benthic invertebrate species present (RL&L/Golder 2002). The construction of the jetty will likely result in a shift towards invertebrate species that prefer rock substrates in the area occupied by the jetty. While this may shift feeding opportunities for flounder species away from the immediate area occupied by the jetty, this is not considered to be a large effect, as sand dominated areas are available in other locations in Roberts Bay (refer to the marine invertebrate discussion in RL&L/Golder 2002). The rock surface of the jetty likely would provide increased feeding opportunities for other species, such as the fourhorn sculpin (*Myoxocephalus quadricornis*) and Arctic char juveniles, which would feed on invertebrates amongst the rocks.

2.1.5.3 Fish Movements

Another potential adverse effect associated with the construction of a jetty is the possible disruption of migratory movements of fish along the shoreline. Wilson and Gallaway (1997) published the results of a long-term study that assessed the effects of the causeways that have been constructed along the Beaufort Sea coastline at Prudhoe Bay, AK. These causeways are several orders of magnitude larger than the jetty proposed at Roberts Bay. For example, the West Dock Causeway is 4.3 km in length, while the Endicott Causeway is approximately 8 km in length. These authors indicated that the migrating coregonids were not significantly affected by the causeways. Given the small size of the Roberts Bay jetty (approximately 95 m in length), it is unlikely to result in any blockages or serious delay in fish movement along the shoreline.

2.1.5.4 Mitigation Features

In order to mitigate the adverse effects that construction of the jetty may have on the local aquatic habitat, the outer face of the structure will be constructed of run-of-quarry rock (up to 0.5 m diameter). This will create a complex three-dimensional interface, with abundant interstitial spaces for fish to utilize. It is anticipated that this would create habitat for juvenile salmonid species (e.g., Arctic char and whitefish species) and other species such as fourhorn sculpin.

2.1.6 Water Level Changes

Tailings pond discharges will result in changes in water levels in Doris Outflow during certain times of the year in the operation phase. As part of the water management strategy for the Project, the maximum discharge rate will be 1,200,000 m^3/y (MHBL 2007a). Most of this water will be released annually in June and July; however, tailings pond discharges will not exceed 10% of the natural instantaneous flow in Doris Creek upstream of the outfall (SRK 2007). Based on this criterion and baseline annual mean hydrology values (AMEC 2003), a mean monthly discharge of approximately 0.206 m^3/s could be released in June (43% of the yearly total), 0.124 m^3/s in July (27%), 0.052 m^3/s in August (11%), 0.069 m^3/s in September (14%), and 0.023 m^3/s in October (5%). Based on the stream stage data, the increased discharge during June and July would not result in an increase in water level in the stream by more than 10 cm (Golder 2005b). During September and October, because flows are typically low during fall, an increase in flow would be beneficial (i.e., it would increase habitat available for rearing or feeding).

To determine if an increase in water velocity due to the tailings pond discharge would affect fish habitat, predicted water velocities were compared to published swimming speeds of fish (Bell 1986). Typical mean flow velocities in Doris Creek are below 0.6 m/s even for peak flow events, and increasing the discharge by 10% would typically increase the mean flow velocity by less than 5%, because increases in discharge result in increases in both flow area and velocity (Golder 2005b). This nominal increase in mean flow velocity would not exceed the published sustained swimming speed of Arctic char (1.1 m/s for a 36 cm fish), lake whitefish (0.88 m/s for 5 to 10 cm fish), and ninespine stickleback (0.90 m/s for 10 cm fish) (Bell 1986) and lake trout (0.5 to 0.8 m/s; Katopodis 1992). It should also be noted that there was conservatism in the estimate since the water velocities used in the calculation were recorded mid-way in the water column, and fish typically swim closer to the bottom where the water velocities are lower. In addition, there are areas of cobble/boulder substrate for fish to use as cover against increased water velocities. There is also habitat available closer to the stream banks that would have lower water velocities than those found in the middle of the channel, thereby allowing for easier navigation by fish.

Based on this, changes in water levels and velocities in Doris Outflow are not expected to adversely affect fish habitat.

2.1.7 Dust Deposition

Project activities during construction and operation could potentially contribute to elevated dust emissions; these include blasting and crushing of quarry rock, power generation, underground mining ventilation, stockpiling of the ore, waste incineration, vehicle traffic, and aircraft landing and taking-off. Dust emissions or total suspended particulates could potentially result in accumulations of sediment on lake bottoms altering fish habitat, thereby affecting near-shore spawning, rearing, foraging or refuge areas. Thresholds have been identified that indicate that an accumulation greater than 1 mm is sufficient to cause decreased fish egg survival (Fudge and Bodaly 1984).

Mitigation procedures for total suspended particulates include dust suppression for Project activities such as the roads, airstrip, ore stockpile, and quarry rock piles.

Dust deposition in the Project area was modelled (Golder 2005d). Results indicated that the predicted maximum dust deposition depth was 132 kg/ha/yr, which is equivalent to a depth of 0.011 mm/yr. This maximum dust deposition occurs amongst the processing and camp buildings. Based on this, the egg survival threshold of 1 mm accumulation will not be exceeded and the Project will not contribute to effects on fish habitat.

2.2 Water Quality

2.2.1 Tailings

Tail Lake will be the recipient water body for all process tailings; thus, this lake will be removed from biological production as a result of reduced water quality. In particular, predicted maximum concentrations of dissolved nitrite will greatly exceed the CCME (1999) federal guideline of 0.06 mg/L commencing in Year 1 until post-closure (SRK 2005c). To avoid potential contamination of fish in the lake, and likely mortalities resulting from the reduced water quality, fish will be removed from Tail Lake with the assistance of harvesters from local communities prior to tailings deposition. Details of the proposed Tail Lake Fish-Out Program are provided in Section 7 of this document.

Following closure, a water cover of at least 3 m above any solids will be maintained to prevent degradation of water quality due to acid generation.

Alternative options for the tailings containment area were assessed in SRK (2005d). Based on these assessments, the tailings containment area could not be relocated or redesigned and the resulting adverse effects can not be mitigated. Therefore, a habitat assessment of Tail Lake to determine potential effects on productive habitat was undertaken (refer to Section 3.1) and a compensation plan developed (refer to Section 4.0).

2.2.2 Tailings Pond Discharges

Water from the tailings containment area will be decanted annually throughout the open-water period, via a pipeline from Tail Lake to Doris Outflow. The quantity of tailings pond decant that will be released will be dependent on the chemical constituents in the water, but will not exceed 10% of the flow in Doris Outflow at any time. Details of the Doris North water management plan can be found in Supporting Document S6 of the Revised Doris North Project Water License Support Document (MHBL 2007a) The release point will be located immediately upstream of the waterfall thereby reducing the length of stream affected by the decant above the waterfall.

Doris Outflow above the waterfall is utilized by lake trout, lake whitefish, and ninespine stickleback from Doris Lake (RL&L/Golder 2002). Upstream fish migration from Little Roberts Lake (and the ocean) is blocked by the waterfall, which is 4.3 m in height. Fish habitat quality in the section between the proposed decant release point (about 75 m above the falls) and the falls was rated as primarily intermediate quality, with sections of poor quality (Rescan 2001).

The annual release of decant water into Doris Outflow will meet the requirements of the federal *Metal Mining Effluent Regulations* (MMER), which regulate the end-pipe-effluent. The MMER were developed under the federal Fisheries Act, with the intent of protecting fish, fish habitat, and the use of fisheries resources in waterbodies adjacent to metal mines. Water quality in Tail Lake will be monitored prior to release to ensure that decant water meets regulatory requirements. If it is determined that the decant water likely would not meet regulatory requirements, the water would be held and/or treated until the water quality meets the requirements. The Doris North water management plan has been designed to regulate the quantity of decant water from Tail Lake to ensure that CCME water quality guidelines for the protection of aquatic life are not exceeded in Doris Outflow below the water fall. Water quality monitoring will be conducted at the tailings pond discharge in Doris Outflow and downstream of the waterfall to confirm that the federal regulations and the CCME water quality guidelines are being met. An aquatic life risk assessment (Golder 2005e) confirmed that the planned mitigation is predicted to be effective at reducing risk to downstream aquatic life. The aquatic life risk assessment indicated that there will be no incremental increase in risk to fish in Doris Outflow (and therefore in Little Roberts Lake proper) as a result of the proposed Doris North Project.

2.2.3 Total Suspended Solids

Sediment may potentially be introduced into the water column during construction activities of the tailings dam, rock drains at road crossings, and anchoring of the water intake barge and the float plane and boat dock. By increasing turbidity and suspended sediment load, this could potentially result in alteration of fish habitat in downstream areas.

To minimize the introduction of sediment into waterbodies, mitigation measures include the following:

- the work site will be isolated to the extent practical during construction, and where appropriate, silt curtains/fences will be employed to prevent the transport of sediment in a waterbody or watercourse;
- working in winter when there is little or no flow in streams; and
- contingency plans for erosion control will be implemented during and after construction.

In addition, water quality monitoring stations will be established upstream and downstream of the dam construction sites during the open water period. Water samples will be taken and turbidity measurements will be made on site. This will allow rapid response to any sediment introduction with appropriate control measures. These water samples will be sent to an analytical laboratory for TSS analysis. This will permit the development of a turbidity/TSS relationship for the streams in the study area. Due to the planned mitigation, increases in turbidity and suspended sediment loads due to project activities will be minimized and are not expected to adversely affect fish or fish habitat.

2.3 Water Withdrawal

Water will be withdrawn from Doris Lake for process water and potable water usage. Water withdrawals from Doris Lake will be 1182.4 m^3/d from October to May and 70 m^3/d from June to October over the life of the project (24 months). This water will not be recycled back into Doris Lake, but rather all water discharge from the processing facilities will be pumped into Tail Lake.

Water balance modelling was conducted to predict the combined effects of water withdrawal from Doris Lake and the dewatering of Tail Outflow on the water levels of Doris Lake (Golder 2005b). The water balance simulation predicted that under mean conditions, mean monthly lake drawdown from natural conditions will vary from 5 mm to 70 mm. The most extreme monthly lake drawdowns from natural conditions calculated by the model varied from 5 mm to 93 mm over the course of the year. These values are within the natural annual variations in lake water level of approximately 500 mm (Golder 2005b).

Water balance modelling will continue during operations to monitor any effects. As well, the water intake structure has been designed to meet the DFO Freshwater Intake End-of-Pipe Fish Screen Guideline (DFO 1995), which incorporates screen size and water withdrawal velocity to prevent fish entrainment and impingement (see Section 2.1.2). Thus, water withdrawal in Doris Lake is not expected to negatively affect fish populations in the lake.

2.4 Blasting

Blasting will be used as part of the underground mining process as well as during quarrying activities. Quarrying activities will occur in four designated locations (west of the camp/mill site, near the peninsula that extends out into Roberts Bay, on the east side of Tail Lake, and at the mill site for rock levelling). Much of the quarrying at Quarry 1 at Roberts Bay was undertaken during the winter and spring to provide rockfill construction of the jetty and the all-weather road. The remainder of the quarries will be used during the construction of the mill and camp facilities, as well as to provide rockfill for additional roads and fisheries enhancement structures.

Runoff retention ponds will be created at the quarry sites, where necessary, and all waters contained in the quarry pit or retention ponds would be tested to ensure it meets water quality guidelines before release to surface water drainages.

Although no in-water blasting will occur, fish abundance can be affected by blasting near water, since blasting creates shock waves that radiate outward from the point of detonation. This may produce post-detonation compressive shock waves that would cause “a rapid rise to a high peak pressure followed by a rapid decay to below ambient hydrostatic pressure” (Wright and Hopky 1998). The drop below ambient hydrostatic pressure causes most of the negative effects on fish (Wright and Hopky 1998), which can range from damage to the swimbladder or other organs (e.g., kidney, liver, or spleen), to the disruption of development and mortality of incubating fish eggs. Changes in fish behaviour have also been observed in relation to exposure to shock waves (Wright and Hopky 1998).

Mitigation measures include:

- following the federal blasting guidelines of Wright and Hopky (1998);
- timing of blasting (most of the blasting of quarries will be conducted during the winter);
- creating runoff retention ponds at the quarries, where necessary, to retain water that contains high levels of residues from blasting; and
- ensuring, through adequate monitoring, that all waters contained in the quarry pit or retention ponds meet the federal water quality guidelines before release to surface water drainages.

The potential negative effects can be successfully mitigated through proper blast planning and monitoring. Wright and Hopky (1998) provide guidelines for use of explosives near fish bearing waters. These guidelines outline setback distances from an explosive detonation point to fish habitat. The guideline sets out to achieve a pressure of less than 100 kPa for various substrate types to minimize harmful effects on fish and fish eggs. To achieve the goal of 100 kPa, the most conservative setback distance to fish habitat in the guideline is 50.3 m using a 100 kg weight of explosive charge in rock substrate. However, DFO-Iqaluit indicated that they have adopted an even more conservative overpressure value of 50 kPa. The calculated setback distance for a 100 kg charge in rock substrate using 50 kPa criteria is 77.6 m. In areas where spawning habitat is present, the federal guideline also stipulates that setback distances must achieve a 13 $mm{\bullet}s^{-1}$ criteria for all types of substrate. The guideline indicates that the most conservative setback distance from spawning habitat is 150.9 m (using a 100 kg weight of explosive charge).

Set back distances for the four proposed quarries calculated for the winter months are provided in Table 1. Distances from the edge of the quarries to the nearest waterbody were within the federal guidelines of 77.6 m for 100 kg charges during non-spawning seasons and were within the guidelines of 150.9 m during spawning and overwinter egg incubation periods. As well, no blasting will knowingly occur within 500 m of a marine mammal, as indicated in the federal explosives guidelines. If blasting is necessary closer than 77.6 m from the water, smaller charge sizes or delays between blasts will be used to remain within blasting guidelines as outlined in Wright and Hopky (1998) and modified by DFO-Iqaluit for application in the Arctic. Some blasting was conducted at Quarry 1 after ice-melt, but monitoring indicated that the guidelines were not being exceeded.

Table 1 Distance of proposed quarries to the nearest waterbody during winter.

Quarry	Nearest Waterbody	Distance (m) to Nearest Habitat Available for Over-Winter Egg Incubation
Quarry #1	Roberts Bay	165[a]
Quarry #2	Unnamed lake to Glenn L.	295
Quarry #3	Unnamed lake to Pelvic L.	159
Quarry #4	Mill site (for rock leveling)	>500

[a] It was assumed that fall or winter spawning fish would not spawn in <2 m water depth, as the eggs would become frozen in ice, therefore, based on the 2006 bathymetry map of Roberts Bay, the shortest distance from the Roberts Bay quarry to the 2 m contour interval was 165 m; the set back distance during the open water period is 14 m. The predominantly fine silt substrate in the near-shore area at Quarry 1 likely would not be used for spawning.

Note: the distances are based on preliminary design for Quarries 2 to 4 and may be changed during detailed design.

Based on the proposed setback distances, adjustment of blast explosives and delays, and given the creation of the runoff retention ponds and monitoring of the quarry water quality before release, blasting activity is not anticipated to directly affect fish abundance.

2.5 Fish Harvesting Activity

Increased fishing pressure, as a result of increased access to a lake, can lead to changes in the fish population structure of a lake (McDonald and Hershey 1989). Even if anglers practice catch-and-release, a percentage of the fish released may die from hooking injuries (Falk *et al.* 1974; Loftus et al. 1988). A no-angling policy for mine personnel and contractors during the life of the mine will be implemented, and will be a condition of employment. Since a no-angling policy will be implemented, no adverse effects on fish populations are anticipated.

2.6 Fish passage

Coarse rock drains will be installed to provide cross drainage along roadways where necessary. This will provide for continued flow within the current drainage pattern. Following mine closure, the rock drains will be breached and the natural drainage areas and flow directions will be re-established.

The ephemeral or intermittent streams where rock drains will be installed do not provide suitable fish habitat (see Section 2.1.4). As such, fish passage will not be an issue; however, the rock drains will be designed to ensure that there is no disruption in stream flows so that downstream habitats will not be affected. Based on this, adverse effects on fish abundance are not expected.

2.7 Inadvertent Release of Deleterious Substances

The risk of inadvertent release of contaminants (e.g., petroleum products) could potentially be associated with machinery operating in and adjacent to water and handling of fuel during the off-loading from the annual re-supply vessels, at the fuel storage tank farm, and during transportation to the mine. Depending on the quantity and type of released substance, fish and fish habitat could be affected. Mitigation measures will include, but are not limited to, the following:

- ensuring that contractors on-site are properly trained in the use and storage of hazardous materials;
- use of containment berms at the fuel storage tank farm;
- a Project specific spill emergency response plan will be developed, followed and updated as required; and,
- spill kits will be strategically located to accommodate any response action.

Provided that mitigation measures are implemented, the inadvertent release of deleterious substances is not anticipated to affect fish habitat. If an inadvertent release of deleterious substances that may affect fish habitat does occur, the appropriate regulatory agencies will be notified, and the spill will be contained and cleaned up immediately.

3.0 EFFECTS ANALYSIS

The following sections quantify the fish habitat that will be disrupted or destroyed by the project. The majority of this section focuses on the tailings impoundment area (i.e., Tail Lake), as this lake will be removed from biological production during the operational phase of the project.

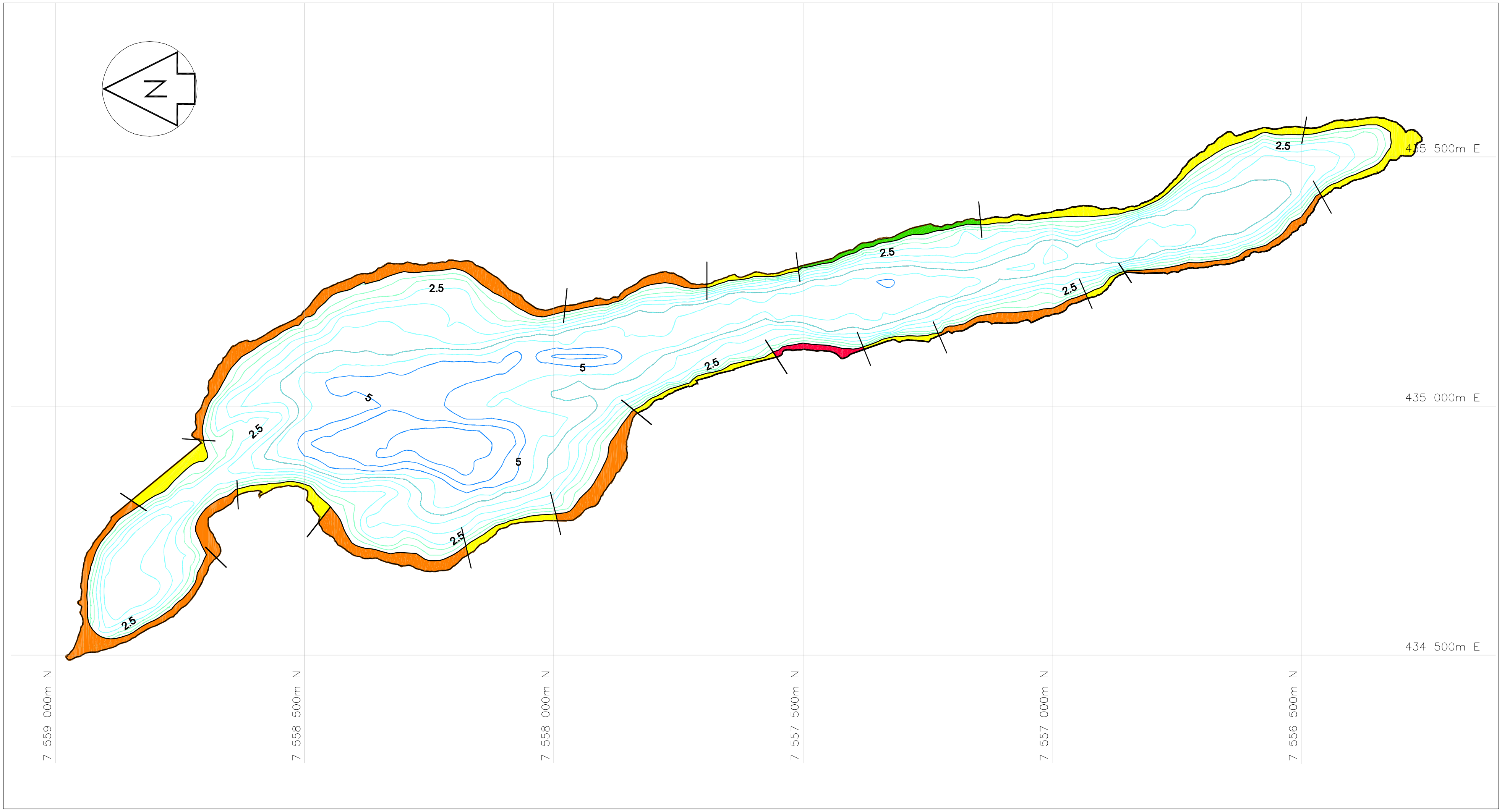
3.1 Tail Lake

3.1.1 Fish Habitat

Tailings will be deposited into Tail Lake, thus the biological productive capacity of this lake will be diminished. A modified Habitat Evaluation Procedure (HEP) outlined in USFWS (1981) was used to calculate the quantity and quality of fish habitats being lost in Tail Lake during the proposed project. HEP analysis combines the habitat quality, defined as Habitat Suitability Index (HSI), with habitat quantity to calculate Habitat Units (HUs). HUs provide a measure that accounts for both the quantity and quality of habitat available for certain species. Multiplying the suitability rating (HSI value) by the area of habitat affected provides the number of HUs available. The HEP approach has been used to assess habitat requirements of fish species associated with other mining projects in the NWT, and is further described in Diavik (1998a and 1998b) and De Beers (2002).

In calculating the area affected by the project, bathymetric survey data of Tail Lake were used to produce a digital bathymetric map displaying contour lines at 0.5 m intervals (Figure 6) and a habitat mapping survey conducted by Rescan (2001) was also used. From these data, Tail Lake was divided into three main habitat environments - two nearshore types and a deepwater type. Since the habitat mapping of Tail Lake did not indicate the distance of the nearshore extending into the lake (only linear shoreline distance was provided), it was assumed that the nearshore with predominantly silt/sand/bedrock substrate types was between contour intervals 0 and 2.5 m, whereas the contour interval for nearshore with predominantly cobble/boulder substrate types was assumed to be 0 to 4 m. (Note: ice depth in lakes in the study area is generally 2 to 2.5 m in depth). Deepwater habitat was categorized as the area of the lake that was greater than 2.5 m depth (with the exception of areas with predominantly cobble/boulder substrates). The maximum recorded depth of Tail Lake is 6.5 m (RL&L/Golder 2002).

To further support the nearshore water depth assumptions given above, Figures 7 to 10 illustrate the depth at which the substrate in Tail Lake transitions from large substrate (preferred fish habitat) to fine substrate (poor quality fish habitat). These data were collected during bathymetric surveys in Tail Lake during August 2003. The surveys were carried out using a BioSonics (Model DT-X) scientific hydroacoustic system. The system uses a digital split beam transducer and geo-references data points to provide real-time depth displays. The Global Positioning System (GPS) has decimeter accuracy. All data are stored directly to the computer hard disk. During the bathymetric survey of Tail Lake, 40 transects were run along the east-west axis and two transects were run across the entire length of Tail Lake along the north-south axis. An additional four transects were surveyed along the north-south axis in the deepest basin at the north end of the lake.



LEGEND

- 0.5-2.0 m CONTOUR LINES
- 2.5-4.0 m CONTOUR LINES
- 5.0-6.0 m CONTOUR LINES

BATHYMETRIC CONTOUR INTERVAL: 0.5 m

HABITAT QUALITY (PREDOMINANT SUBSTRATE)

- POOR (BEDROCK)
- FAIR (SAND/SILT)
- GOOD (BOULDER)
- EXCELLENT (COBBLE/GRAVEL)

Miramar MINING CORPORATION

150 0 150
SCALE METRES

REFERENCE
BASE MAP PROVIDED BY RESCAN (2001)

PROJECT
MIRAMAR HOPE BAY LTD.
DORIS NORTH PROJECT

TITLE
BATHYMETRY AND HABITAT QUALITY OF TAIL LAKE

Golder Associates
Edmonton, Alberta

PROJECT 03-1370-032.1000			FILE No. Tail Lk bath & Hab	
DESIGN	AL	13/11/03	SCALE AS SHOWN	REV. 2
CADD	GMF	19/11/03		
CHECK	AL			
REVIEW				

FIGURE: 6

R:\CAD\2003\1370\03-1370-032\1000\ Drawing file: Figure 1 Tail Lake_ Bath & Hab.dwg Nov 19, 2003 - 9:02am

Figure 7 illustrates the smoothness of a silt substrate in Tail Lake. This was verified using an Ekman grab sample. Figure 8 illustrates the roughness in an area with rock substrate. Figure 9 are snap shots of a transect across Tail Lake from an area classified in the nearshore being from 0 to 4 m. At the bottom of each figure, the GPS (in Latitude and Longitude) are indicated along with the depth at which the curser is positioned. The frame at the top of the page is at the east shoreline and demonstrates that the lake bed roughness ends at about 2.5 m water depth. The middle frame is representative of silt substrate in the deepest portion of the transect and the bottom frame is located at the west shoreline of the lake and the roughness starts again at a water depth of 2.7 m. Similarly, Figure 10 shows the transition zone between rock and fine substrate at a depth of 2.45 m. The top frame is the same transect as the bottom frame but zoomed in on the littoral zone area. Figure 10 is from a transect in the deepest basin of Tail Lake. Based on these illustrations, we feel the assumption for the nearshore water depths are representative of Tail Lake. The high quality habitat extending to a depth of 4 m is probably overly conservative for use in Tail Lake; 2.5 to 3 m is likely more realistic, with areas deeper than this having a predominantly silt substrate.

From the habitat mapping of Tail Lake (derived by Rescan 2001), 19 habitat sections along the shoreline were delineated. These habitat sections were based primarily on substrate type (Figure 6). Only two sections had predominantly cobble/boulder substrate (considered good quality fish habitat); the remainder had silt, sand and/or bedrock as the predominant substrate type. Each section was categorized in relation to its suitability to fish in various life stages (i.e., spawning, nursery, rearing, and foraging). Habitat types were not exclusive to one species or life stage so that each individual physical environment and habitat type could be used for more than one habitat requirement. For example, nearshore boulder and cobble habitat was assessed as providing both spawning and rearing habitat of varying values for particular species. Table 2 summarizes the habitat areas that were used in the calculations of HUs for the effects analysis.

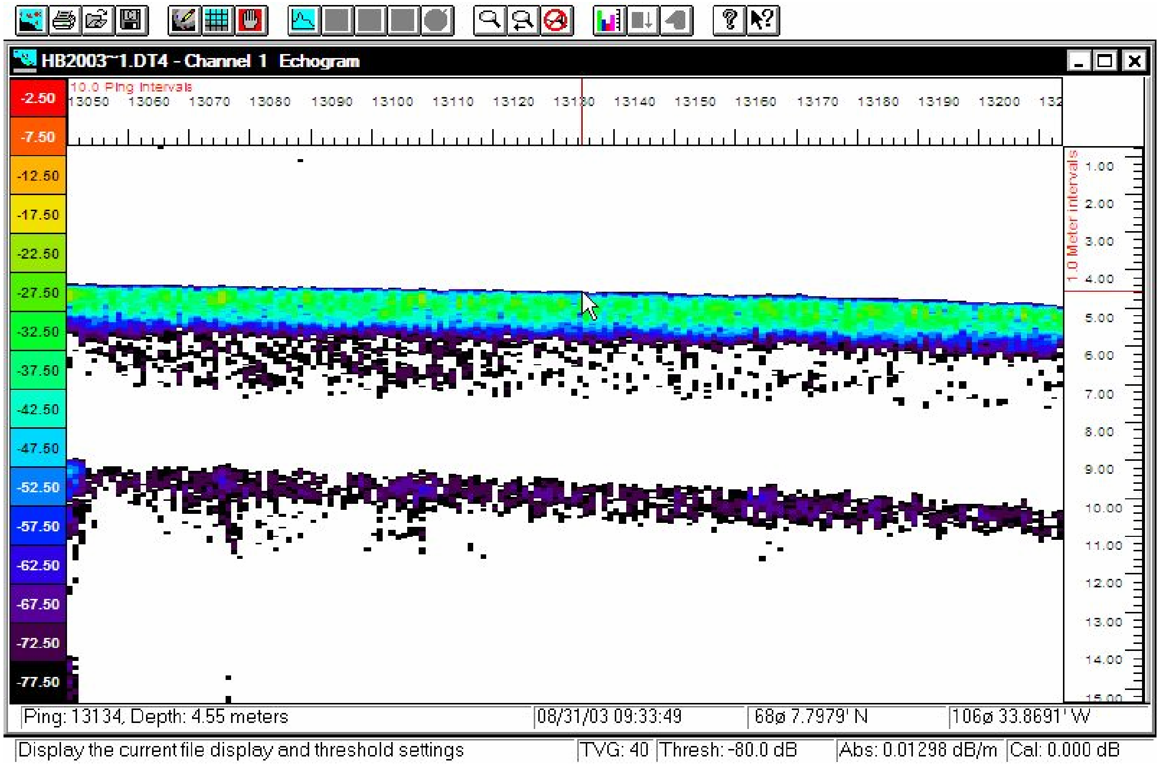


Figure 7 **Example of silt substrate using a scientific hydroacoustic system.**

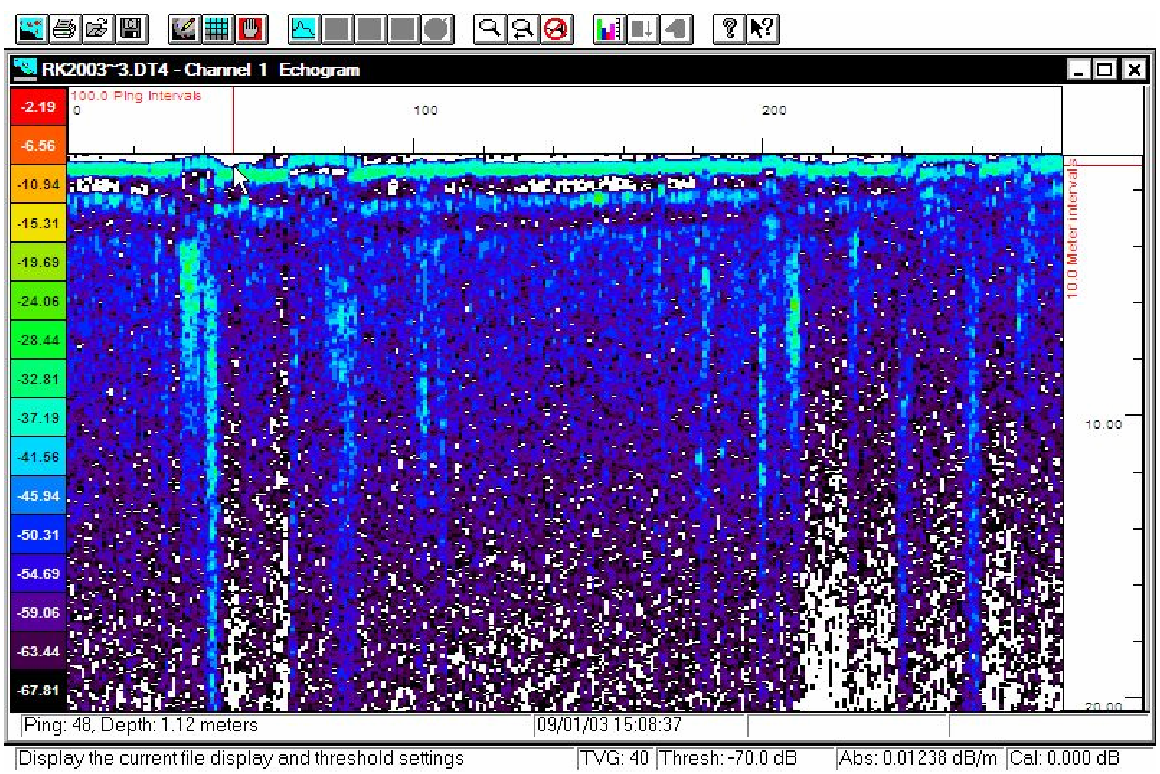


Figure 8 **Example of rock substrate using a scientific hydroacoustic system.**

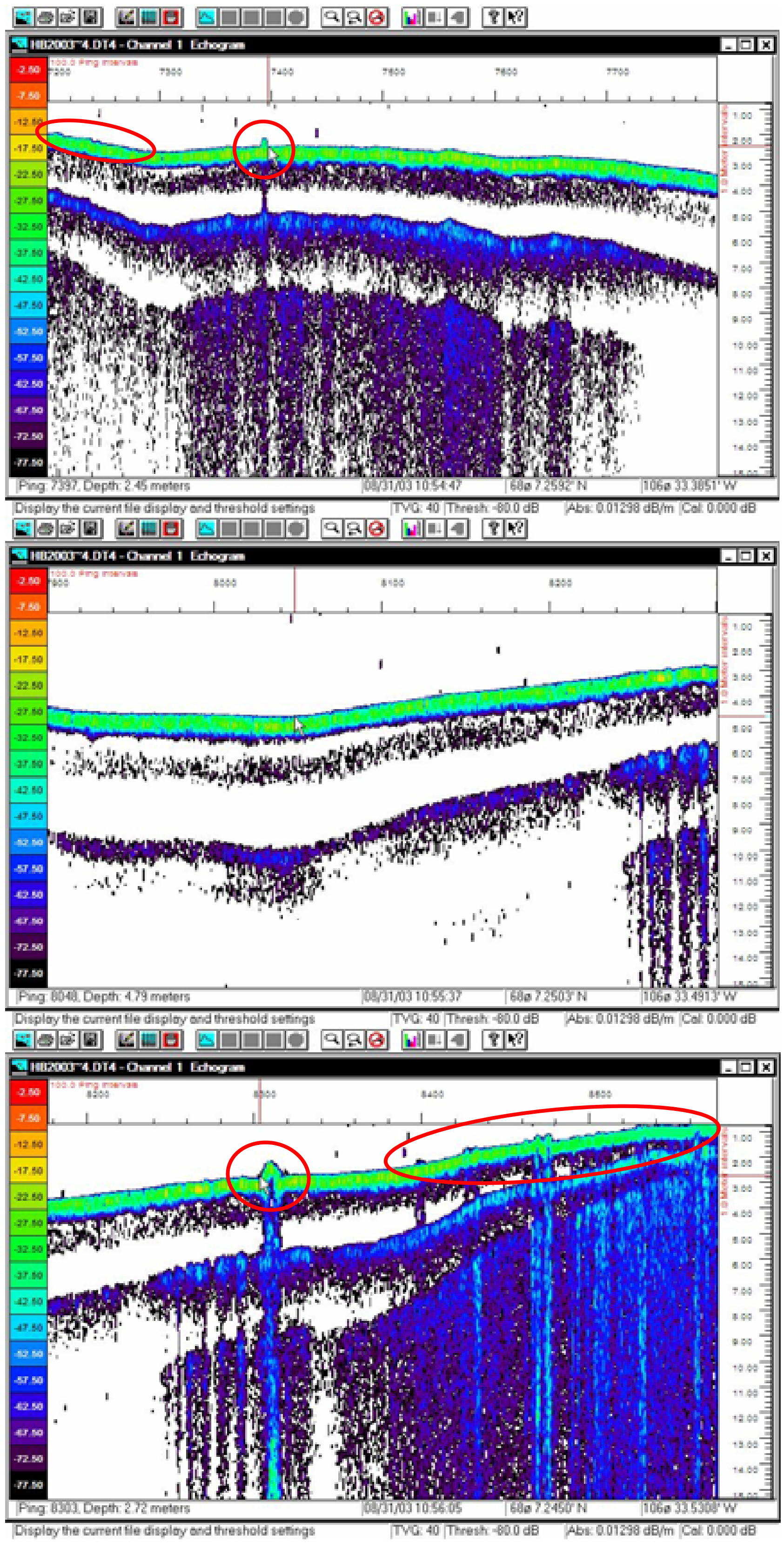


Figure 9 **Lake bed images along a cross-sectional transect in Tail Lake to illustrate the depth of the transition zone from large substrate to fine substrate. Note: depth and geo-referenced positioning are indicated along the bottom of each frame. Circles in red indicate areas of lake bed roughness.**

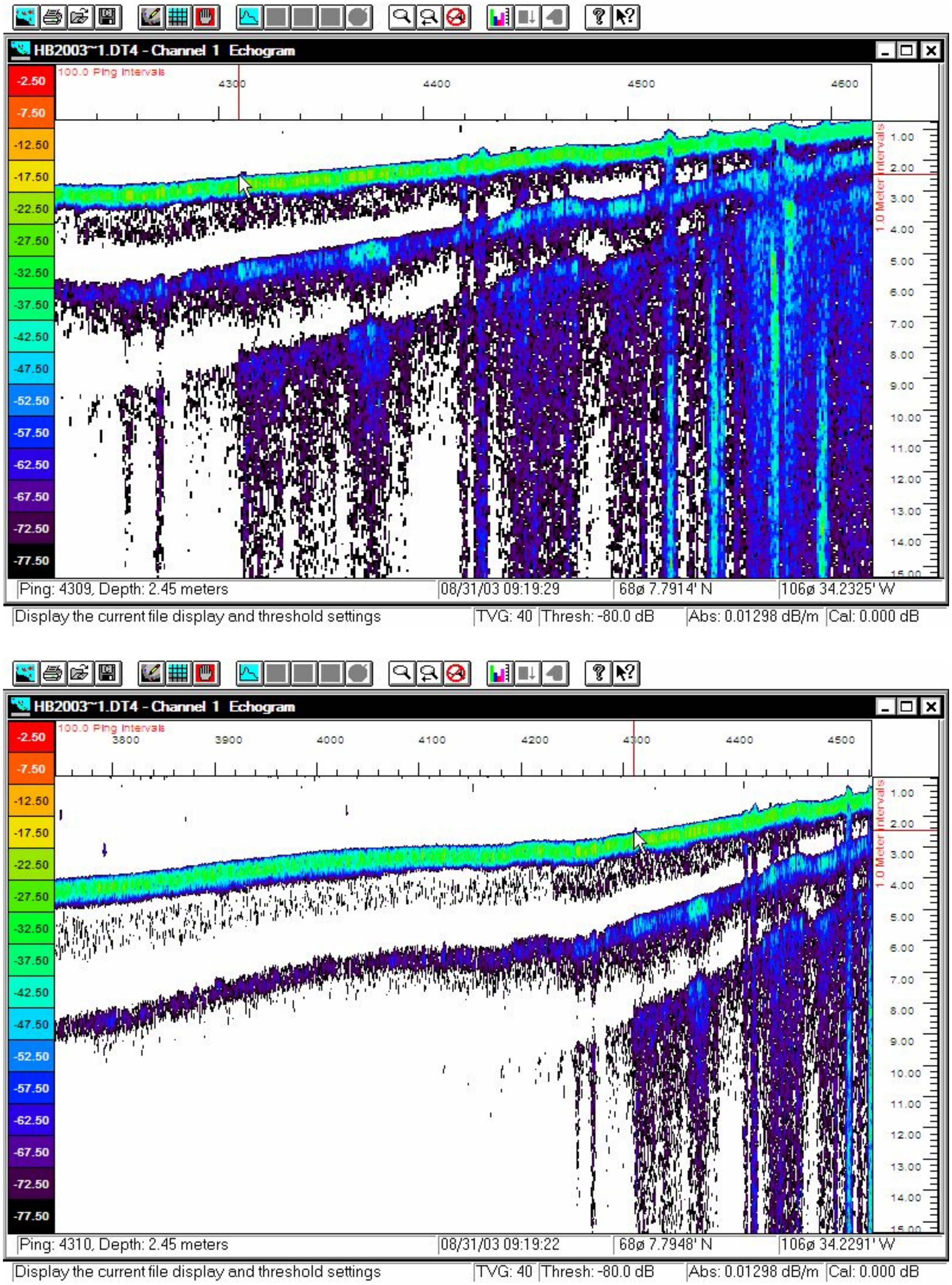


Figure 10 Lake bed images of the shoreline in the main basin of Tail Lake illustrating that the transition zone of large and fine substrate is at 2.5 m depth. Note: both frames are from the same location but the top frame is magnified closest to shore. The curser references the same location in both frames.

Table 2 Habitat areas lost in Tail Lake.

Habitat Type[a]	Habitat No.	Total Habitat Lost (ha) (% of available)
Nearshore Habitat with predominantly fine substrate or bedrock (waters edge to 2.5 m contour)		
(Si/Sa/Be)	1	25.16 (32.8%)
Nearshore Habitat with predominantly large substrate (waters edge to 4 m contour)		
(Bo/Co)	2	3.45 (4.5%)
Deep Water (> 4 m in depth; or > 2.5 m when adjacent to Si/Sa/Be)		
Deep water	3	48.02 (62.7%)
Total		**76.63 (100.0%)**[b]

(a) Si = silt; Sa = sand; Be = bedrock; Bo = boulder; Co = cobble.
(b) The confirmed surface area of Tail Lake

In order to calculate HUs, each type of habitat was assigned a numerical ranking of suitability based on the HSI (habitat suitability index). The area in hectares (ha) of each habitat type was multiplied by the appropriate HSI values to obtain HUs. Once the HUs were calculated, they were then used to predict potential habitat losses caused by the proposed project.

Lake trout was the only species evaluated. The only other fish species present in Tail Lake is ninespine stickleback. Ninespine stickleback was not evaluated because a HSI model was not available. As well, the abundance of ninespine stickleback in Tail Lake was low; thus, once the abundance weighting was factored into the HU calculation, this species would not contribute greatly to the overall HU calculation. The habitat evaluation involved utilizing HSIs for each of the four aforementioned life stages (i.e., spawning, nursery, rearing, and foraging). HSI values range from 0 to 1.0, with a rating of 1.0 being excellent and 0 being unsuitable (Table 3). The criteria used for each category is provided in Appendix C. This HSI model was developed for the Diavik Diamond Project (1998b) and utilized in the Snap Lake Project (De Beers 2002) due to the lack of published models, particularly those applicable to fish species in northern ecosystems. Once HSIs were defined for all life stages, they were applied to the specific habitat types present in Tail Lake (Table 4).

Table 3 Habitat suitability indices and descriptions used to represent habitat quality.

HSI Value	Habitat Description
1.00	Excellent
0.75	Above Average
0.50	Average
0.25	Below Average
0.00	Unsuitable

Note: HSI = habitat suitability index; HSI criteria for lake trout are provided in Appendix C.

Table 4 Habitat suitability indices by habitat type for lake trout in Tail Lake.

Habitat Type	Habitat No.	Spawning	Nursery	Rearing	Foraging
Nearshore with fine substrates	1	0	0.25	0.25	0.25
Nearshore with large substrates	2	0.75	0.50	0.75	0.25
Deepwater	3	0	0	0	0.25

Note: Habitat suitability indices range from 0 (nil) to 1 (excellent).

Table 5 summarizes the calculation used to determine the HUs available in Tail Lake. Since the HUs available will be equivalent to the loss of habitat caused by the proposed project, it is predicted that there will be a loss of 38.65 HUs in Tail Lake. However, previous Arctic EIAs have also incorporated species weighting factors for exploitation and species abundance into the overall habitat unit calculations (Diavik 1999; De Beers 2002). These species weighting factors have also been utilized for the Doris North Project. Species weightings were derived from Minns (1995), which incorporates a defensible methods approach to assessing habitat loss.

The protocol that was followed in the development of species weightings for Tail Lake included consideration of the relative importance of the fauna in terms of fish exploitation activities in the NWT. As a group, domestic/commercial species were given a weighting of exploitation importance of 0.4, sport species were given a weighting of 0.4, and forage species were given a weighting of 0.2. Since lake trout are considered both a domestic/commercial species and a sport species, a weighting of 0.8 was assigned (Table 6).

Table 5 Habitat suitability and habitat units calculated for lake trout in Tail Lake.

Habitat #	Habitat Area (ha)	Spawning		Nursery		Rearing		Foraging		TOTAL HUs
		HSI	HU	HSI	HU	HSI	HU	HSI	HU	
1	25.16 (32.8%)	0	0	0.25	6.29	0.25	6.29	0.25	6.29	18.87
2	3.45 (4.5%)	0.75	2.59	0.50	1.73	0.75	2.59	0.25	0.86	7.77
3	48.02 (62.7%)	0	0	0	0	0	0	0.25	12.01	12.01
Total	**76.63 (100%)**		**2.59**		**8.02**		**8.88**		**19.16**	**38.65**

Note: HSI = habitat suitability index; HU = habitat unit.

Because weightings on the basis of exploitation alone do not account for ecological relationships, weightings were also developed to reflect the relative abundance of lake trout in Tail Lake (Table 6). The final weightings for lake trout in Tail Lake were calculated as the mean of the exploitation and abundance weightings (Table 6).

Table 6 Exploitation and abundance weightings for lake trout in Tail Lake.

Species	Exploitation Weighting	Abundance Weighting	Final Weighting
Lake trout	0.8	1.0	0.9

The total HUs lost in Tail Lake were then determined using the weighted HUs (Table 7). An overall loss of 34.78 HUs is predicted for Tail Lake once species weightings were applied.

Table 7 Total habitat units (HUs) lost with weightings applied for lake trout in Tail Lake.

Life Stage	Weighting	Baseline HUs before Weighting	Baseline HUs After Weighting
Spawning	0.9	2.59	2.33
Nursery	0.9	8.02	7.22
Rearing	0.9	8.88	7.99
Foraging	0.9	19.16	17.24
Total		**38.65**	**34.78**

3.1.2 Fisheries Resources

A fish population estimate and biomass estimate for lake trout in Tail Lake were derived from gill netting data collected during 2002. Using the Petersen mark-recapture index, it was estimated that 2365 lake trout reside in Tail Lake (assuming 10% mortality; upper and lower 95% confidence intervals were 4275 and 1313 fish, respectively). A biomass estimate was derived based on the results of the Petersen index (2365 fish) and the mean weight of lake trout captured (1685 g/fish). The total biomass of lake trout in Tail Lake was estimated as 3986 kg. The lake trout in this lake did not grow to a large size (maximum length of 650 mm and weight of 2500 g) due to the poor forage base in the lake. No small lake trout were captured during the 2002 survey (the smallest fish was 436 mm fork length) indicating that recruitment of juveniles into the population is likely limited by predation of the young by the older lake trout. Most fish (79%) ranged in fork length between 520 and 650 mm. The lake trout of Tail Lake were in poor condition (Figure 11), based on Fulton's condition factor, with the mean condition factor for lake trout in Tail Lake being 0.95, and a range of 0.59 to 1.32. In comparison, the lake trout in Snap Lake region, in lakes with a diverse forage base for lake trout, had mean condition factors ranging from 1.01 to 1.52 (De Beers 2002).

Figure 11 Lake trout captured in Tail Lake during 2003 illustrating the poor condition of fish in this lake.

3.2 Waterbodies Other Than Tail Lake

Habitat alterations/losses caused by project specific activities (excluding Tail Lake) are summarized in Table 8. These alterations/losses were quantified as total area, and not by the HEP analysis used for Tail Lake, since HSIs were not available for some species, such as cisco, ninespine stickleback, and the marine fishes. For project activities, excluding Tail Lake, a net area of 0.203 ha of habitat will be negatively affected by the proposed project after mitigation measures are implemented.

Table 8 Fish habitat affected for the proposed Doris North Project for waterbodies/watercourses other than Tail Lake.

Activity	Waterbody	Fish Species[1] Present	Habitat Quality[2]	Description	Area of Habitat adversely affected (ha)
Dewatering Tail Lake Outflow and construction of Tailings Dam	Tail Outflow	NSST	Low	600 m length; 0.45 m mean width	0.027
Water Intake Structure	Doris Lake	LKTR, CISC, LKWH	Poor	Floating barge	0
Float Plane and Boat Dock	Doris Lake	LKTR, CISC, LKWH	Poor	Floating dock approximately 25 m long and 4 m wide	0
Bridge Crossing	Doris Outflow (u/s waterfall)	LKTR, CISC, LKWH	Fair to Good	No in-stream activity will occur.	0
Watercourse Crossings (Rock Drains)	Unnamed streams	-	Nil	No fish habitat present.	0
Jetty	Roberts Bay	Marine and Freshwater spp.	Good	95 m length, varying from 5.3 m to 35 m width; 3:1 side-slopes after settling; (refer to Appendix A7)	0.176
Total					**0.203**

1 NSST=ninespine stickleback; LKTR=lake trout; CISC=cisco; LKWH=lake whitefish.

2 Habitat quality ratings based on Rescan (2001).

4.0 COMPENSATION

As specified under the Department of Fisheries and Oceans "No Net Loss" policy (DFO 1986), compensation will be required for any project activities that cause HADD after mitigation measures are applied to their maximum potential. This policy was created to ensure that the productive capacity of fish habitat is maintained.

As outlined in the above sections, destruction of fish habitat is expected to occur in Tail Lake and its outflow (tailings containment area and dam) and habitat alteration has occurred in Roberts Bay at the jetty. The following sections outline the proposed compensation plan.

4.1 Tail Lake

4.1.1 Overview

Compensation options for the loss of lake trout habitat in Tail Lake were explored based on DFO's hierarchy of compensation for HADD (DFO 1998a). DFO's preferred option is to create similar habitat or otherwise enhancing the productive capacity of the habitat at or near the development site within the same ecological unit (i.e., "like for like" of species and habitat). Since habitat compensation within Tail Lake is not feasible due to the construction of the Tails Dam and operation of the tailings containment area, sites near the development were then considered.

An area of impedance to anadromous fish passage (e.g., Arctic char) was identified at the outflow of Roberts Lake in fall 2000 and 2001 (H. Wilson, personal observation) and during detailed fisheries sampling in fall 2002 (RL&L/Golder 2003b) and fall 2004 (Golder 2005a). It was also mentioned by an elder during public consultation during community meetings that he had noted stranding of char at that location while working at the silver mine in the area during the late 1960s or early 1970s (H. Wilson, pers. comm.) Increasing accessibility for fish into Roberts Lake was deemed to be the most beneficial compensation option. This would enhance the Arctic char production from Roberts Lake and ensure annual escapement rather than the current condition of periodic escapement.

In the fall of 2002 to 2005, attempts were made to monitor the upstream migration of Arctic char returning from the sea to overwinter in Roberts Lake (RL&L/Golder 2003a, 2003b; Golder 2005a, 2006). Fish fences were installed at the upstream and downstream end of a section of Roberts Outflow located just below the outlet of Roberts Lake. This section of stream is characterized by dispersed flow through large, angular bolder substrate (referred to as a "boulder garden"), which hinders or prevents upstream passage of fish in low to moderate flow years. All fish that passed through the fish fence were tagged with a uniquely numbered anchor tag to assess their movements through subsequent recaptures.

During the 2002 survey, approximately 160 mature Arctic char were captured (RL&L/Golder 2003b). This number was likely lower than the total number of fish in the spawning run, since fish were observed upstream of the fence location prior to installation. In addition, the fence was torn down on three occasions by grizzly bears, thus providing opportunities for fish to advance upstream undetected at the fence. It is possible that the spawning run was twice the size of that documented. Although the dense boulder garden impeded passage of a large number of Arctic char, it is possible that approximately 10% of the run was able to successfully migrate to Roberts Lake. The 2002 study recaptured 11 Arctic char upstream of the boulder garden (representing 7% of the catch); these fish were generally small (less than 1.5 kg in weight), which may have allowed them to pass through the shallow boulder garden area more easily, in comparison to the larger fish. Stranded and dead Arctic char were sighted (by eye or feeling with a hand) in deep, narrow interstitial pockets amongst the boulders in the dense boulder garden. These fish had become trapped as they attempted to migrate up to Roberts Lake and were generally in an exhausted state and were being preyed upon by scavengers (bears and gulls).

During the 2003 survey, approximately 479 Arctic char were captured (RL&L/Golder 2003a). Of those, approximately 342 fish were >250 mm and likely older juveniles or mature fish (71% of the catch). The remainder of Arctic char captured were small (29% of the catch) and were likely using the boulder garden for rearing purposes. Unlike 2002, the 2003 open-water period was a high flow year, and thus the majority (65%) of Arctic char passed through the boulder garden.

During 2004, 403 fish representing four species were caught in Roberts Outflow (Golder 2005a). Arctic char was the predominant species in the overall catch (59%), followed by lake trout (37%). Other species captured were cisco and ninespine stickleback. Recaptures from previous years accounted for 25% of the Arctic char catch. The open-water period during 2004 was a low flow year, which made migration through the boulder garden difficult for large fish. Approximately 78% of the Arctic char population were stranded within the boulder garden section below Roberts Lake, and most likely perished.

During 2005 sampling, 381 fish representing four species were caught in Roberts Outflow (Golder 2006). Again, Arctic char was the predominant species in the overall catch (73%), followed by lake trout (25%). Recaptures from other years represented 21%

of the Arctic char catch. The July-August period in 2005 was a moderate to high flow period, and flow did not appear to impede migrations of Arctic char through the bolder garden section. However, about 65% of the Arctic char population and 49% of the lake trout population were not recaptured at the upstream trap. These fish may have escaped through either the upstream of downstream fences when high winds toppled the fences, or they may have been predated upon by wildlife (e.g., evidence of predation of fish by grizzly bears and Arctic fox was observed).

Hydrological Conditions as an Indicator of Potential Fish Strandings

Stranding of adult Arctic char in the Roberts Lake outlet channel due to low flows was observed by Golder in 2002 (Golder 2003b) and in 2004 (Golder 2005a). However, similar stranding was not observed at the higher discharge levels observed in 2003 and 2005. The following addresses the question of how frequent the stranding is likely to occur.

Flow data were collected from Doris Lake outflow in the Doris North project area during the baseline study years of 1996, 1997, 1998, 2000. Subsequent data collection included manual discharge measurements on the Roberts Lake outflow in 2002 and continuous discharge monitoring on the Doris Lake and Roberts Lake outflows in 2003, 2004, and 2005.

The method for placing the years of 2002 to 2004 in hydrologic context involved the following steps:

1. It was assumed that the Doris Lake and Roberts Lake outflows would have similar hydrological characteristics in any year, based on proximity and similar size and topography. This was examined by comparing the available data from 2003 and 2004, which were the only years with concurrent records.
2. Seven years of data were examined by generating weekly water yields for August and September from the following data:
    a. 1996, 1997, 1998 and 2000 continuous data from the Doris Lake outflow;
    b. 2002 manual discharge data from the Roberts Lake outflow. The three measurements from 19 August, 25 August and 2 September were extended by interpolation and extrapolation to estimate a continuous record from 15 August to 4 September;

   c. 2003 and 2004 continuous discharge data from the Roberts Lake outflow.

3. Weekly water yields for the stranding periods of 2002 and 2004 and adequate passage periods of 2003 and 2005 were examined and used to estimate when stranding and passage conditions may have occurred in previous years.

The continuous, concurrent data from the Doris Lake and Roberts Lake outflows in 2003 and 2004 are presented in Figure 12. The discharge data were normalized by dividing by the respective watershed areas (93.1 km^2 for Doris Lake and 97.8 km^2 for Roberts Lake). There appears to be a reasonable agreement between mean daily discharges for most of the monitoring season. Observed differences from mid- to late-August in 2003 are likely due to differences in rainfall between watersheds. Apparent differences in 2004, where flows are higher at the Roberts Lake outflow in the early season and lower in the late season, are likely due to storage differences in the two watersheds. It appears that in years with little or no late season rainfall, as was the case in 2004, storage in the Doris Lake system, which includes Wolverine, Patch and Ogama lakes in the upper watershed, attenuates flood discharges in the early season and sustains higher flows in the late season. This means that late season water yields from Roberts Lake may be overestimated for dry years, if they are based on measurements from Doris Lake.

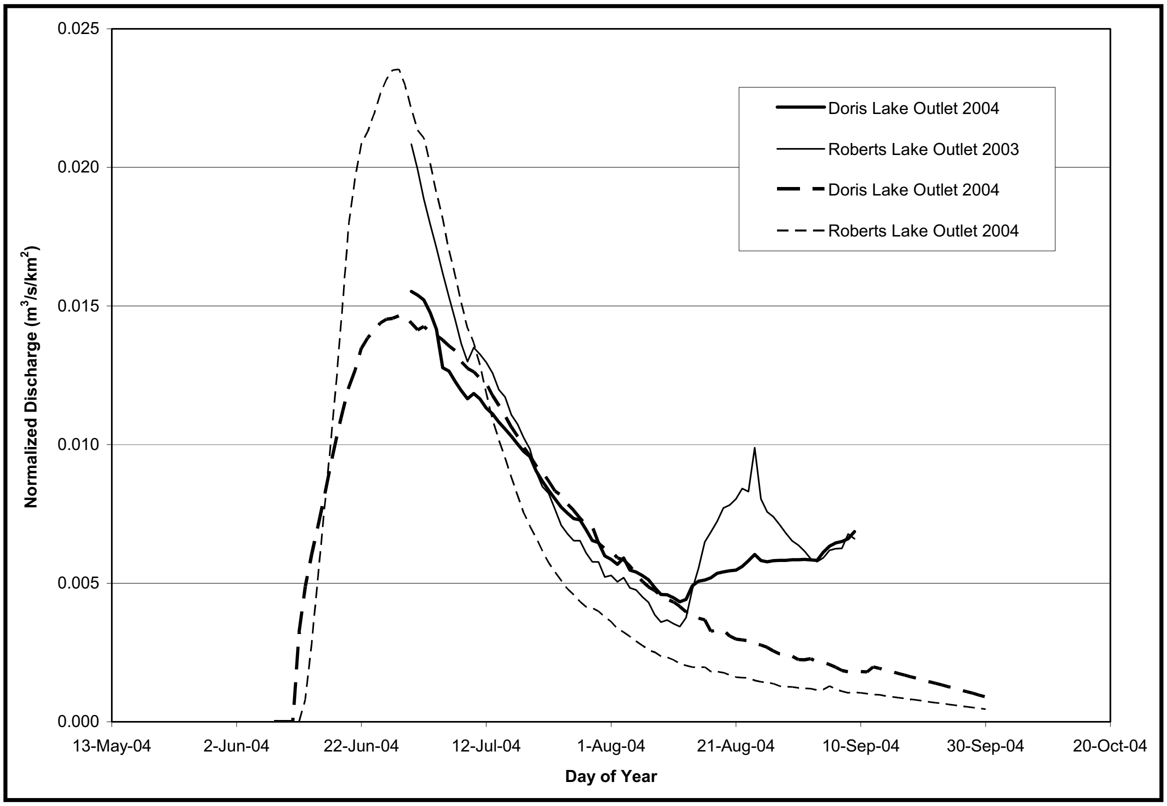


Figure 12 Comparison of discharges at the Doris Lake and Roberts Lake Outflows

Weekly August and September water yields for the available period of record are tabulated in Table 9. The Arctic char spawning run has been observed to occur in these months, so they are the most relevant to the question at hand; however, it should be noted that most of the adult Arctic char upstream migration occurs prior to the middle of September. The data indicate that weekly water yields below 1.1 mm (equivalent to a mean discharge 0.18 m^3/s) will prevent fish passage, and that there is little impediment to fish passage for weekly water yields above 2.3 mm (equivalent to a mean discharge of 0.37 m^3/s). It is assumed that significant impediments to fish passage will continue for weekly water yields up to 1.5 mm (equivalent to a mean discharge of 0.24 m^3/s) and that there will be no impediment to fish passage for weekly water yields above 2.0 mm (equivalent to a mean discharge of 0.32 m^3/s). The values in Table 9 are classified according to this criteria, with “no passage” weeks shaded red, “full passage” weeks shaded green, and those falling in between shaded yellow.

The analysis shows that in five years out of the eight where local monitoring data are available, extended periods exist where there are significant impediments to fish migration at the Roberts Lake outflow.

Within that period of analysis, stranding of Arctic char was observed in the year 2001 (H. Wilson, personal observation); unfortunately, hydrological data were not available during 2001. Fisheries and Oceans Canada (DFO) personnel were on-site at the boulder garden area of Roberts Outflow in 1990 and they noted that stranding also occurred during that year (J. Babaluk, Fish Research Biologist, DFO, pers. comm.). As mentioned previously, stranding was also noted by a local elder in the late 1960s or early 1970s.

Table 9 Measured Weekly Water Yields during Arctic Char Spawning Period (mm).

Week (Commencing at start of August)	Location and Monitoring Year										
	Doris 1996	Doris 1997	Doris 1998	Doris 2000	Roberts 2002	Doris 2003	Roberts 2003	Doris 2004	Roberts 2004	Doris 2005	Roberts 2005
W1	1.4	2.7	1.7	2.5		3.3	2.9	3.3	1.9	4.2	4.4
W2	1.2	2.3	1.4	1.8		2.8	2.3	2.6	1.3	3.5	3.8
W3	1.1	2.3	1.3	1.4	1.1	3.2	4.3	2.0	1.1	3.2	3.6
W4	1.9	2.3	1.3	1.4	0.7	3.5	4.9	1.7	0.9	2.9	3.5
W5	2.4	2.3	1.3	1.3	0.5	3.6	3.8	1.4	0.7	2.7	3.4
W6		2.3	1.6	1.4		4.0	3.9	1.1	0.7	2.6	2.9
W7		3.2	2.1	3.6				1.1	0.5	2.1	2.2
W8		3.6	2.6	4.7				0.8	0.4	1.3	1.3

Note: red indicates weeks of no or very limited fish passage; green indicates weeks of full fish passage; yellow indicates weeks where fish passage is uncertain. Note that most of the upstream Arctic char migration is complete by week W6

Proposed Habitat Compensation Plan

The proposed habitat compensation plan involves the construction of a passage through the dense boulder garden that hinders fish passage at the outflow of Robert's Lake. Presently, this natural boulder garden severely impedes fish passage during low to moderate discharge periods and some fish become stranded within the boulder garden (refer to Photographic Plates 1 to 8), where they often perish (i.e., many are killed by predators such as bears and gulls). This low discharge period typically occurs during the summer migrations for Arctic char.

The addition of a fish passageway through the dense boulder garden would increase the accessibility to Roberts Lake for fish migrating to and from the ocean, resulting in increased availability of rearing, feeding, and spawning habitat, as well as critical overwintering habitat for species such as Arctic char. Arctic char are a highly valued fish species in the Canadian Arctic for sport, domestic, and commercial fishing (Hunter 1970). The Arctic char in the Roberts Lake system are anadromous, and since this population lives part of their life cycle in the highly productive waters of the ocean, these fish are able to attain much larger weights within a shorter time period than landlocked lake trout. By allowing greater access into Roberts Lake and the reduction in the high mortality of adult fish stranded within the boulder garden section, it is expected that the biomass of Arctic char, as well as reproductive success in this lake will increase. The young Arctic char will likely rear in Roberts Lake for 4 to 5 years before migrating to the ocean (Johnson 1980).

4.1.2 Design for the Proposed Fish Passage

The conceptual design for the proposed fish passage works at Roberts Lake Outflow as presented in Revision 5 of the NNLP consisted of a fish passageway against the left bank (looking downstream) of the existing channel. Boulders in a 3 m wide strip would have been positioned to create a step-pool structure, approximately 55 m long, containing 10 rock weirs.

The final design was developed by identifying the “stranding zone” in the middle of the boulder garden and will consist of selective removal of boulders to create a clear flow path in that area. This zone is located downstream of the lake outlet control section and to prevent effects on the lake water level regime, no boulders will be removed from upstream areas. Final design drawings for the fish passage works are provided in Figures D1 to D2 in Appendix D.

Construction of the Roberts Lake outlet low flow fish passage will be done without the use of heavy ground equipment (a helicopter may be used to assist movement of boulders). Access by any type of construction machinery on the ground is severely limited and could only occur during the winter months, to prevent damage to the adjacent tundra. Construction will take place in the summer of 2008, after snowmelt and prior to late season rains and the Arctic char upstream migration begins in early-August. Fish exclusion barriers will be placed upstream and downstream to prevent fish entering the construction area. A fish salvage will be conducted by electrofishing to remove any fish trapped inside the exclusion area.

Large boulders will be broken into sizes that can be moved by manual labor, using a Magnum Blaster™ or equivalent, and will be moved into channel areas downstream of the boulder garden to provide additional fish habitat value. The Magnum Buster™, which is a non-explosive technology, employs the use of a cartridge loaded with 15 g of a nitrocellulose propellant (gunpowder) that when fired produces a rapidly expanding gas. The energy is converted into a hydrostatic pulse by directing the gas into a water filled hole within the rock.

Although the Magnum Buster™ utilizes a propellant which creates less shock than conventional explosives, the setback distance for the use of this product near fish habitat will be calculated based on formulas contained within the "Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters." These formulae have been generated for determining safe setback distances during the use of conventional explosives, and therefore will render conservative values for this purpose.

The simplified formula presented in the "Guideline" for calculating the setback distance (R) to achieve a maximum overpressure is presented below:

$$R = W^{0.5}(K)$$

Where W = Charge Weight in kg
K = K factor coefficient

The value of the K factor coefficient to be used is determined specifically for the physical properties of the substrate that the explosive is detonated in, and the resultant maximum overpressure transferred to the water in contact with that substrate.

The K factor displayed in the "Guideline" for an explosive detonated in solid rock and resulting in a transfer of 100 kPa overpressure to the water is as follows:

$$K = 5.03$$

However, a more conservative guideline of 50 kPa has been adopted for use in Nunavut. Therefore, the adjusted K factor (K_{50}) for calculating setback distance under this restriction has been derived as:

$$K_{50} = 7.76$$

Applying the 15 g mass charge weight contained within each Magnum Buster™ cartridge and the K_{50} factor into the overpressure setback distance calculation, the setback distance calculated for this application becomes:

$$R = W^{0.5}(K_{50})$$

$$= (0.015)^{0.5}\ (7.76)$$
$$= 0.95\ \text{m}$$

Therefore, a maximum overpressure of 50 kPa will not extend more than 0.95 m from the point of detonation.

Considering that boulders being fractured by this technique will likely have a radius ranging from 0.5 to 1 m or greater, the area of instream fish habitat potentially exposed to overpressures greater than 50 kPa will be small (< 2.4 m^2). Mitigation of this potentiality will be managed by isolating the area around each boulder to be fractured with block nets placed outside the setback radius of 0.95 m, and a backpack electrofisher will be used to stun fish for removal and release at a safe distance, prior to each detonation. However, it is possible some juvenile fish may remain within the interstices of the boulders even after electrofishing, and could be within the setback distance of the detonation; however, based on the proposed mitigation, DFO (Iqaluit) has indicated in correspondence with Miramar Hope Bay Ltd. dated 19 October 2007 that a Fisheries Act Section 32 authorization is not necessary for this work.

A cost estimate, broken down by task, for construction of the Roberts Lake Outflow low flow fish passage is summarized in Table 10.

Table 10 Cost Estimate for Roberts Lake Outflow Construction.

Item Description	Unit Cost	Quantity	Cost
Site layout (2 persons x 1 d x 10 h/d)	$105	10	$2,150
Fish exclusion and salvage (2 persons x 1 d x 10 h/d)	$105	20	$2,100
Boulder removal (3 persons x 5 d x 10 h/d)	$60	150	$9,000
Construction supervision and monitoring (1 person x 5 d x 10 h/d)	$105	50	$5,250
Transportation (helicopter access and support) (10 h)	$1,500	10	$15,000
Equipment and Materials (Magnum Blaster, charges, rock drill, shovels, pry bars, etc.)			$15,000
		Subtotal	**$48,450**
Contingency (25%)			$11,850
Engineering Support (10%)			$4,740
		Total	**$65,040**

4.1.3 Habitat Quantification for Roberts Lake and Roberts Outflow

In understanding the potential effects of the proposed compensation, it is worth briefly reviewing the life history and habitat use of anadromous Arctic char. The reader is directed to McCart (1980), Johnson (1980, 1989) or Johnson and Burns (1984) for more detailed discussion of Arctic char life history and habitat requirements.

Fry will emerge from spawning gravels in May and move towards the shore and live and feed among the rocks in the littoral zone of lakes. Johnson (1980) indicate that fry will spend four to five years rearing in freshwater before beginning downstream migrations to the sea. McCart (1980) indicate that in the north slope rivers of the Yukon and Alaska, most char are Age 3 to 4 when taking their first seaward migration, although this can occur as early as Age 1 or 2.

Seaward migrations are undertaken on an annual basis. The char take advantage of the brief period when the seawater is warm enough for char to survive, to feed in the nutrient rich marine environment. As Arctic char lack the ability to survive sub-zero water temperatures (i.e., they lack a blood antifreeze mechanism), there is a movement back into freshwater systems in the late summer and fall. Large Arctic char generally return first, followed by smaller char (RL&L/Golder 2003a).

Unlike salmon (*Oncorhynchus* spp.), Arctic char do not appear to exhibit a strong fidelity to natal streams. Gyselman (1994) indicated that minimum calculated fidelity rate for the Nauyuk Lake system was 34% and the maximum was 55%. Johnson (1980) observed that

> "The emigration of large arctic charr from Nauyuk Lake is balanced by the immigration of untagged charr, presumably from neighboring systems. This results in a length structure that has remained virtually constant over the period of the investigation."

Arctic char spawn in the fall in streams and rivers, usually where there are areas of groundwater up-wellings (McCart 1980). In the central Canadian Arctic, lake spawning is more prevalent as rivers tend to freeze up in winter (Johnson 1980). In Nauyuk Lake/Willow Lake, char spawned in September and October in Willow Lake (Johnson 1980). Spawning beds in Willow Lake were located in limestone gravel (50 to 70 mm diameter) in 3 to 6 m of water (Johnson 1980). Spawning fish generally enter the spawning system the year before they spawn and do not return to sea until after they have spawned (Griffiths et al. 1975; Johnson 1980), although in some populations a small percentage of mature fish can be found in marine areas in the year they would spawn (Craig 1977, as referenced by McCart 1980). For example, the "mature" fish observed in the Roberts Lake outflow stream in 2003 would spawn in the fall of 2004. Anadromous Arctic char do not spawn in successive years, rather they seem to spawn every two to three years.

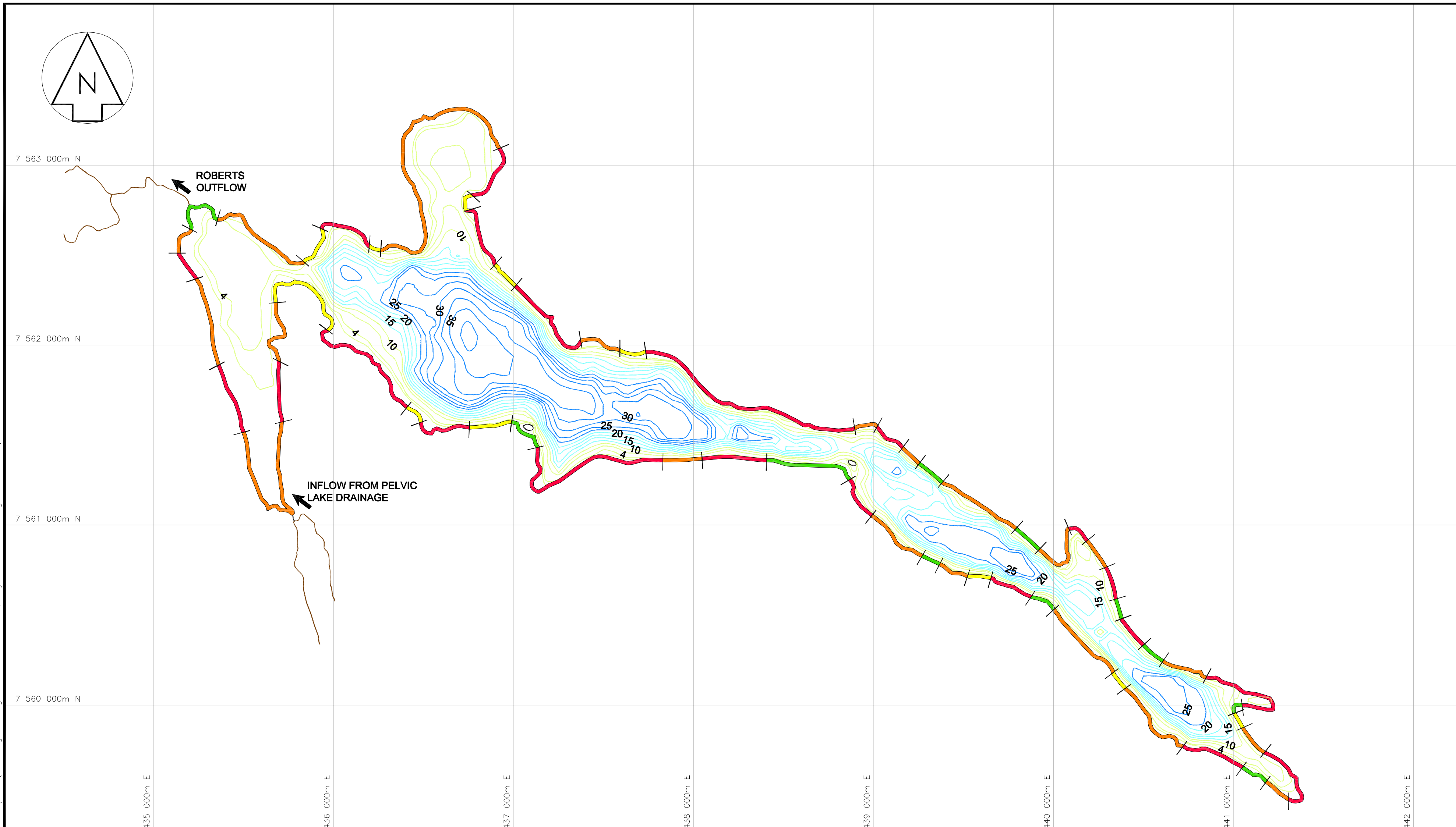
Using the HEP method described in Section 3.1.1, the availability of Habitat Units (HUs) within Roberts Lake were calculated to compare with the loss of HUs in Tail Lake. These calculations were based on bathymetry survey and detailed habitat mapping conducted during 2003 (Figure 13). Similar to Tail Lake, Roberts Lake was divided into three main habitat environments - two nearshore types and a deepwater type based on the bathymetric and habitat data. Arctic char HSI values were used in the calculation of HUs for Roberts Lake (Table 11). Applying the HUs to the areas determined for the three habitat types yields a gain of 322.35 HUs in Roberts Lake fish habitat (Table 12); however, once species weightings were applied (Table 13), an overall gain of 132.16 HUs (Table 14) was attained for Roberts Lake compared to a loss of 34.78 HUs in Tail Lake (Table 7). These calculations result in a 1:3.8 ratio of habitat loss to habitat gain.

Table 11 Habitat suitability indices by habitat type for Arctic char in Roberts Lake.

Habitat Type	Habitat No.	Spawning	Nursery	Rearing	Foraging
Nearshore with fine substrates	1	0	0.25	0.25	0.25
Nearshore with large substrates	2	0.75	0.75	0.75	0.75
Deepwater	3	0	0	0	0.50

Note: Habitat suitability indices range from 0 (nil) to 1 (excellent); refer to Table 3.

In the previous versions of the NNLP, it was anticipated that the original bolder garden enhancement, which was to consist of a step-pool structure, would provide some minor stream rearing habitat enhancement. However, based on the final design of the enhanced passage works in Roberts Outflow, with strategic removal of boulders to provide a thalweg passage channel, would not likely provide the same benefit. It should be noted, however, that placement of the removed rocks within the channel downstream of the boulder garden may enhance rearing habitat in the stream, but it was decided that it would be too difficult to quantify the enhanced Habitat Units.



LEGEND

- 2.5-10 m CONTOUR LINES
- 12.5-20 m CONTOUR LINES
- 22.5-37.5 m CONTOUR LINES

BATHYMETRIC CONTOUR INTERVAL: 2.5 m

HABITAT QUALITY (PREDOMINANT SUBSTRATE)

- POOR (BEDROCK)
- FAIR (SAND/SILT)
- GOOD (BOULDER)
- EXCELLENT (COBBLE/GRAVEL)

REFERENCE

TRANSECTS FOR BATHYMETRY PROVIDED BY GOLDER ASSOCIATES LTD., AUGUST 2003

Miramar MINING CORPORATION

400 0 400
SCALE METRES

TITLE

BATHYMETRY AND HABITAT QUALITY OF ROBERTS LAKE

Golder Associates
Edmonton, Alberta

PROJECT 03-1370-032.1000			FILE No. FigureAREAS-HabQual	
DESIGN	AL	13/11/03	SCALE AS SHOWN	REV. 0
CADD	GMF	14/11/03	**FIGURE: 13**	
CHECK				
REVIEW				

Table 12 Habitat suitability and habitat units calculated for Arctic char in Roberts Lake.

Habitat #	Habitat Area (ha)	Spawning		Nursery		Rearing		Foraging		TOTAL HUs
		HSI	HU	HSI	HU	HSI	HU	HSI	HU	
1	36.20 (9.45%)	0	0	0.25	9.05	0.25	9.05	0.25	9.05	27.15
2	48.70 (12.7%)	0.75	36.53	0.75	36.53	0.75	36.53	0.75	36.53	146.12
3	298.20 (77.84%)	0	0	0	0	0	0	0.50	149.10	149.10
Total	**383.10 (100%)**		**36.53**		**45.58**		**45.58**		**194.68**	**322.37**

Note: HSI = habitat suitability index; HU = habitat unit.

Table 13 Exploitation and abundance weightings for Arctic char in Roberts Lake.

Species	Exploitation Weighting[1]	Abundance Weighting[2]	Final Weighting
Arctic char	0.8	0.02	0.41

[1] Domestic/commercial species = 0.4; Sportfish species = 0.4.
[2] Relative abundance calculated during gill net sampling in Roberts Lake, August 2002.

Table 14 Total habitat units (HUs) gained (with weightings applied) for Arctic char in Roberts Lake.

Life Stage	Weighting	Baseline HUs before Weighting	Baseline HUs After Weighting
Spawning	0.41	36.53	14.98
Nursery	0.41	45.58	18.69
Rearing	0.41	45.58	18.69
Foraging	0.41	194.68	79.82
Total		**322.37**	**132.18**

4.1.4 Changes in Productive Capacity in the Roberts Lake System

The major tenet of DFO's habitat policy for the management of fish habitat is that there be no net loss of productive capacity of fish habitat; however, quantitative assessments of productive capacity are difficult to carryout. DFO (1998b) acknowledges this difficulty and indicates that surrogate habitat values can be considered when assessing the potential effects of a HADD. Descriptors of physical habitat (e.g., area or volume of habitat types) and biological function (e.g., spawning, rearing, food supply, migration areas) can be used as surrogate measures of productive capacity, until ongoing research provides more precise tools for measuring productive capacity. The life history of anadromous Arctic char makes *a priori* assessments of productive capacity, maximum capacity of the lake to support Arctic char, and the potential changes as a result of the proposed compensation plan extremely difficult.

In terms of the fisheries compensation at the Roberts Lake outflow, the compensation will result in the modification of the boulder garden to pass fish on an annual basis. Therefore, there would be spawning fish entering the system annually instead of sporadically, whenever water levels in the stream are high enough to permit the passage of the large bodied spawners. It would also reduce the fish mortality of adult fish attempting to make their way up to overwintering habitats in Roberts Lake. As indicated in Section 4.1.3, this would result in an increase in available habitat units for Arctic char (and other species to a lesser degree). This should result in a net increase in Arctic char production from Roberts Lake. Given the low fidelity of Arctic char, it is anticipated that the spawning escapement will consist of fish for which Roberts Lake is a natal system and immigrants from other systems in the Melville Sound area. Given the tendency for char to stray and utilize non-natal systems, it is anticipated that a stable population structure would develop in the Roberts Lake system, similar to what Johnson (1980) observed in Nauyuk Lake. It should be noted that by improving access to Roberts Lake, this will also permit more non-spawning adults to access the lake, thereby increasing over wintering habitat use in the area.

As Gyselman (1994) suggests, the low fidelity of Arctic char to their natal streams makes management models difficult, as Arctic char tend not to fit the classic fisheries management definition of a “stock.” While the full implications of this have not been fully researched, it may be that Arctic char stocks are better managed as a meta-population, rather than as discrete stocks. While the implications of this concept are beyond the scope of this project, one would expect to see an increase in Arctic char numbers in the Roberts Lake area, given increased use of the lake for spawning and overwintering.

The studies of Roberts Lake carried out to date, have not been designed to assess the population size of the lake or the standing crop, as this would be a very difficult and cost prohibitive; therefore, it is difficult to assess the change to the production of Arctic char in Roberts Lake. Currently it has been assumed that the productive capacity to support Arctic char is not fully utilized in most years. For example, the netting conducted in 2002, while limited in nature, only yielded three non-spawning Arctic char in the lake. Assuming a standing crop similar to that of Key Hole Lake (located immediately north of Roberts Lake on Victoria Island) of 43.5 kg/ha, Roberts Lake should have approximately 16,500 kg. Assuming an average weight of approximately 2800 g (approximate average weight of upstream migrates reported by Johnson 1980 for Nauyuk Lake), the lake could support approximately 5900 Arctic char.

Another factor to consider is the potential to change the condition of lake trout in Roberts Lake. If the production of Arctic char increases in Roberts Lake as a result of the fish habitat compensation, there is the potential to increase the condition of the lake trout as there would be an increased abundance of prey species in the lake. Therefore, it is possible that an ancillary effect of the increased access to the lake by Arctic char is a change in condition factor and possibly growth rates.

Summary of Changes in Productive Capacity in the Roberts Lake System

During years of moderate to low flow, Arctic char become stranded and perish in the boulder garden at Roberts Outflow. Although Arctic char migrations may not be impeded every year, the years that migrations are impeded would result in:

- significant loss of adult and subadult char;
- loss of biomass;
- loss of reproductive potential;
- loss of access to likely critical overwintering habitat in Roberts Lake; and
- reduction in the productive capacity of Roberts Lake to support Arctic char and reduction of the capability of Roberts Lake production to take advantage of the high ocean productivity and subsequent increased biomass return to Roberts Lake.

By increasing accessibility of Arctic char to Roberts Lake, this would greatly increase the productive capacity of Roberts Lake and would more than compensate for the productive capacity of Tail Lake. The lake trout in Tail Lake do not grow to a large size (<650 mm fork length) and are in poor condition due to the poor forage base (see Section 3.1.2). No small lake trout have been captured in Tail Lake indicating that recruitment of juveniles into the population is likely limited by predation of the young by the older lake trout.

4.1.5 Rearing Habitat Enhancement

Based on the bathymetry of Doris Lake, shallow in-shore rearing areas with large substrate are limited in abundance. As such, the creation of rearing habitat at four locations (sites 3, 4, 5 and 6) within Doris Lake are proposed as additional compensation for the loss of fish habitat in Tail Lake. Two other rearing areas in Doris Lake (sites 1 and 2) will be enhanced as compensation for the loss of fish habitat in Tail Outflow (near Ogama and Tail outflows; refer to Section 4.2).

Rearing areas would be located at the south end of Doris Lake, some close to shallow, sandy bays and near the north end in relatively sheltered areas (Figure 14). Rearing habitat will be created by placing rock at surveyed locations on the ice during winter and this material will settle into place during ice melt. Because the proposed enhancement areas will be in areas where the lake bottom is near level and are not located in areas where the littoral zone is steeply sloping, the rock will remain in place after ice melt. Winter construction between February and May 2009 is specified because surface infrastructure is not available or planned for access to the habitat sites, and winter ice road access is the only feasible option and is also desirable from an environmental viewpoint. Haul trucks may access the lake ice surface at a number of sites at the north end of the lake. Rock may be supplied from Quarry #2, at the north end of Doris Lake, or Quarry #3, east of Tail Lake. This method for creating rearing and spawning habitat was previously accepted by DFO for the Diavik Project (Diavik 1998b).

Placement of large substrate will create approximately 1 m high shoals with interstices that will provide rearing and nursery habitat (e.g., cover for feeding and hiding), thereby reducing predation on the juveniles by adult lake trout or other predators. The six rearing areas are sized and shaped to provide a total surface area of 0.44 ha. After the initial placement of materials, the rearing habitat created would be assessed, and if necessary, additional strategic placement of rock would occur during the following winter.

In addition to creating rearing habitat targeted to lake trout, these enhancement areas would also benefit lake whitefish and cisco in Doris Lake. The shoals, which will be located in water approximately 2 to 4 m deep, may also provide spawning habitat for these species.

Detailed designs, specifications and material quantity estimates are provided on Figures D3 to D8 in Appendix D. The rearing enhancement shoals will be constructed of clean, competent and non-acid generating rock riprap, with a median diameter (D_{50}) of 500 mm. Quantity estimates for rock riprap at each rearing shoal are presented in Table 15.

Table 15 Quantity estimates for Doris Lake rearing shoals.

Site	Rock Volume	Surface Area	Compensation for
1	617 m^3	648 m^2	Loss of fish habitat in Tail Outflow (refer to Section 4.2)
2	829 m^3	940 m^2	
3	558 m^3	646 m^2	Loss of fish habitat in Tail Lake (refer to Section 4.1.5)
4	585 m^3	655 m^2	
5	578 m^3	537 m^2	
6	925 m^3	979 m^2	
Total	**4,092 m^3**	**4,405 m^2**	

Cost estimates for constructing the Doris Lake shoals is provided in Tables 16 and 17. Cost estimates exclude design, construction and testing of the ice road, and ice bearing capacity and depth testing at the individual enhancement sites. The length of on-site construction supervision and monitoring depends on the rate at which material can be transported to each site. This is governed by the ice road capacity (bearing and speed restrictions) and the capacity of the available haul trucks.

Table 16 Cost estimate for Doris Lake rearing enhancement construction (Sites 1 and 2).

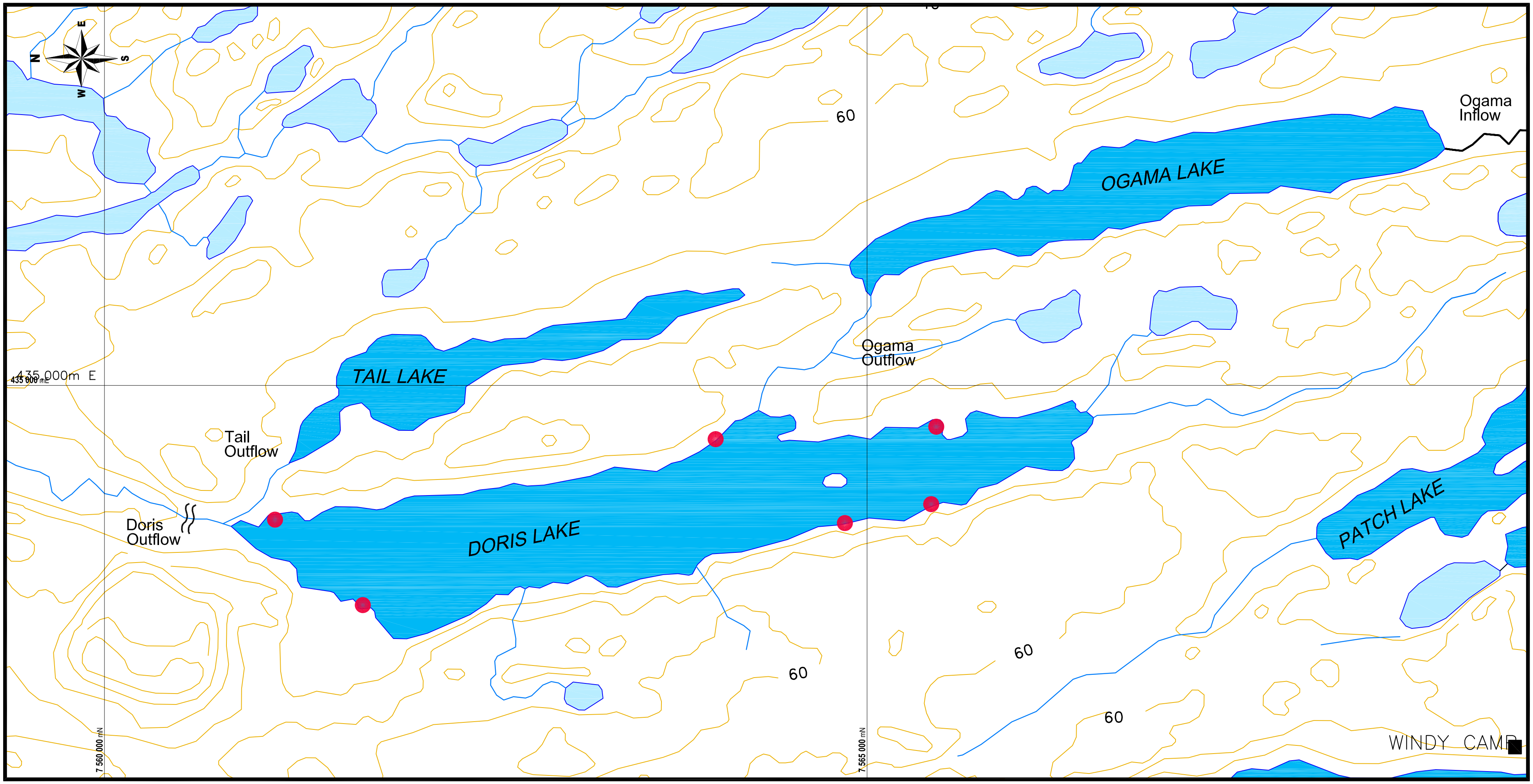
Item Description	Unit Cost	Quantity	Cost
Shoal layout (2 persons x 6.5 h)	$105	13	$1,365
Rock riprap (supplied and placed) (m^3)	$30	31,446	$43,380
Construction supervision and monitoring (1 person x 4 d x 10 h)	$105	40	$4,200
Equipment (survey gear, GPS, ice augers, etc.)			$1,700
		Subtotal	**$50,645**
Contingency (25%)			$12,661
Engineering (10%)			$5,065
		Total	**$68,371**

Table 17 Cost estimate for Doris Lake rearing enhancement construction (Sites 3, 4, 5 and 6).

Item Description	Unit Cost	Quantity	Cost
Shoal layout (2 persons x 13.5 h)	$105	27	$2,835
Rock riprap (supplied and placed) (m^3)	$30	2,646	$79,380
Construction supervision and monitoring (1 person x 8 d x 10 h)	$105	80	$8,400
Equipment (survey gear, GPS, ice augers, etc.)			$3,300
		Subtotal	**$93,915**
Contingency (25%)			$23,479
Engineering (10%)			$9,392
		Total	**$126,786**

4.1.6 Stream Habitat Enhancement

During baseline studies conducted since 2003, juvenile Arctic char are utilizing the accessible sections of tributaries to Roberts Lake. Other studies have also documented young char invading small tributary streams to feed on plankton and insects and face



LEGEND

- Lakes
- Streams
- Waterfall
- Rearing habitat location

500 0 500

Scale Metres

REFERENCE - Base map provided by Rescan, 22 January 2001.

NOTE - Contour interval 20m.

MIRAMAR HOPE BAY LTD.

Title
Locations of Rearing Habitat Enhancement, Doris North Project

Golder Associates
Edmonton, Alberta

Project No.		07-1373-0018	File No.	1731950
Design	DC	15/11/07	Scale As shown	Rev. 1
Cadd	RW	15/11/07		
Check	NS	15/11/07		
Review	GA	15/11/07		

Figure: 14

reduced predation pressures (Hunter 1976). Based on this, previous versions of the “No Net Loss” Plan (RL&L/Golder 2004) proposed that additional pool habitat be created in a small tributary to Roberts Lake.

During the 2004 field season, all of the tributaries to Roberts Lake (*n*=7) were investigated for suitability of creating pool habitat. Only two of the streams had enough water present to sustain fish (Streams E14 and E09; Figure 15). Additional reconnaissances were undertaken in the 2006 and 2007 field seasons to confirm site conditions, and Stream E14 was removed from consideration due to subsurface flow through a willow-covered boulder garden and a large upstream vertical barrier. Detailed surveys were undertaken at Stream E09, upstream of its confluence with Stream E10, and these provided a basis for the design provided in Figures D9 and D10 in Appendix D.

Stream E09 has a steep step-pool structure in its lower reach, with additional pools present in its upper reach, where the channel slope is lower and bed and banks are vegetated (Appendix E). Additional pools will be constructed in the upper reach to provide additional rearing habitat for Arctic char. Previous studies have demonstrated that young-of-the-year char use these slow water velocity areas in streams during development (Heggberget 1984); the use of stream habitats in the Roberts Lake system by young-of-the-year and juvenile Arctic char for rearing was confirmed during studies in 2003. Therefore, providing access to the upstream pool environment will result in the creation of additional preferred char rearing habitat.

Stream E09 is a vegetated, non-alluvial channel, and the presence of existing pools indicates that additional pools should not be subject to siltation and infilling. Plugs of aquatic vegetation will be harvested from nearby pools and anchored into the new pools to accelerate the growth of vegetation in these areas.

The habitat compensation works will be constructed by hand labor, without heavy equipment, to prevent damage to adjacent tundra. Construction will take place in late summer (after mid-August) in 2008, to ensure that the active layer will be unfrozen and surface materials can be excavated. Appropriate sediment control techniques will be used to control suspended sediments within the work area. A cost estimate for the construction is provided in Table 18.

Table 18 Cost estimate for Stream E09 habitat construction.

Item Description	Unit Cost	Quantity	Cost
Siting & layout (2 persons x 1 d x 10 h)	$105	20	$2,100
Pool construction (2 persons x 3 d x 10 h)	$60	60	$3,600
Pool construction (1 persons x 3 d x 10 h)	$105	30	$3,150
Transportation (helicopter access)	$1,500	6	$9,000
Equipment (Survey gear, shovels, pry bars, cameras, etc.)			$500
		Subtotal	**$18,350**
Contingency (25%)			$4,588
Engineering (10%)			$1,835
		Total	**$24,700**

4.2 Waterbodies Other Than Tail Lake

Habitat alterations/losses caused by project specific activities and the associated compensation for these activities are summarized in Table 19. In total, 0.203 ha of habitat, outside of Tail Lake, will be negatively affected by the proposed project; however, compensation would meet the requirements of DFO's "No Net Loss" policy.

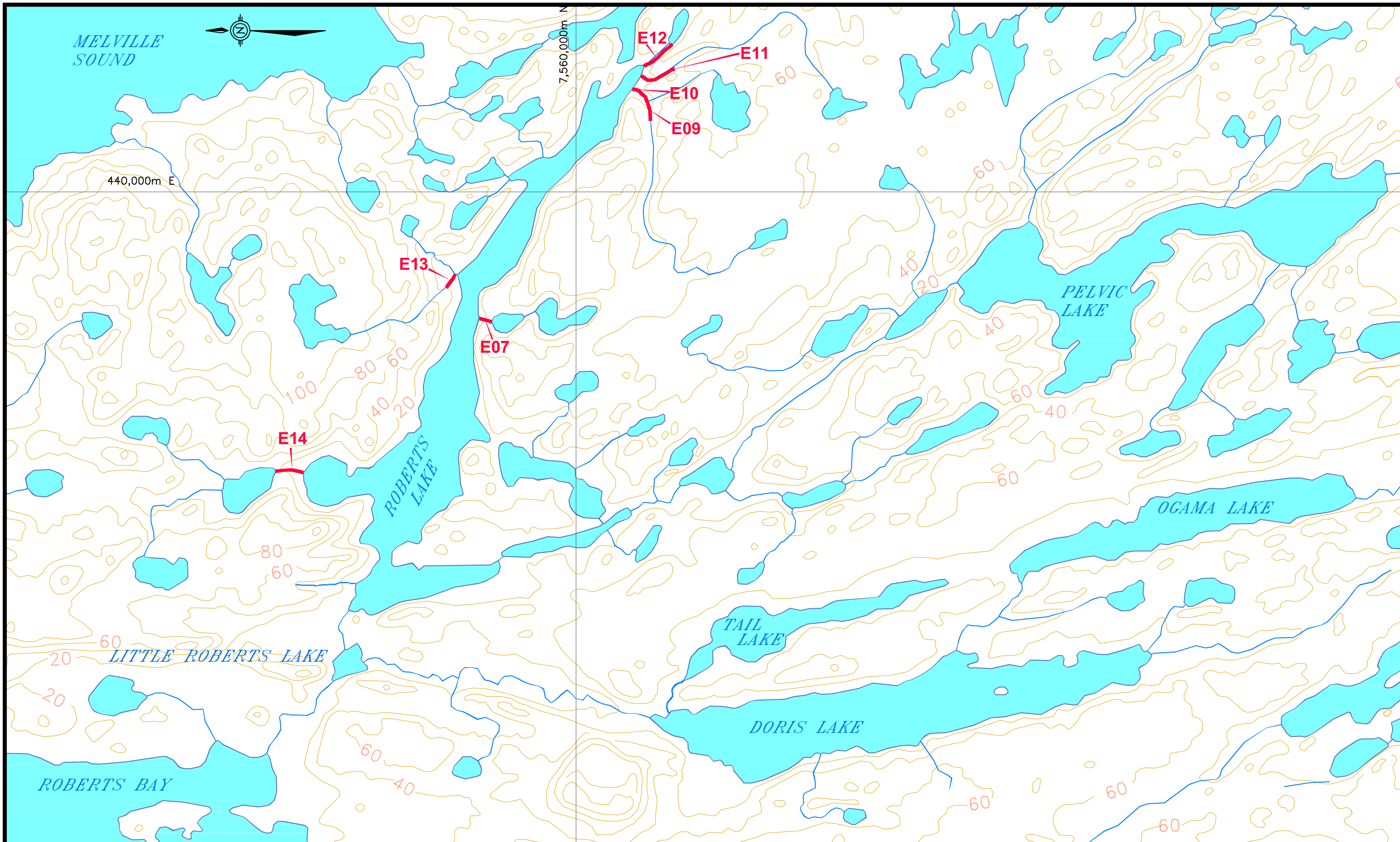
The creation of rearing habitat at two locations within Doris Lake are proposed to compensate for the loss of 0.027 ha in fish habitat in Tail Outflow, as a result of disrupting the natural water flow. Based on the bathymetry of the lake, shallow in-shore rearing areas with large substrate are limited in abundance in Doris Lake. One of the rearing areas would be located at the north end of Doris Lake in a bay near where Tail Outflow flows into Doris Lake and the other rearing area would be located near the inlet from Ogama Lake (Figure 15). Rearing habitat would be created by placing boulder size rock on the ice during winter and this material would settle into place during ice melt.

Table 19 "No Net Loss" summary of fish habitat within the proposed Doris North Project for waterbodies/watercourses other than Tail Lake.

Activity	Waterbody	Fish Species[1] Present	Habitat Quality[2]	Description/Compensation	Area of Habitat Adversely Affected (ha)	Habitat Gain by Compensation (ha)	Net Gain in Fish Habitat (ha)
Dewatering Tail Lake Outflow and Construction of the Tailings Dam	Tail Outflow	NSST	Low	Outflow: 600 m length; 0.45 m mean width Rearing areas in Doris L.: near Tail L. inflow (25 m x 25 m) and near Ogama L. inflow (30 m x 30 m)	0.027	0.153	+0.126
Water Intake Structure	Doris Lake	LKTR, CISC, LKWH	Poor	Floating pump barge	0	0	0
Bridge Crossing	Doris Outflow (u/s waterfall)	LKTR, CISC, LKWH	Fair to Good	No in-stream activity	0	0	0
Watercourse Crossings	Unnamed streams	-	Nil	No fish habitat	0	0	0
Jetty	Roberts Bay	Marine and Freshwater spp.	Good	Jetty: 95 m length; varying from 5.3 m to 35 m width; 3:1 side-slopes after settling; area compensated is area above normal high water level (refer to Appendix A7) Rock reef habitat 1500 m^2 Riprap along jetty slope below HWL 1643 m^2	0.176	0.314	+0.138
Total					**0.203**	**0.467**	**+0.264**

1 NSST=ninespine stickleback; LKTR=lake trout; CISC=cisco; LKWH=lake whitefish
2 Habitat quality ratings based on Rescan (2001).

L:\2007\1373\07-1373-0018\1200\ Drawing file: Fig 16 - Doris North Fish Sampling Site.dwg Sep 14, 2007 - 1:33pm



LEGEND

SAMPLED STREAMS

1.5 0 1.5

SCALE KILOMETRES

Note :
Contour Interval: 20 m

Reference:
Base map provided by Rescan, January 22, 2001.

MIRAMAR HOPE BAY LTD.

TITLE

Streams Sampled for Potential Habitat Enhancement

Golder Associates
Edmonton, Alberta

PROJECT		07-1373-0018
DESIGN	BT	14/09/07
CADD	TY	14/09/07
CHECK	NS	14/09/07
REVIEW	GA	14/09/07

FILE No.	Potent Hab Enhanc		
SCALE	As shown	REV.	0

Figure: 15

Placement of large substrate would create rearing shoals with interstices that would provide rearing and nursery habitat (e.g., cover for feeding and hiding), thereby reducing predation on the juveniles by adult lake trout or other predators. The rearing area located at the north end of Doris Lake would have a surface area of approximately 648 m^2 (0.065 ha) and the rearing area located near the inlet from Ogama Lake would have a surface area of approximately 940 m^2 (0.094 ha). The rearing shoals would be located in water 2 to 4 m deep. This method of creating rearing habitat would yield minimal surface disturbance, since the fill material would be transported to the sites across the ice during winter.

4.2.1 Roberts Bay Jetty

The rockfill jetty that was constructed in Roberts Bay in spring 2007 has adversely affected 0.176 ha of fish habitat (i.e., the part of the jetty above the normal high water level). The jetty has resulted in the alteration of predominately clay and silt tidal flat by the addition of rock substrate (see Golder 2005c and SRK 2005b for description of seabed characteristics along the jetty). This may result in the displacement of some bottom dwelling fish, such as starry flounder, from the immediate footprint of the jetty. The effect of this is considered low for the following reasons:

- the relatively small area occupied by the jetty;
- greater forage opportunities in deeper water (refer to invertebrate data in RL&L/Golder 2002); and
- the presence of extensive areas within Roberts Bay with substrates and habitats similar to where the jetty will be located.

In addition, the rough rock surface of the jetty side-slopes will provide additional habitat for invertebrate populations, Arctic char, lake trout, and coregonids (which have been collected in the vicinity of the jetty prior to its construction), as well fourhorn sculpin and other marine fish species.

Construction of the jetty included the placement of geotextile material (geogrid) on the marine silt and clay substrate prior to placement of run-of-quarry rock out from shore. The geogrid material (see Appendix A8 for typical design specifications) is used to increase the bearing capacity of the foundation, thereby reducing the settlement of the rock into the marine sediments. The width of the geogrid material placed on the bottom was greater than the width of the jetty, to support any rock material that rolls down the side-slopes. This extra width of geogrid material is not expected to adversely affect fish habitat, as benthos in the sediments could still survive in the openings of the geogrid mesh, and the geogrid would likely be colonized by sessile benthic marine species (at least in the deeper sections that do not freeze to the bottom). The excess geogrid material also may provide cover for small fish.

During jetty construction, a silt curtain was deployed around the construction zone to contain suspended solids that were be mobilized as rockfill was placed on the soft marine sediments.

The compensation works originally proposed for the jetty included rock riprap spurs, projecting from the shoreline east of the jetty and from the root of the jetty itself. However, concerns relating to construction of the spurs in shallow water, including the need to construct an additional length of road, resulted in the decision, in consultation with DFO, to replace the shoreline spurs with rock shoals to the west of the jetty location. In addition, the approval for the jetty under the Navigable Waters Protection Act stipulated that the seaward portion of the jetty out from the 1 m contour must be removed down to 1 m below the mean water level upon closure. Thus, it was not considered feasible to construct shallow reef habitat out from the jetty as compensation, only to have to remove much of the rockfill material at closure. It also was not considered economically feasible to build the rock spurs off the jetty in deeper water (i.e., so the crest of the spur was below 1 m depth, because the rock spur would have to be built to above the surface to allow haul trucks to end dump or provide access for a backhoe to extend the spur out from the jetty. This would then require the rockfill to be scalloped back to below the 1 m depth. This method of construction would be very costly due to the large amount of rockfill that would be required. The decision, therefore, was made, in consultation with DFO, to construct all of the compensation works for the jetty at a location to the west of the jetty.

The final design for compensation measures at the jetty includes rock riprap shoals, located in the area to the west of the jetty in water depths of 1.5 to 3.0 m. Design drawings for these works are provided on Figure D11 in Appendix D. Shoals will be constructed with an irregular surface, having a maximum elevation 1.0 m below the water surface elevation to meet navigation requirements and providing for a minimum projection of 0.5 m above the existing seabed.

The shoals have a footprint of 12.0 m by 31.25 m and will be constructed in four locations, equally spaced with a distance of approximately 19 m between each one. This will allow waves to re-suspend fine sediments on the shoals and seabed adjacent to the shoals during summer storms. The design shoals also should minimize effects on offshore currents during the ebb tide, so it is expected that they will not have a great effect on sediment transport processes in the immediate vicinity. Monitoring of the shoals for settlement and sedimentation will be undertaken on an annual basis during mine operations.

Habitat will be created by placing rock at surveyed locations on the ice during winter, and this material will settle into place during ice melt. Because the proposed enhancement areas will be in areas where the seabed is gently sloping, the rock will remain in place after ice melt. Construction will occur between February and May 2008, when the ice on Roberts Bay is thick enough to support the fill. Haul trucks will access the sea ice surface directly from the jetty area. This method of rock placement was recently employed during reef construction at Kugluktuk and at the De Beers Snap Lake project.

The estimated quantity of rock riprap for each shoal is 278 m^3, for a total of 1,112 m^3. A cost estimate for construction is provided in Table 20.

Table 20 Cost estimate for Roberts Bay shoal habitat construction.

Item Description	Unit Cost	Quantity	Cost
Rock riprap (supplied and placed; m^3)	$30	1386	$41,580
Survey crew (2 persons x 1 d x 10 h)	$105	20	$2,100
Depth or ice testing (2 persons x 3 d x 10 h)	$105	60	$6,300
Construction supervision and monitoring (1 person x 3 d x 10 h)	$105	30	$3,150
Equipment (augers, snow machines, safety, etc.)			$500
		Subtotal	$53,600
Contingency (25%)			$13,400
Engineering (10%)			$5,400
		Total	$72,400

5.0 CONTINGENCY PLAN TO THE BOULDER GARDEN ENHANCEMENT

As outlined in Fisheries and Oceans Canada final submission to the Nunavut Impact Review Board on 25 June 2004 (NIRB File No. 177b), Miramar has committed to developing a contingency plan in the event that the proposal to increase fish access to Roberts Lake is not successful. During the 2004 field season, an aerial reconnaissance within the vicinity of the Doris North Project was conducted on 10 and 11 August 2004.

During the reconnaissance flight, two potential enhancement options were located (Figure 16). One area is located approximately 30 km west of the Doris North Project (Site 1; UTM 13 W 0406635E 7551813N), and the other is located approximately 15 km west of the Doris North Project (Site 2; UTM 13 W 0420258E 7554046N).

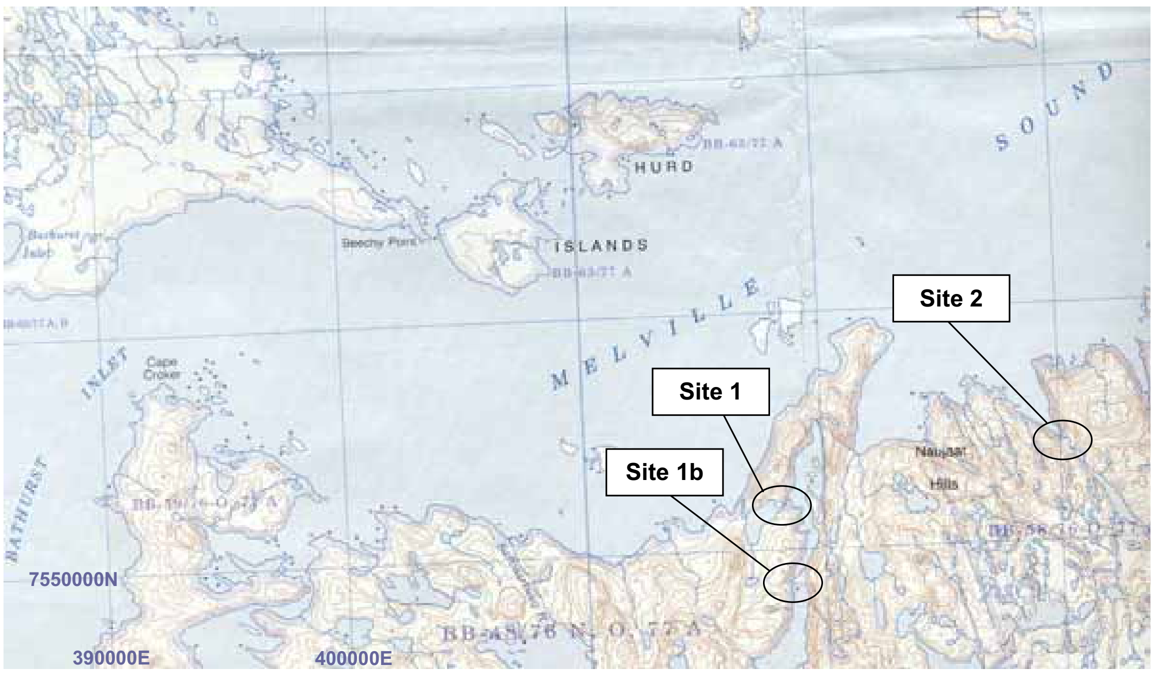


Figure 16 Location of proposed enhancement areas for the contingency to the "No Net Loss" Plan, Doris North Project.

Both sites are located along river systems where sets of waterfalls impede fish passage. The proposed contingency plans involve creating a series of steps and pools to allow increased fish passage through the waterfall areas.

Site 1 has a waterfall that is approximately 2 to 2.2 m in height (Appendix F, Plates 1 to 3). This waterfall is located between two lakes; the distance between the lakes is approximately 450 m. The downstream lake connects directly to the ocean. The inflow to the upstream lake also has an area where there is potential to improve fish passage through two sets of boulder gardens (Site 1b; Appendix F, Plate F4).

A waterfall and a cascade are present at Site 2 (Appendix F, Plates 5 to 8). The waterfall is approximately 1.5 m in height and is a barrier to fish passage. The cascade is not a fish barrier. During the field survey, wildlife were sighted feeding on fish at a pool below the waterfall (Appendix F, Plate 8 indicates the location of the pool).

As discussed, the waterfalls located at each of the sites likely pose a barrier to fish migration. It is anticipated that with the development of a step-pool configuration at each of these waterfall locations, anadromous fish could gain access to spawning and/or rearing habitat that was previously inaccessible at these sites. The step-pool sequence will be based on the principle that water is forced to pool up within the creek channel for a short distance, then drop over a lip or through a constricted opening, thereby causing backwatering into the upstream pool environment. This configuration is based on Rosgen (1996), who developed an approach known as a "vortex rock weir," for creating step-pool conditions in high gradient bedrock-controlled streams typically applied in moderate sloped channels ranging from 2 to 4%. The Rosgen (1996) design incorporates large boulders into the creek channel banks and bottom in a chevron shape, pointing upstream and deflected downwards with gaps, scouring the centre of the channel below the weir and creating staging pools for migrating fish, above and below the structure. These conditions create a series of cascades of higher velocity water that steps the water levels down over a desired distance and into a downstream pool.

As the channels at the proposed Sites 1 and 2 are of considerable gradient, the "vortex rock weir" approach will be modified as required for each site.

6.0 FOLLOW-UP MONITORING

As of 6 December 2002, all metal mining projects will be required to follow the *Metal Mining Effluent Regulations* (MMER), which incorporates an Environmental Effects Monitoring (EEM) program. The objective of the metal mining EEM is to evaluate the effects of mine effluent on fish, fish habitat, and the use of fisheries resources. Biological monitoring studies must include a fish survey (fish population and fish tissue analysis) and a benthic invertebrate community survey, and effluent and water quality monitoring studies, which include effluent characterization, water quality monitoring, and sublethal toxicity testing. The Doris North Project will participate in the metal mining EEM program. During the Nunavut Water License hearing, MHBL committed to continuing water quality monitoring and undertake a benthic invertebrate monitoring program prior to the initiation of the EEM program.

In addition to EEM, a total suspended sediment (TSS) monitoring program was conducted during the installation of the jetty in Roberts Bay in 2007, and TSS monitoring will be conducted during installation of the water intake barge and the float plane and boat dock in Doris Lake, and during the open water period during or after construction of the tailings dams. This will provide a review of the effectiveness of sediment control efforts and ensure compliance with regulatory requirements. It is expected that monitoring requirements will be incorporated into the project's water license and issued by the Nunavut Water Board (NWB).

6.1 Monitoring Associated with the Fisheries Compensation Plan

The fisheries compensation program for the Doris North Project has been designed to ensure that "No Net Loss" in fish habitat productive capacity is achieved as it relates to the DFO policy for the management of fish habitat. The compensation program consists of four main components; these are as follows:

- creation of rearing habitat in Doris Lake;
- creation of additional reef habitat in the vicinity of the jetty in Roberts Bay;
- creation of rearing habitat in a tributary to Roberts Lake; and
- enhancement of the stream channel to facilitate fish migration in Roberts Outflow.

Miramar Hope Bay Limited is committed to working cooperatively with the Department of Fisheries and Oceans and KIA in the design and implementation of a cost-effective follow-up program to assess the effectiveness of the fisheries compensation program.

The proposed follow-up monitoring to assess the effectiveness of the fisheries compensation program will include the components described in the following sections:

6.1.1 Creation of Rearing Habitat in Doris Lake

As part of the project's compensation for the Harmful Alteration, Disruption or Destruction (HADD) to fish habitat, the creation of six near-shore rearing areas in Doris Lake were proposed (Sections 4.1.5 and 4.2). The key measures of enhancement success for these proposed rearing areas are to demonstrate that these areas have established primary and secondary productivity similar to that in non-enhanced rearing areas of Doris Lake (i.e., reference areas). Following one complete open-water season post-construction, a monitoring program will be established to assess the quantity and extent of periphyton growth and benthic macroinvertebrate use in these newly created rearing habitats (i.e., treatment areas). "Reference" areas will be sampled for comparison with "treatment" areas. There will be two types of reference areas sampled. One type of reference area will consist of habitats that are similar to the existing habitat before treatment and the second type of control areas will consist of similar habitats to the treatment areas. Most proposed treatment areas will be placed in areas with sandy substrate. After enhancement, the treatment areas will consist of primarily boulder/rock substrate in waters 2 to 4 m in depth.

This portion of the monitoring program will be similar to that of a control/impact (CI) design, in which an impacted area (i.e., treatment = "newly constructed rearing habitats") is compared to one or more reference (control) areas (i.e., reference = "existing shallow water rearing areas"). The use of at least three reference sites is similar to the requirements of a "before/after control/impact" design summarized by Minns et al. (1995).

This monitoring will continue annually during the operation of the mine (two years) and will be monitored again in Year-1 and Year-5 from decommissioning. Although the main benchmark of success is establishing suitable primary and secondary productivity, fish sampling would also be conducted to assess use of these areas by juvenile fish, in particular lake trout. Fish sampling methods would include snorkeling, underwater videography and backpack electrofishing.

6.1.2 Jetty Fish Habitat Compensation Structures

Fisheries compensation for loss of fish habitat associated with the footprint of the jetty that is above the normal high water level will include the provision of additional reef habitat through the construction of under-water rock reefs to the west of the jetty in

Roberts Bay. The key measures of enhancement success will be the establishment of primary and secondary productivity on the enhancement structures (i.e., which provide food source for fish), as well as the documentation of the use of the structures as rearing and feeding habitat for fish. The follow-up study design will be Control/Impact design similar to that described above for monitoring enhancement structures in Doris Lake. Fish sampling methods would include snorkeling, minnow traps and other trapping methods, and possible use of underwater video and hydroacoustic gear to monitor fish presence along the enhanced and reference sites.

This monitoring will be conducted beginning the summer one year following the construction of the structures, in Year-2 of operation and in Year-2 of active post-closure (i.e., year prior to jetty lowering to below water).

6.1.3 Creation of Rearing Habitat in a Tributary to Roberts Lake

As part of the project's compensation, rearing habitat will be created in a tributary to Roberts Lake (e.g., Stream E09). The key measure of enhancement success is to demonstrate that the newly created rearing habitat supports greater densities of rearing fish than adjacent natural section of the stream. This will be accomplished by doing backpack electrofishing surveys in blocked off sections of the enhanced and natural channels. This monitoring will be conducted annually during the operational period of the mine (two years). This monitoring will also be conducted again in Year-1 and Year-5 from decommissioning.

6.1.4 Enhancement in Roberts Outflow

The main premise behind the proposed enhancement of the boulder garden in Roberts Outflow is to increase accessibility to Roberts Lake for fish migrating upstream from the ocean, and to reduce the mortality of Arctic char that become stranded in the boulder zone. This boulder area restricts fish passage in low to moderate flow years. Available data show that in five out of eight years, there were extended periods of time when fish migration was hindered or blocked. Increasing access through the boulder garden would result in increased Arctic char access to rearing, feeding, and spawning habitat, as well as critical overwintering habitat. One of the key measures of success, therefore, will be the provision of nearly unrestricted passage of Arctic char into Roberts Lake.

Fish fences were used annually to monitor fish migration through the Roberts Outflow boulder garden from 2002 to 2005. This provided a baseline of Arctic char movements and related mortality during a range of flow conditions. After completion of the channel modification (i.e., during the first summer of construction), monitoring of the upstream migration of Arctic char will be undertaken during a moderate or low flow year during the early years of the development to assess fish passage success and mortality during passage through the enhanced section. This will be accomplished by installing fish fences and traps at both the upstream and downstream ends of the boulder garden to count and mark fish at the lower end of the section, and to determine the success of passage by recapturing the fish at the upper end of the section (i.e., at the entrance to the lake). This program will be repeated in Year-9 or Year-10 (depending on flow conditions) to ensure that the enhanced channel is still effective, and to assess the size of the Arctic char run at that time (i.e., reduced mortality and increased access to Roberts Lake should be reflected in increased run size).

It would be difficult to judge success of the enhancement program strictly on numbers of fish returning to Roberts Lake each year, because Arctic char often overwinter in freshwater lakes that are not part of their natal watershed, and the runs can fluctuate widely from year to year. A more direct measure of Arctic char production in the Roberts Lake system could be obtained by monitoring the out-migration of smolts (i.e., first time migrants to the ocean). In the Canadian Arctic, Arctic char juveniles spend the first four to seven years rearing in the lake system where they were born (based on data from Nauyuk Lake; Johnson 1980). The size of the smolt run downstream, which normally occurs in early July, would be an appropriate measure of Arctic char production in Roberts Lake resulting from the improved access and survival of fish passing through the enhanced channel into Roberts Lake.

Based on the advice of DFO, MHBL installed a fish fence in mid June to mid July of 2006 on Roberts Creek below Little Roberts Lake to assess the feasibility of conducting annual counts over a longer-term. Based on the success of the program (i.e., it was possible to keep the smolt fence and trap operational), it appears that monitoring smolt out-migration will provide data useful in assessing the effectiveness of the enhancement facilities in the boulder garden section of Roberts Outflow. Smolt outmigration was monitored again in 2007, and was generally successful, although the two-way smolt fence was inoperable for a couple of days due to high flows.

Based on the results of the 2006 and 2007 smolt out-migration monitoring, the program will be continued annually for a total of a 10 years (i.e., eight more years) to document variations in out-migration run size and composition both prior to, as well as for a long enough period after channel enhancement, to determine any changes in smolt production that could be attributable to the enhancement program. MHBL proposes that the measure of success of the enhancement program would be to increase smolt production in Roberts Lake by an average of 25% over the pre-enhancement average, as the increased number of smolts would rapidly increase in biomass during their periods in the marine environment. Mathieson and Berg (1968) found Arctic char in northern Norway increased in weight by an average of 60.05% per summer season in the marine environment over a five year period. Although growth rates may be lower in the Canadian Arctic, Arctic char put on considerable weight during their forays in the productive marine environment.

A fish sampling program would also be conducted in Roberts Lake during years when the fish fence is operational (i.e., little additional cost, since the sampling crews would be on site to monitor the fish fence); however, given the size of the lake, it would be very difficult to demonstrate that an increase in productivity for Arctic char has occurred. Catch-per-unit-effort (CPUE) will be compared to baseline data. Fish sampling methods include gill nets for adult fish and modified Arctic fyke nets, beach seines and backpack electrofishers for juvenile fish. Tributaries to Roberts Lake will also be sampled using backpack electrofishers to capture young-of-the-year fish or small juvenile fish seeking forage areas and shelter from predators (this program was initiated during summer 2007, with standard sampling sections set up in selected tributaries to Roberts Lake). During the sampling programs in Roberts Lake and tributaries, additional life history information (e.g., length and weight distribution, size at age for juveniles and smolts, etc.) will be collected for Arctic char in the system. It should be noted that mortalities will be kept to a minimum, as the objective of the enhancement program is to increase the standing stock and production of Arctic char in the system.

6.1.5 Summary of the Timing of Fisheries Compensation Follow-up Monitoring

Table 21 provides a summary of the proposed timing of the fisheries compensation follow-up monitoring for the Doris North Project. The timing of the monitoring program assumes that MHBL receives a Water License and other regulatory approvals (including Fisheries Authorization and MMER Schedule II listing) to begin construction in late 2007. This schedule would include construction during 2007 and 2008, with mill operation beginning in Q4 of 2008. The operation phase would continue through 2009 and 2010, with decommissioning in 2011 and 2012.

Table 21 Timing of Fisheries Compensation Follow-up Monitoring.

Monitoring Program	Timing Period	Predicted Calendar Years
Rearing Habitat in Doris Lake (to be constructed April-May 2009)	• Year 1 & 2 of Operation • Year 1 & 5 from Decommissioning	• 2009 & 2010 • 2011 & 2015
Jetty Compensation Structures (constructed April or May 2008)	• First summer after construction • Year 2 of Operation • Year 2 of Active closure (i.e. year prior to jetty lowering to below water)	• 2008 • 2010 • 2012
Tributary E09 to Roberts Lake (to be constructed summer 2008)	• Year 1 & 2 Operation • Year 1 & Year 5 from Decommissioning	• 2009 & 2010 • 2011 & 2015
Enhancement in Roberts Outflow (to be constructed in summer 2008)		
A) Smolt Outmigration	• Annually for 10 years beginning in 2006	• 2006-2015
B) Adult Upstream Migration to Verify Successful Passage	• First year of low or moderate flow after enhancement	• One year 2010-2012
C) Fish Studies in Roberts Lake	• Annually during years when smolt migration is being monitored starting in 2007	• 2007-2015

6.2 Other Fish and Fish Habitat Monitoring Programs

6.2.1 Doris Lake/Tail Inflow Riparian Vegetation Monitoring Program

In addition to the follow-up programs associated with the fisheries compensation program, MHBL has agreed to conduct follow-up monitoring in response to a concern raised by the Department of Fisheries and Oceans relating to potential changes to shoreline habitats along Doris Lake due to dewatering of Tail Lake outflow, and the potential effects on ninespine stickleback rearing habitat along the Doris Lake shoreline.

MHBL has developed and implemented a vegetation monitoring program to characterize and monitor any changes to the plant community along the Tail Lake outflow into Doris Lake. If unforeseen effects to the vegetation along Tail Lake outflow are identified, additional mitigation or compensation measures will be identified and discussed with DFO, prior to implementation.

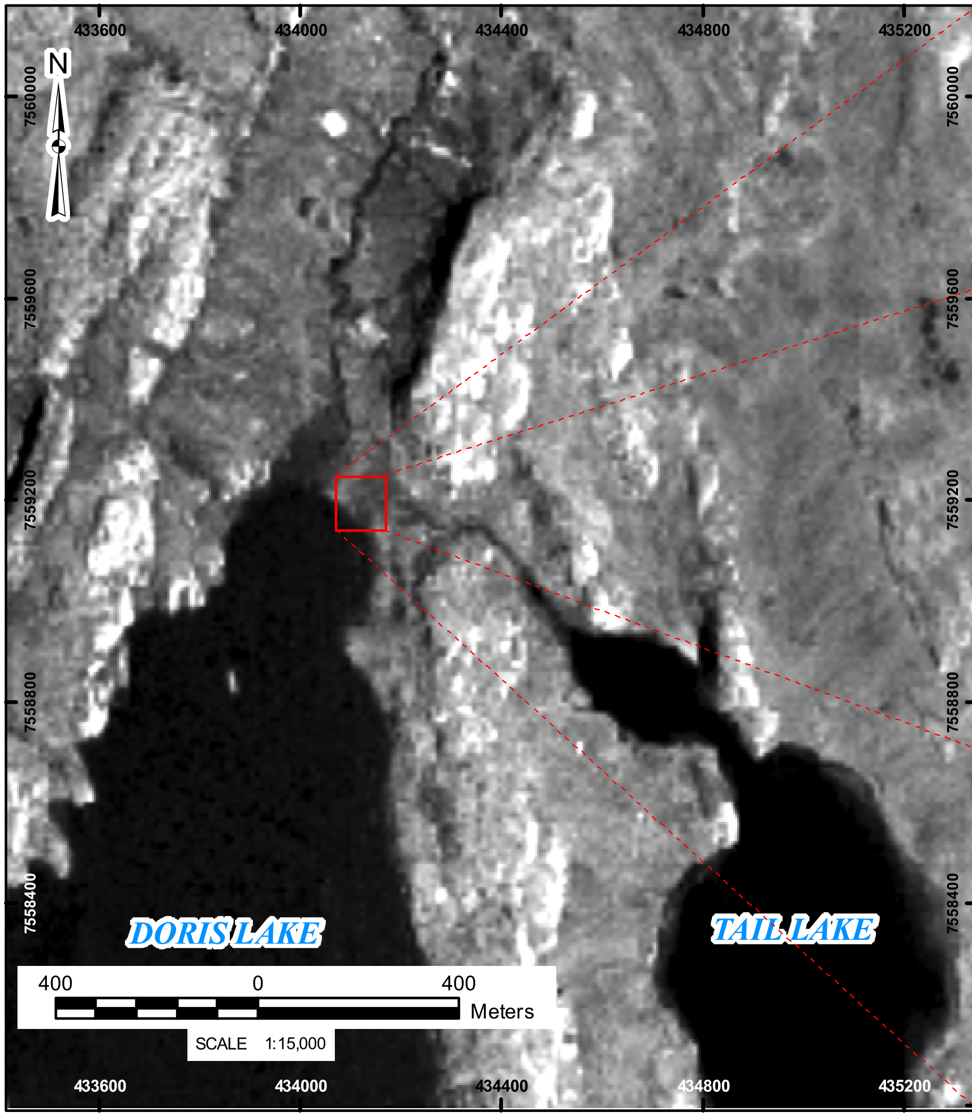
The willow community extends along the Doris Lake shoreline for approximately 50-60 m in the vicinity of the Tail Lake outflow channel and contracts to a metre-wide band following portions of the Tail Lake channel as it moves closer inland. The vegetation along the Doris Lake shoreline, is predominantly comprised of willow (at 70% cover) and sedge (at approximately 45% cover). The willows overhang into Doris lake and Tail Lake outflow channel in a dense mat. As one moves further inland, willow cover become less dense (50% cover) and sedge cover becomes more prominent (60%), suggesting a hydrological gradient.

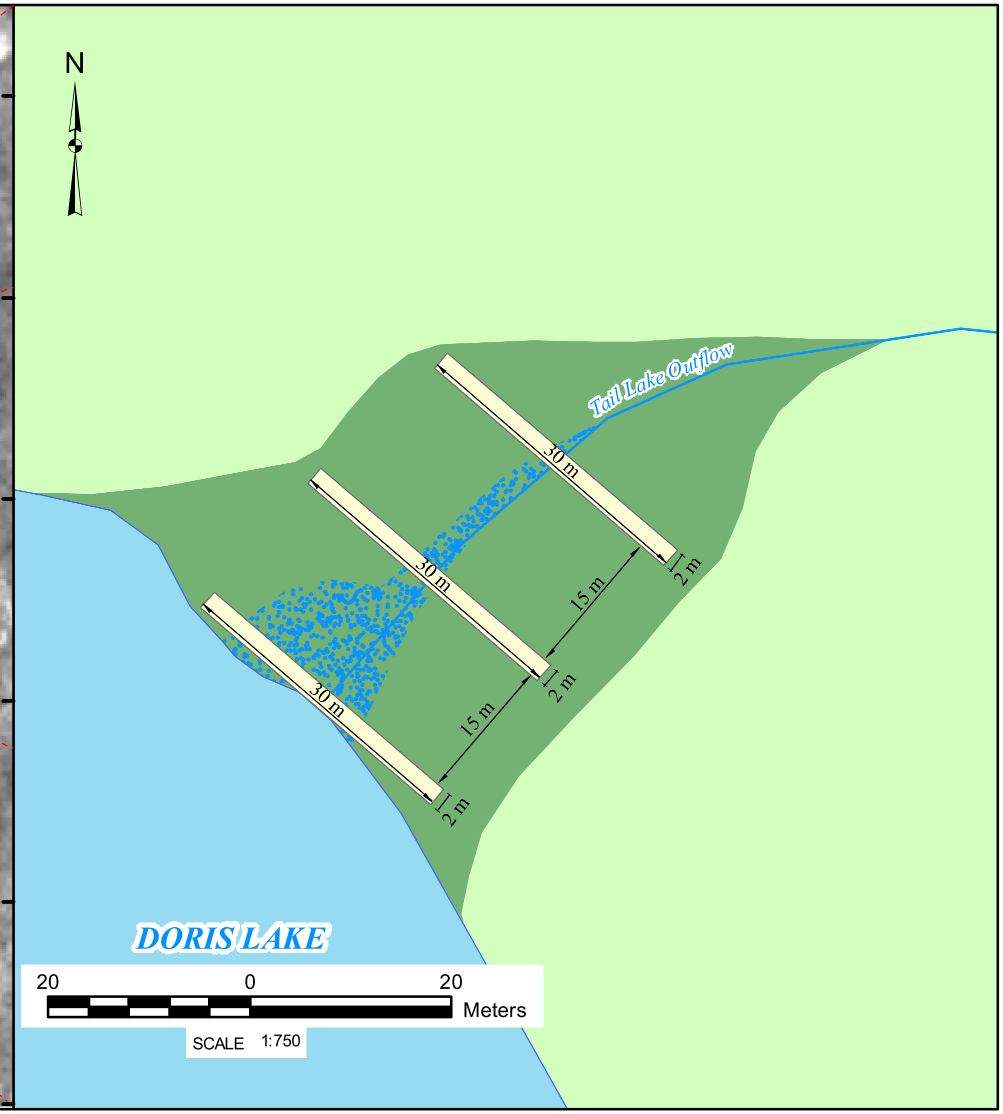
Vegetation surveys were conducted in late June 2007 along the shoreline of Doris Lake in the vicinity of the Tail Lake outflow channel to establish baseline conditions. A belt transect approach was used to evaluate the vegetation in this area in order to best capture the range of plant communities and associated plant species diversity surrounding the Tail Lake outflow. Using a series of transects rather than a single plot approach enables potential changes to vegetation patterns to be more effectively tracked and documented. The dimension of the transects was chosen to best capture the range of variability in vegetation along the narrow corridor that was represented by the willow community in the area of interest. Permanent transect markers were established in 2007 to facilitate consistent sampling of the vegetation transects in subsequent sampling years.

Three transects (2 m by 30 m) were established along a parallel line (roughly in an east-west direction) from the edge of Doris lake inland towards Tail Lake, following the Tail Lake outflow channel (see Figure 17). The first transect was established parallel to the lake's edge, with the Tail Lake outflow channel representing the midpoint of the transect. Subsequent transects were established at 15 m intervals from the first transect.

Vegetation data collected at each transect included general site characteristics (i.e., slope, aspect, moisture and nutrient regime) and plant species and associated percent covers. All species encountered were identified to the species level, where possible. All plant species that could not be identified in the field were collected for subsequent identification back at the office by comparing with herbarium specimens or using taxonomic experts. GPS locations were collected for each start and end point of each transect. GPS locations were also collected where the Tail Lake outflow intersected with Doris Lake and for a portion of the Tail Lake outflow channel. Photographs were taken of the general site and for each transect line. Start and end points of each transect were marked with flagging tape delineating transect number, distance and bearing.

Project: N:\GIS\Projects\2007\1373\0019\6000\Veg\MapDocs\Fig1_Transects.mxd - Plot: N:\Active\2007\1373 Biophysical\07-1373-0019 Miramar EM II Expansion_South of Cambridge Bay\Phase 7000 Vegetation\Reporting\Fig1_Transects.pdf





LEGEND

Transect Areas

Study Area

Vegetation Type

Cotton Grass

Willow / Sedge

Outflow Water Path Areas

REFERENCE

FINAL

Projetion: UTM Zone 13N Datum: NAD 83
Sources: Aerial Photography obtained from Miramar Mining Corporation

This map is for information purposes only. Golder Associates Ltd. does not accept any liability arising from its misuse or misrepresentation, and cannot be held liable for the compatibility, completeness or correctness of the data.

PROJECT

Miramar
Doris Lake Riparian Vegetation Monitoring

TITLE

Doris Lake - Tail Lake Outflow Vegetation Schematic of Study Area Transects

Golder Associates
Edmonton, Alberta

PROJECT No. 07-1373-0019			SCALE AS SHOWN	REV. 1
DESIGN	LV	31 Aug. 2007	**FIGURE: 17**	
GIS	CP	11 Sept. 2007		
CHECK	CDLM	11 Sept. 2007		
REVIEW	XX	?? Aug. 2005		

Variables that will be analyzed for monitoring purposes will include the following:

- plant species richness;
- plant species diversity (Shannon-Wiener Function);
- percent cover by strata (i.e., shrub, forb, graminoid);
- height of tall and low shrub layers; and
- multivariate analysis of community composition.

Based on similar data collected during future vegetation transect monitoring, analyses will be conducted to determine if there is a gradient response in plant community composition or cover that coincides with the construction and operation of the Tail Lake outflow dam.

Site vegetation monitoring will occur over the life of the project at the following time frames:

- prior to start of operation (2007 and 2008);
- during operations (2010); closure (2012); and
- post-closure (~2020).

This will facilitate the comparison of vegetation information at various stages of project development to evaluate any changes to the plant communities as a result of site operations.

6.2.2 Tail Lake Fish Tissue Analyses

Prior to the mine operation, the lake trout in Tail Lake will be removed following the DFO "General Fish-Out Protocol for Lakes to be Lost Due to Mining Developments," It is proposed that the fish would be removed through a netting program using local Inuit fish harvesters. Prior to removal of fish from the lake and possible distribution of the fish for use as human or animal food, lake trout will be collected from Tail Lake. Tissue samples of the fish (i.e., 15 fish) will be analysed for metal contaminants as precautionary testing to confirm the fish are suitable for consumption by humans or animals. For a detailed discussion of the proposed Fish-Out Program for Tail Lake, see Section 7 of this report.

6.3 Cumulative Effects Monitoring

Concerns were expressed during the NIRB conformity and technical review that there may be a cumulative effect of the abandoned Roberts Bay Silver Mine in combination with the Doris North Gold Project. The abandoned Roberts Bay mine is located approximately 5 km north-east of the Doris North project. The abandoned mine area is drained by a small, intermittent stream, which flows from the north into Roberts Lake approximately 250 m east of the outlet of Roberts Lake. Public Works and Government Services Canada has identified localized metal and hydrocarbon contamination at this site and has subsequently prepared a remediation plan scheduled for possible implementation in 2008.

The tributary near the abandoned Roberts Bay Silver Mine was sampled for water quality on 19 August 2003, during a wet period when water was flowing in the stream. Most of the water quality constituents examined were elevated in this tributary compared to other nearby streams sampled during the 2003 program (Golder 2003b). In addition, both total aluminum and total copper exceeded the CCME guidelines for the protection of aquatic life. Aluminum concentration was 199 µg/L and copper was 3.06 µg/L, whereas the CCME guidelines for these metals are 100 µg/L and 2 µg/L, respectively.

The small and intermittent nature of the stream draining the area of the abandoned Roberts Bay mine results in low flow volumes. As such, the contribution to total metal loadings into the lower section of Roberts Lake likely would be small. Similarly, metal loadings in the outflow from Roberts Lake, which pass through Little Roberts Lake, also would be low. As the water quality in Doris Outflow before it enters Little Roberts Lake (where the flow joins the outflow from Roberts Lake) is expected to meet CCME water quality criteria for the protection of aquatic life, the cumulative effects of the Doris North project, in combination with any effects from the abandoned silver mine, are not expected to result in noticeable increase in contaminant concentrations in Arctic char tissues. However, if effluent monitoring at the Doris North Project under the MMER requirement records total mercury concentrations at or above 0.5 µg/L in any sample, then a fish tissue monitoring program will be undertaken to assess the accumulation of metals in fish. At that time, tissue samples from Roberts Lake will also be sampled to assess background levels in those fish. Baseline fish tissue analyses data are available from Roberts Lake from August 2002 (RL&L / Golder 2003b), and would be used to assess if cumulative effects of the two projects were occurring.

Concern was also raised as to the potential for the Arctic char population that will be enhanced by the compensation program to be affected by contaminants from the Roberts Bay Silver Mine. It was concluded that the effects of the abandoned mine on Arctic char would be very small (if any) due to the following:

- The tributary draining the abandoned mine is very small, and intermittent (i.e., only flows during freshet and during periods of high precipitation);

- The tributary draining the abandoned mine area enters into Roberts Lake approximately 250 m from the outflow from the lake. Thus, any contaminants entering Roberts Lake likely would be restricted to the western margin of the lake, with much of the bioavailable (i.e., dissolved) metal loading exiting through the outlet;
- Arctic char do not use the stream draining the abandoned mine area for rearing due to the small size and intermittent nature of the stream;
- Most Arctic char rearing occurs in tributaries or in the main body of Roberts Lake farther away from the source of potential contaminants from the abandoned silver mine; and
- Once Arctic char reach the smolt stage (around five years of age), most of their growth occurs during their summer feeding period in the ocean, well away from the source of any contaminants from the abandoned silver mine.

Based on the above assessment, it is unlikely that there would be any significant contaminant loadings to Arctic char specifically resulting from the abandoned silver mine. As such, fish health or their suitability as food for wildlife or human.

If it appears that future contaminant loadings into Roberts Lake from the abandoned Roberts Bay Silver Mine are higher than anticipated, then MHBL will enter into discussions with DFO and PWGSC to develop an appropriate monitoring program to assess potential implications to the fish compensation program. It is anticipated that the proposed remediation works to be undertaken by PWGSC at the Roberts Bay Silver Mine will undergo environmental assessment prior to implementation and thus this can be addressed through this assessment process.

7.0 FISH -OUT PROGRAM FOR TAIL LAKE

7.1 Background

Tail Lake will be the recipient water body for all process tailings; thus, the lake will be removed from biological production due to decreased water quality. Tail Lake is approximately 77 ha in area and has a maximum recorded depth of 6.5 m (RL&L/Golder 2002). Fish surveys have resulted in the capture of lake trout by gill netting and angling (RL&L/Golder 2003a,b) and a small number of ninespine stickleback by fyke netting, electrofishing, and minnow trapping (Golder 2005). An intensive short-set gill netting and angling program was conducted in Tail Lake during the 2002 field program to determine the population size of lake trout through mark-recapture procedures. The population size of lake trout in Tail Lake was estimated at 2350 to 2650 fish, depending on the use of different estimating methods and assumptions regarding fish mortality rates over the 2000 to 2002 period. The 95% confidence intervals for the estimates ranged between 1313 and 5511 fish.

To avoid potential contamination of fish in the lake, and likely mortalities resulting from reduced water quality, fish will be removed from Tail Lake with the assistance of harvesters from Umingmaktok, Bathurst Inlet and/or other local communities prior to tailings deposition. The proposed Fish-Out Program, outlined below, has been designed according to the draft DFO "General Fish-Out Protocol For Lakes To Be Lost Due To Mining Developments." Information about the fish community, aquatic biology, physical limnology, and habitat in Tail Lake will be collected according to recommended protocols, as appropriate, and will be analyzed and submitted to DFO and KIA following completion.

7.2 Program Objectives

The main objectives of the Fish-Out Program for Tail Lake include:

- minimizing fish waste;
- determining the actual population size, distribution, and density of fish in Tail Lake;
- providing comparisons to evaluate population estimates and lake production models;
- identifying linkages between habitat characteristics and fish populations.

Rigorous scientific procedures will be followed during data collection to provide scientifically defensible data to submit to DFO. Fishermen from the community will work under the direction of a qualified fisheries biologist who will be on site to ensure that the data are collected in a manner that is considered repeatable, defendable and fulfills the commitments outlined in the Fish-Out Program.

7.3 Methods

7.3.1 Fish Community

Fishing efforts in Tail Lake have indicated the fish species composition is made up primarily of lake trout. An unknown number of ninespine stickleback are also present in the lake. Unlike other lakes in the Doris North Project area, Tail Lake does not support Arctic char, lake whitefish or cisco populations (RL&L/Golder 2002). This difference in species diversity is likely the result of Tail Lake's isolation from Doris Lake due to the diminutive size of Tail Outflow that connects these lakes.

The goal of the Fish-Out Program is to provide an accurate description of the size and structure of the fish community in Tail Lake. The Fish-Out Program will involve a complete census of lake trout present in Tail Lake, and will be comprised of two main phases. The marking phase will be the initial phase followed by a catch-per-unit-effort (CPUE) phase. Since the lake will not be dewatered, the CPUE phase will be coupled with the total removal of fish from the lake. Every effort will be made to capture all lake trout susceptible to the fishing gear prior to any physical or chemical alteration to the lake. Collection of ninespine stickleback also will be included in the program, but, due to their small size, it is unlikely that all ninespine stickleback in the lake will be removed prior to use as a tailings impoundment.

7.3.1.1 Marking Phase

A period of catch and release to mark a portion of the lake trout population will be conducted in Tail Lake immediately following ice out (mid July) in 2008. To minimize the mortality risks associated with netting and trapping efforts, fish sampling will be conducted early in the season prior to increases in water temperature. Two field crews (each consisting of one biologist and two locals) will sample simultaneously over a one week period. The goal for this phase is to mark fish, and to live-release fish back to the lake. A target number of 250 lake trout will be marked based on a 10% target of the estimated population size of about 2500 lake trout. It is anticipated this phase will take about one week.

Fyke nets, gill nets, and angling will be used to sample for fish during this phase. Fyke nets will be set in shallow areas of the lake and will be left for the duration of the sampling period. Small mesh gill nets of a variety of mesh-sizes (max 3.2 cm or 1.5”) will be used to limit gilling of fish and reduce mortalities. During this phase, gill net sets will be short in duration (30 to 60 min). Nets will periodically be moved such that all available habitat is surveyed. Date, location, time of set, and time of retrieval will be recorded for each trap net and gill net gang. The trap net or gill net set number and mesh-size will be recorded for each fish captured. All captured fish greater than 250 mm will be marked with a uniquely numbered Hallprint™ T-bar anchor tag (30 mm in length). A fin punch will be given to all fish captured to provide a secondary mark in the event of tag loss. Each fish will be identified to species, weighed, and measured for fork length. Attempts will be made to minimize fish stress and to return the marked fish to the water as soon as possible. Additional data will be collected from any incidental mortalities, including sex and maturity, reproductive status, stomach contents and ageing structures (otoliths, fin rays and/or scales, depending on the fish size).

A subsample of 15 fish will be euthanized at the start of this phase to be analyzed for tissue contaminants. Dorsal muscle from these fish will be sent to the laboratory (with requested rapid turn around) for analysis of metal concentrations and moisture as precautionary testing to confirm that the fish are safe for human consumption. The results of these tests will be reviewed prior to initiation of the second phase of the Fish-Out Program to determine the appropriate use of the fish removed.

7.3.1.2 Catch-per-Unit-Effort (CPUE) / Total Removal Phase

The CPUE phase will begin three to seven days following the completion of the Marking Phase. This phase will serve as the recapture component of the mark and recapture assessment. The goal for this phase is to ensure all fish are removed from the lake and transferred to surrounding aboriginal communities. It is anticipated that this phase will require three to six weeks of fishing effort.

Gill nets will be the primary method for fish removal (CPUE and Total Removal). Mesh sizes will consist of 102 mm (4”), 76 mm (3”), 51 mm (2”), 38 mm (1 ½”), 25 mm (1”), and 22 mm (7/8”). The full range of mesh sizes will be fished at all times. Fishing effort in each mesh size will be increased as CPUE decreases. Gill nets will be set on a rotational basis to ensure the entire lake is fished and to minimize potential fish avoidance behaviour. Some gill nets (1/3 of nets set) will be set at fixed locations and others (2/3 of nets set) will be randomly moved throughout the lake for the duration of the fishing efforts. Net checks will be conducted one to two times per day, depending on catch numbers.

Date, location, time of set, and time of retrieval will be recorded for each gill net gang. Information collected during gill net sets will also include water depth at the beginning and end of each net, substrate data, and surface water temperature. The gill net set number and mesh-size will be recorded for each fish captured. Each fish will be checked for marks, identified to species, weighed, and measured for fork length. Pelvic fin rays and otoliths will be collected from all lake trout and will be used for ageing. Analysis of ageing structures will be completed on 25 individuals from each 50 mm size-class.

Captured fish will be euthanized and placed in plastic bags labeled by date and net set identification number. The lake trout collected during this phase will be packed in ice or frozen and transported to the local communities.

Stomach samples will be collected for future analysis from a minimum of 50 lake trout captured in the lake. These samples will be selected from fish encompassing the range of sizes captured in the lake. Previous sampling efforts in Tail Lake have identified a lack of small size-classes (<430 mm) for lake trout (RL&L/Golder 2003); thus, analysis from small size-classes may be limited.

Netting will continue until CPUE declines and no fish are captured for 48 hours of continuous netting. Nets will be removed for 48 hours and then re-deployed for 48 hours to ensure no fish are captured. After no fish are captured for two consecutive 48 hour periods, gill netting will cease.

After CPUE has declined, additional capture methods will be implemented; fyke nets and minnow traps will be set in shallow areas of the lake to target small fish and to remove them from the lake.

7.3.1.3 Disposition of Salvaged Fish

MHBL has been in consultation with HTOs in the western Kitikmeot including the Elakuktutiak HTO, Umingmaktok HTO, and the Kugluktuk Angonaitit Association as to the desired disposition of fish from the Fish-Out Program. MHBL met with the Elakuktutiak HTO on 26 September 2007 to outline the Fish-Out Program and discussed options for use of the fish from the lake. After considerable discussion, the HTO reached consensus that the fish could be distributed to the communities of Cambridge Bay, Umingmaktok, and Bathurst for dog food, as the fish from Tail Lake are skinny, and thus would not be very desirable for human consumption.

Both the Burnside HTO and the Kugluktuk Angonaitit Association have had previous experience with other Fish-Out programs and it is anticipated that these HTOs would express a desire to be involved or identify workers for the Tail Lake Program.

7.3.2 Population Estimates

Several complementary methods will be used to provide an accurate description of the size and structure of the fish community in Tail Lake. The total number of lake trout removed during the final phase of the Fish-Out Program will be compared to mark/recapture estimates derived during the removal phase.

Mark and recapture estimates for the Fish-Out Program will be confined to a single season census. The adjusted Petersen method will be used to provide an unbiased estimate of population size. Population estimates will also be calculated for lake trout in Tail Lake based on CPUE using both the Delury and Leslie methods (Ricker 1975). Both methods use a regression analysis on CPUE data to estimate populations. They differ in that the Delury method expresses the relationship between CPUE and cumulative effort, whereas the Leslie expresses the relationship between CPUE and cumulative catch. The intercept of the regression line on the cumulative effort (Delury) and cumulative catch (Leslie) axis give an approximate measure of the initial (pre-sampling) population size.

7.3.3 Aquatic Biology/Physical Limnology

The Fish-Out Program will be designed to help evaluate the linkages between habitat and fish production. This will involve characterizing ecosystem components including water chemistry, chlorophyll *a*, zooplankton, and benthic invertebrate communities. These data will contribute valuable information to establish community-environment relationships.

A permanent survey site has been established in the deepest portion of Tail Lake near the north end of the lake. Water quality information has been collected at this location since 1995. Three water quality sampling surveys at this location will be conducted during 2008 prior to physical or chemical alteration of the lake. Sampling will be conducted under ice (April/May period) and during July and August.

7.3.3.1 Water Chemistry

During each survey dissolved oxygen and temperature profiles will be collected at 0.5 m increments from the water surface to 0.5 m above the lake bottom. Secchi depth will be collected by lowering a standard Secchi disk through a hole in the ice (winter) or on the shaded side of the boat (open water), and recording at which depth the disk is no longer visible. Daily surface water temperatures, air temperature, cloud cover, and wind direction will also be recorded. Water quality samples will be collected using a Kemmerer water sampler from 1.0 m below the water surface and 1.0 m above the bottom to prevent contamination with sediments. Sample bottles will be provided by the analytical laboratory to be submitted for subsequent analysis. When required, the appropriate preservative will be added in the field. Water samples will be analyzed for the parameters recommended in the DFO General Fish-Out Protocols, including total phosphorus, total nitrogen, total dissolved solids, dissolved nutrients, total dissolved nitrogen, and total organic carbon. In addition, analysis of total and dissolved metals will also be conducted.

7.3.3.2 Chlorophyll *a*

Chlorophyll *a* samples will be collected using an integrated depth sampler within the euphotic zone of the lake (twice Secchi depth) or to within 0.5 m of the bottom, whichever is less. Three replicates will be collected during the two open water sampling events from the established water quality sampling location and submitted to the lab for subsequent analysis.

7.3.3.3 Zooplankton

Zooplankton sampling will be conducted during each open water sampling event. A 25-30 cm diameter net with 70 to 100 micron mesh will be used to conduct four vertical hauls from bottom to top at the sampling location. Each sample will be submitted to a taxonomist for analysis of zooplankton biomass and taxonomy.

7.3.3.4 Benthic Invertebrates

Benthos biomass and taxonomy samples will be taken once during the mid-August sampling event. A total of 20 Ekman dredge hauls will be taken from four depth intervals: five between 0-2 m; five between 2-4 m; five between 4-6 m; five at depths greater than 6 m. Sixteen of the hauls will be used for biomass determination. One haul conducted at each depth interval will be analyzed for taxonomic purposes. All organisms will be identified to the lowest taxonomic level practical.

7.3.4 Habitat Inventory

Habitat data collected in Tail Lake will provide an understanding of structure and distribution of habitat in the lake in relation to fish catch results. A habitat mapping survey was conducted by Rescan (2001), which identified the main habitat environments.

Although the draft DFO protocol for collection of habitat data cannot be precisely followed, as Tail Lake will not be drawn down, additional field data will be collected to expand on the information gathered during previous habitat surveys. Habitat data will be collected using ground level shoreline surveys and aerial photography. Aquatic vegetation visible from the surface and shallow-water substrate will be mapped in Tail Lake. GIS maps of substrates, depth, slope, and wave energy will be produced in conjunction with DFO.

7.4 Reporting

The data collected during the Fish-Out Program will be provided to DFO and KIA in a data report summary. In addition to the biological data collected, sample analysis results will also be provided. The report will include population estimates for lake trout in Tail Lake using the proposed models. Comparisons will also be made to baseline data available for these lakes. Copies of all field data as well as an electronic database of all data collected will be provided.

7.5 Summary of Timing of Fish-Out Program

The anticipated timing of the fish-out program is as follows:

Component	Estimated Timing (2008)
Marking Phase	10 July (dependent on ice off)
Collection of fish tissue for metals analyses	10-12 July
Initiate CPUE/Removal Phase	24 July (dependent on receipt of fish tissue analyses from the lab)
Water Chemistry Sampling	April/May, mid July, mid August
Chlorophyll a	Mid July and mid August
D.O profiles and Secchi depth	During water quality sampling (see above) and daily when on site during Fish-Out Program
Zooplankton Sampling	Mid July and mid August
Benthos Sampling	Mid August
Tail Lake Habitat	Opportunistically throughout Fish-Out Program
Data Analyses and Reporting	Mid August to 28 February (2009)

8.0 SUMMARY

Based on our evaluation of the potential losses, the mitigation incorporated into the project, and the proposed compensation activities, it is expected that there will be a "No Net Loss" of fish habitat, as outlined by the following:

- ***Tail Lake***: Due to reduced water quality from the processed tailings, 34.8 HUs of fish habitat will be lost in Tail Lake. Compensation includes increasing accessibility to Roberts Lake and habitat enhancement within Roberts Outflow, which could potentially provide 132.16 HUs. This will result in a 1:3.8 ratio of habitat loss to habitat gain.
- Additional compensation for Tail Lake includes:
  - enhancement of rearing habitat at three locations at the south end of Doris Lake and one site at the north end. This will provide an additional net gain of 0.250 ha of fish habitat, which would primarily benefit lake trout survival, the main species being affected by the loss of Tail Lake production; and
  - creation of rearing habitat in a tributary to Roberts Lake. This would primarily benefit Arctic char juvenile survival, thereby complementing the facilitated access of Arctic char into the lake.
- ***Tail Outflow***: Due to the disruption of the natural waterflow caused by the tailings dam, approximately 0.027 ha of fish habitat will be compensated by enhancement of rearing habitat located at the north end of Doris Lake (0.153 ha). This will result in a net gain of 0.126 ha of fish habitat.
- ***Roberts Bay***: Due to the construction of a jetty, approximately 0.176 ha of fish habitat will be compensated by 0.314 ha of reef habitat to the west of the jetty and rockfill along the side slopes of jetty below the normal high water level.

Key to the compensation of HADD during the proposed project will be improvements for Arctic char migration and reduction in high mortality of adults and subadults due to stranding in the shallow boulder area of Roberts Outflow. This will provide greater access to overwintering, spawning, and rearing habitats. Increasing production of Arctic char in the Roberts Lake system will allow larger numbers of fish to take advantage of productive ocean habitats, thereby greatly increasing biomass subsequently returning to Roberts Lake. We feel that the compensation proposed will increase the productive capacity of Roberts Lake, thereby replacing the loss of productive capacity of Tail Lake due to the project. Arctic char are culturally, recreationally and ecologically important to people of the Canadian north. Since Arctic char in this system are anadromous, this species is able to attain a much larger size in a shorter time period than landlocked lake trout (particularly such as those in Tail Lake, which have a very limited forage base). In addition, other species such as broad whitefish, lake whitefish, cisco, least cisco, and lake trout may also benefit through improvements in migration habitat and access to additional stream habitat.

9.0 CLOSURE

The information in this report was prepared for the use of Miramar Hope Bay Ltd., the Nunavut Impact Review Board and participants in the NIRB review process relating to the Doris North Project. The material in it reflects Golder's best judgment in light of information available to us at the time of preparation. Any use of this report or any reliance on or decisions to be made based on it by any other third party are the responsibility of such third party. Golder accepts no responsibility for damages, if any, suffered by any other third party as a result of decision made or action based on this report.

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PHOTOGRAPHIC PLATES

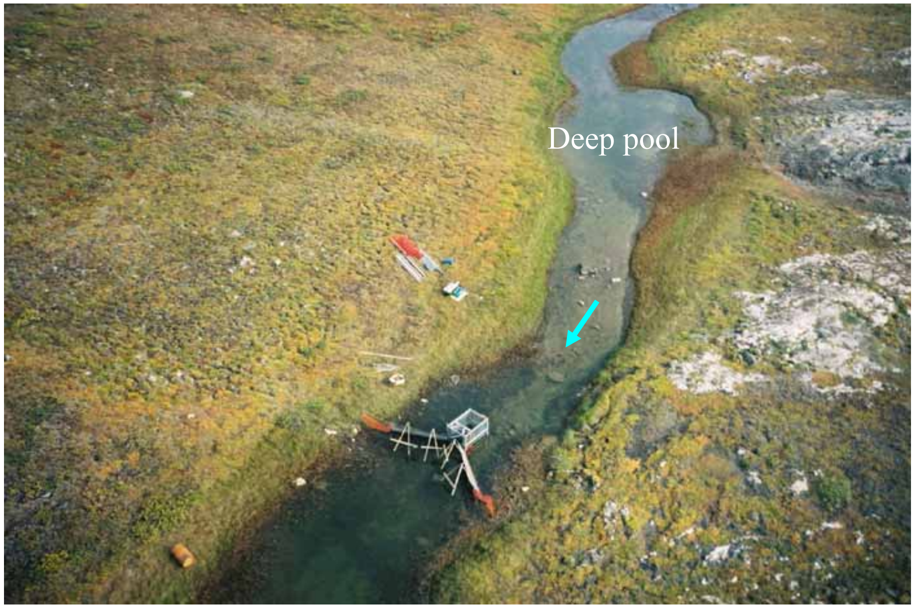


Plate 1 **Roberts Outflow,** *16 August 2002.* Aerial view of fish trap. The deep pool provided a holding area for migrating Arctic char.

Plate 2 **Roberts Outflow,** *27 August 2002.* Large male Arctic char (sample #457) in spawning colors captured at fence and released upstream.

Plate 3 Aerial view of fyke net (FN1) set at upstream end of **Roberts Outflow** (Roberts Lake outlet). Note: Boulder garden, fish fence and trap downstream.

Plate 4 **Roberts Outflow**, *16 August 2002*. Salvage operation of migrating Arctic char trapped between boulders immediately downstream of Roberts Lake.

Plate 5 **Roberts Outflow,** *16 August 2002.* Arctic char trapped in deep pocket between boulders immediately downstream of Roberts Lake.

Plate 6 **Roberts Outflow,** *16 August 2002*. Low level aerial view of Arctic char trapped in boulder garden stranding zone.

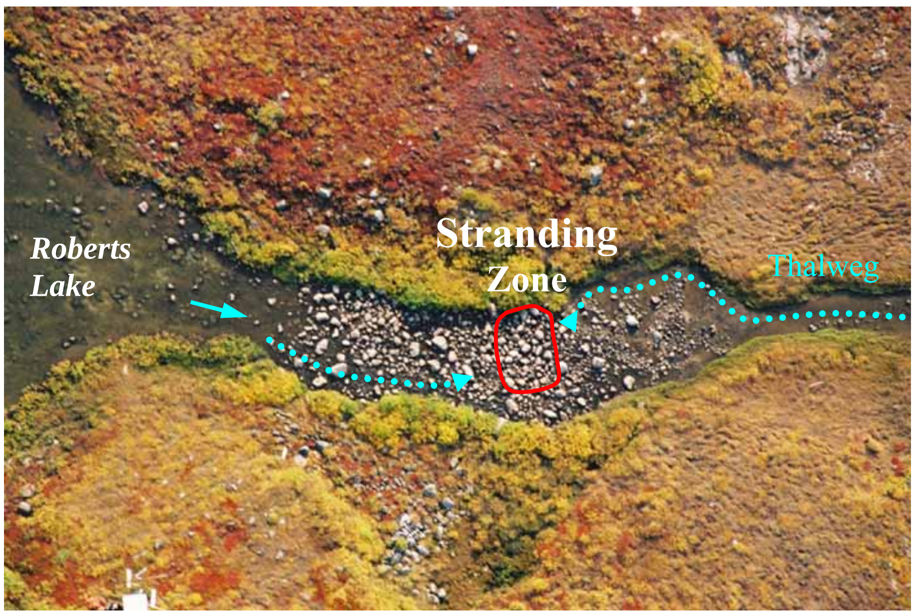


Plate 7 **Roberts Outflow**, *2 September 2002*. Aerial view of boulder garden. Outflow thalweg crosses channel through stranding zone of boulder garden.

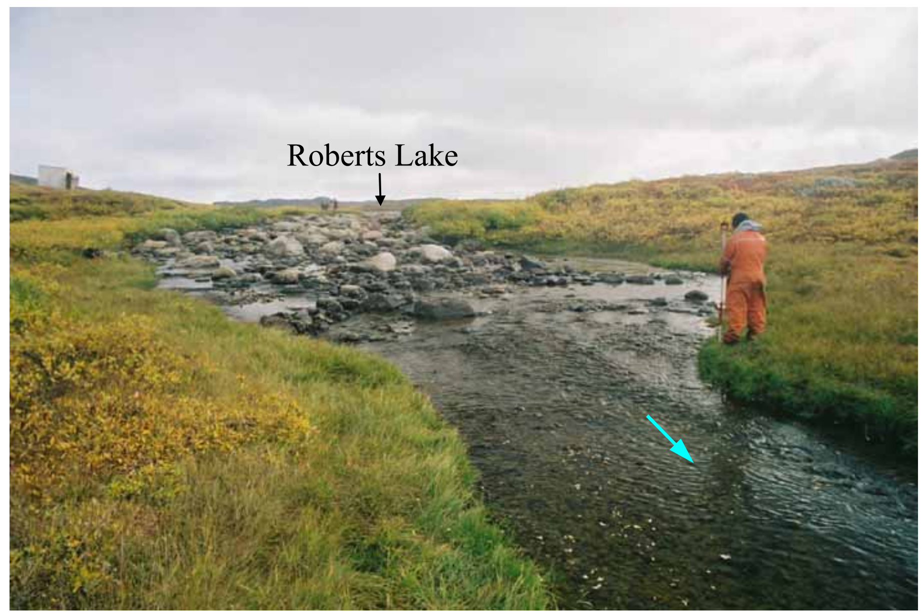
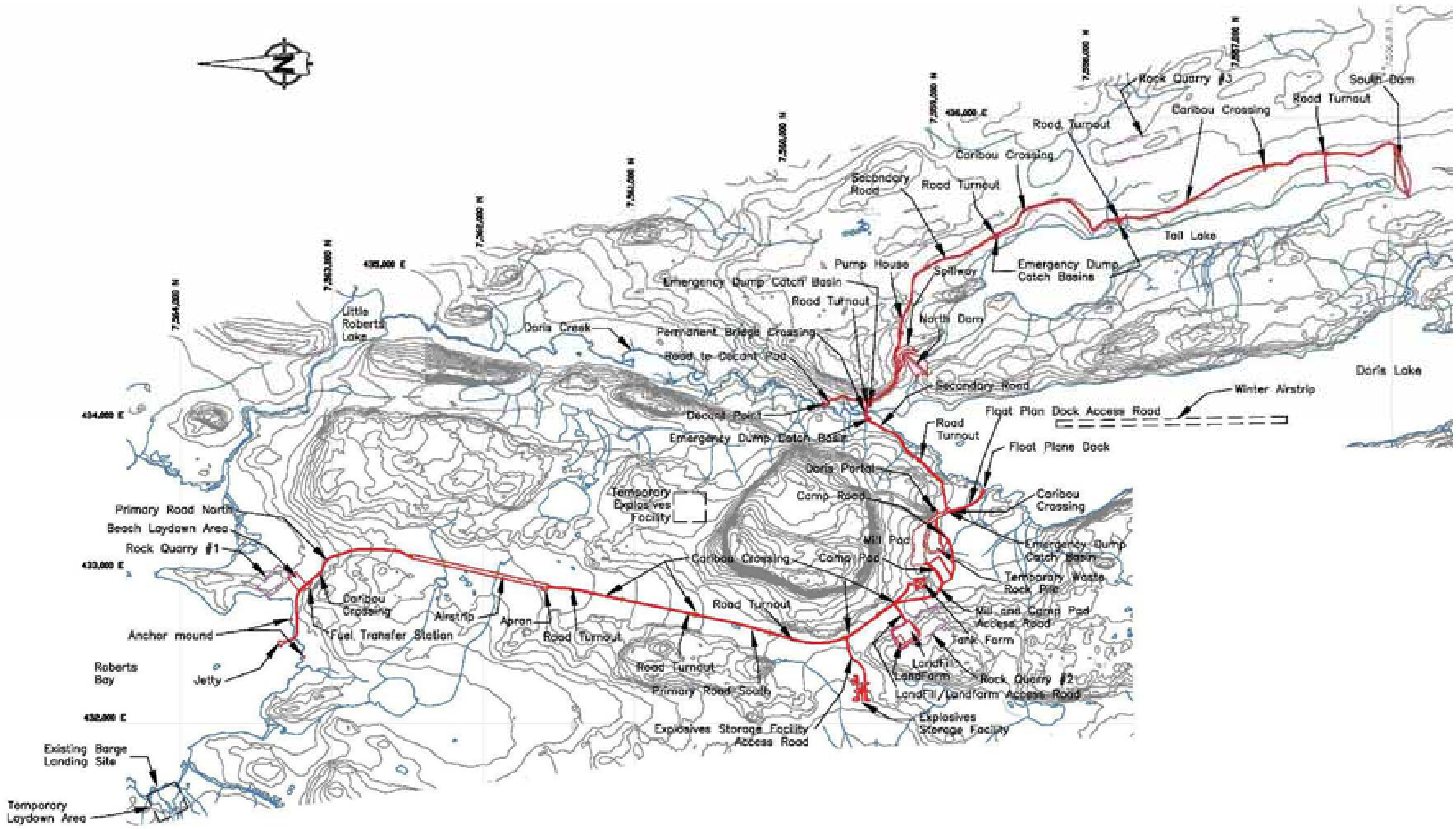


Plate 8 **Roberts Outflow,** *1 September 2002*. Survey measurement of boulder garden to determine stream gradient.

APPENDIX A

Doris North Project Infrastructure and Design Drawings

Appendix A1 Overall Site Infrastructure Layout



Source (MHBL 2007)

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Memo

To:	Larry Connell	**Date:**	August 22, 2007
cc:	Terri Maloof	**From:**	Maritz Rykaart
Subject:	Doris North Project – Preliminary Design Concepts of the North Dam Breach	**Project #:**	1CM014.008

The North Dam will be breached only after the water level in Tail Lake has been lowered to its pre-development elevation of 28.3 m by means of the discharge strategy and in accordance with the water quality objectives as described in the Revised MHBL Water License Application dated April 2007.

The North Dam breach will be carried out based on the following preliminary design concepts, and are illustrated on the attached figure:

1. MHBL will prepare a detailed design of the North Dam breach in accordance with the timeline set out for the Final Closure and Reclamation Plan of the Doris North Project. The preliminary design concepts outlined in this memo however includes all the pertinent components relating to the execution of the breach to ensure the permanent and stable outflow of Tail Lake along its original (pre-mining) watercourse. The final detailed design of the breach will be carried out by a qualified Professional Engineer registered in the Nunavut Territory, with input by a qualified Professional in natural stream morphology.

2. Construction of the breach will be carried out under the supervision of a qualified Professional familiar with the final design, and in accordance with the design specification.

3. A permanent slot will be cut (excavated) through the North Dam, down to the original pre-construction ground elevation. The slot will be centered around the original Tail Lake outflow channel and will measure about 22 m wide in total (at the original Tail Lake outflow elevation), with 2.5H:1V side slopes on either side. These slopes are considered to be the long term stable slopes based on current geotechnical design parameters. If however actual dam performance monitoring through the life of the dam suggests different final slope angles, these slope angles may be revised when final construction of the breach is done. Such modification will be done under the review of a qualified Professional Engineer.

4. Excavation methods for cutting the slot will be as follows:

    a. The *Outer Shell* of the North Dam, which consists of Run-of-Quarry material, will be excavated using conventional construction techniques using a tracked excavator loading rock haul trucks. A portion of this material will be re-used to armor the final cut face and will thus be stockpiled in close proximity to the excavation, most likely upstream of the dam. The excess material will be stockpiled in the North Dam spillway area, as the spillway would no longer be in service. Fill will be placed in 0.5 m thick compacted lifts, using a dozer and compactor.

b. The *Transition Zone* material which consists of processed quarry rock of less than 150 mm nominal size will also be excavated using the same conventional techniques as proposed for the *Outer Shell*. A portion of this material will again be re-used as a transition layer when armoring the cut slopes of the final cut face, and as such this material will be temporarily stockpiled in an area most likely upstream of the dam. The remaining material will be a valuable resource for other closure activities on site, such as the landfill closure and will be used as such. If however there is no other use of this material, it will also be placed in the North Dam spillway area together with the *Outer Shell* material.

c. The *Frozen Core* material, which consists of processed gravel of less than 19 mm nominal size cannot be excavated using conventional construction techniques as it will be a hard frozen mass, equivalent to the permafrost foundation. Therefore the slot through this *Frozen Core* will be cut using conventional drill and blast methods. The blasts will be small controlled directional blasts to ensure that only those materials intended to be removed will be dislodged. The blasted material will be loaded onto rock haul trucks using a tracked excavator. This material will be a valuable resource for other site reclamation activities and where there is a need to re-use this material it will be hauled to those sites. If however there is no use for this gravel it will be placed in the dam spillway area together with the *Outer Shell* material. The *Frozen Core* material will be in the form of frozen lumps of gravel and as such during the first freshet there would be a volume of thaw water being released from this material. Appropriate sediment control matting will be placed along the spillway outlet area to ensure no sediment release into Tail Lake outflow during this period.

5. Whilst the *Frozen Core* is being excavated, the Geosynthetic Clay Liner (GCL) will be encountered. This liner will be cut along the final cut slope of the breach. This portion of the removed liner will be disposed of in the site landfill, or alternatively be removed from site for off-site disposal if the landfill had already been closed.

6. Once the slot cut has been completed, the final cut slopes will be covered with a 0.5 m thick layer of *Transition Zone* material covered with a 2.5 m thick *Outer Shell* consisting of Run-of-Quarry material to ensure physical and thermal stability of the remaining dam flanks. As stated previously, this material will be the same materials as excavated from the breach slot cut. Placement of these materials will be by means of conventional earthworks techniques, i.e. excavator or loader to load haul trucks, and a dozer to spread and place the materials. A compactor will be used to compact the material. Once completed, the slot width at the original Tail Lake outflow elevation will be about 6 m wide.

7. The original Tail Lake outflow channel will be re-established by excavating a defined channel through the *Frozen Core* gravel contained in the key trench. This trench will be armored using appropriately sized stream bed material along the channel bed to ensure erosional stability. The appropriate design of this channel, including the need for re-

establishing aquatic vegetation will be done under the guidance of a qualified Professional in natural stream morphology. Along the leading edges on either side of the key trench a transition layer of appropriate material will be placed to ensure erosional and thermal stability.

8. The reconstructed Tail Lake outflow channel will not require excavation and removal of the thermosyphons. MHBL therefore proposes to keep the thermosyphons in place even after the breach is in place.

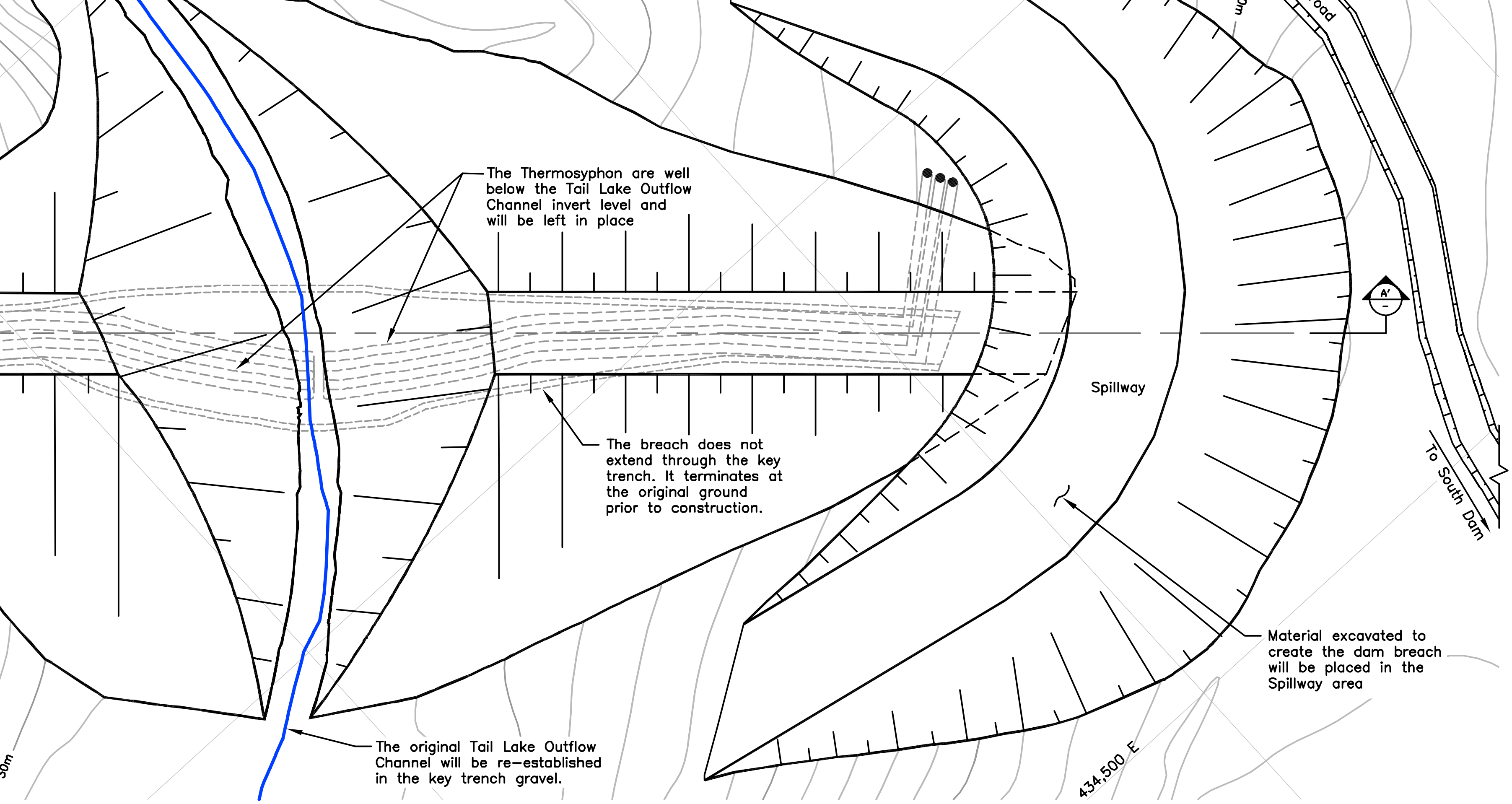
9. Construction of the dam breach could be done at any time of the year. However summer construction would entail managing significant secondary construction issues such as construction of a coffer dam to manage the Tail Lake outflow, added sediment control during construction, as well as construction of access roads over the tundra to facilitate construction. Therefore MHBL will carry out the dam breach during the winter season when a coffer dam will not be required and construction access roads would consist of winter roads.

10. Sediment control during construction would not be required; however, once construction has been completed, and prior to the onset of the first freshet post breaching, sediment control mats will be set along the construction affected areas to contain any sediment release inadvertently caused by construction activities. Since no excavation of the natural permafrost will be carried out, sediment release is not expected to be a concern and these erosion control measures are expected to be a single season precautionary measure.

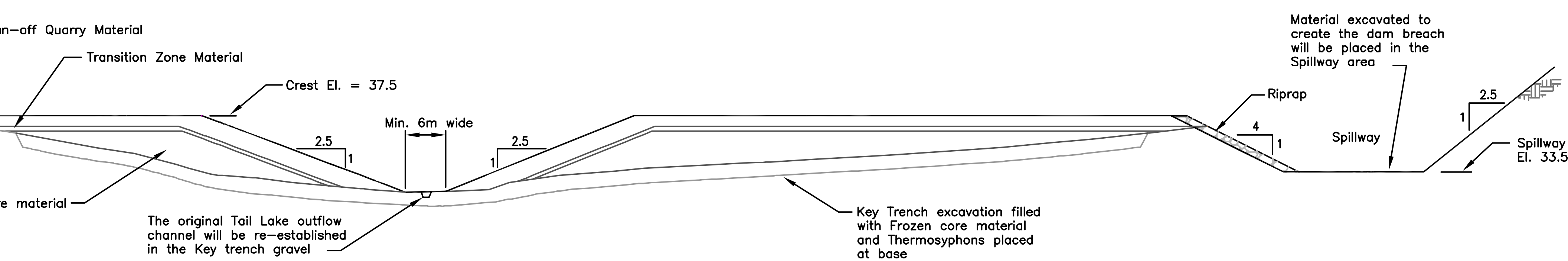
11. The construction quantities for the dam breach based on this preliminary design are as listed in the table below.

Component	Material	Approx. Quantity
Slot Cut (material to be removed)	*Outer Shell*: Run-of Quarry material	24,000 m^3
	Transition Zone: 150 mm nominal size material	2,700 m^3
	Frozen Core: 19 mm nominal size material	5,300 m^3
Protection Cladding (material to be brought back as erosion and thermal protection)	*Transition Zone*: 150 mm nominal size material	480 m^3
	Outer Shell: Run-of Quarry material	9,320 m^3
Volume of material permanently relocated	Mix of *Outer Shell*, *Transition Zone* and *Frozen Core* material	22,200 m^3

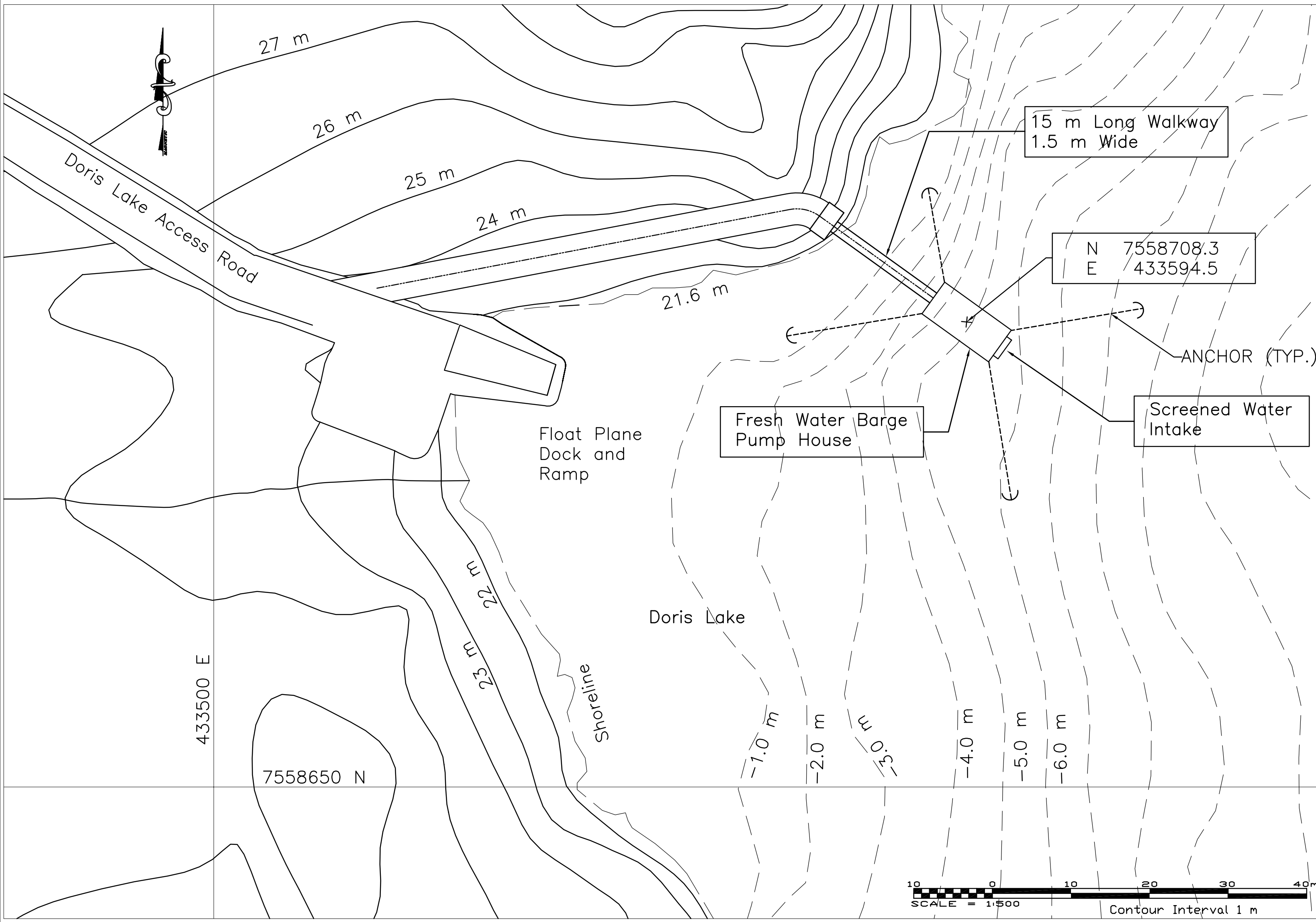
12. An allowance of $810,000 has been included for the final decommissioning of the North Dam. This cost was estimated by SRK and is based on the excavation and partial replacement of about 32,000 cubic meters of rock at a unit rate of $25 per cubic meter. Mobilization/demobilization ($250,000), Engineering ($106,000) and QA/QC construction supervision (96,720) for this work are also included. This work will take place nine years after the cessation of mining; consequently a 3% discount rate was used to calculate the NPV of this expenditure for a total North Dam decommissioning cost of $967,770.



BREACHED NORTH DAM PLAN LAYOUT
1:500 0 10 20 30 40 50 Metres



NORTH DAM LONGITUDINAL SECTION A–A'
1:400 0 100 200 300 400 Metres
2x Vertical Exaggeratioin



Notes

1. Pumping Depth Elevation -3.0 m
2. Pumps equiped with intake screens to meet DFO regulations to prevent fish entrainment

NO.	DATE	REVISIONS	BY
PC	09/04/07	ISSUED FOR PERMITTING	ARW
PB	18/07/07	ISSUED FOR PERMITTING	ARW
PA	21JUN07	ISSUED FOR COMMENTS	ARW

DESIGNED: JOS A. CAVE
DRAWN: LEE G — BM — 21JUN07
CHECKED: ARW

MIRAMAR HOPE BAY LTD.

SNC·LAVALIN Engineers & Constructors

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MIRAMAR MINING CORPORATION
DORIS NORTH MINE

FRESH WATER BARGE PUMP HOUSE
PLAN

PROJECT NO.	AREA	DISC.	DOC.	DRAWING NUMBER	LOC.	REVISION NUMBER
334499	0000	41	D1	0007		PC

Format 'Tabloid' Sheet Size

DATE: 2007/09/04 - 1:37pm
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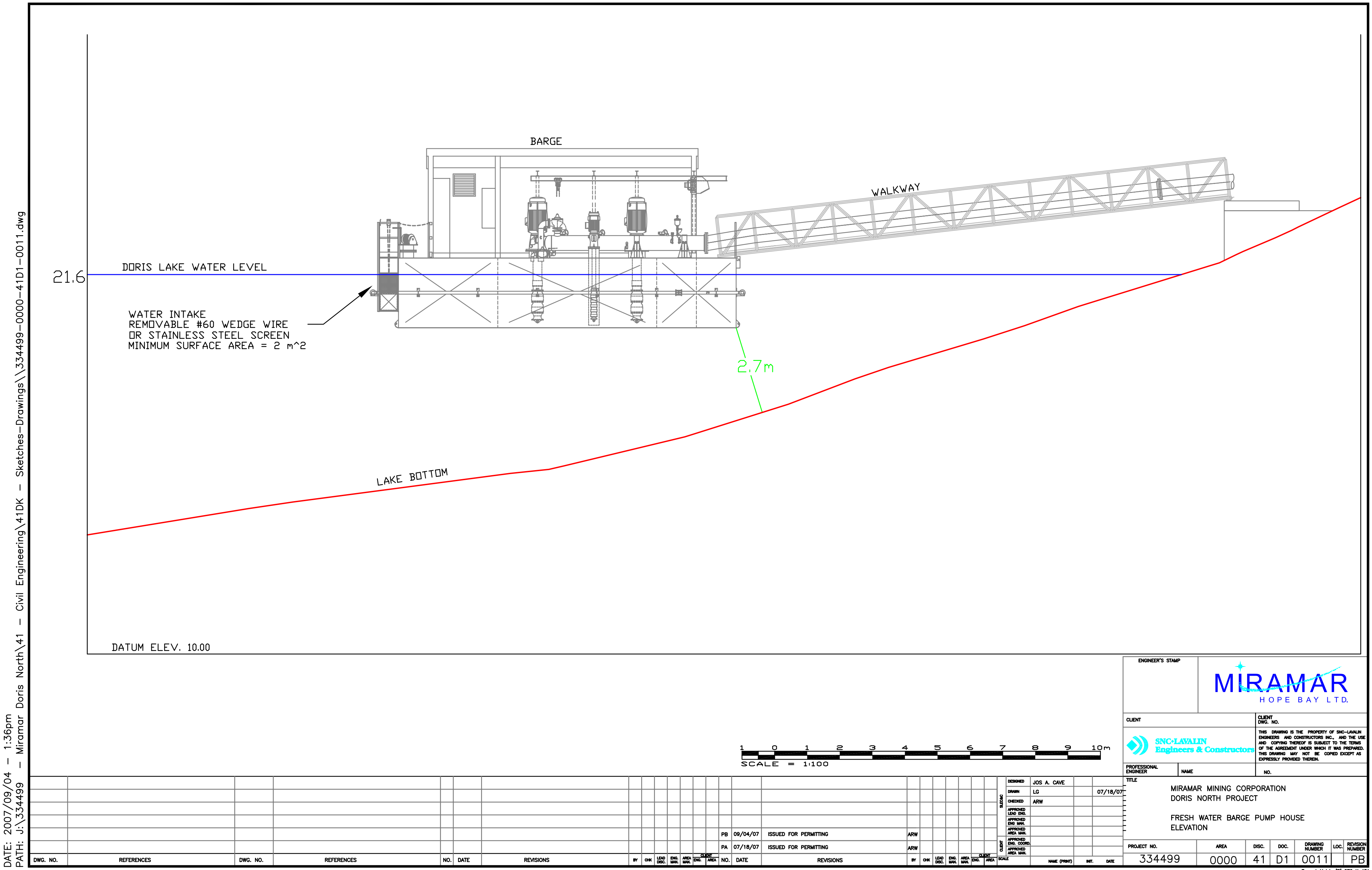
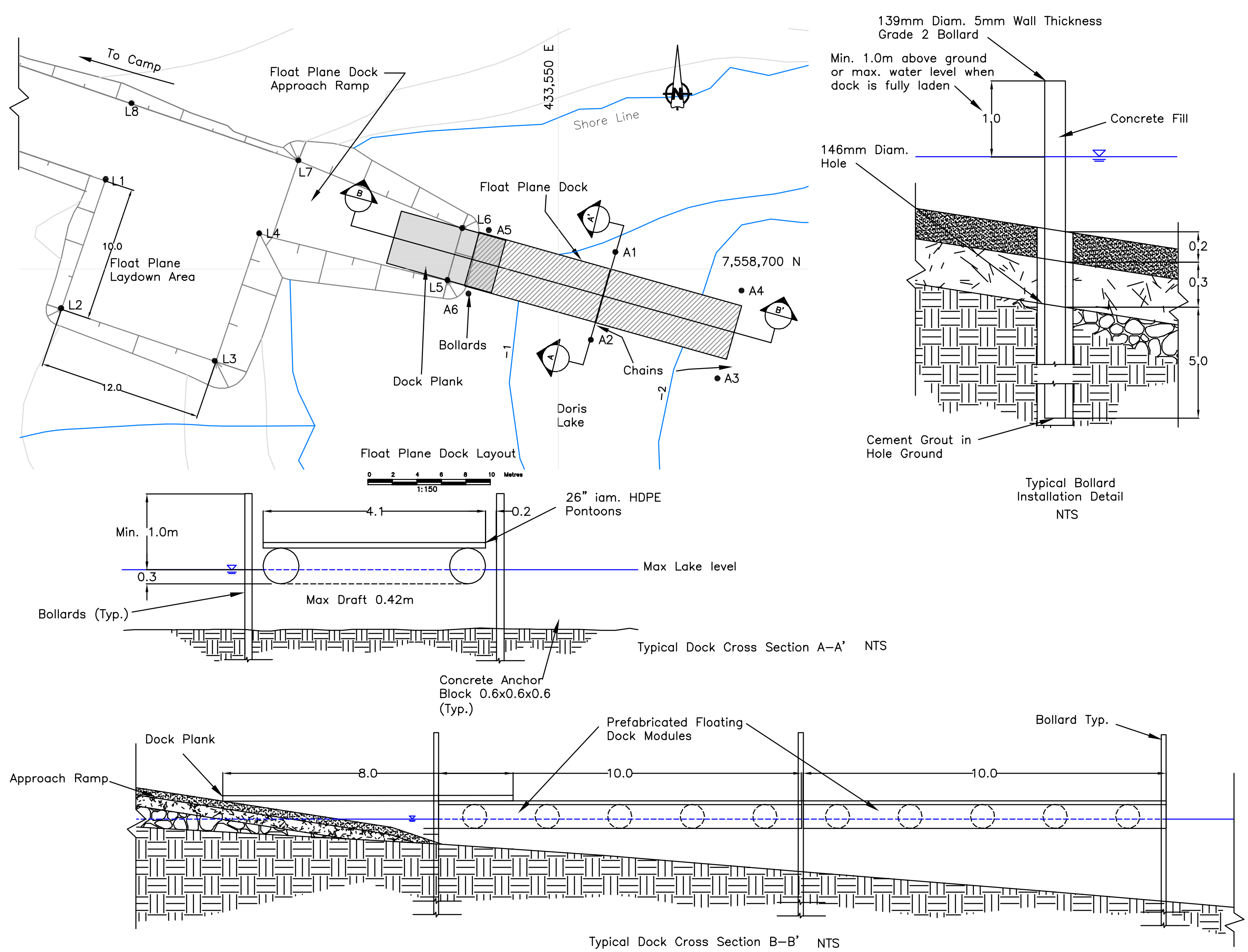
Appendix A3-a FLOATING PUMPSHACK - PLAN VIEW



Appendix A3-b. FLOATING PUMPSHACK - SIDE VIEW



STAKE OUT TABLE		
Point	Northing	Easting
Anchor Blocks		
A1	7558701.2	433554.2
A2	7558694.8	433552.4
A3	7558691.9	433562.7
A3	7558691.9	433562.7
A4	7558698.3	433564.5
Float Plane Dock		
A5	7558702.7	433544.2
A6	7558698.8	433543.1
Float Plane Laydown		
L1	7558706.5	433516.6
L2	7558697.0	433513.4
L3	7558693.2	433524.8
L4	7558702.6	433528.0
L5	7558699.1	433541.8
L6	7558703.0	433542.9
L7	7558708.0	433530.9
L8	7558712.2	433518.6

Legend:

- Natural ground
- Surfacing material
- Select subgrade
- Run of quarry

Notes:

1. Dock loading Pad and access ramp shall be constructed according to the Specification. The dock shall be constructed by the Specialist Contractor meeting the requirements shown on these Drawings and on the Specifications.
2. The submerged anchor tie–in hardware shall meet the requirements shown on Jetty Drawings and Jetty Specifications.
3. The tie in hardware shall be adjustable to suit the variation of the Lake levels.
4. The shore anchor locations can be adjusted by the Engineer to fit site conditions.
5. The minimum submergence of the dock shall be 0.5 m and maximum submergence 1.1 m.

Note: Drawings plotted to half scale

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
				B	WATER LICENSE APPLICATION			
				A	WATER LICENSE APPLICATION			
REFERENCE DRAWINGS				REVISIONS				

Stamped, signed and dated originals submitted to the Nunavut Water Board

PROFESSIONAL ENGINEERS STAMP

SRK Consulting Engineers and Scientists Vancouver

DESIGN: AT | DRAWN: JJH | REVIEWED: EMR
CHECKED: AT | APPROVED: EMR | DATE: Mar. 2007
FILE NAME: Dock_and_Pad.dwg

MIRAMAR HOPE BAY LTD

DORIS NORTH PROJECT
DETAILED DESIGN

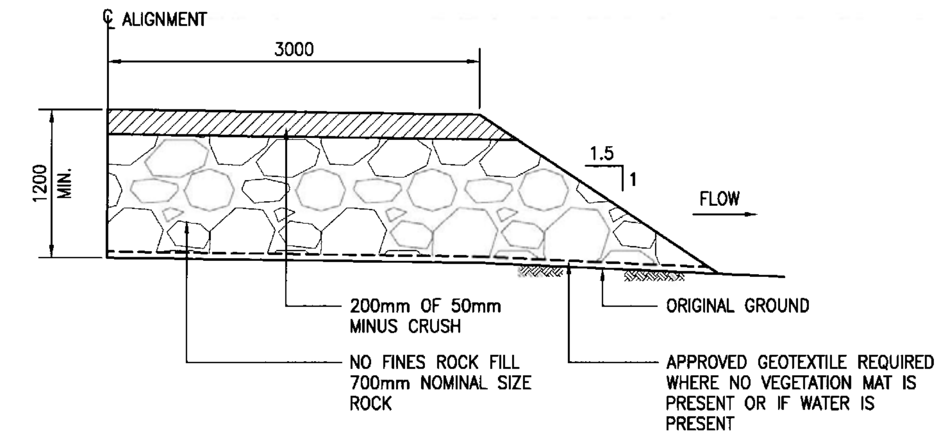
SRK JOB NO.: 1CM014.008

Doris North Project

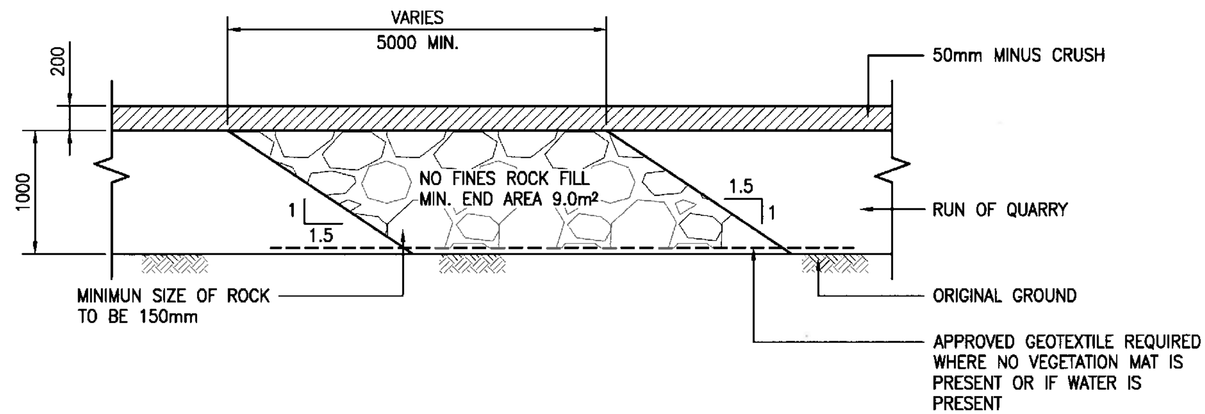
DRAWING TITLE: Float Plane Dock Typical Plan Sections and Details

DRAWING NO.: S-09 | SHEET 17 OF 49 | REVISION NO. B

Appendix A4 FLOAT PLANE AND BOAT DOCK



FLOW THROUGH ROCK DRAIN



FLOW THROUGH ROCK DRAIN INSTALLATION DETAIL IN PERMAFROST AND NON–PERMAFROST

NOTES

1. FLOWS FOR ROCK DRAINS HAVE BEEN LIMITED TO LESS THAN $0.25\ m^3/s$.
2. MAXIMUM/MINIMUM PARTICLE SIZES OF 1000mm AND 150mm CLEAN ROCK.
3. ROCK DRAIN DESIGN
   - VOID RATIO OF 0.5 AND POROSITY OF 1.0
   - SAFETY FACTORY OF 2.0 FOR 1 IN 50 YEAR DESIGN FLOW, WITH MAXIMUN HEAD AT INLET AT TOP OF ROCK DRAIN.
4. REGULAR INSPECTION AND MAINTENANCE WILL BE CARRIED OUT TO PREVENT PLUGGING OF THE VOIDS BY DEBRIS.

1.0 0 1.0
SCALE = 1:40

MIRAMAR HOPE BAY LTD.

SNC·LAVALIN Engineers & Constructors

PA	2007/06/21	ISSUED FOR COMMENTS	ARW
NO.	DATE	REVISIONS	BY

DESIGNED	JOS A. CAVE	JAC	07/06/21
DRAWN	A.TUMANENG	ART	07/06/21
CHECKED	A. R. WACHMANN	ARW	07/06/21

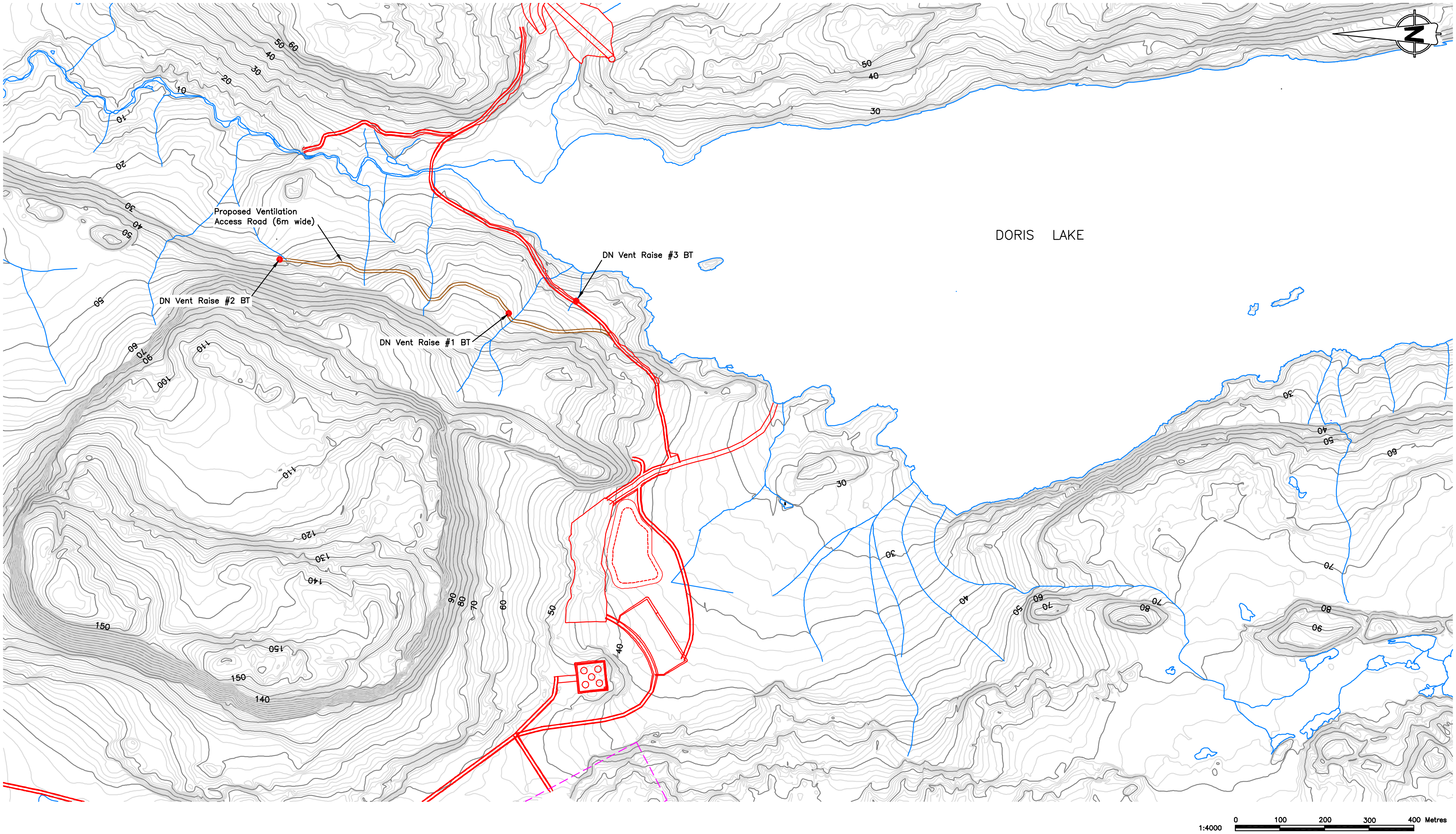
TITLE: MIRAMAR MINING CORPORATION
DORIS NORTH MINE

ROCK DRAIN
DETAILS

PROJECT NO.	AREA	DISC.	DOC.	DRAWING NUMBER	LOC.	REVISION NUMBER
334499	0000	41	D1	0008		PA

DATE: 2007/06/21 – 2:44pm
PATH: J:\334499 – Miramar Doris North\41 – Civil Engineering\41DK – Sketches–Drawings\\Rock Drain Detail.dwg

Appendix A5 TYPICAL ROCK DRAIN FOR ROADS



DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
				A	DRAFT			

REFERENCE DRAWINGS — REVISIONS — PROFESSIONAL ENGINEERS STAMP

SRK Consulting
Engineers and Scientists
Vancouver

DESIGN: AT	DRAWN: VY	REVIEWED: EMR
CHECKED: AT	APPROVED: EMR	DATE: June 2007

FILE NAME: Ventilation Raise.dwg

MIRAMAR HOPE BAY LTD.

DORIS NORTH PROJECT

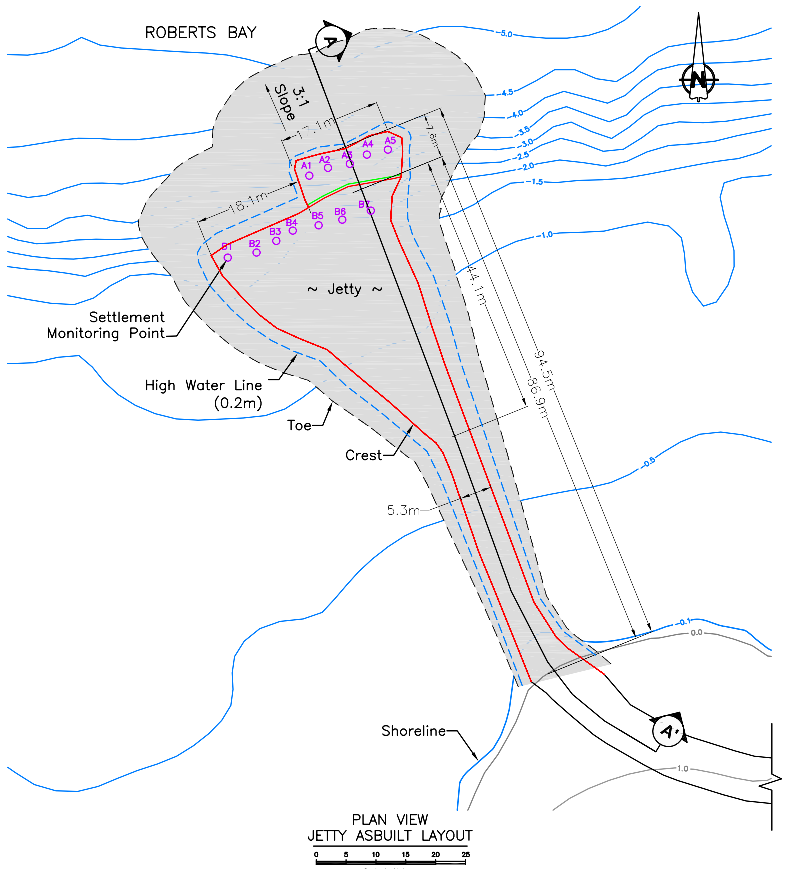
SRK JOB NO.: 1CM014.011

Doris North Project

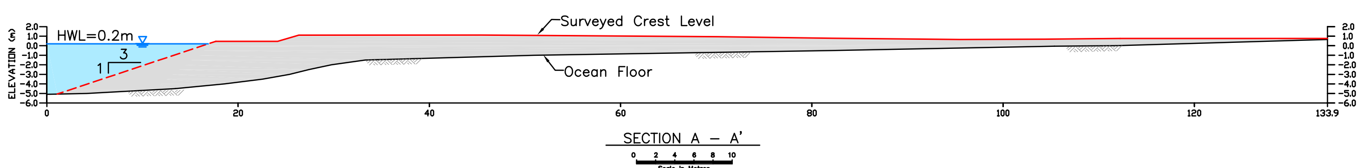
DRAWING TITLE:
Proposed Ventilation Raise
Access Road Layout

DRAWING NO.: - | SHEET: - | REVISION NO.: A

Appendix A6 VENTILATION RAISE ACCESS ROAD



PLAN VIEW
JETTY ASBUILT LAYOUT



SECTION A – A'

Legend:

- Settlement Monitoring Points
- Surveyed Crest As–Built
- Projected High Water Line
- Projected Toe 3H:1V Slope

Notes:

1. Surficial survey was done by Sub–Arctic Surveyor on July 29, 2007 and data was provided by SNC Lavalin.
2. The Bathymetry was done by Golder Associates in Octotber 2006.
3. The topography contour data was provided by Miramar Hope Bay Limited from 2001.
4. Sub–marine and side slopes are based on engineering projection of the Jetty Settlement and overall equilibrium. Side slopes were not surveyed at the time of Figure issue.
5. Ongoing maintenance work is expected to be done on the Jetty and might change the geometry of the Jetty overtime that is not accounted in the engineering projection.
6. Side slopes are projected to have 3H:1V slope approaching equilibrium.

SRK Consulting
Engineers and Scientists
Vancouver B.C.

SRK JOB NO.: 1CM014.008
FILE NAME: Jetty As–built Plan and Sec.dwg

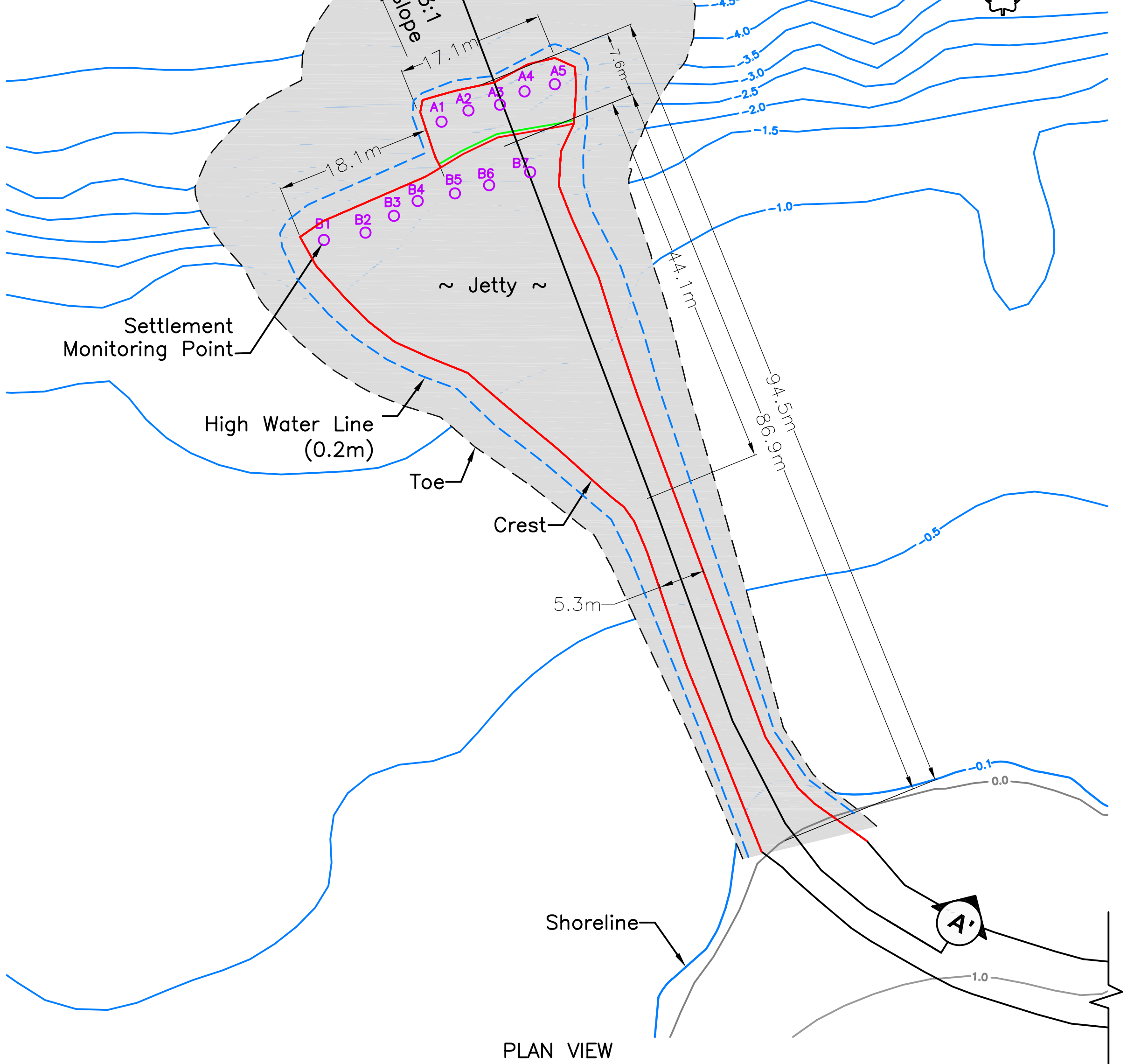
ROBERTS BAY CONSTRUCTION

DORIS NORTH PROJECT

Jetty As-Built

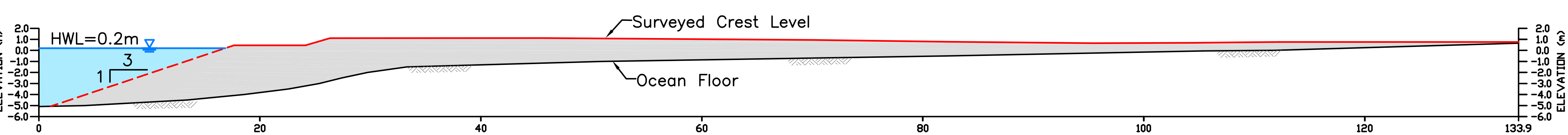
DATE: Sept. 07 | APPROVED: A.T. | FIGURE: A7

Z:\01_SITES\Doris North\1CM014.011_Doris North Construction\Roberts Bay Construction Site Folder\As-built Points\Jetty As-built Plan and Sec.dwg



PLAN VIEW
JETTY ASBUILT LAYOUT

0 5 10 15 20 25
Scale in Metres



SECTION A – A'

0 2 4 6 8 10
Scale in Metres

Projected H
Projected T

Notes:

1. Surficial survey w on July 29, 2007 Lavalin.
2. The Bathymetry v Octotber 2006.
3. The topography c Miramar Hope Bo
4. Sub–marine and engineering proje overall equilibrium at the time of F
5. Ongoing maintenc on the Jetty and the Jetty overtim engineering proje
6. Side slopes are approaching equi

TENAX **LBO SAMP**

Type: **220 - 330 - 440**

Bi-oriented geogrids

TENAX **LBO SAMP** are polypropylene geogrids especially designed for soil stabilization and reinforcement applications.
The **LBO SAMP** geogrids are manufactured from a unique process of extrusion and biaxial orientation to enhance their tensile properties. TENAX **LBO SAMP** features consistently high tensile strength and modulus, excellent resistance to construction damages and environmental exposure. Furthermore, the geometry of the TENAX **LBO SAMP** allows strong mechanical interlock with the soil being reinforced.

Typical applications

Base reinforcement; reduction of required structural fill; load distribution; reduction of mud pumping; subgrade stabilization; embankment stabilization; slope reinforcement; erosion control mattresses.

PHYSICAL CHARACTERISTICS	TEST METHOD	UNIT	DATA	NOTES
STRUCTURE			BI-ORIENTED GEOGRIDS	
MESH TYPE			RECTANGULAR APERTURES	
STANDARD COLOR			BLACK	
POLYMER TYPE			POLYPROPYLENE	
CARBON BLACK CONTENT	ASTM D1603		2.0%	
PACKAGING	ISO 10320		ROLLS IN POLYETHYLENE BAGS WITH I.D. LABEL	

DIMENSIONAL CHARACTERISTICS	TEST METHOD	UNIT	LBO 220 SAMP	LBO 330 SAMP	LBO 440 SAMP	NOTES
APERTURE SIZE MD		mm	41	40	34	b,d
APERTURE SIZE TD		mm	31	27	27	b,d
MASS PER UNIT AREA	ISO 9864	g/m²	250	370	640	b
ROLL WIDTH		m	4.0	4.0	4.0	b
ROLL LENGTH		m	100	75	50	b
ROLL DIAMETER		m	0.41	0.45	0.52	b
ROLL VOLUME		m³	0.69	0.81	1.10	b
GROSS ROLL WEIGHT		kg	107.0	118.0	135.0	b

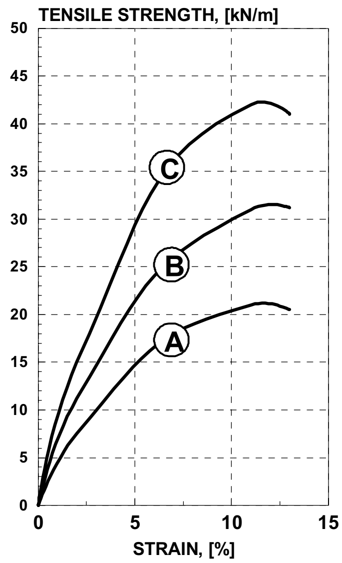
TECHNICAL CHARACTERISTICS	TEST METHOD	UNIT	LBO 220 SAMP		LBO 330 SAMP		LBO 440 SAMP		NOTES
			MD	TD	MD	TD	MD	TD	
STRENGTH AT 2% STRAIN	ISO 10319	kN/m	7.0	7.0	10.5	10.5	14.0	15.0	b,c,d
STRENGTH AT 5% STRAIN	ISO 10319	kN/m	14.0	14.0	21.0	21.0	28.0	30.0	b,c,d
PEAK TENSILE STRENGTH	ISO 10319	kN/m	20.0	20.0	30.0	30.0	40.0	40.0	a,c,d
YIELD POINT ELONGATION	ISO 10319	%	11.0	10.0	11.0	10.0	11.0	11.0	b,c,d

NOTES:
a) 95% lower confidence limit values, ISO 2602
b) Typical values
c) Tests performed using extensometers
d) MD: machine direction (longitudinal to the roll)
TD: transverse direction (across roll width)

TENAX®
Man, Technology, Environment.

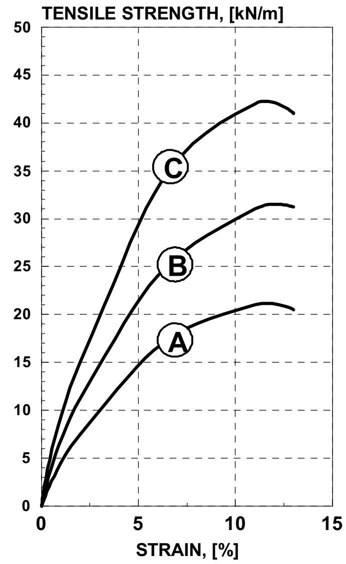
Typical Tensile Characteristics

TENAX LBO SAMP



MD

TENAX LBO SAMP



TD

GEOGRID TYPE:

A = TENAX **LBO 220 SAMP**
B = TENAX **LBO 330 SAMP**
C = TENAX **LBO 440 SAMP**

0799-CPD-25

The TENAX Laboratory has been created in 1980 and has been continuously improved with the purpose of assuring unequalled technical development of the products and accurate Quality Control,

The TENAX Laboratory can perform mechanical, hydraulic and durability tests, according to the most important international standards like ISO, CEN, ASTM, DIN, BSI, UNI.

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Web Site: www.tenax.net

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APPENDIX B

Photographic Plates of Proposed Watercourse Crossing Locations

Plate B1. *21 July 2004.* Downstream view of Stream Crossing #1. Channel was 20-30 cm wide and dry.

Plate B2. *24 August 2004.* Downstream view of Stream Crossing #1 from east side of proposed road. Stream channel was dry.

Plate B3. *21 July 2004.* Downstream view of Stream Crossing #2. Channel was approximately 20 cm wide and 10 cm deep, with flowing water present.

Plate B4. *24 August 2004.* Upstream view of Stream Crossing #2 from west side of proposed road. Channel was dry.

Plate B5. *20 July 2004.* Upstream view of Stream Crossing #3. Channel was approximately 20 cm wide and 5 cm deep.

Plate B6. *24 August 2004.* Downstream view of Stream Crossing #3.

Plate B7. *20 July 2004.* Upstream view of Stream Crossing #4. Channel was approximately 20 cm wide and 10 cm deep and had stagnant water.

Plate B8. *24 August 2004.* Upstream view of Stream Crossing #4.

Plate B9. *21 June 2004.* Downstream view of Stream Crossing #5. The majority of the channel was dry in both June and July.

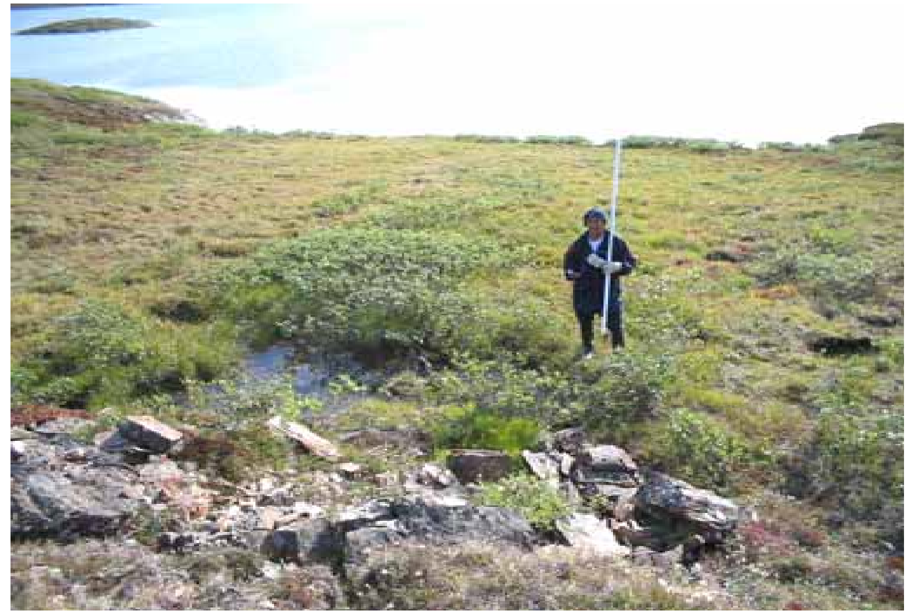


Plate B10. *24 August 2004.* Downstream view of Stream Crossing #5. The majority of the channel was dry.

Plate B11. *21 June 2004.* Downstream view of Stream Crossing #6. The channel had flowing water in June, but was dry in July and August.

Plate B12. *24 August 2004.* Downstream view of Stream Crossing #6. Channel was dry.

Plate B13. *21 July 2004.* Downstream view of Stream Crossing #7. There was no defined channel and no flowing water in either June or July.

Plate B14. *24 August 2004.* Downstream view of Stream Crossing #7. There was no defined channel and no flowing water.

Plate B15. *21 June 2004.* Upstream view of Stream Crossing #8. Flowing water was present in the channel during June, but dry in July and August.

Plate B16. *24 August 2004.* Downstream view of Stream Crossing #8. The stream channel was dry.

Plate B17. *21 July 2004.* Downstream view of Stream Crossing #9. Stream channel was undefined and dry.

Plate B18. *24 August 2004.* South view over Stream Crossing #9. Channel was dry.

Plate B19. *13 July 2007.* Downstream view of vent raise access road watercourse crossing #1 at UTM 433703 m E, 7559310 m N. The watercourse was a vegetated swale with no flowing water.

Plate B20. *13 July 2007.* Downstream view of vent raise access road watercourse crossing #2 at UTM 433773 m E, 7559486 m N. The watercourse was a vegetated swale with no flowing water.

Plate B21. *13 July 2007.* Downstream view of vent raise access road watercourse crossing #3 at UTM 433820 m E, 7559629 m N. The watercourse was a vegetated swale with no flowing water.

APPENDIX C

Habitat Suitability Indices

Table C1 Habitat suitability indices and descriptions developed to describe fish habitat for lake trout.

	SPAWNING					NURSERY				
Physical habitat	**Excellent**	**Above Average**	**Average**	**Below Average**	**Unsuitable**	**Excellent**	**Above Average**	**Average**	**Below Average**	**Unsuitable**
HSI value	1.0	0.75	0.5	0.25	0	1.0	0.75	0.5	0.25	0
Substratum type	Bo dominant	Bo or C	Bo or C	Bo/C with G	Bd or CS	Bo dominant	Bo or C	Bo or C	Bo/C with G	Bd or CS
Substratum size	20-50 cm	10-50 cm	5 - 60 cm	>1 cm	<1 cm	20-50 cm	10-50 cm	5 - 60 cm	>1 cm	<1 cm
Minimum depth	2 m	2 m	1.5 m	<3 m	<3 m	2 m	2 m	1.5 m	<3 m	<3 m
Maximum depth	>4 m	>3 m	>1.5 m	>1.5 m	>1.5 m	>4 m	>3 m	>1.5 m	>1.5 m	>1.5 m
Slope of rock substratum	30 - 50º	30 - 50º	15 - 50º	>0º	>0º	30 - 50º	30 - 50º	15 - 50º	>0º	>0º
Substratum shape	angular/fractured	angular	angular or round	angular or round	-	angular/fractured	angular	angular or round	angular or round	-
Substratum cleanliness	clean	clean	some silt	silt/algae covered	-	clean	clean	some silt	silt/algae covered	-
Depth of interstitial spaces	>30 cm	>20 cm	>10 cm	>3 cm	-	>30 cm	>20 cm	>10 cm	>3 cm	-
Exposure to predominant wind and wave action	full exposure	full exposure	moderate exposure	low exposure	-	full exposure	full exposure	moderate exposure	low exposure	-
Proximity to deep water areas	directly adjacent	-	-	-	not adjacent	directly adjacent	-	-	-	not adjacent
	REARING					FORAGING				
Physical habitat	**Excellent**	**Above Average**	**Average**	**Below Average**	**Unsuitable**	**Excellent**	**Above Average**	**Average**	**Below Average**	**Unsuitable**
HSI Value	1.0	0.75	0.5	0.25	-	1.0	0.75	0.5	0.25	0
Substratum type	Bo/C	C		S/CS	-	Bo/C	-	G/S and pelagic	CS/Bd	-
Substratum size	>6.5 cm	>6.5 cm	<6.5 cm	0	-	25 - 6.5 cm	-	-	-	-
Minimum depth	-	-	variable	variable	-	-	-	-		-
Maximum depth	<10 m	<10 m	variable	variable	-	<10 m	-	<30 m	>30 m	-
Slope of rock substratum	-	-	25º	0º	-	-	-	-	-	-
Substratum shape	round/angular	round/angular	round	100% fines	-	angular or round	-	-	-	-
Substratum cleanliness	-	-	-	-	-	-	-	-	-	-
Depth of interstitial spaces	-	-	-	-	-	-	-	-	-	-
Exposure to predominant wind and wave action	low exposure	low exposure	moderate exposure	full exposure	-	-	-	-	-	-
Proximity to deep water areas	directly adjacent	-	-	not adjacent	-	-	-	-	-	-

Notes: HSI = habitat suitability index; cm = centimetres; m = metres; Bd = Bedrock, Bo = boulder (>25 cm), C = cobble (>6.5 cm), R = rubble (>6.5 cm, angular), G = gravel (>0.2 cm), S = sand (>0.06 mm) and CS = clay/silt (<0.06 mm).

Adapted from Diavik 1998b and DeBeers 2002.

Table C2 Habitat suitability indices and descriptions developed to describe fish habitat for Arctic char.

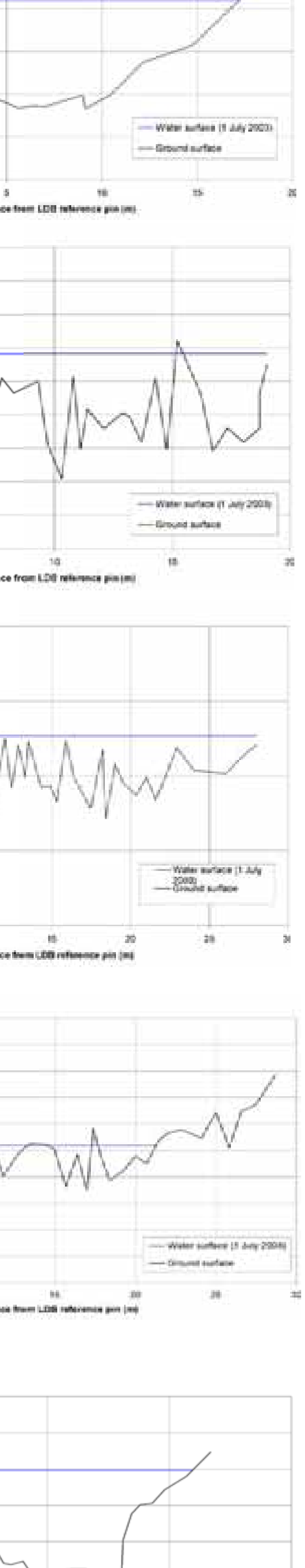
	SPAWNING					NURSERY				
Physical habitat	**Excellent**	**Above Average**	**Average**	**Below Average**	**Unsuitable**	**Excellent**	**Above Average**	**Average**	**Below Average**	**Unsuitable**
HSI value	1.0	0.75	0.5	0.25	0	1.0	0.75	0.5	0.25	0
Substratum type	G dominant	G and C	G or C	Bo/C with G	Bd or CS	G dominant	G and C	G or C	Bo/C with G	Bd or CS
Minimum depth	2 m	2 m	<2 m	<2 m	<2 m	2 m	2 m	1.5 m	<2 m	<2 m
Maximum depth	4.5 m	3 m	3 m	2 m	<2 m	4.5 m	3 m	>1.5 m	>1 m	>1 m
Substratum shape	round	round	angular or round	angular or round	-	round	round	angular or round	angular or round	-
Substratum cleanliness	clean	clean	some silt	silt/algae covered	-	clean	clean	some silt	silt/algae covered	-
Exposure to predominant wind and wave action	full exposure	full exposure	moderate exposure	low exposure	-	full exposure	full exposure	moderate exposure	low exposure	-
Proximity to deep water areas	directly adjacent	-	-	-	not adjacent	directly adjacent	-	-	-	not adjacent
	REARING					**FORAGING**				
Physical habitat	**Excellent**	**Above Average**	**Average**	**Below Average**	**Unsuitable**	**Excellent**	**Above Average**	**Average**	**Below Average**	**Unsuitable**
HSI Value	1.0	0.75	0.5	0.25	-	1.0	0.75	0.5	0.25	0
Substratum type	Bo/C	C		S/CS	-	Bo/C	-	G/S and pelagic	CS/Bd	-
Minimum depth	-	-	variable	variable	-	-	-	-		-
Maximum depth	<10 m	<10 m	variable	variable	-	<10 m	-	<30 m	>30 m	-
Substratum shape	round/angular	round/angular	round	100% fines	-	angular or round	-	-	-	-
Substratum cleanliness	-	-	-	-	-	-	-	-	-	-
Exposure to predominant wind and wave action	low exposure	low exposure	moderate exposure	full exposure	-	-	-	-	-	-
Proximity to deep water areas	directly adjacent	-	-	not adjacent	-	-	-	-	-	-

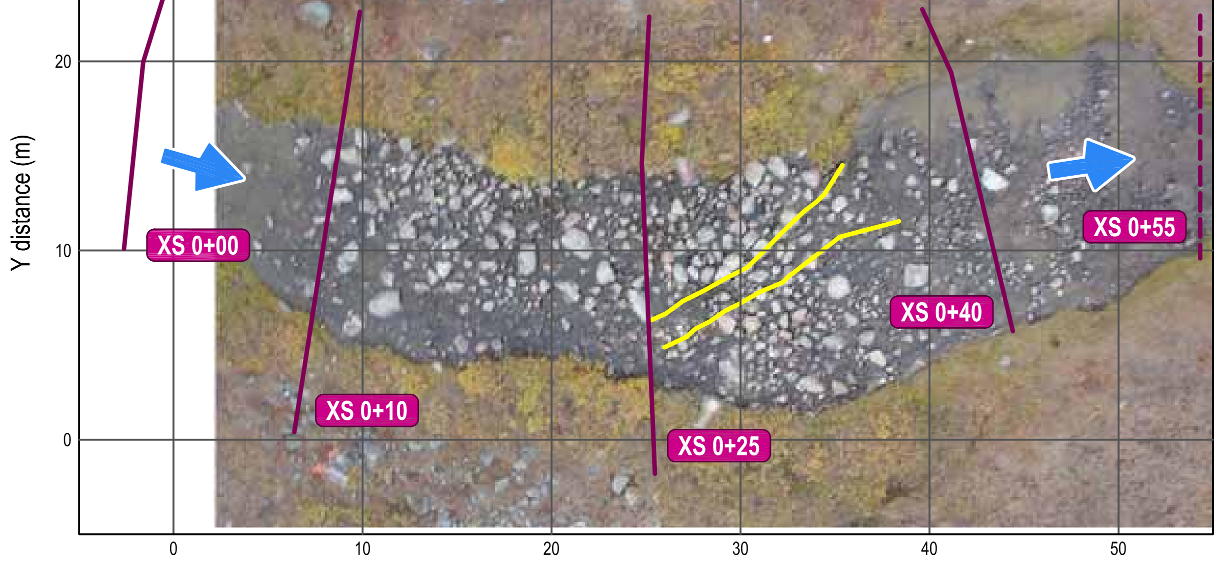
Notes: HSI = habitat suitability index; cm = centimetres; m = metres; Bd = Bedrock, Bo = boulder (>25 cm), C = cobble (>6.5 cm), R = rubble (>6.5 cm, angular), G = gravel (>0.2 cm), S = sand (>0.06 mm) and CS = clay/silt (<0.06 mm).

Adapted from Diavik 1998b and DeBeers 2002.

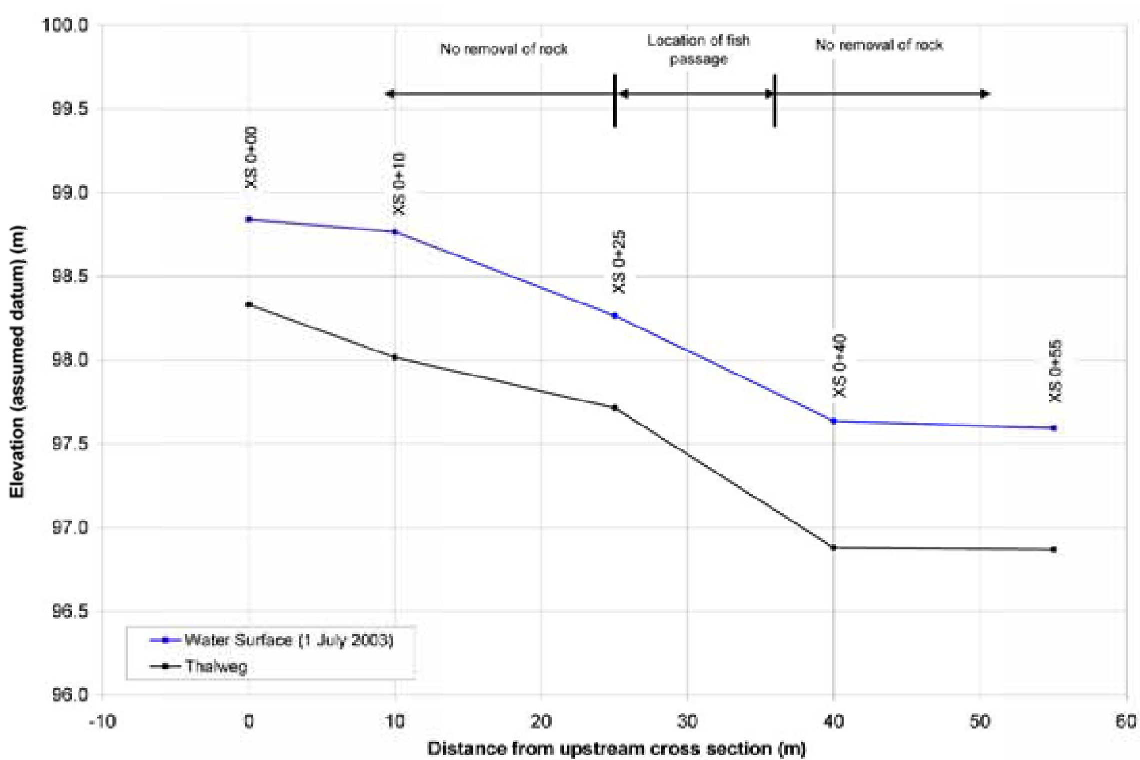
APPENDIX D

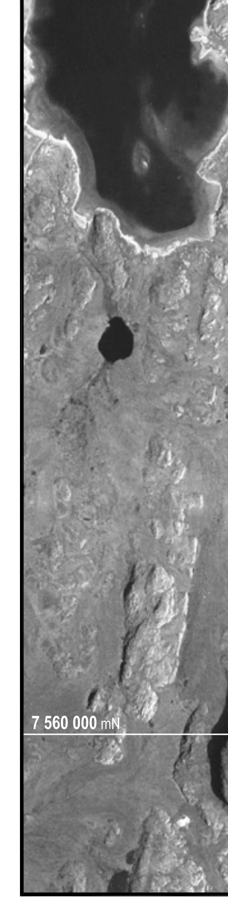
Detailed Design Drawings





Low Water Fish Passage





LEGEND

- Low water
- Cross secti
- Estimated
- Direction o

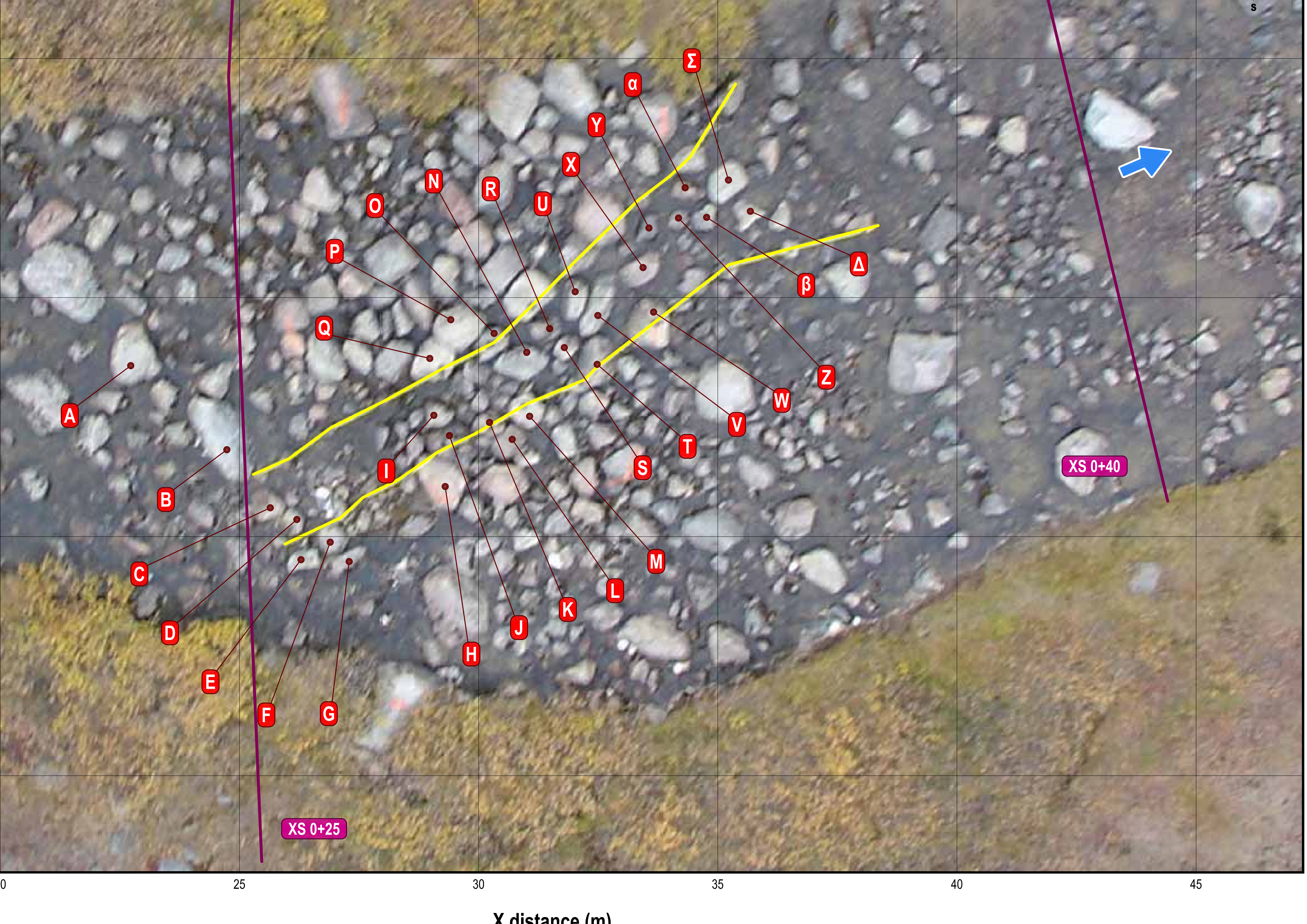
NOTE

1. See Sheet 2 (Figur

Title

F

Low W

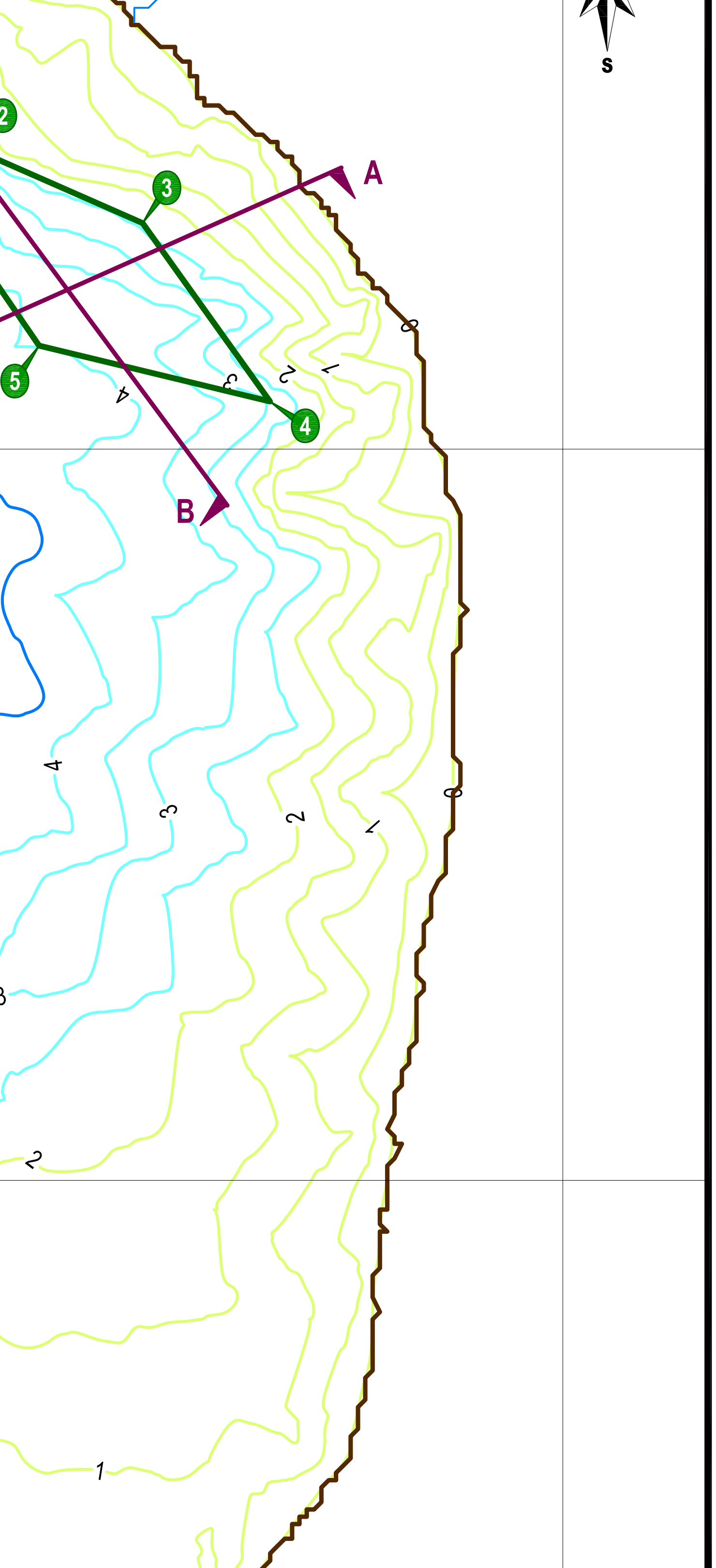


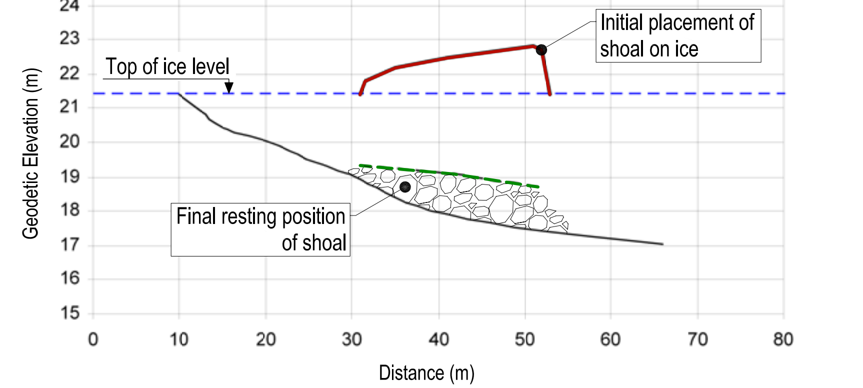
Low Water Fish Passage

al

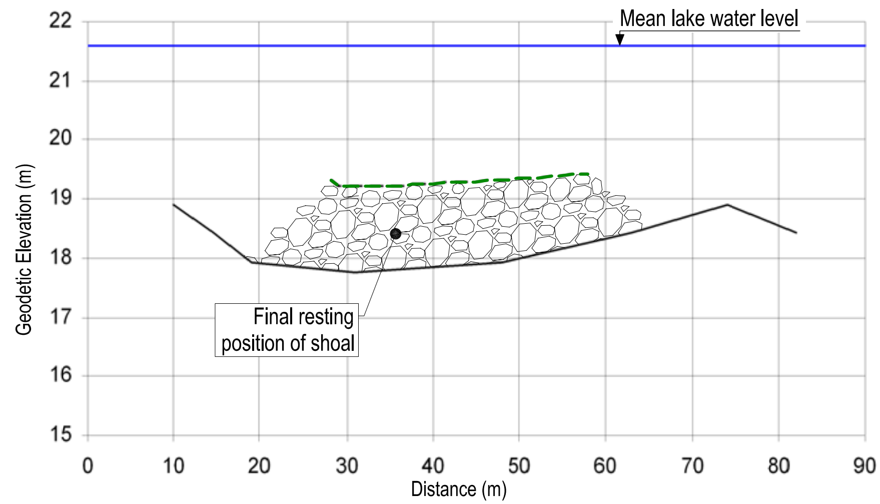
...ld and the construction supervised by a qualified person

Title





Section A-A'



Section B-B'

Site 1

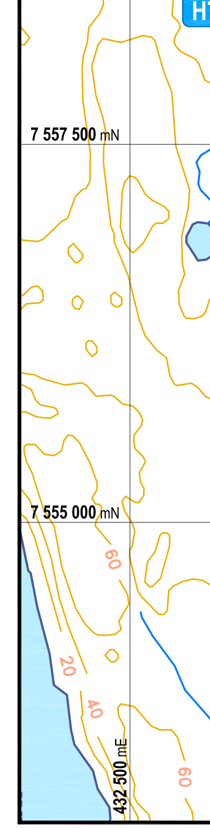
Point	Easting (m)	Northing (m)
1	434 113	7 558 936
2	434 120	7 558 940
3	434 142	7 558 930
4	434 159	7 558 906
5	434 128	7 558 914

Quantities table

Site	Rock riprap (m^3)
1	617

NOTES

1. Shoals shall be laid out in field by a qualified person.
2. Shoals shall be constructed of clean, competent, certified non-acid generating rock.
3. Rock shall meet the specifications for riprap as specified in "Technical Specification for Tailings Containment Area and Surface Infrastructure Components" (SRK 2006).
4. Hauling of material and construction shall take place when there is sufficient ice cover on Doris Lake to support estimated loads.
5. Contractor shall consult with a qualified ice engineer to determine bearing capacity of lake ice cover for transport of material.
6. Rock shall be stockpiled on ice cover to mimic lake bed contours.
7. Top elevation of the shoal shall not be higher than 19.60 m when in its final



LEGEND

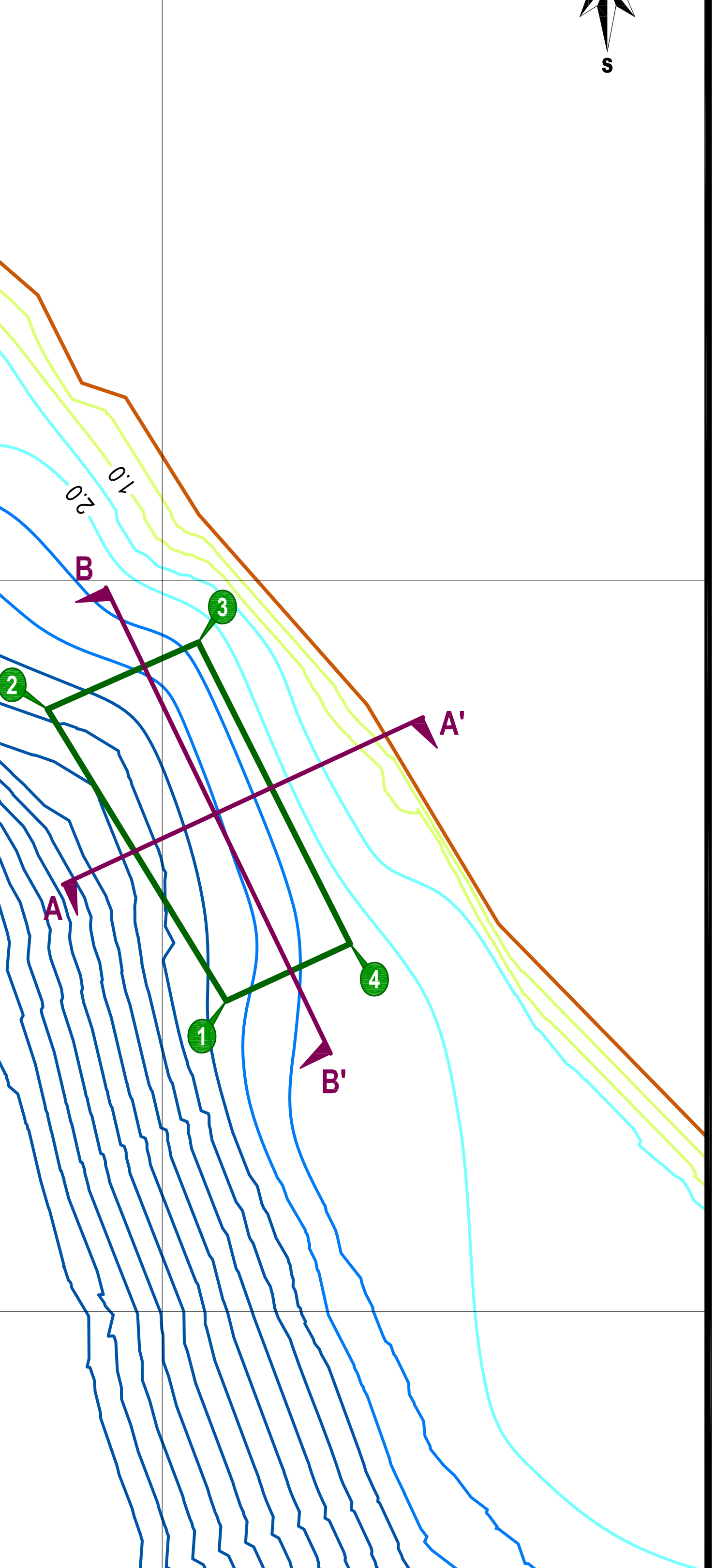
- Extent of s
- Shoreline
- 0.5 - 2.0 m
- 2.0 - 4.0 m
- 4.0 - 5.0 m

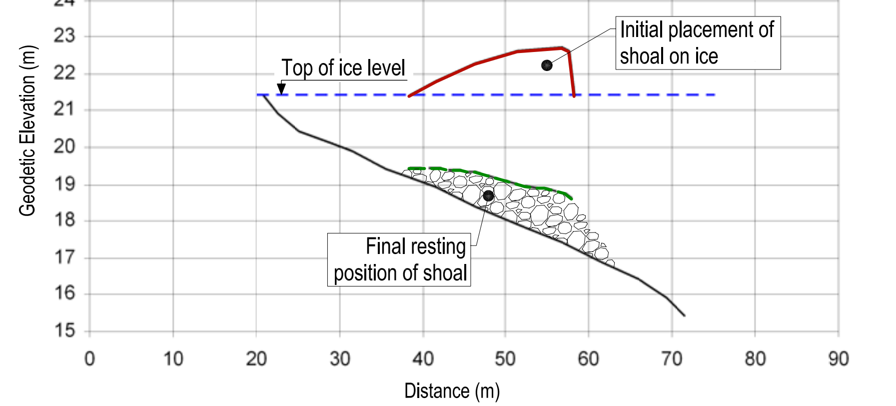
Bathymetric contour i

Reference: Transects for b
SRK Consulting
Containment A

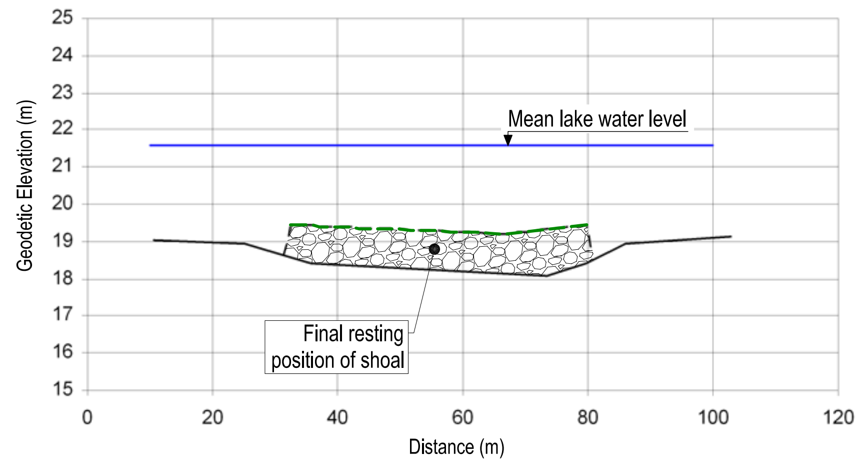
Title

Doris L





Section A-A'



Section B-B'

Site 2

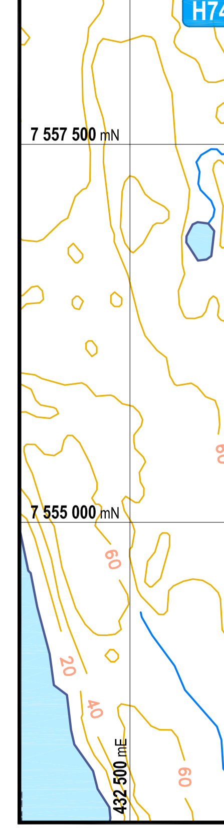
Point	Easting (m)	Northing (m)
1	434 608	7 556 142
2	434 584	7 556 182
3	434 604	7 556 191
4	434 625	7 556 150

Quantities table

Site	Rock riprap (m^3)
1	829

NOTES

1. Shoals shall be laid out in field by a qualified person.
2. Shoals shall be constructed of clean, competent, certified non-acid generating rock.
3. Rock shall meet the specifications for riprap as specified in "Technical Specification for Tailings Containment Area and Surface Infrastructure Components" (SRK 2006).
4. Hauling of material and construction shall take place when there is sufficient ice cover on Doris Lake to support estimated loads.
5. Contractor shall consult with a qualified ice engineer to determine bearing capacity of lake ice cover for transport of material.
6. Rock shall be stockpiled on ice cover to mimic lake bed contours.
7. Top elevation of the shoal shall not be higher than 19.60 m when in its final



LEGEND

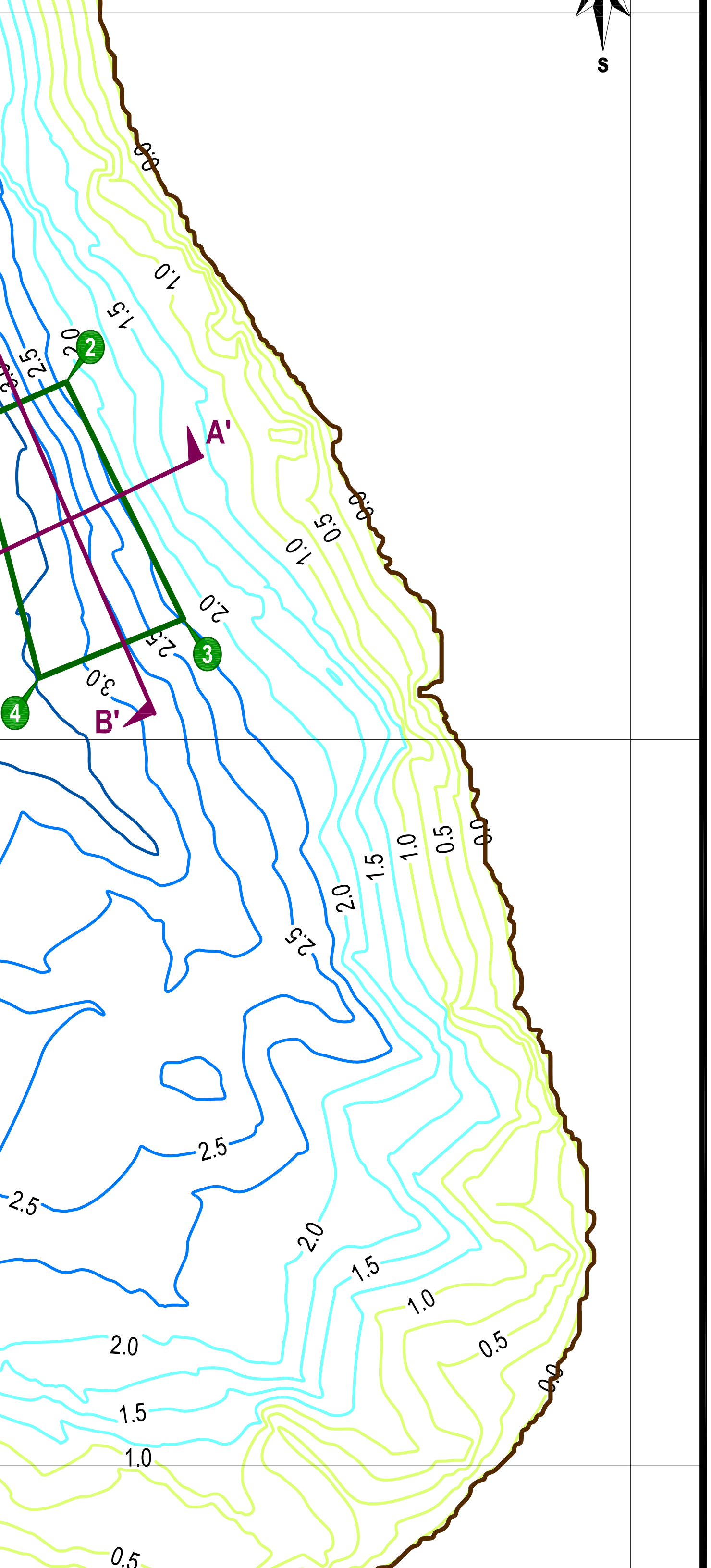
- Extent of s
- Shoreline
- 0.5 - 2.0 m
- 2.0 - 4.0 m
- 4.0 - 8.0 m

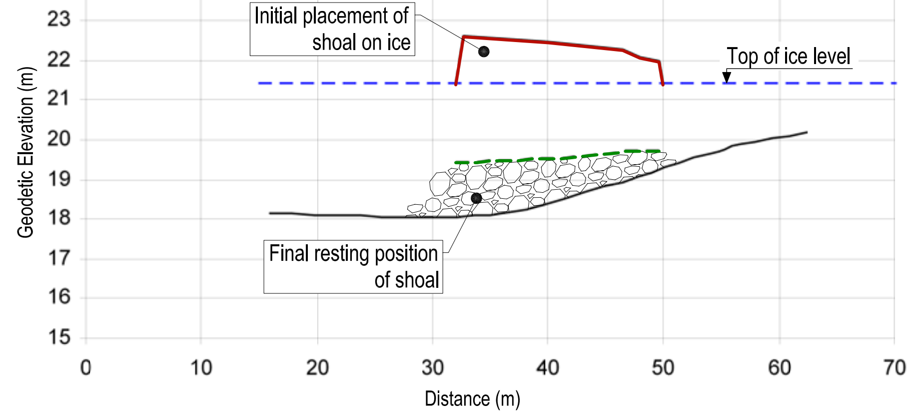
Bathymetric contour i

Reference: Transects for b
SRK Consultin
Containment A

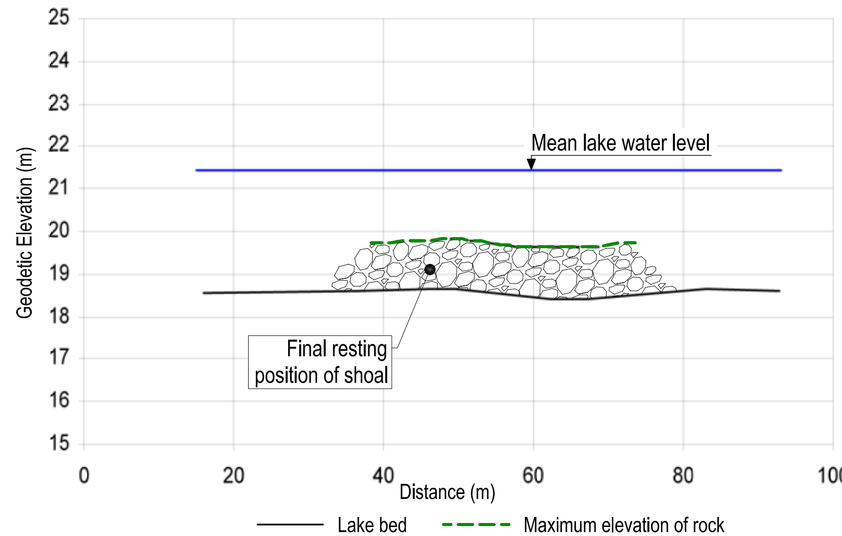
Title

Doris L





Section A-A'



Section B-B'

Site 3

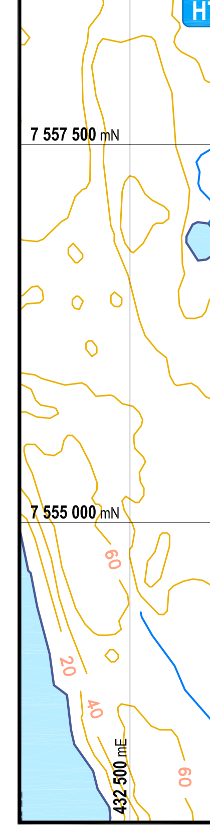
Point	Easting (m)	Northing (m)
1	434 709	7 554 643
2	434 722	7 554 649
3	434 738	7 554 616
4	434 718	7 554 608

Quantities table

Site	Rock riprap (m³)
1	558

NOTES

1. Shoals shall be laid out in field by a qualified person.
2. Shoals shall be constructed of clean, competent, certified non-acid generating rock.
3. Rock shall meet the specifications for riprap as specified in "Technical Specification for Tailings Containment Area and Surface Infrastructure Components" (SRK 2006).
4. Hauling of material and construction shall take place when there is sufficient ice cover on Doris Lake to support estimated loads.
5. Contractor shall consult with a qualified ice engineer to determine bearing capacity of lake ice cover for transport of material.
6. Rock shall be stockpiled on ice cover to mimic lake bed contours.
7. Top elevation of the shoal shall not be higher than 19.60 m when in its final



LEGEND

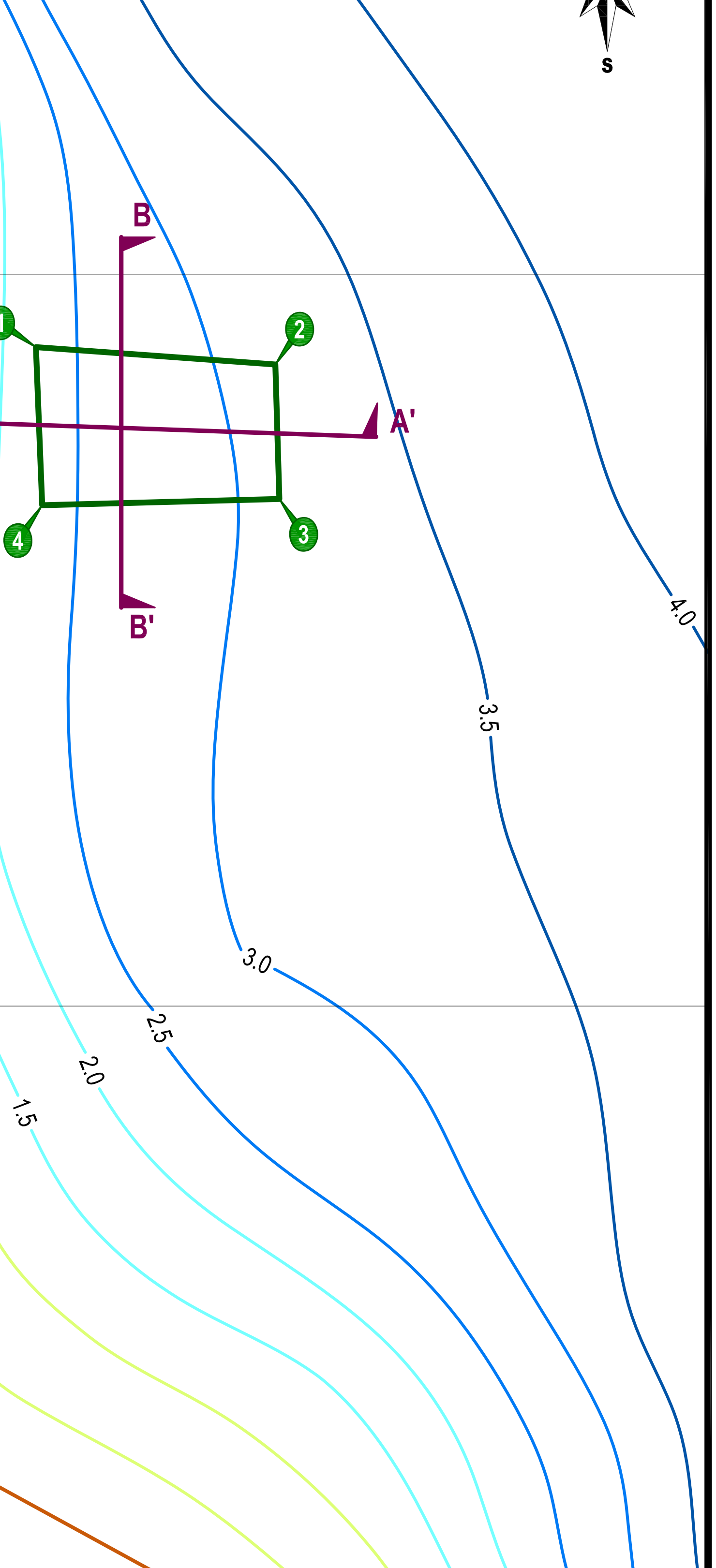
- Extent of s
- Shoreline
- 0.5 - 2.0 m
- 2.0 - 4.0 m
- 4.0 - 5.0 m

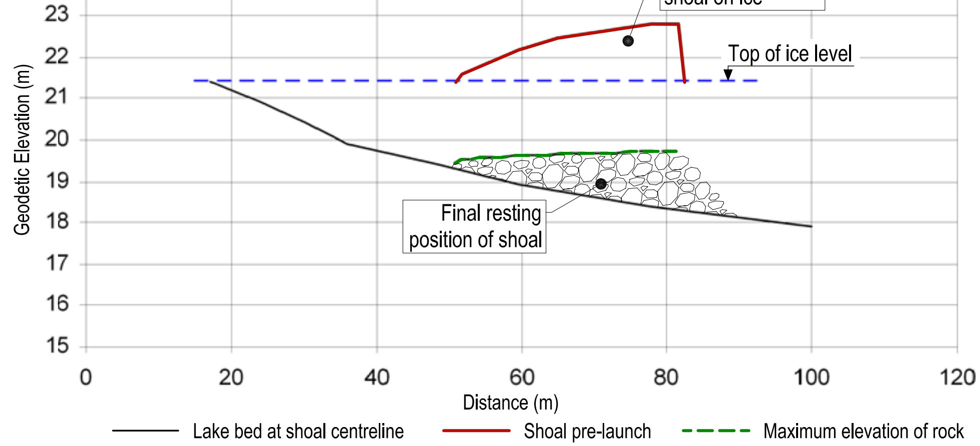
Bathymetric contour i

Reference: Transects for b
SRK Consulting
Containment A

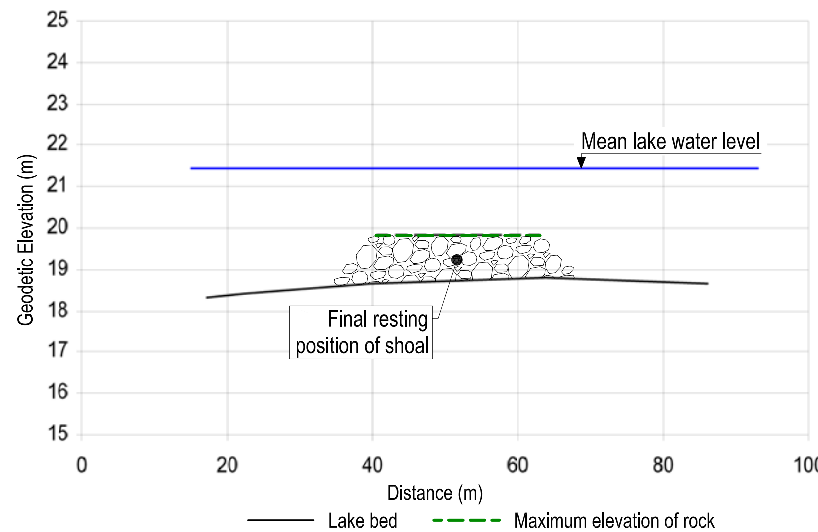
Title

Doris L





Section A-A'



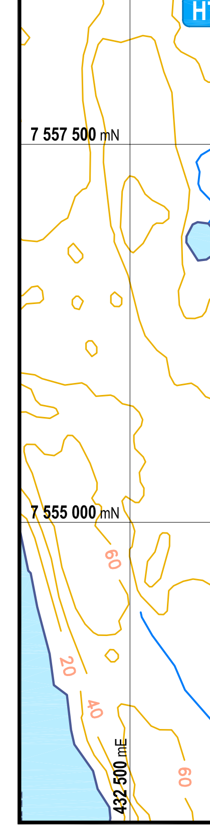
Section B-B'

Site 4		
Point	Easting (m)	Northing (m)
1	434 205	7 554 690
2	434 238	7 554 687
3	434 239	7 554 669
4	434 206	7 554 668

Quantities table	
Site	Rock riprap (m^3)
1	585

NOTES

1. Shoals shall be laid out in field by a qualified person.
2. Shoals shall be constructed of clean, competent, certified non-acid generating rock.
3. Rock shall meet the specifications for riprap as specified in "Technical Specification for Tailings Containment Area and Surface Infrastructure Components" (SRK 2006).
4. Hauling of material and construction shall take place when there is sufficient ice cover on Doris Lake to support estimated loads.
5. Contractor shall consult with a qualified ice engineer to determine bearing capacity of lake ice cover for transport of material.
6. Rock shall be stockpiled on ice cover to mimic lake bed contours.
7. Top elevation of the shoal shall not be higher than 19.60 m when in its final



LEGEND

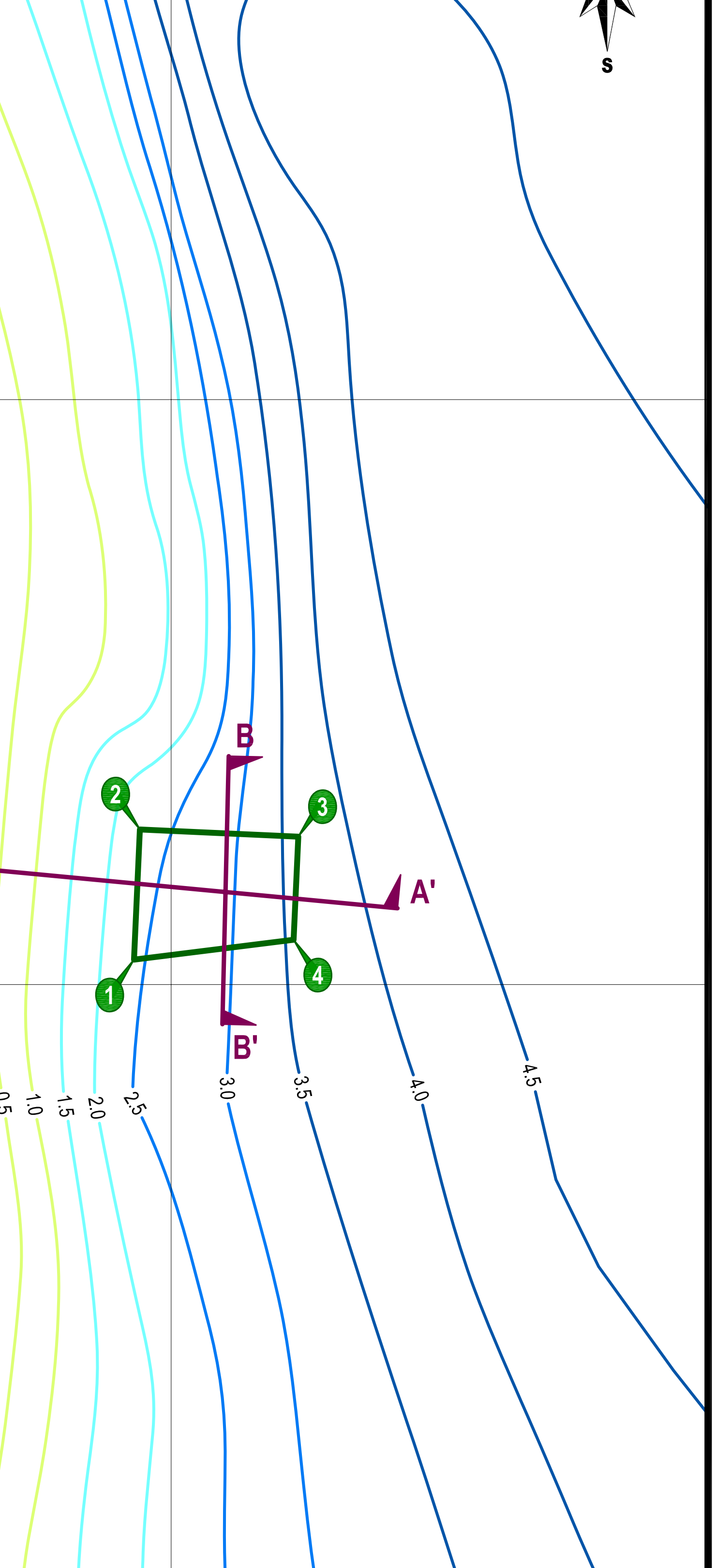
- Extent of s
- Shoreline
- 0.5 - 2.0 m
- 2.0 - 4.0 m
- 4.0 - 5.0 m

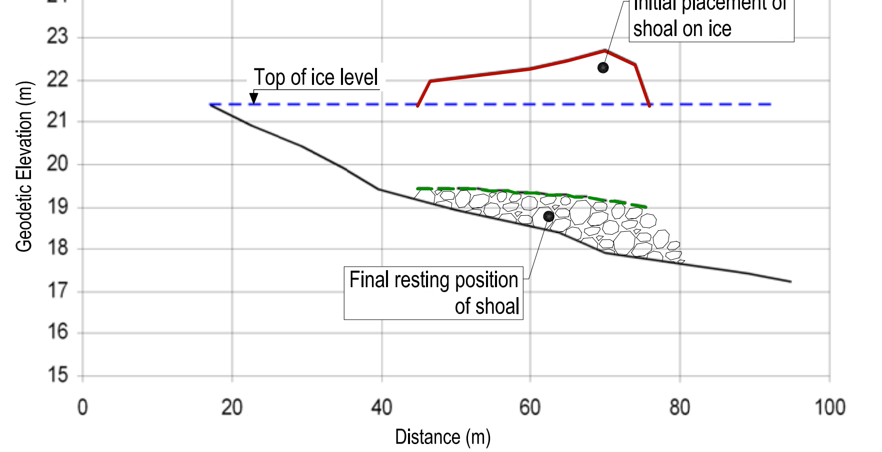
Bathymetric contour i

Reference: Transects for b SRK Consulting Containment A

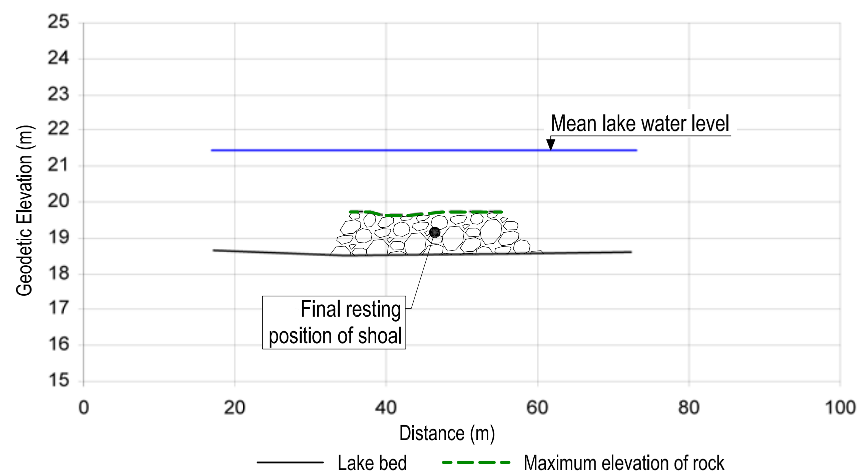
Title

Doris L





Section A-A'



Section B-B'

Site 5

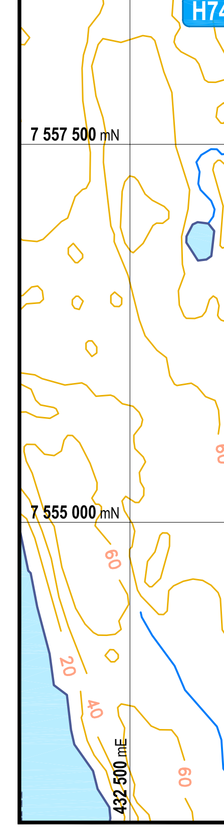
Point	Easting (m)	Northing (m)
1	434 093	7 555 104
2	434 094	7 555 126
3	434 121	7 555 125
4	434 120	7 555 107

Quantities table

Site	Rock riprap (m^3)
1	578

NOTES

1. Shoals shall be laid out in field by a qualified person.
2. Shoals shall be constructed of clean, competent, certified non-acid generating rock.
3. Rock shall meet the specifications for riprap as specified in "Technical Specification for Tailings Containment Area and Surface Infrastructure Components" (SRK 2006).
4. Hauling of material and construction shall take place when there is sufficient ice cover on Doris Lake to support estimated loads.
5. Contractor shall consult with a qualified ice engineer to determine bearing capacity of lake ice cover for transport of material.
6. Rock shall be stockpiled on ice cover to mimic lake bed contours.
7. Top elevation of the shoal shall not be higher than 19.60 m when in its final



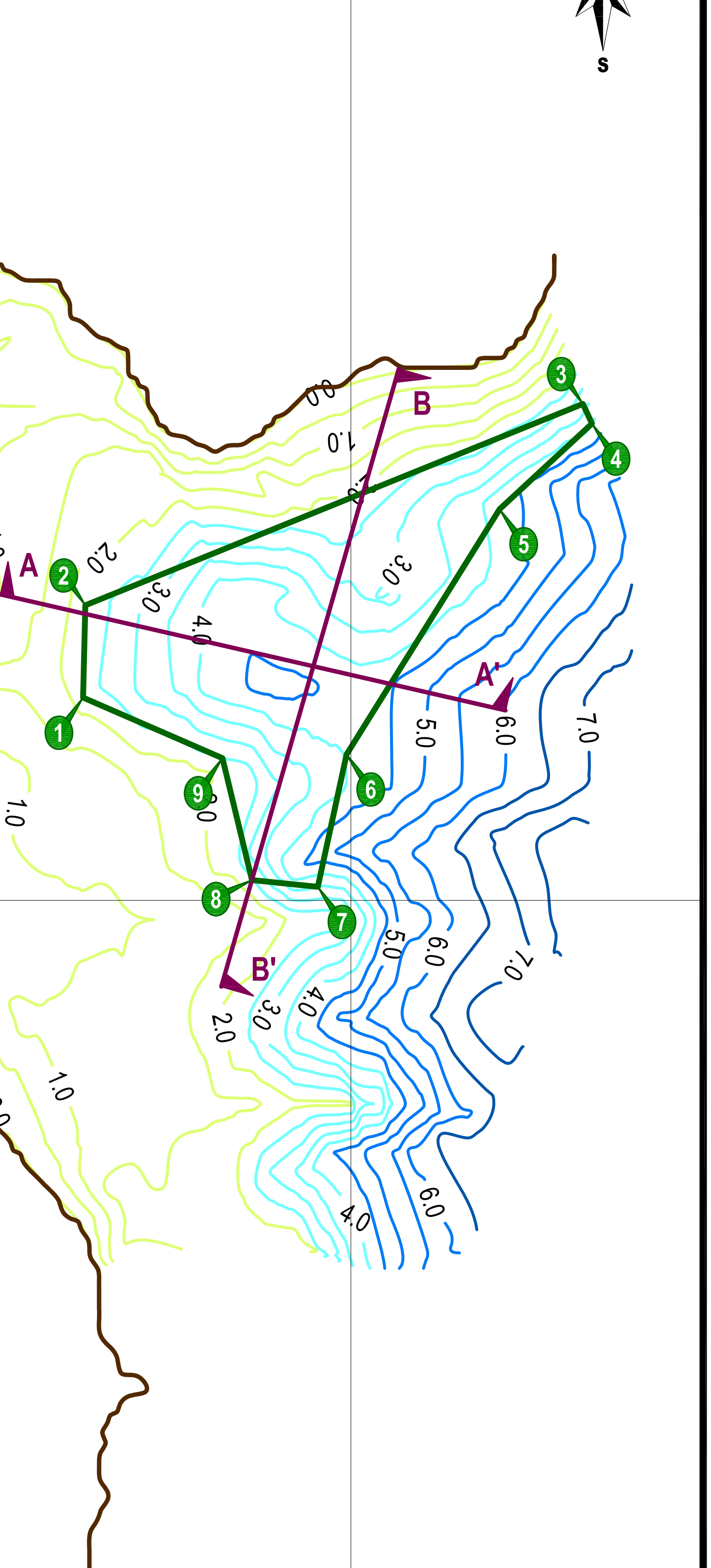
LEGEND

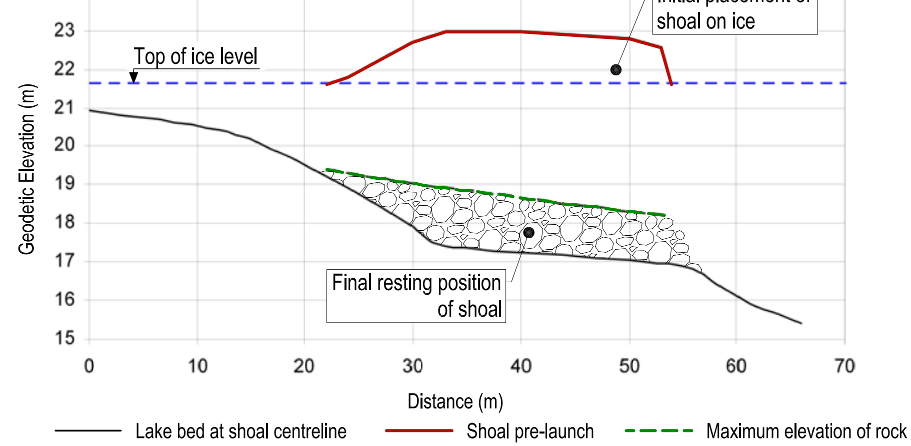
Extent of s
Shoreline
0.5 - 2.0 m
2.0 - 4.0 m
4.0 - 5.0 m

Bathymetric contour i

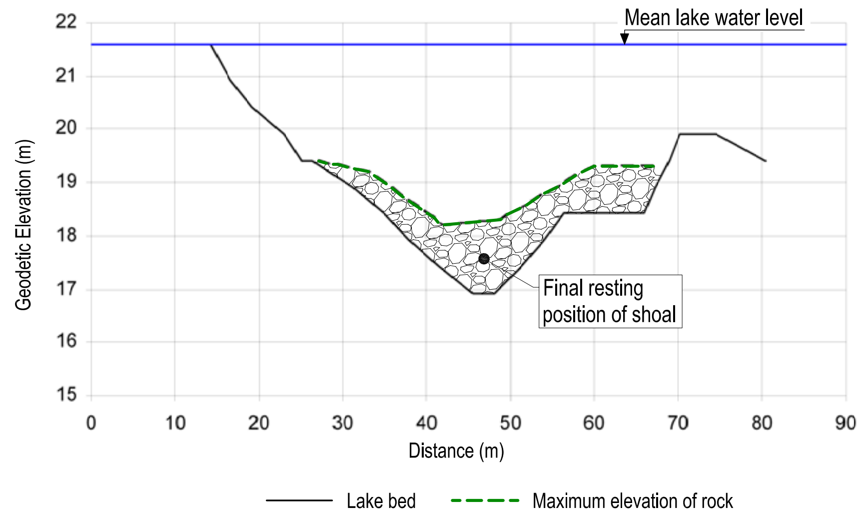
Reference: Transects for b
SRK Consulting
Containment A

Title
Doris





Section A-A'



Section B-B'

Site 6

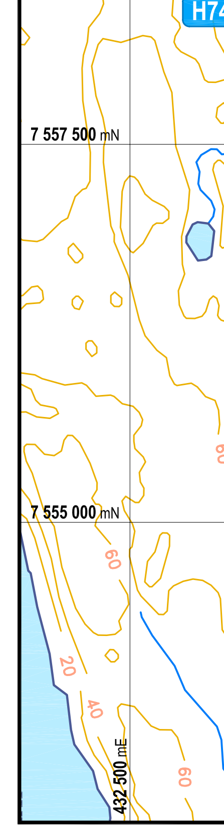
Point	Easting (m)	Northing (m)
1	433 572	7 558 320
2	433 572	7 558 330
3	433 623	7 558 351
4	433 624	7 558 349
5	433 615	7 558 340
6	433 599	7 558 315
7	433 596	7 558 301
8	433 596	7 558 301
9	433 586	7 558 314

Quantities table

Site	Rock riprap (m^3)
1	925

NOTES

1. Shoals shall be laid out in field by a qualified person.
2. Shoals shall be constructed of clean, competent, certified non-acid generating rock.
3. Rock shall meet the specifications for riprap as specified in "Technical Specification for Tailings Containment Area and Surface Infrastructure Components" (SRK 2006).
4. Hauling of material and construction shall take place when there is sufficient ice cover on Doris Lake to support estimated loads.
5. Contractor shall consult with a qualified ice engineer to determine bearing capacity of lake ice cover for transport of material.
6. Rock shall be stockpiled on ice cover to mimic lake bed contours.
7. Top elevation of the shoal shall not be higher than 19.60 m when in its final



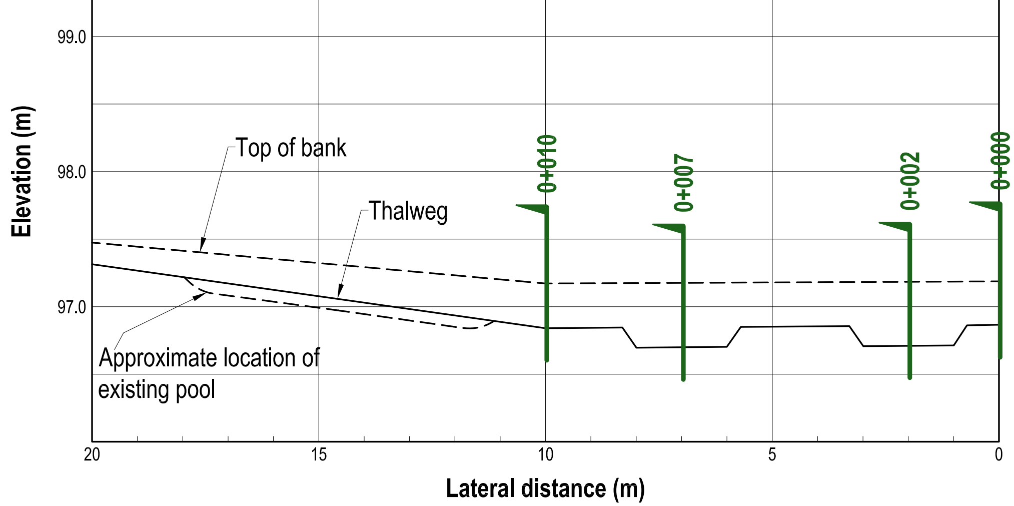
LEGEND

Extent of s
Shoreline
0.5 - 2.0 m
2.0 - 4.0 m
4.0 - 5.0 m

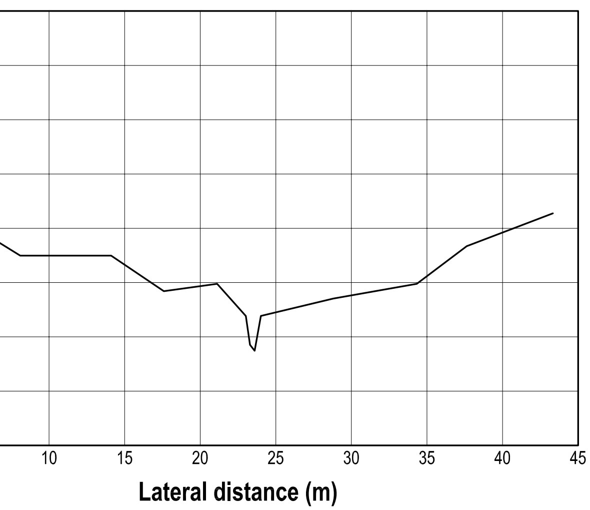
Bathymetric contour i

Reference: Transects for b
SRK Consulting
Containment A

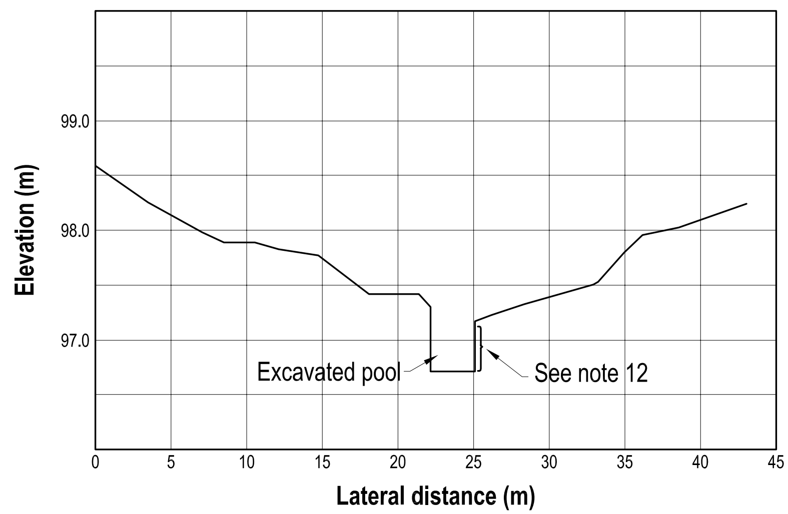
Title
Doris L



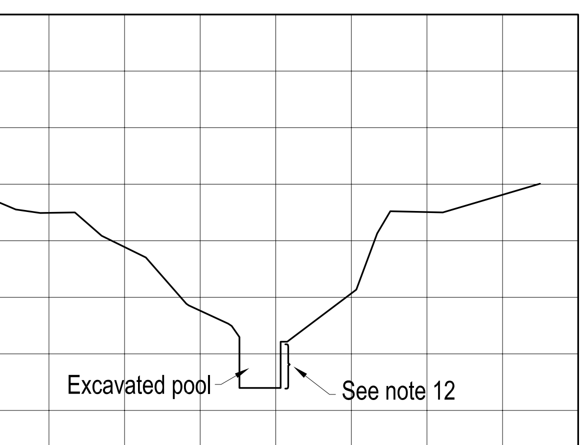
Detail A

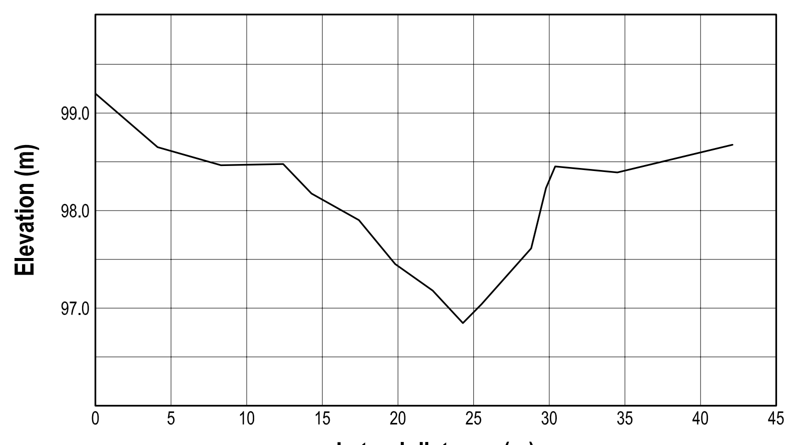


Section 0+000



Section 0+002





4. Pools shall typically
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6. Pools shall be excav
7. Pools shall be excav
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10. Pools shall be exca
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11. Excavated material
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12. Constructed pools a
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constructed pools.

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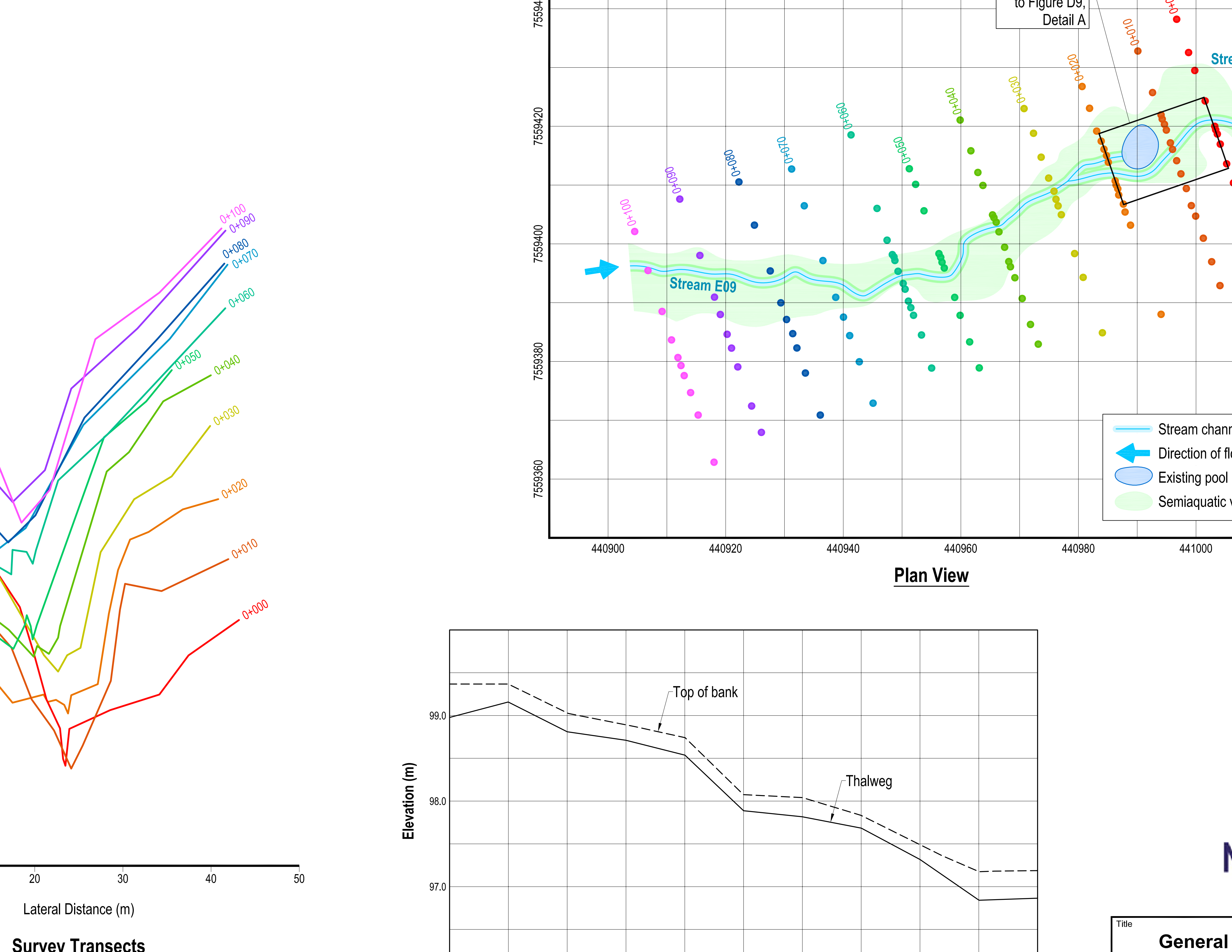
Title
Detail



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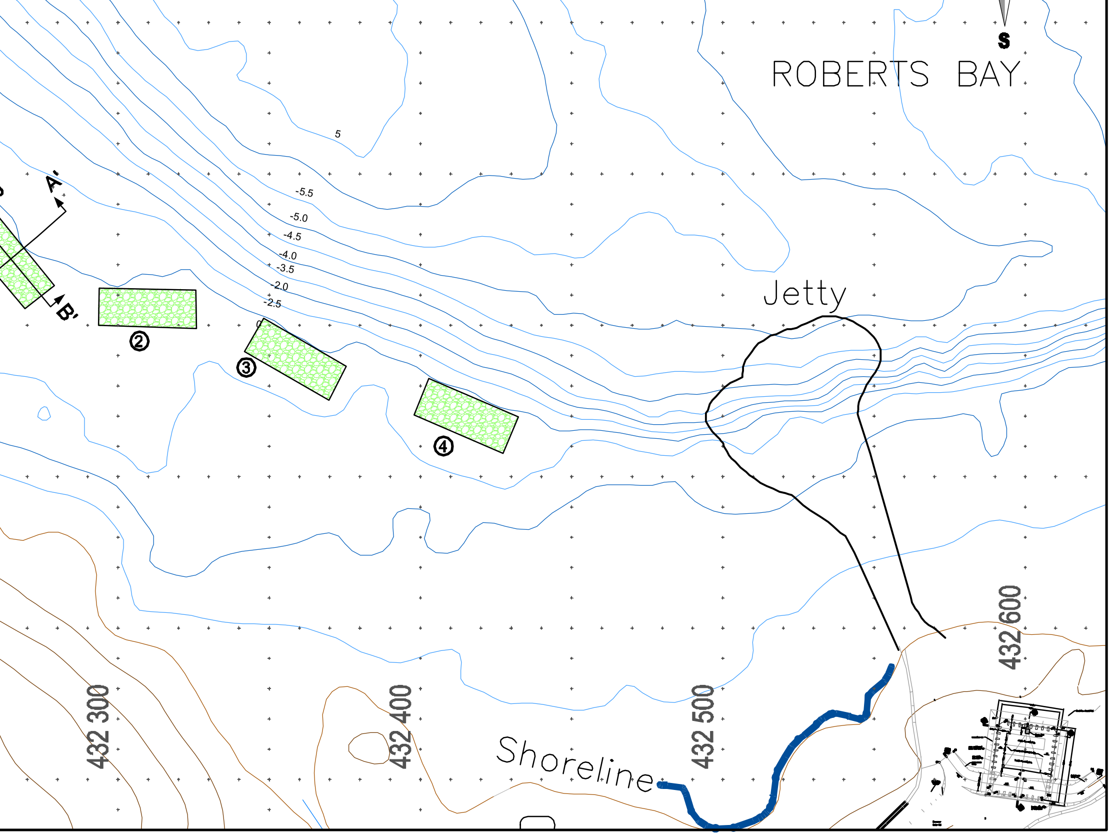
0+090
0+080
0+070
0+060
0+050
0+040
0+030
0+020
0+010
0+000
20
30
40
50
Lateral Distance (m)
Survey Transects
to Figure D9, Detail A
Stream E09
7559420
7559400
7559380
7559360
440900
440920
440940
440960
440980
441000
Stream channel
Direction of flow
Existing pool
Semiaquatic vegetation
Plan View
Top of bank
Thalweg
99.0
98.0
97.0
Elevation (m)
Title
General



Plan of Jetty

SCALE 1:2,500 METRES

footprint and above water areas, of the jetty prior to habitat construction.

3. The contractor shall, in consultation with the fish habitat design consultant, devise a method of construction that meets the compensation design and intent.

4. The contractor shall consult with a qualified ice engineer to determine the bearing capacity of the ice cover if winter construction is considered.

5. A total of four rock riprap shoals shall be constructed offshore, west of the present jetty location.

6. Shoals shall be typically 12 m wide and 31.25 m long.

7. Shoal tops shall be a minimum of 1.0 m below Mean Sea Level.

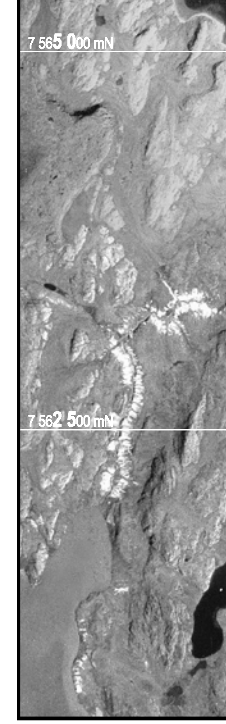
8. Shoals shall be constructed of clean, competent, certified non-acid generating rock.

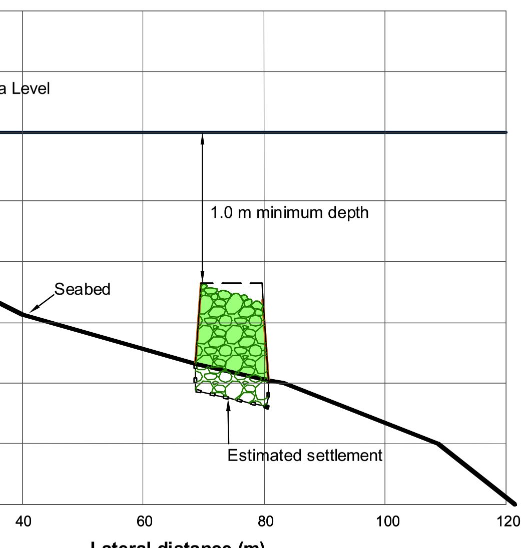
9. Rock shall meet the specifications for riprap as specified in "Technical Specifications for Tailings Containment Area and Surface Infrastructure Components" (SRK, 2006).

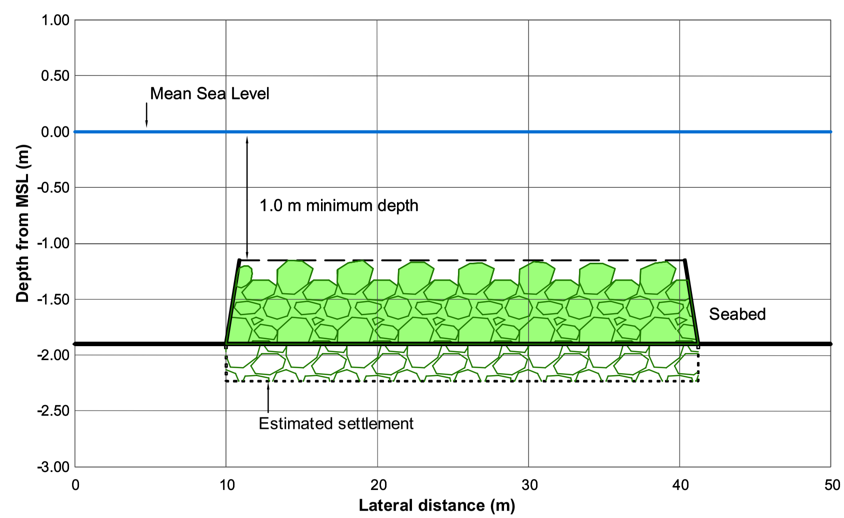
10. Gradation of the rock shall meet the specifications for riprap material as shown on drawing G-05 Revision No. B (SRK, 2007).

11. Construction of the shoals shall be completed by 15 July to protect fisheries.

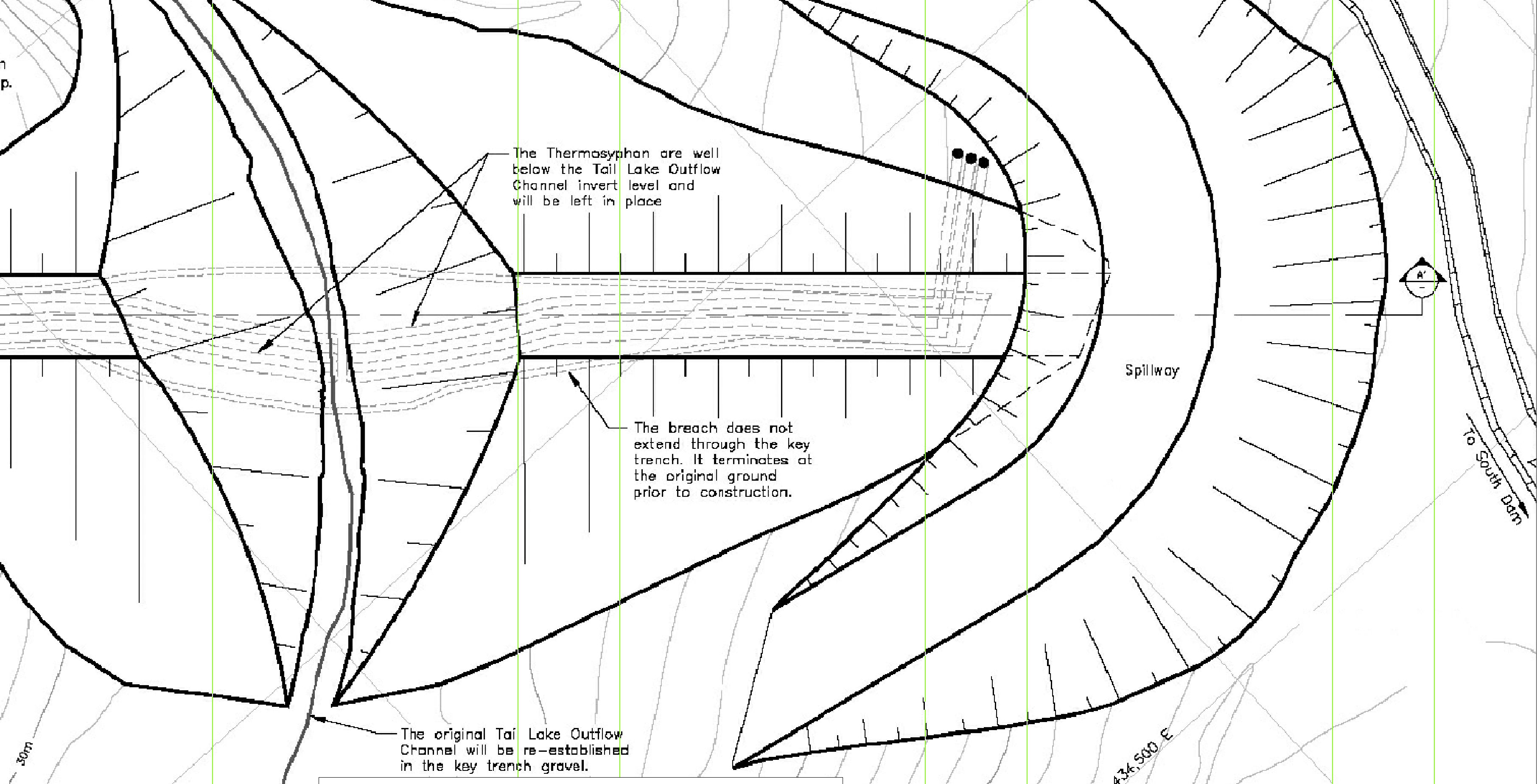
Reference: SRK Consulting Engineers and Scientists, Job No. 1CM014.008, Drawing No. J-01 and J-02, dated March 2007.
SRK Consulting Engineers and Scientists, Technical Specification for Tailings Containment Area and Surface Infrastructure Components, October 2006.



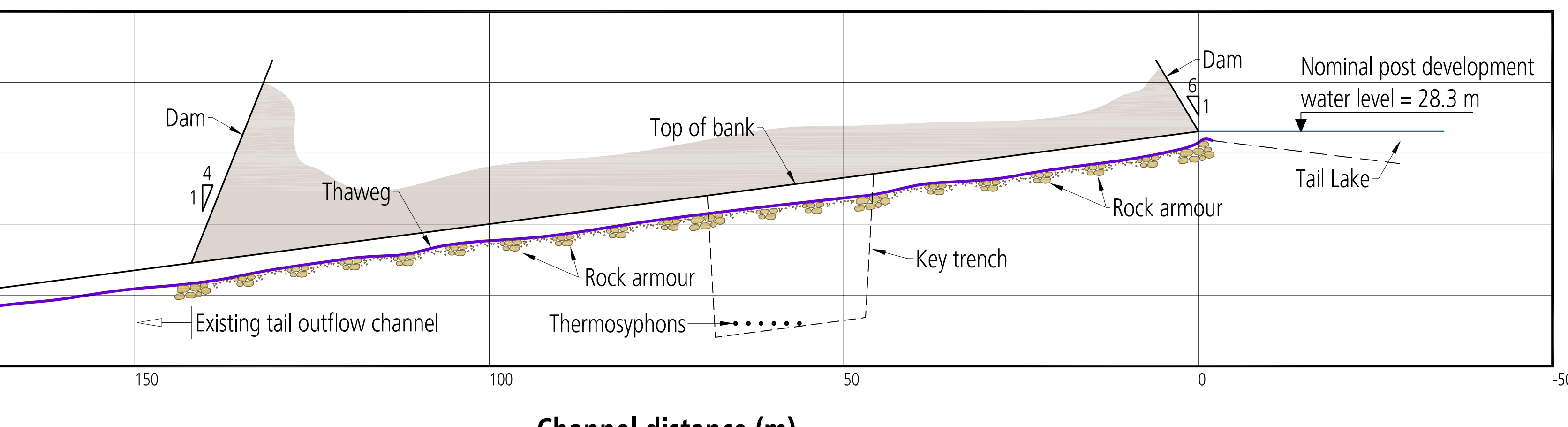




Title
Roberts B



Beached North Dam Plan Layout



scale aerial photo
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3. Derived natural c
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Bankfull depth
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pre-disturbance si

Ty

Title

Tail Lak

APPENDIX E

Photographic Plates of Proposed Stream Enhancement in Tributary E09 to Roberts Lake

Plate 1 Stream E09, *August 2007*. Upstream view of confluence of Stream E09 and Stream E10. Compensation area is highlighted.

Plate 2 Stream E09, *August 2007*. Upstream view of the Stream E09.

Plate 3 Stream E09, *August 2007*. Stream E10 southeast of confluence.

Plate 4 Stream E09, *August 2007*. Ground view from southwest towards confluence of streams

APPENDIX F

Photographic Plates of Enhancement Contingency Plan Locations

Plate 1 **Site 1, *August 2004*.** UTM 13 W 0406635E 7551813N. Upstream view of the waterfall.

Plate 2 **Site 1, *August 2004*.** Downstream view of the waterfall.

Plate 3 **Site 1, *August 2004*.** Upstream view above the waterfall.

Plate 4 **Site 1b, *August 2004*.** Boulder garden area flowing into the lake upstream of the Site 1.

Plate 5 **Site 2, *August 2004*.** UTM 13 W 0420258E 7554046N. Upstream view of waterfall. This waterfall is a barrier to fish passage. The cascade in the background is not a fish barrier.

Plate 6 **Site 2, *August 2004*.** Side view of waterfall.

Plate 7 **Site 2, *August 2004*.** Upstream view of waterfall, which is a barrier to fish passage. Note the cascade in the background.

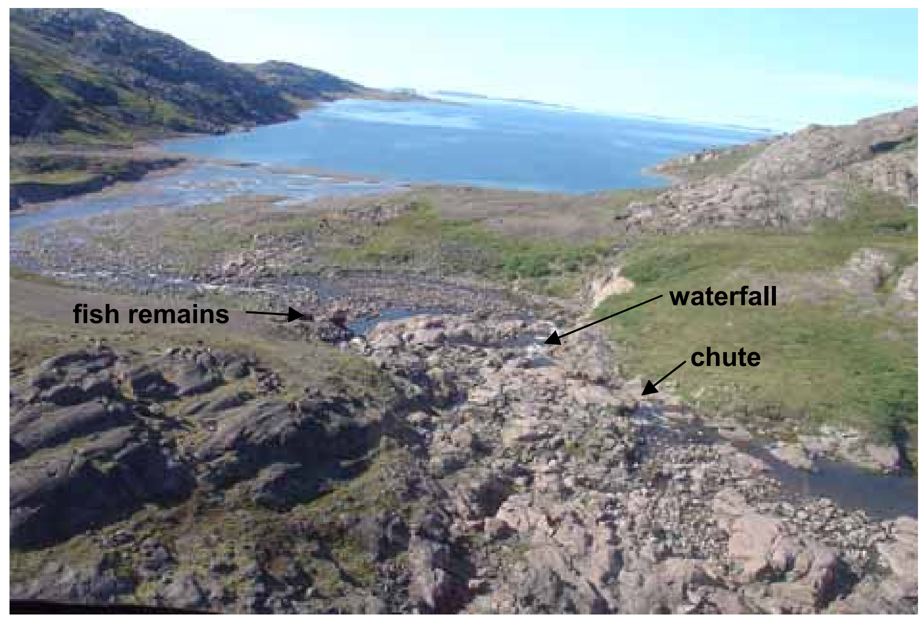

Plate 8 **Site 2, *August 2004*.** Aerial view of the cascading waterfall. The ocean is located in the background of the photo.