Faro Mine Closure
Fermeture de la mine Faro

Project Description (Phase 1)

Prepared for:

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

and

Yukon Government





Prepared by:

SRK Consulting
Engineers and Scientists

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Faro Mine Complex

Prepared for

Indian and Northern Affairs Canada (INAC)

and

Yukon Government, Assessment and Abandoned Mines

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1 Introduction

SRK Consulting (Canada) Inc has prepared this Phase 1 of the Project Description for the Closure of the Faro Mine Complex, Faro, Yukon Territory. The information presented is intended to provide a preliminary discussion on the Project Description and is based on recommendations from the Project Oversight Committee following their review of a report entitled "Options for Closure of the Faro Mine Complex" that was issued in February 2008.

- Under the *Yukon Environmental and Socio-economic Assessment Act* (*YESAA* or the "*Act*") the Faro Mine Closure Project will be required to submit a "Project Proposal". Key elements of the Project Proposal include:
- Project purpose;
- Project description;
- Description of existing environmental and socio- economic conditions; and
- Identification of potential environmental and socio- economic effects and proposed mitigation measures.

The project description referenced above will describe the project through all of its stages in enough detail that anyone reading it will understand what is to be accomplish and how. The level of engineering that goes into the project description should be sufficient to produce feasibility level cost estimates. The final Project Description, which is scheduled for completion by early December 2008, will integrate all of the engineering studies currently in progress and full coordination with the environmental assessment and Socio-economic assessment consultants.

2 Document Organization

This initial phase of the Project Description presents comprehensive lists of all the closure activities grouped by the three main areas of the Project; Faro Mine, Rose Creek Tailings and the Vangorda/Grum areas. In addition to these lists, which are presented in tables attached to this document, are a series of figures and illustrations depicting the current conditions at each area and the proposed closure activities. Each activity in the table has been assigned a work item number which is cross referenced in the attached figures. In the attachment section of this document, are relevant extracts from technical reports that have been prepared over the last few years by different technical groups. Each extract, which provides background supporting material to the reader, is cross referenced to the numbered closure activity work items listed in the tables and shown on the figures. The tables also included columns which provide the cross reference to the relevant technical support documents and a preliminary set of questions and issues relating to the Project Description which remain as work in progress at this stage.

3 Work in Progress

SRK recognizes that there are still many information gaps in the project description which will be addressed as the project unfolds. There are also many decisions that still need to be made before the project description can be finalized. It is therefore SRK's intent that this document be a work in progress which will be updated as decisions are made and as technical data is made available. SRK anticipates that there will be a number of questions and additional information that the EA and SEA consultants will require to complete their tasks. We ask that all request for information and questions reference the work item number provided for each closure activity.

4 Known Information Gaps

Below is a preliminary list of work items that are currently under review:

- Borrow material types and source locations;
- Final waste dump resloping angles;
- Cover details;
- WTP location;
- Pipeline details;
- Does the Intermediate pond Emergency spillway get designed for the PMF or the overflow from the 1 in 500 year peak flow assuming RCDC is fully functional up to its estimated capacity;
- Vangorda Creek Diversion alignment;
- Where does the sludge from the new treatment plant get deposited;
- Project execution details;
- Mill area demolition and reclamation;
- Vangorda Haul Road reclamation; and
- North Fork Rose Creek Rock Drain.

Tables

Table 100-1 Work Area 100 - Faro Mine, Closure Activities

	Work Area Code	Item #	Task #	Sub-Task #	Activity	Brief Description of Activity	Questions and Issues Relevant to Project Descriptions (Work in Progress)	Reference Report (In Progress)	Uncertainties	Crew Type
Faro Pit										
Water Treatment System	101	1	1	1	Construct Water Treatment Plant					
	101	1	2	1	Place pipeline	Run the pipeline from the pit to the plant by excavating a trench then placing 150mm HDPE pipe on a compacted bedding layer.	What is the bedding layer made of and where are the borrow areas?	Task 26		
	101	1	2	2		Once the pipe is laid, backfill the trenches.		1CD003.38 draft (2004)		
	101	1	2	3		A pump will be placed inside a housing.	Does the housing need a foundation?		Fig 18 "vegetated engineered drainage channel"	
	101	1	3	1	Install heat tracing	Supply and install heat tracing in the HDPE pipe.				
	101	1	3	2		Install a heat tracing power feed kit and the electrical thermostat.				
	101	1	4	1	Provide electricity to pump	Supply and install treated power poles, and overhead conductor and transformers.				
Safety Berm	101	2	1	1	Construct access road	Clear the area and then construct the road.	What is the road made of? Where do you source the materials?	need to add: Task 24, sludge storage in pit (1CD003.101)		
	101	2	1	2		Supply road construction materials.				
	101	2	2	1	Place berm materials	Acquire berm material and then move it into place using trucks.	What is the berm material? Where is it sourced from?			
	101	2	2	2		Use a dozer to shape the material.				
Faro Creek										
East Interceptor Channel	102	1	1	1	Construct access road	Clear the area and then construct the road.		"Detailed comparison of alternatives for the relocation of the Faro creek diversion, Faro, YT." Golder Report 2004, p. 17, 18.		
	102	1	1	2		Supply road construction materials.				
	102	1	2	1	Excavate channel	Use excavator and trucks to load, haul and dump soil.				
	102	1	2	2		Soil should be dumped locally.				
	102	1	3	1	Place thermal blanket	Production and stockpiling of granular fill is required.	Where is the raw material coming from?			
	102	1	3	2		The fill will be placed and compacted on an uphill cut slope.				
	102	1	4	1	Place GCL	Supply and place GCL				
	102	1	5	1	Place bedding layer	Production and stockpiling of bedding layer is required.				
	102	1	5	2		The bedding layer will be placed and compacted.				
	102	1	6	1	Place rip-rap	High quality, angular rip-rap will be produced and stockpiled before placing and securing it.	Where will the rip-rap be produced?			
Extension across west of Faro Valley	102	2	1	1	Construct access road	Clear the area and then construct the road.				
	102	2	1	2		Supply road construction materials.				
	102	2	2	1	Excavate channel	Use excavator and trucks to load, haul and dump soil.				
	102	2	2	2		Soil should be dumped locally.				
	102	2	3	1	Place bedding layer	Production and stockpiling of bedding layer is required.				
	102	2	3	2		The bedding layer will be placed and compacted.				
	102	2	4	1	Place rip-rap	High quality, angular rip-rap will be produced and stockpiled before placing and securing it.				
Zone II Pit										
Water Management	103	1	1	1	Install groundwater wells	Drill wells using an air rotary drill rig at ~90m depth.		Task 20e (seepage)		
	103	1	1	2		Install a 6" stainless steel well casing and screen as well as a 6" submersible pump with controls.		seepage interception system (1CD003.73)		
	103	1	1	3		Install a protective housing for the well.		Zone II Seepage Study		
	103	1	2	1	Install a piping system	Run the pipeline from the pit to the plant by excavating a trench then placing 150mm HDPE pipe on a compacted bedding layer.				
	103	1	2	2		Once the pipe is laid, backfill the trenches.				
	103	1	2	3		A pump will be placed inside a housing.				
	103	1	3	1	Install heat tracing	Supply and install heat tracing in the HDPE pipe.				
	103	1	3	2		Install a heat tracing power feed kit and the electrical thermostat.				
	103	1	4	1	Provide electricity to pump	Supply and install treated power poles, an overhead conductor and transformers.				
Oxide Fines/LGSP										
Consolidate oxide fines	104	1	1	1	Relocate to Low Grade Stockpile C	Load, haul, and place compact oxide materials.		Task 30		
	104									
Medium grade stockpile	104	2	1	1	Regrade surfaces and slopes	Flatten surfaces and regrade slopes.				
	104	2	2	1	Place HDPE cover	Place an HDPE liner on a bedding layer (0.3m).				
	104	2	2	2		Place loose till (1.0m) and seed/fertilize using a low helicopter application rate.	Source of Till Borrow ?			
	104	2	3	1	Revegetate stockpile	Seed and fertilize using a helicopter low application rate.				
Low-grade stockpile A	104	3	1	1	Regrade surfaces and slopes	Flatten surfaces and regrade slopes.				
	104	3	2	1	Place HDPE cover	Place an HDPE liner on a bedding layer (0.3m).				
	104	3	2	2		Place loose till (1.0m) and seed/fertilize using a low helicopter application rate.				
	104	3	3	1	Revegetate stockpile	Seed and fertilize using a helicopter low application rate.				
Low-grade stockpile C	104	4	1	1	Regrade surfaces and slopes	Flatten surfaces and regrade slopes.				
	104	4	2	1	Place HDPE cover	Place an HDPE liner on a bedding layer (0.3m).				
	104	4	2	2		Place loose till (1.0m) and seed/fertilize using a low helicopter application rate.				
	104	4	3	1	Manage surface runoff					
	104	4	4	1	Revegetate stockpile	Seed and fertilize using a helicopter low application rate.				
ETA Tailings										
Option 1: Pump tailings to Faro Pit	105	1	1	1	Monitor hydraulics and add lime	Operate the hydraulic monitoring system and the slurry pumping system.		1CD003.53		
	105	1	1	2		Add appropriate quantity of lime in tonnes/CaOH		Task 14d p. 24/25		
	105	1	2	1	Move contaminated soils	Use a truck to move contaminated material to Faro Pit.				
	105	1	2	2		Regrade the area to form a detention pond.	Design?	Task 35 1CD003.81		
Option 2: Haul tailings	105	2	1	1	Move tailings to impoundment	Use a truck to move tailings to Rose Creek tailings deposit.				
	105	2	2	1	Add lime	Add appropriate quantity of lime to waste rock in tonnes/CaOH				
	105	2	3	1	Move contaminated soils	Use a truck to move contaminated material to Faro Pit.				
	105	2	3	2		Regrade the area to form a detention pond.				
	105	2	4	1	Revegetate area	Seed and fertilize using a helicopter low application rate.				

Table 100-1 Work Area 100 - Faro Mine, Closure Activities

	Work Area Code	Item #	Task #	Sub-Task #	Activity	Brief Description of Activity	Questions and Issues Relevant to Project Descriptions (Work in Progress)	Reference Report (In Progress)	Uncertainties	Crew Type
Groundwater collection system (to plant)	105	3	1	1	Install groundwater wells	Drill wells using an air rotary drill rig at ~20m depth.				
	105	3	1	2		Install a 6" stainless steel well casing and screen as well as a 6" submersible pump with controls.				
	105	3	1	3		Install a protective housing for the well.				
	105	3	2	1	Install monitoring wells	Drill wells using an air rotary drill rig at ~20m depth.				
	105	3	2	2		Install a 6" stainless steel well casing and screen				
	105	3	2	3		Install a protective housing for the well.				
	105	3	3	1	Install pumping station	Excavate a sump for manholes.				
	105	3	3	2		install a precast concrete manhole and then backfill and compact around the manhole.				
	105	3	3	3		Install a primary pump.				
	105	3	4	1	Put in a piping system	Excavate a trench for the pipe and lay down 150 mm HDPE pipe on a compacted bedding layer.				
	105	3	4	2		Backfill the ditches.				
	105	3	5	1	Install heat tracing	Supply and install heat tracing in the HDPE pipe.				
	105	3	5	2		Install a heat tracing power feed kit and the electrical thermostat.				
	105	3	6	1	Provide electricity to pump	Supply and install treated power poles, an overhead conductor and transformers.				
Waste Rock										
Reslope Waste Rock	106	1	1	1	Remove vegetation	Clear and grub the forest area around the waste rock toe.		Task 26		
	106	1	2	1	Regrade surfaces and slopes	Enhance the surface runoff by regrading flattened slopes.				
	106	1	2	2		Regrade slopes.				
	106	1	3	1	Pull-back slopes	The slopes that are unable to be re-sloped should be pulled-back and placed at the top of the dump.				
Sulphide Cell	106	2	1	1	Relocate east cell to main cell	Move the sulphide from the east cell to the main cell.				
	106	2	1	2		Compact it in place.				
Waste Rock Cover	106	3	1	1	Place 'vegetative' soil cover or low infiltration soil cover	Place loose till (0.5m) or 0.5m comp. till and 1.5m loose till.				
Steep runoff channels	106	4	1	1	Manage surface runoff	Excavate a channel to install rock drains.				
	106	4	1	2		The rock drains are constructed from rounded, low-quality rip-rap which will be produced, stockpiled, placed and secured.				
Revegetate	106	5	1	1	Revegetate area	Seed and fertilize using a helicopter low application rate.				
Groundwater										
Upgrade of North Fork Rose Creek	107	1	1	1	Construct access road	Clear the area and then construct the road.		1CD003.053		
	107	1	1	2		Supply road construction materials.				
	107	1	2	1	Construct channel	Dump granular material along channel thalweg				
	107	1	2	2		Dump till to create channel berms				
	107	1	3	1	Place geotextile	Put a layer of geotextile under the till layer and also on top of the till layer.				
	107	1	4	1	Place 0.3m till layer	Place and compact with a vibrating drum roller.				
``	107	1	5	1	Place bedding layer	Produce, stockpile and place compacted bedding layer.				
	107	1	6	1	Place rip-rap	Place high-quality, angular rip-rap and secure it.				
Outwash material	107	2	1	1	Relocate outwash material	Move outwash material to intermediate dump				
North Fork Rose Creek Detention Pond	107	3	1	1	Excavate basin	Excavate the sedimentation basin				
	107	3	2	1	Place rip-rap	Place high-quality, angular rip-rap and secure it.				
North Fork Rose Creek Collection System	107	4	1	1	Install groundwater wells	Drill wells using an air rotary drill rig at ~20m depth.				
	107	4	1	2		Install a 6" stainless steel well casing and screen as well as a 6" submersible pump with controls.				
	107	4	1	3		Install a protective housing for the well.				
	107	4	2	1	Install pumping station	Excavate a sump for manholes.				
	107	4	2	2		install a precast concrete manhole and then backfill and compact around the manhole.				
	107	4	2	3		Install a primary pump.				
	107	4	3	1	Put in a piping system	Excavate a trench for the pipe and lay down 150 mm HDPE pipe on a compacted bedding layer.				
	107	4	3	2		Backfill the ditches.				
	107	4	4	1	Install heat tracing	Supply and install heat tracing in the HDPE pipe.				
	107	4	4	2		Install a heat tracing power feed kit and the electrical thermostat.				
	107	4	5	1	Provide electricity to pump	Supply and install treated power poles, an overhead conductor and transformers.				
S-Cluster Collection System	107	5	1	1	Construct access road	Clear the area and then construct the road.				
	107	5	1	2		Supply road construction materials.				
	107	5	2	1	Install cut-off wall	Clear and grub the working area.				
	107	5	2	2		Level and compact the surface.				
	107	5	2	3		Install the cut-off wall (all-inclusive)				
	107	5	3	1	Install the interceptor trench	Excavate the trench and place gravel around the wells.		1CD003.53 p.23		
	107	5	3	2		Backfill the trench using coarse rock.				
	107	5	4	1	Install pumping wells	Install a 6" stainless steel well casing and screen as well as a 6" submersible pump with controls.				
	107	5	4	2		Install a protective housing for the well.				
	107	5	5	1	Install monitoring wells	Drill wells using an air rotary drill rig at ~20m depth.				
	107	5	5	2		Install a 6" stainless steel well casing and screen				
	107	5	5	3		Install a protective well cover				
	107	5	6	1	Install piping	Excavate a trench for the pipe and lay down 150 mm HDPE pipe on a compacted bedding layer.				
	107	5	6	2		Backfill the ditches.				
	107	5	7	1	Install heat tracing	Supply and install heat tracing in the HDPE pipe.				
	107	5	7	2		Install a heat tracing power feed kit and the electrical thermostat.				
	107	5	8	1	Provide electricity to pump	Supply and install treated power poles, an overhead conductor and transformers.				

Table 100-1 Work Area 100 - Faro Mine, Closure Activities

	Work Area Code	Item #	Task #	Sub-Task #	Activity	Brief Description of Activity	Questions and Issues Relevant to Project Descriptions (Work in Progress)	Reference Report (In Progress)	Uncertainties	Crew Type
Miscellaneous										
Roads	108	1	1	1	Reclaim unnecessary roads	Remove culverts and breach stream crossing.				
	108	1	1	2		Scarify road surfaces.				
	108	1	1	3		Seed and fertilize using a helicopter low application rate.				
Buildings	108	2	1	1	Building decontamination	Remove hazardous materials.				
	108	2	2	1	Building demolition	Demolish empty buildings and full buildings.				
	108	2	2	2		Puncture concrete foundations.				
	108	2	2	3		Regrade over demolished buildings.				
Contaminated soils	108	3	1	1	Remove contaminated soils	Excavate hydrocarbon contaminated soils and place in the landfarm.				
	108	3	1	2		Put metal contaminated oil in Low-Grade Stockpile C				
	108	3	1	3		Regrade contaminated area for drainage.				
Landfarm	108	4	1	1	Construct landfarm	Excavate and create berms for use as a biormediation cell.				
	108	4	2	1	Operate landfarm	Use an excavator Cat 330BL/235B to mix soil for the landfarm.				
	108	4	2	2		Need to operate for 3 years.				
	108	4	3	1	Decomission the landfarm	Excavate the soils to be used as a cover.				
	108	4	3	2		Use a dozer to remove the berms.				
Borrow sources	108	5	1	1	Develop borrow sources	Clear and grub the access road.				
	108	5	1	2		Construct the access road.				
	108	5	2	1	Decommission borrow sources	Regrade borrow source slopes.				
	108	5	2	2		Seed and fertilize using a helicopter low application rate.				
Contingency and Allowances										
Contingency					Contingency	20% of direct costs				

Table 200-1 Work Area 200 - Rose Creek Valley Tailings, Closure Activities

	Work Area Code	Item #	Task #	Sub-Task #	Activity	Brief Description of Activity	Questions and Issues Relevant to Project Descriptions (Work in Progress)	Reference Report (In Progress)	Uncertainties	Crew Type
Dams										
Cross Valley	201	1	1	1	Remove pond	Pump water from pond and discharge	How big is pond? What size pump?			
	201	1	2	1	Remove impounded sludge	Excavate and create berms for use as sludge cell on top of tailings	What are berms made of? What is slope? Footprint?	1CD003.45_SludgeManagement		
	201	1	2	2		Place sludge material.				
	201	1	3	1	Remove contaminated soil	Excavate, load, haul and place contaminated soils in mill area				
	201	1	4	1	Prepare spoil area	Clear and grub the area				
	201	1	4	2		Prepare access roads				
	201	1	5	1	Remove dam	Excavate and place dam material that is not used for the intermediate dam toe berm.				
	201	1	6	1	Revegetate dam footprint and impoundment	Seed/Fertilize, helicopter high application rate				
Intermediate Dam	201	2	1	1	Clear and grub spillway	Clear and grub spillway		new spillway design Figure 5.2, see KCB report 11 April 2008. Task 25		
	201	2	2	1	Excavate spillway	Excavate soil and dump locally	Where is the dump located?			
	201	2	2	2		Excavate rock and dump locally				
	201	2	3	1	Construct channel-spillway for flows above 135 m^3/s (1 in 500 year event)	Supply and place geotextile	Type? Thickness?			
	201	2	3	2		Screen, stockpile and place bedding layer	What is bedding layer made of? Where sourced?			
	201	2	3	3		Drill, blast and stockpile high quality, angular rip-rap then place and secure it.	Where sourced?			
	201	2	4	1	Raise dam to provide freeboard	Prepare foundation				
	201	2	4	2		Place common dam fill and impervous glacial till core fill, drainage gravel, and filter				
	201	2	4	3		Place rip rap on upstream face and granular filter under rip rap				
	201	2	5	1	Add extension on north abutment					
	201	2	6	1	Raise and improve the dyke adjacent to the Rose Creek Diversion Channel (RCDC)					
Secondary Dam	201	3	1	1	Densify ground on east limb of dam	Supply and stockpile gravel locally, then dump in appropriate location.				
	201	3	1	2		Drill vibro-replacement stone columns.				
	201	3	1	3		Perform verification testing.	?			
Tailings										
Intermediate Tailings	202	1	1	1	De-water pond	Pump water from Faro pit or water treatment facility				
	202	1	2	1	Upgrade roads	Source road construction materials, if necessary.	From where? What types of materials?	Task 18(b) May 2008, 1CD003.094		
	202	1	2	2		Upgrade road from tailings area to waste rock source				
	202	1	2	3		Construct new access road where necessary				
	202	1	3	1	Cover tailings	Regrade tailings (includes construction of distribution swales)		KCB report 11 April 2008, Appendix V		
	202	1	3	2		Haul waste rock (1m) and cover tailings.				
	202	1	3	3		Haul till (1.0m) and cover tailings.				
	202	1	3	4		Rip rap inlet channel at upstream end of impoundment, granular fill under rip rap				
	202	1	4	1	Revegetate till-covered areas	Seed/Fertilize, helicopter high application rate				
Secondary and Original Impoundment Tailings	202	2	1	1	Upgrade roads	Upgrade road from tailings area to waste rock source				
	202	2	1	2		Construct new access road where necessary				
	202	2	2	1	Cover tailings	Haul waste rock (0.5m) and dump it at tailing impoundment edge, then use small equipment to place the waste rock on the tailings.				
	202	2	2	2		Haul till (1.5m) and dump on impoundment edge, then use small equipment to place it on the tailings.				
	202	2	3	1	Revegetate till-covered areas	Seed/Fertilize, helicopter high application rate				
Rose Creek Diversion Channel										
Upstream portion to PMF (670m3/s)	203	1	1	1	Clear and grub the channel	Use a dozer D10R/N to clear and grub the channel.		see KCB report 11 April 2008 and fig. 5.2		
	203	1	2	1	Excavate channel	Bulk excavate and then soil excavate the pilot channel.				
	203	1	3	1	Place till layer	Place till layer and compact with vibrating drum roller				
	203	1	4	1	Place crushed rock	Place crushed rock as a transition layer.				
	203	1	4	2		Drill, blast and stockpile rock.				
	203	1	4	3		Crush and stockpile rock prior to placement of rock.				
	203	1	5	1	Place gravel	Place gravel as a transition layer.				
	203	1	5	2		Excavate, screen and stockpile gravel.				
	203	1	5	3		Haul gravel and place it.				
	203	1	6	1	Place sand and gravel	Produce, screen and stockpile sand and gravel material.				
	203	1	6	2		Haul and place sand and gravel.				
	203	1	7	1	Place rockfill sheet	Dump and place waste rock.				
	203	1	8	1	Place rip-rap	Screen and stockpile locally blasted rip-rap.				
	203	1	8	2		Haul and dump rip-rap.				
	203	1	8	3		Place and secure rip-rap.				
	203	1	9	1	Place thermal blanket	Over-excavate for thermal protection layer.	Need details			
	203	1	9	2		Produce, screen and stockpile granular fill.				
	203	1	9	3		Dump and place granular fill.				
Fuse Plug	203	2	1	1	Replace RCDC overflow berm	Remove existing overflow berm				
	203	2	1	2		Source, haul, and place sand and gravel fill				
	203	2	1	3		Haul and place till core and gravel road surface				
	203	2	1	4		Haul and place rip rap (class 100) and granular filter under rip rap				
North Fork Rock Drain	203	3	1	1	Construct ramp to haul road	Excavate and doze waste rock material				
	203	3	1	2		Grade road				
	203	3	2	1	Drain breach material	Excavate, load, haul and place breach material in Faro WR Dump				
	203	3	3	1	Create channel	Excavate the channel.				
	203	3	3	2		Supply and place the geotextile and then place a screened bedding layer on top.				
	203	3	3	3		Screen and stockpile, then place rip-rap from NFRD on top of the bedding layer.				
	203	3	4	1	Revegetate disturbed areas	Seed/Fertilize, helicopter low application rate				
	203	3	5	1	Breach drain	Excavate channel				
	203	3	5	2		Supply and place the geotextile and then place a screened bedding layer on top.				
	203	3	5	3		Screen and stockpile, then place rip-rap from NFRD on top of the bedding layer.				
	203	3	6	1	Revegetate disturbed areas	Seed/Fertilize, helicopter low application rate				
	203	3								
Fish By-Pass	203	4	1	1	Construct fish ladder	See scenario 1b from NHC report		nhc report Nov 2006		

Table 200-1 Work Area 200 - Rose Creek Valley Tailings, Closure Activities

	Work Area Code	Item #	Task #	Sub-Task #	Activity	Brief Description of Activity	Questions and Issues Relevant to Project Descriptions (Work in Progress)	Reference Report (In Progress)	Uncertainties	Crew Type
Groundwater Collection										
Cross-Valley Dam Cut-off Wall	204	1	1	1	Construct access	Clear and grub access				
	204	1	1	2		Regrade working area surface				
	204	1	2	1	Install cut-off wall	Install cut-off wall (all-inclusive)				
Cross-Valley Dam Interception Trench	204	2	1	1	Excavate Trench	Excavate trench and spoil locally				
	204	2	2	1	Install piping	Supply and install perforated 450mm HDPE pipe				
	204	2	3	1	Backfill Trench	Screen, stockpile and place gravel in the trench.				
Collect groundwater at interception trench	204	3	1	1	Construct manholes/pumping stations	Excavate sump for manholes				
	204	3	1	2		Supply and place concrete manhole and then backfill and compact around the manhole.				
	204	3	1	3		Install a primary pump.				
	204	3	2	1	Install piping system	Excavate piping trench to Faro Pit.				
	204	3	2	2		Supply and install insulated 150mm HDPE pipe then cover with a screened, compacted bedding layer.				
	204	3	2	3		Backfill the ditches.				
	204	3	3	1	Install heat tracing	Supply and install heat tracing in HDPE pipe.	Length of pipe?			
	204	3	3	2		Supply and install the heat tracing power feed kit.				
	204	3	3	3		Supply and install the thermostat for heat tracing				
	204	3	4	1	Provide Electricity from WTP to pumps	Supply and install treated power poles	Type (concrete, wood)?			
	204	3	4	2		Supply and install overhead conductors	Type?			
	204	3	4	3		Supply and install transformers	What type?			
	204	3	5	1	Install monitoring wells	Drill wells using an air rotary drill rig to approximately 15m depth.				
	204	3	5	2		Install 6" stainless steel well casing and screen.				
	204	3	5	3		Install a protective well cover.	Type?			
Seepage Collection System above intermediate Dam	204	4	1	1	Place collection sumps	Excavate sump				
	204	4	1	2		Supply and place perforated HDPE sump and then supply and install a pump.				
	204	4	1	3		Supply and install protective housing for the pump.				
	204	4	2	1	Install piping system	Excavate a piping trench to CVD GW collection				
	204	4	2	2		Supply and install an insulated 150mm HDPE pipe and then lay down a screened, compacted bedding layer.				
	204	4	2	3		Backfill and compact the ditches.				
	204	4	3	1	Install heat tracing	Supply and install heat tracing in HDPE pipe.				
	204	4	3	2		Supply and install the heat tracing power feed kit.				
	204	4	3	3		Supply and install the thermostat for heat tracing				
	204	4	4	1	Provide Electricity from WTP to pumps	Supply and install treated power poles				
	204	4	4	2		Supply and install overhead conductors				
	204	4	4	3		Supply and install transformers				
Miscellaneous										
Reclaim unnecessary roads	205	1	1	1	Reclaim unnecessary roads	Scarify road surfaces				
	205	1	1	2		Seed/Fertilize, helicopter low application rate				
Contingency and Allowances										
Contingency					Contingency	20% of direct costs				
Allowance: Construction delays from differential settlement/erosion of Tailings	202	1	1	1	Cost of mobilization/demobilization					
Allowance: Reconstruction of Rose Creek	203	1	1	1	Access roads	Prepare access roads	How?			
	203	1	2	1	Construct cofferdam	Prepare cofferdam foundation	How?			
	203	1	2	2		Install main cofferdam				
	203	1	2	3		Prepare seepage collection ditch and berm	What is berm made of? Dimensions?			
	203	1	2	4		Supply and operate pumps for removing seepage				
	203	1	3	1	Construct channel	Excavate channel				
	203	1	3	2		Over-excavate for placement of floodplain erosion protection.				
	203	1	3	3		Excavate for residual structure erosion protection.				
	203	1	4	1	Place rip-rap	Drill, blast, screen, stockpile, place and secure angular, high-quality rip-rap.				
	203	1	5	1	Place gravel substrate	Screen, stockpile, dump and place gravel.				
	203	1	6	1	Remove cofferdam	Excavate material and spoil locally.				
	203	1	7	1	Revegetate riparian area	Revegetate				
Allowance: South Fork Rose Creek Raised Channel	203	2	1	1	Construct access road	Supply or produce road construction materials.				
	203	2	1	2		Clear access road area				
	203	2	1	3		Construct access road				
	203	2	2	1	Construct channel	Load, haul, dump granular material along channel thalweg.				
	203	2	2	2		Load, haul, dump till to create channel berms				
	203	2	3	1	Place geotextile	Supply and place geotextile				
	203	2	4	1	Place 0.3m till layer	Dump and place till then compact with vibrating drum roller.				
	203	2	5	1	Place geotextile	Supply and place geotextile	What kind? Thickness?			
	203	2	6	1	Place bedding layer	Produce, screen and stockpile bedding material.				
	203	2	6	2		Place and compact bedding layer.				
	203	2	7	1	Place rip-rap	Screen and stockpile high-quality, angular rip-rap				
	203	2	7	2		Dump, place and secure rip-rap.				
Allowance Emergency Groundwater Storage Berm (at Cross Valley Dam Location)	204	1	1	1	Place till layer	Place and compact till layer				
	204	1	2	1	Place HDPE liner	Supply and place HDPE Liner and then geotextile on each side of liner.				
	204	1	3	1	Place protection layer	Place and compact till over liner.				

Table 300-1 Work Area 300 - Vangorda/Grum Mine Area, Closure Activities

	Work Area Code	Item #	Task #	Sub-Task #	Activity	Brief Description of Activity	Questions and Issues Relevant to Project Descriptions (Work in Progress)	Reference Report (In Progress)	Uncertainties	Crew Type
Vangorda Pit										
Water Treatment	301	1	1	1	Construct water treatment plant	Construct a new water treatment plant	Capacity, size? Throughput?	Task 26 report (partially)		
	301	1	2	1	Construct pipeline to and from treatment plant	Excavate piping trench	How big of a trench? How much material will be excavated?			
	301	1	2	2		Supply pipes (150mm HDPE) and pumps and install them	Quantity? What kind of pumps, capacity of pipes, how many pipes?			
	301	1	2	3		Supply material for bedding layer and construct a bedding layer, then backfill ditches	What kind of material for bedding layer? How much? Source?			
	301	1	3	1	Install heat tracing system	Supply and install heat trace in HDPE pipe				
	301	1	3	2		Supply and install power feed for heat tracing				
	301	1	3	3		Supply and install electrical thermostate for heat tracing				
Safety Berms	301	2	1	1	Construct access road for construction of safety berms	Clear access road area	Where will the debris be dumped?			
	301	2	1	2		Construct access road	How big is the road? Paved or unpaved? Dust issues?			
	301	2	2	1	Place berm material	Load, haul, dump berm material	Source? Material type? Quantity?			
	301	2	2	2		Grade berms with dozer	Estimated dozer usage?			
Vangorda Pit Waste Rock Piles	301	3	1	1	Regrade waste rock piles	Regrade by flattening surfaces and bubble dump surfaces	How much area needs to be re-graded? Can partly refer to Task 26 report	Task 26 Landform Engr section		
	301	3	1	2		Regrade side slopes of wate rock piles	Refer to Task 26 report	Task 26 Landform Engr section		
	301	3	2	1	Place "low-infiltration" cover over waste piles	Load, haul, and place compacted till (0.5m)	Source of till? Quantity? Compaction specs?	Task 26 report		
	301	3	2	2		Load, haul, and place loose till (1.5m)	Source of till? Quantity?	Task 26 report		
	301	3	3	1	Revegetate	Seed/fertilize, helicopter high application rate	What does "helicopter high application rate" mean?			
Vangorda Dump										
Reslope Dump	302	1	1	1	Regrade waste rock dumps	Regrade by flattening surfaces and bubble dump surfaces		Task 16 (a) and 18(b)		
	302	1	1	2		Regrade slopes of waste dumps		Baritic fines?		
Waste Rock Cover	302	2	1	1	Place low infiltration cover over waste dump	Load, haul, and place compacted till (0.5m)	Source of till?	Task 26		
	302	2	1	2		Load, haul, and place loose till (1.5m)	Source of till?			
Rock Drains	302	3	1	1	Install rock drains for runoff management	excavate channel for rock drains	How much will be excavated? What kind of material will be excavated?			
	302	3	1	2		construct access road	Size of road, paved or unpaved?			
	302	3	1	3		Source rounded, low-quality rip-rap, stockpile at Vangorda stockpile area				
	302	3	1	4		Place and secure rip-rap				
Sediment Control Ditches	302	4	1	1	Construct sediment control ditch at Vangorda dump	Load, haul, and dump locally	Quantity? Where is source exacly?			
Revegetation	302	5	1	1	Revegetate Vangorda dump footprint	seed and fertilize the area, helicopter high application rate	What does "helicopter high application rate" mean?			
Vangorda Creek										
Relocate North of Pit	303	1	1	1	Excavate diversion channel, new channel or a push-back of existing channel?	Carry out rock excavation (drill, blast, muck, load, haul, and dump)		1CD003.15_ Vangorda Creek Diversion (Alternative Analysis, April 2003)		
	303	1	1	2		Carry out soil excavation (excavate, haul, dump)				
	303	1	2	1	Place fill material	Place fill material from soil layer				
	303	1	3	1	Place bedding layer	Produce and stockpile bedding layer material locally	Where is the source? Where will the stockpile be?			
	303	1	3	2		Laod, haul, place, amnd compact the bedding layer				
	303	1	4	1	Place rip-rap	Obtain rip-rap by drilling and blasting	Where is the blast holes located? How many blasts? How intense? What kind of explosive? Where will the explosives be stored?	Task 26		
	303	1	4	2		Screen and stockpile rip-rap material	Where is the stockpile located? How much rip-rap will be stockpiled?			
	303	1	4	3		Load, haul, dump, place, and secure rip-rap				
Plunge Pool	303	2	1	1	Excavate a plunge pool	Excavate a plunge pool	Size? Location? What will happen to the excavated material?			
	303	2	2	1	Place bedding layer	Produce and stockpile bedding layer material locally	Where is the source? How much material needed?			
	303	2	2	2		Load, haul, place and compact bedding layer				
	303	2	3	1	Place rip-rap layer	Obtain rip-rap by drilling and blasting	Where will the blast holes be? How many blasts? How intense? What kind of explosive? Where will the explosives be stored?			
	303	2	3	2		Screen and stockpile rip-rap material	Where is the stockpile located? How much rip-rap will be stockpiled?			
Diversion to Dixon Creek	303	3	1	1	Upgrade existing diversion to Dixon creek	Excavate diversion channel and spoil locally	Spoil locally, but where exactly? And amount?			
Grum Pit										
Water Management	304	1	1	1	Provide biological treatment	Treat water in grum pit	Pumping rate out of pit? Treatment rate?	1CD003.46_PitLakesTreat Task 18(e) 1CD003.099		
Safety Berms	304	2	1	1	Construct an access road	Clear and grub access road footprint		Task 24? (sludge in pit)		
	304	2	1	2		Construct an access road	What is the size, length of the road?			
	304	2	2	1	Place berm materials	Load, haul, and dump berm material	Material type? Source? Quantity? Location?			
	304	2	2	2		Shape berms with dozer				

Table 300-1 Work Area 300 - Vangorda/Grum Mine Area, Closure Activities

	Work Area Code	Item #	Task #	Sub-Task #	Activity	Brief Description of Activity	Questions and Issues Relevant to Project Descriptions (Work in Progress)	Reference Report (In Progress)	Uncertainties	Crew Type
Grum Interceptor Ditch										
Route into Grum Pit	305	1	1	1	Construct an access road	Clear and grub access road footprint		assumed channel from vangorda creek diversion (1CD003.15)		
	305	1	1	2		Construct an access road	What is the size, length of the road?			
	305	1	2	1	Construct headworks dam	Construct an earth dam at headworks using LHD till	Location, size of dam, how much material needed? Source of material?			
	305	1	3	1	Excavate diversion channel	Excavate channel in soil as needed	Size of channel? Length? Route?			
	305	1	3	2		Excavate channel in bedorck as needed	Size of channel? Length? Route?			
	305	1	4	1	Place bedding layer	Produce and stockpile bedding layer material locally	Where is the source? How much material needed?			
	305	1	4	2		Load, haul, place and compact bedding layer				
	305	1	5	1	Place rip-rap	Obtain rip-rap by drilling and blasting	Where will the blast holes be located? How many blasts? How intense? What kind of explosive? Where will the explosives be stored?	Task 26		
	305	1	5	2		Screen and stockpile rip-rap material	Where will the stockpile be? How much rip-rap will be stockpiled?			
	305	1	5	3		Load, haul, dump, place, and secure rip-rap				
Algea Filter	305	2	1	1	Place waste rock from Grum pit at slot cut	Load, haul, and dump waste rock from grum pit	Quantity?			
	305	2	1	2		Place and secure waste rock				
Route out of Pit via slot Cut	305	3	1	1	Construct an access road	Clear and grub access road footprint				
	305	3	1	2		Construct an access road	What is the size, length of the road?			
	305	3	2	1	Excavate diversion channel	Excavate diversion channel in soil	Size, length, route, armoring?			
	305	3	3	1	Place bedding layer	Produce and stockpile bedding layer material locally	Where is the source? How much material needed?			
	305	3	3	2		Load, haul, place and compact bedding layer				
	305	3	4	1	Place rip-rap material	Obtain rip-rap by drilling and blasting	Where will the blast holes be? How many blasts? How intense? What kind of explosive? Where will the explosives be stored?			
	305	3	4	2		Screen and stockpile rip-rap material	Where will the stockpile be? How much rip-rap will be stockpiled?			
	305	3	4	3		Load, haul, dump, place, and secure rip-rap				
Grum Dump										
Re-slope Dump	306	1	1	1	Clear and grub dump toe area	Clear and grub vegetation at the toe of the dump				
	306	1	2	1	Regrade	Regrade by flattening surfaces				
	306	1	2	2		Regrade by flattening bubble dump surfaces				
	306	1	3	1	Pull back slopes that can not be re-sloped	Load, haul, dump, and place at top of the dump				
Sulphide Cell	306	2	1	1	Place "low infiltration" cover	Load, haul, and place compacted till (0.5m)	Source of till?	Task 26		
	306	2	1	2		Load, haul, and place loose till (1.5m)	Source of till?			
Waste Rock Cover	306	3	1	1	Place "vegetative" cover	Load, haul, and place compacted till (0.5m)	Source of till?			
Steep Runoff Channels	306	4	1	1	Install rock drains for runoff management	Excavate channel for rock drains	How big is the channel?			
	306	4	1	2		Obtain rip-rap by drilling and blasting	where will the blast holes be? How many blasts? How intense? What kind of explosive? Where will the explosives be stored?			
	306	4	1	3		Screen and stockpile rip-rap material	Where is the stockpile located? How much rip-rap will be stockpiled?			
	306	4	1	4		Load, haul, dump, place, and secure rip-rap				
Sediment Basins	306	5	1	1	Construct sedimentation basins at the bottom of rock drains	Excavate sedimentation basin	How big is the channel? Dimensions? Design?	Task 20e 1CD003.73 Jan 2007		
	306	5	1	2		Obtain rip-rap by drilling and blasting	where will the blast holes be? How many blasts? How intense? What kind of explosive? Where will the explosives be stored?	Design options for seepage collection June 2004, 1CD003.37		
	306	5	1	3		Screen and stockpile rip-rap material	Where is the stockpile located? How much rip-rap will be stockpiled?			
	306	5	1	4		Load, haul, dump, place, and secure rip-rap				
Revegatate	306	6	1	1	Revegetate waste rock dumps	seed and fertilize the area, helicopter high application rate				
Overburden Dump										
Reslope Dump	307	1	1	1	Regrade surfaces of overburden dump	Flatten surfaces and re-grade slopes to desired gradients				
Revegatate	307	2	1	1	Revegetate overburden dumps	Revegetate overburden dump top surface and slopes	To be used in covers for TMF and/or WR dumps?			
Ore Transfer Pad										
Relocate to Grum Sulphide Cell	308	1	1	1	Excavate acidic material by over-excavating	Load and haul excavated acidic material, and place and compact.				
Reslope Ore Transfer Pad for Drainage	308	2	1	1	Regrade ore transfer pad	Flatten surfaces and re-grade slopes to desired gradients				
Waste Rock Cover	308	3	1	1	Place vegetative cover over waste rock	Load, haul, and place loose till over waste rock (0.5m)	Till source?			
Sediment control Ditches	308	4	1	1	Construct sediment control ditch	Excavate sediment control ditch for ore transfer pad	Size? What will happen to excavated material?			
	308	4	2	1	Construct sedimentation basin for ore transfer pad	Excavate sedimentation basin for ore transfer pad	Size? What will happen to excavated material?			
Revegetate	308	5	1	1	Revegetate or transfer pad	seed and fertilize the area, helicopter high application rate				

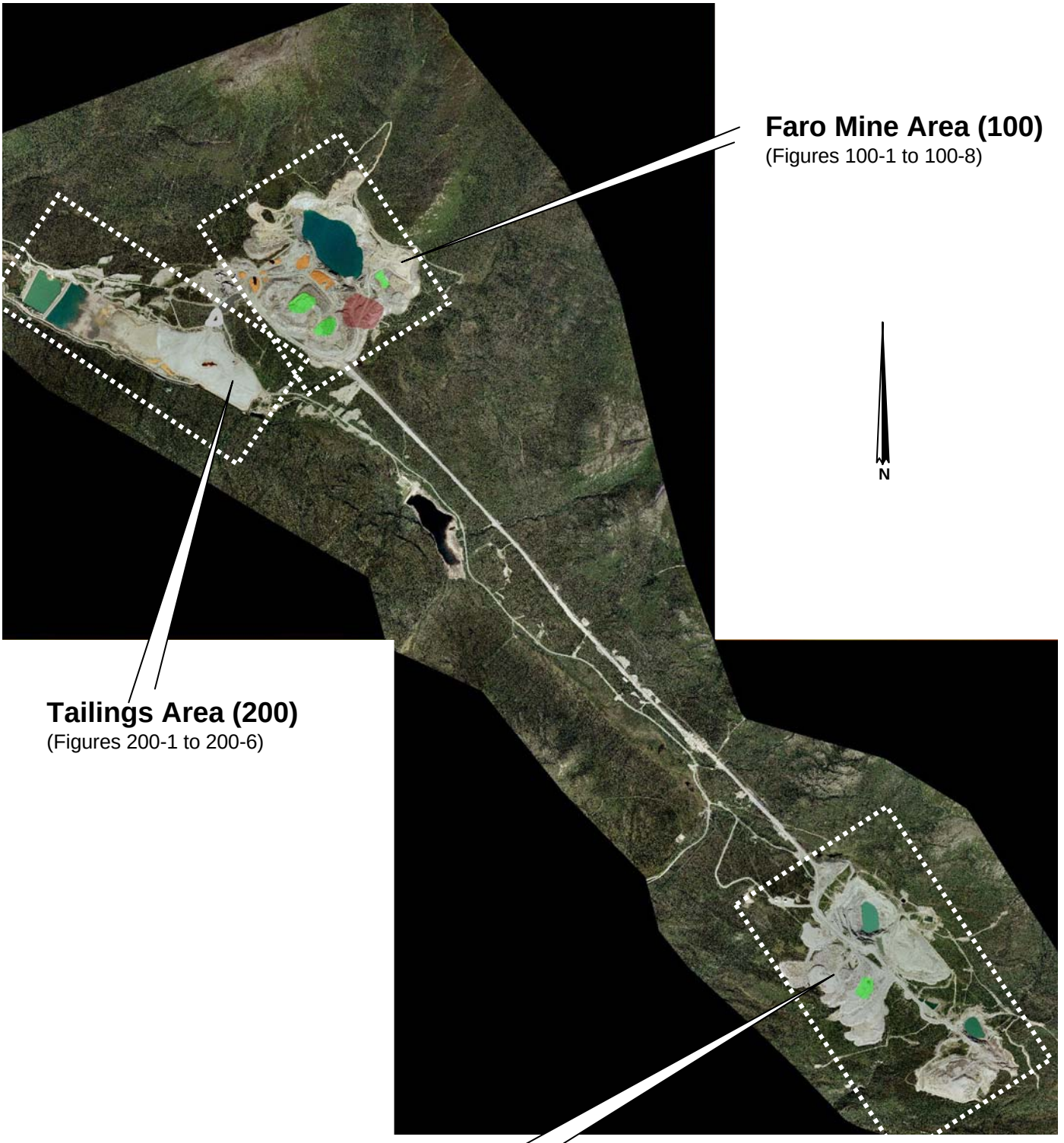
Table 300-1 Work Area 300 - Vangorda/Grum Mine Area, Closure Activities

	Work Area Code	Item #	Task #	Sub-Task #	Activity	Brief Description of Activity	Questions and Issues Relevant to Project Descriptions (Work in Progress)	Reference Report (In Progress)	Uncertainties	Crew Type
Groundwater										
Grum Dump Groundwater Collection to Holding Pond	309	1	1	1	Construct access road	Clear access road area	How big is the area?	1CD003.37 Grum Seepage Collection		
	309	1	1	2		Construct access road	Size of road?			
	309	1	1	3						
	309	1	2	1	Drill and install groundwater	Drill gorundwater wells with an air rotary drill rig (~20m deep holes)	Location of the groundwater wells?			
	309	1	2	2		Install 6 inch stainless steel well casing and screen				
	309	1	2	3		Install 6 inch submersible pump with controls				
	309	1	3	1	Install piping system for groundwater circulation	Excavate a trendh for placing piping				
	309	1	3	2		Source, produce, screen, and stockpile bedding material	What kind of bedding material needed? Source? Quantity?			
	309	1	4	1	Install heat tracing system	Supply and install heat trace in HDPE pipe				
	309	1	4	2		Supply and install power feed for heat tracing				
	309	1	4	3		Supply and install electrical thermostate for heat tracing				
	309	1	5	1	Provide electricity from holding pond to pumps	Supply and install treated power poles				
	309	1	5	2		Supply and install overhead conductor				
	309	1	5	3		Supply and install transformers				
Grum Dump Groundwater Holding Pond	309	2	1	1	Construct groundwater holding pond	Excavate the groundwater holding pond	How big? What will happen to excavated material?	Potential holding pond (1CD003.37) p. 12		
	309	2	1	2						
	309	2	1	3						
	309	2	2	1	Place till material at the base of the holding pond	Load, haul, dump and place till material at the base of the pond	Source of till? Quantity?			
	309	2	2	2		Compact till layer with vibrating drum roller				
	309	2	3	1	Place geotextile over till layer	Supply and place geotextile	Specs of geotextile? Woven, non-woven etc. quantitiy?			
	309	2	4	1	Place bedding layer over geotextile	Produce, screen, and stockpile bedding layer mnaterial	Where is the source? How much material needed? Specs?			
	309	2	4	2		Load, haul, place and compact bedding layer				
	309	2	5	1	Place pump in the groundwater holding pond	Supply the pump and install it				
	309	2	5	2		Build and install housing for primary pump	How many pumps wil be installed.			
	309	2	6	1	Provide electricity to groundwater holding	Supply and install treated power poles				
	309	2	6	2		Supply and install overhead conductor				
	309	2	6	3		Supply and install transformers				
Grum Dump: Groundwater Collection from Holding Pond to Vangorda Pit	309	3	1	1	Install piping system between Grum groundwater holding pond and Vangorda pit	Excavate trench for placing pipes				
	309	3	1	2		Supply and install insulated 150mm HDPE pipe				
	309	3	1	3		Construct bedding layer for pipes	Source of bedding material? Quantity?			
	309	3	2	1	Install heat tracing system	Supply and install heat trace in HDPE pipe				
	309	3	2	2		Supply and install power feed for heat tracing				
	309	3	2	3		Supply and install electrical thermostate for heat tracing				
Vangorda Waste Rock Dump Seepage Collection to Pit	309	4	1	1	Construct access road for seepage collection points	Construct access road for accesing seepage collection points and pipe system				
	309	4	2	1	Drill and install groundwater wells	Drill gorundwater wells with an air rotary drill rig (~20m deep holes)	Location of the groundwater wells			
	309	4	2	2		Install 6 inch stainless steel well casing and screen				
	309	4	2	3		Install 6 inch submersible pump with controls				
	309	4	3	1	Install piping system between seepage collection system and Vangorda pit	Excavate trench for placing pipes				
	309	4	3	2		Supply and install insulated 150mm HDPE pipe				
	309	4	3	3		Construct bedding layer for pipes	Source of bedding material? Quantity?			
	309	4	4	1	Install heat tracing system	Supply and install heat trace in HDPE pipe				
	309	4	4	2		Supply and install power feed for heat tracing				
	309	4	4	3		Supply and install electrical thermostate for heat tracing				
	309	4	5	1	Provide electricity to pumps	Supply and install treated power poles				
	309	4	5	2		Supply and install overhead conductor				
	309	4	5	3		Supply and install transformers				
Vangorda Haul Road										
Removal of Culverts	310	1	1	1	Remove culverts along Vangorda haul road	Excavate haul road and remove culverts	Construct temporary haul roads, safety berms	Task 20b 1CD003.100		
Reclaim Vangorda Haul Road	310	2	1	1	Remove berms	Remove berms by dozing them over road edges				
	310	2	2	1	Scarify Vangorda haul road	Scarify road surface in preparation for vegetating the roads surface				
	310	2	3	1	Revegetate Vangorda haul road	seed and fertilize the area, helicopter high application rate				

Table 300-1 Work Area 300 - Vangorda/Grum Mine Area, Closure Activities

	Work Area Code	Item #	Task #	Sub-Task #	Activity	Brief Description of Activity	Questions and Issues Relevant to Project Descriptions (Work in Progress)	Reference Report (In Progress)	Uncertainties	Crew Type
Miscellaneous										
Buildings	311	1	1	1	Decontaminate buildings	Remove hazardous materials from the buildings	Where will the hazardous material be transported to?			
	311	1	2	1	Demolition of buildings	Carry out demolition of "empty buildings"				
	311	1	2	2		Carry out demolition of "full buildings"				
	311	1	2	3		Puncture all concrete foundations				
	311	1	2	4		Re-grade surface over demolished buildings				
Sludge Pond	311	2	1	1	Place a cover over sludge pond	Supply till then load, haul, dump, and place till material over sludge pond	Source? Quantity?			
Existing Bioremediation Cell	311	3	1	1	Place a cover over existing bioremediation cell	Place the cover by dozing material over existing bioremediation cell	What is the cover material? Source of that material? Quantity?	1CD003.099 Task 18e		
Dams	311	4	1	1	Breach all dams except for Little Creek Dam	Breach the dams by excavating				
	311	4	1	2		Haul and dump excavate dmaterial locally	Where will excavated material be dumped exactly? Quantiity? What kind of material?			
WTP Settling Pond	311	5	1	1	Breach WTP settling pond	Breach WTP settling pond by excavating				
Contaminated soils	311	6	1	1	Remove contaminated soils from the site	Locate and excavate contamintaed soils				
	311	6	1	2		Haul, load, and place contaminated soils in bio-remediation cell				
	311	6	1	3		Re-grade excavated areas for drainage				
New Bioremediation Cell	311	7	1	1	Consruct new bioremediation cell	Create berms for use as the bioremediation cell by excavating	How big is the cell?			
	311	7	1	2		Supply and place HDPE liner for the bioremediation cell	Specs? Quantitty?			
	311	7	1	3		Place bedding layer using local overburden material	Quantity?			
Roads	311	8	1	1	Reclaim unnecessary roads	Remove culverts and breach stream crossings				
	311	8	1	2		Scarify road surfaces in preparation for vegetating the roads surface				
	311	8	1	3		seed and fertilize road surfaces, helicopter low application rate	What does low rate mean here? Does it mean helicopter will not be used that often??			
Borrow Sources	311	9	1	1	Develop borrow sources	Clear and grub borrow source areas				
	311	9	1	2		Construct haul from borrow areas to sites that need borrow material				
	311	9	2	1	Decommission borow sources	Re-grade borrow source slopes				
	311	9	2	2		seed and fertilize used borrow sources, helicopter low application rate	What does low rate mean here? Does it mean helicopter will not be used that often??			
Contingency and Allowances										
Contingency					Contingency	20% of direct costs				
Allowance: Butress the North Vangorda Pit Wall	303	1	1	1	Buttress north Vangorda pit wall	Load, haul and dump to form a buttress for the north Vangorda pit wall	What will be loaded, hauled, and dumped? Where will it come from? How much of that material is needed?			
Allowance: Grum Dump Cut-Off Wall	309	1	1	1	Level and compact a working surface	Clear and grub the working surface area				
	309	1	1	2		Level and compact the surface area				
	309	1	2	1	Construct cut-off wall for Grum Dump	Install cut-off wall (all inclusice)				
Allowance: Vangorda Pit Groundwater Collection	309	2	1	1	Construct access road	Construct access road for Vangorda pit gorundwater collection points				
	309	2	1	2						
	309	2	2	1	Drill and install groundwater	Drill gorundwater wells with an air rotary drill rig (~10m deep holes)	Location of the groundwater wells?			
	309	2	2	2		Install 6 inch stainless steel well casing and screen				
	309	2	2	3		Install 6 inch submersible pump with controls				
	309	2	2	4		Install protective housing (shack)				
	309	2	3	1	Install piping system	Excavate trench for placing pipes				
	309	2	3	2		Supply and install insulated 150mm HDPE pipe				
	309	2	3	3		Construct bedding layer for pipes and backfill the trench				
	309	2	4	1	Install heat tracing system	Supply and install heat trace in HDPE pipe				
	309	2	4	2		Supply and install power feed for heat tracing				
	309	2	5	1	Provide electricity to pumps	Supply and install treated power poles				
	309	2	5	2		Supply and install overhead conductor				
	309	2	5	3		Supply and install transformers				

Figures



SRK Consulting Engineers and Scientists VANCOUVER	Faro Mine Closure Fermeture de la mine Faro	Project Description
		Vicinity Map
Job No: 1CY001.018 Filename: Figure.1_Vicinity_20080902.ppt	Faro Mine Complex	Date: Sep. 2008 / Approved: / Figure: **000-1**



LEGEND

LGO – Low Grade Ore

MGO – Medium Grade Ore

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Faro Mine Closure
Fermeture de la mine Faro

Job No: 1CY001.018

Filename: Figures_2-7_Faro Mine_20080829.ppt

Faro Mine Complex

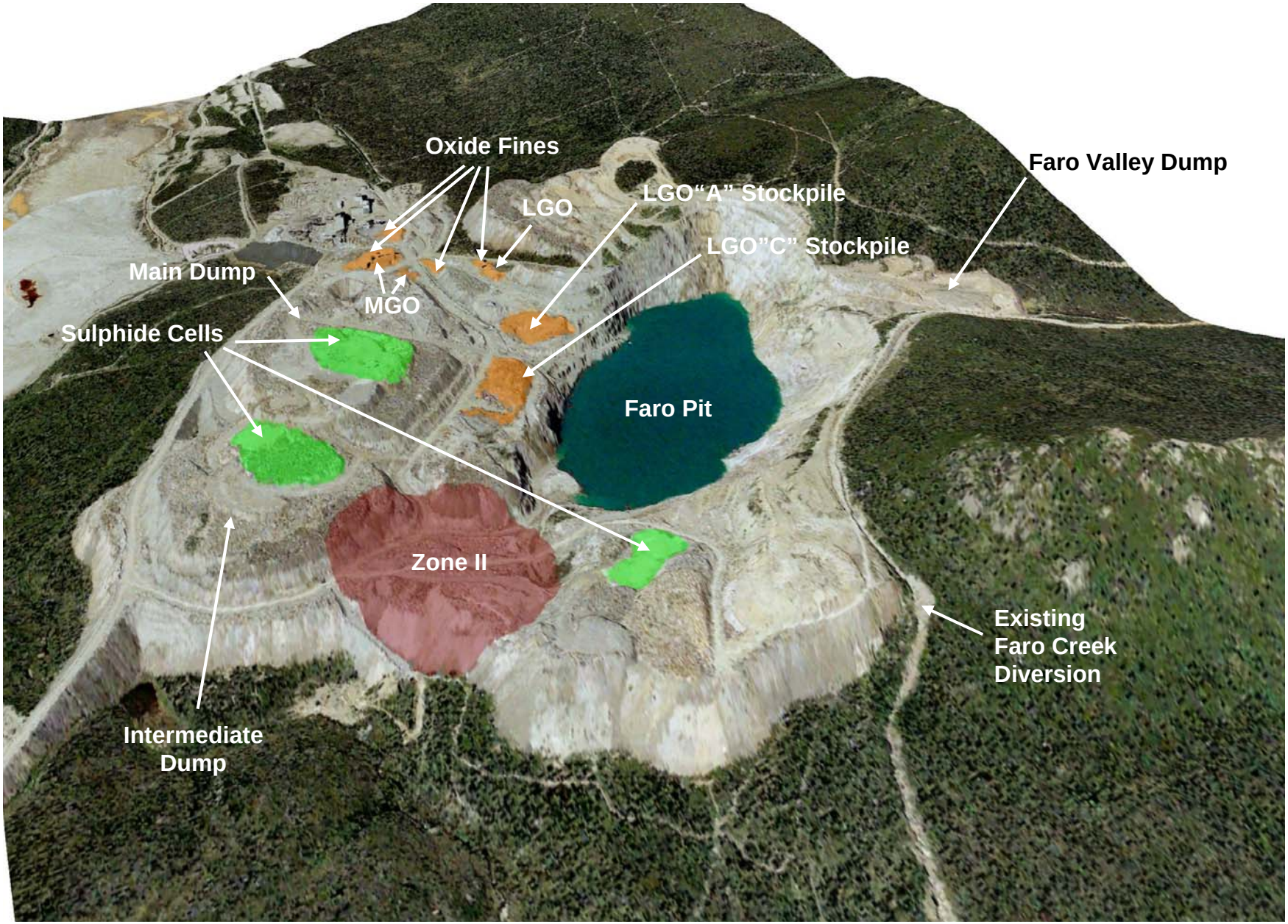
Project Description

Faro Mine Area (100) Site Plan

Date: Sep. 2008

Approved:

Figure: **100-1**



LEGEND

LGO – Low Grade Ore

MGO – Medium Grade Ore

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Faro Mine Closure
Fermeture de la mine Faro

Job No: 1CY001.018

Filename: Figures_2-7_Faro Mine_20080829.ppt

Faro Mine Complex

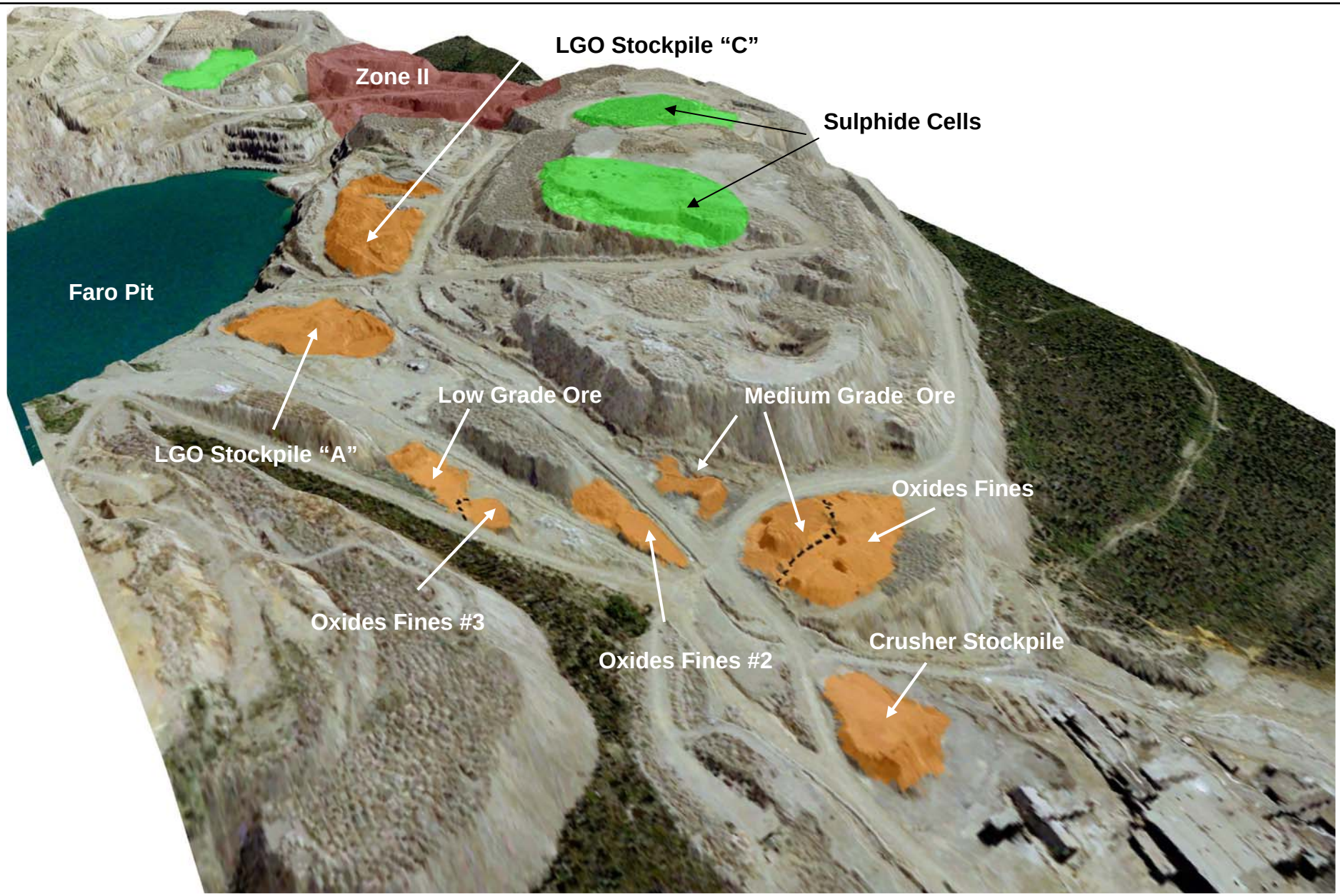
Project Description

Faro Mine Area (100)
3D View A

Date: Sep. 2008

Approved:

Figure: **100-2**



LEGEND

LGO – Low Grade Ore

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Faro Mine Closure
Fermeture de la mine Faro

Job No: 1CY001.018

Filename: Figures_2-7_Faro Mine_20080829.ppt

Faro Mine Complex

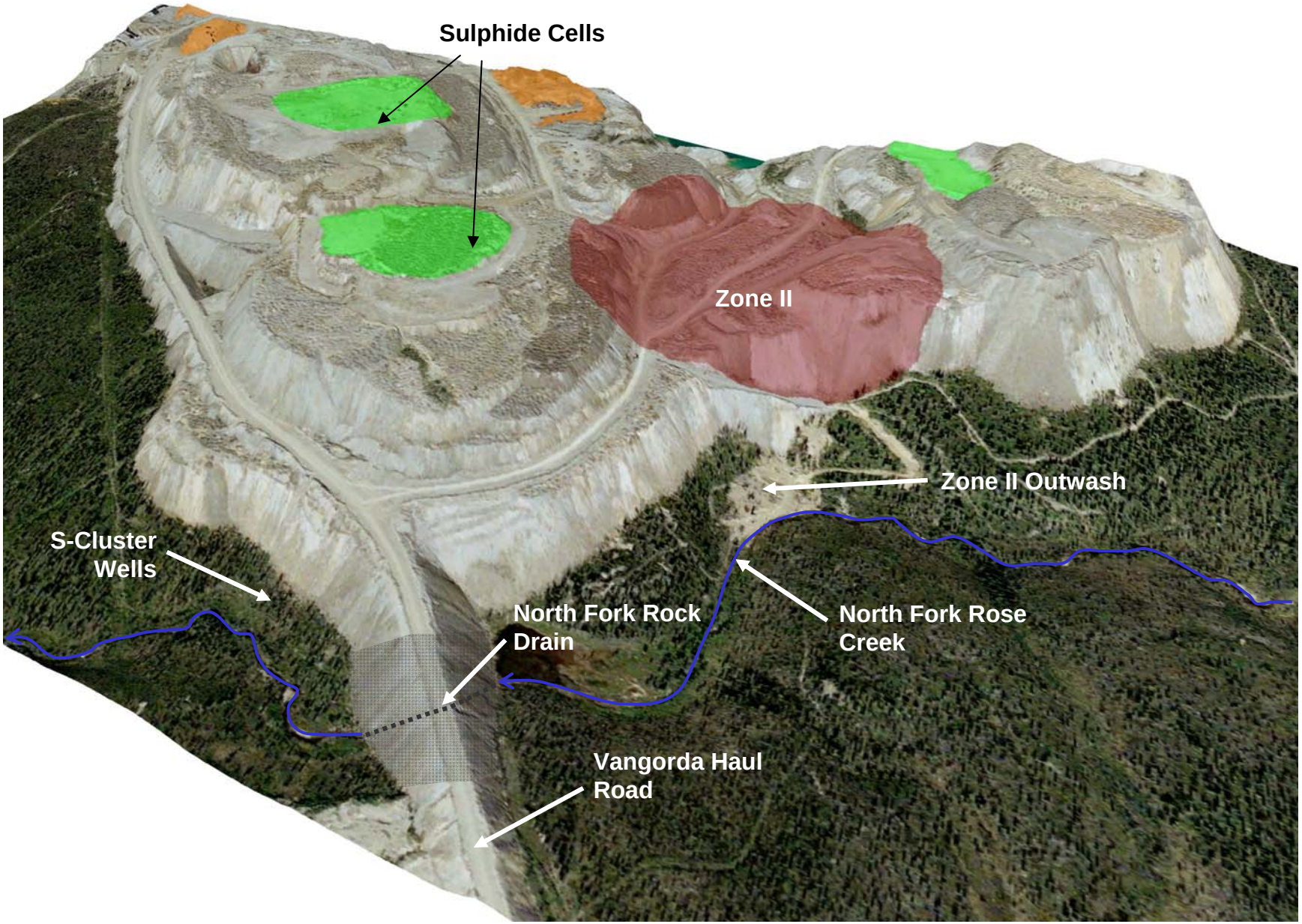
Project Description

Faro Mine Area (100)
3D View B

Date: Sep. 2008

Approved:

Figure: **100-3**



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Faro Mine Closure
Fermeture de la mine Faro

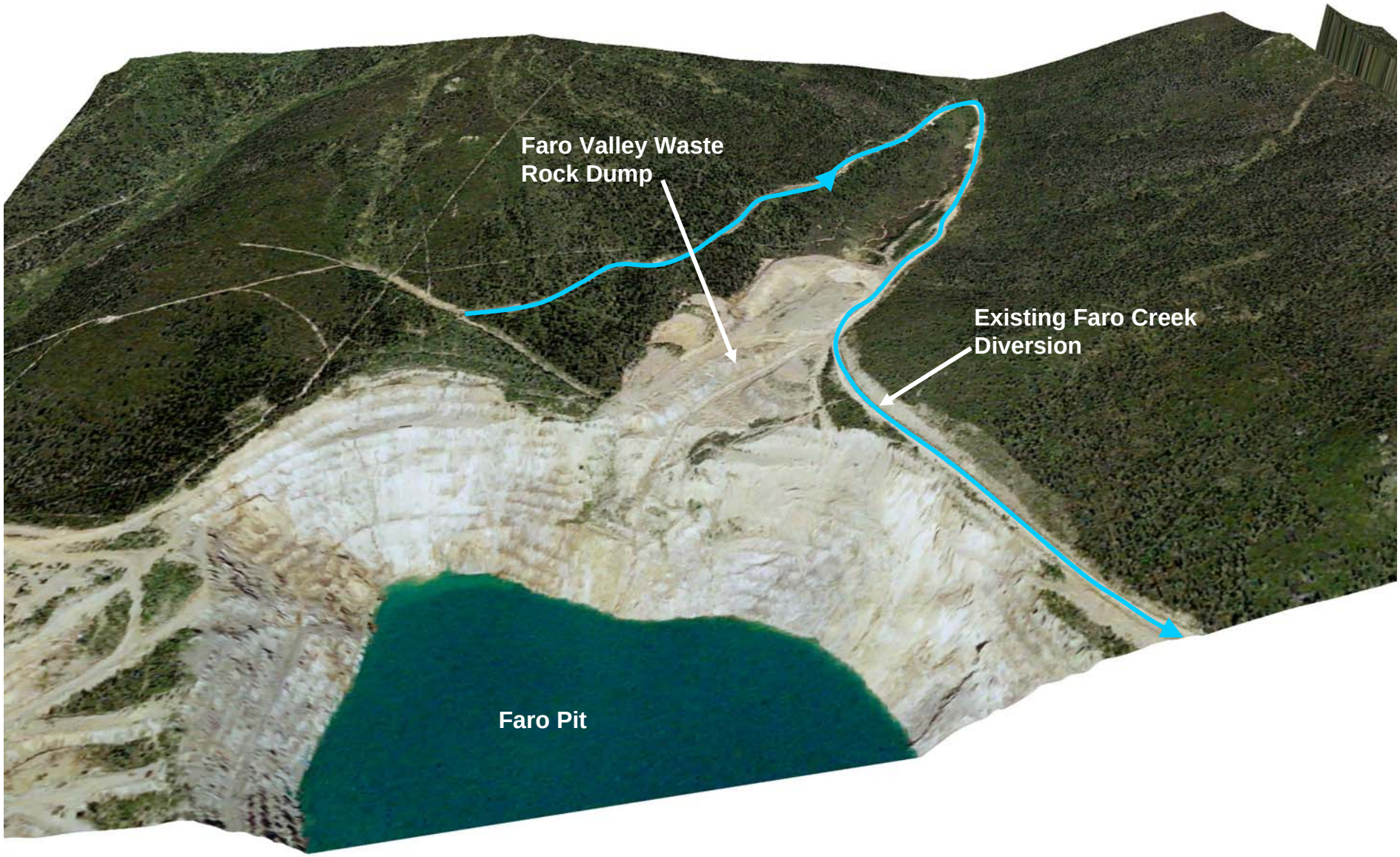
Job No: 1CY001.018
Filename: Figures_2-7_Faro Mine_20080829.ppt

Faro Mine Complex

Project Description

Faro Mine Area (100)
3D View C

Date: Sep. 2008
Approved:
Figure: **100-4**



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Faro Mine Closure
Fermeture de la mine Faro

Job No: 1CY001.018
Filename: Figures_2-7_Faro Mine_20080829.ppt

Faro Mine Complex

Project Description

Faro Mine Area (100)
3D View D

Date: Sep. 2008
Approved:
Figure: **100-5**



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Faro Mine Closure
Fermeture de la mine Faro

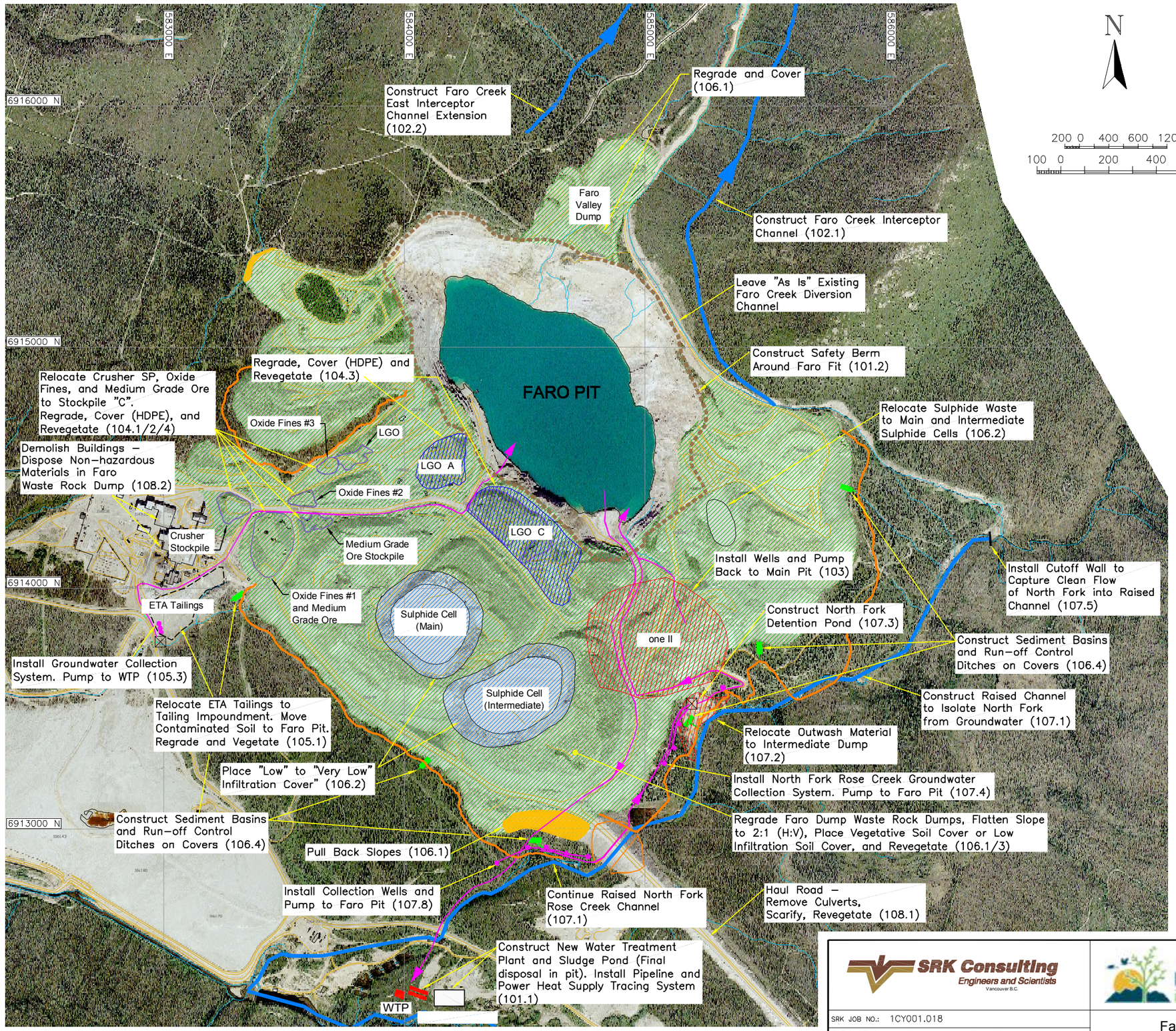
Job No: 1CY001.018
Filename: Figures_2-7_Faro Mine_20080829.ppt

Faro Mine Complex

Project Description

Faro Mine Area (100)
3D View E

Date: Sep. 2008
Approved:
Figure: **100-6**



Legend

Construct Safety Berm Around Faro Pit (101.2)	Closure Activity (work item number, See Table 100-1 for details)
LGO	Low Grade Ore
	Very Low Infiltration Soil Cover (1.0m Compacted Till, 1.5m Loose Till)
	Vegetative Soil Cover (0.5m Loose Till) or Low Infiltration Soil Cover (0.5m Compacted Till, 1.5m Loose Till)
	HDPE Cover (HDPE overlain by 1.0m Loose Till)*
	Waste Rock Slope Pulled-Back
	Collection Sump
	Sediment Collection Basins
	Groundwater Pumping Well
	Water Treatment Plant
	Change in Channel
	Sediment Collection Ditch
	Pipeline
	Resloped Dump Toe
	Safety Berm around Faro Pit

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FILE NAME: Project Description -Faro Pit.dwg

Faro Mine Closure
Fermeture de la mine Faro

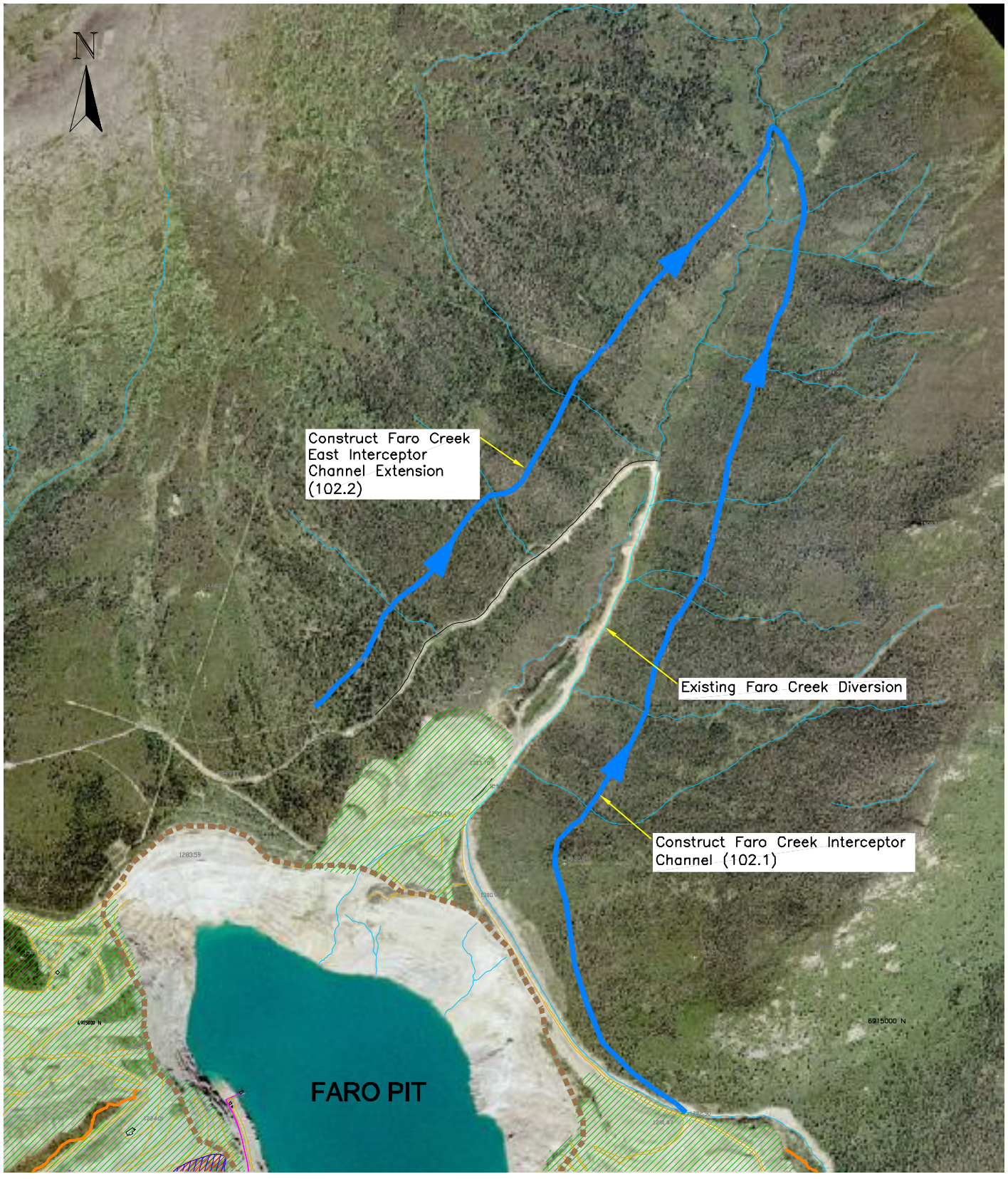
Faro Mine Complex

Project Description

Faro Mine Area (100) Closure Activities

DATE:	APPROVED:	FIGURE:
September 2008	PMH	100-7

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Legend

Construct Safety Berm Around Faro Pit (101.2)

Closure Activity (work item number, See Table 100-1 for details)

0 150 300 450 600 750

Scale in Metres

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Faro Mine Closure
Fermeture de la mine Faro

Project Description

Faro Creek Interceptor Channel (102) Closure Activities

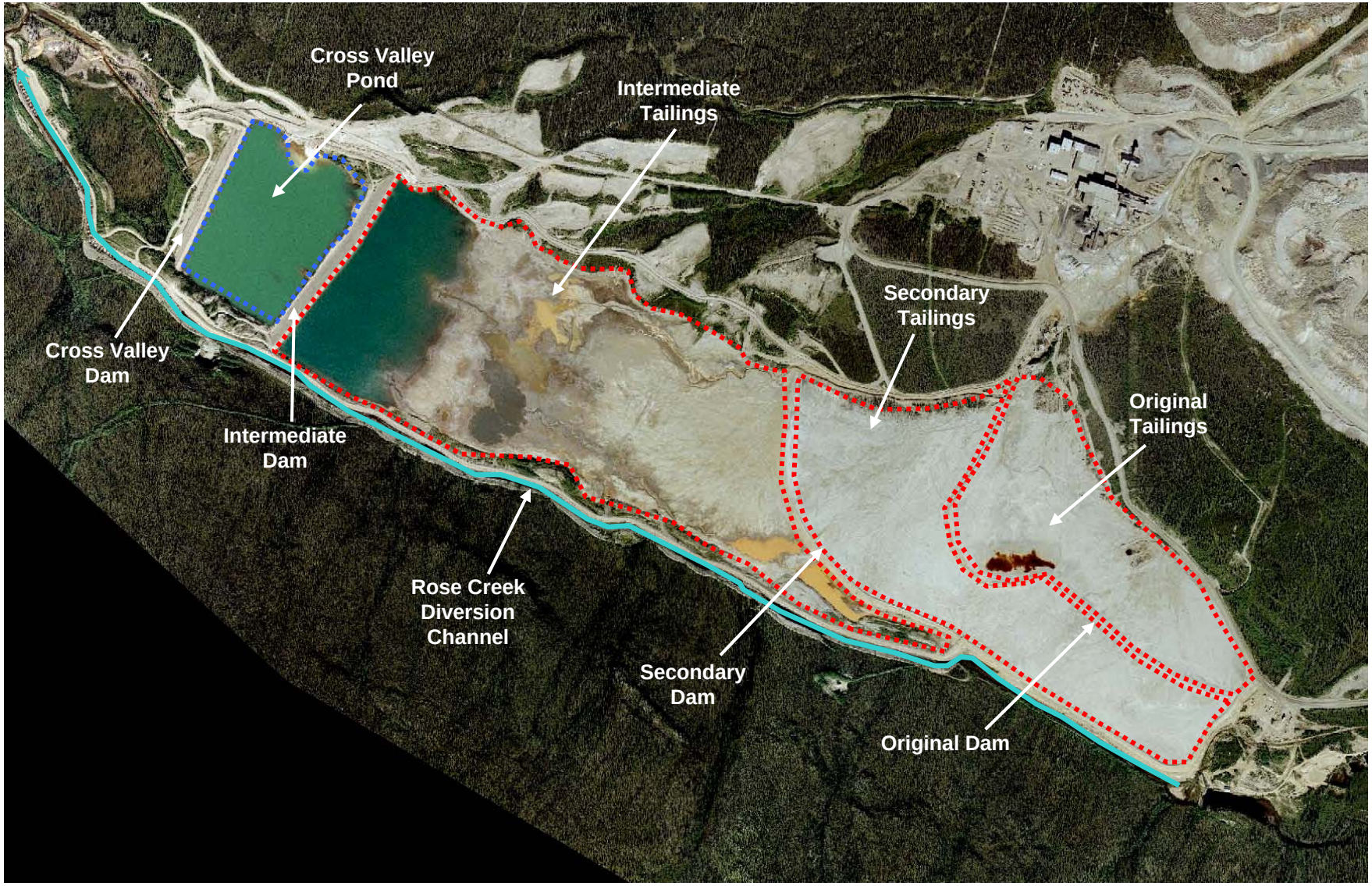
SRK JOB NO.: 1CY001.018

FILE NAME: Project Description -Faro Pit.dwg

Faro Mine Complex

DATE:	APPROVED:	FIGURE:
September 2008	PMH	100-8

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Faro Mine Closure
Fermeture de la mine Faro

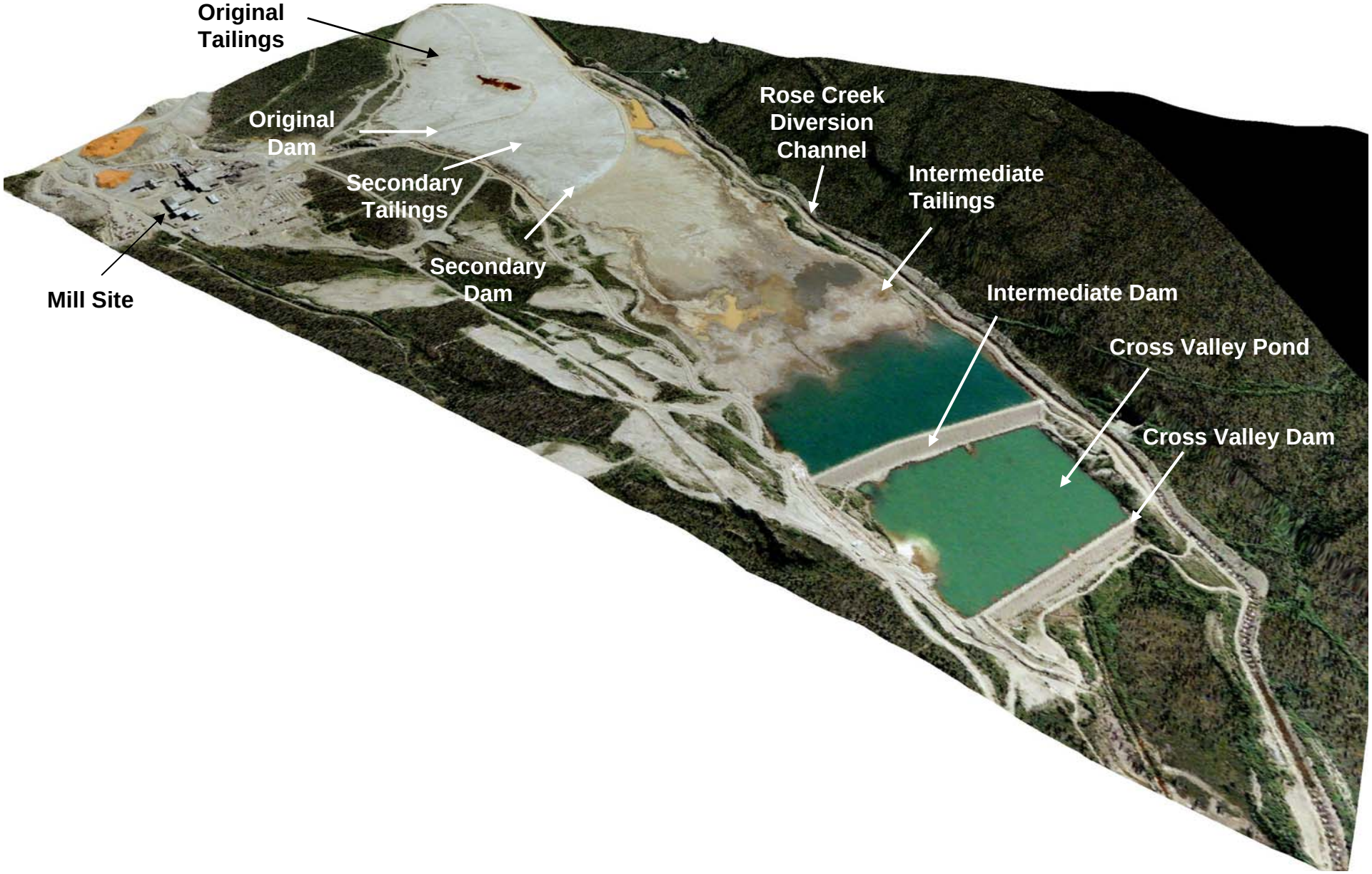
Project Description

Tailings Area (200)
Site Plan

Job No: 1CY001.018
Filename: Figures_Tailings_20080829.ppt

Faro Mine Complex

Date: Sep. 2008
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Figure: **200-1**



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Faro Mine Closure
Fermeture de la mine Faro

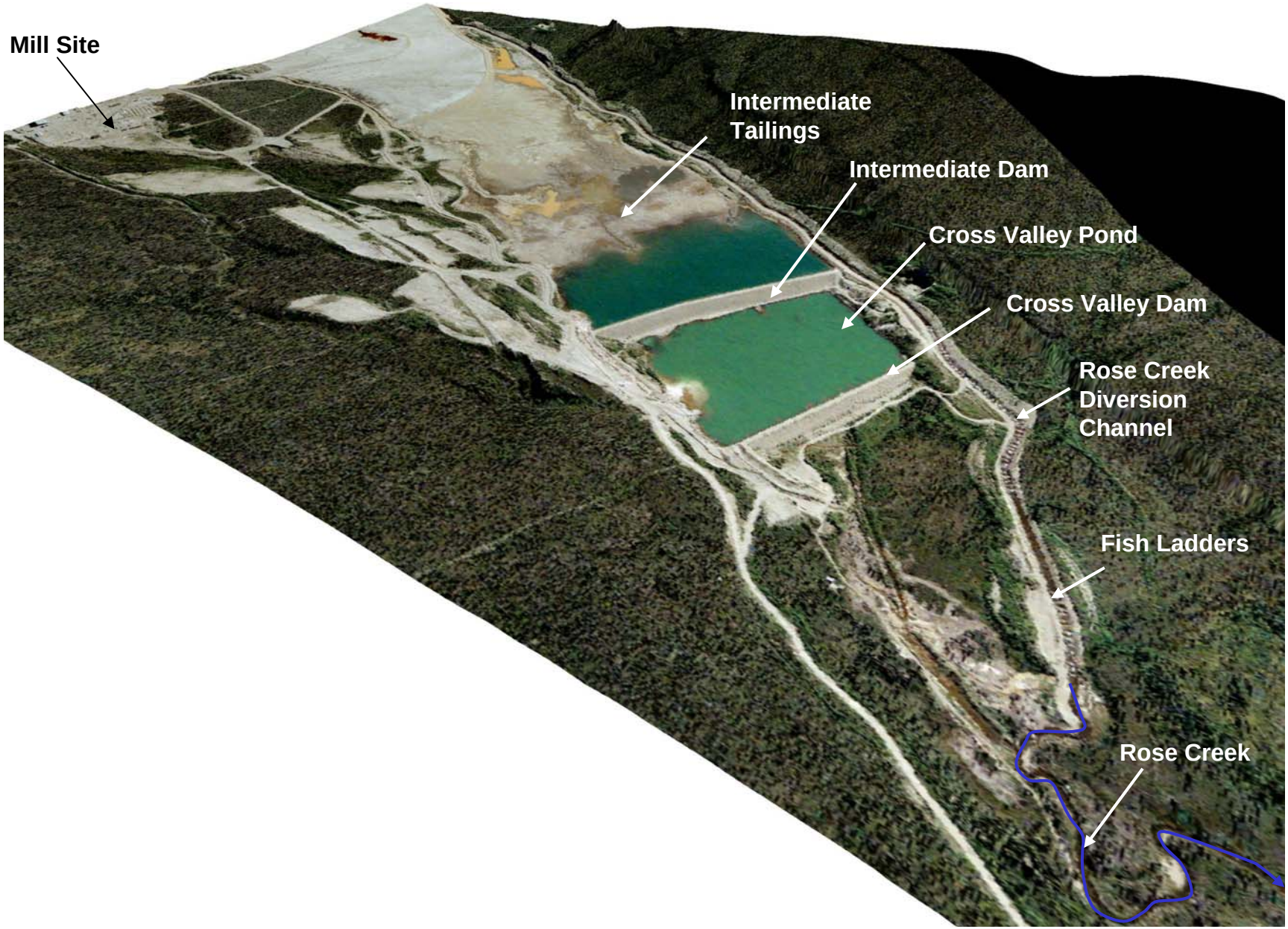
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Filename: Figures_Tailings_20080829.ppt

Faro Mine Complex

Project Description

Tailings Area (200
3D View F

Date: Sep. 2008
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Figure: **200-2**



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Faro Mine Closure
Fermeture de la mine Faro

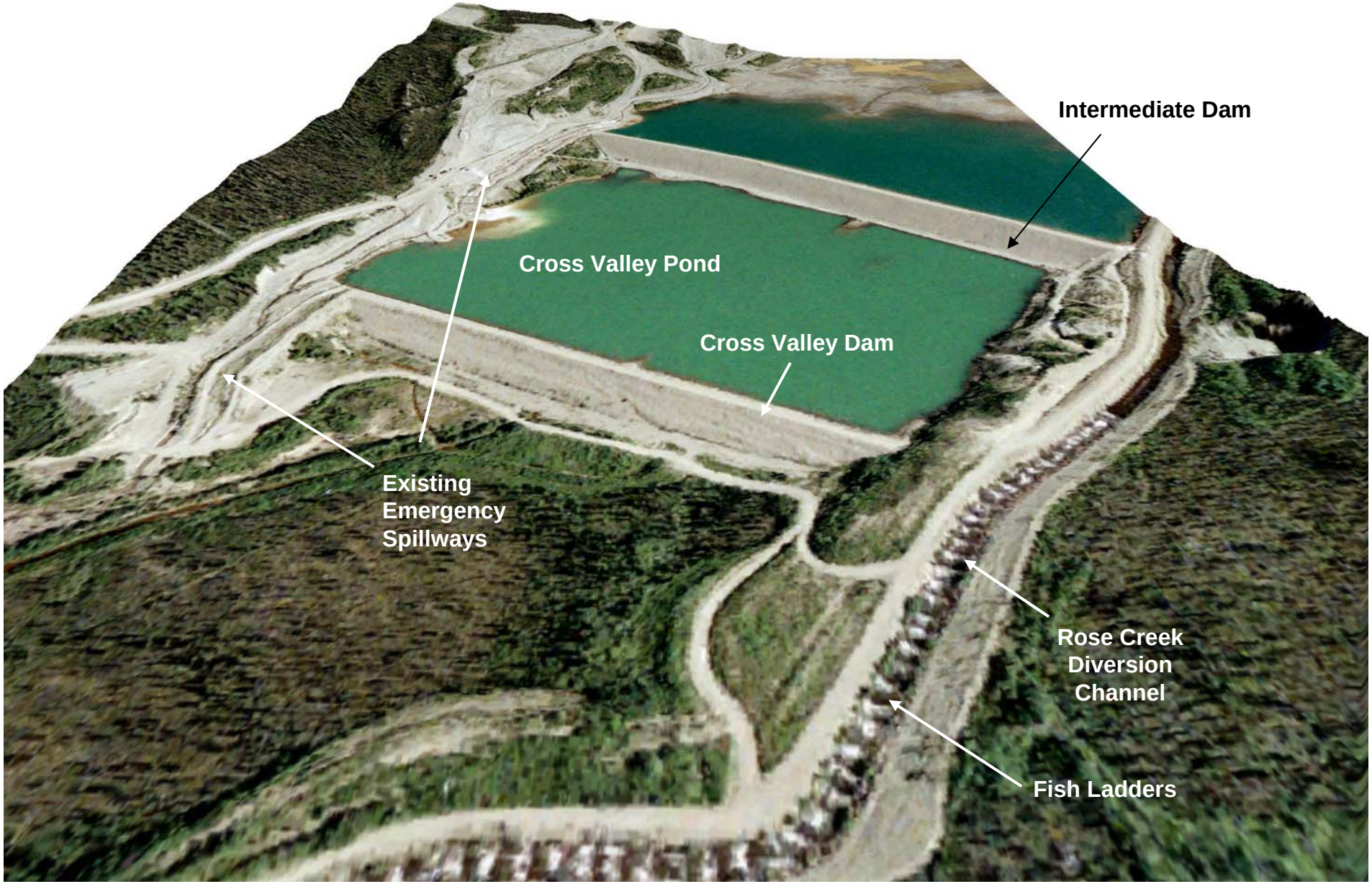
Job No: 1CY001.018
Filename: Figures_10-14_20080902.ppt

Faro Mine Complex

Project Description

Tailings Area (200)–North End 3D View G

Date: Sep. 2008
Approved:
Figure: **200-3**



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Faro Mine Closure
Fermeture de la mine Faro

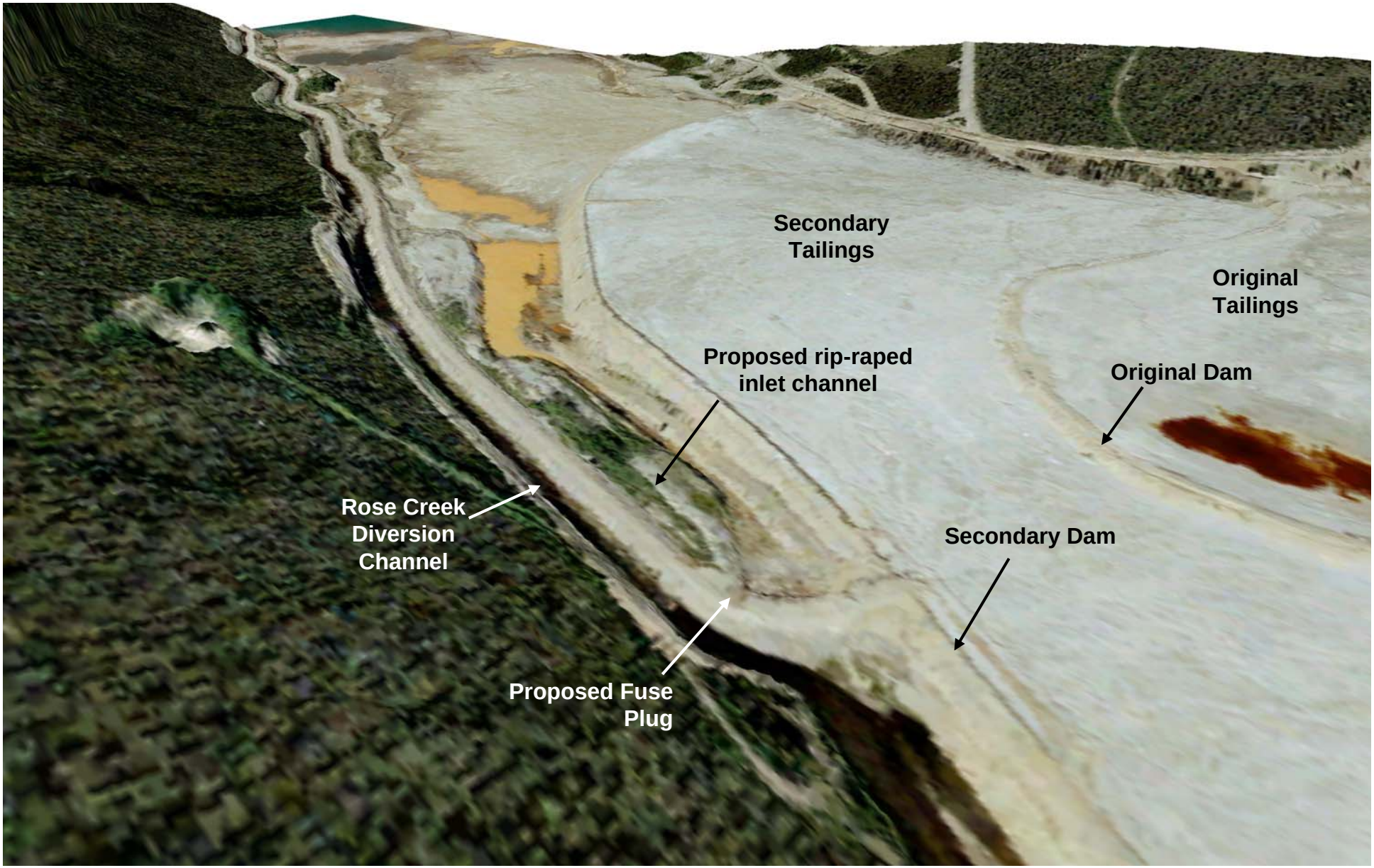
Job No: 1CY001.018
Filename: Figures_10-14_20080902.ppt

Faro Mine Complex

Project Description

Tailings Area (200)
Intermediate Dam - 3D View H

Date: Sep. 2008
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Figure: **200-4**



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Faro Mine Closure
Fermeture de la mine Faro

Job No: 1CY001.018
Filename: Figures_10-14_20080902.ppt

Faro Mine Complex

Project Description

Tailings Area (200)
Proposed Fuse Plug
3D View I

Date: Sep. 2008
Approved:
Figure: **200-5**

Collect Groundwater at Interceptor Trench (204.3)

Construct Cut–Off Wall (204.1)

Construct Interceptor Ditch (204.2)

Construct Intermediate Dam Spillway for Flow above 135m³/s (1:500 year) (201.2)

Upgrade Guardhouse Creek to Intermediate Dam

Construct Emergency Groundwater Storage at CVD (204.1)

Raise Intermediate Dam to Provide Freeboard (201.2)

Reclaim Roads where Appropriate

Pump Impounded Water to WTP (202.1)

Install Seepage Collection System at Intermediate Dam (204.4)

Place Low Infiltration Cover 1.5m Till Cover over 0.5m waste and Vegetate (202.1)

Construct Flow Distribution Swales in Intermediate Impoundment (202.1/3)

Cross Valley Dam

Stabilize Ground at South End with Buttress (201.2.5)

Drain Pond, Remove Sludge. Breach Dam, Revegetate (201.1)

Intermediate Dam

Place Low Infiltration Cover 1.5m Till Cover over 0.5m waste and Vegetate (202.2)

Reconstruct Rose Creek below Fuse Plug to Pass 500 Year Event (135m³/s) (Contingency) (203.1)

Secondary Dam

Replace RCDC Overflow Berm with Fuse Plug that Overtops during the 500 Year Event (203.2)

Water pumped from Faro Pit to WTP

Remove Rock Drain (203.4)

Regrade Inlet Channel and Line with Riprap (202.1)

Stabilize (densify) Ground at East Limb (201.3)

HDS Treatment Facility for contaminated groundwater

North Fork Rose Crk in lined channel

Upgrade RCDC to Fuse Plug for PMF, (670 m³/s) (203.2)

Sludge Pond (Final disposal to Faro Pit)

Treated effluent discharged into Rose Creek

Upgrade South Fork Rose Creek by Raising Channel (Contingency) (203.1)

Cut–off Wall (contingency)

582000 E

583000 E

584000 E

585000 E

6914000 N

6913000 N

6912000 N

N

LEGEND

Remove Rock Drain (203.4)

Closure Activity (work item number)

- Store and Release Cover
- Dam Stabilization Area
- Channel Excavation Area
- Groundwater Collection Well
- Water Treatment Plant
- Groundwater / Seepage Pipeline
- Slurry Wall
- Interceptor Trench
- Seepage Collection Sump

200 0 400 600 1200 feet

100 0 200 400 600 Metres

Faro Mine, Yukon

Contour Interval: 10m
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

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FILE NAME: Project Description –Tailings.dwg

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex

Project Description

Tailings Area (200) Closure Activities

DATE: September 2008 | APPROVED: PMH | FIGURE: 200-6

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Faro Mine Closure
Fermeture de la mine Faro

Project Description

Vangorda/Grum Area (300) Site Plan

Job No: 1CY001.018

Filename: Figures_300-1-4_Vangorda-Grum_20080903.ppt

Faro Mine Complex

Date: Sep. 2008

Approved:

Figure: **300-1**



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Faro Mine Closure
Fermeture de la mine Faro

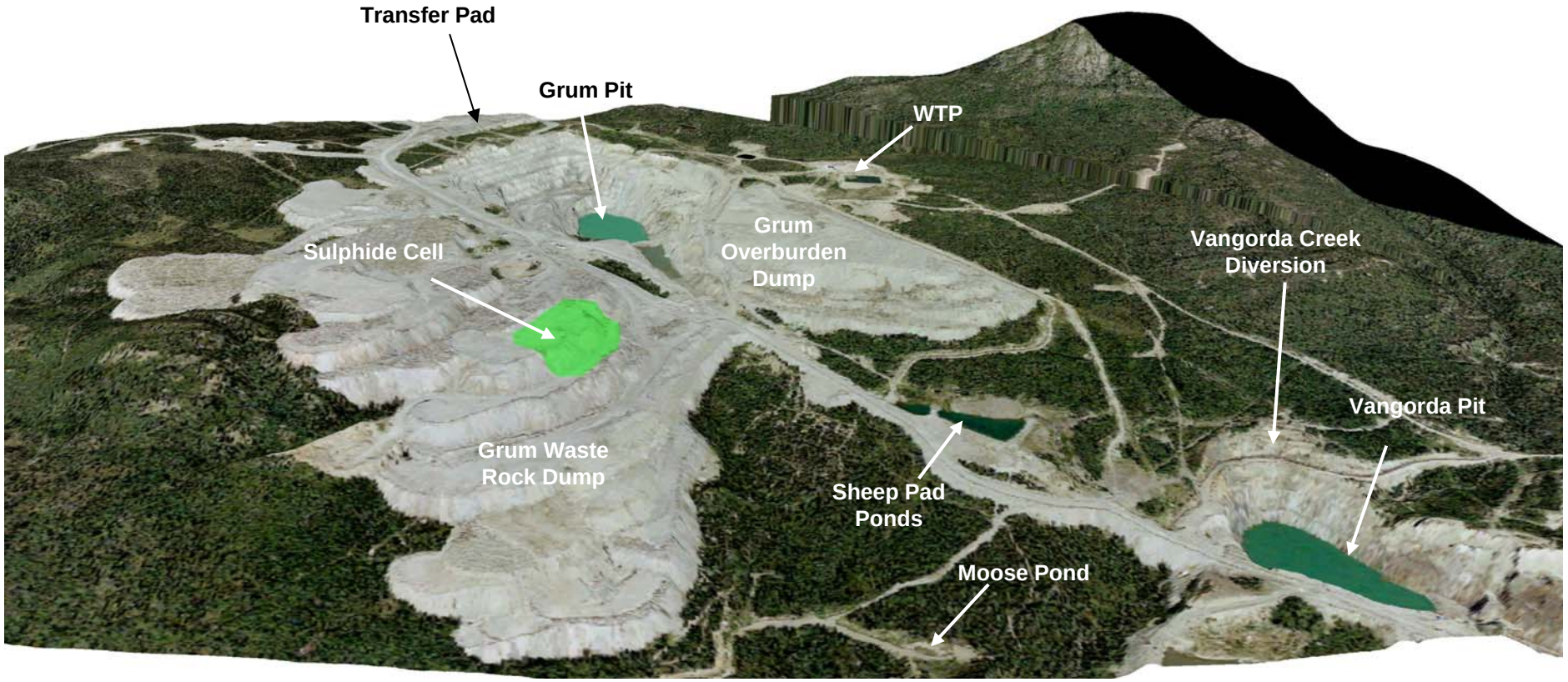
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Faro Mine Complex

Project Description

Vangorda/Grum Area (300)
3D View J

Date:	Approved:	Figure:
Sep. 2008		**300-2**



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Faro Mine Closure
Fermeture de la mine Faro

Job No: 1CY001.018
Filename: Figures_300-1-4_Vangorda-Grum_20080903.ppt

Faro Mine Complex

Project Description

Vangorda/Grum Area (300)
3D View K

Date: Sep. 2008
Approved:
Figure: **300-3**



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Faro Mine Closure
Fermeture de la mine Faro

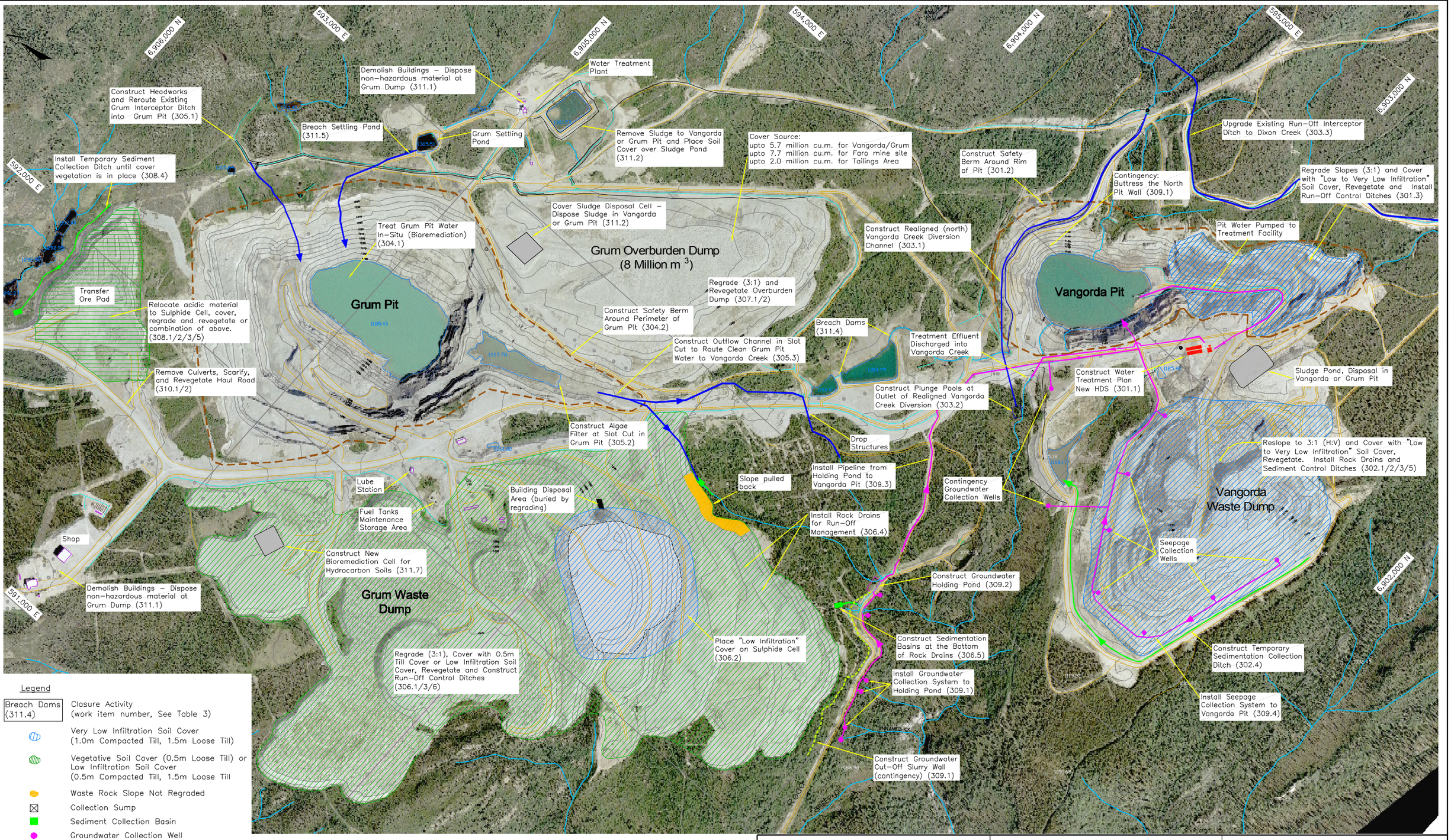
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Filename: Figures_300-1-4_Vangorda-Grum_20080903.ppt

Faro Mine Complex

Project Description

Vangorda/Grum Area (300)
3D View L

Date: Sep. 2008
Approved:
Figure: **300-4**



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SRK JOB NO.: 1CY001.018

FILE NAME: Project Description Grum–Van Pit.dwg

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex

Project Description

Vangorda/Grum Area (300) Closure Activities

DATE:	APPROVED:	FIGURE:
September 2008	PMH	300-5

Attachments

Extracts from Relevant Technical Reports

Work Area 100 – Faro Mine Area

Faro Mine Area (100)

Work Items

101 – Faro Pit

102 – Faro Creek

103 – Zone II Pit

104 – Oxide Fines/LGSP

105 – ETA Tailings

106 – Faro Waste Rock Dumps

107 – Groundwater

108 - Miscellaneous

Work Area Code 101

Faro Pit

Island Copper Mine is successfully using *in-situ* biogeochemical processes in the pit lake to meet permit water quality in the top water layer. However, the pit lake system is still in flux (Fisher and Lawrence 2002) and the long-term performance of biogeochemical processes is unknown. The Island Copper pit lake is also unique because seawater was used to establish meromixis in the lake.

4.5 Summary of Recommendations

Three pit-lake treatment methods were identified for further consideration:

- Lime or some other similar form of chemical treatment to raise the pH.
- Amendments with sugar and alcohol to create anoxic conditions under which SRB precipitate metals.
- Nutrient additions as means of creating algae and phytoplankton that remove metals such as Zn when they settle to the bottom.

Lime treatment has been used successfully in the past for pit lake treatment at Samatosum in B.C. and is still used for lake treatment at the Levack mining complex in Ontario. Issues that would need to be addressed with respect to lime treatment include:

- the lack of Fe in the drainage to co-precipitate trace metals such as Zn;
- whether treatment should occur in the pit or only to the overflow;
- whether additional measures will be required to lower the resulting pH prior to discharge; and
- how to prevent discharge of the resulting precipitates.

According to a paper by Harrington at the recent BC ARD workshop (2002), treatment of pit lakes with sugar, alcohol and proprietary amendments has been very successful in creating anoxic conditions under which SRB precipitate metals. A major limitation for SRB reactors is the input of oxygen in drainage or from surface processes such as wind action. Oxygen associated with the acid drainage at the the Island Copper is the likely reason SRB activity has been limited. Specific issues with respect to sulpate reduction that should be addressed include:

- compatibility with water management limitations and requirements;
- oxygen inputs;
- the quantity and frequency and method of amendment application, and the resulting costs; and
- measures required to address site-specific conditions.

Proprietary amendments (e.g., nutrients) may also represent an issue with respect to implementation and operation costs.

Nutrient additions as means of stimulating the growth of phytoplanktonic algae, is successful at least in the short-term both at the Island Copper and Landusky pit lakes (Adams, 2002). Successful results were also obtained from pilot-scale tests at Equity Silver mine. Equity has a cold climate that although not as harsh may be comparable to Faro. Issues that would need to be

Work Area Code 102
Faro Creek

Table 4-1: Structural Measures to Reduce Rate of Pit Crest Regression

Alternative	Costs / Life	Comments
Fill Buttress	Very High / Long Term	Requires a very large amount of fill within the pit limit, would halt regression altogether.
Place Steel Mesh on Upper Slope	Low / NIL	Typically used for safety purposes to contain rock fall on transportation corridors. Not intended to stabilize slope, and has no effect on overall stability.
Shotcrete Anchored to Upper Slope	Low - Medium / Short Term	Raveling and undercutting below screen precludes long term use.
Shotcrete Anchored to Entire Slope	High / Unknown	Not feasible since no anchorage available on lower slope due to talus on lower slope and on-going creep/raveling of materials.
Interception of Seepage Flows	Medium-High / Short Term	May be difficult to achieve, seepage may only be part of crest regression process, refer to Section 6.

From Table 4-1, it can be seen that in terms of short-term crest stabilization, Alternative 3 appears most favorable. This option would simply stabilize the upper/overburden part of the slope and would be subject to undercutting. This treatment will be directly affected by the rate of lower slope raveling/regression (unknown, but likely similar to crest regression rate). Based on our experience, most attempts at containing such raveling type failures are unsuccessful and hence, it is difficult to estimate the expected service life of such a treatment. It is estimated that the cost per unit length of slope for a 12-m high treatment is approximately $3,800/m including engineering and contingencies (see Appendix II). Thus, the capital cost estimate for installation of a 100m section of shotcrete wall support would be in the order of $380,000.

4.3 Seepage Control at the Crest of the Faro Pit

Control of the seepage at the crest of the Faro Pit is also being considered because:

1) It could reduce the amount of clean water entering the pit and requiring treatment, thus providing a cost savings over the next five to ten years, and;

An impermeable "slurry wall" type of cutoff could be used along the access road along the pit crest. However, in order to impede seepage at the bedrock contact, the slurry wall would have to be keyed into competent bedrock. Given the overburden depths and the limited space, this alternative would likely prove impractical and very costly (as blasting is likely required). Therefore, this option is not considered favorable.

Alternatively, the proposed East Interceptor, which would be upslope of the FCDC, could be excavated to the bedrock contact (if the depth to bedrock is less than 5 m), and keyed into competent bedrock. Test pits indicate that bedrock is shallow in this area. The detailed design of the East Interceptor (if selected as the preferable option) would consider this seepage-collection function as one of the design criteria.

7.0 DETAILED COMPARISON OF EAST INTERCEPTOR AND WEST INTERCEPTOR

7.1 Technical Comparison

The design grade used for both of the channels is 0.5% from the upstream point at Faro Creek to just past the Faro pit. Beyond that point, the grades are steeper to accommodate a transition to the receiving streams.

The two proposed alternatives are equally acceptable from a design point of view. The design section for each channel is the same (Figure 7-1). Both channels are located a safe distance from the pit so as not to be undercut from pit crest regression. Refer to Section 4.1 for discussion of long-term stability.

For the West Interceptor, additional typical design sections would be required for excavations in rock, permafrost, and unfrozen soil. The West Interceptor would present greater logistical challenges during construction, due to the additional length of the total system and the necessary upgrades to UGC and NWID.

In areas where the channel is to be excavated in permafrost, the typical section includes placing a layer of granular material, or thermal blanket, on top of the excavated slope above the channel (Figure 7-1). The purpose of this material is to insulate the native soil below, and to maintain the silty soil in a frozen state throughout the year. This would improve the stability of the cut slope. The thickness of the thermal blanket shown on Figure 7-1 is a preliminary estimate. The actual thickness of the thermal blanket will depend on the ground temperature regime along the alignments of the proposed interceptor channels.

7.2 Capital Cost Comparison

In this section, we have summarized estimated costs for the two proposed diversion alternatives. These numbers are based on preliminary unit prices provided by Pelly Construction (Pelly) of Whitehorse, YT (see Appendix II). Pelly was involved in the construction of the original FCDC and are familiar with the site conditions and construction methods.

7.2.1 East Interceptor

The most significant assumptions made for calculating the estimated costs to construct the East Interceptor were:

- The test pitting program indicated that the majority of the overburden at the East Interceptor would be excavated in frozen ground. Therefore, we have based the estimate on a conservative assumption that 70% of the length of the channel will be excavated in frozen ground, and the remaining 30% in rock.

- Based on conversations with personnel from Pelly, we have assumed that all permafrost will be rippable.

- The entire length of the East Interceptor channel will be constructed completely in cut (Figure 7-2). It is anticipated that the excavated material will be sent to spoil adjacent to the channel, within 500 m haul distance.

- A thermal blanket will be required to protect the uphill side slope.

- The East Interceptor discharges to the existing Faro Creek Diversion, which in turn discharges to the North Fork of Rose Creek. It has been assumed that minimal upgrade will be necessary from the discharge point of the East Interceptor to the North Fork of Rose Creek. Therefore, no allowance has been made for this item in the estimated costs.

FCDC Downstream of Faro Pit

Based on a preliminary inspection of the existing channel of the Faro Creek Diversion Channel between the Northeast Rock Dump and its confluence with the North Fork of Rose Creek, it appears that the channel is founded in a bedrock outcrop for most of its length. It is therefore anticipated that only minor improvements may be necessary to ensure that the channel can pass the design discharge without any substantive damages.

7.2.2 West Interceptor

The most significant assumptions made for calculating the estimated costs to construct the West Interceptor were:

- The test pitting program indicated that most of the West Interceptor would be excavated in frozen ground. However, there will likely be sections which will be excavated in bedrock, or in unfrozen soil. Therefore, we have assumed based on the test pits, that the following proportions will be excavated in each type of material:
    - 60% frozen ground (rippable)
    - 20 % bedrock (drill and blast)
    - 20% unfrozen soil.

The most effective upgrade option is considered to be an excavated trapezoidal channel with a riprap lining (Option 1). Channel dimensions would be approximately 6m base width, minimum 1.5H:1V side slopes, with a minimum 1-m high banks (includes 0.45 m freeboard at 27m^3/sec). The channel would be lined with riprap underlain with a granular filter material (Figure 7-4). This type of construction would be consistent with other parts of the diversion channel and would provide a long-lasting channel lining requiring minimal maintenance. Since this channel section is past the Faro Pit, it would not require additional lining to control seepage into the pit.

The North Wall Interceptor Ditch would also need some improvements if it is to be used as part of a long term diversion scheme. This would involve some localized widening of its base and/or increasing bank heights to increase its capacity. The channel would also need to be lined with riprap along its entire length to its confluence with Rose Creek. For cost estimating purposes, we have assumed that a low-permeability liner is not necessary for this section of the diversion.

Table 6-1: Summary of Capital Cost Estimates

#	Description	Cost Estimate*
1a	East Interceptor	$2.44 M
1b	East Interceptor with extension along west side of Faro Valley	$4.04 M
2a	West Interceptor including Upper Guardhouse and North Wall Interceptor upgrades	$4.15 M
2b	West Interceptor with extension along east side of Faro Valley	$5.85 M
* See details of capital cost estimates in Appendix II.		

7.3 Preferred Relocation Alternative

Based on the above technical and cost comparisons, we recommend that the East Interceptor with an extension of the interceptor along the west side of the Faro Valley (Alternative 1b above) be pursued as the preferred option.

Work Area Code 103
Zone II Pit

Executive Summary

An assessment of groundwater flow and water quality has been carried out in the Zone 2 outwash area (south of the Zone 2 Pit) to assist in the conceptual design of a seepage interception system (SIS) for this area.

The drilling in the North Fork Rose Creek (NFRC) valley encountered permeable glacio-fluvial sediments to a depth of at least 8.2 m (25 ft), overlain in areas by up to 2.5 m (8 ft) of mineralized outwash material from the Zone 2 Pit area. A 24 hour pumping test suggested a transmissivity of about 300 m^2/day in this aquifer and an estimated groundwater flow (west of the NFRC) of about 3.0 L/s (260 m^3/day).

The groundwater pumped from the NFRC aquifer is very dilute (EC ~450µS/cm), with sulphate concentrations slightly less than 100 mg/L. However, the zinc concentrations in this aquifer are significantly elevated (~2.4 mg/L). The current sulphate and zinc loads in groundwater in this area are estimated to be approximately 9 t/yr and 0.23 t/yr, respectively. While the sulphate loading is very small, the zinc loading to groundwater in this area is significant (almost an order of magnitude higher than currently in the Rose Creek aquifer).

Preliminary water balance calculations for the Zone 2 Pit suggest that seepage out of the Zone 2 Pit may be as high as 9,800 m^3/year (0.31 L/s). However, the sulphate and zinc loads currently observed in the NFRC aquifer are lower than those estimated for the Zone 2 seepage suggesting that seepage losses from the Zone 2 Pit may be lower by a factor of 2 to 4. Nevertheless, seepage from the Zone 2 Pit and associated waste rock dumps is believed to be the primary source of zinc contamination in the NFRC aquifer upgradient of the rock drain.

The recommended approach of seepage interception in the Zone 2 outwash area should utilise a combination of methods installed in phases. The initial installation phase would focus on the high concentration/high load zones (below the Zone 2 Pit). Additional system upgrades would be implemented in other areas, if and when required. These contingency measures may, for example, be required in lower concentration/load zones, not initially targeted.

An adaptive management program has been designed that will assess the performance of the initial SIS and will provide for system upgrades, if and when required.

The recommended initial SIS consists of a permeable trench installed down to bedrock combined with a fence of extraction wells screened in the permeable trench and the underlying weathered/fractured bedrock. The SIS is aligned along the toe of the waste rock dumps associated with the Zone 2 Pit and has a length of approximately 400 m. Prior to installation of the initial SIS, the mineralized outwash sediments should be removed and replaced with clean fill.

A brief description of these technologies is provided in our companion report on seepage entitled ***2005 Seepage Investigation at the S-cluster area below the Faro Waste Rock Dump (SRK, 2006b)***. The reader is referred to this companion report for more details on these technologies.

5.2 Recommended Approach

The recommended approach of seepage interception in the Zone 2 outwash area should utilise a combination of methods installed in phases. The use of a combination of methods is recommended for two reasons:

- the heterogeneous nature of the overburden geology; and
- the relatively broad distribution of contamination in the aquifer.

Due to these factors, the individual use of any of the collection methods described would not likely provide the required level of confidence for contaminant capture.

The initial installation phase would focus on the high concentration/high load zones (at the toe of the Zone 2 Pit). Additional system upgrades would be implemented in other areas, as required. These contingency measures may, for example, be required in lower concentration/load zones, not initially targeted.

Contingency remedial phases would be implemented in a timely manner according to a well-defined adaptive management plan integrated with an extensive monitoring network.

5.2.1 Initial SIS

The pumping test analysis has shown that pumping of the alluvial aquifer in this area is a viable option to intercept the impacted groundwater. Excessive leakage from the NFRC is likely not a significant factor as the river appears to be perched (to be confirmed by additional monitoring). Furthermore, loading calculations suggest that seepage from the Zone 2 Pit and overlying waste rock dumps is the most likely source of elevated zinc in the local groundwater.

Therefore, we recommend the installation of a fence of extraction wells aligned along the toe of the waste rock dumps covering the Zone 2 Pit (see Figure 11 for alignment of the SIS). The extraction wells would be screened in the NFRC sediments and in the upper (weathered and/or fractured) bedrock. Although the alluvial sediments have a moderately high hydraulic conductivity, the transmissivity of the aquifer is limited by the relatively shallow depth of the aquifer. The shallow depth limits the available drawdown and therefore the maximum pumping rate that can be used. Assuming an average pumping rate of 30 USgpm (1.9 L/s), the radius of influence of each pumping well is estimated to be about 30-50 m. Depending on local aquifer conditions approximately 4-6 extraction wells may be required to intercept all impacted groundwater flowing towards the NFRC aquifer. For the purpose of this conceptual design, we have assumed the installation of 5 extraction wells at a 50m horizontal spacing (Figure 11).

Work Area Code 104
Oxide Fines/LGSP

4 Summary and Conclusions

4.1 Oxide Fines and Low Grade Ore

4.1.1 Summary

Table 4.1 summarises the revised volume and surface area estimates based on the 2005 field investigations. As shown in the table, some uncertainty remains with respect to the Oxide Fines Stockpile. However, the volume estimates for Low Grade Stockpiles A and C are now fairly well defined. Note that the upper volume estimates, as presented in the previous assessment (SRK, 2005), are shown for the remainder of the stockpiles presented in the table. The reason for this is that, relative to the overall volume, the variance in upper and lower estimates for these stockpiles is small.

Table 4.1: Summary of Updated Oxide Fines and Ore Stockpile Area and Volume Estimates

Description	Planimetric Area (m^2)	Estimated Volume (m^3)
Oxide Fines Stockpiles - contains both green and brown oxide fines, as well as medium grade ore	24,200 to 49,800	693,000 to 1,373,000
Crusher stockpile	12,000	95,000
Medium Grade Stockpile	6,000	138,000
Oxide fines #2	5,000	67,000
Oxide fines #3	5,000	39,000
Low grade ore	7,000	44,000
Low Grade Stockpile A	42,500	256,000
Low Grade Stockpile C	91,000	654,000
Totals	**192,700 to 218,300**	**1,986,000 to 2,666,000**

* Note: For stockpile locations, please refer to Figure 2.1. For areas, please refer to SRK (2005)

As discussed in the preliminary oxide fines management plan (SRK, 2005), three potential strategies were considered namely, cover in place, consolidate to Low Grade Stockpile C or complete relocation to the Faro Pit. That report presented preliminary costs based on the high and low volume estimates, and for two possible fleet configurations. The cost estimates have been revised for the current volume estimates, but for simplicity, only the cost estimates for the high capacity fleet are summarised in the following sections.

4.1.2 Cost Implications

Cover in Place

The cover design, adopted for both the 'cover in place' option and the 'consolidate and cover' option (see next section), comprises a 0.5 m compacted till layer, overlain by a 1.5 m nominally compacted till layer. This cover is expected to reduce infiltration to less than 5 % of the mean annual precipitation. This cover design has not been optimized but has been adopted in this report for the purpose of cost comparisons (and to be consistent with the 2005 assessment).

Based on the cover design and placement requirements, all slopes would be re-graded to 3:1 (H:V) in preparation for cover placement. The maximum down-slope run is assumed to be 50 m. Conservatively it was assumed that runoff length would be restricted to a maximum of 15 m to minimise soil loss.

The estimated costs for covering the ore and oxide fines stockpiles in place are summarised in Table 4.2. As shown in the table, the estimated costs range from about $7.4 to $8.3 million.

Table 4.2: Summary of Estimated Costs for Cover in Place

Location	Low Area	High Area
Oxide Fines Stockpile	$924,000	$1,902,000
Crusher stockpile	$458,000	
Medium Grade Stockpile	$229,000	
Oxide fines #2	$191,000	
Oxide fines #3	$191,000	
Low grade ore	$267,000	
Low Grade Stockpile A	$1,623,000	
Low Grade Stockpile C	$3,476,000	
Totals	**$7,359,000**	**$8,337,000**

Note: Estimates derived for a Cat 777 truck fleet

Consolidate and Cover

A cover construction - water management strategy similar to that proposed for the 'cover in place' option would be adopted for the 'consolidate and cover' option. It should be noted that no attempt was made to determine the most efficient combination of relocation and covering in place but was intended to provide a basis for comparison to covering in place.

The costs estimated for relocating Low Grade Stockpile A is about $1.25 million (not including any lime amendment), compared to a 'cover in place' cost of $1.62 million. It is, therefore, more cost effective to consolidate this pile at the Low Grade Stockpile C location.

The cost to relocate the Oxide Fines Stockpile is estimated to be about $6.1 million for the low volume estimate, and about $8.3 million for the high volume estimate. These estimates assume that

the stockpile extends to the original topography. Should the dump extend to somewhere between the end of the drillhole and the original topography it may be possible that the actual costs will be lower, but no lower than about $1.9 million, which is equal to the volume to the bottom of the drillhole for the smaller footprint area. The corresponding estimated costs to cover this material in place range from $0.9 million to $1.9 million. There is, therefore, a clear cost advantage to cover this material in place.

The estimated costs for covering in place and consolidating the remainder of the Oxide Fines Stockpiles at the Low Grade Stockpile C location are summarised in Table 4.3. Again, only the estimate for the high capacity truck fleet is presented. As shown, the estimated costs are expected to range from about $8 million to $9 million. It should be noted that the volume estimates for determining relocation costs do not include any allowance to also relocate any acidic or metal-rich underlying soils or waste rock. Relocation costs may therefore be higher than indicated.

Table 4.3: Summary of Estimated Costs for Consolidate and Cover Option

Description	Location	Low Estimate	High Estimate
Load, haul, place and compact ore and oxide fines at Low Grade Stockpile C location	Low Grade Stockpile A	$1,249,000	
	Crusher stockpile	$ 603,000	
	Medium Grade Stockpile	$ 875,000	
	Oxide fines #2	$ 425,000	
	Oxide fines #3	$ 247,000	
	Low grade ore	$ 279,000	
Cover in place	Oxide Fines Stockpile	$924,000	$1,902,000
Cover consolidated materials	Low Grade Stockpile C	$3,476,000	
Totals		**$8,078,000**	**$9,056,000**

Note: Estimates shown for high capacity truck fleet (CAT 777).

Complete Relocation to Faro Pit

Estimates for the complete relocation of all the oxide fines and ore stockpiles to the Faro Pit are shown in Table 4.4. As shown, the costs for complete relocation of all the oxide fines and ore are expected to range from about $12.6 million to $16.9 million. As before, the volume estimates for determining relocation costs do not include any allowance for any acidic or metal-rich underlying soils or waste rock. Relocation costs may therefore be higher than indicated. These estimates also do not include the costs associated with lime amendment, should it be required. The need for lime amendment will depend on the long-term management strategy adopted for the pit lake.

Table 4.4: Summary of Estimated Costs for Complete Relocation of the Oxide Fines and Ore to the Faro Pit (Excluding Lime Amendment)

Task	Activity	Low Estimate	High Estimate
Load, haul, place and compact ore and oxide fines in Faro Pit	Oxide Fines Stockpile	$ 4,396,000	$ 8,710,000
	Crusher stockpile	$ 603,000	
	Medium Grade Stockpile	$ 875,000	
	Oxide fines #2	$ 425,000	
	Oxide fines #3	$ 247,000	
	Low grade ore	$ 279,000	
	Low Grade Stockpile A	$ 1,624,000	
	Low Grade Stockpile C	$ 4,149,000	
Total		**$12,598,000**	**$16,912,000**

Note: Estimates shown for high capacity truck fleet (CAT 777).

Alkali Amendment

Consideration may be given to amending the oxide fines and ore during relocation. Lime amendment would achieve the maximum reduction in solute concentrations in percolate from the consolidated heap. Limestone would not achieve similar reductions in solute concentrations, butI, it would sustain a reduction in solute concentrations over a longer period as it is less soluble than lime and, consequently, would not 'wash out'. Nonetheless, considering the reduction in net infiltration anticipated for the cover system, it can be shown that the term of benefit from lime amendment could be considerable. Table 4.5 summarises the estimated costs associated with lime amending. The costs associated with spreading the lime, however, are not included in the estimates. Should the oxide fines and ore be amended with lime during consolidation, the estimated lime amendment costs would be approximately $1.2 million (excludes Oxide Fines Stockpile and Low Grade Stockpile C). In the event of complete relocation to the Faro Pit, the overall lime costs are estimated to be between $2.2 million and $2.7 million.

Table 4.5: Summary of Estimated Costs Associated with Lime Amendment

Location	Lime Demand (kg/tonne)	Lime Cost ($/tonne)	Low Volume Estimate	High Volume Estimate
Oxide Fines Stockpile	2.28	0.73	$505,890	$1,002,290
Crusher stockpile	0.55	0.18	$17,100	
Medium Grade Stockpile	2.28	0.73	$100,740	
Oxide fines #2	12.55	4.02	$269,340	
Oxide fines #3	9.11	2.92	$113,880	
Low grade ore	6.65	2.13	$93,720	
Low Grade Stockpile A	7.34	2.35	$601,600	
Low Grade Stockpile C	2.28	0.73	$477,420	
TOTAL			**$2,179,690**	**$2,676,090**

4.1.3 Conclusions

The 2005 investigations have significantly reduced the uncertainty associated with the volumes of material in Low Grade Stockpiles A and C. Some uncertainty remains in the estimate for the Oxide Fines Stockpile, however.

The cost difference between the 'cover in place' ($7.4 to $8.3 million) and the 'consolidate and cover' ($8.1 to $9.1 million) options is about $1 to 2 million, with the cover in place option being more cost favourable. However, the 'consolidate and cover' option would reduce the foot print of the covered areas from between 19.3 ha and 21.8 ha, to between 11.5 ha and 14.1 ha. That is equal to a 36% to 40% reduction in surface area and would result in a proportional reduction in infiltration and consequently metal and acidity loadings. A corresponding reduction in cover maintenance requirements could also result. The reduction in acidity loadings and maintenance would likely offset the additional construction costs in the long term.

Lime amendment during the consolidation process would add an additional cost of about $1.2 million. The immediate reduction in acidity loadings that would result, as well as the added benefit from limiting solute release during relocation, should justify the additional expense.

Complete relocation to the Faro Pit, inclusive of lime amendment, is estimated to be between $14.8 and $19.6 million.

4.2 Plant Site Area

The preliminary assessment of the plant site fill determined that significant proportions of the fill have properties similar to those of the oxide fines and are acidic, as shown in Figure 3.3. However, it appears that at least some of these areas may represent thin layers of reactive material that have been pushed over the crest of the fills at the plant site area. Other areas show evidence (e.g. mill balls) that ore or ore-like material has been used as sub-grade for roads and parking areas.

5 Recommendations

5.1 Oxide Fines and Ore

As noted, there still remains some uncertainty regarding the volume and areal extent of the Oxide Fines Stockpile. Even so, the cost calculations suggest that, based on the current understanding of the area, cover in place will be more favourable than relocation. While not considered critical, it is nonetheless recommended that, should the opportunity arise (i.e. if a drill is on site and becomes available), additional drilling should be undertaken in this area to establish the material types down to the original topography as well as to define the areal extent of the Oxide Fines Stockpile.

The cost calculations presented herein are not optimized. They also do not consider long-term cost implications that relate to water treatment requirements and cover maintenance. The reason for this is that other closure activities that will occur on site, such as construction of water treatment facilities, have not yet been finalized. By dovetailing water treatment requirements for the covered areas, with other water treatment facilities, for example, overall treatment costs will be lower than in the case where a water treatment plant is constructed for the dedicated purpose of only treating the seepage from the covered areas. It is therefore recommended that once the overall closure strategy is better defined, complete costs associated with each option (including treatment and maintenance) be re-evaluated so that the oxide fines management can be optimised relative to the overall strategy.

5.2 Plant Site Area

It is recommended that these areas be better delineated by excavating additional test pits on the plateaus of the fill areas to determine both the horizontal and vertical (depth below surface) extent of these materials.

583000 E
583500 E
584000 E
584500 E
6914500 N
6914000 N
FARO PIT
Low Grade Stockpile "A"
Low Grade Ore
Oxide Fines #3
Oxide Fines #2
Crusher Stockpile
Medium Grade Ore Stockpile
Brown
Medium Grade Ore
Green
Oxide Fines Stockpile
Low Grade Stockpile "C"
1240.49
1224.01
1188.63
1188.62
1167.47
1163.43
1166.97
1181.59
1211.02
1187.64
1186.47
1232.81
1231.09
1152.85
1164.99
1230
1220
1210
1200
1190
1180
1170
1160
1150
50 0 100 200 300 feet
50 0 50 100 150 Metres
N

SRK CONSULTING
Faro Mine, Yukon

Map Scale:15,000
Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

File Ref: 2003 FARO SITE PLAN-Oxide Fines.dwg

SRK Consulting
Engineers and Scientists

Deloitte & Touche

Assessment of Select Oxide Fines and Ore Stockpiles

Plan of Ore and Oxide Fines Stockpile Locations, based on 2005 mapping

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.077	July 2006	JTC	2.1

Low Grade Stockpile "A"

Low Grade Stockpile "C"

Oxide Fines Stockpile
– contains 2 types of oxide fines, as well as medium grade ore

FARO PIT

PLANT SITE

LGSPA-07
LGSPA-08
LGSPA-06
TP-LGA-1
TP-LGA-2
TP-LGA-3
LGSPC-06
LGSPC-08
LGSPC-07
LGSPC-09
LGSPC-10
MGSP04

583000 E
583500 E
584000 E
584500 E
6914500 N
6914000 N

1240.49
1224.01
1188.63
1188.62
1167.47
1181.59
1163.43
1166.97
1149.26
1149.65
1211.02
1186.47
1187.64
1232.81
1231.09
1165.0
1110.93

Faro Mine, Yukon

Map Scale:1:2000
Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

50 0 100 200 300 feet
50 0 50 100 150 Metres

LEGEND

- LGSPA- 06 — Drill Hole Location
- TP-LGA-1 — Test Pit Location
- Low Grade Ore Deposits

SRK Consulting
Engineers and Scientists
Vancouver

SRK JOB NO.: 1CD003.077

Acad-Faro\2006 Acad drawings\FARO SITE PLAN-Oxide Fines_Task30.dwg

Deloitte & Touche

Anvil Range Mining Complex

Assessment of Select Oxide Fines and Ore Stockpiles

Revised Areas Based on 2005 Investigations

DATE:	APPROVED:	FIGURE:
July 2006	JTC	3.2

Work Area Code 105
ETA Tailings

contact. The results also suggest that lime amendment will be required for these soils, and that the lime demand will range up to 4.1 kg $Ca(OH)_2$ per tonne, with an estimated average of about 0.89 kg $Ca(OH)_2$ per tonne, calculated from the leach extraction test results.

5 Tailings Relocation Options and Costs

5.1 Relocation Options

As has been discussed in previous reports related to the potential relocation of the tailings in the Rose Creek tailings facility, the main options generally considered for tailings relocation consist of the following:

- Dredging;
- Hydraulic monitoring; and
- Mechanical excavation.

Comments on the potential application of these methods to relocate the ETA tailings are provided below.

5.1.1 Dredging and Hydraulic Monitoring

In view of the relatively modest volume of tailings present in the ETA and the high capital costs associated with the establishment of a dredge or hydraulic monitor system, these two methods of tailings relocation are not recommended for the ETA tailings.

However, because hydraulic monitoring is the preferred method under consideration for relocating the tailings in the Rose Creek tailings facility as part of closure, hydraulic monitoring at the ETA may be worth considering on a trial basis, despite the cost. However, there are a number of factors that suggest that information obtained from a trial with the ETA tailings will provide only limited information that is directly transferable to the larger scale relocation associated with the Rose Creek tailings facility. In particular, while the depth of the ETA tailings is a maximum of about 7½ m, the typical thickness is between 3 and 4 m. With this thickness, a substantial portion of the tailings profile consists of relatively dessicated tailings. Given that, except for the first cut, we would expect most of the tailings in the Rose Creek tailings facility to be relatively moist to wet, the limitations of a trial at the ETA become evident. Based on these factors, we do not recommend using hydraulic monitoring of the ETA tailings to attempt to demonstrate how the relocation of the main tailings deposit might proceed.

5.1.2 Mechanical Excavation

The limited area and thickness of the ETA tailings deposit are factors that support the relocation of the ETA tailings by mechanical measures. In particular, an excavator and small fleet of trucks are well suited to this tailings relocation project. Some of the factors that work in favour of mechanical excavation are as follows:

- The ETA tailings comprise a relatively small volume, occupy a concise area, have shallow thicknesses on the sides of the ETA and, over most of the deposit, are underlain by soils which are favourable to equipment traffic.
- There is a strong likelihood that some of the soil underlying the ETA tailings will require removal, and this removal can most efficiently done using mechanical excavation.
- The type of equipment and expertise required for mechanical excavation is available on a local hire basis.

Despite the attractiveness of mechanical excavation, there are portions of the tailings that will be prone to liquefaction in the back of a moving haul truck. Once liquefied, these tailings could flow out the back of the truck and spread over large, uncontrolled areas. It is important, therefore, that the haul trucks used on this program have gates that close properly. Furthermore, the contractor should have contingency plans to address the situation where the gates are insufficient to prevent the escape of liquefied tailings as the tailings are transported to their deposition location. Due to the depth of the wet tailings, it is unlikely that shifting the relocation process to colder periods of the year will overcome the liquefaction issue.

5.2 Relocation Costs

There are three main costs associated with the relocation of the ETA tailings. They include the following:

- Relocation of the tailings by mechanical methods;
- Addition of lime to the tailings as part of tailings re-handling;
- Relocation of contaminated soil beneath the tailings; and
- Addition of lime to the contaminated soils.

As noted in Section 4.1, the estimated volume of tailings is 51,000 m^3. However, it is reasonable to account for potential inaccuracies in the volume estimates. Allowing for another 4,000 m^3 of tailings (about 8%) would provide a reasonable contingency. Recently obtained information from the site indicates that the cost of moving soil is currently in the range of $7.50 to $9.50 per cubic metre. Given the sloppy nature of some of the tailings, the upper end value is probably more realistic for loading, hauling the tailings to the Rose Creek tailings facility, dumping and spreading the tailings.

Assuming lime must be added to all of the tailings and that the average dry density of the tailings is about 2 tonnes per cubic metre, there will be 55,000 m^3 or 110,000 tonnes of tailings requiring lime amendment. As noted in Section 4.3, the average cost of lime addition is $3.30 per tonne of tailings.

The thickness of the soil beneath the tailings that will have to be removed as well will require input from the FMCPO and others. For this report, it has been assumed that a 1 m thickness of soil will

have to be removed from the entire impoundment. This corresponds to a volume of approximately 15,000 m^3. It is relatively inefficient to have to remove 1 m of soil, and as a result, it is assumed that the cost to move this soil to the Rose Creek tailings facility is also $9.50 per cubic metre.

Assuming lime must be added to the contaminated soil and that the average dry density of the soil is about 2 tonnes per cubic metre, there will be 30,000 tonnes of contaminated soil requiring lime amendment. Based on the information in Section 4.4, the average cost of lime addition is $0.37 per tonne of contaminated tailings.

Table 5.1 has been prepared to summarize these quantities and costs based on the assumptions listed above.

Table 5.1 Estimate of Approximate Costs for Tailings Relocation

Item	Quantity	Units	Unit Price	Amount
Move tailings (with 10% contingency on quantity)	55,000	Cubic metres	$9.50	$522,500
Add lime to tailings	110,000	Tonnes	$3.30	$363,000
Move 1-m of contaminated soil beneath tailings	15,000	Cubic metres	$9.50	$142,500
Add lime to contaminated soil	30,000	Tonnes	$0.37	$11,200
Total				**$1,039,200**

With the exception of the contingency applied to the volume of tailings, there is no incremental contingency in the estimated cost provided above.

Detailed groundwater quality monitoring carried out in this area as part of this study (including sampling of recently completed monitoring wells, seeps and surface seepage in the ETA area) has confirmed that groundwater in this reach is highly contaminated. Furthermore, it has shown that concentrations of contaminants of concern (SO4, Zn, Fe, and others) are significantly higher at the downstream side of the ETA (at the mine access road) compared to at the upstream end (at X23). The two likely sources for this increase in contaminant loading in groundwater are (i) the tailings deposited in the ETA and (ii) seepage from the mill area (including associated ore stock piles and waste rock dumps).

The results of the 2004 field investigation demonstrate that all seepage from the ETA area (surface and groundwater) is highly contaminated. In our opinion, this seepage should be collected and treated regardless of the final closure option for the Rose Creek tailings facility. Flow measurements carried out as part of the Rose Creek tailings study (RGC, in progress) indicate that as much as 90% of the combined seepage from the ETA is lost due to leakage into the tailings and/or natural ground before it reaches the Intermediate Pond (RGC, in progress). The results of the 2004 field investigation provide a solid framework for evaluating alternative options for seepage interception in the ETA area. In the following we discuss different options on how to intercept this seepage and present a preliminary conceptual design for the preferred option. For the purpose of this discussion we have assumed that the tailings in the ETA will be removed prior to installation of a SIS.

5.2.2 Discussion of Options

Pump testing has confirmed the feasibility of intercepting the contaminated groundwater in the ETA area by means of a “traditional” fence of interceptor wells. Similarly, the interception of surface seepage is relatively straight forward as the surface seepage is running year-round and flow rates are comparatively steady due to flow attenuation in the WRDs, which represent the majority of the upstream catchment area. Hence, the primary points of discussion in terms of options selection include the location of the SIS and the merits of intercepting the seepage as surface flow versus intercepting (at least part of) the seepage as groundwater.

Three options were identified for the Emergency Tailings Area. Table 8 presents advantages and disadvantages for each option with capital costs assuming a treatment plant is located at the Intermediate Dam.

Option 1 – Surface seepage collected in shallow ditches at toe of WRD (X23), collected in a sump and piped to the treatment plant; groundwater is collected at pumping wells located downgradient of X23 and the mill area valley, and connected to the pipeline from the X23 sump (Figure 11).

Option 2 – Surface seepage is collected in sump located where the surface water crosses under the main access road through a culvert; groundwater is collected at a line of pumping wells (~3) located immediately upstream of the mine access road (Figure 12).

Option 3 – Surface seepage collected in sump at mouth of Faro Canyon; residual groundwater is intercepted by pumping wells at the mouth of Faro Canyon (Figure 13).

Estimated costs for each of the three options were based on available surface and subsurface water flow estimates. Surface water collection systems are based upon gravity drained sumps, linked to common main lines with the pumping well outlet lines. All pipes are HDPE, insulated and buried to three meters, the estimated freeze penetration depth. Pipeline size was determined based on a conservative estimate of baseflow rates. Pipeline costs assume that water is directed to a treatment plant located close to the Intermediate Dam.

Sumps were sized to baseflow rates and designed for minimal storage. At this time, sump designs are only preliminary and costs are based on installation of one HDPE manhole each. Estimates of flood discharge rates and volumes for catchments beneath the WRDs are not well understood. Sump dimensions at this time are considered conservative for flow rates that have been observed at monitoring stations such as X23, but may need to be scaled up if and when further understanding of seepage from the WRDs becomes available and the risk of spillover from higher flow rates can be assessed.

Pumping well systems for options 1 and 3 are conservatively estimated, based on available data from the results of testing close to the main access road.

Preliminary estimated capital costs associated with each option are included in Appendix H. Note that the cost of providing a power connection to the selected pumping site(s) has not been included in this capital cost. Operating costs for each collection system are estimated in Table 9, with pumping costs based on pipeline options discussed in section 5.2.4.

Table 9: Estimated Operating Costs

	Pipeline Option		
Design Option	5a	5b	5c
1	$33,000	$21,000	$23,000
2	$39,000	$28,000	$29,000
3	$33,000	$21,000	$23,000

Operating costs assume power at $0.13 per kWhr, and sumps require 0.33 days to clean using a suction pump truck or other available equipment. Routine inspections are assumed to require one day for all options.

5.2.3 Preliminary Preferred Collection Option

At this time, Option 2 is the preferred collection option. An evaluation of advantages and disadvantages (Table 8) indicates that option 2 has the greatest number of favourable attributes.

An initial assessment of options that took the presence of tailings into account indicated:

- A high probability of contamination bypassing the collection system
- A high probability of increased loading to the treatment plant due to infiltration or flow through the tailings
- A very low probability of reclamation of the ETA

If tailings are retained in the ETA, each of the options presented would require modifications. In the event that tailings do remain in the ETA, option 2 still provides the best means of collecting seepage before reaching downstream environments.

In the event that tailings are removed, option 2 collects seepage closest to the source with the greatest chance of capturing residual contamination (from the ETA area), which is likely to exist for many years. Option 1 does not collect any residual contamination, and option 3 allows residual contamination to continue flowing through Faro Creek Canyon, possibly leading to further discoloration due to iron oxidation and seepage into the subsurface, which is not as well understood as in the ETA.

Option 2 could provide a strategic advantage to ETA tailings removal. Water level measurements recorded during the 2004 field program indicate that in the area of the new drillholes, the lower sections of the tailings are saturated. It is probable that this occurs upgradient towards X23 as well. Excavation to alluvium in the area of the proposed fence, emplacement of a clean fill bench and installation of the pumping wells upon this bench prior to tailings removal, could both allow dewatering of much of the tailings pore water, as well as capturing infiltration if a hydraulic monitoring method were used (*i.e.*, high pressure water guns). Figure 14 is a schematic design drawing based on data from the new drillholes illustrating this option.

A preliminary pumping well configuration for option 2 must take into account the probable presence of hydraulic boundaries as well as the implications of limited available drawdown. Pumping rates must be configured to capture all subsurface flow while protecting the wells themselves. High Fe concentrations in ETA water (refer to table 6) indicate that if screens are exposed to oxygen during pumping, fouling will likely occur, decreasing screen lifetime and efficiency. As shown on Figure 14, total available drawdown to the top of the screened interval is approximately three meters. Fe concentrations in the groundwater suggest that if the water level drops below the screened area, encrustation problems would likely decrease screen effectiveness, thereby increasing long-term maintenance and the need for possible replacement ("well-fouling").

Selection of proper pumping rates will take into account the geometry of the flow system, as boundary effects caused by valley walls will increase total drawdown. Boundary effects will likely be present for pumping systems in all of the collection system options (but least pronounced for option 2).

Based on the preliminary geophysical survey data for the ETA, three pumping wells should provide the necessary capture zone to collect all subsurface flow in the ETA. Each of the pumps would be rated based on overlapping cones of depression taking into account the available data on the location of valley walls. The pumping system shown in Figure 14 would likely be comprised of a central pump with a higher rating than the two peripheral pumps. Designs would be based on available drawdown to the top of the screened interval with a margin of safety to keep the screens submerged. As a backup, each pump would be equipped with automatic controls linked to pressure transducers that would shut down the pump if too much drawdown occurred.

The cost estimate for option 2 includes the possibility of different pump ratings based on the results of a simple numerical model that accounts for valley geometry based on the preliminary geophysical survey. All pumping system costs include automatic controls.

5.2.4 Pipeline Options

The total length of pipeline required connecting collection systems at NFRC and the ETA will be dependent on final location of the treatment plant. Until this location is chosen, final alignments for collection pipelines cannot be completed. Three options are available based on possible treatment plant locations:

1. Pump all water to Faro Pit
2. Gravity drain/pump to treatment plant near base of Faro Creek Canyon
3. Gravity drain/pump to treatment plant near Intermediate Dam

Costs for each of these alternatives are included in the cost breakdowns included in Appendix H. Costs included in Table 10 assume the treatment plant is located near the Intermediate Dam (pipeline Option 3).

In the case of tailings removal from the ETA, final topography will influence the ultimate alignment of any pipeline. For the purpose of this cost assessment, pipelines are assumed to follow the shortest path down grade from collection system to possible treatment plant location.

For freeze protection, pipelines are assumed to be insulated and installed to a minimum 3 m burial depth. An alternative option for freeze protection is the installation of a heat trace system within pipelines.

Table 10 and 11 show estimated relative capital and operating cost for burial versus heat tracing for 1,000 m of pipeline.

Table 10: Estimated Capital Costs for 1000 m Pipeline

Option	Materials	Excavation	Capital Cost
Heat Trace with HDPE insulated pipe	$125,000	0	$125,000
3 m excavation with HDPE insulated pipe and manholes every 500m	$112,000	$54,000	$166,000

Table 11: Estimated Annual Operating and Total Costs for 1000 m Pipeline

Option	Maintenance	Power Requirements/yr[1]	Sum Capital and Operating Costs
Heat Trace with HDPE insulated pipe	$2,000 (clear manholes and inspect electrics?)	$9,400	$134,000
3 m excavation with HDPE insulated pipe and manholes	$1000 (clear manholes)	$0	$166,000

[1]The power requirements are based on current rates of $ 0.13 per KWhour and operating requirements of 6 months per year @ 5 W/ft (16.5 W/m) for the heat trace.

Use of a heat trace system allows pipelines to be laid along the ground surface and makes no assumption about pipeline support structures. A significant benefit of heat trace is that the pipelines are easily accessed for repairs or service. In addition, pipeline removal, if ever required in the future, is relatively inexpensive to undertake.

The total length of pipeline required to connect collection systems at NFRC and the ETA will be dependent on final location of the treatment plant. Until this location is chosen, final alignments for collection pipelines cannot be completed. In the case of tailings removal from the ETA, final topography will control the ultimate alignment of any pipeline. For the purpose of this cost assessment, pipelines are assumed to follow the shortest path down grade from collection system to possible treatment plant location.

Work Area Code 106
Faro Waste Rock Dumps

Work Area Code 107
Groundwater

5.1.2 Discussion of Options

The water quality monitoring in this area indicates that both shallow (and potentially perched) groundwater in the overburden soils as well as deeper groundwater (in deeper till and weathered bedrock) is similarly impacted and may require interception. For the purpose of this discussion it is therefore assumed that all groundwater flowing above and within weathered bedrock will have to be intercepted.

The general depth to bedrock in this area (>10m) and the local constraints of space and topography generally preclude the use of a seepage collection ditch to intercept all of the impacted groundwater. Conversely, the local subsurface conditions (till-like material with significant local heterogeneity) are not well-suited for an active interception system using a "traditional" fence of wells for several reasons. First, this fine-grained material will likely require a very tight spacing of interceptor wells (in the order of 5-10m) owing to its relatively low hydraulic conductivity. Second, the combination of low K material and limited available drawdown (<5m) will result in frequent cycling of individual pumps and potential "fouling" of the well screens requiring high maintenance of the pumping system. Finally, the presence of local heterogeneity may result in some by-pass of groundwater, in particular of shallow groundwater in perched layers, which may already be present and/or could develop in response to pumping.

Based on these considerations, at this time our preferred option for seepage collection along this reach would be to engineer a high permeability zone in which a series of pumping wells are installed (see Figure 9). This high K zone would be constructed by excavating a trench to the maximum depth feasible (likely 6-7m) and backfilling it with coarse fill (clean sand and gravel). The pumping wells would be drilled and completed after construction of the backfilled trench and screened partially in the backfill and partially in the underlying till and weathered bedrock. The purpose of this high K zone is threefold. First, the zone facilitates interception of any shallow seepage (including contaminated surface runoff currently observed throughout the area). Second, the presence of a high K zone reduces the number of pumping wells required to maintain adequate drawdown along the line of interception. Thirdly, this set-up would significantly improve pumping operations (and therefore maintenance) because of a reduction in pump cycling and fluctuations in the local water table.

Figure 10 shows the preliminary alignment of the proposed seepage interception system (SIS) including preliminary locations of pumping wells. The alignment of the SIS will have to be finalized once the full extent of the area impacted by WRD seepage has been determined. The exact number, locations, and screen interval of the pumping wells will also have to be finalized once additional field investigations (including hydraulic testing) have been completed.

It is envisioned that the SIS would be operated using automatic pump switches, which maintain a small but significant drawdown (say at least 0.3m) below the creek elevation at all times. An excessive drawdown (say >1m) should be avoided as it would induce seepage from the North Fork Rose Creek towards the SIS. Monitoring wells would be installed to monitor the performance of the SIS and demonstrate "compliance". A concern during operation of the SIS would be the potential for

iron oxidation when groundwater enters the well casing and comes in contact with air. This could result in clogging of the well screen and/or pump reducing the efficiency of the pumping system ("well fouling"). In order to minimize such well fouling, the pumping system should therefore be designed and operated in such a way that the screen of a given pumping well remains saturated at all times.

A preliminary estimated capital cost based on three pumping wells and a ditch system of the required length is estimated at approximately $712,000. The number of pumping wells and ditch length is only representative at this time. Until further assessment of the area is complete, a final cost estimate cannot be completed. This does not include the cost of setting up power to the site. A breakdown of this cost estimate is included in Appendix H.

Annual operating costs are estimated at approximately $27,000 including power and routine maintenance, assuming no significant work on the pumping system is required. Re-furbishing of wells due to fouling (iron, calcium encrustation, etc.) will be necessary on the scale of 10-15 years, though determination of exact frequency will not be possible until real conditions have been observed. This will require mobilisation of a drill to site and approximately 1.5 days per well. Based on three pumping wells at today's rates, refurbishing costs would be approximately $27,000 including drill, mob/demob and crew. If pump replacement were required, available site equipment could be used for pump removal (*e.g.*, HIAB) with pump replacement costs of approximately $30,000 for three wells.

5.2 Emergency Tailings Area Collection System

5.2.1 Overview

A review of the historic monitoring data indicated that WRD seepage is day-lighting at the toe of the Main Dump and has impacted shallow groundwater flow moving in the permeable alluvial soils of the historic Faro Creek channel, referred to here as the ETA (see Appendix A). Additional field investigations carried out in 2004 have provided a better understanding of groundwater flow in the ETA. Drilling and geophysical surveys in the lower part of the ETA have confirmed the presence of highly permeable alluvial sediments (sand and gravel) in the old Faro Creek channel. The results of hydraulic testing suggest that approximately 6 L/s of highly impacted groundwater is flowing in these alluvial soils. Flow measurements suggest that approximately half of this groundwater flow emerges in a discrete seepage face immediately downstream of the mine access road. Most of the remaining groundwater flow appears to discharge to surface along the lower reach of the Faro Creek Canyon.

Detailed flow measurements of surface seepage further upstream also suggest that the upper reach of the Faro Creek channel (between the toe of the WRD dump and just upstream of the ETA) represents a groundwater discharge zone where WRD seepage is discharging to surface.

Work Area Code 108
Miscellaneous

Ponds

Buildings

Contaminated Soils

Landfarm

Borrow Sources

Work Area 200 – Rose Creek Valley Tailings

Rose Creek Valley Tailings (200)

Work Items

201 – Dams

202 – Tailings

203 – Rose Creek Diversion Channel

204 – Groundwater Collection

205 – Miscellaneous

Work Area Code 201
Dams

- Construction of flow distribution swales in the Intermediate Impoundment;
- Construction of a spillway on the right abutment of the Intermediate Dam to carry the PMF; and
- Raising the Intermediate Dam and the RCDC dyke to allow adequate freeboard during passage of the PMF through the impoundment.

If the Intermediate Dam were left at its present crest elevation, a very large spillway cut would be necessary to pass the PMF because of the small storage capacity of the dam. Thus, we examined the effects of increased storage by raising the Intermediate Dam and the RCDC dyke on spillway dimensions in terms of costs. These costs estimates were sufficiently accurate to make comparisons but not to estimate actual costs for the alternative. This comparative cost estimate shows that a 20 m wide spillway at the invert together with raising the Intermediate Dam crest to Elev. 1058.8 m and the RCDC to a minimum crest Elev. of 1058.6 m was the lowest cost option.

Using project unit costs, the total estimated cost for this PMF flood handling alternative is $90 M, excluding GST. This includes $19M of indirect costs and a contingency of $15M. Without indirect costs and contingency, the estimated costs are approximately $56M of which about $36M is for the tailings blanket costs. The direct spillway costs are estimated to be about $10M.

This cost estimate is based on information available to date and is only our opinion of probable cost for budgetary purposes. Actual cost depends on many factors which can change with time, including site and market conditions at the time of construction. Construction costs are very high at this time in Western Canada and the north. They may escalate in future if the current market conditions persist.

Our work has been done in the absence of a comprehensive understanding of the closure options being considered by the Planning Office. This has not been a detriment to the execution of the work but, rather, there may be economies which can be realized or our work may precipitate consideration of other issues. For instance, the tailings cover recommended will have to be integrated or made part of a dry cover to prevent acid mine drainage if that option is being considered. Also, removal of the Polishing Pond at the toe of Intermediate Dam will increase the seepage gradient through the foundation soils which may affect predictions of contaminant migration. These and all other similar issues are for others to consider.

This is a preliminary design to establish feasibility and to estimate costs so that this flood handling option can be compared to other alternatives. In order for construction to be tendered, detailed design will have to proceed. Detailed design would included a thorough investigation of depth to rock on the right abutment of the Intermediate Dam, delineation of borrow areas, integration of the design with the overall closure plan, and re-estimation of the costs at the time of construction, among other issues.

3. DESIGN

3.1 WMC PMF Estimate

The recommended 24-hour Probable Maximum Flood (PMF) values for the Rose Creek Diversion are as follows (WMC, 2006):

- Upper end of Rose Creek Diversion Channel 674 m^3/s
- Lower end of Rose Creek Diversion Channel 692 m^3/s

This PMF estimate includes the flood that would pass through the Rose Creek Diversion Channel which collects runoff from the North Fork of Rose Creek, the South Fork of Rose Creek, and the south slope above the Rose Creek Diversion Channel. These catchments are designated as A, B and C, respectively, in Figure 3.1. The PMF estimate does not, by definition, include the runoff from the catchment along the north slope of the Intermediate Impoundment, which is designated as catchment D in Figure 3.1. This north slope runoff will discharge into the tailings impoundment so has to be included with the flood waters that pass by the Intermediate Dam.

WMC (2006) indicates the total catchment at the lower end of the Rose Creek Diversion Channel (i.e., catchments A+B+C) to be 217.3 km^2. We estimate the catchment of the north slope of the Intermediate Impoundment (catchment D) to be about 12 km^2. This catchment area assumes that the North Slope Diversion Ditch has failed or has been decommissioned before or during the flood. For the present purposes, we have estimated the PMF value for catchment D to be 38 m^3/s by proportional area. Hence total PMF for catchments A+B+C+D would be about 730 m^3/s.

3.2 Design Concept

The proposed design concept for passage of the PMF through the Intermediate Pond is illustrated in Figures 3.3 to 3.6. The proposed flood handling works would include the following:

- Breach of the Cross Valley Dam, removal of the sludge/sediments in the polishing pond, and reinstatement of Rose Creek and its tributary within the polishing pond;
- Replacement of the RCDC overflow berm with a fuse plug such that it fails at the 500-year flood level in the RCDC;
- An upgrade of the RCDC from its upstream end to the fuse plug to carry the PMF flow;
- Leveling the tailings in the Intermediate Impoundment and placing a 1.5 to 2 m waste rock and soil (glacial till) cover on the tailings;
- Construction of flow distribution swales in the Intermediate Impoundment;
- Construction of a spillway on the right abutment of the Intermediate Dam to carry the PMF; and
- Raising the Intermediate Dam and the RCDC dyke to provide adequate freeboard during passage of the PMF through the impoundment.

This report describes the upgrade of the RCDC from its upstream end to the fuse plug. Nhc (2006) indicated that improvements are also required at the upstream end of the RCDC and along the North Fork Rose Creek. These proposed improvements are discussed in detail in the nhc report and are not part of our scope.

We recommend leveling or grading of the tailings where practicable to reduce velocities and therefore erosion of tailings during flooding. Based on available pond topography

and bathymetry, it is estimated that the tailings in the Intermediate Impoundment could be leveled to an average elevation of approximately 1048.5 m. Placement of a 2 m waste rock and soil cover over the leveled tailings would result in an average soil cover elevation of 1050.5m.

Our work is partly based on the bathymetric survey for the Cross Valley Pond and the Intermediate Impoundment, which was completed in 2004, and is presented in Appendix III.

These recommendations are based only on flood velocity reduction requirements and are not meant to replace cover recommendations by others to reduce acid generation in the tailings. We expect that the design of the final tailings cover will be done by others to accommodate these and other requirements.

3.3 Flood Routing

The capacity of the existing Rose Creek Diversion Channel is estimated to be a 500-year flood, which is 135 m^3/s (nhc, 2006). The following three scenarios have been considered for routing the PMF through the Intermediate Impoundment:

- Scenario A

  Up to 135 m^3/s flows through the RCDC, and flows above 135 m^3/s pass through the Intermediate Impoundment. This assumes that the RCDC is fully functional up to its estimated capacity.

- Scenario B

  The initial portion of the PMF hydrograph up to 135 m^3/s flows through the RCDC, and the rest flows through the Intermediate Impoundment. This assumes that the RCDC fails as soon as the PMF flow reaches 135 m^3/s.

- Scenario C

  The entire PMF passes through the Intermediate Impoundment. This is the worst case scenario and it assumes that the RCDC has failed prior to the PMF event.

The PMF hydrographs for the three scenarios are shown in Figure 3.2. These hydrographs were routed through the Intermediate Impoundment using our in-house flood routing spreadsheet. In order to determine the optimum combination of spillway size and dam raising, the flood routing was carried out with various spillway widths ranging from 15 to 100 m.

The results of the flood routing are summarized in Tables 3.1 to 3.3. Scenario A results in the lowest pond inflows, outflows and water levels because a significant portion of the PMF (135 m^3/s) is assumed to be carried by the RCDC throughout the PMF event. Scenarios B and C result in higher pond inflows, outflows and water levels. The results for Scenario B are almost the same as those for Scenario C because only a small portion of the PMF is assumed to be carried by the RCDC in Scenario B. As expected, the larger the spillway size the larger the discharge through the spillway and the lower the resulting pond water level. All three scenarios indicate that the PMF level will be higher than the crest of the existing Intermediate Dam (El. 1049.4 m) and that the dam needs to be raised if the PMF is to be routed through the impoundment.

Scenario A is based on the assumption that the RCDC will be fully functional up to its estimated capacity during the entire PMF event. Because assuming the RCDC is fully functional during such a large flood event cannot be relied upon, Scenario A is not recommended for design. Since the flood routing results for Scenarios B and C are similar, we have used Scenario C to carry forward the preliminary design.

Table 3.1 PMF Routing for Scenario A

Top of Tailings Cover (m)	Spillway Control Elevation (m)	Spillway Bottom Width (m)	Peak Inflow to Pond (m^3/s)	Peak Outflow from Pond (m^3/s)	Max. Pond Water Elevation (m)
1050.5	1050.5	15	595	388	1056.9
		20	595	418	1056.4
		25	595	444	1055.9
		40	595	485	1055.0
		75	595	538	1053.9
		100	595	553	1053.4

Table 3.2 PMF Routing for Scenario B

Top of Tailings Cover (m)	Spillway Control Elevation (m)	Spillway Bottom Width (m)	Peak Inflow to Pond (m^3/s)	Peak Outflow from Pond (m^3/s)	Max. Pond Water Elevation (m)
1050.5	1050.5	15	730	554	1058.3
		20	730	584	1057.5
		25	730	605	1056.9
		40	730	644	1055.7
		75	730	686	1054.4
		100	730	693	1053.8

Table 3.3 PMF Routing for Scenario C

Top of Tailings Cover (m)	Spillway Control Elevation (m)	Spillway Bottom Width (m)	Peak Inflow to Pond (m^3/s)	Peak Outflow from Pond (m^3/s)	Max. Pond Water Elevation (m)
1050.5	1050.5	15	730	559	1058.3
		20	730	588	1057.6
		25	730	607	1057.0
		40	730	645	1055.7
		75	730	686	1054.4
		100	730	694	1053.8

3.4 Intermediate Dam and RCDC Dyke Raise

The existing Intermediate Dam crest is at El. 1049.4 m, and the existing RCDC dyke crest varies from 1060.5 m at the overflow berm to 1053 m at the Intermediate Dam. Routing of the PMF through the Intermediate Impoundment (Tables 3.1 to 3.3) indicate that the flood levels will be much higher than the existing dam and the RCDC dyke, therefore both the Intermediate Dam and the RCDC dyke need to be raised in order to contain the flood waters and to provide adequate freeboard.

To establish freeboard at the dam for the PMF, wave effects have been estimated. The maximum hourly wind speed recorded at the Faro Airport (Station no. 2100517) is 50 km/hr (31 miles/hour). For estimating the wind set-up and wave run-up for the Intermediate Dam, a conservative wind speed of 60 miles/hour has been used which results in a wind set-up plus wave run-up of about 0.4 m. Given that the wind set-up and wave run-up are estimated to be 0.4 m and that the Intermediate Dam is assigned a High to Very High Consequence category, a minimum freeboard allowance of 1.0 m is recommended to the top of the dam and the top of the RCDC dyke. Flood routing results indicate that the pond water level would remain within 1 m of the peak flood level for about 6 to 10 hours. Therefore, the flood freeboard would remain at 1 m for only a short time, and would increase to more than 1 m as the flood level in the pond drops. The

required dam and dyke elevations are shown in Tables 3.4 and 3.5, respectively, for various assumed spillway widths. Typical sections of the raised Intermediate Dam and the RCDC dyke, based on the optimum combination of the Intermediate Dam spillway size, and the dam and RCDC dyke raises discussed in Section 4, are shown in Figures 3.4 and 3.5. Crest elevations do not include any measures to protect the impervious core against frost damage.

Table 3.4 Intermediate Dam Crest Elevations for Scenario C

Spillway Bottom Width (m)	Max. PMF Flood Elevation (m)	Freeboard to top of Dam Core (m)	Elevation of Top of Dam Core (m)	Dam Crest Elevation* (m)
15	1058.3	1.0	1059.3	1059.5
20	1057.6	1.0	1058.6	1058.8
25	1057.0	1.0	1058.0	1058.2
40	1055.7	1.0	1056.7	1056.9
75	1054.4	1.0	1055.4	1055.6
100	1053.8	1.0	1054.8	1055.0

* Dam crest elevation includes 0.2 m of gravel road surfacing on top of the dam core.

Table 3.5 RCDC Dyke Crest Elevations for Scenario C

Spillway Bottom Width (m)	Max. PMF Flood Elevation (m)	Freeboard (m)	Dyke Crest Elevation (m)
15	1058.3	1.0	1059.3
20	1057.6	1.0	1058.6
25	1057.0	1.0	1058.0
40	1055.7	1.0	1056.7
75	1054.4	1.0	1055.4
100	1053.8	1.0	1054.8

3.5 RCDC and Fuse Plug

Currently, the RCDC can pass the 500-year flood ($135 m^3/s$). No change in the RCDC downstream of the fuse plug is proposed since flows in excess of the 500–year flood are

to be routed through the Intermediate Impoundment. However, an upgrade of the RCDC upstream of the fuse plug is required such that it can carry the full PMF flows. A typical upgraded cross section of the RCDC is shown on Figure 3.4. Figure 3.4 shows a 20 m wide RCDC channel. The channel width required to carry the PMF through this reach is only 15 m but a 20 m wide channel is proposed to allow for potential blockages. A 20 m wide channel will provide approximately 17% extra flow area and 22% extra discharge capacity. An alternative to widening the channel to account for blockages would be to encroach onto the channel freeboard. This is not desirable since the higher water level will result in larger flow depth along the toe of the Secondary Dam East Limb.

The top of the existing RCDC overflow berm is at El. 1058 m, and we understand that it may also contain some large rock. The estimated 500–year water level in the RCDC near the overflow berm is at El. 1059.5 m, therefore the top of the proposed fuse plug needs to be set at this level such that it fails at the 500-year flood flow. A proposed cross section of the fuse plug is shown in Figure 3.5. Since the existing overflow berm may contain some large rock, it should be removed in its entirety.

Once the flood water depth in the RCDC overtops the fuse plug, the fuse plug should begin to erode. As the plug erodes, the flow into the Intermediate Impoundment will increase. The division of flow into the downstream RCDC channel and the inlet channel to the Intermediate Impoundment depends on the channel and fuse plug geometry. The peak PMF flow in the RCDC at the fuse plug is estimated to be about 680 m^3/s. Assuming that the fuse plug erodes to the bottom of the RCDC channel, approximately 80 m^3/s will flow through the RCDC downstream and the remaining 600 m^3/s will flow into the Intermediate Pond. Higher flows can be maintained in the RCDC channel by constructing a concrete sill in the fuse plug such that the plug does not erode to the bottom of the RCDC channel. The construction of such a concrete sill has not been investigated at this preliminary design stage. Regardless of whether or not a concrete sill

is incorporated into the fuse plug, the plug would have to be reconstructed once it fails at the 500-year flood level.

3.6 Intermediate Tailings Pond

As indicated in Section 3.2, it is estimated that the tailings in the Intermediate Impoundment could be leveled to an average elevation of approximately 1048.5 m. A 1.5 to 2 m thick waste rock and soil cover should be placed over the tailings to prevent mobilization of the tailings during passage of flood through the impoundment. The waste rock would be placed over the tailings and the soil (glacial till) cover would be placed over the waste rock. With a 2 m thick cover, the average elevation of the top of the cover will be 1050.5 m. In order to provide some positive drainage of the cover, the tailings in the impoundment would need to be graded such that the top of the cover is at El. 1049.5 m near the spillway and El. 1051.75 m at the downstream end of the inlet channel. This will result in a grade of about 0.15% for the cover. Such a flat gradient should keep the flood flow velocities over the cover relatively low as well as allow the water to quickly pond over the cover as the flood waters come through the fuse plug.

In order to distribute the flood waters throughout the impoundment before the water ponds over the entire impoundment, distribution swales should be constructed as shown in Figures 3.3 and 3.4. These swales will be excavated in the tailings and covered with 2 m waste rock and soil such that the finished swales are 1 m deep with 10H:1V side slopes, as shown in Figure 3.4. At a channel gradient of 0.15%, each swale will have a full flow capacity of 10 m^3/s at a velocity of 0.9 m/s which is an acceptable velocity for glacial till like material without any erosion protection.

The inlet channel to the Intermediate Impoundment is relatively narrow near the fuse plug (Figure 3.3). The channel gradually widens to 250 m approximately 700 m

downstream of the plug. This 700 metres of the inlet channel will be re-graded to match the top of the tailings cover at its downstream end and the bottom elevation of the RCDC at the fuse plug. Flow velocities in the inlet channel, particularly near the fuse plug, will be high. The entire 700 m of the inlet channel will be lined with riprap to provide erosion protection.

The construction work in the impoundment will require careful scheduling. Some of the work, such as re-grading the tailings and placement of the waste rock cover may have to be carried out during the winter while the tailings are frozen or partially frozen.

3.7 Intermediate Dam Spillway

Figures 3.3 and 3.4 show the proposed alignment and section of the Intermediate Dam spillway. The spillway will discharge into a tributary of Rose Creek downstream of the Intermediate Dam, as shown. The spillway will be located such that the maximum PMF flow depth is within bedrock. The bedrock encountered at the site has significant foliation, with dips at 25 to 27º towards the impoundment. Therefore, for preliminary design we have assumed channel side slopes of 1H:1V for excavation in bedrock and have provided 5 m wide benches at 10 m intervals. The bedrock cuts will also require rock support, which have been assumed to be on a 1 m x 1 m grid pattern. Channel side slopes in overburden will be 2.5H:1V.

3.8 Secondary Dam

The top of the existing Secondary Dam is approximately at El.1062 m. The PMF level in the RCDC, flowing parallel to the Secondary Dam East Limb, is estimated to be El.1060.9 m at the upstream end of the RCDC and El.1057.6 m near the fuse plug. This leaves a flood freeboard of 1.1 m to 4.4 m, which is considered to be adequate.

3.9 Cross Valley Dam and Pond

The Cross Valley Pond needs to be drained, and the sludge and sediments which may have accumulated over the years need to be removed to allow construction of the Intermediate Dam raise. The sludge and sediments would have to be disposed of at an appropriate disposal site. For the purpose of preliminary design it has been assumed that the Cross Valley Dam is breached, and that the Rose Creek channel and its tributary between the Cross Valley Dam and the Intermediate Dam are restored.

Materials removed from the Cross Valley Dam could be used for the Intermediate Dam raise, however temporary stock piling of some of the removed materials may be required while the foundation for dam raise is being prepared.

581 000 mE
582 000 mE
583 000 mE
584 000 mE
6 915 000 mN
6 914 000 mN
6 913 000 mN
6 912 000 mN
1200
1150
1100
1050
1000
950
PLANT SITE
FARO DUMPS
NORTH SLOPE DIVERSION CHANNEL
℄ CLOSURE SPILLWAY
RE–DIRECT TREATED WATER PIPELINE TO THE CLOSURE SPILLWAY
REGRADE TAILINGS IN INTERMEDIATE IMPOUNDMENT AND PLACE WASTE ROCK AND SOIL COVER
REINSTATE TRIBUTARY CHANNEL
EXISTING EMERGENCY SPILLWAY
SECONDARY DAM
REGRADE INLET CHANNEL AND LINE WITH RIPRAP
REMOVE RCDC OVERFLOW BERM AND CONSTRUCT FUSE PLUG
TAILINGS COVER EL. 1051.75
REINSTATE ROSE CREEK CHANNEL
TAILINGS COVER EL. 1049.5
RAISE INTERMEDIATE DAM
BREACH CROSS VALLEY DAM
RAISE RCDC DYKE
℄ FLOW DISTRIBUTION SWALE, TYPICAL
FLOW
GOODALL CK.
GILCREST CK.
RIPRAP APRON
UPGRADE RCDC TO CARRY PMF
ROSE CREEK DIVERSION CHANNEL (RCDC)
REMOVE SLUDGE AND SEDIMENTS FROM CROSS VALLEY POND
A 3.4
B 3.4
C 3.4
D 3.4
E 3.5
F 3.5
G 3.6

NOTES:

1. BASE PLAN TAKEN FROM 2003 FARO SITE PLAN1_VER2000.DWG PROVIDED BY SRK.
2. ELEVATIONS ARE ABOVE MEAN SEA LEVEL.
3. CONTOUR INTERVAL IS 2 m.

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED 11 APRIL, 2008

SCALE 0 500 m

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CLIENT
DELOITTE & TOUCHE INC.
ANVIL RANGE MINING COMPLEX

Klohn Crippen Berger

PROJECT
ROSE CREEK TAILINGS FACILITY
INTERMEDIATE DAM SPILLWAY – PMF FLOOD HANDLING

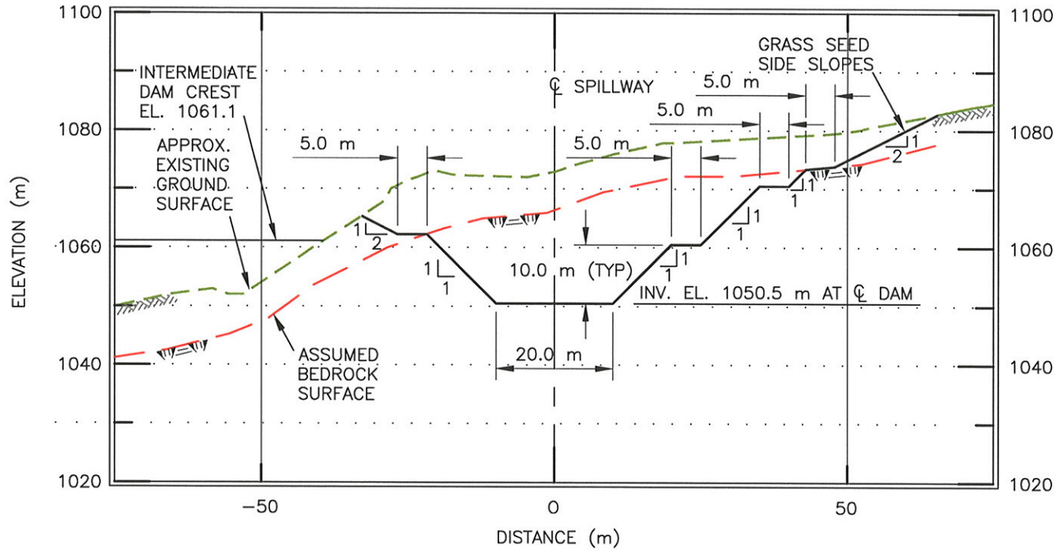
TITLE
PROPOSED FLOOD HANDLING WORKS PLAN

PROJECT No. M09237 A06

FIG. No. 3.3

KCB-R-MLB

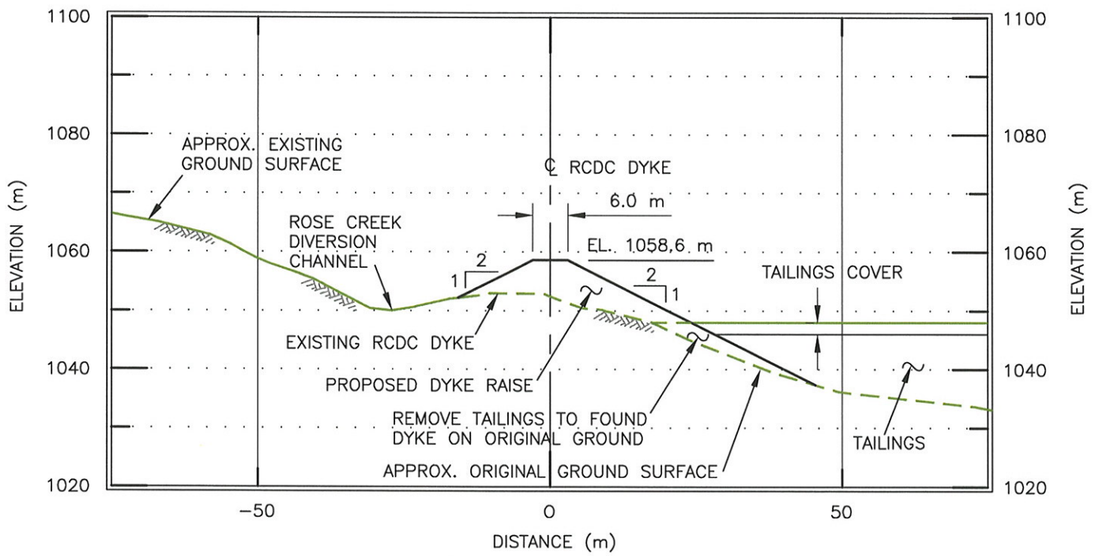
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Xrefs: Blk--RoseCreek--Aug2004



SECTION A CLOSURE SPILLWAY

SCALE A

3.3



TYPICAL SECTION B OF RCDC U/S OF INTERMEDIATE DAM

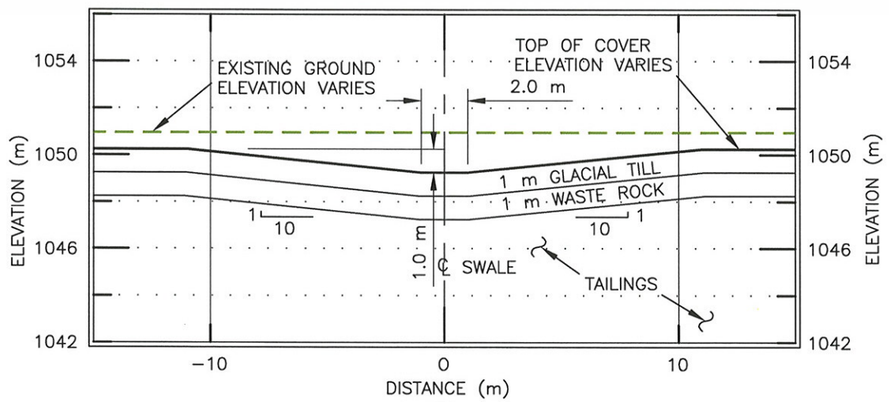
SCALE A

3.3

RCDC TYPICAL SECTION C UPSTREAM OF FUSE FLUG

SCALE B

3.3



TYPICAL SECTION D FLOW DISTRIBUTION SWALE

SCALE C

3.3

SCALE A: 0 40 m

SCALE B: 0 20 m

SCALE C: 0 10 m

LEGEND

RCDC ROSE CREEK DIVERSION CHANNEL

NOTES:

1. RCDC DYKE RAISE SHOWN IS BASED ON A 20 m WIDE SPILLWAY.
2. ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL.

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DELOITTE & TOUCHE INC.
ANVIL RANGE MINING COMPLEX

Klohn Crippen Berger

PROJECT

ROSE CREEK TAILINGS FACILITY
INTERMEDIATE DAM SPILLWAY – PMF FLOOD HANDLING

TITLE

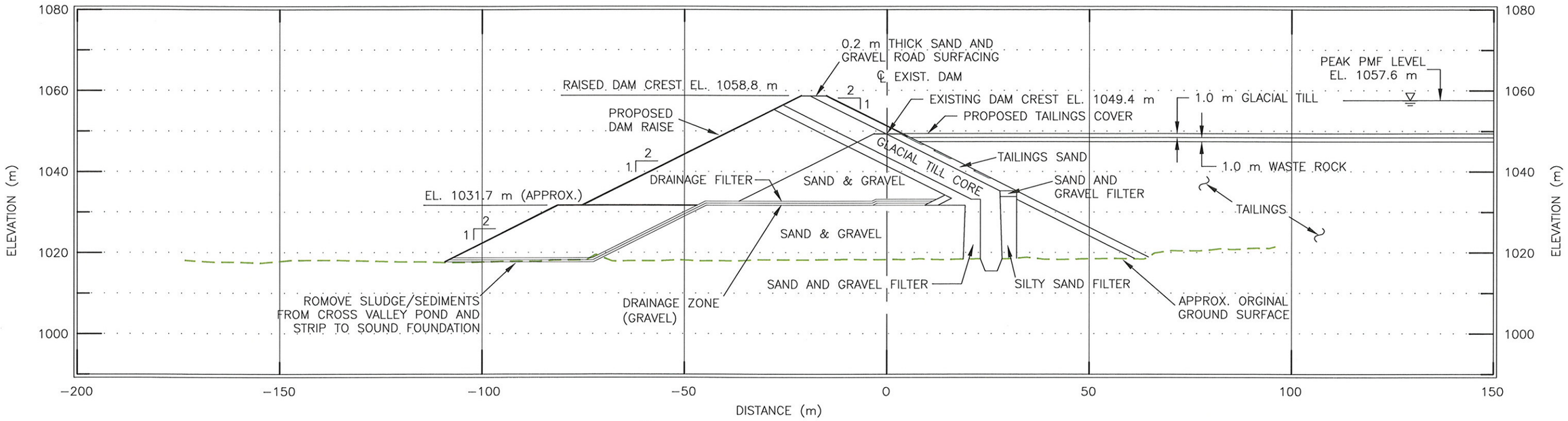
PROPOSED FLOOD HANDLING WORKS
SECTIONS AND DETAILS
SHEET 1 OF 3

PROJECT No. M09237 A06

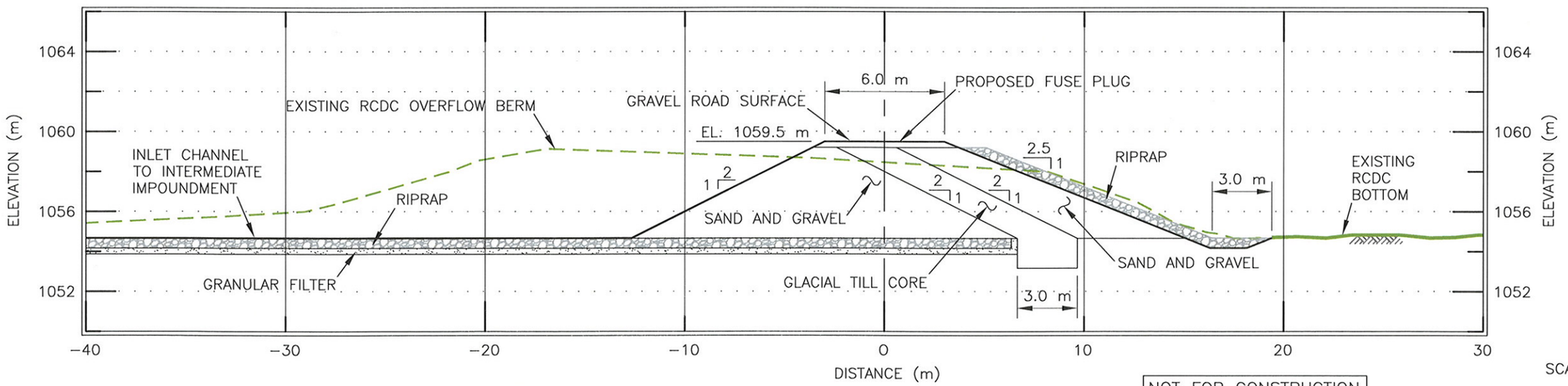
FIG. No. 3.4

KCB-R-MLB

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Xrefs: B4--RoseCreek--Aug2004



SECTION E INTERMEDIATE DAM RAISE
SCALE A 3.3



SECTION F RCDC FUSE PLUG
SCALE B 3.3

LEGEND

RCDC ROSE CREEK DIVERSION CHANNEL

NOTES:

1. INTERMEDIATE DAM RAISE SHOWN IS BASED ON A 20 m WIDE SPILLWAY.
2. ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL.

SCALE A 0 40 m

SCALE B 0 10 m

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ROSE CREEK TAILINGS FACILITY
INTERMEDIATE DAM SPILLWAY – PMF FLOOD HANDLING

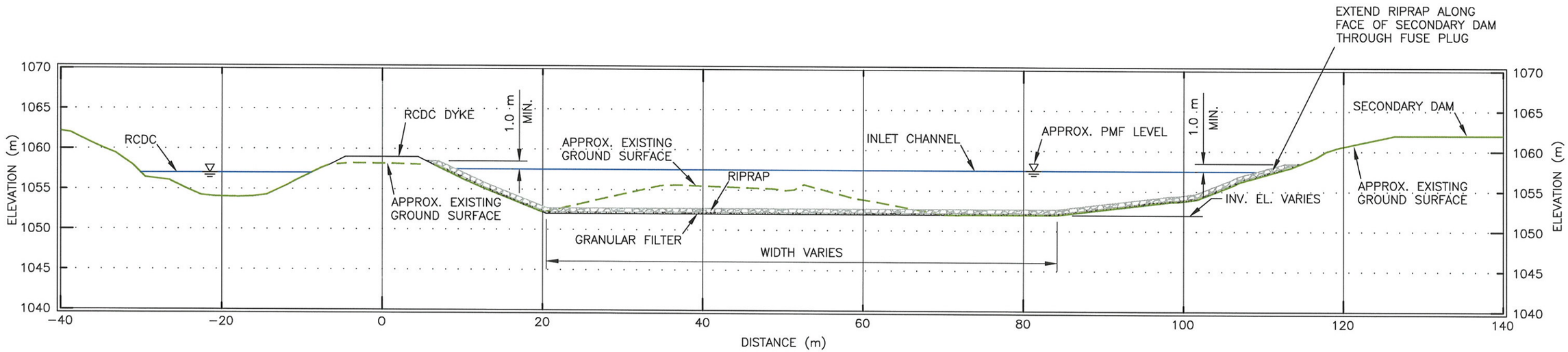
TITLE
PROPOSED FLOOD HANDLING WORKS
SECTIONS AND DETAILS
SHEET 2 OF 3

PROJECT No. M09237 A06

FIG. No. 3.5

KCB-R-MLB

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Xrefs: BM-RoseCreek-Aug2004



SECTION G (3.3) INTERMEDIATE IMPOUNDMENT INLET CHANNEL

LEGEND

RCDC ROSE CREEK DIVERSION CHANNEL

NOTES:

1. ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL.

NOT FOR CONSTRUCTION

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SCALE 0 20 m

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ANVIL RANGE MINING COMPLEX

Klohn Crippen Berger

PROJECT

ROSE CREEK TAILINGS FACILITY
INTERMEDIATE DAM SPILLWAY – PMF FLOOD HANDLING

TITLE

PROPOSED FLOOD HANDLING WORKS
SECTIONS AND DETAILS
SHEET 3 OF 3

PROJECT No.	FIG. No.
M09237 A06	3.6

K03-R-MLB

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Xrefs: Bit-RoseCreek-Aug2004

Work Area Code 202
Tailings

surface area) to the Faro pit and covering the remainder in-situ, and (c) covering of the in-situ tailings. The tailings relocation options are being evaluated as a separate task, and do not form part of the scope of work presented in this report.

SRK completed a preliminary cover assessment study (SRK 2004) that discussed what could be achieved by covering the Rose Creek tailings impoundment with a cover consisting of locally available soils and/or benign waste rock. A workshop was held in February 2004, in Vancouver, at which the results of the preliminary cover assessment were discussed, together with the results of site wide engineering studies completed in 2003 as part of the final reclamation planning. It was concluded that if the Rose Creek tailings were to be covered in-situ, the cover should be a "terrestrial" cover. The conceptual design for this cover presented at the workshop was a layer of "run-of-mine" benign waste rock (such as the calc-silicate from the Faro pit). It was envisioned that the thickness of this cover be limited to the minimum that could practically be placed.

The function of the "terrestrial" cover would be threefold: (a) prevent wind erosion; (b) limit access to exposed tailings by human and animal contact, and; (c) prevent vegetation from establishing directly on the tailings. Limiting infiltration and shedding of runoff were considered unimportant, and limiting oxygen ingress was considered unnecessary. The design life of the cover has not been determined; however, it is generally understood that the cover would have to continue to maintain its functionality in perpetuity, and that in order to achieve that, monitoring and maintenance of the cover would be required in perpetuity.

Subsequent to the February 2004 workshop, but after the construction of the trial covers, information become available suggesting the amount of infiltration that will ultimately flow through the Rose Creek tailings may have to be reduced as far as practical through the use of a cover. Therefore, the requirement to construct covers that fulfill the function of reducing infiltration and/or shedding runoff may have to be reconsidered. Cover design concepts are still under discussion, but the most recent studies suggest that a typical tailings cover for this site might consist of 0.5 m of waste rock overlain by 1.5 m of lightly compacted till. The till surface would likely be seeded and fertilized.

Actual construction of any type of cover at this site poses significant constructability challenges, including:

- trafficability of the tailings; and
- settlement of the final cover (both consolidation and thaw settlement).

In addition to these constructability issues, there are also some long-term sustainability issues, including:

- increased geochemical load, albeit very small, as a result of the release of pore water during consolidation-induced settlement;
- potential for tailings fines to locally migrate upwards through the cover and appear as "boils" (both under normal conditions, freeze-thaw cycles and as a result of infrequent but potentially severe seismic action);
- potential for cover failure as a result of tailings liquefaction triggered by infrequent but potentially severe seismic action;

4.2 Key Items of Cost Uncertainty

There are several items which are subject to uncertainty beyond what would be considered normal for a cost estimate at the level commensurate with this study. In particular, these items correspond to potential changes and unknowns which might affect the presented cost estimates.

One of the items is related to the review and monitoring of the deconstruction activities. In conjunction with the breaching of the Faro Fresh Water Storage Dam several years ago, numerous reviews were undertaken by various parties over the course of planning and permit approval. These reviews added significantly to the overall cost of the project. The current cost estimates do not allow for the permitting procedure and related costs.

Another item of significant uncertainty is the sediment control measures that may be required. This study assumes that most of the work will occur in the fall/winter season, when flows in the creeks and drainages are low or, in some cases, absent. In addition, each of the dump areas has an adequate buffer zone for sediment to settle naturally before reaching the nearest creek. However, since the gradation distribution and related classification testing on the waste rock material has not been done, it is premature to predict with confidence the specific requirements for sediment control. If additional or more sophisticated sediment ponds are required, the costs for sediment control could increase significantly.

One of the closure options for the Rose Creek tailings impoundment is for the tailings to remain in place and for a complex (i.e. multi-layer) cover to be placed over the tailings. In the event this option is selected, the details of the cover will be determined as part of the final engineering design. However, a large quantity of material would be required for this cover and it is likely that the cover volume will be of the same order of magnitude as the volume of material that will be removed from the combined RC and HR-8 drainages. The RC drainage is of particular interest since the rock drain at this drainage is comprised of waste rock that is relatively inert geochemically. In the event that substantial portions of the material removed from one or both of these drainages are used as cover material, there would be an incremental cost of hauling this material. On the other hand, there could be a reduction in the cost of providing “new” cover material for the tailings impoundment. In any case, this variant to the hauling costs has not been calculated as part of this study.

Work Area Code 203
Rose Creek Diversion Channel

these areas have been overlain with fill materials for some period of time and may not be subject to significant future deformations. In other areas, depths to bed rock are fairly shallow and complete sub excavation of the overburden may be warranted. On potentially unstable slopes and fill slopes, buttressing with structural rock fills may be employed to ensure stability.

3.2.4 Seepage

Seepage in the current RCDC was mitigated by installation of a compacted silt layer along the dike face which extended and abutted the cut rock section in places . In replacing the dike, a new impermeable barrier composed of a 500 mm thick layer of compacted low permeability soil, such as till from the Vangorda / Grum plateau, would be installed on the inside face of the channel. This barrier would be protected by a filter layer and overlying granular layers.

3.2.5 Surface erosion

Surface erosion would be limited by minimizing slope-length factors where possible and applying erosion control through reseeding, mulching and revegetation. Mass failures, slips or mass wasting along cut slopes can be avoided by proper drainage and conservative cut and fill slope grades according to materials encountered or used during construction.

3.3 Environmental

The primary environmental legislation impacting the closure conceptual design of the RCDC is the federal *Fisheries Act*. While overall review of the mine closure plan will encompass other environmental attributes and issues, design of the RCDC channel will impact fish and fish habitat which are managed by Fisheries and Oceans Canada (DFO). Preliminary recommendations from the DFO representative suggest that fish passage and to a less extend, fish habitat within or affected by the RCDC designs are the critical issues.

Rose Creek is currently habitat for Arctic Grayling (*Thymallus arcticus*), which inhabit the creek above and below the mine site, and Chinook Salmon (*Oncorhynchus tshawyscha*), which utilized habitats immediately below the mine site in Rose and Anvil Creeks and are expected to eventually utilize the RCDC and Rose Creek above the mine site. While other species of fish reside in these creeks, migration and access to habitats for these two species are a priority.

3.3.1 Fish passage

While no specific direction has been given by DFO, we have assumed hydraulic and habitat criteria complementary to both juvenile and adult fish in the design. These criteria will influence the RCDC designs, specifically the design of the steep section weirs and the thalweg channel. Eco-hydraulic criteria used in the design process included maintaining upstream and downstream passage by ensuring adequate flow depth, velocities and hydraulics over a range of hydrologic conditions up to the mean annual

flood. This would ensure a very high percentage of time that the RCDC would provide passage opportunities for migrating fish.

3.3.2 Fish habitat

There is limited fish habitat within the RCDC, except possibly just upstream of the channel inlet. The current design does not attempt to create habitat within the length of the channel proper. Furthermore, the design must preclude impacts to downstream water quality which could result if there were increasing contaminant concentration, turbidity, or temperature.

3.4 Structural

The PMF design should be simple and robust, therefore no mechanical systems, metal work or operator controls have been used. The overall designs rely predominantly on open water, free surface hydraulics and hydrotechnical design elements. At transitions between the hydraulic structures – spillways and flow control structures – the stability of the RCDC channel will be ensured with sections of mass steel-reinforced concrete which are secured to bedrock and buried to provide frost protection. The primary design criteria will be to ensure the channel can not degrade or back cut and destabilize the remaining RCDC and tailings. The keyed sections would be located above the spillway sections, at the flow control structures, and at the transition to the steep channel. Structural reinforced concrete within the hydraulic structures such as the spillway also provides fail-safe operation during the PMF.

Notional sizing has been provided in the conceptual design, but final sizing will be determined by detailed structural analyses and physical model testing. Complete stress, shear, and bearing analysis will be conducted on these structures to account for hydraulic forces, earth pressures, dynamic forces, rock bearing capacity, and potential rock scour and erosion. Shape and size of these structures will be modified to meet all structural geotechnical, hydraulic, and seismic requirements.

3.4.1 Foundation and bearing

The keyed sections would entail excavation to bedrock and re-building with thick-walled mass concrete structure. Rock strength and bearing would be assessed during construction and anchoring requirements engineered at that time. Notional design and costing includes a provision for anchor bolting of all walls and block features.

3.4.2 Hydraulic and seismic loading

Keying and footing to bedrock also provides bearing and lateral resistance for the expected hydraulic forces on these structures during the PMF. Reinforcing and structural design would comply with seismic requirements during time of construction.

3.4.3 Ice loading and Ice jams

Structural ice-related loading is expected to be negligible during a PMF event. If significant sheet ice formed over the channel, rock protection provides expansion room

unmovable, or blocked more than 30% of the channel, failure of the riprap bank armouring or overtopping of the bank could occur.

Rock riffles will be constructed within the low flow channel of the steep sections to maintain fish passage up the steep channel. In the current steep section of the RCDC, the rock weir structures constructed with 1.0 to 1.5 m diameter rock have been successful in maintaining fish migration and have remained relatively stable and intact. The riffles will be designed similar to the rock weirs except they will have a shallow slope on their downstream face allowing fish to swim up the face while providing increased stability and support. Details on riffle design and location is provided by the accompanying drawings.

nhc has undertaken physical modelling of similar ramp structures utilizing rock surfacing and riffles for stability and fish passage assessments. The work undertaken showed that the constructed riffle structures provide improved depth of flow and a wider range of suitable hydraulic conditions over a range of inflows. The inter-rock spacing developed from the large materials used provides multiple passage opportunities in comparison to a fishway that may have a limiting condition for smaller fish sizes or weaker-swimming species.

Figure 2 Example of Modelled Spillway and Riffle Structure (nhc, 2003)



Using a physical model, the stability of the steep channel design section and proposed countermeasures can be further tested. Potential scour, erosion, and breach scenarios can be modeled under various conditions – including the PMF – and stability and potential damage assessment of the riffle sections can be tested.

4.5 Grade and Hydraulic Control Structures

As discussed earlier, the grade and hydraulic control structures provide a fail-safe against catastrophic failure of the hydraulic structures current considered in the design scenarios. It is likely that the ultimate structural designs will integrate seismic loading requirements that will supersede any hydraulic, impact or ice loading on the reinforced concrete structures. However, the structural design should assume the following loading factors (CDA, 1999, pg. 9-3):

Work Area Code 204
Groundwater Collection

Work Area Code 205
Miscellaneous

Work Area 300 – Vangorda/Grum Mine Area

Vangorda/Grum Mine Area (300)

Work Items

301 – Vangorda Pit

302 – Vangorda Dump

303 – Vangorda Creek

304 – Grum Pit

305 – Grum Interceptor Ditch

306 – Grum Dump

307 – Overburden Dump

308 – Ore Transfer Pad

309 – Groundwater

310 – Vangorda Haul Road

311 - Miscellaneous

Work Area Code 301
Vangorda Pit

Rudimentary covers were used as the base case for the cover optimization. For each dump area, the incremental cost of upgrading the covers was compared to the incremental benefit of the reduction in the net present value (NPV) of water treatment costs to determine the net benefit.

The following sections describe the methodology and assumptions used to determine each of these cost components. The cover types for each individual dump in the mine areas were then varied to determine the change of the overall NPV. Figures 1 and 2 outline the individual dump areas for the Faro and Vangorda/Grum areas, respectively.

2.2 Water Treatment Costs

Water quality estimates were derived for each scenario using the water quality prediction spreadsheet presented in the pending SRK report for 2007/08 Task 17B, Update Dump Water Quality Predictions. The water quality model allows the user to select a cover thickness for each individual mine area and to generate a set of water quality predictions. For each cover type, the model assumes an infiltration rate and a neutralization potential (NP) depletion rate, as presented in Table 2. In each case, twelve water quality estimates were derived for various years from Years 1 to 1000, to reflect the degradation of the dump water quality over time.

Table 2: Water Quality Model Assumed Cover Properties

Category	Infiltration Rate (% of MAP)	NP Depletion Rate
No Cover	45%	100%
Rudimentary Cover	25%	50%
Low Infiltration Cover	5%	10%
Very Low Infiltration Cover	2%	5%

Infiltration Rate = % of Mean Annual Precipitation (MAP)

The water quality results for the twelve cases from Year 1 to 1000 were then input to the Water Treatment Plant Capital and Operating Cost model spreadsheet, presented in the SRK report 1CD003.054, Water Treatment Requirements for the Anvil Range Site. The primary assumptions for estimating capital and operating costs were:

- Water treatment occurred year round;
- Quicklime will be supplied to the site at a cost of $373 per tonne;
- Flocculant costs of $6,000 per tonne;
- Labour costs of $30 per hour (2 employees, 40hr/week);
- Power costs $0.11 / kWh; and
- 35% overhead rate.

Work Area Code 302
Vangorda Dump

1 Introduction

The current recommended closure options for the Faro and Vangorda/Grum mine areas include a range of possible cover types, relocation variants, and re-sloping of the waste dumps to stable landforms. This document describes cost-benefit analyses of the cover type and relocation variants. It also assesses requirements for re-sloping and landform stability, and develops landform design tools for the mine area waste dumps. It is expected that the analyses and tools provided herein will provide a basis for the final selection of cover types, relocation variants and landform designs.

2 Cost-Benefit Analysis of Cover Variants

2.1 Methods

An increase to the soil cover thickness over the waste dumps increases the costs of the cover construction, as well as reduces the amount of infiltration through the cover. This reduction in infiltration will reduce the amount of seepage through the dumps, reducing the costs of water treatment over the long term. The objective of this cost-benefit analysis is to determine where the increase in cover thickness will provide an overall savings in total costs.

The soil cover types used in the analyses are the same as those described in Attachment C of the SRK Report "Options for Closure of the Faro Mine Complex" (February 2008). Table 1 below lists and briefly describes the types of soil covers.

Table 1: Types of Soil Covers

Category	Description
No Cover	• Un-covered rock surface allowed to weather and, if possible, re-vegetate naturally.
Rudimentary Covers	• Cover rock with the minimum thickness of soil needed to allow plant growth (0.5 m).
Low Infiltration Covers	• Cover rock with layers of soil to significantly reduce the amount of water entering the surface of the waste. • The cover used in the analysis was a "store and release" cover incorporating a compacted, low permeability, 0.5 m thick layer of till overlain by 1.0 m of uncompacted till.
Very Low Infiltration Covers	• Cover rock with layers of soil and/or synthetic materials to minimize the amount of water entering the surface of the waste. • The cover used in the analysis was a "store and release" cover as above except consisting of 1.0 m of compacted till, overlain by 1.5 m of uncompacted till.

Table 3: Cover Types

Cover Type	Cover Description	Compacted Lift Thickness
Rudimentary Cover	0.5 m of uncompacted till	N/A
Low Infiltration Cover	0.5 m of compacted till overlain by 1.0 m of uncompacted till	0.25 m (2 lifts)
Very Low Infiltration Cover	1.0 m of compacted till overlain by 1.5 m uncompacted till	0.25 m (4 lifts)

2.4.1 Quantities

The thicknesses of each cover type are shown in Table 3 above. The dump areas were obtained from topographical maps. For each dump, areas were obtained for the flat surfaces and the sloped surfaces. All dumps were assumed to be regraded to 3H:1V. The sloped surface areas were assumed to increase by 5% due to the regrading.

2.4.2 Unit Cost Inputs

Equipment Rates

Equipment rates used in the estimates were obtained from the BC Blue Book, an equipment rental rate guide produced by the British Columbia Road Builders & Heavy Construction Association. The equipment rates included ownership, maintenance and repair costs only. The rates do not include operator costs, fuel costs, overhead or profit (these were added in subsequent steps).

Fuel

A fuel cost of $1.30 per litre was used throughout the cost estimate.

Equipment fuel rates used in the estimates were derived based on the equipment horse power, obtained from the Caterpillar Performance Handbook. The equation used to calculate the fuel rate is:

Fuel Rate ($/hr) = HP x FF x Fuel Cost per Liter

where: HP = horsepower

FF = Fuel Factor (Liter/hr/HP)

The fuel factors for each type of equipment represent the average fuel consumed per hour per horsepower. The fuel factors used in determining the fuel costs were as follows:

Table 4: Equipment Fuel Factors

Equipment Type	Fuel Factors (L/hr/HP)	Source
Excavators	0.130	CAT Handbook
Loaders	0.121	CAT Handbook
Dozers	0.135	CAT Handbook
Trucks	0.065	CAT Handbook
Compactors	0.130	CAT Handbook

6 Cover Constructability

6.1 General

Whilst it may be possible to design a cover capable of achieving specific target infiltration or oxygen ingress rates, these designs can only be realized if they can in fact be implemented. This section attempts to highlight some of the difficult construction issues that must be dealt with at the ARMC. Suitable engineering solutions can be found for each of the aspects discussed here, however it is likely that it would invoke a cost premium, which may not be acceptable.

6.2 Re-Sloping Requirements for Waste Rock Piles

As stated previously, the ICAP study recommended that re-contouring of the Faro waste rock pile be limited to areas where there is not positive surface drainage. At the time it was felt that re-contouring would disturb the existing oxidized surface waste rock and uncover more un-oxidized material. On the contrary, the ICAP did recommend re-contouring of the Vangorda and Grum waste rock piles, prior to covering them with a till cover.

For the purpose of this report we have calculated the amount of waste rock material that would have to be moved if all the waste rock piles at the ARMC were to be re-contoured to have positive drainage (i.e. top slopes flattened to remove voids and graded at 1%) and maximum side slopes of 2.5H:1V. This slope angle was considered to be the maximum that would still allow for safe and efficient placement of a soil cover, should it be required.

Our analysis of re-contouring earthworks volume are conservative, since we have only accounted for re-contouring of side slopes that are not bordering on an open pit, and we have used typical representative sections to conduct the calculations.

Based on these estimates, re-contouring of the Faro waste rock pile would require moving 3.1 million cubic meters of material, or approximately 2.4% of the 129 million cubic meters of material contained in this conglomerate of piles. The Grum waste rock pile would require re-contouring to the tune of 0.42 million cubic meters of material, or 1.8% of the 23.6 million cubic meters contained in the waste rock pile. At the Vangorda waste rock pile, approximately 0.6 million cubic meters of material would have to be re-handled for re-contouring, which would be equal to 1.8% of the total waste rock pile volume of 32.5 million cubic meters of material.

The re-sloping would also have an impact on the final surface areas of the waste rock piles that would be exposed, and that would have to be covered. These surface areas are summarized in Table 18. Based on these calculations, we have also determined that there would no areas where the re-sloping of the waste rock piles would cause problems with respect to encroaching on streams or

Work Area Code 303
Vangorda Creek

The photographic analysis is a poor surrogate for actual field investigation. To confirm and/or improve the graphical tool developed in this report, the till slopes need to be further investigated in the field.

4.3.2 Channel Armouring

The channel armouring requirement is related to the flow velocity of water in the channel. For vegetated channels, typical limiting velocities are 1 to 2 m/s. At velocities higher than 2 m/s, armouring (e.g. rock armour) is required to prevent channel erosion.

A number of watershed scenarios were considered to develop a relationship between watershed size/ground slope and channel armouring needs. For each scenario, the peak 1-in-100 year flow was calculated using the rational method. Intensity data for the calculations was obtained from the Carmacks IDF (Intensity-Duration-Frequency) curve. The peak flows were then converted into velocities assuming a conceptual channel design, and the resulting velocities were checked against limiting values. The watershed scenarios are listed in Table 12.

Table 12: Watershed Scenarios

Slope (%)	Watershed Area (ha)
2	3, 10, 30, 100
5	3, 10, 30, 100
20	1, 3, 5, 7, 9, 10, 100
33	1, 3, 5, 7, 9, 10, 100

There are two assumptions in the analysis:

- The Mannings ‘n’ value was assumed to be 0.05 in all calculations, which is suitable for vegetated channels, but not suitable for armoured channels. However, since the objective of the analysis was to find out the limiting design configuration for vegetated channels, the use of “n=0.05” serves the purpose of the curve in Figure 17.
- A fixed channel geometry was assumed in all analyses. Selection of the channel geometry is arbitrary and for the purposes of this report, the channels were assumed to have a 2-m wide base and 1V:3H side slopes. The depth of flow changes based on other variables (it varied from 0.1m to 0.6m based on scenario).

Watersheds yielding velocities higher than 2 m/s were plotted in the group “Engineered Rock Armor Waterway”, and those with a resulting velocity of 2 m/s or lower were plotted in the group “Engineered Vegetated Waterway”. The resulting curve is shown in Figure 17.

Results show that for 33% slopes (re-sloped dump face slopes) bio-engineered channels will be sufficient if the watersheds are kept below about 5 ha. The new slope faces will need to be divided into sub catchments of 5 ha or less in order to avoid the necessity for armouring in the drainage channels.

the diversion. As the consequences of a diversion breach are not considered to be catastrophic, diversion design using the full PMF was not carried out.

4.1.3 Energy Dissipation

To prevent undue scouring at the confluence with natural drainage systems such as Dixon Creek and the original Vangorda Creek, riprap lined plunge pools have been used to slow the re-entry into the existing stream channels where appropriate. A riprap lined chute was incorporated into Option 1 (North Pit Wall) to slow velocities.

4.1.4 Erosion Protection

Erosion protection in the form of riprap has been incorporated into the design of each option to prevent erosion of the channel sections. The protection is required to ensure the long-term stability of the structures. A 30cm sand filter zone would be required beneath the riprap layer to control loss of fines. The medium angular rock size (D_{50}) for the riprap was determined using a Rock Chute Design computer program developed by the US Department of Agriculture (USDA). A riprap borrow area would be developed as close to the site as possible.

4.1.5 Geomorphology Impacts on other Stream Courses

The diversion of the Vangorda Creek flow to Dixon Creek may impact the flow characteristics and geomorphology of the downstream channel. Dixon Creek is a tributary of Shrimp Creek which flows into Vangorda Creek 2.5km below the Vangorda Pit. A review of the potential geomorphologic impact of the diversion of Vangorda Creek on the Dixon and Shrimp Creek would need to be conducted prior to the next screening stage.

4.1.6 Leakage Potential

Leakage potential is an issue for each of the options. Although it appears that the rock mass around the north pit wall is relatively tight, the need for measures to seal the channel would require additional investigation. A till blanket has been proposed to seal the channel in the ramp across the pit in Option 2. Settlement of the rockfill which could lead to cracking of the till blanket remains an issue. In Option 3 (realignment to Dixon Creek), the potential for seepage through bottom of the channel where bedrock is encountered will require further investigation.

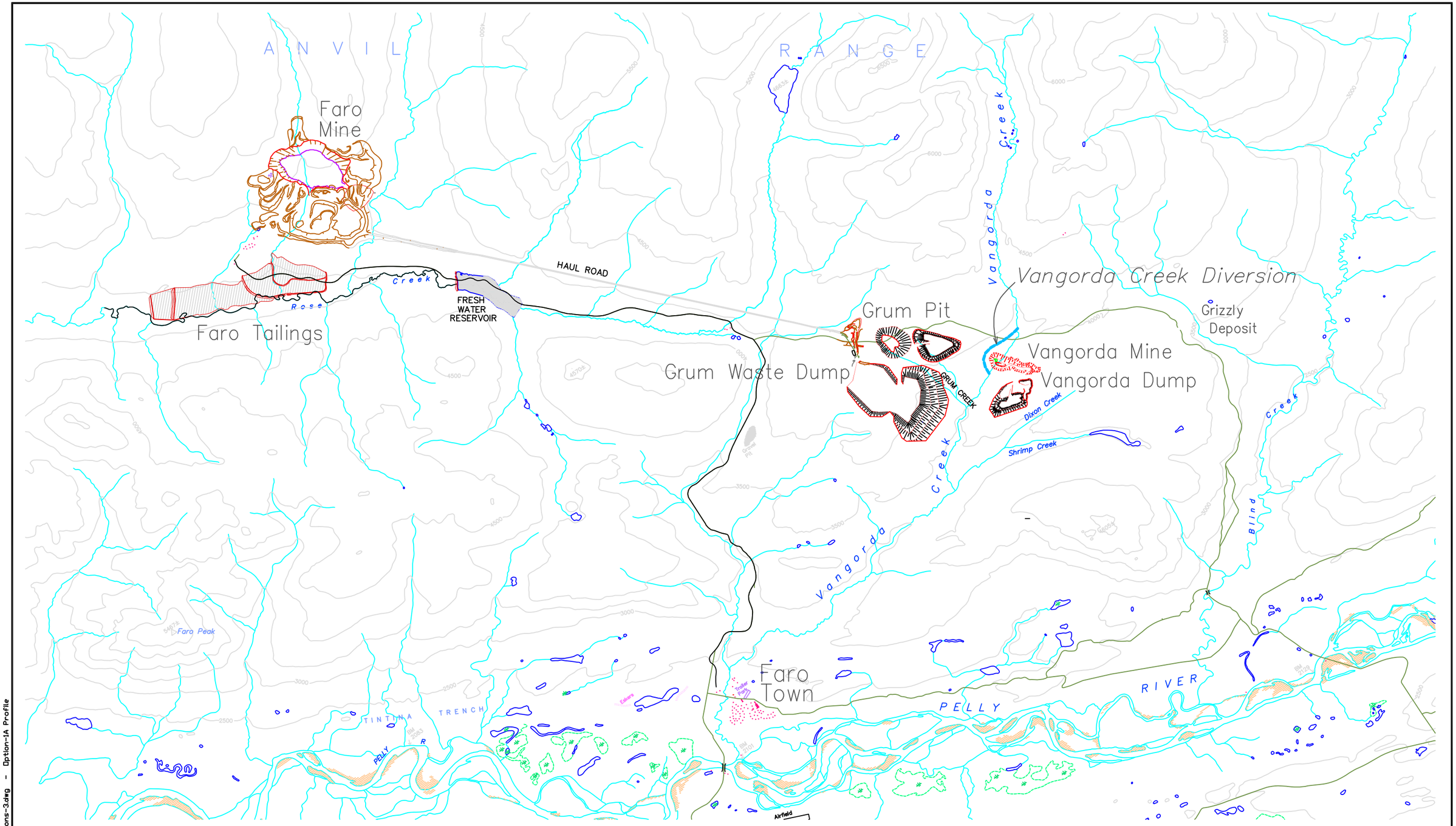
4.2 Alternative Designs

4.2.1 Option 1 - North Pit Wall

Option 1 is based on the alternative scheme recommended in the 1996 ICAP. The proposed design generally follows the horizontal alignment of the existing diversion but requires a steeper grade in some of the reaches so as to avoid a very steep drop to Vangorda Creek as it crosses the haul road. A layout for this option is shown in Figure 3. The existing drop box system would be removed and the plunge pool would be relocated downstream. The horizontal alignment from about STA 4+40 to 6+40 was set back several metres from the existing flume alignment to provide adequate safety margin against future undercutting of the channel from ongoing ravelling and bench failures. To determine the set back an angle of repose of 35 degrees was selected and a minimum distance of 15m was used as the set back from the edge of the channel to the potential ravelling boundary as shown in Figure 4.

The insitu rock that would be encountered along the proposed alignment consists of calcareous and non-calcareous phyllite. This material is observed to have weathering potential, which could lead to damaging erosion over time and possible blockage of the channel. Because of this, the slope of the channel has been maintained where possible with maximum grade of one (1) percent. To achieve this slope in the key reaches around the perimeter of the pit, a steeper (10%) chute section was incorporated in the design at STA. 2+80. This section of the rock channel would be armoured with competent riprap. No riprap protection would be required for sections of the channel with a slope of 1% or less. All other sections of the channel would require riprap erosion protection. A filter layer of compacted sand would be placed prior to placement of the riprap in areas with cohesive soils such as till.

Where the channel is cut in soil, the channel has sideslopes of 2:1 H:V. Those sections which are in rock would have sideslopes of 1:1 (H:V). A profile of the vertical alignment is presented in Figure 5 and typical sections along the alignment representing each of the reaches are presented in Figures 6 to 8. A summary of the earthwork quantities and materials for this option is presented in Table 3. Detailed quantities and sections along the alignment are shown in Appendix A.



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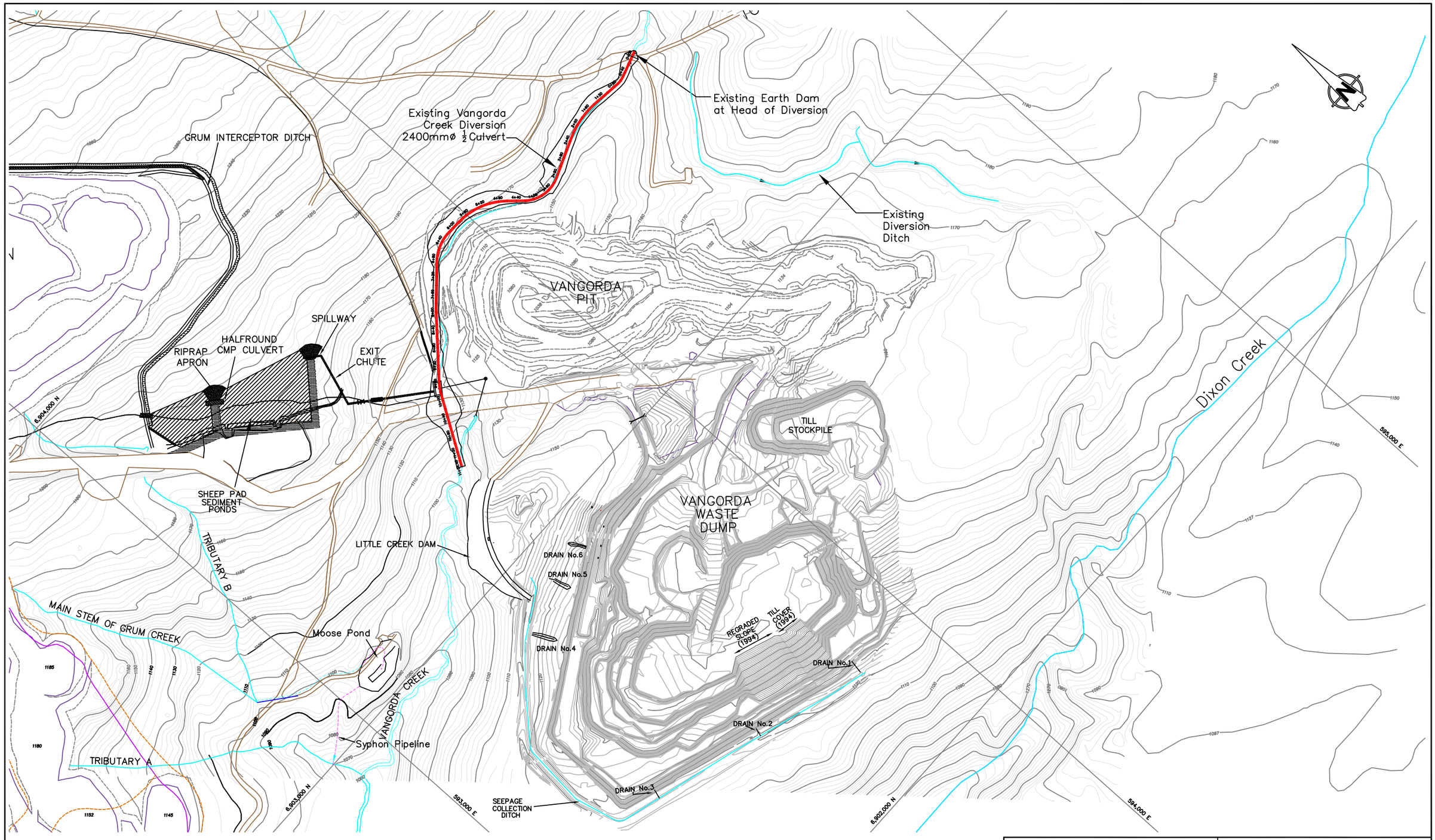
SRK Consulting
Engineers and Scientists

DELOITTE & TOUCHE INC.

VANGORDA PLATEAU MINE

Vicinity Map

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.15	April 2003		1



Notes 1) Datum = NAD 27
2) Coordinates = UTM
3) Contour Interval = 2m

0 50 100 150 200 250 300 350 400 450 500m
Scale 1:8000

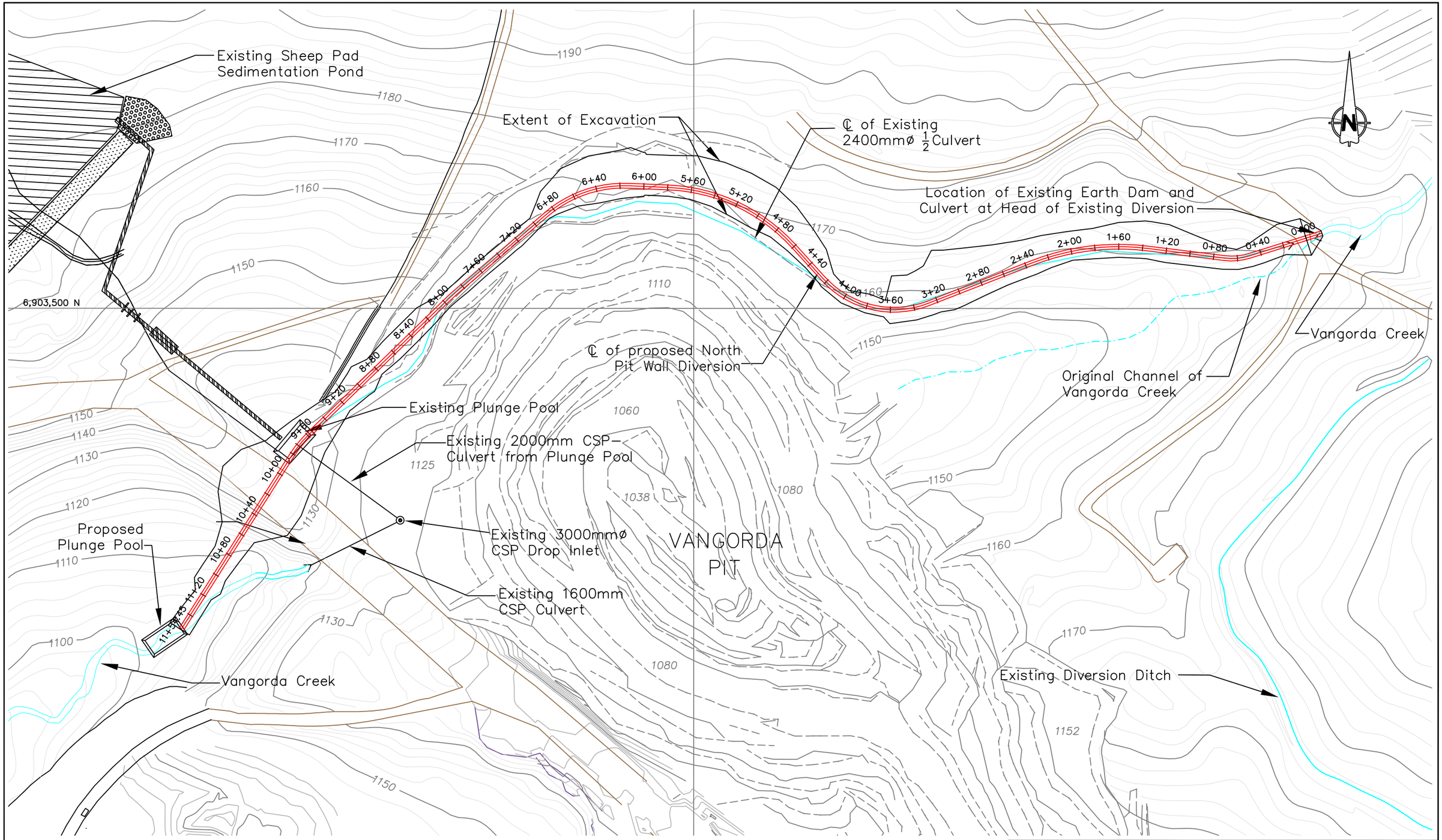
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VANGORDA PLATEAU MINE

Location Map

PROJECT NO.	DATE	APPROVED	FIG.
1CD003.15	April 2003		2



Notes 1) Datum = NAD 27
2) Coordinates = UTM
3) Contour Interval = 2m

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Scale 1:3000

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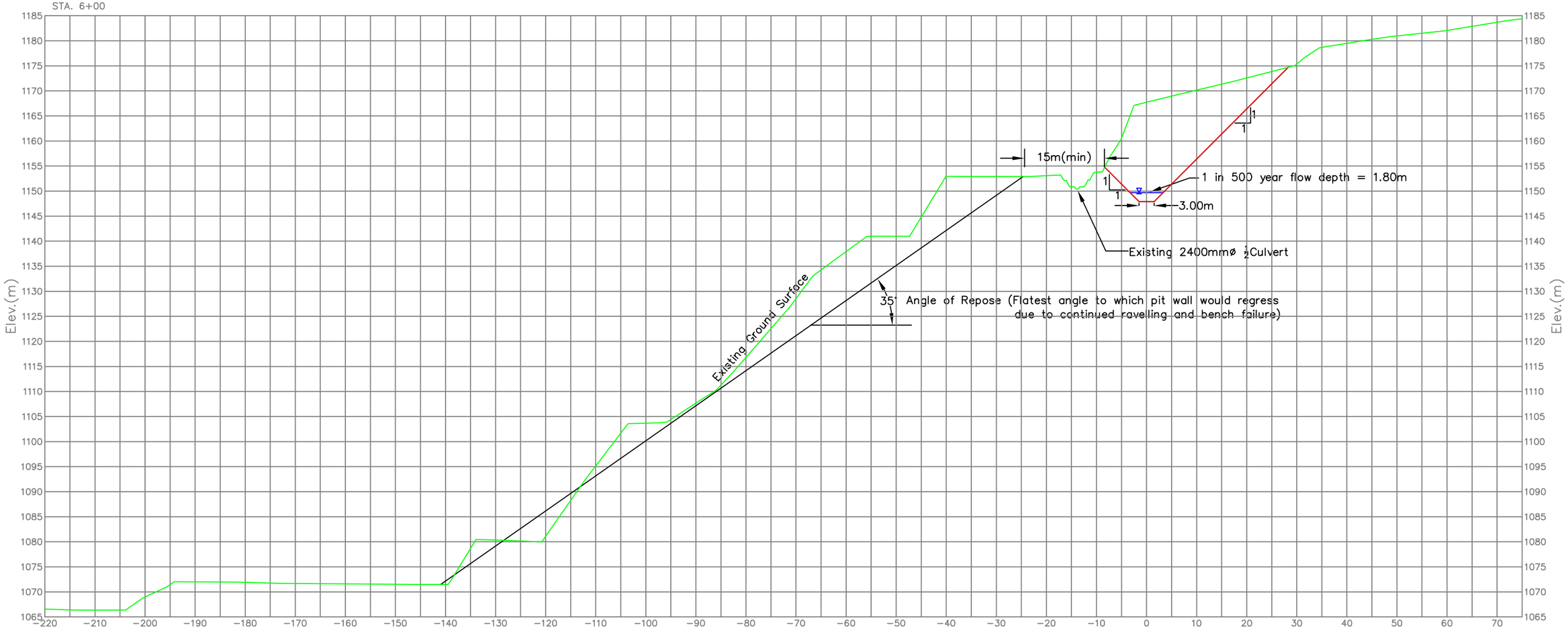
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VANGORDA PLATEAU MINE

Option 1– North Pit Wall Plan

PROJECT NO.	DATE	APPROVED	FIG.
1CD003.15	April 2003		3

STA. 6+00



0 5 10 15 20 25 Metres
1:800

File Ref: SITE_PLAN-Diversions-3.dwg – Option-1A Sections(5)

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VANGORDA PLATEAU MINE

Option – 1 North Pit Wall
Section Sta. 6+00

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.15	April 2003		4

Work Area Code 304
Grum Pit

4 Conclusions and Recommendations

An evaluation of the Grum Pit lake monitoring data suggests that annual winter inflows, when surface inflows are expected to minimal and contributions from direct precipitation are small, are likely attributable to baseline groundwater inflows. Furthermore, these winter inflows have decrease steadily over time as the pit lake elevation has increased, which is consistent with decreasing groundwater inflows as hydraulic heads decrease relative to the surrounding natural water table.

Using these winter baseflows and extrapolating over the remainder of the year, it can be shown that under current conditions up to 76 % of the net inflow to the pit lake may be groundwater inflow (wall seeps), with the balance from natural runoff.

Using the observed changes in groundwater inflows with increased elevation, it is projected that the annual ground water influx would decrease by up to 40 % by the time the threshold elevation of 1210.8 m asl., as proposed in the AMP, is reached. At an elevation of about 1220.8 m asl, i.e. 10 m above the threshold elevation proposed in the AMP, the groundwater inflows would decrease further, by up to 53 % of current flows. Correspondingly, annual inflows would decrease by about 48 % and 60 % respectively.

Using these inflow rates, the remaining storage capacity in the pit after the threshold elevation of 1210.8 m asl. is reached would be sufficient to store inflows for up to 40 years. At an elevation 10 m above this (i.e. 1220.8 m asl.) the decrease in flow rate would still result in storage for in excess of 20 years. Even at current inflow rates, storage for about 8 years would remain.

Under extreme climate conditions, such as a PMP event and assuming all of the precipitation that falls in the catchment reports to the pit, would have the effect of reducing the storage capacity by the equivalent of about 1 year storage time. Consequently the threshold elevation proposed in the AMP has been set very conservatively.

Increasing the threshold elevation by 10 m from that proposed in the AMP could have significant benefits to the pit lake water quality. In particular, at the higher elevation a significant proportion of the reactive sulphidic wall rock will be inundated and thus long-term loadings will be reduced. Short-term loadings, however, could increase as a result.

Another benefit is that it would be possible to extend the biological treatment program to further improve the water quality within the pit lake.

In the event that it becomes necessary to treat and discharge water from the Grum Pit lake, the bench scale tests indicated that it is likely that the presence of algae will not interfere with the treatment efficiency. Even if there is interference not detected by the bench scale tests, the experience gained at the Faro Mill treatment system has indicated that a lead time of about 1 year between termination

Work Area Code 305
Grum Interceptor Ditch

Work Area Code 306
Grum Dump

5.3 Grum Creek

5.3.1 Seepage Collection Options

At this time, seepage collection options presented in the SRK report ***Design Options for Seepage Collection, Grum Waste Rock Dump, June 2004*** are considered appropriate.

Three collection options were presented in the Grum Dump design option report. The following is a summary for each option with associated cost estimates.

1. Sediment and Seepage Control Ditches

   This option proposes a sedimentation basin for collection of clean water and removal of suspended load before release to a tributary, and till-lined open channels to capture and convey seepage and shallow subsurface waters that require water treatment. Capital cost was estimated at about $418,000. Operational costs would be minimal, involving inspection of ditches and sumps, as well as occasional removal of sludges.

2. Sediment Control Ditch, Seepage Collection Sumps and Pipes

   Option 2 describes the use of seepage-specific HDPE sumps connected via pipelines to a central pond holding area, from where contaminated water would be directed to a treatment plant. Capital cost was estimated at approximately $559,000. Operational costs would include maintenance of the sumps and holding pond. Additional maintenance costs would arise if pumping stations were required along the pipeline.

3. Groundwater Collection Wells

   The use of groundwater collection wells was presented as an option, but no system proposed due to unavailability of groundwater data. No cost estimates were provided for this option.

At this time, available water quality data for the deeper, confined, aquifer system suggests that, in the local area of the newly installed monitoring wells, WRD seepage impacts are not present. From a planning perspective, if groundwater collection was required from the deeper aquifer, interception wells would be the only option due to the depth of the aquifer. Methodology for collection of shallow groundwater will depend on the thickness and depth of the shallow aquifer.

Table 3. Zinc loading estimates

Scenario	Thickness (m)	Width (m)	Hydraulic Conductivity (m/s)	Gradient	Flux (L/s)	Zn Concentration (mg/L)	Load (tonnes/yr)
1	5	200	$2x10^{-5}$	0.1	2	0.02	0.001
2	5	1000	$1x10^{-4}$	0.1	50	0.02	0.032
3	20	200	$2x10^{-5}$	0.1	8	0.02	0.005
4	20	1000	$1x10^{-4}$	0.1	200	0.02	0.126

These calculations present a range of loading estimates based on very simple assumptions. It is recognized that the area is likely more complex than assumed here, but additional detail is not justified based on the available data. Based on these scoping calculations, the current zinc loads in the shallow and deep aquifers are estimated to be very small (0.001 t/yr and 0.005 t/yr, respectively). Assuming "worst-case" conditions, the zinc loading in the shallow and deep aquifer would still be less than 0.2 tonnes/year combined. Note that a width of 1000 m for these "worst-case" scenarios is considered very conservative, i.e. significantly greater than what is expected based on our experience. Even for these "worst-case" conditions the estimated zinc load in groundwater (<0.2 tonnes/year) would be much lower than the estimated zinc load in seepage from other waste rock dump areas (in particular at the Faro Mine) at the Anvil Range Mining Complex.

Based on these estimates and current observed conditions, seepage collection is not recommended at this time. However, this area should be monitored for any potential increase in zinc concentrations in the existing monitoring wells. If zinc concentrations in the local groundwater should increase beyond currently observed levels, seepage interception may be required to protect Vangorda Creek.

5 Options for Seepage Interception System

In the event that groundwater quality in the Grum area deteriorates to a level that it could impact the downstream aquatic environment (Vangorda Creek) seepage collection will be required. Preliminary seepage collection options were presented previously in the SRK report: ***Design Options for Seepage Collection, Grum Waste Rock Dump, June 2004***. Three seepage collection options were presented in that report:

1. Sediment and seepage control ditches,

2. Sediment control ditch, seepage collection sumps and pipes, and

3. Groundwater collection wells.

Readers are referred to the report for detailed descriptions of these options. At this time, these options remain appropriate for the Grum area. If future monitoring determined that contamination remained constrained to the shallow aquifer, a collection system comprised of ditches and sumps may be sufficient. If significant contamination occurs in the deeper aquifer system, groundwater

surface. This station was sampled as part of the routine monitoring from well installation in 1996 to 2001. Results from this monitoring are shown in Appendix B3. Sulphate and metal concentrations and pH levels were stable over the monitoring period and appear very similar to results from P96-9a and V15 over the same period. Sulphate concentrations at P96-9b suggest that water sampled in this well is influenced by upgradient sulphides.

5 Closure Method Options

5.1 General

A number of closure methods for handling Grum waste rock dump seepage and surface runoff were considered in this study. Examples of these methods are outlined below and are illustrated in Figures 7 and 10.

5.2 Option 1 – Sediment and Seepage Control Ditches

The selective placement of ditches for capture of runoff and seepage can be an effective water management tool. Where surface runoff requires only settling of suspended solids to meet discharge criteria, significant cost can be avoided by diverting runoff water away from water that requires further treatment. An example of such an application is illustrated in Figure 7, where a proposed riprap-lined sediment control ditch is located to intercept and convey clean, sediment-laden water to a sedimentation basin that discharges to the environment. Figure 8 presents a profile along the centreline of the proposed ditch. Details of a proposed sedimentation basin are presented in Appendix C. Figure 12 provides a typical section through the ditch. The ditch and riprap sizing was based on the 100 year rainfall event which would have a peak instantaneous flow of $0.7m^3$/sec.

The proposed sedimentation basin located as shown in Figure 7 would capture surface runoff from upslope, remove the suspended load, and release discharge-quality water to Tributary A. This strategy would require a minimal amount of maintenance in the form of ditch and basin inspection and clean-out of the basin when sufficient solids accumulated.

In this option, it is also proposed to construct a till-lined open channel to capture and convey surface seepage and shallow subsurface waters that require water treatment. The till would be protected with a layer of rip rap, 0.25 thick, as shown in Figure 12. The channel depth and rip rap sizing was based on a 100 year flood event with a peak flow of $0.7m^3$/sec. An alignment of the proposed seepage collection ditch is also shown on Figure 7. Figure 9 presents a profile along the centreline of the proposed ditch. The primary function of the ditch is to collect the known seeps at SRK-GD04, SRK-GD06, and SRK-GD05.

Seeps SRK-GD01 and SRK-GD02 will continue to flow into the main stem of Grum Creek. This flow will be contained in the holding pond above the Grum toe access road, and the entire volume will report to the water treatment plant.

Work Area Code 307
Overburden Dump

Work Area Code 308
Ore Transfer Pad

Work Area Code 309
Groundwater

5.3 Option 2 – Sediment Control Ditch, Seepage Collection Sumps and Pipes

Where localised sources of contaminated water exist, sumps may be a practical alternative to the collection of the seepage water. Sumps can capture deeper flows than ditches and can be located for optimum capture performance, whereas location of ditches can be dictated by grade requirements and greater constructability constraints. Sumps, which would consist of precast HDPE manholes, would require some method (eg. gravity- or pump-driven piping) for conveying contaminated water to a treatment plant.

Sumps could be located at known points of contaminated seepage. This strategy would have the benefit of minimising the capture and treatment of clean runoff and groundwater that otherwise would not require treatment. Figure 3 shows sump located to capture known or potential seepage at EC-1, at SRK-GD05/EC-2/SRK-GD06, and at SRK-GD01/ SRK-GD02.

An alternative to moving contaminated water from a collection point to a treatment plant or holding pond via ditching is through the use of piping. Piping has the advantages of having no seepage losses and no risk of blockages from debris, snow, etc. If the water is pumped, pipe routing is not constrained by grade. A major disadvantage of using piping in a cold climate is the risk of water freezing within the pipes and the maintenance and repairs required in such situation. In addition, if pumps are used, these require servicing, maintenance, and inspection on an active basis. The pipes would therefore have styrofoam installation, as shown on Figure 12.

Grum dump seepage could be collected in sumps at or near seep locations and transferred to a central water treatment plant via piping. This option is schematically illustrated in Figure 10. Piping from SRK-GD05, SRK-GD06 and EC-Seep 1 would be routed down the Grum toe access road to the holding pond. Piping from SRK-GD01 and SRK-GD02 would be routed parallel to the main stem of Grum Creek, on the east side of the valley, and would also report to the holding pond.

A holding pond is required to maintain a reserve volume of water for treatment plant feed. Optimum treatment plant efficiency occurs under conditions of steady, constant inflow; a holding pond minimises fluctuations in the volume of contaminated water requiring treatment. A potential location for a holding pond downgradient of the Grum waste rock dump is shown in Figure 10. A holding pond at this location would provide the added benefit of allowing suspended solids from main stem Grum Creek to settle out prior to treatment.

5.4 Option 3 – Groundwater Collection Wells

Collection wells located between the Grum waste rock dump and Vangorda Creek could be implemented as a method of collecting contaminated groundwater and delivering it to a treatment plant. These wells would require active pumping, possibly on a year-round basis, and would be subject to the difficulties associated with pumps and piping discussed above. The collection well

Work Area Code 310

Vangorda Haul Road

and culvert removal. The pickup truck has been selected for the labourer and spotter to use around the site for the installation of sediment control structures and for managing truck traffic. They hydro-seeding truck would be mobilized for re-vegetation when the earthworks at each drainage are completed.

Small equipment rental, installation and consumables costs have been built into the larger unit costs. All heavy equipment is assumed to be available for the construction at the specified cost listed in the site wide closure options report (SRK, 2008). Some small equipment costs have been selected on the basis of the 2008 B.C. Blue Book.

3.3 Manpower

It is assumed that the work will be undertaken using multiple shifts, so that work will proceed 24 hours per day, 7 days per week for the duration of construction. The cost estimate accounts for the required size of the work crew needed for the construction, including technicians and engineers. Monitoring and environmental personal are not included in this cost estimate, nor is there an allowance for food and lodging for project-related personnel.

3.4 Earthworks and Excavation Criteria

It is assumed that the deconstruction works on the haul road will start at the west end, at the Faro side of the FMC, and move 'one drainage at a time' to the east. However, the sequence could also be east to west or the work could start near the middle and then proceed sequentially to the east and west ends. Whatever sequence is selected, it will be essential to maintain access based on the existing roads.

The overall slope of the waste rock fill on either side of the breach is assumed to be 2 horizontal to 1 vertical (2H:1V). This slope has been selected on the basis of a 1.5H:1V angle of repose for the waste rock.

The minimum base width of each drainage channel has been taken as 5 m, except for the RC drainage. The north fork of Rose Creek is a major perennial creek and it is expected that a 25 m base width may be necessary at RC. However, as noted previously, and subject to input from other technical disciplines, it may be reasonable to reduce the base width to as low as about 10 m. Post-closure, light vehicle access across these drainages is considered feasible only in winter months or low flow periods.

The deconstruction method of the embankments will be a combination of excavation and dozer breach. Excavation will be done in 5 m deep bench cuts. Temporary haul roads will be constructed on 10 m vertical increments to simultaneously service two benches and thereby minimize temporary road construction. Safety berms should be considered pending the development of the detailed construction method by the Contractor. The hauling distance and slope length will vary slightly for each bench cut. The overall distance and grade do not affect cycle time significantly or lead to changes in the number of haul trucks.

The material near the bottom of the embankments which are less than 10 m in height will probably be removed by dozer methods because of limitations related to truck manoeuvrability. The dozer will also complete the final slope grade on either side of the drainage and will decommission all temporary haul roads related to the deconstruction process.

Drainages that require haul and dump operations will have a dump site identified at the nearest possible location. It is assumed that all the material removed from the excavation, including the culvert, can be buried inside the respective dump site. Each dump site, breached area and area of disturbance will be reclaimed by hydro-seeding, which should eliminate the potential need for topsoil haulage.

It is assumed the dump locations identified in this study are suitable and that permits for closure purposes will be obtainable.

3.4.1 Breaching Details for Rose Creek

The dump area for deconstruction of the RC drainage is approximately 450 m away and has sufficient capacity to hold all material from the breach. After the breach is completed, all the temporary haul roads and disturbed areas will be re-graded for closure and hydro-seeded. The breach is estimated to required 205 days of hauling to remove all the designated material. Figure 2 shows the proposed breach layout.

3.4.2 Breaching Details for HR-8

The dump areas for deconstruction of the HR-8 drainage are approximately 650m away. Three different areas have been identified to accommodate all the material removed from the drainage. The breach is estimated to require 47 days of hauling to remove the designated material. Figure 3 shows the proposed breach layout.

3.4.3 Breaching Details for HR-3

There is no proposed dump area for the deconstruction of the HR-3 drainage because the proposed removal will be done solely by dozer breach. The breach is estimated to require 19 days of dozer time. Figure 4 shows the estimated area of disturbance associated with the breach.

3.5 Sediment Control

Sediment controls, such as silt fences and sedimentation ponds, will be installed downstream of the construction areas. The cost of silt fences has been estimated on the basis of a quote from the Layfield Group. The cost of sedimentation ponds has been estimated as a unit cost of $50,000 each. The final design of the sedimentation ponds will require engineering that accounts for grain size distribution of the waste rock, precipitation and catchment areas.

An option for the RC drainage that was not specifically explored as part of this study is the potential use of the three sediment ponds at the site of the former fresh water pump house. These ponds

Table 4.2: Detailed Breakdown of Reclamation Costs for RC, HR-8 and HR-3

Task	Item	unit	quantity	unit rate	total	Task Sub-Total
RC						**$ 7,175,000**
MOB/DEMOB						$ 133,000
	Mobilization	unit	1	$ 66,398.30	$ 66,398	
	Demobilization	unit	1	$ 66,398.30	$ 66,398	
PRE-CONSTRUCTION						$ 306,000
	LHDP Elev 1135m Construction Haul Road to Dump site	m^3	16,860	$ 5.73	$ 96,628	
	LHDP Elev 1125m Construction Haul Road to Dump site	m^3	16,790	$ 5.73	$ 96,227	
	Regrade Elev 1115m Construction Haul Road from old road	m^3	270	$ 5.73	$ 1,547	
	Regrade Elev 1105m Construction Haul Road from old road	m^3	783	$ 5.73	$ 4,488	
	Regrade Elev 1095m Construction Haul Road from old road	m^3	833	$ 5.73	$ 4,774	
	Install Silt Fences	m	200	$ 7.61	$ 1,523	
	Install Sedimentation Pond	unit	2	$ 50,000.00	$ 100,000	
ROAD BREACH						$ 5,004,000
	Excavate Haul Road fill down to Elev. 1135m	m^3	157,561	$ 5.73	$ 903,012	
	Excavate Haul Road Fill down to Elev. 1125m	m^3	179,614	$ 5.73	$ 1,029,399	
	Excavate Haul Road Fill down to Elev. 1115m	m^3	193,339	$ 5.73	$ 1,108,060	
	Excavate Haul Road Fill down to Elev. 1105m	m^3	179,969	$ 5.73	$ 1,031,434	
	Excavate Haul Road Fill Down to Elev. 1095m	m^3	139,106	$ 5.73	$ 797,243	
	Dozer Breach Leftover material	m^3	52,401	$ 0.19	$ 10,063	
	Remove Rock Drain	m^3	15,000	$ 8.30	$ 124,550	
POST-CONSTRUCTION			916,990			$ 64,000
	Dress Haul Road Side Slopes	m^2	30,164	$ 0.19	$ 5,792	
	Redress construction Haul Roads	m^2	16,825	$ 0.19	$ 3,231	
	Revegetation on the overall disturbed areas	m^2	101,244	$ 0.54	$ 54,672	
IN-DIRECTS						$ 1,668,000
	Engineering	%	10%		$ 537,400	
	Survey	hr	224	$ 130.00	$ 29,120	
	Contingency	%	20%		$ 1,101,400	
HR-8						**$ 1,981,000**
MOB/DEMOB						$ 133,000
	Mobilization	unit	1	$ 66,398.30	$ 66,398	
	Demobilization	unit	1	$ 66,398.30	$ 66,398	
PRE-CONSTRUCTION						$ 145,000
	Clear temporary haul foot print	m^2	1,177	$ 4.17	$ 4,912.01	
	Establish Haul Roads to Dump sites	m^3	6,610	$ 5.73	$ 37,883.12	
	Install Silt Fences	m	200	$ 7.61	$ 1,522.88	
	Install Sedimentation Pond	unit	2	$ 50,000.00	$ 100,000.00	
ROAD BREACH						$ 1,220,000
	Excavate Haul Road Fill down to Elev. 1175m	m^3	175,368	$ 5.73	$ 1,005,063	
	Excavate Road Fill down to bottom of Creek	m^3	24,199	$ 5.73	$ 138,687	
	Dozer Breach Leftover material	m^3	0	$ 0.19	$ -	
	Remove Rock Drain	m^3	10,000	$ 7.61	$ 76,144	
POST-CONSTRUCTION			209,566			$ 26,000
	Dress Side Slopes	m^2	14,866	$ 0.19	$ 2,855	
	Redress construction Haul Roads	m^3	6,089	$ 0.19	$ 1,169	
	Revegetation	m^2	40,183	$ 0.54	$ 21,699	
IN-DIRECTS						$ 457,000
	Engineering	%	10%		$ 139,100	
	Survey	hr	94	$ 130.00	$ 12,220	
	Contingency	%	20%		$ 304,800	
HR-3						**$ 218,000**
MOB/DEMOB						$ 44,000
	Mobilization	unit	1	$ 21,758.60	$ 21,759	
	Demobilization	unit	1	$ 21,758.60	$ 21,759	
PRE-CONSTRUCTION						$ 104,000
	Install Silt Fences	m	450	$ 7.61	$ 3,426.48	
	Install Sedimentation Pond	unit	2	$ 50,000.00	$ 100,000.00	
ROAD BREACH						$ 15,000
	Dozer Breach material to top of culvert	m^3	15,728	$ 0.19	$ 3,020.20	
	Remove Culvert	hr	12	$ 167.95	$ 2,015.40	
	Cleared up channel slope at bottom of crossing	m^3	3,000	$ 3.11	$ 9,341.25	
POST-CONSTRUCTION						$ 4,000
	Dress Side Slopes	m^2	2,572	$ 0.19	$ 493.91	
	Revegetation	m^2	6,000	$ 0.54	$ 3,240.00	
INDIRECT						$ 51,000
	Engineering	%	10%		$ 12,300	
	Survey	hr	38	$ 130.00	$ 4,940	
	Contingency	%	20%		$ 33,400	

Work Area Code 311
Miscellaneous

Buildings

Sludge Management

The metal concentrations are calculated independently of pH, but pH is required as an input to the treatment cost model. A pH value of 3, 5 or 7 was assigned to each year based on the sludge generation rate calculated from the metal concentrations, as shown in Figure 3.

In each of the twelve cases, the water quality results generated a capital cost, an operating cost, and the amount of sludge produced for that given year. The capital cost used in the water treatment NPV calculations was the cost for a treatment plant needed to treat the Year 100 flows and water quality.

The total yearly operating cost included a capital replacement cost. The capital replacement cost was assumed to be the cost of the Year 100 plant divided over a period of thirty years.

The Net Present Values were then obtained by interpolating the yearly operating costs for the twelve cases between Years 1 and 1000 and adding the plant capital cost in Year 1. A discount rate of 3% per annum was adopted in all NPV calculations. A summary of the water treatment costs is provided in Attachment 1.

2.3 Sludge Disposal Costs

Cumulative sludge volumes were generated for each water treatment simulation to Year 1000. For the base case simulation, the total sludge volumes generated were 11,350,000 m^3 for the Faro Mine Area and 2,194,000 m^3 for the Vangorda-Grum Mine Area. All sludge volumes generated, even for the rudimentary covers, can be disposed of in the pits. As a result, sludge disposal costs were not included in the cover optimization.

The volume available for sludge in the Faro pit is estimated as 12,000,000 m^3 in the case of complete tailings relocation with the Plug Dam. The decision to construct the Plug Dam is dependant on the alternative chosen for the Rose Creek Tailings Area. If the complete tailings relocation alternative is chosen, the plug dam is required regardless of the sludge volumes. If the partial relocation alternative is chosen, then there is sufficient storage capacity (23,400,000 m^3) for the sludge volumes, even in the base case simulation that the plug dam will not be required.

The volume available for storage in the Grum Pit is estimated to be greater than 7,000,000 m^3, which is significantly larger than the sludge volume generated in the base case simulation.

2.4 Cover Construction Costs

Cover construction costs were prepared for each of the individual dumps. The cover construction costs include relocating and placing cover material from the Grum Overburden Dump plus the cost of compaction as necessary. Table 3 below shows the three cover types as well as the compaction requirements for each cover.

Existing Bioremediation Cell

Dams

WTP Settling Pond

New Bioremediation Cell

Roads

Borrow Sources

Miscellaneous

Borrow Areas

- 0.7 to 4.7 Mm^3 at the Rose Creek Tailings Facility (surface area of 234 ha);
- 1.2 to 8.1 Mm^3 at the Faro Waste Dumps (surface area of 407 ha);
- 0.2 to 1.0 Mm^3 at the Vangorda Waste Dumps (surface area of 51 ha); and
- 0.5 to 3.1 Mm^3 at the Grum Waste Dumps (surface area of 153 ha).

Soil, suitable for use as low permeability cover material, is comprised mainly of glacial till and is found at both the Faro and Vangorda Plateau areas. The estimated till reserves in the Faro area are in excess of 3 Mm^3 but the till deposits are generally thin and may involve relatively high re-vegetation costs as part of closure. Additional reserves are believed to be present north of the tailings impoundment and at several locations which are not currently accessible by road. In the Vangorda Plateau area, there are in excess of 8 Mm^3 of stockpiled till at two overburden dumps. In addition, the available mapping and surficial data suggest that an unknown quantity of intact till occurs as blankets near the Vangorda and Grum pits.

Granular soil, suitable for use as cover material or, following processing, for erosion protection, drain material and concrete aggregate, occurs locally as glaciofluvial and alluvial deposits. In excess of 1.5 Mm^3 have been identified in the Faro area at the haul road and Rose Creek sites. Additional reserves are believed to be present downstream of the tailings impoundment, at locations which are not currently accessible by road. The confirmed granular reserves at the Vangorda Plateau area are in excess of 0.3 Mm^3, and the occurrence is relatively patchy. Most of the readily available granular soils were removed during previous construction activities. However, a granular deposit in upper Vangorda Creek may, based solely on mapping, comprise in excess of 0.5 Mm^3 of material.

Coarse rock fill is not readily available and must be obtained by processing granular deposits or geochemically suitable waste rock, or by quarrying bedrock. In the Faro area, two main sources of coarse rockfill have been identified. The main source is durable, non-acid generating calc-silicate waste rock that is present at select zones in the waste dumps and in the rock drain that spans the North Fork of Rose Creek. The available volume of calc-silicate waste rock is estimated to be in excess of 1.0 Mm^3. A single quarry adjacent to the Rose Creek diversion has the potential to provide coarse rock fill of variable quality, but the volume of coarse rock fill that may be produced by screening select glaciofluvial and alluvial deposits in the Faro area is thought to be inconsequential. In the Vangorda Plateau area, two potential sources of coarse rock fill were identified. The quarry at the Grum Dump may have up to 30,000 m^3 of reserves and it may be possible to quarry an unknown volume of rock from a granitic outcrop near the Faro-Vangorda haul road.

significant surficial geologic units with respect to this borrow study are described below. The abbreviated material descriptions, which normally appear as two letters in brackets (one upper case and one lower case), are explained in the legend provided on Figures 2 through 4.

Alluvial Deposits

The alluvial materials comprise alluvial plain (Ap), terrace (At), fan (Af) and complex (Ax) deposits and generally consist of sand, silt, pebble, cobble and boulder mixtures. They may be up to 10 m thick and the fan deposits may be greater than 10 m thick. These deposits occur within the main drainages and are up to 600 m wide in the Rose Creek valley and 50 m wide in the North Fork Rose Creek and Next Creek valleys (Figure 2). The alluvial fan deposits consist of coarse sand, pebbles cobbles and mudflow deposits up to or greater than 10 m thick. The alluvial plain deposits consist of silt, sand and pebbles with reworked cobbles and boulders and are up to 10 m thick. These materials mostly consist of 'clean' granular materials (sand to boulder size) and form important existing and future target borrow materials.

Colluvial Deposits

The colluvial deposits generally consist of gravels with lenses of sand and silt and are found on slopes and at the base of slopes. They generally occur as thin veneers (Cv) less than 1m thick, or as aprons (Ca) which have coalesced at the base of slopes. Colluvial deposits most commonly overlie bedrock above the treeline, but also overlie older morainal till deposits on lower slopes.

Glaciofluvial Deposits

The glaciofluvial deposits consist of stratified to massive, poorly to well sorted, gravel and sand with minor silt and cobbles, deposited by meltwater originating from glacial ice. These deposits are common in Rose Creek and the major northeast tributaries. Important derivatives include the glaciofluvial plain (Gp) deposits from 3 m to 10 m thick and glaciofluvial complex (Gx) deposits up to 40 m thick.

Glacial Till

Till deposits generally consist of unsorted clay, silt, sand, pebbles and cobbles with minor boulders, deposited by or from glacial ice. Till is common as a veneer (Tv, <1

m thick) over much of the Faro and Vangorda-Grum areas and grades into blanket deposits (Tb, >1 m thick) on more gentle slopes and valley bottoms.

Organic Deposits

Organic deposits (O) mostly consist of peat and woody material and overlie lacustrine, till or poorly drained glaciofluvial and alluvial deposits, but rarely occur as a significant geologic deposit.

3. POTENTIAL BORROW MATERIAL REQUIREMENTS

Broad closure alternatives identified during the Closure Alternatives Workshop (Deloitte, 2002) provided the basis for subsequent scoping level designs. These designs, which were completed in 2002 (SRK, 2003a), define the general material types and range in material volumes that may be required for future mine maintenance and closure activities.

3.1 Material Types

Borrow materials that may be required for future mine maintenance and closure activities are described below:

- cohesive soils for construction of low permeability covers or vegetative covers,
- granular soils for use as filter or drain material, stabilizing fill, road fill, protective covers for geosynthetic materials, erosion protection and concrete aggregate,
- coarse rock fill for erosion protection in channels (riprap) and road ballast,
- general fills for covers, slope stabilization and potential needs, and
- organic soils for establishing vegetative covers.

Table 3.1 identifies the target geological units that, in their current form or as a result of processing, will be capable of providing the borrow materials listed above.

Table 3.1
Required Borrow Materials and Target Geological Units

Borrow Material	Target Geological Units
Cohesive Soils	• Glacial till deposits (Tv, & Tb)
Granular Soils	• Alluvial deposits (Af, Ap, At & Ax) • Glaciofluvial deposits (Gp, Gx, Gc & Gt)
Coarse Rock Fill	• Screened material from alluvium & glaciofluvium • Bedrock (obtained from quarries by drilling and blasting) • Calc-silicate cobbles and boulders in the Faro waste rock dump & North Fork rock drain
General Fills	• Glacial till, glaciofluvium and alluvium • Calc-silicate gravels in the Faro waste rock dump & North Fork rock drain
Organic Soils	• Organics (O)

5. RESULTS FROM FARO MINE AREA

5.1 Haul Road Borrow Site

5.1.1 Existing Granular Borrow

The haul road borrow site is an existing borrow site located just off the Faro-Vangorda haul road, near the North Fork Rose Creek rock drain outlet (Figure 2). Bond (2001) mapped the site as glaciofluvial complex (Gx). At the time of this fieldwork, a screening plant was in operation at this site. Local contractors were screening 10,000 m^3 of cobbles and boulders (20, 40 and 60 cm gradations) for lining of the Faro Creek diversion around the back of the Faro open pit.

A total of four test pits (TP B-02-42, to B-02-45, inclusive) were excavated at this site. It appears that the eastern end of the pit has been exploited, but deeper deposits of predominantly sand with some fine gravel, remain at the western limit of the developed area.

According to mapping and reconnaissance work, an extension to the glaciofluvial deposit extends to the west of the developed area and borders Rose Creek. This area is considerably lower in elevation, and appears to be eroded by previous meandering of the Rose Creek channel. Shallow deposits of sand and gravel likely remain near Rose Creek. However, access to this area is difficult and, as a result, no test pits were completed in this area.

Based on site reconnaissance and the test pit program, it is estimated that 150,000 m^3 of material remain at and immediately adjacent to the developed portion of this site (80% of which is predominately clean sand). This material would appear to be a good source of concrete sand aggregate.

5.1.2 Potential Impervious Materials:

An area parallel to the haul road, southeast of the granular deposits, indicated the potential for glacial till deposits (Figure 2). The area is a relatively long, flat ridge that gently slopes to the southwest, to Rose Creek. The topography of this ridge is flat with a poorly drained, slightly hummocky surface. There are several areas of shallow ponded water. The surface characteristics of the area northeast of the haul road are very similar, which suggests the deposit may extend some distance beyond the haul road.

Five test pits (TP B-02-37 to B-02-41, inclusive) were excavated in this area. The test pit excavations encountered shallow deposits (less than 3m thick) of brown glacial till over bedrock (phyllite). This soil unit is typically comprised of sand with some silt and gravel, and a trace of clay. It is non-plastic to low plastic with moisture contents ranging from 8 to 13%. It is less dense than a basal till. Some of the pits exhibited sporadic permafrost (without visible ice).

There is an estimated 720,000 m^3 of material available on this ridge (southwest of the haul road), with additional material likely available northeast of the haul road.

5.1.3 North Fork Rock Drain

Coarse fragments of calc-silicate waste rock were used to develop a rock drain in the causeway at the point where the Vangorda-to-Faro haul road crosses the North Fork of Rose Creek. The haul road is about 60 m high in this location.

Information contained in the design report for the rock drain (Golder, 1986) indicates the calc-silicate zone is approximately 70 m long along the road centerline, and extends effectively from the road surface to the natural ground. Boulders with a mean diameter of 0.5 m size are believed to occupy a zone 3.6 m thick at the base of the calc-silicate zone. Based on these dimensions, the estimated volume of calc-silicate rock in the haul road is 450,000 m^3.

5.2 Rose Creek Borrow Site

The Rose Creek borrow site is located approximately 1 km downstream of the Cross Valley Dam (most westerly dam at the Rose Creek tailings storage facility) on the right bank of Rose Creek (Figure 2). The borrow site includes three existing borrow areas located within alluvial fan (Af) and glaciofluvial plain (Gp) deposits. The materials, excluding the cobble and boulder fraction, consist of poorly graded gravel with sand (GP) and silty gravel with sand (GM). There are frequent cobble-sized clasts and occasional boulders. A significant volume of silt and organic material is present at one of the borrow areas (west pit).

The three existing borrow sites cover a combined area of approximately 120,000 m^2. Assuming an average depth of 4.2 m over an available reserve area of 370,000 m^2, and excluding the waste material at west pit, there may be up to 1.4 million (M) m^3 of granular fill available at the site.

The Phase 2 investigation explored the existing workings as well the remaining deposits found on the perimeter. There are three distinct areas, joined by a washed-out road, within the Rose Creek borrow site. Each of the three areas is discussed below.

5.2.1 West Pit Area

The west pit area (Area #1 on the photos in Appendix C) is the largest of the three areas. It extends southeast to the banks of Rose Creek. The area is generally flat and appears to have a seasonal spring flowing from east to west through the centre. The vegetation comprises scrub brush where it has not been stripped by workings.

Nine test pits (TP B-02-01 to B-01-08 and TP B-02-10) were excavated at the west pit area. In general, the deposit consists of between 3 and 5 m of relatively clean, well-graded gravel and sand. Some of the test pits displayed lenses of mixed fine sand and silt. The base of the deposit is bounded by silt and very fine sand that, in some cases, coincided with the ground water table. Sporadic permafrost was found on the northeast side of this area.

This segment of the Rose Creek borrow site is approximately 225,000 m^2 and, at an average depth of 4 m, a volume of 900,000 m^3 is estimated. However, the field suggests that 20% of this material is likely to comprise unusable silt and organic soil. The usable portion of this deposit, therefore, is about 720,000 m^3.

To the southwest, on the other side of Rose Creek, there is a comparable area with the potential of an additional large quantity (~ 300,000 m^3) of sand and gravel.

5.2.2 Centre Pit Area

The centre pit area (Area #2 on the photos in Appendix C) is intermediate in size between the other two areas. It is flat in the centre where it has been developed and rises to form small hills adjacent to the Rose Creek flood plain. It also rises gently to the northeast where a house on private property is located. A flowing creek divides the centre zone from the east pit area. Coarse gravel occupies the creek bed, likely due to seasonal high-velocity flows. The vegetation beyond the stripped out area is predominately black spruce.

Six test pits (TP B-02-09 and TP B-02-11 to 02-15, inclusive) were excavated in the centre pit area. It is comprised of predominately well graded, relatively clean (less than 5% fines) gravel and sand. There are lenses of fine sand and silt. There also

appears to be a boulder layer in the upper horizon of the deposit. A considerable volume of rounded boulders appears to have been removed from this area.

With an area of 90,000 m^2 and an average depth of 5 m, although the deposit typically ranges in depth from 4 to 6 m, the estimated volume of the deposit is 450,000 m^3.

5.2.3 East Pit Area

The east pit area (Area #3 on the photos in Appendix C) is the smallest of the three and has been extensively stripped. The main part of the deposit is flat due to stripping. A large hill rises to the southwest and appears to be comprised of granular soils. The vegetation at the perimeter of this area is predominately black spruce.

Two test pits (TP B-02-16 and B-02-17) were excavated in this area. Predominantly clean, poorly graded sand was encountered at the toe of the hill, near the southwest limit of this area (TP B-02-16). The excavated pit workings, to the northeast indicate the presence of coarser material. However, this end of the pit is extensively stripped out.

Based on the test pits, the available depth of granular soil is approximately 3.75 m over the southwest two thirds of the deposit, which represents an area of 60,000 m^2. This corresponds to a volume of 225,000 m^3. Based on the available data, it is suspected that the majority of this soil is clean (less than 5%) sand with some fine gravel. This is a potential source of concrete sand.

5.3 Rose Creek Haul Road Borrow Site

The Rose Creek haul road borrow site is a 2-km section of road between the southwest limit of the Tailings borrow site and the Rose Creek borrow site (Figure 2). The general topography along this section of road has a southwesterly slope to the Rose Creek valley. Upslope of the road, the ground rises at approximately 12 to 14 degrees for about 50 m, and then steepens to approximately 14 to 18 degrees. Between the road and Rose Creek, the ground is considerably steeper. The slope is well drained and the cover vegetation is dense black spruce. Mapping by Bond (2001) indicates the area is comprised of a till blanket over bedrock.

Eight test pits (TP B-02-18 to B-02-25, inclusive) were excavated along accessible areas upslope of the road. The test pits were all very similar, and encountered 3 to 6 m of brown silt till. The brown till is comprised of nearly equal parts of gravel, sand,

and silt, with a lesser (10%) amount of clay. It is moist, non-plastic to low plastic, and firm (i.e. fairly easy to excavate). Sporadic zones of permafrost (Nnb) were observed in some of the test pits.

Given an average depth of 4 m and an aerial extent of approximately 200,000 m^2, the volume of the brown till is estimated to be 800,000 m^3. In addition, it is possible that thinner deposits exist upslope of this defined area.

5.4 Tailings Borrow Site

The Tailings borrow site is located between the east end of the Rose Creek haul road borrow site and approximately the North Fork of Rose Creek (Figure 2). Pipeline Road and the mine access road intersect the area. The topography is gently sloping and generally smooth as it rises up from the tailings pond. This area is mapped by Bond (2001) as a complex of colluvium veneer (Cv) and till blanket (Tb). Material has been removed from four main borrow sites within this area. The total area disturbed by borrow activity is approximately 250,000 m^2. Both granular and low permeability (till) soil materials exist within these areas and probably both were borrowed for construction of the tailings facilities. There appears to be an abundance of till materials remaining at these borrow sites, but very little clean, granular material. Scattered rock outcrops (closely fractured schist) were noted throughout the area. Vegetation typically comprises black spruce.

Eleven test pits (TP B-02-26 to B-02-36, inclusive) were excavated along the roads at this site. As well, mapping of the exposed faces at the stripped borrow sites was completed. Typically all of the pits and exposures revealed brown till over bedrock. The till is very similar to that found on the Rose Creek haul road. It is comprised of nearly equal parts of gravel, sand, and silt with a lesser amount (10%) of clay. It is moist, non-plastic to low plastic and firm. Sporadic zones of permafrost (Nnb) were observed in some of the test pits.

The till thickness is variable, but in those areas where the till is more substantive, the thickness typically ranges from 4 to 5 m. The areas that have a 4 to 5 m thickness of till occupy a combined area of 385,000 m^2, which leads to an estimated volume in excess of 1,700,000 m^3.

5.5 Rose Creek Diversion Quarry

The Rose Creek Diversion quarry is located on the south side of the Rose Creek Diversion Channel, opposite the Intermediate Tailings Dam (Figure 2). Approximately 30,000 m^3 of phyllite schist riprap have been quarried from the site to line the Rose Creek Diversion Channel. The schist is variably strong to very strong, slightly weathered (some moderately weathered) with closely to moderately widely spaced joints which produce cobble to boulder-sized blocks. This rock is of variable quality (fair to good) but the quarry could be expanded, based on further outcrops noted upslope of the quarry face. The Rose Creek Diversion Channel currently cuts off access to the quarry.

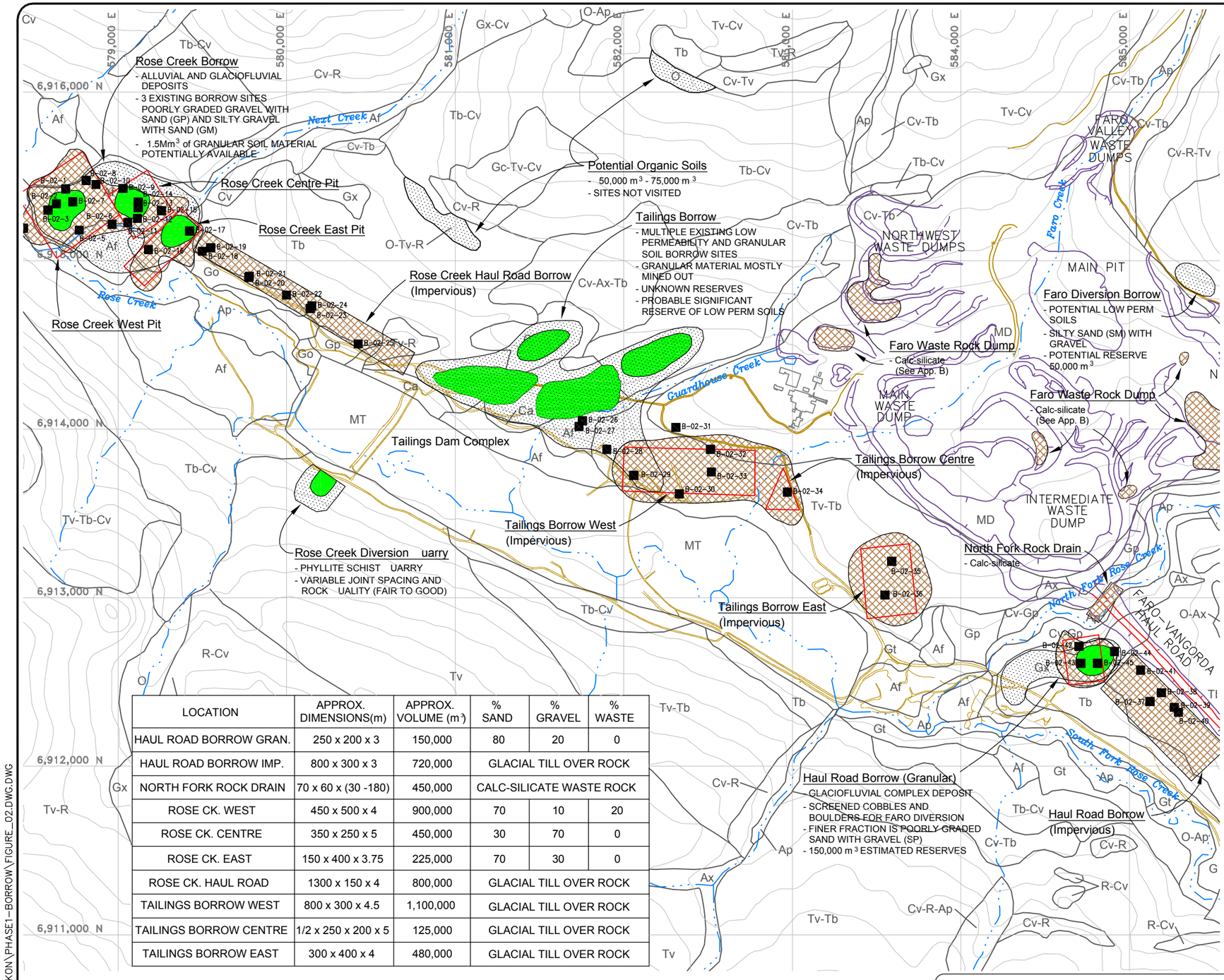
Further assessment of this quarry was not undertaken as part of the Phase 2 investigation.

5.6 Faro Waste Rock Dumps

Calc-silicate waste rock has been identified as being a suitable borrow material due to its physical durability and non-acid geochemical character. Estimates presented in the 1996 ICAP (Robertson Geoconsultants Inc., 1996) indicate the calc-silicates represent approximately 31%, or 80 million tonnes, of the waste rock in the Faro Dumps.

As part of SRK's 2002 geochemical field investigations (SRK, 2003b), eight test pits were completed in areas of the Faro waste rock dumps that were mapped as exposures of calc-silicate waste rock. Details concerning the locations of these test pits and the calc-silicate exposures are provided in Appendix B (Figure B1). The calc-silicate waste rock typically contained between 40 and 60% fines, with the remainder of the clasts being greater than 10 cm. The clasts greater than 10 cm were typically between 20 cm and 50 cm, although some boulders of up to 1 m diameter were encountered. Intrusives, schist and other rock types were mixed with the calc-silicates in some of the test pits. Acid-base accounting tests are still in progress but, based on earlier testing, this material is expected to be non-acid generating.

The test pits indicate the depth of the calc-silicates in these exposures is greater than 2 m. Assuming a 2 m thickness over the areas shown in Figure B1, the quantity of calc-silicate waste rock would be in the order of 600,000 m^3.



LOCATION	APPROX. DIMENSIONS(m)	APPROX. VOLUME (m³)	% SAND	% GRAVEL	% WASTE
HAUL ROAD BORROW GRAN.	250 x 200 x 3	150,000	80	20	0
HAUL ROAD BORROW IMP.	800 x 300 x 3	720,000	GLACIAL TILL OVER ROCK		
NORTH FORK ROCK DRAIN	70 x 60 x (30 -180)	450,000	CALC-SILICATE WASTE ROCK		
ROSE CK. WEST	450 x 500 x 4	900,000	70	10	20
ROSE CK. CENTRE	350 x 250 x 5	450,000	30	70	0
ROSE CK. EAST	150 x 400 x 3.75	225,000	70	30	0
ROSE CK. HAUL ROAD	1300 x 150 x 4	800,000	GLACIAL TILL OVER ROCK		
TAILINGS BORROW WEST	800 x 300 x 4.5	1,100,000	GLACIAL TILL OVER ROCK		
TAILINGS BORROW CENTRE	1/2 x 250 x 200 x 5	125,000	GLACIAL TILL OVER ROCK		
TAILINGS BORROW EAST	300 x 400 x 4	480,000	GLACIAL TILL OVER ROCK		

LEGEND (from Bond, 1999)

UATERNARY

HOLOCENE

MINE DISTURBANCE

MD- mine disturbance; consisting of an open-pit and stripped till and bedrock accumulations. Bedrock and surficial sediments exposed in open-pit.

MINE TAILINGS

MT - mine tailings; consisting of sand, silt and some clay.

ORGANIC DEPOSITS

O - organics; consisting of woody sedge peat, variable thickness. White River ash accumulations are commonly associated with poorly drained peaty areas.

ALLUVIAL DEPOSITS

Ap - alluvial plain; silt, sand and pebbles with reworked cobbles and boulders occurring as bars, overbank floodplain deposits, 0 - 10 m thick; floodplain subject to periodic floods. Small valley alluvial plains may not be mapped at this scale.

Ap (active) - alluvial plain; area of Pelly River floodplain that has been recently active.

At - alluvial terrace; silt, sand, and pebbles with reworked cobbles and boulders occurring as low terrace deposits, 0 - 10 m thick.

Af - alluvial fan; coarse sand, pebbles, cobbles and mudflow deposits, up to or 10 m thick. Appear as vegetated, often peat covered, landforms developed during post-glacial sedimentation.

Ax - complexes of Ap and Af undivided. Common when a stream is unconfined and also in narrow valleys where side-entry alluvial fans cannot be differentiated from an alluvial plain.

PLEISTOCENE AND HOLOCENE (UNDIVIDED)

COLLUVIAL DEPOSITS

Cv - colluvium veneer; conforms to bedrock topography, <1 m thick.

Ca - colluvium apron; coalescing colluvial fans at the base of a slope, 1 m thick.

Cz - mass wasting; includes slumping, debris slides and rockfalls. Slumping and rockfalls are Common on Mt. Mye.

LATE PLEISTOCENE (WISCONSINAN) - McCONNELL GLACIATION

GLACIOLACUSTRINE DEPOSITS

Lb - glaciolacustrine blanket; 1- 40 m thick.

GLACIOFLUVIAL DEPOSITS

Gp - glaciofluvial plain; 3 - 10 m thick.

Gt - glaciofluvial terrace; <10 m thick.

Gx - glaciofluvial complex; 1 - 30 m thick, composed of deposits of outwash, glaciolacustrine and minor till deposited in an ice contact environment. Hummocky topography is associated with this depositional setting. Crevasse fillings were mapped in the upper part of Vangorda Creek valley.

GLACIAL DEPOSITS

Tv - till veneer; conforms to underlying topography, <1 m thick.

Tb - till blanket; gently to moderately sloping plain controlled by bedrock or underlying surficial deposits, 1 m thick.

Tx - till complex; till blanket or veneer composed of meltout till and minor ice contact glaciofluvial deposits.

LOWER CAMBRIAN TO CRETACEOUS

BEDROCK

R - bedrock; common on plateau summits and ridges on Mt. Mye and Sheep Mountain.

EXISTING UARRY OR BORROW

POTENTIAL UARRY OR BORROW

AREA IDENTIFIED IN PHASE 1 (TOO THIN OR UNTESTED)

MINE INFRASTRUCTURE

EXISTING ACCESS ROAD

PHASE 2 BORROW TEST PIT B–02–40

N

0 500 1000

SCALE IN METERS
1:25,000

REFERENCE

BOND, J.D. (OPEN FILE 1999-10)
SURFICIAL GEOLOGY MAP AND TILL GEOCHEMISTRY OF MOUNT MYE (105K/3&6 W), CENTRAL YUKON TERRITORY

SRK Consulting
Engineers and Scientists

PROJECT NO.	DATE	REVISION
1CD003	04/03	A

FIGURE 2

FARO MINE SITE
Surficial Geology and
Soil and Rock Borrow Locations

* STA.#3 * T:\YUKON\PHASE1–BORROW\FIGURE_02.DWG.DWG

6. RESULTS FROM VANGORDA PLATEAU AREA

6.1 AEX Creek Schist Quarry

The AEX Creek schist quarry is located in AEX Creek, near the Faro-Vangorda haul road and approximately 650 m northwest of the ore haul shop (Figure 4). The old rock quarry site, which is now infilled with water, is mapped as till veneer overlying bedrock (Tv-R). The rock quality is variable and compromises approximately 70% slightly to moderately weathered, closely jointed, strongly foliated, strong schist and 30% slightly weathered, widely jointed, weakly foliated, very strong schist. Approximately 10,000 m^3 of material appear to have been extracted from this quarry with a minor stockpile of the stronger rock remaining. Another 10,000 m^3 of good rock may not be obtainable by drill and blast methods, but the occurrence of good rock is patchy.

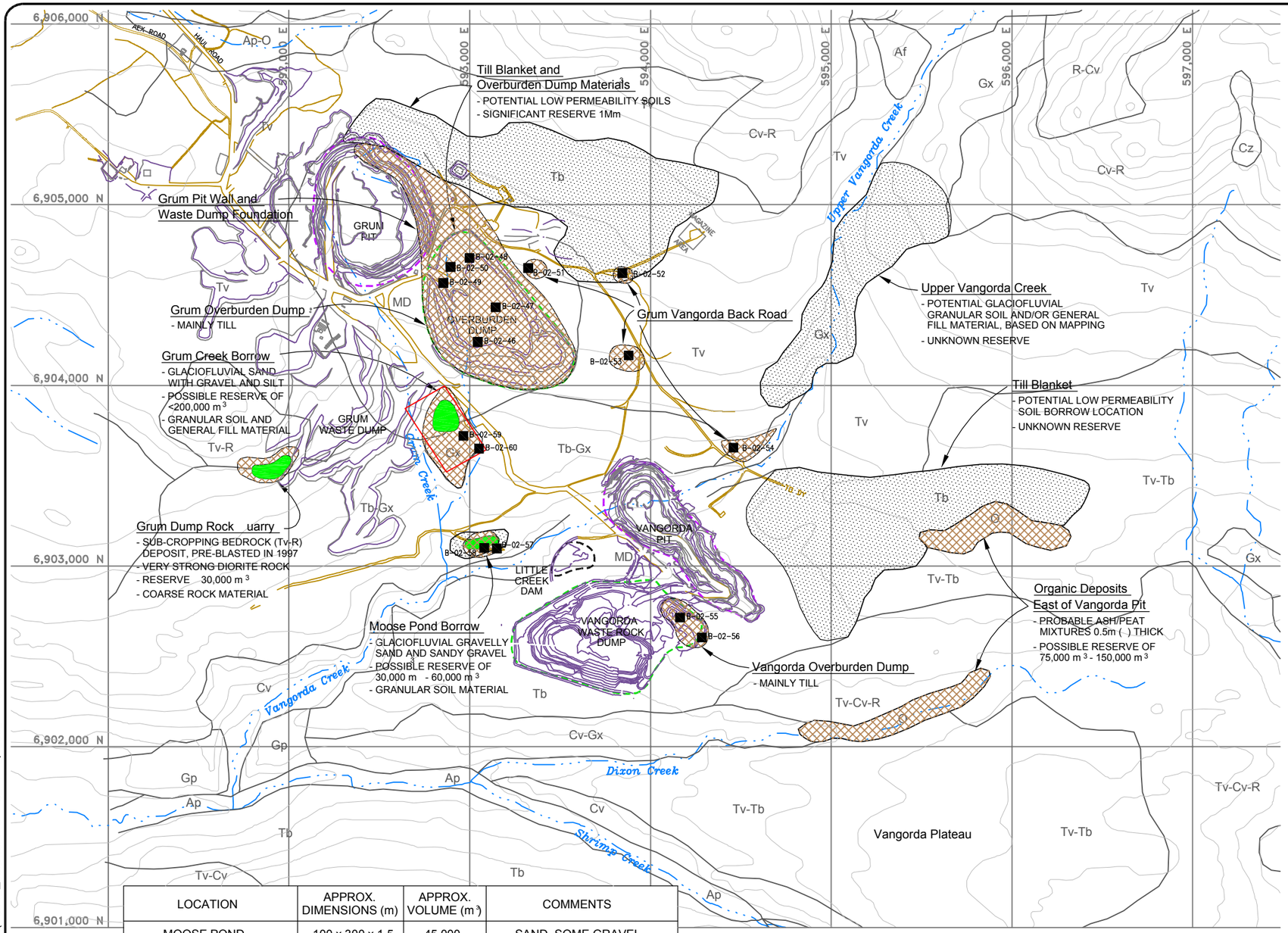
6.2 Grum Dump Quarry

The Grum Dump quarry is located at the south end of the Grum Dump (Figure 3), which is in an area mapped as till veneer (<1 m thick) overlying bedrock (Tv-R). The quarry was pre-blasted in 1997 and a total of 10,000 m^3 was recently processed for use as graded riprap at the Fresh Water Supply Dam. Site personnel estimate that an incremental 5,000 m^3 of pre-blasted rock remain in place. The pre-blasted material has a relatively high fines content (approximately 20%) because the source, a diorite dyke, was originally 'sub-cropping' with some till cover. The material is high quality dioritic rock, which is dark greyish green (with brown iron-stained surfaces), slightly weathered and very strong. The angular clasts produced from blasting range from gravel to large boulders (2 m diameter) and were screened to produce riprap for the Fresh Water Supply Dam. It is difficult to estimate the available reserve at this quarry, but it may be as much as 30,000 m^3 of additional useable riprap-grade rock.

6.3 Moose Pond Borrow Site

The Moose Pond borrow site is located on the north bank of Vangorda Creek, opposite Little Creek Dam, in an area that is mapped as a complex glaciofluvial (Gx) deposit (Figure 3). Access to this site is good.

A sample of the material at this site was collected during Phase 1 and two test pits (TP B-02-57 and B-02-58) were excavated during Phase 2. The laboratory result from Phase 1 indicated the material comprised of well-graded sand with gravel (SW). TP



LOCATION	APPROX. DIMENSIONS (m)	APPROX. VOLUME (m3)	COMMENTS
MOOSE POND	100 x 300 x 1.5	45,000	SAND, SOME GRAVEL
GRUM CREEK	400 x 250 x 2	<200,000	SAND & GRAVEL
GRUM, VANGORDA BACK ROAD #51 #52 #53 #54	100 x 100 x 1 60 x 100 x 2.5 200 x 100 x <1 1/2 x 400 x 300 x 1	100,000	SAND & GRAVEL
VANGORDA OVB DUMP	200 x 200 x 10	400,000	GLACIAL TILL
GRUM OVERBURDEN DUMP	1000 x 700 x 12	8,000,000	GLACIAL TILL
ORGANIC DEPOSITS EAST OF VANGORDA PIT	800 x 150 x .5 1100 x 150 x .5	150,000	PEAT

LEGEND (from Bond, 1999)

UATERNARY

HOLOCENE

MINE DISTURBANCE

MD- mine disturbance; consisting of an open-pit and stripped till and bedrock accumulations. Bedrock and surficial sediments exposed in open-pit.

MINE TAILINGS

MT - mine tailings; consisting of sand, silt and some clay.

ORGANIC DEPOSITS

O - organics; consisting of woody sedge peat, variable thickness. White River ash accumulations are commonly associated with poorly drained peaty areas.

ALLUVIAL DEPOSITS

Ap - alluvial plain; silt, sand and pebbles with reworked cobbles and boulders occurring as bars, overbank floodplain deposits, 0 - 10 m thick; floodplain subject to periodic floods. Small valley alluvial plains may not be mapped at this scale.

Ap (active) - alluvial plain; area of Pelly River floodplain that has been recently active.

At - alluvial terrace; silt, sand, and pebbles with reworked cobbles and boulders occurring as low terrace deposits, 0 - 10 m thick.

Af - alluvial fan; coarse sand, pebbles, cobbles and mudflow deposits, up to or 10 m thick. Appear as vegetated, often peat covered, landforms developed during post-glacial sedimentation.

Ax - complexes of Ap and Af undivided. Common when a stream is unconfined and also in narrow valleys where side-entry alluvial fans cannot be differentiated from an alluvial plain.

PLEISTOCENE AND HOLOCENE (UNDIVIDED)

COLLUVIAL DEPOSITS

Cv - colluvium veneer; conforms to bedrock topography, <1 m thick.

Ca - colluvium apron; coalescing colluvial fans at the base of a slope, 1 m thick.

Cz - mass wasting; includes slumping, debris slides and rockfalls. Slumping and rockfalls are Common on Mt. Mye.

LATE PLEISTOCENE (WISCONSINAN) - McCONNELL GLACIATION

GLACIOLACUSTRINE DEPOSITS

Lb - glaciolacustrine blanket; 1- 40 m thick.

GLACIOFLUVIAL DEPOSITS

Gp - glaciofluvial plain; 3 - 10 m thick.

Gt - glaciofluvial terrace; <10 m thick.

Gx - glaciofluvial complex; 1 - 30 m thick, composed of deposits of outwash, glaciolacustrine and minor till deposited in an ice contact environment. Hummocky topography is associated with this depositional setting. Crevasse fillings were mapped in the upper part of Vangorda Creek valley.

GLACIAL DEPOSITS

Tv - till veneer; conforms to underlying topography, <1 m thick.

Tb - till blanket; gently to moderately sloping plain controlled by bedrock or underlying surficial deposits, 1 m thick.

Tx - till complex; till blanket or veneer composed of meltout till and minor ice contact glaciofluvial deposits.

LOWER CAMBRIAN TO CRETACEOUS

BEDROCK

R - bedrock; common on plateau summits and ridges on Mt. Mye and Sheep Mountain.

EXISTING UARRY OR BORROW

POTENTIAL UARRY OR BORROW

AREA IDENTIFIED BY BOND, UNTESTED IN PHASE 2

MINE INFRASTRUCTURE

EXISTING ACCESS ROAD

PHASE 2 BORROW TEST PIT B-02-40

REFERENCE

BOND, J.D. (OPEN FILE 1999-7)
SURFICIAL GEOLOGY MAP AND TILL GEOCHEMISTRY OF MOUNT MYE AND FARO (105K/3&6 E), CENTRAL YUKON TERRITORY

N

0 500 1000

SCALE IN METERS
1:25,000

SRK Consulting
Engineers and Scientists

PROJECT NO.	DATE	REVISION
1CD003	04/03	A

FIGURE 3

VANGORDA - GRUM AREA
Surficial Geology and Soil and Rock Borrow Locations

* STA.#3 * T:\YUKON\PHASE1-BORROW\FIGURE_03.DWG * SEPT 12, 2002 * 10:48:22 AM *

7. HAUL ROAD BETWEEN FARO AND VANGORDA PLATEAU

A few developed granular borrow sites and a potential rock quarry exist along the Faro-Vangorda haul road that runs between the Faro and Grum open pits. The borrow sites have been largely exhausted, similar to most of the granular borrow sites in the Vangorda Plateau area.

7.1 Granular Deposit East of the Fresh Water Supply Reservoir

A series of connecting borrow pits define what once was a considerably large deposit of sand and gravel southeast of the Fresh Water Supply Reservoir (Figure 4). The approximate coordinates of this deposit are N6,910,000, E587,100.

No test pits were excavated in this area, but it appears that the bulk of the available material has been removed. The remaining deposits could be used for local work but will be relatively inefficient to develop.

7.2 Granular Deposit near Ore Haul Shop

An area along the west fork of Vangorda Creek, on the northeast side of the haul road across from the ore haul shop was investigated previously. The approximate coordinates of this deposit are N6,905,900, E591,600. No new work was completed in this area, but a series of test trenches were excavated previously along the northeast side of the creek (opposite side of creek to the road). These pits were excavated in an area of bush-type vegetation typical of granular soils, but the exposed material appears to be predominately silt.

7.3 Potential Granular Deposit

A ridge with the shape and colour similar to glaciofluvial deposits found elsewhere on the site was noted northeast of the Faro-Vangorda haul road during the Phase 2 field investigations. This area was viewed from the haul road (GPS coordinates: N6,906,550, E590,900). It is estimated to be less than 1 km off the road, but due to limited access, the ridge was not investigated.

7.4 Potential Granitic Quarry

An extensive outcrop of granitic bedrock on the Faro Mine Road, at the old Vangorda-Grum turnoff, was visited during the Phase 1 investigation. This outcrop is approximately 1.5 km northwest of the ore haul shop (Figure 4). Outcrop ridges can

The first phase of the investigation, undertaken in July and August 2002, comprised compilation of a database of existing geological information, preliminary sampling of seven potential borrow areas and laboratory testing of these samples for routine soil classification. The Phase 1 report, issued in August 2002, provided a preliminary assessment of the locations, available volumes and characteristics of potential borrow sources. The report also provided recommendations for the execution of the Phase 2 investigation.

Phase 2 of the investigation, undertaken in September through November 2002, comprised a detailed field reconnaissance, the excavation of 60 test pits in areas with existing road access and laboratory testing of representative samples to confirm soil classification and revegetation potential. The Phase 2 report, issued in April 2003, included a revised assessment of the locations, available volumes and characteristics of potential borrow sources (Figures 1 through 4).

The conclusions arising from this two-phase study were as follows. The quantities of granular soils and cohesive soils at the Anvil Range Mining Complex that are currently accessible by road access are likely to be adequate for most cover scenarios. However, granular soils are more common close to Faro and cohesive soils are more common at the Vangorda Plateau. Therefore, depending on the specific cover requirements at each mine area, haulage costs could be relatively high if material had to be hauled between Vangorda Plateau and the Faro mine site. In a scenario such as this, it may be more cost-effective to develop access to new borrow areas. Potential quarry sites capable of providing rock suitable for riprap are scarce in the immediate vicinity of the tailings containment area and waste dumps. The best source of riprap is processed calc-silicate waste rock from the Faro waste rock dumps or the rock drain at the North Fork of Rose Creek. Organic soils are not widely available and, where present, typically require the development of road access.

Additional Borrow Studies in 2004/05

As part of a series of geophysical studies in October 2004, Aurora Geosciences Ltd. of Whitehorse completed ground penetrating radar and seismic refraction surveys at three potential borrow areas (Figure 5) identified following two-stage borrow studies undertaken in 2002 and 2003. The areas of study were situated on the Vangorda - Grum side of the ARMC. Two of the areas involved fine grained soils (till) and the third involved granular soils (sands and gravels of glaciofluvial origin).

SRK issued the final summary report in 2006. It summarized the program objectives, provided a brief overview of the field investigation and its results and provided recommendations related to further studies that may be appropriate, depending on the details of the final closure plan. The GPR survey failed to conclusively map bedrock at most sites because of signal attenuation and scattering. In general, the seismic refraction interpretation produced more definitive results, but the interpretations were complicated by a high velocity layer that could represent either dense till or weathered bedrock. In order to obtain more meaningful interpretations, the geophysical contractor recommended the completion of a drilling program to calibrate the geophysical data.

2 Site conditions

The following description of the conditions at the Anvil Range Mining Complex is taken primarily from Bond (2001).

2.1 Location and Physiography

Faro mine is located within the Anvil District, which is located within the Yukon Plateau physiographic subdivision. The Anvil Range lies at the core of the district, with summits rising above 1,800 m and intermediate surfaces, such as Vangorda Plateau, that flank the uplands.

2.2 Bedrock Geology

The stratigraphic sequence comprising the Anvil District extends from the Precambrian to the Ordovician and includes the Mount Mye, Vangorda and Menzie Creek Formations. The Mount Mye and Vangorda Formations comprise deep marine schist and phyllite sequences with other minor lithologies. The mid Cretaceous Anvil Range plutonic suite intrudes these rocks and is comprised of granite, granodiorite and quartz monzonite lithologies. Regional dips of the metasediments are to the southwest and northeast away from the batholith. Target materials for coarse and durable riprap material generally include the coarse-grained igneous rocks (granite, diorite and granodiorite), calc-silicates and more competent (weakly foliated) schists and phyllites.

2.3 Surficial Geology

The surficial geology of the Anvil Range Mining Complex is summarized on three maps that cover the areas shown by Figure 1. Figures 2, 3 and 4 show the surficial geology, according to Bond (2001), of the Faro mine site area, the Vangorda-Grum area and most of the area between the two mining complexes, respectively. The abbreviated material descriptions, which normally appear as two letters in brackets (one upper case and one lower case), are explained in the legends provided on Figures 2 through 4.

The Anvil District has been subject to repeated glaciation. The last glaciation occurred between 25,000 and 10,000 years ago late (Wisconsinan McConnell glaciation). Significant surficial materials were deposited during this period including morainal till veneers (<1 m thick) and till blankets (>1 m thick). Glaciofluvial and glaciolacustrine deposits are generally located on lower range slopes flanking active drainage channels. Recent alluvium and organic (sporadic) deposits are found throughout the area with veneers of colluvium blanketing upland slopes. Brief comments on the each of the main surficial deposits are provided below.

2.3.1 Alluvial Deposits

The alluvial materials comprise alluvial plain (Ap), terrace (At), fan (Af) and complex (Ax) deposits and generally consist of sand, silt, pebble, cobble and boulder mixtures. They may be up to 10 m thick and the fan deposits may be greater than 10 m thick. These deposits occur within the main drainages and are up to 600 m wide in the Rose Creek valley and 50 m wide in the North Fork Rose Creek and Next Creek valleys (Figure 2). The alluvial fan deposits consist of coarse sand, pebbles cobbles and mudflow deposits up to or greater than 10 m thick. The alluvial plain deposits consist of silt, sand and pebbles with reworked cobbles and boulders and are up to 10 m thick. These materials mostly consist of 'clean' granular materials (sand to boulder size) and form important existing and future target borrow materials.

2.3.2 Colluvial Deposits

The colluvial deposits generally consist of gravels with lenses of sand and silt and are found on slopes and at the base of slopes. They generally occur as thin veneers (Cv) less than 1m thick, or as aprons (Ca) which have coalesced at the base of slopes. Colluvial deposits most commonly overlie bedrock above the treeline, but also overlie older morainal till deposits on lower slopes.

2.3.3 Glaciofluvial Deposits

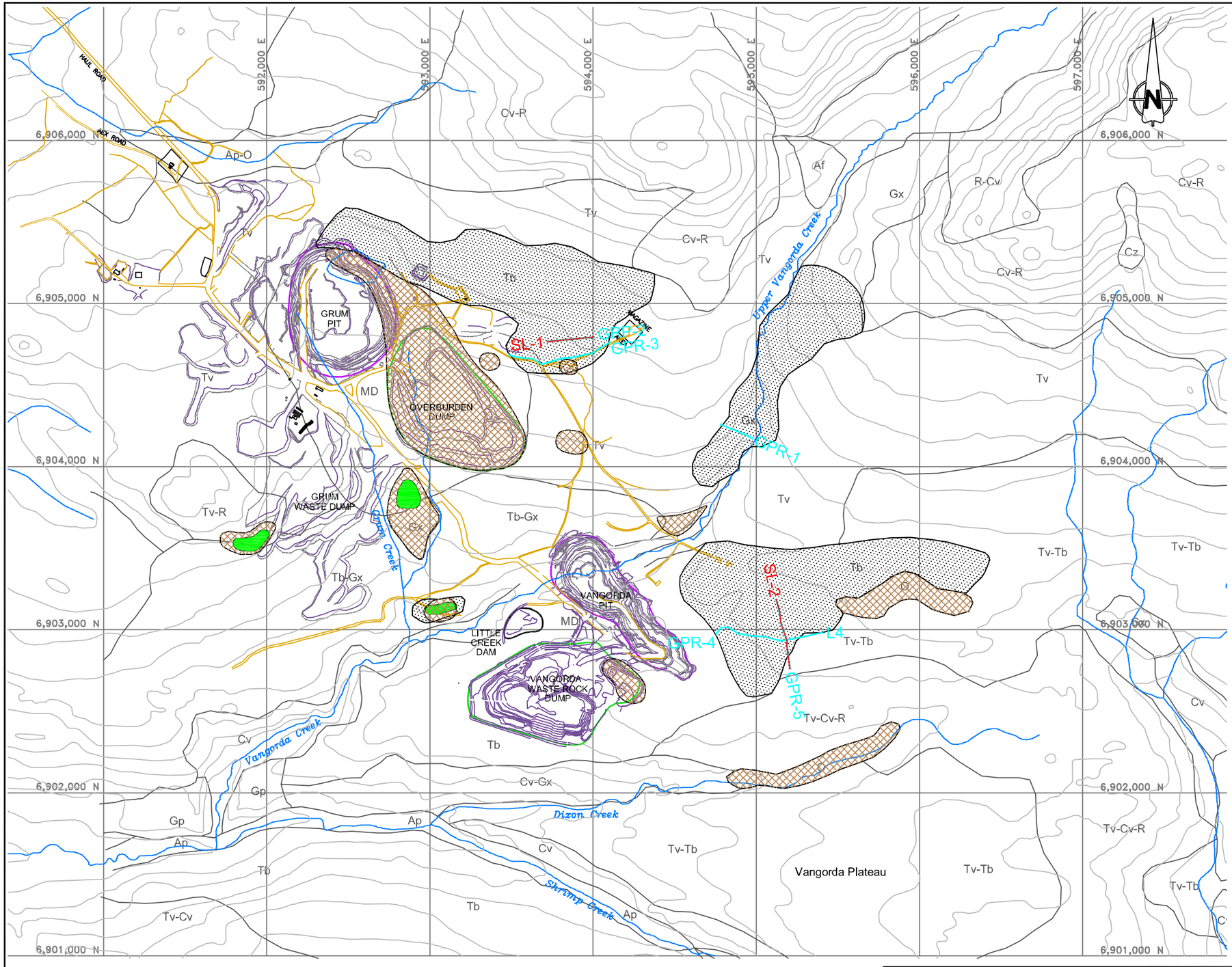
The glaciofluvial deposits consist of stratified to massive, poorly to well sorted, gravel and sand with minor silt and cobbles, deposited by meltwater originating from glacial ice. These deposits are common in Rose Creek and the major northeast tributaries. Important derivatives include the glaciofluvial plain (Gp) deposits from 3 m to 10 m thick and glaciofluvial complex (Gx) deposits up to 40 m thick.

2.3.4 Glacial Till

Till deposits generally consist of unsorted clay, silt, sand, pebbles and cobbles with minor boulders, deposited by or from glacial ice. Till is common as a veneer (Tv, <1 m thick) over much of the Faro and Vangorda-Grum areas and grades into blanket deposits (Tb, >1 m thick) on more gentle slopes and valley bottoms.

2.3.5 Organic Deposits

Organic deposits (O) mostly consist of peat and woody material and overlie lacustrine, till or poorly drained glaciofluvial and alluvial deposits, but rarely occur as a significant geologic deposit.



LEGEND (from Bond, 1999)

QUATERNARY

HOLOCENE

MINE DISTURBANCE

MD- mine disturbance; consisting of an open-pit and stripped till and bedrock accumulations. Bedrock and surficial sediments exposed in open-pit.

MINE TAILINGS

MT - mine tailings; consisting of sand, silt and some clay.

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Ax - complexes of Ap and Af undivided. Common when a stream is unconfined and also in narrow valleys where side-entry alluvial fans cannot be differentiated from an alluvial plain.

PLEISTOCENE AND HOLOCENE (UNDIVIDED)

COLLUVIAL DEPOSITS

Cv - colluvium veneer; conforms to bedrock topography, <1 m thick.

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Cz - mass wasting; includes slumping, debris slides and rockfalls. Slumping and rockfalls are Common on Mt. Mye.

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Gx - glaciofluvial complex; 1 - 30 m thick, composed of deposits of outwash, glaciolacustrine and minor till deposited in an ice contact environment. Hummocky topography is associated with this depositional setting. Crevasse fillings were mapped in the upper part of Vangorda Creek valley.

GLACIAL DEPOSITS

Tv - till veneer; conforms to underlying topography, <1 m thick.

Tb - till blanket; gently to moderately sloping plain controlled by bedrock or underlying surficial deposits, >1 m thick.

Tx - till complex; till blanket or veneer composed of meltout till and minor ice contact glaciofluvial deposits.

LOWER CAMBRIAN TO CRETACEOUS

BEDROCK

R - bedrock; common on plateau summits and ridges on Mt. Mye and Sheep Mountain.

- EXISTING QUARRY OR BORROW
- POTENTIAL QUARRY OR BORROW IDENTIFIED IN PHASE 2 (2003)
- AREA IDENTIFIED BY BOND, UNTESTED IN PHASE 2 (2003)
- MINE INFRASTRUCTURE
- EXISTING ACCESS ROAD
- GPR SURVEY LINE (2004)
- SEISMIC REFRACTION SURVEY LINE (2004)

0 500 100 1500 METERS

1: 25000

REFERENCE

BOND, J.D. (OPEN FILE 1999-7)
SURFICIAL GEOLOGY MAP AND TILL GEOCHEMISTRY OF
MOUNT MYE AND FARO (105K/3&6 E), CENTRAL YUKON TERRITORY

SRK Consulting
Engineers and Scientists
Vancouver

SRK JOB NO.: 1CD003.078

FILE NAME: Figure_05_1CD003.078.dwg

Deloitte & Touche

Vangorda-Grum Area

GPR-Survey Lines and Seismic Refraction Survey Lines from 2004/05 Program

DATE:	APPROVED:	FIGURE:
May 06		5

weight, portable drill operated by Rocky Mountain Soil Sampling Inc. was used to undertake the field investigations during 2005. The objective of these investigations was to evaluate the likelihood that significant volumes of till material exist in these target areas.

4.2 Field investigation

Following a review of the SRK borrow studies in 2002/03 and the recent mapping from Bond (Figures 6 and 7), five target areas were identified for investigation. At each of these areas, the surficial geological mapping indicated that the material at surface consists of a till blanket (unit Tb, till greater than 1 m thick). The locations of these areas, which are shown on Figures 8 and 9, were as follows:

- The north slope above the Cross Valley Dam;
- Between the Faro waste rock dumps and the original tailings impoundment;
- East of the former Fresh Water Supply Reservoir, below the haul road;
- East of the North Fork of Rose Creek, above the haul road; and
- Northwest of the Faro waste rock dumps.

The field activities associated with the investigation of these areas comprised the following:

- Visual inspections, supported by available surficial geological mapping, aerial photographs and an electronic global positioning system (GPS) locator;
- Completion of 14 drill holes (B-AD-01(B) through B-AD-14) in an initial phase of drilling in August 2005; and
- Completion of nine additional drill holes (B-TE05-01 through B-TE05-03 and B-TW05-04 through B-TW05-09) in a second phase of drilling in September 2005.

Both phases of drilling were undertaken using a small, manually-portable drill operated by a two-man crew from Rocky Mountain Soil Sampling Inc. Drill holes ranged in depth from 0.3 to 6.5 m, with a mean depth of 2.8 m. The locations of the 23 drill holes are shown on Figures 8 and 9.

An inspector from SRK identified the proposed location of each drill hole using a GPS unit, supervised the drilling, collected soil samples from select drill holes and logged each drill hole. The drill hole logs are included in Appendix A.

4.3 Laboratory Testing Programs

Soil samples collected during the drilling program were delivered to EBA Engineering Consultants (EBA) in Whitehorse for routine classification testing. Specific laboratory test performed by EBA included gradation analyses and moisture content determinations. The results of these laboratory tests are provided in Appendix B.

Table 1: Summary of potential cover material volumes & haul distances

Material Type	Source (Location)	Estimated Volume (Million m^3)	Calculated Maximum Haul Distance (km)			
			Rose Creek Tailings	Faro Waste Rock Pile	Grum Waste Rock Pile	Vangorda Waste Rock Pile
Till	Grum overburden dump	8.00	18.9	18.1	3.8	4.9
	Vangorda overburden dump	0.40	19.6	18.8	4.5	2.9
	Haul road	0.72	5.6	4.7	12.3	14.8
	Rose Creek haul road	0.80	5.7	10.5	19.4	21.9
	Faro tailings	1.70	4.7	9.5	18.4	20.9
Galcio-fluvial	Haul road	0.15	5.6	4.7	12.3	14.8
	Moose pond	0.45	18.7	17.9	3.6	2.9
	Grum creek	0.20	18.7	17.9	3.6	2.8
	Vangorda/Grum back road	0.10	19.8	19.0	4.7	4.2
	Upper Vangorda creek	0.50	20.4	19.6	5.3	4.3
	Rose creek	1.40	6.7	11.4	20.4	22.8
Organics	East of Vangorda dump	0.075–0.15	20.4	19.6	5.3	4.3
	Faro west	0.05–0.075	6.0	10.8	19.7	22.2

The borrow source investigation estimated the volume of potential cover materials primarily based on the aerial extent of the deposits. The depth of the deposits was estimated based on local anecdotal knowledge of the area as opposed to actual deep drilling results. Based on these estimates, there is approximately 11.62 million cubic meters of till material, 2.8 million cubic meters of glaciofluvial material and between 0.125 to 0.225 million cubic meters of organics.

4.3 Laboratory Testing Program

4.3.1 Introduction

The evaluation of the effectiveness of a soil cover rests on a detailed assessment of the unsaturated geotechnical properties of the waste and potential cover material. Representative samples of the waste and potential cover materials were collected by SRK in June 2003, specifically for testing of these properties. This section presents the detailed results of this testing program.

4.3.2 Sample Collection, Shipping & Testing Requirements

Field samples were collected for laboratory testing by Dr. Maritz Rykaart, P.Eng. a Senior Geotechnical Engineer from SRK Vancouver, on June 10 and 11, 2003. Eight samples were collected with one sample each of the tailings (beach tailings from the Original impoundment) and waste rock (re-handled waste rock from the re-contoured slopes on the Vangorda waste rock pile), two samples containing glaciofluvial deposits, and the remaining four were till samples. The sample locations were identified in the field using a hand-held GPS, and Table 2 lists the complete

The determination of the saturated volumetric water content (θ_s), for each SWCC was a direct outcome of the test, whilst the determination of the AEV, the residual matric suction (ψ_r) and the residual moisture content (θ_r) for each test was carried out using the construction technique proposed by Fredlund and Xing (1994), using the van Genuchten curves presented in Figures 9, 10 and 11. Table 11 list these properties for each of the tested samples.

Table 11: Summary of soil water characteristic curve results

Sample No.	Material Type	θ_s (%)	AEV (kPa)	θ_r (%)	ψ_r (kPa)
SRK-03-C01	Till	27.8	10.0	3,000	6.0
SRK-03-C01 – large test	Till	28.7	0.1	3,000	4.0
SRK-03-C02	Till	27.0	20.0	3,000	6.0
SRK-03-C04	Till	26.0	1.0	3,000	4.0
SRK-03-C06	Till	26.2	20.0	3,000	3.0
SRK-03-C03	Glaciofluvial	22.8	3.0	3,000	2.0
SRK-03-C03 – large test	Glaciofluvial	23.1	0.1	3,000	4.0
SRK-03-C05	Glaciofluvial	24.6	3.0	3,000	2.0
SRK-03-C07	Tailings	38.0	3.0	3,000	4.0
SRK-03-C08	Waste Rock	36.1	0.1	3,000	3.0

4.3.10 Unsaturated Hydraulic Conductivity

The unsaturated hydraulic conductivity curves for each of the samples were developed from the SWCC data using a number of empirical formulations. The saturated hydraulic conductivity value for each sample was taken initially from the laboratory data as presented in the previous section. Later adjustments were made to these curves based on in-situ saturated hydraulic conductivity measurements (see next section of this report). The corresponding unsaturated hydraulic conductivity curves are presented in Figures 18 to 21 for each of the material types tested.

4.4 Summary of Cover Materials

The borrow source investigation estimated the volume of potential cover materials primarily based on the aerial extent of the deposits. The depth of the deposits was estimated based on local anecdotal knowledge of the area as opposed to actual deep drilling results. Based on these estimates, there is approximately 11.62 million cubic meters of till material, 2.8 million cubic meters of glaciofluvial material and between 0.125 to 0.225 million cubic meters of organics.

The most abundant potential cover material is the till deposits. The till is predominantly silicatious, having a specific gravity of 2.7, and is predominantly well graded sandy-clay (CL) to clayey-sand (SC) with a plasticity index between 2 and 10. This material generally has 20% gravel content with the sand fraction between 34 and 43%, and a fines content of 38 to 50%. One of the tested till samples were a non-plastic silty-sand (SM), consisting of zero gravel content, 71% sand and 29% fines.

cadastral boundaries. The current toe-lines of the main waste rock piles and the anticipated toe-lies after re-sloping are presented on Figures 22a and 22b.

Table 18: Summary of waste rock pile surface areas

Waste Rock Pile	Footprint surface area (ha)			3D surface area (ha)	
	Before re-sloping		After resloping[2]	Before re-sloping[1]	After re-sloping[3]
	ICAP	Revised[1]			
Faro	335	347	357	370	381
Grum	128	148	153	154	159
Vangorda	43	59	59	62	62

1. Surface areas calculated based on latest air photography.
2. Surface area calculated based on estimated new footprint due to re-contouring.
3. Arbitrary correction of 3% based on increased footprint.

6.3 Volume of Cover Material/Borrow Area Rehabilitation

Based on the areas of each of the waste rock piles that would require covering (602 ha in total), each 50 cm layer of cover would require 3.01 million cubic meters of cover material. This is 8% more than the total volume of glaciofluvial material available on site, and about 26% of the estimated volume of till. Also, it is evident that there is no way that sufficient organic material could ever be harvested to cover these areas. If all the glaciofluvial material was used, it would mean that there would be vast areas of currently undisturbed ground that would have to be rehabilitated in addition to the waste facilities. Using till as a cover material therefore would appear to be the only viable option considering the vast volumes required.

The Rose Creek tailings impoundment covers a surface area of approximately 196 ha, consisting of 42 ha of the Original impoundment, 55 ha of the Secondary impoundment and the remaining 99 ha in the Intermediate impoundment. Covering this surface area with a 50 cm layer of cover would require 1.96 million cubic meters of material.

Based on these numbers, if all the ARMC waste areas were to be covered with till only, there would be sufficient material to use a cover of 150 cm thick. Alternatively, if everything was to be covered in glaciofluvial material only, the maximum cover thickness would be 50 cm.

6.4 Vegetation Season

The till cover test section at the Vangorda waste rock pile has been in place for almost 10 years, and although the design called for this cover to be vegetated, this was never done after construction. Subsequently this slope has been left to nature to vegetate, and it is evident that this has not occurred. There is practically no signs of natural vegetation on this area, suggesting, that if a positive attempt is not made to vegetate a till cover, then vegetation would not happen naturally.

If the top surface of the dumps are graded at 2%, there will be no need for armouring channels draining areas of up to 100 ha. If the slope is increased to 5%, channel armouring becomes necessary for catchments of 100 ha or higher. However this may be avoided by building a larger channel than the one assumed here.

4.3.3 Conceptual Drainage Design

For the conceptual drainage design it is assumed that slopes will be re-sloped to 1V:3H (18.4^{o}). Figure 15 shows that gullies start to occur at an overland flow path of about 55 m along a 1V:3H slope. Therefore if a re-graded slope is longer than 55 m, there should be benches to divert surface water flowing down the slope face. One of the most common areas of erosion is at the crest of slopes. Therefore surface water should be directed away from crests to the extent possible. In addition, berms should be constructed along crests (typically 2 m high) to block any excessive water.

Top surfaces of the re-sloped dumps should be divided into catchments of less than 100 ha so that bio-engineered channels will be sufficient. Top surfaces can be graded to 2% if the size of the watersheds on the top surfaces are kept at a maximum of 100 ha. If 5% re-grading of top surfaces is chosen, the maximum allowable watershed size will be a value between 100 ha and 30 ha. Slope faces of the re-sloped dumps (at 33% slopes) should be divided into catchments of 5 ha or less. This can be achieved by building wavy slope faces as opposed to flat ones.

Figures 18 to 20 show the layout of conceptual drainage channels. The surface water is diverted through the channels and discharged into either an open-pit or nearby creeks.

4.4 Limitations

The example engineered landforms presented in this report do not address all the dumps. Further studies are needed to advance the work presented here to cover all the dumps within the Faro mine complex. The following items are included here as points of further evaluation in detailed design:

- Hydrological analyses presented in this report need field verification through investigation of slopes in the field.
- Although, the slopes are likely to be re-graded to at least 1V:3H (where applicable), it may be acceptable to re-grade the slopes to 1V:2H where only rudimentary covers are required.
- There may be a number of locations where push-down re-grading may be impractical due to extensive pull-back (e.g. above S-wells, northeast side of Low Grade Ore, and Faro dump upstream of rock drain). In the detailed design stage, a comparison and evaluation can be made between the options of a-) not covering these areas, and b-) carrying out extensive pull back.

2) It could reduce the amount of raveling of the pit wall and decrease the rate of crest regression.

Based on the preliminary pit crest stability review and the detailed site investigations, which included an assessment of possible seepage control measures at the northeast crest of the Faro Pit slope, two seepage mechanisms are considered plausible at this location (see Figure 4-2).

4.3.1 Shallow Seepage through Active Layer[1]

Test pits above the northeast crest (along the alignment of the proposed East Interceptor) indicated that the frozen ground is continuous, at shallow depths, in the slope above the existing FCDC. In several test pits, seepage was observed at the contact between the vegetative layer and the underlying soil.

Based on the above observations, it is possible that the frozen ground impedes the flow of groundwater, thus restricting the flow to the thawed portion of the active layer, above the permafrost, during summer months. This would suggest that the groundwater flow upslope of the FCDC is shallow and would be readily intercepted by the FCDC. The proposed East Interceptor would also intercept the groundwater flow if this seepage mechanism is taking place. Hence, it would be unlikely that the seepage flow observed at the northeast pit crest originates upslope of the FCDC.

It is our understanding that sections of the FCDC channel was re-lined during the summer of 2003 with an impermeable liner. This appears to have reduced seepage at the pit slope significantly, but some seepage persists. This observation seems to support the theory that the majority of the seepage reporting to the northeast pit wall was from leakage from the FCDC. The residual seepage may originate from upslope of the FCDC.

4.3.2 Deeper Seepage along Bedrock – Overburden Contact

It was previously postulated that the seepage at the Faro Pit northeast crest was derived from groundwater flow along the overburden – bedrock contact (see Ref. 2). This could occur if the active layer upslope of the FCDC thawed quickly in the spring, and to a depth equal to or greater than the depth to bedrock. This would allow the water to infiltrate down to the overburden - bedrock contact and seep along the surface of the bedrock under the FCDC until it reached the pit wall. The weathered surface of the bedrock is usually more permeable than the overburden material and the parent bedrock.

[1] Depth of soil above the permafrost that will thaw on an annual basis.

Sludge Management

4 Final Disposal Location and Methods

Short-term sludge management strategies have been developed and are being implemented for the three water treatment systems at the Anvil Range Site as follows:

- The sludge produced at the Faro Mill Water treatment system will be piped by gravity flow to a cell that has been constructed on the Rose Creek tailings impoundment (SRK, June 2004). The disposal cell comprises a 1.5 m high berm that has been constructed on the tailings in the original tailings impoundment at a location adjacent the old cover test plots.
- Sludges from the Down Valley treatment system that have accumulated in the Cross Valley Pond are to be physically relocated by truck and shovel to the same cell constructed for the containment of the Faro Mill treatment sludges.
- Treatment sludges from the Vangorda-Grum water treatment plant are periodically removed from the settling pond to purpose built cells contained within the Grum Overburden dump.

These short-term strategies are adequate for the interim period, though they will clearly not suffice for long-term sludge disposal. The following options have been proposed for long-term management of water treatment sludges:

- Disposal on the Rose Creek tailings impoundment;
- Disposal on the Main Waste Rock dump and/or other waste rock dumps;
- Disposal in the Faro Pit at the Faro site and/or in the Vangorda Pit at the Vangorda-Grum site;
- Disposal in a purpose-built sludge management area; and
- Recycling

These options are addressed in the sections below.

4.1 Rose Creek Tailings Impoundment

In active operations, tailings ponds are commonly used for sludge management. During operations, sludges are typically slurried with the tailings or pumped directly to the Tailings impoundment. In post-operation conditions, however, it would only be possible to dispose of the sludges on top of the tailings. Sludge disposal on the Rose Creek tailings would require that the tailings impoundment is stable. In order to achieve the necessary stability, upgrades of the Intermediate Dam, Second Dam and the Rose Creek Diversion would, as a minimum, be required.

As noted in Section 2, while the sludges are expected to remain stable under ambient conditions, it is a requirement that the sludges not contact acid generating materials as, over a prolonged time, the buffering capacity of the sludges will be depleted. Alternatively, disposal of the sludge on the tailings is expected to act as a cover which will limit future oxidation. Typically, treatment sludge tend to desiccate and crack in the near surface as moisture evaporates, which may lead to the

3 Disposal Area Volumetrics

Figures 4 and 5 present the key numbers from previous work on estimating the storage volumes available in the Faro Pit. The volumes available for sludge storage are summarized in Table 2. Comparing the last column of Table 2 with the last two columns of Table 1 shows that:

- If the covers perform as expected, the sludge could be managed in the Faro pit for over 1000 years for the cover options that restrict infiltration and/or oxidation, except if the tailings are completely relocated. In that case, the remaining storage volume in the pit would be consumed after about 600 years for the option that restricts infiltration only.
- If only rudimentary covers are constructed, the storage capacity of the Faro Pit would be consumed much more rapidly, in 100-400 years depending on whether the tailings are relocated into the pit.
- If the covers restrict infiltration but not oxidation, the storage volume available in the pit will be consumed in roughly half the time as if the covers restrict oxidation.

These findings are likely to remain true even when the additional sludge from the treatment of groundwater from the tailings area is considered. The latter two findings are likely to be very significant when cost-benefit analyses of the cover variants is completed, and could lead to clear preferences against rudimentary covers and for oxidation-limiting covers.

One alternative to storage in the pit is to build a new sludge containment cell. Table 3 shows the area that would be required if the sludge were stored in a new cell with an average height of 10 m. For comparison the current tailings impoundment has a surface area of about 196 ha. The results show that the containment cell would need to be large, and imply that this option would only be practical over the very long term if the covers perform well and sludge densities can be increased significantly above the assumed 20%.

Table 2: Summary of Storage Volumes available in Faro Pit

Option	Elevations Available for Sludge (feet)	Volume Available for Sludge (m3)
No tailings relocation, no Plug Dam	1051 - 1151	36,000,000 m^3
No tailings relocation with Plug Dam	1051 - 1168	45,000,000 m^3
Partial tailings relocation, no Plug Dam	1106 - 1151	23,400,000 m^3
Partial tailings relocation with Plug Dam	1106 - 1168	32,500,000 m^3
Complete tailings relocation, no Plug Dam	Not feasible	
Complete tailings relocation with Plug Dam	1147 - 1168	12,000,000 m^3