Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex Closure and Remediation Plan

YESAA Project Proposal

Draft 1

Prepared for:

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

and

Yukon Government

March 2010

Disclaimer

This initial draft of the Project Proposal has not been reviewed in its entirety by the original authors and members of the Technical Advisory Team for consistency in technical content.

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A2 Public Consultation Presentations (May 2009)

A3 IPRP/Federal Meeting Presentation (Jan 29/31, 2008)

B Environmental Conditions

B1 Anvil Range Mine - 2005 Investigation of Hydrocarbon-Contaminated Soils (GLL, 2006)

B2 Current Environmental Conditions Supporting Document (AECOM, 2009)

B3 Aquatic Ecosystem Monitoring Program, Faro Mine, Yukon (Minnow, updated 2010)

C Socio-Economic Conditions

C1 Socio Economic Baseline Conditions (L. Zanasi, 2010)

D Hydrogeology & Hydrology

D1 Detailed comparison of Alternative for the Relocation of the Faro Creek Diversion (Golder, 2004)

D2 Continued Seepage Investigation - Zone 2 Pit Outwash Area (SRK/RGC, 2007)

D3 2005 Seepage investigation at the ETA (SRK/RGC, 2006)

D4 2005 Seepage Investigation at the Emergency Tailings Area (SRK/RGB, 2005)

D5 2005 Seepage Investigation at the Grum Dump Area (SRK/RGC, 2007)

D6 Hydrotechnical Study for Closure Planning, Faro Mine Site Area, Yukon (nhc, BGC, 2004)

D7 Rose Creek Probable Maximum Flood (WMC, 2006)

D8 Review of Flood Estimation Methodologies, Faro Mine, Yukon Territory (Golder, 1988)

D9 Rational Method, Email (P. Bryan, 2009)

D10 An Analysis of Probable Maximum Precipitation for the Faro Mine Site, Yukon Territory (Taylor/Hale, Oct.2005)

D11 An Analysis of Probable Maximum Precipitation for the Faro Mine Site, Yukon Territory (Taylor/Hale, Dec 2005)

E Geochemical Characterization

E1 Assessment of Select Oxide fines and Ore Stockpiles (SRK, 2007)

E2 Preliminary Seepage collection Options Faro & Grum Waste Rock Dumps (SRK/RGC, 2006)

E3 2008 S-cluster Groundwater Investigation and Option Assessment - DRAFT (SRK/RGC, 2008)

E4 Geochemical Studies of Waste Rock at the Anvil Range Mining Complex - Phase 3 (SRK, 2004)

E5 2007 Waste Rock and Seepage Monitoring Report (SRK, 2008)

E6 Initial Review of Groundwater Quality - Memo (RGB, 2004)

E7 2005 Seepage Investigation at the S-cluster area Below the Faro Waste Rock Dump (SRK/RGB, 2006)

E8 Continued Seepage Investigation Zone 2 Pit Outwash Area (SRK/RGC, 2007)

E9 Overview of WQ Model - Presentation (LG, 2009)

E10 Design Options for Seepage Collection Grum Waste Dump (SRK, 2004)

E11 Water Quality Model (LG, 2010)

F Geotechnical

F1 RCTailings Impoundment Seismic Stability Assessment- Report, Addendum (KCB, June 2006)
F2 RCDC Closure Scenarios - Geotechnical Considerations (NWH, 2004)

G Care and Maintenance

G1 2008 Annual Inspection, Waste Water Management Facilities (SRK, 2009)
G2 AMP Event#4 response: 2008 Status Report (SRK, 2008)
G3 2007 Annual Inspection, Waste Water Management Facilities (SRK, 2008)
G4 AMP Event#4 response: 2007 Status Report (SRK, 2008)

H Reclamation and Revegetation
H1 2008 Reconnaissance-level landform grading field investigation (BGC/SRK, 2009)
H2 Waste Rock Cover Trials - Preliminary Performance Report - Draft (SRK, 2008)
H3 Investigation in Support of Progressive Reclamation of the Emergency Tailings Area (SRK, 2006)
H4 Mine Area Cover Optimization and Landform Engineering (SRK 2008)
H5 Results from Trial Covers at Rose Creek Tailings Impoundment: 2007 Data Summary (SRK, 2008)
H6 Monitor Mine Waste Rock Trial Covers: 2007 Data Report (SRK, 2008)
H7 Anvil Range Mining Complex Additional Borrow Studies (SRK, 2006)
H8 Additional Borrow Studies (SRK, 2006)
H9 Phase 2 Borrow Source Survey, Faro Mine, Yukon (SRK, 2003)
H10 Faro-Vangorda Haul Road Reclamation Costs Estimate (SRK, 2008)
H11 Waste Rock Pile Cover Trial - Construction As-built Report (SRK, 2006)
H12 Design and Installation of a Seepage Interception and Pumping System at the S-wells Area (SRK 2009)
H13 Re-Vegetation Study: Waste Rock Dumps and Tailings Impoundment (EDI, 2008)
H14 Revegetation Plan - Draft November 2009 (EDI, 2009)
H15 Monitor Mine Waste Rock Trial Covers: 2009 Data Report (SRK, 2010)

I Water Management

I1 Anvil Range Pit Lakes - Assessment of Post Closure Conditions (SRK, 2004)
I2 Sludge Management - 2007/08 Task 24 - Final (SRK, 2008)
I3 Anvil Range Water Treatment Sludge Management Plan (SRK, 2004)
I4 North Fork Rock Drain (BGC, 2006)
I5 PMF Flood Handling - Phase 1 - Letter (KCB, 2007)
I6 Intermediate Dam Spillway - PMF Flood Handling (KCB, 2008)
I7 Water & Load Balance Study for Rose Creek Tailings Storage Facility (RGC/SRK, 2006)
I8 Evaluation of In-Situ Treatment (SRK, 2006)
I9 Supplement Treatment of Grum Pit Water (SRK, 2008)
I10 Alternative Assessment of the Vangorda Creek Diversion (SRK, 2003)
I11 Water Treatment Requirements for the Anvil Range Site - Draft (SRK, 2005)
I12 Investigation of Anvil Range Mining Corporation Waste Dump Water Balance Vangorda Trail Covers Water Balance (J.R. Janowicz, 2008)
I13 Investigation of Anvil Range Mining Corporation Waste Dump Water Balance Average and Low Prediction Year Water Balance (J.R. Janowicz, 2007)
I14 Investigation of Anvil Range Mining Corporation Waste Dump Water Balance Final Water Balance (J.R. Janowicz, 2006)

I15 Emergency Preparation Plan for Selected Dams and Water Diversions Structures

J Demolition

K Alternatives and Chosen Approaches

K1 Faro Mine Complex - Options for Closure, including Attachments (SRK, 2008)

L Monitoring and Maintenance Plans

M Implementation Strategy

N Cost Estimate

Note: All documents are available for download from the Faro Mine Complex – Project Proposal FTP site.

Italiced documents are in progress.

List of Acronyms and Abbreviations

AAQS	Ambient Air Quality Standards
AMP	Adaptive Management Plan
amsl	above mean sea level (elevation)
ARD	Acid Rock Drainage
ARMC	Anvil Range Mining Corporation
ANFO	ammonium nitrate/fuel oil
AP	Acid potential
ASL	Above Sea Level
B/Fa	Dwarf Birch/Subalpine
B/L/Fa	Dwarf Birch/Lichen/Subalpine Fir
BTU	British Thermal Unit (a unit of energy)
B/W	Dwarf Birch/Willow
CACs	Classified as Criteria Air Contaminants
ConPAC	Construction Personnel Accommodation Complex
CFR	Code of Federal Regulations
cfs	cubic feet per second (a unit of flow)
CH4	Methane
CME	Canadian Council of Minister of the Environment
CO	Carbon Monoxide
COPC	Contaminants of Potential Concern
CRA	Canada Revenue Agency
CVD	Cross Valley Dam
CWS	Canada-Wide Standards
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
Dd	Deciduous
DES	Denison Environmental Services
DFO	Department of Fisheries and Oceans
DMR	Discharge Monitoring Reports
DO	Dissolved Oxygen
D&T	Deloitte and Touche Inc.
DTA	Yukon Northern Affairs Program Devolution Transfer Agreement
EC	Executive Council Office
EIS	Environmental Impact Statement
EPT	Ephemeroptera, Plectoptera, and Tricoptera
ESA	Endangered Species Act of 1973, as amended
ETA	Emergency Tailings Area
FCDC	Faro Creek Diversion Channel
FEIS	Final Environmental Impact Statement
FMC	Faro Mine Complex

g	unit of gravitational acceleration (9.8 m/s2 or 32.17 feet/s2)
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GMS	Game Management Subzones
GOTP	Grum Ore Transfer Pad
Gr	Graminoid
USgpm	US gallons per minute (a unit of flow)
HAPs	Hazardous Air Pollutants
HDPE	High Density Polyethylene
HDS	High Density Sludge
hp	horsepower (a unit of power)
HRSDC	Human Resources and Social Development Canada
HVAS	High Volume air Sampling
ICAP	Integrated Comprehensive Abandonment Plan
ID	Intermediate Dam
IFQG	Interim Freshwater Quality Guidelines
INAC	Indian and Northern Affairs Canada
IPRP	Independent Peer Review Panel
KCB	Klohn Crippers Berger
kg $CaCO_3$ eq/t	kilogram calcium carbonate equivalent per tonne (a unit of concentration
kW	kilowatt (a unit of power)
LFN	Liard First Nation
LGSP	Low Grade Ore Stockpiles
LSA	Local Study Area
M	Magnitude
MAET	Mean Annual Evapotranspiration
MAE	Mean Annual Lake Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MCE	Maximum Credible Earthquake
MDLs	Method Detection Limits
MOE	Ministry of the Environment
Mx	Mixed Coniferous-Deciduous
µg/m^3	micrograms per cubic meter (a unit of concentration)
µg/L	micrograms per liter (a unit of concentration)
mg/L	milligrams per liter (a unit of concentration)
MOU	Memorandum of Understanding
NAAQS	National Ambient Air Quality Standards
NANA	NANA Regional Corporation
NFRC	North Fork of Rose Creek
NGOs	non-government organizations
NOX	Oxides of Nitrogen
NPDES	National Pollutant Discharge Elimination System
NP	Neutralization Potential

NRCan	Natural Resources Canada
NWI	North Wall Interceptor Ditch
OHMP	Alaska Department of Natural Resources, Office of Habitat Management and Permitting
O.I.C.	Order in Council
OF	Oxide Fine
ORP	Oxidation-Reduction Potential
pcf	pounds per cubic foot (a unit of density)
PEL	Probable Effects Levels
PGA	Peak Ground Acceleration
PGC	Pacific Geoscience Centre
PM10	Particulate Matter less than 10 microns in diameter
PMF	Probable maximum Flood
ppm	parts per million (a unit of concentration)
PSD	Prevention of Significant Deterioration
RCDC	Rose Creek Diversion Canal
RFFA	Reasonably Foreseeable Future Actions
RLUs	Reclamation Landscape Units
RRDC	Ross River Dena Council
RSA	Regional Study Area
SAG	Semi-Autogenous Grinding Mill
SFN	Selkirk First Nation
SIS	Seepage Interception System
SO_2	Sulphur Dioxide
STP	Sewage Treatment Plant
S/W	Sedge/Willow
Sw/W	White Spruce/Willow
Sw/Fm	White Spruce/Feather Moss
TDS	Total Dissolved Solids
TMF	Tailing Management Facility
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
UFA	Umbrella Final Agreement
USCG	United States Coast Guard
US EPA	United States Environmental Protection Agency
USGS	United Stated Geological Survey
USFWS	United States Fish and Wildlife Service
VC	Valued Components
VOCs	Volatile Organic Compounds
VKT	Vehicle Kilometres Travelled
VSECs	Valued Socio-economic Components
VWRD	Vangorda Waste Rock Dump

WAH	Western Arctic Herd
W/B	Willow/Dwarf Birch
WET	Whole Effluent Toxicity
W/S	Willow/Sedge
W/Sw	Willow/White Spruce
WTP	Water Treatment Plant
YESAA	Yukon Environmental and Socio-economic Assessment Act

Glossary

Acid potential (AP):	The maximum potential acid generation from a sample
Acid rock drainage (ARD):	Low pH drainage (pH of 2.0 to 4.5) resulting from oxidation of sulfides
Active layer:	The overlying ground surface layer that freezes every winter and thaws every summer
Alkalinity:	A measure of a material's ability to neutralize acids
Apron feeder:	Device used to supply material, such as ore or waste rock, to a process, such as a crusher
Aquifer:	A permeable body of rock or regolith that both stores and transports groundwater
Baghouse:	The large chamber or room for holding bag filters used to filter gas streams from a furnace
Ball mill:	A steel cylinder containing steel balls used to grind ore. The mill is rotated causing the balls to cascade and grind the ore
Bathymetry:	The measurement of the depth of bodies of water
Biota:	The living organisms of a region
Block faulting:	A type of faulting in which fault blocks are displaced at different orientations and elevations
Carbonaceous:	Consisting of, containing, relating to, or yielding carbon
Chert:	A member of a group of sedimentary rocks that consist primarily of microscopic silica crystals. Chert may be either organic or inorganic, but the most common forms are inorganic
Clarifier:	A device for filtering a liquid
Concentrate:	A fine product separated in the milling process that contains a high percentage of valuable metal
Consolidation:	A process by which soils decrease in volume. It occurs when stress is applied to a soil that causes the soil particles to pack together more tightly, therefore reducing volume
Diffusive flux:	The rate of dissolved molecules crossing a unit area by diffusion, where dissolved molecular species moves from regions of high concentration to regions of low concentration

Effluent:	Liquid discharged as waste. This liquid waste can take the form of tailings impoundment effluent, mine water, mill process water, smelter effluent, treatment pond or treatment facility effluent, seepage or surface drainage from a mining site
Facies:	A rock or stratified body distinguished from others by its appearance or composition
Fault:	A fracture or fracture zone along which there has been displacement of the sides relative to one another parallel to the fracture
Flocculation:	Refers to a process where a solute comes out of solution in the form of floc or "flakes." The term is also used to refer to the process by which fine particulates are caused to clump together into floc. The floc may then float to the top of the liquid, settle to the bottom of the liquid, or can be readily filtered from the liquid
Flocculent:	A chemical used to promote flocculation by causing colloids and other suspended particles in liquids to aggregate, forming a floc
Freeboard:	The distance between normal water level and the top of a structure, such as a dam, that impounds or restrains water
Freshet:	An increase of water flow during the late winter or spring, owing to increased precipitation and snow melt in the watershed
Froth flotation:	A method of mineral concentration which separates the various minerals in the feed by utilizing the differing surface properties of the minerals. The separation is achieved by passing air bubbles through the mineral pulp and adjusting the chemistry of the pulp by using various reagents. Separation occurs by the valuable minerals adhering to the air-bubbles which form the froth floating on the surface of the pulp
Geochemistry:	The study of materials and chemical reactions in rocks, minerals, magma, seawater, and soil
Gyratory crusher:	A machine that crushes ore between an eccentrically mounted crushing cone and a fixed crushing throat. Typically, it has a higher capacity than a jaw crusher
Hydrogeology:	The geology of groundwater, with particular emphasis on the chemistry and movement of water
Hydrology:	The study of the occurrence, distribution, and circulation of the natural waters of the earth
In-situ:	In the natural or original position. Applied to rock, soil, or fossil when occurring in the situation in which it was originally formed or deposited

Jaw crusher:	A machine in which rock is broken by the action of swinging steel plates
Leaching:	A chemical process for the extraction of valuable minerals from ore; also, a natural process by which ground waters dissolve minerals, thus leaving the rock with a smaller proportion of some of the minerals than it contained originally
Lysimeter:	An instrument for measuring the water percolating through soils and determining the materials dissolved by the water
Macrophytes:	The macroscopic plants in the aquatic environment
Metallurgy:	The study of extracting metals from their ores
Neutralization potential (NP):	A measure of a material's capability to neutralize acidity, expressed in units of kilogram of $CaCO_3$ equivalent per metric tonne of sample (kg $CaCO_3$/t)
Ore:	A mixture of minerals, from which one or more metals may be economically extracted
Overburden:	All the materials that are located above the desired ore deposit (i.e. soil or vegetation such as trees, plants, and rock)
Oxidation:	The process of combining with oxygen ions. A mineral that is exposed to air may undergo oxidation as a form of chemical weathering
Periphyton:	The assemblage of micro-organisms attached to and living upon submerged solid surfaces. While primarily consisting of algae, the periphyton also includes bacteria, fungi, protozoa, rotifers, and other small organisms
Permafrost:	Ground that remains at or below zero degrees Celsius for a minimum of two consecutive years
Piezometer:	A small diameter water well used to the measure the hydraulic head of groundwater in aquifers
Physiography:	The physical features of the earth's surface. For example, a flood plain, or a glacial feature
Plate:	A section of the earth's lithosphere, constantly moving in relation to the other sections
Potable:	Suitable for drinking
Precipitate:	An insoluble substance that has been formed from substances dissolved in a solution

Reagents:	A substance or mixture that is useful in chemical analysis or synthesis
Rifting:	The tearing apart of a plate to form a depression in the Earth's crust and often eventually separating the plate into two or more smaller plates
Riparian area:	A form of wetland transition between permanently saturated wetlands and upland areas. These areas exhibit vegetation or physical characteristics reflective of permanent surface or subsurface water influence. Lands along, adjacent to, or contiguous with perennially and intermittently flowing rivers and streams, glacial potholes, and the shores of lakes and reservoirs with stable water levels are typical riparian areas. Excluded are such sites as ephemeral streams or washes that do not exhibit the presence of vegetation dependent upon free water in the soil
Slurry:	In mining, slurry is a liquid waste material
Specific gravity:	The mass of a unit volume of a substance relative to the mass of a unit volume of water
Stripping ratio:	The ratio of tons of overburden waste material to tons of ore in an open pit mine. The waste rock removed in order to expose the ore body in an open pit mine is hauled only once to a waste disposal area, in contrast to strip mining where waste rock is replaced to reclaim the flat lying mined-out area
Syngenetic:	Pertaining to a mineral deposit formed contemporaneously with the enclosing rock
Tailings:	Mineral refuse from a milling operation usually deposited from a water medium
Taliks:	Unfrozen zones that can exist within, below, or above permafrost layers
Talus	A pile of rock fragments lying at the bottom of the cliff or steep slope from which they have broken off
Thaw bulbs:	A zone of thawed ground below or surrounding a man-made structure placed on or in permafrost and maintained at temperatures above 0 degrees Celsius
Thermistor:	A resistor made of semiconductors having resistance that varies rapidly and predictably with temperature
Thrust fault:	A fault in which two sections of rock have moved apart vertically, marked by a hanging wall that has moved upward relative to the footwall and by a dip of 45º or less

Thrust sheet:	A body of rock above a large-scale thrust fault
Total dissolved solids (TDS):	The total quantity of minerals (salts) in water, usually measured by weight in milligrams per liter (mg/L) or parts per million (ppm)
Toxicosis:	A pathological condition resulting from poisoning
Wetlands:	Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions

Chapter 1

Introduction

1 Introduction

1.1 Project Introduction

This project proposal describes the Closure and Remediation Plan for the Faro Mine Complex (FMC) located near the Town of Faro, Yukon (Figure 1.1). The FMC spans a length of approximately 15km, falling within the watersheds of Rose and Vangorda Creeks, both of which are part of the Pelly River watershed. Two major sites comprise the FMC: (1) the Faro Mine Site, located approximately 15km north of the Town of Faro, and (2) the Vangorda Plateau (the Grum and Vangorda mines), located approximately 9km northeast of the Town of Faro (Figure 1.2). The two sites are connected by a heavy haul road approximately 12km in length. Mining at the FMC began in 1969 and ceased permanently in 1998. The main components of the FMC include three open pit mines (Faro, Grum and Vangorda) and associated waste rock dumps, tailings storage facilities, milling facilities, water treatment facilities, access roads, stream diversions, water storage impoundments and other appurtenances.

The Closure and Remediation Plan is intended to protect people and the environment from current and future effects associated with facilities and disturbances from the past mining activities. The overall plan is comprised of three phases including construction, adaptive management and long-term site maintenance. The construction phase will include construction and implementation of closure and remediation measures that will focus on providing long-term physical stability at the site to support stabilization and control of geochemical conditions. The adaptive phase will be an opportunity to monitor the performance of the closure and remediation measures and implement improvements to address any identified deficiencies. The final phase, long-term site maintenance, will be a permanent site presence for collection and treatment of contaminated water from the site, maintenance of remaining facilities and structures as well as monitoring of on-site and off-site conditions.

The construction and adaptive phases of the closure and remediation project are the primary subjects of this report, while recognizing that the long-term site, maintenance and monitoring will be required. The two initial phases of the project will address environmental degradation, resulting in improved long-term conditions for some environmental components and reduction in future degradation for others. The implementation of the closure and reclamation works will have environmental and socio-economic effects of their own. These potential effects are addressed in this report.

The overall philosophy for the project is to complete a closure and remediation plan that provides long-term protection for people and the environment, while minimizing adverse environmental and socio-economic effects and maximizing socio-economic benefits locally and in Yukon.

1.2 Proponent Information

Describe administrative and project management structures for closure plan implementation. Identify responsible parties, roles of other parties/groups and administrative approaches for implementation. Identify key commitments re: project execution. (Note: this will require input from governments about how they plan to manage the closure project, and possibly about plans for procurement.)

1.3 Project Background

1.3.1 Site History: The Faro Mine and the Ross River Dena

The Ross River Dena and their ancestors have been living as hunter gatherers on their traditional territory in the central Yukon for thousands of years.

It is a common mistake to view hunter-gatherers as eking out a miserable existence on the very edge of survival. It is true that First Nations people could — and did — face starvation if their environment turned against them, but that is equally true of agricultural societies who faced famine if their crops failed. The nomadic hunter-gatherers also enjoyed more mobility, flexibility, and leisure than their agricultural cousins did. Indeed, Marshall Sahlin has described hunter-gatherer peoples as "the original affluent society."[1]

This relative affluence showed itself not just in time for leisure, but also in an economic surplus that was the norm in pre-contact Yukon societies. These surpluses resulted in a flourishing trade network. Catherine McClellan writes:

> "Long before the arrival of white men, the Coast Indians were bringing candlefish (or oolichan) grease, dried seaweed, dried clams, clamshells, plant medicines, cedar boxes and seashells into the southern Yukon. Seashells were said to be like jewels to Yukon Indians, and in return for these shells they offered copper, furs, tanned hides, and the lichen dyes and mountain goat hair used in making Chilkat blankets."[2]

Long accustomed to trade, and with adaptability as one of their defining characteristics,[3] the North's original peoples were well positioned to adapt to the first major shift in the Yukon's economy, the introduction of the European fur trade.

By the mid-1800s the Hudson Bay Company was exploring and beginning to establish trading posts in Kaska territory in northern BC and the southeast Yukon. In 1840 Robert Campbell pushed up the Liard River and reached the banks of a large river that he named the Pelly. But although the HBC

[1] Sahlin, Marshal. 1972. *Stone Age Economics*. p.1.

[2] McClellan, Catherine. 1987. *Part of the Land, Part of the Water*. p.235.

[3] Cruikshank, Julie. 1975. *Their Own Yukon*. p.1.

built a trading post at Frances Lake in 1842, another at Pelly Banks in 1845, and Campbell eventually built Fort Selkirk at the junction of the Pelly and Yukon rivers in 1848, the supply route over the Liard was difficult and expensive and competition from coastal Tlingit traders for furs was fierce. In 1852 a group of Tlingits took commercial competition to another level by burning down Fort Selkirk.[4]

Although the trading posts were new to the interior First Nations of the Yukon like the Ross River Dena, the trading process and European trade goods were not — the latter had been reaching them for decades via middle-men. Ken Coates writes:

> "...they [Yukon First Nations] took from the trade only what they wanted; the trade was a supplement to their way of life and did not control it. Conversely, the natives exerted considerable influence over the pace and direction of the trade."[5]

The Ross River Dena likely traded for European goods through a trade network of Tlingit and Tahltan trading though the Russian American Company or through the Hudson Bay at Fort Simpson at the mouth of the Nass River.[6]

First Nations were creating a mixed or dual economy in which people continued their subsistence way of life while trapping to satisfy new needs. Although this dual economy of subsistence and furs continued successfully in the Yukon for nearly a century, the volatile nature of the fur market with its changing fashions and fluctuating demands probably made its eventual demise inevitable.

The collapse of fur prices following WWII led to the closing of many trading posts in the Yukon, including some in the traditional territory of the Ross River Dena. The Ross River post itself, however, remained open and acted as a crucial linchpin in the mixed economy and its seasonal round. However, the 1950s were a hard time in the region. There were few, if any, alternatives for earning any cash income apart from trapping and fur prices were so low it was difficult to break even on a trapping season let alone make a profit.

Mye Mountain Area Seasonal Round[7]

The seasonal harvest round began with the salmon run in late July and early August. People would gather to fish salmon mostly at Blind Creek. Other salmon fishing sites included where the bridge crosses the Pelly River at Faro and at Fish Hook near the mouth of Anvil Creek. Once the salmon run was over, people walked up the high country on Mt. Mye to hunt and preserve hoary marmot and arctic ground squirrels and to pick berries. As the moose rut began hunting groups would move

[4] Coates, Ken S. and William R. Morrison. 1988. Land of the Midnight Sun.pp.20-25

[5] Coates, Ken S. and William R. Morrison. 1988. Land of the Midnight Sun p.29.

[6] Weinstein. 1992. p.50

[7] Adapted from Weinstein, 1992. pp.59-61

down to areas near the tree line to hunt and dry a supply of moose meat. After caching the dry meat, people would walk back to the trading post at Ross River to purchase the supplies needed for the coming winter. Rafts would then be built to return to the Mt. Mye area and the families would disperse to different trapping areas around the mountain and its streams. A short visit back to Ross River might be made during the winter to sell some furs, buy supplies or perhaps for Christmas celebrations. After the fox trapping ended in late winter, the different family groups would converge at Swim Lakes to trap lynx and for the spring fishery. Swim Lakes provided grayling, suckers, whitefish and pike. Later in the spring, when a good crust developed on the snow, most of the men would travel very quickly by dog team north to Sheldon Lake and other areas for the spring beaver hunt. (Under good conditions the trip from Swim to Sheldon Lake would take only two days). The women, children and elders would be left at Swim Lakes to continue to prepare a stock of dried fish. In late May the men would walk back to Swim Lakes and then all the families would walk to Ross River to trade the furs. The summer interlude at Ross River was effectively a vacation for most of the people. The teenagers and youngest adults would be given the responsibility of providing fresh meat for everyone but socializing, dancing, story telling and stick gambling were the main activities. In late July people would leave again for the salmon fishery.

The importance of the Mye Mountain area to the Ross River Dena who used it is summed up by Weinstein:

> "The ecology of the Kaska lands requires that people move around to make a living because the critical animal resource species are rarely found in the same location. Mye Mountain is one of the rare places where, as the elders say, "there is everything" — moose, caribou, gophers, whistlers, fresh water fish and salmon. Sheep are also found in this zone, but they are only hunted as a delicacy. Sheep meat is not preserved, it is only eaten fresh."[8]

Another, similar description is that the region acted as a First Nation supermarket. There was no need to travel great distances to get a wide variety of food and furs, it is all right there.

Kaska Land Use and the Traditional Land Stewards

Weinstein sums up the difficulties in defining the Kaska land use system precisely:

> "The Kaska system of land and harvesting access is difficult to define because of its inherent flexibility. To outsiders, the flexibility often gives it an appearance of being open and without rules. The basic principles of the Kaska system rest on the notion of sharing and ensuring, primarily, that the needs of the community are met and, secondarily, that the needs of other people who want to harvest in the area are taken care of if there is a harvestable surplus beyond the requirements for conservation. The rules for access and land use were based on social affiliation, again with only informally defined limits. Part of the Indian system of resource

[8] Weinstein, 1992. p.71-72

> management was an assessment of the animal abundance to determine if family lands could support more people. In those cases other families were invited. Consequently, resource management was both economic and social."[9]

On one level the system of Kaska land use allowed anyone to use any of the First Nation's land and resources as they needed. But in practice: "the combination of ecology, culture and history result in particular individuals and family groups having recognized authority over different regions of the band's territory.[10] These are the traditional land stewards of a particular region.

The area centred on Mye Mountain was primarily used by approximately 6 to 8 extended families:

> "The people for whom the Mye Mountain/Anvil Creek/Blind Creek areas were primary resource lands at the time of development included the direct descendants of the earlier generation of people from that country. These included Selkirk Billy, Aklack, Billy Atkinson, Long Hair John, Gumbala, Nahlier, Pat Johnnie (Peter Ladue's maternal grandfather), and Sue Bill (Jack Ladue's first wife's father) and their spouses. The group also included people who married into these families or who were invited to join these groups. During the period prior to the mine construction, Joe Ladue, Hoole McLeod, Jack Sterriah, Old Man Jules and Jack Ollie's wife and some of their family members regularly trapped in the affected areas."[11]

The Mye Mountain families had a network of cabins and camps that were used regularly in the seasonal round:

> "There were three groups of cabins on the Pelly River in the Faro area; one at the present Faro bridge site, another at the mouth of Blink Creek, and the third at Fish Hook — just upriver from the mouth of Anvil Creek. All of these were residential sites for the salmon fishery and for winter trapping and were used as departure points for the dry meat hunt. There was a degree of over-lap and flexibility in the use of these sites; some people had cabins at more than one location and varied their use of the cabins from season to season."[12]

At the time of the 1969 fire there were three cabins, belonging to Joe Ladue, Joe Etzel, and Arthur John, at the site of the Faro bridge. Fish Hook was the home base of the Ladue family with cabins belonging to Arthur John, Peter Ladue, Jack Ladue and Joe Ladue. In addition, Swim Lakes had several well established sites for use during the spring fishery.

[9] Weinstein, 1992. pp.85-86

[10] Weinstein. 1992. pp.19-20.

[11] Weinstein, 1992. pp.87-88

[12] Weinstein, 1992. p.76

1.3.2 History of the Faro Mine Site

Mining at the Faro Mine Complex took place between 1969 and 1998, with several temporary cessations of varying lengths. The Faro Mine was the first developed, followed in the late 1980s by the mines of the Vangorda plateau: Vangorda Mine followed by Grum Mine.

Al Kulan with the assistance of Kaska prospectors Jack Ladue, Robert Etzel, Joe Etzel, Art John and Jack Sterriah, discovered and staked the Vangorda deposit in 1953. While this deposit was considered too small and remote for development at the time, it led to the 1965 discovery of the Faro deposit by Dynasty Explorations. The Grum deposit was discovered in 1973.

Anvil Mining Corporation opened the Faro Mine in 1969 and continued operations, under the name Cyprus Anvil Mining, until 1982 when economic conditions forced a shut-down. Operations at the Faro Mine resumed under Curragh Resources Ltd. in 1985. Curragh recognized limited remaining resources in the Faro Pit and began seeking approvals and constructing infrastructure, including the 12 km Vangorda Haul Road, for mining at the Vangorda and Grum Mines. Mining at Vangorda Mine commenced in 1990 and continued, concurrent with mining at Faro Mine, until mid-1992 when resources in the Faro Pit were depleted. In late 1992, Curragh sought bankruptcy protection and ceased mining operations. Curragh began stripping of overburden and waste rock from the Grum Pit in 1991, but had not commenced ore production prior to the 1992 shut-down.

Anvil Range Mining Corporation (ARMC) formed in 1994 to purchase the Faro Mine Complex from the receiver. ARMC resumed operations in 1994 with a pre-stripping and mill refurbishment program. Ore production began at the Grum Mine in August 1995 followed by resumed production at the Vangorda Mine. ARMC terminated mining operations in late-1996 for economic reasons and, following a financial restructuring, restarted in 1997. Mining continued until early 1998 when ARMC sought bankruptcy protection.

Ore processing for all ores at the Faro Mine Complex took place through a single mill located at the Faro Mine. From the start of production until 1992, tailings were deposited behind a series of dams located in the Rose Creek Valley adjacent to the mill site. The initial tailings storage facility was constructed in 1969, with additional impoundments constructed in 1974 and 1982. The two later impoundments necessitated the construction and extension of a diversion for Rose Creek. Subsequent to completion of mining in Faro Pit in 1992, the Faro Pit became the primary tailings storage facility, with the older impoundments being used only in emergency circumstances.

Following the final shut-down in 1998, the FMC entered a care-and-maintenance phase. Care-and-maintenance activities have been carried out to prevent unacceptable environmental effects and manage environmental risks associated with the site. This requires ongoing collection and treatment of contaminated water along with extensive maintenance and monitoring programs. From 1998 to early 2009, Deloitte and Touche Inc. (D&T) conducted care-and-maintenance activities at the site acting as the interim receiver for ARMC. In early 2009, D&T was discharged from these duties and Yukon Government assumed management responsibility. Yukon Government has established a

contract with Denison Environmental Services (DES) to continue care-and-maintenance activities while the closure and remediation plan is finalized and approved. Closure Planning History

The methods for closure and remediation of the Faro Mine Complex have been under consideration for over 25 years, through a series of processes. However, the original mine development for the Faro Mine did not give significant consideration to the importance of mine closure. The potential geochemical effects of mining sulphide mineral deposits were not well understood at the time and the initial mine was not developed or operated with consideration of future closure requirements. Also, much of Yukon's natural resource management regulatory regime was not in place during the initial mine development.

Several studies related to the closure of portions of the site were completed during operations. The planning and permitting for the 1982 expansion of the tailings storage facility led to the development of a closure plan for this important component of the site (Klohn Leonoff 1981). This plan was updated as operations expanded and changed (SRK 1991). In 1988, Curragh Resources prepared a closure plan for other components of the Faro Mine (Curragh Resources, 1988).

Planning and permitting for the Vangorda and Grum Mines in 1989-1990 considered the long-term environmental implications of these developments and recognized the potential geochemical concerns associated with mining of the sulphide minerals. Plans for closure and long-term management of environmental effects were incorporated in project planning and addressed through the environmental assessment and regulatory processes. The potential need for a permanent site presence to address contamination was identified.

The first comprehensive closure and remediation plan for the whole Faro Mine Complex was prepared by ARMC, the "Integrated Comprehensive Abandonment Plan" (RGC, 1996). This plan was never approved or implemented.

The closure planning process that led to the proposed FMC Closure and Remediation Plan began in 2002 under the guidance of D&T. In 2003, after seeking independent expertise about remaining mineral values at the mine, the federal and territorial governments concluded that the FMC did not have sufficient remaining value to support renewed operation or the costs associated with mine closure and reclamation. At that time, the governments accepted responsibility for closure planning and closure implementation and assumed responsibility from D&T for managing the development of a closure and remediation plan. This project proposal describes the results of the closure planning process undertaken since 2003.

1.3.3 Closure Planning Framework

Describe administrative structure for closure planning – i.e. role of 4(5) governments, creation of Oversight Committee, etc. Briefly describe community engagement. (Note: See Section 3 of the Options Report.)

The Faro Mine Complex is identified as a "Type II Site" in the 2001 "Yukon Northern Affairs Program Devolution Transfer Agreement" (DTA) between the Governments of Canada and Yukon. This agreement created requirements for Canada, Yukon Government and affected First Nations, in this case the Selkirk First Nation, Ross River Dena Council and Liard First Nation, to work cooperatively in addressing the FMC. The DTA also included Canada's acknowledgement of financial responsibility for closure and remediation of the FMC.

The overall project management and administration related to all Type II Sites including theFMC is directed by the Type II Steering Committee, comprised of senior representatives of Canada and Yukon, with Canada represented by Indian and Northern Affairs Canada (INAC) and Yukon represented by the Department of Energy, Mines and Resources. Each government has established internal capacities to address their closure planning and project management responsibilities.

In early 2004 Canada, Yukon, Selkirk First Nation and the Ross River Dena Council endorsed a partnership agreement in which they committed to work cooperatively to develop a closure plan for the FMC, with the Ross River Dena Council acting on behalf of the Kaska Tribal Council. The role for First Nation governments was realized through the creation of the project Oversight Committee, comprised of senior representatives from each government. Subsequent changes led to the direct participation of Liard First Nation on the committee. The Oversight Committee was tasked with providing overall strategic direction to the closure project, and with recommending a closure option for the FMC.

Canada and Yukon have dedicated internal resources to the development of a closure plan. The planning process is guided by the Faro Senior Project Manager and supported by other members of the Faro Project Management Team that includes internal staff as well as external technical consultants. Canada and Yukon have provided resources to all three First Nation governments for the establishment of community offices for the Faro Mine Closure Planning project, including full-time coordinators in each First Nation community. The community offices have resources for technical assistance as necessary. Resources have also been provided to the Town of Faro for a community liaison throughout the closure planning process.

A diverse team of technical consultants provides support to the Faro Project Management Team, advising on all aspects of closure planning as well as carrying out studies, site investigations and designs.

The Oversight Committee and the Faro Project Management Team seek input, as necessary to support closure planning, from other groups and agencies. In 2006, the committee endorsed the establishment of an Independent Peer Review Panel (IPRP) comprised of nine international experts in fields relevant to the closure and remediation of the FMC. The IPRP continues to provide advice about the adequacy of the closure planning process and activities. Throughout the closure planning process, the Project Management Team has utilized ad-hoc technical working groups to support and advise on closure planning activities. These working groups have provided opportunities for participation by relevant government agencies.

1.3.4 Land Tenure

The Faro Mine Complex is located entirely on crown land, most of which is administered by Yukon Government. A small portion of the Vangorda/Grum site is within the municipal boundary of the Town of Faro. The site is located in the traditional territory of the Kaska Nation, including the overlapping territories of the Ross River Dena Council and the Liard First Nation. The site falls within the watershed of the Pelly River, which flows downstream into the traditional territory of the Selkirk First Nation.

Neither of the Kaska First Nations has finalized a land claim agreement but there are several land selections surrounding the site that are subject to interim protection for the Ross River Dena Council. These include rural land selections that abut much of the left bank of Rose Creek and both banks of Anvil Creek downstream of the site. There is one site specific land selection located along the right bank of Rose Creek approximately 2km downstream of the tailings impoundment. Additional nearby rural selections are located northeast and southeast of the site.

The site is located in the Kaska Land Use Planning Region established by the Yukon Land Use Planning Council. A planning commission has not been appointed for this planning region and the regional land use planning process has not been initiated.

Until the conclusion of the DTA in 2003, most of the land at the FMC was administered by INAC. While the FMC was in operation, the operators held numerous types of mineral and land tenures as well as other permits and authorizations including:

- Quartz mining claims covering all of the mining and operating areas.
- Surface leases covering mining and operating areas.
- Water licences for use of water and deposit of waste.

The original permits, authorizations and leases were issued by INAC, but the responsibility for their administration transferred to Yukon Government as part of the DTA. D&T retained the claims, permits, leases and authorizations in good standing during its administration of the care-and-maintenance program. This included consolidation of the water licences for the FMC into a single care-and-maintenance licence that applied from 2003 through early 2009.

The conclusion of the ARMC receivership and assumption of care-and-maintenance administrative responsibility by Yukon Government led to some changes in the administration of land tenure and regulatory instruments. First, the entire FMC and areas that may be subject to disturbance as a result of the closure and remediation project are subject to Order in Council (O.I.C.)2008/168 under the *Quartz Mining Act*. The O.I.C. prohibits staking and prospecting under both the *Quartz Mining Act* and the *Placer Mining Act*. Yukon Government established the O.I.C. to prevent any future conflicts between closure/remediation activities and mineral exploration activities. Most of the mining claims covering the FMC have now expired. Second, Yukon Government did not renew the water licence for the site, instead choosing to operate the site under Section 37 of the *Waters Act* whereby the

Yukon Government can take appropriate measures at an abandoned site to address potential adverse effects on the environment. The surface leases at the site remain in good standing and provide for continued care-and-maintenance activities as well as necessary site access control and security.

Completion of the closure and remediation project will require retention of existing surface leases. Additional land tenure may be required for specific activities including the development of borrow pits for construction materials, and the establishment of permanent facilities at the site. A water licence will also be required for implementation of the closure and remediation plan and for long-term operations.

1.3.5 Project Purpose

The overall purpose of the FMC Closure and Remediation Project is to protect people and the environment from current and future effects associated with facilities and disturbances from past mining activities.

There are several key issues that drive the need for implementing an effective closure and remediation plan. These include public and worker safety, contamination of water, risks from severe events (i.e. floods and earthquakes), contamination of air and land by dust, and possible direct contact of humans and animals with metal-rich waste materials. The Oversight Committee identified these issues early in the closure planning process and agreed upon some broad closure objectives intended to ensure that the closure and remediation plan would address the key issues while providing socio-economic benefits locally and in Yukon. The overarching objectives include:

- Protect human health and safety;
- Protect and, to the extent practicable, restore the environment, including land, air, water, fish and wildlife;
- Return the mine site to an acceptable state of use that reflects pre-mine land use where practicable;
- Maximize local and Yukon socio-economic benefits; and
- Manage long term site risk in a cost effective manner.

Within these overarching objectives, each party on the Oversight Committee had different and independent sub-objectives and interests, which were not always convergent. Ultimately, the Oversight Committee approved the five overarching objectives, each with some guiding principles. The approved objectives and guiding principles are attached as Appendix A.

At the beginning of the closure planning process, initial monitoring and evaluation of site conditions and trends confirmed that the site was not causing significant environmental degradation in either the aquatic or terrestrial environments. In fact, the monitoring programs indicated that discontinuation of mining activities and implementation of well-managed care-and-maintenance programs were leading to some improvements in local environmental conditions.

However, scientific and engineering studies also confirmed that conditions at the site will worsen significantly with time due to the ongoing oxidation of waste rock, tailings and pit walls. If left unabated, these trends would eventually overwhelm the capability of care-and-maintenance activities leading to unacceptable environmental effects; something that can only be prevented by timely implementation of effective closure and remediation measures. Control and minimization of contaminant mobilization and transport in the short-term is critical to preventing long-term contamination and severe degradation of the aquatic environment. For the terrestrial environment, closure and remediation measures are needed to address ongoing contamination from exposed waste materials including contaminant transport by dusting.

The need for closure planning for the FMC has also been driven by regulatory requirements. Since the early 1980s, water licences for the project have included requirements for comprehensive closure planning. These requirements led to submission of the "Integrated Comprehensive Abandonment Plan" (RGC, 1996) for example. The most recent water licence, issued to D&T in 2003, included closure planning requirements similar to those included in earlier licences. In addition to a general requirement for preparing a comprehensive closure plan, the licence specified some design criteria for the closure plan.

- Decommissioned tailings-related facilities and structures must be designed to withstand the maximum credible earthquake and the probable maximum flood.
- Long-term physical stability of all watercourses and tailings deposits is to be ensured with minimal post-operational maintenance.
- The long-term water quality in Rose Creek downstream of the tailings facilities must comply with the Canadian Water Quality Guidelines for the Protection of Aquatic Life (Canadian Council of Ministers of the Environment).

1.3.6 Project Scope

Describe broad scope of Faro Mine Closure project – what works and activities are included and what are excluded.

TBD Excerpt from EA chapter.

1.3.7 Required Authorizations and Regulatory Approvals

The FMC Closure and Remediation Project is subject to assessment under the *Yukon Environmental and Socio-economic Assessment Act* (YESAA). The project also requires a variety of regulatory authorizations and land dispositions.

Many of the activities that form part of the closure and remediation plan are included in the *Assessable Activities, Exceptions and Executive Committee Projects Regulations* under YESAA. Most importantly, the project is the "decommissioning of a mine" as described in Schedule 1, Part 1, Item 3 of the regulations. Because the FMC had a processing capacity of up to 15,000t/day, the

closure and remediation project passes the threshold for submission of a project proposal to the executive committee of the Yukon Environmental and Socio-economic Assessment Board, as described in Schedule 3, Item 3 of the YESAA regulations.

The closure and remediation project will require a water licence for construction of diversions, construction/modification of impoundments, use of water, collection and treatment of contaminated water, and discharge of waste water. Dispositions of land in the form of leases will be required for conducting closure and remediation activities and addressing site security and required access control. Permanent land dispositions will be required for facilities that will remain on site permanently. While the water licence and land dispositions are the major Yukon Government approvals required for the closure and remediation plan, other Yukon Government authorizations will be required for specific components including

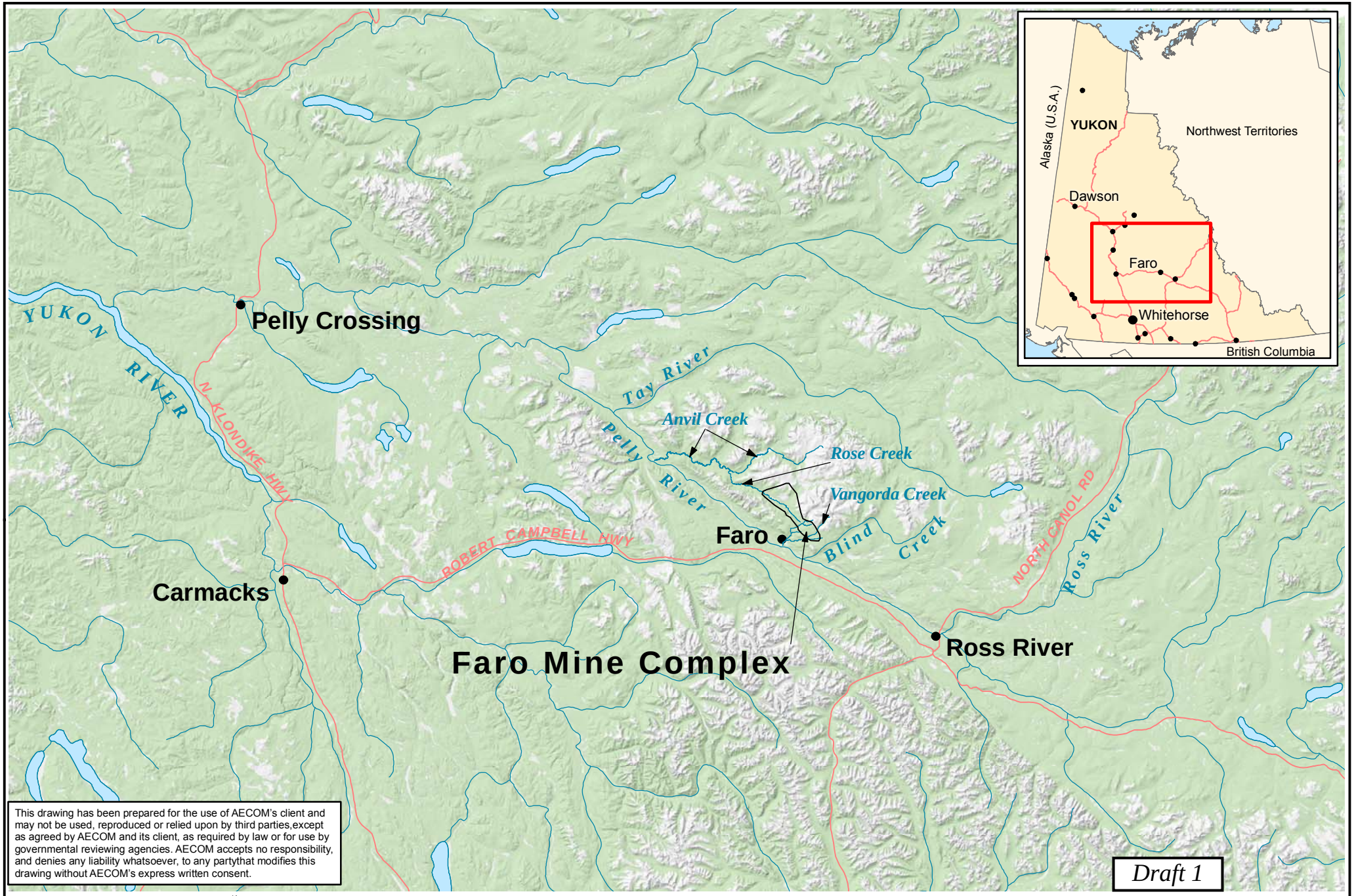
- Land Treatment Facility Permit for treatment of hydrocarbon contaminated soils.
- Commercial Dump Permit for an on-site landfill.
- Sewage Disposal System Permit.

Segregation of the clean water in the North Fork of Rose Creek from the contaminated site waters requires construction of a man-made channel for the creek as it passes the site. The stream modifications will likely constitute destruction of fish habitat under the *Fisheries Act* leading to a requirement for a Fisheries Authorization from Fisheries and Oceans Canada.

Production of construction materials, especially rip-rap, may require blasting in borrow areas. Blasting activities may require authorization from Natural Resources Canada.

The permits and authorizations described above establish Yukon Government, Fisheries and Oceans Canada and Natural Resources Canada as YESAA decision bodies for the project. In addition, INAC has accepted financial responsibility for the closure and remediation of the FMC. Because of its role as the primary funder for the project, INAC will also be a decision body.

Figures



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Draft 1

Map notes:

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UTM Zone 8N, NAD83

AECOM

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

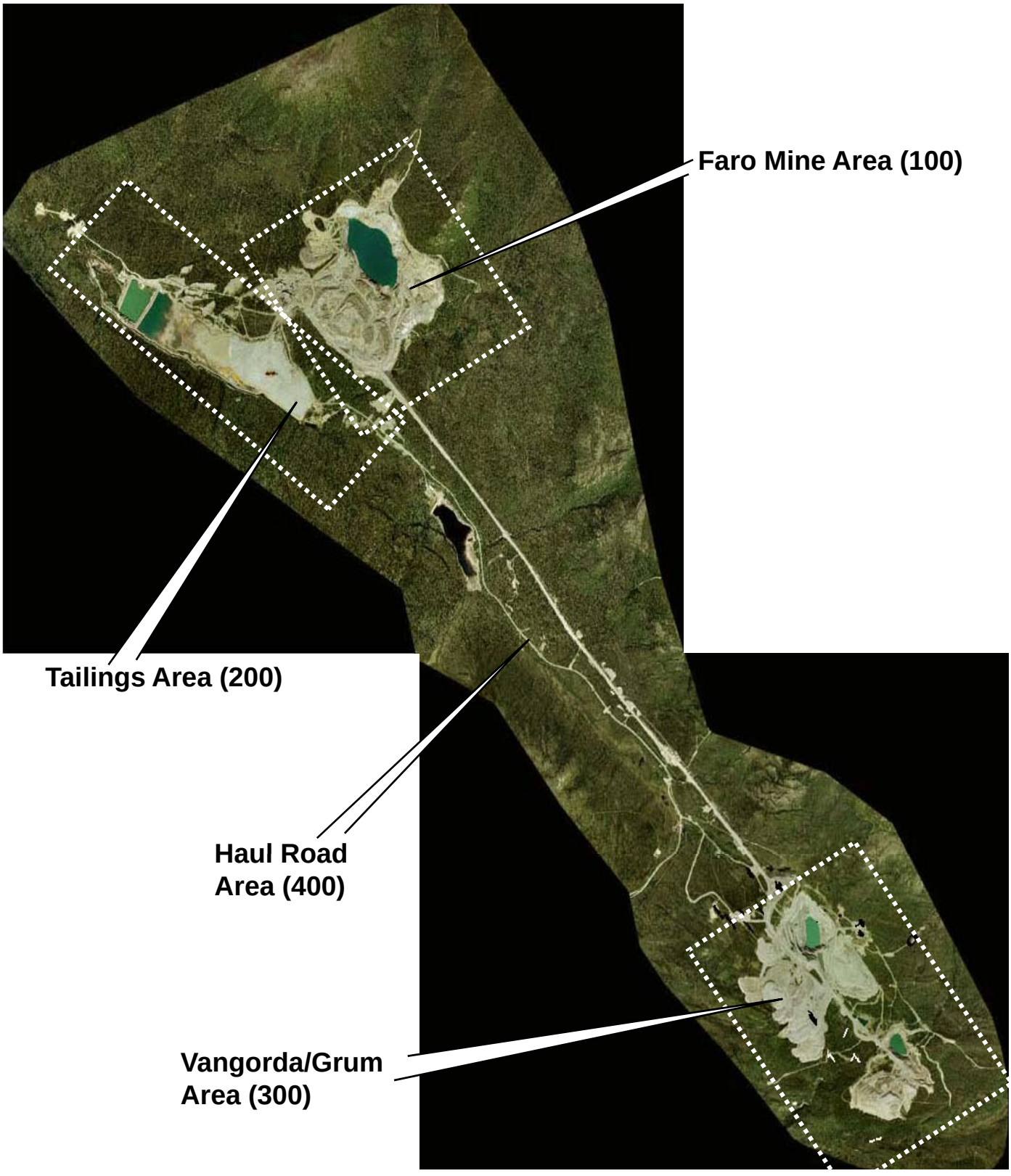
File Name: 60119234_Fig1-1_Faro Complex Location Overview_v2_rh_18Feb2010.mxd

Faro Mine Complex
Closure and Remediation

Project Proposal

Faro Mine Closure
Location Map

Date:	Approved:	FIGURE:
February 2010		1-1



Source: SRK Consulting

Faro Mine Closure Fermeture de la mine Faro	Faro Mine Complex Closure and Remediation	Closure Areas
Job No: 1CY001.026 Filename: Figure 1.2_Closure Areas_20100222.ppt	Project Proposal - Draft 1	Date: Feb. 2010 | Approved: | Figure: 1.2

Chapter 2

Consultation

2 Consultation

2.1 General

Community engagement has played an important role throughout the closure planning process for the FMC. This community engagement included extensive consultation initiatives with various affected "communities" including First Nation governments, First Nation citizens, affected communities, government agencies and the Yukon public. Beyond the consultation initiatives, First Nation governments also hold an additional direct participation role as decision-makers through the Oversight Committee, providing a strong voice for First Nations' views and perspectives. The community engagement activities have addressed legal requirements for consultation, but have gone beyond these requirements seeking to build broad community support for a project that can bring long-term environmental and socio-economic benefits to Yukon.

2.2 Consultation Duties

From the outset, the Oversight Committee expressed its desire for an open and transparent closure planning process that would share information and then seek and utilize input.

"The planning process must provide equal access and influence for diverse voices and treat all opinions with respect. Above all, the work must be done in a way that secures public support and confidence in the undertakings." (GLL, 2005)

To achieve this goal, the Oversight Committee established requirements for communication strategies with "specific activities to ensure communities, special interest groups, regulatory boards and advisory committees, government departments, the media and the public are all well informed about the planning initiative" (GLL, 2005).

The Oversight Committee's vision guided the closure planning team during site investigations, closure alternatives evaluation and closure plan design. A particularly important component of the communications and consultation included activities to engage First Nations. The Oversight Committee directed the closure planning team to ensure that First Nations (governments and citizens) understood the site, issues, options and project, allowing them to contribute meaningfully to closure planning discussions and decisions. There was early recognition that First Nations' leaderships would need well-informed communities to support their decision-making roles on the Oversight Committee.

The closure planning approach prescribed by the Oversight Committee provided an ideal context for addressing legal requirements for consultation, including those required for YESAA. Under subsection 50(3) of YESAA, proponents of projects that will be assessed by the Executive Committee are obliged to consult with "any First Nation in whose territory, or the residents of any community in which, the project will be located or might have significant environmental or socio-

economic effects." For the proposed FMC Closure and Remediation project, this establishes consultation obligations in relation to:

- Ross River Dena Council (RRDC) because the project will occur within their traditional territory.
- Liard First Nation (LFN) because the project will occur within their traditional territory which fully overlaps with that of the RRDC.
- Selkirk First Nation (SFN) because water leaving the site will flow into the SFN traditional territory, and thus could have significant environmental effects.
- Residents of the Town of Faro because the project could have significant environmental or socio-economic effects in their community.
- The general Yukon public because of the scale of the project which could lead to significant socio-economic effects in other communities including Whitehorse.

This chapter provides a summary of consultation activities undertaken during the development of the proposed Closure and Remediation Plan for the FMC. These activities have fulfilled the consultation requirements under YESAA as one component of meeting broader consultation and participation duties.

All of the consultation activities conducted during the closure planning process have, at a minimum, adhered to the principles of consultation enshrined in First Nation Final Agreements: (1) providing information about the project in sufficient form and detail to allow people to understand the project and prepare their views, (2) providing a reasonable period of time for people to prepare their views, and an opportunity to present those views, and (3) giving full and fair consideration to all of the views presented. In most cases, the activities met a higher standard of consultation, actively seeking and responding to input, and utilizing the information in plan development.

2.3 Capacity for Participation – Resources for First Nations and Communities

Early in the closure planning process (2004), the parties to the partnership agreement (Canada, Yukon, RRDC and SFN) recognized that the First Nation partners lacked adequate financial resources and expertise to participate meaningfully and equitably in the closure planning process. To resolve this deficiency, Canada and Yukon agreed to provide financial resources to the First Nation governments to facilitate the establishment of dedicated offices in each community. Each First Nation hired a local coordinator, with specific responsibility for FMC closure and remediation planning. General duties of the local offices included:

- Coordinating First Nation community input to the Faro Mine closure planning process.
- Securing the services of technical expertise to support the First Nation community's and government's informed involvement in the closure planning process.

- Coordinating community meetings, information sessions and workshops to inform the community and gather their input. Some topics included closure objectives, closure studies, closure alternatives and options and traditional knowledge.
- Disseminating information about the mine site and the closure planning process to the community, and gathering input from the community.
- Maintaining a library of relevant reports, studies and documentation in the community.
- Coordinating local hire where required for closure planning related work.
- Liaising with other governments about the closure planning process.
- Supporting the participation of the First Nation government in their decision-making role on the Oversight Committee.
- Participating in closure planning working groups and programs.

Each First Nation hired consultants as expert technical advisors. The First Nation coordinators and their technical advisors played active roles through all stages of the closure planning process, working as part of the overall closure planning team. Through this process, the First Nation governments were not only consulted about the project, but were part of its development.

When LFN became an active participant in the Oversight Committee in 2008, Canada and Yukon began providing similar funding to support participation. LFN established a similar office and secured services of an expert technical advisor.

The Oversight Committee also recognized that the Town of Faro would require support to ensure that the Town and its residents could engage effectively in the closure planning process. Canada and Yukon provided financial resources for the Town of Faro to hire a part-time community coordinator dedicated to closure planning for the Faro Mine. The coordinator worked within the community to improve the communities understanding of the proposed project and the closure planning team's understanding of the community's views and concerns.

Since 2004, Canada and Yukon have contributed substantial resources to these community programs. The programs have facilitated very active participation of communities throughout the closure planning process and, therefore, a very high level of community understanding about what is proposed and why.

2.4 Consultation Activities

2.4.1 Introduction

The closure planning team conducted consultation at all stages of planning for the Faro Mine Closure, from the establishment of closure objectives through to the development of the final closure plan. Based on research conducted for the Faro Mine closure project in early 2004, this inclusive and long-term approach to consultation was considered particularly important for First Nation

communities. Results from this research illustrated that First Nations' understanding of and support for proposed mine closure projects was much more comprehensive for projects where effective consultation and engagement had been an integral component throughout their closure planning processes.

Once the consultation was underway, the team continually adjusted the project and approaches based on input received. At key milestones in the planning process the Oversight Committee utilized the input received to support decision-making. Critical phases of the consultation were guided by explicit communication and consultation plans endorsed by the Oversight Committee. The consultation conducted during each major closure planning stage is described below. Note that these stages were not strictly sequential and sometimes overlapped in time.

2.4.2 Stage 1 – Closure Planning Introduction and Closure Objectives

Initial meetings with First Nations and communities focused on introducing the history of the FMC and need and purpose of closure planning for the FMC. These initial discussions occurred in 2004 and early 2005 to advise people about the upcoming closure planning process and their opportunities to participate. Introductory meetings and discussions included:

- April 2004 – 2-day workshop in Ross River, meeting in Faro and meeting in Pelly Crossing about the FMC and closure planning process.
- June 2004 – 2-day workshop in Ross River about the FMC.
- February 2005 – meeting with Selkirk Renewable Resources Council for status update.
- February 2005 – meeting with government interdepartmental working group for status update about site and closure planning.
- In the early stage of closure planning, closure objectives were an important topic of consultation activities, including at some of the meetings and workshops described above. As described in Section 1.3.5, five overarching objectives, agreed to by the Oversight Committee, have guided the closure planning process. In developing these broad objectives and their underlying, guiding principles the closure planning team and the Oversight Committee relied on the results of consultation with a variety of groups and agencies.
- The closure planning team engaged with government departments, First Nation governments and the Town of Faro to seek input about their expectations for a FMC closure plan. Yukon Government, Selkirk First Nation, Ross River Dena Council (at the time on behalf of the Kaska Nation), Environment Canada, Fisheries and Oceans Canada, Indian and Northern Affairs Canada and the Town of Faro provided input describing their expected and desired outcomes from any closure plan. Depending on the group, methods of engagement ranged from meetings/workshops to written requests. First Nations' technical advisors assisted in gathering, interpreting and compiling input from First Nations.
- All of these inputs were compiled and the results categorized into the five major categories. Many of the individual objectives, expectations and desires compiled within these broad

categories could be divergent. The Oversight Committee ultimately agreed on five overarching objectives, each with a series of guiding principles. These objectives became an important tool for selection of closure alternatives and refinement of the proposed closure plan.

2.4.3 Stage 2 – Issues Scoping and Closure Studies

Between 2003 and 2006, approximately forty studies were undertaken to better understand the site and potential closure options. Throughout this issues scoping and closure studies stage of the closure planning project, consultation with a variety of groups and agencies guided decisions about the studies and investigations that were conducted. There were three main instruments for consultation and involvement: (1) periodic workshops helped define the overall range of studies and investigations that should be completed, (2) working groups guided the completion of specific studies and investigations, and (3) presentation and discussions of results in communities.

Over the period from April 2002 through January 2005 the closure planning team convened a total of five workshops intended to provide results of previous studies and provide a forum for considering these results and planning future work. At each workshop there were detailed presentations of results from studies and investigations. With the benefit of this information, participants developed lists of outstanding data gaps, potential closure methods, outstanding technical uncertainties. These needs were refined into work plans for further investigations and studies. The process iteratively identified and refined potential methods over a these years as participants defined the technical uncertainties for specific options and designed studies to address outstanding data gaps and critical uncertainties. Participants at these workshops included specialist consultants, First Nation governments and technical advisors, federal government departments (INAC, EC, DFO), Yukon Government (Environment, Energy Mines and Resources, Executive Council Office), Town of Faro, and Yukon Salmon Committee). The workshop discussions and conclusions are summarized in a series of reports (Deloitte & Touche Inc. 2003, 2004a, 2004b, 2005).

The closure planning team created technical working groups to provide guidance for specific studies and investigations. While some informal groups had existing in 2003, there were formal invitations in 2004, 2005 and 2006 seeking expressions of interest from government agencies and First Nations about participation in technical working groups. This resulted in the creation of technical working groups for most of the key studies and investigations. Membership varied depending on the projects, but included representatives from Indian and Northern Affairs Canada, Environment Canada, Fisheries and Oceans Canada, Health Canada, Yukon Environment, Yukon Energy Mines and Resources, Yukon Executive Council Office, Selkirk First Nation and Ross River Dena Council. The working groups met as needed during the course of studies and guided the conduct of the studies, reviewed results, assisted with interpretation, etc.

Some of the working groups have continued their involvement throughout the closure planning process with addition of members (e.g. Liard First Nation) as appropriate.

The completion of initial studies and investigations provided information to support consultation activities with a broader range of stakeholders and interested people. In 2005 the closure planning team met with various stakeholders, groups and individuals to discuss the closure planning process, site issues and results of ongoing studies and investigations. The discussions were supported by appropriate presentation materials. Examples of presentation materials used for these meetings are provided in "supporting document re: consultation." Key stakeholder meetings and workshops related to the scoping of issues and ongoing site studies are summarized below in Table 2.1.

Table 2.1: Consulation Meetings on Issues and Studies, 2005

Date	Group/Agency/Stakeholder	Purpose/Content
April 12-13, 2005	Selkirk First Nation	Community Meeting, Process and Studies Results.
April 20, 2005	Kaska Leadership Meeting	Process and Studies Update.
June 13, 2005	Selkirk First Nation	Community Meeting, Process and Studies Results (continued from April 13).
June 14, 2005	Ross River Dena Council	Community Meeting, Process and Studies Results.
June 20, 2005	Selkirk First Nation	Home visits re: closure planning information and questions.
August 9, 2005	Selkirk First Nation	Community Meeting, Process and Studies Results.
August 17, 2005	Yukon Chamber of Mines	Introduction and process review.
September 8, 2005	Yukon Conservation Society	Introduction and process review.
September 19, 2005	Canadian Parks and Wilderness Society	Introduction and process review.
September 20, 2005	Yukon Fish & Wildlife Management Board	Introduction and process review.
September 21, 2005	Yukon Salmon Committee	Process and Studies Results.
October 4, 2005	Yukon Chamber of Commerce	Introduction and process review.
October 26, 2005	Kaska Leadership Meeting	Process and Studies Update.
November 17, 2005	Selkirk First Nation	Open House, Community Meeting re: 2005 Studies, upcoming plans re: alternatives.
November 18, 2005	Faro Town Administration	Meeting re: 2005 Studies, upcoming plans re: alternatives.
November 22, 2005	YESAB	Meeting re: closure planning process, studies completed, upcoming plans re: alternatives.
November 30, 2005	YG & GC interdepartmental working group	Administrative and issues overview.
December 2, 2005	Kaska Leadership, Ross River	Process and Studies Update.
December 6, 2005	INAC Contaminated Sites Staff	Process and Studies Update.
December 8, 2005	Yukon Mining Advisory Board	FMC Closure Planning Overview.
December 9, 2005	Yukon Conservation Society, CPAWS, Yukon River Inter-Tribal Watershed Council	Meeting re: site issues, closure planning process, upcoming plans re: alternatives.
December 16, 2005	Yukon Chamber of Mines, Yukon Chamber of Commerce	Administrative and issues overview.
December 21, 2005	YG and GC interdepartmental technical working group	Technical studies results/update, upcoming plans re: alternatives.

An additional component of consultation undertaken during the issues scoping and studies phase of the closure planning project was associated with D&T's "Community Liaison Committee." This committee, comprised of a broad range of stakeholders, met annually in Faro to tour the site and to learn about and discuss site conditions, closure planning studies and the closure planning process. This forum provided an opportunity for many stakeholders to understand and discuss each others' views and provide input for consideration by the closure planning team.

2.4.4 Stage 3 – Closure Options Development

As described in Chapter 6 of this Project Proposal, the technical studies completed by late 2005 had allowed the refinement of numerous closure methods into a smaller number of closure alternatives for each of the major mine areas. These alternatives were intended to capture the range of feasible alternatives for mine closure. During meetings with stakeholders in late 2005, the closure planning team introduced this "example alternatives" concept to prepare people for the next phase of the closure planning process. Due to the importance of the options analysis and selection stages, the team developed communication and consultation plans that defined a three phase coordinated approach to providing information and gathering input. The first phase of the plans involved providing information about the proposed alternatives and seeking input about the adequacy of the proposed range of alternatives. The second and third phases applied to, and were implemented during, the closure options selection and closure plan development stages of the closure planning process. To ensure effective consideration of the input received during this stage, there were detailed minutes recorded for all stakeholder meetings. Questions, issues, suggestions and answers arising from these meetings are compiled in a detailed database that has and will continue to support their consideration in closure planning and implementation.

Consultations during the options development staged involved a variety of tools and techniques including meetings and workshops with stakeholders, communities and government agencies; site tours and on-site discussions; and distribution/review of alternatives documents. In addition to these consultation activities, First Nations continued to participate directly in the process including participation at technical meetings used to define and refine the alternatives. Meetings, workshops and some site tours are summarized below in Table 2.2. Examples of presentation materials used for these meetings are provided in "supporting document re: consultation." Draft reports describing the ranges of alternatives were distributed for comment and review, and as support documents for meetings, at various stages during the consultation. Recipients of various versions included Ross River Dena Council, Selkirk First Nation, Environment Canada, Environment Yukon, Health Canada, Fisheries and Oceans Canada and the Town of Faro. Both Selkirk First Nation and Ross River Dena Council and their technical advisors participated in detailed technical discussions about the risks associated with all of the alternatives. Environment Canada also participated in these discussions which led to refinement of the range of alternatives as well as the approach to many closure approaches.

Table 2.2: Consultation Activities during Options Development

Date	Group/Agency/Stakeholder	Purpose/Content
April 18, 2006	Faro Town Council	Phase I Consultation – Presentation and discussion of options.
April 18, 2006	Faro public meeting	Phase I Consultation – Presentation and discussion of options.
April 20, 2006	Pelly Crossing public meeting	Phase I Consultation – Presentation and discussion of options.
April 27, 2006	Ross River public meeting	Phase I Consultation – Presentation and discussion of options.
May 5, 2006	Selkirk Renewable Resources Council	Phase I Consultation – Presentation and discussion of options.
May 24, 2006	Selkirk First Nation	Phase I Consultation – Presentation and discussion of options.
June 6, 2006	Environmental Non-Government Organizations	Phase I Consultation – Presentation and discussion of options.
June 8, 2006	Ross River Dena Council, Chief & Council and Advisory Council	Phase I Consultation – Presentation and discussion of options.
June 15, 2006	Chamber of Commerce, Chamber of Mines, Whitehorse Star	Phase I Consultation – Presentation and discussion of options.
June 16, 2006	Media Briefing	Phase I Consultation – General overview of options.
June 22, 2006	Whitehorse Public Meeting	Phase I Consultation – Presentation and discussion of options.
June 23, 2006	YESAB and Staff	Phase I Consultation – Presentation and discussion of options and closure planning process.
July 20, 2006	YG Interdepartmental Working Group	Phase I Consultation – Overview and discussion of alternatives.
September 20, 2006	Joint Community Tour (reps from Pelly Crossing, Faro & Ross River)	Update on alternatives, discussion of technical challenges.
November 23, 2006	CPAWS / Yukon Environmental Network	Phase I Consultation – Overview and discussion of alternatives.
January 12, 2007	YG and GC Interdepartmental Working Group	General overview and update re: alternatives and closure planning process.
February 21, 2007	Yukon Salmon Committee	Phase I Consultation – Overview and discussion of alternatives using 3-D site model.
March 15, 2007	Town of Faro	Discussion of options and presentation of evaluation process.
March 16, 2007	Ross River	Discussion of options and presentation of evaluation process.
March 26, 2007	Pelly Crossing	Discussion of options and presentation of evaluation process.

Environmental and socio-economic assessment work began in earnest during the options development stage of the closure planning process. The work began with compilation of baseline information and the identification of environmental and socio-economic values. Members of the environmental and socio-economic assessment teams participated in at least one of the "Phase I" consultation meetings in each community and with each First Nation. At these meetings, the

environmental and socio-economic assessment teams presented information about their proposed assessment approaches and specifically sought information about values. The information received helped define the scope of assessment (values, temporal scope, spatial scope) for the project and identify key data and information gaps.

One common thread throughout many of the community meetings related to the potential effects of the existing and proposed projects on the environment and human health. Investigations and predictions related to these effects had been completed and were recognized as a critical component of the upcoming environmental and socio-economic assessments. Because of the significant interest in these topics and their relationship to the assessment process, the closure planning team held meetings with SFN, RRDC and Town of Faro communities in the fall of 2006 to provide information about the environmental conditions, human health risks. Following the presentation of this information, the environmental and socio-economic assessment teams led discussions about the issues, values and concerns of community members. Examples of presentation materials used for these meetings are provided in "supporting document re: consultation."

Overall, the input gathered from consultations during the closure options development stage was used, in combination with input from additional technical studies and the IPRP to refine the alternatives and create a short-list of options for consideration in the options selection stage.

2.4.5 Stage 4 – Closure Options Evaluation and Selection

As described in Chapter 6 of this Project Proposal, by the end of the options development stage, the closure planning team had established a short-list of options supported by sufficient technical detail so they could be meaningfully evaluated against the closure objectives. The evaluation and selection process merged these two key closure planning paths.

The Oversight Committee recognized that its members would each need strong technical input as well as feedback from their constituents in order to make informed, defensible decisions about closure options. The closure planning team implemented Phase 2 of the consultation and communications plans. The options evaluation and selection process involved extensive consultation with a variety of agencies and stakeholders. It included concerted efforts to understand the views of the communities and constituencies represented on the Oversight Committee. Finally, all members of the Oversight Committee including First Nations were directly involved at both the technical and decision-making levels during evaluation and selection of options.

The technical evaluation process (Core Assessment Process) is described in Section 6.2.4 of this Project Proposal. First Nations community coordinators and technical advisors participated directly in the Core Assessment Process. Details of that participation are described in "Faro Mine Closure, Assessing the Alternatives, An Application of Multi-Attribute Utility Analysis" (Hodge, 2008, Attachemnt E of SD K1). The process and the short-list of options under consideration were the topic of a series of community meetings. Once the technical evaluation process was underway, the Core Assessment Team met with two formal committees at key stages during the evaluation process:

the Assessment Process Working Group – Communities, and the Assessment Process Working Group – Government. For some meetings these groups were combined.

Once the technical evaluation process was complete, there were a series of workshops and meetings to present and discuss the results. These supported internal discussion and overall (i.e. technical and other considerations) evaluation of alternatives for each of the governments represented on the Oversight Committee. For each First Nation, community coordinators supported by technical advisors convened community workshops to identify and discuss community members preferences for closure options and approaches. The closure planning team participated at these workshops to provide support and technical input.

Meetings and workshops related to the options evaluation and selection processes are summarized in Table 2.3.

Table 2.3: Consultation and Participation Activities during Options Evaluation and Selection

Date	Group/Agency/Stakeholder	Purpose/Content
May 9-11, 2007	Core Assessment Team meeting	Establish process for options evaluation.
May 23, 2007	Assessment Process Working Group (Combined)	'Kick-off' meeting on Evaluation Process
May 24, 2007	Assessment Process Working Group - FNs	FN participation in Evaluation Process
June 13, 2007	Ross River Community Meeting	Outline evaluation process; review/comment on APWG outputs; describe alternatives carried into evaluation process
June 14, 2007	Pelly Crossing Community Meeting	Outline evaluation process; review/comment on APWG outputs; describe alternatives carried into evaluation process
June 16, 2007	Faro Community Meeting	Outline evaluation process; review/comment on APWG outputs; describe alternatives carried into evaluation process
June 27, 2007	Whitehorse Public Meeting	Describe revised alternatives carried into evaluation process
July 6, 2007	Yukon Salmon Committee	Faro Mine site tour, discussion of alternatives to be evaluated.
July 19, 2007	Environmental Non-Government Organizations	Update on revised alternatives, including costs and employment; evaluation process.
August 3-6, 2007	Core Assessment Team meeting	Alternatives evaluation meeting.
October 9, 2007	Assessment Process Working Group (Combined)	Review and discuss materials to support evaluation process
November 5-9, 2007	Evaluation of alternatives	Evaluate alternatives against objectives
November 21, 2007	Assessment Process Working Group - FN	Discussion on Community Assessment of Options
December 12, 2007	Assessment Process Working Group - Government	Discussion on Government Assessment of Options
January 9, 2008	Meeting with FN community coordinators & technical advisors	Review process for community evaluation of closure options
January 22, 2008	Pelly Crossing community meeting	Update on closure options and evaluation process
January 23, 2008	Ross River community meeting.	Update on closure options and evaluation process
February 12-14, 2008	Ross River Closure Options Evaluation Workshop	Community evaluation of closure options
February 27-28, 2008	Assessment Process Working Group – Government	Inter-governmental workshop to discuss closure options evaluation results.
March 3-5, 2008	Pelly Crossing Closure Options Evaluation Workshop	Community evaluation of closure options
April 1, 2008	Liard First Nation technical committee	Review and discuss closure options
April 11, 2008	LFN community open house	Review closure options and closure planning process
April 24, 2008	LFN Community Meeting and Workshop	Review and discuss closure options, evaluation process and evaluation results.

2.4.6 Stage 5 – Closure Plan Development and Assessment

The Oversight Committee utilized the input received from the alternatives evaluation process and the associated consultation to inform its decision-making about preferred closure options for the FMC. The Oversight Committee's recommendation triggered a series of additional consultation requirements related to the project.

First, the Oversight Committee concluded that the complexity of the decision and the project warranted some detailed explanation of the rationale for the selected closure options for SFN and RRDC. This need was addressed by meetings in these communities in which members of the technical design team and the IPRP presented the recommended closure options and discussed how the proposed approach would resolve key community issues.

Second, Phase 3 of the consultation and communication plans obligated the team to provide communities and stakeholders with information about the decision that had been made. The closure planning team addressed this consultation need through a series of community meetings.

Third, the Oversight Committee's decision triggered the need for further consultation and discussion related to the environmental and socio-economic assessments of the proposed closure and remediation plan. With the closure options now selected, these consultations could now focus on how best to carry out the project to minimize adverse effects and maximize benefits. The closure planning team created an environmental and socio-economic assessment working group to facilitate compilation of input from stakeholders during the preparation of the environmental and socio-economic assessments. Membership on this working group included representatives from SFN, RRDC, LFN, the Town of Faro as well as the closure planning, environmental assessment and socio-economic teams and representatives of various federal and Yukon government departments.

Meetings and workshops conducted during the closure plan development and assessment stage are described in Table 2.4.

Table 2.4: Consultation and Participation Activities during Closure Plan Development and Assessment

Date	Group/Agency/Stakeholder	Purpose/Content
July 9, 2008	Meeting with Town of Faro, SFN, RRDC	Economic Preparedness for closure implementation.
September 27, 2008	Ross River community meeting.	Present and clarify recommended closure option.
September 28, 2008	Pelly Crossing Community Meeting	Present and clarify recommended closure option.
February 10, 2009	Faro Community meeting	Presentation of recommended closure option.
February 11, 2009	Ross River Community meeting	Presentation of recommended closure option.
February 12, 2009	Pelly Crossing Community meeting	Presentation of recommended closure option.
February 17, 2009	3 Meetings: with elders, with LFN Council, and Community meeting	Presentation of recommended closure option.
May 26, 2009	EA/SEA Working Group meeting	Status and issues re: EA/SEA.
May 28, 2009	Ross River EA/SEA Community Meeting	Status and issues re: EA/SEA.
May 28, 2009	Town of Faro EA/SEA Community Meeting	Status and issues re: EA/SEA.
June 9, 2009	Watson Lake EA/SEA Community Meeting	Status and issues re: EA/SEA.
June 16, 2009	Pelly Crossing, EA/SEA Working Group Meeting	Status and issues re: EA/SEA.
June 16, 2009	Pelly Crossing, EA/SEA Community Meeting	Status and issues re: EA/SEA.

As the environmental and socio-economic assessments have proceeded, the teams have utilized input received to refine the scope of the assessments (values, spatial scope, temporal scope), update baseline information, define appropriate mitigation and evaluate the significance of potential effects.

2.5 First Nations' Traditional Knowledge

From the beginning of the closure planning process, First Nations have stressed traditional knowledge as a valuable source of input for understanding the site and environment as well as the proposed project and its outcomes. The importance of traditional knowledge is highlighted as one of the guiding principles for the mine closure objectives endorsed by the Oversight Committee:

"Use traditional knowledge in the planning process, and give traditional knowledge the same weight as scientific knowledge."

As partners in the closure planning process, First Nations have been in a position to utilize traditional knowledge in their participation and to ensure that it is fully considered by other partners in the process. Because of the ongoing consultation with First Nations and the participation of First Nations in technical closure planning and overall decision-making, traditional knowledge has been inherently considered and incorporated throughout the closure planning process. In addition to this informal outcome, there have also been formal initiatives to compile and utilize traditional knowledge more explicitly.

All First Nations involved in the closure planning for the FMC have internal protocols for compiling, sharing and utilizating traditional knowledge information. Concerns about ownership of this information and its important contextual framework are paramount in these protocols. These protocols and concerns required careful management of the approaches for compiling and using traditional knowledge for the FMC closure and remediation project.

Early in the planning process, the need for traditional knowledge was identified for some specific studies and investigations. For some of these projects, specific agreements were reached between FNs and researchers to support the gathering and use of traditional knowledge information during the conduct of these studies. For example an investigation of terrestrial contamination from the Faro Mine relied heavily on traditional knowledge information to guide selection of species and locations for sampling. The results of this program were critical to evaluating human health risks – which are potentially tied to human uses of species and locations. Both of these studies continue to provide formative input for the environmental and socio-economic assessments.

As the closure planning proceeded, the team recognized that compilations of traditional knowledge by First Nations were often constrained by resource issues. To ensure that the First Nations affected by the Faro Mine could compile relevant information, each of the First Nation community offices received funding to conduct traditional knowledge studies. The First Nations each led these studies and compiled information, utilizing their internal processes to determine what information could be shared with whom, and how it could be used. These traditional knowledge programs took place over a period of two to three years and the results continue to the First Nations' participation and input for closure planning. In addition, the components shared directly with the closure planning team continue to be incorporated into the closure plan design as well as the environmental and socio-economic assessments.

2.6 Conclusion

Consultation has been an integral component of through all stages of closure planning for the FMC. In fact, consultation has been only one component of a broader community engagement strategy aimed at securing broad public understanding and support for the project through involvement in all stages of project planning. For First Nations, the consultation is a key component of ensuring that these governments can fulfill their broader role as decision-makers and partners in the process.

Chapter 3

Project Location and Current Site Conditions

3 Project Location and Current Site Conditions

3.1 Project Location

The Faro Mine Complex is located approximately 200 km north northeast of Whitehorse, the capital of the Yukon Territory (Figures 3.1). The Faro Mine Complex consists of the Faro Mine and Tailings areas, located approximately 15 km north of the Town of Faro, and the Vangorda/Grum area located approximately 9 km northeast of the Town of Faro (Figure 3.2). A 12 km haul road connects the two sites. The Faro Mine area includes the Faro Pit, waste rock dumps and the former ore processing facilities which have been retrofitted for water treatment purposes. The Tailings area includes a series of dams and impoundments located below the mine in the Rose Creek valley. The Vangorda/Grum area includes the Vangorda and Grum Pits and waste rock dumps, as well as water treatment facilities. All ore from Vangorda/Grum area was processed at the Faro Mine, so there are no processing or tailings in the Vangorda/Grum area.

The mine sites are located in the watersheds of two tributaries of the Pelly River. The Faro Mine and Tailings areas are in the Rose Creek watershed, which drains to the Pelly River via Anvil Creek. The Vangorda/Grum area is in the Vangorda Creek watershed, which joins the Pelly River at the Town of Faro.

The entire complex falls within the traditional territory of the Kaska Nation. Before mine development, the Kaska people from the area utilized the area around the mine extensively for traditional activities. The Pelly River downstream of the mine site bisects the traditional territory of the Selkirk First Nation and is integral to the life and health of its people.

Figure 3.3 provides an overview of the Faro Mine Complex. For closure planning purposes, the Complex was divided into the three areas shown in Figure 3.2, namely the Faro Mine area, the Tailings area, and the Vangorda/Grum area. Each of these areas is described below. These short descriptions are only intended to provide an orientation that will prepare the reader for the subsequent discussions of the assessment of the proposed closure and reclamation plan. Descriptions of the site components and environmental conditions were compiled and summarized in detail in "2004 2008 Water Licence Renewal – Environmental Assessment Report" (Gartner Lee Ltd., 2003). Technical reports describing subsequent studies, investigations and designs provide additional detail about specific components and are referenced below where appropriate.

3.2 Current Site Conditions

3.2.1 Faro Mine Area

Figure 3.3 provides an overview of the Faro Mine Area which includes the Faro Pit, Faro waste rock dumps, Faro Creek Diversion, ore stockpiles, the mill and other ancillary facilities.

Mining at the Faro Mine Complex began along the northwest side of the Faro Pit. The pit was expanded to the west and south until it reached its current size of roughly 1700 m long and 1000 m wide. The pit was allowed to flood in the 1990s, after the economically extractable ore was mined, and now contains a water body that is commonly referred to as the Faro Pit lake. The walls of the pit contain significant pockets of mineralized rock. Above the water level, this rock continues to release contaminants into the pit lake. Much of the south and east walls of the pit are covered by waste rock that also release contaminants into the water. The northeast pit wall is physically unstable, and is gradually ravelling downwards into the pit. The water level in the Faro Pit is maintained safely at about 15 m below the overflow elevation to the receiving environment (via Zone II pit). Annual pumping and treatment is carried out to manage the water level. Approximately 1.5 million m3 of water is pumped annually from Faro Pit to the treatment plant

A second pit to the southeast, known as the Zone 2 Pit, was mined in the 1970's and 1980's. The Zone 2 pit was subsequently backfilled with waste rock and is no longer visible on surface. There is, however, a continuing need to extract contaminated water from the backfilled pit. Underground mining areas were also developed to the southwest of the main pit, through a portal that is now submerged by the pit lake.

Waste rock was deposited in a series of dumps that surround the pit. There is now a total of about 260 million tonnes of waste rock in the Faro dumps, and they cover roughly 335 ha of surface area. There are roughly 30 separate dumps, each with a unique history and composition.

The geochemistry of the dumps has been studied extensively (SRK 2004a, 2004b, 2006a, 2007a) and much of the waste rock at the Faro Mine Area is acid-generating and is leaching metals. At the broadest level, it is helpful to distinguish three groupings. The most mineralized material occurs in a series of low grade ore and oxide fines stockpiles. Although that material represents less than 10% of the total volume of waste, it has a high metals content and is therefore a significant source of contaminants. The next most mineralized material is found in three sulphide cells, which are areas where sulphide waste was purposefully segregated during some of the mining. The sulphide cells are not as well delineated as the low grade ore and oxide fines, so volumes are harder to estimate. But the relatively high metal content and acid generating potential of the material suggest that the sulphide cells are also disproportionately large sources of contaminants. The remainder of the waste rock dumps are variable in composition. In general however, there are areas of acidic and metal-leaching waste in most of the dumps, and none of the dumps can be considered completely benign.

Infiltration through waste rock dumps is leading to contamination of groundwater at the Faro Mine Area. This groundwater contamination is causing increasing contaminant levels in some surface waters, though these surface water changes are not ecologically significant at this time. Contamination of groundwater is expected to increase significantly in the future.

Two main areas of groundwater contamination have been identified between the North Fork of Rose Creek and the adjacent waste dumps. The Zone II Pit outwash area is located below the Zone II Pit, and the so-called "S-Well" area is located below at the southernmost extension of the Main Dump,

where it branches off to the Vangorda haul road (SRK 2006b, 2007b). These areas are both located close to the North Fork of Rose Creek.

Recent investigations of groundwater and surface water quality in the S-Well area indicated high levels of contaminants in close proximity to the North Fork of Rose Creek with a component of the contaminated groundwater discharging into the creek. In addition, increasing trends in contaminant levels within the creek were evident, particularly in the winter low flow period. In early 2009, a first phase groundwater interception system was installed in the S-Well area with the collected water being pumped to the Faro Pit. This system was subsequently upgraded in the fall of 2009.

Studies conducted in the Zone II Pit outwash area have identified that contaminated groundwater is likely seeping from the waste rock dumps with potential contribution from the outwash area itself and, perhaps the Zone II Pit. Presently this area is not currently contributing a significant load to the North Fork of Rose Creek, contaminated groundwater could eventually, if not already, travel down gradient in the permeable materials underneath the creek and possibly discharge to the creek downstream.

Significant groundwater contamination has also been identified in the Emergency Tailings Area (ETA), located below the mill and stockpiles (SRK, 2006c). As the name suggests, the area was used for emergency deposition of tailings, but recent studies have shown that the groundwater contamination arises at least in part from the waste rock located above the tailings. The ETA is also the only point in the Faro Mine area where there is significant surface water seepage from the waste rock. (Other seeps are ephemeral or internal.) Measures to capture the ETA surface and groundwater, and send it directly to water treatment, were implemented in 2007 which provides for seasonal collection and treatment of water from this area. In 2010 this system will be upgraded to include year-round collection.

Faro Creek initially flowed directly over the Faro Pit area and joined Rose Creek near the middle of the current tailings area. As the pit expanded, it was necessary to re-route the creek into its current alignment. The Faro Creek Diversion Channel captures the water above the northernmost dumps and routes it to the northeast of the pit where it flows into the North Fork of Rose Creek. The Faro Creek West Valley Interceptor Ditch collects runoff from the west hillside above Faro Creek and directs the flow into the diversion. The diversion has been upgraded several times. However, recent studies have shown that it is not stable for the long term, and specifically further movement of the northeast pit wall will breach the channel if it is left in its current alignment (Golder Associates Ltd., 2004a).

The North Fork of Rose Creek flows below and to the southeast of the Faro mine area. The North and South Forks of Rose Creek join immediately upstream of the tailings area. The North Fork of Rose Creek passes in close proximity to several large waste rock dumps and flows through a rock drain constructed as part of the Vangorda haul road.

Water Treatment for the removal of zinc and other contaminants has been conducted at the Faro Mine Area for may years. This has involved water treatment using lime in the former mill as well the use of a simplified lime addition system to treat water from the Intermediate Pond. The water treatment system in the mill utilizes several modified components for the former milling facility. The system relies on lime addition and mixing in modified flotation cells with clarification in former tailings thickeners. Water from the mill treatment system is discharge to the Cross Valley Pond for polishing prior to discharge to the receiving environment. Sludge or treatment solids generated in the mill treatment system is pumped to a bermed sludge storage facility on the Original Impoundment.

Water treatment at the outflow of the Intermediate Pond (the "Down Valley") was started in 1992. Water treatment has continued, on an as-required basis, since that time, to reduce the water levels in the Intermediate Pond. The methods employed for the treatment have involved raising the pH of the Intermediate Pond effluent with lime and subsequently utilizing the Cross Valley Pond for settlement of the treatment sediments.

Ore processing took place in the mill complex located just southwest of the mine area. There are a number of structures in the mill area that remain in use, including the office, warehouse and the portions of the mill that have been converted to water treatment. The mill pad appears to consist of a range of rock materials, with hydrocarbon and metal contamination evident in many areas in the mill area (Gartner Lee Ltd., 2006a).

3.2.2 Tailings Area

Figure 3.4 provides an overview of the Tailings Area which includes four dams (three tailings storage dams and one water polishing pond dam), the Rose Creek Diversion and various ancillary facilities.

Throughout most of the operating periods at the Faro Mine Complex, tailings were deposited in the three impoundments that comprise the Rose Creek Tailings Facility. The Original Impoundment was used from 1969 to 1975, has a surface area of 41.7 hectares, and holds about 6,300,000 m3 of tailings. The Secondary Impoundment was used from 1975 to 1982 and again in 1986. It has a surface area of 54.5 hectares and contains about 10,400,000 m3 of tailings. The Intermediate Impoundment was used from 1986 to 1992, has a surface area of 99 hectares and contains about 11,900,000 m3 of tailings. In total, there are 28.6 Mm3 of tailings in the Tailings Area. Tailings produced from 1992 to 1998 were deposited in the Faro Pit.

The impoundments were created by a series of dams and dam raises. The dams that created the Original Impoundment are now almost entirely buried by the secondary tailings, but the Secondary and Intermediate Dams remain in function. The east limb of the Secondary Dam is relatively low, rising only about 4 m above the natural topography. The west limb of the Secondary Dam is higher, rising about 27 m, about half of which is now covered by the intermediate tailings. The Intermediate Dam is about 35 m high at its highest point.

The stability of the dams has been comprehensively investigated. Those studies concluded that the Intermediate Dam would be stable in the Maximum Credible Earthquake (MCE), but that weaknesses in the underlying soils mean that the Secondary Dam would require upgrading in two areas to ensure stability in the MCE (Klohn Crippen 2006a, 2006b). The geotechnical properties of the tailings have also been studied in detail, and the conclusion is that they would be subject to liquefaction and localized movement even in earthquakes that are less strong that the MCE (Golder Associates 2004b, 2006a, 2006b).

The Cross Valley Dam is located about 500 m downstream of the Intermediate Dam. It has a maximum height of about 19 m and creates a polishing pond for treated water discharged from the Intermediate Impoundment and the mill water treatment system. Studies of the stability of the Cross Valley Dam indicate that the underlying soils could liquefy in the MCE, and that substantial upgrades would be required to ensure stability (Klohn Crippen 2006a, 2006b).

The tailings contain an excess of acid generating sulphide minerals, and in fact most of the exposed tailings surface is quite acidic, with very high levels of soluble metals. The acidic conditions extend up to 6 m deep in the Original Impoundment. Precipitation passing through the tailings picks up some of the soluble contaminants and transports them down into the underlying tailings and soils.

Extensive groundwater investigations throughout the tailings area have identified an essentially continuous aquifer of sand and gravel outwash below the tailings. Sampling to date has identified increasing trends in concentrations of some contaminants in some areas beneath the tailings. However, this groundwater contamination is limited and is not ecologically significant at this time. One possibility is that the contaminants are being temporarily held up by reactions with the organic soils that lie between the tailings and much of the aquifer. Contamination of the groundwater below the tailings is expected to increase significantly at some time in the future. (Gartner Lee Ltd., 2007, Robertson GeoConsultants 2006, SRK 2006d).

A number of water management structures are also present in the tailings area. The most significant of these is the Rose Creek Diversion Channel, which routes the entire flow of Rose Creek around the tailings impoundments and Cross Valley pond. Recent reviews of the diversion and the local hydrology have concluded that the present configuration of the diversion can accommodate a 1:500 year flood event. Larger floods would spill onto the surface of the Intermediate Impoundment, overwhelm the small spillway on the Intermediate Dam, and breach the Intermediate Dam and the Cross Valley Dam. Other water management structures of note include Guardhouse Creek and the North Wall Interceptor Ditch, which divert clean water from the north side of the valley, and the emergency spillways around the Intermediate and Cross Valley Dams.

3.2.3 Vangorda/Grum Area

Figure 3.5 provides an overview of the Vangorda/Grum Mine Area which includes the Vangorda Pit, Vangorda Waste Rock, Grum Pit, Grum Waste Rock, Grum Overburden, Vangorda Water Treatment Plant, Little Creek Dam and various ancillary facilities.

The Vangorda pit is about 1150 m long and 350 m across at its widest point. The deepest point in the pit was about 150 m from the crest, but the bottom of the pit is now completely flooded. The southeast half of the pit is narrower and shallower, and includes a ramp and ore and waste stockpiles. Water quality in Vangorda Pit is the worst of the three pits on the site (SRK 2006e). Annually during the open water season, water is pumped from Vangorda Pit to the Vangorda Treatment System for treatment prior to discharge to Vangorda Creek.

The Grum pit is roughly circular with a diameter of about 1000 m from crest to crest. A ramp that was cut as part of the Phase 2 expansion extends a further 300-400 m to the southeast. The north wall of the Grum Pit is a till slope that is gradually sliding into the pit. The pit bottom has been allowed to flood. Pit wall rock and waste rock continue to release contaminants into the water that accumulates in both pits. Presently, contaminated water in Grum pit is currently treated biologically in-situ by the addition of nutrients to the pit, resulting in stabilization and settling of contaminants.

There are three waste rock dumps in the Vangorda/Grum area: the Vngorda Dump, the Grum Dump, and the Grum Overburden Dump. There are a number of much smaller waste deposits in the area, for example above the Vangorda Pit ramp and on the ore transfer pad located to the west of the Grum Pit.

The Vangorda Dump contains about 16 million tonnes of material and covers about 40 hectares. Geochemical studies of the Vangorda Waste Rock indicate that the Vangorda waste is net acid generating. The walls of the Vangorda Pit and the in-pit dumps are also net acid generating and are strong sources of acidity and metals. The Vangorda waste rock dump includes a seepage collection system and all water collected requires treatment before it can be released. The seepage from the dump is captured by a ditch and stored behind Little Creek Dam prior to transfer to the Vangorda pit and eventually the water treatment plant. The contaminant load from the Vangorda waste rock is expected to continue increasing over the next few decades, and water will require treatment for several centuries. Without collection and treatment, contaminated loads would severely impair aquatic ecosystems.

The Grum Dump contains about 28 million tonnes of waste covering about 128 hectares. It includes a sulphide cell where most of the Grum sulphidic waste was placed. The sulphide cell in the Grum Dump also contains strongly acid generating material, but the remainder of the Grum Dump contains only pockets of acidic material (SRK 2004a, 2007a). Water quality down-gradient of the Grum Dump has also begun to deteriorate, but does not currently require treatment. Groundwater contamination is expected to increase in the future.

During operations, Grum ore was hauled out of Grum Pit and stored on the Grum Ore Transfer Pad prior to being hauled to the Faro mill. The current understanding is that the ore transfer pad was constructed by placing clean phyllite waste on original ground northwest of the pit to form a large, level to moderately sloping facility to accommodate transfer of ore to trucks for the haul to Faro. Operating practice was to temporarily store ore above grade on the ore transfer pad and some ore remains stockpiled at this time.

The Grum Overburden Dump covers about 46 hectares and contains overburden and till that was stripped from the surface of the Grum deposit.

The major water management structure in the area is the Vangorda Creek diversion. Prior to mining, Vangorda Creek flowed directly over the Vangorda deposit. The diversion was constructed to capture the creek and route it along the northwest rim of the pit. However, the diversion was designed for only a 1:100 year flood event, and it has required extensive maintenance since mining ceased. Furthermore, the pit wall below the diversion is expected to ravel back over time, and eventually cut off the current alignment of the diversion.

Other water management structures in the area include a water treatment plant and settling pond located above the Grum Pit, which are used to treat water from the Vangorda Pit and Waste Rock. There are also a number of small ditches and sediment ponds around both the Grum and Vangorda pits. The Grum Interceptor Ditch diverts Grum Creek in a riprapped channel around the upper perimeter of the Grum Pit and discharges the flow into the sedimentation ponds called the Sheep Pad Ponds, built to capture sediment from the Grum Interceptor Ditch before discharging into Vangorda Creek.

The Vangorda Water Treatment Plant was constructed in 1990 as part of the initial development of the Vangorda/Grum Mine Area. It is a conventional lime treatment system with an associated clarification pond. Sludge from the clarification pond is removed by suction truck and deposited in an interim sludge disposal facility located on the Grum Overburden Dump.

3.3 Site Operational History

Anvil Mining Corporation began operating the Faro Mine in 1969 and continued operations, under the name Cyprus Anvil Mining, until 1982 when economic conditions forced a shut-down. To support tailings disposal, Cyprus Anvil developed three tailings impoundments in the Rose Creek Valley. The second one, constructed in 1974, required an initial diversion of Rose Creek. The third one, developed in the early 1980s, necessitated construction of the existing Rose Creek Diversion Channel and two dams across the Rose Creek Valley.

Operations at the Faro Mine resumed under Curragh Resources Ltd. in 1986. Curragh recognized limited remaining resources in the Faro Pit and began seeking approvals and constructing infrastructure, including the 12 km Vangorda Haul Road, for mining at the Vangorda/Grum Mine. Mining at Vangorda commenced in 1990 and continued, concurrent with mining at Faro Mine, until mid-1992 when resources in the Faro Pit were depleted. Once mining ceased in Faro Pit, Curragh began depositing tailings in the Faro Pit. In late 1992, Curragh sought bankruptcy protection and ceased mining operations.

Operations resumed in 1994 under Anvil Range Mining Corporation who continued mining the Vangorda deposit and proceeded with the development of the Grum Deposit. Stripping of the Grum Pit began prior to the 1993 94 shutdown, but the bulk of the Phase 1 mining occurred from 1994-98.

Processing of ore from the Grum deposit began in mid-1995. Anvil Range Mining Corp. terminated mining operations in late-1996 for economic reasons and, following a financial restructuring, restarted in 1997. Mining continued until 1998 when Anvil Range ceased mining operations and sought bankruptcy protection, with Deloitte and Touche Inc. appointed as interim receiver. At the time of closure, an expansion of the Grum Pit was underway and approximately 3-6 years of additional mining was anticipated. The mine has not operated since 1998 and is now considered permanently closed.

In 2003, after seeking independent expertise about remaining mineral values at the mine, the federal and territorial governments concluded that the Complex did not have sufficient remaining value to support renewed operation or the costs associated with mine closure and reclamation. At that time, the governments agreed to accept responsibility for closure planning and closure implementation at the Faro Mine Complex.

The Faro Mine Complex has remained in care-and-maintenance mode since 1998. From 1998 to 2009 care and maintenance activities were carried out under the control of the court appointed interim reeiver, Deloitte and Touche Inc. In March 2009, care and maintenance responsibilities at the Faro Mine Complex were taken over by Denison Environmental Services under a three-year contract overseen by Government of Yukon. Ongoing care and maintenance activities include:

- Ongoing collection and treatment of contaminated water;
- Management of uncontaminated runoff;
- Inspection and maintenance of dams and diversion channels;
- Environmental monitoring including water quality and flow;
- General maintenance;
- Site security; and
- Various early reclamation activities to ensure ongoing protection of the receiving environment.

3.4 Closure Issues

The brief site descriptions provided above mention most of the issues that drive the need for implementation of a closure and reclamation plan at the Faro Mine Complex. In general, the key issues relate to public and worker safety, contamination of water, risks from severe events (i.e. floods and earthquakes), contamination of air and land by dust, and possible direct contact of humans and animals with metal-rich waste materials. All of the components of the proposed closure and reclamation plan discussed in this report are designed to address these issues.

Tables 3.1 to 3.3 provide component-by-component summaries of concerns that will need to be addressed by any closure plan.

Table 3.1: Closure Issues – Faro Mine Area

Site Component	Description of Issues
Faro Creek Diversion	The Faro Creek Diversion is located immediately adjacent to the Faro Pit. Flood flows or raveling of the pit wall will eventually breach the diversion causing the clean Faro Creek water to flow into the contaminated Faro Pit. If not corrected, this would lead to release of contaminated water from the pit, causing severe effects on aquatic ecosystems.
Faro Pit	Without pumping/treatment, the Faro Pit would eventually fill with water and overflow because inflows from runoff and seepage exceed outflows. The quality of water in the pit is affected by mineralized rock on the pit walls and by surrounding waste rock. The pit cannot be allowed to overflow because the water quality of the pit water would severely affect aquatic ecosystems if released without treatment. The water would be further contaminated because it would flow through the waste-rock-filled Zone 2 Pit before reaching the environment. Water quality is expected to remain problematic for several centuries.
Oxide Fines & Low-Grade Ore	The oxide fines and low-grade ore stockpiles are strongly mineralized materials and contain significant soluble contaminants. These stockpiles are contaminating groundwater. Without remediation, the level of contamination would increase over the next few decades, continue for several centuries and be sufficient to severely impair aquatic ecosystems. Oxide fines and low-grade ore may be contributing to transport of contaminants by dust.
Waste Rock	Much of the waste rock from the Faro Mine is acid-generating and will leach metals. The leaching process has begun and, without remediation, the contaminant loading from these materials would increase over the next several decades and continue for several centuries. While there are some segregated pockets (i.e. sulphide cells) of strongly acid-generating waste rock, the waste rock at the Faro Mine Site is generally poorly segregated. As a result, all of the waste rock dumps at Faro would release contaminants and could lead to severe contamination of aquatic ecosystems. Waste rock may be contributing to transport of contaminants by dust.
Emergency Tailings Area	Tailings and other materials placed in the old Faro Creek channel are leading to contamination of groundwater in this area. Waste rock dumps upgradient of the Emergency Tailings Area (ETA) are also contributing to the contaminant loads. The old Faro Creek channel likely serves as a conduit for transmission of contaminants into the aquifer in the Rose Creek Valley where, without collection and treatment, they would contaminate Rose Creek (RGC, 2006). If the loads present in the ETA were to reach Rose Creek, they would cause severe effects on the aquatic ecosystem. The ETA may be contributing to transport of contaminants by dust.

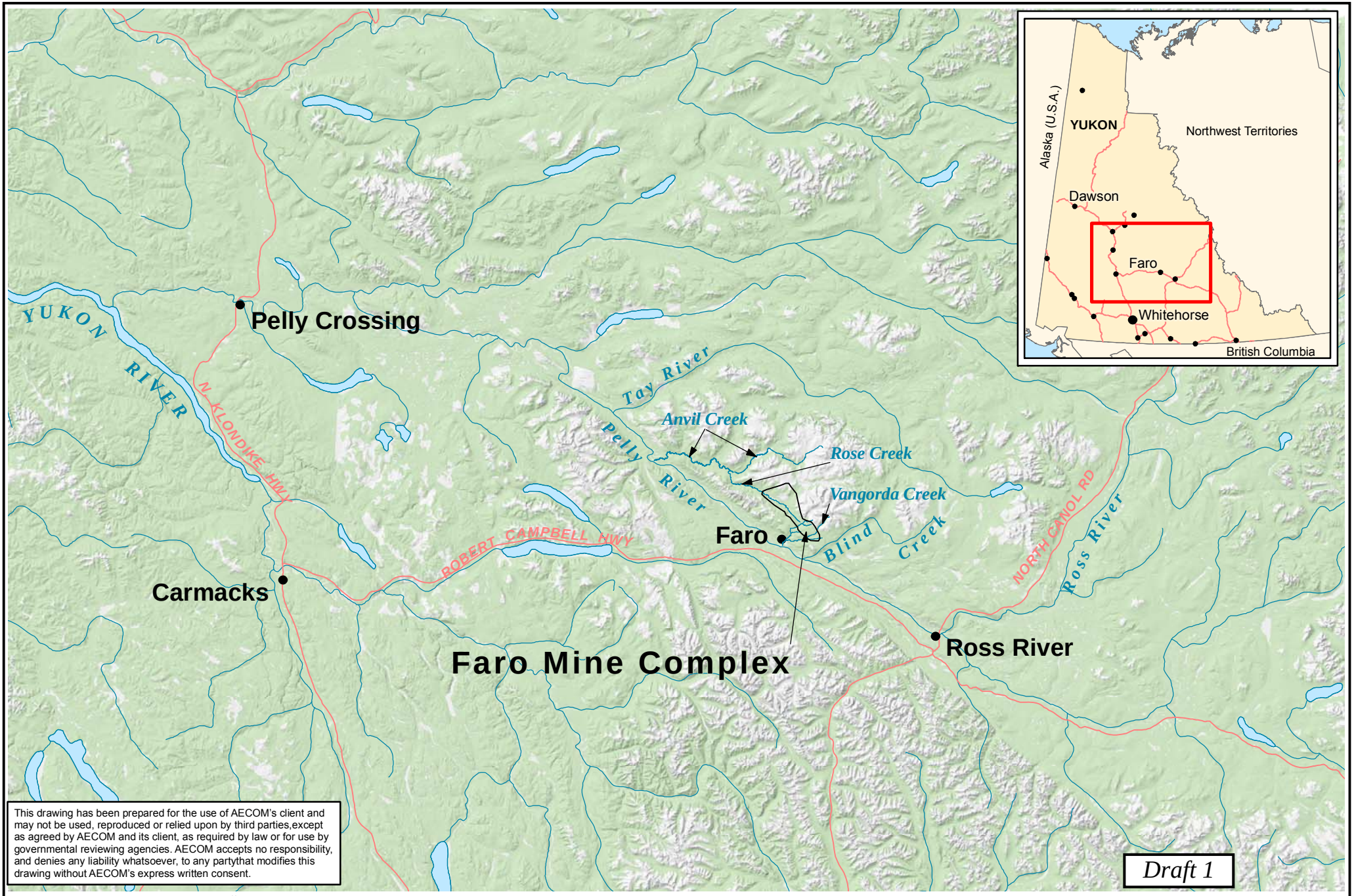
Table 3.2: Closure Issues – Tailings Area

Site Component	Description of Issues
Tailings	There are approximately 57 million tonnes of tailings stored in the Rose Creek Valley, behind three dams. The tailings are strongly acid-generating and those that have been exposed to air contain very high levels of soluble contaminants. These contaminants are moving down through the tailings and into the underlying sand and gravel aquifer (RGC, 2006). Although monitoring indicates that contaminants are not yet causing adverse effects on the aquatic environment, it also shows that some contaminants are mobile in the aquifer. Attenuation appears to be delaying the release of contaminants of concern, but this is expected to be temporary and once breakthrough occurs, the contaminant loads are expected to be sufficient to severely impair the aquatic ecosystem unless contaminated groundwater is collected and treated (SRK, 2006e). The tailings are expected to remain as a source of contaminants for several centuries. Contaminant transport in dust from the exposed tailings surface is causing widespread contamination of the terrestrial environment (GLL, 2006b). Without remediation, continued long-term accumulation of these contaminants in the surrounding environment would lead to adverse effects on the health of species that are of ecological and cultural importance (SENES, 2006).
Rose Creek Diversion	The Rose Creek Diversion which carries Rose Creek around the tailings and tailings dams is located above, and adjacent to, a large portion of the tailings and two major dams. A failure of the diversion during a flood could cause a dam failure and/or erode tailings, leading to severe effects on the downstream aquatic ecosystem. Such a failure would also affect traditional uses by local people, especially Selkirk First Nation citizens who live downstream. The flood routing capacity in the Rose Creek Valley needs to be upgraded because the current diversion does not have sufficient capacity for a probable maximum flood (Water Management Consultants, 2006, Taylor, 2005), the design event considered necessary for this facility. The current facility also requires upgrading to address susceptibility to other failure modes.
Tailings Dams	The tailings dams must provide a stable location for tailings containment because release of tailings to the environment would cause unacceptable long-term ecological effects. To avoid any tailings release, the dams must be capable of withstanding severe floods and earthquakes. The dams must perform satisfactorily for several centuries because the tailings are expected to remain a source of contamination in the long-term. Some dams need upgrading so that they can withstand the Maximum Credible Earthquake – the design event considered necessary for these facilities (Klohn Crippen, 2006a, 2006b).

Table 3.3: Closure Issues – Vangorda/Grum Mine Area

Site Component	Description of Issues
Vangorda Creek Diversion	The Vangorda Creek Diversion is located immediately adjacent to the Vangorda Pit. The Diversion was not designed for long-term service as the initial project plan envisioned re-routing of Vangorda Creek back through the mined-out Vangorda Pit. This is no longer possible due to water quality. The existing diversion requires extensive, ongoing maintenance and repairs to keep it functional. Without an upgraded diversion, flood events will breach the diversion causing clean Vangorda Creek water to flow into the contaminated Vangorda Pit. Storage in the Vangorda Pit is limited and if a diversion failure were not corrected quickly, it would lead to release of contaminated water from the pit, causing severe effects on aquatic ecosystems.
Vangorda and Grum Pits	Without pumping/treatment, the Vangorda and Grum Pits would both fill with water and overflow because inflows from runoff and seepage exceed outflows. The quality of water in both pits is affected by mineralized rock on the pit walls and by surrounding waste rock. The quality of water in Vangorda Pit is currently the worst of all three pits at the Faro Mine Complex. Vangorda Pit is also the smallest pit and would overtop most quickly without pumping and treatment. Water quality in Vangorda Pit is expected to remain problematic for several centuries. Release of this water without treatment would cause severe effects on the aquatic ecosystem. Without treatment, water quality in Grum Pit would also remain problematic at least for decades. The contaminant loads in Grum Pit, though sufficient to impair aquatic ecosystems, are not expected to be as severe as for Vangorda Pit.
Vangorda Waste Rock	The Vangorda Waste Rock dump contains a high proportion of acid-generating materials. Seepage from the Vangorda Waste Rock dump is currently collected and treated. The contaminant load is expected to continue increasing in the next few decades, and the water will likely require treatment for several centuries. Without collection and treatment, contaminant loads would be sufficient to severely impair aquatic ecosystems if not collected and treated.
Grum Waste Rock	The Grum Waste Rock Dump contains a segregated sulphide cell. Monitoring indicates that contaminant loading from the Grum Waste Rock dump is increasing over time. Without remediation, contaminant release from the sulphide cell and the other waste would increase over the next few decades, continue for several centuries and severely impair aquatic ecosystems. The sulphide cell will be the main source of contamination from the Grum Waste Rock.

Figures



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Draft 1

Map notes:

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UTM Zone 8N, NAD83

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Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File Name: 60119234_Fig1-1_Faro Complex Location Overview_v2_rh_18Feb2010.mxd

Faro Mine Complex
Closure and Remediation

Project Proposal

Faro Mine Closure
Location Map

Date:	Approved:	FIGURE:
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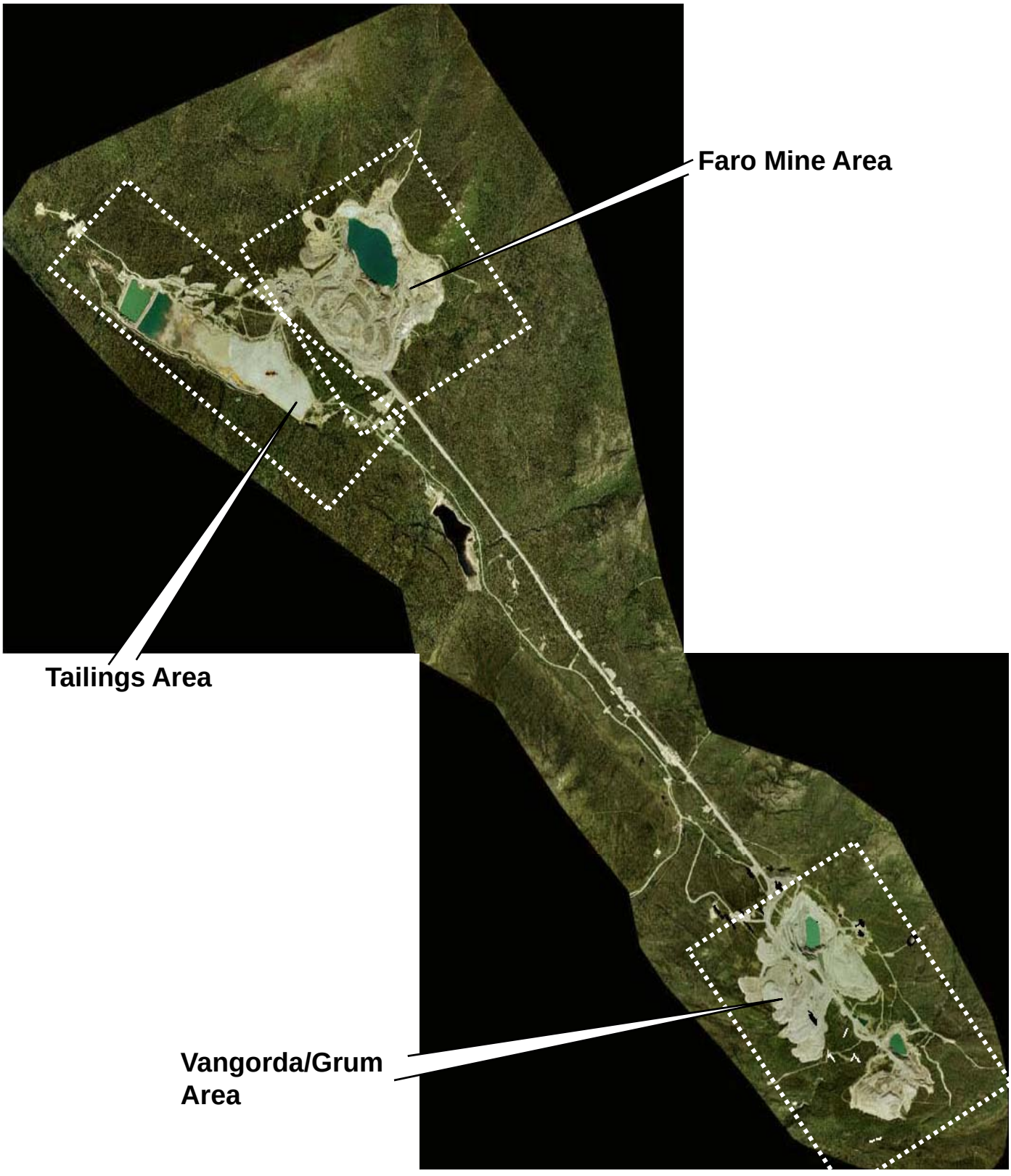

Source: SRK Consulting

Faro Mine Closure / Fermeture de la mine Faro	Faro Mine Complex Closure and Remediation	Closure Areas
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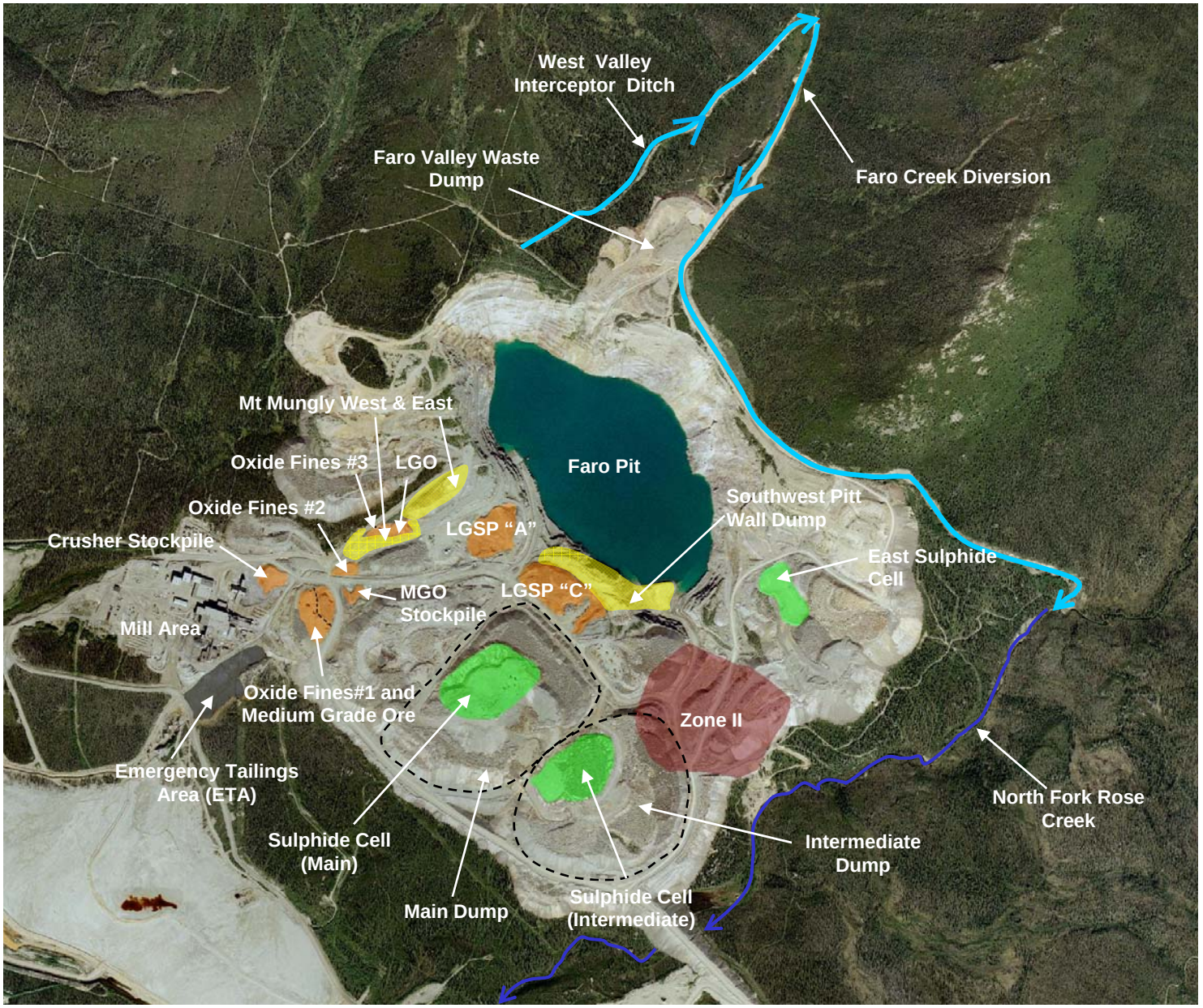

Source: SRK Consulting

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Faro Mine Area and Major Components

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Date: February 2010

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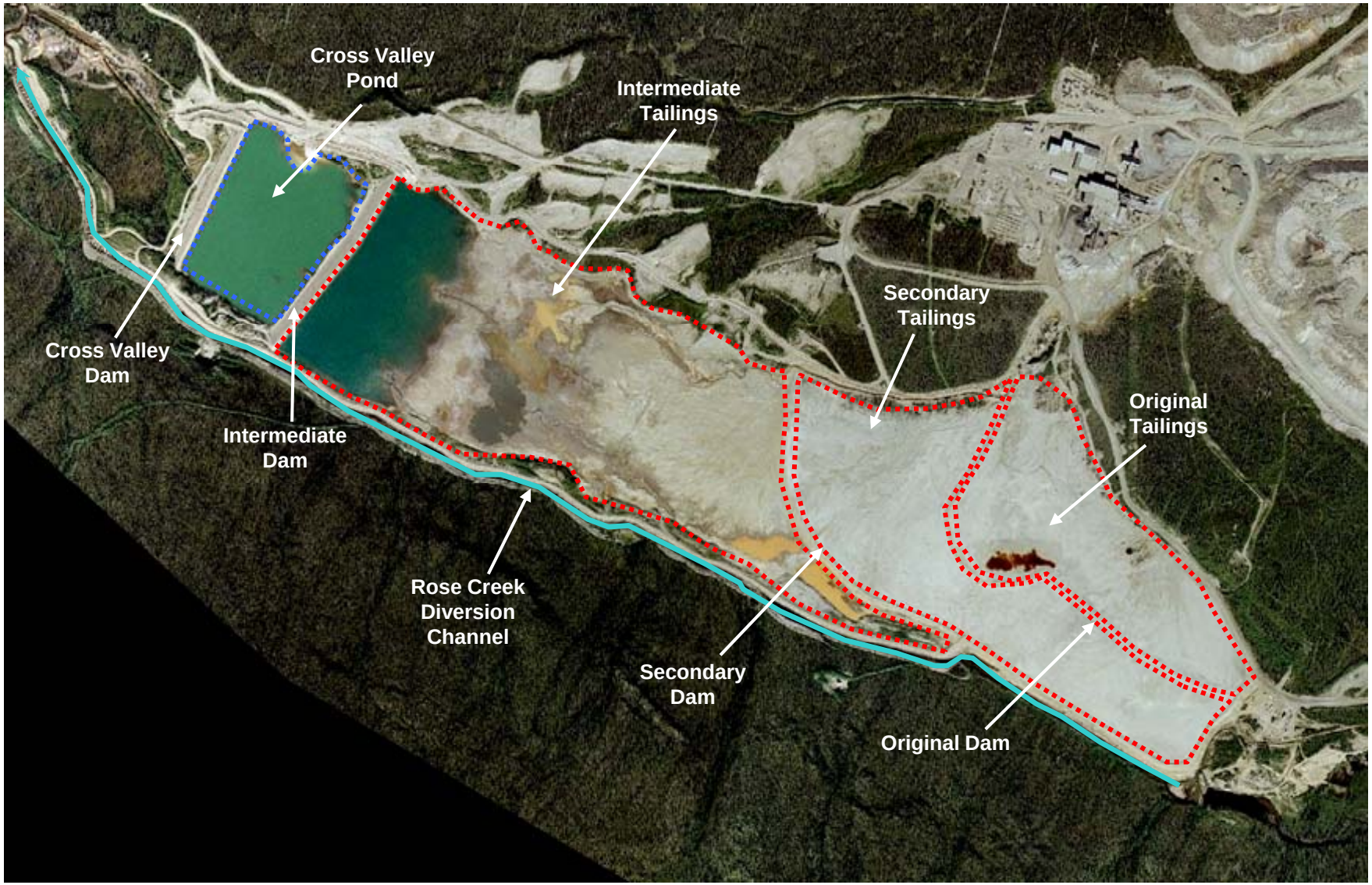

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Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Tailings Area and Major Components

Job No: 1CY001.026

Filename: Figures 3.3-5_AreaComponents_20100215.ppt

Project Proposal – Draft 1

Date: February 2010

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Figure: 3.4

Source: SRK Consulting

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Vangorda/Grum Area and Major Components

Job No: 1CY001.026

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Chapter 4

Current Environmental Conditions

4 Current Environmental Conditions

4.1 General

The Faro Mine Complex covers two major areas: the Faro mine area (Faro Site) and the Vangorda/Grum area (Vangorda/Grum Site). The Faro Site contains the major historic operations of the mine where the Faro Main Pit, mill, tailings impoundments, tailings ponds and waste rock piles are located. The Vangorda/Grum Site is 16 kilometres southeast of the Faro Site and contains two smaller open pits and waste rock piles as shown in Figure 3. 2.

4.2 Climate and Atmospheric Environment

4.2.1 Climate

The Faro Mining Complex is located in the Anvil Range Mountains within the Macmillan Highlands of the Yukon Plateau-North ecoregion, (Janowicz *et al.* 2005) contained within the Boreal Cordillera Ecozone. The climate of the Boreal Cordillera Ecozone is marked by long cold winters and short warm summers and ranges from subhumid to semi arid with the coldest mean temperatures occurring in the Yukon Plateau Region (Environment Canada 2005). The climate is characterized as sub-arctic continental with a large annual range in temperature and relatively moderate amounts of annual precipitation. The strong seasonal variation in temperature is further accentuated by elevation difference. Winter temperatures can be 10 degrees lower in valley bottoms as compared to uplands, due to temperature inversions. During the summer months, temperatures adhere more closely to the environmental lapse rate with valley bottom temperatures higher than upland areas (Janowicz *et al.* 2005).

Data Sources

Data from meteorological stations operated by Environment Canada at the town of Faro and by the Faro Closure Office at the Faro Mining Complex were used to describe the climate in and around the mining complex. These stations can be seen on Figure 4.1. An elevation stations at the Faro Mining Complete are approximately 500 m higher in elevation than the ones at the Town of Faro. A description and discussion of the stations can be found in *Section 1.1.2 Current Environmental Conditions Supporting Document* (AECOM 2009).

Temperature

Temperatures at the Town of Faro are typical of the cold winters and warm summers seen in this region. The daily average temperature is lowest in January at -21.5 ^{o}C and highest in July at 15 ^{o}C. Temperatures at the Faro Mine Complex generally slightly cooler during the summer as would be expected with the elevation difference. Winter temperatures at the Town of Faro can be as much as 10 ^{o}C lower than at the Mining Complex due to temperature inversions (Janowicz *et al.* 2005).

A strong correlation was seen between temperatures at the Environment Canada Stations at the Town and Faro and the stations at the Mining Complex. These correlations can be seen on Figures 1.1-6 and 1.1-7 in the *Current Environmental Conditions Supporting Document* (AECOM 2009)

Wind

The majority of the winds at all the meteorological stations are in the calmer (0.5-5.7 m/s) to calm (<0.5 m/s) wind classes. Frequency of wind classes at the Environment Canada, Faro AUT Station show calmer winds 97% of the time and calm winds none of the time. The frequency of wind classes at the Faro on Site station show calm winds 9% of the time and calmer winds 88% of the time. The frequency of Wind classes at the VanGrum Station show calm winds 2% of the time and calmer winds 96 % of the time.

Wind directions are summarized in Table 4.1.

Table 4.1: Summary of Wind Directions and Faro Climate Stations

Station	Overall	Summer	Winter
Faro AUT	SW & NE	NW or SE	SE
Faro on Site	Southern Quadrants	All Directions	Eastern Quadrant (variable)
VanGrum on Site	NW & SE	NW & SE	NW & SE

Wind roses and frequency distribution charts can be seen on Figures 1.1-8 to 1.1-10 in the *Current Environmental Conditions Supporting Document* (AECOM 2009).

Solar Radiation

Solar radiation at the Faro Mine Complex varies considerably throughout the year due to it northern location. The lowest and highest daily average solar daily radiation occurs in December at 0.13 KW and June at 5.60 KW respectively. The daily average solar radiation for each month can be seen on Table 1.1-2 of the *Current Environmental Conditions Supporting Document* (AECOM 2009) and the variation throughout the period of record at the Faro Mine Complex can be seen on Figure 1.1-11 of the *Current Environmental Conditions Supporting Document* (AECOM 2009).

Precipitation, Evaporation and Evapotranspiration

Precipitation, evaporation and evapotranspiration are described in Section 4.6 Hydrology baseline summary.

4.2.2 Atmospheric Environment

For the purposes of this assessment, atmospheric environment refers to the conditions of the atmosphere in the vicinity of the project. These conditions will be described by the following valued components (VCs):

- Air quality; and

- Greenhouse gases (GHGs).

Air quality has been selected as a VC because of its intrinsic importance to the health and well-being of humans, wildlife, and vegetation.

GHGs have been selected as a VC because of their intrinsic importance to climate change as a regional and international issue.

Local Study Area

The local study area (LSA) for the assessment of air quality and GHGs is the zone of influence of the project air emissions, including the sensitive receptors nearest to the mine site.

Air Quality and GHG Issues

Air quality and GHGs baseline information was collected for the LSA and is summarized in this section. Both the construction and post-closure phases related to the proposed remediation activities can affect local air quality through the release of airborne dust, diesel emissions, and release of mine associated tailings. The mine closure also has the potential to affect existing GHG levels during its construction phase due to increased diesel emissions.

Baseline Ambient Air Quality Assessment

Baseline ambient air quality data were obtained from federal emission inventory reports, and site specific ambient air quality monitoring. Ambient air quality objectives and standards from the federal and Yukon governments were used to assess the existing ambient air quality surrounding the Faro mine site. The federal air quality objectives included:

- National Ambient Air Quality Objectives (NAAQOs); and
- Canada-Wide Standards (CWS).

The Yukon government has endorsed the CWS for $PM_{2.5}$ through the Canadian Council of Minister of the Environment (CCME).

For contaminants that did not have criteria outlined by the federal or Yukon governments, air criteria from British Columbia were used. British Columbia is the next nearest jurisdiction and shares some common air quality issues and concerns with Yukon. As such, air criteria from this province are considered reasonable to assess existing air quality. British Columbia has set ambient air quality criteria for all key air quality indicators, except for some of the particulate matter constituents. To fill these gaps, air quality criteria from Ontario were used.

RWDI conducted two ambient air monitoring programs in 2005 to assess ambient air quality in the project region. No useful data were obtained. Due to very wet weather conditions during the sampling period, negligible amounts of fugitive emissions were detected from the mine site during both sampling programs (RWDI 2005).

In 2008, Senes Consultants Limited conducted an ambient air monitoring program for total suspended particulates (TSP) and fine particular matter (PM_{10}). Samples were collected at eight sites located in the Faro Mine Complex and one site in the town of Faro. The sampling period was 24 hours. The monitoring program took place in July, August, September and October. Figure 4.1 depicts the locations for the air monitoring sampling stations for this program.

All TSP and PM_{10} concentrations were below federal and provincial ambient air quality criteria. The maximum TSP result (95 $\mu g/m^3$) occurred in the Vangorda and Grum Area on the breach dam beside the effluent discharge pond between the Vangorda and Grum pits. The maximum PM_{10} result (19 $\mu g/m^3$) occurred in the Vangorda and Grum Area, northwest of the Grum pit beside the ore transfer pad.

This analysis included data from three days with elevated 24-hour precipitation (greater than 1mm). Precipitation is known to scavenge suspended particles through a process known as wet deposition, thereby reducing the atmospheric concentration. The amount and frequency of precipitation during the Senes sampling program did not significantly affect data collection or the results.

The particulate concentrations were also analyzed for the following parameters: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, phosphorus, potassium, selenium, silver, sodium, strontium, tellurium, thallium, tin, titanium, vanadium, zinc and zirconia. Of all of the parameters analyzed, none were found to exceed their respective ambient air quality criteria.

Gap Analysis

The air monitoring program had low data recovery. The air monitoring program resulted in eighty valid samples for an ambient air quality analysis. This results in a data recovery of 68%. This is below the typical limits outlined in relevant sampling manuals and air monitoring protocols. The low data recovery may be a result of technical issues encountered during the original field surveys and monitoring data periods.

Also, for majority of the monitoring program, the following monitoring stations were not downwind of the Project site:

- TL1 and TL2 for the mine tailings in the Faro Mine area;
- RC1 for the mine tailings and pit in the Faro Mine area;
- A1 for the pit in the Faro Mine area; and
- VG1 for the Grum pit and transfer pad in the Vangorda area.

As a result, these stations were primarily impacted by natural dust and not mine related dust.

Criteria Air Emissions Inventory

Existing releases of air contaminants are generally classified as criteria air contaminants (CACs), which include PM, Sulphur Dioxide (SO_2), Oxides of Nitrogen (NOx), Carbon Monoxide (CO) and Volatile Organic Compounds (VOCs).

There are no industrial facilities in the vicinity of the Faro Mine Site reporting emissions. Therefore, the other significant source of air emissions in the study area is the town of Faro. The town of Faro produces air contaminant emissions that are typical of a small urban center, such as transportation fuel emissions.

The National Pollutant Release Inventory reports that the leading sources of air contaminant emissions in the Yukon are natural sources. VOCs were the most significant air contaminant (by mass), at 800 kt per year. Natural sources were the largest emitter of VOCs. Open sources and natural sources account for majority of the 14 kt annual particulate emissions in the existing environment. Open sources comprise of anthropogenic processes such as construction, waste, mine tailings, and agriculture.

GHG Emission Inventory

Total GHG emissions are determined based on the major greenhouse gases: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). These GHGs are typically reported as total GHGs called CO_2 equivalents (CO_{2e}). Total GHGs for Yukon in 1990 and 2004 are described in this section.

Energy is the leading source for GHG emissions in the Yukon. Energy represents a combination of both stationary combustion sources and transportation sources. Transportation accounts for the majority of the emissions for both 1990 and 2004 energy emissions, at 57% and 65%, respectively.

Overall, there is a decreasing trend in energy GHG emissions in the Yukon, where total GHG emissions decreased between 1990 and 2004 and the Yukon's percentage of national greenhouse gas emissions has also slightly decreased since 1990. The impact of mining on GHG levels has been decreasing, with oil and gas development, tourism and public administration growing in importance. In 2006, Yukon's GHG emission total was 0.4 Mt. This is a 27% reduction since 1990 levels. Since 1990, Yukon's population has increased by 12%, yet the per capita GHG emissions have decreased from 19.4 to 12.6 t GHG per person.

4.3 Noise (TBD)

4.4 Terrain

4.4.1 Physiography

The physical geography of the Faro area can be broadly divided into three main areas (Bond 2001) which are illustrated in Figure 4.3.

- The broad, linear southeast-northwest trending **Tintina Trench**. The Trench is the dominant structural feature of the area and is occupied by the northward flowing Pelly River. The Pelly River floodplain has an elevation of approximately 600m above sea level (ASL).
- The upland areas of the Swim Basin (not shown) and the **Vangorda Plateau**. The bulk of the mine facilities are located on the Plateau. The Plateau generally parallels the Tintina Trench and is drained by the Vangorda Creek watershed to the south and Rose Creek to the northwest. The Plateau ranges in elevation from 1,000 to 1,400 m ASL. A ridge of hills and mountains divide the Plateau from the Tintina Trench, most significant of these is Sheep Mountain to the southeast and Faro Peak to the northwest.
- The third physiographic region is the **Anvil Range** Mountains. The Anvil Range is located to the northeast of the Vangorda Plateau and rises to a series of peaks over 2,000 m ASL. The Range is characterized by steep, U-shaped alpine valleys terminating into amphitheatre-like valleys (cirques), shattered rock and frost shattered bedrock (felsenmeer) above 1,770 m. Major summits in the Anvil range include Mount Mye, east of the Grum and Vangorda open pits, and Mount Aho, north of the Faro Main Pit.

4.4.2 Surficial Geology

The purpose of describing surficial geology in the baseline is to provide background information to support the description of the potential borrow sources described in Section 8.8 of the Project Description, Borrow Area Development. Figures 8.1 and 8.2 in the Project Description illustrate the surficial geology and show the locations of the potential borrow sources that will be required for Project activities.

A number of studies describe the surficial geology in the area and are summarized in a 2006 Borrow Studies Report by SRK. Two investigations were completed in 2002 and 2003 which included detailed field reconnaissance work and laboratory testing to confirm soil classification and revegetation potential. In 2004 and 2005, Aurora Geosciences Ltd. and SRK completed a seismic survey to characterize the geophysical characteristics.

The landforms and surficial deposits of the Vangorda Plateau have been shaped and are attributable to the last ice age, which is estimated to have existed in the Yukon between 35,000 and 10,000 years ago. The southern Yukon was covered by at least four Cordilleran (i.e., mountain) ice sheets. These glaciations, from oldest to the youngest are named the Nansen, the Kalza, the Reid and the McConnell (Bond 2001). The landforms of the Faro area are for the most part attributed to the youngest of the Yukon glaciations, the McConnell.

Significant surficial material in the study area consists of bedrock and associated loose bodies of sediment (colluvium), glacial till, and outwash sands and gravels created by glacial melt water (Figure 4.4). Glacial sediments deposited in lakes (glaciolacustrine), modern sediment deposited by rivers (alluvial) and organic deposits are found sporadically but are not discussed in detail herein. The following discussion of surficial materials is derived from the Quaternary geology and till geochemistry of the Anvil district, central Yukon Territory (Bond 2001):

Bedrock – bedrock and/or felsenmeer is frequently found at surface in the alpine areas of the Anvil Range. Elsewhere, mountain slopes are covered in thin veneer of colluvium (materials derived from slope movement processes) derived from the local bedrock. Glacial deposits are relatively absent above 1,500 m, although meltwater channels were identified as high as 1,700 m. Solifluction (mass wasting of waterlogged sediment creeps downslope) is common above the tree line.

Morainal Deposits (Till) – glacial till is poorly sorted deposits of clay, silt, sand, gravel and angular boulders which is deposited directly from glacial ice. A thick blanket of till is found covering the Vangorda Plateau. In some locations where pre-glacial valley existed, the till deposits can be over 100 m thick (e.g., Grum Valley). Generally, till deposits thin to a veneer (<1 m) along the valley walls and are generally absent above 1,500 m. Till also commonly underlies glaciofluvial deposits in areas of former meltwater drainage. The area surrounding the Grum and Vangorda Deposits is characterized by a thick till blanket overlying bedrock.

Glaciofluvial Deposits – during the retreat of the glaciers, melting water derived from the decaying ice transported and deposited sand and gravel in the valley bottoms and associated lateral meltwater channels. These deposits are typically crudely stratified varying from sand with some silt to cobble gravels. These materials are found as significant valley fills as in the Rose Creek valley, as kame terraces (irregularly shaped hill or mound of sand, gravel and till) at the mouth of alpine valleys or as glacial terraces and complexes associated with the Vangorda Creek valley and the Tintina Trench. Glaciofluvial deposits host the Rose Creek aquifer that underlies the Faro Mine tailings facility. The Faro townsite is located on a major glaciofluvial (and glaciolacustrine) terrace with a well developed stagnant ice (i.e., hummocky terrain) glacial fluvial complex to the northwest of the townsite. The valley bottom glaciofluvial deposits are frequently covered by silts, sands and gravel derived from contemporary stream.

Alluvial Deposits – generally consist of sand, silt, pebble, cobble and boulder mixtures. These deposits occur within the main drainages and are up to 600m wide in the Rose Creek valley and 50m wide in the North Fork Rose Creek and Next Creek valleys. The alluvial fan deposits consist of coarse sand, pebbles cobbles and mudflow deposits up to or greater than 10m thick. The alluvial plain deposits consist of silt, sand and pebbles with reworked cobbles and boulders and are up to 10m thick. These materials mostly consist of ‘clean’ granular materials (sand to boulder size) and form important existing and future target borrow materials.

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 less than 1m thick, or as aprons

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.

Organic Deposits – 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.

The majority of the natural soil located in the Faro Mine Complex consist of granular soils (i.e., locally derived tills, glacial outwash deposits and fluvial deposits). The region is within an area of discontinuous permafrost.

4.5 Geology

The area surrounding the Faro Mine Complex is underlain by metamorphic and volcanic bedrock. The Proterozoic and Paleozoic schists and phyllites were intruded by the Anvil Batholith, which consists of granite, granodiorite and quartz monzonite. The crystalline nature of these rocks typically creates a very low primary porosity (0-10%), therefore and groundwater flow through the bedrock likely occurs along planes of weakness or deformation, such as fractures, faults or shear zones. Predicting the occurrence of groundwater and its flow direction in this type of rock is difficult at best, and there is little information available for the Anvil District.

The geology of the Anvil District has been described in detail in RGC 1996. The stratigraphy of the Anvil District consists of regionally metamorphosed sedimentary bedrock. The degree of metamorphism ranges from moderate (schist) to low (phyllite). The lower part of the sequence is the most important with respect to the Anvil Range ore bodies as it refers to the Mount Mye and Vangorda Formations. During the Cretaceous, the meta-sediments were intruded by the Anvil Batholith, a granitic pluton that varies in composition from granite to granodiorite to quartz monzonite.

The Mt. Mye Formation is represented by schists, with the dominant rock type being grey, noncalcareous, weakly carbonaceous phyllite with lesser interlayered black carbonaceous phyllite and schists. The Vangorda Formation is represented by light to medium grey to greenish-grey calcareous phyllites. Five ore deposits have been identified in the Anvil Range area: Faro, Grum, Vangorda, Grizzly (previously DY) and Swim. Mining is complete (depletion of known economic reserves) in Faro and Vangorda deposits, partially complete in Grum and has not occurred in Grizzly or Swim. The three deposits at which mining has taken place are described in the *Current Environmental Conditions Supporting Document* (AECOM 2009) along with additional information on geology in the Anvil District.

4.6 Geological Hazards and Seismicity

4.6.1 Geological Hazards Overview

Geological hazards resulting from natural conditions have the potential to significantly impact facilities and infrastructure at a mine site. An assessment of hazards at the Faro Mine Complex was described by BGC in a 2001 report. This report reviews surficial and bedrock geological information and assesses the climatic and topographic conditions related to mine infrastructure locations using a qualitative risk assessment for structures situated in the Rose Creek valley.

Some of the following geological hazards may exist at the site:

- Landslides, in either soil or rock (i.e., slope movements) and falls;
- Debris torrents; and
- Fault movements.

The first two hazards have similar consequences. Failure debris that travels into the mine complex area may impact a pond of water, a water channel, the access roads or some other component of the mine infrastructure such as a pipeline, dam or treatment facility. If the debris falls into a pre-existing body of water, a wave could be generated that would overtop the water retention structure (a dam or dike). If the debris falls into a channel, then the channel could be blocked, or if the volume of debris is small, the hydraulic capacity of the channel will be changed. If the debris falls on the road, then access could be blocked. Other component specific consequences (e.g., complete damage to a water treatment pipeline) are possible as well.

The third hazard, fault movements, consists of the rapid movement of the ground beneath one of the site structures or channels.

4.6.2 Slope Movement and Falls

As described in Section 4.3, most of the natural soil located in the Faro Mine Complex consist of granular soils; i.e., locally derived tills, glacial outwash deposits and fluvial deposits. These soils are not particularly prone to slope stability hazards, except for the mechanism of river erosion and within active fluvial fans. Even in these two cases, slope stability issues will likely be confined to local failures due to oversteepening and eroding water. The colluvial deposits that have been mapped at the Faro Mine Complex are either soils that are actively moving or soils that have moved downslope into their current position. The colluvial soils should be considered to be quasi-stable or in an active state of movement. These materials are typically located on the steeper sections of the surrounding Rose Creek or Vangorda Creek valleys and could provide erratic rockfalls into the valley or local small slides.

Unless rockslides occur in very weak rock masses, rockslides are controlled by the discontinuities within the rock mass. Most rock slope failures can be classified as either: planar failures, wedge failures, toppling failures or circular failures. The initiation of failures would be dependent upon

site-specific geological controls (foliation planes, joints, etc.) and the orientation and height of exposed surfaces.

For rock falls to occur there needs to be exposed rock faces, steep slopes on the exposed faces and adverse geological controls. The areas of the Faro Mine site that are the most likely candidates for exposure to rock fall hazards are the exposures located above the former FWS Dam reservoir area and the Rose Creek Diversion Canal. The steepness of the overall slopes in the area of the Faro Mine Complex range up to 30 degrees. Some local oversteepening in the area surrounding the creeks and rivers is likely. In addition, the exposed rock slopes are likely locally steeper than the general overall slope angles.

Earthquake loading should also be considered as part of any slope stability assessment. Earthquakes can have two main effects on the stability of the slopes; increased horizontal force in the slope that decreases the stability and liquefaction of soil within the slope or at the foundation. As noted for soil slides, the addition of earthquake loading will adversely affect the stability of rock slopes.

4.6.3 Debris Flows

Debris flows consist of a spatially continuous movement where the soil/rock moves as a viscous liquid. This type of failure may occur in the upper reaches of the surrounding mountains and feed soil and rock into the Faro Mine Complex. For this type of failure to occur, steep slopes and debris within a steep area would be required. It is envisioned that only in the high altitudes along some headwaters of the creeks that this type of failure could occur.

4.6.4 Fault Movements

A major regional fault located close to the Faro Mine Complex is the Tintina Trench. Known faults within the Faro Mine Complex include the Rose Creek Fault, Vangorda Fault, Blind Creek Fault, and the Tie Fault. The primary geological hazard resulting from faults is fault movements that induce earthquakes. If the fault is located in the immediate vicinity, then the direct movements of the fault can impact structures and slopes. The secondary geological hazard resulting from faults is local slides within the rock mass. The rock mass, located at a fault zone, can generally be recognized by a zone of intense shearing, fracturing and brittleness of the rock. These factors combine to potentially form the boundaries of rock slides or falls.

4.6.5 Seismicity

Earthquakes can produce both ground ruptures and seismic shaking of the ground, depending upon the magnitude (M) of the earthquake, the distance from the epicenter and the local site-specific conditions. Both of these resultant occurrences have the potential to impact engineered structures, such as dams and other water diversion structures. Before any impact analyses can be undertaken on the various engineered structures, it is necessary to estimate the level of seismic shaking that a structure may undergo. This task is generally referred to as a seismic hazard assessment. Peak

ground acceleration (PGA) values resulting from seismic events are stated as a percentage of gravity (g).

Vick 1983 noted that there are three main approaches to seismic risk assessment that will likely result in different estimates of potential site acceleration values:

- **Historical seismicity approach** – examination and summary of historic earthquake record proximal to the site in question.
- **Probabilistic approach** – refinement of the historical approach where the historical record is the basis of a probabilistic analyses to determine a unique probability of occurrence for each possible level of seismic acceleration.
- **Deterministic approach** – where an estimate of the maximum seismic acceleration is based on an assessment of available geological data without regards for past historic events. The geological data is used to determine the nearest fault and then to estimate the magnitude of the earthquake that would result on this fault. This approach is commonly applied in areas where active earthquake-generating faults exist. Generally, the acceleration estimated by this method is termed as "maximum" or "maximum credible".

A range of PGA's have been used for designing various facilities at the Faro Mine Complex. The studies and design values are described in Table 4.2. The closure design criteria, as described in the Project Description, SD A1 , SRK 2010, are different than the values that were used for an operating mine.

Table 4.2: Summary of Earthquake Loading

Study	Return Period Event				
	475	1,000	10,000	Estimated MCE (based on twice the 475-year event)	MCE
Klohn Leonoff (1981)	0.07g	0.10g	0.32g (probabilistic)	0.14g	0.40 g (deterministic)
Dome PGC (1984)	0.063g	0.08g		0.126g	
Golder (1989)	0.08g			0.16g	
RGC (1996)	0.05g		0.13g	0.10g	
BGC/PGC (2001)	0.063g	0.080g		0.126g	

In the Abandonment Plan for Faro Mine Tailings report, dated September 1981, Klohn Leonoff (Klohn) noted that the closure design criteria would be much different than the values used for an operating mine. Therefore, Klohn recommended that the MCE be used for the design criteria. The data available at that time was very limited and a conservative approach was taken. Based on the historical movement rates within the Tintina Trench, Klohn estimated that an earthquake with a magnitude of M6.5 could occur. Using an empirical formula that included the distance from the site to the location of the earthquake, a peak ground acceleration of 0.40g was estimated. Using the same

methodology and an estimated M6.0 earthquake within the local faults of the Rose Creek Valley, a peak ground acceleration of 0.36g was estimated for the site facilities.

Statistical analysis was also performed by Klohn, based on earthquake analysis provided by GSC Pacific Geoscience Centre (PGC). The 10,000-year event resulted in a peak ground acceleration of 0.32 g. The analysis was also performed to estimate the 475-year return period earthquake, which was determined to be 0.07g. The report noted that one method used to estimate the MCE (maximum considered earthquake) was by doubling the magnitude of the 475-year event and that this would result in an MCE of 0.14 g.

In a Dome Petroleum memo dated September 1984, based on information supplied by the PGC (GSC 2001), the seismic risk for the Faro area was calculated to be 0.063 g for a 475-year return period and 0.08 g for the 1,000-year return period event.

In a report dated March 1986, "Report on design and proposed construction, Rose Creek Water Reservoir Dam Raising" Kilborn Engineering performed pseudo-static analysis on the proposed dam raise. It was noted that the analysis was performed using a "conservative design earthquake" value of 0.15 g.

In a report dated February 1989, Appendix I of the report entitled "1988 Performance Monitoring and Additional work on the Down Valley Tailings project: Faro Mine", Golder Associates Ltd. used a PGA value of 0.08 g (475-year return period) as part of an analysis of the geotechnical stability of the FWS Dam. It was noted that the earthquake parameters used for this analysis of the FWS Dam were based on the values employed in the 1980 design of the Down Valley Tailings containment project. The design earthquakes for that project were a PGA of 0.052 g (100-year return period) and 0.097 g (200-year return period). The determination of these design earthquakes were based on a statistical analysis of historical earthquakes, based on data provided from the Pacific Geoscience Centre.

In a report dated November 1996, Appendix A of the report "Anvil Range Mining Complex – Integrated Comprehensive Abandonment Plan (ICAP)" RGC had an assessment of the seismic ground motions for the Faro area performed. This was based on historical data and the assumption that earthquake loading would be transmitted through rock.

The RGC report noted that "there is no evidence of more recent displacement along the Tintina Fault and the fault is not included as an earthquake source zone in either the H or R zonations given in the GSC report, i.e., the fault is not considered active and no maximum magnitude has been defined for the fault. Thus, it is unrealistic to consider a deterministic estimate of seismic ground motions at Faro in which an earthquake is assumed to occur on the Tintina."

The estimates in the report dated November 2001, entitled "Physical Stability Assessment of the Fresh Water Supply Dam" undertaken by BGC, were based on information provided by the Pacific

Geoscience Center, which estimated these parameters on the basis of historical earthquake loading and the 1990 NBCC seismic zoning maps.

The above information indicates that the seismic loading design criteria have been quite variable in the 20 years that have been reviewed for the Faro area. It should be noted that the design horizontal acceleration determined for the 475-year return period has been relatively consistent in this period from 0.05 g to 0.08 g. Using the suggestion provided in Klohn 1981 that the maximum credible earthquake (MCE) is twice the magnitude of the 475-year event, relatively consistent values emerge for the magnitude of this event, from 0.10 g to 0.16 g even though the single deterministic analysis resulted in a larger magnitude.

In addition to the above information, a seismic hazard assessment was performed for the Faro Mine Complex in 2004. This assessment considered the regional seismicity and regional geological features, including the Tintina Trench (Atkinson 2004). Findings of this assessment concluded that for a 10,000-year return period ground motion, the mean peak ground acceleration (PGA) is 546 cm/s_2 for existing soil conditions at the Faro site (likely NEHHRD D soil conditions), and a median PGA of 343 cm/s_2 (Atkinson 2004). These ground motions correspond to an earthquake of approximately M7.0, at a distance of 10 to 20 km from the Faro site.

In the report titled "Seismic Stability of Cross Valley Dam – 1 in 500 Year Earthquake", Klohn Crippen Berger concluded that the Cross Valley Dam will not fail under a 500 year return period earthquake, but would fail if shaken by a MCE (Klohn 2007). This work predicted that the 1 in 500-year earthquake, a M5.8 producing 0.11 g at the Cross Valley Dam, would not liquefy the foundation soils. The report noted that structures such as the Cross Valley Dam are regulated to survive the 1 in 500-year motions during temporary closure design and construction.

4.7 Hydrology

4.7.1 Introduction

The Faro mining Complex is located within the catchments of two tributaries to the Pelly River, Vangorda Creek and Anvil Creek. The drainage areas of these two tributaries are 91 km^2 and 980 km^2, respectively. The Vangorda Plateau development is wholly contained within the Vangorda Creek catchment and the Faro development is wholly contained within the Rose Creek catchment, which is the largest tributary to Anvil Creek. Figure 4.5 is a smaller scale map that shows the locations of the tow historical mine developments within the catchments of Anvil Creek and Vangorda Creek. Figure 4.5a and Figure 4.5b are larger scale maps that display the stream network in the immediate vicinity of these two catchments.

The objective of the baseline is to characterize present-day hydrological conditions within the Anvil Creek and Vangorda Creek catchments. As the Faro Mining Complex is made up of two historic mining developments, the baseline characterization takes into account the legacy effects on current surface hydrology patterns that resulted from historic mining activities. For the most part, historic

effects have been very localized in terms of water quantity (i.e., flow rates and volumes). At the mouths of Vangorda and Anvil Creeks, the difference between current and pre-mining conditions is imperceptible. In the immediate vicinity of the mine site, however, there was significant alteration of surface flow as a result of the construction of diversion and collection ditches to facilitate the mining of ore and placement of waste rock and tailings. These ditches had the effect of altering drainage patterns.

The four open pits at the mining complex have also affected local hydrology by acting as groundwater sinks and enhancing evaporative losses. The tailing deposits and waste dumps have immense void spaces and regulate the runoff by temporarily storing water in these voids and releasing the water at a slower rate that the surrounding area. This alteration in the release of runoff by the tailings and waste rock dumps is problematic from a water quality perspective because the release from waste rock dumps and tailings can be relatively high during periods of low flow in receiving streams, such as during the winter months.

The Current Environmental Conditions Supporting Document (AECOM 2009) focused on two main elements:

- **Regional Hydrology** – developing relationships and means to characterize the hydrology of the area surrounding the mining complex through a climatic water balance and a regional analysis; and
- **Local Hydrology** – developing a water balance for the Anvil and Vangorda Creek catchments to understand the effects of the Project on local hydrology.

4.7.2 Data Sources

Both actual water quantity data (streamflow and storage volumes) as well as climatic and geographic data was used in characterizing the regional and local hydrology. Streamflow records were collected from the monitoring networks operated by the Water Resources branch of Yukon Environment and the Water Survey of Canada. Table 3.1-1 of the *Current Environmental Conditions Supporting Document* (AECOM 2009) provides details of the stations used in the baseline and Section 3.1.2.1 of the *Current Environmental Conditions Supporting Document* (AECOM 2009) provides further discussion of the data collected from these stations.

Streamflow records have also been collected at the Faro Mining Complex by various site personnel and consultants since the mine began operation in the late 1960's. These records have varied from a few spot measurements to nearly two decades of near-continuous stage measurements. Table 3.1-2 of the *Current Environmental Conditions Supporting Document* (AECOM 2009) provides details of these stations. This data was used where possible to either directly in the analysis or indirectly in verifying the relationships and means once they were developed. Other sites, not listed in Table 3.1-2, were monitored for other programs such as hydrogeology. These spot measurements have been used indirectly in the construction of the mine water balance.

Site personnel also maintained detailed water level records for four open pits and ponds formed behind Little Creek Dam, Intermediate Dam and Cross Valley Dam. This information was used in the water balances to model the changes in storage at the various reservoirs at the mining complex.

Climate data was also collected from both government agencies and onsite records. The Meteorological Service of Canada and the Water Resources Branch of Environment Yukon operate a network of climate stations. The mining complex also runs two climate stations, one on the Faro Dump and one on the Grum Dump. Table 3.1-3 in *Current Environmental Conditions Supporting Document* (AECOM 2009) provides details on these stations and the locations of these stations are shown on Figure 4.5a and Figure 4.5b.

4.7.3 Regional Hydrology

The reconstruction of the mine site water balance requires streamflow rates at numerous locations throughout the local catchments. Although extensive flow monitoring has been undertaken at the mining developments, it is not practical to measure flow at all points of interest. For this reason a climatic water balance and a regional analysis were developed to characterize the regional hydrology. These relationships were used to estimate flows at location where no, or minimal flow measurements have been collected.

Two primary hydrological statistics were of interest for the *Current Environmental Conditions Supporting Document* (AECOM 2009) – mean annual runoff and low flows. The climatic water balance and regional analysis both provide estimates of mean annual runoff and the regional analysis also provides estimates of low flows. Mean annual runoff (MAR) is defined in this baseline report as the portion of precipitation that is not subsequently evaporated. This excess precipitation is shed from the catchment by either overland flow, interflow and groundwater recharge. A number of different statistics are used to characterize low flows that are summarized below. For more detailed discussion, refer to Section 3.1.2.1 in *Current Environmental Conditions Supporting Document* (AECOM 2009).

Climatic Water Balance

The climatic water balance estimates MAR by determining, and taking the difference between, the mean annual precipitation (MAP) and mean annual evapotranspiration (MAET) or mean annual lake evaporation (MAE). All of the above values are expressed as depths, such as millimetres used in this report.

The distribution of precipitation tends to vary according to elevation throughout mountainous regions. A relationship was developed relating MAP and elevation for the Faro and Vangorda Plateau sites. This relationship used the precipitation normals published for three Meteorological Survey of Canada stations, Ross River Airport, Faro Airport and Anvil as well as the summer rainfall data from the Grum and Faro Dump stations. As snowfall data was not available from the Grum and Faro Dump stations, a relationship was developed to estimate snowfall at these locations in relation to the Faro Airport. The analysis shows an increase in MAP with increase in elevation with the

dumps at the Faro Mine Complex (at elevations of 1,250 and 1,200 masl) receiving 7% to 10% more rainfall than the Faro Airport at valley bottom (at an elevation of 717 masl).

The values used for MAET and MAE were calculated using the WREVAP model from Environment Canada's National Hydrology Research Institute. The WREVAP Model was applied to the waste rock dump stations as well as following government operated stations: Mayo A, Whitehorse A, Williams Creek and Pelly Ranch. MAET rates for the Faro and Grum Dumps were estimated to be 229 mm and 246 mm respectively. MAE rates for Faro and Grum Dumps were estimated at 472 mm and 484 mm respectively.

Regional Analysis

The regional analysis involved developing empirical relationships between hydrological statistics from different catchments in the region that could then be used to provide flow estimates at ungauged locations. As discussed above the two statistics examined in this baseline study are MAR and low flows.

The regional analysis for MAR presented in the baseline was originally developed in 1996, as part of the first closure plan for the Faro Mine Complex, known as the ICAP (RGC, 1996). The baseline presents MAR in relation to elevation on Figure 3.1-15 of the *Current Environmental Conditions Supporting Document* (AECOM 2009). This figure is a reproduction, with some modifications, of the graph that was used in the 1996 ICAP report. Elevation was chosen as the comparing variable because, as stated above, precipitation in mountainous regions is dependent on elevation. The elevation of a catchment in this graph refers to the median elevation of a catchment. As with MAP, MAR increases with increased elevation.

A discussion of the results, the application of the relationship to streams in the area, and the testing of the original ICAP relationship between catchment elevation and MAP can be found in Section 3.1.3.3 of the *Environmental Conditions Supporting Document* (AECOM 2009).

Low Flow Hydrology

Low flow hydrology is of particular interest at the Faro Mine Complex as contaminant concentrations in receiving streams tends to be highest during periods of low flow, particularly winter months. To help understand the effects of low flows on water quality, it was important to understand the low flow hydrology of the Anvil Creek and Vangorda catchments. Unlike the regional analysis for MAR, the regional analysis for low flows used a statistical frequency analysis to estimate the range of low flows that can be expected in local streams.

The statistics used in the baseline to characterize low flow are the minimum seven-day flow and low annual flow, each with a return period of two, ten and fifty years. The minimum seven-day flow is the lowest average flow over seven consecutive days per year. The low annual flow estimates the lowest average flow throughout an entire year for a given return period. Each statistic is expressed

with the number of days, the letter 'Q' and the return period (i.e., the 2-year annual minimum seven-day flow is expressed as 7Q2).

In order to be able to compare catchments of various sizes, flows can also be expressed as discharge per unit area of the catchment or unit discharge. The unit discharges were then used to examine the relationship between the 7-day low flows, MAR and drainage area. The 7-day low flows were found to be virtually independent of drainage area, while a relationship did exist between 7-day low flows and MAR with wetter catchments tending to have higher low flows. A discussion of these relationships can be found in the Low Flow Hydrology Section of 3.1.3.3 of the *Environmental Conditions Supporting Document* (AECOM 2009).

Patching Streamflow Data

To characterize the seasonal variation in flow, a historical water balance was constructed over a monthly timestep from January 2005 to December 2007 using the various streamflow records discussed above. This required a continuous flow record over the 36 month period. Where data was missing, the various relationships described above were used to patch the missing streamflow data. A discussion of the estimated streamflow data can be found in Section 3.1.3.2 of the *Environmental Conditions Supporting Document* (AECOM 2009).

4.7.4 Present-Day Water Balance

The baseline hydrology of the Faro Mining Complex was documented by reconstructing the historical water balances of the Anvil Creek and Vangorda Creek catchments. The reconstruction was limited to the period from January 1, 2005 and December 31, 2007 in order to capture a period representative of the present-day conditions, prior to the implementation of the mine closure plan. This time period was chosen to represent present day conditions as there were several significant construction projects that occurred prior to January 2005 that altered surface hydrology. Although some additional construction projects were carried out during the period of the historical water balance, these were aimed at improving water quality and had relatively minor influences on surface hydrology.

The baseline surface hydrology conditions in this report refer to the conditions as they exist today, as characterized by the water balance between 2005 and 2007, not prior to the development of the two mines. The characterization of baseline surface hydrology for the Faro Mining Complex is largely driven by the need to understand the linkages between water quality and water quantity. To accurately predict the water quality that will be achieved with the proposed closure plan, it was important to first characterize the yield and seasonal distribution of runoff from potential contaminant sources, such as open pits, waste rock dumps and the tailings area. It was equally important to estimate the yield and seasonal distribution of flows within the receiving streams. To capture information on seasonal variations of runoff, both for contaminant sources and receiving streams, the present–day water balance was constructed on a monthly time step.

As no significant transfers of water exist between the Faro and Vangorda Plateau developments under present-day conditions, separate water balances were developed for the Anvil Creek and Vangorda Creek catchments.

Flow sheets were used to summarize the overall water balances calculated for each catchment, and are shown on Figure 4.6. To ease interpretation of the data, the flowsheets depict only the most important features of the catchment water balances. Subcatchment boundaries are dictated by the locations of key receiving points, diversion channels and main mine elements such as pits, waste dumps and tailings impoundments. Flows between the various key receiving points and catchments are represented with a flowline and number representing the average annual flow over the 36-month period of the historical water balance in m^3/s. The water balance flowsheets for each catchment are summarized below and in greater detail in Sections 3.1.4.1 and 3.1.4.2 of the *Environmental Conditions Supporting Document* (AECOM 2009).

Anvil Creek Catchment

The Anvil Creek catchment is characterized using four key receiving points, as shown on Figure 4.5a and Figure 4.5b:

- North Fork at **X2**;
- Rose Creek at **X14;**
- Rose Creek at its mouth; and
- Anvil Creek at its Mouth.

The Anvil Creek catchment was further divided into ten subcatchments (A through J). Labelled catchments A, B, G and I, and J can be seen on Figure 4.5. The smaller subcatchments are illustrated on Figure 4.5a. The flowsheet for the Anvil Creek catchment can be seen on Figure 4.6 and the various elements of the catchments and flow estimation are described in detail in Section 3.1.4.1 of the *Environmental Conditions Supporting Document* (AECOM 2009).

Vangorda Creek Catchment

The Vangorda Creek catchment is characterized using two key receiving points:

- Vangorda Creek at **V27**; and
- Vangorda Creek at **V8**.

The Vangorda catchment was divided into eight subcatchments (labelled K through R). Catchments K and R can be seen on Figure 4.5 and smaller catchments L, M, N, O and P can be seen on Figure 4.5b. The flowsheet for the Vangorda Creek catchment can be seen on Figure 4.6 and the various elements of the catchment and flow estimation are described in detail in Section 3.1.4.2 of the *Environmental Conditions Supporting Document* (AECOM 2009).

4.8 Hydrogeology

4.8.1 Local and Regional Study Areas

The Local Study Area (LSA) is the area of immediate project influence on the environment, shown on Figure 4.7. The LSA is based on the physical and hydrogeologic footprint of the Faro Mine Complex. It incorporates the areas affected by historical mining operations including the Faro Mine Area, the Rose Creek Tailings Area and the Vangorda/Grum Mine Area. The mine access road is also included in the groundwater LSA because it was constructed of waste rock. The LSA includes surficial overburden aquifers, and shallow fractured bedrock located mostly along valley bottoms in areas disturbed by historical mining operations. The depth of the LSA includes the thickness of overburden sediments and the upper fractured bedrock where there is active groundwater flow. This depth corresponds to the maximum depth of the current monitoring network (and the depth of available groundwater quality information).

The Regional Study Area (RSA) is defined to incorporate areas outside of the project footprint that may be important if project effects extend beyond the LSA. The RSA was based on the watershed boundaries of Rose Creek/Faro Creek drainage basin to the west, the Vangorda Creek drainage basin to the east, and extends south to the confluence of Vangorda Creek with the Pelly River (incorporating Town of Faro water supply wells), as shown on Figure 4.7. The aerial extent of the groundwater RSA uses drainage basins because of the interaction between both groundwater and surface water systems. The RSA boundary will allow for a determination of potential cumulative effects of the project on downstream receiving environments.

4.8.2 Baseline Data Collection

Groundwater quality data collected between 2005 and 2007 (which includes effects related to historical mining and ongoing mine maintenance) are considered to reflect baseline conditions. Groundwater flow data collected between 2005 and 2008 are considered to reflect baseline groundwater flow conditions. A total of 134 wells are currently monitored on an annual, biannual or quarterly basis. This is divided into 16 wells sampled at the Vangorda/Grum side and 118 on the Faro side.

Groundwater flow (quantity) and groundwater quality baseline information for the Faro/Rose Creek tailings and Vangorda/Grum areas are summarized below. Contamination issues resulting from historical mining operations affect groundwater quality in both areas. Historical mining activities and existing mine infrastructure such as dams, open pits, modified surface water channels and pumping systems have an influence on groundwater flow directions and rates. The following paragraphs summarize all data collected used in establishing baseline conditions:

Groundwater levels within the mine area have been monitored in an extensive network of groundwater wells. Water level information is contained in the site database and summarized in

yearly groundwater monitoring reports. Hydraulic conductivity testing was completed during several monitoring well installation studies, during recent groundwater characterization work, and during seepage interception studies. Historical mining and care and maintenance activities/facilities (e.g., dams, open pits, ponds, modified surface water channels, groundwater pumping systems and water treatment plant operations) have an influence on baseline groundwater flow directions and rates.

Groundwater quality throughout the site has been monitored using a network of conventional monitoring wells and multi-level monitoring wells with sampling points extending throughout the overburden aquifer and tailings profile. Statistical summaries and analyses were performed on groundwater quality data for the baseline water quality period (2005-2007) to define baseline groundwater quality conditions. Baseline conditions include existing contamination issues resulting from historical mining operations that now affect groundwater quality in all areas within the footprint of the Faro Mine Complex.

Data sources for hydrogeology baseline definition include field data, engineering and scientific reports, technical memos and scholarly literature sources. There are many documents produced by many different authors for the Faro project. The *Current Environmental Conditions Supporting Document* (AECOM 2009) includes a detailed list of relevant documents relating to the hydrogeology of the site.

4.8.3 Groundwater Flow (Quantity)

Figure 4.7 shows inferred groundwater flow directions in the Rose Creek and Vangorda Creek valleys based on topographic and drainage features. Groundwater flows from higher elevation recharge areas to lower elevation areas in the valley bottoms and the open pit mines. Within the lower portions of valleys, overburden sand and gravel aquifers are present, particularly Rose Creek. Discharge of groundwater occurs along the streams in valley bottoms and in the mine pits that have been dewatered.

Groundwater is recharged by infiltrating precipitation. Groundwater levels are usually higher after spring runoff increases infiltration, with higher levels also occurring at some locations after wet weather in the fall.

Water level elevations in wells near dams and impoundments are highly influenced by the water level of the pond behind the dam, and may have relatively constant water levels. Surface water diversions may also locally affect groundwater flow directions and velocities.

The presence of permeable waste rock dumps results in a greater portion of precipitation infiltrating. This water tends to resurface down gradient of the waste rock dumps, usually with impaired water quality due to contact with oxidized sulphide minerals in the waste rock (Project Description, SD A1, SRK 2010).

4.8.4 Faro Mine/Rose Creek Tailings Area

An unconfined sand and gravel aquifer was present in the Rose Creek Valley prior to development of the mines and tailings impoundment. Development of the tailings impoundment resulted in the placement of a thick layer of lower permeability tailings on top of the aquifer. The layer of lower permeability tailings caused development of surface ponds, higher groundwater levels and downward groundwater hydraulic gradients (recharge). Upward groundwater flow gradients (discharge) are present in the Rose Creek Valley bottom downstream of the tailings dams.

During the care and maintenance period (which includes the baseline period) the partially dewatered Faro Pit was, and continues to be used for water storage associated with the water treatment plant. Baseline water levels in the pit are maintained within recommended upper and lower limits. These pumping levels cause some local groundwater inflow to the Faro Pit. Groundwater inflow rates will decrease as the pit water level rises. Faro Pit water elevations are highly seasonal, typically reaching maximum levels in May and minimum levels in September.

The Rose Creek diversion channel along the south side of the tailings impoundment is a perched channel 21 relative to the elevation of the natural channel. This results in a downward migration of surface water from the stream bed which eventually recharges the groundwater system and flows northward into the tailings impoundment.

4.8.5 Vangorda/Grum

The Vangorda Pit is located on the south side of Vangorda Creek; Grum Pit is located on the north side of Vangorda Creek. Groundwater flow from the Grum Pit, Vangorda Pit and associated waste rock dumps is towards Vangorda Creek. Flow from the Grum Pit and rock dump is southward towards Vangorda Creek. Groundwater flows from the Vangorda Pit and rock dump westward toward Vangorda Creek. Available hydrogeological information suggests that affected groundwater from the Grum and Vangorda mine facilities discharges to Vangorda Creek near the mine sites.

The water levels in the Vangorda Pit recovered more than 50 m between 1998 and 2002 due primarily to groundwater inflows from the northwest to northeast (upgradient) direction. Leakage of surface water into the Vangorda Pit was also a contributing source of water during this period. The pit was pumped down four times between 2002 and 2005. Water levels in the pit gradually increased due to groundwater inflows during the baseline period. In 2008, the maximum recommended pit water level was exceeded and further pumping was again required.

The Grum pit was developed in a small depression in the hillside. The surficial deposits at the Grum Pit were thicker than at the other pits. The aquifer in the Grum area is comprised of sand and gravel and is capped by a thin layer of glacial till deposits. This Grum aquifer was dewatered by pumping wells during mine operations prior to 1997 which induced groundwater flow toward the pit from upgradient areas. Since mining ceased, the Grum Pit has been allowed to flood, and pit wall rock and waste rock continue to release contaminants into the water that accumulates in the pit. Since pumping ceased, water levels in the pit have recovered almost 60 m due primarily to groundwater

inflows. Without pumping and treatment, the Grum Pit would fill with water and overflow because inflows from runoff and seepage exceed outflows. Without treatment, water quality in Grum Pit would remain problematic for decades. As water levels in the pit rise possible seepage losses (outwards groundwater flow instead of inward flow) may occur in subsequent years if the pit is not pumped down.

Groundwater Quality

Groundwater quality data collected between 2005 and 2007 has been selected as the baseline water quality period. Background groundwater quality and affects from historical mining operations have been documented for this baseline period. Wells are currently monitored and the results have been reported in the Annual Report submitted to the Yukon Water Board. Acid rock drainage (ARD) and metal leaching from the tailings and waste rock dumps is by far the most significant effect on groundwater quality at the Faro mine complex. Other types of contamination (such as??) affect small areas of the Faro mine complex to a lesser extent.

For the purposes of this baseline and the assessment of affects, sulphate and zinc have been selected as the key indicators of ARD processes and groundwater quality. Elevated sulphate concentrations are frequently the first indicator of ARD affect as sulphate is not attenuated (it shows up much earlier than other metal contaminants). Dissolved zinc (resulting from ARD and metal leaching) has relatively high mobility compared with iron, manganese and other metals elevated in groundwater. Of these metals, dissolved zinc has the highest potential for environmental due to the very high on-site concentrations and relative mobility, while other indicators of ARD/metal leaching include decreasing alkalinity over time and depressed pH.

The existing groundwater wells were grouped based on mean sulphate and mean zinc concentrations observed over the baseline water quality period. The range of mean sulphate and zinc values and associated classification of groundwater quality are presented in Table 4.3.

Table 4.3: Summary of Criteria Used for Classification of Groundwater Quality for the Baseline Period (2005-2007)

Groundwater Quality Classification	Mean SO_4 Concentration (mg/L)	Mean Zn Concentration (mg/L)
Unaffected	0-40	0-0.05
Low	40-590	0.05-0.5
Moderate	590-2,000	0.5-5
High	2,700-5,000	5-50
Very High	>50,00	>50

Figure 4.8 and Figure 4.9 show groundwater quality classifications for the groundwater monitoring wells in the Faro and Grum/Vangorda mine areas, respectively. Areas with the highest level of contamination as shown on Figure 4.8 and Figure 4.9 are summarized in Table 4.4.

Table 4.4: Summary of Highest Levels of Effects in the Different Mine Areas

Groundwater Quality Classification	Mine Area Location
Unaffected	Downgradient of Cross Valley Dam
Low	Northeast, Faro Waste Rock Dump
Moderate	Toe of intermediate dam Grum/Vangorda Waste Rock Dumps Zone II Outwash Area
High	Second impoundment (Rose Creek tailings) Intermediate impoundment (Rose Creek tailings) Faro Waste Rock Dump – S-Cluster wells area Emergency Tailings Area (ETA)

4.8.6 Faro

During the baseline period and in more recent years, monitoring results have shown increasingly higher levels of zinc contamination in specific areas. A significant deterioration of groundwater quality in the Rose Creek aquifer has occurred due to the ARD processes within the Faro waste rock dumps and tailings area, particularly during the past three years. Seepage from the tailings impoundment and emergency tailings area (ETA) are affecting the entire depth of the Rose Creek sand and gravel aquifer at some locations. Moderate levels of contamination are present just downstream of the intermediate and Cross Valley Dams, indicating that the attenuation capacity of the aquifer soils/sediments beneath the Rose Creek tailings is being exhausted.

Wells further downgradient of the Cross Valley Dam are characterized by much better groundwater quality than within the mine footprint, rock dump and tailings impoundment areas. The presence of low to moderate levels of contamination in this downgradient area is an indication that some contaminated groundwater is seeping below the dam.

Groundwater in the Zone II outwash area is contaminated by seepage from the Faro waste rock dumps, and is characterized by relatively low sulphate concentrations but higher zinc concentrations. Contaminated groundwater in the Zone II area could, in turn, lead to impaired surface water quality in North Fork Rose Creek.

Groundwater in the S-cluster area, down slope of the Faro waste rock dumps, has also deteriorated in recent years and has the potential to affect water quality in the nearby North Fork of Rose Creek.

4.8.7 Vangorda/Grum

Effects of seepage from the Grum waste rock dump are limited to shallow depths. A gradual increase in sulphate, magnesium, and to a lesser extent zinc concentration has been observed in the shallow groundwater draining toward Vangorda Creek. The lower permeability of sediments and till in the Vangorda area and the more recent mining history appear to have resulted in a delayed and therefore decrease in levels of groundwater contamination from waste rock seepage as compared to

the Faro mine area. There was a recent increase, however, in sulphate, magnesium and zinc concentrations at the southwest corner of the Vangorda rock dump.

The receiving environment in the Grum/Vangorda Mine Site is Vangorda Creek which drains the mine footprint and waste rock dumps in this area. Seepage from Grum and Vangorda waste rock dumps discharges to Vangorda Creek within 1 km of the toe of the rock dumps.

Concern has been expressed in the past by Faro residents that contaminated groundwater from the Vangorda/Grum area could affect the Faro Municipal well located 8 km down slope from the pits. This issue was assessed by Gartner Lee Limited (2007) and it was concluded that any contaminated groundwater would discharge to the Vangorda Creek in close proximity to the mine site and would not migrate to the Faro municipal well. Furthermore the potential for the Faro well drawdown cone to intercept Vangorda Creek and draw in potentially contaminated surface water to the well was also considered by Gartner Lee Limited (2007). This report concluded that movement of creek water to the Faro municipal well was highly unlikely. The conceptual model for groundwater flowing from the Grum/Vangorda Mine Site indicates there is no viable subsurface pathway to the Town of Faro water supply wells, located more than 8 km downstream.

4.9 Surface Water Quality

4.9.1 Introduction

Surface water quality in the area of the Faro and the Vangorda/ Grum mine areas currently shows the signature of former mine activities, such as groundwater with high zinc and sulphate concentrations transported to surface water, and discharges from treatment plants and polishing ponds. Surface water quality does not currently meet CCME guidelines for the Protection of Aquatic Life for several parameters at locations internal to the site, but for some parameters this is due, at least in part to naturally elevated background levels of these parameters. It is expected that in the absence of any further closure efforts at the site, surface quality would deteriorate further due to the advancement of acid rock drainage plumes from the waste rock piles and through seepage at the foot of the tailings impoundments and polishing pond. Closure planning has been proposed in an effort to define activities that will minimize the further deterioration of surface water quality in the near and far areas of the site by keeping clean water clean, by preventing contaminated groundwater from reaching surface waters and by slowing acid mine drainage processes (through minimizing infiltration) to allow for improved natural attenuation and by consolidating the most potentially problematic rock and tailings to identified locations.

The following characterizes existing water quality conditions at the Faro Mine Complex, in terms of two local study areas based on portions of the watersheds of Faro and Rose Creek, and of Shrimp/ Vangorda and Grum Creek, and in terms of one regional study area which includes portions of the Rose/ Anvil Creeks and Pelly River watersheds. The footprints of former mine and proposed closure activities are largely contained within the two local study areas. Regional water quality is based on water quality downstream of the former mine and proposed closure activities. Existing water quality

will be compared with projected water quality as predicted through modelling (see SD E11, Water Quality Model, LG 2010). The boundaries of the local and regional study areas are shown in Figure 4.10.

4.9.2 Water Quality Monitoring Sites

Surface water quality has been extensively monitored at the Faro Mine Complex for regulatory compliance, environmental monitoring, and for closure planning purposes since at least the cessation of mining activities in 1998. Selected water quality data collected though these programs has been used to characterize existing surface water quality conditions based on a reference period of 2005 to 2007, although historic data from 1998 to 2007 was used to identify long term trends.

Key water quality monitoring stations were selected for characterisation of existing conditions based on:

- Locations that would best monitor upstream of historic mining activity and downstream of closure activities;
- The adequacy of the monitoring data to characterise the site (number of samples, seasonality of samples, quality of samples, etc.);
- the availability of additional data at or near the location that would supplement assessment of overall affects of activities to the aquatic environment (flow monitoring, sediment monitoring, benthic monitoring, etc.); and
- locations more likely to be accessed by local populations.

The water quality monitoring locations are shown in Figure 4.10, Figure 4.11 and Figure 4.12.

4.9.3 Contaminants of Potential Concern

Water quality was characterised through the evaluation of minimum, maximum, median, average, 25-percentile and 75-percentile concentrations of parameters identified as contaminants of concern and as significant in understanding water quality interactions.

Total metals of concern were identified based on a review of existing water quality, seeps quality and sediment quality with respect to 32 parameters. Any parameters that were observed to exceed existing quality guidelines in any of the three media were selected as potential contaminants of concern. The list of 20 metals identified through this screening, which was undertaken by SENES as part of a risk assessment process, is shown in Table 4.5 (SENES 2009), along with the phase in which elevated concentrations were observed.

Three total metals were found in seeps in the Faro LSA that were not observed to be elevated in any phase of the Vangorda LSA: beryllium, chromium and silver. Five parameters were elevated in surface waters monitored at Vangorda that were not elevated in Faro surface water (but were elevated in Faro seeps): aluminum, arsenic, copper, selenium and vanadium.

The water quality guideline to which existing conditions were compared is also shown in Table 4.5. The guideline value is based on CCME Guidelines for the Protection of Aquatic Life, as developed for the site. In the absence of a CCME guideline, the alternate guideline is indicated (Minnow 2008).

Silver and cadmium method detection limits were generally too low for comparison with the guidelines, and therefore could not be evaluated. However, some higher concentrations were observed. This was also true for thallium, where the elevated concentrations were observed in sediment only.

Table 4.5: Contaminants of Potential Concern (COPC) and Water Quality Guidelines

Parameter	Where Identified as COPC1	Water Quality Guidelines
Total Metals		
Aluminum	*SW, Seep*	0.1
Antimony	SW	0.02[a]
Arsenic	*Sediment, SW, Seep*	0.005
Beryllium	Seep	0.0038[a]
Boron	SW	1.2
Cadmium	SW, Seep	0.00003
Chromium	Seep	0.001
Cobalt	SW, Seep	0.004
Copper	*SW, Seep*	0.002
Iron	SW, Seep	0.3
Lead	Sediment, SW, Seep	0.002
Manganese	SW, Seep	1
Nickel	Sediment, Seep	0.065
Selenium	*SW, Seep*	0.001
Silver	Seep	0.0001
Strontium	SW	9.3[b]
Thallium	Sediment	0.0008
Tin	SW	0.035[c]
Vanadium	*SW, Seep*	0.006[a]
Zinc	Sediment, SW, Seep	0.03
Other Parameters		
Conductivity (lab)	Mine discharge SW elevated with respect to reference SW	-
Hardness	Interpretation of guideline	-
Ammonia	Exceeds guideline in SW	0.24
pH (field)	Lower than guideline in SW	6.5 - 9.0
Sulphate	Exceeds guideline in SW	50
Total Suspended Solids	Exceeds guideline in SW	8
All units are in mg/L, except where indicated.		SW = surface water
1	Total metals COPCs as developed through SENES Risk Assessment, Appendix B (draft); February 2009.	
Bold	Identified on Faro side, but not on Vangorda side	
Italics	Identified in Vangorda side surface water, but only in Faro side seeps	
	CCME Guideline - Water Quality Guideline shown is based on CCME Guidelines for Aquatic Life, as developed in Faro Background Data Evaluation (Minnow 2008)	
	BC - WQG - Water Quality Guideline is based on the British Columbia Water Quality Guideline for freshwater, as identified in Faro Background Data Evaluation (Minnow 2008)	
a	Ontario Provincial Water Quality Objective, or Interim Objective	
B	Strontium Guideline is based on effects on fish, as identified in Faro Background Data Evaluation (Minnow 2008)	
C	Tin Guideline is based on effects on zooplankton, as identified in Faro Background Data Evaluation (Minnow 2008)	

Parameters other than metals were also identified as COPCs since existing surface water quality exceeds (or in the case of pH, is less than) existing water quality guidelines. Conductivity has also been added in water quality characterisation since water quality internal to the site shows elevated conductivity in comparison with reference site conductivity.

4.9.4 Faro Water Quality

The following summarizes water quality observed over the period from 2005 to 2007 in the Faro Creek/ Rose Creek watershed, based on water quality observed in the creeks, in the area near the footprint of the former Faro mine and tailings ponds. Table 4.6 presents a summary of water quality (minimum, maximum and median of COPC and other significant parameters) for the Rose Creek local study area.

Faro Creek, Rose Creek, Upper Guardhouse Creek – Reference Water Quality

Upstream of the former mine and of the proposed closure activities, naturally elevated concentrations of aluminum and copper were observed infrequently (<20% of samples), and the concentrations of these elements remain in roughly the same range from upstream of the mine to downstream of the tailings ponds. It has been noted that cadmium levels are also slightly elevated with respect to guidelines (Minnow 2008), but as previously noted, this could not be evaluated at many sites, due to high Method Detection Limits (MDLs) for this parameter. In addition to aluminum and copper, elevated concentrations of silver, cadmium, chromium, iron, selenium and zinc were infrequently observed upstream in the North Fork of Rose Creek. The elevated concentrations were generally observed during spring sampling events (approximately mid-May to June), concurrent with elevated total suspended solids.

Rose Creek and Upper Guardhouse Creek/Northwall Interceptor - Run-off, Mine Effluent and Internal

Downstream of the Faro Waste Rock Dumps, many of the parameters that were infrequently elevated upstream of the dumps, continued to show infrequent elevated concentrations, including aluminum, copper and iron. However, elevated silver, cadmium, chromium and selenium were not observed, likely due to dilution from Faro Creek, a tributary that flows into the North Fork of Rose Creek upstream of the Waste Rock Dumps. In addition to the infrequently elevated metals that are also observed upstream of the Dumps, infrequent elevated lead and frequently elevated zinc (over half of the samples) is observed, along with an increase in sulphate concentrations. This provides an indication of groundwater discharge to surface water in the area adjacent to the toe of the Main East and Intermediate Dumps.

Table 4.6: Rose Creek Local Study Area Water Quality Summary Table 2005-2007

Parameter		Ag	Al	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Se	Sr	Zn	Cond.	Hard.	NH_3-N	pH	SO_4	TSS
Bgrnd Benchmark		**<0.00005**	**0.156**	**<0.001**	**0.00004**	**<0.001**	**<0.001**	**0.002**	**0.246**	**0.0264**	**<0.001**	**<0.001**	**<0.001**	**0.18**	**0.0164**	**303**	**158**	**0.03**	**6.6-8.2**	**20.3**	**3**
WQ Guidelines		**0.0001**	**0.1**	**0.005**	**0.00003**	**0.004**	**0.001**	**0.002**	**0.3**	**1**	**0.065**	**0.002**	**0.001**	**9.3[b]**	**0.03**	**-**	**-**	**0.24**	**6.5-9**	**50**	**8**
FDU (n ~ 7)	Median	-	0.074	-	0.0001	-	-	0.0005	0.07	0.002	0.0005	0.0005	-	0.02	0.0025	33	11.5	0.0075	7.45	1.76	1
	Min	< 0.00005	0.047	< 0.0002	0.00001	< 0.0002	< 0.0002	0.0004	< 0.05	0.001	0.0004	0.0006	< 0.0002	0.013	0.003	19	7	< 0.01	7.1	1.04	< 1
	Max	< 0.00025	**0.18**	< 0.001	< 0.0002	< 0.001	< 0.001	**0.003**	0.14	0.004	< 0.001	< 0.001	< 0.001	0.033	0.011	56	21.1	0.02	7.9	2.1	< 1
R7 (n~ 36)	Median	0.000125	0.018	0.0005	0.0001	-	0.0005	0.0005	0.115	0.014	0.0005	-	0.0005	0.12	0.0025	203	107	0.0075	7.8	8.85	0.50
	Min	< 0.00005	< 0.005	0.0004	0.00001	< 0.0002	< 0.0002	0.0003	< 0.05	0.005	0.0004	< 0.0002	0.0005	0.035	< 0.001	53	28	< 0.01	7.3	1.7	< 1
	Max	**0.0004**	**0.35**	0.002	**0.0004**	< 0.001	**0.002**	**0.003**	**1.41**	0.15	< 0.001	< 0.001	**0.002**	0.19	**0.035**	294	147	0.07	8.2	16.9	**21**
W10 (n ~ 8)	Median	-	0.0315	0.0005	0.0001	0.0005	-	0.001	0.025	0.0005	0.0005	0.0005	0.0005	0.0536	0.00375	104	50.4	0.005	7.6	3.59	0.5
	Min	< 0.000005	0.011	0.0001	0.000018	0.000014	< 0.0001	0.00085	0.015	0.00045	< 0.00002	0.000134	< 0.00004	0.027	0.0017	55	27	< 0.005	7.2	2.5	< 1
	Max	< 0.00025	**0.13**	< 0.001	< 0.0002	< 0.001	< 0.001	**0.003**	0.14	0.007	< 0.001	< 0.001	< 0.001	0.063	0.023	123	60	0.04	7.9	4.3	3
R1 (n ~ 9)	Median	0.00015	0.0156	0.00045	0.000227	0.00032	0.00036	0.00067	***0.394***	0.125	0.00382	0.00041	0.00044	0.185	0.00359	223	116	0.05	7.61	21.9	1
	Min	< 0.000005	0.0061	0.00033	0.000007	0.00008	< 0.0001	0.00037	0.246	0.047	< 0.00002	0.00009	< 0.00004	0.118	0.0007	158	75.8	< 0.005	7.00	13.4	< 1
	Max	0.0008	0.0358	< 0.001	< 0.003	< 0.001	< 0.001	**0.002**	**0.990**	0.38	0.031	< 0.001	< 0.001	0.32	0.013	285	203	0.1	8.00	29.6	2
X2 (n~ 32)	Median	-	0.0215	0.0005	0.0001	-	0.0005	0.0005	0.19	0.0635	0.00075	0.0005	-	0.12	***0.033***	188	102	0.005	7.50	16.5	0.5
	Min	< 0.00025	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.001	< 0.05	0.019	< 0.001	< 0.001	< 0.001	0.042	0.015	61	33	< 0.01	7.10	4	< 1
	Max	< 0.00025	**0.27**	< 0.001	< 0.0002	< 0.001	< 0.001	**0.003**	**0.66**	0.21	0.002	**0.007**	< 0.001	0.23	**0.18**	344	187	0.06	8.00	39.7	**9**
X3 (n~ 36)	Median	-	0.021	0.0005	-	-	0.0005	0.0005	0.205	0.0825	0.0005	0.0005	0.0005	0.148	0.0235	220	122	0.01	7.65	21.9	0.05
	Min	<0.00025	0.0025	0.0005	<0.0002	<0.001	0.0005	0.0005	0.06	0.022	0.0005	0.0005	< 0.001	0.053	0.006	82	40	< 0.01	7.10	5.9	< 1
	Max	<0.00025	**0.35**	0.001	<0.0002	<0.001	**0.002**	**0.003**	**1.02**	0.15	0.002	**0.004**	< 0.001	0.23	**0.14**	368	181	0.18	8.10	45.9	**13**
X5 (n~ 67)	Median	0.000125	0.008	0.0005	0.0001	***0.006***	-	0.001	0.19	4.82	0.012	0.0005	0.0005	0.68	***0.15***	1300	692	***0.89***	7.80	***683***	0.5
	Min	< 0.00025	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.001	< 0.05	0.86	0.002	< 0.001	< 0.001	0.27	0.018	297	266	0.08	7.10	74.2	< 1
	Max	0.001	0.039	< 0.001	0.0005	**0.026**	< 0.001	0.005	1.02	**26.5**	0.051	**0.005**	**0.003**	1.03	**0.47**	2260	1230	**1.67**	8.80	**1180**	5
X10 (n~ 40)	Median	0.000125	0.011	0.0005	0.0001	0.0005	-	0.0005	0.221	0.045	0.0005	0.0005	0.0005	0.155	***0.036***	245	127	0.005	7.80	25.4	0.5
	Min	< 0.000005	0.0045	0.00022	0.00001	0.000079	< 0.0001	0.00043	< 0.05	0.009	< 0.00002	0.000145	< 0.00004	0.05	0.011	79	40	< 0.005	**5.00**	5.4	< 1
	Max	0.0023	**0.25**	< 0.001	< 0.0002	< 0.001	< 0.001	**0.003**	**0.81**	0.089	0.003	**0.005**	< 0.001	0.26	**0.1**	421	212	0.03	8.50	45.8	**14**
X13 (n~ 36)	Median	-	0.005	0.002	0.0001	0.006	-	0.00075	2.02	10.4	0.0145	-	0.0005	0.66	0.006	1645	831	***0.62***	7.20	***756***	4
	Min	< 0.00025	< 0.005	< 0.001	< 0.0002	0.002	< 0.001	< 0.001	0.55	6.01	0.011	< 0.001	< 0.001	0.44	< 0.005	852	578	0.35	7.00	422	1.0
	Max	< 0.00025	0.031	0.003	0.0006	**0.012**	< 0.001	**0.002**	**3.26**	**14.5**	0.019	< 0.001	**0.002**	0.87	0.015	2700	1120	**0.77**	7.70	**939**	6.0
X14 (n~ 93)	Median	0.000125	0.024	0.0005	0.0001	0.0005	0.0005	0.001	0.3	0.78	0.002	0.0005	0.0005	0.19	***0.033***	340	175	0.09	7.8	***99.3***	1
	Min	< 0.000005	0.0025	0.00029	0.00002	0.00023	< 0.0001	0.00042	0.12	0.19	0.0009	0.00021	< 0.00004	0.055	0.011	112	54	< 0.005	7.2	16.8	< 1
	Max	0.0023	**0.58**	0.002	0.0003	**0.015**	< 0.001	**0.012**	**1.59**	**16.0**	0.03	**0.008**	**0.002**	0.63	**0.25**	1630	812	**0.56**	8.4	**704**	**46**

Note: statistics calculated setting results <MDL equivalent to 1/2 MDL; Units: mg/L except pH, and conductivity (μS/cm)

CCME Guideline - Water Quality Guideline shown is based on CCME Guidelines for Aquatic Life, as developed in Faro Background Data Evaluation (Minnow 2008)

BC - WQG - Water Quality Guideline is based on the British Columbia Water Quality Guideline for freshwater, as developed in Faro Background Data Evaluation (Minnow 2008)

a *Calcium Guideline is based on effects on zooplankton, as developed in Background Benchmark Report (Minnow 2008)*

b *Strontium Guideline is based on effects on fish, as developed in Background Benchmark Report (Minnow 2008)*

Bold *Maximum Exceeds Guideline*

Bold, italics *Median Exceeds Guideline*

underlined *>50% of samples < Method Detection Limit (MDL)*

\- *100% of samples <MDL*

Water flows, water quality and sediments quality along a reach of the North Fork of Rose Creek was studied intensively, along with the groundwater in the area immediately adjacent to the reach, and under the creek due to observed metals increases. The area is commonly referred to as the "S-wells" area and it is downstream of a rock drain that carries the creek through the Haul Road. The studies confirmed that zinc loading was occurring along this section of the creek; that the increased concentrations were observed most frequently during winter when the groundwater contributed the base flow to the creek; and that the source of the zinc was likely from groundwater recharge to the North Fork of Rose Creek from the Faro Main East and Intermediate Dumps. A trench interception and pumping system was installed in the winter of 2008/ 2009 to collect groundwater flows in this area and pump them to the Faro Pit. It is expected that zinc loading along this reach of the North Fork of Rose Creek will decrease due to the interception of groundwater.

The South Fork of Rose Creek, which intercepts the Haul Road and runs parallel to the Haul Road, through the former freshwater reservoir, contributes elevated iron (more than half of samples) and infrequently elevated copper. Unlike water in the North Fork of Rose Creek, elevated aluminum is not observed.

The North and South Forks of Rose Creek converge upstream of the tailings facilities. Rose Creek is directed around the tailings to the south through a constructed diversion channel. The water quality upstream and immediately downstream of the tailings is generally comparable, with the same infrequently elevated metals concentrations as downstream of the Waste Rock dumps, including lead, and frequently elevated zinc. The comparable water quality indicates that there is little or no recharge to the creek from the tailings water. This is expected, since the creek bottom elevation is generally higher than the tailings surface elevation. The infrequent elevated metals continue to be observed concurrent with elevated spring suspended solids.

Water discharged from the Cross Valley Dam and seepage downstream of the Cross Valley Dam show continuously elevated levels of ammonia and sulphate, as well as increased hardness and conductivity. Cobalt, iron and manganese are elevated in more than half of the samples from these sources, as is zinc from the Cross Valley discharge only. Elevated lead and selenium are also observed in over 25% of discharge samples. Strontium from these two sources is higher generally than reference water concentrations.

In Rose Creek, downstream of the mixing zone of the Rose Creek Diversion, discharges from the Cross Valley Dam and seepage downstream of the Cross Valley Dam, the signature of the discharge is still evident, though muted through dilution. Higher hardness, conductivity, ammonia and sulphate are observed, along with cadmium, cobalt, lead and selenium (infrequent), and frequently elevated iron, manganese, and zinc. Infrequent elevated silver, aluminum, and copper are likely carried through from background upstream water.

4.9.5 Vangorda/Grum Water Quality

The following summarizes water quality observed over the period from 2005 to 2007 in the Vangorda Creek watershed, based on water quality observed in the creeks, in the area near the footprint of the former Grum and Vangorda mining areas. Table 4.7 presents a summary of water quality (minimum, maximum and median of COPC and other significant parameters for the Vangorda local study area.

Upper Vangorda Creek and the Upper West Fork of Vangorda Creek - Reference

Alkaline conditions, low solids and concentrations of some cadmium and chromium that exceeded water quality guidelines were observed in reference waters isolated from mine influence.

Sheep Pad Pond, Shrimp Creek, Grum Creek and Vangorda Creek

Mine runoff and effluent waters from the Sheep Pad Pond and Grum Creek contained calcium, hardness, cadmium, zinc, sulphate and manganese at concentrations that were an order of magnitude above reference levels, and other trace metals that exceeded reference levels by a factor of two.

Water quality in the main stem of Vangorda Creek downstream of the mine footprint reflected the influence of the mine activity with elevated levels of aluminum, copper, iron, manganese, nickel, sulphate and zinc. Elevated sulphate levels were often associated with years when the Vangorda treatment plant was operating (2005, 2006, not 2007) and there were discharges via the clarification pond and Sheep Pad Pond.

West Fork of Vangorda Creek and Vangorda Creek Main Stem

Water quality in the West Fork of Vangorda Creek downstream of the mine footprint reflected the influence of the mine activities as levels of aluminum, copper, iron, manganese, nickel, lead and zinc; total suspended solids were also elevated between 2005-2007 and this was attributed to a natural debris flow.

Water quality in the main stem of Vangorda Creek upstream from the confluence of the Pelly River has elevated concentrations of aluminum, copper, iron, manganese, nickel strontium sulphate, and zinc in comparison to the reference locations.

4.9.6 Rose Creek, Anvil Creek, Vangorda Creek and the Pelly River - Regional Water Quality

Vangorda Creeks drains to the Pelly River. The confluence of the two water bodies is near the town of Faro. Rose Creek drains to Anvil Creek, which in turn also drains to the Pelly River. The confluence of Anvil Creek and the Pelly River is approximately 64 km downstream of the Vangorda/Pelly confluence. Table 4 8 presents the summary of water quality (minimum, maximum and median of COPC and other significant parameters) within the regional study area, including the Pelly River.

Table 4.7: Vangorda Local Study Area Surface Water Quality Summary Table 2005-2007

Parameter		Ag-T	Al-T	As-T	Cd-T	Co-T	Cr-T	Cu-T	Fe-T	Mn-T	Ni-T	Pb-T	Se-T	Sr-T	Zn-T	Cond.	Hard.	NH_3-N	pH	SO_4	TSS
Bgrnd Benchmark		**<0.00005**	**0.156**	**<0.001**	**0.00004**	**<0.001**	**<0.001**	**0.002**	**0.246**	**0.0264**	**<0.001**	**<0.001**	**<0.001**	**0.18**	**0.0164**	**303**	**158**	**0.03**	**6.6-8.2**	**20.3**	**3**
WQ Guidelines		**0.0001**	**0.1**	**0.005**	**0.00003**	**0.004**	**0.001**	**0.002**	**0.3**	**1**	**0.065**	**0.002**	**0.001**	**9.3[b]**	**0.03**	**-**	**-**	**0.24**	**6.5 - 9**	**50**	**8**
VR (n~5)	Median	-	0.0245	0.00018	0.00002	0.000028	0.0001	0.0008	0.029	0.00176	0.00025	0.0002	0.00006	0.0566	0.0024	79.0	35.0	0.0058	7.3	7	0.5
	Min	<0.000005	0.0205	<0.0001	0.00001	0.000017	< 0.0002	0.00045	0.024	0.00107	0.00017	0.000149	0.00006	0.042	0.0009	62.0	28.9	< 0.005	6.87	5.0	< 1
	Max	<0.00001	0.0627	0.0002	**0.000036**	< 0.0002	**0.0015**	0.0010	0.042	0.00267	<0.0005	0.000347	<0.0005	0.064	0.0049	103	44.2	0.028	8.44	7.8	3.0
V1 (n~17)	Median	-	0.012	0.0005	0.0001	0.0005	0.0005	0.0005	0.025	0.00072	0.0005	0.0005	0.0005	0.0539	0.0025	73.0	32.7	0.0050	7.58	10	0.5
	Min	< 0.000005	0.0051	< 0.00002	< 0.000005	< 0.000005	< 0.0001	0.00029	0.005	0.0004	< 0.00002	0.000008	< 0.00004	0.022	0.0006	35.0	13.0	< 0.005	6.37	3.62	< 1
	Max	< 0.00025	**0.99**	*0.002*	< 0.0002	< 0.001	< 0.001	*0.0020*	0.14	0.014	< 0.001	< 0.001	**0.011**	0.11	**0.038**	125	59.0	*0.030*	8.3	12.4	*3.0*
V25BSP (n~34)	Median	0.000125	0.0265	0.0005	***0.00055***	***0.004***	0.0005	***0.004***	0.08	0.102	0.002	0.0005	0.0005	0.45	***0.0755***	735	420	0.020	7.9	***387***	0.50
	Min	< 0.00025	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.001	< 0.05	< 0.001	< 0.001	< 0.001	< 0.001	0.074	0.026	119	63	< 0.01	7.0	27.8	< 1
	Max	**0.0005**	**1.55**	0.002	**0.0048**	**0.035**	**0.002**	**0.018**	**2.12**	**13.1**	0.006	**0.008**	**0.003**	1.71	**0.26**	2190	1300	**0.46**	8.3	**1340**	**34**
V2 (n~49)	Median	0.000125	0.019	0.001	0.0001	0.0005	0.0005	0.001	0.09	0.002	0.003	0.0005	0.0005	0.82	0.018	1900	1210	0.005	8.0	***940***	0.5
	Min	< 0.00005	0.004	0.0008	0.00008	< 0.0002	0.0002	< 0.001	< 0.01	0.0006	< 0.001	0.0003	< 0.001	0.61	< 0.005	1270	719	< 0.01	7.5	554	< 1
	Max	< 0.01	**0.13**	< 0.03	< 0.01	< 0.02	< 0.01	< 0.02	**0.63**	0.036	< 0.02	< 0.03	**0.002**	1.09	**0.074**	2410	1460	0.04	8.3	**1160**	**18**
V4 (n~12)	Median	-	0.0521	0.00055	7.42E-05	0.00036	0.00041	0.000965	0.277	0.0418	0.000853	0.000363	0.00063	0.299	0.00338	522	294	0.010	8.20	49.1	2.00
	Min	< 0.000005	0.0019	0.00047	0.000016	0.000045	< 0.0001	0.00055	0.13	0.017	< 0.00002	0.000011	0.00044	0.14	0.0013	281	154	< 0.005	7.92	22.5	< 1
	Max	< 0.00025	**0.22**	< 0.001	< 0.0002	< 0.001	< 0.001	**0.002**	**0.53**	0.0854	0.002	< 0.001	**0.002**	0.398	0.009	670	411	0.040	8.30	**63.7**	**13.0**
V6A (n~14)	Median	-	0.042	0.001	0.0001	0.0005	0.0005	0.0005	0.133	0.0071	0.0005	0.0005	0.0005	0.109	0.0165	182	91.5	0.0075	7.95	28.2	1.0
	Min	< 0.000005	0.0146	0.00091	0.00003	0.000032	< 0.0001	0.00038	0.076	0.004	< 0.00002	0.000359	< 0.00004	0.053	0.013	99	47	< 0.005	7.4	13.6	< 1
	Max	< 0.00025	**0.76**	0.003	< 0.0002	< 0.001	< 0.001	**0.003**	**0.61**	0.027	< 0.001	**0.002**	**0.015**	0.24	**0.031**	315	182	**0.32**	8.3	**53.5**	**11.0**
V27 (n~13)	Median	-	0.02	0.0005	0.0001	0.0005	0.0005	0.0009	0.049	0.0035	0.0005	0.0005	0.0005	0.0978	0.0257	210	97	0.005	7.88	***50.2***	0.50
	Min	< 0.000005	< 0.005	< 0.00002	0.00004	0.000015	<0.0001	0.00062	0.009	0.00095	< 0.00002	0.000134	< 0.00004	0.02	0.016	47	17	< 0.005	7.50	8.46	< 1
	Max	< 0.00025	**0.16**	< 0.001	< 0.0002	**0.04**	< 0.001	**0.002**	**0.36**	0.039	< 0.001	**0.002**	< 0.001	0.211	**0.0318**	420	209	0.03	8.30	**106**	6
V5 (n~29)	Median	0.000125	0.16	0.0005	0.0001	0.0005	0.0005	0.001	***0.37***	0.026	0.002	0.0005	0.0005	0.27	0.009	453	265	0.005	8.1	***77.8***	***9***
	Min	< 0.00001	0.024	< 0.001	0.00004	0.00027	0.0008	< 0.001	0.090	0.007	0.001	0.00052	< 0.001	0.12	0.0039	172	126	< 0.005	7.4	28.0	2
	Max	**0.0004**	**6.95**	**0.005**	**0.0003**	**0.005**	**0.016**	**0.018**	**11.0**	0.19	0.02	**0.01**	**0.003**	0.4	**0.046**	793	436	0.11	8.4	**174**	**249**
V8 (n~39)	Median	-	0.04	0.0005	0.0001	0.0005	0.0005	0.001	0.15	0.026	0.002	0.0005	0.0005	0.28	0.015	514	293	0.005	8.1	***121***	1
	Min	< 0.00001	< 0.005	0.0004	0.00004	0.00012	0.0003	< 0.001	0.049	0.006	< 0.001	0.0003	< 0.0005	0.1	0.0070	174	112	< 0.005	7.3	33.3	< 1
	Max	< 0.00025	**1.37**	< 0.05	< 0.002	**0.007**	< 0.005	**0.045**	**2.13**	0.38	< 0.02	**0.04**	< 0.05	0.48	**0.064**	781	449	0.13	8.5	**312**	**67**
VGMAIN (n~35)	Median	0.000125	0.012	0.0005	0.0001	0.0005	0.0005	0.0005	0.07	0.007	0.002	0.0005	0.0005	0.24	0.019	438	249	0.005	8.0	***129***	0.5
	Min	< 0.00025	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.001	< 0.05	0.002	< 0.001	< 0.001	< 0.001	0.081	0.010	170	86	< 0.01	7.5	32.9	< 1
	Max	**0.0003**	**0.49**	0.002	**0.0004**	< 0.001	< 0.001	**0.052**	**0.95**	0.61	0.011	**0.008**	**0.003**	0.58	**0.086**	804	526	0.11	8.5	**399**	**23**

Note: statistics calculated setting results <MDL equivalent to 1/2 MDL; Units: mg/L except pH, and conductivity (μS/cm)

CCME Guideline - Water Quality Guideline shown is based on CCME Guidelines for Aquatic Life, as developed in Background Benchmark Report (Minnow 2008)

BC - WQG - Water Quality Guideline is based on the British Columbia Water Quality Guideline for freshwater, as developed in Background Benchmark Report (Minnow

a *Calcium Guideline is based on effects on zooplankton, as developed in Background Benchmark Report (Minnow 2008)*

b *Strontium Guideline is based on effects on fish, as developed in Background Benchmark Report (Minnow 2008)*

Bold *Maximum Exceeds Guideline*

italics *Reference Station Value Meets or Exceeds Background Benchmark*

Bold, italics *Median Exceeds Guideline*

underlined *>50% of samples < Method Detection Limit (MDL)*

- *100% of samples <MDL*

Table 4.8: Rose Creek, Anvil Creek and Pelly River RSA Water Quality Summary Table 2005-2007

Parameter		Ag	Al	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Se	Sr	Zn	Cond.	Hard.	NH_3-N	pH	SO_4	TSS
Bgrnd Benchmark		**<0.00005**	**0.156**	**<0.001**	**0.00004**	**<0.001**	**<0.001**	**0.002**	**0.246**	**0.0264**	**<0.001**	**<0.001**	**<0.001**	**0.18**	**0.0164**	**303**	**158**	**0.03**	**6.6-8.2**	**20.3**	**3**
WQ Guidelines		**0.0001**	**0.1**	**0.005**	**0.00003**	**0.004**	**0.001**	**0.002**	**0.3**	**1**	**0.065**	**0.002**	**0.001**	**9.3[b]**	**0.03**	**-**	**-**	**0.24**	**6.5-9**	**50**	**8**
FC (n~4)	Median	-	0.0346	0.00009	0.0000095	0.0000185	0.0001	0.00049	0.032	0.00097	0.000225	0.000128	-	0.0263	0.00195	37	13.4	-	6.85	2.5	0.5
	Min	< 0.000005	0.0293	0.00006	0.000009	0.000015	0.0001	0.00039	0.024	0.0007	< 0.00002	0.000088	< 0.00004	0.0222	0.0015	29	12.2	< 0.005	6.45	1.2	< 1
	Max	< 0.000005	0.0797	0.0002	0.000013	0.00005	**0.001**	0.0009	0.066	0.00261	0.00024	0.00032	< 0.00004	0.0296	0.0061	41	16.0	< 0.005	8.01	2.9	2
P1 (n~4)	Median	0.000004	0.0524	0.000385	0.0001775	0.0000735	0.0003125	0.000995	0.135	0.0163	0.00455	0.000147	0.001045	0.203	0.0183	358	190	0.00338	8.08	***63.45***	2.38
	Min	< 0.000005	0.0090	0.0003	0.00015	0.000026	< 0.0001	0.0007	0.04	0.0117	0.00406	0.00007	0.0008	0.164	0.0142	292	154	< 0.005	7.40	55.5	< 1
	Max	0.000007	0.137	0.00049	**0.000219**	0.00015	**0.001**	0.0015	*0.253*	0.0212	*0.0049*	0.00025	*0.00124*	*0.224*	*0.0234*	400	216	0.006	8.39	**68.5**	5
R6 (n~10)	Median	0.000125	0.0156	0.0005	0.0001	0.0005	0.0005	0.0005	0.115	0.014	0.0005	0.0005	0.0006	0.137	0.0025	304	158	0.005	8.05	20.3	0.5
	Min	< 0.000005	0.0067	< 0.00002	0.00001	0.000013	< 0.0001	0.00035	< 0.05	0.00512	< 0.00002	0.00002	0.0007	0.106	0.0004	240	132	< 0.005	7.5	19.3	< 1
	Max	**0.0017**	0.140	< 0.001	< 0.0002	< 0.001	**0.003**	**0.003**	0.18	0.0208	*0.002*	< 0.001	*0.002*	*0.25*	0.006	382	261	0.02	8.3	**80.1**	2
P2 (n~4)	Median	-	0.0557	0.0003675	0.000178	0.00008	0.0001625	0.00107	0.144	0.0177	0.00464	0.000159	0.0010275	0.207	0.0185	354	189	0.01	8.06	***62.1***	3.63
	Min	< 0.000005	0.0093	0.0002	0.00015	0.000038	< 0.0001	0.00088	0.041	0.0114	0.00419	0.000106	0.0008	0.165	0.0149	294	153	< 0.005	7.69	54.5	< 1
	Max	< 0.000005	**0.131**	0.00054	**0.000204**	0.00014	0.0003	0.0013	0.247	0.0267	0.0049	0.000189	**0.00119**	0.234	0.0238	390	214	0.026	8.63	**68.2**	**8**
P3 (n~4)	Median	-	0.0608	0.00036	0.0001165	0.000083	0.0006375	0.00105	0.121	0.0152	0.00346	0.000116	0.0008875	0.1935	0.0113	346	182	0.0045	7.57	***57.2***	3.63
	Min	< 0.000005	0.0069	0.0002	0.000082	0.000032	< 0.0001	0.00079	0.027	0.0095	0.00233	0.000073	0.0008	0.171	0.0063	293	156	< 0.005	7.17	53.3	< 1
	Max	< 0.000005	**0.177**	0.00049	**0.000145**	0.00019	0.0023	0.0014	0.261	0.0201	0.0046	0.00023	0.00098	0.209	0.0145	380	200	0.007	8.16	**59.8**	**8**
P4 (n~4)	Median	-	0.0426	0.0003825	0.00012825	0.000066	0.000225	0.0010175	0.118	0.018725	0.00330	0.000208	0.000895	0.19275	0.0125	346	178	0.0095	7.91	***57.0***	3.125
	Min	< 0.000005	0.0103	0.0002	0.00009	0.000033	< 0.0001	0.00085	0.036	0.0111	0.00268	0.000168	0.0007	0.145	0.0078	271	142	< 0.005	7.16	45.4	< 1
	Max	< 0.000005	0.097	0.00053	**0.000177**	0.0001	0.0007	0.0013	0.199	0.0267	0.00383	0.00026	**0.00108**	0.222	0.0175	390	209	0.025	8.41	**61.2**	7
R4 (n~10)	Median	0.000125	0.007	0.0005	0.0001	0.0005	0.0005	0.0005	0.0905	0.117	0.00091	0.0005	0.0005	0.208	0.0126	383	199	0.018	7.95	***79.6***	0.5
	Min	< 0.000005	0.0046	< 0.00002	0.00001	0.000045	0.0001	0.0005	0.047	0.017	0.0005	0.000129	< 0.00004	0.125	< 0.005	238	117	< 0.005	7.27	26.4	< 1
	Max	**0.0006**	0.0209	< 0.001	**0.00006**	< 0.001	< 0.001	0.00103	0.17	0.938	0.00203	< 0.001	**0.002**	0.26	0.025	514	262	0.042	8.4	**127**	3
R5 (n~4)	Median	0.000125	0.018	-	-	-	-	0.0005	0.11	0.028	-	-	0.00075	0.12	0.0025	275	150	-	8.1	26.6	0.5
	Min	< 0.00025	0.017	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.001	< 0.05	0.016	< 0.001	< 0.001	< 0.001	0.11	< 0.005	252	135	< 0.01	7.5	21.7	< 1
	Max	**0.0006**	0.03	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.001	0.17	0.077	< 0.001	< 0.001	< 0.001	0.26	0.007	383	272	< 0.01	8.3	**80.3**	3
R11 (n~6)	Median	0.000125	0.021	0.0005	-	-	-	-	0.08	0.0195	-	-	0.0005	0.15	0.0025	311	165	0.0125	7.95	48.3	0.5
	Min	< 0.00025	0.007	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.001	< 0.05	0.005	< 0.001	< 0.001	< 0.001	0.12	< 0.005	245	135	< 0.01	7.4	38.6	< 1
	Max	**0.0009**	0.061	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.001	0.12	0.059	< 0.001	< 0.001	**0.002**	0.28	0.008	383	290	0.03	8.2	**81.9**	4

Note: statistics calculated setting results <MDL equivalent to 1/2 MDL; Units: mg/L except pH, and conductivity (μS/cm)

CCME Guideline - Water Quality Guideline shown is based on CCME Guidelines for Aquatic Life, as developed in Faro Background Data Evaluation (Minnow 2008)

BC - WQG - Water Quality Guideline is based on the British Columbia Water Quality Guideline for freshwater, as developed in Faro Background Data Evaluation (Minnow 2008)

a *Calcium Guideline is based on effects on zooplankton, as developed in Background Benchmark Report (Minnow 2008)*

b *Strontium Guideline is based on effects on fish, as developed in Background Benchmark Report (Minnow 2008)*

Bold *Maximum Exceeds Guideline*

italics *Reference Station Value Meets or Exceeds Background Benchmark*

Bold, italics *Median Exceeds Guideline*

underlined *>50% of samples < Method Detection Limit (MDL)*

\- *100% of samples <MDL*

Anvil Creek water quality is generally harder than Rose Creek water and exhibits a higher conductivity. The pH is slightly alkaline with a median value of 8. Sampling in Anvil Creek has occurred less frequently than in Rose Creek, it is possible that some of the infrequent elevated concentrations observed in Rose Creek were simply not captured in sampling events or that elevated concentrations do not occur.

At the mouth of Rose Creek, approximately 24 km from the tailings, the signature of historic mine activities on Rose Creek is not evident. While there are infrequent elevated levels of silver, cadmium and selenium, the range and occurrence is similar to reference water concentrations. Total suspended solids were associated with the elevated metals. Calcium and sulphate were elevated at the mouth of Rose Creek, but not significantly in comparison with the Anvil Creek and Pelly River reference sites.

Evaluation of water quality collected from Anvil Creek and the Pelly River monitoring programs indicates that although waters draining from the Faro and Vangorda mine sites may influence water chemistry within Anvil Creek and the Pelly River, the signature of drainage is not readily apparent or consistent between sampling dates and programs. Although some spatial trends in total zinc, copper, and lead concentrations were occasionally evident, natural contributions to the watershed combined with significant dilution (and limited data) suggest that the mine-related influences on Anvil Creek and the Pelly are not readily detectable.

Water quality at the downstream boundary of the Pelly River RSA is characterized by neutral to slightly alkaline pH and low sulphate concentrations. Cadmium concentrations were consistently above the CCME derived benchmark of 0.00003 mg/L.

4.10 Aquatic Organisms and Habitat

The Anvil/Rose Creek and Vangorda Creek watersheds influenced by the Faro Mine Complex have an area of 980 km^2 and 90 km^2 respectively, and are tributaries to the Pelly River. To put this into spatial context, the Pelly River watershed has a total drainage area of 51,000 km^2. A broad watershed ecosystem perspective is needed to capture a key issue identified: the transport of contaminants from the mining site and potential downstream effects on water quality and aquatic resources. As well, there is considerable connectivity of salmon and other aquatic resources between the Anvil/Rose and Vangorda Creek systems and the broader watershed. The Pelly River watershed has been classified as a higher sensitivity watershed in the development of the new placer mining regime based mainly on the relatively high level of utilization by adult salmon and salmon spawning and relatively good water quality (low turbidity).

An extensive aquatic data base with respect to metals in stream sediments, metals in fish tissues, abundance and diversity of benthic invertebrates, and fish species utilization exists for the Anvil/Rose watershed dating back to the early 1970's and the Vangorda watershed dating back to the early 1990's. Some caution is necessary when trying to interpret data trends extending over three

decades, especially where the data compatibility is heavily dependent on consistency of sampling and analytical techniques used.

A significant data gap is the lack of information on periphyton algae that represents an important component of the stream ecosystem, and has a high sensitivity to heavy metal contamination. The Project is located in a highly mineralized area that is reflected in high natural levels of metals in surface waters. For examplem maximum levels of zinc, cadmium and copper at reference station R7 on North Fork Rose Creek exceed CCME (2003) surface water quality guidelines (see Table 4.6).

Groundwater contamination issues resulting from historical mining operations affect groundwater quality in both the Faro and Vangorda/Grum areas. Historical mining activities and proposed mine closure facilities such as dams, open pits, modified surface water channels and pumping systems have, and will have an influence on groundwater flow directions and rates.

The most significant aquatic resources in the Anvil/Rose and Vangorda Creek system are primarily adult Chinook salmon and Chinook spawning habitat and, secondly, juvenile Chinook salmon and salmon rearing habitat. The next most significant aquatic resources in this system are freshwater fish species and freshwater fish habitat, especially Arctic grayling that are utilized for food. The importance of Chinook salmon and Arctic grayling stems from the limited abundance of each fish species and their habitats, their environmental sensitivity and their social and cultural importance.

4.10.1 Study Areas

The local and regional study areas are the same as the surface water quality and are shown on Figure 4.13.

4.10.2 Stream Sediment Quality

Vangorda Creek: Stream sediment sampling on Vangorda Creek has been conducted since 1993 and sediments analysed for copper, lead and zinc, which are known to be toxic to aquatic organisms at high concentrations, as well as for arsenic. The results indicate that the highest concentrations appear at the site V-27 located downstream of the Grum and Vangorda pits and waste rock piles, with highest concentrations in lead and zinc. Levels of all four metals have dropped significantly at this site since 2001; 2007 copper and arsenic dropped to levels comparable to the reference site (V1) but lead and zinc levels remained somewhat elevated, exceeding Interim Freshwater Quality Guidelines (ISQG) and Probable Effects Levels (PEL). Levels of all four metals at the two far field sites (V5 and V8) were somewhat elevated in the 1990's but at reference site levels by 2007.

Anvil/Rose Creek: Stream sediment sampling on Anvil/Rose Creek has been conducted sporadically since 1973 and consistently since 2004. The analysis of data has indicated that the key indicators of mine influence on stream sediments were arsenic, lead, manganese and zinc and to a lesser extent copper. Levels of all five metals were the highest at the three near field sites (R2, R3 and R4) and have consistently exceeded ISQG and PEL guidelines for arsenic, lead and zinc and ISQG guidelines for copper. There are no guidelines for manganese. Arsenic and cadmium levels

have consistently exceeded ISQG guideline levels at all sites including the three reference sites for arsenic and two of three reference sites for cadmium. These findings suggest that elevated levels of arsenic and cadmium may in part, be,a natural phenomenon. However, lead, zinc and manganese levels at the three most affected near field sites remain highly elevated and significantly above background levels at reference sites.

Levels of Zinc and Lead: Of concern are persistently elevated levels of zinc and lead in stream sediments that exceed CCME (2003) Probable Effects Level (PEL) at R2(X14) and Vangorda at V27 (Table 8.33). Downstream levels in both watersheds show a declining trend with levels at V8 on Vangorda Creek and A2 and A3 on Anvil Creek dropping to CCME (1999) Interim Sediment Quality Guidelines (ISQG), and to reference levels below ISQG at A1. Upstream reference stations in both watersheds are below ISQG levels indicating that the elevated levels downstream of the mine sites can likely be attributed to historic mining activities. It is also important to note that levels of zinc and lead in sediments on Anvil/Rose are relatively higher and attenuate much more slowly than on Vangorda which may reflect the relatively longer duration of mining impacts on the Anvil/Vangorda system.

Table 4.9: Existing Metal Concentrations in Stream Sediments

	Metal Concentrations – 1999-2006 mean (mg/l)	
Station	**Zinc (mg/l)**	**Lead (mg/l)**
Anvi/Rose Watershed Stations		
R7	**80**	**18**
R6	**118**	**15**
R1	**203**	**73.9**
R2	**955**	**306**
R3	**577**	**190**
R4	**311**	**150**
R5	**277**	**128**
A4	**339**	**105**
A3	**268**	**68**
A2	**216**	**50**
A1	**112**	**20**
Vangorda Watershed Stations		
V1	**115**	**40**
V5	**96**	**28**
V27	**710**	**1367**
V8	**208**	**86**

Notes:

Exceeds CCME Probable Effects Levels (PEL = 315 mg/l, Pb = 91.3 mg/l).

Exceeds CCME Interim Sediment Quality Guidelines (ISQG Zn = 123 mg/l, Pb = 35 mg/l).

Below CCME Interim Sediment Quality Guidelines.

4.10.3 Benthic Invertebrates

The abundance and diversity or richness (as reflected by the number of taxa) of benthic invertebrates represent a commonly accepted indicator for aquatic productivity and health. Sampling for benthic invertebrates has been undertaken sporadically on Vangorda and Anvil/Rose Creeks since the early 1970's and systematically as a requirement of water licences since 1988 on Anvil/Rose Creek) and 199l on Vangorda Creek.

Abundance and Diversity of Benthic Invertebrates

The abundance and diversity of benthic invertebrates increased gradually with some fluctuations during the 1990's at all sites on both the Vangorda and Anvil/Rose Creek systems and levelled off in the late 1990's. These trends were evident even at the most affected site on the Vangorda system (V-27) and the most affected sites on the Anvil/Rose System (R2, R3 and R4), where levels of lead, zinc and arsenic in sediments generally exceeded both ISQG and PEL guidelines. In addition, these sites exhibited a high abundance of pollution sensitive taxa which indicates that levels of these metals in sediments have had little effect on the abundance and diversity of benthic invertebrates. The most affected Vangorda site (V-27) exhibits benthic diversity and abundance similar to the upstream reference site (V-1) and somewhat lower diversity than the downstream far field sites (V-5 and V-8). This diversity and abundance may be explained in part by changing stream characteristics such as gradient, altitude and flows. In addition, some of the measured increases in diversity or number of taxa and possibly abundance in later years may be due to improved and more rigorous sampling and analytical techniques.

Metals in Tissues

Metal concentrations in benthic invertebrates were monitored for the first time in 2002 and again in 2006. Benthic invertebrates represent the most important component in the diet of most stream fish including freshwater species and juvenile Chinook salmon. Accumulation of metals in fish could represent a health concern to fish and for human consumption of the fish. In general, affected sites on the Vangorda and Anvil/Rose systems exhibited higher levels of lead, zinc and copper in benthic invertebrates than the control site. The higihest levels of lead and zinc in benthic invertebrates are found at the most impacted site R2 (X14) and the lowest levels at reference site R6. Levels of arsenic, cadmium and mercury in benthic invertebrates for affected sites were generally similar or lower than the control site.

4.10.4 Fish and Fish Habitat

Fish Abundance and Diversity

Fish species found in monitoring programs throughout the Anvil/Rose Creek system and the lower reaches of Vangorda Creek include: Arctic grayling, slimy sculpin, burbot, round whitefish and longnose sucker and juvenile Chinook salmon. Arctic grayling and slimy sculpin are the most common freshwater species. Chinook salmon, Arctic grayling and Slimy sculpin are currently

abundant and distributed in the Anvil/Rose creek drainage up to the Faro mine site. In addition, adult Chinook salmon have been documented on the lower portions of Anvil Creek and Vangorda Creek. As a result, the lower reach of Anvil Creek up to the confluence of Rose Creek, and the first 200 m of Vangorda Creek are classified as high sensitivity Chinook salmon spawning habitat.

Since 2004, a few Chinook salmon (3-6 fish) have been recorded spawning regularly on Anvil Creek at station A4. Spawning Chinook have been observed on Anvil Creek near the confluence of Rose Creek. There is anecdotal information of spawning Chinook on Rose Creek immediately below the Faro mine site, and in 2010 a pair of spawning Chinook was observed over a redd in the Rose Creek diversion adjacent to the tailings area.

Juvenile Chinook salmon are abundant in the lower reaches of Anvil Creek at densities comparable to reference streams in the area (Blind Creek). Juvenile Chinook salmon have been recorded in lower numbers in Rose Creek up to just below the mine site at station R2(X14) shown on Figure 4.10. This station represents the receiving point for discharges from mine activities. (R2 is located about 65-70 km upstream from the Pelly River, and is considered the maximum distance that juvenile Chinook salmon will migrate up a tributary from the mainstem of a natal stream like the Pelly River).

Juvenile Chinook salmon, Arctic grayling and Slimy sculpin are abundant in the lower reaches of Vangorda Creek up to the Town of Faro where further upstream movement is blocked by natural barriers. Fish are absent from the West Fork and Upper Vangorda Creek due to impassible barriers near the Town of Faro that include a perched culvert on the Faro access road, a steep gradient and natural waterfall. There are no fish in the Vangorda LSA above this point.

Rearing Chinook juveniles are present in very large numbers in the lower sections of Vangorda Creek from June to September and equivalent to densities in nearby Blind Creek. Blind Creek is an important spawning tributary to the Pelly River located upstream from Vangorda Creek. The juvenile salmon migrate into tributary streams from natal streams and spawning areas in spring to feed and rear during the summer when densities of benthic invertebrates are high. The juvenile salmon then leave the streams in late fall or early winter. Juvenile salmon are also found throughout the Anvil/Rose Creek system but in much lower densities.

Arctic grayling are present in the LSA in South and North Forks of Rose Creek up to the rock drain on the haul road. The rock drain represents a barrier to fish movement. Juvenile Arctic grayling and juvenile Slimy sculpin are abundant and throughout the LSA on the Anvil/Rose Creek system including the diversion and the North and South Forks of Rose Creek at the mine site at the most impacted receiving water quality site at R2(X14) below the mine site.

The abundance of juveniles and in particular juvenile sculpin would indicate that reproduction and recruitment is not affected by existing water quality. A related Sculpin species (Cottus bairdi) was identified as one of the most sensitive fish species to contaminants such as Zinc and Cadmium (Minnow 2010). Reproduction is the most sensitive biological function that would be affected first

by inadequate water quality and other environmental stresses. Thus evidence of good reproduction in Slimy sculpin is a good sentinel species indicator of fish health for all species including Chinook salmon and Arctic grayling.

Fish Habitat

Habitat suitability mapping identifies the presence of high sensitivity adult salmon and salmon spawning habitat at the lower sections of both the Anvil/Rose Creek and Vangorda systems. Habitat suitability mapping also identifies extensive moderate sensitivity salmon rearing habitat up to the Faro Mine project site on the Anvil/Rose Creek system and on the lower reaches of the Vangorda Creek system. Minnow (2007) reviewed all fish studies from 1989 to 2005 completed at the Faro Mine complex and summarized the habitat requirements and habitat availability of Arctic grayling, Chinook salmon and slimy sculpin. They concluded that the South and North Forks of Rose Creek had excellent rearing habitat for Arctic Grayling. They also concluded that the South Fork of Rose Creek provided excellent spawning, rearing and overwinter habitat for slimy sculpin and that there is relatively high fish species diversity and abundance below the tailings facility discharge in Rose Creek relative to reference areas on lower Anvil Creek. The authors suggest that mine-related activities have not adversely affected Anvil/Rose fish populations.

In terms of the overall abundance and availability of habitat types within the Pelly River watershed, 4% of the total stream length is classified as migration and spawning habitat for adult Chinook salmon, 24% as Chinook rearing habitat and 61% as freshwater fish habitat.

Metals in Tissues

Analysis of metals in fish tissues have been carried out since 1975 (*Tables 4.4.5-4.4.10 ,Current Environmental Conditions Supporting Document* AECOM 2009). Tissues analyzed include Arctic grayling muscle and liver tissue, and slimy sculpin whole body tissue. The data shows little difference between fish from affected and reference sites and relatively few instances where human or wildlife consumption benchmarks were exceeded. The data suggests that mining activities have had little or no influence on the quality of fish tissue in the Anvil/Rose and Vangorda Creek systems.

Zinc levels in whole Sculpin body tissue over the past decade (1997-2007) show some elevation at R2(X14) and V8 over reference sites (R6) and reference streams (B1) and are about three to four times higher than levels in Arctic grayling tissue at both reference and impacted sites (see Existing Environmental Conditions Table 4.4-12 &13). Cadmium tissue concentrations are comparable for Slimy sculpin and Arctic at all reference and impacted sites with the exception of elevated levels at V8 for both species.

The highest tissue metal levels for zinc and cadmium for both Slimy sculpin and Arctic grayling were at V8. Slimy sculpin and Arctic grayling muscle metal concentrations are within human and wildlife consumption benchmarks for all metals including zinc and cadmium over the past decade.

4.11 Vegetation

The Faro Mine Complex is located within the Yukon Plateau-North Ecoregion, in the Boreal Cordillera Ecozone of the Yukon (Environment Canada 2005). The region consists of rolling uplands, small mountain groups, and nearly level tablelands dissected by U-shaped valleys. The mine complex lies within the zone of discontinuous, widespread permafrost, wherein Turbic Cryosolic and Eutric Brunisolic soils predominate and occasional pockets of Dystric Brunisols occur on coarse-textured morainal and glacio-fluvial materials (Environment Canada 2005).

Data sources for the LSA are primarily Project field data collection, 1:10,000 scale black and white aerial photos and a 1:20,000 colour ortho photo of the area. The 2007 draft revegetation program conducted by EDI was consulted for additional information regarding natural communities within the Project (EDI 2008). Data sources for contaminant accumulation in vegetation in the RSA are the results of the Anvil Range Mine Complex – Terrestrial Effects Study: Investigation into Metal Concentrations in Vegetation, Wildlife and Soils, prepared for Deloitte & Touche Inc. on behalf of the Faro Mine Closure Planning Office by Gartner Lee Limited (2006a).

4.11.1 Local Study Area (LSA)

A vegetation Local Study Area (LSA) is designed to represent the diversity of vegetation in the immediate Project area and to encompass the area within which all direct effects and some indirect effects of Project activities on vegetation are likely to occur. A vegetation map of the area has been developed at a scale of 1:20,000, using aerial photography and field data (completed in 2007). For the purposes of this project, the LSA includes the area within a 1 km wide buffer around mine facilities, infrastructure and road corridors, and covers an area of approximately 81.2 km^2. The LSA for vegetation is shown on Figure 4.14.

4.11.2 Regional Study Area (RSA)

The Regional Study Area (RSA) encompasses the area within which any regional affects of Project activities on vegetation are predicted to occur. The RSA includes the area within which accumulations of contaminants above background levels have been recorded, and is illustrated on Figure 4.15.

4.11.3 Vegetation Associations

The mine complex straddles the boreal and subalpine zones. Thirteen vegetation associations were identified and mapped within the 81.2 km^2 Local Study Area (Figure 4.14). The map does not include mine facilities, infrastructure and road corridors. Vegetation associations in the boreal zone, below 1,200 m, include forested and wetland associations in the low elevation valley bottoms and low-lying terrain. The boreal zone contains a number of associations linked to morainal and glacio-fluvial terrain and influenced by fire. Closed forests of white spruce/willow cover the largest portion, 45% of the LSA. There are small areas of pine, mixed coniferous-deciduous and deciduous forests. Also present are shrub associations of dwarf birch and willow. Poorly drained lowland sites

support dwarf birch, willow, sedge and graminoid associations. The areas of the Project LSA above 1,200 m are in the subalpine zone, which is dominated by tall shrub vegetation. Scattered open spruce and fir forests occur at the lower limits, grading into lower stature shrub, herb and lichen communities at upper elevations. Native vegetation has historically been removed from a 16.1km^2 area by the development of the Faro Mine Complex and almost no vegetation is present on these areas at present. Brief descriptions of the thirteen vegetation associations are presented below.

Sedge/Willow (S/W)*:* This wetland association is common in both the boreal and subalpine zone and occurs in (moist/wet) depressions or drainage areas. A mixture of sedge and graminoid species dominates the area, with shrubs such as willows and dwarf birch present around the edges of the wetland. Wetland mosses are also abundant.

Willow/Sedge (W/S): The willow/sedge association is linked with standing or flowing water, usually along lakes, ponds and creek drainages and is common over a wide elevation range throughout the study area. Various willow species are dominant in the shrub layer while sedge species and wetland mosses are common below.

Willow/White Spruce (W/Sw): The willow/white spruce vegetation is often found in a riparian drainage or draw, along creeks or rivers primarily in the boreal zone. An open canopy of mature white spruce is scattered among a well-developed shrub layer of willow and birch. Ground cover is often a combination of ericaceous shrubs, sedge species, lichens and mosses.

Willow/Dwarf Birch (W/B): This riparian vegetation association is widespread in lower elevations, occurring on gentle to steep slopes in the boreal zone. Willow species and dwarf birch are co-dominant in a well-developed shrub layer along with scattered young white spruce trees. Sparse grasses and forbs are present while moss and lichen cover varies with water and nutrient availability.

Dwarf Birch/Willow (B/W): The birch/willow vegetation association is characteristic of slopes at higher elevations. Dwarf birch is the dominant shrub, however willow species, Labrador tea, shrubby cinquefoil and bog bilberry are also present. A variety of ground shrubs are found in the understory and lichens often dominate the groundcover. Krummholtz subalpine fir and white spruce occur occasionally.

Dwarf Birch/Lichen/Subalpine Fir (B/L/Fa)*:* This vegetation association is a subalpine/alpine community characterized by bedrock outcrops and windswept ridges at higher elevations. Dwarf birch is the dominant cover species followed by a high percentage of lichen. Krumholtz subalpine fir is the dominant tree species along with scattered white spruce. Various ericaceous shrubs (i.e., low woody shrubs that are part of or related to the heather family) are also present.

Dwarf Birch/Subalpine Fir (B/Fa): The birch/fir vegetation association is a subalpine community occurring on well-drained soils and slopes. Dwarf birch is the dominant cover species with the dominant tree being scattered subalpine fir. Willows, Labrador tea, mountain juniper and white

spruce may also be present. Low growing shrubs, various graminoid species and assorted lichens cover the ground.

White Spruce/Willow (Sw/W): The white spruce/willow association is the most frequent vegetation association within the study area, occurring in both the boreal and the subalpine zones on various upland and lowland slopes. White spruce dominates the tree canopy along with scattered subalpine fir. A well-developed shrub layer dominated by tall willows is evident, along with dwarf shrubs of horsetails and graminoids. Moss and lichen species are also common throughout.

White Spruce/Feather Moss (Sw/Fm)*:* This vegetation association occurs most frequently on well-drained mesic sites in lowland areas throughout the boreal zone. The tree canopy is comprised of dense white spruce trees with a sparse shrub and herbaceous understory, and a thick carpet of feathermosses.

Pine (Pl): The Pine vegetation association consists of a dominant tree canopy of lodgepole pine. It is found mostly on upland areas around the Grum and Vangorda pit at the SE end of the LSA in the boreal zone and is a typical mid-successional forest following fire. A tall and varied shrub layer is common and followed by a lower scattered shrub layer. Ground cover species are noted at lower cover values with feathermosses common throughout.

Mixed Coniferous-Deciduous (Mx): This vegetation association establishes on well drained sites over a broad elevation range. It is a mixture of coniferous and deciduous trees including white spruce, trembling aspen, balsam poplar and lodgepole pine. Depending on moisture and nutrients, subalpine fir and/or black spruce may also be present. This is often a young forest whereby trees are in both the tree canopy and shrub layer. Additional tall and low growing shrubs fill in the understory, while mosses and lichens moderately cover the ground.

Deciduous (Dd): The deciduous vegetation association often establishes on sites regenerating from a disturbance, whether it be fire or human development. Sites tend to be located on well-drained slopes in the boreal zone that are rich in diversity. Trembling aspen is the dominant tree species followed by balsam poplar on moister sites. Tall shrubs include willow species, Sitka alder and often white spruce. Both the low growing shrubs and herbaceous layer are abundant with various species.

Graminoid (Gr): The graminoid vegetation association is found in lowland areas on and around the project footprint in the boreal zone. It generally comprises an area re-established from seed mixtures of grasses and low growing forbs as in the freshwater reservoir located SE of the tailings pond along the access road.

4.11.4 Rare or Threatened Plant Species

A rare plant survey was undertaken in 2008 on selected areas below four waste rock slopes. No rare species were found, however this does not rule out the existence of rare species in the area.

4.11.5 Vegetation Health

The results of the terrestrial effects study for the Faro Mine Complex show that the presence of the mine has resulted in elevated concentrations of several elements both at the mine site and in the surrounding area. The area affected by some elements is large and is represented in Figure 4.15. For example, concentrations of lead are elevated in an area known to be at least and probably greater than 1,760 km^2. Two distinct element sources are associated with the mine and mining operations. The mine itself is the source of most elemental deposition; however, a breach of the tailings dam in 1975 resulted in the deposition of tailings along watercourses to the northwest of the mine site. These tailings deposits, which occur discontinuously, may provide a secondary source of water- and air-borne deposition and could extend the area affected by elevated elemental concentrations. The presence of elevated elemental concentrations in plants consumed by humans and animals indicates that these elements are entering the environmental food chain and also have the potential to be incorporated into the human food chain.

4.12 Wildlife

Baseline wildlife information was documented for the Faro Mine Complex. A review of literature from published and government sources and consultation with local authorities was used to assess the distribution and abundance of wildlife species within the study area. No information documenting distribution and abundance of wildlife species is available after 2007.

The most prominent wildlife concerns apparent in the area were related to thinhorn (fannin) sheep populations that move through and reside very near the Faro Mine Complex and the level of tailings-related contaminants in wildlife, particularly those in moose.

Information was collected on seven species or species-groups occurring within the study area: thinhorn (fannin) sheep, grizzly bear, moose, woodland caribou, migratory birds, furbearers and small mammals. These species were selected based on their Territorial and Federal status designations, socio-economic value, vulnerability to project affects, and stakeholder concern. A summary of the findings for each species is presented below, as well as a briefing of the state of knowledge regarding contaminant levels in wildlife that may occur near the Faro Mine.

4.12.1 Local Study Areas (LSA)

The Local Study Area (LSA) captures direct effects on wildlife from the project activities in project impact assessment and is particularly concerned with habitat availability. The LSA used in this baseline description varies by VEC.

For furbearers, small mammals, and birds, the vegetation LSA will be used. This area is illustrated in Figure 4.14. This LSA is limited to the immediate project footprint and surrounding areas (i.e., within a 1 km radius surrounding the Faro Mine Complex. This area totals 81.2 km^2, of which 16.1 km^2 is made up of the footprint of the current mine infrastructure and roads.

For wide-ranging species, a larger LSA applies and corresponds to Game Management Subzones (GMS), which are legal boundaries that define an area by game management objectives established by Yukon Environment. The following list describes the LSA for each wide-ranging VEC:

- Moose: GMS 4-42 to 4-47, 4-51;
- Thinhorn sheep: GMS 4-43 to 4-47, 4-51; and
- Grizzly bear: GMS 4-44 to 4-47, 4-42, 4-51.

The LSA for the contaminant study is similar to the ones used for wide-ranging species (GMS 4-42 to 4-46) because particulate matter will be released into the atmosphere during closure activities and may have far-reaching affects.

4.12.2 Regional Study Area (RSA)

However, it was necessary to include regional data where feasible and appropriate, primarily to provide a context for local scale data. In some cases, there were no data available that were specific to the local area, and regional scale data were used to form conclusions regarding local conditions.

4.12.3 Thinhorn Sheep

In the Pelly and Ogilvie Mountains of the Yukon Territory, fannin sheep occur, which are a colour variant of thinhorn sheep and are somewhat intermediate between Dall and Stone sheep in appearance (O. dalli dalli and O. dalli stonei, respectively). In the Game Management Subzones (GMSs) that encompass the Faro Mine, there were a minimum of 183 fannin sheep observed during a 2002 survey (Government of Yukon, Department of Environment 2002). The population appears generally stable and not thought to be over harvested.

Fannin sheep in the Faro area generally occur on Sheep Mountain, Rose Mountain, and Mount Mye. A reasonable understanding of seasonal ranges and movement patterns in the Faro area exists, as twice a year fannin sheep migrate through the infrastructure of the Vangorda/Grum area of the Faro Mine Complex, as shown in Figure 4.16. Sheep migrate between mid-May and late June from wintering ranges on Sheep Mountain to summering areas, often on Mount Mye (McLeod 1981; Schweinsburg 1990). Fall migration takes place in mid-September to mid-October, when sheep move from widespread summer ranges to early winter and rutting areas on Sheep Mountain. Sheep in the area near the Faro Mine have tended to show some resilience to disturbance and continue to re-use migratory routes (such as migrations through Vangorda mine area), despite ongoing anthropogenic disturbances.

Thinhorn sheep have high socio-economic value in the Yukon as a game and subsistence species, and for their non-consumptive value (primarily wildlife viewing). In the Town of Faro, fannin sheep are integral to the annual sheep and sandhill crane (Grus canadensis) viewing festival. Infrastructure and interpretative trails that support wildlife viewing have been built near the town. Managers have

also focused efforts to reduce disturbance on wintering sheep, by declining woodcutting applications and barricading areas to deter snowmobile access.

4.12.4 Woodland Caribou

Woodland caribou are relatively uncommon in the area near the Faro Mine, although a portion of the winter range of the Tay River herd is relatively close to the Mine. The Northern Mountain woodland caribou populations (of which the Tay River herd is one) are listed as Sensitive in the Yukon (Canadian Endangered Species Conservation Council 2006), and federally designated as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2007) and Schedule 1 of the *Species at Risk Act (SARA)*.

The population of the Tay River herd was last estimated to be 3,758 (+/- 571) animals, based on a 1991 survey (Government of Yukon 1997a). Although the Tay River caribou herd is relatively small and widely dispersed, it appears stable in population levels given the currently low harvest pressure.

4.12.5 Moose

Moose in the Faro area occur at densities of approximately 405 moose per 1,000 km^2 (Government of Yukon 2004), although the actual population of moose in the LSA is unknown and likely fluctuates. Relative to other parts of the Yukon, densities of moose are consistently high in the Faro area. Moose have high socio-economic value in the Yukon as a game and subsistence species, and moose populations in and near the Faro area are considered a high management priority by Government, First Nations, and local stakeholders (R. Ward, pers. comm. 2007). The moose harvest rate in the GMSs near the Faro Mine tends to be near the limit of sustainable levels, and an increase in harvest pressure on moose is a concern of both local stakeholders and the Yukon Government. Thus far, the Government has closely regulated and monitored populations that encompass the Faro Mine.

4.12.6 Grizzly Bears

Grizzly bears are a listed species that may occur near the Faro Mine on a regular basis. Federally, grizzly bears are designated as Special Concern (COSEWIC 2007) due to habitat loss, low reproduction, and slow recovery rates. Grizzly bears are considered Sensitive in the Yukon (Canadian Endangered Species Conservation Council 2006). The current territory-wide estimate of grizzly bears in the Yukon is 6,000 to 7,000 grizzly bears (Government of Yukon 1997b).

Although not necessarily an indication of population size or trends, grizzly bears have been sighted regularly near the Faro Mine by onsite mining staff. The area-based mortality measure of 6.31 bears/year/1,000 km^2 in the GMS that encompasses the Faro Mine is exceedingly high in comparison to neighbouring GMS's. Habitats near the Faro Mine appear to support high densities of prey species such as moose and thinhorn sheep. Vegetation cover in the area includes abundant berry-producing plants that provide forage. Given these factors, it is likely that the area including and surrounding the Faro Mine has a relatively high production and/or density of grizzly bears.

4.12.7 Migratory Birds

Migratory birds are protected under the federal *Migratory Birds Convention Act* (*MBCA*). Migrations in the Yukon Territory make up the Pacific Flyway, a migratory route known to provide critically important areas for large numbers of waterfowl that migrate north to nest and raise young. Waterbirds (such as ducks, geese, and cranes) need suitable habitat for staging and congregation behaviours. These tend to be areas that have abundant food and are ice-free in early spring. Waterbird habitat in the Faro area is restricted to the lowland areas around Rose, Next, and Vangorda Creeks, since much of the area surrounding the mine site is made up of mid slopes that do not provide suitable habitat for waterbirds. Most creeks close to the Faro Mine Complex are too small and fast flowing for much of the staging and congregation behaviours exhibited by waterbirds.

Landbirds (such as passerines, upland game birds, woodpeckers, and raptors) are common and have been observed throughout the Faro region either through surveys or by incidental sightings (Canadian Wildlife Service 2007). The LSA is made up primarily of upland areas containing mature spruce, fir, and pine forests, and contains suitable habitat for many landbirds. The most abundant birds observed in Government survey records included the common raven, Swainson's thrush, American robin, and dark-eyed junco (Canadian Wildlife Service 2007). A Harlan's hawk (a red-tailed hawk subspecies) and a colony of bank swallows were also observed on the mine site in August, 2007. The swallow colony occurs in a roadside cut bank which consists of a small, sandy cliff that appears to provide suitable nesting habitat for swallows (bank swallows typically nest in cut banks of rivers and other waterbodies). Bank swallows are not listed by COSEWIC (2007), and are identified as Secure in the Yukon (Canadian Endangered Species Conservation Council 2006).

4.12.8 Furbearers

Trapper harvest of furbearers is an important economic activity in much of the Yukon. The largest portion of trappers' incomes in the Yukon is from the sale of lynx and marten pelts, but wolverine, red fox, wolf, muskrat, and beaver are also valued. Relatively few lynx are taken annually. Other species of furbearers harvested by trapping may include mink, ermine, and red squirrel. All of the furbearers identified above occur in the LSA. Among these animals, wolverines are listed as Sensitive in the Yukon (Canadian Endangered Species Conservation Council 2006) and as Special Concern by COSEWIC (2007). All other species are considered Secure in the Yukon (Canadian Endangered Species Conservation Council 2006), although no population or abundance surveys for furbearers have taken place in the LSA in recent years (H. Slama, pers. comm. 2007).

4.12.9 Small Mammals

Small mammals are considered an important species in the Yukon due to their significance as both furbearing species (primarily squirrels), as well as prey species for carnivores. In a contaminant-related study conducted from 2004 to 2005 in the Faro area, Gartner Lee Limited (2006b) documented the presence of several small mammal species, including northern red-backed vole, common shrew, heather vole, deer mouse, Siberian lemming, and least chipmunk. Of the small mammals trapped in these studies, the most common species collected were northern red-backed

vole, followed by common shrew, deer mouse, heather vole, least chipmunk, and Siberian lemming. All species observed in 2004 and 2005 are considered Secure by the Government of Yukon (Canadian Endangered Species Conservation Council 2006).

4.12.10 Wildlife Contaminants

The level of contaminants in wildlife (lead and zinc primarily, but also other metals) is an important wildlife concern associated with the current state of the mining facilities in Faro (Middler 2007). The airborne transportation of tailings related contaminants is likely the greatest source of elevated concentrations of mine-related contaminants in the LSA (Gartner Lee Limited 2006b).

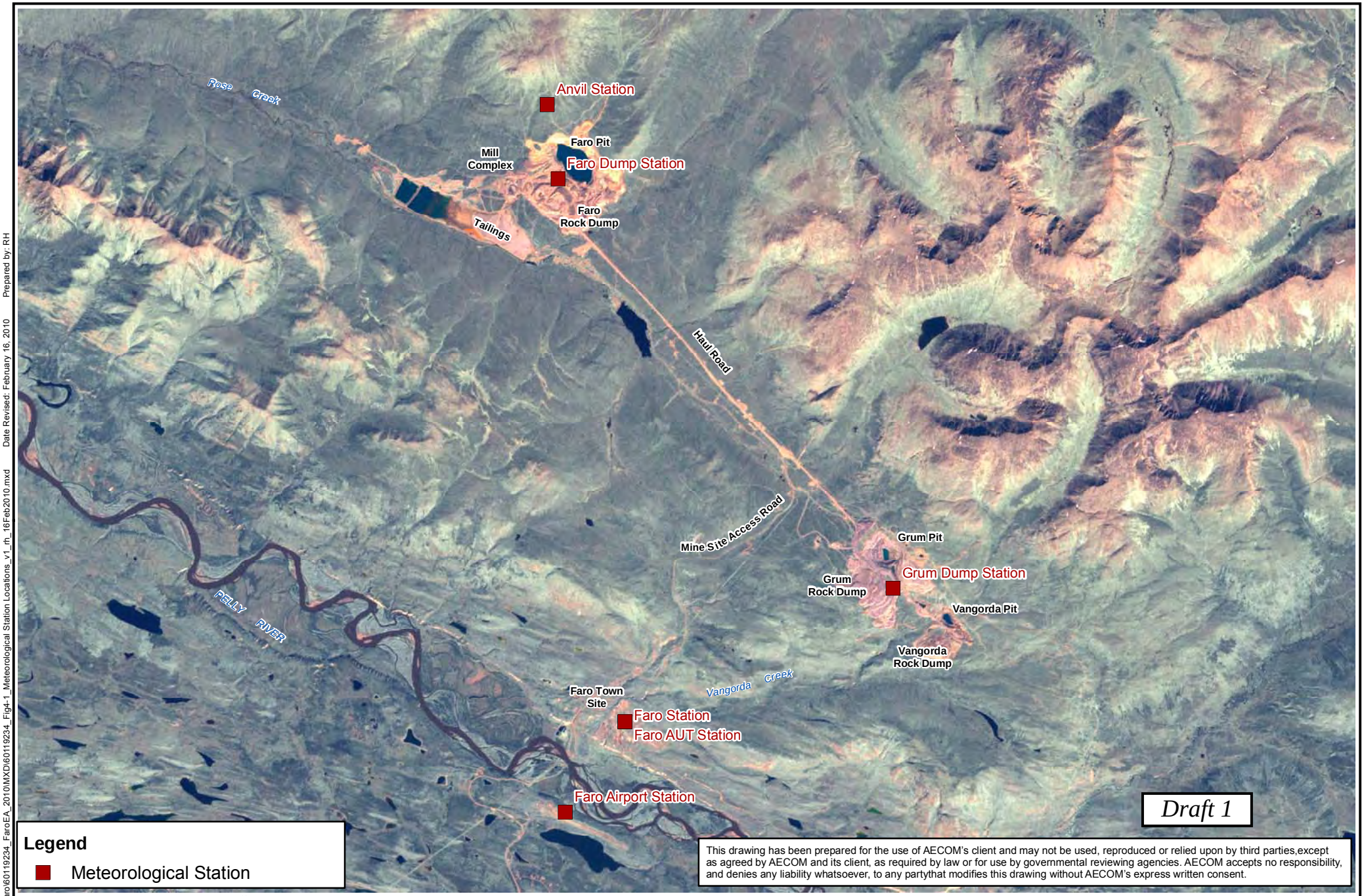
The presence of contaminants in wildlife from the Faro Mine is detailed in a previous study (Gartner Lee Limited 2006b), and updated by Gamberg (2008) for moose and caribou. In 2004 and 2005, ten species were collected for tissue analyses from hunted and trapped wildlife (Gartner Lee Limited 2006b). Those species included woodland caribou, moose, sheep, American marten (*Martes americana*), hoary marmot (*Marmota caligata*), Arctic ground squirrel (*Spermophilus parryii*), muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), willow ptarmigan (*Lagopus lagopus*), and ruffed grouse (*Bonasa umbellus*). Small mammals were collected and tested for heavy metal concentrations, including lead, zinc, copper, arsenic, iron, silver, thallium, barium, chromium, mercury, nickel, selenium, antimony, cadmium, and cobalt (Gartner Lee Limited 2006b).

The highest elevations in lead concentration in animal tissue ranged from 4.6 to 18.7 times greater than reference samples in the Yukon (for beaver kidney and willow ptarmigan liver samples, respectively). High elevations of levels of lead were present in red-backed voles and shrews, and moderately elevated levels of copper, iron, thallium and nickel were also observed in most small mammals. Moderate elevations were also detected for mercury and selenium in American marten, willow ptarmigan, and moose. Iron concentrations in sheep kidneys were 1.1 times greater than to the Yukon-wide hunter survey samples, and silver concentrations were 5.1 times greater in Tay River caribou muscle and than in the nearby Finlayson herd.

Among hunted and trapped wildlife, elevated lead concentrations were found in caribou, American marten, willow ptarmigan, and beaver. Moderate elevations were also detected for mercury and selenium in American marten, willow ptarmigan, and moose.

Updated sampling data from 2005 to 2007 for moose (N=2) and caribou (N=6 [muscle] and 7 [liver, kidney]) indicated that most elements did not change substantially from earlier tests (i.e., 2004 to 2005), although concentrations of arsenic and zinc appear to have increased in both moose and caribou. Lead concentrations had increased in moose, while mercury had increased in caribou in comparison to earlier sampling. Zinc concentrations recorded in moose and caribou from this LSA fall into the high/toxic range for domestic cattle (Gamberg 2008), and continued monitoring of contaminant loads in wildlife is recommended.

Figures



Legend

- Meteorological Station

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Map notes:

N W E S

0 1 2 3 4

Kilometers

1:125,000

UTM Zone 8N, NAD83

AECOM

Faro Mine Closure
Fermeture de la mine Faro

Job No: 60119234

Filename: 60119234_Fig4-1_Meteorological Station Locations_v1_rh_16Feb2010.mxd

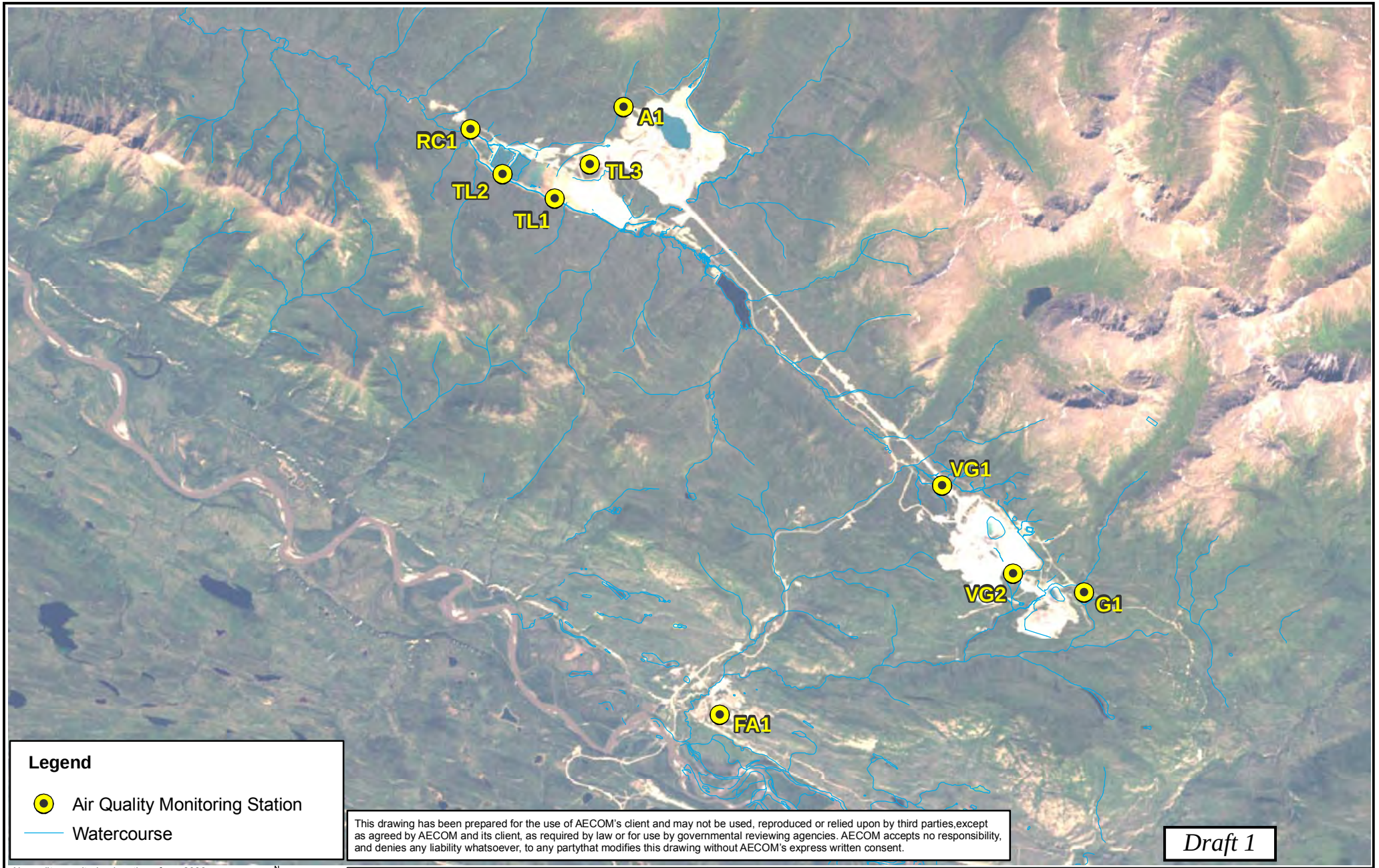
Faro Mine Complex
Closure and Remediation

Project Proposal

Climate Station Locations

Date:	Approved:	FIGURE:
February 2010		4-1

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-1_Meteorological Station Locations_v1_rh_16Feb2010.mxd Date Revised: February 16, 2010 Prepared by: RH



Legend

- Air Quality Monitoring Station
- Watercourse

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Draft 1

Air quality monitoring locations from 2008 Baseline Air Quality Monitoring Assessment for Faro Mine Complex, SENES Consultants Limited, January 2009.

N W E S

0 1 2

Kilometers

1:125,000

UTM Zone 8N, NAD83

AECOM

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File: 60119234_Fig4-2_Air Quality Monitoring_v1_rh_17Feb2010.mxd

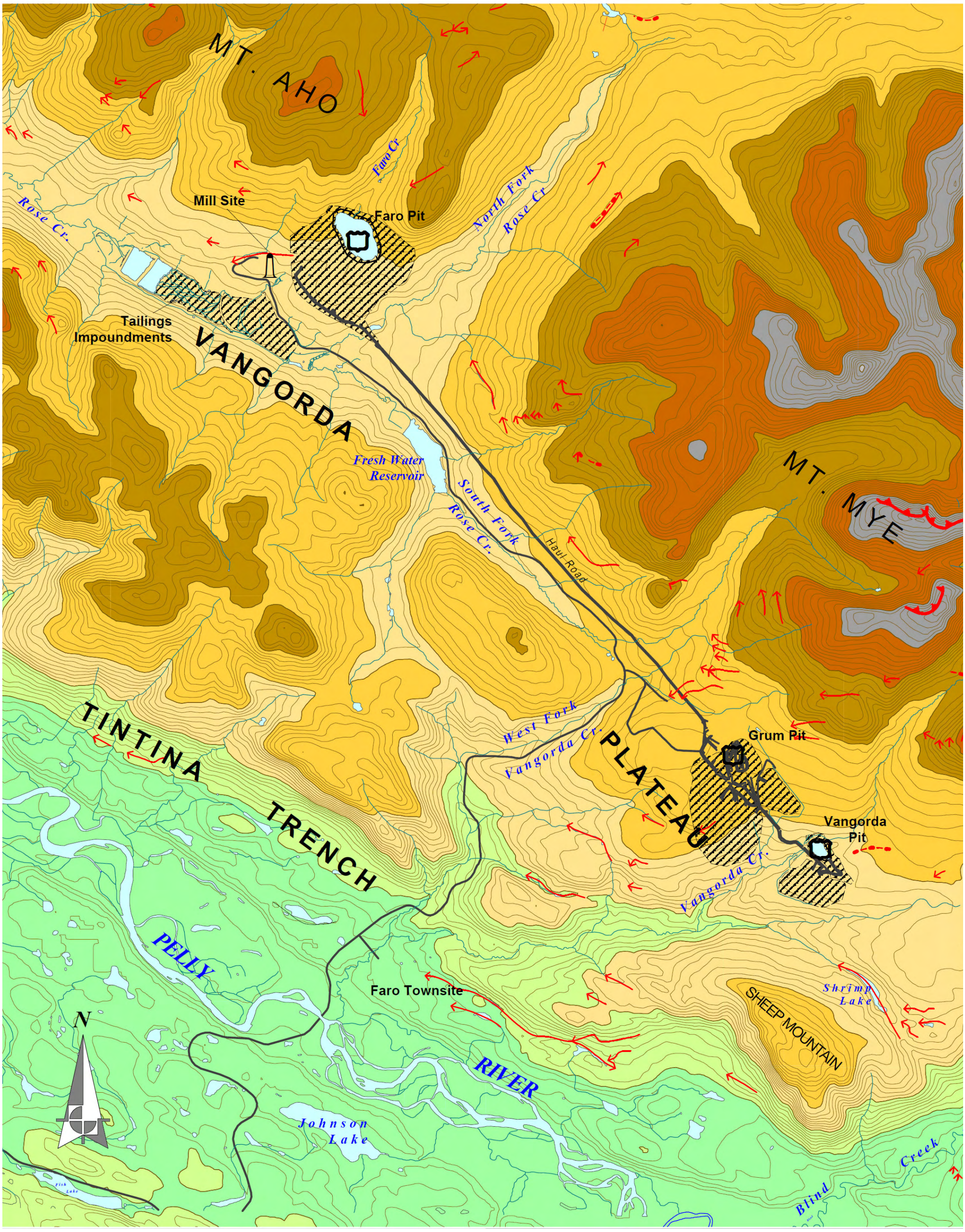
Faro Mine Complex
Closure and Remediation

Project Proposal

Air Quality Monitoring Stations

Date:	Approved:	FIGURE:
February 2010		4-2

File Location: W:\G\SIGIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-2_Air Quality Monitoring_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: RH Project: 60119234



LEGEND

ELEVATION RANGES (metres ASL)

- below 800 m
- 800-1,000 m
- 1,000-1,200 m
- 1,200-1,400 m
- 1,400-1,600 m
- 1,600-1,800 m
- above 1,800 m

SYMBOLS

- Cirque
- Glacial meltwater channel
- Moraine ridge

1 0 1 2 3

Kilometers

Scale: 1:75,000

Draft 1

SOURCE: Surficial Geology from "Quaternary geology and till geochemistry of the Anvil District, central Yukon Territory (Bulletin 11)" Bond, J.D., 2001.

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Physiographic Setting

Job No: 60119234

File: 60119234_Fig4-3_Physiographic Setting_v1_rh_16Feb2010

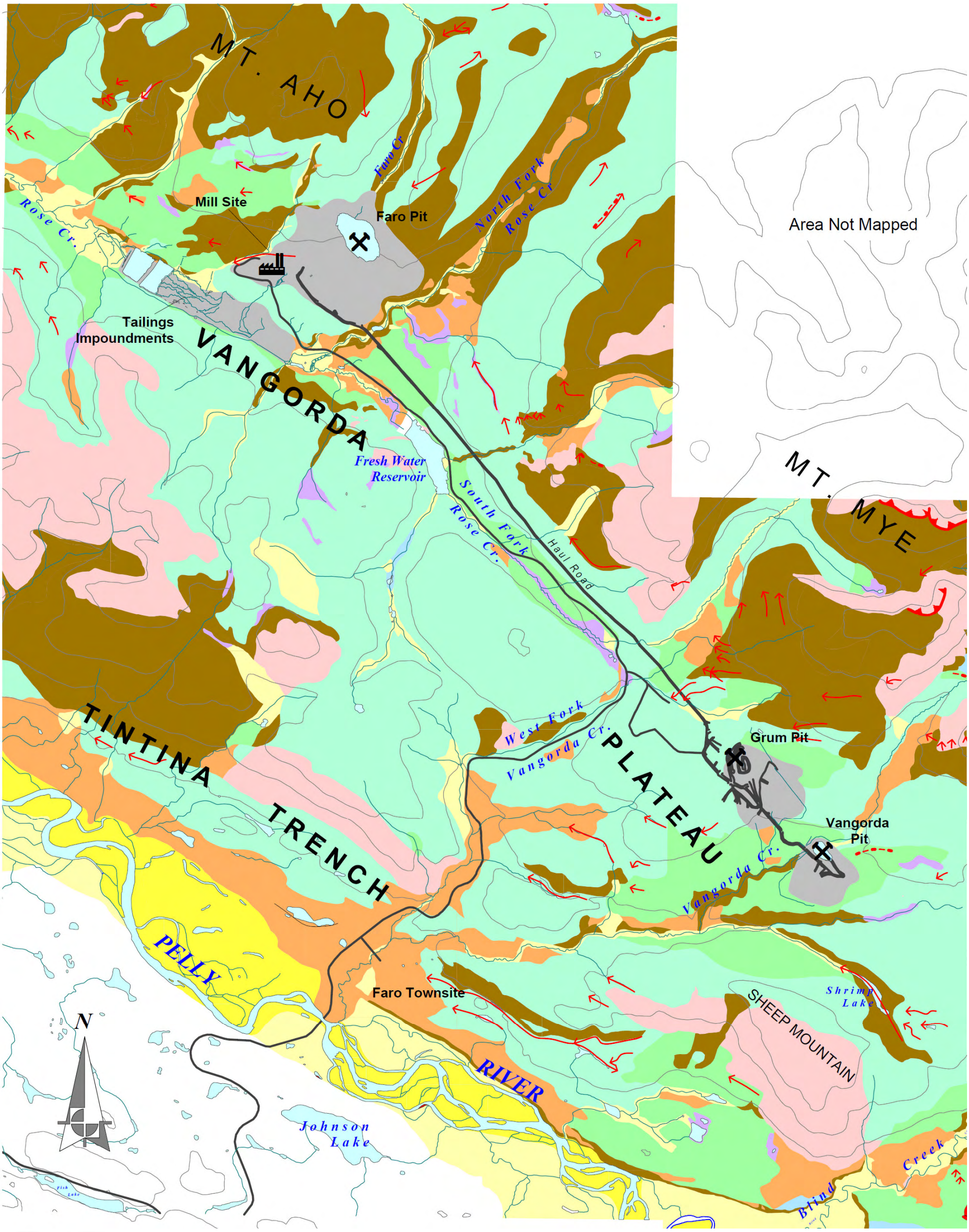
Project Proposal

Date: February 2010

Approved:

Figure: 4-3

AECOM



LEGEND

SURFICIAL MATERIALS

- Anthropogenic
- Colluvium
- Fluvial (Active)
- Glaciofluvial
- Fluvial
- Glaciolacustrine
- Morainal Veneer (Till)
- Morainal Blanket (Till)
- Organic
- Bedrock

SYMBOLS

- Cirque
- Glacial meltwater channel
- Moraine ridge

1 0 1 2 3

Kilometers

Scale: 1:75,000

Draft 1

SOURCE: Surficial Geology from "Quaternary geology and till geochemistry of the Anvil District, central Yukon Territory (Bulletin 11)" Bond, J.D., 2001.

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Surficial Geology and Landforms

AECOM

Job No: 60119234

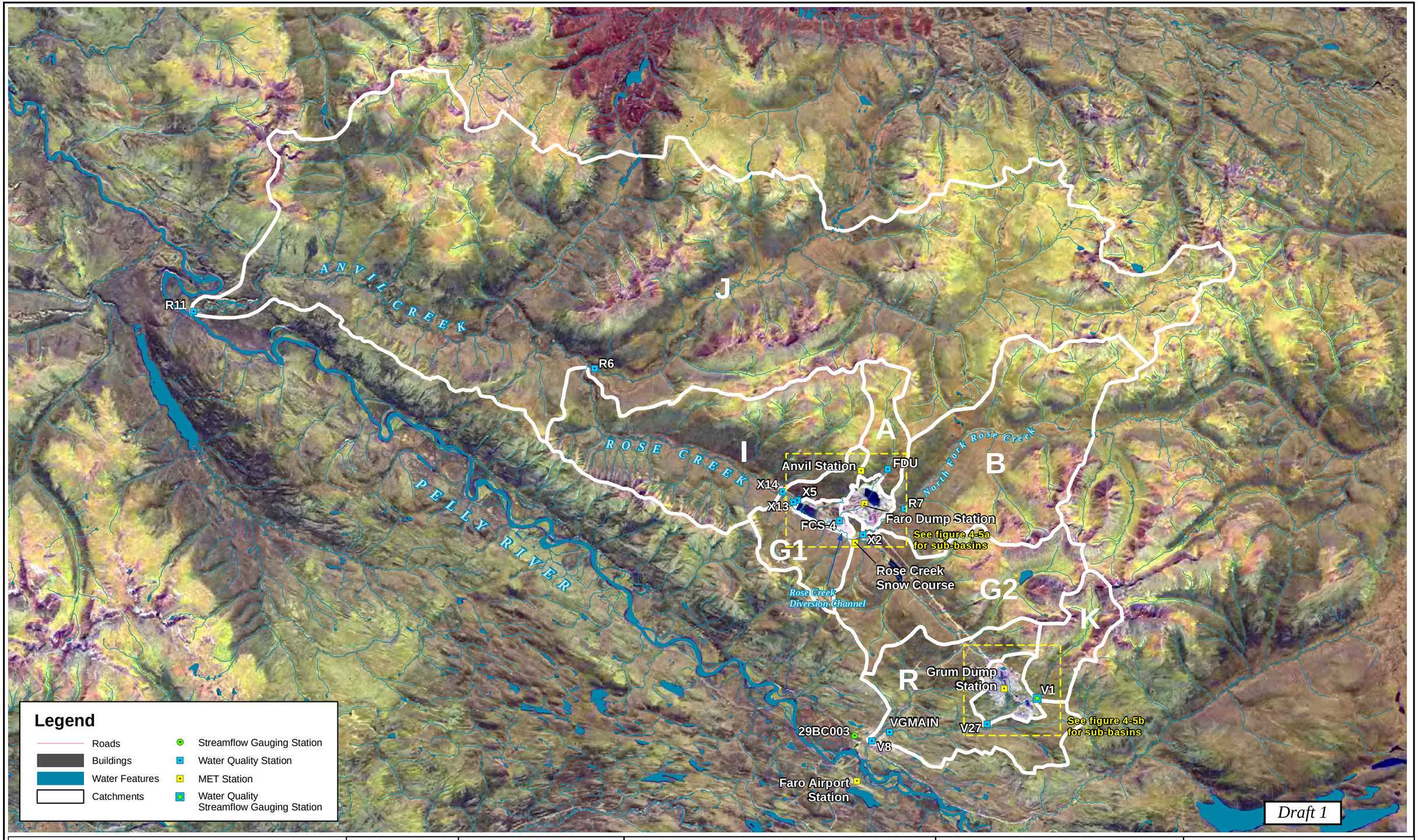
File: 60119234_Fig4-4_Surficial Geology and Landforms_v1_rh_16Feb2010

Project Proposal

Date: February 2010

Approved:

Figure: 4-4



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N W E S

1:200,000
UTM Zone 8N, NAD83

Map Notes:

0 3 6 9 12 Km

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Project Proposal

Faro Mine Complex Catchments

Date:	Approved:	FIGURE:
February 2010		4-5

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-5_Overview Catchments_v1_rh_17Feb2010.mxd
Date Revised: February 17, 2010
Prepared by: RH

Legend

- Pipeline
- Effluent Pipeline
- Pre-Mine Drainage
- Index Contours
- Subcatchments
- Tailings Impoundment
- Water Treatment Pipeline
- Existing Surface Drainage
- Intermediate Contours
- Waterbodies
- Buildings

FDU
Faro Creek
Anvil Station
A
R7
North Fork Rose Creek
C
E1
F4
G1
B
Faro Dump Station
D
F3
F2
E2
F1
G2
X2
H
FCS-4
09BC003
Rose Creek
Rose Creek Snow Course
X5
X14
X13
RCDC
Rose Creek Diversion Channel
I

Draft 1

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1:30,000
UTM Zone 8N, NAD83

- Streamflow Gauging Station
- MET Station
- Water Quality Station

0 0.5 1 1.5 2 Km

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Project Proposal

Anvil Creek Sub-catchment

Date:	Approved:	FIGURE:
February 2010		4-5a

Prepared by: RH
Date Revised: February 17, 2010
File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-5a_Faro Site Catchments_v1_rh_17Feb2010.mxd

Legend

- Pipeline
- Effluent Pipeline
- Pre-Mine Drainage
- Index Contours
- Tailings Impoundment
- Subcatchments
- Water Treatment Pipeline
- Existing Surface Drainage
- Intermediate Contours
- Waterbodies
- Buildings

N
K
L
M
O
P1
P2
Q
R
V1
Vangorda Creek
Grum Creek
Grum Dump Station

Draft 1

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1:20,000
UTM Zone 8N, NAD83

- MET Station
- Water Quality/ Streamflow Gauging Station

0 0.5 1 1.5 Km

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Project Proposal

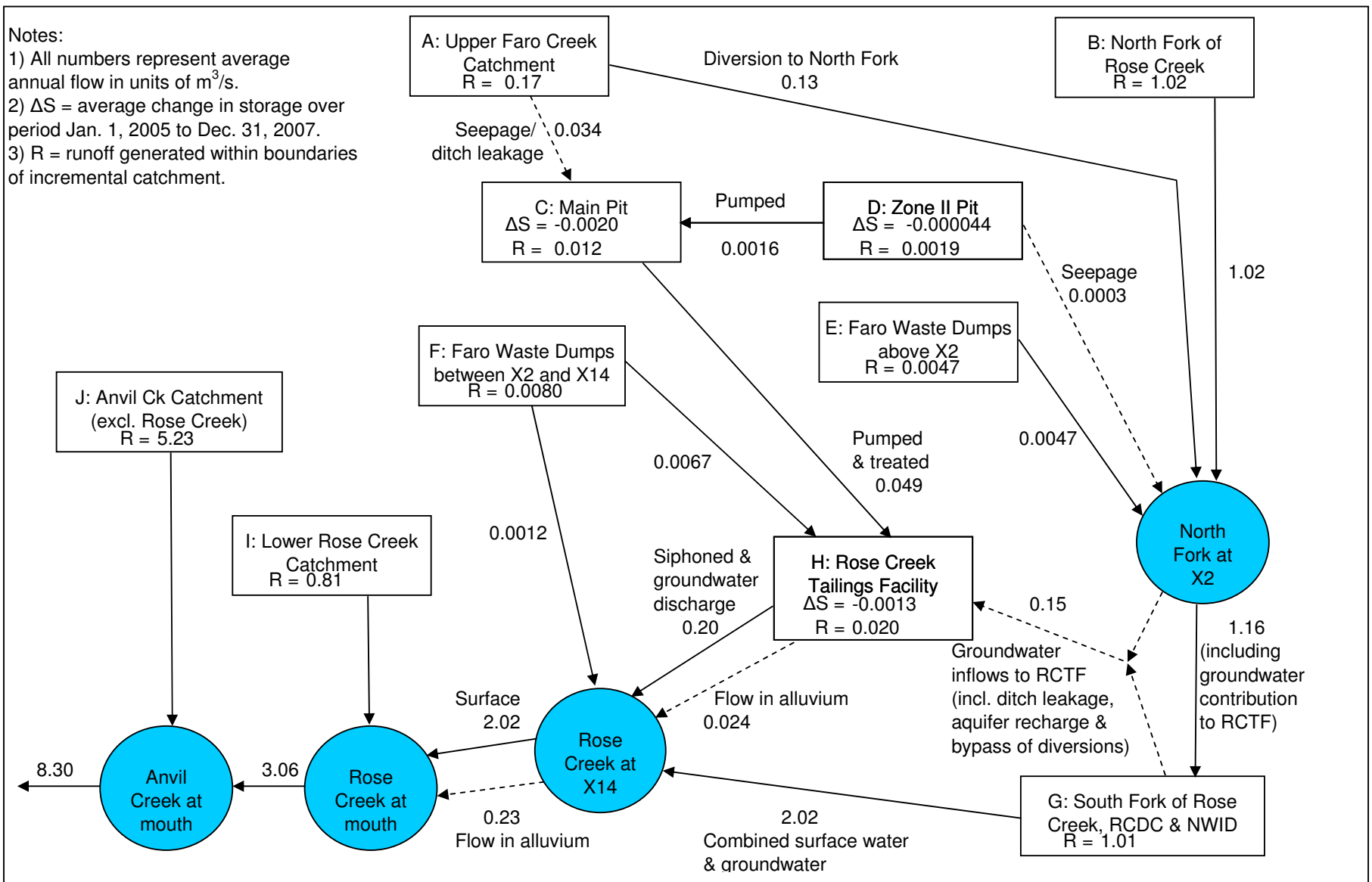
Vangorda Creek Sub-catchment

Date:	Approved:	FIGURE:
February 2010		4-5b

Date Revised: February 17, 2010 Prepared by: RH

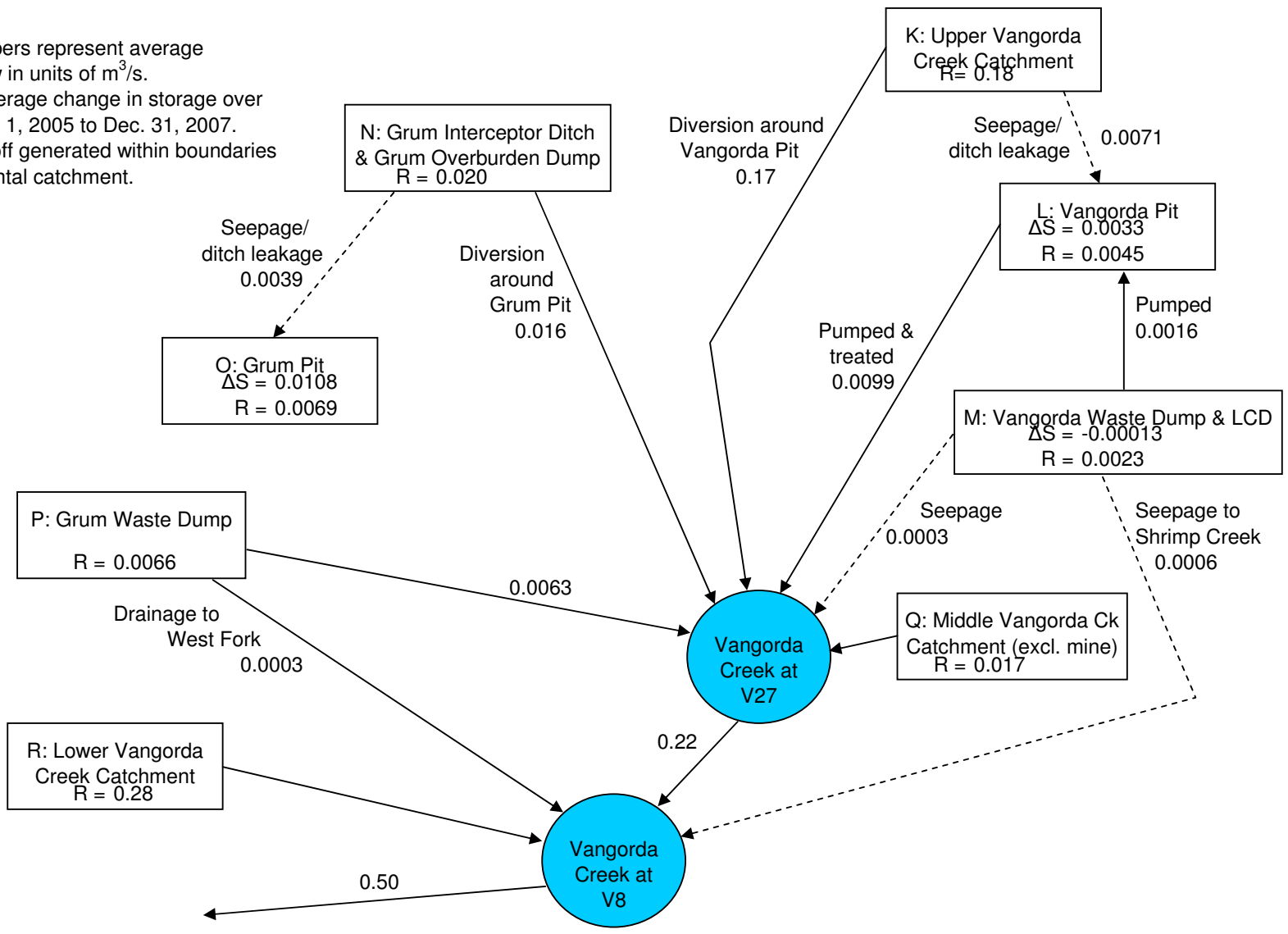
File Location: W:\GIS\GIS_P\data\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-5b_Vangorda Site Catchments_v1_rh_17Feb2010.mxd

Notes:
1) All numbers represent average annual flow in units of m^3/s.
2) ΔS = average change in storage over period Jan. 1, 2005 to Dec. 31, 2007.
3) R = runoff generated within boundaries of incremental catchment.



A) Anvil Creek Catchment (2005 to 2007)

Notes:
1) All numbers represent average annual flow in units of m^3/s.
2) ΔS = average change in storage over period Jan. 1, 2005 to Dec. 31, 2007.
3) R = runoff generated within boundaries of incremental catchment.



B) Vangorda Creek Catchment (2005 to 2007)

Draft 1

Prepared by Pat Bryan for AECOM (March 2009)

Faro Mine Closure
Fermeture de la mine Faro

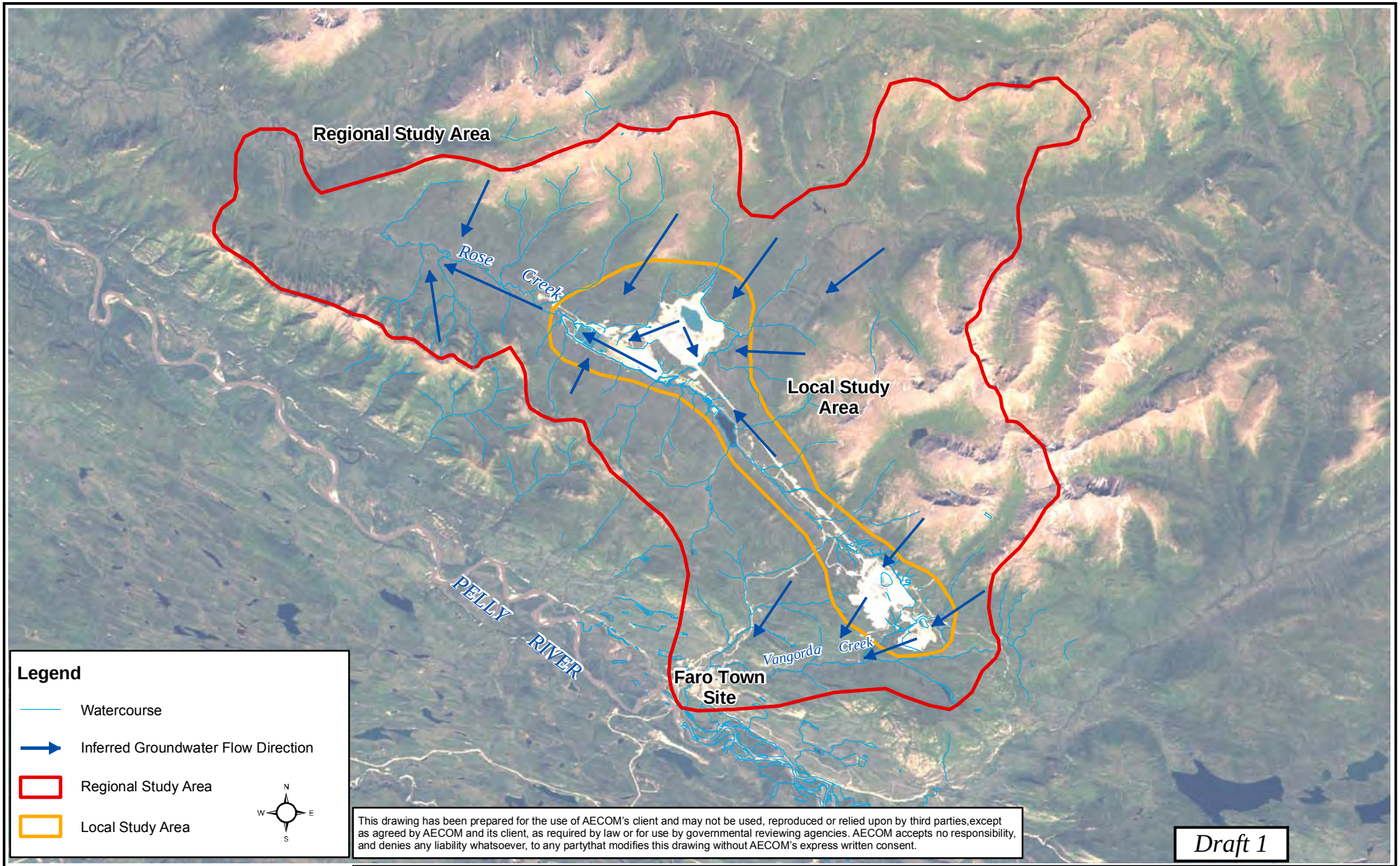
Job No: 60119234
File: 60119234_Fig4-6_Water Balance Schematic_v1_rh
_16Feb2010

Faro Mine Complex
Closure and Remediation

Project Proposal

Average Annual Water Balance Anvil Creek Catchment (A) and Vangorda Creek Catchment (B)

Date:	Approved:	Figure:
February 2010		4-6



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Draft 1

Basemap: Orthoshop, Calgary, AB, November 2003. Prepared for SRK Consulting. Based on August 2003 aerial photography. Shaded relief colour orthorectified image at 15m resolution compiled by Yukon Gov't, Dept of Infrastructure, Yukon Geomatics, Landsat 7.

0 2.5 5
Kilometers
1:200,000
UTM Zone 8N, NAD83

AECOM

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File Name: 60119234_Fig4-7_Groundwater Study Areas_v1_rh_17Feb2010.mxd

Faro Mine Complex
Closure and Remediation

Project Proposal

Local and Regional Groundwater Study Areas for the Faro Mine Complex

Date:	Approved:	FIGURE:
February 2010		4-7

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-7_Groundwater Study Areas_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: RH Project: 60119234

Prepared by: RH

Date Revised: February 17, 2010

File Location: W:\GIS\GIS_PdataIFaro\60119234_FaroEA_2010\MXD\60119234_Fig4-8_Faro Contamination_v1_rh_17Feb2010.mxd

Legend

Monitor Symbols

- Monitor Location: Not Enough Data to be Included
- Monitor Location Data Used in this Assessment
- Multi-level Monitor Location Data Used in this Assessment (See details in table)

Contamination Classification of Zinc and Sulphate

- Unaffected: Below Detection to Low Levels of Zinc and Sulphate Concentrations
- Low: Low Levels of Zinc and Sulphate Concentrations
- Moderate: Moderate Levels of Zinc and Sulphate Concentrations
- High: High Levels of Zinc and Sulphate Concentrations
- Very High: Very High Levels of Zinc and Sulphate Concentrations (Screened in Tailings)

Watercourse

Impoundment (original)

Contours

Index Contours (10m)

Intermediate

Level of Contamination in Multilevel Wells

P03-01		Depth (m)	P03-04		Depth (m)	P03-08		Depth (m)
P03-01-01	Unaffected	46.79	P03-04-01	Moderate	58.22	P03-08-01	Unaffected	32.61
P03-01-02	Unaffected	38.86	P03-04-02	Moderate	47.55	P03-08-02	Low	28.35
P03-01-03	Low	30.63	P03-04-03	Moderate	41.45	P03-08-03	Low	24.69
P03-01-04	Low	24.54	P03-04-04	Low	35.05	P03-08-04	Low	23.16
P03-01-05	Low	18.44	P03-04-05	Moderate	26.06	P03-08-05	Moderate	21.64
P03-01-06	Low	13.26	P03-04-06	Very High	17.37	P03-08-06	Moderate	20.12
P03-01-07	Very High	10.82	P03-04-07	Very High	15.54	P03-08-07	Moderate	17.07
P03-01-08	Very High	9.3	P03-04-08	Very High	13.72	P03-08-08	Low	14.02
P03-01-09	Very High	7.77	P03-04-09	Very High	12.8	P03-09		
P03-02			P03-05			P03-09-01	Low	35.05
P03-02-01	Low	33.83	P03-05-01	Moderate	44.5	P03-09-02	Low	32.31
P03-02-02	Low	30.48	P03-05-02	Low	36.88	P03-09-03	Low	27.13
P03-02-03	Low	22.86	P03-05-03	Low	27.74	P03-09-04	Low	23.77
P03-02-04	Low	16.76	P03-05-04	Low	23.47	P03-09-05	Low	21.95
P03-02-05	Very High	13.72	P03-05-05	Moderate	21.64	P03-09-06	Low	18.9
P03-02-07	Very High	11.89	P03-05-06	Moderate	18.59	P03-09-07	Low	18.41
P03-02-08	Very High	8.84	P03-05-07	Very High	14.02	P03-09-08	Low	9.45
P03-02-09	Very High	7.62	P03-05-08	Very High	10.97	P03-09-09	Low	7.62
			P03-06			P05-01		
			P03-06-01	Moderate	25.91	P05-01-01	Low	25.45
			P03-06-02	Moderate	22.86	P05-01-02	Moderate	19.82
			P03-06-03	Moderate	19.81	P05-01-03	Moderate	16.77
			P03-06-04	Moderate	16.46	P05-01-04	Moderate	11.28
			P03-06-05	Moderate	14.33	P05-01-05	Moderate	5.48
			P03-06-06	Very High	12.5	P05-01-06	Moderate	3.35

Groundwater Contamination - Classification Criteria

Contamination Classification	Mean SO4 concentration (mg/L)	Mean Zn concentration (mg/L)
Unaffected	0-40	0-0.05
Low	40-590	0.05-0.5
Moderate	590-2000	0.5-5
High	2700-5000	5-50
Very High	>5500	>50

Draft 1

N W E S

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AECOM

0 250 500

Meters

1:17,500

UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Basemap: Orthoshop, Calgary, AB, November 2003.
Prepared for SRK Consulting. Based on August 2003 aerial photography.
All other data, AECOM, 2008/2009.

Faro Mine Complex
Closure and Remediation

Project Proposal

File Name: 60119234_Fig4-8_Faro Contamination_v1_rh_17Feb2010.mxd

Groundwater Contamination in Monitoring Wells at the Faro Site, based on Zinc and Suphate Concentrations

Date: February 2010

Approved:

FIGURE: 4-8

Grum Pit

Grum Rock Dumps

Vangorda Pit

Vangorda Rock Dump

Moose Pond

Vangorda Creek

Little Creek Dam

Little Creek Pond

SRK04-5 A,B

BH05-9B-R

P96-9 A

SRK05-05C

SRK05-08

SRK05-07

SRK05-09

SRK05-06

V37

V36

P2001-03

P2001-02 A,B

V35

V34

Draft 1

Legend

Monitor Symbols

- Monitor Location: Not Enough Data to be Included
- Monitor Location Data Used in this Assessment

Contamination Classification of Zinc and Sulphate

- Unaffected: Below Detection to Low Levels of Zinc and Sulphate Concentrations
- Low: Low Levels of Zinc and Sulphate Concentrations
- Moderate: Moderate Levels of Zinc and Sulphate Concentrations
- High: High Levels of Zinc and Sulphate Concentrations
- Very High: Very High Levels of Zinc and Sulphate Concentrations (Screened in Tailings)

- Watercourse
- Impoundment (original)

Contours

- Index Contours (10m)
- Intermediate

Groundwater Contamination - Classification Criteria

Contamination Classification	Mean SO4 concentration (mg/L)	Mean Zn concentration (mg/L)
Unaffected	0-40	0-0.05
Low	40-590	0.05-0.5
Moderate	590-2000	0.5-5
High	2700-5000	5-50
Very High	>5500	>50

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AECOM

N W E S

0 125 250

Meters

1:15,000

UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Basemap: Orthoshop, Calgary, AB, November 2003.
Prepared for SRK Consulting. Based on August 2003 aerial photography.
All other data, AECOM, 2008/2009.

Faro Mine Complex
Closure and Remediation

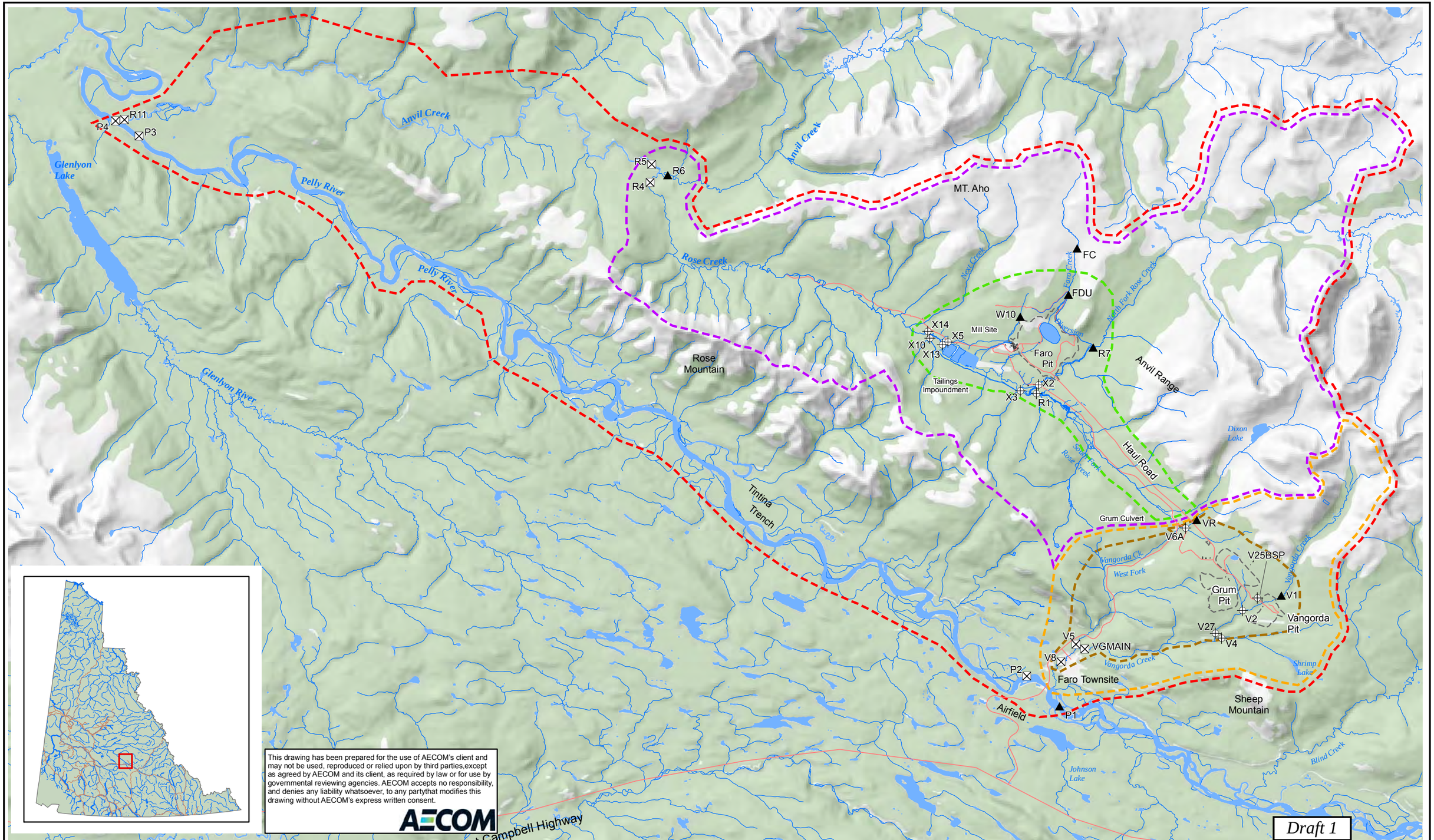
Project Proposal

File Name: 60119234_Fig4-9_Vangorda Contamination_v1_rh_17Feb2010.mxd

Groundwater Contamination in Monitoring Wells at the Vangorda/Grum Site, based on Zinc and Suphate Concentrations

Date:	Approved:	FIGURE:
February 2010		4-9

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-9_Vangorda Contamination_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: RH



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AECOM

LEGEND

- Reference Site
- Receiving Site
- Mine Run-off Effluent and Internal Site
- Roads
- Regional Study Area
- Rose Creek Local Study Area
- Vangorda Local Study Area
- Rose Creek Watershed
- Vangorda Watershed
- Surface Water
- Buildings

N W E S

0 2 4

Kilometers

1:150,000

UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File Name: 60119234_Fig4-10_Surface Water Quality Overview_v1_rh_17Feb2010.mxd

Faro Mine Complex
Closure and Remediation

Project Proposal

Surface Water Quality Study Areas

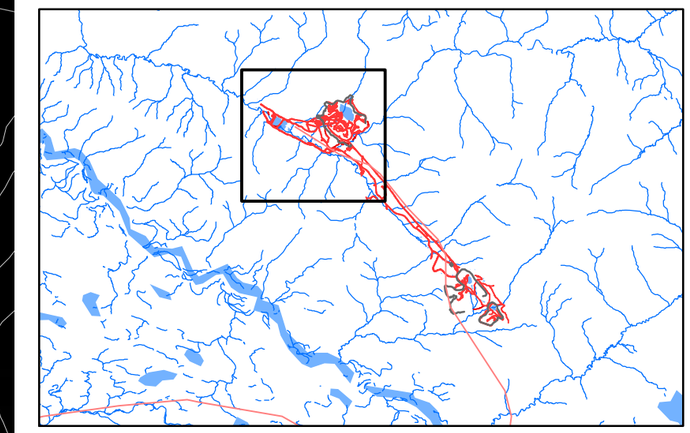
Date:	Approved:	FIGURE:
February 2010		4-10

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-10_Surface Water Quality Overview_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: RH

Legend

- Reference Site
- Mine Run-off Effluent and Internal Site
- Pre-Mine Drainage
- Effluent Pipeline
- Water Treatment Pipeline
- Pipeline
- Roads
- Existing Surface Drainage
- Buildings

FC
FDU
R7
W10
X2
R1
X3
X5
X14
X13
X10



Draft 1

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AECOM

N E S W

0 250 500

Meters

1:35,000

UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File Name: 60119234_Fig4-11_Faro Surface Water Quality_v1_rh_17Feb2010.mxd

Faro Mine Complex
Closure and Remediation

Project Proposal

Faro Mine Site
Surface Water Quality
Sampling Locations

Date: February 2010

Approved:

FIGURE: 4-11

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-11_Faro Surface Water Quality_v1_rh_17Feb2010.mxd Date Revised: February 19, 2010 Prepared by: MM

VR

V6A

V1

V25BSP

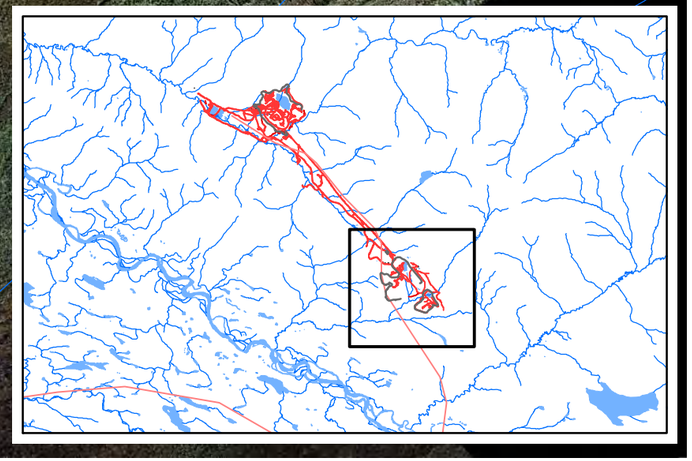
V2

V27

V4

V27

Draft 1



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AECOM

LEGEND

- Reference Site
- Mine Impacted Site
- Receiving Site
- Buildings
- Water Treatment Pipelines
- Roads
- Existing Surface Drainage
- Buildings

0 250 500

Meters

1:20,000

UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File Name: 60119234_Fig4-12_Vangorda Surface Water Quality_v1_rh_17Feb2010.mxd

Faro Mine Complex
Closure and Remediation

Project Proposal

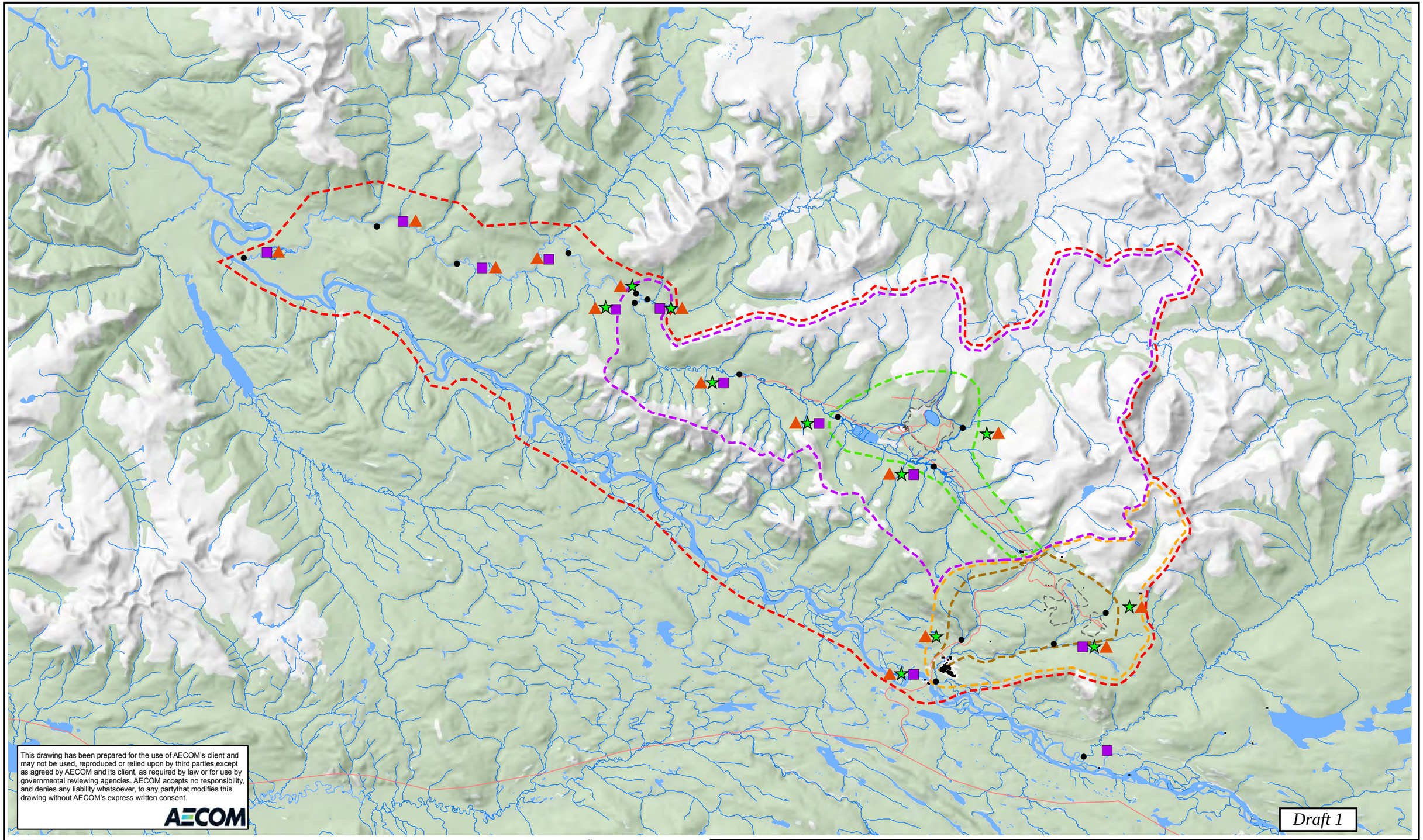
Vangorda Plateau Mine Site Surface Water Quality Sampling Locations

Date: February 2010

Approved:

FIGURE: 4-12

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-12_Vangorda Surface Water Quality_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: RH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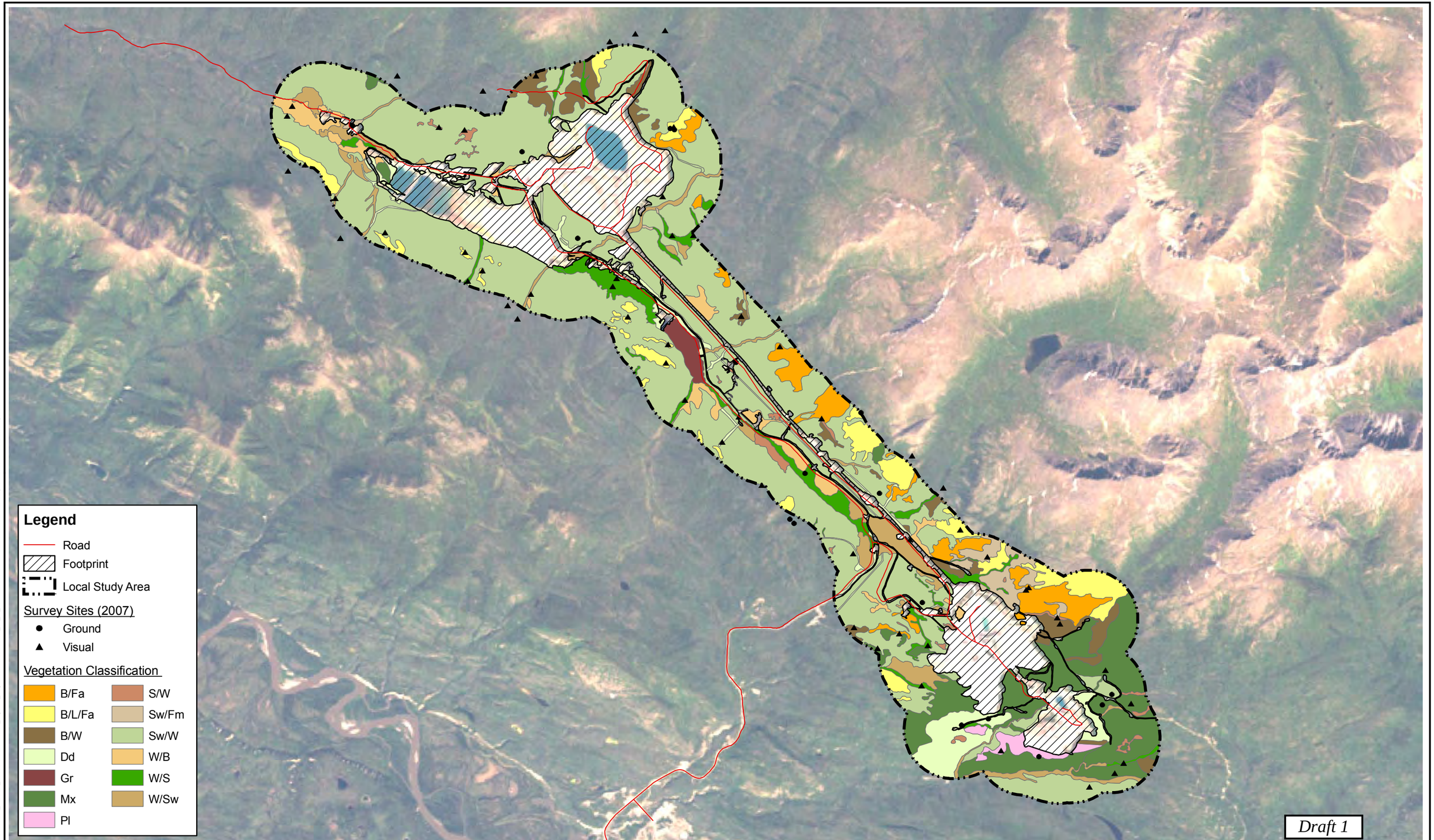
AECOM
Draft 1
LEGEND
Benthic Invertebrate
Fish Sampling
Stream Sediment
Roads
Regional Study Area
Rose Creek Local Study Area
Vangorda Local Study Area
Rose Creek Watershed
Vangorda Watershed
Pits
Buildings
N
W
E
S
0 1 2 3 4 5
Kilometers
1:200,000
UTM Zone 8N, NAD83
Faro Mine Closure
Fermeture de la mine Faro
Project Number: 60119234
File Name: 60119234_Fig4-13_Aquatic Resources_v1_rh_17Feb2010.mxd
Faro Mine Complex
Closure and Remediation
Project Proposal
Aquatic Resources
Study Area
Date: February 2010
Approved:
FIGURE: 4-13
File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-13_Aquatic Resources_v1_rh_17Feb2010.mxd
Date Revised: February 17, 2010
Prepared by: RH



Map notes:
Base data obtained from the Yukon Department of Environment, Information Management & Technology Branch.
National Topographic Database (NTDB) provided by the Government of Canada, Natural Resources Canada at 1:50,000 scale.
Survey sites provided by AECOM Canada Ltd.
Vegetation classification conducted by AECOM Canada Ltd. from aerial photography at 1:10,000 scale.
Local study area delineated by AECOM Canada Ltd.

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AECOM

N
W E
S

0 250500
Meters

1:72,549

UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File Name: 60119234_Fig4-14_Vegetation Associations_v1_rh_17Feb2010.mxd

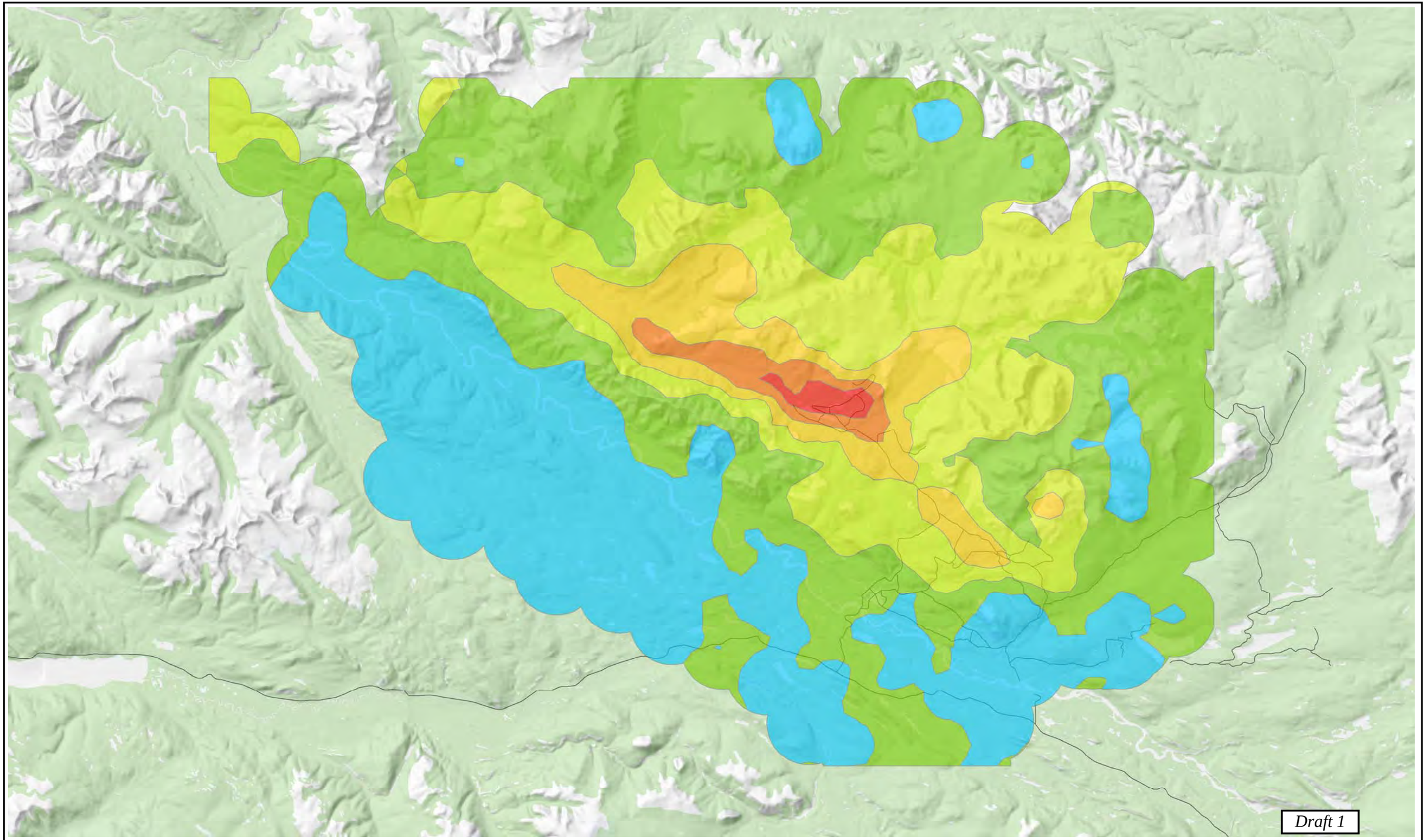
Faro Mine Complex
Closure and Remediation

Project Proposal

Vegetation Associations and 2007 Survey Sites

Date:	Approved:	FIGURE:
February 2010		4-14

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010MXD\60119234_Fig4-14_Vegetation Associations_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: RH



LEGEND

Concentration Range

0.2 - 1.6	Zone 1	17 - 61	Zone 4
1.6 - 4.6	Zone 2	61 - 210	Zone 5
4.6 - 17	Zone 3	210 - 748	Zone 6

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AECOM

N W E S

0 3 6

Kilometers

1:250,000

UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File Name: 60119234_Fig4-15_Lead Lichens_v1_rh_17Feb2010.mxd

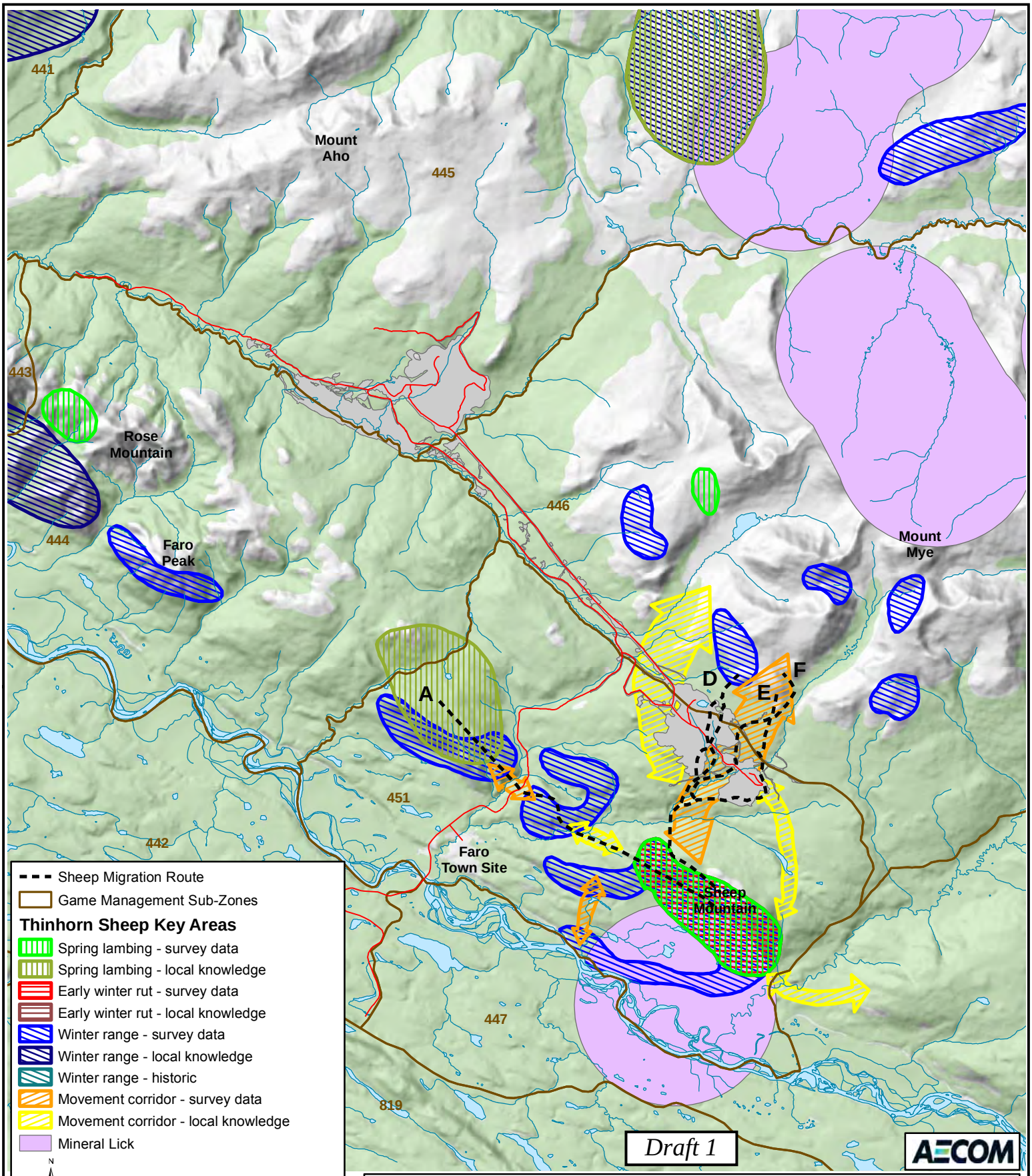
Faro Mine Complex
Closure and Remediation

Project Proposal

Standard Geostatistical Kriging of Lead in Lichen

Date:	Approved:	FIGURE:
February 2010		4-15

File Location: W:\GIS\GIS_Data\Faro\60119234_FaroEA_2010MXD\60119234_Fig4-15_Lead Lichens_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: MM



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Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Thinhorn Sheep

Project Number: 60119234

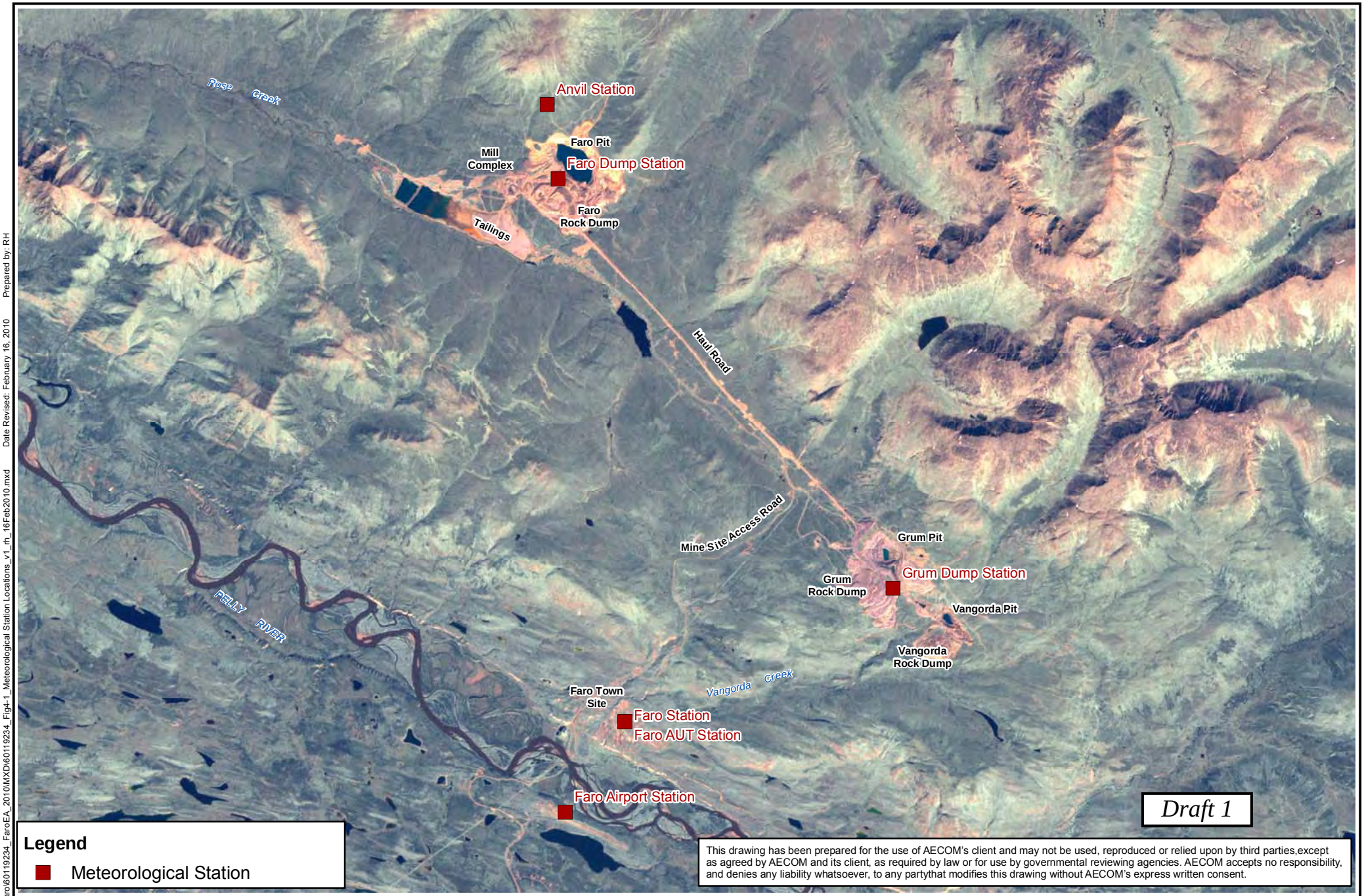
File Name: 60119234_Fig4-16_Thinhorn Sheep_v1_rh_17Feb2010.mxd

Project Proposal

Date:	Approved:	FIGURE:
February 2010		4-16

File Location: W:\GIS\GIS_P\data\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-16_Thinhorn Sheep_v1_rh_17Feb2010.mxd Date Revised: February 18, 2010 Prepared by: RH

Figures



Legend

- Meteorological Station

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Map notes:

N W E S

0 1 2 3 4

Kilometers

1:125,000

UTM Zone 8N, NAD83

AECOM

Faro Mine Closure
Fermeture de la mine Faro

Job No: 60119234

Filename: 60119234_Fig4-1_Meteorological Station Locations_v1_rh_16Feb2010.mxd

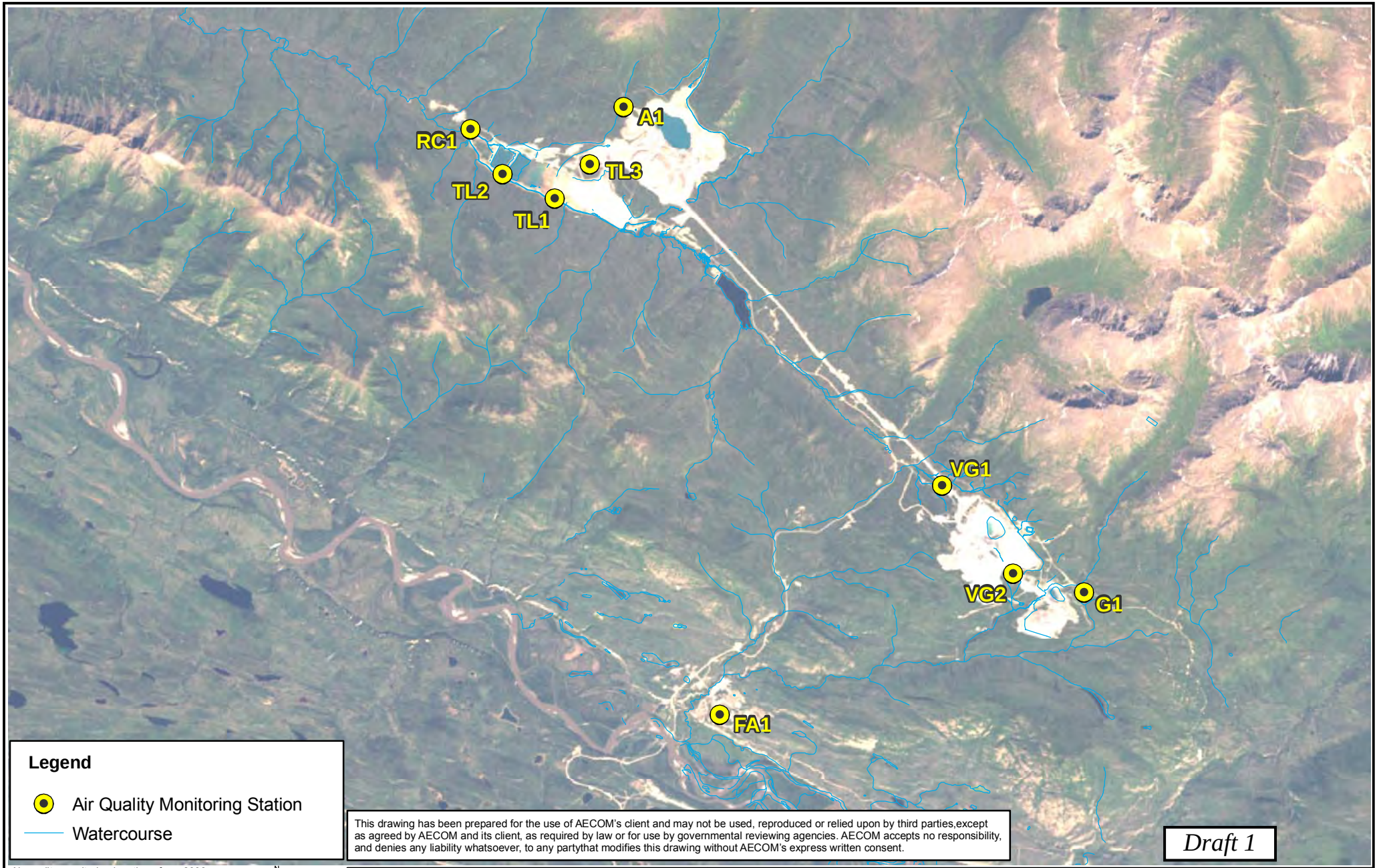
Faro Mine Complex
Closure and Remediation

Project Proposal

Climate Station Locations

Date:	Approved:	FIGURE:
February 2010		4-1

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-1_Meteorological Station Locations_v1_rh_16Feb2010.mxd Date Revised: February 16, 2010 Prepared by: RH



Legend

- Air Quality Monitoring Station
- Watercourse

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Draft 1

Air quality monitoring locations from 2008 Baseline Air Quality Monitoring Assessment for Faro Mine Complex, SENES Consultants Limited, January 2009.

N W E S

0 1 2

Kilometers

1:125,000

UTM Zone 8N, NAD83

AECOM

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File: 60119234_Fig4-2_Air Quality Monitoring_v1_rh_17Feb2010.mxd

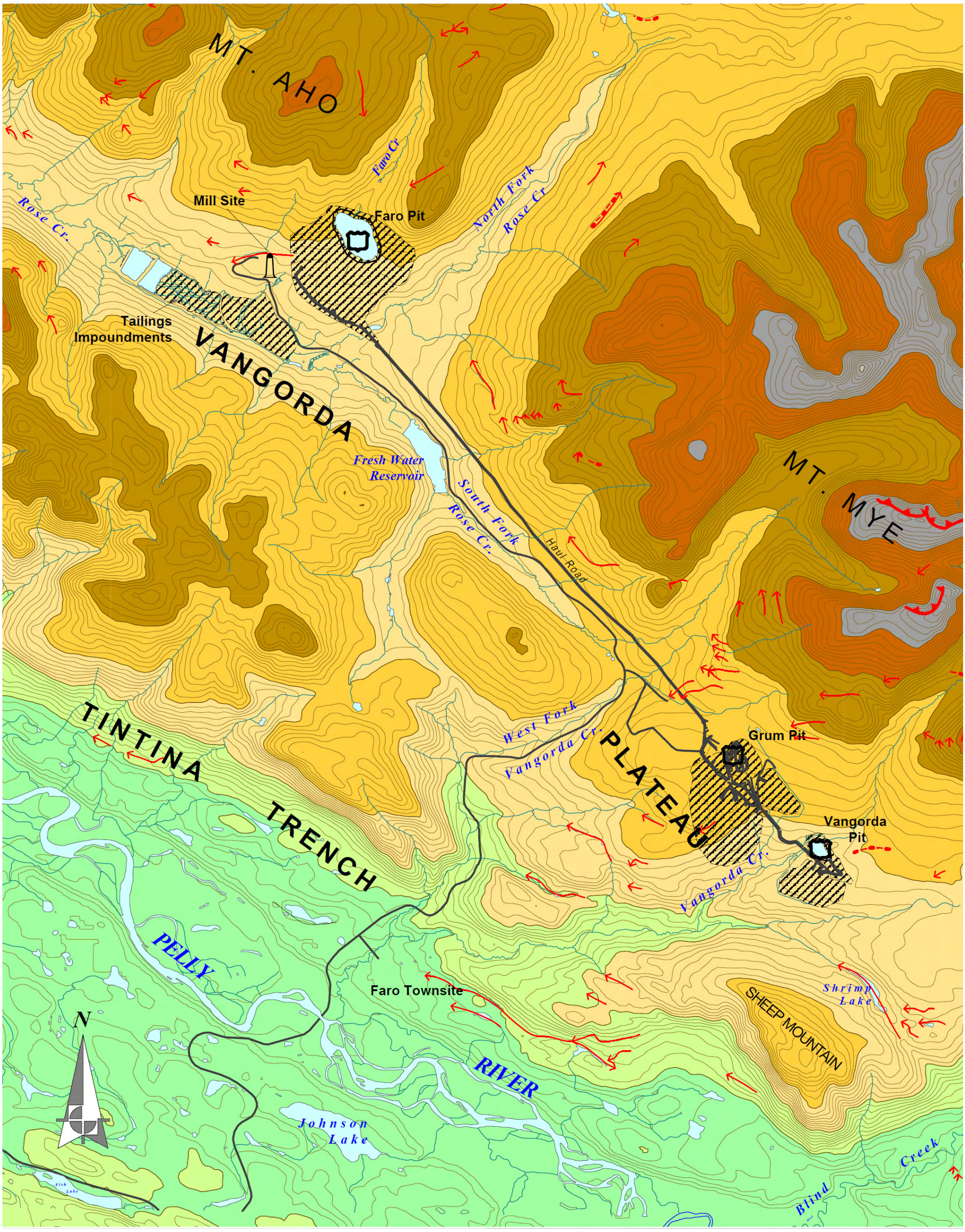
Faro Mine Complex
Closure and Remediation

Project Proposal

Air Quality Monitoring Stations

Date:	Approved:	FIGURE:
February 2010		4-2

File Location: W:\G\SIGIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-2_Air Quality Monitoring_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: RH Project: 60119234



LEGEND

ELEVATION RANGES (metres ASL)

- below 800 m
- 800-1,000 m
- 1,000-1,200 m
- 1,200-1,400 m
- 1,400-1,600 m
- 1,600-1,800 m
- above 1,800 m

SYMBOLS

- Cirque
- Glacial meltwater channel
- Moraine ridge

1 0 1 2 3

Kilometers

Scale: 1:75,000

Draft 1

SOURCE: Surficial Geology from "Quaternary geology and till geochemistry of the Anvil District, central Yukon Territory (Bulletin 11)" Bond, J.D., 2001.

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Physiographic Setting

Job No: 60119234

File: 60119234_Fig4-3_Physiographic Setting_v1_rh_16Feb2010

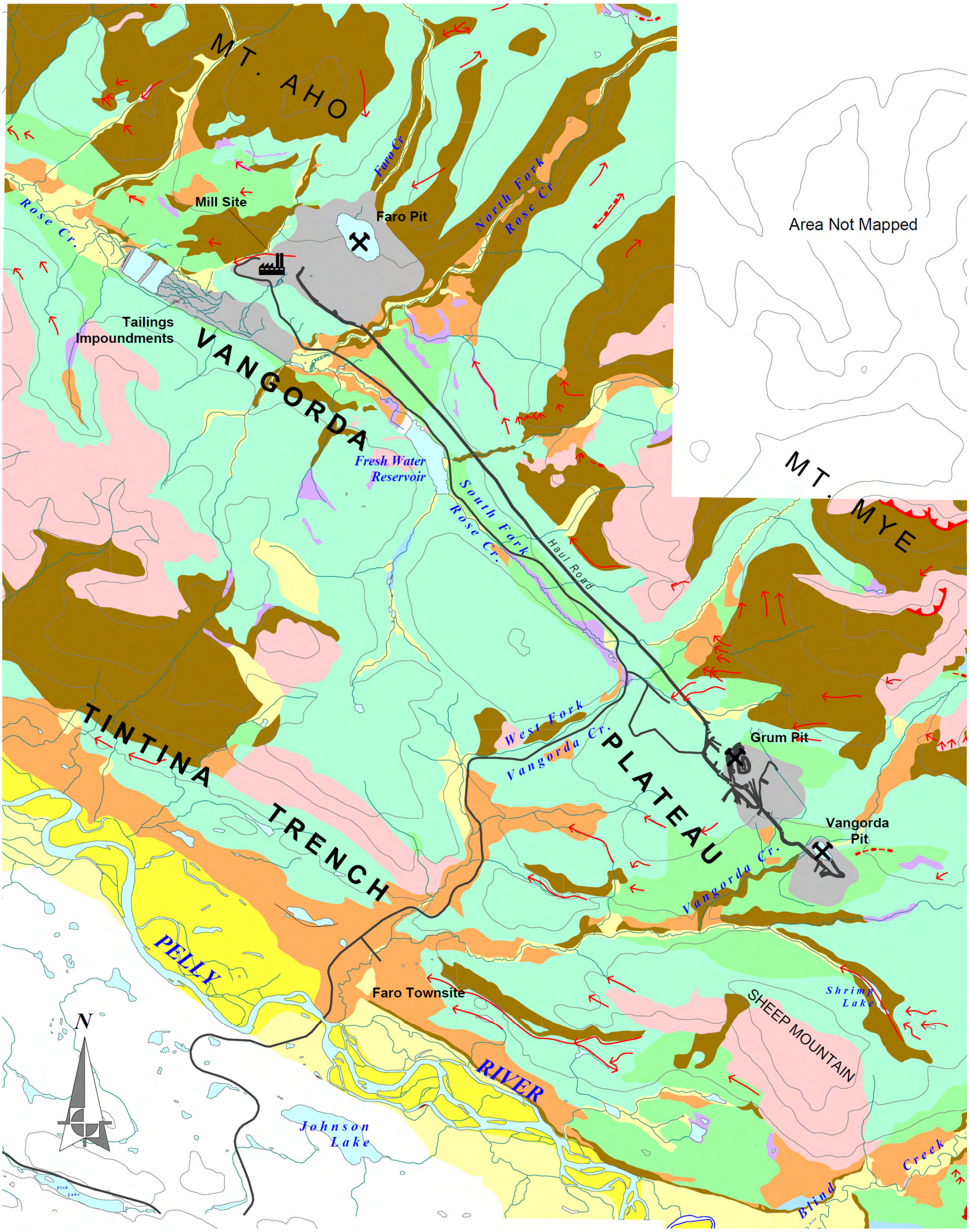
Project Proposal

Date: February 2010

Approved:

Figure: 4-3

AECOM



LEGEND

SURFICIAL MATERIALS

- Anthropogenic
- Colluvium
- Fluvial (Active)
- Glaciofluvial
- Fluvial
- Glaciolacustrine
- Morainal Veneer (Till)
- Morainal Blanket (Till)
- Organic
- Bedrock

SYMBOLS

- Cirque
- Glacial meltwater channel
- Moraine ridge

1 0 1 2 3

Kilometers

Scale: 1:75,000

Draft 1

SOURCE: Surficial Geology from "Quaternary geology and till geochemistry of the Anvil District, central Yukon Territory (Bulletin 11)" Bond, J.D., 2001.

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Surficial Geology and Landforms

AECOM

Job No: 60119234

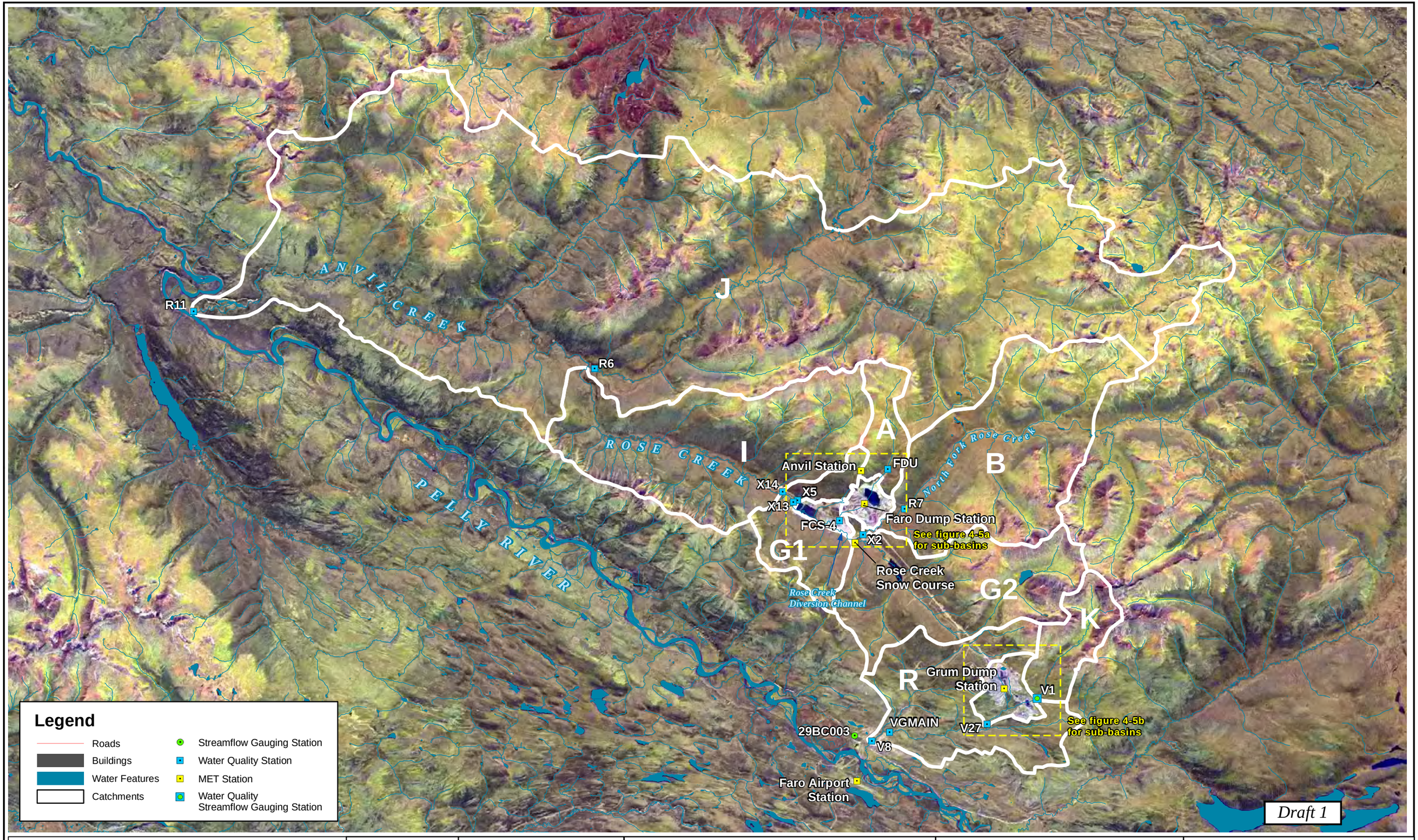
File: 60119234_Fig4-4_Surficial Geology and Landforms_v1_rh_16Feb2010

Project Proposal

Date: February 2010

Approved:

Figure: 4-4



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N W E S

1:200,000
UTM Zone 8N, NAD83

Map Notes:

0 3 6 9 12 Km

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Project Proposal

Faro Mine Complex Catchments

Date:	Approved:	FIGURE:
February 2010		4-5

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-5_Overview Catchments_v1_rh_17Feb2010.mxd
Date Revised: February 17, 2010
Prepared by: RH

Legend

- Pipeline
- Effluent Pipeline
- Pre-Mine Drainage
- Index Contours
- Subcatchments
- Tailings Impoundment
- Water Treatment Pipeline
- Existing Surface Drainage
- Intermediate Contours
- Waterbodies
- Buildings

FDU
Faro Creek
Anvil Station
A
R7
North Fork Rose Creek
C
E1
F4
G1
B
Faro Dump Station
D
F3
F2
E2
F1
G2
X2
H
FCS-4
09BC003
Rose Creek
Rose Creek Snow Course
X5
X14
X13
RCDC
Rose Creek Diversion Channel
I

Draft 1

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1:30,000
UTM Zone 8N, NAD83

- Streamflow Gauging Station
- MET Station
- Water Quality Station

0 0.5 1 1.5 2 Km

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Project Proposal

Anvil Creek Sub-catchment

Date:	Approved:	FIGURE:
February 2010		4-5a

Prepared by: RH
Date Revised: February 17, 2010
File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-5a_Faro Site Catchments_v1_rh_17Feb2010.mxd

Legend

- Pipeline
- Effluent Pipeline
- Pre-Mine Drainage
- Index Contours
- Tailings Impoundment
- Subcatchments
- Water Treatment Pipeline
- Existing Surface Drainage
- Intermediate Contours
- Waterbodies
- Buildings

N
K
L
M
O
P1
P2
Q
R
V1
Vangorda Creek
Grum Creek
Grum Dump Station

Draft 1

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1:20,000
UTM Zone 8N, NAD83

- MET Station
- Water Quality/ Streamflow Gauging Station

0 0.5 1 1.5 Km

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Project Proposal

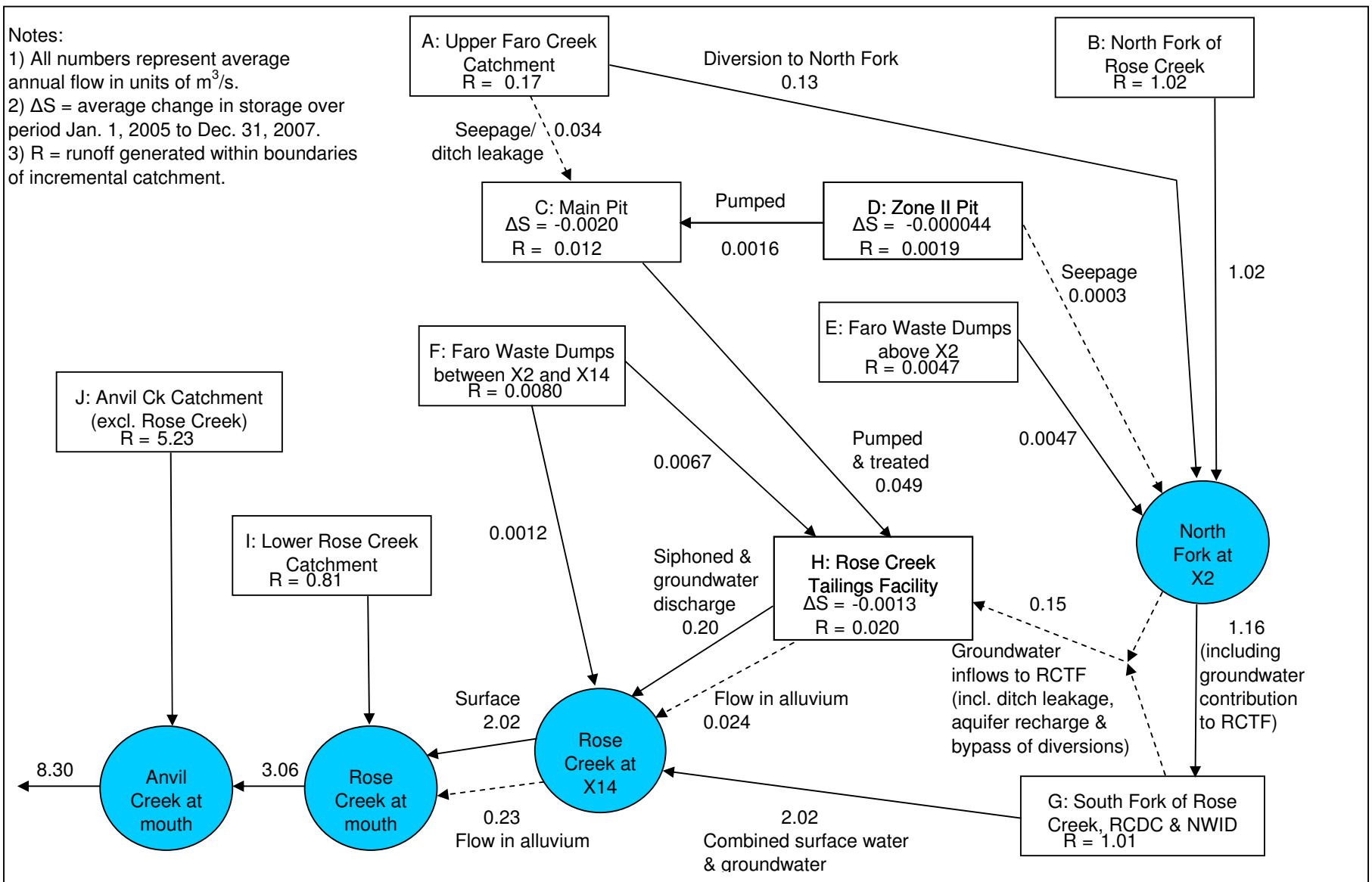
Vangorda Creek Sub-catchment

Date:	Approved:	FIGURE:
February 2010		4-5b

Date Revised: February 17, 2010 Prepared by: RH

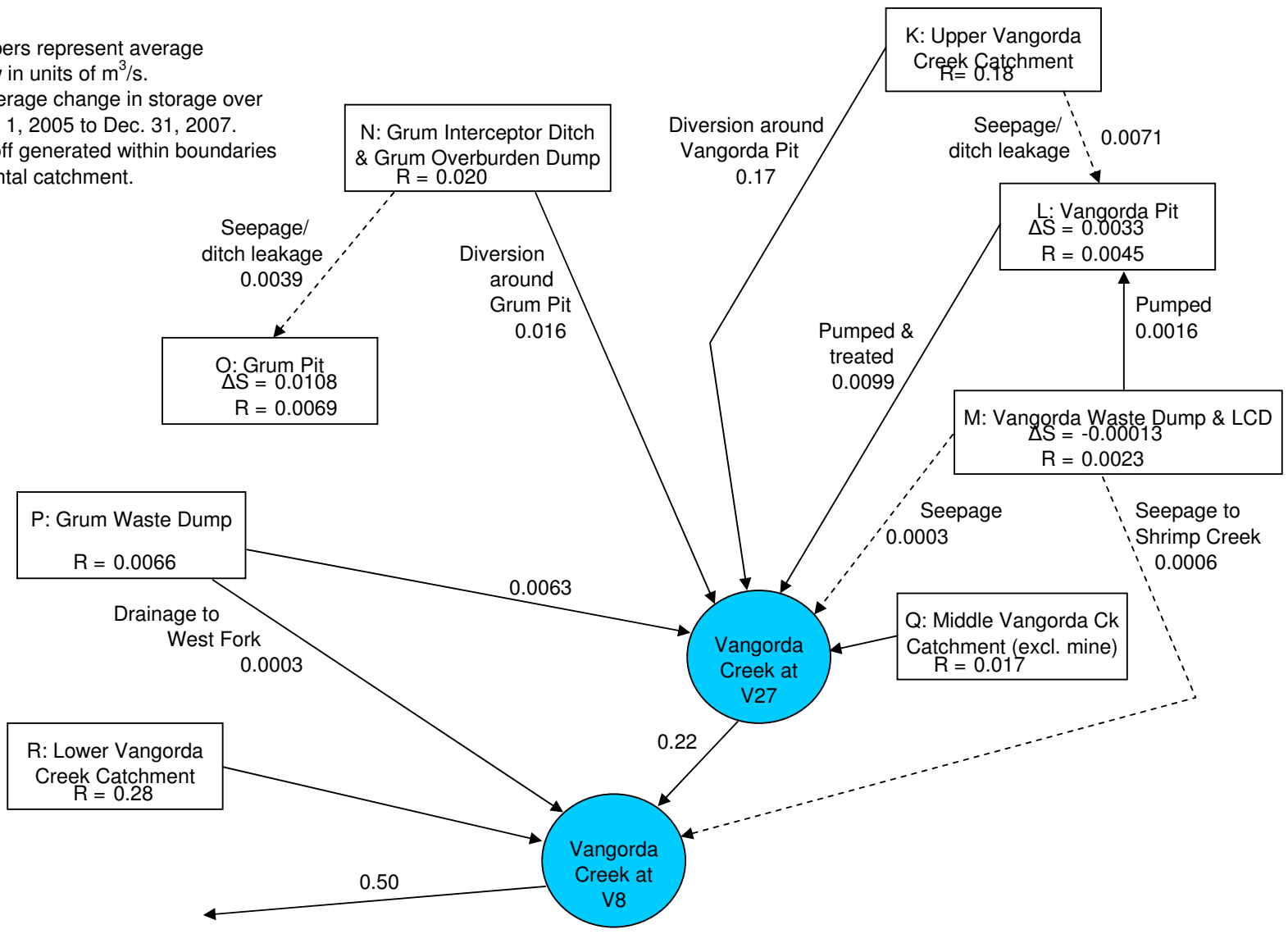
File Location: W:\GIS\GIS_P\data\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-5b_Vangorda Site Catchments_v1_rh_17Feb2010.mxd

Notes:
1) All numbers represent average annual flow in units of m^3/s.
2) ΔS = average change in storage over period Jan. 1, 2005 to Dec. 31, 2007.
3) R = runoff generated within boundaries of incremental catchment.



A) Anvil Creek Catchment (2005 to 2007)

Notes:
1) All numbers represent average annual flow in units of m^3/s.
2) ΔS = average change in storage over period Jan. 1, 2005 to Dec. 31, 2007.
3) R = runoff generated within boundaries of incremental catchment.



B) Vangorda Creek Catchment (2005 to 2007)

Draft 1

Prepared by Pat Bryan for AECOM (March 2009)

Faro Mine Closure
Fermeture de la mine Faro

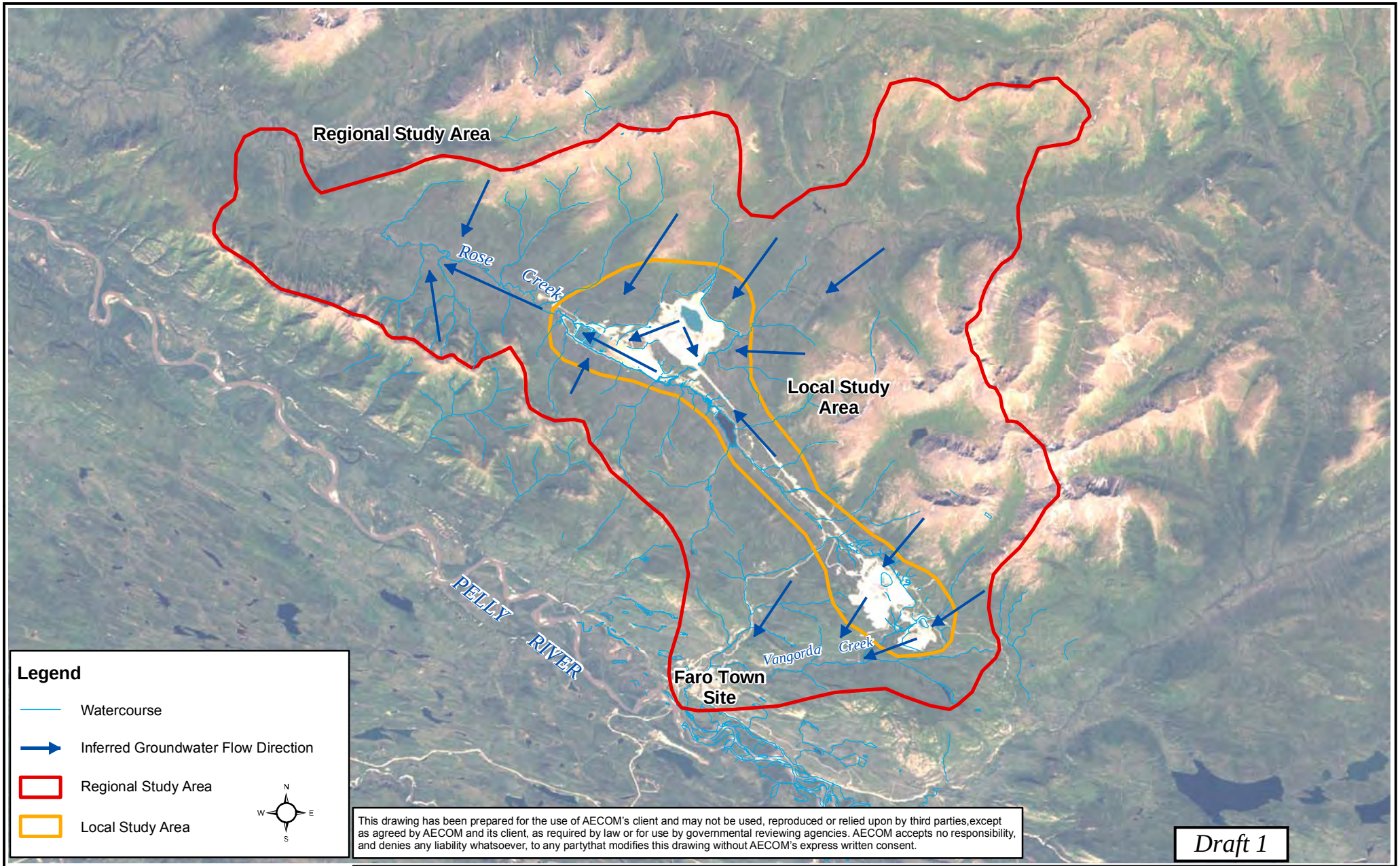
Job No: 60119234
File: 60119234_Fig4-6_Water Balance Schematic_v1_rh
_16Feb2010

Faro Mine Complex
Closure and Remediation

Project Proposal

Average Annual Water Balance Anvil Creek Catchment (A) and Vangorda Creek Catchment (B)

Date:	Approved:	Figure:
February 2010		4-6



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Draft 1

Basemap: Orthoshop, Calgary, AB, November 2003. Prepared for SRK Consulting. Based on August 2003 aerial photography. Shaded relief colour orthorectified image at 15m resolution compiled by Yukon Gov't, Dept of Infrastructure, Yukon Geomatics, Landsat 7.

0 2.5 5
Kilometers
1:200,000
UTM Zone 8N, NAD83

AECOM

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File Name: 60119234_Fig4-7_Groundwater Study Areas_v1_rh_17Feb2010.mxd

Faro Mine Complex
Closure and Remediation

Project Proposal

Local and Regional Groundwater Study Areas for the Faro Mine Complex

Date:	Approved:	FIGURE:
February 2010		4-7

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-7_Groundwater Study Areas_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: RH Project: 60119234

Prepared by: RH

Date Revised: February 17, 2010

File Location: W:\GIS\GIS_PdataIFaro\60119234_FaroEA_2010\MXD\60119234_Fig4-8_Faro Contamination_v1_rh_17Feb2010.mxd

Legend

Monitor Symbols

- Monitor Location: Not Enough Data to be Included
- Monitor Location Data Used in this Assessment
- Multi-level Monitor Location Data Used in this Assessment (See details in table)

Contamination Classification of Zinc and Sulphate

- Unaffected: Below Detection to Low Levels of Zinc and Sulphate Concentrations
- Low: Low Levels of Zinc and Sulphate Concentrations
- Moderate: Moderate Levels of Zinc and Sulphate Concentrations
- High: High Levels of Zinc and Sulphate Concentrations
- Very High: Very High Levels of Zinc and Sulphate Concentrations (Screened in Tailings)

Watercourse

Impoundment (original)

Contours

Index Contours (10m)

Intermediate

Level of Contamination in Multilevel Wells

P03-01		Depth (m)	P03-04		Depth (m)	P03-08		Depth (m)
P03-01-01	Unaffected	46.79	P03-04-01	Moderate	58.22	P03-08-01	Unaffected	32.61
P03-01-02	Unaffected	38.86	P03-04-02	Moderate	47.55	P03-08-02	Low	28.35
P03-01-03	Low	30.63	P03-04-03	Moderate	41.45	P03-08-03	Low	24.69
P03-01-04	Low	24.54	P03-04-04	Low	35.05	P03-08-04	Low	23.16
P03-01-05	Low	18.44	P03-04-05	Moderate	26.06	P03-08-05	Moderate	21.64
P03-01-06	Low	13.26	P03-04-06	Very High	17.37	P03-08-06	Moderate	20.12
P03-01-07	Very High	10.82	P03-04-07	Very High	15.54	P03-08-07	Moderate	17.07
P03-01-08	Very High	9.3	P03-04-08	Very High	13.72	P03-08-08	Low	14.02
P03-01-09	Very High	7.77	P03-04-09	Very High	12.8	P03-09		
P03-02			P03-05			P03-09-01	Low	35.05
P03-02-01	Low	33.83	P03-05-01	Moderate	44.5	P03-09-02	Low	32.31
P03-02-02	Low	30.48	P03-05-02	Low	36.88	P03-09-03	Low	27.13
P03-02-03	Low	22.86	P03-05-03	Low	27.74	P03-09-04	Low	23.77
P03-02-04	Low	16.76	P03-05-04	Low	23.47	P03-09-05	Low	21.95
P03-02-05	Very High	13.72	P03-05-05	Moderate	21.64	P03-09-06	Low	18.9
P03-02-07	Very High	11.89	P03-05-06	Moderate	18.59	P03-09-07	Low	18.41
P03-02-08	Very High	8.84	P03-05-07	Very High	14.02	P03-09-08	Low	9.45
P03-02-09	Very High	7.62	P03-05-08	Very High	10.97	P03-09-09	Low	7.62
			P03-06			P05-01		
			P03-06-01	Moderate	25.91	P05-01-01	Low	25.45
			P03-06-02	Moderate	22.86	P05-01-02	Moderate	19.82
			P03-06-03	Moderate	19.81	P05-01-03	Moderate	16.77
			P03-06-04	Moderate	16.46	P05-01-04	Moderate	11.28
			P03-06-05	Moderate	14.33	P05-01-05	Moderate	5.48
			P03-06-06	Very High	12.5	P05-01-06	Moderate	3.35

Groundwater Contamination - Classification Criteria

Contamination Classification	Mean SO4 concentration (mg/L)	Mean Zn concentration (mg/L)
Unaffected	0-40	0-0.05
Low	40-590	0.05-0.5
Moderate	590-2000	0.5-5
High	2700-5000	5-50
Very High	>5500	>50

Draft 1

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AECOM

0 250 500

Meters

1:17,500

UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Basemap: Orthoshop, Calgary, AB, November 2003.
Prepared for SRK Consulting. Based on August 2003 aerial photography.
All other data, AECOM, 2008/2009.

Faro Mine Complex
Closure and Remediation

Project Proposal

File Name: 60119234_Fig4-8_Faro Contamination_v1_rh_17Feb2010.mxd

Groundwater Contamination in Monitoring Wells at the Faro Site, based on Zinc and Suphate Concentrations

Date: February 2010

Approved:

FIGURE: 4-8

Grum Pit

Grum Rock Dumps

Vangorda Pit

Vangorda Rock Dump

Moose Pond

Vangorda Creek

Little Creek Dam

Little Creek Pond

SRK04-5 A,B

BH05-9B-R

P96-9 A

SRK05-05C

SRK05-08

SRK05-07

SRK05-09

SRK05-06

V37

V36

P2001-03

P2001-02 A,B

V35

V34

Draft 1

Legend

Monitor Symbols

- Monitor Location: Not Enough Data to be Included
- Monitor Location Data Used in this Assessment

Contamination Classification of Zinc and Sulphate

- Unaffected: Below Detection to Low Levels of Zinc and Sulphate Concentrations
- Low: Low Levels of Zinc and Sulphate Concentrations
- Moderate: Moderate Levels of Zinc and Sulphate Concentrations
- High: High Levels of Zinc and Sulphate Concentrations
- Very High: Very High Levels of Zinc and Sulphate Concentrations (Screened in Tailings)

- Watercourse
- Impoundment (original)

Contours

- Index Contours (10m)
- Intermediate

Groundwater Contamination - Classification Criteria

Contamination Classification	Mean SO4 concentration (mg/L)	Mean Zn concentration (mg/L)
Unaffected	0-40	0-0.05
Low	40-590	0.05-0.5
Moderate	590-2000	0.5-5
High	2700-5000	5-50
Very High	>5500	>50

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AECOM

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Meters

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UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Basemap: Orthoshop, Calgary, AB, November 2003.
Prepared for SRK Consulting. Based on August 2003 aerial photography.
All other data, AECOM, 2008/2009.

Faro Mine Complex
Closure and Remediation

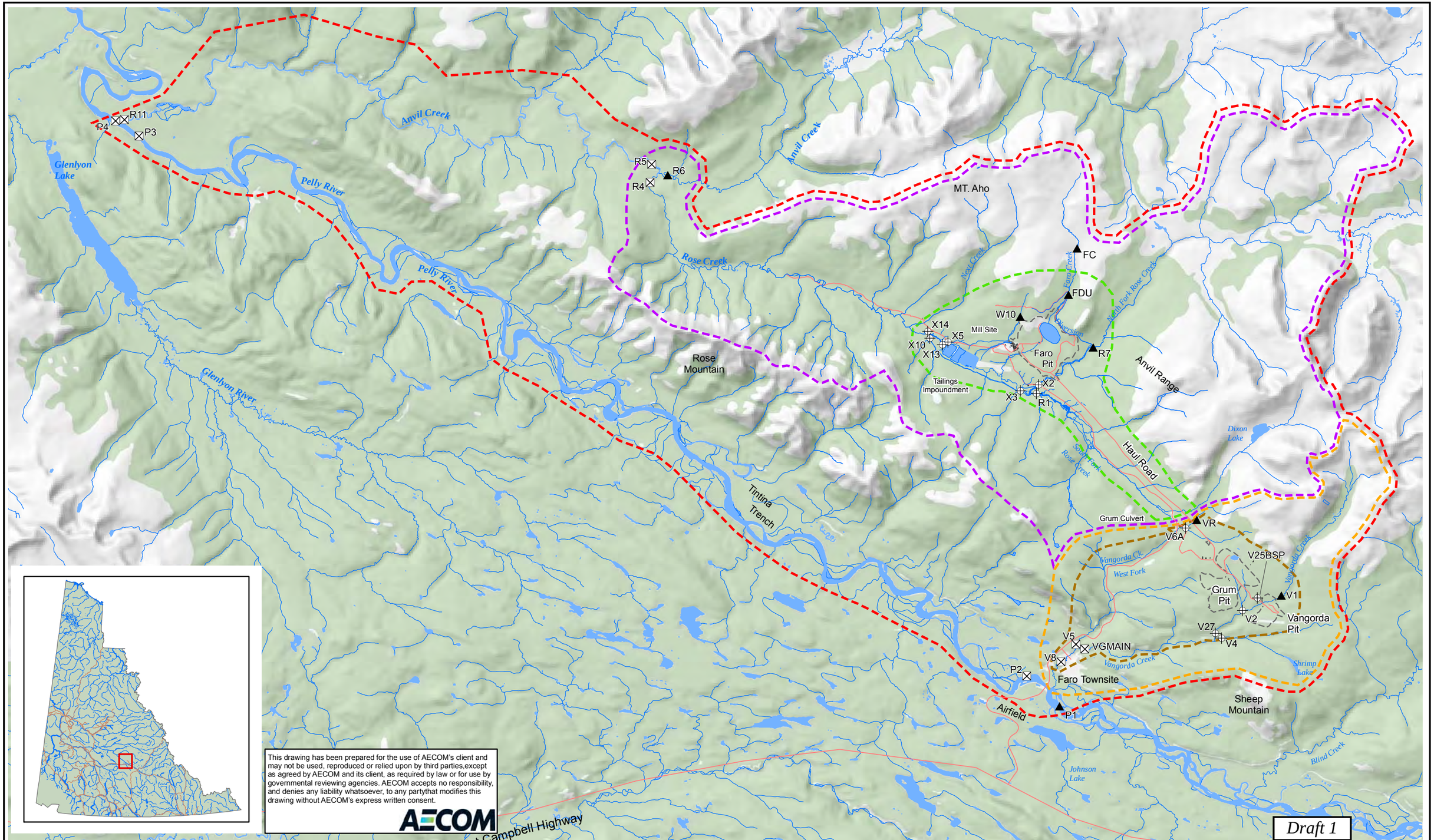
Project Proposal

File Name: 60119234_Fig4-9_Vangorda Contamination_v1_rh_17Feb2010.mxd

Groundwater Contamination in Monitoring Wells at the Vangorda/Grum Site, based on Zinc and Suphate Concentrations

Date:	Approved:	FIGURE:
February 2010		4-9

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-9_Vangorda Contamination_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: RH



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LEGEND

- Reference Site
- Receiving Site
- Mine Run-off Effluent and Internal Site
- Roads
- Regional Study Area
- Rose Creek Local Study Area
- Vangorda Local Study Area
- Rose Creek Watershed
- Vangorda Watershed
- Surface Water
- Buildings

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0 2 4

Kilometers

1:150,000

UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File Name: 60119234_Fig4-10_Surface Water Quality Overview_v1_rh_17Feb2010.mxd

Faro Mine Complex
Closure and Remediation

Project Proposal

Surface Water Quality Study Areas

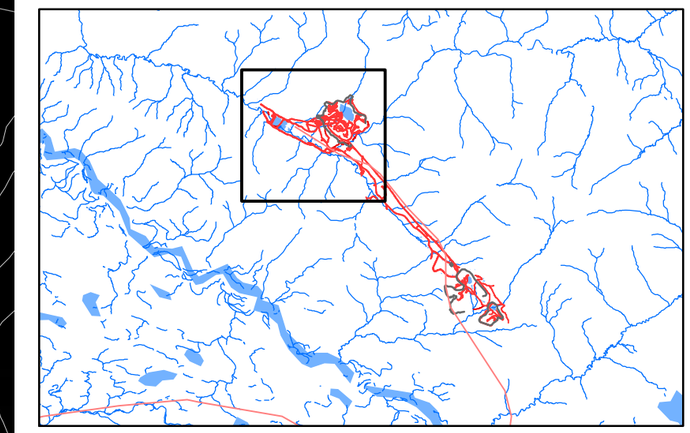
Date:	Approved:	FIGURE:
February 2010		4-10

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-10_Surface Water Quality Overview_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: RH

Legend

- Reference Site
- Mine Run-off Effluent and Internal Site
- Pre-Mine Drainage
- Effluent Pipeline
- Water Treatment Pipeline
- Pipeline
- Roads
- Existing Surface Drainage
- Buildings

FC
FDU
R7
W10
X2
R1
X3
X5
X14
X13
X10



Draft 1

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AECOM

N E S W

0 250 500

Meters

1:35,000

UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File Name: 60119234_Fig4-11_Faro Surface Water Quality_v1_rh_17Feb2010.mxd

Faro Mine Complex
Closure and Remediation

Project Proposal

Faro Mine Site
Surface Water Quality
Sampling Locations

Date: February 2010

Approved:

FIGURE: 4-11

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-11_Faro Surface Water Quality_v1_rh_17Feb2010.mxd Date Revised: February 19, 2010 Prepared by: MM

VR

V6A

V1

V25BSP

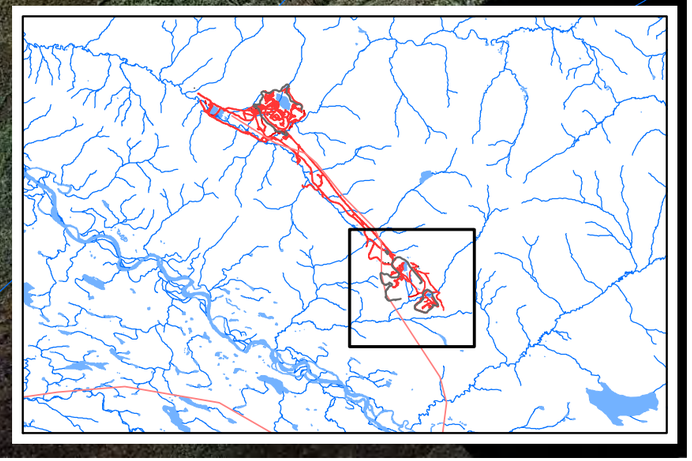
V2

V27

V4

V27

Draft 1



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LEGEND

- Reference Site
- Mine Impacted Site
- Receiving Site
- Buildings
- Water Treatment Pipelines
- Roads
- Existing Surface Drainage
- Buildings

0 250 500

Meters

1:20,000

UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File Name: 60119234_Fig4-12_Vangorda Surface Water Quality_v1_rh_17Feb2010.mxd

Faro Mine Complex
Closure and Remediation

Project Proposal

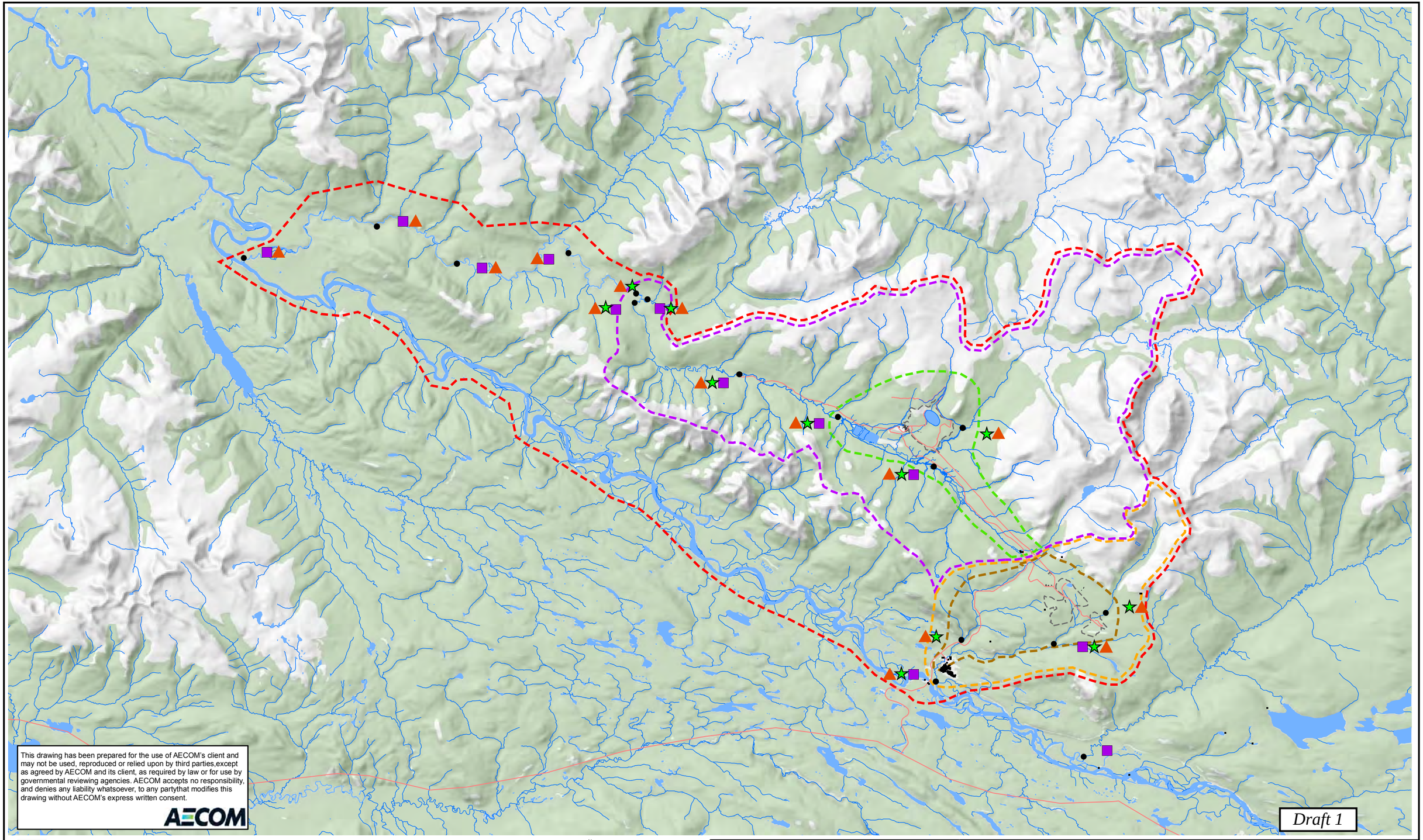
Vangorda Plateau Mine Site Surface Water Quality Sampling Locations

Date: February 2010

Approved:

FIGURE: 4-12

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-12_Vangorda Surface Water Quality_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: RH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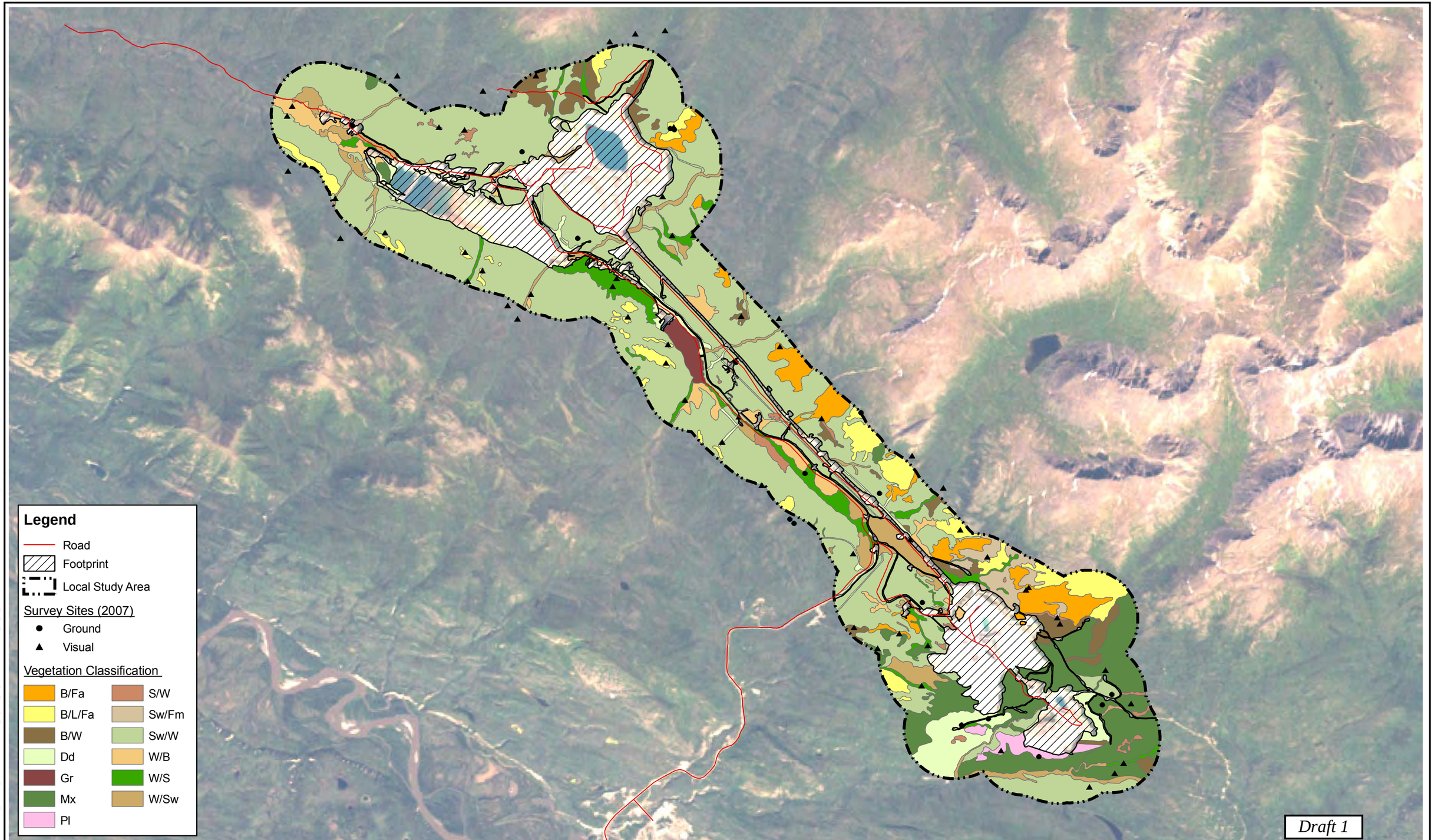
AECOM
Draft 1
LEGEND
Benthic Invertebrate
Fish Sampling
Stream Sediment
Roads
Regional Study Area
Rose Creek Local Study Area
Vangorda Local Study Area
Rose Creek Watershed
Vangorda Watershed
Pits
Buildings
N
W
E
S
0 1 2 3 4 5
Kilometers
1:200,000
UTM Zone 8N, NAD83
Faro Mine Closure
Fermeture de la mine Faro
Project Number: 60119234
File Name: 60119234_Fig4-13_Aquatic Resources_v1_rh_17Feb2010.mxd
Faro Mine Complex
Closure and Remediation
Project Proposal
Aquatic Resources
Study Area
Date: February 2010
Approved:
FIGURE: 4-13
File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-13_Aquatic Resources_v1_rh_17Feb2010.mxd
Date Revised: February 17, 2010
Prepared by: RH



Map notes:
Base data obtained from the Yukon Department of Environment, Information Management & Technology Branch.
National Topographic Database (NTDB) provided by the Government of Canada, Natural Resources Canada at 1:50,000 scale.
Survey sites provided by AECOM Canada Ltd.
Vegetation classification conducted by AECOM Canada Ltd. from aerial photography at 1:10,000 scale.
Local study area delineated by AECOM Canada Ltd.

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Meters

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UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File Name: 60119234_Fig4-14_Vegetation Associations_v1_rh_17Feb2010.mxd

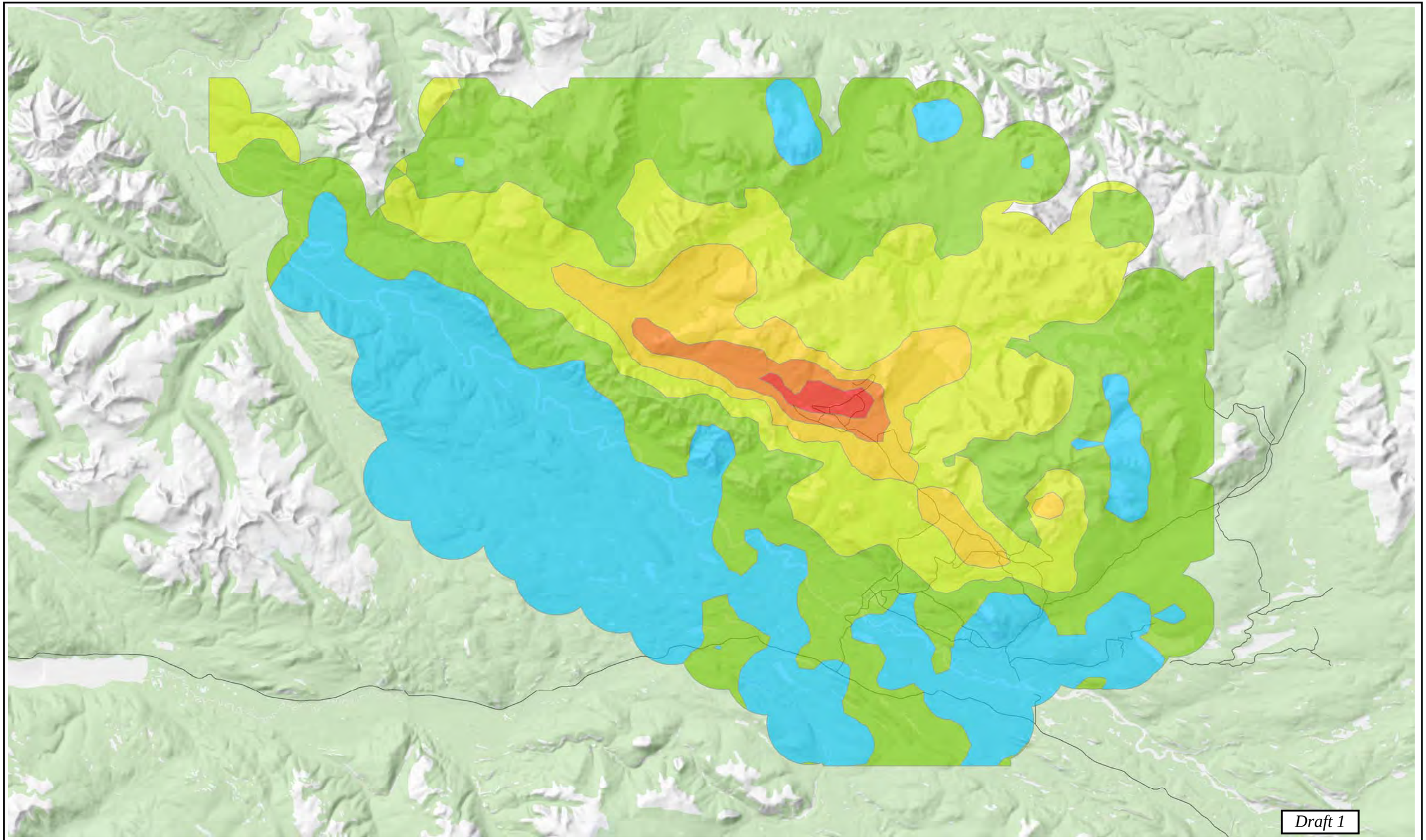
Faro Mine Complex
Closure and Remediation

Project Proposal

Vegetation Associations and 2007 Survey Sites

Date:	Approved:	FIGURE:
February 2010		4-14

File Location: W:\GIS\GIS_Pdata\Faro\60119234_FaroEA_2010MXD\60119234_Fig4-14_Vegetation Associations_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: RH



LEGEND

Concentration Range

0.2 - 1.6	Zone 1	17 - 61	Zone 4
1.6 - 4.6	Zone 2	61 - 210	Zone 5
4.6 - 17	Zone 3	210 - 748	Zone 6

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AECOM

N W E S

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Kilometers

1:250,000

UTM Zone 8N, NAD83

Faro Mine Closure
Fermeture de la mine Faro

Project Number: 60119234

File Name: 60119234_Fig4-15_Lead Lichens_v1_rh_17Feb2010.mxd

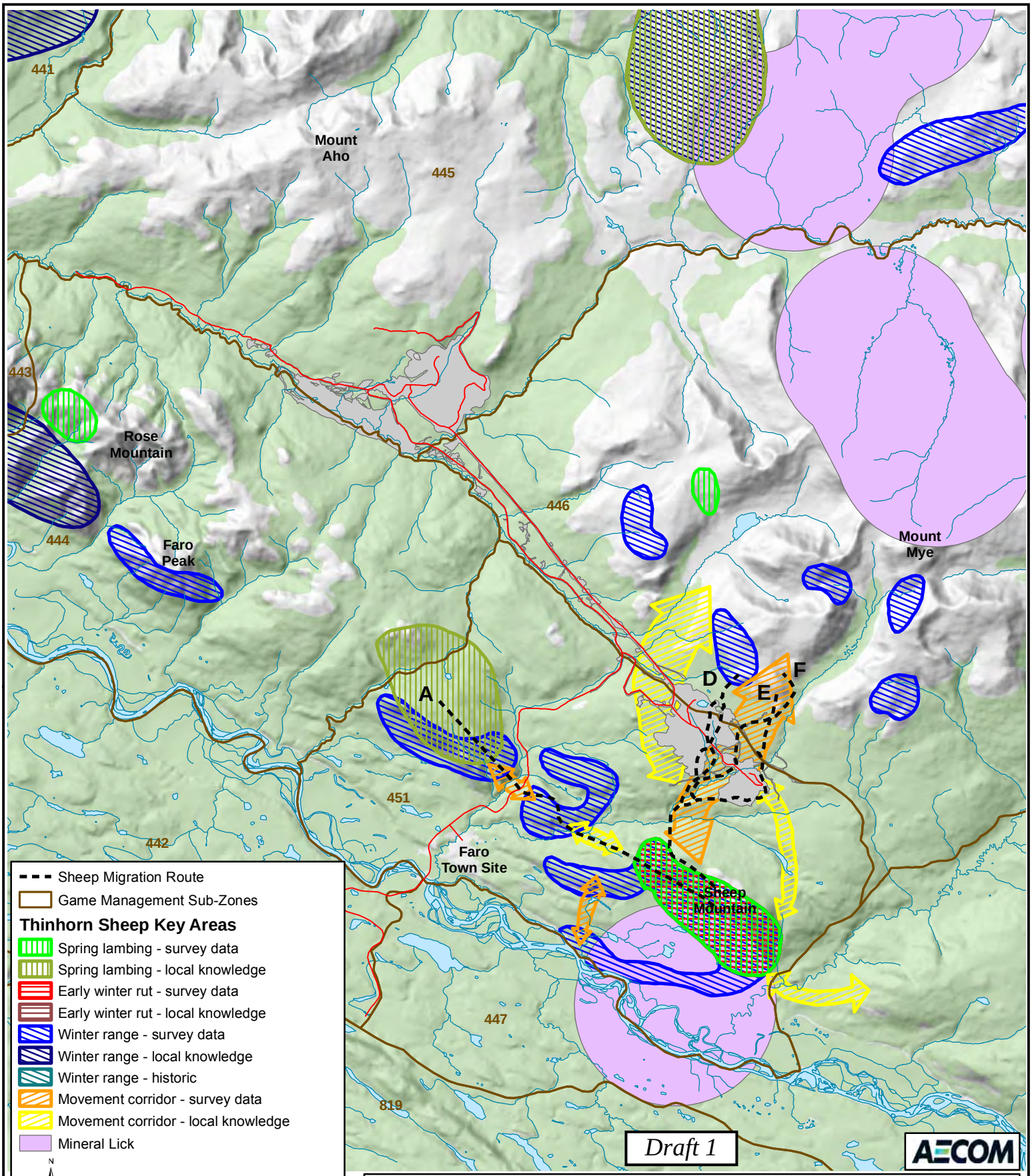
Faro Mine Complex
Closure and Remediation

Project Proposal

Standard Geostatistical Kriging of Lead in Lichen

Date:	Approved:	FIGURE:
February 2010		4-15

File Location: W:\GIS\GIS_Data\Faro\60119234_FaroEA_2010MXD\60119234_Fig4-15_Lead Lichens_v1_rh_17Feb2010.mxd Date Revised: February 17, 2010 Prepared by: MM



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Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Thinhorn Sheep

Project Number: 60119234

File Name: 60119234_Fig4-16_Thinhorn Sheep_v1_rh_17Feb2010.mxd

Project Proposal

Date:	Approved:	FIGURE:
February 2010		4-16

File Location: W:\GIS\GIS_P\data\Faro\60119234_FaroEA_2010\MXD\60119234_Fig4-16_Thinhorn Sheep_v1_rh_17Feb2010.mxd Date Revised: February 18, 2010 Prepared by: RH

Chapter 5

Current Socio-Economic Conditions

5 Current Socio-Economic Conditions

5.1 Socio-economic Setting

The Yukon Environmental and Socio-economic Assessment Board requires proponents show that they are aware of the background social and economic conditions against which the project will take place. Specifically, YESAB writes that a general understanding of the historical trends and current status of:

- societal relationships with the biophysical environment;
- political and social resources;
- culture, attitudes, social-psychological conditions;
- economic and financial background; and/or
- relevant population (or demographic characteristics (e.g. age, gender, education and employment distributions).

will be valuable in helping with identifying valued components and initial effects as completely as possible from the start.[1]

5.1.1 Yukon

The Yukon is a large territory with a small population and the heavy reliance on government that is typical of relatively remote jurisdictions across the circumpolar north. Although the Yukon has a variety of economic and industrial sectors, government — largely financed through federal transfers — is by far the largest. It can be said that Canadian sovereignty is the Yukon's largest export.

Mining has traditionally been the mainstay of the Yukon's private sector industry. In fact, the territory owes its separate existence to the Klondike Gold Rush of 1896-1898. The dependence on mining gave rise to boom-and-bust cycles typical of economies dependent on natural resources. Until this century, the size of the non-aboriginal population fluctuated with the fortunes of the mining industry and its associated boom/bust cycle.

Whitehorse, the territorial capital, has become increasingly important. With more than three-quarters of the population it dominates the territorial economy. Most services are only available in Whitehorse as it is the largest market. Residents of rural Yukon are increasingly dependent on trips to the capital city for more and more goods and services. Rural communities, where the First Nation population is concentrated, are not keeping up with the high incomes and economic prosperity of the

[1] Yukon Environmental and Socio-economic Assessment Board. *Guide to Socio-economic Effects Assessments.* June 2006. p.33.

capital. Yukon rural communities — like other rural and First Nation communities across Canada — suffer disproportionately from a number of social and economic problems, including generally high unemployment, low income, alcohol and drug abuse and relatively low educational levels.

In 1992, the Council for Yukon Indians (today the Council of Yukon First Nations) and the federal and territorial governments signed the Umbrella Final Agreement (UFA) to serve as the template for individual land claims agreement. Among the many provisions of that agreement is the creation of YESAA, a new system of environmental and socio-economic assessment. The UFA includes provisions for self-government giving signatory First Nations a number of additional powers. Most Yukon First Nations, including the Selkirk First Nation, have signed land claims and self-government agreements. However, significantly for this project, the Ross River Dena and the Liard First Nation have not. These two remain "Yukon First Nations without final agreements", a term preferred over "Indian Act bands' although the Indian Act continues to apply to their operations Although they lack formal land claim and self-government agreements with the associated ability to raise own source revenues to facilitate their own social and economic development agendas, they rely on Aboriginal rights and title to assert their right to self determination.

Yukon Demographics and Labour Force

The Yukon's population was 34,157 at the end of December 2009, up 0.7% from a year earlier according to the Yukon Bureau of Statistics. The Yukon's population has been increasing since 2000 — when 30,776 people lived in the territory — and has surpassed its 1997 peak of 33,519. More than 75% of Yukoners live in Whitehorse or its immediate vicinity with most of the rest distributed in 16 small, widely scattered communities.

The territory's population is evenly divided between men and women; there is no frontier-style skew toward men. In the 2006 Census, just over 25% of respondents identified themselves as aboriginal.

The median age of the Yukon's population is 38.4 according to the 2006 Census, only slightly under the Canadian figure of 39.5 years and up sharply from the 2001 figure of 35.8. The territory therefore does not have an unusually young population. However, the Yukon has proportionately far fewer seniors aged 65 and up than the Canadian average (7.5% versus 13.7%) and similar proportions of the population aged 14 and under. The territory does have a skew in the population structure toward working-aged adults aged 25 to 64 years (59.9% compared to 55.3% in Canada as a whole).

Yukoners' highest levels of schooling appear to track Canadian averages very closely. The 2006 Census found no significant differences between the territory and the country as a whole in the percentage of population aged 15 and over who had not finished high school, held high school diplomas, had apprenticeships or trades certifications, or held university degrees. Yukoners are somewhat more likely than Canadians as a whole to hold college certificates or diplomas.

The Yukon has a labour force participation rate of 78.1% according to the 2006 Census, much higher than the Canadian rate of 66.8%, a result mainly of the lower proportion of seniors. However, the

territory's unemployment rate of 9.4% in May of 2006 (when the 2006 Census was taken) was also considerably higher than the Canadian rate of 6.6%. For December 2009 the Yukon Bureau of Statistics reported that the Yukon had an unemployment rate of 6.9%, up from the 5.5% recorded a year earlier. The Yukon's current unemployment rate is lower than the Canadian average of 8.5% and the BC rate of 8.4% but higher than the unemployment rate for the western provinces of Alberta (6.7%), Saskatchewan (4.8%), and Manitoba (5.7%).

Incomes are generally higher in the Yukon than in Canada as a whole. In 2006 the Census put the Yukon's median income at $31,352 compared to Canada's $25,615. Earnings are also generally higher in the Yukon as is the proportion of income derived from work rather than government transfers or other income.

Yukon Economy and Industrial Structure

The Yukon's real (adjusted for inflation) GDP totalled $1.424 billion in 2008, up 4.3% from 2007. Real (adjusted for inflation) GDP growth has been strong, up rising at an average rate of 4.0% annually from 2004 through 2008.

The territory's 2008 GDP by industry is summed up in the table below.

Table 5.1: Yukon Industries as a percentage of GDP: 2008

Industry	Percentage of GDP
Public administration	22.8%
Finance, insurance and real estate	18.0%
Construction	8.5%
Health care and social assistance	8.1%
Retail trade	6.2%
Educational services	6.1%
Other services (except public administration)	4.2%
Accommodation and food services	3.8%
Information and cultural industries	3.8%
Mining and oil & gas extraction	5.1%
Wholesale trade	3.1%
Transportation and warehousing	2.8%
Professional, scientific and technical services	2.6%
Utilities	2.3%
All others	2.9%

Source: Yukon Bureau of Statistics 2008 Yukon GDP by Industry.

The territorial economy is dominated by industries that are largely the purview of governments. The public sector contribution to GDP tends to be in the range of 40% of the Yukon's overall economic activity, compared to the Canadian average of about 15%. Federal government transfers to the Yukon government have been increasing, in part because of the devolution of some powers to the territorial government. Federal transfers account for approximately 70% of the Yukon government's budget. The federal government also spends directly in the Yukon employing 620 people in September 2009. It also provides funding directly to First Nation governments.

Although the Yukon has traditionally relied on mining as an economic mainstay, the industry entered into a prolonged slump following the closure of the Faro lead-zinc mine in January of 1998. By 2002 there were no operating hard-rock mines in the Yukon, mineral exploration spending had declined steeply, and even placer gold production had fallen to a 23-year low. The total value of mineral production in the territory fell from $407 million in 1996 to $33.6 million in 2003. In 2004 the value of total mineral production began to rise and mineral exploration expenditures have risen sharply, increasing from $22 million to almost $133 million in 2007. In October 2007 Sherwood Copper officially opened the Minto mine, ending a 5-year stretch of no operating hard-rock mines in the Yukon.

Inflation, as measured by the consumer price index, has been somewhat higher in Whitehorse than in Canada as a whole in 2007, 2008 and the first half of 2009 (note that inflation is measured for Whitehorse rather than the Yukon as a whole). However, from July through November of 2009 Whitehorse consumer prices have been declining rather than increasing, resulting in deflation rather than inflation.

5.1.2 Faro

Faro, located above the north bank of the Pelly River approximately 70km from Ross River, is the Yukon's newest community. It was built in 1969 to house the Faro mine workers and their families. The community's relatively short history has been marked by wild population swings as the mine has opened and closed.

The Anvil Mining Corporation (later Cyprus Anvil) made the decision to go into production in 1967 and construction of the town began in the fall of 1968. In June of 1969 a forest fire roared through the area, destroying 48 of the 50 newly built houses. However, three months later, the first families moved into the new town. The 1970s were boom times for Faro. The mine was profitable, wages were high, there were the benefits of heavily subsidized housing, and the town grew. In 1981, it was the highest income community in Canada and reached a peak population of over 2,000 people.

In the early 1980s metal prices dropped, and Cyprus Anvil began losing money and building up debt. A temporary shutdown was announced in June of 1982 and the shutdown continued as metal prices remained very low. A stripping operation, heavily subsidized by government, provided some work

from mid-1983 to October of 1984. In May 1985 the company announced it was mothballing the mine.

By July 1985, Faro was a virtual ghost town. There was no apparent reason for anyone to remain, but a stubborn few hung on, believing that, contrary to all the evidence, Faro had a future. In November 1985 Curragh Resources Inc took over the mine, mill and housing with substantial help from the federal and Yukon governments in the form of loan guarantees, subsidized power and highway upgrades. In the spring of 1986 the Faro mine and mill were back in operation and the mine was profitable. By 1992 however, the company was mired in difficulties and these drove the company to bankruptcy. In April of 1993 the Faro mine was shut down for the second time. Again, the town's population dropped precipitously, although it never fell below approximately 400 residents.

Anvil Range Mining Corporation bought the property in 1994 with no direct government assistance. Production began again in August of 1995. Full commercial production was achieved by November 1995. In November of 1996, however, Anvil Range suddenly announced that there would be a temporary closure of the mine by the end of the year. The mill would continue to operate until March 1997 using stockpiles of ore. Lower metal prices and a higher Canadian dollar were given as the reasons for the shutdown. Anvil Range declared bankruptcy in April 1998, leaving the property in the hands of a receiver.

Faro Demographics and Community Economy

Since 2000, the town's population has remained stable at just under 400 residents. In December 2009 the Yukon Bureau of Statistics put the population of Faro at 402. The 2006 Census reported a community population of 340, with 16% identifying themselves as aboriginal people.

Statistics on the GDP of individual Yukon communities are not kept, but a reasonably good indicator of the size of the local money economy is the aggregate personal income figure collected by the Canada Revenue Agency (CRA). In the 2007 tax year (the latest for which data is available), residents of Faro reported a total of $10.54 million in income from all sources. It is important to note that this represents only the formal, dollar economy; the value of subsistence activities and any other unpaid work are not captured by dollar measures of economy size.

The Yukon Bureau of Statistics keeps a spatial price index for Faro and the latest available figures (for April of 2009) show that the cost of living in the community is 18.0% higher than in Whitehorse.

The 2006 Census found a relatively low labour force participation rate in Faro (64.3% versus 78.1% for the Yukon) and an unemployment rate of 13.9%. Although unemployment is higher than the Yukon figure as a whole, Faro has lower unemployment than many other rural communities in the territory.

Various levels of government provide a substantial number of the jobs in Faro. In 2006 the Census found that 39% of the labour force was employed in public administration, education, health care and social assistance. About 14% of the labour force reported that they worked in mining. Sales and service occupations are the most common for Faro residents and include those working in the retail sector, daycare workers, restaurant and hotel workers and others. Almost as numerous are those who work in the trades and in the transportation occupational cluster, which includes most construction workers, equipment operators and truck drivers (many of whom are employed by governments).

Average incomes in Faro are now somewhat lower than the territorial average. The 2006 Census found the average family income in Faro to be $68,599, approximately 80% of the Yukon average of $86,085 while the median family income (where half of families make more and half make less) was 85% of the Yukon median.

Faro Social Infrastructure and Issues

Faro has been an incorporated municipality since 1970 and the Town collects property taxes, delivers a variety of municipal services, and has the authority to pass bylaws in the municipality. The community has an Official Community Plan, Zoning Bylaw and most recently has prepared an Integrated Community Sustainability Plan. The Yukon government provides other community infrastructure and services including the school and the Health Centre.

Policing in Faro is the responsibility of the Royal Canadian Mounted Police who maintain a local detachment. Fire protection, ambulance and search and rescue services are provided by volunteer organizations.

The RCMP released detailed records of reported incidents of crime for all of the Yukon communities from 1995 through 2003 but has not for any year since. From 1995 through 2003 the average number of reported crimes in Faro was 95 per year. However, because of the abrupt drop in population following the closure of the mine in 1998, the average figure does not apply well to e.g., 2002 and 2003 when the number of reported crimes were 22 and 26 respectively. On a per capita basis, the reported crime rate in Faro has tended to be the lowest in the Yukon. In 2003, for example, Faro had 7.2 reported crimes per 100 residents, far below the Yukon average of 32.4. As with overall crime, the level of reported violent crime in Faro is the lowest in the Yukon at 1.1 per 100 residents in 2003 compared with the Yukon average of 4.1 per 100 residents for the same year.

The Yukon government maintains the Faro Community Health Centre staffed by nurse practitioners. The territorial government also provides schooling in Faro through the Del van Gorder School, which offers classes from Kindergarten through to Grade 12. In June 2009 total enrolment was 44 for all grade levels. Yukon College operates a satellite community campus in Faro. The community campus provides academic upgrading courses, GED, computer training and various occupation-related courses in Faro. The community continues to lobby for the establishment of a mine training centre in Faro.

Faro has a municipal recreation centre that offers a variety of programs and recreation opportunities including an indoor hockey rink, a four sheet curling rink, summer swimming pool, squash court and weight room. The community has also built a highly unusual golf course that winds its way through the centre of the community.

5.1.3 Ross River

Ross River is located on the south bank of the Pelly River near the confluence of the Ross and Pelly Rivers. The South Canol Road runs through the community with a seasonal ferry providing access to the North Canol during the summer. The community is approximately 10 km from the Campbell Highway. Ross River is the second closest community to the Faro mine.

A trading post was initially established in Ross River in 1901 at a traditional First Nations gathering spot. World War II and the years immediately following brought massive changes to Ross River with the building of the Canol Road and pipeline. The late 1940s and early 1950s also saw the permanent closure of most of the region's fur trading posts — including Pelly Banks, Sheldon Lake, Rose Point, Frances Lake and Macmillan River. The Canol Road shifted the commercial centre of the community to the south bank of the Pelly River and the federal government pressured the First Nation to relocate across the river from the Old Village.

Mining exploration increased in the region around Ross River through the 1950s and an exploration and mining boom occurred in the 1960s and 1970s with the discovery and development of the Faro mine. Although some Ross River Dena people did work in mining exploration the mining boom did little to benefit most of the First Nation. The re-openings of the Faro mine and a smaller mining exploration boom in the mid-1990s brought more economic benefits to the First Nation and its people than in the 1960s and 1970s, but those benefits remained relatively small and social problems remained large. The more recent increase in exploration activity in the region has benefited Ross River residents; employment levels in this field have increased to the point that in 2007 mining exploration projects had difficulty finding local residents to work.

The Ross River Dena Council is the First Nation government in Ross River. The RRDC is a member of the Kaska Tribal Council along with the Liard First Nation based in Watson Lake. Other Kaska people live in northern British Columbia. The Ross River Dena Council has developed and implemented a mining strategy to guide their relationship with mining companies interested in working within their traditional territory.

Ross River Demographics and Community Economy

Since the mid-1980s, Ross River's population has hovered around the 350 mark. In December 2009 the Yukon Bureau of Statistics put the population of Ross River at 367. The 2006 Census reported a community population of 310, with over 87% identifying themselves as aboriginal people.

Statistics on the GDP of individual Yukon communities are not kept but, as stated earlier, a reasonably good indicator of the size of the local money economy is the aggregate personal income

figure published by the CRA. In the 2007 tax year (the latest for which data is available), residents of Ross River reported a total of $7.44 million in income from all sources. It is important to note that this represents only the formal, dollar economy; the value of subsistence activities and any other unpaid work are not captured by dollar measures of economy size.

The Yukon Bureau of Statistics does not keep a spatial price index for Ross River. It is therefore difficult to estimate how much greater the cost of living is in the community compared with Whitehorse. However, given its proximity to Faro, it would be reasonable to expect that it would be a similar 18% higher.

The 2006 Census found that Ross River has a relatively high labour force participation rate compared with other rural communities but it is lower than for the Yukon as a whole (73.3% to 78.1%). Unemployment, however, was found to be very high at 21.2%.

Various levels of government provide Ross River's economic base. In 2006 the Census found that 53% of the labour force was employed in public administration, education, health care and social assistance. The most common jobs are in the trades and transportation occupational cluster, which includes most construction workers, equipment operators and truck drivers (many of whom are employed by governments). Sales and service occupations are equally common jobs for Ross River residents and include those working in the retail sector, daycare workers, restaurant and hotel workers and others.

Average incomes in Ross River are far below the territorial average. The 2006 Census found the average family income in Ross River was $50,585, was approximately 60% of the Yukon average of $86,085 while the median family income (where half of families make more and half make less) was 68% of the Yukon median.

Ross River Social Infrastructure and Issues

Ross River is the home community of the Ross River Dena, a Kaska First Nation and it is a predominantly aboriginal community. The Ross River Dena Council (RRDC) is not recognized as a self-governing First Nation by the federal or territorial government under the UFA because of the absence of a land claim settlement and completed self government agreement. However, the RRDC does see itself as exercising inherent self-government rights over its traditional territory. The First Nation delivers a variety of services to its citizens in the community. The community of Ross River has no form of local or municipal government.

The RCMP maintains a detachment in the community. Fire and ambulance services are provided by volunteer organizations. The Yukon government maintains a Health Centre staffed with community nurse practitioners in the community. The Ross River School offers Kindergarten through Grade 10. A total of 63 students were enrolled in all grades in June 2009. The community has some recreational facilities including a hockey rink but not a full-fledged recreation centre.

In their 2006 Integrated Community Sustainability Plan, people in Ross River identified substance abuse as a serious health and social problem in the community and made the elimination of such abuse a long-term community goal. Another community health issue identified in the plan was the need for clean, high quality water in the community and better means of sewage disposal.

RCMP crime statistics show that, between 1995 and 2003, Ross River averaged 249 reported crimes annually. On a per capita basis Ross River tends to have one of the highest levels of reported crime in the Yukon. In 2003, for example, there were 68.1 reported crimes per 100 residents, almost double the Yukon average of 32.4 per 100 residents. Ross River appears to have a particularly high level of reported violent crime with 17.6 reported incidents per 100 residents in 2003, more than four times the Yukon rate of 4.1 per 100 residents.

5.1.4 Pelly Crossing

The area around Pelly Crossing has always been used as an important hunting, fishing, and trapping area for the Northern Tuchone people of the Selkirk First Nation. The Selkirk First Nation people would usually gather several times a year near the confluence of the Pelly and Yukon rivers at Fort Selkirk. After the building of the all weather road from Whitehorse to Mayo in 1950 and the cessation of paddle wheeler service, Fort Selkirk was no longer on a major transportation route. People began to re-settle along the river at Minto Landing near the new highway and then at Pelly Crossing where the federal government established a new settlement at the site of the Van Bibber homestead.

Pelly Crossing has remained a small community made up largely of Selkirk First Nation people. In 1997 the Selkirk First Nation signed land claim and self-government agreements, creating a self-governing First Nation. The Selkirk First Nation now exercises control over its settlement lands and provides a wide variety of services to its citizens.

The recent development and opening of the Minto copper mine across the Yukon River from Minto Landing has brought large-scale industrial economic development into the Selkirk First Nation's traditional territory for the first time. The community's location downstream of the Faro mine and tailings give it a strong environmental connection to the Faro closure project. However, its distance by road from the site likely gives it a weaker connection than closer communities in the economic and social spheres.

Pelly Crossing Demographics and Community Economy

Since the mid-1980s, Pelly Crossing's population has averaged about 380 residents. In December 2009 the Yukon Bureau of Statistics put the population of Pelly Crossing at 320. The 2006 Census reported a community population of 300, with over 83% identifying themselves as aboriginal people.

As noted earlier, statistics on the GDP of individual Yukon communities are not kept. A reasonably good indicator of the size of the local money economy is the aggregate personal income figure published by the Canada Revenue Agency. In the 2007 tax year (the latest for which data is

available), residents of Pelly Crossing reported a total of $6.32 million in income from all sources. It is important to note that this represents only the formal, dollar economy; the value of subsistence activities and any other unpaid work are not captured by dollar measures of economy size.

The Yukon Bureau of Statistics does not keep a spatial price index for Pelly Crossing which makes it difficult to estimate how much greater the cost of living is in the community compared with Whitehorse. However, the latest (April 2009) spatial price index shows Carmacks being 14.5% more expensive than Whitehorse and Mayo as 21.4% more expensive suggesting that Pelly Crossing is likely in the 15-20% range.

The 2006 Census found that Pelly Crossing has a slightly higher labour force participation rate (75%) than Faro (73.3%) but it is slightly lower than for the Yukon as a whole (75% to 78.1%). Unemployment, however, was found to be very high at 22.2%, similar to Ross River at 21.2%.

Various levels of government provide Pelly Crossing's economic base. In 2006 the Census found that 53% of the labour force was employed in public administration, education, health care and social assistance. The most common jobs are in the trades and in the transportation occupational cluster, which includes most construction workers, equipment operators and truck drivers (many of whom are employed by governments). Sales and service occupations are equally common jobs for Pelly Crossing residents and include those working in the retail sector, daycare workers, restaurant and hotel workers and others.

Average incomes in Pelly Crossing are far below the territorial average. The 2006 Census found the average family income in Pelly Crossing was $58,818, approximately 68% of the Yukon average of $86,085 while the median family income (where half of families make more and half make less) was 62% of the Yukon median.

Pelly Crossing Social Infrastructure and Issues

Pelly Crossing is the home community of the Selkirk First Nation, and it is a predominantly aboriginal community. The Selkirk First Nation is recognized as a self-governing First Nation by the federal government under the UFA, which exercising inherent self-government rights over its traditional territory. The First Nation delivers a variety of services to its citizens in the community. Pelly Crossing has no form of local or municipal government, which means that the First Nation delivers many municipal services by default.

There is a resident RCMP detachment in the community. Fire and ambulance services are provided by volunteer organizations. The Yukon government maintains a Health Centre staffed with community nurse practitioners in the community. The Eliza Van Bibber School offers Kindergarten through Grade 12. In June 2009 a total of 57 students were enrolled. The community has some recreational facilities including a hockey rink but not a full-fledged recreation centre.

RCMP crime statistics show that, between 1995 and 2003, Pelly Crossing averaged 230.3 reported crimes annually. On a per capita basis Pelly Crossing tends to have one of the highest levels of

reported crime in the Yukon. In 2003, for example, there were 57.2 reported crimes per 100 residents, almost double the Yukon average of 32.4 per 100 residents. Pelly Crossing appears to have a particularly high level of reported violent crime with 8.9 reported incidents per 100 residents in 2003, more than two times the Yukon rate of 4.1 per 100 residents. The data suggests that the crime situation in Pelly Crossing is similar to that in Ross River.

5.1.5 Watson Lake/Liard First Nation

The Liard First Nation (LFN) has an interest in the Faro mine closure project as it is located within the Kaska traditional territory that the LFN shares with the Ross River Dena Council. Watson Lake, along with neighbouring Upper Liard, Two Mile and Two and One-Half Mile Villages, is the home community of the Liard First Nation.

Watson Lake is situated in the south-eastern corner of the Yukon at the junction of the Alaska and Campbell highways. The Stewart Cassiar Highway whose northern end is just north of Watson Lake provides a link to tidewater in Stewart, British Columbia. The community is considered to include not only the Town of Watson Lake, but also the adjoining Kaska First Nation settlements of Upper Liard along the Alaska Highway, and Two and One-Half Mile Village and Two Mile Village on the Campbell Highway. The settlement of Lower Post just across the border in British Columbia is also often considered part of Watson Lake as well.

Although there were a number of trading posts and First Nations settlements in the area, notably Lower Post which also had a residential school, Watson Lake itself was only established during the Second World War when an airfield was built and the Alaska Highway was routed through this area and Watson Lake became an accommodation and supply centre servicing the highway and airfield construction.

The economy of the Watson Lake area has depended on being a transportation hub and a supply centre for mines in the area, notably Cassiar asbestos and the Sa Dena Hes lead-zinc mine while they operating, and for the Cantung mine. There has also been logging and sawmilling in the area in the past as the southeast is home to the Yukon's largest trees because of the relatively wetter climate. The Yukon's one producing natural gas field, Kotaneelee, is located in the territory's south-eastern tip.

Watson Lake/Liard First Nation Demographics and Community Economy

Since the mid-1980s, Watson Lake's population has averaged around 1,500 residents. In December 2009 the Yukon Bureau of Statistics put the population of Watson Lake at 1,555. The 2006 Census reported a community population of 1,210, with over 45% identifying themselves as aboriginal people.

A reasonably good indicator of the size of the local money economy is aggregate personal income figure published by the CRA. In the 2007 tax year (the latest for which data is available), residents of Watson Lake reported a total of $35.0 million in income from all sources. It is important to note

that this represents only the formal, dollar economy; the value of subsistence activities and any other unpaid work are not captured by dollar measures of economy size.

The Yukon Bureau of Statistics keeps a spatial price index for Watson Lake and the latest available figures (for April of 2009) show that the cost of living in the community is 17.9% higher than in Whitehorse.

The 2006 Census found that the Liard First Nation has a significantly lower labour force participation rate than Faro, Ross River or Pelly Crossing and the Yukon as a whole (63.8% to 78.1%). First Nation unemployment is substantially higher at 45.9% than the other rural Yukon communities and Yukon as a whole.

As with almost every community in the Yukon, various levels of government provide Watson Lake's (and the Liard First Nation's) economic base. In 2006 the Census found that 53% of the labour force was employed in public administration, education, health care and social assistance. The most common jobs are in the trades and in the transportation occupational cluster, which includes most construction workers, equipment operators and truck drivers (many of whom are employed by governments). Sales and service occupations are equally common jobs for Watson Lake residents and include those working in the retail sector, daycare workers, restaurant and hotel workers and others.

Average incomes in the Liard First Nation are far below the territorial average. The 2006 Census found the average family income in Liard First Nation, $41,180 was approximately 48% of the Yukon average of $86,085 while the median family income (where half of families make more and half make less) was 43% of the Yukon median.

Watson Lake/Liard First Nation Social Infrastructure and Issues

Watson Lake, along with neighbouring Upper Liard, Two Mile and Two and One-Half Mile Villages, is the home community of the Liard First Nation. The Liard First Nation is not recognized as a self-governing First Nation but does see itself as exercising inherent self-government rights within its traditional territory. The First Nation delivers a variety of services to its citizens in Upper Liard, Two and two and a half mile subdivisions and Lower Post BC.

Watson Lake has been incorporated since 1984 and the Town government delivers a variety of municipal services to the community.

Policing in Watson Lake is the responsibility of the RCMP who maintain a detachment in the community. Fire and ambulance services are provided by volunteer organizations. The Yukon government maintains a 12-bed hospital in the community. The Johnson Elementary School offers Kindergarten through Grade 7 and the school had 115 students enrolled in June of 2009. The Watson Lake Secondary School offers Grades 8 to 12 and had an enrolment of 103 students in June 2009. The community has a full-fledged recreation centre including a hockey rink etc.

RCMP crime statistics show that, between 1995 and 2003, Watson Lake averaged 158 reported crimes annually. On a per capita basis Watson Lake tends to have one of the highest levels of reported crime in the Yukon. In 2003, for example, there were 67.2 reported crimes per 100 residents, almost double the Yukon average of 32.4 per 100 residents. Watson Lake appears to have a particularly high level of reported violent crime with 8.9 reported incidents per 100 residents in 2003, more than double the Yukon rate of 4.1 per 100 residents.

5.2 Identified Interests

YESAB states that communities, governments, other organizations and individuals have an interest in a proposed project when they believe that a project may have an effect — positive or negative — on a part of the social and economic system that they, or those they represent, value. However, individuals, communities or organizations do not necessarily have to identify their own interests. Any participant in the process, including the proponent and the assessor, can identify interests.

YESAB's *Guide to Socio-economic Effects Assessment* states that interests are typically identified based on:

- Institutional recognition;
  - A socio-economic attribute is acknowledged in the laws, plans or policies of government agencies or private groups.
- Public recognition; and
  - Segments of the public demonstrate that they recognize the importance of a particular socio-economic attribute.
- Technical recognition
  - Scientific and/or traditional knowledge recognizes the importance of a particular socio-economic attribute.[2]

The proposed closure of the mine at Faro will likely have effects on things valued by a variety of interested parties. The table below contains a summary list of entities judged to have a likely socio-economic interest in the closure of the Faro mine. (Following the table is a series of sections detailing the nature of the interest in the project). The interested parties have been identified through a variety of means including, for some, self-identification in previous effects assessments.

It is important to note that while the governments of Canada and the Yukon have overlapping interests and roles in the project, only their interests as regulators and representatives of specific public interests are included here. The roles of proponent and manager are not.

[2] Yukon Environmental and Socio-economic Assessment Board. *Guide to Socio-economic Effects Assessments.* June 2006. p.35

Table 5.2: Identified Socio-economic Interests

Identified interest
Government of Canada
• Indian and Northern Affairs
• Human Resources and Social Development Canada
• Health Canada
• Natural Resources Canada
Yukon Government
• Department of Economic Development
• Department of Education
• Department of Energy, Mines & Resources
• Department of Health and Social Services
o Environmental Health Services Branch
• Department of Tourism
o Heritage Branch
• Department of Highways and Public Works
• Department of Community Services
o Emergency Measures Organization
• Department of Justice
• Women's Directorate
• Yukon Workers' Compensation Health and Safety Board
• Department of Environment
• Yukon College
• Yukon Energy Corporation
First Nations
• Ross River Dena Council
• Selkirk First Nation
• Liard First Nation
Municipalities
• Town of Faro
Communities
• Faro
• Ross River
• Pelly Crossing
• Watson Lake
Groups, businesses and individuals
• Kaska traditional land stewards
• Ross River trapper's group
• Faro Real Estate Ltd.
• Deuling Stone Outfitters Ltd.
• Yukon Mine Training Association

5.2.1 Government of Canada

The government of Canada still has areas of responsibility in the Yukon that create likely socio-economic interests in the Faro mine closure in its roles as regulator, delivery of services to non-settled First Nations and representative of particular public interests. Areas of interest for the federal government include:

- **Indian and Northern Affairs Canada (INAC).** Through its Northern Affairs Program INAC has a mandate for the sustainable development of the North's communities and natural resources. INAC also has the primary responsibility for meeting the federal government's duties and responsibilities to First Nations. This responsibility has particular bearing on the Ross River Dena Council and the Liard First Nation, neither of which has settled land claims and remain Indian Act Bands.
- **Human Resources and Social Development Canada (HRSDC).** HRSDC has a very broad mandate that includes managing the Employment Insurance program and a variety of training initiatives.
- **Health Canada.** Health Canada is responsible for funding the delivery of health services to First Nations.
- **Natural Resources Canada (NRCan).** Among its other responsibilities, NRCan has a regulatory role in enforcing Canada's Explosives Act.

5.2.2 Yukon Government

The Yukon government represents all Yukon residents and provides a wide variety of services to the population of the territory. The following Yukon government departments, branches, and directorates have been identified as likely having an interest in the Faro mine closure project.

- **Department of Economic Development.** Economic Development's interests include: increasing the Yukon's Gross Domestic Product (GDP), increasing government revenues, opportunities for Yukon businesses, and increasing Yukon First Nations participation in economic development.
- **Department of Education.** Education's interest in the project will likely be focussed on providing for any increase in the population of school-age children brought about by the project, and providing appropriate adult training and education programs to help Yukoners take advantage of employment opportunities.
- **Department of Energy, Mines and Resources.** Apart from its regulatory role in the mining sector, EMR has an interest in the effects this project may have on mine site remediation best practices that would be applicable to other projects. .
- **Department of Health and Social Services.** The interests of the Health side of the Department include any effect on its community nursing stations and its provision of emergency medical services, including air medivacs. The interests of the Social side of the Department are likely to include effects the project may have on: alcohol and drug services, social assistance, child and family services, and youth justice services.
  - **Environmental Health Services Branch.** The Environmental Health Services branch of the Department of Health and Social Services is concerned with the prevention and suppression of disease and enforces legislation involving drinking water, sewage, food services, and other public nuisance issues. The branch's interest will be in the supply of potable water and sewage services to any temporary camp if such a camp is planned for the project and the

capacity of the existing water and sewer infrastructure in Faro to accommodate those involved in the mine reclamation work.

- **Department of Tourism.** Tourism's broad interests in the Faro mine closure are that tourism be recognized as an industry with economic value, and that likely effects on any particular tourism operator or event be mitigated. They will also be interested in how this project may affect regional tourism development and the supply and availability of tourism support services.
  - **Heritage Resources Branch.** The interests of the Heritage branch of the Department of Tourism are the protection of any archaeological or heritage resources that may be affected by the project. This includes whether any site components, including equipment, has heritage interpretive value.
- **Department of Highways and Public Works.** Highways' broad interest in the Faro mine closure project arise from the department's core role in the construction and maintenance of safe and efficient transportation infrastructure in the Yukon. Specific interests will likely include the additional volume of traffic generated, the routes used and any additional maintenance that may be required as a result. Included are effects on bridges and airports.
- **Department of Community Services.** Community Services is responsible for solid waste facilities in non-incorporated communities. The department is also responsible for wildland fire management and so has an interest in projects that may result in fires.
  - **Emergency Measures Organization.** The EMO has an interest in any project that may result in a civil emergency requiring disaster response.
- **Department of Justice.** Justice's interest in the Faro mine project will be any effect the project has on crime, justice and policing in the affected communities and the Yukon.
- **Women's Directorate.** The Women's Directorate's role is to support the Yukon government's commitment to the economic, legal, and social equality of women. Its interests in the Faro project include: family violence, employment opportunities for women, and training opportunities for women.
- **Yukon Workers' Compensation Health and Safety Board.** The YWCHSB has an interest in all large projects in the Yukon through their role in workplace safety.
- **Department of Environment.** The Department of Environment's socio-economic interest in the Faro project will be the project's effect on hunting, fishing and trapping in the region. The department also has an interest in any hazardous waste generated or exposed by the project.
- **Yukon College.** Yukon College has an interest in any project that may affect demand for training, both general preparation for work courses and more specific and targeted training.
- **Yukon Energy.** Yukon Energy will have an interest if the project becomes a significant consumer of power.

5.2.3 First Nations

The following First Nations have identified interests in the socio-economic effects assessment of the Faro mine closure. In general the First Nations have an interest that the beneficial economic effects of the project not be diminished by an increase in social problems, which are already apparent in their respective communities. These issues are of particular concern because they have been part of the legacy of some past projects.

- **Ross River Dena Council.** The mine site is within the traditional territory of the Ross River Dena Council and Ross River is the closest First Nation community to the site. The First Nation's socio-economic interests in the project are wide-ranging. They include: economic development, including employment and business opportunities along with the resulting increases in incomes, a broad array of health, cultural and social concerns including the potential for alcohol and drug abuse, increases in crime and family violence, and the preservation of cultural integrity and the ongoing cultural continuity of the First Nation. Other related concerns include any impacts on health status and the economic aspects of subsistence activities.

  From a policy perspective, the RRDC has a specific interest in the site restoration standard to be achieved and its implications for future mining projects within its traditional territory. This includes not only the condition to which the site is restored but also how the restored state may influence future land use options and traditional use activities (e.g. hunting/fishing).

- **Selkirk First Nation.** The Selkirk First Nation has an interest in the Faro project because it is downstream of the Faro mine. The Selkirk First Nation's likely socio-economic interests in the project include business and employment opportunities and the social issues that arise with an increase in incomes. In addition the SFN has an interest in the effects of downstream water quality on subsistence resource use.

- **Liard First Nation.** The Liard First Nation has an interest in the Faro project because it is located within Kaska traditional territory. The Liard First Nation's likely socio-economic interests in the project include: business and employment opportunities, the social issues that arise with an increase in incomes, and perhaps, the economic aspects of subsistence activities.

5.2.4 Municipalities

The Town of Faro has an obvious and direct interest in the Faro closure project. The Town's interests focus on several possible socio-economic effects including: an increase in population, the potential for an increase in its tax base, and increased use of the infrastructure and services — including water, sewer, solid waste disposal, roads and recreation facilities — that are provided by the municipality.

5.2.5 Communities

The following communities have identified interests in the socio-economic effects assessment of the closure and reclamation of the Faro mine.

- Faro. The community of Faro has obvious and direct interests in the project, most overlapping with those of the Town of Faro. Those interests include: the likely increase in community population, employment and business opportunities, and the effects on community infrastructure and services.
- Ross River. Ross River is close to the project and has socio-economic interests in the decommissioning of the Faro mine. The community as a whole has socio-economic interests in the project apart from the interests of the Ross River Dena Council. Those interests will likely be centred on employment and business opportunities.
- Pelly Crossing. The community of Pelly Crossing has been identified as having an interest in the Faro closure project through the interest of the Selkirk First Nation. The wider community's interests likely mirror those of the SFN: business and employment opportunities and the social issues that arise with an increase in incomes.
- Watson Lake. Like Pelly Crossing, the wider community of Watson Lake has been identified as having an interest in the Faro closure project through the interest of the Liard First Nation. The wider community's interests likely mirror those of the LFN: business and employment opportunities and the social issues that arise with an increase in incomes.

5.2.6 Groups, Businesses and Individuals

Groups, businesses and individuals that appear to have clear and direct interests in the Faro mine closure project are:

- The traditional land stewards of the area affected.
- The Ross River trappers who use the group trap line that takes in much of the Robert Campbell Road area between the mine site and Ross River.
- Faro Real Estate Ltd., which currently owns much of the vacant housing stock in Faro and could be in a position to supply housing for workers on the project.
- Deuling Stone Outfitters Ltd., the area's outfitter.
- The Yukon Mine Training Association, a partnership between the mining industry and Yukon First Nations, whose mandate is to build the labour market capacity in the Yukon for mining and related industries.

5.3 Valued Socio-economic Components

Valued socio-economic components, or VSECs, are defined by the Yukon Environmental and Socio economic Assessment Board as those parts of the socio-economic fabric that are valued because of their importance to the community, specifically because of their:

- Integral connection to, or reflection of, the socio-economic system;

- Commercial or economic value; and/or
- Their role in maintaining quality of life in a community.[3]

Some VSECs are specific to a particular community or interest, but many overlap among communities and interests. All of the VSECs identified for the Faro project have been grouped into three clusters below:

- Sustainable livelihood;
- Community vitality; and
- Health and socio-cultural well-being.

The VSECs have been identified through a variety of means:

- Existing community plans and strategies including the Integrated Community Sustainability Plans for Faro and the Ross River Dena Council;
- Community meetings and validation workshops held to identify and confirm VSECs for the Faro mine held in Faro and Ross River;
- Meetings between Faro mine closure team and representatives of the Selkirk and Liard First Nations;
- Community meetings/workshops held to identify and validate VSECs for the Ketza River and Mactung North American Tungsten mines held in Faro and Ross River in 2007 and 2008; and
- Responses by many interests (including government interests) to YESAB's assessment of other projects, including the Carmacks Copper mine project and the Carmacks-Stewart/Minto Spur transmission line project.

It is very important to note that, although it is necessary to break down the VSECs into individual components for the purpose of effects assessment, many of the VSECs are very closely linked and often produce feedback loops between them. This is most obvious in the health and socio-cultural well-being VSECs. For example, damage to cultural continuity damages family integrity, leads to increased alcohol and drug abuse and domestic violence that damages individual health and so on. These are pervasive systematic issues that resist neat categorization.

5.3.1 Sustainable Livelihood

The sustainable livelihood cluster of VSECs includes most of those factors normally considered to fall in to the economic sphere — all those things that are about people making a living or helping to make that happen.

[3] Yukon Environmental and Socio-economic Assessment Board. *Guide to Socio-economic Effects Assessments.* June 2006. p.36.

- Traditional economic activities — hunting, fishing, gathering, trapping
- Employment
- Employability
  - Education
  - Training
  - Experience
- Infrastructure
  - Transportation
  - Power & communication
  - Municipal services
- Economic development
  - Economic growth
  - Equitable distribution of economic benefits between and within communities
  - Broad participation in economic development
  - Government revenues
- Economic diversification
  - Minimizing boom and bust cycles
- Healthy business sector
  - Business opportunities, immediate and long-term
  - Business capacity

5.3.2 Community Vitality

The community vitality cluster VSECs are those that speak directly to life in the community and how to make it better.

- Community population
  - Community demographics
  - Housing adequacy & land availability
- Safety and security
  - Reduce crime level
- Social cohesion
  - Social/community events
  - Volunteerism
  - Reducing discrimination & racism
- Quality of life
  - Recreation opportunities
  - Recreation facilities
- Community infrastructure & aesthetic

  - Municipal services
  - Decent place to live
- Governance, political structure
  - Decision making capacity
  - Planning capacity
  - Protection of whistle blowers

5.3.3 Health and Socio-cultural Well-being

The health and socio-cultural well-being VSEC cluster covers a broad range of issues that, although frequently raised as important or fundamental, are often very difficult to measure.

- Best possible health
  - Individual health
  - Systemic, comprehensive approach to health
  - Sense of purpose in life
- Health and social services infrastructure and programs
- Reducing alcohol and drug abuse
- Reducing domestic abuse and violence
- Public health and safety
- Workplace health and safety
- Family resilience and self-sufficiency
  - Intact families
  - Cohesion of extended family
  - Food security
- Cultural continuity
  - Heritage sites
  - Land-based social and cultural activities
  - Language preservation and restoration
  - Sharing traditional knowledge and stories

5.4 Preliminary Determination of Potential Effects

Which of the VSECs will be potentially affected, either positively or negatively, by the Faro reclamation project? Coming to a preliminary determination for some is straightforward, (e.g. the project will result in a clear and measurable increase in the Yukon's GDP.) For other VSECs, however, such a determination is not straightforward. The preliminary determination of potential effects is summarized in the tables below.

Table 5.3: Preliminary Determination of Potential Effects on Sustainable Livelihood VSECs

VSEC	Potential effect
Sustainable livelihood	
Traditional economic activities — hunting, fishing, gathering, trapping	Direct negative effect if the increased industrial activity in the region reduces the ability of people to pursue these activities. Long–term positive effect possible if environmental reclamation work reverses the disruption of harvesting by mine development Indirect effect as a result of the project increasing the size and importance of the local wage economy.
Employment	Direct effect through all phases of the project. Job opportunities will be available, and local unemployment rates potentially reduced.
Employability	
Education	Direct effect if school age population of Faro increases.
Training	Direct effect as contractors will employ apprentices and provide other forms of training to employees, likely in partnership with other organizations.
Experience	Direct effect as employment on the project will provide work experience, potentially over a significant time period depending on the trade or service requirement. Direct effect if project training and hiring practices either diversify the local labour force skills or attracts new entrants to the workforce that would otherwise not be employable.
Infrastructure	
Transportation	Only minor effect on road transportation infrastructure anticipated through small increase in traffic volumes.
Power & communication	No significant effect anticipated. The pumping of tailings, which would have had a significant effect on power consumption, has been eliminated as an option.
Municipal infrastructure	No significant effect anticipated unless significant increase in local population in Faro or Ross River. An increase population in Faro may strain the ability of the Town to provide services given the age and condition of some of the infrastructure.
Economic development	
Economic growth	The project will directly affect economic growth, at the Yukon & community levels.
Equitable distribution of benefits between & within communities	Will depend on policy choices made.
Broad participation in development	Direct positive effects through providing trades, technical and professional jobs to the entire cross-section of Yukon society. Business opportunities will also be available to a broad cross-section of Yukon society if project contracts are scaled appropriately.
Government revenues	The project will directly increase government revenues through various taxes. Likely significant positive effect on Town of Faro revenues if there is a significant increase in population or use of housing for the project.
Economic diversification	
Minimizing boom & bust cycles	Direct effect on Yukon and regional economic diversification as the construction phase of the project is designed to be extended over approximately 14 years.
Healthy business sector	
Business opportunities, short & long term	The project will provide a variety of business opportunities, especially over the 14-year construction phase.
Business capacity	The project may positively affect business capacity through the business opportunities it will offer.

Table 5.4: Preliminary Determination of Potential Effects on Community Vitality VSECs

VSEC	Potential effect
Community vitality	
Community population	The project may have an effect if a significant number of employees choose to move to communities in the region.
Demographics	No significant effect anticipated.
Housing & land availability	Faro has housing available for employees of the project. Ross River has little or no housing or land available.
Safety & security	
Reduced crime levels	The project may have an indirect effect on crime levels through the increase in incomes provided by employment and business opportunities. The effect may be to either increase or decrease crime levels.
Social cohesion	
Social/community events	The project may have an effect through the sponsorship of community events.
Volunteerism	No significant effect anticipated.
Reducing discrimination & racism	Will require adoption and enforcement of clear policies for all employers on the project.
Quality of life	
Recreation opportunities	No significant effect anticipated.
Recreation facilities	No significant effect anticipated unless Faro or Ross River population increases significantly.
Community infrastructure & aesthetic	
Municipal services	Little effect anticipated unless Faro or Ross River population increases significantly. An increased population in Faro may strain the ability of the Town to provide services given the age and condition of some of the infrastructure.
Decent place to live	No significant effect anticipated.
Governance & political structure	
Decision-making capacity	Project will have an effect on First Nation government's capacity. Project decisions will depend on level of First Nation participation in the process.
Planning capacity	Project will have an effect on First Nation government's planning capacity. The length of the process and high degree of participation may have a positive capacity-building effect.
Protection of whistle blowers	Will require adoption and enforcement of clear policies for all employers on the project.

Table 5.5: Preliminary Determination of Potential Effects on Health & Socio-cultural Well-being VSECs

VSEC	Potential effect
Health & socio-cultural well-being	
Best possible health	
Individual health	The project will likely have indirect effects on individual and family health through offering employment and increasing incomes.
Systemic, comprehensive approach to health	Through a variety of likely mitigation measures, the project will have an indirect positive effect on efforts to increase systemic approaches to health.
Sense of purpose in life	Employment has a positive effect on people's sense of purpose in life.
Health and social services infrastructure and programs	Local health infrastructure may be affected by the project depending in part on possible population increases and in part on project policies for treatment of workplace injuries. Social services and programs may be affected depending on population changes and project policies.
Reducing alcohol and drug abuse	The project will likely have an indirect effect on alcohol and drug abuse through an increase in employment and incomes. This effect may be positive or negative.
Reducing domestic abuse and violence	The project will likely have an indirect effect on domestic abuse and violence through an increase in employment and incomes. This effect may be positive or negative.
Public health and safety	The Faro project will have potential direct effects on public health and safety especially during the 14-year construction phase including: increased traffic and the possibility of on or off-site accidents and spills. Possible positive effect from reduction of metal levels in harvested animals and plants.
Workplace health & safety	This, like any project, will have direct effects on the health and safety of its own workforce.
Family resilience & self-sufficiency	Potential effect from increased employment and incomes. This effect may be positive or negative.
Intact families	Potential effect from increased employment and incomes. This effect may be positive or negative.
Cohesion of extended family	Potential effect from increased employment and incomes. This effect may be positive or negative.
Food security	Potential negative effect from increased employment reducing opportunities for subsistence activities.
Cultural continuity	
Heritage sites	Effects dependent on whether heritage sites are discovered, disturbed, or restored by the project.
Land-based social and cultural activities	Potential effect from increased employment reducing opportunities for these activities. Increased income could positively effect the ability to cover the cost of vehicles, equipment and supplies to travel on the land.
Language preservation & restoration	No significant effect anticipated.
Sharing traditional knowledge and stories	The project may stimulate a reconnection with the traditional knowledge of the Faro mine site and area.

5.5 Socio-economic Baseline

In an effects assessment, the baseline provides the necessary indicators for answering the question; what effects will the project have on the community or other interest? The baseline indicators are what we measure anticipated changes against. In YESAB's *Guide to Socio-economic Effects Assessments*, the following direction on selecting baseline indicators is given:

> The social and economic assessment indicators are derived from the VSECs and point to measurable change in human population, communities and social and economic relationships resulting from a proposed project. The delineation of socio-economic assessment indicators defines categories of social and economic change and selects the most suitable measures from which to describe current conditions and predict change. It achieves the goals of scoping by focusing on the most important categories of change and on useful and meaningful indicators.[4]

Therefore, the socio-economic baseline presented here has not been put together to provide a backdrop for the effects assessment and as a background primer for those not familiar with the communities. Rather, all of the data on the communities, and for the Yukon that make up the baseline has been selected to provide useful indicators for measuring the anticipated effects on each of the identified valued socio-economic components (VSECs) for the work proposed to achieve the closure of the Faro mine. The baseline indicators will also provide the means for longer term socio-economic effects monitoring as the project proceeds. It is also important to note that the anticipated effects of the project on the baseline indicators assist in devising effective mitigation and enhancement measures during the effects assessment itself.

There is not always a clear and direct indicator for each of the VSECs. Where this is the case, we have either selected indicators that, singly or together, provide an indirect or proxy means of measurement. We have not provided a quantifiable indicator at all where there is no value in doing so. In these cases we acknowledge that the VSEC that has no directly quantifiable measure may be under-valued or under-stated. Where that is the case, we describe any indirect or anecdotal evidence for our assumptions of how the Faro project will affect it. Providing an indicator that has only a tenuous or tangential relationship to the VSEC at best will not assist in the assessment and may distract from what is actually valued. We have tried to avoid including data simply because it is available.

The table below summarizes the linkages between the VSECs, the interests associated with each VSEC and the baseline indicator.

The detailed baseline, including explanations for why each indicator was chosen, can be found in Supporting Document C1.

[4] YESAB. June 2006. *Guide to Socio-economic Effects Assessments*.p.49

Table 5.6: VSECs, Interests and Indicators

VSEC	Interest	Indicator
Sustainable livelihood		
Traditional economic activities: hunting, fishing, gathering, trapping.	Yukon Environment Ross River Dena Council Selkirk First Nation Liard First Nation Traditional land stewards Ross River group trappers	Trapping harvest data (Yukon Environment) Description of level of harvest activity and displacement
Employment	Yukon Economic Development RRDC/Ross River Selkirk First Nation/Pelly Crossing Liard First Nation/Watson Lake Faro/Town of Faro	Employment rate Unemployment rate Participation rate (Census 2006)
Employability		
Education	Yukon Education Yukon Women's Directorate RRDC/Ross River Faro/Town of Faro	Highest level of education (Census 2006)
Training	HRSDC Yukon College Yukon Women's Directorate RRDC/Ross River Selkirk First Nation/Pelly Crossing Liard First Nation/Watson Lake Faro/Town of Faro Yukon Mine Training Association	Number of courses & completion rates for selected training courses (Yukon Mine Training Association)
Experience	RRDC/Ross River Selkirk First Nation/Pelly Crossing Liard First Nation/Watson Lake Faro/Town of Faro	Occupational breakdown (Census 2006)
Infrastructure		
Transportation infrastructure	Yukon Highways	Description Traffic count data (Yukon Highways)
Power & communication infrastructure	Yukon Energy	Description
Municipal infrastructure	Town of Faro Yukon Community Services	Description Proportion of municipal budget needed for O&M
Economic development		
Economic growth	INAC Yukon Economic Development RRDC/Ross River Selkirk First Nation/Pelly Crossing Liard First Nation/Watson Lake Faro/Town of Faro	Yukon GDP (Yukon Bureau of Statistics) Personal income by community (Canada Revenue Agency)

VSEC	Interest	Indicator
Equitable distribution of economic benefits between and within communities	RRDC/Ross River Selkirk First Nation/Pelly Crossing Liard First Nation/Watson Lake	Description
Broad participation in economic development	Yukon Economic Development Yukon Women's Directorate RRDC/Ross River Selkirk First Nation/Pelly Crossing Liard First Nation/Watson Lake	Women's and First Nation's employment, participation rates (Census 2006) Availability of daycare spaces (Yukon Health & Social)
Government revenues	Federal government Yukon government Ross River Dena Council Selkirk First Nation Liard First Nation Town of Faro	Municipal taxes (Town of Faro) Federal and Yukon income taxes by community GST data by community (Canada Revenue Agency)
Economic diversification	INAC Yukon Economic Development Yukon Tourism RRDC/Ross River Faro/Town of Faro Liard First Nation Deuling Stone Outfitters Ltd.	Employment by industry (Census 2006) Description
Minimizing boom & bust cycles	RRDC/Ross River Faro/Town of Faro	Personal income by community over time (Canada Revenue Agency) Population fluctuations over time (Yukon Bureau of Statistics)
Healthy business sector	Yukon Economic Development RRDC/Ross River Faro/Town of Faro	Number of business licences (Town of Faro) Number of businesses & employees (Yukon Bureau of Statistics)
Business opportunities, short & long term	Yukon Economic Development RRDC/Ross River Faro/Town of Faro Liard First Nation	Description
Business capacity	RRDC/Ross River Faro/Town of Faro Liard First Nation	Description
Community vitality		
Community population	RRDC/Ross River Faro/Town of Faro Liard First Nation Pelly Crossing/SFN	Community population & growth pattern (Yukon Bureau of Statistics)

VSEC	Interest	Indicator
Demographics	RRDC/Ross River Faro/Town of Faro	Demographic profile (families, children) Ethnicity (Census 2006) School enrolment data (Yukon Education)
Housing & land availability	RRDC/Ross River Faro/Town of Faro Faro Real Estate Ltd.	Dwelling units (Census 2006) Housing prices (Real estate listings) Available lots (Yukon EMR)
Safety & security		
Reduced crime levels	Yukon Justice RRDC/Ross River Faro/Town of Faro	Community crime rates (Yukon Bureau of Statistics)
Social cohesion		
Social/community events	RRDC/Ross River Faro/Town of Faro	Description Frequency, participation levels
Volunteerism	RRDC/Ross River Faro/Town of Faro	Description Stability and longevity of community organizations
Reducing discrimination & racism	Ross River Dena Council LFN/Watson Lake	Income differentials between First Nations & others & over time (Census 2006)
Quality of life		
Recreation opportunities	RRDC/Ross River Faro/Town of Faro Liard First Nation Pelly Crossing/SFN	Description Level of participation
Recreation facilities	RRDC/Ross River Faro/Town of Faro Liard First Nation Pelly Crossing/SFN	Description Type, nature and levels of use
Community infrastructure & aesthetic		Investment in community aesthetics
Municipal services	Town of Faro	Description Adequacy and condition Lifecycle
Decent place to live	RRDC/Ross River Faro/Town of Faro Liard First Nation Pelly Crossing/SFN	Description Length of residency (Census 2006)
Governance, political structure and decision-making capacity	RRDC/Ross River Faro/Town of Faro Liard First Nation Pelly Crossing/SFN	Description Empowerment and influence on relevant decision-making
Health & socio-cultural well-being		

VSEC	Interest	Indicator
Best possible health		
Individual	Health Canada Yukon Health and Social Services RRDC/Ross River LFN/Watson Lake Faro/Town of Faro	Selected Health Survey statistics (Statistics Canada)
Systemic, comprehensive approach to health	Health Canada Yukon Health and Social Services RRDC/Ross River LFN/Watson Lake Faro/Town of Faro	Description
Sense of purpose in life	RRDC/Ross River LFN/Watson Lake Faro/Town of Faro	Description
Health and social services infrastructure and programs	Health Canada Yukon Health and Social Services RRDC/Ross River LFN/Watson Lake Faro/Town of Faro	Description of community health program uptakes.
Reducing alcohol and drug abuse	Yukon Health and Social Services Yukon Women's Directorate RRDC/Ross River Faro/Town of Faro	Alcohol sales data (Yukon Liquor Corporation) Reported drug incidents and criminal code traffic incidents data (Yukon Bureau of Statistics)
Reducing domestic abuse and violence	Yukon Health and Social Services Yukon Women's Directorate Yukon Justice RRDC/Ross River	Domestic violence statistics (Yukon Bureau of Statistics)
Public health and safety	Natural Resources Canada Yukon Energy, Mines and Resources Yukon Environmental Health RRDC/Ross River	Traffic accident rates (Yukon Highways)
Workplace health & safety	Yukon WCHSB RRDC/Ross River	Mining accident rate (Yukon WCHSB and WorkSafeBC)
Family resilience & self-sufficiency		
Intact families	RRDC/Ross River Liard First Nation Pelly Crossing/SFN	Ratio of single parent families to all families (Census 2006)
Cohesion of extended family	RRDC/Ross River Liard First Nation Pelly Crossing/SFN	Households and families (Census 2006)
Food security	RRDC/Ross River	Inflation rate, food (Yukon Bureau of Statistics)
Cultural continuity		
Heritage sites	Yukon Heritage Branch Ross River Dena Council	Description Site quality and significance

VSEC	Interest	Indicator
Land-based social and cultural activities	Ross River Dena Council Traditional land stewards Ross River group trappers	Description
Language preservation & restoration	Ross River Dena Council	Description Speakers of aboriginal languages (Census 2006)
Sharing traditional knowledge and stories	Ross River Dena Council	Description

5.5.1 Traditional Knowledge and the Socio-economic Baseline

Traditional Knowledge is defined internationally as "the content or substance of knowledge that is the result of intellectual activity and insight in a traditional content, and includes know-how, skills, innovations, practices and learning that form part of traditional knowledge systems and knowledge that is embodied in the traditional lifestyle of a community or people, or is contained on codified (written) knowledge systems passed between generations.[5]

Two Traditional Knowledge reports were prepared to inform this process: one by the Ross River Dena Council and one by the Selkirk First Nation. These reports document some of the knowledge shared with the local research teams. Not all of the traditional knowledge was shared due to the highly sensitive and confidential nature of the some of the information. The two reports still provide information that is not for the public domain and therefore will not be included as support documents and the references to the content of the reports will be very general and used without direct quotations.

Information provided in the reports is very useful and the general domains of knowledge include the following:

- Information on the land, the traditional economy related to harvesting the land – types of food (animals, birds, fish), useful plants, water, rocks, wood and other natural resources accessed;
- Information on the traditional way of life, sense of history and the deep connection and belonging with the land;
- Information about historical community and family activity according to the seasons;
- Information on the traditional view of land (including all that lives there) stewardship including how the First Nation people observed and interpreted nature in order to survive - an understanding of the interconnectedness of all things;

[5] (World Intellectual Property Organization, Glossary of Terms, accessed on Jan. 10, 2010 http://www.wipo.int/tk/en/glossary)

- General information of the existence of geographic, historical and spiritual sites of specific importance;
- Identification of trail systems for protection with no specific site information;
- Information on the traditional territory, use and occupancy of the First Nation people;
- Information on the changes observed in the land and living things in recent times;
- The confidence on the high level of traditional knowledge that is still available and worry about passing it on to future generations;
- Values and traditions that need to be taken into account in establishing VSECs and measurement programs for monitoring;
- Insight into the cultural strengths of the community grounded in history and traditions for consideration in assessing social effects and mitigation alternatives;
- The spiritual and healing significance of the land in general and specific sites in particular;
- Documentation of the concern about the effects of historical contamination and environmental contamination into the future – the worry of loss of traditional food sources and the lack of income necessary and the health effects of "store bought food";
- Traditional patterns of long distance travelling on the land and the connection to neighbouring nations;
- Traditional laws and system of laws (SFN report);
- Information on traditional laws and how wisdom was transmitted through the generations – stories, legends and myths (RRDC report);
- Discussion of both positive and negative effects of increased income and opportunities;
- Information on more recent impacts of mining and related development which needs to be considered in looking at what has worked and not worked related to impacts in the past including the remaining deeply felt sense of loss sue to the impact of the Faro development (RRDC report);
- Insight into gender roles – men and women with an emphasis being placed on primarily men's knowledge which is knowledge of the land and rules for interacting with plants and animals, although women also participated in fishing, hunting and gathering. References made to women related to preparing feasts, what women were not allowed to do. Both genders are referenced in looking at rituals and ceremonies and how respect and harmony was supported. (RRDC report)

Many of the questions related to the use of the land asked of the TK research process where answered directly or indirectly. Gaps that remain include more information on how the families and communities functioned historically which would assist in the economic and social effects assessment.

The SEA team intends to rely on traditional knowledge to do the following:

- Provide information on historical and current background and context to inform the VSECs identification, indicator development and possible mitigation measures;
- Provide information on the traditional economy and mainstream economic activity in order to support the best possible opportunities for people in both;
- Provide information on historical and cumulative effects so that the project managers can learn from the past and manage cumulative effects to the extent possible going forward;
- To support the best possible understanding the First Nation peoples' relationship to the land and how that affects the community including traditional stewardship roles and the link between the health of the land and the health of the community and the need for restoration of harmony; and
- To support the understanding of what cultural continuity and resilience means to the communities and to ensure cultural values and strengths are supported in building further resilience.

The SEA team have reviewed the TK reports and the following is a summary of what we understand to be the primary messages from them that helps provide a basis for the work of the socio-economic assessment:

- Traditional life was integrated and balanced: First Nation people lived in harmony with the land and relied on an intimate and comprehensive knowledge of the land and all that lived there to survive and thrive;
- Travelling large and expansive traditional territories in tune with the seasons provided varied food sources and supplied goods to meet the needs of the people;
- Rivers as a method of travel, a source of food and water were and remain of fundamental importance;
- Working together and sharing among family and community members and neighbouring Nations were strong values;
- All the knowledge necessary to live abundantly on and with the land was passed down through oral tradition;
- Rich culture, traditional teachings and traditional laws governed behaviour with the land, all the inhabitants of the land and other people;
- Culture and language are deeply valued and the threat of loss due to the weakening of intergenerational transmission is ever present; and
- To the extent possible, that sense of integrity of the land with the community is to be restored through the project, new benefits shared with those affected and negative effects mitigated as much as possible.

Understanding this, what we know of the current socio-economic conditions from the Traditional Knowledge research and other information is as follows:

- Land and Water Disruption – The land and water around the Faro site and downstream have been affected and will continue to be affected. The purpose of the project is to restore the site as much as possible.
- Relational Disruption – The relationship between the people and the land in the impacted area has been affected. The trust that the land will always be there to provide for the people has been disrupted. The project needs to be structured to restore that relationship and the trust to the extent that it is possible and realistic.
- Cultural Disruption – The Faro mine site development combined with other impacts related to colonization, acculturation and mainstream industrial development has impacted the culture and the transmission of culture in its wholeness between generations. (cultural continuity) Communities are committed to cultural revival which depends on language and the project needs to ensure no further negative impact as a result of the project.
- Community Disruption – As a result of the above noted impacts, community integrity, relationships within extended families and the natural ability of the community to respond and adapt to change has been impacted. The community has social problems, violence and lack of respect between people that were not features of traditional society. To the extent possible, the project needs to not add to the community disruption and provide positive options to support the community in restoring its strength.

These disruptions in the natural ebb and flow of traditional life were felt on the individual and collective levels. Therefore, the strategies for assessment and mitigation of impacts need to be considered on both the individual and collective (family and community) levels.

Chapter 6

Alternatives and Chosen Approaches

6 Alternatives and Chosen Approaches

6.1 General

The proposed FMC Closure and Remediation Plan was selected after consideration of alternatives to the remediation project as well as alternative means of carrying out the project. The scope of alternatives considered is large and complex due to the many site components, range of issues to be resolved and the various objectives of five different governments as well as other interested groups. This chapter provides an overview of the alternatives considered and the rationale for the chosen approaches, including the methodology for evaluating key alternatives.

6.2 Alternatives to the Closure and Remediation Project

Early in the planning process, the closure planning team recognized the substantial costs associated with planning for and implementing closure and remediation for the FMC. To justify these costs, the planning team investigated the implications of two alternatives to the remediation project: (1) no intervention and (2) continued care-and-maintenance. The results of the investigations confirmed that both of these alternatives would lead to severe environmental degradation and unacceptable risks of catastrophic failures. As such, these alternatives would not be capable of addressing the objectives specified by the Oversight Committee or meeting the requirements specified in the water licence.

6.2.1 No Intervention Alternative

An Ecological and Human Health Risk Assessment (SENES, 2006) evaluated the long-term environmental and health implications associated with the "no intervention" alternative. This alternative assumed no control or collection of water flowing into or out of waste rock dumps, mine pits and the tailings impoundment. The analysis of the alternative utilized predictions of long-term water quality to assess potential risks to the environment and humans. SENES concluded that the "no intervention" alternative could result in adverse effects on aquatic, terrestrial and human receptors.

In addition to the predicted unacceptable environmental degradation, the "no intervention" alternative fails to address physical stability risks associated with extreme climatic or earthquake events. Some critical tailings retention and water management structures at the site are not currently capable of withstanding probable maximum flood and maximum credible earthquake events, thus creating unacceptable risks of failure over long periods of time. Such failures would lead to release of soluble metals and acid generating waste materials into the local aquatic environment. Lack of maintenance in a "no intervention" alternative would exacerbate the physical risks.

The potential for severe environmental degradation and the risks of catastrophic failures demonstrate that "no intervention" is not a viable long-term alternative for the FMC.

6.2.2 Continued Care-and-Maintenance Alternative

The current care-and-maintenance program follows a risk-based adaptive management approach. Site activities including water collection and treatment are undertaken to ensure that contaminant releases from the site do not cause unacceptable effects in the aquatic environment. Other activities are intended to minimize effects on the terrestrial environment. An extensive monitoring program provides ongoing feedback to confirm the status of mine and environmental components. The monitoring program support an adaptive management plan that is intended to identify areas of potential concern in a timely manner and allow effective responses for preventing environmental degradation. This adaptive management approach has functioned effectively since it was established in 2003 and has led to implementation of several measures and activities to correct problematic trends identified through the monitoring program.

For the long-term, the alternative of continued care-and-maintenance using an adaptive approach was considered by the closure planning team. However, the concept was rejected for two reasons. First, like the "no intervention" alternative, the continued care-and-maintenance alternative fails to address the physical stability risks associated with extreme climatic or earthquake events.

Second, the predictions of long-term contaminant loading from tailings and waste rock identified significant future increases in loading under all prediction scenarios. The loading predictions indicated that source and transport control would be necessary in combination with adaptive management to limit the rate of contaminant release from the site. Without such source and transport control, the contaminant loading rates are likely to reach such elevated levels that adequate care-and-maintenance responses will no longer be possible. There are significant time delays between production of contaminant loads, and their release to the aquatic environment. As a result, the source and transport control measures must be put in place long before there are effects identified at the site perimeter or in the receiving environment. Therefore, the necessary measures need to be part of an overall closure and remediation strategy, and environmental protection cannot rely solely on adaptive management of care-and-maintenance activities, though adaptive management will form part of any closure plan.

6.3 Alternative Means for Closure and Remediation

An exhaustive range of alternative means for carrying out closure and remediation at the FMC has been considered during the current closure planning process. The options identification process began in 2002 and concluded in 2008 when the members of the Oversight Committee agreed on a recommended closure plan. However, it is important to recognize that the complex and varied natures of the site and project dictate that the proposed closure and remediation plan contains flexibility for variants in closure alternatives for specific mine and closure plan components. Thus the evaluation of alternatives within the framework of the selected closure plan is an ongoing and iterative process.

The overall process for selecting a closure and remediation plan for the FMC included several main phases. The first phase, the iterative identification and screening of closure methods, involved the identification of a broad range of possible closure methods followed by technical investigations of their practicality, performance and feasibility. The second phase involved the consolidation of closure methods into a total of thirteen "example alternatives" covering the three main areas of the Faro Mine Complex: the tailings, Faro Mine area and Vangorda/Grum Mine area. The third phase further narrowed the range of options under consideration and established a short list of options for each mine area. A total of six options were considered during this phase. The fourth phase involved a rigorous analysis of performance of the short listed options. These initial four phases of the alternatives analysis process are described in "Options for Closure of the Faro Mine Complex" (SRK, 2008). During the fifth phase, the governments represented on the Oversight Committee considered the results of the options analysis and the Oversight Committee identified a recommended plan.

6.3.1 Phase 1: Identification and Screening of Closure Methods

For the current closure planning process, the initial phase of identifying and evaluating alternatives was guided by a series of workshops held between 2002 and 2005. Participants (specialist consultants in the key technical discipline, federal, territorial and First Nation governments, the town of Faro, Yukon regulatory agencies, Environment Canada, the Department of Fisheries and Oceans, and the Yukon Salmon Committee) at five workshops identified, reviewed and discussed potential closure methods for mine components. The process iteratively identified and refined potential methods over a these years as participants defined the technical uncertainties for specific options and designed studies to address outstanding data gaps and critical uncertainties. Over the years 2003-2006, approximately forty studies were undertaken to better understand the site and potential closure options, at a total cost of several million dollars. The workshop discussions and conclusions are summarized in a series of reports (Deloitte & Touche Inc. 2003, 2004a, 2004b, 2005).

The study program began in 2002 with scoping level studies aimed at gaining an understanding of site components and issues. Each year, the focus of the studies narrowed as the understanding of closure methods improved. Partial listings of the types of studies carried out from 2003 through 2006 are provided below.

- 2003 programs included evaluation of seepage conditions, initial assessment of waste dump water balances, evaluation of waste dump and tailings cover methods, identification of priority seepage collection areas, initial assessment of tailings groundwater, evaluation of tailings relocation methods, identification and evaluation of options for the Faro and Vangorda Creek diversions, and evaluation of earthquake conditions.
- 2004 programs included field trials of in-situ treatment of pit water, development of waste rock water quality predictions, initiation of cover field trials, evaluation of options for water management in Faro Pit, initial design options for seepage collection, refinement of understanding of tailings groundwater, evaluation of options for Vangorda Pit, investigation of potential borrow sources, initial design for tailings relocation using hydraulic monitoring,

various water treatment related studies, assessment of tailings stability in earthquake conditions, investigations to support design of dam and diversion upgrades for Rose Creek and the tailings area, initial design of groundwater collection for the Rose Creek aquifer, investigation of terrestrial effects, evaluation of need for site specific water quality objectives, investigation of hydrocarbon contamination and completion of ecological and health risk assessment.

- 2005 programs included more detailed investigation of borrow sources, continued updating of water quality predictions using updated monitoring results, more detailed design of various components (Faro Pit plug dam, inflow/outflow channels, seepage collection systems, creek diversions, dam upgrades, tailings relocation plan, etc.), ongoing monitoring and analysis of various ongoing field trials and re-evaluation of probable maximum flood estimate.
- 2006 programs included ongoing monitoring and analysis of various ongoing field trials, investigations related to tailings reprocessing and additional more detailed design for various mine components.

Attachment A-3 of "Options for Closure of the Faro Mine Complex" (SRK, 2008) summarizes the range of alternatives that were considered for each mine component during the first phase of the options analysis. Earlier alternatives evaluation processes were conducted during previous closure planning processes and the results of these analyses were also considered. The above referenced tables describe the outcomes of the first phase of the alternatives selection process, identifying which methods were carried forward into the "example alternatives" phase of the process and the rationale for not considering specific methods further. Studies and investigations have continued since 2006 to further refine alternatives and methods.

6.3.2 Phase 2: Example Alternatives

Utilizing the results of workshops, closure studies, input from project participants (federal and Yukon government departments, the Faro Project Management Team, and the Ross River Dena Council and Selkirk First Nation), risk analysis meetings and ecological and human health risk assessment (SENES, 2006), SRK consolidated the closure methods into a series of "example alternatives" intended to represent the range of options that the prior work had shown to be technically reasonable. Through late 2005 and most of 2006, additional work was completed to refine the initial example alternatives and eventually to complete detailed descriptions including cost estimates, residual risks and environmental performance for four example alternatives in each of three mine areas: Faro Mine, Vangorda/Grum Mines and Tailings.

In September 2006, the Faro Mine Closure Project Management Team commissioned an Independent Peer Review Panel (IPRP), made up of nine of leading experts in the scientific and engineering disciplines underlying mine closure planning for the FMC. The IPRP's purpose was to review the example alternatives and the supporting technical documentation and confirm that these alternatives represented an appropriate range of options and that there was adequate technical information to support a detailed evaluation of the alternatives. The IPRP produced its final report on the example alternatives in March 2007. One of the significant findings of the IPRP report was

that an additional alternative, based on a water cover over the tailings, should be considered. This alternative was subsequently added to the list of example alternatives, for a total of thirteen alternatives in the three areas.

The following subsections describe the example alternatives, including the water cover alternative, for each of the three major mine areas.

Example Alternatives – Faro Mine Area

Major components of the Faro Mine Area are shown on Figure 6.1. Four example alternatives were identified for the Faro Mine area.

- Alternative 1: Flow Through Pit – redirect Faro Creek into the Faro Pit, creating a flow through pit lake, relying on biological treatment in the pit lake to reduce contaminant levels.
- Alternative 2: Upgrade Faro Creek Diversion – establish an upgraded Faro Creek Diversion and continue to manage Faro Pit as a contaminated water pit.
- Alternative 3: Minimize Construction – delay the reconstruction of the Faro Creek Diversion until absolutely necessary and construct only minimal covers on waste rock.
- Alternative 4: Minimize Water Treatment – relocate some waste rock materials and construct robust covers on waste rock, to minimize requirements for future water treatment.

Table 6.1 describes how each mine component was to be addressed in each of the four example alternatives for the Faro Mine Area.

All of the four example alternatives included various requirements for long-term contaminated water management (contaminated water collection/conveyance, water treatment), construction of soil covers and long-term inspection, maintenance and repair (e.g. water conveyance ditches, soil covers, water collection, conveyance and treatment equipment).

The major differences among the alternatives reflect different approaches to:

- Closure of the Faro Creek Diversion, which was assumed to be either rerouted into the Faro Pit, or maintenance of a long-term diversion around the Faro Pit;
- Long-term water treatment, which was assumed to be either biological water treatment in the Faro Pit, or chemical water treatment in a treatment plant; and
- Reducing contaminant loadings from waste rock, which in all cases involves construction and revegetation of soil covers, but with different levels of waste relocation and different cover designs.

Table 6.1: Example Alternatives for the Faro Mine Area

Component	Alternative 1 Flow-Through Pit	Alternative 2 Upgrade Faro Creek Diversion	Alternative 3 Minimize Construction	Alternative 4 Minimize Water Treatment
Surface Water Diversions	Re-route Faro Creek to pit. Raise North Fork as needed to prevent contamination by seepage or contaminated groundwater.	Upgrade Faro Creek Diversion now. Raise North Fork as needed to prevent contamination by seepage or contaminated groundwater.	Upgrade Faro Creek Diversion in future as needed Raise North Fork as needed to prevent contamination by seepage or contaminated groundwater.	Upgrade Faro Creek Diversion now. Raise North Fork as needed to prevent contamination by seepage or contaminated groundwater.
Contaminated Water Management	Collect contaminated groundwater in ETA, S-well and Zone II areas. Store water in pit for seasonal biological treatment.	Collect contaminated groundwater in ETA, S-well and Zone II areas. Store in pit for seasonal treatment in High Density Sludge plant.		Collect contaminated groundwater in ETA, S-well and Zone II areas. Store in pit for seasonal treatment in High Density Sludge plant with possible future switch to biological treatment in pit.
Waste Rock				
Oxide Fines/ Low-Grade Ore	Consolidate with plastic cover	Consolidate with plastic cover	Cover with 0.5 m soil and revegetate	Relocate to Pit with lime
Sulphide Cells	Cover with 2 m soil and revegetate	Cover with 2 m soil and revegetate	Cover with 0.5 m soil and revegetate	Consolidate with 2.5m soil cover
Faro Valley Dump	Cover with 0.5 m soil and revegetate	Cover with 0.5 m soil and revegetate	Cover with 0.5 m soil and revegetate	Relocated to sulphide cell with 2.5m soil cover and revegetate
Other Waste Rock	Reslope and cover with 0.5 m soil and revegetate	Reslope and cover with 0.5 m soil and revegetate	Cover flat areas with 0.5m soil and revegetate. No resloping	Reslope and cover with 2 m soil and revegetate
Faro Pit	Store contaminated water for in-pit biological treatment. Discharge water each year after treatment is effective.	Construct berm around pit rim to reduce risk of inadvertent access. Use pit for storage of contaminated water.		
Emergency Tailings Area	Relocate tailings and collect groundwater	Relocate tailings and collect groundwater	Leave as is	Relocate tailings and collect groundwater

Example Alternatives – Tailings Area

Major components of the Tailings Area are shown in Figure 6.2. Four example alternatives were initially developed for the tailings area but one additional alternative was added and evaluated following review of the initial list by the IPRP.

- Alternative 1: Stabilize in Place – upgrade tailings dams and creek diversions to withstand severe earthquake and flood events, cover the tailings in place and collect/treat contaminated water permanently.
- Alternative 2: Complete Relocation – relocate all of the tailings to the Faro Pit and re-establish Rose Creek in the valley after collecting and treating residual contaminated water.
- Alternative 3: Partial Relocation – relocate the tailings from the Intermediate Impoundment, upgrade remaining tailings dams and creek diversions to withstand severe earthquake and flood events, cover remaining tailings and collect/treat contaminated water permanently.
- Alternative 4: Minimize Construction – upgrade tailings dams and creek diversions to withstand severe earthquake and flood events, leave tailings in place with fence and annual dust control measures and collect/treat contaminated water permanently.
- Alternative 5: Water Cover – re-grade tailings, raise the Intermediate Dam, upgrade Intermediate Dam spillway, upgrade upper portions of the creek diversion, construct cut-off wall at Intermediate Dam and establish permanent flow-through, water cover over tailings surface.

Table 6.2 describes how each mine component was to be addressed in each of the five example alternatives for the tailings area.

For tailings example alternatives, the biggest distinction related to whether tailings would remain in place or be relocated. Alternative 2, which proposed complete relocation of the tailings to the Faro Pit, proposed 10-15 years of relocation activities followed an estimated 10-20 years of groundwater cleanup. All of the other alternatives proposed to leave at least some of the tailings in the valley, and therefore identified requirements for long-term management of contaminated water.

The alternatives with varying amounts of tailings remaining in the valley differed in how they would deal with the Rose Creek Diversion. Alternatives 1 and 4 included upgrading of the entire Rose Creek Diversion to enable it to pass the Probable Maximum Flood around the tailings. Alternative 3 included relocation of the tailings below the most hazardous sections of the Rose Creek Diversion, so that the creek could eventually be routed back to the valley floor over those reaches. Alternative 5 also removed the creek from the most hazardous sections of the diversion, but in this case routed it over the tailings pond to a new spillway on the north side of the valley.

Table 6.2: Example Alternatives for the Tailings Area

Component	Alternative 1 Stabilize in Place	Alternative 2 Complete Relocation	Alternative 3 Partial Relocation	Alternative 4 Minimize Construction	Alternative 5 Water Cover
Surface Water Diversions	Upgrade entire length of Rose Creek Diversion to pass Probable Maximum Flood (PMF).	Keep Rose Creek in channel during relocation and for roughly 20 years of groundwater cleanup, then re-route it to the valley floor.	Upgrade Secondary Dam portion of Rose Creek Diversion to PMF. Re-route remainder to valley floor after tailings relocation and groundwater cleanup.	Upgrade entire length of Rose Creek Diversion to pass Probable Maximum Flood (PMF).	Upgrade Secondary Dam portion of Rose Creek Diversion to PMF. Route remainder over tailings surface to new spillway on north side of Intermediate Dam.
Contaminated Water Management	Install well system along toe of Cross Valley Dam. Collect contaminated groundwater. Store in pit for seasonal treatment.	Collect contaminated groundwater from tailings footprint for estimated 10 to 20 years. Store in pit for seasonal treatment.	Install well system along toe of Secondary Dam to collect contaminated groundwater from tailings. Also collect groundwater from footprint of relocated tailings. Store in pit for seasonal treatment.	Install well system along toe of Cross Valley Dam. Collect contaminated groundwater. Store in pit for seasonal treatment.	Construct cut-off wall through Intermediate Dam to reduce seepage rates through tailings. Install well system along toe of Cross Valley Dam. Collect contaminated groundwater. Store in pit for seasonal treatment.
Tailings					
Original & Secondary	Construct 2 m thick rock/soil cover. Revegetate.	Complete a 10-15 year project to hydraulically mine and pump all tailings to the Faro Pit, with lime addition to neutralize acidity.	Construct 2 m thick rock/soil cover. Revegetate.	Fence tailings and apply dust suppression measures annually.	Partially relocate to Intermediate tailings to create level surface and cover with pond.
Intermediate			Relocate to Faro Pit		Cover with relocated Secondary tailings and cover with pond.
Dams					
Cross-Valley	Remove (Breach)				
Intermediate	No Action	Remove (Breach)	Remove (Breach)	No Action	Raise and Construct new spillway
Secondary	Upgrade to MCE	Remove (Breach)	Upgrade to MCE	Upgrade to MCE	Upgrade to MCE
Original	No Action	Remove (Breach)	No Action	No Action	No Action

The alternatives with varying amounts of tailings remaining in the valley also differed in how they proposed to manage the tailings surface. Alternatives 1 and 3 included soil covers to limit infiltration and prevent dust release or direct uptake of tailings by animals. Alternative 5 included a water cover to limit further tailings oxidation and prevent dust and direct uptake. Alternative 4 did not identify methods to control infiltration or oxidation, and relied on dust suppressant and fences to prevent dust release and direct uptake. All of the "leave in place" alternatives included geotechnical modifications to make the dams stable, even in the Maximum Credible Earthquake.

Example Alternatives – Vangorda Grum Area

Major components of the Vangorda/Grum Mine Area are shown in Figure 6.3. Four example alternatives were identified for the Vangorda/Grum Mine area.

- Alternative 1: Backfill Vangorda Pit – relocate the Vangorda waste rock into the Vangorda Pit, relocate Vangorda Creek over the backfilled pit, cover Grum waste rock, collect contaminated water from Grum waste rock and treat contaminated water using biological treatment in the Grum Pit.
- Alternative 2: Stabilize in Place – upgrade the Vangorda Creek Diversion around the Vangorda Pit, cover Vangorda and Grum waste rock, collect contaminated water from Grum and Vangorda waste rock and treat contaminated water using lime treatment.
- Alternative 3: Minimize Construction – delay the reconstruction of the Vangorda Creek Diversion until absolutely necessary, construct only minimal covers on waste rock and collect/treat contaminated water using lime treatment.
- Alternative 4: Minimize Water Treatment – relocate the Vangorda waste rock into the Vangorda Pit, relocate Vangorda Creek over the backfilled pit, cover Grum waste rock with robust covers, collect contaminated water from Grum waste rock and treat contaminated water using biological treatment in the Grum Pit.

Table 6.3 describes how each mine component was to be addressed in each of the four example alternatives for the Vangorda/Grum area.

The major differences among Alternatives 1 and 2 arose from decisions either to place the Vangorda waste rock back in the Vangorda Pit, or to stabilize it in place, which in turn leads to decisions about where the final channel for Vangorda Creek would be located (either over the pit if it is backfilled, or around the pit if not). Alternatives 3 and 4 represented further expansions on those two approaches with Alternative 3 being similar to Alternative 1 but with thinner covers on waste rock and Alternative 4 being similar to Alternative 2 but with thicker covers on waste rock. Alternatives 2 and 4 proposed reliance on biological treatment while Alternatives 1 and 3 would have had requirements for chemical treatment in a high density sludge plant. All example alternatives for the Vangorda/Grum area included long-term groundwater collection and covers for the Grum waste rock.

Table 6.3: Example Alternatives for the Vangorda/Grum Mine Area

Component	Alternative 1 Backfill Vangorda Pit	Alternative 2 Stabilize in Place	Alternative 3 Minimize Construction	Alternative 4 Minimize Water Treatment
Surface Water Diversions	Re-route Vangorda Creek in erosion protected channel over backfilled pit. Maintain Grum Creek diversion.	Upgrade Vangorda Creek Diversion now. Maintain Grum Creek diversion.	Upgrade Vangorda Creek Diversion in future as needed. Maintain Grum Creek diversion.	Re-route Vangorda Creek in erosion protected channel over backfilled pit. Maintain Grum Creek diversion.
Contaminated Water Management	Collect contaminated groundwater below Grum Dump. Store in Grum Pit for biological treatment. Include contingencies for collection of Vangorda Pit groundwater and HDS treatment of Grum Pit water.	Collect contaminated groundwater below Grum Dump and Vangorda Waste. Store in Vangorda Pit for periodic extraction and chemical treatment in High Density Sludge (HDS) plant.	Collect contaminated groundwater below Grum Dump and Vangorda Waste. Store in Vangorda Pit for periodic extraction and chemical treatment in High Density Sludge (HDS) plant.	Collect contaminated groundwater below Grum Dump. Store in Grum Pit for biological treatment. Include contingencies for collection of Vangorda Pit groundwater and HDS treatment of Grum Pit water.
Waste Rock				
Vangorda Waste Rock	Relocate to Vangorda Pit. Add lime to neutralize acidity. Compact during backfilling to reduce permeability.	Cover with 2 m soil and revegetate	Cover with 0.5 m soil and revegetate	Relocate to Vangorda Pit. Add lime to neutralize acidity. Compact during backfilling to reduce permeability.
Grum Sulphide Cell	Cover with 2 m soil and revegetate	Cover with 2 m soil and revegetate	Cover with 0.5 m soil and revegetate	Consolidate with 2.5m soil cover
Other Grum Waste Rock	Reslope and cover with 0.5 m soil and revegetate	Reslope and cover with 0.5 m soil and revegetate	Cover flat areas with 0.5m soil and revegetate. No resloping	Reslope and cover with 2 m soil and revegetate
Ore Transfer Pad	Relocate ore to Vangorda Pit and cover remainder with 0.5 m soil and revegetate	Relocate ore to Grum Sulphide cell and cover remainder with 0.5 m soil and revegetate	Cover with 0.5 m soil and revegetate	Relocate ore to Vangorda Pit and cover remainder with 2 m soil and revegetate
Vangorda Pit	Backfill with neutralized Vangorda waste rock to cover all pit walls.	Construct berm around pit rim. Use pit lake for storage of contaminated water.	Construct berm around pit rim. Use pit lake for storage of contaminated water.	Backfill with neutralized Vangorda waste rock to cover all pit walls.
Grum Pit	Construct berm around pit rim. Use pit lake for storage and biological treatment of contaminated water.	Construct berm around pit rim.	Construct berm around pit rim.	Construct berm around pit rim. Use pit lake for storage and biological treatment of contaminated water.

6.3.3 Phase 3: Short-Listed Options

The example alternatives described above were reviewed by the IPRP and were the subject of a series of meetings with governments, communities, interest groups and the public. Some of the methods and alternatives were also addressed in ongoing technical studies. Based on the input received and updated technical information, several of the example alternatives were dropped from further consideration, and others were consolidated into a short list of options.

The results of the analysis of the example alternatives led to a short-list that included one option for the Faro mine area, three options for the tailings and two options for the Vangorda/Grum mine area.

- The Minimize Construction alternatives for all three areas failed to meet standards for good mine closure practice. The minimal covers proposed for the mine areas would leave many areas exposed, and would have excessive maintenance requirements. The lack of a cover on the tailings would present a high risk of future dust releases and direct contact by animals. As a result, these options were removed from further consideration.
- The detailed evaluation Alternative 1 for the Faro Mine area demonstrated that this alternative was not feasible because the proposed in-pit treatment would not be sufficient on its own resulting in water management challenges for high volumes of dilute contaminated water. This alternative was removed from further consideration.
- Alternatives 2 and 4 for the Faro Mine area were both considered feasible and provided similar performance against the objectives. The main difference between the two was related to the design of covers on waste rock. The two alternatives were combined into the single remaining alternative for the Faro Mine area, an alternative that included a range of possible cover and relocation variants as well as some groundwater management improvements recommended by the IPRP.
- Alternative 1 for the tailings (stabilize in place) could mitigate most of the risks associated with the tailings facility, using well-proven methods. Some revisions to the alternative could ensure reduction of remaining risks by redesign of methods for handling extreme floods, and by groundwater management improvements recommended by the IPRP.
- Alternative 2 for the tailings (complete relocation) could mitigate most of the risks associated with the tailings. Based on the IPRP's recommendations however, this alternative was revised to include provision for future (potentially long-term) collection of mine area contaminated water in the Rose Creek valley even after tailings relocation.
- Alternative 3 for the tailings (partial relocation) remained on the short list because it could address the major tailings related risks without the expense of full relocation. Specifically, it could remove the risks associated with flood-induced dam failures by relocating all of the tailings that lie below the Rose Creek Diversion.

- Alternative 5 for the tailings (water cover) presented similar performance expectations to those for Alternative 1, but with higher costs and significantly greater risks. It was therefore removed from further consideration.
- Alternative 1 for the Vangorda/Grum Mine was considered feasible and could mitigate most of the risks associated with the Vangorda/Grum Mine.
- Alternatives 2 and 4 for the Vangorda/Grum Mine area were both considered feasible and both provided similar performance against the objectives put forward by stakeholders. The main difference between the two was related to the design of covers on waste rock. As a result, these were consolidated into a single alternative.

Details of short listed options for the Faro Mine area, Tailings area and Vangorda/Grum Mine area are described in Tables 6.5, 6.6 and 6.7 respectively. All of the options included some common elements that were recognized as part of any closure plan.

Common Elements for All Closure Plan Options

- Covering/Relocating of waste materials to prevent dust release and direct uptake by animals, and to reduce infiltration.
- Upgrade of diversions including the reestablishment of Vangorda Creek and Faro Creek in stable locations and upgraded to pass their respective 1:500 year floods.
- Long-term groundwater collection at high efficiencies.
- Long-term water treatment on the Faro side of the property.
- Risks to water quality in creeks from uncaptured seepage.
- Long-term site presence for water collection/treatment, security, inspections, maintenance, and environmental monitoring. A stable source of long-term funding and governance will be required.
- Adaptive management to address uncertainties about site conditions and performance of proposed closure and remediation activities.

Table 6.4: Combined Option for Faro Mine Area

Component	Combined Option (Figure 6.4)
Surface Water Diversions	
Faro Creek	Upgrade diversion.
North Fork Rose Creek	Construct channel to isolate creek from contaminated groundwater.
South Fork Rose Creek	If seepage escapes along North Fork and contaminated groundwater reaches South Fork, construct channel to isolate South Fork Rose Creek from contaminated groundwater.
Contaminated Water Management	
Groundwater Collection	Construct and operate local collection systems at ETA, S-wells, the Zone II pit and the Zone II outwash area. Install monitoring wells and additional collection wells where needed in other areas.
Water Treatment	Store water in pit. Extract water for treatment in HDS treatment plant (combined with tailings area water treatment). Continue for long term.
Waste Rock	All specific methods for waste rock to be refined using cost-benefit analyses.
Oxide Fines/ Low-Grade Ore	Consolidate and construct low infiltration or very low infiltration covers, or relocate to pit with lime.
Sulphide Cells	Construct low or very low infiltration covers. Consolidate isolated pockets to larger cells.
Faro Valley Dump	Construct low infiltration cover.
Other Waste Rock	Construct rudimentary cover.
Faro Pit	Construct berm around pit rim to reduce risk of inadvertent access. Use pit lake for storage of contaminated water prior to treatment.
Emergency Tailings Area	Relocate tailings and construct groundwater collection system.

Table 6.5: Recommended Options for Tailings Area

Component	Option 1 Stabilize in Place (Figure 6.5)	Option 2 Complete Relocation (Figure 6.6)	Option 3 Partial Relocation (Figure 6.7)
Surface Water Diversions			
Rose Creek Diversion	Upgrade section along Secondary Dam to PMF. Upgrade remainder to 1:500 or 1:1000 year flood. Enhance fuse plug to allow floods greater than channel capacity to flow over tailings in cross-tailings channel to improved spillway.	Re-route to valley floor after tailings relocation and groundwater cleanup are complete. An isolated channel may be required to prevent contamination by WR seepage.	Upgrade section along Secondary Dam to PMF and re-route remainder to valley floor after tailings relocation and groundwater cleanup are complete. An isolated channel may be required to prevent contamination by WR seepage.
North Wall Interceptor	Upgrade and maintain	Allow return to natural channel after tailings relocation and groundwater cleanup are complete. An isolated channel may be required to prevent contamination by WR seepage.	Allow return to natural channel after tailings relocation and groundwater cleanup are complete. An isolated channel may be required to prevent contamination by WR seepage.
Contaminated Water Management			
Groundwater Collection	Install cut-off wall and trench or drain system along the toe of either the Cross Valley or Intermediate Dam. Collect contaminated groundwater from tailings and any escaped seepage from mine area.	After tailings are relocated, install local groundwater capture systems where aquifer is contaminated. Operate for at least 20 years. Include contingency for long-term collection of escaped mine area seepage.	Install cut-off wall and trench or drain below toe of Secondary Dam. After tailings are relocated, install local groundwater capture systems where aquifer is contaminated. Operate for at least 20 years. Include contingency for long-term collection of escaped mine area seepage.
Water Treatment	Store water in pit for seasonal treatment or treat year-round in HDS treatment plant. Continue for long term.	Store water in pit for seasonal treatment or treat year-round in HDS treatment plant. Continue for 20 years. Include contingency for long-term treatment of escaped mine area seepage.	Store water in pit for seasonal treatment or treat year-round in HDS treatment plant. Continue for long term. Include contingency for long-term treatment of escaped mine area seepage.
Tailings			
Intermediate	Construct 2 m rock/soil cover. Construct armoured channel where extreme floods would pass over tailings.	Relocate to Faro Pit with lime addition to neutralize acidity	Relocate to Faro Pit with lime addition
Original & Secondary			Construct 2m rock/soil cover
Dams			
Cross-Valley	Breach or partial breach (with upgrade to MCE). Partial breach would provide reservoir for contaminated water management.	Breach or partial breach (with upgrade to MCE). Partial breach would provide reservoir for contaminated water management.	Breach or partial breach (with upgrade to MCE). Partial breach would provide reservoir for contaminated water management.
Intermediate	Expand spillway to pass PMF.	Breach or partial breach (with upgrade to MCE). Partial breach would provide reservoir for contaminated water management.	Breach or partial breach (with upgrade to MCE). Partial breach would provide reservoir for contaminated water management.
Secondary	Upgrade to MCE	Remove or breach	Upgrade to MCE
Original	No Action	Remove or breach	No Action

Table 6.6: Recommended Options for Vangorda/Grum Area

Component	Option 1 Backfill Vangorda Pit (Figure 6.8)	Option 2 Revised Stabilize in Place (Figure 6.9)
Surface Water Diversions		
Vangorda Creek Diversion	Re-route into lined and erosion-protected channel over backfilled Vangorda Pit. Design and construct channel to pass 1:500 year flood.	Relocate upslope to stable location and upgrade to pass 1:500 year flood.
Grum Creek	Maintain diversion for long term.	Maintain diversion for long term.
Contaminated Water Management		
Groundwater Collection	Install groundwater collection system below Grum waste rock. Include contingency system to collect contaminated groundwater, if any, from backfilled Vangorda Pit.	Install groundwater collection system below Grum waste rock and seepage collection system for Vangorda Waste Rock. Include contingency system to collect contaminated groundwater, if any, from Vangorda waste rock pile.
Water Treatment	Store contaminated water in Grum Pit. Use biological method to pre-treat water in Grum Pit. Discharge pre-treated water directly if contaminant concentrations are low enough. If not, periodically extract and treat water using active HDS plant and dischargel.	Direct contaminated water to Vangorda Pit for storage. Use biological method to pre-treat water in Grum Pit and discharge directly if quality acceptable. Periodically extract contaminated water from Vangorda Pit and possibly Grum Pit and treat using active HDS plantl.
Waste Rock	All specific methods for waste rock to be refined using cost-benefit analyses.	
Vangorda Waste Rock	Relocate to Vangorda Pit, with lime addition to neutralize acidity. Compact during deposition to minimize hydraulic conductivity and settlement.	Cover with low infiltration or very low infiltration soil cover
Grum Sulphide Cell	Cover with low infiltration or very low infiltration soil cover	Cover with low infiltration or very low infiltration soil cover
Other Grum Dump	Cover with rudimentary or low infiltration soil cover	Cover with rudimentary or low infiltration soil cover
Ore Transfer Pad	Relocate part to Vangorda Pit. Cover remainder with rudimentary soil cover.	Relocate part to Grum Sulphide Cell. Cover remainder with rudimentary soil cover
Overburden Dump	Use part for cover construction. Re-vegetate remainder.	Use part for cover construction. Re-vegetate remainder.
Pits		
Vangorda Pit	Backfill with waste rock to cover all exposed highwalls.	Construct berm around pit rim to reduce risk of inadvertent access. Use pit lake for storage of contaminated water prior to treatment.
Grum Pit	Construct berm around pit rim to reduce risk of inadvertent access. Use pit lake to store and pre-treat contaminated water.	Construct berm around pit rim to reduce risk of inadvertent access. Use pit lake to store and pre-treat contaminated water prior to treatment.

6.3.4 Phase 4: Core Assessment Process

The fourth phase in the evaluation of alternatives for the FMC Closure and Remediation Plan, referred to as the "Core Assessment Process" involved a rigorous evaluation of the six short-listed options against the objectives of the project. Broad objectives had been prescribed by the Oversight Committee (Section 1.3.5) and these formed the basis for evaluating the short-listed options utilizing a multi-attribute utility analysis. This approach was intended to provide a technically defensive evaluation of the range of feasible alternatives while also building trust among key project interests.

Multi-attribute utility analysis was recommended by the IPRP and is a well recognized method to assess options that involve a wide range of objectives, especially when some of those objectives are divergent or cannot easily be expressed in monetary terms. The analysis was facilitated by two individuals with extensive experience using the method, Dr. Anthony Hodge and Dr. Lee Merkhofer. The overall outcome of the process is described in "Options for Closure of the Faro Mine Complex" (SRK 2008) with detailed descriptions of the multi-attribute utility analysis contained in Attachment E of that report: "Faro Mine Closure, Assessing the Alternatives, An Application of Multi-Attribute Utility Analysis" (Hodge et al., 2008).

As directed by the Oversight Committee, the assessment quantified performance of the options in relation to objectives related to public health and safety; restoration, protection and enhancement of the environment; effects on traditional and local land use; local and Yukon socio-economic benefits; and cost. To ensure a broad range of perspectives, participants on the assessment team included representatives from the federal and Yukon governments, the Selkirk First Nation and the Ross River Dena Council, First Nation technical advisors, the project technical advisor team, and the Independent Peer Review Panel. The process quantified performance against objectives for both the short-term (years 1 – 40) and long-term (beginning after year 40 and ending 500 to 1000 years later). It also quantified the range of uncertainty, both downside and upside, for the options/objectives.

To ease the evaluation of alternatives, the single remaining option for the Faro Mine area was combined with each of the tailings options, leaving a total of three options at the Faro Mine/Tailings area and two options at the Vangorda/Grum Mine area. At the end of the lengthy process, the assessment team concluded that there were few significant differences between the options when evaluated against the objectives. The results are described in detail in "Options for Closure of the Faro Mine Complex" (SRK 2008) and Attachment E of that report.

The main differences that the assessment team identified among the Faro Mine/Tailings options included:

1. Tailings relocation options were expected increase risks to public health and safety in the short-term. The variances related primarily to safety risks arising from trucks going to and from the site. Options with tailings relocation would require substantially more truck trips (hauling lime) and therefore present a higher risk of accidents. For the long term-scoring, the reasoning was similar but the ranking reversed, because the tailings relocation options would have lower long-term lime demands.

2. Tailings relocation options were expected to cause more adverse effects on the environment as well as local and traditional land use in the short-term. These would arise from the duration and the risk of activities during the implementation phase, because the relocation options take longer to complete and also result in substantial handling of contaminated tailings materials. The longer period of time needed to complete the relocation and clean up groundwater in the valley after tailings relocation would also result in longer duration restrictions on traditional or local land use.
3. Tailings relocation options included increased short-term, risks of dam failure, tailings release or environmental contamination because the existing facilities would be in place for longer.
4. Options that leave tailings in the valley were expected to have greater risks for long-term effects on the environment and land use. These differences reflected concerns about long-term risks associated any tailings that are left in place. Land use risks may include possible problems with long-term funding or management leading to dam failure. Environmental risks also include failure of groundwater collection and treatment arising from the same root causes.
5. The options were expected to vary slightly in relation to socio-economic benefits in both the short-term and long-term, with tailings relocation options expected to provide greater benefits in the short-term and other options expected to excel in the long-term.
6. The cost estimates for the three options varied significantly, with complete relocation for the tailings being most expensive and stabilizing the tailings in the valley having the lowest cost.

The main differences that the assessment team identified among the Vangorda/Grum options included:

1. The option that entailed relocation of the Vangorda waste rock into the pit was expected to increase risks to public health and safety in the short-term. The variances related primarily to safety risks arising from trucks going to and from the site because the waste rock relocation would require substantially more truck trips (hauling lime) and therefore present a higher risk of accidents.
2. The assessment team identified some short-term risks for the environment for both options, but they reflect opposing factors. In both cases the necessary work can be completed early in the 40 year time frame identified for the short-term. The pit backfilling option would ultimately provide greater environmental protection, but there would be risks during the construction period when the pit is partially filled and the creek not yet re-established. The backfill pit option would also be at greater risk if funding ceases. The stabilize-in-place option on the other hand, would entail less significant construction related risks, but retain a greater risk associated with failure diversion after construction was completed.
3. The options were expected to have different effects on land use for both the short term and long term. The pit backfilling would return one portion of the site nearly to its original topography and eventually allow re-establishment of traditional and local uses of the area.

4. The options were expected to vary slightly in relation to socio-economic benefits in both the short-term and long-term, with the pit backfilling option expected to provide greater benefits in the short-term but less in the long-term. For evaluating socio-economic benefits, the assessment process combined the two major components. Because of the expenditure differential between the Faro Mine/Tailings area and the Vangorda/Grum area, the differential in socio-economic benefits from the Vangorda/Grum area was inconsequential in the analysis.
5. The cost estimates for the options varied significantly, with the backfill pit option having the highest cost.

Multi-attribute utility analysis approaches frequently include methodology for weighting of the objectives followed by aggregation of scores for individual objectives using the weighting. This methodology can be used to identify overall preferences considering input from all participants on all objectives and time periods. Weighting of objectives is an inherently subjective process, with the results being very dependent on the specific perspectives of those participating. As a result, the assessment team did not complete this component of the analysis because it did not fall within the original mandate of the core assessment process. Instead, the Oversight Committee undertook the balancing of benefits, effects and costs, effectively the weighting of objectives, during Phase 5 of the alternatives evaluation. At its conclusion, the Core Assessment Process provided recommendations for the Oversight Committee about the relative performance of each option in relation to each of the identified objectives.

6.3.5 Phase 5: Recommended Option

During Phase 5 of the alternatives evaluation, the Oversight Committee compiled and considered input about the options and developed a consensus recommendation about which options to pursue as a remediation and closure plan for the FMC.

The results of the Core Assessment Process (Phase 4) were one important consideration and the results were initially presented and discussed with two "Assessment Process Working Groups," one comprised of representatives from federal and Yukon government departments and one comprised of community representatives. Following these initial group discussions, each government represented on the Oversight Committee (federal, territorial, Ross River Dena Council, Liard First Nation and Selkirk First Nation) conducted internal evaluations of the options. First Nation governments led multi-day workshops in their communities to seek input about the options. The federal and Yukon governments engaged in discussions with relevant departments, sharing information about the core assessment process and technical investigations while seeking their views about the options.

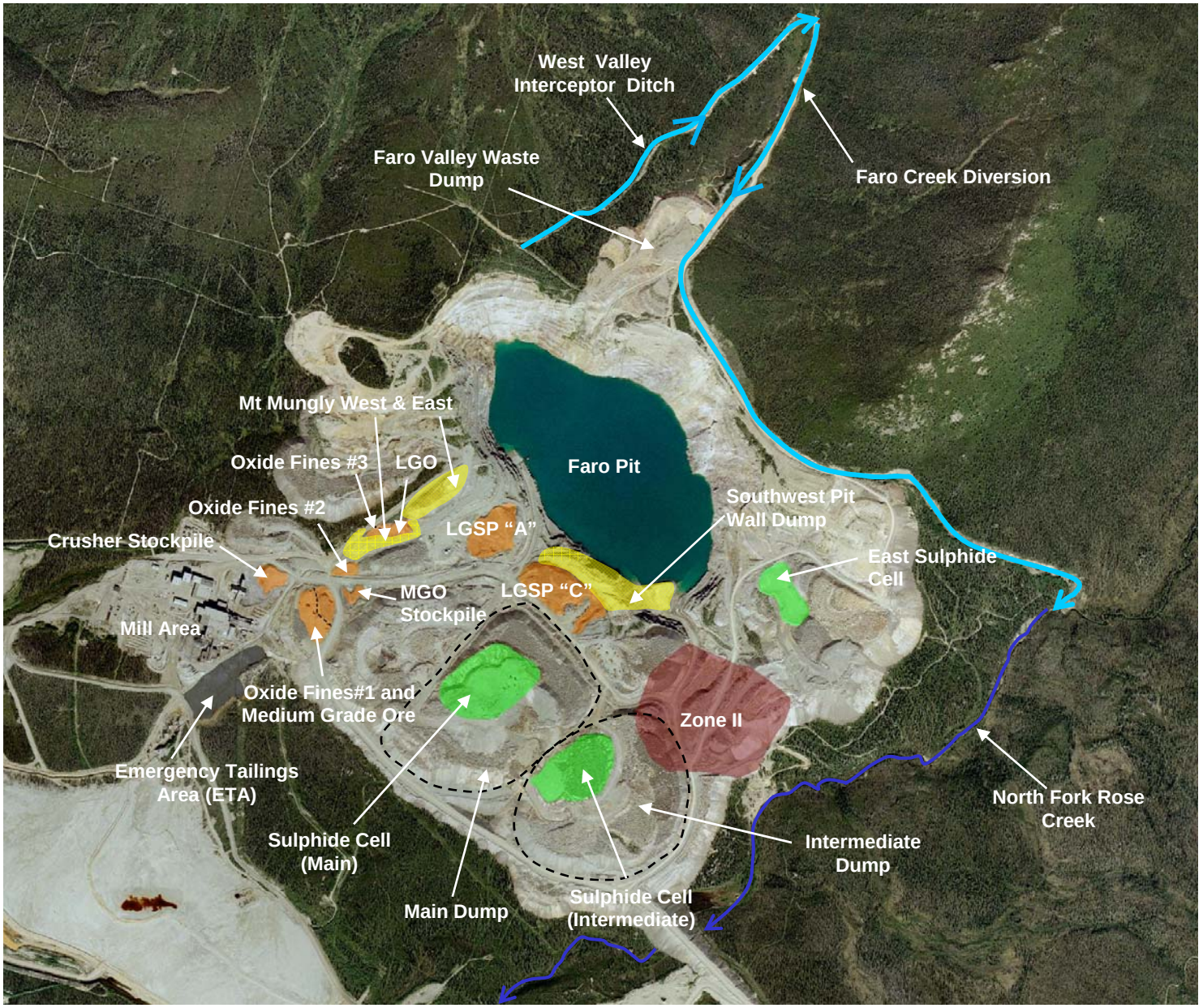
Once these internal evaluations were complete, the Oversight Committee met to discuss the costs, benefits and effects associated with the options and to discuss preferences. The Committee reached a consensus about the preferred approach, concluding that it provided the best balance for achieving the overarching objectives established at the outset of closure planning. The preferred options for the remediation and closure plan involved stabilizing the tailings in the valley (Option 1 in

Table 6.5), leaving the Vangorda Waste Rock in place (Option 2 in Table 6.6). The plan also involved conducting the activities described in Table 6.4 in the Faro Mine area.

While the alternatives evaluation process identified preferred closure options, those options retain substantial flexibility with respect to specific activities that will be conducted as part of the closure plan. Engineering analyses have been used to guide the selection of specific closure activities (e.g. cover designs) that are described in this project proposal and will continue to be used in refining activities and approaches throughout closure implementation and post-closure phases.

Details of the preferred closure and remediation plan are described in Chapter 7.

Figures



Source: SRK Consulting

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Faro Mine Area and Major Components

Job No: 1CY001.026

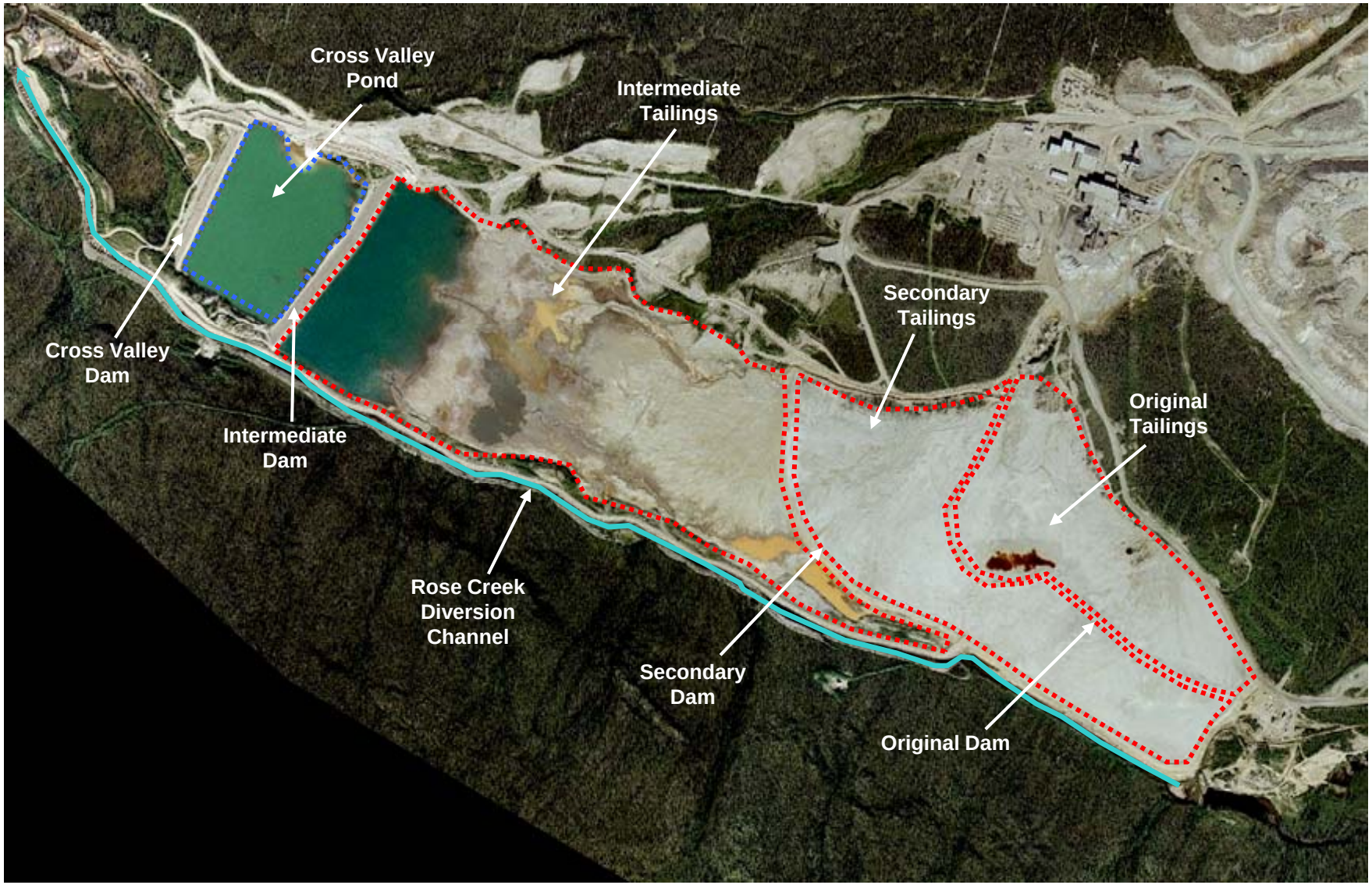
Filename: Figures 3.3-5_AreaComponents_20100215.ppt

Project Proposal – Draft 1

Date: February 2010

Approved:

Figure: 6.1



Source: SRK Consulting

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

Tailings Area and Major Components

Job No: 1CY001.026

Filename: Figures 3.3-5_AreaComponents_20100215.ppt

Project Proposal – Draft 1

Date:	Approved:	Figure:
February 2010		6.2

Source: SRK Consulting

Faro Mine Closure
Fermeture de la mine Faro

Faro Mine Complex
Closure and Remediation

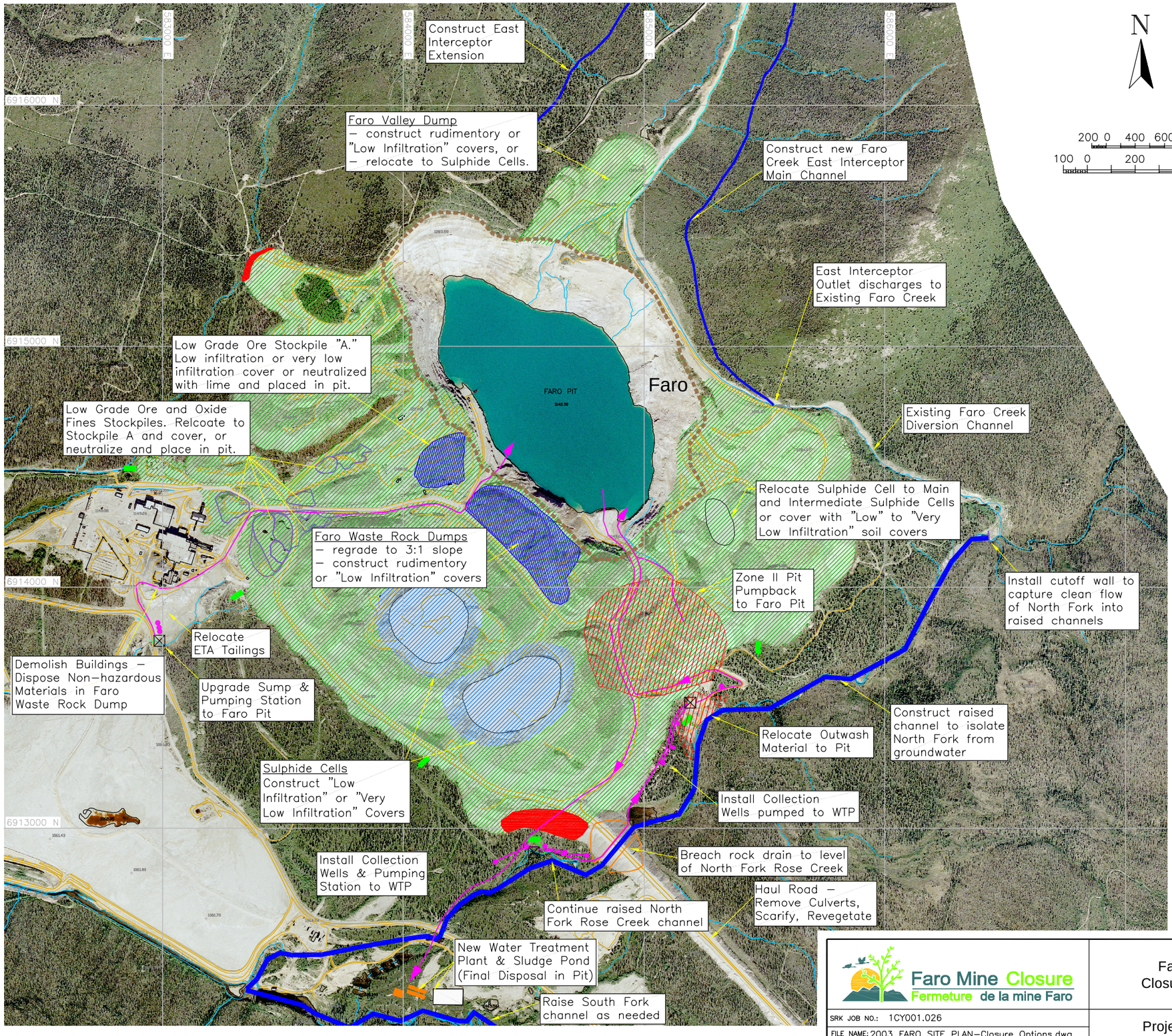
Vangorda/Grum Area and Major Components

Job No: 1CY001.026

Filename: Figures 3.3-5_AreaComponents_20100215.ppt

Project Proposal – Draft 1

Date:	Approved:	Figure:
February 2010		6.3



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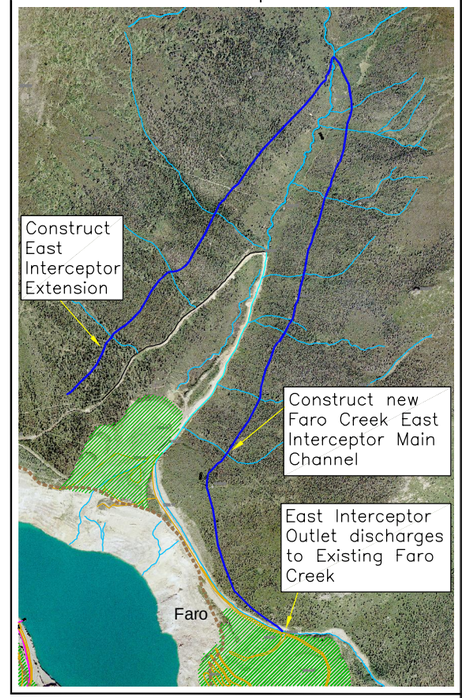
200 0 400 600 1200 feet

100 0 200 400 600 Metres

FARO CREEK DIVERSION

East Interceptor Ditch



Legend

- Waste Rock Slope Pulled–Back
- Collection Sump
- Sediment Collection Basin
- Groundwater Pumping Well
- Water Treatment Plant
- Pipeline
- Safety Berm around Faro Pit

Notes:

1. Closure activities shown reflect options presented in "Options for Closure of the Faro Mine Complex" (SRK 2008) report.
2. Selection of final cover thicknesses to be optimized based on further engineering and cost–benefit analysis.

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026

FILE NAME: 2003 FARO SITE PLAN–Closure Options.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Faro Mine Area Option

DATE:	APPROVED:	FIGURE:
Feb. 2010	–	6.4

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580000 E
581000 E
582000 E
583000 E
584000 E
585000 E
6914000 N
6913000 N
6912000 N

Cut–off Wall
Interception Trench
Remove Impounded Sludge
Groundwater Collection From Interception Trench: Pumped to Faro Pit
Remove or breach Cross–Valley Dam
PMF Out–flow Spillway
Upgrade Guardhouse Creek to Intermediate Dam
Water pumped to Treatment Facility
Seepage Collection Sumps
Stabilize Dam: Ground Densification and/or Buttress
Low Infiltration Cover 1.5m till over 0.5m waste rock
ETA Groundwater Collection (part of the Faro Mine Area Alternatives)
Variant: Lined PMF Flood Channel
Low Infiltration Cover 1.5m till over 0.5m waste rock
Low Infiltration Cover 1.5m till over 0.5m waste rock
Downstream section RCDC dyke upgraded to pass 1:500 or 1:1,000 yr flood
Water pumped from Faro Pit for treatment
Remove Rock Drain
HDS Treatment Facility for contaminated groundwater
North Fork Rose Crk in lined channel
PMF flow energy dissipation structure
Stabilize Dam: Ground Densification
Upgrade Upstream section of RCDC to pass PMF (Q=670 m /s)
Sludge Pond (Final disposal to Faro Pit)
Treated effluent discharged into Rose Creek
South Fork Rose Crk in lined channel
Possible Cut–off Wall

N

LEGEND

- 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

Note:

Closure activities shown reflect options presented in "Options for Closure of the Faro Mine Complex" (SRK 2008) report.

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

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026
FILE NAME: Tailings – Closure Options.rev01.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Tailings Area Option 1
Stabilize In Place

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Feb. 2010	–	6.5

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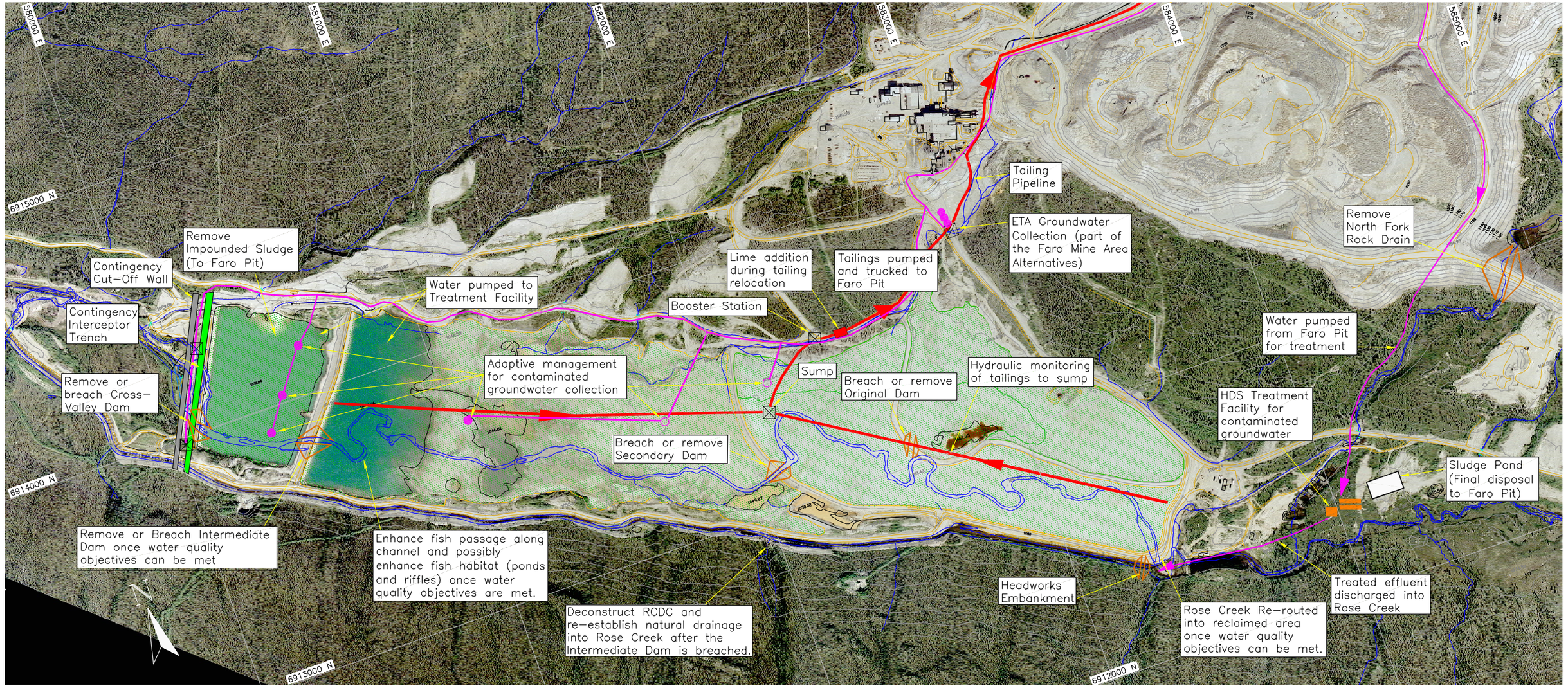

LEGEND

- Revegetated Area
- Collection Sump
- Groundwater Collection Well
- Water Treatment Plant
- Groundwater / Seepage Pipeline
- Tailings Pipeline
- Slurry Wall
- Interceptor Trench

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

Note:

Closure activities shown reflect options presented in "Options for Closure of the Faro Mine Complex" (SRK 2008) report.

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026
FILE NAME: Tailings – Closure Options.rev01.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Tailings Area Option 2
Complete Relocation

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Feb. 2010	–	6.6

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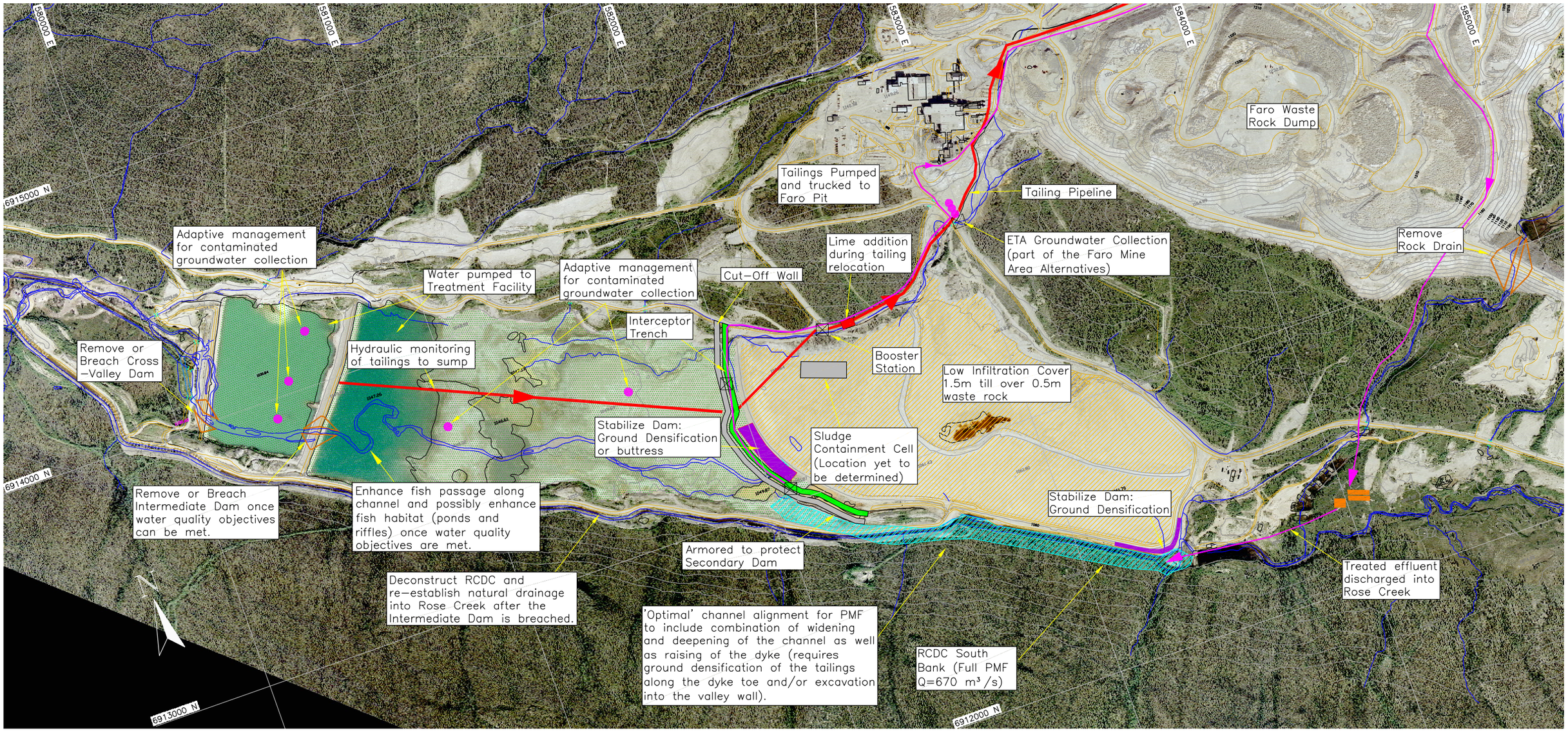

LEGEND

- Revegetated Area
- Store and Release Cover
- Collection Sump
- Groundwater Collection Well
- Water Treatment Plant
- Groundwater / Seepage Pipeline
- Tailings Pipeline
- Slurry Wall
- Interceptor Trench

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

Note:

Closure activities shown reflect options presented in "Options for Closure of the Faro Mine Complex" (SRK 2008) report.

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026
FILE NAME: Tailings – Closure Options.rev01.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Tailings Area Option 3
Partial Relocation Option

DATE:	APPROVED:	FIGURE:
Feb. 2010	–	6.7

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6,906,000 N
593,000 E
Demolish Buildings – Dispose non–hazardous material at Grum Dump
6,905,000 N
Water Treatment Plant
594,000 E
6,904,000 N
595,000 E
6,903,000 N
Grum Creek alignment in–to Pit
Temporary Sediment Collection Ditch until cover vegetation is in place
Breach Settling Pond
Headworks Embankment
Grum Settling Pond
Sludge Pond
Blaster's Shack
Cover Source:
up to 5.7 million cu.m. for Vangorda/Grum
up to 7.7 million cu.m. for Faro mine site
up to 2.0 million cu.m. for Tailings Area
Vangorda Creek Alignment including drop structures and erosion control
Breach Ditch
592,000 E
Safety Berm
Cover Sludge Disposal Cell
In–Situ biological treatment in Pit Lake
Overburden Dump (8 Million m³)
Safety Berm
Low infiltration to very low infiltration soil cover
Upgrade ramp for haul road traffic
Relocate acidic material to Vangorda Pit, cover, regrade and revegetate remaining material
Transfer Ore Pad
Grum Pit
Widen road for haul road traffic
Regrade (3:1) and Revegetate Overburden Dump
Contingency Groundwater Collection System: Pumped to Grum Pit
Vangorda Pit
Algae filter
Breach Dam
Proposed Holding Pond
Contingency HDS Treatment Facility
Contingency Sludge Pond
Drop Structures
Possible creek alignments out of Grum Pit
Seepage pumped to Grum Pit
Breach Little Creek Dam
Building Disposal Area (buried by regrading)
Lube Station
Fuel Tanks
Vangorda Waste Dump
Maintenance Storage Area
Shop
Sulphide Cell: Cover with "Low infiltration" or "very Low infiltration" soil cover
Slope pulled back
Bioremediation Cell for Hydrocarbon Soils
Relocate waste rock and contaminated foundation soils to Vangorda Pit, Regrade, and revegetate dump footprint
591,000 E
Grum Waste Dump
Demolish Buildings – Dispose non–hazardous material at Grum Dump
Regrade (3:1), cover with Rudimentary or Low infiltration soil cover, revegetate and construct runoff control ditches
6,902,000 N
Till Berm used as Vangorda Pit Cover
Groundwater Collection Wells
Contingency Slurry Wall
QT

Contour Interval: 10m
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

Legend
- Waste Rock Slope Not Regraded
- Sediment Collection Basin
- Groundwater Collection Well
- Water Treatment Plant
- Proposed Creek Alignment
- Sediment Collection Ditch
- Groundwater / Seepage Pipeline
- Slurry Wall
- Safety Berm

Notes:

1. Closure activities shown reflect options presented in "Options for Closure of the Faro Mine Complex" (SRK 2008) report.
2. Selection of final cover thicknesses to be optimized based on further engineering and cost–benefit analysis.

0 100 200 300 400 500 m

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026
FILE NAME: Site_Plan_2004–Closure Options.rev01.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Vangorda/Grum Option 2 Backfill Vangorda Pit

DATE:	APPROVED:	FIGURE:
Feb. 2010	–	6.8

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6,906,000 N
593,000 E
6,905,000 N
594,000 E
595,000 E
6,903,000 N
6,902,000 N
000 E

Demolish Buildings – Dispose non–hazardous material at Grum Dump

Water Treatment Plant

Cover Sludge Pond– Dispose Sludge in Vangorda Pit

Vangorda Creek Diversion North of Pit. Re–alignment, deepening, erosion control and upgrade to Dixon Creek Diversion.

Grum Creek alignment in to Pit

Breach Settling Pond

Headworks Embankment

Grum Settling Pond

Temporary Sediment Collection Ditch until cover vegetation is in place

Cover Source:
up to 5.7 million cu.m. for Vangorda/Grum
up to 7.7 million cu.m. for Faro mine site
up to 2.0 million cu.m. for Tailings Area

Blaster's Shack

Safety Berm

Cover Sludge Disposal Cell

Overburden Dump (8 Million m³)

Regrade (3:1) and Revegetate Overburden Dump

Widen road for haul road traffic

Safety Berm

Contingency: Buttress the North Pit Wall

Pit Water Pumped to Treatment Facility

Vangorda Pit

Transfer Ore Pad

Relocate acidic material to Sulphide Cell, cover, regrade and revegetate or combination of above.

Grum Pit

Breach Dam

Treatment Effluent Discharged into Vangorda Creek

Regrade, Cover with "Low to Very Low Infiltration" Soil Covers, and revegetate.

Proposed HDS Treatment Facility

Sludge Pond; Disposal in Vangorda Pit

Drop Structures

Plunge Pool

Seepage Pumped to Pit

Possible creek alignments out of Grum Pit

Seepage Pumped to Vangorda Pit

Contingency Groundwater Collection Wells

Regrade, Cover with "Low to Very Low Infiltration" Soil covers, revegetate, and add runoff control ditches

Little Creek Dam

Vangorda Waste Dump

Building Disposal Area (buried by regrading)

Slope pulled back

Lube Station

Fuel Tanks

Maintenance Storage Area

Shop

Bioremediation Cell for Hydrocarbon Soils

Sulphide Cell: Cover with "Low infiltration" or "very Low infiltration" soil cover

Grum Waste Dump

Seepage Collection Wells

Demolish Buildings – Dispose non–hazardous material at Grum Dump

Regrade (3:1), cover with Rudimentary or Low infiltration soil cover, revegetate and construct runoff control ditches

Temporary Sediment Collection Ditch until cover vegetation is in place

Groundwater Collection Wells

Contingency Slurry Wall

Road

UNNAMED CK

Contour Interval: 10m
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

Legend

- Waste Rock Slope Not Regraded
- Sediment Collection Basin
- Groundwater Collection Well
- Water Treatment Plant
- Proposed Creek Alignment
- Sediment Collection Ditch
- Groundwater / Seepage Pipeline
- Slurry Wall
- Safety Berm

Notes:

1. Closure activities shown reflect options presented in "Options for Closure of the Faro Mine Complex" (SRK 2008) report.
2. Selection of final cover thicknesses to be optimized based on further engineering and cost–benefit analysis.

0 100 200 300 400 500 m

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026
FILE NAME: Site_Plan_2004–Closure Options.rev01.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Vangorda/Grum Option 1 Stabilize in Place

DATE:	APPROVED:	FIGURE:
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Chapter 7

Project Description

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Figure 7.4: Tailings Area (200) Closure Activities
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Figure 7.6: Vangorda/Grum Area (300) Closure Activities
Figure 7.7: Project Schedule

7 Project Description

7.1 General

The selection of a preferred closure and remediation plan by the Oversight Committee led to further refinement and design to support the plan. The supporting document "Faro Mine Complex, Final Closure and Remediation Plan, Project Description" (SD A1, SRK 2009) provides detailed descriptions of the proposed closure plan and activities. This chapter provides a summary of the Project Description but readers should refer to the full document for technical details.

While the alternatives evaluation process identified preferred closure options, those options retain substantial flexibility with respect to specific activities that will be conducted as part of the closure plan. Engineering analyses have been used to guide the selection of specific closure activities and methods (e.g. cover designs) that are described in this project proposal and the Project Description. As expected with a project of this scale, further refinements will continue throughout closure implementation and post-closure phases. As such, this chapter provides the current and common understanding of the proposed closure activities but recognizes that variations are still possible for some activities and elements. These will be engineering refinements and are not expected to result in changes in predicted effects from the project. Where there is uncertainty or anticipated variances, these have been identified in the document.

7.2 Project Overview

The Oversight Committee directed the closure planning team to prepare a closure and remediation plan that included the "Stabilize-in-Place" alternatives for both the Faro Mine/Tailings area and the Vangorda/Grum area. The resulting closure and remediation plan includes the following main components:

7.2.1 Faro Mine Area

- Retain Faro Pit as a contaminated water storage reservoir and utilize it for storage of water treatment sludge.
- Divert clean water around the site:
  - Reconstruct the Faro Creek Diversion to improve physical stability and flood handling capability.
  - Breach the North Fork Rock Drain and construct a lined channel for North Fork Rose Creek to avoid contamination by groundwater.
  - Construct, maintain and/or upgrade other local diversions.
- Relocate some waste rock to consolidate into smaller areas.
- Cover waste rock with engineered covers designed to meet specific needs of each waste rock component (i.e. cover design varies depending on types of rock being covered).

- Relocate the tailings in the Emergency Tailings Area into the tailings pond.
- Collect contaminated ground and surface water for storage in Faro Pit and seasonal treatment using lime precipitation in a high density sludge water treatment plant.

7.2.2 Tailings Area

- Upgrade flood handling facilities for Rose Creek:
  - Reconstruct upper Rose Creek Diversion Canal to pass the probably maximum flood (PMF) and provide a fuse plug to divert peak flows into the Intermediate impoundment.
  - Repair lower Rose Creek Diversion Canal to pass the 1:500 year flood event.
  - Construct a new spillway on the Intermediate Dam, capable of passing the PMF flow from Rose Creek, for use in floods larger than 1:500 year events only.
  - Raise the Intermediate Dam to provide flood routing capacity for the PMF.
  - Construct water conveyance and erosion control facilities on the tailings cover in the Intermediate Impoundment.
- Upgrade the Secondary Dam to withstand the maximum credible earthquake (MCE).
- Breach the Cross Valley Dam and clean up sediments.
- Cover the tailings with an engineered cover.
- Collect contaminated ground and surface water for storage in Faro Pit and seasonal treatment using lime precipitation in a high density sludge water treatment plant.

7.2.3 Vangorda/Grum Mine Area

- Retain Vangorda Pit as a contaminated water storage reservoir and utilize it for storage of water treatment sludge.
- Retain Grum Pit as a pit lake, utilizing biological treatment to remove contaminants if effective, with a contingency for treatment using lime precipitation in a high density sludge water treatment plant.
- Divert clean water around the site:
  - Build a new Vangorda Creek Diversion to improve physical stability and flood handling capacity.
  - Construct, maintain and/or upgrade other local diversions.
- Cover waste rock with engineered covers designed to meet specific needs of each waste rock component (i.e. cover design varies depending on types of rock being covered).
- Collect contaminated ground and surface water for storage in Vangorda Pit and seasonal treatment using lime precipitation in a high density sludge water treatment plant.
- Breach watercourse crossings on the Vangorda Haul Road.

7.3 Site Wide Common Components

The Closure and Remediation Plan includes several common components that are the fundamental elements of the Plan. These elements and concepts have been applied in all areas of the FMC. They include: covers, contaminated water collection, water treatment, surface water management, environmental adaptive management, and long-term site management. This section provides an overview for each of these concepts.

7.3.1 Covers

Covers will be placed over almost all contaminated mine waste materials including waste rock dumps and the Rose Creek tailings impoundment. These covers will be one of the key measures that support achieving the site wide closure objectives related to environmental conditions and land use. One of the key purposes of covers is to minimize infiltration of water into the waste materials. Other purposes include erosion control, establishment of appropriate post-reclamation land uses, isolation of contaminants, dust control and aesthetic reclamation.

Four general types of covers will be used on the site, depending on the characteristics of the underlying waste material. Table 7.1 summarizes the design and functions for these covers.

Table 7.1: Cover Types and Functions

	Cover Type			
	Rudimentary Cover	**Low Infiltration Cover**	**Very Low Infiltration Cover**	**Tailings Cover**
Cover Design	Loosely compacted till layer (0.3 to 1m thick)	Compacted till barrier layer (0.5 to 1m thick) and loosely compacted till layer (0.3 to 1m thick)	Compacted till barrier layer (1 to 1.5m thick) and loosely compacted till layer (0.3 to 1m thick) OR Complex cover consisting of; (1) bedding layer (0.3m compacted granular material or geotextile), (2) synthetic liner (Bituminous or HDPE), (3) upper bedding layer (0.3m compacted granular material, or geotextile), and (4) loosely compacted till (0.3 to 1m thick)	Trafficability layer if required (0.5m to 1m waste rock) underlying loosely compacted till layer as store-and-release component and growth medium (1 to 1.5m thick)
Physically isolate waste from human/terrestrial life	Yes	Yes	Yes	Yes
Provide a substrate that would support succesional vegetation	Yes	Yes	Yes	Yes
Reduce infiltration to specific target levels	No	Yes	Yes	No
Cover Performance (Target Infiltration)	Estimated to be less than 20% of MAP (expected range of 15-25%)	Less than 5% of MAP (expected range of 3-8%)	Less than 0.5% of MAP	Estimated to be 10% of MAP (expected range of 5-20%)

The site climatic conditions and the characteristics of the available soil materials for cover construction led to the decision to construct store-and-release covers to achieve the target infiltration rates. All of the covers include an upper loosely compacted till layer that serves as a store-and-release component of the cover. Store-and-release relies, in part, on vegetation for reducing infiltration through covers. Most of the covers also incorporate barrier layers (compacted soil, or synthetic) to minimize infiltration during periods when the water balance overwhelms the store-and-release capacity.

The cover design and performance targets described in Table 7.1 are based on a series of cover studies conducted at the site since 2002. These included multi-year investigations of water balances using large scale test covers. Preliminary predictive numerical modeling and analysis of the cover trial data indicate that these are realistic and achievable performance targets for covers at this site, using the available till cover material. Definitive final designs to achieve these performance targets have not been prepared, and will be refined as site specific performance data is collected and

analysed (SD H15, SRK 2010). The site water and load balance (SD E11, in progress by GEEC) utilized these target ranges for predicting water quality impacts from the site.

- Long term cover integrity is of paramount importance and led to the application of landform engineering principles to facilitate surface water management, erosion control and re-vegetation success. To support this approach, the site was divided into a series of Reclamation Land Units (RLUs), as shown in Figures 7.1a to 7.1h each RLU consists of specific features including landscape, soil cover, vegetation, surface treatment, slope/aspect, and drainage. For each of these, specific reclamation prescriptions are identified that define how every area of the site will be reclaimed including final landscape, cover type, surface treatments and re-vegetation. A comprehensive description of the re-vegetation plan is described in "Faro Mine Complex, Closure and Remediation Plan, Revegetation Plan" (SD H14, EDI 2009, Draft, to be finalized).

The project description identifies specific cover types for specific waste rock areas. An iterative process has guided decisions about what cover designs are appropriate for specific waste rock. This process evaluated the balances between source chemistry, cover construction costs, water treatment costs, uncertainty associated with predicted infiltration rates and source chemistry as well as collection practicality and efficiency (SD H4, Mine Area Cover Optimization and Landform Engineering, SRK 2008).

7.3.2 Contaminated Water Collection

Protection of the aquatic ecosystem from mine contaminants will require long-term (100s of years) collection of contaminated ground water, seepage and surface water. For all areas of the mine, the site water and load balance model predicts that contaminated groundwater flowing from beneath waste storage facilities (i.e. waste rock dumps, tailings) is a potentially significant contaminant load source that would cause unacceptable effects on the aquatic environment. Once reclamation is complete, the covers will ensure that most surface water remains free of chemical contaminants, but extensive groundwater and seepage collection systems will be required to collect water that is affected by contact with waste materials. These collection systems will be required for the Faro Mine, Vangorda/Grum Mine and tailings areas.

When contaminant loading from specific areas is at its peak, very effective collection of ground water and seepage will be required. Past experience at the site confirms that these peaks will occur at different times from different sources, and they will gradually develop over time. Indicator substances like sulphate will provide early warning about migration of contaminants of concern. This pattern will allow for iterative implementation of groundwater collection systems. Groundwater collection is well suited to this approach because initial systems can be upgraded and supplemented with additional components or systems as needed. With this approach, very effective collection systems will be in place as the contaminant loads increase.

Contaminated water collection systems will include appropriate use of a variety of methods including: interception wells, high permeability pumping trenches, cut-off walls, interceptions

trenches, collection sumps, bedrock grouting. Passive treatment options like permeable reactive barriers could also be used in some areas if proven to be effective.

The timing for construction of collection systems is dependent on the migration of contaminants from the site and will be guided by an adaptive management plan. Once an initial collection system is in place, the adaptive management plan will be revised to understand performance and guide decisions about modifications and improvements. The framework for the adaptive management plan is described in Chapter 13 of the Project Description (SD A1, SRK 2009). A similar adaptive management plan has been in effect at the site since 2003 and has led to the construction and improvement of collection systems already in place.

At the Faro Mine/Tailings area, the development of contaminated water collection systems will recognize that a collection system down-gradient of the tailings in the Rose Creek Valley will be the ultimate collection point for water that escapes collection systems around the waste rock.

7.3.3 Water Treatment

Water treatment to remove zinc and other contaminants will be a long-term requirement for both surface and groundwater at the Faro Mine, Tailings and Vangorda/Grum Mine areas. Water treatment programs are a major component of current care-and-maintenance activities at both sites and their importance will persist throughout the closure and post-closure phases, with water treatment requirements expected to last at least several hundred years. Both the quantity and quality of water requiring treatment will change over time, potentially in both adverse and favourable ways at different stages in the project. Water treatment programs and facilities will need to be flexible to accommodate these changes.

The existing water treatment plants in the Faro Mill and at Vangorda/Grum will continue to operate during the initial years of the closure project, but will eventually be replaced by new treatment plants that similarly rely on lime addition but with high density sludge processes. These new systems will produce lower volumes of sludge that has suitable density for final storage at the bottom of the Faro and Vangorda pits. Sludge quantities are expected to be substantial due to the long duration of water treatment. Current estimates indicate that these pits have storage capacity for several hundred years.

The site water and load balance indicates that water treatment using lime precipitation will provide effluent that will be protective of the aquatic environment. Small particles of sludge that are not removed in the HDS system can lead to total metal concentrations that exceed such targets. To provide added protection against high total metals concentrations, it is proposed that the system include a contingency polishing step using sand filters. Table 7.2 shows the anticipated effluent quality from the HDS system. The zinc levels are provided with and without the sand filter.

Table 7.2: Anticipated Effluent Quality (mg/L)

Total Metals	Target Effluent Limit (mg/l)
Aluminum	0.01
Arsenic	0.005
Beryllium	0.005
Boron	0.1
Cadmium	0.005
Cobalt	0.005
Copper	0.009
Iron	0.005
Lead	0.015
Magnesium	0.025
Manganese	0.3
Nickel	0.06
Zinc (without Sand Filter)	0.1
Zinc (With Sand Filter)	0.05

Construction activities during closure implementation (cover construction, waste rock re-sloping, tailings dewatering) will create additional and sometimes unpredictable water treatment requirements. Flexibility will be particularly important during this phase of the project. Contingency treatment capacity and/or storage capacity will be necessary at that time. Pits provide substantial excess storage capacity and existing treatment plants will provide treatment contingency once new plants are operational.

For post-closure requirements, construction of new water treatment facilities will be phased to provide appropriate capacities at appropriate times. Water treatment plants will be the primary on-site facility during the post-closure phase and will be located accordingly to minimize energy requirements and provide convenient access. Current plans are for the Faro Mine water treatment plant to be located at the former BXL site at the east end of the tailings, with effluent discharge downstream of the confluence of the north and south forks or Rose Creek. The Vangorda water treatment plant will be located adjacent to the Vangorda Pit, with discharge to Vangorda Creek.

7.3.4 Surface Water Management

Surface water management for the FMC Closure and Remediation Plan follows the principle of segregating clean water from contaminated water, especially water that has been chemically altered by waste materials. Due to the effects of construction activities, surface water management requirements are fundamentally different for the closure implementation phase and the post-closure phase.

During the post-closure phase, the focus of surface water management is to convey clean water around the site in diversions (Faro Creek Diversion, Rose Creek Diversion, North Fork Rose Creek

lined channel, Vangorda Creek Diversion, and other local surface water diversions), and to convey clean surface runoff from the site into these local creeks.

Surface water management during the closure implementation phase is much more challenging because construction activities will contaminate runoff at the site. Some of that runoff will be chemically altered while some be affected only be increased suspended solids. These types of water will require additional segregation with appropriate treatment methods applied: either removal of metal contaminants in a water treatment plant or removal of suspended solids by settling.

The construction-related surface water management plan is discussed in detail in Chapter 12 of the Project Description and is based on Best Management Practices (BMP), to control, route, collect and treat surface water runoff from those areas that will be disturbed and reclaimed during the closure implementation. The following general concepts guide that strategy:

- Clean water will, to the extent practical, be kept separate from water which doesn't meet discharge criteria and will be diverted into the downstream environment as quickly and efficiently as possible.
- Water which is likely to be clean, other than elevated levels of suspended solids, will typically be directed to settling ponds prior to discharge.
- Water which has, or may have, elevated metal levels will be captured and treated prior to discharge.

Active surface water management structures will consist of diversion ditches, berms and sedimentation ponds. On waste rock dumps, berms will be constructed both at the top and bottom of slopes, to minimize surface runoff onto and control runoff from slopes. Intermediary diversion channels will be used where appropriate. Ditches will be constructed to convey diverted runoff to sedimentation basins and, if clean, discharged to creeks. If not suitable for discharge, water will be directed or pumped for treatment. To the extent practical, re-grading, covering and re-vegetation will be conducted within a short time frame to limit the susceptibility to erosion.

7.3.5 Environmental Adaptive Management

An adaptive management approach will be a critical component of any successful closure plan for the Faro Mine Complex. Comprehensive monitoring, investigation, research and design programs have formed the basis for predictions about future site conditions and performance of closure measures. However, actual site conditions and performance will vary from the assumptions used in the predictions. For many project components, there are areas of outstanding uncertainty about future conditions where variations from the assumptions could lead to effects on the environment. The Environmental Adaptive Management Plan, the framework of which is described in Chapter 13 of the Project Description, will be implemented for these areas of uncertainty to detect changes in site conditions or performance in a timely manner and guide appropriate and effective responses that will prevent unacceptable environmental effects.

The AMP provides an operational structure for detecting changes as well as developing and implementing timely responses. This structure is comprised of several common elements that are included in each specific AMP and which provide the framework that is necessary to ensure that the AMPs will be proactive in detecting changes and implementing responses before unacceptable environmental effects occur. The following common elements form part of each specific AMP.

- "Event" describes the specific event that is addressed by the AMP.
- "Possible Environmental Consequences" describes the environmental consequences that could arise if the event were allowed to proceed without appropriate responses.
- The "Narrative Response Trigger" is a narrative description of the trigger for the AMP event and leads to the development of the specific indicators and thresholds.
- "Specific Indicators" describe the environmental parameters to be monitored and assessed as part of the AMP. The indicators are selected to provide early detection of relevant changes in environmental conditions or system performance.
- "Specific Thresholds" define the conditions for specific indicators that would lead to actions being taken. There are often a series of staged thresholds or multiple thresholds for an individual event.
- "Monitoring Requirements" describes the monitoring (e.g. parameters, locations, frequencies) that will be carried out to support implementation of the AMP. Monitoring requirements may change at various stages of an AMP.
- "Evaluation of Monitoring Results" describes the methods and processes that will be used to evaluate the monitoring data and determine whether any specific thresholds have been reached or exceeded.
- "Approach to Development of Response/Mitigation/Intervention" describes the overall approach to responses that will be implemented if any thresholds have been reached or exceeded. In most cases, the responses will include a range of actions that may be taken to address the events. The selection of appropriate responses would depend on the conditions of changed site conditions or system performance.

For the FMC Closure and Remediation Plan, the key events that will be addressed through specified adaptive management plans include the following.

- Rose Creek Aquifer
  - Phase 1 – degradation of aquifer water quality leading to collection and treatment requirements.
  - Phase 2 – bypass of water around the Rose Creek Aquifer collection system
- Contaminated Groundwater/Seepage
  - Phase 1 – degradation of groundwater or seepage quality down-gradient of a mine component, leading to collection or treatment requirements.

  - Phase 2 – bypass of water around a mine component collection or treatment system

- Receiving Water Quality – degradation of water quality in receiving waters downstream of the mine site.
- Receiving Water Flow – changes in winter flows downstream of the mine site due to groundwater collection activities (potential effects on fish and fish habitat).
- Receiving Water Temperature – changes in water temperatures (winter) downstream of the mine site due to groundwater collection activities (potential effects on fish and fish habitat).
- Water Treatment Source Water Quality/Quantity – ability of treatment systems to function effectively in changing conditions:
  - Changes in water quality, water quantity or parameters of concern for water that is being treated.
  - Emerging sources requiring treatment.
- Cover Vegetation Success/Performance – vegetation on soil covers failing to meet objectives (e.g. erosion control, vegetation coverage, invasive species, wildlife habitat, etc.)
- Terrestrial Effects – effects on the terrestrial environment are different than anticipated.
- Sludge Management – sludge properties or quantities lead to the need for major changes in approach for sludge management.

The Environmental AMP for the Faro Mine Complex is an integral component of the mine closure project. The AMPs will guide decisions in three broad areas: (1) timing for implementation of mine closure measures (e.g. Rose Creek Aquifer collection), (2) locations for implementation of mine closure measures (e.g. waste rock seepage collection areas), and (3) performance adequacy of closure measures that have been implemented (e.g. vegetation success). Due to these areas of application, without the AMPs the project would cause unacceptable environmental effects. Because of the critical nature of the AMPs, a governance structure must be in place to support effective application of the adaptive management approach.

7.3.6 Long-Term Site Management

A “walk away” closure plan is not possible for the FMC due to the ongoing oxidation of sulphide waste materials which will continue to produce soluble contaminants for many centuries. As a result, the following activities are expected to continue permanently at the site:

- Collection and treatment of contaminated water.
- Maintenance and repair of site structures including dams, diversions and covers.
- Monitoring of site and environmental conditions.

7.4 Closure Activities for the Faro Mine Area

The following sections describe the proposed closure activities for the Faro Mine area. The Faro Pit will remain in place and serve as a storage reservoir for contaminated water and a permanent repository for water treatment sludge. Faro Creek Diversion and other local diversions will be upgraded to convey clean water around the site. A new lined channel will be constructed for North Fork Rose Creek to segregate clean water from contaminated water. The oxide fines will be consolidated and all waste rock will be covered. The tailings in the Emergency Tailings Area will be moved to the Rose Creek tailings and the area cleaned up. Groundwater and seepage collection systems will be established as needed and contaminated water will be treated for discharge to Rose Creek. A variety of other activities will also be part of the closure plan: e.g. pit safety berms, building demolition and hydrocarbon contaminated soil remediation. Figure 7.2 and the sections below provide an overview of the closure activities for the Faro Mine area. A more in-depth discussion including rationale for the activities described below can be found in the full Project Description document.

7.4.1 Faro Pit

A safety berm will be constructed around the Faro Pit to reduce the risks associated with people and animals accessing the pit. The berm will be about 2.0m high with 2H:1V side slopes and construction is scheduled for Year 13 of the Project.

The Faro Pit will be a permanent pit lake, and will be used as a reservoir for contaminated water from the Faro Mine and tailings area. This will include water collected from Zone II Pit, Emergency Tailings Area, S-Wells Area, Rose Creek Aquifer and other collection systems that are constructed and require treatment as decided by the Adaptive Management Plan. Stored contaminated water from collection systems will be pumped from the pit during the summer for treatment before being released to Rose Creek. Water levels in the pit will be managed to provide sufficient capacity for contingency contaminated water storage needs.

The Faro Pit will also serve as the permanent repository for water treatment sludge from the new high density sludge water treatment system. A tremie system would be used to place the sludge near the pit bottom, and prevent mixing with the water column. The volume available in the pit is estimated to be about 35,000,000 m3 providing capacity for over 300 years of sludge storage. Substantial additional storage could be provided if needed in the future by constructing a plug dam in the pit.

7.4.2 Clean Water Diversion

Faro Creek Diversion Channel

The Faro Creek Diversion will be relocated and expanded to improve its flood handling capacity, minimize seepage losses to the Faro Pit (where they increase water treatment volumes) and address physical stability concerns for the Faro Pit wall. This would involve construction of a new diversion

channel that would intercept Faro Creek and run along the eastern slope of Faro Creek Valley, above the existing channel, but out of the range of potential Faro pit wall stability issues. Once past the pit, the new channel would discharge into the existing channel and continue to flow into North Fork Rose Creek. The plan also calls for constructing a new West Valley interceptor upslope of the existing ditch to convey clean water from this area away from the Faro Pit.

The new channel will have capacity to convey a 1:500 year flood event and will include an emergency overflow system to direct larger flows (up to the probably maximum flood) into the Faro Pit without leading the failure of the channel.

The Faro Creek Diversion upgrade will likely be completed early in the Project, but timing will be driven by the results of pit wall monitoring used to assess risks. In the meantime, the Faro Pit has adequate storage for more than one full year of flows from the diversion, providing adequate contingency for repair if failure occurs.

North Wall Interceptor Ditch/Upper Guardhouse Creek

Uncontaminated surface runoff from the north side of Rose Creek Valley, including Upper Guardhouse Creek, is currently diverted to Rose Creek at the north end of the tailings impoundment area by the North Wall Interceptor ditch. Minor improvements will be required to upgrade and realign these diversion facilities for long-term service.

North Fork Rose Creek Channel/North Fork Rock Drain

Clean water in the North Fork Rose Creek is in close proximity to contaminated groundwater and seepage from waste rock in this area. To facilitate effective segregation of clean and contaminated water in this area, a new low permeability channel offset from the existing alignment of the North Fork of Rose Creek will be constructed. This activity would be carried out in conjunction with removal of the North Fork Rock Drain from the Vangorda Haul road.

The major components of the proposed North Fork Rose Creek channel include:

1. A cut-off wall to bedrock at the upstream end of the lined channel, anticipated to be a cemented-slurry wall with soil cement and/or bedrock grouting as needed or is appropriate.
2. A low permeability “floodplain” designed to accommodate the peak flow for a probable maximum flood (384 m^3/s).
3. A low permeability channel within the floodplain, designed for a 1:500 year flood event (81 m^3/s).

- Final decisions have not been made about the type of low permeability liner to be used. Materials with good long-term durability are under consideration including compacted till, geosynthetic clay liner, high-density polyethelene (HDPE) or bituminous material. The channel will include a pilot channel to route the winter flow under the ice and riprap cover on the liner to provide erosion protection. The diversion of the North Fork Rose Creek into a constructed

channel will result in the destruction or alteration of fish habitat and lead to requirements for fish habitat compensation. These will be addressed through an appropriate fish habitat compensation plan that will include provisions for appropriate flows and habitat features in the constructed channel.

The construction of the channel will occur in phases as part of an adaptive management plan based on ground and surface water quality. The initial section of the channel is expected to extend from the approximately the confluence of the Faro Creek Diversion/North Fork Rose Creek to the Mine Access Road. Depending on groundwater conditions, the low permeability channel may ultimately be extended as far as the confluence with South Fork of Rose Creek.

7.4.3 Waste Rock Consolidation and Covering

All waste rock at the Faro Mine area will be covered. Some high strength materials will be consolidated before covering, based on cost-benefit analysis considering the costs of relocation versus the costs of cover construction. A variety of cover types will be applied to various waste rock elements at the Faro Mine area, utilizing appropriate cover types as described in Section 7.2.1. Cover placement will require re-sloping of waste rock. For low and very low infiltration covers, slopes will be no steeper than 3H:1V. For rudimentary covers, outer slopes will be re-graded to no steeper than 3H:1V where practical and inner slopes will be no steeper than 2H:1V. Re-sloping activities at the Faro Mine area will increase the disturbance area by about 350,000m^2.

After contouring and re-sloping, all waste rock areas will be covered as soon as practical in order to minimize potential adverse water quality impacts. The Grum Overburden dump will be the source for soil cover material. Surface water will be managed by lined and unlined plateau channels and a number of armoured slope channels to minimize erosion. Despite erosion control measures, some sediment control using ditches and basins will also be necessary, especially during freshet and storm events. Vegetation will be applied in accordance with the RLU designations as described in Section 7.2.1.

The remediation methods for Faro Mine area waste rock elements are illustrated on Figure 7.3 and described in Table 7.1. Additional detail is provided in the text below.

It should be noted, however, that final selection of the cover type is still subject to further review and technical evaluation.

Table 7.3: Faro Mine Waste Rock Remediation Methods

Faro Mine Waste Rock Element	Surface Area (m^2)	Closure Treatment
Faro Valley North	130,803	Rudimentary Cover
Faro Valley South	31,116	Rudimentary Cover
Medium Grade Ore Stockpile	24,087	Relocate to Low Grade Stockpile C and cover remaining area with Rudimentary Cover.
Crusher Stockpile	22,334	Relocate to Low Grade Stockpile C and cover remaining area with Rudimentary Cover.
Low Grade Ore	7,000	Relocate to Low Grade Stockpile C and cover remaining area with Low Infiltration Cover.
Oxide Fines Stockpile	26,663	Relocate to Low Grade Stockpile C and cover remaining area with Rudimentary Cover.
Low Grade Stockpile A	36,139	Very Low Infiltration Cover.
Upper Northwest Dump	122,901	Remove rock from Guardhouse Creek for use in tailings trafficability layer. Cover remaining area with Rudimentary Cover.
Middle Northwest Dump	150,497	Rudimentary Cover
Lower Northwest Dump	126,110	Rudimentary Cover
Mt. Mungly West	33,947	Low Infiltration Cover
Mt. Mungly East	38,500	Low Infiltration Cover
Fuel Tank Dump W	10,283	Rudimentary Cover
Fuel Tank Dump E	105,025	Rudimentary Cover
Upper Parking Lot Dump	50,355	Rudimentary Cover.
Lower Parking Lot Dump	28,524	Rudimentary Cover.
Stock Piles Base	86,387	Rudimentary Cover
Low Grade Stockpile C	109,541	Very Low Infiltration Cover
South West Pit Wall Dump	68,000	Low Infiltration Cover
East Sulphide Cell	17,441	Very Low Infiltration Cover
Main + Intermediate Dump Sulphide Cell	173,647	Very Low Infiltration Cover
Ranch Dump	41,905	Rudimentary Cover
Ramp Zone Dump	62,696	Rudimentary Cover
Main Dump West	191,789	Rudimentary Cover
Main Dump East	334,089	Rudimentary Cover
Intermediate Dump	316,928	Rudimentary Cover
Outer Haul Road West	214,463	Rudimentary Cover
Outer Haul Road East	98,304	Rudimentary Cover
Outer Northeast Dump	15,768	Rudimentary Cover
Zone II West	89,936	Rudimentary Cover
Zone II East	141,000	Rudimentary Cover
Lower Northeast Dump	291,738	Rudimentary Cover
Upper Northeast Dump	266,385	Rudimentary Cover

7.4.4 Oxide Fines, Medium Grade Ore and Low Grade Ore Stockpiles

The Oxide Fines and Low-Grade Ore Stockpiles are the sources of the most contaminated water in the Faro area. The closure plan for these materials entails consolidating into a smaller area to reduce the footprint area by approximately 40 percent. The surface area reduction would result in a proportional reduction in the cost of cover construction as well as infiltration. The oxide fines, the medium grade ore stockpile, crusher stockpile and a small area of low grade ore will be relocated to the Low Grade Ore Stockpile "C." All low-grade ore and oxide fines will receive very low infiltration covers consisting of a synthetic liner or an equivalent depth of compacted till. The infiltration barriers will be covered with a 0.3 to1m-thick growth medium that will be seeded and fertilized.

7.4.5 Mt. Mungly Dumps (East and West), Southwest Pit Wall Dump

The Mt. Mungly and Southwest Pit Wall dumps are closely associated with the low-grade ore and oxide fines stockpiles, but their loading is predicted to be less. Low infiltration covers will be placed on these materials. The low infiltration cover will consist of 1 metre compacted till with a 0.3 to 1m thick growth medium that will be seeded and fertilized.

7.4.6 Sulphide Cells

Three sulphide cells at the Faro Mine area would contribute significant contaminant loads. These waste rock elements will be covered with Very Low Infiltration soil covers consisting of a compacted till barrier layer 1 to 1.5m thick covered with a 0.3 to 1m thick growth medium that will be seeded and fertilized.

7.4.7 Other Faro Mine Area Waste Rock

All remaining waste rock elements at the Faro Mine Area will receive rudimentary covers. Internal slopes will be no steeper than 2H:1V and outer slopes no steeper than 3H:1V where practical. Where space is limited, such as above the S-Wells, the dump crest will be pulled back. There may be some areas of the outer slopes where the toe cannot be extended and it is not practical to pull the crest back. In these locations, the slopes may be steepened to more than 3H:1V but they will be no steeper than 2H:1V.

A small portion of the Northwest Dump that is located in Upper Guardhouse Creek would be excavated and used for the trafficability layer on the tailings.

7.5 Remediation of the Emergency Tailings Area

Remediation of the Emergency Tailings Area (ETA) will entail two primary activities: removal of the tailings and interception of impacted ground and surface water. The ETA tailings will be removed to facilitate effective collection of the seepage from the rock piles and to reduce the contaminant loading to the groundwater. Groundwater, seepage and surface water management will be an integral part of the tailings relocation activity. An interim groundwater and seepage collection

system began operating in the ETA downstream of the Mine Access Road in 2007 and this will continue to operate with necessary improvements until completion of the ETA remediation activities. Additional water management facilities will be required before the tailings can be moved including: (1) a sump with a down gradient cutoff wall downstream of waste rock dumps and upstream of the ETA (X23) for groundwater and surface water collection, (2) a sump and pumping station upstream of the mine access road for diversion of waters collecting in the ETA during construction, and (3) a diversion ditch along the southeast side of the ETA to divert clean runoff into the NFRC at the upstream end of the Rose Creek Tailings Facility.

The tailings along with underlying contaminated soil will be mechanically (excavators and trucks) relocated to the Rose Creek Tailings Facility where they will be covered as part if the remediation of that facility. Once the relocation is complete, permanent water management facilities will be finalized to collect contaminated water and divert clean water.

7.6 Contaminated Water Collection

A general description of the approach for contaminated water collection is provided in Section 7.2.2. Specific plans for contaminated water collection in the Faro Mine area are described in this section. Water from all of these collection points indentified will be pumped to Faro Pit for storage and subsequent treatment, or directly to a treatment plant. These sections describe areas with current plans for collection systems. The Adaptive Management Plan may identify additional areas that require treatment and these would be added as appropriate throughout the life of the Project.

7.6.1 Emergency Tailings Area

An interim groundwater and seepage collection system began operating seasonally in the ETA in 2007. This system will be upgraded to improve efficiency and will begin operating year-round. Additional collection systems, as described in Section 7.3.4 will be installed to allow for tailings relocation activities. Once the tailings and contaminated soil are removed, contaminated water collection systems will be upgraded and constructed for long-term service. The design of facilities will be refined as remediation progresses, but current understandings of conditions indicate that long-term collection systems in the vicinity of the ETA will include:

- A sump with a down gradient cutoff wall downstream of waste rock dumps in the old Faro Creek Valley (X23).
- A sump with a down gradient cutoff wall in the northern canyon, below the mill, for groundwater and surface water interception (the mill canyon sump), similar to the X23 interception system.
- A sump above the mine access road, at the lowest elevation area in the reclaimed ETA.

7.6.2 Lower Guardhouse Creek

Lower Guardhouse Creek currently mixes clean and contaminated water sources, consolidating seepage from the mill pad, runoff from the area between the creek and NW Interceptor ditch, and leakage from the ditch. This water currently discharges contaminated water into the Rose Creek Tailings area. The primary source of loading to Lower Guardhouse Creek appears to be drainage from the mill pad and crusher stockpile via a collection ditch discharging into Lower Guardhouse Creek.

Seepage and groundwater interception systems will be established below the mill pad to collect contaminated water and route it to the ETA collection system. From there, the water will be collected and treated with ETA water. Surface water interception will include a sump and pumping station An insulated, heat traced pipeline will be constructed from the collection sump, over the mill pad cover, to tie in to the ETA pipeline. Excavate, place liner and riprap a sump at the upstream end of Lower Guardhouse Creek, just outside of the toe of the final mill pad cover. A pumping station with a variable-speed pump will be installed.

The objective of this work is to intercept seepage from the mill pad and associated stockpiles and redirect this water to the Faro Pit via a pipeline connecting with the ETA pipeline (Activity 105). Surface water interception will include a sump and pumping station. Should monitoring indicate the need for additional components, these would be upgraded and/or supplemented with groundwater collection facilities that may include collection wells and a cut-off wall.

Residual drainage below the interception system will continue to discharge to the Rose Creek Tailings area. If residual seepage from Lower Guardhouse Creek continues to have significant load this water will be intercepted and pumped to the Faro Pit as appropriate, in accordance with the adaptive management plan.

7.6.3 Zone II Pit

During closure, contaminated water from the buried Zone II pit will be pumped to the Faro Pit for storage and subsequent treatment. The maximum water level in the pit will be maintained about 1m below the North Fork Rose Creek to reverse the direction of groundwater flow. It is likely that these modifications will be implemented during care and maintenance.

7.6.4 Zone II Pit Outwash

Zone II Pit outwash material adjacent to North Fork Rose Creek is currently a source of contamination. Loading from this source is expected to increase with time. To reduce future contaminant loading, the outwash material will be excavated and relocated to the Intermediate Sulphide Cell where it will be covered with a Very Low Infiltration Soil Cover. Following removal of the outwash material, a seepage collection system comprising an interceptor trench and pumping wells will be installed to collect contaminated water from adjacent waste rock dumps. Additional

system components would be added as appropriate in accordance with the Adaptive Management Plan.

7.6.5 S-Wells Groundwater Collection

Contaminated groundwater and seepage in the S-Wells area accumulates from adjacent waste rock dumps. Concerns about adverse effects on water quality in the North Fork Rose Creek led to the installation of an initial seepage and groundwater collection system at this location in early 2009. Upgrades were completed later in 2009 and additional upgrades are planned for 2010. The objective of this work is to capture contaminated groundwater relatively close to the source, before it discharges into the NFRC or becomes more dispersed and cannot be captured as efficiently. Two aquifer systems have been identified in the S-Wells area and a long-term collection system will need to address both.

In the shallow aquifer, the initial interception system consisted of an interceptor trench excavated to approximately 3.5 to 4m depth across the expected width of the aquifer. This trench was subsequently expanded to capture additional flows. A central corrugated metal pipe sump was installed to a depth of approximately 6 to 7m for the pumping system, from which water is pumped to the Faro Pit.

The initial collection system for the deep aquifer is comprised of two pumping wells. The next phase of the deep aquifer interception system will focus on additional pumping wells completed into weathered bedrock in the areas of highest contaminant concentrations.

The subsequent stage of the adaptive management strategy would be installation of a cut-off wall. This cut-off wall would be constructed if monitoring indicates that the shallow aquifer sump and deep aquifer pumping wells alone do not provide sufficient capture of contaminated groundwater.

7.6.6 Water Treatment

As described in Section 7.2.4, lime addition with high density sludge production has been selected as the primary water treatment methodology for application at the FMC. In the Faro Mine area, the existing water treatment plant will continue to operate during the initial years of the closure implementation.

There is substantial uncertainty about the timing of treatment capacity requirements because source water quantity and quality will vary with time. Construction related activities will add additional uncertainty. Given that range of uncertainty, phased construction of water treatment capacity is practical. Initial capacity of approximately 5000 USgpm will provide flexibility to deal with shorter treatment seasons, additional flows from wet years and unpredictable inputs during construction activities. In the early closure implementation years, the existing treatment system will still be available for contingency treatment. Storage capacity in the Faro Pit will provide additional contingency for unexpected treatment requirements. Also, the Adaptive Management Plan includes detailed adaptive management monitoring, triggers and responses to ensure that water treatment

requirements will be addressed as needed. This initial 5000 USgpm system should be constructed as soon as practicable. Early construction would reduce risks associated with the current plant, and provide the site with additional capacity prior to starting major earthworks.

Collection of water from the tailings area would lead to construction of Phase 2 of the treatment system, with an additional capacity of approximately 5000 USgpm. Timing and final capacity for this phase would be guided by the Adaptive Management Plan.

The construction of new water treatment facilities will include a new polishing pond that will be used as a final discharge point from the Water Treatment Plant.

Once the new treatment system is operational the sludge will be disposed in the Faro pit. A tremie system would be used to place the sludge near the pit bottom, and prevent mixing with the water column. The volume available in the pit, without constructing a plug dam, is estimated to be about 35,000,000 m^3 providing capacity for over 300 years of water treatment. If higher sludge densities are assumed, and if consolidation is taken into account, that estimate would increase to over 500 years. A plug dam in the pit could provide substantial additional capacity.

Sludge produced from the existing water treatment plant has a much lower solids content and is not suitable for disposal in the pit. This sludge is currently stored in impoundments on the tailings surface. This practice will continue until the tailings are covered. During closure, the sludge will remain on the tailings (distributed and/or incorporated) under the cover materials. In this location, any excess alkalinity will serve to neutralize acidity in the tailings. If low-density sludge is produced after placement of the tailings cover, that sludge will be placed in an appropriate location on waste rock where alkalinity can be similarly consumed, and where the material will ultimately be covered.

7.6.7 Miscellaneous Faro Mine Closure Activities

There are number of miscellaneous closure activities to be conducted at the Faro Mine area. Similar activities would be required in other parts of the FMC. These activities include, but are not limited to:

Site roads that are not necessary for post-closure activities will be reclaimed by scarifying surfaces and pulling back safety berms. All culverts and watercourse crossings will be removed. Disturbed surfaces will be re-vegetated.

The existing mill and administrative buildings will not be needed post-closure and will be a long term safety hazard. Prior to any demolition works, a full inspection will be performed on all site buildings to identify hazardous waste, salvageable materials, and structural safety concerns. All non-salvageable material and non-hazardous wastes will be buried within the toe of the resloped waste rock dump. Salvageable materials and hazardous wastes will be transported off-site for proper disposal. Contaminated foundation will be broken up and buried in the contaminated waste pile or landfarm, depending on the contaminant. Clean foundation will be left in place and covered with 1m of loose growth medium and re-vegetated.

All disturbed areas from remediation activities, including borrow areas, will be revegetated. The vegetation selected will help to stabilize slopes and prevent erosion.

There are hazardous materials and contaminated soils around the plant site area that could cause long-term impact on the surrounding environment. There has been some sampling to identify soils contaminated with unacceptable levels of metal and hydrocarbons and any potentially acid generating soils in the mill area. Based on current testing results, all soils, including hydrocarbon contaminated soils, that contain high levels of metals will be consolidated, relocated and covered.

Any soils that are contaminated with only hydrocarbons will be treated at an on-site landfarm. The facility will be lined and sized according to the amount of estimated waste. The lining system would be a 1.5mm HDPE liner sandwiched between two layers of 542g/m^2 non-woven geotextile. Granular soil cushioning layers will be deployed as base and topping cap in the landfarm. A dose of fertilizer will be spread over the initial contaminated soil to facilitate bacteria growth.

Once all hydrocarbon and metals contaminated soils have been removed, the mill area will be covered with rudimentary cover and revegetated. Some of the contaminated soil and waste may contain other chemicals. Any material contaminated with potentially hazardous chemical will be transported off site to a permitted disposal facility.

All other hazardous wastes will be consolidated and transported off site for proper disposal.

7.7 Closure Activities for the Rose Creek Tailings

The following sections describe the proposed closure activities for the Rose Creek Tailings area. Flood handling facilities will be upgraded to provide capacity to convey a PMF safely past the tailings facility. Earthquake resistance of tailings facilities will be upgraded to ensure that they can withstand a MCE. The Cross-Valley Dam will be breached and sediments from the Cross-Valley Pond cleaned up. Tailings will be covered with a rock and soil cover. Groundwater contamination will be monitored and a very effective groundwater collection system will be established to collect contaminated water from the Rose Creek aquifer before contaminants of concern enter Rose Creek. Contaminated water will be treated before release into Rose Creek. Figure 7.4 and the sections below provide an overview of the closure activities for the Rose Creek Tailings area. A more in-depth discussion including rationale for the activities described below can be found in the full Project Description document.

As with other components of the FMC Closure and Remediation Plan, there are a number of variances that could be used for some closure components.

7.7.1 Flood Routing for the PMF

In their current circumstances, the potential for flood events to cause diversion and/or dam failures in the Rose Creek Tailings Facility presents one of the largest risks at the FMC. Recognizing this risk, previous water licences for the site established requirements for any closure plan to upgrade these

facilities to convey the PMF. Various options for upgrading conveyance capacity were considered early in the alternatives evaluation process (Chapter 6) and the final selected approach relies on the results of many technical studies, engineering investigations and input from the IPRP.

The proposed concept involves separate approaches for floods smaller than 1:500 year events and floods larger than this. The Rose Creek Diversion Canal (RCDC) will have capacity for floods up to a 1:500 year flood event. Floods larger than this will breach a "fuse plug" section of the diversion canal and flow into the Intermediate Tailings Impoundment and then exit the facility via a PMF spillway on the north side of the Intermediate Dam. Components of this flood routing approach are described below and illustrated on Figure 7.5.

7.7.2 RCDC Upstream of Fuse Plug

The section of the RCDC adjacent to the Second Dam, between the confluence of the North and South Forks of Rose Creek and the fuse plug, requires permanent capacity to convey the PMF. This section will be upgraded for a capacity of 674m^3/s by minor reshaping of the channel geometry plus the addition of rip rap to prevent erosion. The existing channel has sufficient cross-section area to pass the PMF in its current configuration.

7.7.3 Fuse Plug

A fuse plug will be constructed in the RCDC at the east end of the Intermediate Impoundment. This special part of the RCDC dyke will overtop and fail when flows exceed the estimated peak for a 1:500 year flood event. In these events, the remaining flows from the flood will flow into the Intermediate Impoundment where they can be safely conveyed through the spillway and back into Rose Creek. The existing RCDC already has a fuse plug, but it needs to be upgraded for closure. The existing fuse plug will be removed and rebuilt with material that will be designed to fully breach when flows exceed the 1 in 500 year event. The top of the rebuilt fuse plug will be at El. 1059.5m, which will direct all floods smaller than the 1:500 year event (135m^3/s) along the existing RCDC alignment. The fuse plug will have an upstream facing of riprap which will overly a till core designed to prevent seepage through the structure. Erodible sand and gravel will make up most of the fuse plug.

7.7.4 RCDC Downstream of Fuse Plug

Downstream of the fuse plug, the RCDC will be required to pass the flow of Rose Creek on a year-round basis for all flows up to the 1:500 year flood event (135m^3/s). The channel currently has capacity for this, however the freeboard is inadequate. In addition, sections of the dike, particularly in the vicinity of the ID, have experienced settlement in the past. These conditions need to be repaired and upgraded. Final design details still need to be completed but activities are likely to include dyke raises in some areas to provide additional freeboard, improvements in erosion protection, and repair/upgrade of the drop structures in the steep channel section downstream of the Intermediate Dam.

7.7.5 Erosion Dissipation Structures

When floods overtop the fuse plug, the water will flow into the Intermediate Impoundment, over the top of the Intermediate tailings. An erosion dissipation layer consisting of a riprap apron will be constructed on the tailings cover, for about 700m down gradient of the fuse plug, in the area where the flow velocity would be high enough to damage the cover. Beyond the erosion dissipation layer, swales (depressed alignments in the tailings cover) will be constructed in the till cover to keep the flow distributed over as large an area as possible and ensure flow velocities that are acceptable for the till material that forms the cover.

7.7.6 Intermediate Dam

All flood events larger than the estimated 1:500 year event will flow into the Intermediate Impoundment and must be conveyed safely past the dam. These flows will be accommodated in a new spillway constructed in bedrock at the north abutment. During the PMF, flood waters will temporarily enter the impoundment area faster than they can be routed out via the spillway. The extent to which the PMF flood waters rise within the Intermediate impoundment will depend on the spillway inlet invert, channel width, freeboard requirements and the final surface gradient of the tailings. Raising of the Intermediate Dam will be required to provide adequate temporary storage capacity in major flood events.

Optimization still needs to be completed to finalize the appropriate balance between spillway sizing and dam raise. Klohn Crippen Berger (SD I6, KCB 2008) completed two studies that evaluated spillway design on the basis of two concepts which bracket the range of realistic design options. The first study was based on maintaining the invert of the spillway inlet at a level commensurate with the existing tailings level and leading to a dam raise of approximately 4.8 to 9.4m. The second study considered minimizing any dam raise but resulted in a need for substantial tailings re-grading. These two concepts bracket the range of possible variants. Both technically feasible and have similar potential effects. While the final design of these elements will require further study beyond what has been completed to date, it is likely that the spillway design will be somewhere between Options 1 and 2, with the expectation that the spillway inlet invert will have to drop several metres to limit the ID crest raise to an elevation at or below the elevation of the existing RCDC crest.

The spillway width is likely to be in the order of 20 to 30m wide and will route the flood around the Intermediate Dam and into the drained Cross Valley pond area. It is intended that the spillway will be located such that the maximum PMF flow depth is within bedrock. Available data suggests that the bedrock is relatively susceptible to physical degradation due to freeze-thaw processes. Therefore, portions of the spillway may have to be concrete lined.

Current information suggests that the crest of the ID will likely be raised by between 2 and 4.6m (the elevation of the RCDC). For any dam raise, the core will be raised by tying in additional glacial till with the existing till core. At approximately el. 1032m, there is a drainage layer, with an overlying filter layer, within the downstream portion of the existing ID. The detailed design of the ID raise

will account for the extension of this drainage/filter layer through the material placed on the downstream face of the ID as part of the dam raise. Erosion protection will be placed on the downstream face of the ID.

7.7.7 Secondary Dam

There is loose soil in the foundation of the Secondary Dam. The dam foundation in the area near the inlet to the RCDC requires upgrading to provide an adequate safety factor against foundation liquefaction, and potential dam failure, during the Maximum Credible Earthquake (MCE). Dynamic compaction methods will be used to improve foundation strength.

7.7.8 Cross Valley Dam

The CVD will be breached in order to allow water to egress from the Intermediate Dam spillway and enter the Rose Creek downstream of the CVD. The extent of the breach may vary depending on the potential need for the material that comprises the CVD. The CVD is comprised of approximately 260,000 m^3 of material that is available for use in a raise of the ID or, if necessary, on other aspects of mine closure.

Prior to breaching the Cross Valley Dam, the Cross Valley polishing pond will be drained and the sludge and sediments, which may have accumulated over the years, removed to allow the construction of the ID Raise. The sludge and sediments will be disposed at the existing sludge pond to the north of the tailings impoundment.

7.7.9 Tailings Cover

A cover will be placed over the Rose Creek Tailings area with the objectives of preventing direct contact by wildlife and birds with the tailings and to minimize contaminated runoff. The general design concept for the tailings cover entails a 0.5m thick waste rock trafficability layer and a 1.5m thick layer of loosely compacted till.

Most of the trafficability layer will be placed in late winter when the tailings are frozen. Rock drain placement over the Intermediate Tailings will advance in a general downslope direction, starting in the vicinity of the Faro Creek channel. Fewer constraints are likely needed at the Original and Secondary Impoundments. During final design of the cover, some adjustments may be deemed appropriate, such as the possible elimination of the waste rock trafficability layer from all or part of the Original and Secondary Impoundments where drainage and trafficability conditions are better than other areas.

Some areas of the tailings surface are currently utilized for storage of water treatment sludge. This material will remain on the tailings with the cover placed on top. Some spreading and/or incorporation of the sludge material will be necessary prior to cover placement.

A 1.5m thick layer of loosely compacted till will be placed over top of the waste rock, but the timing of the till placement will depend on the condition of the tailings below the waste rock, as well as the thickness of the waste rock layer. To the maximum extent practical, the placement of the till cover will follow the advance of the rock cover. The till layer will subsequently be vegetated using, to the extent possible, vegetation types appropriate for the region and the needs of wildlife.

It is expected that some level of maintenance will be required until the vegetation has become established and is significantly stabilizing the till cover. It is also expected that differential settlement will occur over time. The cover should be capable of handling the differential settlement with little or no impact. If depressions form that result in ponds, these will be filled in with additional till as part of long-term cover maintenance.

However, in response to a large earthquake, it is possible that the ruptures and/or boils may form in the surface of the tailings cover. Should this occur, it is likely that some tailings will report to the surface of the cover. The volume of tailings will depend on a variety of factors, such as the magnitude and duration of the earthquake, the location of the water table and the condition of the cover relative to the time of year.

The slopes on the downstream face of the Secondary Dam are presently too steep to accommodate the construction of a stable cover. These slopes will be modified by regrading and the possible relocation of tailings to develop an overall slope that will be suitable for the placement of a stable tailings cover.

Long-term water management on the tailings will require refinement once the cover is in place, but some components are anticipated to be necessary. Groundwater discharge areas will require the construction of a sub-cover drainage layer that will facilitate the capture and conveyance of this groundwater for treatment. Water which reports to the bottom of Faro Creek canyon will be intercepted before it flows onto the tailings area. This approach will be adjusted if closure measures in the ETA lead to clean water at the mouth of the canyon.

While the long term objective is for all water which reports to the surface of the tailings area to pass over the tailings cover and flow through the spillway into Rose Creek, it is expected that during closure implementation and for some unknown period thereafter, this water will require treatment prior to discharge. For this reason, water which reports to the surface of the tailings area during closure implementation and for some unknown period thereafter will be directed to the pond upstream of the ID where it will be collected for treatment. Based on this expectation, it is likely that the current ID pond will be modified in order to reduce the total capacity of the ID Pond and, probably, to isolate the tailings from the pond water.

7.7.10 Groundwater Collection

A seepage interception system (SIS) will be installed across the Rose Creek Valley in the vicinity of the Intermediate Dam (ID) and Cross Valley Dam (CVD) alignments. The timing of final design, construction and upgrade of this system will be guided by the Adaptive Management Plan.

The SIS will consist of a cut-off wall keyed into bedrock and an up-gradient shallow, permeable trench with a series of pumping wells that direct water either to a central sump or directly into a pipeline, from which water will be pumped to the Faro Pit or directly to the WTP during the treatment period of the year (early spring to early winter). The cut-off wall will be constructed in the vicinity of the Intermediate Dam/Cross-Valley Dam and will include grouting of bedrock to minimize bypass. The permeable collector trench will be installed up gradient of the cut-off wall. It will be at least 5m deep and 1m wide and backfilled with a permeable material. Once the SIS is operational, it is intended to maintain a hydraulic barrier to transmission of contaminants downstream to Rose Creek: i.e. the hydraulic heads downstream of the cut-off wall will be higher than those upstream.

A monitoring system will be installed up and down gradient from the collector system to assess performance and identify system bypass. The results of the monitoring program will be used to assess the need for further additions or upgrades to the system, in accordance with the Adaptive Management Plan.

In the event of site-wide power failure and shut-down of the SIS, sufficient temporary power will be available to pumping of contaminated water to either the ID pond or to the Faro Pit.

The Rose Creek Aquifer collection system will be the furthest down-gradient collection system at the Faro Mine site. All water that escapes collection systems in the mine area will eventually report to the Rose Creek Aquifer. Available information from groundwater investigations and pumping tests indicates that the Rose Creek Aquifer is primarily a sand and gravel aquifer with good connectivity, making it a good location for effective groundwater collection. The IPRP supported reliance on collection in this area as the ultimate defence against contamination of Rose Creek.

7.7.11 Water Treatment

Water treatment for the entire Faro Mine portion of the property will rely on an amalgamated water treatment system. The proposed approach is described in Section 7.3.6 and incorporates treatment needs for the Rose Creek aquifer. As noted in that section, the second phase of the treatment system may need to be constructed to address capacity requirements for Rose Creek aquifer collection, but this is dependent on the timing of treatment requirements from a variety of sources. The Adaptive Management Plan will provide adequate warning to allow careful design, planning and implementation of appropriate water treatment capacity.

7.7.12 Miscellaneous Tailings Closure Activities

Preliminary Design and Construction Methods

Section 7.3.7 describes a number of miscellaneous closure activities that will be conducted across the entire site (e.g. building removal, road decommissioning). These activities will be completed in the tailings area as needed. Some additional miscellaneous activities that will occur in the tailings area include:

- The tailings in the Faro Creek Canyon, downstream of the Emergency Tailings Area, will be "flushed out of the canyon and deposited on the surface of the tailings area prior to covering."
- Vegetation within the RCDC channel and on the downstream face of the ID will be removed.
- Post-closure maintenance will be a required as and when necessary. This is likely to include, but not be limited to, spillway maintenance, cover repair (from erosion), vegetation removal from the RCDC and ID face.
- Annual geotechnical inspections will be required for key structures, such as the ID, RCDC and the ID spillway.

7.8 Closure Activities for the Vangorda/Grum Mine Area

The following sections describe the proposed closure activities for the Vangorda mine area. The Vangorda Pit will remain in place and serve as a storage reservoir for contaminated water and a permanent repository for water treatment sludge. The Grum Pit will also remain in place with contaminant removal using biological treatment. Vangorda Creek Diversion and other local diversions will be upgraded to convey clean water around the site. Waste rock will be re-graded and covered. The Grum Overburden Dump will be removed for used as cover material and the site reclaimed. Groundwater and seepage collection systems will be established as needed and contaminated water will be treated for discharge to Vangorda Creek. A variety of other activities will also be part of the closure plan: e.g. pit safety berms, building demolition and hydrocarbon contaminated soil remediation. Figure 7.6 and the sections below provide an overview of the closure activities for the Vangorda/Grum Mine area. A more in-depth discussion including rationale for the activities described below can be found in the full Project Description document.

7.8.1 Vangorda Pit

A safety berm will be constructed around the Vangorda Pit to reduce the risks associated with people and animals accessing the pit. The berm will be about 2.0m high with 2H:1V side slopes.

The Vangorda Pit will be a permanent pit lake, and will be used as a reservoir for contaminated water from the Vangorda and Grum Mine areas. This will include water accumulating in the pit itself as well as water collected from the Vangorda and Grum waste rock dumps. Timing for collection of contaminated water from these and other locations will be decided in accordance with the Adaptive Management Plan. Stored contaminated water from collection systems will be pumped

from the pit during the summer for treatment before being released to Vangorda Creek. Water levels in the pit will be managed to provide sufficient capacity for contingency contaminated water storage needs and for flood storage, as required by the proposed Vangorda Creek Diversion design.

The Vangorda Pit will also serve as the permanent repository for water treatment sludge from the new high density sludge water treatment system. A tremie system would be used to place the sludge near the pit bottom, and prevent mixing with the water column. The volume available in the pit is estimated to be about 6,000,000 m3 providing capacity for over 1000 years of sludge storage.

7.8.2 Grum Pit

A safety berm will be constructed around the Grum Pit to reduce the risks associated with people and animals accessing the pit. The berm will be about 2.0m high with 2H:1V side slopes.

The Grum Pit will be a permanent pit lake, accumulating water from the local catchment which will eventually fill the pit to spill elevation in the Slot Cut portion of the pit. Biological treatment, entailing the addition of fertilizer to the pit during the summer, began in 2004 and will continue during the closure project. The enhanced algal growth in the pit has decreased the overall depth weighted concentrations of zinc from 10 mg/L at the start of the program to 6.5 mg/L at the end of the 2008 program, while maintaining minimal nutrient concentrations in the water column.

Current estimates indicate that biological treatment will produce water of satisfactory quality for discharge to Vangorda Creek. At first, this discharge will require seasonal management, with discharge at appropriate times during the active biological season to ensure low metal and nutrient contaminant levels. A series of polishing ponds will be constructed in the Slot Cut which will allow any biomass trapped in the pit to be settled prior to discharge into natural drainage, though past water quality conditions in late summer indicate that this may not be necessary. The polishing ponds will be wetland type feature constructed in a terraced configuration to slow the flow of water so the biomass can be consumed prior to discharge to the environment. Eventually, the contaminant removal balance may allow establishment of a flow-through pit with no further requirements for biological treatment or seasonal discharge management.

Water treatment in the Grum Pit will be managed in accordance with the Adaptive Management Plan with water treatment using lime addition in a water treatment plant as a contingency treatment method.

7.8.3 Clean Water Diversion

Vangorda Creek Diversion

Vangorda Creek must be permanently diverted from its natural alignment that flows into the highly contaminated Vangorda Pit. The risks associated with failure of the any and subsequent flooding of the pit and overflow of water into Vangorda Creek are important considerations in planning for Vangorda Creek Diversion upgrades. Water quality risks in lower Vangorda Creek necessitate a

design concept that will allow safe management of extreme flows up to the PMF. The proposed concept recognizes the technical challenges and costs associated with construction of a PMF channel for Vangorda Creek. Energy dissipation and erosion protection in the steep lower portion of this diversion present a significant challenge.

The proposed diversion concept entails safe management of peak flood events by providing a combination of flood routing and storage for future treatment. The main component of the system will be construction of a new Vangorda Creek Diversion alignment following a near-surface route northwest of the Vangorda Pit, with grades varying from 1.5 percent in the upper reaches to a relatively steep grade of 11% in the lower reach. This channel would have capacity for flows up to 1:100 to 1:200 year flood events (final choice of sizing to be optimized in final design). A stepped chute approach has been considered for energy dissipation in the steep sections of the diversion but the overall length of this steep section and the fact that no similar type of structure has ever been attempted create challenges even for a channel to convey these proposed flows.

To address flows larger than 1:100 to 1:200 year floods, the intake structure for the diversion will be constructed with an overflow system. All flows larger than the peak flows for the design events, would overtop the overflow at the intake and would flow down the original Vangorda Creek channel into the Vangorda Pit. The Vangorda Pit provides adequate capacity to store the incremental volume of water that would accumulate in events larger than the design events for the diversion channel. While this water would become contaminated and require treatment in the water treatment system, events would be infrequent. For all predicted flows, the system would prevent overflow of contaminated water into Vangorda Creek. Note that the proposed overflow at the intake for the Vangorda Diversion is fundamentally different from the fuse plug proposed for the Rose Creek Diversion: the Vangorda Diversion overflow would be erosion resistant and the diversion channel would continue to convey water up to its full capacity (1:100 to 1:200 year) while the Rose Creek Diversion fuse plug would be erodible and the remaining flow in the Rose Creek Diversion Canal would be minimal.

Surface Runoff Interceptor Ditch to Dixon Creek

Uncontaminated surface runoff from the northeast side of the Vangorda will be diverted to the south and into Dixon Creek via the Dixon Creek Diversion. The channel will be upgraded to pass the 1:500 year storm. This will require a minimum of 1.5m in channel depth and a base width of at least 1.5m. Depending upon the results of the seepage investigation, the base materials in the channel may also need to be upgraded. A filter material and riprap sized for the flows in the channel will be placed in order to prevent erosion.

Grum Interceptor Ditch

The Grum Interceptor currently diverts clean water around the Grum Pit and Grum Overburden. Once Grum pit chemistry supports a flow-through operating system, the Grum Interceptor Ditch will be breached to allow water to flow into and through the Grum Pit. An earth dam will be built at the headworks using low permeability material from a local borrow area. The earth dam will reroute the

runoff from the original diversion channel to the new interceptor. The water will run off the pit walls and into the pit. Slots will be cut into the pit bench crest if necessary to let the water flow through. Channels will be excavated along flat sections of the alignment and berms will be constructed if excavation is not possible.

7.8.4 Waste Rock Remediation

All waste rock at the Vangorda/Grum Mine area will be covered. A variety of cover types will be applied to various waste rock elements, utilizing appropriate cover types as described in Section 7.2.1. Cover placement will require re-sloping of waste rock. For low and very low infiltration covers, slopes will be no steeper than 3H:1V except in circumstances where steeper slopes are required. For rudimentary covers, outer slopes will be re-graded to no steeper than 3H:1V where practical and inner slopes will be no steeper than 2H:1V.

After contouring and re-sloping, all waste rock areas will be covered as soon as practical in order to minimize potential adverse water quality impacts. The Grum Overburden dump will be the source for soil cover material. Surface water will be managed by lined and unlined plateau channels and a number of armoured slope channels to minimize erosion. Despite erosion control measures, some sediment control using ditches and basins will also be necessary, especially during freshet and storm events. Vegetation will be applied in accordance with the RLU designations as described in Section 7.2.1.

The remediation methods for Vangorda/Grum Mine area waste rock elements are illustrated on Figure 7.6 and described in Table 7.2. Additional detail is provided in the text below.

It should be noted, however, that final selection of the cover type is still subject to further review and technical evaluation.

Table 7.4: Vangorda/Grum Mine Waste Rock Remediation Methods

Vangorda/Grum Mine Waste Rock Element	Surface Area (m^2)	Closure Treatment
Vangorda Main Dump Sulphide Cell	39,900	Very Low Infiltration Soil Cover
Baritic Fines	2,431	Very Low Infiltration Soil Cover
Vangorda Dump	232,125	Low Infiltration Cover
Vangorda Pit Waste Rock Piles	40,463	Low Infiltration Soil Cover
Grum Dump Sulphide Cell	187,000	Low Infiltration Soil Cover
Grum Dump (excl. Sulphide Cell)	1,046,600	Rudimentary Cover
Ore Transfer Pad	107,000	Low Infiltration Cover

7.8.5 Vangorda Main Dump Sulphide Cell and Baritic Fines

The sulphide cell and baritic fines are significant sources of contaminants at the Vangorda Dump and will receive very low infiltration soil covers consisting of a barrier layer of approximately 2.5m of compacted till. The infiltration barriers will be covered with a 0.3 to1m-thick growth medium that will be seeded and fertilized. Target infiltration is less than 0.5% of mean annual precipitation.

7.8.6 Vangorda Main Dump

The remaining portions of the Vangorda Dump will be re-graded and covered with a low infiltration soil cover consisting of a 1 to 1.5m of compacted till covered with a 0.3 to 1m thick growth medium that will be seeded and fertilized. Most of the main dump slopes will be regraded to 3H:1V by pushing material from the crest down towards the toe area. There are some areas of the dump where the toe cannot be extended and material will be pushed sideways or hauled. Slightly steeper slopes (i.e. 2.7H:1V) may be required in these areas to minimize the amount of material that has to be hauled or pushed sideways.

7.8.7 Vangorda Pit Waste Rock Piles

There are some small waste rock dumps in the southeastern portion of the Vangorda Open Pit. The pit lake will not rise far enough to cover these dumps with water, so they will be regraded to 3H:1V slopes and covered with a low infiltration cover consisting of a 1 to 1.5m of compacted till covered with a 0.3 to 1m thick growth medium that will be seeded and fertilized.

7.8.8 Grum Dump Sulphide Cell

The Grum waste rock was constructed with a segregated sulphide cell containing waste rock that is more reactive and therefore a more significant source of contaminants. A low infiltration cover is planned for the Grum sulphide cell, though a more robust cover is under consideration as part of early remediation activity. Construction of a more robust cover in this location would provide valuable information about construction requirements for these types of covers. The planned low infiltration cover would consist of a 1 to 1.5m of compacted till covered with a 0.3 to 1m thick growth medium that will be seeded and fertilized.

7.8.9 Grum Dump (Excl. Sulphide Cell)

Aside from the sulphide cell, the Grum Dump is not considered to be a major source of future contamination. This waste rock will be covered with a rudimentary cover consisting of 0.3 to 1m of till that will provide a growth medium for re-vegetation. Prior to placement of the cover, the dump slopes will be regraded to a 3H:1V for outer slopes, with internal dump slopes up to 2H:1V. A portion of the slope running next to the “Main Stem of Grum Creek” will be pulled back as shown on Figure 7.6. The toe of the slope cannot be pushed forward as it is close to the creek.

7.8.10 Ore Transfer Pad

Design Criteria

The Grum Ore Transfer Pad (GOTP) on the northwest side of the Grum Pit consists of an estimated 1,259,000m^3 of remaining ore and phyllite waste rock. The remaining ore material has not been well quantified, but could be a sources of elevated contaminant concentrations. The pad will receive a low infiltration cover consisting of a 1 to 1.5m of compacted till covered with a 0.3 to 1m thick growth medium that will be seeded and fertilized.

7.8.11 Grum Overburden Dump

The Overburden Dump is the primary source of glacial till borrow material for cover construction at all areas of the FMC (i.e. Tailings, Faro Mine, Vangorda Grum Mine). It is anticipated the all the material present in the Overburden Dump will be used. Furthermore, current till borrow requirements call for an additional 1Mm^3 of till to be excavated from beneath the overburden dump. Once all borrow material at the dump has been removed, the area will be re-graded and re-vegetated.

7.8.12 Contaminated Water Collection

A general description of the approach for contaminated water collection is provided in Section 7.2.2. Specific plans for contaminated water collection in the Vangorda/Grum Mine area are described in this section. Water from all of these collection points indentified will be pumped to Vangorda Pit for storage and subsequent treatment, or directly to a treatment plant. These sections describe areas with current plans for collection systems. The Adaptive Management Plan may identify additional areas that require treatment and these would be added as appropriate throughout the life of the Project.

7.8.13 Grum Waste Rock Seepage and Groundwater Collection

An existing ditch collects seepage at the southeast corner of the Grum Waste Rock Dump and diverts it to a natural topographic depression (Moose Pond) where it exfiltrates to ground. The groundwater flow path has a gradient towards Vangorda Creek and collection of contaminated water will likely be required in the near future. As with other areas of the site, seepage and groundwater interception systems will be established in accordance with the Adaptive Management Plan. The similar plan established in 2004 led to construction of the collection facilities currently in place. The interception system will focus initially on high concentration areas and likely utilize pumping wells with a centralized sump in the vicinity of where Grum Creek crosses the access road. Water would be pumped, year-round, from the sump to Vangorda Pit. A cut-off wall and/or permeable collector trench could be constructed uphill of the access road should more effective collection be required.

Because current contaminant concentrations in Grum Waste Rock seepage are relatively low, investigations are under way to evaluate local in-situ treatment methods that would delay the need to pump water directly to Vangorda Pit. Should these prove effective, they may be implemented as interim measures.

7.8.14 Vangorda Waste Rock Dump Seepage Collection

There is currently a seepage collection system in place at the Vangorda Waste Rock Dump. This system consists of French Drains which funnel the seepage into a seepage collection ditch that discharges to Little Creek Pond. A permanent seepage collection system will be required for the Vangorda Waste Rock Dump once it is reclaimed. Part of the reclamation will include new seepage collection wells at the toe of the pit dump slopes to collect and pump water to the pit. Little Creek Dam, the current seepage collection reservoir will continue to operate as an interim sediment control facility for several years after closure is complete, but will eventually be decommissioned.

Active collection of groundwater from the Vangorda Waste Rock Dump is currently not required, but may become necessary in the future if contaminant concentrations increase sufficiently. This uncertainty will be addressed in the Adaptive Management Plan. Initial collection systems would likely consist of groundwater wells pumping to Vangorda Pit.

7.8.15 Vangorda Pit Dumps

Seepage collection wells will be established at the toe of the re-graded pit dump slopes to collect contaminated water from these materials for pumping to Vangorda Pit.

7.8.16 Grum Pit

Contaminated water management for the Grum Pit catchment is addressed in Section 7.5.2.

7.8.17 Water Treatment

As described in Section 7.2.4, lime addition with high density sludge production has been selected as the primary water treatment methodology for application at the FMC. In the Vangorda/Grum Mine area, the existing water treatment plant will continue to operate during the initial years of the closure implementation and potentially throughout that period.

The timing and scale of future treatment requirements especially from the Grum Waste Rock means that any plans for water treatment on the Vangorda/Grum side of the property will need to be adaptable. Construction related activities will add additional uncertainty. Potential additional collection and treatment requirements from the Vangorda Dump and/or the Grum Pit could also affect water treatment needs. Finally, the need for contingency treatment to address inflow of clean water from Vangorda Creek during extreme floods needs to be considered.

Over the last several years, running the 2000 USgpm plant for treatment periods of only 60 days or less has been sufficient to control or even draw down the water level in the Vangorda pit. With the addition of an improved clarifier, it is reasonable to expect that the current plant has adequate capacity to treat all flows from the Vangorda area during the closure period. The Grum pit passive treatment system has proven to be highly effective at removing zinc from the surface water and shows promise for being the only treatment required for Grum Pit. If this treatment approach is

successful, as the pit fills, it will become necessary to engineer a system for seasonal release of the treated water.

Once closure measures are complete, an active treatment system would definitely be required for the Vangorda flows, but it is possible that it may be much smaller than the current system. Depending on the flows needing treatment, the plant could have a capacity of 500 to 1700 USgpm.

A number of contingency measures have been identified that could be used to address additional water treatment capacity requirements. Early in the project, this may include construction of expanded clarifying capacity that could be used by the existing water treatment plant. This could be constructed at the location of the proposed new treatment plant for future use. Also, a 2500 USgpm treatment plant may eventually be required of lime treatment of all flows at the Vangorda/Grum site is needed.

Once the new treatment system is operational the sludge will be disposed in the Vangorda pit. A tremie system would be used to place the sludge near the pit bottom, and prevent mixing with the water column. The volume available in the pit is estimated to be about 6,000,000 m^3 providing capacity for over 1000 years of water treatment.

The interim operation of the existing treatment system will continue to produce sludge with much lower density. For similar reason to those discussed for the Faro Mine area, this sludge is not suitable for storage in the Vangorda Pit. Sludge produced from the existing treatment system is currently stored in impoundments on waste rock. Storage of sludge at suitable locations on waste rock is expected to continue for the duration of operation of the existing treatment system. The excess alkalinity in the sludge will neutralize some acid potential in the waste rock.

7.8.18 Vangorda Haul Road

The Vangorda Haul Road between the Faro and Vangorda/Grum sites comprises waste rock fill that is typically about 30m wide and ranges in height from less than 10m to about 56m above original ground. The closure plan for the haul road entails breaching all watercourse crossings including the North Fork Rock Drain, and re-vegetating the areas disturbed during this work. The safety berms on the road will be flattened and all flat surfaces of the remaining parts of the haul road will be scarified and re-vegetated. Access trails will be re-established to allow traditional and local land use activities. Final decisions have not been made about re-sloping of side slopes on the haul road.

There is a minimum amount of Potentially Acid Generating rock within the fill and this is not considered a significant issue. It is expected that some of the non-acid generating material will be used as borrow material for other closure activities.

7.8.19 Miscellaneous Vangorda/Grum Closure Activities

Section 7.3.7 describes a number of miscellaneous closure activities that will be conducted across the entire site (e.g. building removal, road decommissioning). These activities will be completed in the

Vangorda/Grum area as needed. Some additional miscellaneous activities that will occur in the Vangorda/Grum area include:

- Removal and proper disposal of existing sludge located on the Grum Overburden Dump. During closure the sludge will be removed from the existing cells and tremmied to the bottom of the Vangorda Pit.
- Breaching the dams at the Sheep Pad Ponds (sediment ponds) and WTP Settling Pond when they are no longer required.

7.9 Borrow Material Requirements and Sources

Closure activities for Faro Mine Complex will require large volumes of natural material for construction of elements such as covers and channel protection.

The following lists the different types of material that would be used for closure activities:

- Glacial till for low permeability covers, vegetative covers, stabilizing or general fill;
- Granular soils for use in filter or drain material, stabilizing fill, general fill, road construction, protective covers for geosynthetic materials, erosion protection, and concrete aggregate;
- Coarse granular soil for erosion protection in channels (riprap) and road ballast;
- Organic soils for vegetative covers; and
- Waste rock used in the tailings cover, safety berms, and fuse plug construction.

Table 7.3 provides a summary of the available material types and quantities that have been identified at the Faro and Vangorda sites.

Tables 7.4 to 7.6 provide summaries of the source, type and quantity of material that will be required for the closure activities at each of the three areas.

Criteria used to select the final borrow sources include:

- Minimize disturbance area while maximizing volume;
- Avoid developing below grade and creating a crater which will collect and store water;
- Where material is excavated above bedrock maintain 0.5m of overburden for reclamation; and
- Rock quarries used for riprap should be geochemically tested prior to development.

When a borrow source is selected, standard industry practice will apply. Clearing and grubbing will be completed including salvaging the timber or disposing of it according to forestry practice. Topsoil and organics from the grubbing operation will be stockpiled nearby for later reclamation use. Surface water management practices will be adopted around all ground disturbances. The borrow area will be developed in benches according to equipment specifications and landscape. When the borrow/quarry is exhausted or work is completed, the slopes should be flattened to 3H:1V for

long-term stability and the surface shaped to encourage natural drainage. A 0.3m lift of organic material from the stockpile would be spread for revegetation.

Existing borrow areas will have minimal additional disturbance, but new borrow areas will create new areal disturbance. Table 7.7 below shows the areas that will be disturbed. All efforts will be made to minimize disturbance while developing new borrow areas.

Table 7.5: Borrow Material Balance

Sources	Material	Capacity (m^3)	Allocated (m^3)	Remaining Material (m^3)
Faro Area				
Rose Creek	Granular	1,400,000	1,110,000	290,000
Rose Creek Haul Road	Till	800,000	743,000	57,000
Tailings Borrow	Till	500,000	-	500,000
Haul Road	Granular	150,000	150,000	-
	Till	720,000	257,000	463,000
Faro WR Dumps				
Calc. Silicate areas (Areas 1,2,3,4)*	Waste Rock	600,000	62,000	538,000
NW Dumps	Waste Rock	681,000	681,000	-
Rose Creek Diversion Quarry*	Riprap	200,000	15,000	185,000
Vangorda/Grum				
Grum Overburden Dump (and Foundation)	Till	9,000,000	8,881,000	119,000
Vangorda Overburden Dump	Till	400,000	390,000	10,000
NE Area of Grum Pit	Till	1,500,000	-	1,500,000
Grum-Vangorda Back Road	Granular	100,000	-	100,000
Moose Pond Borrow	Granular	45,000	40,000	5,000
Grum Creek Borrow	Granular	200,000	170,000	30,000
Grum Dump Quarry	Riprap	30,000	24,000	6,000
Other				
North Fork Rock Drain (Calc. Silicate)	Waste Rock/Rip Rap	722,000	161,000	561,000
Intermediate Dam Spillway	Riprap	275,000	275,000	-
Cross Valley Dam Breach	Granular	38,700	38,700	-

*Estimated Capacity

Table 7.6: Summary of Borrow Material Requirements at the Faro Area

Location	Material Type							
	Glacial Till		Granular Soils		Coarse Granular (Riprap)		Waste Rock (Calc Silicate)	
	m^3	Source	m^3	Source	m^3	Source	m^3	Source
Faro Mine Area								
Faro Pit								
Safety Berm							22,000	NRFD
Mt. Mungly (W+E), South West Pit Wall Dump	283,436	Grum Overburden Dump						
Diversions								
Faro Creek Diversion			89,100	Haul Road Borrow	6,750	Faro WR Dumps		
West Valley Extension			4,263	Haul Road Borrow	3,553	Faro WR Dumps		
North Wall Interceptor			8,100	Rose Creek Borrow	10,800	Faro WR Dumps		
Guard House Creek								
Zone II Pit								
Collection Pipeline			273	Haul Road Borrow				
Oxide Fines								
LGSC A - Very Low Infiltration Cover	36,139	Vangorda Overburden Dump	21,683	Haul Road Borrow				
LGSC C - Very Low Infiltration Cover	109,541	Vangorda Overburden Dump	65,724	Rose Creek Borrow			454	Faro WR Dumps
ETA Tailings Area								
Collection Pipeline			722	Haul Road Borrow				
Sulphide Cells								
Main and Intermediate – Very Low	173,647	Grum Overburden Dump	104,188	Rose Creek Borrow				
East Cell – Very Low	17,441	Grum Overburden Dump	10,464	Rose Creek Borrow				
Faro Waste Rock Dumps								
Rudimentary Cover	2,366,797	Grum Overburden Dump			3,567	NFRD		
	152,706	Haul Road Borrow						
	420,000	Rose Creek Haul Road						
Groundwater Collection Systems								
North Fork Rose Creek	104,181	Haul Road Borrow	30,975	Haul Road Borrow	25,887	NFRD		
Zone II Outwash Collection System			70	Haul Road Borrow				
S-Wells Collection System			738	Haul Road Borrow	775	NFRD		

Table 7.7: Summary of Borrow Area Requirements at the Rose Creek Tailings Area

	Material Type							
Location	**Glacial Till**		**Granular Soils**		**Coarse Granular (Riprap)**		**Waste Rock (Calc Silicate)**	
	m^3	**Source**	**m^3**	**Source**	**m^3**	**Source**	**m^3**	**Source**
Rose Creek Borrow Tailings								
Dams								
Intermediate Dam Raise	63,000	Rose Creek Haul Road	38,700	Cross Valley Dam Breach	6,300	Rose Creek Diversion		
			744,300	Rose Creek Borrow				
Intermediate Dam Spillway			4,450	Rose Creek Borrow	8,900	Rose Creek Diversion		
Secondary Dam			2,339	Rose Creek Borrow				
Tailings								
Tailings Cover (0.5m WR, 1.5m Till)	2,867,445	Grum Overburden Dump					275,000	Intermediate Dam Spillway
							680,815	NW Dumps
Rose Creek Borrow Diversion Channel								
Upstream of Fuse Plug	45,000	Rose Creek Haul Road	162,615	Rose Creek Borrow	78,000	NFRD		
Erosion Dissipation Structure					38,000	Faro WR Dumps		
North Fork Rock Drain			1,177	Haul Road Borrow	1,962	Faro WR Dumps		
Fuse Plug	700	Rose Creek Haul Road	3,550	Rose Creek Borrow	700	Faro WR Dumps		
Raise Downstream portion of RCDC Dike	189,000	Rose Creek Haul Road						
Groundwater Collection								
Intermediate Dam Interception Trench			2,025	Rose Creek Borrow	30,375	NFRD		
Intermediate Dam Groundwater Collection System			2,211	Rose Creek Borrow				

Table 7.8: Summary of Borrow Material Requirements at the Vangorda Area

Location	Material Type							
	Glacial Till		Granular Soils		Coarse Granular (Riprap)		Waste Rock (Calc Silicate)	
	m^3	Source	m^3	Source	m^3	Source	m^3	Source
Vangorda/Grum Mine Area								
Vangorda Pit								
Safety Berm	15,000	Vangorda Overburden Dump						
Pit Waste Rock Cover (Low Infiltration)	132,281	Vangorda Overburden Dump						
Vangorda Dump								
Baritic Fines Synthetic Cover	3,485	Vangorda Overburden Dump	3,485	Moose Pond Borrow				
Waste Rock Cover (Low Infiltration)	1,197,077	Grum Overburden Dump			977	Grum Dump Quarry		
Sulphide Cell	53,311	Grum Overburden Dump	31,987	Moose Pond Borrow				
Vangorda Creek Diversion								
New Vangorda Diversion			3,203	Moose Pond Borrow	10,677	Grum Dump Quarry		
Upgrade Dixon Creek			2,104	Grum Creek Borrow	4,909	Grum Dump Quarry		
Grum Pit								
Safety Berm	20,000	Vangorda Overburden Dump						
Grum Interceptor Ditch	24	Vangorda Overburden Dump	2,359	Grum Creek Borrow	5,056	Grum Dump Quarry		
Grum Dump								
Sulphide Cell –Very Low Infiltration	271,746	Grum Overburden Dump	163,047	Grum Creek Borrow				
Main Dump - Rudimentary Cover	72,315	Vangorda Overburden Dump			2,708	Grum Dump Quarry		
	1,512,768	Grum Overburden Dump						
Ore Transfer Pad								
Rudimentary Cover	137,569	Grum Overburden Dump						
Groundwater Collection Systems								
Grum Dump GW Collection System	1,476	Vangorda Overburden Dump	2,450	Grum Creek Borrow				
Vangorda Dump GW Collection System			704	Moose Pond Borrow				
Water Treatment								
Faro Misc. Pipelines			975	Haul Road Borrow				
Faro/Tailings Plant Polishing Pond	25,689	Rose Creek Haul Road						
Vangorda/Grum Misc. Pipelines			517	Moose Pond Borrow				

Table 7.9: Areas of Disturbance at Faro, Rose Creek Tailings, and Vangorda/Grum

Location	Borrow Material Used	Estimated New Disturbance Area
Faro Area Sources	m^3	m^2
Rose Creek (Granular)	1,053,000	239,881
Rose Creek Haul Road (Till)	787,000	91,683
Haul Road (Granular)	149,000	49,567
Haul Road (Till)	604,000	34,727
Rose Creek Diversion Quarry (Riprap)	109,000	36,290
Faro Regrade	N/A	350,000
Vangorda/Grum Sources		
Vangorda Overburden Dump (Till)	400,000	65,998
Moose Pond (Granular)	6,000	4,202
Grum Creek (Granular)	7,000	3,456
Grum Dump Quarry (Riprap)	24,000	12,163
Other Disturbance Due to Construction		
Faro Creek Diversion	N/A	75,700
West Valley Interceptor Ditch	N/A	51,300
Intermediate Dam Spillway	28,624	27,654
Vangorda Creek Diversion	N/A	32,800
North Wall Interceptor Ditch	N/A	55,600
North Fork Rose Creek Upgrade	N/A	84,000
Grum Regrade	N/A	37,900

7.10 Project Execution Strategy

The Project Description includes a preliminary project schedule for the execution of the Faro Mine Complex Reclamation and Closure Project. It is expected that the sequencing of many of the closure and reclamation activities presented in this preliminary schedule will change before a final execution strategy is adopted. Social, environmental, economic and cultural factors have not been fully considered to-date and these are likely to influence final scheduling. However, in an attempt to provide some of the required information for the assessment the future socio-economic opportunities and some of the environmental effects of the project, the Project Description presents an overall activity sequencing strategy along with a closure cost estimate and cashflow. Preliminary estimates are also provided for equipment fleets, required workforce (e.g. employment levels for skilled workers, specialized trades and professionals), transportation requirements, fuel requirements, and lime requirements. Number of trucks trips required to mobilize equipment to site and an estimate of the number of fuel and lime delivery vehicles needed over the life of the project. The workforce estimate provides an annual breakdown of employment levels for skilled workers, specialized trades and professionals.

7.10.1 Strategic Sequencing Component Activities

Figure 7.7 (Preliminary Project Schedule), illustrates the currently anticipated schedule that provides for construction occurring over a 14 year period. It is expected that there would be a two to three year phase-in period to allow development of local capacity. This would likely occur between Year minus 1 to Year 1. After this period, work would be scheduled to provide continuity of expenditure and employment over the remainder of the implementation period. The implementation period would be followed by long-term care and maintenance. It is also expected that there would be an estimated 25-year transition period where a more hands-on adaptive management approach would be adopted before the site care and maintenance settles down to a long-term equilibrium. Site management and water treatment will be required in perpetuity.

There are a number of activities that have been classified as high priority and have currently been scheduled for early remediation between Year minus 3 and Year 1. These include the covering of the Grum Sulphide Cell and the construction of the upgraded Vangorda Creek Diversion. Removal of the tailings and underlying contaminated soil at the Emergency Tailings Area (ETA) may also be considered from early remediation. Additional activities may arise due to ongoing adaptive management programs, for example further advancement of the groundwater collection system at the S-Wells area.

A number of factors have been considered in developing this initial strategy for sequencing the major key closure activities other than the activities scheduled for early remediation. These factors include:

1. Prioritizing activities to optimize the reduction in the release of contaminants to the environment, targeting initial closure activities on the major sources of environmental contamination.
2. With respect to sources of contaminants to the aquatic receiving environment, the waste rock, particularly that at the Faro side of the property, is the largest source of contaminants. Of those the oxide fines, medium grade ore stockpile and Low Grade Ore Stockpiles A and B are a major source of water contamination at the site.
3. Reducing the risk associated with flooding in the tailings area and the associated loss of tailings to Rose Creek.
4. Identifying critical path items, interactions between the various closure components and inter-dependencies.
   - For example, the removal of the North Fork Rock Drain and its impact on the haul road from Vangorda. The removal of the rock drain will restrict vehicular access from Vangorda to the Faro Rock Dumps. Therefore alternate sources of clean waste rock such as the calcareous phyllite in the Northwest dump are being considered
5. Cash Flow and Workforce Requirements.

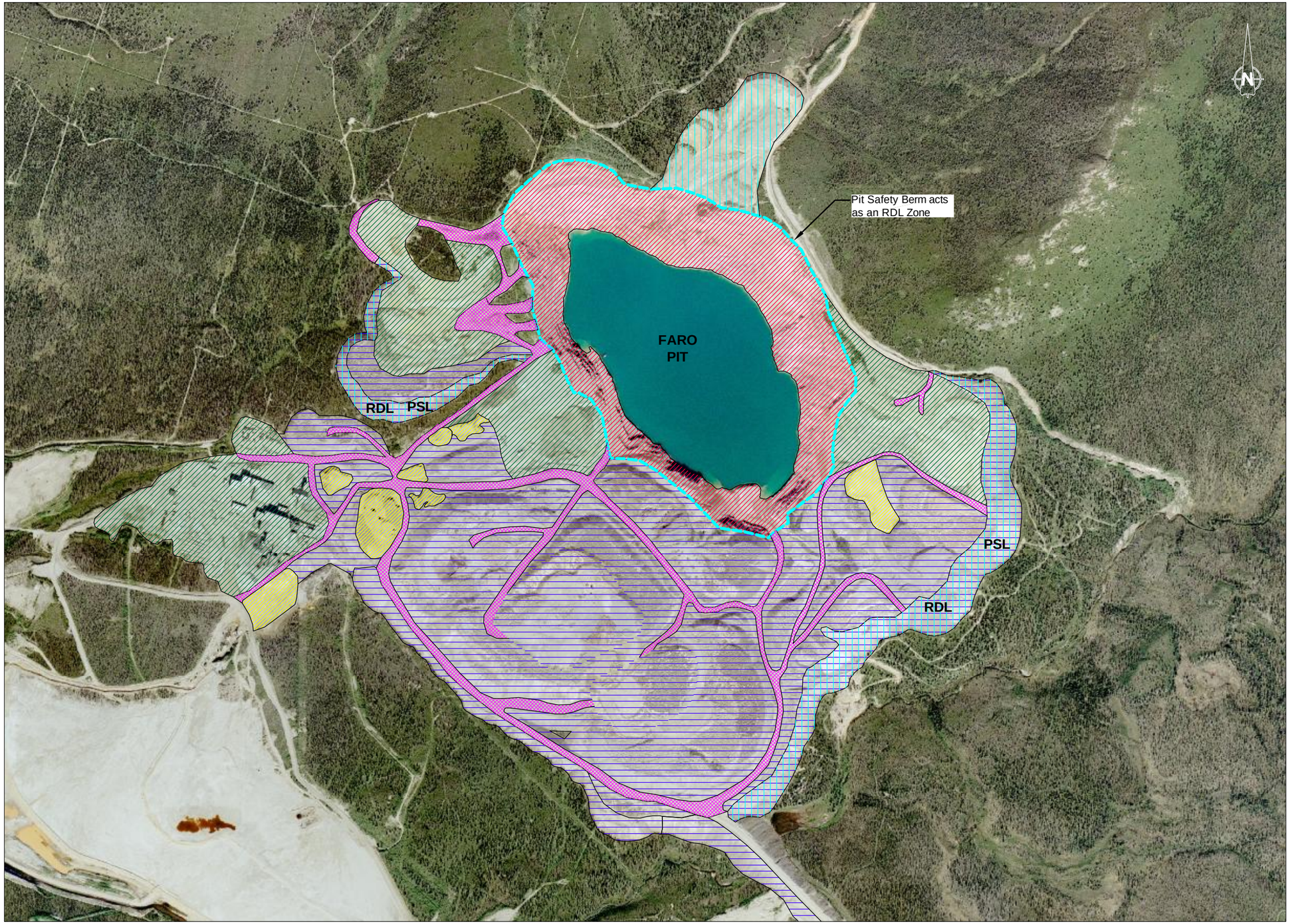
In consideration of the above factors, an overall schedule was developed as shown in Figure 7.7. Some key closure activities are discussed below.

The remediation of the oxide fines and the low grade ore stockpiles is one of the first activities to take place (Year 1). This was given a high priority as the waste is considered a major source of the water contamination on the site. Regrading, resloping and covering of the remainder of the remainder of the waste rock dumps at the Faro Mine area would follow in Year 2 to Year 6, focusing on higher source areas (East, Main and Intermediate Sulphide Cells) first.

Construction of the flood management structures associated with the Rose Creek Tailings facility would be initiated the following year (Year 2) to alleviate concerns about tailings release during a flood event greater than the current capacity of the Rose Creek Diversion Channel. This would involve construction of the Intermediate Dam Spillway, raising of the Intermediate Dam, breaching of the Cross Valley Dam and raising of the Rose Creek diversion dyke.

In order to maintain vehicular access from the Vangorda till borrow sources to the Faro dumps, breaching of the North Fork Rock Drain would not occur until the covers on the Faro waste rock dumps (including the oxide fines, low grade ore stockpiles and the sulphide cells) are completed. The closure plan calls for the trafficability layer in the tailings cover to consist of about 1 million cubic metres of large size granular material such as waste rock. As covering the tailings is considered a high priority, several potential borrow sources for the trafficability layer were considered. The current source of this material is the Northwest dumps and the excavation of the Intermediate Dam Spillway. The regrading and cover placement on the Grum and Vangorda waste rock dumps are also scheduled to start in Year 7. The existing water treatment facilities at both Vangorda and Grum would continue to operate during the construction period and would complement the two new plants at Faro and Vangorda. It is expected that the WTP at Faro would be built within the first few years of the closure implementation phase. The demolition of the Faro Mill buildings and reclamation of the resulting mill area would start in Year 11.

Figures



LEGEND

Landscape Features:

Code	Description
LSL	Leave As-is (stable)
LUL	Leave As-is (unstable)
REL	Relocate
PSL	Ensure Physical Stability
PDL	Promote Drainage
RDL	Restrict Drainage
PAL	Provide Access

0 200 400 600 800 1000

Scale in Metres

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026

FILE NAME: Faro_Landscape Features.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Faro Mine Area
Landscape Features

DATE:	APPROVED:	FIGURE:
Feb. 2010	PMH	7.1a

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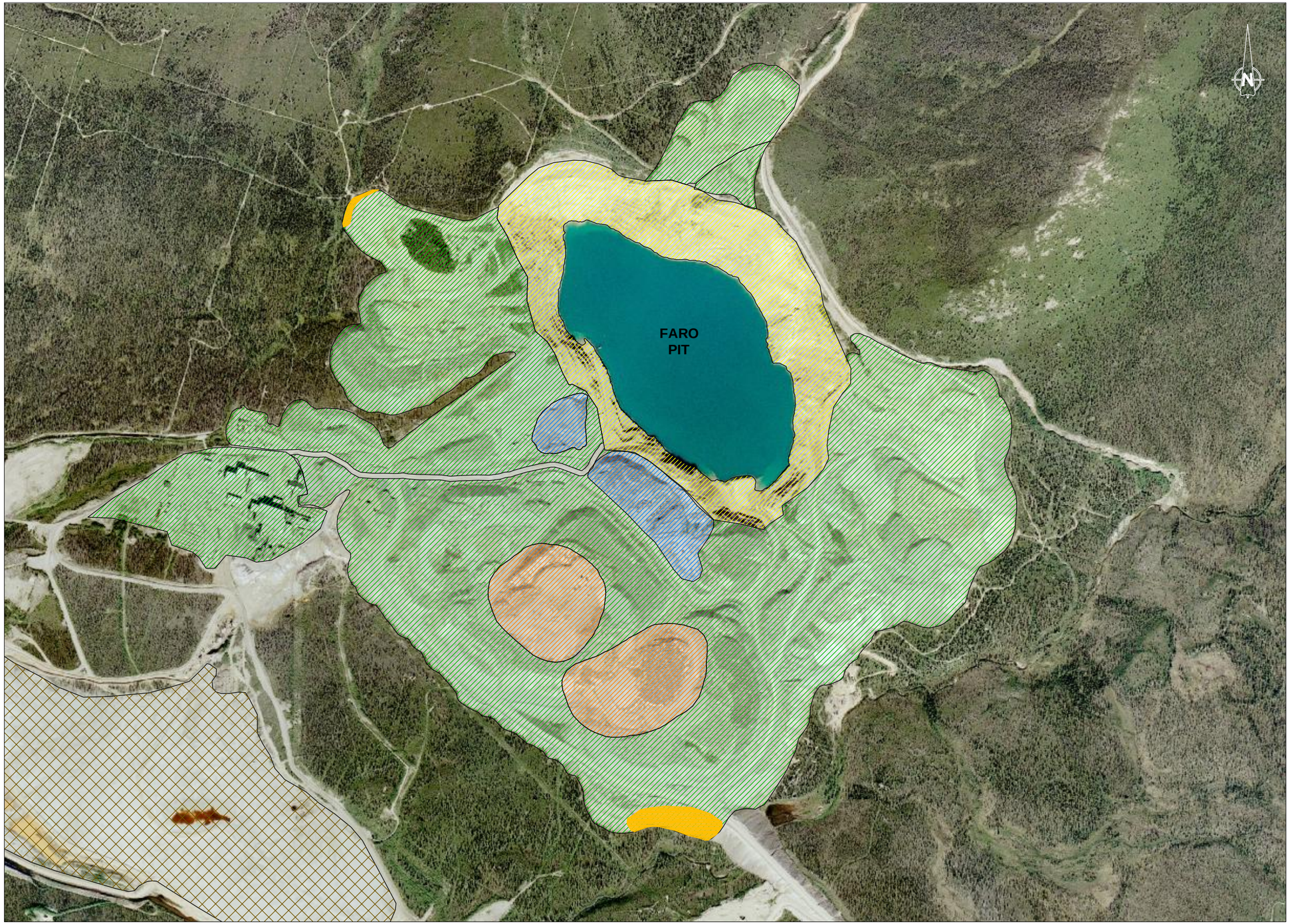

LEGEND

Cover Types:

Code	Description
NOC	No Cover
RUC	Rudimentary Cover (1m of Loose Till)
LIC	Low Infiltration Cover (1m of compacted Till overlain by 1m lightly compacted Till)
VLC	Very Low Infiltration Cover (Min. 2.5m compacted Till overlain by 1m loose Till)
TAC	Tailings
-	Waste Rock Slope Pulled-Back

0 200 400 600 800 1000

Scale in Metres

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026

FILE NAME: Faro_Grum Covers.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Faro Mine Area
Cover Types

DATE:	APPROVED:	FIGURE:
Feb. 2010	PMH	7.1b

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LEGEND

Vegetation Types:

Code	Description
NOV	No Vegetation
ALV	Agronomic Grass-Legume Mix
ANV	Annual Nurse Crop + Native Grass Mix + Native Woody Species
NGV	Native Grass Seed Mix
NWV	Native Grass Seed Mix + Native Woody Species
RIV	Riparian

Surface Treatment Types:

Code	Description
PLS	Planar - applied to slopes
RLS	Rough and Loose - applied to flat, stable sections and plateaus

0 200 400 600 800 1000
Scale in Metres

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026
FILE NAME: Faro_Grum Vegetation Cover.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Faro Mine Area
Vegetation Covers and Surface Treatments

DATE:	APPROVED:	FIGURE:
Feb. 2010	PMH	7.1c

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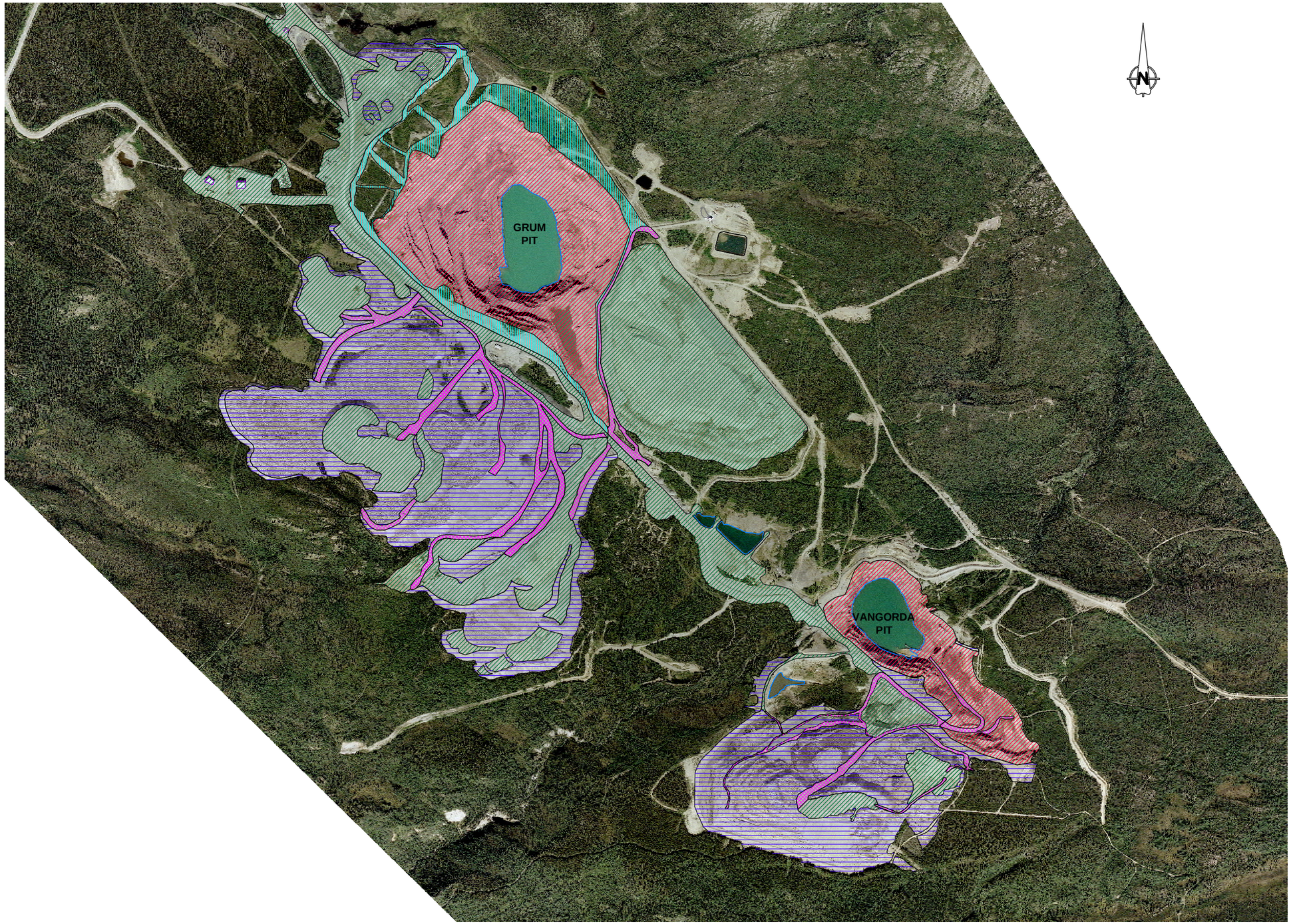

LEGEND

Landscape Features:

Code	Description
LSL	Leave As-is (stable)
LUL	Leave As-is (unstable)
REL	Relocate
PSL	Ensure Physical Stability
PDL	Promote Drainage
RDL	Restrict Drainage
PAL	Provide Access

0 200 400 600 800 1000

Scale in Metres

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026

FILE NAME: Faro_Landscape Features.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Grum and Vangorda Mine Area Landscape Features

DATE: Feb. 2010 | APPROVED: PMH | FIGURE: 7.1d

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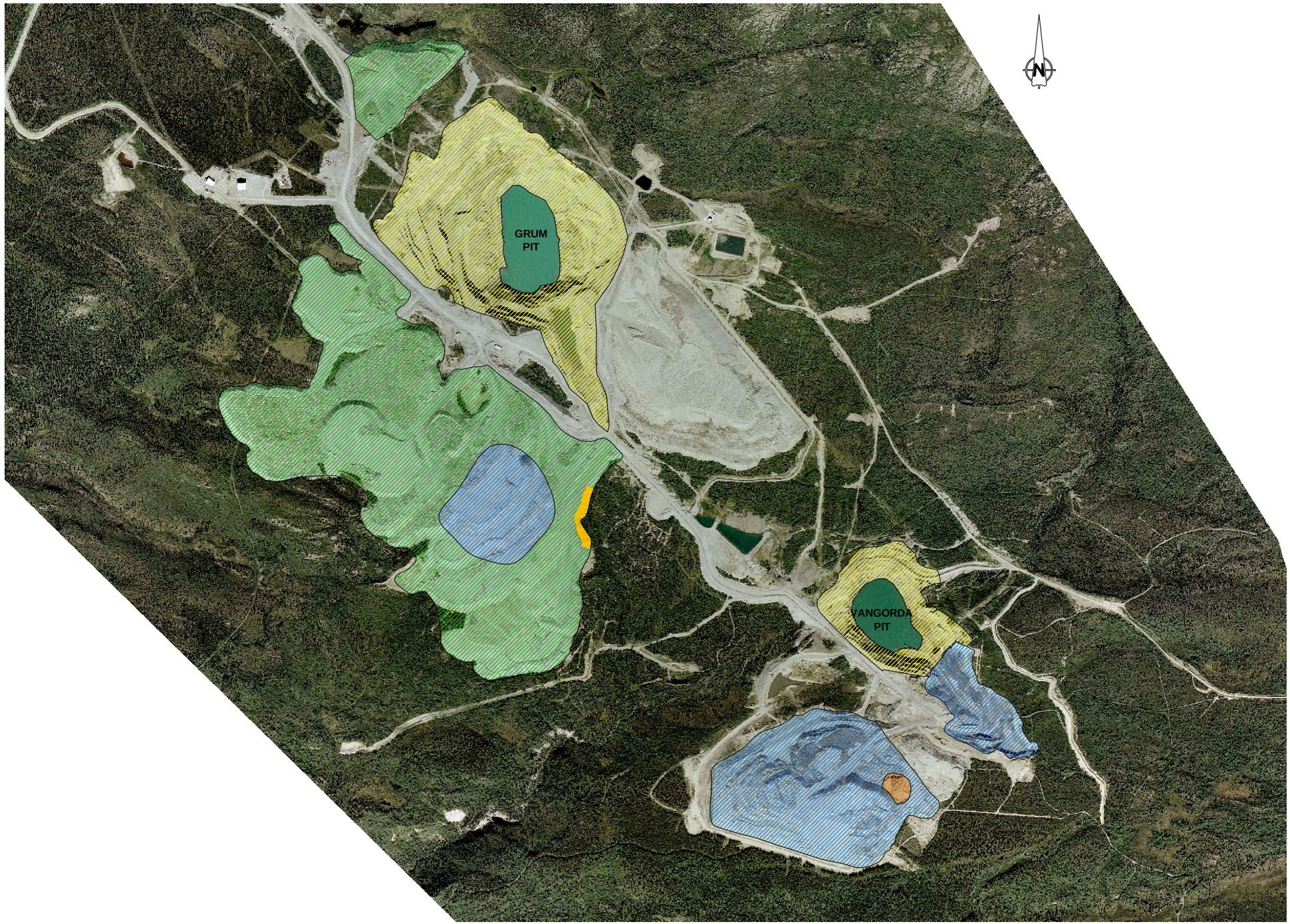

LEGEND

Cover Types:

Code	Description
NOC	No Cover
RUC	Rudimentary Cover (1m of Loose Till)
LIC	Low Infiltration Cover (1m of compacted Till overlain by 1m lightly compacted Till)
VLC	Very Low Infiltration Cover (Min. 2.5m compacted Till overlain by 1m loose Till)
-	Waste Rock Slope Pulled-Back

0 200 400 600 800 1000

Scale in Metres

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026

FILE NAME: Faro_Grum Covers.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Grum and Vangorda Mine Area Cover Types

DATE:	APPROVED:	FIGURE:
Feb. 2010	PMH	7.1e

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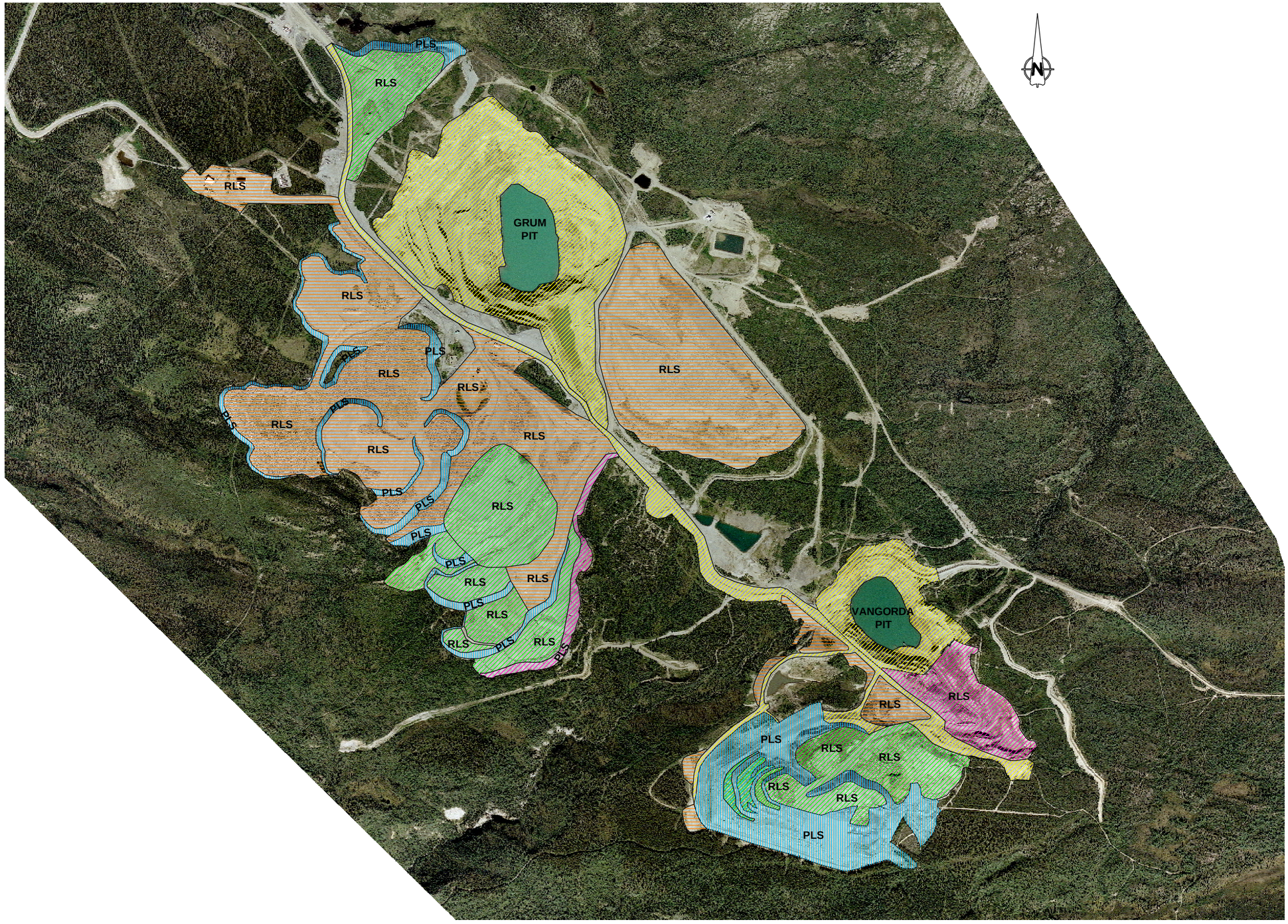

LEGEND

Vegetation Types:

Code	Description
NOV	No Vegetation
ALV	Agronomic Grass-Legume Mix
ANV	Annual Nurse Crop + Native Grass Mix + Native Woody Species
NGV	Native Grass Seed Mix
NWV	Native Grass Seed Mix + Native Woody Species
RIV	Riparian

Surface Treatment Types:

Code	Description
PLS	Planar - applied to slopes
RLS	Rough and Loose - applied to flat, stable sections and plateaus

0 200 400 600 800 1000

Scale in Metres

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026

FILE NAME: Faro_Grum Vegetation Cover.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Grum and Vangorda Mine Area Vegetation Covers and Surface Treatments

DATE: Feb. 2010 | APPROVED: PMH | FIGURE: 7.1f

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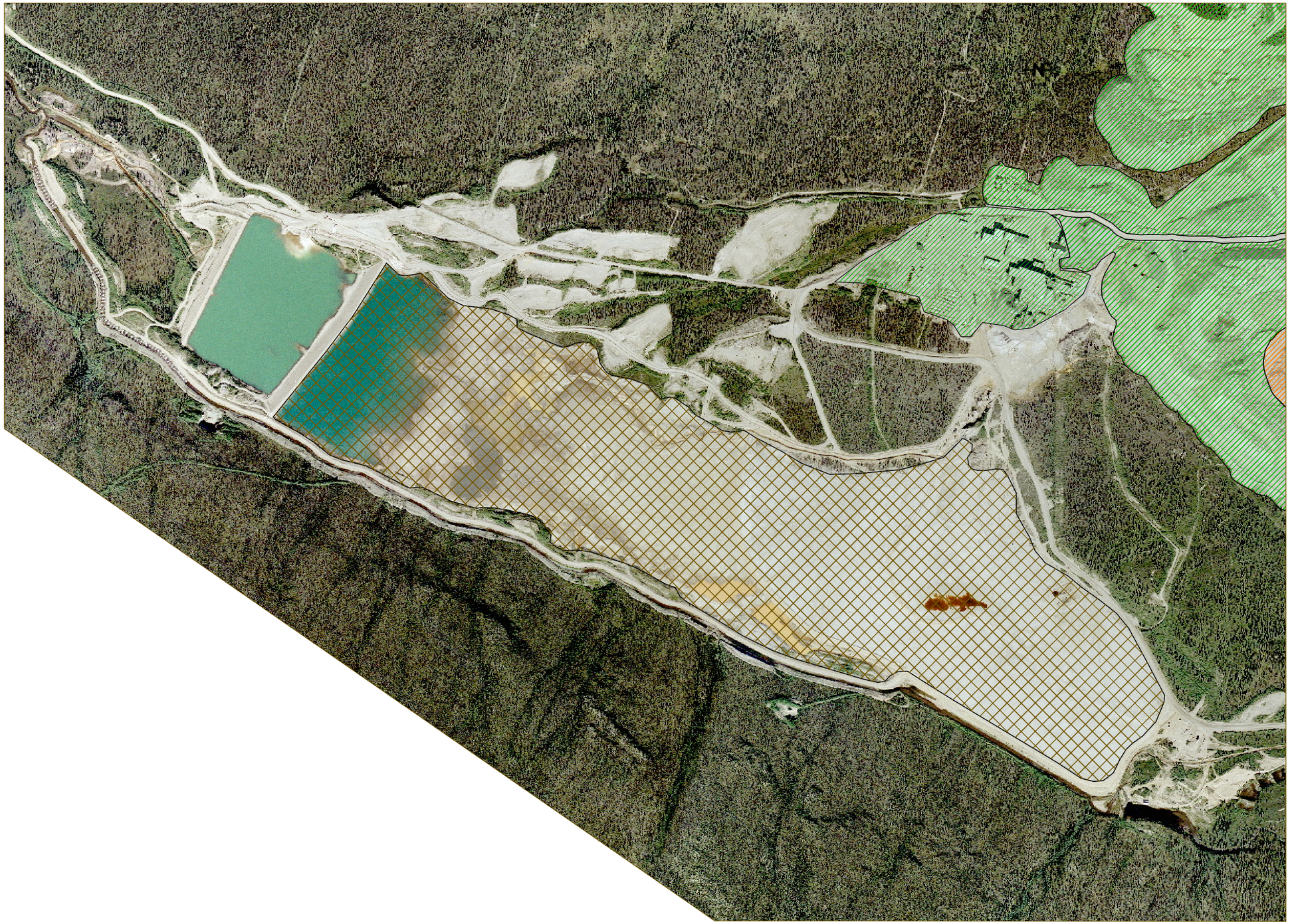

LEGEND

Cover Types:

Code	Description
NOC	No Cover
RUC	Rudimentary Cover (1m of Loose Till)
LIC	Low Infiltration Cover (1m of compacted Till overlain by 1m lightly compacted Till)
VLC	Very Low Infiltration Cover (Min. 2.5m compacted Till overlain by 1m loose Till)
TAC	Tailings Cover (0.5m of waste rock, overlain by lightly compacted till)

0 200 400 600 800 1000

Scale in Metres

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026

FILE NAME: Faro_Grum Covers.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Tailings Area Cover Types

DATE: Feb. 2010 | APPROVED: PMH | FIGURE: 7.1g

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LEGEND

Vegetation Types:

Code	Description
NOV	No Vegetation
ALV	Agronomic Grass-Legume Mix
ANV	Annual Nurse Crop + Native Grass Mix + Native Woody Species
NGV	Native Grass Seed Mix
NWV	Native Grass Seed Mix + Native Woody Species
RIV	Riparian

0 200 400 600 800 1000

Scale in Metres

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026

FILE NAME: Faro_Grum Vegetation Cover.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Tailings Area
Vegetation Cover

DATE:	APPROVED:	FIGURE:
Feb. 2010	PMH	7.1h

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583000 E
584000 E
585000 E
586000 E
6916000 N
6915000 N
6914000 N
6913000 N

N

200 0 400 600 1200 feet
100 0 200 400 600 Metres

Construct West Valley Extension (102.2)

Regrade and Cover (106.1)

Consolidate with relocated LGO, Crusher SP, Oxide Fines(#1, 2, 3), and Medium Grade Ore Stockpile, Cover (Very low Infiltration, synthetic, or soil equivalent) and Revegetate (104.4)

Haul 681,000m^3 of Waste to Tailings Pond for Trafficable Layer (202.1/2)

Faro Valley Dump

Construct Faro Creek Diversion (east valley) (102.1)

Regrade LGSP "A", Cover (Very low Infiltration, synthetic, or soil equivalent) and Revegetate (104.3)

Existing Faro Creek Diversion Channel to be decommissioned and revegetated

FARO PIT

Relocate Crusher SP, Oxide Fines(#1, 2, 3), LGO, and Medium Grade Ore to LGSP "C". Regrade and cover remaining area with rudimentary cover and revegetate (104.1/2).

Construct Safety Berm Around Faro Fit (101.2)

Regrade, Cover (Low Infiltration) and Revegetate (106.3/1/2/3)

LGO

Oxide Fines #3

Mt. Mungly (east)

Mt. Mungly (west)

Cover, Revegetate East Sulphide Cell Waste (106.2/1)

Regrade, Reslope, Cover and Revegetate Main and Intermediate Sulphide Cells (106.2/2)

Decontaminate and Demolish Buildings (108.2)

LGSP "A"

Oxide Fines #2

Southwest Pit Wall Dump

LGSP "C"

East Sulphide Cell

Crusher Stockpile

Medium Grade Ore Stockpile

Install Groundwater Wells, Piping, Heat Tracing for Zone II Pit Water Management (103.1)

Install Cutoff Wall to Capture Clean Flow of North Fork into Raised Channel (107.1B)

ETA Tailings

Oxide Fines #1 and Medium Grade Ore

Main Sulphide Cell

Zone II

Construct Sediment Basins and Run-off Control Ditches on Covers (106.4)

Relocate Contaminated Soil from Mill Site Area and Cover (Synthetic/Soil) (108.3/4)

Remove Tailings to Rose Creek Tailings Facility (105.1)

Construct Low Permeability Channel to Isolate North Fork from Groundwater (107.1)

Intermediate Sulphide Cell

Relocate Outwash Material to Intermediate Dump (107.2)

Install ETA Collection System. Pump to Faro Pit, if applicable (105.2)

Install Zone II outwash groundwater interception wells and trench. Pump to Faro Pit, if applicable (107.3).

Construct Sediment Basins and Run-off Control Ditches on Covers (106.4)

Regrade and Reslope Waste Rock Dumps (106.1B)

Place Cover on remaining Waste Rock and Revegetate (106.3/4/5)

Install S-wells Groundwater Collection System (107.5)

Haul Road - Remove Culverts, Scarify, Revegetate (108.1)

Develop and Decommission Faro Borrow Sources (108.5)

WTP

Sludge Pond

Construct Polishing Pond (205.2)

Construct New Water Treatment Plant and Sludge Pond (Final disposal in pit). Install Pipeline and Power Heat Supply Tracing System (101.1/3)

Legend

Construct Safety Berm Around Faro Pit (101.2)	Closure Activity (work item number)
LGSP	Low Grade Ore Stock Pile
	Rudimentary Cover (vegetative soil cover) (1m of Loose Till)
	Low Infiltration Cover (1m of compacted Till overlain by 1.0m lightly compacted Till)
	Very Low Infiltration Cover (Minimum 2.5m compacted Till 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

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026
FILE NAME: 1CY001_026-20_Rev_A.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Faro Mine Area (100) Closure Activities

DATE: Feb. 2010 | APPROVED: PMH | FIGURE: 7.2

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Faro Pit

Mt. Mungly (east)
(see Detail 2)

LGO

Oxide Fines #3

Mt. Mungly (west)
(see Detail 2)

LGSP "A"
(see Detail 1)

Crusher Stockpile

Oxide Fines #2

LGSP "C"
(see Detail 1)

Southwest Pit Wall Dump
(see Detail 2)

East Sulphide Cell
(see Detail 1)

Relocate Oxide Fines to LGO "C"

Medium Grade
Ore Stockpile

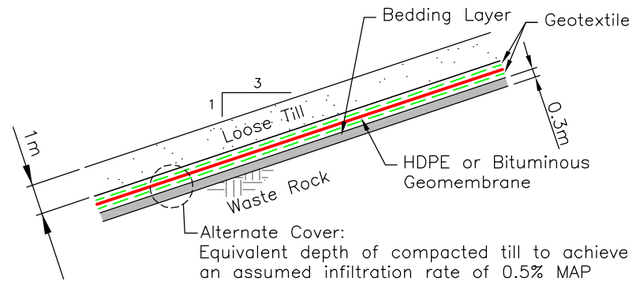
Oxide Fines #1
and Medium
Grade Ore

Main
Sulphide Cell
(see Detail 1)

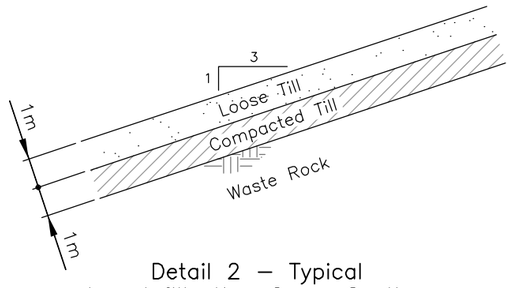
West Rock Dumps
(see Detail 3)

Intermediate
Sulphide Cell
(see Detail 1)

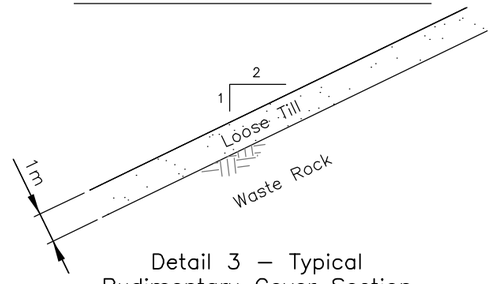
0 100 200 300 400 500
Scale in Metres



Detail 1 – Typical Very
Low Infiltration Cover Section



Detail 2 – Typical
Low Infiltration Cover Section



Detail 3 – Typical
Rudimentary Cover Section

0 2 4 6 8 10
Scale in Metres

Legend

LGO	Low Grade Ore
LGSP	Low Grade Ore Stockpile
	Very Low Infiltration Cover and resloping location. (See Detail 1)
	Low Infiltration Cover and resloping location. (See Detail 2)
	Rudimentary Cover and resloping location. (See Detail 3)

Note

Final selection of cover type is still subject to further review upon technical evaluation.

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026

FILE NAME: 1CY001_026-4_Rev_A.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Cover Details for Waste Rock, Sulphide Cells and Oxide Fines (104 / 106)

DATE:	APPROVED:	FIGURE:
Feb. 2010	PMH	7.3

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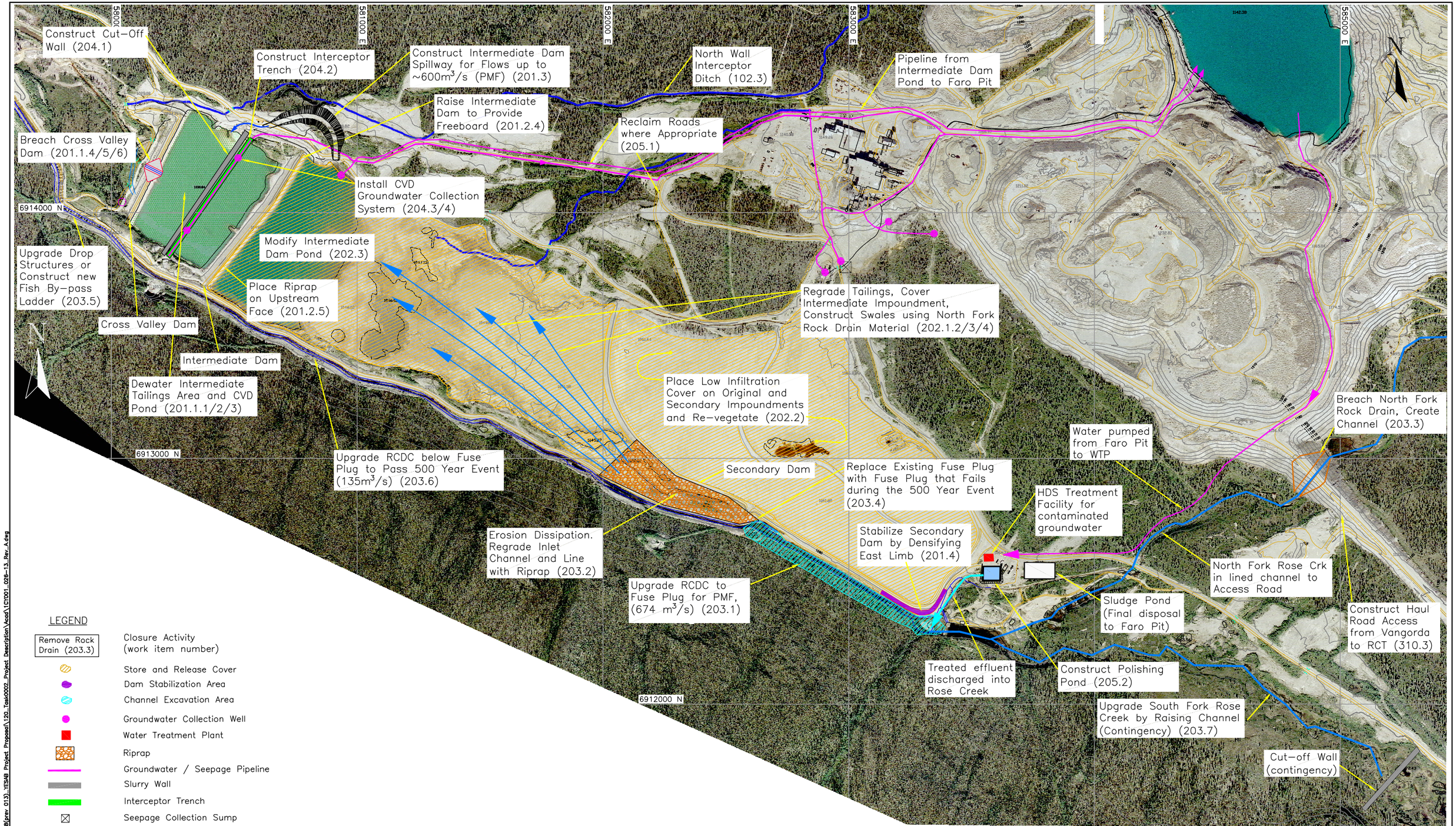

LEGEND

Remove Rock Drain (203.3)	Closure Activity (work item number)
	Store and Release Cover
	Dam Stabilization Area
	Channel Excavation Area
	Groundwater Collection Well
	Water Treatment Plant
	Riprap
	Groundwater / Seepage Pipeline
	Slurry Wall
	Interceptor Trench
	Seepage Collection Sump

REFERENCE

Klohn Crippen Berger report titled "Intermediate Dam Spillway – PMF Flood Handling", dated April 2008 with job number M09237A06.

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

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026
FILE NAME: 1CY001_026–13_Rev_A.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Tailings Area (200) Closure Activities

DATE: Feb. 2010 | APPROVED: PMH | FIGURE: 7.4

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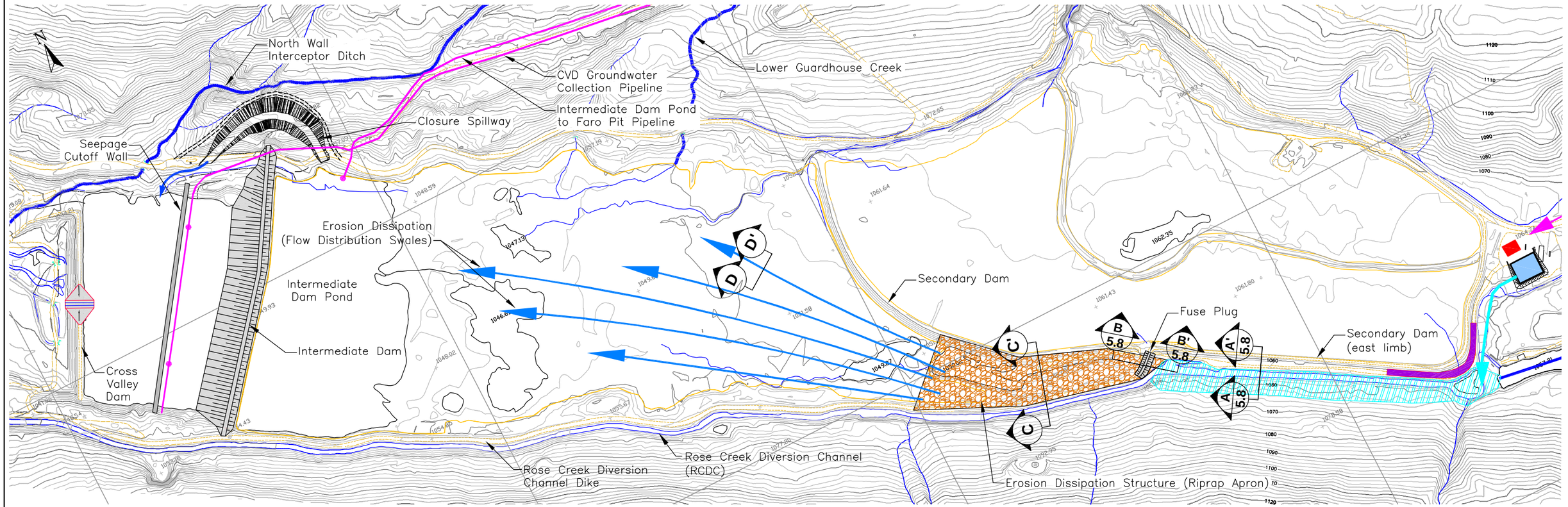
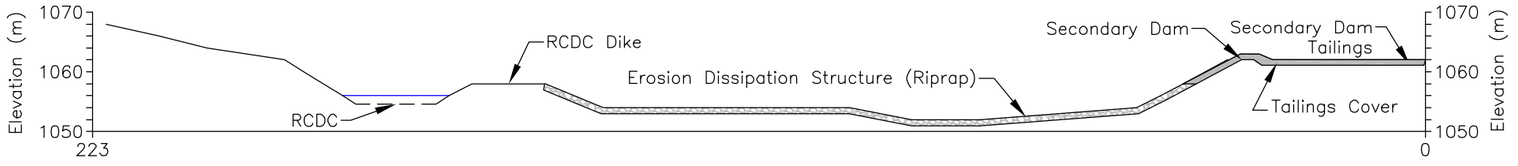


0 100 200 300 400 500

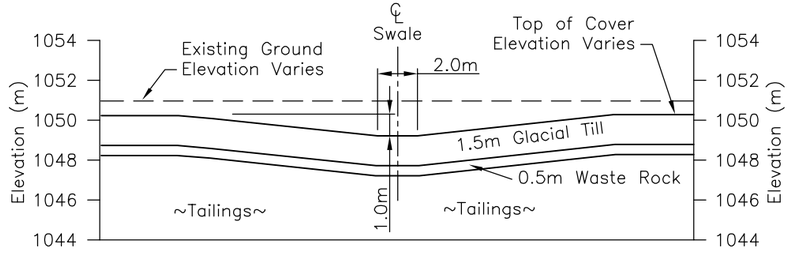
Scale in Metres



C CROSS SECTION C - C'

0 10 20 30 40 50

Scale in Metres



D TYPICAL FLOW DISTRIBUTION SWALE

0 2 4 6 8 10

Scale in Metres

NOTES

1. All dimensions in metres unless noted otherwise.
2. Design of spillway and elevation of Intermediate Dam crest and RCDC crest are dependent on detailed design study.

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

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.:	1CY001.026
FILE NAME:	1CY001_026-7_Rev_A.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Fuse Plug Plan (203.4)

DATE:	APPROVED:	FIGURE:
Feb. 2010	PMH	7.5

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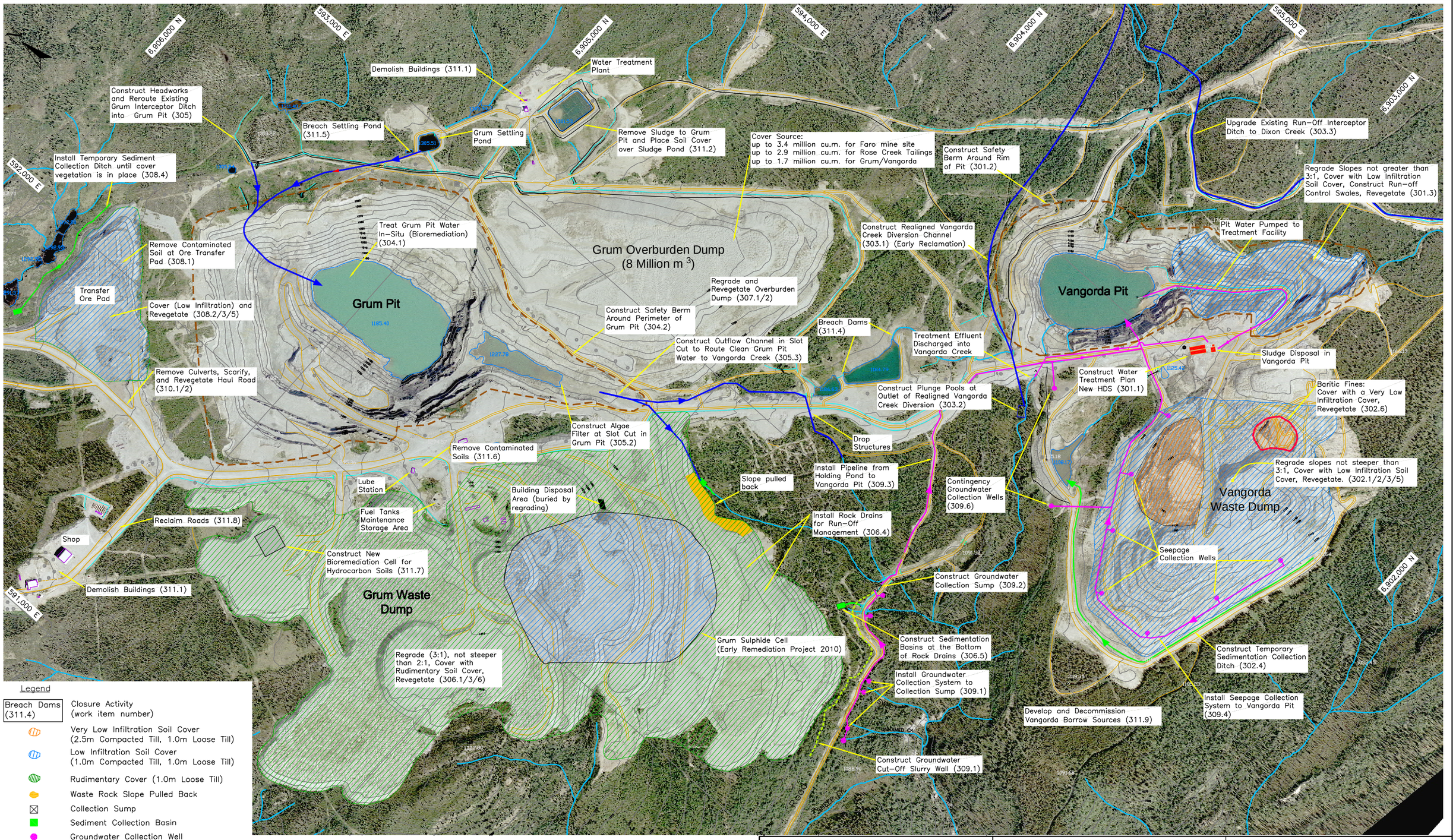

Legend

Breach Dams (311.4)	Closure Activity (work item number)
	Very Low Infiltration Soil Cover (2.5m Compacted Till, 1.0m Loose Till)
	Low Infiltration Soil Cover (1.0m Compacted Till, 1.0m Loose Till)
	Rudimentary Cover (1.0m Loose Till)
	Waste Rock Slope Pulled Back
	Collection Sump
	Sediment Collection Basin
	Groundwater Collection Well
	Water Treatment Plant
	Proposed Creek Alignment
	Sediment Collection Ditch
	Groundwater / Seepage Pipeline
	Slurry Wall
	Safety Berm

Note: 3:1 resloping is defined as 3H:1V.

Contour Interval: 10m
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

0 100 200 300 400 500 m

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.026
FILE NAME: 1CY001_026-14_Rev_A.dwg

Faro Mine Complex
Closure and Remediation

Project Proposal - Draft 1

Vangorda/Grum Area (300) Closure Activities

DATE:	APPROVED:	FIGURE:
Feb. 2010	PMH	7.6

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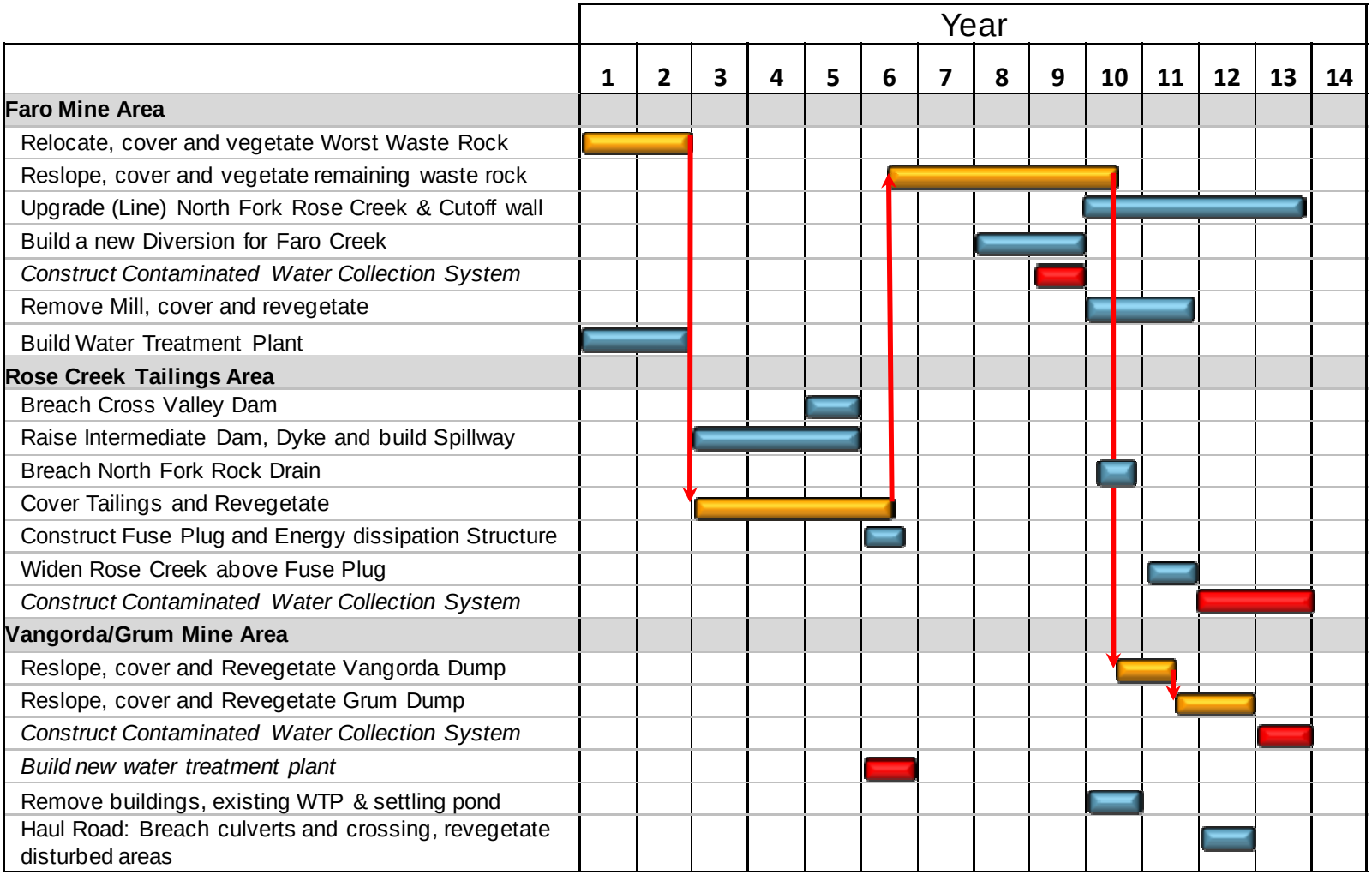


Critical Path

Subject to Adaptive Management Plan

Source: SRK Consulting

Faro Mine Closure
Fermeture de la mine Faro

Job No: 1CY001.026

Filename: Figure 7.7_Schedule_20100216.ppt

Faro Mine Complex
Closure and Remediation

Project Proposal – Draft 1

Project Schedule

Date: February 2010

Approved:

Figure: 7.7

Chapter 8

Environmental Effects Assessment

8 Environmental Effects Assessment

8.1 Impact Assessment Methodology and Scope

8.1.1 Sources of Information

Several key sources of information were used in the assessment of environmental effects. These include:

- Current Environmental Conditions Supporting Document (AECOM 2009).
- Water Quality Model (GEEC 2010).
- Aquatic Impact Assessment Related to Current and Future Zinc, Cadmium, and Sulphate Concentrations at Faro Mine, Yukon (Minnow Environmental 2010).
- Probabilistic Human Health and Ecological Risk Assessment of Final Closure and Remediation Plan for Faro Mine Complex (Senes Consultants 2010).

The AECOM 2009 document provides a detailed description of current environmental conditions at the Faro minesite, largely represented by the period 2005-2007. This document describes the baseline conditions against which the predicted environmental effects associated with the Project are measured.

For the aquatic resources (groundwater, hydrology, surface water quality and aquatic organisms and habitat), the Water Quality Model was the source of water quality and flow predictions used in the assessment. The model predicts water quality in the post-closure period, and assumes that the all water collection and treatment facilities are implemented and operating. (The model does not attempt to predict water quality conditions during the construction phase – the assumption used for this period is that current collection and treatment of contaminated water will continue, and that the water quality during the 15-year construction phase will be similar to existing conditions). The assumptions and methods used in the Goldsim model are described in detail in the Supporting Document E11- Water Quality Model. Both the Minnow and Senes reports also relied on the model predictions in their respective analyses.

Studies conducted at the minesite indicate that acidification and leaching processes have the potential to result in substantial increases in metal loadings to surface waters downstream of the Faro Mine complex over the next several decades and will continue for centuries. In particular, zinc, cadmium and sulphate concentrations were identified as substances of potential concern. Minnow conducted a preliminary assessment of the potential for predicted concentrations to impact biota residing in surface waters downstream of the mine, based in toxicity data presented in the scientific literature. Toxicity data for zinc, cadmium and sulphate were summarized and compared to current and predicted surface water quality downstream of the mine to identify potential impacts to aquatic biota. Relationships to hardness were also considered.

Senes carried out a human health and risk assessment to support of the environmental assessment for the Project. Their assessment considered chemical levels in both the terrestrial and aquatic environment, but focused on the aquatic environment as this has the potential to be most impacted in the future. Existing conditions based upon information collected between 2002 and 2007 were used to provide a reference against which the effects of the Project were compared. The predicted water quality (GEEC 2010) was used to identify a list of contaminants of potential concern (COPC). The potential toxic effects of COPC were measured for different receptors in the aquatic environment, including benthic invertebrates and fish. Those COPC identified as posing a significant ecological risk in surface waters were carried forward to the assessment of effects on surface water quality and aquatic organisms.

8.1.2 Assessment Approach

An issue based approach was used for the Faro Closure Project (the Project) environmental impact assessment. This approach focused the environmental assessment process on the key issues identified by those most likely to be affected by the Project: the Kaska Dena and Selkirk First Nations, local communities of Faro, Ross River and Pelly Crossing, and governments.

While consultation occurred to identify the preferred closure option and associated benefits and costs, Project scientists reviewed relevant documents and data compiled since the mine ceased operations to more clearly define the technical and environmental issues that are common to all closure options under consideration. Once the preferred closure option was selected and a draft of the project description was available, the issues were then grouped based on the likely effects on different environmental components (air, water or terrestrial environments), and an interaction matrix was developed to identify the Project activities in the construction and post-closure phases that could affect each environmental component. The issues were reviewed by the Project engineers to assist in identifying mitigation into the project design, and by the Project scientists to help focus the impact analysis.

8.1.3 Valued Ecosystem Components, Indicators and Thresholds

Valued ecosystem components (VECs) are *any part of the environment that is considered important by the proponent, public, scientists and government involved in the assessment process* (Canadian Environmental Assessment Agency, 1999). Valued ecosystem components were selected to represent key components of each discipline that could be affected by Project activities.

Indicators and thresholds are used to measure impacts to VECs. An indicator measures the condition of a VEC, and appropriate indicators were chosen for each VEC.

A threshold is typically defined as a measurable parameter (indicator) that demonstrates the level of change in a VEC beyond which unacceptable adverse effects occur. The change is measured against the existing (or baseline) conditions. In this instance, the Project will result in a change from the existing conditions, although in many instances, the predicted effect will be a positive change over time as compared to the existing conditions. The concept of a threshold as a limit beyond which

unacceptable change occurs, therefore, is not applicable in this context. At the same time, however, current standards in the practice of EA are largely silent on the matter of thresholds to assess an *acceptable level of positive change*.

For the purposes of this EA, thresholds are defined to be conditions equal to but not worse than, the existing condition of the chosen indicators. The threshold(s) represents **no net change** in the existing conditions, either negative or positive. While the status quo (existing conditions) may not be acceptable to many stakeholders, for the purposes of this EA, the threshold for measuring change is based upon the existing conditions.

8.1.4 Performance Objectives– Improvement Over Time

Improvement in the existing environmental conditions at the Faro mine site and the surrounding area is a primary closure objective. Prevention/reduction of further deterioration in environmental conditions is another broad closure objective. For certain disciplines, such as vegetation and terrestrial wildlife, specific objectives may be proposed that represent an improvement in a VEC over time. Where appropriate, specific objectives for each VEC have been identified, that, when achieved, represent a significant improvement in the VEC/indicator. These specific objectives are described in the following sections, and represent continued improvement over time.

Where predicted effects are expected to be worse than existing conditions (i.e. threshold of no net change is exceeded) these predicted adverse effects must be considered in the context of the broad closure objectives for the Faro Mine Site. Much of the waste rock at the Faro mine complex is acid-generating and will leach metals. The leaching process has begun, and without remediation, the contaminant loading from these materials would increase over the next several decades and continue for several centuries. The waste rock is poorly segregated at the Faro site, and as a result, all of the waste rock dumps at Faro would release contaminants that would lead to severe contamination of the aquatic ecosystem. Similarly, at the Vangorda and Grum sites, contaminants released from the waste rock will continue to increase in the next few decades and water will likely require treatment for several centuries. It is important to consider that while certain trends will continue to worsen as compared to baseline conditions, the Closure Plan will attenuate and greatly reduce the magnitude of effects than would occur if no closure plan was implemented and baseline conditions were allowed to continue to deteriorate. These effects are not a result of the Project, but are an unfortunate legacy of historic mining activity.

8.1.5 Spatial Scope of Assessment

The spatial scope of the assessment has been defined to include the areas directly and indirectly affected by closure activities, and predicted post-closure residual effects. For each biophysical component, two study areas were defined:

- the Local Study Area (LSA) which is the area directly affected by Project activities, (represents the currently disturbed areas at the site) and are used to assess the direct (and some indirect) impacts of the Project on VECs; and

- the Regional Study Areas (RSA) which are used to assess indirect impacts that may extend beyond the LSA.

The LSAs and RSAs vary for each environmental component. Water-related components typically define study areas based on watershed boundaries, or portions of watersheds directly influenced by the Project. Terrestrial components typically define study areas based on the areas directly and indirectly affected by historic mining operations and closure activities (e.g., extent of deposition of contaminated dust). The LSAs and RSAs for each environmental component are described in the following sections. As well, within an environmental component, different VECs may be appropriate for the LSA and RSA.

8.1.6 Temporal Scope of Assessment

The Project has been described in several key phases, based upon construction and post-construction activities. The figure below describes each phase, its duration, and assumptions. This assessment is focussed on the Closure Implementation and Initial Post-Closure Phases, as this represent a 25-year time span that is the maximum term of a Yukon water licence, and it is assumed that the proponent will be seeking a 25-year water licence for the Project. While longer term effects are considered, any such predictions of effects are necessarily much less certain, and are not within the scope of the regulatory permitting process.

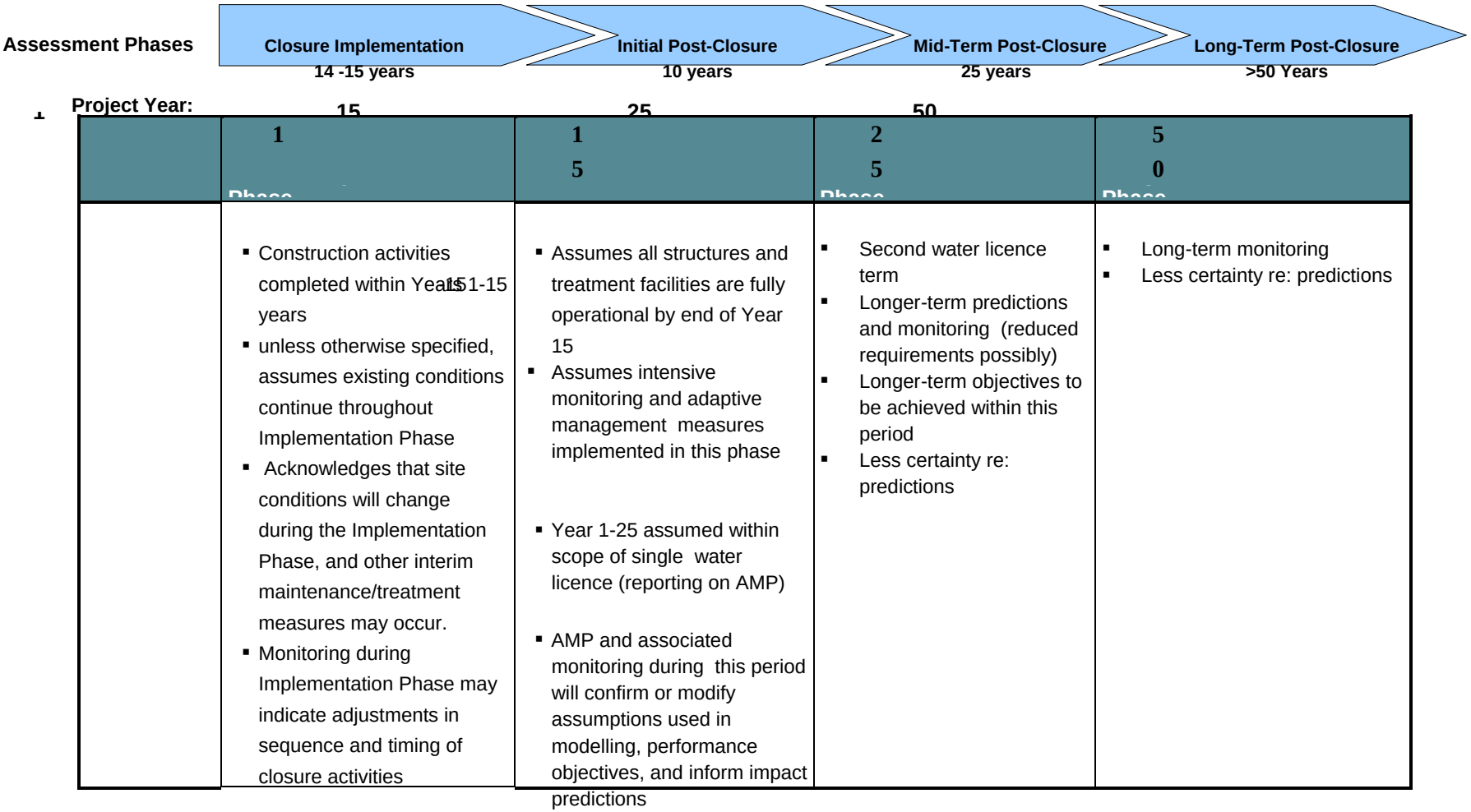


Figure 8.1: Project Phases

8.1.7 Defining Baseline Conditions

This assessment is based upon the existing environmental conditions under the Faro Care and Maintenance Program, not the pre-mining conditions nor any other historic condition. Thus, the existing conditions at the Faro site define the "baseline" for this assessment. Data collected during the Care and Maintenance period - since mining activities ceased in 1998 until the end of 2007 - have been used to collectively describe and define the existing conditions, or "baseline" for this assessment. The assessment of effects is based upon the predicted changes resulting from the Project closure activities, as compared to the existing conditions. While data continues to be collected (2008, 2009), the impact assessment is based largely upon data collected between 2005 and 2007. Annual data reports subsequent to 2007 continue to be provided to regulators, but are not included as part of the baseline conditions.

8.1.8 Impact Statements

Once the potential interactions between environmental components and Project activities were identified, impact statements were developed. The impact statements describe cause and effect pathways between Project activities and each environmental component and are used to help predict the likely outcome for each Project phase. Project activities expected to cause similar effects on the same VECs or related issues identified by a number of sources were combined into a single impact statement.

8.1.9 Assessment of Impacts

The cause and effect between the Project activities that could contribute to environmental change and the potential impact was systematically analyzed for each impact. The assessment of each impact statement was described using the following headings:

- Background Information;
- Assessment Method;
- Assessment; and
- Conclusion .

Results were quantified where possible using the results of modeling or other calculations (e.g., water quality at receiving locations; areas disturbed by the project footprint, area of effective (functional) aquatic habitat loss or reduction). Professional judgement of the assessment team was also used.

8.1.10 Mitigation Measures

For many stakeholders, the Closure Plan itself represents a massive mitigation effort to restore and protect the environment of the Faro Mine Complex and surrounding areas. For this assessment, the evaluation of impacts includes consideration of specific mitigation measures that would eliminate or

reduce potential negative effects during the Implementation Phase (approximately 14 - 15 years of construction activities), as well as further mitigation during the Post-Closure Phase. Design changes to the Project, Best Management Practices and other measures that prevent or minimize the potential environmental effects of the Project were identified. These are addressed under two categories:

- Mitigation by Design – mitigations, including Best Management Practices, which have been built into the Project design; and
- Discipline Specific Mitigation – mitigations prescribed by the Project environmental assessment team to further reduce predicted Project effects.

8.1.11 Residual Impact Rating

Residual effects are those impacts remaining after all mitigations are implemented, i.e., impacts that cannot be mitigated. Residual effects were rated for each impact statement, focusing on the indicator thresholds for each VEC and using the criteria shown in Table 8.1.

Table 8.1: Residual Impact Rating Criteria

Criteria	Rating Term	Definition
Direction	Positive	Beneficial change.
	Neutral	No change.
	Negative	Adverse change.
Geographic Extent	Local	Effect is limited to the Local Study Area.
	Regional	Effect extends to the Regional Study Area.
	Extra-regional	Effect extends beyond the Regional Study Area.
Duration[1]	Short-term	Effect lasts <3 years.
	Medium-term	Effect continues from 3 to 9 years.
	Long-term	Effect continues from 10 to 50 years.
	Permanent	Effect is permanent beyond 50 years.
Frequency	Once	Effect occurs once during construction, operations or closure.
	Intermittent	Effect occurs occasionally or periodically.
	Continuous	Effect occurs continuously during all or any phase.
Reversibility	Reversible	Effect is reversed after the activity ceases.
	Non-Reversible	Effect will not be reversed when activity ceases.
Magnitude	None	Magnitude is relative and assigned based on professional judgement. Magnitude combines the overall impact of the project activities on the Valued Ecosystem Component, combining the ratings of the above criteria, measured against the threshold for the indicator.
	Negligible	
	Low	
	Medium	
	High	

Note:
Duration identified in this table is generalized. This criterion is re-defined for each environmental component in the environmental assessment related to that component.

8.1.12 Significance Determination

Significance indicates whether a Project is likely to cause unacceptable adverse environmental effects, taking into account the implementation of mitigation measures. Significance of an impact is determined by the magnitude of the residual impact. Adverse residual effects of moderate or high magnitude have the potential to have significant adverse effects, depending upon the regional extent and duration of the impact. Consideration of the likelihood of the impact occurring and the degree of confidence in the data used in the assessment are also considered in assigning significance. Significance was determined using the significance rating criteria summarized in (Table 8.2). The likelihood of the impact occurring and the degree of confidence in the data used to assess the impact was also considered when determining significance.

Table 8.2: Significance Rating Criteria

Impact Magnitude	Geographic Extent	Duration	Significance
No effect	Any geographic extent	Any duration	Not Significant
Low	Any geographic extent	Any duration	Not Significant
Moderate	Local Regional	Any duration	Not Significant
	Beyond regional	Permanent	Significant
High	Local	Short term Medium term Long term	Not Significant
		Permanent	Significant
	Regional Beyond regional	Any duration	Significant
Rating Qualifiers			
Likelihood	Low Medium High	The likelihood (or probability) of the impact occurring.	
Degree of Confidence	Low Medium High	The degree of confidence in data used to assess the impact.	

8.1.13 Monitoring and Follow-up

Monitoring is used to measure the effectiveness and accuracy of the impact predictions, or when there is a low level of confidence in the data used to make those predictions. Follow-up is the adaptive management that may be required if predicted impacts are exceeded. Recommendations for monitoring and follow-up were prepared after completion of the residual effects analysis. Adaptive Management Planning is a key component of the Project, as it will be used to identify trends and provide a systematic process for identifying the timing and sequencing of mitigation measures during the Project life. The approach to AMP, monitoring and other management plans is discussed in Section 10.

8.2 Atmospheric Environment

8.2.1 Atmospheric Environment Assessment Objectives

The goal of the air quality assessment is to identify potential effects from Project activities for VECs identified in the baseline.

For the purposes of this assessment, atmospheric environment refers to the conditions of the atmosphere in the vicinity of the Project. These conditions will be described by the following valued ecosystem components (VECs):

- Air quality; and
- Greenhouse gases (GHGs).

Air quality has been selected as a VEC because of its intrinsic importance to the health and well-being of humans, wildlife, and vegetation. Several epidemiological studies published over the last few decades have demonstrated the link between poor air quality and negative human health outcomes.

Similarly, GHGs have been selected as a VEC because of their intrinsic importance to climate change as a regional and international issue. GHGs are gases that essentially trap the heat of the sun within the Earth's atmosphere, which causes the Earth's temperature to rise.

The assessment focuses on potential air quality issues associated with the Project, such as the emissions of air contaminants by construction activities related to the Closure Implementation Phase. The Post-Closure period has the potential to have a positive impact on local air quality through the mitigation of fugitive dust and cessation of emissions from road and equipment use.

During the Closure Implementation Phase, particulate matter may be emitted from operations such as consolidation of tailing piles, grading, covering piles, excavation, building construction and demolition, road construction and reclamation, combustion emissions from stationary and mobile sources, and road traffic. Combustion emissions from equipment use will also result in emissions of Criteria Air Contaminants (CACs) and GHGs.

The threshold for the determination of significant effects on the atmospheric environment is defined as follows:

A significant adverse effect is one in which:

- There are frequent or sustained emissions that have a high contribution to the Yukon Territory Sector air contaminant emissions (EC, 2008);
- The duration of the adverse effect is long-term or permanent (greater than 10 years);
- The effect on air quality will persist during and/or after the Project is complete; or
- The ecological or social context is substantially affected by air emissions from Project activities.

A positive effect is one in which:

- There are measurable reductions of the atmospheric contaminant loading as a result of Project actions.

A quantitative threshold used for assessing the Project impact on air quality is the total Yukon Territory Sector air contaminant emissions (EC, 2008). This threshold represents the baseline conditions and includes the existing contribution from the status quo.

Table 8.3: Air Quality VECs, Indicators and Thresholds

VEC	Project Objectives	Indicator	Baseline Case from which to measure change	Threshold[1]
Air Quality and GHGs	Closure Implementation Phase Post-Closure long-term improvement compared to status quo (i.e., reduction in the Faro Mine Complex contribution to regional air contaminant emissions)	Total Suspended Particulates (TSP) Fine Particulate Matter (PM_{10} and $PM_{2.5}$) CACs GHGs	Yukon Territory Sector Emissions for 2006 Annual Emissions	40,000 tonnes/year of particulate matter emissions, which is the current regional emissions of particulate matter for the Yukon Territory Sector Emissions in 2006 Annual Emissions.

1. Source for Threshold: Extracted from NPRI 2006 (EC, 2008).

8.2.2 Potential Issues, Interactions, and Concerns

The Project has the potential to affect the local air quality primarily through construction activities related to the proposed remediation activities. The construction activities involved in the Project which have the potential to affect the local air quality and contribute to regional air pollution include:

- Earth moving activities with typical equipment such as dozers, compactors, smooth drum rollers, excavators, dump trucks, water trucks, graders and scrapers;
- Transportation of contaminated soils during the consolidation activities; and
- Particulate matter emissions during grading, sloping, and covering activities.

The potential effects during the construction phase will be related to the airborne particulate matter and diesel emissions generated by construction activities. Combustion emissions from construction activities have the potential to affect existing GHG and CAC levels during the construction phase due to increased vehicles and construction equipment on the Project site. Construction activities may also emit airborne PM from road particulate matter and storage piles.

The long-term operational phase of the remediated site has the potential to affect the local air quality due to the additional green space to be in place on the Project site. The area is expected to have a positive change in air quality due to the capping of contaminated sediment. Table 8.4 below summarizes the Project activities and potential issues.

Table 8.4: Summary of Issues, Interactions and Concerns

Project Activity	Air Quality Parameter	Issue/Interaction/Concerns
Closure Implementation Phase: Road Traffic Earth Moving Activities Material handling associated with staging and storage areas	GHGs CACs Particulate Matter	Increased diesel combustion emissions from construction equipment and truck traffic will result in GHG emissions Increased diesel combustion will result in emissions of CACs Material handling activities, road traffic, earth moving activities and construction activities may result in particulate matter emissions which affect nearby commercial and residential properties.
Post-Closure Phase: Reduced fugitive emissions of mine and traffic-related particulate matter	GHGs CACs Particulate Matter	Increased green space will provide more GHG sinks and as a result will reduce GHG emissions Covered and vegetated sediment will reduce atmospheric emissions of contaminated sediment.

Greenhouse Gases (GHGs)

GHGs are gases in the earth's atmosphere which prevent the loss of heat into space. While GHGs are essential in maintaining a stable temperature and occur naturally, the rising levels of these gases in the earth's atmosphere largely due to human activity have caused serious concern, particularly over the past few years. The main effect of high levels of GHGs in the atmosphere is an increasing average global temperature which can cause extreme weather conditions and rising sea-levels. Common GHGs include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide.

Project-related sources of GHGs primarily include vehicles, as well as construction equipment exhaust.

Critical Air Contaminants (CACs)

CACs include air quality parameters such as sulphur dioxide ($_{SO2}$), oxides of nitrogen (NO_x), carbon monoxide (CO), and particulate matter (PM). SO_2 is a colourless gas with a distinctive odour similar to that of burnt matches. It is produced in combustion processes by the oxidation of sulphur in fuel. It has also been known to damage trees and crops. SO_2, along with NO_x, is the main causes of acid rain.

NO_x are almost entirely made up of nitrogen oxide (NO) and nitrogen dioxide (NO_2). Together, they are often referred to as NO_x. Most NO_2 in the atmosphere is formed by the oxidation of NO, which is emitted directly by combustion processes, particularly those at high temperature and pressure, such as internal combustion engines. The levels of NO and NO_2, and the ratio of the two gases, together with the presence of hydrocarbons and sunlight are the most important factors in the formation of ground-level O_3 and other oxidants. NO_x and SO_2 react with other substances in the air to form acidic precipitation. The largest human health concern associated with oxides of nitrogen is effects on the respiratory system.

CO is a colourless, odourless, tasteless gas and is produced by the incomplete burning of fossil fuels.

PM is characterized according to size. PM is the general term used for a mixture of solid particles and liquid droplets in the air. It includes aerosols, smoke, fumes, particulate matter, ash and pollen. The types of PM related to the Project are dust fall, total suspended particulate (TSP), particulates less than 10 microns (PM_{10}) and particulates less than 2.5 microns ($PM_{2.5}$). There are both natural and human sources of PM. The biggest human source of PM are combustion sources, mainly the burning of fuels in internal combustion engines for automobiles, power plants, and windblown dust from construction sites and other land areas where the water or vegetation have been removed.

Project-related CAC emissions will be released through the combustion of fuels, primarily during the construction phase. This includes emissions from vehicle traffic as well as construction equipment. CAC emissions may also be released during consolidation, grading, sloping, and covering activities.

8.2.3 Impact Assessment

Local Study Area

The local study area (LSA) for the assessment of air quality and GHGs is the zone of influence of the project air emissions, including the sensitive receptors nearest to the mine site.

Closure Implementation Period

Impact Statement AQ1: Project activities (consolidation, grading, covering, traffic, etc.) will result in the release of air contaminant emissions (TSP, PM_{10}, $PM_{2.5}$, NO3, SO_2 , and CO) and GHGs in the vicinity of these activities.

Closure Implementation Phase activities involve the disturbance and transportation of soils and surface materials, which will encourage the entrainment of particulate matter into the ambient air, potentially resulting in fugitive particulate matter emissions. Building construction and demolition and road construction and traffic can also release fugitive particulate matter. The construction equipment used in these activities is powered by the combustion of fossil fuels, which are known sources of CACs and GHGs.

Assessment Methods

A qualitative assessment was completed for greenhouse gases and CACs. However, a quantitative assessment was completed for the potential atmospheric emissions of particulate matter. The basis for this methodology is that fugitive emissions of contaminated particulate matter are a primary pathway for the transport of mine-related contaminants.

The quantitative assessment was based on the development of an air emissions inventory for the project using established protocols developed by the United States Environmental Protection Agency

(US EPA) and Ontario's Ministry of the Environment (MOE) used for identifying significant sources and contaminants and estimating emissions.

Scheduled Project activities were reviewed to identify the period with the highest anticipated air contaminant emissions throughout the duration of the Project. These data were derived from the Project Description and supporting studies. As such, Project Description Draft 4 (SD A1, SRK 2009) and the Preliminary Project Schedule (see Section 7.10) and supporting studies for the Faro Mine Complex were reviewed in conjunction to determine the worst case year during which the particulate emissions were in abundance. From the schedule of Project activities and the Project description, it was determined that Project activities in Year 2 would result in the highest amount of particulate matter emissions. Year 2 was determined to be the period with the highest particulate emissions as it is the year that has highest amount of materials being handled. However, it should be noted that Project activities scheduled for Year 1 would result in the highest amount of contaminated particulate matter emissions. As such an annual emissions inventory was developed for both Year 1 and Year 2.

For each activity taking place during this period, relevant activity levels and durations were established, and industry specific emission factors were applied to quantify the total emissions. An emission factor is an industry-averaged value that relates activity levels to contaminant releases. Emission factors are collected, reviewed, and updated by the US EPA in their document entitled AP-42 Compilation of Air Pollutant Emission Factors. The most recent edition (the fifth edition) was used. For emissions from equipment use, the US EPA NONROAD 2008 emissions model was used. Data required for calculating the emissions were extracted from Project Description 4. However, some additional information and assumptions derived from other sources are outlined below.

- Moisture and silt content: Silt and moisture content for material storage piles and borrow sources were obtained from the Addition Burrow Studies of September 2006. However, silt and moisture contents were not available for the sulphide cells. As such, in efforts to be conservative, it was assumed that the moisture content of the sulphide cells would be the 20th percentile of the minimum moisture content of all available moisture data for piles and borrow sources. The silt content of the sulphide cells would be the 80th percentile of the maximum silt content of the borrow sources. The silt content for road dust was obtained from the US Environmental Protection Agency documents: http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0202.pdf.
- Active piles: The tailings and mill area are determined to be sources of wind-borne dust. Initially, the tailings will be covered with soil "cement" to prevent dust dispersion and then covered with rocks in the winter. Therefore, the only time these areas will emit dust will be the time during which they are covered with till but not yet covered and revegetated. In addition, the sulphide cells and borrow sources used for consolidation activities are also considered as active material piles, which are sources of wind-borne dust.

- Surface Area: The surface areas for the active piles are required for calculating emissions from erosion activities. This information was obtained from the Additional Borrow Studies report prepared by SRK Consulting (September 2006).
- Precipitation Data: The Environment Canada website was used to obtain the percent of days with precipitation above 5mm. The Faro A station gives 42% (2005) and 38% (2006). However, to account for variability in the climate and to be conservative, 30% was used to account for the percentage of time with precipitation above 5mm.
- Mean Wind Speed: The on-site meteorological station at the Faro Mine was used to calculate mean wind speed for the 2004 to 2008 period. Mean wind speed was determined to be 2.16 m/s.
- Vehicle Kilometres Travelled (VKT): Estimating the VKT has the greatest uncertainties as details are lacking, i.e., whether equipment is stored on site. Based on the Project schedule, conservative assumptions were made with respect to vehicle storage on-site and vehicle trips to site.
- Vehicle Speed: Vehicle speeds were obtained from equipment manufacturer's websites such as (http://www.cat.com/cda/layout?m=308644&x=7).
- Rock Density: Mean density of all rock types (2.73 g/cm3) was obtained from Britannica Online Encyclopaedia website (http://www.britannica.com/EBchecked/topic/505970/rock/80185/Density).
- Erosion control factors for particulates from erosion of piles was assumed to be a low 20%. Road watering control factors for road dust was assumed to be 75%. However, with appropriate mitigation such as watering, control factors range up to 90%.
- Assumed each year will have 214 days of construction activity based on the months that do not have snow cover.
- Assuming that the worst case scenarios will not occur for approximately 9 – 10 years, it was assumed a fleet year of 2008 will be used for mobile equipment such as trucks, excavators, loaders, dozers, compactors, graders, and drills.

The result of the development of the emissions inventory is a summary of emission rates for particulates on an annual basis for the purpose of comparison to the baseline Yukon Territory sector emissions. Emission rates are primarily activity-specific. As such, emission rates will vary throughout the Project. For this reason, the annual time periods with the highest anticipated air particulate emissions was assessed.

Assessment Results

The construction activities involved in the Project, which have the potential to affect air quality and potentially contribute to air pollution include:

- Covering and revegetating activities;

- Material consolidation, regrading and resloping of on-site materials such as the Main and Intermediate Sulphide cells;
- Modification of the intermediate dam pond;
- Construction of access haul roads;
- Construction of the Faro water treatment plant(s) and piping;
- Lime addition for ongoing water treatment and for blending material activities; and
- Care and maintenance activities.

These construction activities will require the use of a number of pieces of heavy construction equipment and vehicles including: excavators, loaders, dozers, compactors, graders, drills and trucks. The large diesel powered equipment will generate combustion gases including: CO_2, CO, NO3, N_2O, $_{SO2}$, VOCs, PAHs, and PM.

The use of construction equipment and trucks will also generate airborne PM from road dust as they travel to and from, as well as on, the construction site. PM will also be generated from the delivery, movement and erosion of materials. The summary of particulate matter emissions by Project activities in Year 1 and Year 2 are summarized in Table 8.5 and Table 8.6, respectively.

Table 8.5: Source Emission Rates for Year 1

Source Description	Materials Handling (tonnes/yr)	Wind-Based Erosion (tonnes/yr)	Road Dust (tonnes/yr)	Grading (tonnes/yr)	Equipment Use (tonnes/yr)	Threshold Emissions (tonnes/yr)	Comparison to Threshold (%)
Total Suspended Solids	330	34	48	0.005	32.7	38,265	1.2%
PM10	156	17	14	0.002	32.7	18,897	1.2%
PM2.5	49	7	2	0.001	31.8	11,257	0.8%

Table 8.6: Source Emission Rates for Year 2

Source Description	Materials Handling (tonnes/yr)	Wind-Based Erosion (tonnes/yr)	Road Dust (tonnes/yr)	Grading (tonnes/yr)	Equipment Use (tonnes/yr)	Threshold Emissions (tonnes/yr)	Comparison to Threshold (%)
Total Suspended Solids	490	14	56	0.016	37.3	38,265	1.6%
PM10	232	7	16	0.008	37.3	18,897	1.5%
PM2.5	73	3	2	0.003	36.2	11,257	1.0%

Discussion and Conclusions

Project activities in the implementation phase are expected to result in emissions of particulate matter from fugitive dust and combustion. Materials handling is the leading source particulate emissions for the Project. It is important to understand the contribution of the Project's particulate emissions in relation to the study area. The 2006 National Emissions Inventory Report summarized

the particulate emissions for Yukon Territory. In 2006, Yukon Territory was responsible for 38,265 tonnes of TSP; 18,897 tonnes of PM_{10}; and 11,257 tonnes of $PM_{2.5}$. In relation to Yukon Territory's particulate emissions, the Project operations contributed to 0.8 – 1.6% of Yukon Territory's annual particulate emissions.

Note that there is a high likelihood that emissions will be generated, but some uncertainties exist in the data used to assess the potential impact. This uncertainty is based on restrictions in data availability, uncertainty pertaining to the Project schedule, and restrictions in the assessment methods due to emission factors. These uncertainties are common for assessing potential future impacts from Project activities and as a result, worst case scenarios are assessed to provide a conservative assessment.

Post-Closure Periods

Impact Statement AQ2: Project activities in the post-closure period will result in a positive effect as a result in a decrease of air contaminant emissions from the status quo.

Assessment Method

The post-closure assessment was qualitative as the overall impact will be positive. The emissions inventory developed for the closure implementation phase was used to identify which sources and emissions would be affected, and whether this effect would act to increase or decrease the air emissions indicators.

Assessment

As the mine is no longer active, fugitive particulate matter from wind erosion and road use for site care and maintenance purposes are the current primary sources of emissions. Any on-site equipment use would also contribute products of combustion, with particulate matter as the contaminant released by the most mine-related sources.

In the post-closure period, all of these emission sources will be eliminated or reduced. The use of on-site equipment will be significantly reduced, decreasing emissions of combustion products, including GHGs, CACs and particulate matter. Internal site roads will largely be reclaimed and as a result road use will be reduced. Therefore, the traffic-related fugitive particulate matter emissions will also be reduced. Ore, tailings, and waste rock piles will be consolidated, graded, covered, and revegetated. All of these post-closure period activities have the potential to reduce fugitive particulate matter caused by wind erosion, as factors influencing wind erosion include surface area, slope, and the particle size distribution of the surface material. In particular, consolidation and covering of the mine waste piles with nearby surface material sources will help inhibit emissions of mine-waste related particulate matter, such that any fugitive particulate matter are expected to more closely resemble natural sources in composition. Further, application of a vegetative cover will

inhibit all fugitive particulate matter emissions from the area and help reduce GHGs emissions by providing vegetative sources as a GHG sink.

Discussion and Conclusions

The post-closure period will meet the threshold of no negative change from the existing conditions. In fact, from an air quality perspective, the effect is expected to be positive, with significant reductions in emissions of CACs and GHGs.

Regional Study Area

Closure Implementation Period

The assessment for the Regional Study Area is identical to that for the Local Study Area, as the Thresholds are regional. Some plant emissions could potentially disperse downwind outside of the LSA into the RSA. Through dilution, dynamic transport, and chemical transformation, atmospheric concentrations of these contaminants will be reduced in the RSA as compared to the LSA. Given the relatively small contribution of the Project emissions to the regional emissions, the effect of the Project-based emissions on the RSA is expected to be relatively short-lived and diminutive.

Post- Closure Period

The assessment for the Regional Study Area is identical to that for the Local Study Area, as the thresholds are regional. Plant emissions will be reduced compared to the status quo, resulting in a small positive long-term effect on the air emissions and concentrations in the RSA.

8.2.4 Mitigation Measures

Prior to discussing recommendations for additional mitigation measures, it is important to emphasize the aspects of mitigation that are inherent to the Project, which are defined to be "mitigation by design." As previously discussed, the current primary sources of mine-related air emissions are wind-based erosion of mine waste piles, fugitive road dust, material handling and equipment use. Re-sloping, capping and vegetative covering will reduce emissions of particulate matter by wind erosion. Cessation of road use and road reclamation will reduce associated fugitive road dust.

Additional mitigation measures to limit fugitive road dust include:

- site road management including potentially watering road surfaces to minimize track-out onto local roads;
- truck cleaning/washing stations should be set up at the exit from the site to prevent track-out of dust, debris and potentially contaminated material (during the removal of debris from the ECF footprint and Pier 15 stabilization);
- Minimize trips and trip distances as possible;
- Apply speed restrictions and a No Idle policy; and

- Apply dust suppressants to loaded material.

Additional mitigation measures applying to wind erosion of mine waste piles and material handling include, if necessary:

- Periodically apply a dust suppressant to mine waste piles, where appropriate; and
- Suspend earth moving operations during extreme high wind events.

Additional mitigation measures applying to capping include, if necessary:

- Periodically apply a dust suppressant to mine waste piles.

A dust management plan should be developed and implemented which includes the mitigation measures for staging and storage areas and road traffic. These mitigation options will be applied as necessary given the variable Project activities and climate conditions that could lead to dust generation.

Mitigation measures that are to be considered for all emission sources include the following:

- The implementation of the contractors Health and Safety Plan for onsite workers;
- Development and implementation of a communications protocol for real-time air monitoring exceedances; and
- Use of a real-time air monitoring program as a project management tool for implementing appropriate mitigation measures.

A project specific air quality monitoring program will be implemented as a project management tool for air quality emissions. The monitoring results will be compared to specified action levels and community criteria. If the results are higher than any of the action levels, appropriate mitigation measures will be implemented. Mitigation measures may include reducing activity construction rates, changing location of construction activities, the use of dust suppressants, etc.

8.2.5 Significance Determination

Residual Impact Rating

The residual impact rating for AQ1 describes the fact that, despite mitigation by design and additional mitigation measures, some air contaminants and GHGs will be released during the closure implementation period. The period with the highest activity levels is short-term; emissions from these activities cease immediately upon cessation of activities (with the exception of wind erosion). Some activities occur simultaneously, with additive effects in terms of total site-wide emissions. However, these activities occur intermittently and in geographically separate areas, thereby reducing their impact at any particular time or place. On the whole, the emissions are low compared to existing regional emissions. With effective mitigative measures implemented, significant residual effects on air quality and GHGs during the closure implementation phase are unlikely. Due to the distance of the nearby residences, the effect of ground level concentrations on community air quality

are expected to be low. The construction activities will be of a medium term duration, and affect a local geographical area. The effect on air quality will also be reversible after the closure implementation phase is complete. Therefore, no significant adverse residual effects on the atmospheric environment are likely to occur.

The residual impact rating for AQ2 describes the fact that the overall post-closure impact will be positive, reducing emissions of air contaminants, particularly fugitive dust, compared to existing conditions. The prevention of airborne releases of contaminated particulate matter due to consolidation and capping will have a positive, lasting, regional impact. As such, no significant residual effects on air quality and GHGs from the post closure phase of the Project are likely.

Table 8.7 provides a summary of the residual environmental effects and recommended mitigation for air quality.

Table 8.7: Air Quality Residual Impact Rating

Project-Environment Interaction	Potential Positive (P) or Negative (N) Effect	Mitigation	Significance Criteria for Environmental Effects					Significance (S = significant, NS = not significant)
			Geographic Extent	Duration	Frequency	Reversibility (R= reversible NR = Not reversible)	Ecological Context	
CLOSURE IMPLEMENTATION PHASE								
Covering and revegetation activities; material consolidation, regrading and resloping of on-site materials such as the Main and Intermediate Sulphide Cells; modification of the intermediate dam pond; construction of access haul roads; Construction of the Faro water treatment plants and piping; lime addition; and care and maintenance activities.								
Use of construction equipment, daily heavy truck movements, material transfer activities, and regrading and resloping of material piles may increase ground level concentrations of CACs (including particulate matter) and GHGs.	**N**	on-site speed limits on-site road house keeping including potentially watering truck cleaning / washing stations at the exit from the site implement a “No Idle” policy on site develop and implement dust management plan. real-time air monitoring program as a project management tool to implement appropriate mitigation measures.	Regional	Medium Term	Intermittent	R	NA	NS

8.2.6 Monitoring and Follow-up

As discussed in Section 8.2.5, an Air Quality Monitoring program will be implemented as a project management tool for air quality emissions. Real-time monitoring will be implemented downwind of activities. The monitoring results will be compared to specified action levels. If the results are higher than any of the action levels, appropriate mitigation measures will be implemented. The real-time monitoring will focus available resources on those contaminants that pose the most significant risks during construction activities. PM_{10} has been selected as a target compound that can be monitored effectively on a continuous basis using portable equipment.

$_{PM10}$ have been selected based the following criteria:

- Typical emissions expected from the construction activities; and
- Limitations and effectiveness of real-time monitoring equipment in measuring the types of air emissions typically released to the air by these activities and the mobility of the monitoring equipment.

Any construction activity that moves or disturbs soil at the site can potentially result in air emissions of particulate matter (i.e., dust). Solid or liquid particles (aerosols) can be released from construction activities into the ambient air, including soil and road dust particles, heavy metal particulates and droplets of organic compounds. Control of particulate emissions at the construction source will limit concentrations of these elements (as particulate-borne concentrations) in the ambient air surrounding the site. TSP and the PM_{10} fractions are considered more representative of dust that can be generated by earthworks. $PM_{2.5}$ is typically not monitored around earthworks, despite its greater potential health impacts. The smaller fraction is normally emitted by combustion sources. The PM_{10} fraction is considered more protective of human health than TSP and therefore has been selected as the most appropriate dust parameter to monitor on a continuous, real-time basis.

The monitoring will begin at the start of closure activities and continue until the site remedial activities are completed (Year 15).

8.3 Noise (Senes)

8.4 Hydrology

8.4.1 Introduction

The Project includes a large number of activities dealing with water management to prevent contaminated groundwater and surface runoff from flowing into downstream water courses, to protect existing structures, and to eventually establish a natural flow regime where possible. While hydrology, the quantity and distribution of surface water flow, is not considered to be a Valued Ecosystem Component, it has a great influence on the aquatic environment. The objective of this

analysisis to describe the changes in flow resulting from Project activities, most particularly during the post-closure period, in order to inform the aquatic environment effects assessment.

8.4.2 Study Area

The Local Study Areas encompass the historic mine development footprints at Faro and Vangorda/Grum. The Regional Study Area includes the Anvil Creek Drainage and the Vangorda Creek Drainage that contains both mining areas and drain into the Pelly River. Regional effects are considered to be represented by change in flow in the Pelly River at the mouths of Anvil and Vangorda Creeks. Historically the mining development has had negligible effects on flow outside its immediate development area. The boundaries of the catchment areas are shown on Figure 4.5, and more detailed sub-drainages within the two local study areas are shown on Figures 4.5a and 4.5b.

8.4.3 Data Sources

Existing Conditions

The supporting hydrology baseline of the Faro Mine Complex was prepared in early 2009 and considered the period from January 2005 to December 31, 2007 as a period representative of present day conditions. This period was chosen because prior to 2005, there were several significant construction projects that affected flow locally at the Faro Mine Complex. The "baseline", therefore, refers to the conditions as they currently exist (post-2005), not prior to the mining development. It should be noted that the baseline hydrology does not include anticipated changes to the local surface hydrological regime as a result of potential interim reclamation activities related to ongoing care and maintenance of the site that may be completed prior to start of closure activities in 2012. These activities may include installation and ultimate upgrade of S-Well collection system, upgrade of ETA collections system to year-round operations, implementation of year round pumping from the Zone II Pit, and covering of the Grum Sulphide Cell with a very low infiltration cover.

The baseline describes the present-day hydrological conditions within the Anvil Creek and Vangorda Creek catchments. A critical hydrological statistic that was used to support the assessment is mean annual runoff (MAR). Mean annual runoff (MAR) is defined as the proportion of precipitation that is not lost to evaporation/evapotranspiration. The climatic water balance and regional analysis presented in the hydrology baseline (Section 4.6) and in Section 3.1.3.3 of *Current Environmental Conditions Supporting Document* (SD B2, AECOM 2009) provided estimates for MAR for key locations within the Anvil and Vangorda Creek catchments (see Table 3.1-10 of SD B2, AECOM 2009). Mean annual flow can then be calculated based on the drainage area for each subcatchment area.

To characterize the seasonal variation in the mean annual flow, the monthly historical water balance presented in the baseline was used. Due to limited winter flow data, patched monthly flow data was used to estimate the missing monthly winter flows. On the Faro side, patched flow records were developed for station R7 in the North Fork of Rose Creek and for station X14 in Rose Creek. On the Vangorda side, a patched flow record was developed for Vangorda Creek at station V8. For each

station, a monthly flow distribution was then established for each station based on estimated mean monthly flow from 2005 to 2007. On the Faro side, the distribution for flow in Faro Creek and the North Fork of Rose Creek is based on the distribution at R7, and the distribution for Rose and Anvil Creeks is based on that at X14. On the Vangorda side the monthly flow distribution for all receiving environment locations (V27 and V8) are based on the distribution calculated for Vangorda Creek at V8.

GoldSim Model

While the baseline report ultimately summarized the present day conditions based on the average annual flow at these key points, the *Faro Mine Complex Site Water Quality and Water Balance Model* (GEEC 2010) was used in the assessment of impacts on receiving environment flows in the Rose Creek/Anvil Creek and Vangorda Creek drainages, specifically during winter low flow conditions. This model, while not specifically a hydrological model, is based on MAR and was used to estimate possible changes in surface water flow post-implementation of the proposed Closure and Reclamation Plan. During the implementation period of about 15 years, it has been assumed that flows will be similar to baseline and will continue throughout this period. This assumption has been carried through the assessment of aquatic effects. A description of the model including assumptions and results made can be found in the above noted report (GEEC 2010).

8.4.4 Impact Assessment Methods

Changes to surface flow that result from the Project is not considered as a VEC in this assessment. However, the assessment of the changes to flows post-closure has been completed to inform the assessment of effects on the aquatic environment. For this reason the objective of the hydrology assessment is to describe and quantify, where possible, the changes in flows resulting from the various closure activities and highlight flow monitoring that would need to occur as part of the adaptive management planning.

The activities that affect flow have been presented according to the key receiving points they would directly affect. The Rose Creek drainage that encompasses the Faro Mine Area (including pits and waste rock) and Tailings Area, includes receiving points X2 on the North Fork of Rose Creek and X14 on Rose Creek. In Anvil Creek, key receiving points include the confluence of Rose and Anvil Creek and the mouth of Anvil Creek. The Vangorda Creek drainage that contains the Grum and Vangorda Pits and associated waste rock dumps, includes receiving points V27 on Vangorda Creek and V8 in lower Vangorda Creek. All other receiving points are downstream of these receiving points, and are not assessed in terms of effects from specific activities.

From the Goldsim model, the estimated mean monthly flows at these key receiving points were compared just prior to and following closure implementation (2012 compared to 2027). The winter low-flows in Rose Creek at X14 and in Vangorda Creek are of particular interest to the aquatics effects assessment. As mentioned previously, although not a rigorous hydrological model, the results of the Goldsim Model can be used to provide a high level indication of the potential changes

to surface water flow as a result of the Project, specifically mean monthly flow during the winter low-flow period. It should be noted that the model assumes that the following interim remediation measures have been completed by the start of closure (2012), and which are not captured in the 2005 to 2007 hydrology baseline conditions:

- Implementation and upgrade of S-Well Collections system (at 98% efficiency);
- Upgrade of ETA collection system to year-round operations (70% efficiency);
- Covering of Grum Sulphide Cell with very low infiltrations cover;
- Seasonal discharge of biologically treated effluent from Grum Pit; and
- Implementation of year-round pumping from Zone II Pit well to Faro Pit.

Furthermore, the model assumes that the flow through the aquifer is approximately 60 L/s at the toe of the Tailings Area. This does not include seepage inflows from upstream areas such as the ETA area. The model handles the inflows from the ETA area and surrounding waste rock separately, estimated at 10 L/s, and any escaping seepage is added to the aquifer flow. In addition, the model assumes that both the Intermediate and Polishing Ponds are removed within the first year of closure implementation. These two ponds are known to recharge the aquifer at approximately 30 L/s for the Intermediate Pond and 9 L/s for the Polishing pond (RGC 2005).

8.4.5 Impact Assessment

Activities affecting flow in the Anvil Creek Drainage

All closure activities in the Anvil Creek Drainage are contained within the Rose Creek sub-drainage. Tables 8.9 and 8.8 provide an overview of the project activities that will affect flow in the North Fork Rose Creek and Rose Creek, respectively. Relocation of the Faro Creek Diversion Channel, lining of the North Fork of Rose Creek, collection of contaminated groundwater in the Zone II Outwash Area, and covering of the waste rock dumps in the North Fork sub-drainage will directly impact flows in the receiving environment at X2. Seasonal discharge of treated effluent in Rose Creek at the inlet to the Rose Creek Diversion Channel may also result in minor changes in flow during the open water season. The covering of the waste rock dumps and tailings in the Rose Creek Sub-catchment will also change surface runoff and seepage regimes. Many of the closure activities associated with the Rose Creek Diversion Channel and the Intermediate Dam are related to upgrading various components to allow the Probable Maximum Flood (PMF) to pass safely through the system and will not affect the normal flows in the system.

The biggest potential impact on surface water flow in the Rose Creek sub-drainage is the year-round collection of contaminated groundwater from the Rose Creek Aquifer. This water will be collected at a target collection efficiency of 98% and routed to the Faro Pit for storage and seasonal treatment and discharge. This represents a potential loss of what is understood to be a significant contribution to the winter flows in Rose Creek downstream of station X14.

Flows downstream in Rose Creek and in Anvil Creek will not be directly affected by closure activities but by the changes in surface water flows upstream. Based on annual average flow, it is estimated that Rose Creek contributes approximately 37% of the flows to Anvil Creek, and Anvil Creek contributes approximately 4% of the flow to the Pelly River. Therefore, small changes in the flow of Anvil Creek will have a negligible effect of the flows in the Pelly River.

Table 8.8: Activities Affecting Flow in the North Fork of Rose Creek at X2

Activity	Description	Effect
Relocation of the Faro Creek Diversion Channel	The Faro Creek Diversion channel would be rebuilt further up the slope due to slope stability concerns close to the Faro Pit wall.	The new channel will reduce the amount of leakage from the existing channel to the Faro Pit. This will result in a potential increase in flow in the North Fork of Rose Creek. Flow monitoring before and after construction should be carried out to quantify the change of flow and its effects to the aquatic environment.
Zone II Pit Outwash Groundwater Collection System	A series of wells will be installed in the Zone II Pit outwash area to collect contaminated groundwater seepage that currently flows into the North Fork of Rose Creek.	As the total contribution or loss of groundwater in this channel is not well quantified, the effect of installing pumping wells is not known, and the flows should be monitored before and after construction to quantify the change of flow and its effects to the aquatic environment.
Lining North Fork of Rose Creek	Upgrades to the channel will include relocation and lining with an impervious liner to reduce groundwater seepage.	As the total contribution or loss of groundwater in this channel is not well quantified, the effect of lining the channel is unknown and the flows should be monitored before and after construction to quantify the change of flow and its effects to the aquatic environment.
S-well Groundwater Collection	A groundwater collection system is presently installed in the S-Well area to intercept contaminated groundwater before it seeps into the North Fork of Rose Creek. It is expected that this collection system will be upgraded prior to closure implementation (2012).	As the total contribution or loss of groundwater in this channel is not well quantified, the pumping contaminated groundwater from this area is unknown and the flows should be monitored before and after construction to quantify the change of flow and its effects to the aquatic environment.
Emergency Tailings Area Remediation	Clean surface water currently discharging into the Emergency Tailings Area will be diverted around the emergency tailings area and discharged into the North Fork of Rose Creek.	Flows in the North Fork of Rose Creek will increase.
Covering the Faro Waste Rock Dumps	Covering the waste rock dumps with very low, low or rudimentary covers.	Surface runoff would increase from the dump area as less will be lost to infiltration.

Table 8.9: Activities Affecting Flow in Rose Creek at X14

Activity	Description and potential effect	
Rose Creek Tailings Cover	Water that flows onto the surface of the Rose Creek Tailings Area is currently pumped and treated before discharge. In the long term, when water quality is sufficient, surface runoff on the Rose Creek tailings area will be allowed to flow over a spillway and directly into Rose Creek.	The flow regime of discharge into Rose Creek would be altered post-implementation, and follow the natural runoff patterns.
Groundwater Collection	The majority of groundwater seepage at the toe the Intermediate Dam and Cross Valley Dam will be intercepted to stop the flow of contaminated groundwater from reaching Rose Creek and other downstream receiving environments.	This activity is expected to significantly reduce groundwater inflows to Rose Creek downstream of the Tailings Area. Groundwater flow is believed to contribute a significant portion of the winter flows in Rose Creek. The contribution of groundwater to the flow in Rose Creek below the Cross Valley Dam are not well quantified at this time; however, it is believed that the interception of the majority of groundwater will significantly decrease the winter flows at X14.
Discharge of Treated water into Rose Creek	Seasonal discharge of treated water at the inlet to the Rose Creek Diversion Channel during summer.	The point of discharge is located upstream of the current seasonal discharge location, upstream of X14. During the seasonal discharge period, this will result in increased flows in Rose Creek downstream of the proposed discharge location. Further downstream in the Rose Creek sub-catchment, the impact of the summer discharge on flows is minimal. Estimated overall increases of up to ~3% will occur in summer due to both discharge of water and increased surface runoff from the dump areas.
Covering the Faro Waste Rock Dumps	Covering the waste rock dumps with very low, low, or rudimentary covers.	Surface runoff would increase from the dump area as less will be lost to infiltration. Overall, estimated increases of up to ~3% occur will occur in summer due to both discharge of water and increased surface runoff from the dump areas.

Winter flows at Rose Creek and Anvil Creek

To assess the effects of groundwater collection on the winter flows in Rose and Anvil Creeks, the estimated mean monthly flows at X14 and below the confluence of Rose and Anvil Creeks prior to (2012) and following closure implementation (2027) were compared for March. These estimates were obtained from the Goldsim model. Based on the seasonal flow distribution for Rose Creek, March exhibits the lowest monthly flows. The results of this comparison are presented in Table 8.10. Overall, based on these results, the year-round collection of groundwater, primarily aquifer water, will result in a potential reduction of winter low flows of at least 10.3%.

Table 8.10: Estimated Changes in Winter Low Flow (March) – Rose Creek (X14) and Anvil Creek (below confluence with Rose)

Creek	Flow (m^3/s) Prior to Closure (2012)	Flow (m^3/s) Post Closure (2027)	Change in Flow Rate (m^3/s)	Change in Flow Rate (%)
Rose Creek	0.426	0.382	- 0.044	-10.33
Anvil Creek	0.868	0.824	-0.044	-5.07

As noted in Section 8.4.4, the Goldsim model is not a hydrological model, but the predicted results do provide a good indication of the magnitude of change in winter flows that could occur. Furthermore, as noted in Section 8.4.4, the model assumes that both the Intermediate and Cross Valley Pond are removed at the start of closure implementation, which together are estimated to recharge approximately 40 L/s to the aquifer. Taking into account the loss of this input to the aquifer system, there is the potential for a decrease in winter flow from current conditions of up to 84 L/s or 20%. Given the scarce data and the various model assumptions, a field program should be implemented to establish the winter flow needs on Rose Creek.

Activities affecting flow in the Vangorda Creek Drainage

Closure activities in the Vangorda Creek Drainage include covering of the Grum and Vangorda waste rock dumps, collection of contaminated groundwater at the toe of the dumps, ongoing seasonal discharge from Vangorda Pit and in-situ treatment and seasonal discharge from Grum Pit. The closure activities in this drainage will directly affect flows at V27 and V8.

At station V27, the catchment of Vangorda Creek contributes approximately 44% of flow in Vangorda Creek. The catchment areas of Vangorda Creek, and the Pelly River at the confluence with Vangorda Creek, are 91 km2 and 22,100 km2 respectively. The catchment area of Vangorda Creek is 0.4% of the catchment of the Pelly River. Small changes in the flow of Vangorda Creek, therefore, will have a negligible effect of the flows in the Pelly River.

Table 8.11: Activities affecting Flow at Vangorda Creek at V27 and V8

Activity	Description	Effect
Dixon Creek Diversion	The current interceptor ditch that diverts clean water around the north east side of the Vangorda Pit will be upgraded to minimize losses of clean water into the Pit.	The amount of flow diverted in the upgraded ditch will increase. The overall effect of the upgrading of the ditch on the flow at V27 and V8, however, is thought to be minimal.
Breach of Grum Interceptor Ditch and Divert to Grum Pit	Water that is currently diverted around Grum Pit will be diverted into the pit, biologically treated, and ultimately discharged to the receiving environment.	While the same quantity of water will be flowing through the system, the runoff characteristics may be changed as flow will be buffered by the Grum Pit
Grum Groundwater Collection and Vangorda Waste Rock Dump Seepage Collection	Groundwater collection systems to capture contaminated water from the Grum and Vangorda Waste Rock Dumps will be implemented as needed as part of the Adaptive Management Plan.	The total contribution or loss of groundwater to downstream water courses is not well quantified and the effects of decreasing groundwater seepage are unknown. Flows should be monitored before and after construction to quantify the change in flows.
Breaching of dams at the Sheep Pad Pond and the Water Treatment Plant Settling Pond	The dams at the Sheep Pad Pond and the Water Treatment Plant Pond will be breached and rip rapped accordingly to allow flow through the system.	While the same quantity of water will be flowing through the system, the runoff characteristics may be changed.
Covering the Vangorda Dump, Grum Dump, and Grum Ore Transfer Pad	Covering the waste rock dumps with very low, low, or rudimentary covers.	Surface runoff would increase from the dump area as less will be lost to infiltration. Overall, with the discharge from Grum Pit, discharge of treated water and covering of the dumps results in an increase in summer flows of up to ~ 1.45% at location V8.
Discharge of treated water into Vangorda Creek	Seasonal discharge of treated water from Treatment Plant and In-situ treatment in Grum Pit to Vangorda Creek summer.	The location of this discharge is assumed to be in close proximity to the existing discharge location. This will result in increased flows during the discharge period in Vangorda Creek downstream of the proposed discharge location, particularly due to the addition of a discharge from Grum Pit. The Grum Pit discharge is assumed to be in place at the start of closure implementation (2012). During summer discharge period, the introduction of the discharge from Grum Pit will result in an increase in flow at location V8 during the discharge period of up to ~ 1.8% when compared to conditions without the discharge from Grum Pit.

Winter flows at Vangorda Creek at V27

To assess the impacts of groundwater collection on the winter flows in Vangorda Creek, the estimated mean monthly flows at V27 and V8 prior to (2012) and following closure implementation (2027) were compared for March. These estimates were obtained from the Goldsim model. Based on the seasonal flow distribution for Vangorda Creek March exhibits the lowest monthly flows. The results of this comparison are presented in Table 8.12. Overall, based on these results, the year-round collection of contaminated groundwater from the toe of the dumps will result only a

small reduction in winter low flows, (as compared to Rose Creek), particularly at location V8. Again, given the scarce data and various model assumptions, a field program should be implemented to establish the winter flow requirements for aquatic resources on Vangorda Creek.

Table 8.12: Estimated Changes in Winter Low Flow (March) – Vangorda Creek (V27 and V8)

Creek	Flow (m^3/s) Prior to Closure (2012)	Flow (m^3/s) Post Closure (2027)	Change in Flow Rate (m^3/s)	Change in Flow Rate (%)
Vangorda Creek (V27)	0.039	0.036	0.003	-7.2
Vangorda Creek (V8)	0.082	0.079	0.002	-3.6

8.4.6 Monitoring and Conclusions

The assessment of changes to hydrology at the Faro Mine Complex post implementation of the Project should be considered to be qualitative and preliminary given the uncertainty of the groundwater contributions and losses at various points throughout the mining complex. This assessment does givean indication of the areas that may be affected and can help to guide the development of a more comprehensive flow monitoring program when considered in light of the Aquatic Effects assessment and areas of concern for aquatic life.

In general there are three major types of activities that will affect the surface flows:

- lining of channels with impervious material cutting off inflow and outflow of groundwater;
- placement of covers on dumps to reduce infiltration into dumps which will result in increased surface runoff from the covered areas; and
- interception and pumping of groundwater which would reduce the flow, especially winter flow into gaining portions of watercourses.

In the Anvil Creek drainage, the collection of contaminated groundwater, primarily from the pumping of the Rose Creek Aquifer downstream of the Tailings Area, will have the greatest influence on changes to flow, resulting in reduction in flows during the critical winter low flow period.

In the Vangorda Creek drainage, the changes predicted to winter flows in the Vangorda Creek drainage are smaller as compared to those in Rose Creek, particularly at location V8.

To facilitate assessment of changes in surface water flow patterns as a result of implementation of the Project, a comprehensive flow monitoring program should be implemented. Key components of this program should include:

- continuous flow monitoring including winter low flow conditions;
- monitoring upstream and downstream of key project components to provide flow data at adequate resolution to confirm predicted changes to surface water flow; and
- detailed monitoring of all site discharges.

8.5 Hydrogeology

8.5.1 Introduction

Groundwater Quantity and Quality were identified as VECs for this project based on concerns raised by stakeholders and environmental assessment scientists. Groundwater quantity is a VEC because the pumping of large quantities of potentially contaminated water followed by seasonal (summer) treatment and discharge to surface streams in the summer will reduce groundwater discharges to streams during the winter low flow period. Winter discharge of groundwater to streams provides a base flow of unfrozen water below the ice that supports overwintering habitat for fish and aquatic life. Groundwater quality is a VEC because of the concerns raised about groundwater contamination and its potential effects on receiving waters, and potential effects on the drinking water supply for the Town of Faro.

8.5.2 Hydrogeology Assessment Objectives and Methods

The objective of the Hydrogeology (groundwater) assessment is to identify effects (i.e., changes form baseline conditions) caused by Project activities on Groundwater Quantity and Groundwater Quality. These effects can be positive (better than baseline) or negative (worse than baseline).

This assessment was conducted using an issue-focussed approach. The identified issues for the VECs are as follows:

- **Issue GW1- Groundwater Quantity** – Extraction of contaminated groundwater from Project wells and trenches (with subsequent treatment and discharge to surface water streams) will reduce groundwater flow and discharge to downstream receiving waters.. Proposed construction activities such as the draining of ponds, lining of stream channels, raising or breeching of dams and the alteration of water levels in pits will alter groundwater flow directions and flow volumes. These changes may, in turn, affect health of aquatic life in the receiving environment.
- **Issue GW2 – Groundwater Quality** – Extraction of contaminated groundwater from project wells and trenches (with subsequent treatment and discharge to surface water streams) will positively affect groundwater quality discharging to downstream surface water streams. Storage and handling of fuel and other chemicals during mine reclamation activities has the potential to affect groundwater quality. Proposed construction activities such as the draining of ponds, lining of stream channels, raising or breeching of dams and the alteration of water levels in pits will alter groundwater flow directions and flow volumes which may have negative effects on groundwater quality.
- **Issue GW3 - Groundwater Quality** – Closure Implementation activities will involve the transportation, storage and use of fuel and various other chemicals. Spills or leaks of these materials have the potential to cause localised groundwater contamination.

Valued Ecological Components

The two groundwater VECs identified in the baseline are Groundwater Quantity and Groundwater Quality.

Groundwater quantity was selected as a VEC due to the proposed capture of 98% of groundwater flows from the installation of proposed groundwater collection systems. The concern is focussed on groundwater fed winter flows affecting the North Fork Rose Creek (Faro Mine Site), Rose Creek (Rose Creek Tailings Facility), and Vangorda Creek (Vangorda/Grum Mine Site).

Groundwater quality was also identified as a VEC by scientists, regulators, and community members who expressed concern about groundwater contamination. The Project itself is a comprehensive mitigation measure to address the residual effects from historical mining operations. One of the primary objectives of the Project is to capture, contain and treat all contaminated groundwater within the footprint of the Faro Mine Complex.

Groundwater temperatures are not expected to change due to Project activities; therefore, this is not considered a groundwater issue. If groundwater discharge to creeks is reduced, however, this may reduce the moderating effect that groundwater temperatures have on surface water temperature. This temperature modifying effect can prevent streams from freezing to the bottom during winter low flow periods and thus provide over wintering habitat for aquatic life. This issue is considered under the aquatic effects assessment in Section 8.7.

The VECs, indicators and thresholds used for the assessment, as identified in Section 8.1 Effects assessment are provided in Table 8.8 below.

Table 8.13: Hydrogeology VECs, Indicators and Thresholds

VEC	Project Objectives	Indicator	Baseline Case from which to Measure Change	Threshold
GW- VEC1 Groundwater Quantity	To maintain groundwater flows to creeks downstream of mining areas, particularly during low flow winter periods, in order to protect the over wintering habitat of aquatic life.	– Groundwater elevations relative to adjacent surface water elevations (vertical hydraulic gradient) - Stream winter low flow volumes attributable to groundwater discharge (i.e., base flow) based on available stream flow information and base flow separation techniques. – Unfrozen water depth in streams downstream of groundwater collection systems in winter.	– Baseline (1998-2007) groundwater elevations adjacent to NFRC, Rose Creek and Vangorda Creek downstream of groundwater extraction systems; – Baseline low flow volumes during winter in NFRC, Rose Creek and Vangorda Creek.[1] – Baseline unfrozen water depth in streams downstream of groundwater collection systems in winter.	– Seasonal range of baseline groundwater elevations relative to adjacent surface water elevations (i.e., vertical hydraulic gradients) – minimum baseline (1998-2007) low flow volumes during winter in NFRC, Rose Creek and Vangorda Creek. – Minimum baseline stream low flow volumes attributable to groundwater discharge (i.e., base flow). – Minimum baseline depth of unfrozen water in streams down stream of groundwater collection systems in winter.
GW - VEC2 Groundwater Quality	To maintain existing baseline groundwater quality downstream of historical mining areas and prevent contaminated groundwater from discharging to surface water streams, protecting surface water quality for aquatic life and drinking water purposes.	Groundwater quality, particularly pH, sulphate, zinc and other metal concentrations, at monitoring wells downstream of former mining areas and groundwater extraction systems and upstream of groundwater discharge areas to surface streams.	Baseline Groundwater quality (1998-2007) as described in the groundwater baseline report.	The maximum concentrations of the contaminants of concern measured during 1998 -2007 and documented in the Baseline Report (i.e., maintain existing groundwater quality)

[1] Available winter flow data is sporadic, and thus not adequate to establish baseline conditions. Monitoring of winter flows and stream depth (unfrozen) over next few years will be necessary to establish adequate measure of current winter flow regime.

Indicators

The indicators chosen for groundwater quantity and quality are provided in Table 8.8.

Groundwater quality indicators include contaminants of potential concern (COPC) that have been compiled for the aquatic environment of the Faro Mine Complex (SENES, 2010). The COPC for Rose Creek and Vangorda Creek include the following: Aluminum; Arsenic; Boron; Cadmium; Cobalt; Copper; Iron; Manganese; Nickel; Lead; Antimony; Selenium; Tin; Strontium; Thallium; Vanadium; Zinc. Additional COPC affecting Rose Creek include Silver; Beryllium and Chromium.

Petroleum hydrocarbons in soils have been identified near (historic) maintenance areas, fuel storage areas, and adjacent to the ETA area (Section 3.2 Current Site Conditions). Extensive areas of hydrocarbon contamination of groundwater have not been identified. Hydrocarbon contamination is considered to be minimal compared to the issue of acid rock drainage (ARD) from mine wastes.

Assessment Methods

The assessment was conducted by developing a sound understanding of the hydrogeological conditions at the site based on information in the baseline report (AECOM 2009) and the numerous previous reports on groundwater quality and quantity at the Faro Mine complex (see list of Supporting Documents). This information was considered in light of the Project as described in Section 7,. The impact assessment was then conducted using the professional judgement of a senor hydrogeologist with several decades of experience in groundwater issues at mine sites, waste management facilities and contaminated sites including the operation of groundwater collection and treatment systems that operated over periods of several years.

8.5.3 Local Study Area– Closure Implementation Period

The Closure Implementation Phase includes the first 14 to 15 years of the Project. The actual implementation dates for some of the proposed contaminated groundwater extraction systems will be determined in accordance with the Adaptive Management Plan, and will be based on groundwater and surface water monitoring trends and results. For the purposes of this assessment, it is assumed that all the proposed contaminated groundwater extraction systems will be installed during the Closure Implementation Phase.

This assessment considers the two key areas, the Faro/Rose Creek Tailings area and the Vangorda/Grum area separately as these areas are located within separate drainages. Closure activities pertaining to each of these areas are described in Section7. (The Rose Creek Tailings activities are also considered within the Faro area as they are located within the Rose Creek drainage).

Impact statements for the two indentified VECs, Groundwater Quantity and Groundwater Quality, are provided for each of these areas. The assessment discussion is organized according to specific project activities/components.

Faro Area

Impact Statement GW1 - Extraction of contaminated groundwater from wells and collection trenches (with subsequent treatment and discharge to surface water streams) will reduce groundwater discharge (quantity) to downstream receiving surface water streams (NFRC and Rose Creek). Proposed construction activities such as the draining of ponds, lining of stream channels, raising or breeching of dams and the alteration of water levels in pits will alter groundwater flow directions and flow volumes.

In general, groundwater is recharged in upland areas and discharged to creeks and rivers in valley bottoms within the stream channel and/or adjacent riparian areas. Groundwater discharge conditions occur when groundwater elevations are greater than surface water elevations. This causes an upward pressure gradient and upward groundwater flow. Upward groundwater flow and discharge to streams adds flow to the stream which is particularly valuable for maintaining stream flows during periods when there is little or no surface runoff, (i.e., during frozen winter conditions at Faro).

Discharge of groundwater is relatively consistent in quantity of flow, temperature and quality. Surface water flow, temperature and quality are more variable due to weather and seasonal effects. Groundwater velocities are orders of magnitude slower than surface water flow rates and groundwater flow travel times from recharge to discharge locations are typically tens or hundreds of years. Groundwater, therefore, is isolated from the effects of weather and seasonal effects that cause greater variation in surface water flow, temperature and water quality. Groundwater temperatures are typically about the same as the mean average annual air temperature. Upward groundwater flow in stream bottoms will cool stream temperatures during summer and will raise temperatures in winter. In the Faro climate, groundwater discharge to deeper streams will prevent freezing to the bottom of the channel. This temperature modifying effect of groundwater discharge is beneficial for providing over-wintering habitat below the ice for fish and other aquatic life.

The capture and treatment of contaminated groundwater using extraction wells and/or groundwater collection trenches with sumps is a major component of the closure plan at Faro and Vangorda/Grum. The design objective is to collect and treat 98% of contaminated water at the site. As soon as pumping commences, the groundwater elevations immediately decline and start to create a drawdown cone. As pumping continues, the drawdown cone extends radially outward from the pumping well. Generally the pumping rate is set so that pumping water level in the well eventually becomes stable and stops declining, otherwise the well will go dry. The drawdown cone will continue to extend laterally for weeks or months until the pumping rate is balanced by the infiltration of precipitation above the drawdown cone or a recharge boundary such as a surface water body. As the drawdown cone advances under a surface water body the hydraulic gradient and the direction of groundwater flow will reverse from upward (discharge) to downward (recharge). Instead of groundwater discharging upward and providing flow and temperature moderation to the stream, surface water will seep downward into the groundwater system.

The Project Description (Section 7) describes contaminated groundwater collection systems in a number of locations within the Local Study aAea that will be activated as required to prevent movement of contaminated groundwater to surface streams. In most cases specific pumping rates, drawdown cones and capture areas cannot be defined until further hydrogeological investigations, monitoring, modelling and system design work is completed. The Adaptive Management Plan has been designed to allow optimal design of these groundwater collection systems based on the most recent information of groundwater flow and quality.

Faro Groundwater Quantity Assessment Results

Assessment results are described below for individual Faro components of the proposed project.

Faro Waste Rock Dumps

Oxide fines and low grade ore stockpiles (LGSP) will be consolidated and covered achieving a 40% reduction in surface area and therefore a reduction in infiltration/metal and acidity loadings. Sulphide cell remediation will consist of covers used to reduce infiltration, and consolidation of smaller piles of highly reactive material into larger dumps where practical. All remaining waste rock at the Faro site will be re-graded, re-sloped, and covered while maximizing surface water management and revegetating disturbed areas.

The placement of low permeability cover material over mine waste rock will reduce infiltration of precipitation into the waste rock and increase surface runoff - thus reducing local groundwater recharge and reducing the volume of contaminated groundwater produced. Precipitation that runs off the mine waste covers (runoff will not be contaminated) will infiltrate and recharge groundwater in areas beyond the waste rock piles or discharge directly to surface water. Therefore it is reasonable to expect that the mine waste rock covers will reduce the volume of contaminated groundwater recharged below the waste rock piles but will increase the volume of clean groundwater recharged in the areas beyond the edge of the waste rock piles. Furthermore, although the waste rock covers are not designed to prevent entry of air, they will likely reduce the ease with which air can enter the waste rock piles and interact with sulphide minerals. This is expected to slow down the ARD reactions and improve groundwater quality. When both groundwater quantity and quality are considered the effect of the waste rock/mining waste covers will have a positive effect and therefore they are not discussed further.

Faro Pit

The Faro Pit will be used as a central collection pond for all contaminated water collected in the Faro Mine area and Rose Creek Tailings Facility Areas. Contaminated water will be stored in the pit for seasonal treatment in a High Density Sludge (HDS) plant. Recent studies have shown that the progressive unravelling of the Faro pit wall will ultimately undermine the diversion channel; therefore, it will eventually be necessary to relocate the Faro Creek Diversion Channel (in addition to the Faro East interceptor ditch) to a new alignment further up the hillside. This will keep clean water

routed outside of the Faro Pit and also minimize seepage losses that could impact the stability of the Faro pit walls.

Water level within the Faro Pit affects groundwater levels near the pit. If water levels in the pit are kept at lower elevations , groundwater will tend to move towards the pit. If pit water levels rise above baseline static levels due to the pumping of additional contaminated water to the pit, then outward flow of contaminated groundwater through the pit walls may occur. Water levels in the pit are managed within a specific range due to concerns about: prevention of overflow to the Zone II Pit, geotechnical stability of the pit walls; pit wall ARD geochemistry issues; and for water management purposes associated with water treatment. Faro Pit water level management objectives should also consider groundwater flow or quality issues in the vicinity of the pit. Lowering the water level in the pit will tend to reduce the volume and rate of contaminated groundwater movement to downslope surface water streams.

The Project plans to manage water levels in Faro Pit as they are currently being managed during the care and maintenance program (see Section 7.4.1) The impact, if any, is therefore considered to be negligible in magnitude, local in extent and permanent in duration if used in perpetuity as planned.

Faro Zone II Pit

The Zone II Pit is buried with waste rock and is hydraulically connected to the Faro Pit on the downgradient side. A new 150 mm diameter well will be installed in the Zone II Pit to replace the existing well, and will be installed to a depth of ~90 m. Groundwater will be pumped to the Faro Pit in order to prevent Zone II pit water levels from rising and discharging over the rim of the pit as contaminated groundwater moving through waste rock. The new well will be deeper and therefore capable of pumping at higher rates, creating greater drawdown and capture of greater quantities of contaminated groundwater. The Zone II well is totally surrounded by waste rock including oxide fines, sulphide cells and relocated low grade ore stockpiles. It is highly likely, therefore, that this well will only collect contaminated groundwater (i.e., the drawdown cone will not extend beyond the waste rock piles). Increased pumping may reduce groundwater elevations below the waste rock piles, but when groundwater quality and quantity are considered the new well and greater pumping capability are considered to have a positive impact.

S-Cluster Area

A first-phase groundwater collection system was installed in the S-cluster area in early 2009. During the construction phase, an interceptor ditch and sump combined with pumping will be installed for the shallow aquifer to keep water levels within the ditch low and gradients toward the sump (instead of NFRC). For the deep aquifer, a collection system is proposed in high concentration areas that includes small diameter pumping wells installed into weathered bedrock and overlying permeable materials. A pipeline will be used to transport the intercepted contaminated groundwater to the treatment plant or the Faro pit.

The S-Cluster groundwater collection system locally reduces groundwater flow and discharge to NFRC. The groundwater that is collected, however, is highly contaminated; therefore, the reduced groundwater flow to NFRC is considered a positive effect when both groundwater quality and quantity are considered.

Zone II Outwash Area

Several remediation activities are planned for Zone II Outwash Area, including relocation of outwash material to the intermediate sulphide cell and the installation of a localized groundwater collection system. Cut-off walls and possible grouting of bedrock along the cut-off wall alignment are planned to reduce the contaminant load to NFRC and underlying aquifer. A pipeline will be used to pump contaminated water back into Faro Pit Lake for storage before water treatment.

The Zone II Outwash Area groundwater collection system locally reduces groundwater flow and discharge to NFRC. The groundwater that is collected, however, is highly contaminated; therefore, the reduced groundwater flow to NFRC is considered a positive impact when both groundwater quality and quantity are considered in the assessment.

Emergency Tailings Area (ETA)

Construction phase reclamation activities to be completed at the Emergency Tailings Area (ETA) include the removal of the ETA tailings and the installation of a groundwater collection system. Prior to removal of the tailings, a sump will be installed downhill of the current mine access road to intercept day-lighting contaminated seepage and pump it to the Faro Pit. Following removal of the tailings, a shallow sump in combination with a groundwater collection system, consisting of a series of shallow pumping wells near the mine access road, will be installed.

The ETA groundwater collection system locally reduces groundwater flow and discharge to the Rose Creek Tailing Management Facility (TMF), which already has highly contaminated groundwater. This activity is not assessed to have a negative effect on groundwater flow.

Faro Creek Diversion Channel

Medium priority areas are defined to be the Guardhouse Creek near the mill, below the mill near the ETA, and below the Intermediate Dump. Each of these areas will have conceptual groundwater collection systems and AMP measures defined, but implementation is not considered urgent at this time. The magnitude of impact on groundwater quantity from these potential activities is assessed to be low and of local extent. When impacts to surface water quality are considered the overall impact is positive.

North Fork Rose Creek Channel Alteration

North Fork Rose Creek channel will be raised and conveyed past potential areas where contaminants could seep into the creek (beginning where Faro Diversion channel enters NFRC and extends to the confluence with the SFRC - a distance of about 3.5 km). The channel will be lined in order to minimize seepage into the ground and/or upwelling of groundwater into the channel (i.e., keeps clean water clean, and contaminated water separated from the clean water). The stream bed of NFRC will also be raised in order to ensure there is no potential for an upward groundwater seepage gradient into the channel.

The effect of elevating and lining the NFRC channel may vary from place to place and perhaps seasonally. Isolating the stream from upward discharge of contaminated groundwater from the waste rock pile will be a positive effect. Isolating the creek from clean groundwater flow from the opposite side could be considered a negative effect because it may prevent discharge of clean groundwater to the east side of the creek that may be important for maintaining winter low flows that support overwintering aquatic habitat. It is not clear that the vertical hydraulic gradients (upwards discharge or downwards recharge) have been adequately determined along all reaches of NFRC. Vertical gradients may vary or reverse from upstream to downstream reaches. Vertical hydraulic gradient may also vary or reverse due to seasonal changes in groundwater and surface water elevations.

The impact of the proposed Rose Creek Channel alteration on groundwater quantities may vary between stream reaches and seasonally. However, the magnitude of the groundwater impact is assessed to be low and of local extent. When impacts to surface water quality are considered the overall impact is positive.

Rose Creek Diversion Channel

The Rose Creek Diversion Channel will be upgraded to include the construction of an inlet structure and fuse plug, designed for the 1:500 year return flow. This design would allow overtopping and erosion of the fuse plug, directing all flow over the Intermediate Tailings Impoundment. Following such an event, minor repair of the diversion channel and dike from the fuse plug to the confluence with the natural channel of Rose Creek (below the Cross Valley Dam) will be required. The post-closure phase will require regular/annual inspection and monitoring, as well as potential maintenance and repairs to the creek channel (Section 10.2.5).

GLL (2002) provides a water balance of groundwater flows in the vicinity of the Rose Creek Tailings Impoundment based on a 3D ModFlow groundwater model. Flows from the upstream aquifer were calculated to be 23.1L/s. Groundwater discharges to the upper section of the Rose Creek Diversion Channel were calculated to be 0.5L/s. Seepage from the lower section of the Rose Creek Diversion Channel to groundwater was estimated to be 1.05L/s.

The infiltration of clean surface water from the lower portion of the diversion channel may be partially responsible for better than expected groundwater quality in some of the monitoring wells

downstream of the Cross Valley Pond. This infiltration also increases the volume of groundwater flow that is available to sustain Rose Creek winter flows further downstream. Any potential upgrades to the diversion channel should consider these beneficial effects and try to maintain or enhance them.

Tailings Impoundment Cover

The cover proposed for the Rose Creek Tailings Impoundment will consist of a layer of 0.5 m of waste rock to provide stability for construction vehicles, topped with 1.5 m of loosely compacted glacial till, with differential settlement expected over time. The cover will also be re-vegetated for aesthetic and erosion prevention purposes. The final elevation of the tailings soil cover is expected to be 1,050.5 masl with a 0.15% slope to prevent surface water ponding.

The cover will reduce infiltration into the tailings area, although due to the flat slopes and nature of the cover, there will continue to be some infiltration. The cover will not prevent oxygen migration or prevent ARD processes but will tend to attenuate these processes somewhat. The proposed cover will slightly reduce groundwater recharge in this area, but recharge through the tailings would result in highly contaminated groundwater. For these reasons, the Rose Creek Tailings cover is considered to have a positive effect when both groundwater quality and quantity are considered in the assessment.

Intermediate Dam, Cross Valley Dam, Cross Valley Pond and Groundwater Collection System

The Intermediate Dam will be raised 1,058.8 masl in order to accommodate flood flows in the event that the fuse plug is eroded. A new spillway will be constructed in rock to route flood water around the Intermediate Dam (see Figure 7.5). The Cross Valley Dam will be partially breached in order to allow water to egress from the spillway and enter the reconstructed Rose Creek. In addition, in order to allow construction of the Intermediate Dam raise, the sludge and sediments accumulated in the Cross Valley Dam polishing pond will be removed. The original polishing pond floor and the remainder of the dam will be re-vegetated. Discharge of treated water from the treatment plant will be to a polishing pond upstream of the tailings impoundment which then discharges to the Rose Creek Diversion channel.

A groundwater collection system will be installed near the toe of the Intermediate Dam to capture all contaminated groundwater from the Rose Creek Tailings area. The collection system will consist of a shallow, permeable trench with a series of pumping wells that will direct water to a central sump located within the permeable trench. Collected water will be pumped from the sump to the Faro pit. A monitoring system will be installed up and down gradient from the collection system in order to assess performance and identify any system bypass. A cut-off wall may be installed downgradient if required.

GLL (2002) provides a water balance of groundwater flows in the vicinity of the Rose Creek Tailings Impoundment based on a 3D ModFlow model. Based on pond levels at the time, the model predicted 52.6 L/s of groundwater recharge from the base of the Cross Valley pond.[2] This is the largest input into the groundwater flow system, greatly exceeding the flow from the upstream aquifer (23.1 L/s) and runoff/recharge (12.73 L/s).

The largest outputs (groundwater discharge) from the modelled water budget were toe seepage from the Cross Valley Dam (43.7 L/s), discharge to the old Rose Creek Channel downstream of the Cross Valley Dam (11.5 L/s) and flow in the downstream aquifer (31.5 L/s). The water level elevation in the Cross Valley Pond provides a strong downward pressure that drives groundwater to depth in below the pond, based on particle tracking in the model. Groundwater discharge at the toe of the Intermediate dam was estimated to be much less (1 L/s).

The draining of the pond and breaching of the Cross Valley dam will result in substantial changes in groundwater elevations, flow volumes and discharge locations. Draining of the pond will remove the hydraulic head driving downward groundwater movement to depth and greatly reduce or eliminate the toe seepage from the Cross Valley Dam. Draining of the pond, however, will increase the hydraulic head below the Intermediate dam causing more downward groundwater flow and much more seepage at the toe of the Intermediate Dam. This increased seepage and deeper groundwater flows in the aquifer will be captured by the groundwater collection system. The plan is to collect 98% of the groundwater flows that pass under the intermediate dam (see Section 7.7.10).

The draining of the Cross Valley Pond, breeching of the Cross Valley Dam, raising the Intermediate Dam and installation/operation of the proposed groundwater collection system will reduce groundwater flow in the Rose Creek aquifer downstream of the Cross Valley Pond by 98% and thus will reduce groundwater discharge to Rose Creek by 98%. Seasonal water treatment and discharge to creeks will increase stream flows during summer months that will mask the effects of the reduced groundwater discharge during the summer. During the winter low flow period, however, when the groundwater is pumped to Faro Pit and the water treatment plant is not discharging, there will be a reduction in groundwater contribution to surface flows in Rose Creek. It is expected that the reduction in groundwater discharge during winter months will substantially reduce Rose Creek low flows and reduce the depth and extent of unfrozen water in the stream below the ice available for over wintering aquatic habitat. The potential effects of reduced groundwater flows on aquatic organisms are discussed in Section 8.7.

[2] More recent estimates indicate up to 80 L/s or groundwater recharge as discussed in PD Chapter 8.2.2.

These negative effects on groundwater quantity (flow) are assessed to be regional in geographic extent as the effects will extend down Rose Creek into the RSA. The duration of the impacts is permanent and the frequency is continuous if perpetual groundwater collection and treatment is required. The magnitude of the impact is assessed to be medium. The likelihood of the impact occurring is high. The confidence in the data used is low to medium. The groundwater flow model is sophisticated and based on considerable data. However the confidence of the assessment will be even higher after additional work is done on the detailed design of the proposed construction activities and the groundwater model is used to assess the anticipated impacts.

Faro Groundwater Quality Assessment Results

Impact Statement GW2 Groundwater Quality: Extraction of contaminated groundwater from Project wells and trenches (with subsequent treatment and discharge to surface water streams) will positively affect groundwater quality discharging to downstream surface water streams. Closure Implementation construction activities including decommissioning of the Cross Valley Pond and installation of the groundwater collection system may affect groundwater quality by reducing the infiltration of clean treated surface water into the ground, which currently dilutes contaminant concentrations in groundwater downstream of the Rose Creek tailings area and improves the quality of groundwater discharging to Rose Creek.

Draining the Cross Valley Pond, breeching of the Cross Valley Dam, raising the Intermediate Dam and installation/operation of the proposed groundwater collection system as discussed above will affect groundwater quality as well as groundwater flow. Draining the Cross Valley Pond will eliminate a large volume (52.6 L/s) of "clean" treated surface water that recharges the groundwater flow system in this area. This recharge drives the groundwater flow system downward and dilutes the groundwater from upgradient areas below the tailings impoundment. The infiltration of "clean" surface water from the Cross Valley Pond may be partially responsible for better than expected groundwater quality in some of the monitoring wells downstream of the Cross Valley Pond. The treated water has increased Neutralization Potential due to the high-density lime treatment system and 2-stage pH adjustment it has undergone. This treated water does contain elevated sulphate concentrations because these are not removed during the treatment process.

After the Cross Valley Pond is drained and the dam has been breached, there will be minimal if any infiltration and recharge of clean surface waterin the former pond area. This loss of dilution of water with elevated pH and alkalinity may result in poorer groundwater quality downstream of the Cross Valley Dam. This negative effect is considered to be local in geographic extent (although it may extend into the RSA and therefore be considered a regional effect). The duration is assessed to be permanent. The confidence in the data used for the assessment is low to medium. Confidence of the assessment will be even higher after additional work is done on the detailed design of the proposed construction activities and the model is used to assess the anticipated impacts. Mitigation options may reduce the impact (see 8.5.6).

The expected deterioration of groundwater quality from residual mining waste materials is not considered to be a closure related impact, but rather a legacy of historic mining activity that will cause groundwater quality to deteriorate over time due to the inevitable ARD processes, despite the implementation of the Closure Plan. The proposed collection and treatment of contaminated groundwater will improve groundwater quality downgradient of the two mine areas, as compared to the quality that would be expected if the closure plan was not implemented. This, clearly, is one of the main objectives of the Closure Plan and is considered to be positive result of the Closure Plan. This positive result will, to a large extent, counteract/delay the inevitable long term deterioration of groundwater quality caused by ARD from residual waste materials from historical mining operations. This legacy effect cannot be reversed but will be greatly attenuated and managed with the Closure Plan in place. Since the direction of this impact is positive, there is no need to assess it further.

Vangorda/Grum Mine Area

Impact Statement GW1: Collection and treatment of contaminated groundwater from the Vangorda/Grum Mine Area will change the groundwater quantity of the down gradient aquifer at the onset of pumping during the Construction Implementation Period (years 1 – 15). Proposed construction activities such as the draining of ponds, lining of stream channels, raising or breeching of dams and the alteration of water levels in pits will alter groundwater flow directions and flow volumes.

Vangorda / Grum Groundwater Quantity Assessment Results

Assessment results are described below for the Vangorda / Grum components of the proposed project.

Vangorda/Grum Waste Rock Dumps

The waste rock dumps at both the Vangorda and Grum sites will be covered in order to decrease infiltration into the dump and prevent dust migration and uptake by animals. Re-sloping of the dumps will required to provide geotechnical stability and prevent cover erosion. The covers will consist of 1 m of lightly compacted till (to allow re-vegetation) overlying 1 m of compacted till. Swales will also be incorporated into the covers to aid in erosion prevention and achieve revegetation objectives.

The placement of low permeability cover material over mine wastes will reduce infiltration of precipitation into the waste rock and increase runoff - thus reducing local groundwater recharge and reducing the volume of contaminated groundwater produced. Precipitation that runs off the mine waste covers will infiltrate and recharge groundwater in areas beyond the waste rock piles or discharge directly to surface water. When both groundwater quantity and quality are considered the effect of the waste rock/mining waste cover systems will have a positive effect.

Vangorda / Grum Surface Drainage Changes

The Vangorda Creek Diversion Channel will be upgraded to withstand a 1:500 year flood, with energy dissipation and erosion prevention measures incorporated into the design. The channel will also be realigned in order to optimize cut material and slope, and to avoid impacting the pit if damage to the channel occurs. A plunge pool will be constructed at the outlet of the diversion channel to dissipate the energy of the water before it re-enters Vangorda Creek southwest of the pit.

The Grum Interceptor Ditch diverts Grum Creek in a rip-rapped channel around the upper perimeter of the Grum Pit and discharges the flow to the Sheep Pad Pond sedimentation ponds. The existing Grum Interceptor Ditch will be breached, in addition to the Grum settling pond and flow will be routed into the Grum Pit. In situ bioremediation will occur within the Grum Pit using fertilizer to enhance the growth of algae and bacteria to remove the metals from the water (conducted in spring and summer when organic growth is possible). A series of polishing ponds will be constructed in the Slot (cut into the pit bench if necessary to let water flow through and prevent overtopping the pit) which will allow biomass trapped in the pit to be treated prior to discharge into the natural environment. In addition, the Sheep Pad Pond dams and the Water Treatment Plant (WTP) settling pond will no longer be needed and will therefore also be breached.

The surface drainage measures that lower surface water elevations such as breaching dams and ponds or deepening surface drainage channels are expected to locally lower groundwater levels in immediately adjacent areas and will cause minor alterations in local groundwater flow direction. However these effects are assessed to be local in geographic extent, permanent in duration and negligible to low in magnitude. For this reason, these localized effects are not assessed further.

Vangorda / Grum Pit Water Level Changes

After all closure measures have been implemented, there will be a perpetual requirement for water treatment. The objective of the new water treatment system is to be compatible with the volume and concentration of contaminated water, considering (seasonal) storage, and to meet the criteria for effluent discharge which is protective of the environment. The second water treatment plant is to be located downhill of the Vangorda Pit, between the pit and waste dump allowing the plant to be reasonably central to the sources of contaminated water. A high-density lime treatment system and 2-stage pH adjustment would be utilized, identical to the proposed water treatment system at the Faro site. Effluent will be discharged to a polishing pond, likely Little Creek Pond located to the northwest of Vangorda waste dump, with a residence time of at least 24 hours (see Section 7). In addition, all treatment sludge will be discharged to a sludge pond prior to disposal in Vangorda Pit. Construction of the water treatment plant is expected to start after completing the covers on Vangorda waste dump.

Proposed seasonal water treatment relies on use of the Vangorda pit to contain pit inflows and any other contaminated water collected during the winter when water treatment is not being conducted. The Vangorda pit is the smallest pit but currently has the worst water quality of all three pits at the

Faro Mine Complex. The pit water quality is affected by mineralized rock on the pit walls and by surrounding waste rock. Inflows from seepage and runoff exceed outflows, so the pit is slowly filling up. This indicates that there is currently an inward hydraulic gradient and groundwater flow toward the pit at least on the uphill sides. In the future, additional water from seepage collection systems at the toe of Vangorda waste dump will be pumped to the pit prior to treatment, further increasing the volume of water entering the pit. It is anticipated that the pit levels will be managed so that they do not rise above the static water level; otherwise, groundwater gradients would reverse and there would be potential for contaminated water to migrate outward away from the pit (see Section 7.8.17).

The proposed plan for drainage and in situ bioremediation within the Grum Pit will maintain pit levels at a relatively constant level and therefore minimal changes in the groundwater flow system will be caused by the proposed activities in the Grum Pit.

The potential changes in the Grum and Vangorda Pit water levels are expected to locally lower or raise groundwater levels in immediately adjacent areas and may cause minor alterations in local groundwater flow direction. However these effects are assessed to be local in geographic extent, permanent in duration and negligible to low in magnitude, and are not assessed further.

Vangorda / Grum Seepage Interception Systems

To capture contaminated groundwater seeping from the Grum Waste Rock Dump seepage interception will be implemented as an adaptive management measure, focusing initially on high concentration areas. Pumping wells would be constructed and pipeline alignments cleared along the access road below the Grum Dump. The central sump would be excavated in the vicinity of where Grum Creek crosses the access road. Collected seepage will be pumped to the Vangorda Pit for storage prior to treatment. If monitoring indicates insufficient capture of contaminated groundwater, a cut-off wall and permeable collector trench would be constructed uphill of the access road as a contingency.

There is currently a seepage collection system in place at the Vangorda Waste Rock Dump consisting of French Drains which discharge into a seepage collection ditch that discharges to Little Creek Pond. More active collection of groundwater seepage from the VWRD is currently not required, but may become necessary in the future if contaminant concentrations increase sufficiently. A conceptual plan for future contaminated groundwater seepage collection consists of pumping wells installed from the existing access road along the toe of the WRD. The contaminated groundwater would be pumped and discharged to the Vangorda Pit via a pipeline along the existing road to the pit.

The proposed Grum and Vangorda waste rock dump groundwater collection systems will locally reduce groundwater flow and discharge to Vangorda Creek. The anticipated groundwater capture volumes are expected to be low relative to creek flows because the groundwater collections systems will constitute a much smaller portion of the watershed. The groundwater collection will extract water from thin sand lenses in the glacial till or from fractured bedrock. These strata are of lower

permeability and are much less extensive than the Rose sand and gravel aquifer at the Faro site. The groundwater pumping volumes and drawdown cones are therefore expected to be much smaller for the Vangorda/ Grum groundwater collection systems. The groundwater that is collected will be highly contaminated. Therefore the groundwater collection systems near Vangorda Creek are considered to have a positive impact when both groundwater quality and quantity are considered.

Vangorda / Grum Groundwater Quantity Assessment Results

Impact Statement GW2: Extraction of contaminated groundwater from Project wells and trenches (with subsequent treatment and discharge to surface water streams) will positively affect groundwater quality discharging to downstream surface water streams. Proposed construction activities such as the draining of ponds, lining of stream channels and the alteration of water levels in pits will alter groundwater flow directions and flow volumes which may have negative effects on groundwater quality.

The expected deterioration of groundwater quality from residual mining waste materials is not considered to be a Project related impact, but rather an extension of mine legacy conditions that will deteriorate over time due to the inevitable ARD processes, despite the implementation of the Closure Plan. This legacy effect cannot be reversed but will be greatly attenuated and managed with the Closure Plan in place.

The proposed collection and treatment of contaminated groundwater caused by historical mining areas will improve groundwater quality downgradient of the Grum and Vangorda mine areas, as compared to the quality that would be expected if the closure plan was not implemented. When both groundwater quantity and quality are considered the effect of the Grum and Vangorda seepage collection systems will have a positive effect and therefore they are not discussed further.

No potential LSA groundwater quality impacts have been identified for the proposed project activities in the Vangorda / Grum area.

8.5.4 Local Study Area - Post-Closure Period

Assessment Method

The assessment of effects during the Post – Closure phase was conducted using professional judgement similar to the assessment for the implementation phase.

Groundwater Quantity Assessment Results

In the post-closure phase all closure construction activities will be completed and all the groundwater pumping systems are assumed to be in place and operating, although the timing of installing these systems is dependent on the groundwater monitoring results. The potential changes in the groundwater extraction system and its operation will be modified as dictated by the Adaptive Management Plan (AMP).

No major year-to-year changes in the groundwater elevations, groundwater flow systems, or groundwater discharge to streams caused by Project activities are predicted. If groundwater conditions do change in the post-closure period, then it is expected that the AMP would trigger appropriate actions, where and when required, to respond to these changes. For instance, if pumping drawdown cones increased due to drier climate conditions and there was inadequate groundwater discharge to streams, then the AMP would trigger actions (e.g., reduced pumping rates) so that groundwater flow conditions regained the desired equilibrium. Assuming appropriate AMP triggers and responses, there are no anticipated Project effects during the post closure period. The proposed groundwater extraction systems and groundwater treatment are proposed to continue in perpetuity.

Groundwater Quality Assessment

ARD and metal leaching are expected to continue with increasingly rapid degradation of groundwater quality in areas where the mine wastes become acidic. The timing of these geochemical processes cannot be accurately predicted. The AMP has been proposed to deal with this uncertainty by reviewing monitoring results and trends to determine the timing and scope of the required Project activities.

The various groundwater interception systems outlined in the (Section 7.3.2) are intended to counteract this trend of decreasing groundwater quality over time. The AMP will fine tune the operation of existing environmental control systems and recommend the implementation of upgrades or changes in operation if required.

8.5.5 Regional Study Area: Closure Implementation and Post-Closure Phases

Impact Statement GW1: Extraction of contaminated groundwater from wells and collection trenches (with subsequent treatment and discharge to surface water streams) will reduce groundwater discharge (quantity) to downstream receiving surface water streams (NFRC and Rose Creek).

Based on our current understanding of the groundwater flow system and the effects of the proposed groundwater collection system, there is no reason to expect that any of the pumping drawdown cones will extend beyond the boundaries of the LSA into the RSA. The effects of reduced groundwater flow in the LSA are unlikely to be measureable outside the LSA because the water that is removed is then treated and discharged into either Rose Creek or Vangorda Creek within the LSA. It is expected that within the RSA, groundwater elevations will not change from current conditions. Therefore Impact Statement GW1 Groundwater Quantity is not assessed for the RSA.

Impact Statement GW3 Groundwater Quality –Project activities will involve the transportation, storage and use of fuel and various other chemicals. Spills or leaks of these materials have the potential to cause localised groundwater contamination.

Issue GW3 considers the potential for groundwater quality degradation caused by the storage, handling and use of fuel and other chemicals during remediation activities. Other chemicals would include oil, anti freeze and hydraulic fluid used in construction vehicles and water treatment

chemicals. There may also be some requirement for blasting so ammonium nitrate or other blasting residuals are also possible. Use of calcium chloride or similar products for road dust control can degrade groundwater quality if over used. These types of activities may take place anywhere within the RSA. The above- mentioned issues are common to most construction projects and will be dealt with using environmental management plans, best management practices and spill response plans. Potential impacts from these activities are expected to be low in magnitude, local in geographic extent and generally short or long term in duration.

Impact Statement GW2: Extraction of contaminated groundwater from Project wells and trenches (with subsequent treatment and discharge to surface water streams) will positively affect groundwater quality discharging to downstream surface water streams.

Concern has been expressed in the past by Faro residents that contaminated groundwater from the Vangorda/Grum area could affect the Faro Municipal well located 8km down slope from the Vangorda and Grum pits. This issue was assessed by Gartner Lee Limited (2007) and it was concluded that any contaminated groundwater would discharge to the Vangorda Creek in close proximity to the mine site and would not migrate to the Faro municipal well. Furthermore the potential for the Faro well drawdown cone to intercept Vangorda Creek and draw in potentially contaminated surface water to the well was also considered by Gartner Lee Limited (2007). This report concluded that movement of creek water to the Faro municipal well was highly unlikely.

Discussion and Conclusions

Based on the available information, measurable impacts on groundwater flow in the RSA are not expected. Measureable impacts on groundwater quality from construction activities will be managed and mitigated using environmental management plans, best management practices and spill response plans. The potential for the Faro drinking water well to be contaminated by groundwater migrating from the Vangorda and Grum areas is highly unlikely, with the proposed collection and treatment systems proposed. Any residual effects are expected to be low in magnitude, local in geographic extent and short term in duration.

8.5.6 Mitigation Measures

Mitigation by Design

The groundwater collection and treatment components of the Project are themselves a major mitigation of the effects on groundwater quality caused by legacy mining activities.

While precise details on groundwater collection systems, pumping rates and extent of drawdown cones are not available at this time, it is understood that these will be determined during further investigations, detailed design and collection system initiation periods. Initial operational results will be monitored and will be used to adjust pumping rates and drawdown cones to maximize collection of contaminated groundwater and to minimize collection of uncontaminated groundwater that provides baseflow to streams. When this data becomes available three- dimensional

groundwater flow modeling with particle tracking should be completed for well capture zones and to predict long term capture efficiencies and potential reductions in groundwater discharge quantities to streams.

Many of the proposed groundwater collection systems have downgradient barrier walls proposed as options to restrict collection of downgradient "clean" groundwater and restrict the extent of the drawdown cone in the downgradient direction. This can be a useful mitigation to restrict the extent of the downgradient drawdown cone and minimize the potential reduction in groundwater discharges to creeks. It is also a useful mitigation strategy to reduce the pumping and treatment volumes required to prevent off site movement of contaminated groundwater.

Specific Mitigation

Specific Mitigations are measures recommended by the Project environmental assessment team to further reduce predicted Project effects.

The major issues identified in this groundwater assessment are the effects on groundwater quantity and quality that are expected when the Cross Valley polishing pond is drained and the groundwater interception system is installed near the Intermediate Dam of the Rose Creek Tailings impoundment. This interception is designed to capture 98% of the groundwater flow in the aquifer.

As such, these activities are expected to remove a large quantity of treated water that currently recharges the local groundwater aquifer and flow system. The local groundwater system presently discharges to Rose Creek and helps to sustain winter low flows in the creek, and moderate water temperatures that maintain areas of water below ice that provide overwintering habitat for aquatic life.

The recharge of large quantities (estimated to be even greater than the entire flow from the upstream aquifer) of treated water from the base of the pond is currently diluting the contaminant concentrations from the tailings impoundment. It is also causing the groundwater flow to dip downwards so that the contaminated water discharges further downstream in Rose Creek. This longer travel path provides more time for contaminant attenuation processes to reduce concentrations. Furthermore the treated water has elevated pH and alkalinity levels which tend to further promote attenuation of metal contaminants.

The following specific mitigation measures are proposed to address these issues.

1. The installation of a system of groundwater extraction wells in the Rose Creek aquifer installed through the final covered tailings impoundment is worth considering if routine monitoring indicates further degradation of groundwater quality in the Rose Creek aquifer. A series of groundwater collection wells installed in areas of identified poor water quality and screened just below the tailings would have the following advantages:
    a. Such a system would tend to capture contaminated groundwater near the tailings source in the upper part of the aquifer where the metal concentrations are higher and the volume of

water that would need to be collected and treated would be less. This would reduce the volume of water collected compared to capturing it downstream of the Cross Valley dam.

b. These wells would be at a similar elevation as the water treatment plant thus pumping costs would be less, in perpetuity.

c. The wells would only have to be pumped during the summer when treatment capacity was available. Groundwater travel times from one end to the other end of the tailings facility are estimated to be in the order of ten years. Higher pumping rates during the summer should be capable of capturing the annual flux of contaminants without winter operation, except perhaps at the downstream end of the impoundment. This can be confirmed with digital groundwater modeling and particle tracking.

d. The proposed Rose Creek groundwater interception system will likely still be required at some point to capture seepage below the intermediate dam but volume of contaminated groundwater that needs to be collected may considerably less. This will reduce the amount of pumping required and will likely allow a larger volume of uncontaminated groundwater from upstream to discharge to Rose Creek and provide additional winter flows under the ice for over wintering aquatic habitat.

2. If further investigations confirm that recharge of large quantities of treated water from the base of the Cross Valley Pond is currently diluting the contaminant concentrations from the tailings impoundment, then the discharge location for the proposed new water treatment plant could be changed. The Cross Valley Pond must be drained to permit the raising of the Intermediate Dam. After this has been completed, however, treated water from the new plant could be piped with gravity flow to an infiltration facility (shallow ponds or trenches) downslope of the Intermediate Dam instead of discharging the water to Rose Creek just below the confluence with NRRC. This would allow groundwater recharge in the area upgradient of Rose Creek during the summer with later discharge of groundwater to the creek in winter.

8.5.7 Significance Determination

The impact rating criteria included in Section 8.1 were applied to adverse effects that remain after mitigation measures are applied (i.e., residual effects). These residual effects and the assessed ratings for groundwater are provided below in Table 8.9. None of the residual impacts were rated as significant.

Table 8.14: Hydrogeology Residual Impact Rating[1]

Impact Statement	VEC	Indicator	Project Phase	Residual Impact Rating					
				Direction	Extent	Duration	Frequency	Reversibility	Magnitude
Faro LSA GW1	Groundwater Quantity	Groundwater discharge to Rose Creek sustaining winter low flows	Closure Implementation and Post Closure	Negative	Local	Permanent	Continuous	Reversible	Medium
Faro LSA GW2	Groundwater Quality	Groundwater concentrations of contaminants downgradient of mining areas eventually discharging to Rose Creek	Closure Implementation and Post Closure	Negative	Regional	Permanent	Continuous	Reversible	Medium
Vangorda Grum LSA GW1	Groundwater Quantity	Groundwater discharge to Vangorda Creek sustaining winter low flows	Closure Implementation and Post Closure	Negative	Local	Permanent	Continuous	Reversible	Low
Vangorda Grum LSA GW1	Groundwater Quality	Groundwater Concentrations of Contaminants downgradient of mining areas eventually discharging to Vangorda Creek	Closure Implementation and Post Closure	Positive	Local	Permanent	Continuous	Reversible	Medium
RSA GW2	Groundwater Quality	Groundwater concentrations of contaminants downgradient of fuel or chemical storage or handling locations	Closure Implementation and Post Closure	Negative	Local	Long Term	Intermittent	Reversible	Low

[1]Shading indicates these impacts are either positive or small (probably not residual).

8.5.8 Monitoring and Follow-up

Additional Investigations for Detailed Design

The feasibility of collecting contaminated groundwater from the Rose Creek Tailings Dam should be further investigated by installing several pumping wells and observation wells, both below the Intermediate Dam and through the tailings, when access to these areas becomes feasible. Long term pumping tests (i.e., two to four weeks) should be conducted with continuous monitoring of water levels and pumping rates and frequent water quality testing. This data will be useful for assessing whether the Rose Creek groundwater interception system should be installed where it is currently proposed below the Intermediate Dam, and whether supplementary wells through the tailings would have advantages.

Monitoring of Groundwater Extraction Systems

Groundwater levels and water quality in areas upgradient and downgradient of local groundwater extraction systems should be monitored on a regular basis to allow system effectiveness to be assessed and optimized.

Monitoring of Stream Baseflows

Flows in NFRC, RCDC and Rose Creek downstream of the Cross Valley Dam should be monitored for low flows during winter months. Ice thickness and the depth of water below the ice should also be monitored.

Monitoring of Groundwater Hydraulic Gradients near Streams

Ground water monitoring well nests should be installed at key locations along NFRC, RCDC and Rose Creek. Staff gauges and stilling wells should be installed nearby in the creeks. Geodetic elevations of these installations should be surveyed. Water level transducers and dataloggers should be installed to continuously measure groundwater levels and surface water levels over the non frozen season to assess vertical hydraulic gradients (upward groundwater discharge or downward groundwater recharge).

Monitoring of Groundwater Quality

The current program of annual monitoring of groundwater should continue in order to assess any trends in groundwater quality over time at various areas of the Faro Mine Complex.

Establishment of Groundwater Level and Quality Early Warning and Compliance Points

Discussions should be held with technical advisors, regulators and other stakeholders to determine appropriate locations for early warning and compliance monitoring of groundwater quality.

8.6 Surface Water Quality

8.6.1 Overview

The Faro Mine Closure has the potential to affect surface water quality with implications to aquatic life, wildlife and drinking water sources. Existing surface water quality has been well documented in the proposed Closure Plan area with the overall goal of assembling a comprehensive understanding of the existing conditions in receiving waters in the study area (AECOM 2009). This information was summarized in Section 4.6.3 of this report and helps inform the assessment of impacts of the Project on surface water quality. Project activities described in Section 7.0 of this report and form the basis of effects pathways considered in this assessment. The surface water impact assessment was based on the summary of information provided in the following documents:

- SENES Consultants Ltd. 2010. Probabilistic Human Health and Ecological Risk Assessment of Final Closure and Remediation Plan for Faro Mine Complex. Draft Report. February, 2010.
- Minnow Environmental Inc. 2010. Aquatic Impact Assessment Related to Current and Future Zinc, Cadmium and Sulphate Concentrations at Faro Mine, Yukon. February 2010.
- Predictions for surface water quality provided for the Project Description by Gomm Environmental Engineering Consultants (January 2010).
- Descriptions of existing surface water quality provided in Section 4.0 of this Impact Assessment document.
- AECOM (2009). Faro Mine Complex Closure and Reclamation – Project Proposal Current Environmental Conditions Supporting Document. March 2009.

8.6.2 Study Area Description

The following summary is taken from AECOM (March 2009).

The Faro Mine Complex footprint is located within two watersheds: the Rose Creek watershed (includes Faro Creek drainage) and the Vangorda Creek watershed. The Rose Creek watershed forms a part of the larger Anvil Creek watershed, as Rose Creek is a tributary of Anvil Creek. Anvil Creek and Vangorda Creek are tributaries of the Pelly River. The two watersheds (Rose Creek and Vangorda Creek) receive drainage from the mine sites by means of surface run-off, treated effluent discharge, natural and diverted surface water inflows and groundwater/surface water interactions. The confluence of Rose Creek and Anvil Creek is located approximately 24 km (linear distance) downstream of the nearest site of mine activities (foot of tailings ponds).

The larger Anvil Creek watershed and the Vangorda Creek watershed are contained within the larger watershed of the Pelly River, which, in turn, drains to the Yukon River. The confluence of Anvil Creek and the Pelly River is approximately 40 km from the Rose Creek/Anvil Creek confluence, and is therefore approximately 64 km from the nearest site of mine activities. The confluence of Vangorda Creek and the Pelly River is approximately 17 km from the nearest former mine and

proposed closure activities along Vangorda Creek. Along the Pelly River, it is approximately 64 km from the Vangorda Creek confluence to the Anvil Creek confluence.

Local Study Areas

There are two Local Study Areas (LSAs) for surface water quality: Rose Creek and Vangorda LSAs. The two LSAs are based on the physical and hydrological footprint of the Faro and Vangorda/Grum mine sites respectively and include drainages that are directly influenced by site infrastructure associated with closure activities including the haul roads, waste rock piles, pits and discharges of treated water. The LSA extends from reference stations, which are located upstream from the Faro and Vangorda/Grum mine sites, to the first monitoring point downstream of treated effluent discharge points and site influenced drainage inflows. The water quality LSAs for the environmental assessment of the Closure and Remediation Plan of the Faro Mine Complex are illustrated in Figure 4-10 along with the LSA boundaries. Sampling stations referred to in this assessment are shown in Figures 4-11 (Faro/Rose Creek) and Figure 4-12 (Vangorda Creek).

Rose Creek LSA – General Description

The Rose Creek LSA encompasses a section of the Rose Creek watershed, with boundaries just upstream of former mine and proposed closure activities, to a point downstream of the former mining activities and proposed closure activities. The Rose Creek LSA includes sections of the watersheds of several tributaries that flow into Rose Creek. Faro Creek has been diverted north of the Faro Pit, and flows into the North Fork of Rose Creek at a location northeast of the Faro Pit. The North Fork of Rose Creek flows past the eastern edge of the Faro waste rock dumps and is joined by the South Fork of Rose Creek in the area southeast of the Faro waste rock dumps and of the Tailings Ponds. Rose Creek then flows westward via the Rose Creek diversion constructed south of the Tailings Ponds, and on to Anvil Creek.

The downstream boundary of the Rose Creek LSA is downstream of the Tailings Ponds and the mixing zone after the confluence of the North Wall Interceptor and Rose Creek. Water quality is characterised in Rose Creek at water quality monitoring station X14. Station X14 is the first station downstream of all mine activities and so forms the downstream extent of the Rose Creek Local Study Area. Water quality predictions for Station X14 were therefore used for the assessment of impacts within the LSA.

Vangorda Creek LSA – General Description

The Vangorda LSA encompasses a section of the Vangorda Creek watershed, with boundaries just upstream of the former mine to a point downstream of the former mining activities and proposed closure activities. Sections of the watersheds of several tributaries that flow into Vangorda Creek are included. Vangorda Creek flows southward around the western side of the Vangorda Pit via the Vangorda Diversion Flume through to the Plunge Pool. At the Plunge Pool, the flows are merged with those from the Sheep Pad Sediment Ponds and from the Vangorda Pit Northwest Interceptor.

The Sheep Pad Sediment Ponds receive flows from the Grum Interceptor Ditch and from the Clarification Pond, which receives discharge from the Vangorda Wastewater Treatment Plant. Vangorda Creek flows to the west of the Grum Waste Rock Dumps, and to the east side of the Vangorda Waste Rock Dump, to its confluence with the Pelly River just downstream of the Town of Faro. Both Shrimp Creek and the West Fork of Vangorda Creek flow into Vangorda Creek downstream of the Plunge Pool.

Station V8 is located just upstream of the confluence of Vangorda Creek with the Pelly River. It is the first station downstream of all mine activities and so forms the downstream extent of the Local Study Area. Water quality predictions for Station V8 were therefore used for the assessment of impacts within the LSA.

Regional Study Area

The Regional Study Area (RSA) is established to assess if there are likely Project effects beyond the LSAs and if they contribute to the cumulative effects assessment for the Project. As surface water quality impacts are generally limited by geographic features creating watershed boundaries, the Pelly RSA has been defined as the portion of the catchment area of the Pelly River watershed in the near vicinity of the drainages of the Faro/ Rose/ Anvil Creeks and of the Vangorda Creek drainage (Figure 4.10). The key point for assessment of water quality in the RSA is station P4, in the Pelly River downstream of the confluence of Anvil Creek. The "net effect" of water quality inputs from the Faro and Vangorda Creek LSAs will be determined for water quality predictions made at this site. Water quality predictions for site P2, the Pelly River downstream of the confluence with Vangorda Creek, will also be used to determine if there are any likely impacts within the 64 km of the Pelly River between the Vangorda and Anvil Creek confluences.

8.6.3 Impact Assessment - Methods

A number of Closure Plan activities will affect surface water quality. Activities incorporated as part of the closure plan (including blasting, excavation, emergency tailings area relocation, cover placement, water diversion construction, water collection systems construction, water treatment plant construction, building destruction and building construction and water management) may result in the release of various substances into the surface water aquatic environment. Over the long-term, the closure planning activities are designed to reduce the potential for release of acid mine drainage from waste rock and tailings left from former mine operations. Changes to surface water quality ultimately have the potential to affect the end user of the resource: water for use by humans and wildlife to drink and for the protection of aquatic life. Protection of aquatic life is the most sensitive use – aquatic organisms are exposed continually to water over their gills and so the potential for contaminant uptake is higher than the potential for uptake by ingestion. The effects assessment was therefore focused on potential impacts to aquatic life.

The surface water quality impact assessment relies on the data and conclusions presented in other reports, namely:

- Existing conditions water quality was described in AECOM (2009).
- "Background" water quality used as input to the risk assessment was compiled in Minnow (2008).
- Identification of COPC and Ecological Risk Assessment was completed by SENES (2010).
- Detailed assessment of the toxicity to aquatic life of Zn, Cd and SO4 was completed by Minnow (2010).
- The Project Description (Draft 4) was prepared by SRK Consulting (2009).
- Predicted water quality was provided by GEEC (2010).

The impact assessment uses the interpretations and conclusions of these supporting documents to place the predictions into the EA context and determine residual effects (after mitigation) and provide the determination of significance. The impact assessment followed the following procedure:

- Pathways of effect were determined from SRK (Project Description Draft 4, 2009);
- Valued Ecosystem Components (VEC) were identified;
- A preliminary list of Contaminants of Potential Concern (COPC) was developed for the site that consisted of all metals measured on site in groundwater seeps and surface water. The initial list was screened using the following criteria to arrive at the final list of COPC that were used for the assessment (SENES 2010). Those COPC that met the following criteria were retained:
  - Concentrations that exceeded the Method Detection Limit (MDL),
  - Concentrations in areas downstream of the site exceeded reference area concentrations,
  - Sufficient data on toxicity was available to make an assessment,
  - Concentrations in surface water exceeded CCME guidelines for protection of aquatic life and
  - Concentrations in groundwater seeps were 100X greater than CCME Guidelines and reference concentrations and thus posed a risk should they enter surface water.
- Those COPC identified as posing a significant ecological risk in surface waters by SENES (2010) were carried forward for the impact assessment; and
- The impact assessment used aquatic toxicity summaries from Minnow (2010) and predicted water quality for site surface waters from GEEC (2010) to determine the likelihood of significantly adverse impacts to surface water quality.

Pathways of Effect

Impact statements were developed to describe cause and effect pathways between Project activities and surface water quality. Five potential pathways of effect for surface water were identified and reviewed:

- **SWQ1** – Closure Plan related activities during the Implementation phase of the Project (first 15 years) may have an effect on surface water quality in the creeks in the Faro / Rose and Vangorda study areas. These activities would include soil disturbance and potential transport of solids to surface water, spills of material or refuelling activities. The potential for impacts from these activities is diverse and spread over a large area of the site and cannot be predicted or modelled. These activities can be well managed and mitigated through standard operating procedures, however, and ensured through engineering protocols such as silt management, spills prevention and management and any potential impacts addressed in Implementation phase monitoring and the Adaptive Management Framework for the Implementation phase of the project. (see Water Management Plan).
- **SWQ2** – Inputs from contaminated groundwater and seepage flows that are not captured and managed may have a detrimental effect on surface water quality during the construction phase and in the post-closure phase. These pathways were not addressed explicitly in the surface water assessment, but this pathway of residual seepage was quantified in the predictive water quality model prepared by GEEC (2010) and any impacts are therefore included in the predictions of surface water quality for the closure phases. Explicit impact assessment, therefore, was not carried out.
- **SWQ3** – Discharge of treated effluents to receiving water will alter water quality by adding loadings of COPC that remain after treatment during the construction phase and throughout the remediation phase. This pathway was quantified in the predictive water quality model prepared by GEEC (2010) and any impacts are therefore included in the predictions of water quality for the closure phases. Explicit assessment, therefore, was not carried out.
- **SWQ4** – Remediation of contaminant sources on-site and collection and treatment of contaminated groundwater and surface water will increase the concentrations of several contaminants of concern in the receiving environment during the remediation phase but will prevent the greater degradation of water quality that will result if these sources are not controlled. This pathway was therefore assessed for the closure and remediation of the mine site and impacts were predicted. They must, however, be interpreted within the context of a "do nothing" scenario, in which source terms are not collected and managed, and receiving water quality degrades.

Valued Ecosystem Components (VECs)

An issue-based approach was used to develop Valued Ecosystem Components (VECs) for surface water quality, and this served to focus the sampling program for existing conditions. The primary issues, as described by elders in the surrounding communities, by Project scientists and by regulators, are whether activities associated with mine closure will result in changes to the aquatic environment, specifically surface water quality, and what the impact of any changes will be.

The VEC selected for the impact assessment is **surface water quality**. Surface water quality is a critical component of the aquatic receiving environment and any changes in this component may

impact the ability of the receiving environment to support aquatic life and provide a source of safe drinking water. The VEC has been selected for this assessment because surface water quality is important to the surrounding First Nations communities, fish and fish habitat and the food chain, and it was also identified as important by regulators and Project scientists.

Contaminants of Potential Concern

Although surface water quality was identified as a VEC, not all aspects of water quality are predicted to change as a result of the closure plan. It was necessary therefore to identify those components of surface water quality that were likely to be degraded by remediation activities, or continue despite remediation efforts, and which were therefore most likely to generate significant adverse effects. These contaminants of potential concern (COPCs) were initially identified through a risk assessment screening process that was based on existing water quality by SENES (SENES 2009) and were later finalized in the final risk assessment report (SENES 2010). The following details are taken from SENES (2010).

Concentrations in surface water were compared statistically to background/baseline concentrations in the study area. Those chemicals that were found to be significantly different from background/baseline were then compared to CCME surface water quality guidelines for protection of aquatic life. The CCME aquatic life guidelines are lower (more stringent) than the CCME drinking water guidelines for the metals considered in this assessment, and so the aquatic life guidelines provide a conservative assessment of risk.

To ensure that all COPCs were identified in the screening process, an additional screening step that involved data collected from the Faro and Vangorda-Grum seeps was used since these seeps could lead to higher concentrations in the surface water in the future. A dilution factor of 1:100 was applied to the maximum measured seep concentrations to account for attenuation before the seeps reached the surface water and for dilution in surface water. The dilution factor of 1:100 was selected based on groundwater seepage to the creeks from the water quality model. These diluted seep concentrations were then compared to reference concentrations and CCME guidelines for aquatic life. If a chemical had a concentration with the applied dilution factor below reference concentrations, it was not considered further. Those chemicals that were found to be significantly greater than reference concentrations were then compared to CCME guidelines for water (for protection of aquatic life). If the diluted seep concentrations exceeded the guideline value, or if guidelines were not available, then the chemicals were carried through the risk assessment.

Chemicals were dropped from the COPC selection process if toxicity data were not available since they could not be quantified in the risk assessment. This adds some uncertainty to the assessment. This risk assessment, however, builds on previous risk assessments for the site and the lack of toxicity data generally denotes chemicals that are not toxic, the final COPC list captures the chemicals of major concern at the Faro Mine Complex.

The 32 chemicals that were considered by SENES (2010, Appendix B) were : aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), bismuth (Bi), boron (B), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), lithium (Li), magnesium (Mg), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), silicon (Si), silver (Ag), strontium (Sr), thallium (Tl), thorium (Th), tin (Sn), titanium (Ti), tungsten (W), uranium (U), vanadium (V), zirconium (Zr) and zinc (Zn).

For the Faro site (Rose Creek) B, Cd, Co, Mn, Pb, Sb, Sn, Sr and Zn were identified as COPC in surface water and carried through in the risk assessment. Consideration of data from Faro Seeps identified Ag, As, Be, Cr, Cu, Ni, Se and V as additional COPC. Sulphate was included as a COPC as there was a high potential for it to be mobilized by acid generation within the tailings and to enter surface waters. Although published guidelines to assess the toxicity of sulphate do not exist the toxicological literature was reviewed and summarized by Minnow (2010). A total of 18 COPC were retained for the Ecological Risk Assessment. Table 8.15 shows the step-by-step screening process used to screen COPCs for the Faro Site. The final two columns show which COPC generated a Screening Index value >1 for the predicted post-remediation water quality, thus indicating the potential for risk to aquatic life (SENES (2010).

Table 8.15: Screening Process for COPC at Faro Site

COPC Identified for Screening		COPC Carried Forward Faro Site						SI > 1 Existing Closure	SI > 1
		> MD I	>Reference	Toxicity Data	> CCMF	Seeps	Final List	Table H-3	Table H-4
Aluminum	Al	Al							
Antimony	Sb	Sb	Sb	Sb	Sb		Sb		
Arsenic	As	As	As	As		As	As		
Barium	Ba	Ba	Ba						
Beryllium	Be					Be	Be	Be	
Bismuth	Bi								
Boron	B	B	B	B	B		B		
Cadmium	Cd	Cd	Cd	Cd	Cd		Cd	Cd	Cd
Chromium	Cr	Cr	Cr	Cr		Cr	Cr	Cr	Cr
Cobalt	Co	Co	Co	Co	Co		Co		
Copper	Cu	Cu				Cu	Cu		Cu
Iron	Fe	Fe	Fe						
Lead	Pb	Pb	Pb	Pb	Pb		Pb	Pb	
Lithium	Li	Li	Li						
Magnesium	Mg	Mg	Mg						
Manganese	Mn	Mn	Mn	Mn	Mn		Mn	Mn	
Mercury	Hg								
Molybdenum	Mb	Mb	Mb	Mb					
Nickel	Ni	Ni	Ni	Ni		Ni	Ni		
Selenium	Se					Se	Se		
Silicon	Si	Si							
Silver	Ag	Ag				Ag	Ag	Ag	
Strontium	Sr	Sr	Sr	Sr	Sr		Sr		
Thallium	Tl								
Thorium	Th								
Tin	Sn	Sn	Sn	Sn	Sn		Sn		
Titanium	Ti	Ti							
Tungsten	W								
Uranium	U	U	U	U					
Vanadium	V					V	V		
Zirconium	Zr								
Zinc	Zn	Zn	Zn	Zn	Zn		Zn	Zn	Zn
Sulphate	SO_4						SO_4		

Tables H3 and H4 are in SENES (2010).
SO_4 was evaluated by Minnow (2010).

For the Vangorda site As, B, Cd, Co, Cu, Mn, Pb, Sb, Se, Sn, Sr, V and Zn were identified as COPC and carried through in the risk assessment. Consideration of data from Vangorda and Grum seeps identified Be and Ni as additional COPC. Sulphate was included as a COPC as it was for the Faro assessment. A total of 15 COPC were retained for the Ecological Risk Assessment. Table 8.16 shows the step-by-step screening process used to screen COPCs for the Vangorda Site. The final two columns show which COPC generated a Screening Index value >1 for the predicted post-remediation water quality, thus indicating the potential for risk to aquatic life (SENES (2010).

Table 8.16: Screening Process for COPC at Vangorda Site

COPC Identified for Screening		COPC Carried Forward Vangorda Site						SI > 1 Existing Closure	SI > 1
		> MD I	>Reference	Toxicity Data	> CCMF	Seeps	Final List	Table H-3	Table H-4
Aluminum	Al	Al	Al	Al					
Antimony	Sb	Sb	Sb	Sb	Sb		Sb		
Arsenic	As	As	As	As	As	As	As		
Barium	Ba	Ba	Ba						
Beryllium	Be					Be	Be	Be	
Bismuth	Bi								
Boron	B	B	B	B	B				
Cadmium	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd
Chromium	Cr	Cr	Cr	Cr				Cr	
Cobalt	Co	Co	Co	Co	Co	Co	Co	Co	
Copper	Cu	Cu	Cu	Cu	Cu	Cu	Cu		Cu
Iron	Fe	Fe	Fe						
Lead	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	
Lithium	Li	Li	Li						
Magnesium	Mg	Mg	Mg						
Manganese	Mn	Mn	Mn	Mn	Mn	Mn	Mn		
Mercury	Hg								
Molybdenum	Mb	Mb	Mb	Mb					
Nickel	Ni	Ni	Ni	Ni		Ni	Ni		
Selenium	Se	Se	Se	Se	Se	Se	Se		
Silicon	Si	Si							
Silver	Ag	Ag						Ag	
Strontium	Sr	Sr	Sr	Sr	Sr		Sr		
Thallium	Tl								
Thorium	Th								
Tin	Sn	Sn	Sn	Sn	Sn	Sn	Sn		
Titanium	Ti	Ti	Ti						
Tungsten	W								
Uranium	U	U	U	U					
Vanadium	V	V	V	V	V	V	V		
Zirconium	Zr								
Zinc	Zn	Zn	Zn	Zn	Zn	Zn	Zn	Zn	Zn
Sulphate	SO_4	SO_4	SO_4	SO_4	SO_4	SO_4	SO_4		

Tables H3 and H4 are in SENES (2010).
SO_4 was evaluated by Minnow (2010).

Zinc, cadmium and sulphate were identified for a more specific assessment as there was a high potential for these substances to be mobilized by acid generation within the tailings and to enter surface waters. Existing concentrations of zinc and cadmium exceed, or were predicted to exceed, generic guidelines (in the case of sulphate, adequate guidelines do not exist). In addition, the toxicity of zinc is influenced by hardness, and hardness varies seasonally in the mine site surface waters. Minnow (2010) completed a more detailed assessment of the potential for toxicity of Zn, Cd and sulphate in Anvil Range waters to guide the determination of impacts. Copper was identified for a more detailed assessment as post-remediation concentrations exceeded the Screening Index value of 1 (SENES, 2010).

Hydrocarbons are also present in the soils at the Faro Mine Complex in areas with elevated metals levels. Soil remediation is a component of the Faro Closure plan and so hydrocarbons and other organic chemicals were not considered in the risk assessment (SENES, 2010).

Total Suspended Solids (TSS) were screened for consideration as they could be mobilized to surface waters by surface disturbances during the Implementation phase of the Project (SWQ1). The turbidity of TSS in water reduces light penetration, can impair olfaction and vision in fish, and can impair gill function. Where TSS settle to the creek bed they can impair survival of benthic invertebrates and early life stages of fish.

VEC selection, indicators and thresholds are summarized in Table 8.17.

Table 8.17: Issue/VEC/Indicator/Threshold Table

Discipline component	Issue Identified and Reason for Selection as VEC	VEC	Indicator/COPC	Thresholds
Surface water quality	Surface water contamination identified in consultation with communities/elders, regulators and by Project team scientists.	Surface water quality`	•Trace metal concentrations at LSA/RSA indicator stations. •Faro Site: Ag, As, B, Be, Cd, Co, Cr, Cu, Mn, Ni, Pb, Sb, Se, Sn, Sr, V and Zn. •Vangorda Site: As, B, Be, Cd, Co, Cu, Mn, Ni, Pb, Sb, Se, Sn, Sr, V and Zn. •Sulphate (SO_4) •TSS	•Canadian Water Quality Guidelines for Protection of Aquatic Life (CCME, 2003) •Where applicable changes from background levels where guidelines are already exceeded. •Minnow (2010) for Zn, Cd and SO4. •SENES (2010) for summary of COPC selection/risk assessment.

Impact Assessment Pathways

The assessment of each Impact Statement/Pathway was reviewed for the surface water VEC. The impact assessment process typically identifies mitigation measures that may prevent or minimize the identified potential environmental impacts. Residual impacts are then assessed for those impacts remaining after all appropriate mitigations have been implemented. This Project, however, cannot be assessed in this way as the Project itself is mitigation of actual and potential threats from the former mining activities. All Impact Statement /Pathways represent the potential responses to mitigation procedures implemented as part of the closure plan. Therefore, the impact assessment is based upon the predictions of impact to surface water quality predicted by GEEC (2010) with no consideration of additional mitigation. Additional mitigation measures and mitigation or management of unforeseen impacts will be addressed through the Adaptive Management Plan for the project to ensure that the impacts predicted and accepted in the final EA will not be exceeded.

Four impact statements/pathways were identified (Section 8.6.3) but only one was carried forward through the detailed impact assessment process. The rationale for this is provided below:

- **SWQ1 –Implementation Phase Activities.** Any potential impacts associated with these activities are prevented/managed by construction phase monitoring and management and the Adaptive Management Framework for the construction phase of the project. Explicit assessment was not therefore carried out.
- **SWQ2 –Unmanaged Contaminated Groundwater and Seepage Flows** were quantified in the predictive water quality model prepared by GEEC (2010) and any impacts are therefore included in the predictions of surface water quality for the closure phases. Explicit assessment was not therefore carried out. (see Chapter 10 in Supporting Document A1, Water Quality Prediction)
- **SWQ3 – Discharge of Treated Effluents to Receiving Water** were quantified in the predictive water quality model prepared by GEEC (2010) and any impacts are therefore included in the predictions of water quality for the closure phases. Explicit assessment was not therefore carried out (see Chapter 10 of the Project Description (Draft 4), Water Quality Prediction)
- **SWQ4 – Remediation of Contaminant Sources On-site and Collection and Treatment of Contaminated Groundwater and Surface Water** was assessed for the closure and remediation of the Anvil Range site and impacts were predicted. They must, however, be interpreted within the context of a "do nothing" scenario, in which source terms are not collected and managed and receiving water quality degrades. (see Chapter 10 of the Project Description (Draft 4),, Water Quality Prediction).

Therefore, the Impact Assessment focuses only on SWQ4- Remediation of Contaminant Sources On-site and Collection and Treatment of Contaminated Groundwater and Surface Water. The nature of the Project is to prevent serious degradation of the surface waters over the long-term. The site remediation, however, will result in short and long-term water quality degradation as a result of seasonal discharge of treated waters that exceed water quality guidelines and the seepage of a small percentage of contaminated groundwater that is not captured and diverted for treatment. Although impact predictions must ultimately be interpreted in the context of what would happen in the absence of remediation, the assessment must also reflect the nature of the Project.

The site-wide water quality model was developed to provide estimates of contaminant concentrations over time, assuming that all groundwater seepage, from either the tailings area or the waste rock dumps, is collected and routed to the Faro Pit on the Faro side, and Vangorda Pit on the Vangorda side. It further assumes that the Faro pit water is treated using a high density sludge treatment system and discharged seasonally (May to September) to the receiving environment. The model assumes that the water in Grum Pit will continue to be treated biologically, and during the open water season treated surface water in Grum pit will be discharged to Vangorda Creek. Predictions over the longer term, once closure has been implemented (from Year 2027 – 2037, when the first, remediation phase water licence will expire) were utilized for the assessment of water quality.

The water quality model showed that COPC concentrations could continue to rise slowly after 2037 but the certainty of these predictions was not sufficient to support an impact assessment. Monitoring during the first 10 years post remediation will provide data to support predictions of impact when the Water Licence is renewed.

During the implementation phase of the Project (2012 – 2027), it was assumed that current pumping and treatment of water at the site will continue, and that site water management plans will address any construction-related issues related to control and management of surface waters (SWQ1). While the model did provide predictions of water quality during this phase of the Project, the model assumption was that there would be no attenuation of contaminant loading, and that loads would be instantaneously added to the system. As a result, the water quality predictions for this phase are not useful for assessment purposes.

Impact Assessment Criteria

The assessment was carried out by scoring Project impacts under each of seven impact criteria formulated specifically for the site based on review of the risk assessment (SENES 2010) and aquatic toxicity (Minnow 2010) assessments. These are elaborated below:

- **Direction of Change** – Although the closure and remediation will result in improvement of water quality as compared to a scenario where no remediation occurred, concentrations of some COPCs will increase in some receiving waters, and so the only possible ratings for the project are "neutral" and "negative".
- **Geographic Extent** – The extent of water quality impacts will be assessed against predicted changes at the downstream boundaries of the Faro Creek (**Station X14**) and Vangorda Creek (**Station V8**) for Local Study Area (LSA) impacts. Impacts from the Vangorda LSA that are present at Station P2 in the Pelly River downstream of the Vangorda Creek confluence will be classified as Regional Study Area (RSA) impacts and "extra-regional" if they are still present at Site P3, upstream of the Anvil Creek confluence. The Rose Creek LSA ends at Station X14 which is 24 km upstream of the confluence of Rose and Anvil Creeks. Any water quality impacts documented in Anvil Creek downstream of the confluence of Rose Creek will be classified as "regional" in extent. Impacts that extend to Station P4 on the Pelly River downstream of the Anvil Creek Confluence will be classified as "extra regional".

Duration - The Faro Project will involve the collection, treatment and discharge to surface water over the long-term (>200 years) and so any impacts are long-term. The predictions of surface water quality, however, show four distinct phases of water quality. The three post construction phases are illustrated in Figure 8.2 using the 95th percentile of the "best estimate" predicted zinc concentrations at Station X-14 as an example.

- Implementation Phase (2012-2027, short-term) is the construction phase. Although the existing care and maintenance procedures will be carried out during this period such that maintenance of existing water quality conditions is likely, the water quality model does not include any attenuation of contaminants entering the system. The contaminant loads are assumed to instantly

enter the system. Therefore, any water quality predictions in the Implementation Phase are not valid for this assessment, and for this reason, the assessment is focused on predictions of future water quality after all closure activities have been completed (Year 14-15) and are operational. The potential for impacts from TSS during the implementation phase is diverse and spread over a large area of the site and cannot be quantified or modeled. These activities, however, can be well managed and mitigated through standard operating procedures and ensured through engineering protocols such as silt management, spills prevention and management. Guidelines exist for TSS in surface water (CCME, 2003) and can be included as triggers within the Adaptive Management Framework for the Implementation phase of the Project. (see Water Management Plan). Any impacts from TSS would be short term. Specific predictions for TSS were not, therefore, completed as part of the impact assessment. No impacts were assessed as "short term" duration.

- Post-Closure (Remediation) Phase in Year 15 (2027), all remedial measures are assumed to be in place. Concentrations that exceed thresholds within this time frame would be assigned "medium term" duration. The assessment was focused on the duration of the first Water Licence for the project which expires in 2037. All impacts were therefore assessed as "medium term" duration.
- Long-term From 2050 - 2144 concentrations begin rising as some acidified and metals-enriched groundwater intercepts surface water and so concentrations that still exceeded thresholds within this time frame would be assigned a "long term" duration. Concentrations decline again after 2150. The long term predictions are uncertain, however, and so no impacts were assessed as a "long-term" duration.

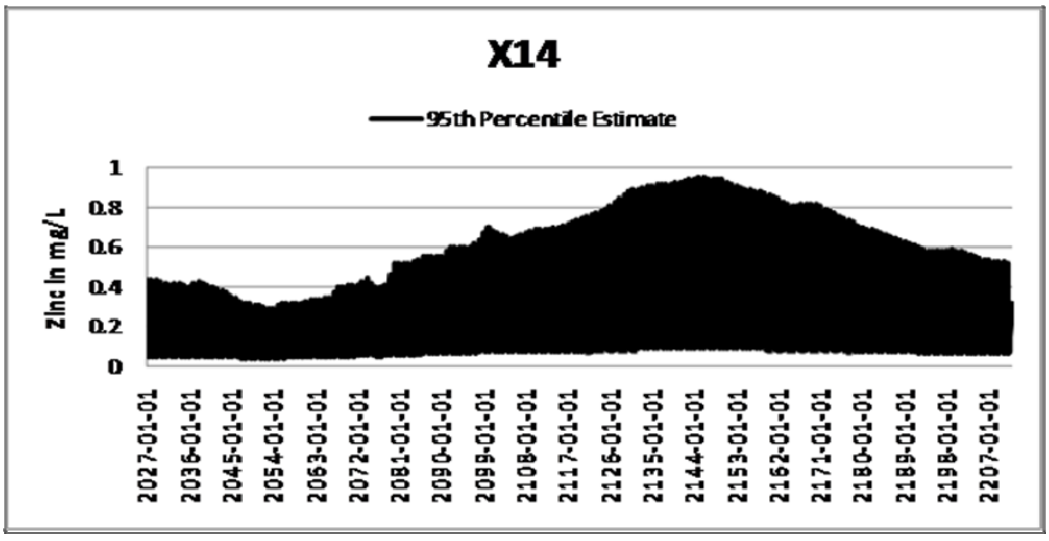


Figure 8.2: Duration of Predicted Water Quality Impacts using Zinc as an example

Frequency – Surface water impacts were predicted using a model with a monthly time step and so the minimum resolution of frequency of impact is monthly. Surface water quality will, however, vary over the course of a year in response to a) the natural increase from low base flow to high spring freshet flows and b) the seasonal discharge of treated water to Rose and Vangorda Creeks.

This is illustrated in Figure 8.3 for Zn at Station X-14. SENES (2010) estimated risk to aquatic life comparing "Toxicity Reference Values" (TRVs) for each receptor to concentrations of COPC. The TRVs are constants for the risk determination (but would vary slightly in response to hardness in the receiving waters) but COPC concentrations do vary. It is therefore feasible that COPC concentrations would exceed TRVs for part of the year (risk potential) and be below them for the rest of the year; (no risk potential). As a result, a low rating is assigned if the COPC concentration <TRV all year, moderate is assigned where COPC concentration is >TRV for part of the year (i.e. seasonal risk during the freshet or the baseflow period); and a high rating is assigned if the COPC concentration >TRV all year (continuous risk).

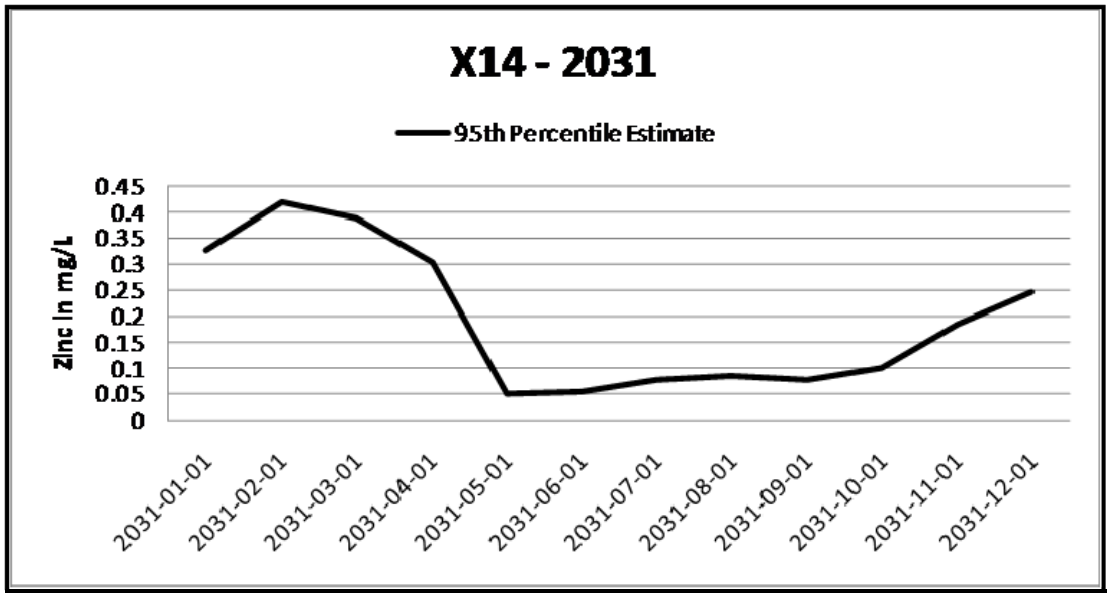


Figure 8.3: Annual Cycle of Predicted Concentrations of Zinc during the Post-Implementation Phase

Timing – Two ratings for timing were established that consider the likely ecological receptors that may respond to water quality changes. The aquatic toxicity assessment (Minnow 2010) identified the embryo-larval and hatching stages as the most sensitive for fish and so the "Low" severity rating is for impacts observed during the freshet (summer period) when salmonid fish eggs have hatched and more tolerant juveniles and adults are likely to inhabit the receiving waters or are able to avoid degraded stretches of the creeks. The "High" severity rating is assigned for impacts observed during the winter base flow period when salmonid early life stages are likely to be impacted by changes in water quality.

Reversibility – Reversibility of effect is generally considered to be desirable in the EA process. For this Project, however, the effect being assessed is treatment and management of deleterious substances to prevent serious long-term adverse effects to surface water. As such, the concept of reversibility is not applicable to this Project, as it would mean that surface waters would not revert to baseline conditions, but to conditions that were more adverse. Reversibility was not, therefore, used as an assessment criterion.

Magnitude – Assessment of the "magnitude" of effect begins by assigning ratings based on increasing numeric values for the impact. In this case, it was determined as the degree by which predicted concentrations of COPC exceeded thresholds of aquatic toxicity for a variety of aquatic organisms and classes of organisms (i.e. by the interpretation of "risk" provided in SENES 2010). The ratings for magnitude must also be ecologically meaningful and so magnitude of effect was rated by placing the numeric results of the toxicity assessment into ecological context. This reflected the fact that the toxicity thresholds were established for primary producers (algae), secondary producers (benthos and zooplankton) and consumers (fish) by Minnow (2010) and SENES (2010).

Surface water was identified as a VEC to reflect, in part, the importance of the local and regional waters as habitat for fish which are valued as food for humans and wildlife. Therefore the highest rank for magnitude of impact was assigned where toxicity thresholds for fish were exceeded.

The lowest rank for magnitude of impact was assigned where toxicity thresholds were exceeded for algae. Although algae are primary producers at the base of the aquatic food chain and therefore important, the low rank reflects the fact that a) primary production in streams is largely dependent on external sources of particulate organic matter that are deposited into streams (i.e. wetland drainage or leaf fall) and b) there are many species of algae such that the function lost by the most sensitive species that informed the development of toxicity thresholds is likely replaced by another, more tolerant species. As such, the stream system contains redundancies of primary production, such that loss of the most sensitive species will have a low magnitude of ecological impact.

A moderate magnitude of impact was assigned where toxicity thresholds were exceeded for benthos or zooplankton. Zooplankton are an insignificant component of the food chain in high gradient streams but were included in the toxicity assessment as a surrogate for benthic organisms (Minnow pers. comm. 2010). Although both zooplankton and benthos can be important secondary producers they are, like the algae, composed of many species of varying sensitivity, such that there is redundancy in their function in the aquatic food chain.

The six impact criteria are summarized in Table 8.6.4 and impact definitions for each are arranged in order of increasing severity of adverse effect ("Rating" in Table 8.18). In all cases, a conservative assessment was used in that impacts were assessed if any COPC exceeded the assessment criteria. This provides a conservative assessment and also recognizes the difficulty in determining joint action among COPCs. Neither the Ecological Risk Assessment (ERA, SENES, 2010) nor the toxicity assessment (Minnow, 2010) considered the toxicity of COPCs in mixtures in which one or more were elevated.

Table 8.18: Residual Impact Rating and Criteria

Criteria	Rating Term	Definition of Impact Severity
Direction	Positive	Beneficial change.
	Neutral	No change.
	Negative	Adverse change.
Geographic Extent	Local	Effect limited to the Local Study Area.
	Regional	Effect extends to Regional Study Area.
	Extra-regional	Effect extends beyond the RSA.
Duration	Short-term	Effect lasts <12 years – Construction Phase Impact only.
	Medium-term	Effect occurs over the first 25 years post- remediation.
	Long-term	Effect continues more than 25 years, extending up to the end of the water quality predictions (~200 years).
Frequency	Never	COPC always < TRV.
	Seasonal	COPC > TRV seasonally.
	Year-round	COPC > TRV year round
Timing	Low	The effect can occur during the open water season (freshet, June to October) when mobile juveniles and adult life stages are present in receiving waters.
	High	The effect can occur during the winter months (base flow November to May) when sensitive and non-motile life stages are present in receiving waters.
Magnitude	Low	Predicted water quality concentrations > surface water quality thresholds for most sensitive primary producers.
	Moderate	Predicted water quality concentrations > surface water quality thresholds for most sensitive secondary producers.
	High	Predicted water quality concentrations > surface water quality thresholds for most sensitive fish or fish life stage.

8.6.4 Impact Assessment

The Impact Assessment focuses only on **SWQ4- Remediation of Contaminant Sources On-site and Collection and Treatment of Contaminated Groundwater and Surface Water**. Water quality is predicted to deteriorate in the short and long-term as a result of seasonal discharge of treated waters that exceed water quality guidelines and the seepage of contaminated groundwater that has not been captured and diverted for treatment. These impacts are assessed according to the methods described in Section 8.2.

The assessment was completed as follows:

- The surface water quality assessment was completed for Sites X14 (Faro LSA), V8 (Vangorda LSA), P2 (Pelly River RSA at Vangorda confluence) and P4 (Pelly River RSA at Anvil Creek confluence);
- The results of the ecological risk assessment (SENES 2010) were reviewed to identify those COPC for which risks had been identified, locations of sites where risks were identified, and for what ecological groups (i.e. algae, benthos fish). The SENES assessment was based, in part, on Minnow (2010) to determine the potential risk posed by Zn, Cd and Cu;

- The water quality predictions for those COPC and sites for which risks were identified were summarized from GEEC (2010);
- Water quality predictions and risk assessment results were compared to the detailed aquatic toxicity results provided by Minnow (2010);
- The severity of impacts was rated according to each of the criteria identified in Table 8.6.4; and
- The final determination of significance was made using the results of the severity rating for the seven criteria.

Results of Risk Assessment

SENES (2010) provided an ecological risk assessment (ERA) for existing conditions based on measured data for 2002-2007 and for the remediated mine site for the period 2028-2212. They used toxicity reference values (chronic effects concentration (EC20) endpoints) and predicted concentrations of COPC at various locations to generate a Screening Index (SI) estimate of risk for different groups of aquatic organisms. They noted that the SI values are not estimates of the probability of ecological impact but that they are positively correlated with the potential of an effect. That is, higher SI values do not relate to a higher risk, but imply greater potential of an effect. SI values greater than 1 suggest that there is a potential of observing adverse effects on some species. Therefore, a risk was likely for all comparisons in which the SI was >1.

Potential toxic effects of COPC were estimated for different levels of biological and ecological organization. The aquatic receptors chosen for the assessment represent several trophic levels in typical creek and river ecosystems – phytoplankton, aquatic plants, zooplankton, benthic organisms, forage fish and predator fish. The aquatic SI values for all species were estimated for the assessment locations for the predicted mean and 95th percentile COPC concentrations in the receiving waters.

SENES provided the following conclusions from their ERA:

Existing Conditions – The results of the assessment of the existing conditions indicate that there are potential adverse effects on:

- sensitive algal species in Rose Creek and Vangorda Creek near the mine site and pits due to elevated concentrations of zinc;
- aquatic plants exposed to chromium at Vangorda Creek upstream and Pelly River at Pelly Crossing (i.e. sites not influenced by the mine site); and
- benthic invertebrates, zooplankton and predator fish exposed to cadmium at Pelly River at locations both upstream and downstream of mine influence locations. Although this could be interpreted as a mine related impact the SI values were lower at the downstream locations.

Results of the risk assessment of the predicted post closure conditions were therefore interpreted as impacts where the post closure assessment indicated a greater potential for impact than from the existing conditions.

Final Closure and Remediation Plan - The results of the assessment showed that with the exception of cadmium, copper, selenium and zinc, the predicted concentrations post-closure were generally less than for existing conditions. Potential adverse effects were identified for:

- a number of aquatic receptors in Rose Creek and Vangorda Creek due to exposure to cadmium, copper and zinc:
    - SI values were above 1 for benthic invertebrates, zooplankton, and predator and forage fish exposed to cadmium. These values are due to the selection of the lowest TRVs for the most sensitive species for each given aquatic receptor.
    - SI values were above 1 for phytoplankton, zooplankton, predator fish and forage fish exposed to zinc. These values are due to the selection of the lowest TRVs for the most sensitive species for each given aquatic receptor.
- phytoplankton, benthic invertebrates, zooplankton and forage fish exposed to Copper at X14; and
- benthic invertebrates and zooplankton exposed to copper at V8.

Selenium concentrations were below levels of potential effect at all sites and so Se was not carried forward for further assessment.

Sulphate

Sulphate was not assessed as a COPC by SENES (2010). Although sulphate has a low toxicity to aquatic life, high concentrations could occur as mine wastes oxidize. Minnow (2010) therefore retained sulphate, along with Zn and Cd, among a list of COPC because of its potential to significantly exceed generic receiving water quality guidelines. They reviewed toxicity data for sulphate and the concentrations predicted by GEEC (2010) and concluded that:

- sulphate levels are expected to be similar to or slightly lower than current concentrations following mine closure; that is, typically less than current levels of 120 mg/L or less (see table 3.2 Minnow, 2010);
- of the species tested to date, those which are most sensitive to sulphate and which occur in western Canada are the amphipod *Hyallela azteca*, and the aquatic moss *Fontinalis anitpyretica*, which have shown sulphate effects at concentrations between 250 and 275 mg/L (at hardness of 100 mg/L); and therefore; and
- as sulphate concentrations are expected to be lower than current levels (i.e. <120 mg/l), no effects to aquatic biota would be expected from exposure to sulphate downstream of the Faro or Vangorda sites.

Regional Study Area

The SENES (2010) ecological risk assessment (SENES, Figure 6.4) showed no risk to aquatic receptors in the Pelly River:

- the highest predicted concentrations of Zn were below the level of potential risk to all aquatic organisms except phytoplankton at Site P2, Pelly River downstream of Vangorda Creek, and Site P4, Pelly River downstream of Anvil Creek.
- All predicted concentrations of Zn exceeded the level of potential risk for the most sensitive algal species at Sites P2 and P4 in the Pelly River but this was due use of a very conservative toxicity reference value. This suggests that this impact can be discounted.
- the highest predicted concentrations of Cd were below the level of potential risk to all aquatic organisms at Site P2, Pelly River downstream of Vangorda Creek, and Site P4, Pelly River downstream of Anvil Creek.

The impact assessment was therefore carried forward for exposure to elevated zinc, copper and cadmium concentrations at Rose Creek (X14) and Vangorda Creek (V8).

Faro LSA

Table 8.19 summarizes the risk assessment results for zinc, copper and cadmium toxicity at X14 (Faro LSA) as taken from Figure 6.4 in SENES (2010). It shows which statistical metric of predicted water quality exceeds the Screening Index Value of 1 for each ecological group. "Mean" denotes that the mean predicted water quality exceeds the SI (high level of risk) and "95th" indicates that only the highest predicted concentrations (those at the 95th percentile or greater) exceed the SI (low level of risk). "NR" denotes no risk where SI values were < 1 for all predictions of water quality.

Table 8.19: Risk Assessment Results for Cd, Cu and Zn at X14

	Faro: SI > 1		**(SENES Fig. 6.4)**		
	Phytoplankton	Benthos	Zooplankton	Forage	Predator
Cd	NR	Mean	Mean	95th	Mean
Cu	95th	Mean	Mean	95th	NR
Zn	5th	5th	Mean	95th	Mean

These results show that mean predicted concentrations of:

- Cd generate a high potential risk to benthos, zooplankton and predator fish;
- Cu generate a high potential risk to benthos and zooplankton; and
- Zn generate a high potential risk to zooplankton and predator fish.

Zinc concentrations pose the greatest risk to phytoplankton and benthos as the 5th percentile estimates exceed the SI. These groups are therefore at the greatest risk in the LSA.

The results show that the 95th percentile of predicted concentrations of:

- Cd generate a low potential risk to forage fish;
- Cu generate a low potential risk to phytoplankton and forage fish; and
- Zn generate a low potential risk to forage fish.

Cadmium concentrations pose no potential risk to phytoplankton and Cu concentrations pose no potential risk to predator fish.

Vangorda LSA

Table 8.20 summarizes the risk assessment results for zinc, copper and cadmium toxicity at V8 (Vangorda LSA) as taken from Figure 6.4 in SENES (2010). It shows which statistical metric of predicted water quality exceeds the Screening Index Value of 1 for each ecological group. "Mean" denotes that the mean predicted water quality exceeds the SI (high risk) and "95th" indicates that only the highest predicted concentrations (those at the 95th percentile or greater) exceed the SI (low risk). "NR" denotes no risk where SI values were < 1 for all predictions of water quality.

Table 8.20: Risk Assessment Results for Cd, Cu and Zn at V8

	Faro: SI > 1		**(SENES Fig. 6.4)**		
	Phytoplankton	Benthos	Zooplankton	Forage	Predator
Cd	NR	95th	95th	NR	95th
Cu	NR	95th	95th	NR	NR
Zn	5^{th}	5^{th}	Mean	NR	95th

These results show that 5th percentile and mean predicted concentrations of:

- Zn generate a high potential risk to phytoplankton, benthos and zooplankton.

The results show that the 95th percentile of predicted concentrations of:

- Cd generate a low potential risk to benthos, zooplankton and predator fish;
- Cu generate a low potential risk to benthos and zooplankton; and
- Zn generate a low potential risk to predator fish.

Cadmium concentrations pose no potential risk to phytoplankton or forage fish; Cu concentrations pose no potential risk to phytoplankton, forage or predator fish, and zinc concentrations pose no potential risk to forage fish.

Review of Minnow (2010) and SENES (2010) therefore supports, with one exception, the SENES (2010) conclusion that "In summary, the results of the aquatic assessment indicate that there may be potential effects in some very sensitive species found in Rose Creek (X14) and Vangorda Creek (V27) from exposures to cadmium and zinc for the final closure and remediation plan. These areas

are limited spatially in comparison to the watershed area." The exception is the potential risks posed by elevated copper concentrations in Rose Creek at X14 and Vangorda Creek at V8.

Subsequent steps of the impact assessment are therefore limited to zinc, copper and cadmium in the LSA.

Discussion of surface water impacts – Faro LSA

SENES (2010, Table 2.6)) used the mean monthly concentrations of zinc, cadmium and copper for the period 2028 – 2209 (post-implementation) at X14 for their risk assessment and these values are presented in Tables 8.21 to 8.22. The additional water quality summaries in Tables 8.21. – 8.23 were obtained either from the summary of current conditions by AECOM (2009) or calculated for each phase of the closure from the results in GEEC (2010 - best estimate model, 95th percentile predictions). Statistics are provided for the minimum, median, 95th percentile and maximum values of the 95th percentile concentration predicted by GEEC (2010). These are therefore conservative estimates, as there is a 95% probability that concentrations will be lower.

Table 8.21: Water Quality Summary for Zinc at X14

X14-Zinc	Minimum	Median	95th Percentile	Maximum
Current Conditions (2005-2007, AECOM 2009)	0.011	0.033		0.25
Initial Remediation Stage (2027-2037)	0.048	0.070	0.076	0.076
Long-term Remediation Stage (2038-2212)	0.040	0.196	0.751	0.951
Profile Life (2028-2212, SENES, 2010)	0.011	0.136	0.53	1.66

Table 8.22: Water Quality Summary for Cadmium at X14

X14-Cadmium	Minimum	Median	95th Percentile	Maximum
Current Conditions (2005-2007, AECOM 2009)	0.00002	0.0001		0.0003
Initial Remediation Stage (2027-2037)	0.000053	0.000089	0.000406	0.000407
Long-term Remediation Stage (2038-2212)	0.000054	0.00027	0.00046	0.00049
Profile Life (2028-2212, SENES, 2010)	0.000005	0.0002	0.002	0.01

Table 8.23: Water Quality Summary for Copper at X14

X14-Copper	Minimum	Median	95th Percentile	Maximum
Current Conditions (2005-2007, AECOM 2009)	0.00042	0.001		0.012
Initial Remediation Stage (2027-2037)	0.0025	0.0031	0.0052	0.0055
Long-term Remediation Stage (2038-2212)	0.0025	0.0044	0.011	0.013
Profile Life (2028-2212, SENES, 2010)	0.00045	0.001	0.002	0.007

The predicted zinc, cadmium and copper concentrations (GEEC 2010, best estimate, 95th percentile) over the 200 years of post-closure are presented in Figure 8.4. The predicted values remain relatively stable for the initial post-closure stage (10+ years following implementation, 2027-2037) but zinc and copper concentrations are predicted to double over the very long term and then to decline.

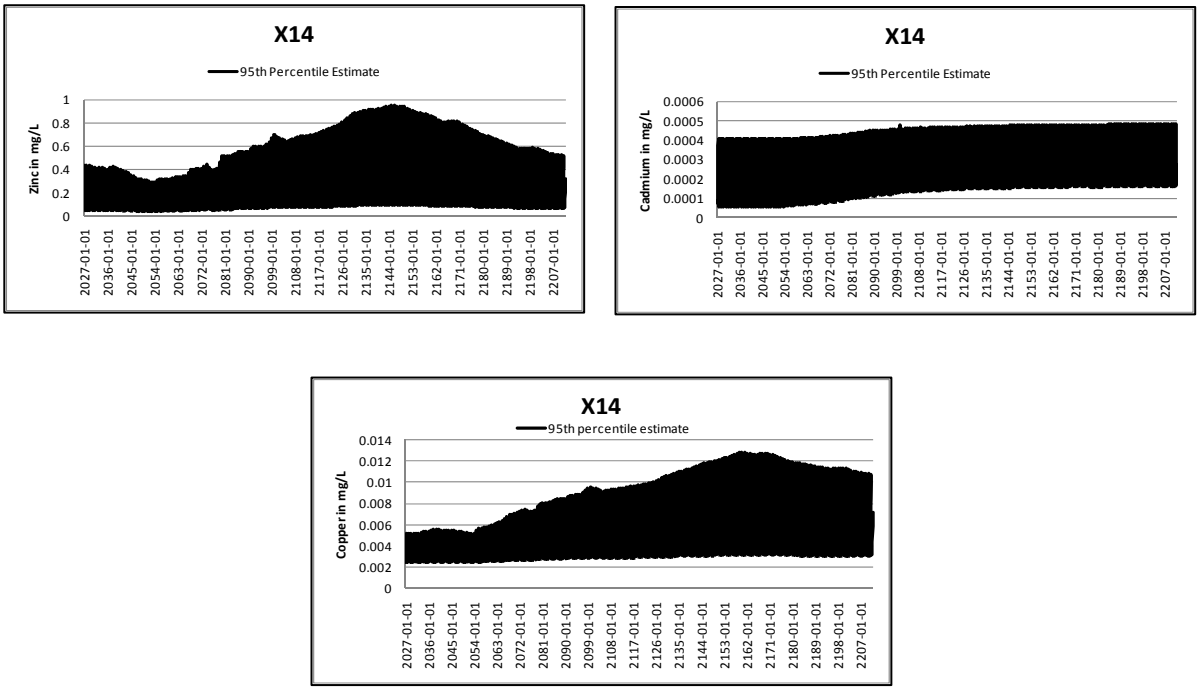


Figure 8.4: Predicted Concentrations of Zinc (left), Cadmium (right) and Copper (bottom) over 200 years of closure

The impact assessment is focused on conditions during the immediate post-closure period (2027-2036), when predictions reflect implementation of all remedial measures during the term of the first water licence. Figure 8.5 presents predicted concentrations of zinc, cadmium and copper (GEEC 2010, best estimate, 95th percentile) for a typical post-construction year and plots the Toxicity Reference Values (TRVs, SENES 2010) for each aquatic group identified as being "at risk" in Table 8.6.5. This illustrates the seasonality of predicted effects.

- Zinc concentrations are lowest during the peak freshet in May, increase slowly as flows decrease over the summer, and rapidly as groundwater flows dominate in the winter, peaking at concentrations < 0.4 mg/L in early February. Median and 95th percentile concentrations exceed forage and predator fish TRVs during the winter base flow period only and exceed TRV values for zooplankton and benthos for all but the early summer period.
- Cadmium concentrations show a different pattern, peaking in late summer at 0.0004 mg/L and dropping rapidly with the onset of winter to concentrations of 0.0001 mg/L or less. Median and 95th percentile concentrations exceed TRV values for benthos, zooplankton and predator fish during the late summer period only.

- Copper concentrations show the same seasonal cycle as zinc, peaking in the winter baseflow period and dropping during freshet and summer. Median copper concentrations are just below the TRV values for benthos, zooplankton and predator fish during freshet. The 95th percentile concentrations exceed the TRV values for benthos, zooplankton and predator fish and approach the TRV for forage fish during freshet. Because the TRV values are only exceeded by the 95th percentile concentrations for a brief period is a very low probability of impact from copper.

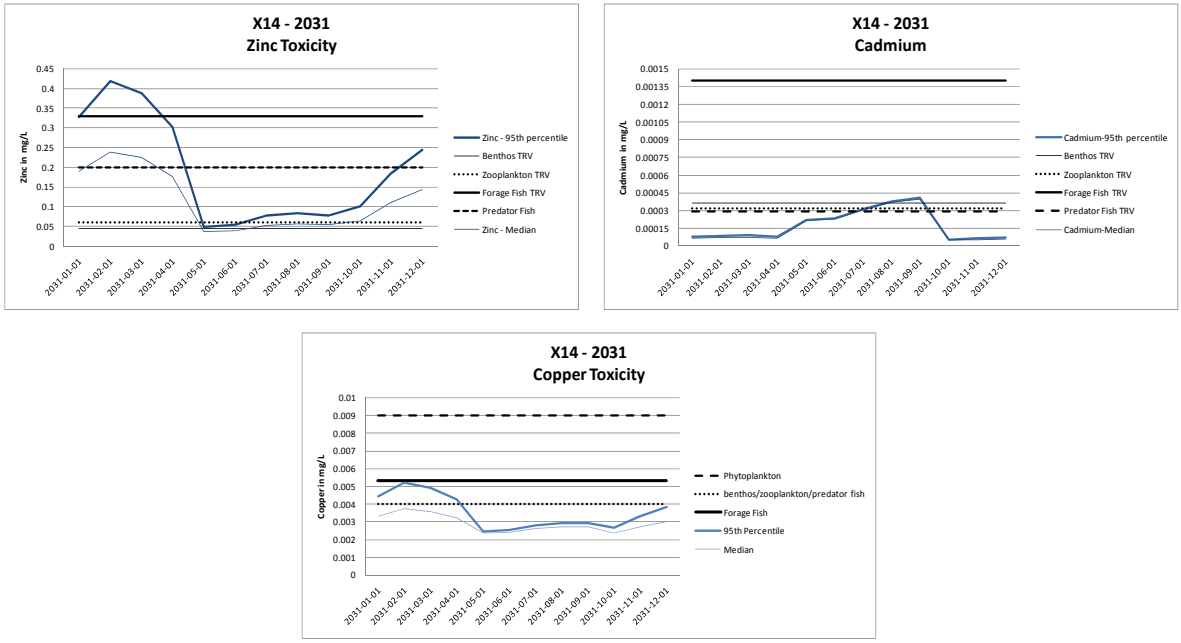


Figure 8.5: Typical Annual Cycle of Zinc (left), Cadmium (right) and Copper (bottom) at X14

The toxicity of zinc and copper are reduced as water hardness increases and so interpretation of the significance of predicted zinc concentrations must consider that effect. Figure 8.6. shows the predicted annual cycle of hardness at X14 for a typical year during the post –closure period. Hardness values in Rose Creek are lowest during the winter months and increase from ~150 mg/L to 250 mg/L during the late summer in response to the discharge of treated water with high levels of hardness from the lime used in the treatment plant (Figure 8.6.).

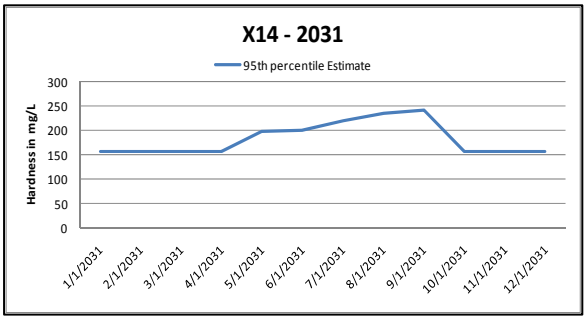


Figure 8.6: Seasonal Pattern of Hardness at X14 after Closure

The low hardness values in the winter will therefore increase the toxicity of zinc at the time of year when zinc concentrations are highest in Rose Creek. The risk assessment (SENES 2010) used a toxicity reference value for zinc that was corrected to a standard hardness of 200 mg/L. The risk assessment therefore underestimates the risk from zinc during that period when zinc concentrations are highest in Rose Creek, and overestimates it during those times when concentrations are lowest. Minnow (2010) provided summaries of zinc toxicity that were corrected to hardness values of 50, 100, 200, and 300 mg/L and these showed that zinc toxicity increased as hardness decreased. COPC concentrations exceed TRV values during the winter months without accounting for the lower hardness (Figure 8.6.7) such that consideration of lower winter hardness may increase toxicity, but does not change the risk assessment.

Copper poses a very low risk in Rose Creek and this risk does not change when the TRV values for benthos and zooplankton are corrected for hardness. The TRV for predator fish increases when it is corrected for predator fish (Table 5.1, SENES 2010). Therefore copper remains at low risk year round.

Discussion of Surface Water Impacts – Vangorda LSA

Table 8.20 summarizes the results of SENES (2010) and shows that copper only poses a potential risk to benthos and zooplankton in Vangorda Creek when concentrations exceed the 95th percentile. SENES concluded that only Zn and Cd posed a potential risk (see section 8.6.3.1, above) and so the following discussion is focused only on zinc and cadmium.

SENES (2010, Table 2.6)) used the mean monthly concentrations of zinc and cadmium for the period 2028 – 2209 (post-closure) at V8 for their risk assessment and these values are presented in Tables 8.24 and 8.25. The additional water quality summaries in Tables 8.24 and 8.25 were obtained either from the summary of current conditions by AECOM (2009) or calculated for each phase of the closure from the results in GEEC (2010 - best estimate model, 95th percentile predictions). Statistics are provided for the minimum, median, 95th percentile and maximum values of the 95th percentile concentration predicted by GEEC (2010). These are therefore conservative estimates, as there is a 95% probability that concentrations will be lower.

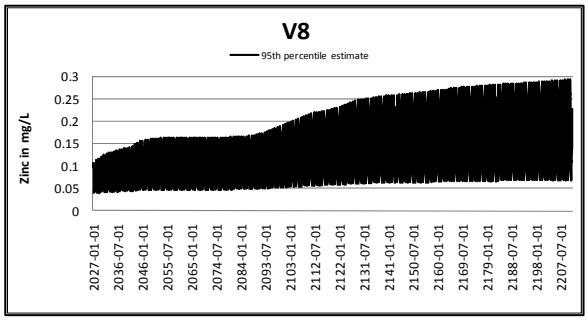
Table 8.24: Water Quality Summary for Zinc at V8

X14-Zinc	Minimum	Median	95th Percentile	Maximum
Current Conditions (2005-2007, AECOM 2009)	0.007	0.015		0.064
Initial Remediation Stage (2027-2037)	0.039	0.077	0.136	0.136
Long-term Remediation Stage (2038-2212)	0.044	0.127	0.290	0.293
Profile Life (2028-2212, SENES, 2010)	0.003	0.061	0.35	1.475

Table 8.25: Water Quality Summary for Cadmium at V8

X14-Cadmium	Minimum	Median	95th Percentile	Maximum
Current Conditions (2005-2007, AECOM 2009)	0.00004	0.0001		<0.002
Initial Remediation Stage (2027-2037)	0.000083	0.00013	0.00017	0.00018
Long-term Remediation Stage (2038-2212)	0.000097	0.00018	0.00018	0.00031
Profile Life (2028-2212, SENES, 2010)	0.000007	0.00012	0.001	0.002

The predicted zinc and cadmium concentrations (GEEC 2010, best estimate, 95th percentile) over the 200 years of post-closure are presented in Figure 8.7. Concentrations of both increase for the first 20 years post-closure, remain relatively stable for the next 50 years and then begin to increase.



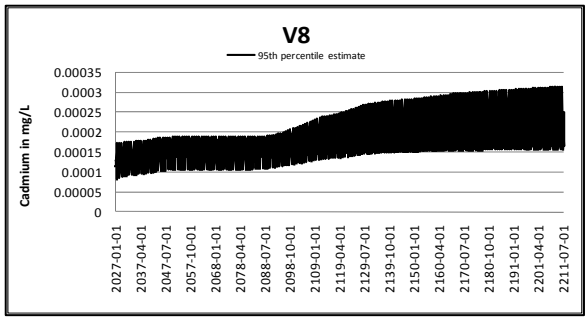


Figure 8.7: Predicted Concentrations of Zinc (left) and Cadmium (right) over 200 years of closure

The impact assessment is focused on conditions during the immediate post-closure period (post 2027), when predictions reflect implementation of all remedial measures. Figure 8.8 presents predicted concentrations of zinc and cadmium (GEEC 2010, best estimate, 95th percentile) for a typical post-closure year.

- Zinc concentrations are lowest during the peak freshet in May, increase slowly as flows decrease over the summer and groundwater flows dominate in the winter, and peak at concentrations ~0.12 mg/L in late March. Median and 95th percentile concentrations are below TRV values for forage and predator fish at all times of the year. 95th percentile zinc concentrations exceed the zooplankton and benthos TRV values during the winter baseflow and late summer periods. Median zinc concentrations are at or below the TRV value for zooplankton year round, but exceed the benthos TRV during the winter.
- Cadmium concentrations show a different pattern, peaking in late summer at ~0.00018 mg/L and dropping rapidly with the onset of winter to concentrations of ~0.00009 mg/L. Cadmium concentrations do not exceed TRV values for any aquatic life at any time of year.

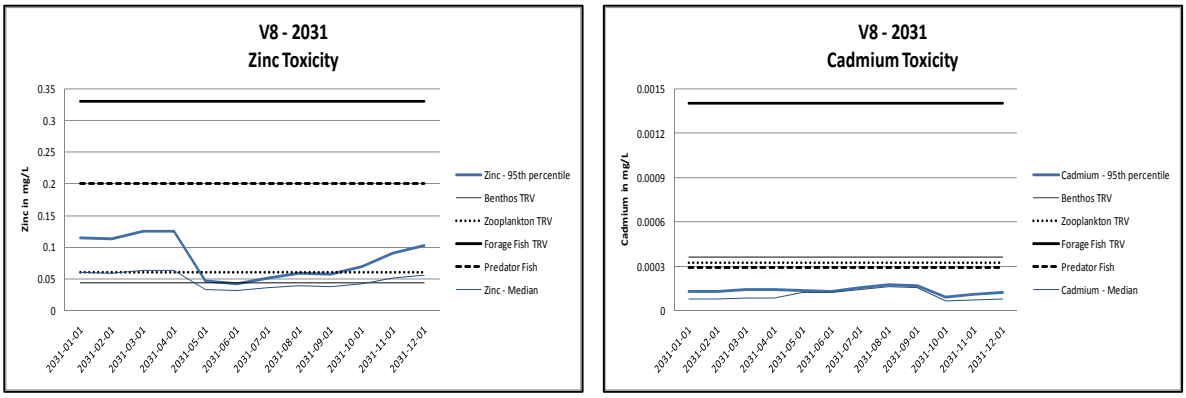


Figure 8.8: Typical Annual Cycle of Zinc (left) and Cadmium (right) at V8

The toxicity of zinc is moderated by water hardness and so interpretation of the significance of predicted zinc concentrations must consider that effect. Figure 8.9 shows the predicted annual cycle of hardness at V8 for a typical year during the post-closure period. Hardness values are lowest during the winter months and increase from ~170 mg/L to 220 mg/L during the late summer in Vangorda Creek in response to discharge of treated water with high lime content.

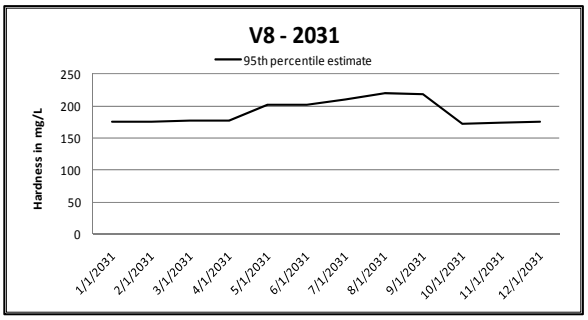


Figure 8.9: Seasonal Pattern of Hardness at V8 after Remediation

The lower hardness values in the winter will therefore increase the toxicity of zinc at the time of year when zinc concentrations are highest in Vangorda Creek. The risk assessment (SENES 2010) used a toxicity reference value for zinc that was corrected to a standard hardness of 200 mg/L. The risk assessment therefore underestimates the risk from zinc during that period when concentrations are highest in Vangorda Creek, and overestimates it during those times when concentrations are lowest. Minnow (2010) provided summaries of zinc toxicity that were corrected to hardness values of 50, 100, 200, and 300 mg/L and these showed that zinc toxicity increased as hardness decreased. 95th percentile zinc concentrations exceed the TRV values for zooplankton and benthos during the winter months without accounting for the lower hardness (Figure 8.8).

Consideration of lower hardness may increase toxicity, but does not change the risk assessment. Median zinc concentrations exceed TRV values for benthos and are the same as TRV values for zooplankton during winter months. Correcting for a hardness of ~180 mg/L in winter would increase the toxicity of zinc. This would classify zooplankton as "potentially at risk" during winter

months where they are not considered so at a hardness of 200 mg/L and would increase the degree of potential risk determined for benthos at 200 mg/L hardness.

8.6.5 Significance Determination

Impact ratings were determined for each study area (LSA and RSA) for each of the criteria using the rationale presented in Section 8.2.5. A description of the determination for each criterion is presented here and the overall summary provided in Table 8.26.

Direction – A high impact rating was assigned for each LSA as water quality will continue to deteriorate from existing conditions in spite of remedial efforts and risks to aquatic life will therefore increase. No risks to aquatic life were assessed for the Regional Study Area that were not already present under existing conditions (SENES 2010) and so the impact rating was low. This assessment must be interpreted, however by considering the deterioration in water quality that would occur without the remediation activities.

Geographic Extent – Potential risks to aquatic life were predicted for each LSA but no risks were predicted for the RSA at the Pelly River. Anvil Creek receives flow from Rose Creek and so is downstream of the Rose Creek LSA and upstream of the RSA boundary at the Pelly River. Water quality in Anvil Creek was therefore assessed downstream of the confluence with Rose Creek (Station R5) and upstream of the confluence with the Pelly River (Station R11). Zinc concentrations are plotted against zinc TRVs for station R5 and R11 in Figure 8.10 and show that there is no potential risk to forage or predator fish at either site. Zinc concentrations exceed TRVs for zooplankton and benthos during the winter baseflow period at both sites in Anvil Creek even though baseflow concentrations decrease with distance downstream (R5 to R11). There is no potential risk from cadmium or copper to any aquatic life in Anvil Creek. The geographic extent of impact is therefore rated as “Moderate” for the Rose Creek LSA and “Low” for the Vangorda LSA.

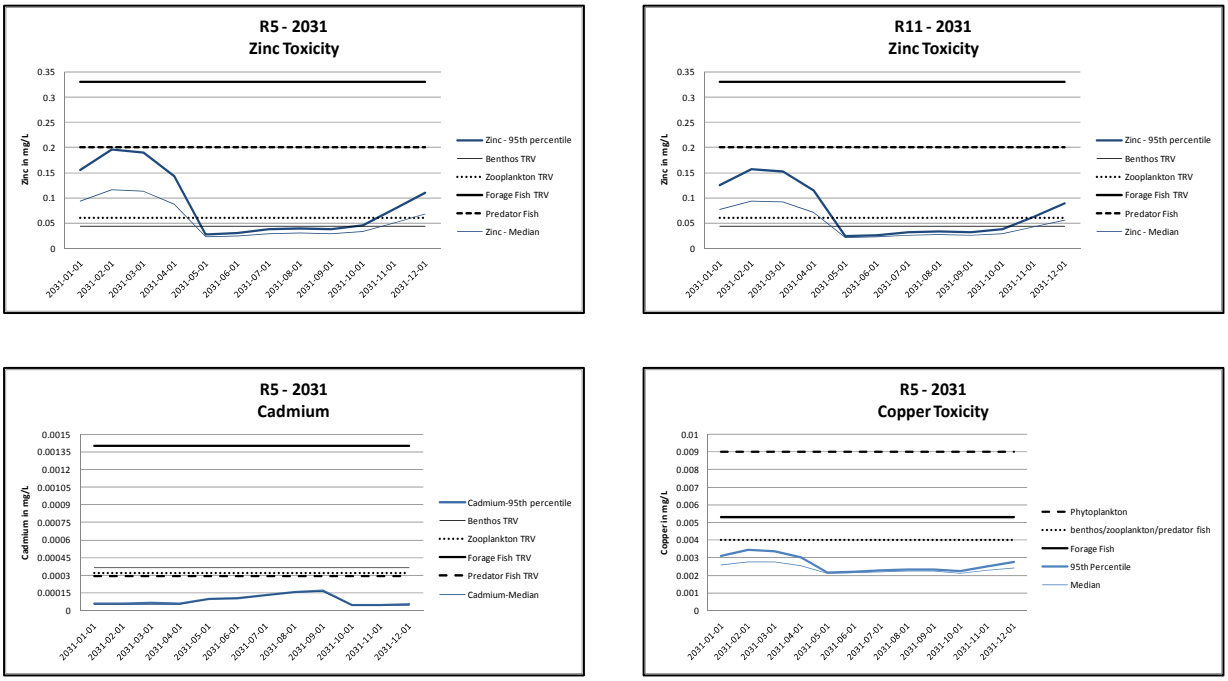


Figure 8.10: Zinc Toxicity in Anvil Creek at Station R5 and R11, Cadmium and Copper Toxicity at Station R5

Duration – All impacts in the LSA will be present for the long term and are therefore rated "high". This assessment must be interpreted, however by considering the deterioration in water quality that would occur without the remediation activities.

Frequency – Zinc and cadmium concentrations in Rose and Vangorda Creeks vary over the course of the year. Zinc and cadmium concentrations will exceed TRVs for several forms of aquatic life year-round in Rose Creek and so impacts here are rated "High". Zinc concentrations will exceed TRVs for some forms of aquatic life seasonally in Vangorda Creek and so this impact is rated "Moderate".

Timing – COPC concentrations exceed the TRVs for some forms of aquatic life during the sensitive period of freshet when embryo-larval stages of fish are present in Rose and Vangorda Creeks and so this impact is rated "high".

Magnitude – COPC concentrations in Rose Creek will be high enough to produce potential risks to all forms of aquatic life in Rose Creek and so this impact is rated "high". COPC concentrations will produce potential risks to invertebrates but not fish in Vangorda Creek and so this impact is rated "moderate".

Table 8.26: Summary of Impact Ratings for Anvil Range Assessment

Criteria	Rating Term	Impact	Faro LSA	Vangorda LSA	Pelly RSA
Direction	Neutral	L			L
	Negative	H	**H**	**H**	
Geographic Extent	Local	L		**L**	N
	Regional	M	**M**		
	Extra-regional	H			
Duration	Short-term	L			N
	Medium-term	M			
	Long-term	H	**H**	**H**	
Frequency	Never	L			N
	Seasonal Risk	M		**M**	
	Continuous Risk	H	**H**		
Timing	Low – Freshet	L			N
	High – Base Flow	H	**H**	**H**	
Magnitude	Low	L			N
	Moderate	M		**M**	
	High	H	**H**		
N = No risk/no impact					

Conclusion

Significant adverse effects to water quality are predicted for the both Local Study Areas (Rose and Vangorda Creeks) following the implementation of mine closure activities. Impacts are restricted to the Local Study Area for Vangorda, extend slightly into the Regional Study Area for Rose Creek and will persist for as long as remediation is required at the site. This conclusion must be interpreted however in the context of a "do nothing" scenario, which would result in far more serious impacts to water quality.

8.6.6 Mitigation and Monitoring

Mitigation

The significant adverse effects are not considered to be mitigable through Project design. The Project (SRK 2009) is focused on preventing ongoing and future deterioration of water quality by implementing a series of remedial and restoration measures that are designed to the prevailing engineering standards. The Project itself is considered a massive mitigation effort, and the impacts described herein are considered legacy effects of historic mining activities, not of the Closure Project itself.

An Adaptive Management Plan is being developed and will be implemented. It will describe a process of monitoring and management to a) respond to changes that cause water quality to depart from the predictions that informed this assessment and b) allow ongoing improvement of processes and remedial measures that may improve water quality from the conditions that were predicted as part of this assessment. The specific response measures and the timing for implementing any such measures cannot be known at this time, but are understood to be tested and available technologies. Such measures could include improvements to the capture of groundwater or surface water, improvements to the cover of various areas to reduce infiltration or improvements to the treatment system, but the responses of water quality to these measures cannot be predicted at this time.

Surface Water Quality Monitoring

Monitoring of surface water quality at the mine site has been ongoing since the mine was operating, has been refined and modified during the Care and Maintenance period, and will continue as part of the closure plan. This impact assessment was guided by water quality results for the period 2005-2007. Future monitoring of surface water quality will be required to a) measure the response to implementation of remedial measures, b) verify the impact predictions that guided this assessment and c) detect any unforeseen pathways of effect or unpredicted changes in water quality.

Long-term monitoring programs are currently being developed by (Minnow 2007). At present the proposed long term monitoring program addresses three key elements:

- an aquatic ecosystem monitoring program will address the chemical and biological responses of the surface waters receiving mine drainage and discharge.
- a perimeter monitoring program will measure the concentrations and loadings of mine-related substances at the perimeter of the Faro and Vangorda sites where contaminants are released from the mine sites (source areas) to the natural environment (downstream surface waters).
- a source area monitoring program, will track source conditions relative to predictions and monitor the performance of any treatment systems and/or mitigation. It will include waste rock, pits, seeps, groundwater, surface water, and the Faro tailings basin.

The monitoring program will be reviewed and refined as the Project proceeds to specify sampling locations, parameters and schedules. It will be linked to the Adaptive Management Program so that management activities are informed by the monitoring results. The details will ultimately be prescribed and regulated through the Project water licence.

8.6.7 Conclusions

Four potential pathways of effect for surface water were identified and reviewed:

- **SWQ1** – Closure Plan related activities during the construction phase of the Project. These can be mitigated through prevention and management and any potential impacts addressed in construction phase monitoring and the Adaptive Management Framework for the construction phase of the Project. No significant adverse effect.

- **SWQ2** – Inputs from contaminated groundwater and seepage flows that are not captured and managed. Any impacts from this pathway are included in the predictions of surface water quality (Pathway SWQ4). Explicit assessment was not therefore carried out.
- **SWQ3** – Discharge of treated effluents to receiving water any impacts from this pathway are included in the predictions of surface water quality (Pathway SWQ4). Explicit assessment was not therefore carried out.
- **SWQ4** – Remediation of contaminant sources on-site and collection and treatment of contaminated groundwater and surface water.

Significant adverse effects to water quality are predicted for the Local Study Areas (Rose and Vangorda Creeks). These adverse effects are related to the legacy of mining activities, and are not a result of the Project itself. Impacts are restricted to the Local Study Area for Vangorda, extend into the Regional Study Area for Rose Creek and will persist for as long as remediation is required at the site. This conclusion must be interpreted however in the context of a "do nothing" scenario, which would result in far more serious impacts to water quality.

8.7 Aquatic Organisms and Habitat

8.7.1 Aquatics Assessment Objectives and Methods

The objectives of the aquatics assessment for the Closure and Remediation Plan for the Faro Mine Complex (the Project) are to:

- Identify effects of the Project on aquatic organisms and habitat;
- Identify appropriate mitigation;
- Evaluate the predicted residual effects and their significance; and
- Identify aquatics monitoring requirements.

Potential impacts to fish and fish habitat resulting from the Project can be described as:

- Short to medium term impacts resulting from construction activities that may result in temporary impacts or reduction in fish and habitat productivity; and
- Long term impacts resulting from the final design and operation of the Project that may result in changes (positive or negative) in fish and habitat productivity.

The footprint of the Project on fish habitat is relatively small; however, the 15-year duration and widespread construction activities throughout the Faro mine complex has the potential to adversely affect downstream fish habitat in terms of water flows and quality. These potential effects may occur during the construction period and over the longer term. While contaminated water quality from mine wastes is not a direct fish habitat issue, water quality in the receiving environment will continue to deteriorate with time as a result of ongoing acidification of mine waste. Despite efforts to collect and treat contaminated water, water quality in the receiving environment will continue to

deteriorate over time The Project will help to reduce degradation of water quality in the Rose Creek and Vangorda Creek drainages over the long term. This will result in a reduced potential for adverse effects on aquatic health and fish habitat productivity than would be the case if the site was not remediated. This is the context within which the assessment of effects must be considered.

8.7.2 Issue Focused Approach

The primary issues for aquatic resources are whether the Project activities will affect:

- Health of fish and fish populations.
- Fish habitat.
- Aquatic health.

The major water quality issues arising from past mining activities involve heavy metals such as copper, zinc and cadmium that are toxic to aquatic resources in high concentrations but are normally found in lower concentrations in the natural environment. When concentrations of heavy metals become elevated to levels that may result in adverse impacts to the environment, they are referred contaminants of potential concern (COPC).

The data on heavy metals in the environment presented in the baseline (Current Environmental Conditions Supporting Document, AECOM 2009) indicates that the levels of heavy metals in water, stream sediments, benthic invertebrates and fish have stabilized or declined, and that some recovery of environmental health may be occurring since the closure of the mine over a decade ago. Existing conditions with respect to heavy metals in the aquatic environment, while of concern, are not particularly alarming. However, there is some evidence that acidification of waste rock dumps and tailings is occurring and accelerating and that the attenuation capacity of underlying sediments for acidic groundwater may be declining. Predictive water quality modeling (GEEC 2010) indicates that waste rock dumps and tailings will likely continue to acidify over the long term and that despite the proposed collection and treatment of contaminated groundwater, some seepage off the site could result in elevated levels of heavy metals such as Zn and Cd that do not, and will not meet water quality guidelines downstream.

The Pelly River watershed has been classified as a higher sensitivity watershed (for purposes of placer mining regulation) due to the high level of utilization by adult salmon and salmon spawning, and relatively good water quality. The overall abundance and availability of habitat types within the Pelly watershed is characterized as follows:

- 4% of the total stream length is classified as the highest sensitivity migration and spawning habitat for adult Chinook salmon (Oncorhynchus tshawytscha);
- 24% is classified as moderate sensitivity Chinook rearing habitat; and
- 61% is classified as lower sensitivity freshwater fish habitat.

These important factors were considered in the assessment of Project effects on fish habitat in the Anvil/Rose Creek and Vangorda Creek drainages and the risk to salmon and freshwater fish in the Pelly River watershed.

8.7.3 Valued Ecosystem Components, Indicators and Thresholds

Three VECs were identified for this assessment:

- Fish and fish population health (Chinook salmon, Arctic grayling and Slimy sculpin).
- Fish habitat (spawning and rearing).
- Aquatic health and productivity.

Chinook salmon were selected as a VEC because of their social and cultural importance and limited abundance and distribution in the Yukon River and Pelly River watersheds. Chinook salmon have very specific spawning and rearing habitat requirements that are found within the RSA. Arctic grayling were chosen because of their social and cultural importance and broad distribution within the Yukon and Pelly River watershed and within the RSA and the Anvil/Rose Creek LSA. Slimy sculpin were chosen because of resident nature and sensitivity to contaminants, widespread abundance and distribution, and importance as an indicator species.

Spawning and rearing habitat was chosen as a VEC because of its sensitivity and fundamental importance to fish and fish population health, and because Project impacts to fish are largely a result of impacts to fish habitat.

Aquatic health was chosen as a third VEC because the effects on aquatic health are best considered at lower levels of the food chain. The diversity if benthic invertebrate species as well as the abundance of pollution sensitive taxa are main indicators of aquatic health. Slimy sculpin is a species that spends it entire life in a small section of stream and therefore exhibits elevated levels of metals in tissues as compared to Chinook salmon or Arctic grayling that only use the stream for a short or intermittent period. A closely related sculpin species, the mottled sculpin, is considered to be one of the most sensitive aquatic organisms to concentrations of zinc which is one of the most important contaminants of concern at the mine site.

For each VEC, measurable indicators and a baseline case from which to measure change are identified, and thresholds for rating impacts are developed. These are listed in Table 8.27.

Table 8.27: Aquatic Organisms and Habitat VECs, Indicators and Thresholds

VEC	Project Objectives	Indicator	Baseline Case from which to measure change	Threshold
Fish and Fish Population Health (Chinook Salmon, Arctic Grayling and Slimy sculpin)	• Maintain species abundance and condition within norm for reference streams and sites • Maintain metal concentrations in fish tissues with safe levels for human and wildlife consumption • Maintain metal concentrations in fish tissues within safe tolerance limits for fish	• Fish species abundance and condition factor • Metal concentrations in fish tissues • Slimy sculpin metal concentrations in tissues and condition factor	• Existing conditions/trends in impacted stream reaches • Conditions in reference stream and site conditions	• Threshold : Existing conditions • Human or wildlife consumption guidelines • CCME Guidelines for Protection of Aquatic Life • Slimy sculpin metal concentrations and condition factor within norm for reference streams and sites
Fish Habitat (spawning and rearing)	• Maintain and enhance total area of fish habitat • Maintain and enhance productivity of fish habitat	• Change in extent of Fish Habitat • Change in total suspended sediments • Minimum riparian flows • Abundance of key benthic invertebrate species	• Change in linear length/area of stream fish habitat • Existing stream conditions/trends in impacted stream reaches • Conditions in reference streams and sites	• DFO's No Net Loss habitat policy • DFO's guidelines for increased TSS and water withdrawal in streams • Abundance of benthic invertebrates within norm of reference streams and sites
Aquatic Health (Benthic Invertebrates; slimy sculpin)	• Maintain and enhance aquatic health and productivity	• Diversity of Benthic Invertebrates • Abundance of pollution sensitive benthic invertebrates • Metal concentrations in benthic invertebrates • Water quality • Metal concentrations in Stream Sediments • Slimy sculpin metal concentrations in tissues and condition factor	• Existing conditions/trends in impacted stream reaches • Conditions in reference streams and sites	• Diversity of benthic invertebrates within norm for reference streams and sites • Abundance of pollution sensitive benthic invertebrates within norm for reference streams and sites • Metal concentrations in benthic invertebrates within norm for reference streams and sites • CCME Water Quality and Sediment Guidelines for Protection of Aquatic Life • Slimy sculpin metal concentrations and condition factor within norm for reference streams and sites

Pathways of Effects

Fish utilization of smaller tributary streams for spawning and rearing is due, in part, to the quality and productivity of the habitat that they provide. These tributary streams, such as Anvil/Rose and Vangorda Creeks, are generally clear and shallow with very low suspended sediments and sufficient gradients and flows to provide suitable habitat for periphyton algae and benthic invertebrates. These invertebrates are the primary food source for juvenile Chinook salmon, Arctic grayling and Slimy sculpin. The pools and riffles and undercut banks provide the necessary habitat for fish, with deeper water and lower flow velocities and protection from predators. These are also ideal conditions for spawning and egg survival.

Streams that provide overwintering habitat for fish and overwinter egg incubation for Chinook salmon are limited in the Yukon. Overwinter flows that would allow for successful spawning of Chinook salmon in the Anvil/Rose Creeks would depend largely on groundwater contributions. Thus the interception or interruption of groundwater flows can have a significant effect on overwinter flows and quality of fish habitat.

Water quality parameters such as elevated levels of heavy metals and suspended sediments can affect aquatic health in terms of the abundance and diversity of benthic invertebrates and other primary and secondary production of the aquatic food chain. Some heavy metals can accumulate in the food chain and eventually reach levels that result in negative biological effects. Suspended sediments can smother benthic invertebrates and fish eggs, reduce light transmission to primary producers and at higher levels affect the ability of fish to feed. Benthic invertebrates that are most sensitive to pollution are mayflies, caddisflies and stoneflies. These invertebrates are the preferred fish food, so elevated levels of metals and suspended solids can have a direct impact on fish habitat productivity and on the health of fish and fish populations.

Instream works such as the reconstruction and diversion of streams, stream crossings, or obstructions to upstream migration can affect the quality and quality of fish habitat and thus the productive capacity. Near stream works and construction activity in the watershed can result in the runoff that increases suspended sediments, introducing contaminants and nutrients in streams with impacts on water quality, aquatic health and fish habitat productivity.

For this assessment, three impact statements have been used to discuss potential impacts to fish health and populations (AR1), fish habitat (AR2) and aquatic health (AR3). The three Impact Statements and pathways of effects for each impact statement are summarized below:

Impact Statement AR1: Project activities affecting surface water quality may have an effect on fish (Chinook salmon, Arctic grayling and Slimy sculpin) health and populations.

There are three pathways whereby changes in water quality during construction and operation of the Project may impact health of fish and fish populations:

- Pathway 1: Discharges from the treatment plants into Rose Creek and Vangorda Creek.
- Pathway 2: Sedimentation from site runoff during construction.
- Pathway 3: Contamination of receiving waters from surface runoff and groundwater seepage that is not collected.

Impact Statement AR2: Project activities including surface disturbance causing sedimentation, groundwater interception, channel diversion, and reconstruction and removal of barriers to fish movement may directly affect fish habitat.

Under Impact Statement AR2 there are four pathways that may result in physical alterations to fish habitat:

- Pathway 1: Sedimentation from site runoff during construction.
- Pathway 2: Groundwater collection.
- Pathway 3: Channel upgrading and lining.
- Pathway 4: Construction and removal of stream barriers to fish movement.

Impact Statement AR3: Project activities affecting surface water quality may have an effect on aquatic health and productivity.

Under Impact Statement AR3 there are 3 pathways by which changes in water quality may impact aquatic health:

- Pathway 1: Discharges from the treatment plants into Rose Creek and Vangorda Creek.
- Pathway 2: Sedimentation from site runoff during construction.
- Pathway 3: Contamination of receiving waters from surface runoff and groundwater seepage that is not collected.

8.7.4 Impact Assessment

Local Study Area - Implementation Period (2012-2026)

Impact Statement AR1: Project activities affecting surface water quality may have an effect on fish (Chinook salmon, Arctic grayling and Slimy sculpin) and fish population health.

Background

The potential for continued contamination of surface waters and groundwater is the major concern with respect to impacts to the health of downstream fish and fish populations during the implementation phase. The upgrading and lining of stream channels to divert clean water around the site, the covering of waste rock dumps and tailings areas to reduce groundwater infiltration and contamination, and the interception and treatment of contaminated surface drainage and groundwater should result in gradual improvements to downstream surface water quality as construction activities

are completed. In-stream work and extensive disturbance in the drainage area during construction will likely result in some short term increases in suspended sediments in downstream surface waters with negative impacts to fish and population health even with the application of best management practices. The quality of discharged treated water will continue to be a potential concern until new and improved water treatment plants are constructed.

Assessment Methods

The assumption used in this assessment is that water quality during the implementation period will be similar to the existing conditions as collection and treatment of contaminated water will continue throughout this phase of the project. Water quality will likely improve as Project activities are implemented to reduce levels of contaminated surface runoff and construction-related sedimentation at the Faro and Vangorda/Grum sites. The key questions are:

- What are the current trends of existing water quality on fish and population health; and
- To what extent and how rapidly will water quality improve or change with project activities during the implementation period.

Assessment Results

Pathway 1: Discharges of treated water into the receiving environment on Rose Creek and Vangorda Creek

Water quality is expected to be maintained during the construction phase and improved with the construction of new and more efficient treatment plants in the future. New treatment plants will be phased in and constructed as part of the AMP when required but this may not be until well after the initial 15- year construction and closure period.

The impact of Project activities during construction is expected to maintain or possibly reduce concentrations of contaminants in treated discharge and reduce overall loadings of contaminants to receiving waters with neutral or possibly positive effects on fish and fish populations and aquatic organisms at X14, and downstream to the confluence of Rose Creek with Anvil Creek (LSA boundary).

The section of Vangorda Creek between the Vangorda mine area and the Town of Faro is not fish habitat. Project activities are expected to result in maintained or possibly improved water quality at the receiving point V27 just below the mine site, and at V8 which is fish habitat.

Pathway 2: Sedimentation from site runoff

Sedimentation from site runoff is expected to increase during the construction phase notwithstanding the application of best management practices to control runoff and sedimentation. Projects activities that will directly impact fish habitat, such as the reconstruction of the North Fork Rose Creek channel and the removal of the rock drain and culverts, and activities adjacent to fish habitat such as

the construction of water management structures at the Faro tailings facility are of most concern. Project activities such as the re-grading and covering of waste rock dumps and tailings, construction of borrow pits and roads also have the potential to increase sediment loadings in streams through site runoff and drainage. While no construction activities at Vangorda will be undertaken in fish habitat, there is potential for downstream sedimentation effects from site runoff and drainage and thus will also require the application of best management practices.

Arctic grayling and Slimy sculpin are less sensitive than Chinook salmon to increases in total suspended solids and resulting sedimentation because of differences in reproductive biology (broadcast spawners vs. specific spawning beds; spring vs. fall spawners etc). A very low level of juvenile Chinook rearing and spawning occurs in the upper portion of the Rose Creek watershed within the LSA. The Vangorda Creek watershed is not fish habitat except for its lower reaches. The lengthy duration of construction activities at the mining sites and extensive disturbances in the LSA watersheds is of concern even with the rigorous application of best management practices.

Both Anvil/Rose Creek and Vangorda watersheds are clear water systems with seasonal mean total suspended sediment (TSS) levels of <5 mg/l and maximum levels of <25 mg/l at most stations. Periodic short term increases in TSS in receiving waters above existing background levels can be expected from Project activities and from site runoff during high precipitation and flood periods. Events that result in short term elevated levels of TSS also occur naturally in undisturbed systems, and Arctic grayling and Slimy sculpin are well adapted to deal with such periodic events. Some temporary reduction in fisheries productivity, however, can be expected during the implementation period.

The effects resulting from construction activities spanning up to 15 years will require a planned application of best management practices and include on-site environmental monitoring to monitor the effective application of these practices. Thresholds will require that medium term increases in TSS be <5 mg/l, with short- term increases of <25 mg/l which is the standard applied to the most sensitive fish habitat in watershed authorizations for placer mining in the Yukon under the federal Fisheries Act.

Pathway 3: Contamination of receiving waters from surface runoff and groundwater seepage

The construction of covers on waste rock dumps and tailings areas, upgrading and lining of North Fork Rose Creek, construction and upgrading of groundwater collection systems will, once in place, reduce acid mine drainage from the site and improve surface water quality. Water quality during the construction phase is expected to be maintained a current levels, or possibly improved as closure activities are implemented. Current levels of contaminants are not having any detectible effects on fish and fish population health in the Faro LSA as evidenced by the abundance of Arctic grayling and Slimy sculpin adults and juveniles (Tables 4.4-5 to 4.4-10 AECOM 2009) condition factors (Table 8.28), levels of contaminants in fish flesh (Table 8.29) and high abundance and diversity of sensitive and important benthic invertebrate organisms in the LSA including the most impacted sites on Rose Creek (Table 8.30). The Vangorda LSA is not fish habitat.

Table 8.28: Summary of Fish Condition Factors (2004-2007)

Station (Figure 4-10)	Location	Species				Level of Contaminant Impact
		Arctic grayling		Slimy sculpin		
		N	C.F.[1]	N	C.F.[1]	
R1	S. Fork Rose Creek at Faro mine site	15	1.2705	16	1.1620	Low
R2	Rose Creek below Faro mine site	10	1.1545	16	0.9849	High
R4	Rose Creek near Anvil confluence	10	1.1850	13	1.0816	Medium
R5	Anvil Creek near Rose confluence	10	1.2184	6	1.0378	Low
V8	Vangorda Creek below Faro Townsite	15	1.0256	12	1.4183	Medium
R6	Anvil Creek above Rose confluence	7	1.0616	20	1.2090	Reference
B1	Blind Creek	15	0.9906	NA	NA	Reference

Table 8.29: Summary of Metal Concentrations in Fish Tissues for the period 1997-2007 (Insert Table 4.4-13 attached - will need to be formatted!

Metal	Station									
	Anvil/Rose System								Blind System	Vangorda System
	R6	R1	R2	R4	A4	A3	A2	A1	B1	V8
Slimy Sculpin Whole Body Tissue (mg/kg ww)										
Cadmium	0.062	0.038	0.039	0.046	0.056	0.075	0.085	0.230	0.096	0.269
Zinc	35.0	35.1	46.7	51.6	48.3	35.9	42.9	46.0	26.0	56.2
Arctic Grayling Muscle Tissue (mg/kg ww)										
Cadmium	0.024	0.021	0.032	0.219	0.062	0.044	0.034	0.075	0.035	0.1157
Zinc	8.9	10.2	10.5	8.3	14.8	9.4	10.1	18.5	9.4	14.8
Arctic Grayling Liver Tissue (mg/kg ww)										
Cadmium	NA	0.197	0.970	NA	NA	NA	NA	NA	1.285	1.048
Zinc	NA	27.0	27.7	NA	NA	NA	NA	NA	27.4	32.1

Reference Sites

Moderately Impacted Sites

Heavily Impacted Sites

Table 8.30: Summary of Benthic Invertebrate Abundance and Diversity

Station	Abundance (Mean number of organisms)	Diversity (Mean number of taxa)	Percentage of pollution sensitive organisms (Mayflies, Stoneflies, Caddishly)	Level of Contaminant Impact
Anvil/Rose Creek Watershed Stations[1]				
R7	17,442	41.3	16.3	Reference
R6	17,426	45.2	25.6	Reference
R1	27,608	56.2	18.5	Low
R2	12,969	47	33.7	High
R3	13,296	39.2	39.2	Medium
R4	5,448	46	32.7	Medium
R5	18,802	44.7	25.7	Low
Vangorda Watershed Stations[2]				
V1	2145	28.2		Reference
V5	8672	39.3		Low
V27	4413	27.8		High
V8	3649	32.7		Medium

Notes: (1) Mean number of organisms for period 1997-2006; Mean number of taxa for period 1996-2006; Percentage of pollution sensitive organisms for period 2000-2006.
(2) Mean number of organisms for period 1997-2007; Mean number of taxa for period 1997-2007.

Discussion and Conclusions

- Construction activities affecting surface water quality will have no adverse effects on fish and fish population health, but will require the application of best management practices and rigorous monitoring to ensure that these measures are effective.
- Water quality in the receiving environments (X14 and V8) is expected to be similar to existing conditions, as collection and treatment of contaminated groundwater and surface water is continued throughout the construction phase. As Project activities are implemented (covers placed on mine wastes), water quality may improve slightly due to improved collection and treatment and reduced runoff from the site.

Impact Statement AR2: Project activities including surface disturbance causing sedimentation, channel diversion, groundwater interception, and reconstruction and removal of barriers to fish movement may directly affect fish habitat.

Background

Certain Project activities have the potential to cause direct and indirect physical alteration of fish habitat in the Faro LSA. The Vangorda LSA is not fish habitat except in its lower reaches downstream of the Faro townsite. Project activities that will directly alter fish habitat in the Faro LSA include the upgrading and lining of the North Fork Rose Creek. The removal of the rock drain on North Fork Rose Creek will create some additional fish habitat and provide for fish passage and access to habitat upstream of the rock drain. The removal and upgrading of the culverts at the access

road and haul road on South Fork Rose Creek will provide for fish passage and access to upstream sections of the creek and net increases in area of fish habitat.

The re-grading of rock waste dumps, placement of covers and development of borrow areas and activities adjacent to fish habitat have the potential to result in sediment loading and increased TSS from surface site runoff with potential for adverse impacts to fish habitat. While the Vangorda LSA for the most part is not fish habitat, sediment loading from surface site runoff can result in downstream impacts to fish habitat.

Assessment Methods

Upgrading, realignment and lining of North Fork Rose Creek

The assessment of impact to fish habitat productivity resulting from the reconstruction and lining of the North Fork of Rose Creek is based on the length of stream channel affected, and estimated losses of productivity during the ecological recovery period. There will be some benefits to fish habitat values upstream of R7 associated with the removal of the rock drain, but this has not been included so the above assumptions are conservative.

The following assumptions have been made to calculate the length of affected stream channel:

- The reach of North Fork Rose Creek from the access road to the rock drain (907 m) is estimated to be 100% productive.
- The reach from the rock drain to R7 (2358 m) is estimated to be 50% productive because of the barrier to fish movement by the rock drain, resulting in 1179 m of fully productive fish habitat.
- In total, there is estimated to be 2086m of fully productive fish habitat (907 m + 1179 m = 2086 m).

Loss of productivity of the fully productive length of stream (2086 m) affected during the 25- year period (yrs 1-25, assuming that construction occurs in Years 1-3 (see Section 7.XXX Project Implementation Schedule) :

- Loss of productivity for the 3 year period of construction (Years 1-3) estimated at 100% (i.e. 3 years of productivity lost).
- Loss of productivity for the 7- year post construction recovery period (Years 4-10) estimated at 50% (i.e. 3.5 years of productivity lost).
- Loss of productivity for the 15 year period following the 10 years of construction and recovery estimated at 90% (i.e. 1.5 years of productivity lost).
- Total loss of productivity over a 25 year period of construction and post construction is sum of the stream length effected (2086 m at 100% productivity) multiplied by the estimated loss of productivity for each of the 3 periods i.e. (2086 m X 3 years) + (2086 X 3.5 years) + 2086 X 1.5 years) = 16,668 m/years (i.e. equivalent to 16,668 m of stream productivity lost for one year).

Removal of rock drain

The rock drain will be removed in year 15 when the activities requiring use of the haul road are completed and the road is no longer needed. The removal of the rock drain will create some new fish habitat in its footprint. It will also remove a barrier to the upstream movement of fish and thus increase the productivity of the stream reaches above the rock drain. The estimated changes in habitat productivity are based on the following assumptions:

- The footprint of the rock drain will result in 235 m of new habitat that will have 0% productivity in the first 3 years, 50% productivity in the next 7 years i.e. (235 m X 0 years) + (235 m X 3.5 years) = 823 m years.
- The removal of the rock drain will increase the habitat productivity of the 2358 m of stream habitat above the drain to R7 from 50% to 100% over a 10 year period from year 16 to year 25 i.e. 2358 m X 50% X 10 years = 11,790 m years.
- Total gain in productivity from the removal of the rock drain over a 25 year construction and post construction period is 823 + 11,790 = 12,613 m years.

Removal of perched culverts on South Fork Rose Creek

These culverts will be removed in Year 15 when the haul road is no longer needed. These perched culverts present a complete barrier to upstream fish movement thereby reducing the productivity of upstream reaches. The removal of the culvert at the access road will open up 500 m of stream habitat between the access road and the haul road. The removal of the culvert at the haul road will open up an additional 3000 m of stream above to access road leading to a small headwater wetland. This wetland is assumed to sustain some fish populations as adult grayling were observed in a pool below the culvert on the haul road in 2009 and these fish could only have come downstream. Changes in habitat productivity are based on the following accounting procedures and assumptions:

- The 500 m stream reach between the access road and haul road has no habitat value at this time and removal of the culvert at the access road will increase productivity from 0% to 100%. This will result in a 100% increase in productivity of 500 m for 10 years from years 16-25 after the closure period i.e. 500 m X 10 years = 5000 m years.
- The 3000 m stream reach from the haul road to the wetland has a productivity value of 50% at this time due to lack of upstream connectivity and evidence of some downstream utilization by fish populations from the wetland. The removal of the culvert at the haul road will result in a 50% increase in habitat productivity of the 3000 m of stream for 10 years i.e. 3000 m X 50% X 10 years = 15,000 m years.
- The above projects will result in a net gain of 20,000 m years of habitat productivity over the 25 year licence period. A summary of habitat losses and gains is presented in Table 8.31.

Table 8.31: Summary of Fish Habitat Losses and Gains

Project Activity	Description of Habitat Change		Change in Productivity	
	Length of Stream affected	Timing	Loss - 25 year Project period	Gain -25 year Project period
Upgrading and Lining of N. Fork Rose Creek	R7 to top of Rock drain - 2358 m X 50% habitat value = 1179 m Bottom of Rock drain to Access Road – 907 m Total 2086 m	Year 12	Year 1-3 100% = 3.0 years Year 4-10 50% = 4.0 years Year 11-25 10% = 1 years (3 years + 4 years + 1 year = 8 years of productivity lost) Total Loss Year 1-25 = 8.0 years X 2086 m = 16,688 km years stream habitat lost	
Removal of Perched Culverts on S. Fork Rose Creek at Access Road and Haul Road	1. Access Road to Haul Road – 500 m 2. Haul Road to upstream wetland 3500 m Total 4000 m	Year 15		1. 500 m – 100% productivity gain 2. 3000 m – 50 % productivity gain Total Gain Year 16-25 (500mX100%) + (3000X50%) = 2000 m X 10 years = 20,000 km years stream habitat gained
Removal of Rock Drain on Haul Road	1. Length of Rock Drain (235 m) new stream habitat 2. Productivity of stream from top of Rock drain to R7 (2358 m) increased by 50%	Year 15		1. Year 1-3 0% = 0 years Year 4-10 50% = 3.5 years Total gain year 16-25 (3.5 years X 235 m = 823 m years) 2. 2358 m X 50% = 1179 m X 10 years = 11790 km years habitat gained Total 823 m years + 11790 m years = 12613 m years stream habitat gained
			16,688 m years lost	**32,613 m years gained**

Assessment Results

Pathway 1: Sedimentation from site runoff

In-stream works and sedimentation from surface runoff have the potential to affect fish habitat directly or indirectly over the 15- year construction period. Of particular concern will be the sensitive spawning and overwinter incubation period of September to May for Chinook and the spring spawning period for Arctic grayling and Slimy sculpin in May. Adverse impacts to fish habitat will be avoided if the DFO guidelines and Fisheries Act requirements for TSS and discharge of sediments for the placer mining industry (ie TSS <25 mg/l above background for the most sensitive habitat) are met (DFO Pelly River Watershed Authorization, 2008). Adherence to these guidelines will require application of best management practices for the duration of construction, with ongoing monitoring and evaluation as part of the AMP. It will also require the presence of independent environmental monitors on site.

No adverse impacts to fish habitat are likely to occur from sedimentation resulting from surface runoff during the construction period with the rigorous application of best management practices to manage surface water (see Water Management Plan –Construction).

Pathway 2: Groundwater Collection

The interception and withdrawal of groundwater at the Faro site can affect downstream habitat in three ways:

1. A reduction in downstream surface flows, especially during the critical low flow winter period when water treatment and discharge is not occurring but collection of groundwater continues.
2. Reductions in warmer groundwater contributions to downstream flows during the winter and potential impacts to important upwelling areas.
3. A reduction in water hardness during the winter low flow period and increases in toxicity of contaminants.

Current average annual groundwater contributions at X14 are estimated at <10% of total flows. Interceptions of groundwater will increase during the construction period as the collection system is installed and becomes operational. The water quality model, while not a hydrological model, does provide an estimation of surface flows (GEEC 2010). This model estimates that there will be a reduction in surface flow of approximately 10% at X14 and 5% at R5 during the lowest winter flow period in March. These estimated reductions in flows are not anticipated to result in any adverse impacts to fish habitat.

March winter flow reductions at the Vangorda site are estimated at 7% at V27 (which is not fish habitat), and 3% at V8 below the town of Faro (which is fish habitat). These estimated reductions in flows are not anticipated to result in adverse impacts to fish habitat.

While the estimated reductions in groundwater contributions to surface flows is not likely to result in adverse habitat effects, it may be more significant in terms of upwelling areas of warmer groundwater that provides important winter microhabitats for fish. There are no known Chinook salmon spawning areas below the mine site on Rose Creek (downstream of X14). Monitoring of winter flows including potential upwelling areas on Rose Creek downstream from X14 should be undertaken as part of the AMP.

Significant seepage of contaminated groundwater as a result of acidification of waste rock dumps is not anticipated during the construction period. However, the significant predicted reductions in surface water hardness in winter from 300-400 mg/l to <200 mg/l and the reduced toxicity buffering capacity could be a significant issue over the longer term, as predicted concentrations of zinc and cadmium at X14 will increase at X14.

No adverse impacts are likely from groundwater inception and withdrawal at the mine site during the construction period.

Pathway 3: Channel upgrading and lining

The upgrading and lining of 3265 m of North Fork Rose Creek between the access road and R7 will result in a temporary loss of productivity equivalent to 13,559 m/years during the construction period and an additional 3129 m/years of productivity in the following 10 years of post closure or a total of 16,668 m/years. This estimated loss of productivity will be offset by 32,613 m/years of habitat productivity over this same timeframe, resulting from the removal of the rock drain and perched culverts on the South Fork Rose Creek in Year 15. A summary of these predicted changes in habitat productivity from Project activities are presented in Table 8.31.

The deferment in habitat productivity during the construction period will cause some short term impacts to habitat productivity, but these are not considered to be significant as no known critical habitats (Chinook salmon spawning) will be affected. Equivalent rearing habitat exists in South Fork Rose Creek, below the access road and the diversion on N. Fork Rose Creek, and in the diversion itself that will sustain fish populations over this period.

There will be some short term reduction of habitat productivity during the construction period but this is not considered significant as no critical habitat is involved and alternative habitat exists to sustain fish populations on and above the site.

Pathway 4: Construction and removal of stream barriers to fish movement

The removal of the rock drain in Year 15 will create an additional 235 m of new stream habitat, representing about 823 m/years of productivity over a ten year post construction period. It will also remove a barrier to upstream migration of fish and result in improved productivity of an additional 11,790 m/years over this period.

The removal of the perched culverts on the access road and haul road on S Fork Rose Creek in Year 15 will provide upstream access and connectivity for fish and generate an additional 20,000 m/years habitat productivity during the 10 year post-construction period. A summary of these predicted changes in habitat productivity from Project activities are presented in Table 8.31.

The removal of the rock drain and perched culverts at the end of the construction period will result in a net gain in habitat productivity 32,613 m years during the 10- year post-construction period.

Discussion and Conclusions

Groundwater interception and sedimentation from site runoff are not expected to result in any adverse impacts to fish habitat in the Faro and Vangorda LSAs during the closure period. The upgrading and lining of the North Fork of Rose Creek will result in some short term loss of habitat productivity during the implementation period, but this effect will be more than offset by habitat productivity gains resulting from the removal of the rock drain and perched culverts on the South Fork of Rose Creek.

Impact Statement AR3: Project activities affecting surface water quality may have an effect on aquatic health and productivity

Background

Project activities such as collection of groundwater, discharges from treatment plants, re-grading and covering of waste rock dumps and tailings, borrow pits and upgrading and lining of the N. Fork Rose Creek can all directly affect water quality through sedimentation from site runoff, collection and treatment of contaminated water, discharges of treated water, and acid mine drainage from surface runoff and groundwater seepage. However, in terms of aquatic ecosystem health, all disturbances in the watershed are cumulative, including other land use activities and natural events such as forest fires, and have the potential to affect aquatic health.

While historic mining activities at Faro have significantly influenced aquatic health in the past, ecosystems are also resilient and can recover when the stressors are removed. Existing water quality is the end result of decades of changes in stresses from mining and other unrelated activities on the site.

While there are a number of reference sites and some reference data for both the Anvil/Rose and Vangorda watersheds that inform the existing environment baseline, for the most part these reference sites are upstream and headwater sites. Further downstream in watersheds, stream morphology and ecology changes, especially in steep gradient watersheds like Anvil/Rose and Vangorda. These reference data and conditions must be interpreted in this light, and although limited, reference data from a non-impacted adjacent watershed such as Blind Creek are also useful. It is also important to consider that the Anvil/Rose and Vangorda watershed represent highly mineralized natural systems

with high levels of some elements that have conditioned aquatic species and aquatic health for thousands of years.

Assessment Methods

The assessment of effects resulting from discharges from treatment plants and sedimentation (Pathways 1 and 2) has been addressed under Impact Statements AR1 and AR2 and will not be repeated here as it is relevant for aquatic health as well.

A detailed assessment of predicted changes to water quality and impacts to the aquatic environment at a trophic level during post-closure is found in Section 8.6. The aquatics assessment depends heavily on the predictive water quality model developed by Gomm Environmental (GEEC 2010) and on ecological assessments untaken by Senes (2010) and Minnow (2010). The assessment of aquatic effects will focus on the ecological significance of the water quality assessment, and takes into account more local species and conditions. Additional aquatic health indicators such as abundance and diversity of benthic organisms including the most sensitive taxa, metal concentrations in benthic invertebrates, stream sediments and fish tissue will be evaluated against the appropriate thresholds outlined in Table 8.27.

Existing water quality data is based on the period 2005-2007. Summaries of benthic abundance and diversity data and stream sediment contaminant data is based on the period 1997 – 2007.

It is also important to consider that CCME water quality and sediment guidelines and TRVs developed by Senes (2010) and impact endpoints presented by Minnow are for the most sensitive test results for the most sensitive species. While this is appropriate for the assessment to identify the most conservative effects levels, these are endpoints for the most sensitive individual species and do not necessarily reflect endpoints for the broader taxa and trophic community level. There are orders of magnitude differences in sensitivity for related species and members of the same trophic community.

Assessment Results

Pathway 1: Discharges from treatment plants into Rose Creek and Vangorda Creek

As discussed above, levels of contaminants in effluent quality discharged from treatment plants at the Faro and Vangorda sites are expected to be maintained or improved as new treatment plants are constructed. The new treatment plants will reduce zinc concentrations in discharge by an order of magnitude from current 0.5 mg/l to 0.05 mg/l (Project Description, Draft 4, Chapter 8.2.5, SRK 2009) with corresponding improvements in levels of other contaminants with the possible exception of cadmium. A consequence of increased interception of groundwater on zinc concentrations in the receiving waters is that hardness levels during the winter months will not increase over the course of the winter but remain constant at around 150-200 mg/l. This has the potential to increase the toxicity of zinc. While zinc levels in winter are not expected to increase during the closure period, water

quality model predictions indicate significant increases in winter zinc levels post-closure. This is due to ongoing acidification of the waste rock dumps and contaminants in groundwater that will start affecting downstream surface waters in spite of the remediation efforts to collect and treat contaminated water.

As outlined above, levels of cadmium in treatment plant discharges are expected to increase as larger volumes of groundwater with low levels of cadmium are collected and treated during the closure period. Thus cadmium levels from discharges and in receiving waters can be expected to increase during the summer treatment period and peak during the low flow period in fall at about 0.0004 at stations at X14 and V27. While these predicted values are well above the CCME (2003) guideline of 0.00003 mg/l, they do not exceed the TRV of the most sensitive species (Table 8.32). Increases in cadmium levels in discharge during the closure period will be accompanied by higher levels of hardness from the treatment process, thereby reducing toxicity. No adverse effects to aquatic health are therefore expected as a result of discharge from treatment plants.

Table 8.32: Summary of Contaminant Concentrations

Contaminant	Station	Contaminant Concentration (mg/l)							
		Existing & Construction (2012-2026)		Post- Closure (2027-2036)		Long-Term (2027-2212)		Toxicity Reference Valuesi Effect Concentrations2 (mg/l)	
		Median	Max	Median	Max	Median	Max		
Zinc	V27	0.0257	0.0318	0.076	0.195	0.084	0.528	Phyto[1]	0.002
	V8	0.0150	0.0640	0.044	0.100	0.052	0.427	Zoo[1]	0.06
	P2	0.0156	0.0401	0.023	0.023	0.023	0.025	Benthos[1]	0.04
	X14	0.0330	0.2500	0.088	0.427	0.113	0.994	P. Fish[1]	0.20
	R4	0.0126	0.0250	0.068	0.368	0.088	0.797	F. Fish[1]	0.33
	A1	0.0046	0.0238	0.035	0.170	0.042	0.361	Chinook Salmon[2]	0.424
	P4	0.0134	0.0458	0.024	0.030	0.024	0.038	Sculpin[2]	0.106
								CCME[3]	0.03
Cadmium	V27	0.00007	0.00044	0.0001	0.0003	0.0002	0.0006	Phyto[1]	0.0200
	V8	NA	NA	0.0001	0.0002	0.0001	0.0005	Zoo[1]	0.0003
	P2	0.00018	0.00051	0.0002	0.0002	0.0002	0.0002	Benthos[1]	0.0004
	X14	0.00006	0.00030	0.0001	0.0004	0.0002	0.0005	P. Fish[1]	0.0003
	R4	0.00003	0.00014	0.0001	0.0003	0.0002	0.0004	F. Fish[1]	0.0014
	A1	0.00003	0.00017	0.0001	0.0001	0.0001	0.0002	Chinook[2] salmon	0.0110
	P4	0.00013	0.00063	0.0002	0.0002	0.0002	0.0002	Sculpin[2]	0.00346
								CCME[3]	0.00003

Notes: 1. Sennes, 2010
2 Minnow 2010
3 CCME 2003

A review of the primary aquatic health indicator, benthic invertebrate species diversity and pollution sensitive species abundance, is presented in Table 8.30. The data indicates that at the receiving water stations X14(R2) and V27, species diversity and abundance of pollution sensitive invertebrates are at or above reference station levels and within the norm of other less impacted locations downstream.

Concentrations of zinc and lead in stream sediments are highly elevated above guidline levels and reference levels at receiving water stations at the Faro and Vangorda sites, with downstream trends to lower and reference levels. Zinc and lead in benthic invertebrate tissues also show the highest levels at the most impacted station R2 (V14) and the lowest levels at reference station R6 which could indicate some effects from elevated levels in sediments (*Current Environmental Conditions Supporting Document, Tables 4.3-6 and 4.3-7,* AECOM 2009).

The primary indicators of aquatic health - diversity of benthic invertebrates and abundance of pollution sensitive taxa - indicate no significant adverse impacts from contaminants in current discharges from water treatment plants. As it is assumed that water quality in discharges from treatment plants will either be similar to existing during implementation period, or improve in post-closure period, indicators of aquatic health are unlikely to change, or possibly improve as discharge quality improves. Existing concentrations of metals in stream sediments are unlikely to change as a result of the Project, and are expected to remain in situ for decades.

Pathway 2: Sedimentation from site runoff

Sedimentation from site runoff is expected to be temporarily elevated by construction activities such as the re-grading of waste dumps, the placement of cover materials, and the upgrading and lining of North Fork of Rose Creek. As vegetation cover becomes established and the new channel stabilized, sedimentation from site runoff will decline.

Benthic invertebrates, especially pollution sensitive species that include mayflies, stoneflies and caddisflies, are highly sensitive to levels of Total Suspended Sediments (TSS). The application of best management practices during the construction period will keep elevations of TSS within water quality objectives of < 25 mg/l foro the most sensitive habitats, No adverse impacts to aquatic health are expected with the application of best management practices to control sedimentation from site runoff.

Pathway 3: Contamination from surface runoff and groundwater seepage

Contamination from surface runoff and groundwater seepage is expected to decline over the construction period as covers are established on waste rock dumps and tailings, contaminated surface water is controlled and reduced, the North Fork Rose Creek is upgraded and lined, and the groundwater collection system is upgraded. The acidification of waste rock dumps is not expected to significantly change from existing conditions during the construction period. Current pumping and treatment of contaminated groundwater will continue throughout the construction phase.

The diversity of benthic invertebrates and abundance of the most sensitive species at receiving sites X14(R2) and V27 are at reference levels. Median concentrations for zinc and cadmium currently meets the CCME (2003) guidelines at both sites, and maximum levels are within toxicity reference and endpoint levels for benthic invertebrates and fish species with the exception of maximum zinc levels at X14(R2).

No adverse impacts from contamination from surface runoff at the site and contaminated groundwater seepage are expected during as a result of Project activities during the construction phase.

Discussion and Conclusions

No adverse impacts to aquatic health are expected from Project activities during the construction period and existing aquatic health is expected to be maintained or improved.

Local Study Area - Post Closure Periods (2027-2036)

Impact Statement AR2: Project activities including surface disturbance causing sedimentation, groundwater interception, channel diversion and reconstruction and removal of barriers to fish movement may directly affect fish habitat.

Pathway 2: Groundwater collection at the Faro site

During the post-closure period, the construction activities will be completed, and it is only the ongoing interception of groundwater that is relevant to the post-closure period for this impact statement. The predicted effects on fish habitat that are related to the interception of groundwater have been assessed under Impact Statement AR2, Closure Implementation Period. The results of that assessment are also relevant for the post-closure period, and will not be repeated here.

Impact Statement AR1: Project activities affecting surface water quality may have an effect on fish (Chinook salmon, Arctic grayling and Slimy sculpin) health and populations.

Impact Statement AR3: Project activities affecting surface water quality may have an effect on aquatic health.

Background

Water quality is predicted to decline during the 10- year post closure period (GEEC 2010) with elevated levels of zinc and cadmium (Table 8.32). The predictions are conservative, and their accuracy will depend the on the rate of acidification of the waste dumps, the actual attenuation of contaminated groundwater flows, and the efficiency of the groundwater collection and treatment systems and cover performance. While it is useful to assess predicted post- closure levels of zinc and cadmium and other COPCs, any decisions for managing water quality at the site will and should be guided monitoring programs to as part the Adaptive Management Plan (reference).

Assessment Methods

The assessment of Project activities focussed on the effects of predicted increases in levels of zinc and cadmium in receiving waters on fish and fish population health, and on aquatic health in terms of diversity of benthic invertebrates. Phytoplankton and zooplankton are not important components of stream ecosystems and toxicity reference values are not considered ecologically significant in streams. Periphyton algae are an important component of stream ecosystems, but such data has not been collected as part of ongoing monitoring programs, nor is toxicity data avaialbe for such taxa.

Predicted median and maximum levels of zinc and cadmium at the receiving points and lower limits of the Rose LSA (X14 and R4) and Vangorda LSA (V27 and V8) were compared to CCME (2003) guidelines for water quality, Toxicity Reference Values (TRV) for general trophic categories of invertebrates and fish according to SENES (2010), and Effect Concentrations (EC) for fish species found in these systems (Minnow 2010). These values are summarized in Table 8.32.

TRV for benthic invertebrates are very conservative and based on the most sensitive test results for the most sensitive benthic invertebrate species in the literature. There are many taxa and species of benthic invertebrates with higher effect concentrations, even for the same families (e.g. for Mayflies see Table 3.3 in Minnow 2010). Thus an exceedance of the TRV for benthic invertebrates is considered an impact to aquatic health in terms of some incipient loss of productivity but not a loss of the benthic invertebrate community.

The fish community, on the other hand, is limited to only five or six species, of which three are considered major species. If the TRV or EC values are exceeded for one or several fish species the impact is considered to be of higher magnitude if it represents a potential loss of a major fish species from the system.

Toxicity data is available for zinc and cadmium for two of the three major fish species in the system: Slimy sculpin (closely related to Mottled sculpin for which there is data) that are found in the system and are the most sensitive fish species, and Chinook salmon which are one of the more tolerant species. The toxicity data is for the most sensitive life stages (i.e. newly emerged fry and alevins) for both these species. Thus any exceedance of TRV or EC for these fish species represents a significant potential impact to the fish community.

Assessment Results

Post closure median and maximum zinc and cadmium levels at receiving and downstream LSA stations at X14 and R4 on Rose Creek and V27 and V8 on Vangorda are predicted to exceed the CCME guideline of 0.03 mg/l and 0.00003 mg/l respectively (see Table 8.32). Predicted levels of zinc and cadmium during the post closure period are compared to TRV thresholds for benthic invertebrates and EC thresholds for Slimy sculpin and Chinook salmon, and are evaluated in terms of potential impacts in Table 8.34 and Table 8.35.

Table 8.33: Effects of Predicted Zinc Concentrations during Post Closure Period (2027-2026) at Faro LSA and Vangorda LSA

Station	Benthic Invertebrates TRV = 0.040 mg/l		Slimy sculpin EC = 0.106 mg/l		Chinook salmon EC = 0.424 mg/l	
	Median (mg/l)	Max (mg/l)	Median (mg/l)	Max (mg/l)	Median (mg/l)	Max (mg/l)
V27 Vangorda Receiving	0.076	0.195	0.076	0.195	0.076	0.195
V8 Vangorda Downstream	0.044	0.100	0.044	0.100	0.044	0.100
X14 Rose Creek Receiving	0.088	0.427	0.088	0.427	0.088	0.427
R4 Rose Creek Downstream	0.068	0.368	0.068	0.368	0.068	0.368

Notes:

No impact	Impact to Benthic Invertebrate diversity and Productivity	Low impact to fish species	High impact to fish species

Table 8.34: Assessment of Impacts of Predicted Cadmium Concentrations during the Post Closure Period (2027-2026) at Faro LSA and Vangorda LSA

Station	Benthic Invertebrates TRV = 0.0004 mg/l		Slimy sculpin EC = 0.00346 mg/l		Chinook salmon EC = 0.0110 mg/l	
	Median (mg/l)	Max (mg/l)	Median (mg/l)	Max (mg/l)	Median (mg/l)	Max (mg/l)
V27 Vangorda Receiving	0.0001	0.0003	0.0001	0.0003	0.0001	0.0003
V8 Vangorda Downstream	0.0001	0.0002	0.0001	0.0002	0.0001	0.0002
X14 Rose Creek Receiving	0.0001	0.0004	0.0001	0.0004	0.0001	0.0004
R4 Rose Creek Downstream	0.0001	0.0003	0.0001	0.0003	0.0001	0.0003

Notes:

No impact	Impact to Benthic Invertebrate diversity & Productivity	Low impact to fish species	High impact to fish species

The comparisons of predicted levels of zinc and the TRV for benthic invertebrates indicates that diversity and productivity will be affected at median levels for all stations in the Faro and Vangorda LSAs with the exception of V8. Neither Slimy sculpin nor Chinook salmon will be impacted by predicted median levels of zinc within the Faro and Vangorda LSAs. Maximum levels of zinc are predicted to exceed the EC for Slimy sculpin at the receiving point (V27) on Vangorda Creek, and for both receiving (X14) and downstream (R4) stations on Rose Creek. Maximum levels for zinc slightly exceed the EC for Chinook salmon at X14; however, salmon are not abundant at this location 70 km upstream from the Pelly River. The predicted maximum levels of zinc on Rose Creek are of concern as they are sustained during the low flow winter period of Dec – May, and are

associated with significant reductions in hardness as a result of groundwater collection at the Faro minesite (see Minnow 2010 Fig 3.2)

Predicted cadmium levels within the Faro and Vangorda LSAs are below the TRV for benthic invertebrates and EC for Slimy sculpin and Chinook salmon with one exception. Maximum cadmium levels that just exceed the EC for Slimy sculpin at X14.

Discussion and Conclusions

- Elevated zinc concentrations in receiving waters during the post-closure period will result in adverse effects to benthic invertebrate productivity resulting from a reduction in species diversity and aquatic health throughout the Faro and Vangorda LSAs.
- Adverse affects to Slimy sculpin are likely in the Faro LSA during the winter period.
- Elevated cadmium levels are not likely to result in adverse effects to benthic invertebrate productivity or diversity, aquatic health, or to slimy sculpin and Chinook salmon in the Vangorda and Faro LSAs.

There is significant uncertainty underlying the timing of predicted elevated levels of zinc and cadmium during the post closure period as this will depend on the rate of acidification of waste rock dumps and the efficiency of collecting contaminated groundwater. Additional uncertainty is associated with the degree of conditioning and adaptation of benthic invertebrates and fish species to elevated levels of zinc and other contaminants in the Anvil/Rose and Vangorda drainages. High levels of diversity and abundance of benthic invertebrates and fish species like Slimy sculpin are likely testimony to some adaptation during decades of mine operations. However the high level of mineralization and elevated background levels of many contaminants have likely resulted in a level of conditioning over historical time frames and a level of resiliency not found in naive laboratory test organisms.

Regional Study Area - Closure Implementation Period (2012-2026)

Background

The Regional Study Area (RSA) is shown on Figure 4-10, and includes the lower reaches of Vangorda and Anvil Creeks to their confluences with the Pelly River, and extends downstream on the Pelly River to Station P4 (R11). The lower section of Vangorda Creek represents a short but productive reach in terms of rearing habitat for juvenile Chinook salmon. There is little additional drainage and flow augmentation on Vangorda Creek below V8, so flows and water quality at V8 represent conditions in the Vangorda portion of the RSA.

Anvil Creek supports Chinook salmon spawning and juvenile rearing habitat. It has a high productive capacity for salmon rearing and other fish species over a distance of about 40 km. Anvil Creek has relatively high flows that are roughly double that of Rose Creek at its confluence with Anvil Creek. Anvil Creek supports salmon spawning habitat, with incubation of eggs and emerging

fry over the 6 month low flow period. These sensitive life stages are especially vulnerable to flows and water quality during this long winter exposure period.

Assessment Method

There are no physical works proposed for the RSA, so the only potential impacts of Project activities within the RSA would be indirect effects on downstream water quality and flows.

Potential water quality effects include the flowing pathways:

- Contamination of receiving waters from surface runoff and groundwater seepage that is not collected;
- Groundwater collection; and
- Sedimentation from site runoff.

The assessment is based mainly on the predicted effects of these pathways at the downstream end of the LSA and the potential for downstream dilution from additional drainage. The Anvil Creek RSA is distinguished by the additional overwinter water quality and habitat requirements resulting from salmon spawning.

Assessment Results

Table 8.32 shows that median zinc levels during construction are within CCME (2003) guideline levels of 0.03 mg/l. Maximum zinc levels exceed guidelines somewhat at V8 on Vangorda Creek and at the Pelly River stations. The elevated maximum levels at V8 exceed the TRV for benthic invertebrates, but existing populations at this site have a high diversity that is equivalent to reference levels. As such, no impacts to aquatic health and productivity are anticipated during the construction period. The elevated maximum levels of zinc at the two Pelly River stations represent natural background conditions, as the Vangorda and Anvil/Rose drainages only represent 0.4% and 4% of the upstream Pelly drainage.

Both median and maximum levels of cadmium at the two Pelly River stations exceed CCME (2003) guidelines as do maximum levels at A1 at the lower end of the Anvil RSA. The maximum levels at the Pelly River stations also exceed the TRV for benthic invertebrates but these are considered natural background levels and should not result in any additional impacts to species diversity and aquatic health and productivity. The maximum levels of cadmium at A1 are within the TRV of benthic invertebrates and no impacts are anticipated.

Total suspended solids (TSS) from sedimentation from site runoff during the construction period will be controlled through the application of best management practices. No adverse impacts within the LSA and downstream in the RSA, therefore, are anticipated. Rigorous on site management and ongoing monitoring during construction will be required.

The predicted reduction in flows during the March low flow period from the groundwater collection system are estimated at 10% at X14, and 5% at A4 in the RSA (Table 8.36). For the Vangorda site, the March flow reductions are estimated in the order of 7% at V27 and 4% at V8 at the lower end of the LSA (Table 8.37). These flow reductions will have no adverse impacts on fish habitat in the RSA.

Table 8.35: Estimated Changes in Winter Low Flow (March) - Rose Creek (X14) and Anvil Creek (Below confluence with Rose)

Creek	Flow (m^3/s) Prior to Closure (2012)	Flow (m^3/s) Post Closure (2027)	Change in Flow Rate (m^3/s)	Change in Flow Rate (%)
Rose Creek	0.426	0.382	- 0.044	-10.33
Anvil Creek	0.868	0.824	-0.044	-5.07

Table 8.36: Estimated Changes in Winter Low Flow (March) - Vangorda Creek (V27 and V8)

Creek	Flow (m^3/s) Prior to Closure (2012)	Flow (m^3/s) Post Closure (2027)	Change in Flow Rate (m^3/s)	Change in Flow Rate (%)
Vangorda Creek (V27)	0.039	0.036	0.003	-7.2
Vangorda Creek (V8)	0.082	0.079	0.002	-3.6

Discussion and Conclusions

No adverse impacts are likely in the RSA during the closure period. It is assumed that water quality during the construction period will be maintained at current levels, and may slightly improve as Project activities are implemented.

Regional Study Area - Post Closure Period (2027-2036)

Background

During the post closure period, the water quality model predicts that levels of zinc in Anvil Creek and to a lesser extent on Vangorda Creek during the low flow winter period will be elevated (Table 8.32). Increasing levels of zinc are predicted as a result of the ongoing process of acidification of mine wastes, and residual amounts (≤ 2%) of contaminated groundwater entering the receiving waters. While the collection and treatment system will capture most of the groundwater, increased levels of zinc in receiving waters are due in part to reduced flows during the winter period. During the winter, reduced hardness levels (currently 300-400 mg/l reduced to ≤200 mg/l) from reduced groundwater flows will increase the concentrations of zinc. (see Surface Water Quality Assessment – Fig 8.6.7 and Minnow (2010) Fig 3.2). Of particular concern are potential impacts to incubating salmon eggs and sensitive emerging fry during the winter period from November to May.

Assessment Method

V8 approximates water quality and zinc levels in lower Vangorda Creek in the RSA. Zinc levels at station R4 on Rose Creek were divided by a factor of 2 to derive zinc concentrations at the upper end of the Faro RSA on Anvil Creek. Values at Station A1 represent levels at the lower end of Anvil Creek. Winter zinc concentrations are assumed to be represented by maximum zinc concentrations. These values are summarized in Table 8.32.

Assessment Results

Median zinc concentrations are at or near CCME guideline levels of 0.03 mg/l in both the Vangorda Creek and Anvil Creek portions of the RSA, and at or below the TRV of benthic invertebrates. Maximum zinc concentrations of 0.100 and 0.170 mg/l for Vangorda and Anvil Creeks respectively exceed the CCME guidelines and the TRV for benthic invertebrates. These maximum concentrations would occur during the winter, however, when the impact on aquatic productivity would be much reduced. Maximum zinc concentrations are at or slightly above the EC for Slimy sculpin, but well below the EC for Chinook salmon (Table 8.32).

- There is a low potential for adverse impacts to benthic invertebrate diversity and aquatic health and productivity in the RSA resulting from elevated maximum winter zinc concentrations.
- There is a low potential for adverse impacts to Slimy sculpin during the winter period in the Anvil Creek portion of the RSA.
- There are no adverse impacts predicted for the Pelly River portion of the RSA. No adverse impacts to Chinook salmon, including incubating eggs and emerging fry, are anticipated as a result of elevated winter zinc concentrations in Anvil Creek.

Long Term Post Closure (post 2036)

No formal assessment will be conducted for long term post closure after the 25 year licence period. The water quality model predicts that the acidification of the waste rock dumps will likely continue and accelerate over the long term, possibly peaking in about 100 years with zinc concentrations at receiving water greater than the levels predicted at the end of the 25- year term of the water licence (approximately 1.0 mg/l at X14).

8.7.5 Mitigation Measures

While the Closure Project as a whole is a complex mitigation of a contaminated site, additional measures are recommended for mitigation during the 15-year construction period. Where the proposed Project activities are not considered adequate to prevent adverse affects to aquatic organisms and habitat, or where the Project activities may cause additional adverse impacts, mitigation measures are recommended.

There are many uncertainties with respect to the timing and rates of acidification of the waste rock dumps, the efficiencies and effects of key Project components such as covers and the groundwater collection and treatment system, and the sensitivities and thresholds of affected aquatic organisms including fish. Thus mitigation and fish habitat compensation, where necessary, must be considered a key component of the long term AMP that is developed and implemented as part of this Project.

Potential impacts from Project activities during construction, such as sedimentation from site runoff and instream works, will be mitigated largely through the application of best management practices. Because of the extensive and long term nature of construction activities, a comprehensive best management practices plan needs to be developed prior to start of the project and implemented with independent on site monitoring with scheduled review and revisions as necessary through the AMP process.

Recommendations for mitigation are outlined below:

1. Mitigation by design
    - Consideration of releases from treatment plants during the winter low flow period. The current proposal is for seasonal treatment and discharge, with no discharge during the winter. There would be benefits from increased winter flows of relatively clean treatment water, but the major benefit would be from increased toxicity buffering from carbonates used in the treatment process. Other mechanisms for increasing winter flows to receiving waters should also be considered.
    - Incorporate fish habitat features that will enhance fish habitat values and productivity for fish in the design of the North Fork channel and rock drain and culvert removals. This could include the establishment of pool and riffle and instream habitat structures and reclamation and vegetation of riparian habitat areas.
2. Other mitigation
    - While the existing Rose Creek diversion is functioning fish habitat that allows for upstream passage of fish, habitat quality and productivity could be improved by incorporating more habitat features and structures into the upstream, low gradient portion of the diversion and by reclamation and vegetation of riparian shoreline areas.
    - Develop a comprehensive best management practices plan prior to the start of construction with independent on site environmental monitoring and with evaluation and review provisions to keep it current and effective over the 15- year construction period.

8.7.6 Significance Determination

Potential residual adverse effects were identified as follows:

Local Study Area – Post Closure Period

- Elevated zinc concentrations in receiving waters during the post-closure period will result in adverse effects to benthic invertebrate productivity resulting from a reduction in species diversity and aquatic health throughout the Faro and Vangorda LSAs.

- Adverse affects associated with elevation zinc levels to Slimy sculpin are likely in the Faro LSA during the winter period.

Regional Study Area – Post Closure Period

- There is a low potential for adverse impacts to benthic invertebrates diversity and aquatic health and productivity in the RSA resulting from elevated maximum winter zinc concentrations.
- There is a low potential for adverse impacts to Slimy sculpin during the winter period in the Anvil Creek portion of the RSA.

Residual Impact Rating and Determination of Significance

The impact rating criteria shown on Table 8.1 were applied to the adverse effects that remain after mitigation measures are applied (i.e. residual effects). These residual effects for aquatics are summarized in Table 8.38. Based on the Significance Rating Criteria in Table 8-2, none of the residual effects are considered to be significant.

Table 8.37: Aquatics Residual Impact Rating

Impact Statement	VEC	Indicator	Project Phase	Residual Impact Rating					
				Direction	Extent	Duration	Frequency	Reversibility	Magnitude
AR1	Fish and Population Health	Slimy sculpin abundance and condition factor	Post Closure	Negative	Local	Permanent	Intermittent	Not applicable	Low
AR3	Aquatic Health and Productivity	Benthic Invertebrate diversity	Post Closure	Negative	Local/regional	Permanent	Continuous	Not applicable	Moderate

8.7.7 Monitoring and Follow-up

Adaptive management is a critical component of this Project given the inherent uncertainties of the predictions of future water quality and associated potential effects on aquatic organisms and habitat. Intensive monitoring will be necessary during all phases of the Project (construction and post-closure). The focus of the aquatics monitoring program should be benthic species abundance and diversity as an indicator of aquatic health. Of particular interest is the 60-70 km long Anvil/Rose system where most of the fish and aquatic values are located. This section of the Anvil/Rose system supports fish habitat and salmon spawning and rearing, and will be influenced by the critical low flow winter period. Regular monitoring should also be undertaken on adjacent Blind Creek watershed as a reference watershed. In terms of fish and fish population health monitoring, the focus should be on Slimy sculpin because of their relative abundance in the system and their resident status and sensitivity to the major contaminants of concern.

8.8 Vegetation

8.8.1 Introduction

The broad remediation objectives for the Project identified by the FMC Oversight Committee are to:

- Restore to the extent practicable the land, air and water environments including protection of fish and wildlife; and to
- Reclaim the land to pre-mining uses where practicable.

The landform and land use objectives of the Project are to:

- Reliably prevent long-term impacts to the terrestrial and aquatic environment and protect human health; and to
- Increase productivity; improve aesthetics and compatibility with surrounding land uses.

These objectives form the context for planning reclamation and revegetation of the Faro Mine complex. Guidance is also provided by the Yukon and Federal governments on revegetation of mines:

1. Technical Guideline #T-12 of the Yukon Mine Site Reclamation and Closure Policy: Financial and Technical Guidelines states that revegetation objectives are “to ensure physical stability and to prevent a temporary loss of wildlife habitat utilization from becoming permanent, through the re-establishment of a vegetative mat (food source, hide, etc.) leading to self-sustaining native vegetation” (Yukon Energy, Mines and Resources 2009).
2. The 2009 Environment Canada Environmental Code of Practice for Metal Mines recommends that post-closure landscapes, the species used in revegetation and the resulting plant community should be consistent with the goals of mine closure and the intended post-closure use of the site.

Species native to the area around the mine site should be used for this purpose, and invasive species should never be used.

Covers of clean fill material will be used to construct stable landforms over Faro Mine Complex disturbances, isolate toxic substrates from the surface environment, reduce infiltration of water into buried toxic materials and provide a surface for revegetation. Secondary objectives of the covers include promoting landform variability, vegetation succession towards native plant communities and minimizing long term maintenance.

During the design evaluation and engineering design, disturbed areas of the Project were divided into Reclamation Landscape Units (RLUs). The design of each RLU is driven by chemical and physical stability of the underlying substrates, risk of failure of the cover, creating site conditions necessary to promote revegetation and the requirements of vegetation species to assist in cover objectives. Revegetated covers are key to reducing the loading of contaminants into the terrestrial environment and restoring the project area to be compatible with surrounding land uses.

8.8.2 Impact Assessment Methods

The objectives of the vegetation assessment for the Closure and Remediation Plan for the Faro Mine Complex (the Project) are to:

- Identify effects of the Project on the baseline condition of vegetation components of the ecosystem;
- Identify mitigation;
- Evaluate the predicted residual effects and their significance; and
- Identify vegetation monitoring requirements.

8.8.3 Issue Focused Approach

An issue based approach was used to focus the Valued Ecosystem Component (VEC) selection for vegetation. The primary issues for vegetation are whether Project activities will:

- Improve the health of vegetation on the landscape and reduce the potential for transfer of contaminants to wildlife and humans through plant uptake and ingestion;
- Develop a stable, self sustaining cover of vegetation on the landscape, consistent with native vegetation communities in the region where possible;
- Maintain ecosystem diversity through minimizing impacts to rare species and minimizing introductions of non-native and non-native invasive species; and
- Minimize new impacts to native vegetation due to project activities.

8.8.4 Valued Ecosystem Components

VECs were selected to represent key components of vegetation that could be affected by Project activities. Indicators and thresholds were chosen to measure changes in the VEC. The Valued Ecosystem Components (VECs) selected for the vegetation impact assessment are:

- Vegetation Health;
- Stable and self-sustaining vegetation covers on the landscape, consistent with native vegetation communities in the region where possible; and
- Vegetation diversity.

For each VEC; measurable indicators and a baseline case from which to measure change are identified. For the purposes of this closure EA, thresholds for rating impacts are defined as conditions equal to, but not worse than, the existing condition of the chosen indicators. The threshold(s) represents no net change in the existing conditions, either negative or positive. Indicators are chosen to evaluate potential Project effects on each of the VECs selected. Although the threshold for rating impacts is no net change from baseline conditions of the vegetation VECs, performance targets have been identified for vegetation health, vegetation diversity and vegetation covers.

Table 8.38: Vegetation VECs, Indicators, Thresholds and Performance Targets

VEC	Project Objectives	Indicator	Baseline Case and Threshold from which to measure change	Performance Targets
Vegetation diversity	*Short and long term* • Minimize impacts to rare plants. • Minimize impacts to uncommon vegetation associations. • Minimize introduction of non-native species and prevent introductions of non-native invasive species.	• Uncommon vegetation associations, • Rare plant species • Non-native species • Introduction and spread of Yukon category #1 invasive species.	Existing conditions both onsite (disturbed) and off-site (natural)	• >20% loss of a population of rare (S1, S2) or "may be at risk" plant species • <10% long-term cover of non-native species • < 1% persistent cover of Yukon category 1 invasive plant species
Stable and self-sustaining vegetation covers on the landscape, consistent with native vegetation communities in the region where possible	*Short term*: reduce surface erosion; reduce water infiltration into covers; establish initial vegetation cover using native species where possible. *Long term*: establish self sustaining plant community and succession towards native plant composition	*Short term*: Sufficient plant species cover and diversity to reduce erosion and allow infill by native species. *Long term*: Sufficient plant density and diversity to stabilize erosion; evidence of self-regenerating plant communities.	*Short term*: Existing conditions on disturbances on site. *Long term*: Existing conditions both onsite (disturbed) and off-site (natural).	*Short term*: satisfactory cover performance (see objectives for each cover type Table 7.1); > 30% vegetation cover of 5 or more native or non-native species after 5 years; (see RLU section) *Long term*: > 50% cover of 10 or more perennial species including local native species where possible
Vegetation health	*Short term:* • Reduce aerial deposition of Zn and Pb. • Minimize additional inputs of TSP dust onto plants and soils. *Long term*: • Minimize aerial deposition of Zn, Pb and other metals. • Minimize uptake of metals by plants rooted on covers. • Minimize inputs of TSP dust onto plants and soils.	• Cumulative deposition of zinc and lead on soils and plants. • Annual accumulation of TSP • Concentrations of metals in tissues of plants rooted on covers overlying toxic materials.	Existing conditions in the Regional Study Area	*Short term:* • Reduce cumulative deposition of Zn • Reduce cumulative deposition of Pb • Minimize increases in annual deposition of TSP *Long term*: • Reduce aerial deposition rates of metals to exceed CCME or WHO standards. • Metals levels in plants rooted on covers <3x background levels. • TSP deposition <4.6 gm/m^2/yr

Notes: Total Suspended Particulates (TSP), zinc (Zn) and lead (Pb).

8.8.5 Impact Assessment

A number of Project activities will affect vegetation both positively and negatively as follows:

- Vegetation clearing (for new surface disturbance) and vegetation burial will result in direct loss of vegetation and may affect vegetation diversity.
- Revegetation of the exposed substrates of the Faro Mine complex will increase the cover of vegetation and the value of wildlife habitat in the area.
- Importing reclamation seed, vehicles and materials from outside the Project area will introduce non-native species and may introduce invasive non-native species to the area.
- Deposition of dust and metal rich dust affect vegetation health and ecosystem health.
- Placement of covers on the exposed metal rich substrates of the mine waste will positively affect vegetation health by reducing the loading of contaminants into the ecosystem.
- Vegetation rooted on covers over toxic materials may uptake metals into vegetation, potentially affecting plant health creating a pathway for wildlife and human uptake.

Changes in the abundance and health of vegetation ecosystem components can result in effects to soils, air, surface water quality, habitat, wildlife and human use of the area.

Local Study Area/Closure Implementation Period

Impact Statement V1: New borrow source development, stream realignments, infrastructure development, re-sloping of waste rock piles, road decommissioning and revegetation of constructed covers will result in losses of native vegetation, creation of new vegetation communities and changes to vegetation diversity in the LSA.

Background

During the 15 year closure implementation phase, direct loss of vegetation will occur through surface disturbance or burial, as a result of Project activities. The surface area of new direct losses will be approximately 125.3 ha (1,252,921 m^2), and increase of 7.8% over the existing baseline disturbance area of 1,612.7 ha (16,127,000 m^2) at the Faro Mine Complex. Small additional losses may continue during the initial post-closure period (15 – 25 years) when adaptive management will be implemented to promote site stability, revegetation and closure objectives. Surface disturbance will result in loss of living vegetation, propagules and seed on or near the ground surface. Soils required for plant growth may also be lost and substrate quality, moisture levels and temperature may change.

Project activities that will result in surface disturbance or burial include: excavating new channels and constructing access roads to reroute Rose Creek, North Fork Rose Creek and Vangorda Creek into new alignments, re-sloping waste rock piles; constructing access roads and infrastructure and pads for groundwater management; excavation of the North Fork Rose Creek detention pond; development of multiple borrow sources to provide materials for covers, haul road decommissioning

and development of post-closure infrastructure. Excavation of contaminated soils from around the Faro emergency tailings area will also result in loss of vegetation.

Indirect effects on vegetation growth and distribution can occur through changes in soil moisture due to damming and diversion of Rose Creek, North Fork Rose Creek and Vangorda Creek and impounding of water along roadways and infrastructure pads.

Placement and revegetation of covers will increase the area of vegetation and change the diversity of vegetation in the LSA. Permanent positive changes in vegetation cover will result from the placement of substrate covers suitable for plant growth (Table 7.1). Several project areas may not have covers applied, such as talus slopes, haul road surfaces and old borrow pits, but revegetation may be promoted on these surfaces. Development of vegetation communities will be allowed to occur either naturally or facilitated by methods such as seeding, transplanting, addition of soil, fertilizer, or surface amendments. Revegetation strategies for exposed waste rock will be driven by the engineering design requirements for constructed covers. All cover types have been designed to allow natural vegetation succession and are therefore able to support forested plant communities without compromising the structural properties of the covers (Table 7.1). Table 8.11 summarizes the extent of each cover type on each major project component.

Table 8.39: Cover Type Requirements at each Project Site

Cover Type	Faro Waste Rock		Vangorda/Grum Waste Rock		Rose Creek Tailings		Total Area of Covers	
	Surface Area (m^2)	% Total Area	Surface Area (m^2)	% Total Area	Surface Area (m^2)	% Total Area	Surface Area (m^2)	% Total Cover Area
Very Low Infiltration Soil Cover	336768	10%	42331	3%			379099	5%
Low Infiltration Cover	147447	4%	566588	34%			714035	10%
Rudimentary Cover	2980086	86%	1046600	63%			4026686	57%
Tailings Cover					1952000	100%	1952000	28%
Totals	3464301	100%	1655519	100%	1952000	100%	7071820	100%

Reclamation Landscape Units (RLUs)

During the design evaluation and engineering design stage, project areas to be reclaimed were grouped into Reclamation Landscape Units (RLUs) based on requirements for constructed cover performance, site stability, surface water management and site characteristics such as slope and aspect. Constraints to RLU design include; steep slopes, the toxicity of underlying materials, proximity to streams and critical infrastructure, etc. RLUs were designed in consideration of the associated risks, such as landform failure, cover failure, vegetation cover failure, vulnerability to extreme episodic events and climate change. Engineering cover trials (SRK Draft November 2008) and revegetation trials (EDI 2008, 2009) have been initiated and will continue, in order to further the design of covers and suitable reclamation/revegetation procedures.

Each categorized RLU has specific reclamation objectives, reclamation designs, revegetation strategies and target revegetation objectives. RLUs describe and lay out the basic landscape plan for progressive closure, reclamation and revegetation of the Faro Mine Complex. RLUs are presented the Project Description – Draft 4: Appendix A (SRK 2009).

Vegetation plays an important function for erosion control, site stability and for reducing water infiltration through constructed covers (Table 7.1). For very low infiltration covers, vegetation on the covers will be required to capture water entering the soil column and transpire it back to the atmosphere. The targeted performance goal of these covers is to allow passage into the underlying substrates of less than 0.5% of mean annual precipitation. Target infiltration levels for low infiltration covers, tailings covers and rudimentary covers are 5%, 10% and 20% of mean annual precipitation respectively (Table 7.1).

A number of techniques will be used to establish vegetation on covers in the short term (3-5 years after the initiation of reclamation), including use of seed, cuttings, seedlings, fertilizer and surface amendments (EDI 2010). Emphasis will be placed on using native stock where possible. Where commercial seed cultivars of native plant species do not provide sufficient cover within three to five years of the start of revegetation, non-native seed species may be used to colonize reclamation sites.

Long-term revegetation objectives for the project are to develop stable and self-perpetuating vegetation covers on the landscape, consistent with native vegetation communities in the region where possible. Within the general design of RLUs (and as a secondary objective), there is the opportunity to promote landform variability, adapt the reclamation to surrounding geographic and natural vegetation features and incorporate community input into landform/vegetation cover objectives and reclamation species.

Native shrub and tree cuttings and seedlings will be established on many RLUs to increase the species diversity and structural diversity of developing vegetation communities, promote succession and diversify wildlife habitat features.

An adaptive management plan will be in place for continuous monitoring and upgrading of RLUs when necessary.

Assessment Method

The assessment of direct and indirect loss of vegetation is necessarily qualitative since engineering designs that can be overlain on the vegetation association maps of the LSA have not been developed yet for the project.

Changes to vegetation diversity can occur through; creation of early seral reclamation associations, selective loss of vegetation associations linked to project activities such as stream realignment and borrow source development, and losses of rare plants. Vegetation diversity can also be altered by the introduction of non-native plants and invasive non-native plant species. The assessment of changes

to vegetation diversity is also qualitative since spatially specific engineering designs have not been developed yet for the project.

Assessment

Vegetation Loss from Surface Disturbance and Burial

Thirteen vegetation associations, including one reclaimed association, were mapped in the LSA. Three vegetation associations are uncommon, occupying less than 1% of the landscape (see Table 1.6-1 Current Environmental Conditions Supporting Document, AECOM 2009). The graminoid association, occupying 0.6% of the LSA, is a reclaimed area of seeded grass cultivars and low growing forbs on the former site of the freshwater reservoir located SE of the tailings pond along the Faro Mine access road. The area of early seral vegetation communities dominated by reclamation grass cultivars will increase during closure implementation, as the 1,612.7 ha baseline footprint (19.9% of the LSA) is progressively reclaimed and revegetated (see Table 5.1-1 Current Environmental Conditions Supporting Document, AECOM 2009).

The sedge/willow wetland association occupies 0.7% of the LSA. It occurs in both the boreal and subalpine zone in moist to wet depressions or complex glaciofluvial drainage areas where water collects either above or below the ground, due to alluvial and organic deposits, till blankets and colluvium veneers. The mapped patches of sedge/willow wetland in the LSA at some distance form the project footprint, with the exception of one patch upslope of Grum pit. The substrates beneath sedge/willow wetland are not likely to be targeted for borrow material therefore no impacts are predicted to this association with the possible exception of a small area of road construction.

The pine vegetation association occupies 0.6% of the LSA. It is found mostly on upland areas around the Grum and Vangorda pit at the SE end of the LSA in the boreal zone. These areas are identified as being till blankets of gently to moderately sloping plains controlled by bedrock or underlying surficial deposits. This vegetation association is a typical mid-successional forest following fire. Two patches of pine are mapped in the LSA, SW of the Vangorda pit. A portion of the larger patch will likely be directly impacted by resloping of the Vangorda waste rock dump. Indirect effects may also occur from surface water drainage from the covered and reclaimed slopes until vegetation establishes on the reclaimed surfaces. However, pine forests are common beyond the LSA on the lower slopes of Sheep Mountain and on the plateau above the Pelly River (Staniforth 1998).

The white spruce/feather moss association occurs on well-drained mesic sites in lowland areas throughout the boreal zone. It is present in 1.3% of the LSA primarily in a patch directly north of Grum pit. The terrain is a combination of till blankets and veneers over bedrock, as well as colluvium veneers conforming to bedrock. This association will be impacted by construction of headworks above Grum pit, breaching the settling pond and rerouting the existing interceptor ditch.

Changes to Vegetation Diversity

Changes to vegetation diversity can occur through loss of selective vegetation associations from project activities such as stream realignment and borrow sources that target particular ecosystem components. The North Fork of Rose Creek will be realigned from its natural channel into an artificial channel constructed upslope. The willow/white spruce vegetation association occupies 4% of the LSA and is found along creeks in the boreal zone. Permanent impacts to this association are predicted to occur due to changes in surface and near surface water flow in the North Fork Rose Creek drainage.

A variety of borrow materials are required by the Project (Table 8.12). While the majority of till will be sourced from the Vangorda overburden pile to minimize the need for development of new sources of borrow material, there will be some need for additional materials from other sources. Access to these sources will be minimized, and all are located within the FMC complex. Development of borrow sources accounts for 43% (537,967 m2) of the new project surface disturbance. Surface disturbance is estimated 297,106 m2 for developing granular material, 48,453 m2 developing rip-rap and 192,408 developing till deposits (see Table 7.7). Acquiring most of this material will result in loss of natural vegetation associations and permanent changes to the underlying substrates. Most of the potential borrow sites are on lower slopes and valley floors, in less common vegetation associations. In many potential borrow areas, the depths of the source materials are shallow and excavation of till materials will leave a relatively large footprint. Losses of riparian and valley floor vegetation associations are anticipated, particularly on alluvial and glaciofluvial deposits.

Table 8.40: Required Borrow Materials and Target Geological Units

Borrow Material	Target Geological Units
Cohesive Soils	Glacial till deposits
Granular Soils	Alluvial deposits, Glaciofluvial deposits
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

Source Document: Additional Borrow Studies – 2005/06 Task 17a Prepared by: SRK Consulting Project 1CD003.078 Date Submitted: 22 September 2006.

Impacts to rare plant populations can negatively affect diversity if losses of individuals or associated habitat affect population viability. Limited rare plant surveys were conducted in 2008 on areas where waste rock will be re-sloped adjacent to Faro and Grum waste rock piles (*Appendix F, Current Environmental Conditions Supporting Document, AECOM 2009*). All of the survey areas have experienced some human disturbance in the form of unsurfaced roads and trails, scalped areas, piled earth and deposited boulders from the waste rock piles. No rare plant species were observed during the 2008 surveys. Additional pre-disturbance surveys will be required once spatially defined footprints for project activities in undisturbed vegetation can be identified.

Changes to vegetation diversity can also occur through creation of early seral vegetation covers of seeded or transplanted species. Proposed revegetation treatments for RLUs include:

- Agronomic grasses and forbs;
- Annual or short-lived cover crop plus native seed mix;
- Native seed mix;
- Native seed mix plus native shrub staking/seedlings;
- Herbaceous or woody plantings; and
- Natural recovery.

Reclamation seeding will use commercially available cultivars of plant species, primarily grasses. Seed mixes will introduce new species, some of which will persist for many years. Cover crops of non-native grass species that grow rapidly and will not persist (i.e., lasting one to two years) may also be used for site stabilization and erosion control. Natural establishment of colonizing species from the local area will also occur. Opportunities to enhance treatments with plants of interest to local communities are also proposed.

Exposed mineral substrates are sites for establishment of disturbance-adapted exotic weeds. Seed mixes can include quantities of undesirable weedy or invasive species. Vehicles and equipment transported from other areas have the potential to introduce weed species to new locations on tires or cavities in the undercarriage. The likelihood that exotic seed will be introduced to the Project area in trace quantities is high. Natural mitigating factors, including cold temperatures, short growing seasons, nutrient poor substrates and arid conditions will reduce numbers of invasive species that establish and rates of spread.

Conclusions

Vegetation Loss from Surface Disturbance and Burial

Moderate losses of natural vegetation associations in the LSA, including some uncommon associations, will occur due to expansion of the project footprint. However, reclamation and initiation of revegetation strategies on the disturbed, exposed surfaces of the 1,612.7 ha baseline footprint will result in improvement in the cover of vegetation on the footprint and in the LSA over timeframe of the 15 year Closure Implementation Phase.

Changes to Vegetation Diversity

Changes to vegetation diversity due to Project activities will occur through;

- Loss of riparian and valley floor vegetation associations due to project activities such as stream realignment and new borrow source development.

- Creation of large areas of early seral reclamation associations on baseline disturbances and on new surface disturbances, the largest of which will be from new borrow source development.
- Introduction of non-native plants and invasive non-native plant species in seed mixes and through vehicle transfer.

There is potential for project activities to impact rare plant species and their associated habitat, however, surveys have not yet been conducted on all areas of predicted disturbance to native vegetation.

Post-Closure Phases

Impact Statement V2: Maintenance, adaptive management and revegetation of exposed substrates will increase vegetation cover, native plant diversity, and vegetation community structure, resulting in stable and self-sustaining vegetation covers.

Background

Reclamation/revegetation objectives for each RLU during post-closure phases are to:

- Continue to minimize infiltration of water into the covers;
- Continued erosion control;
- Establish sustainable vegetation cover; and
- Establish successional trajectory towards native plant communities consistent with surrounding natural vegetation.

All cover types have been designed to allow natural vegetation succession to forested plant communities without compromising the structural properties of the covers (Table 7.1). Risks to revegetating RLUs over time include landform failure, cover failure, vegetation cover failure, vulnerability to extreme episodic events and climate change.

An intensive adaptive management program is required for the initial post-closure period (Years 15-25). Regular monitoring of reclaiming landscapes will be linked to performance criteria for reclamation / revegetation objectives for each RLU. Performance criteria should include:

- Erosion control (short to long-term):
  gullying thresholds;
  minimum live veg cover threshold;
  minimum live veg plus litter cover threshold; and
  minimum # of live stems per hectare.
- Diversity (resilience):
  Minimum number of species per unit area (e.g., >5 sp/ 100 m2 at >2% cover each);
  evenness in species abundance over the treatment area; and
  e.g., absence of invasive species (category #1 Yukon Invasiveness rank).

- Sustainability:
  e.g., presence of x number of native species;
  presence of x number of long-lived perennial species; and
  presence of reproducing species (fruit/seed production).

Assessment Method

The assessment of impacts on vegetation cover and composition on reclaimed surfaces during the post-closure period is predictive, based on conceptual plans for monitoring, maintenance and adaptive management of the Faro Mine Complex during the initial post-closure period.

Assessment

Early successional plant communities will exist on the reclaimed project areas for many years. There are a number of reasons for this. Climate and soil nutrient conditions in the north result in slow growth rates. Seeded reclamation grass cultivars can persist for many years on a site and can inhibit establishment of other species if sufficiently dense. Introduced plant species are often highly competitive on exposed substrates and do not allow natural re-introduction of native species from surrounding areas. Components of mature vegetation communities, particularly mosses, lichens and coniferous trees, require years to re-establish. It might take decades for reclaimed vegetation communities to recover characteristics similar to natural communities in the area. For RLUs where risks of failure dictate particular surface treatments, succession towards natural plant communities may not be the objective.

However, natural dispersal of seed from the environment surrounding the Faro Mine Complex will continuously add viable locally-adapted seed to reclaimed landscapes. As vegetation cover and diversity increases and construction activities on the site decrease, vulnerability to establishment and spread of invasive species should decline. Over time the diversity, resilience and structure of reclaiming vegetation communities is predicted to increase. Adaptive management will be used to assist revegetation towards self-perpetuating plant communities that do not need inputs of fertilizer or other management.

Conclusions

With the implementation of intensive monitoring and a responsive adaptive management program in the initial post-closure period, vegetation cover stability and density, native plant diversity and community structure are predicted to increase through the initial, mid- and long-term post closure periods.

During the mid-term and long-term post-closure periods, monitoring requirements will likely be much reduced and long term objectives for establishing sustainable vegetation covers and establish successional trajectory towards native plant communities consistent with surrounding natural vegetation will likely be achieved. However, there is less certainty in these predictions as long-term

risks to revegetating RLUs over time such as landform failure, cover failure, vulnerability to extreme episodic events and climate change are unknown.

Closure Implementation and Post-Closure Phases

Impact Statement V3: Plant species rooted on covers overlying toxic materials may uptake metals and assimilate them into their tissues, thereby transferring toxins to the surface environment.

Background

Ore bodies, waste rock and tailings at the Faro Mine Complex are a concentrated source of trace metals, including lead, arsenic, zinc, copper, iron, silver, thallium, barium, mercury, chromium nickel, selenium and a number of others in small concentrations (Gartner Lee 2006).

The design of covers overlying metal-rich mine waste all include a barrier layer of compacted till overlain with a loosely compacted till layer (0.3 to 1 m thick) designed to support plant growth (Table 7.1) The most toxic wastes will have the further addition of a synthetic barrier layer beneath the tills. Tailings covers have a trafficability layer of 0.5 m to 1m waste rock (if required) underlying a loosely compacted till layer 1 to 1.5 m thick.

The primary purpose of the covers is to isolate contaminated mine waste from the surface environment and minimize infiltration of water into underlying mine wastes. They are not specifically designed to prevent roots from reaching mine waste. However, since roots generally follow the water column, the underlying compacted till layer will likely act as a deterrent to deeper rooting if it also reduces water penetration further into the covers. Higher nutrient content in upper soils will also encourage shallower rooting (Stoltz and Greger 2006).

There is evidence from other mine waste covers that plants can penetrate covers of clayey morainal substrates. Taprooted tree species such as pine have the ability to root deeply through both looser and compacted materials (Stoltz and Greger 2006).

Uptake of heavy metals in higher plants (plants with roots, shoots and a vascular system for moving water and nutrients around the plant) can occur from the soil through the root system. Plants vary in their ability to uptake and store metals. Uptake is generally increased in acidic soils and in soils with low organic matter content (Fitter and Hay 2002). The tills intended as a growth medium on the covers are very low in organic matter but are not acidic (sampled at pH 8, EDI 2009). They are variable in their metal content, with some till source samples showing elevated metal levels including zinc, such as at the Grum Overburden Dump (EDI 2009).

The extent of metal accumulation in plant tissues varies between species and between populations within species (Fitter and Hay 2002). It also varies with soil properties, types of plant tissues and tissue age (Simon-Hettich et al. 2001). Metals tend to concentrate in older tissues such as in evergreen leaves of crowberry (Empetrum nigrum) (Salemaa, 2003) and less so in short-lived structures like berries. Many metals concentrate more in root tissues than in above ground

structures. Zinc and copper concentrate slightly more in roots than shoots. The majority of iron is stored in roots and lead absorbed from soils concentrates almost exclusively in root tissues (Fitter and Hay 2002).

The ability of plants to immobilize lead in root tissues and reduce transfer to above ground shoot tissues can also be enhanced by the applications of phosphate, a component of fertilizer (Cao et al. 2003).

Metals in soils can also inhibit plant growth in a number of ways and can affect their ability to colonize and revegetate contaminated soils (Fitter and Hay 2002).

Assessment Method

Assessment of the potential for vegetation species growing on covers to uptake metals from underlying waste into their tissues is qualitative, based on conceptual engineered cover designs and review of literature on metal uptake by plants.

Assessment

Metal uptake by vegetation species growing on covers designed to create a barrier to the underlying metal-rich waste has the potential to affect vegetation growth and survival, transfer buried metals to the surface environment and the potential to transfer metals to other species including birds, mammals and people.

The ability of each species and each structural type (graminoids, forbs, shrubs and trees) to penetrate through the covers and to absorb metals is variable and cannot be quantified without on-site monitoring.

At baseline, very few areas of the abandoned mine site support vegetation and the metal content of this vegetation and its source is unknown. Rudimentary covers over relatively inert mine waste will be used on 57% (4,026,686 m2) of the total cover area and are not of concern for uptake of metals. Of the total area to be covered, those over metal-rich waste include; tailings covers over 28% (1,952,000 m2) of the area, low infiltration covers over 10% (714,035 m2) of the area and very low infiltration covers over 5% (379,099 m2) of the area (Table 8.11).

Placement of covers will provide a much greater surface for growth and some potential for vegetation to uptake metals from beneath the covers to the surface. However, by minimizing infiltration of mean annual precipitation through the barrier layers to less than 5 (3-8)% for low infiltration covers, less than 0.5% for very low infiltration covers and less than 10 (5-20)% for tailings covers (Table 7.1), the availability of moisture to support plant growth below these barriers are not likely to be favourable. The cold climate, short growing season and poor nutrient levels of the till materials may also limit growth through the bottom of the covers.

Conclusions

Although the proposed Covers at Faro have not been engineered to stop metals uptake by vegetation, it is expected that the depth of covers and use of a relatively impenetrable layer over more toxic materials, will greatly reduce the availability of trace metals to vegetation species. Other site conditions including relatively neutral soil pH, cold soils and poor nutrient levels should are limit growth potential through the protective cover layers. Little uptake of metals is anticipated by the suite of vegetation species predicted to establish on the covers. However, any metals brought to the surface environment can be expected to persist and cycle in the terrestrial ecosystem either in living vegetation, dead and decaying vegetation or in the soil. Metals may become less available in time if metals are bound in plant roots.

Regular monitoring of tissues for all trace metals from the diversity of plants growing on the covers will occur to address uncertainties in impact predictions. An adaptive management plan will be implemented if levels of trace metals are approaching or exceed three times background levels.

Regional Study Area

Closure Implementation and Post-Closure Periods

Impact Statement V4: Construction activities, placement of covers and revegetation of exposed substrates will result in changes in the concentrations of TSP and metal-rich dust generated and subsequently deposited on vegetation in the LSA and the RSA.

Background

As a result of past mining activities and the current state of the Faro Mine Complex, elevated metal concentrations occur in vegetation, soils and wildlife near the Faro Mine Complex. A Terrestrial Effects Study completed in 2006 collected data to understand the distribution and movements of elevated elemental concentrations in the terrestrial environment (Gartner Lee Ltd. 2006). A detailed summary of the findings of this study is presented in the Environmental Baseline supporting document.

The information collected in the terrestrial environment shows that past operations at the Faro Mine Complex have resulted in metal concentrations in the mine area that are greater than the reference/background levels. For example, lead concentrations near the mine are up to 450 times those at reference sites and the lead isotope analysis indicates that the majority of the lead deposited in the study area was from mine ores. The concentrations of metals that originated from the mine site are generally higher near the mine and decline with distance from the mine. Deposition of some metals from the mine site is still occurring in the immediate area, mostly during the snow-free period. Metal concentrations greater than the reference/background levels have been detected in plants, small mammals and other wildlife in the area.

Sources of lead deposition in the study area are primarily from ore from the Faro Mine Complex. Although lead from the ore is mixed with non-ore lead in some areas, lead from the ore is

widespread in the study area and often comprises over 90% of that found in both soils and moss bags (which capture aerial dust). Lead from Faro Mine Complex ores also comprises 60% to 90% of the lead found in soils at sampling sites in the Anvil Creek floodplain.

Lead that occurs in floodplain soils is probably largely the result of the tailings dam breach, which occurred in 1975. Moss bag sampling indicated that mine ores are the source of almost 100% of the lead that is currently being deposited in the study area (Gartner Lee Ltd 2006).

The primary means by which metals are currently spread into the terrestrial environment and onto vegetation and soils is by wind transported dust. The Terrestrial Effects Study indicated that mine-generated deposition for a number of elements is ongoing. Lead had the highest amount of deposition and elevated levels are concentrated in the vicinity of the tailings impoundment / mill complex and northwest down the Rose Creek valley.

Elements other than lead which have been deposited historically or currently include arsenic, barium, nickel, aluminum, manganese, silicon, and uranium. Disparities between observed cumulative elemental concentration elevation and current elemental deposition suggest that:

- the contribution of current mine-site elemental dust sources is different than historical contributions, due to different operational and closure conditions; and / or
- the period monitored by moss bag exposure does not reflect the entire range of conditions that have contributed to cumulative elemental elevation in the study area.

Assessment Method

Increased loading of metals into the environment surrounding the Faro Mine Complex has occurred in the past, to unacceptable levels in many areas. For the purposes of this EA, thresholds for assessing impacts to vegetation health are defined as conditions equal to, but not worse than, the existing metal load levels. The threshold represents no net change in the existing conditions, either negative or positive. The assessment of change from this threshold will be qualitative and predictive.

Assessment

During the active closure implementation phase of the Project, large volumes of clean fill material will be moved during resloping of the mine site, development of borrow sources and construction of till covers over mined materials. This activity will produce increased levels of TSP dust relative to baseline levels throughout the 15 year decommissioning phase. This dust is not expected to be metal rich. Progressive reclamation and revegetation will ameliorate this effect but levels of TSP dust will be higher and will be deposited near the mine site and further away in the region. During the post-closure period, levels of TSP are expected to decline substantially as construction activity declines and vegetation and litter accumulate on exposed ground surfaces.

Metal-rich dust currently being generated from exposed toxic materials at the mine site and deposited by wind into the surrounding environment will stop as soon as they are covered by the

engineered covers. The amount of metal-rich dust generated at the mine sites will progressively decline during the closure implementation period as the closure plan is implemented. Residual exposed sources of metal-rich dust that will not be covered are the sediments deposited during the 1975 tailings breach and surface dust already deposited off site, that may be re-suspended by wind. Most other sources associated directly with the mine footprint will be covered, with the exception of the walls of the mine pits. Overall, sources for cumulative additions of metal-rich dust to the ecosystem will be greatly reduced.

Conclusions

Levels of TSP are expected to be higher than at baseline during the closure implementation period and then declining to lower than baseline levels during the post-closure period.

Isolation of metal-rich dust from the ground surface will have an immediate effect on further dispersal but it may take many years to detect changes to load levels in vegetation and soils in the LSA and the RSA.

8.8.6 Mitigation Measures

Mitigation measures are based on regulatory requirements, guidelines, industry best management practices, professional experience and information gathered through community meetings/consultations. Mitigation by design includes features of the Project design that will reduce impacts to the environment, including vegetation. Specific mitigation measures include best management practices and activities to address Project induced effects on vegetation.

Mitigation by Design

The development of RLUs forms the major component of mitigation by design for impacts to vegetation cover. The details for the revegetation treatments for each RLU will be developed using the results of cover trials and revegetation trails established in 2008 continuing in succeeding years (Jacobsen et al. 2008, Omtzigt 2009). Preliminary design criteria for the RLUs are described in Section 7.2.1. Adaptive management throughout the closure implementation and initial post-closure period will be critical to refine successful reclamation and revegetation methods for each RLU.

The closure design's use of engineered covers over toxic materials is the major component of mitigation by design that will reduce impacts to vegetation health.

Table 8.41: Vegetation Mitigation Measures

Project Activity	VEC Affected	Impact Caused	Discipline-Specific Mitigation	Impact Reduced
Construction of the new infrastructure, re-alignment of streams; development of borrow sources	Vegetation cover and diversity	Direct loss of native vegetative abundance and diversity through removal	Minimize footprint as possible and use existing haul road or other non-toxic rock for fill material	Reduce loss of vegetation abundance and diversity and minimize time frame for re-establishment of vegetation cover
Construction of engineered covers; development of borrow sources; operation of roads	Vegetation health	TSP dust generation and deposition on soils and vegetation	Suppress dust on construction areas, infrastructure and roads	Reduce TSP emissions during decommissioning activities
Transport of oxide fines and other toxic waste materials	Vegetation health	Metal-rich dust generation and deposition on soils and vegetation	Suppress dust on construction areas, infrastructure and roads	Reduce metal-rich dust emissions during decommissioning activities
Closure reclamation and revegetation activities	Vegetation cover and diversity	Indirect loss of vegetative diversity through use of non-native reclamation species and potential introduction of exotic invasive plants to the site	Establish a revegetation research program to test local species for suitability Use native seed or non-persistent seed to revegetate exposed erosion-prone soils Test seed mixes for Yukon Class 1 Invasive species	Reduce loss of vegetative diversity
Closure of haul road	Vegetation cover	Potential increase in vegetation cover	Loosen (scarify) road surfaces and the airstrip to more readily allow the establishment of vegetation	Minimize time frame for re-establishment of vegetation cover
Transportation of equipment, vehicles or seed mixes to the Project area	Vegetation diversity	Direct loss of vegetative diversity through potential introduction of exotic invasive plants to the region	Ensure all equipment is cleaned and weed free prior to transportation to the Project to reduce potential for establishment of exotic invasive plants to the region	Reduce loss of vegetative diversity

Integration of Revegetation Initiatives with Local First Nations Stakeholders

Opportunities are being explored by local First Nations communities to produce plant materials of local interest for use on Faro mine reclamation areas. These mitigation opportunities should be integrated into reclamation planning for each RLU. A secondary objective within the general design of RLUs is to promote landform variability, adapt the reclamation to surrounding geographic and natural vegetation features and incorporate community input into vegetation species and landform/vegetation cover objectives.

8.8.7 Residual Effects

Residual effects are those that remain when all mitigation options have been incorporated into Project design, construction, operation and closure. The criteria identified in the Biophysical Impact Assessment Methodology Section were used to rate the residual effects of Project activities on vegetation VECs. The overall rating is a professional judgment based on consideration of magnitude in relation to indicator thresholds, geographic extent, duration, frequency and reversibility of the impacts. The applications of these descriptors for each vegetation VEC, are provided in Table 8.14.

Table 8.42: Vegetation Residual Impact Rating

Impact Statement	Vegetation VEC	Indicator	Project Phase	Residual Impact Rating					
				Direction	Extent	Duration	Frequency	Reversibility	Magnitude
V1	Vegetation Diversity	Natural Vegetation Associations	Closure Implementation	Negative	Local	Permanent	Once	Not reversible	Moderate
		Reclaimed Vegetation Covers	Closure Implementation	Positive	Local	Short to Long-term	Continuous	Reversible	Moderate
		Presence of Non-native Invasive Species	Initial Post-Closure Period and Beyond	Negative	Local	Permanent	Intermittent	Not reversible	Low
		Rare Plant Species	Closure Implementation		Unknown data deficient				
V2	Stable and self-sustaining vegetation covers	Revegetation coverage	Initial Post-Closure Period and Beyond	Positive	Local	Permanent	Continuous	Not reversible	Moderate
		Revegetation species diversity & Structure	Initial Post-Closure Period and Beyond	Positive	Local	Permanent	Continuous	Not reversible	Moderate
		Presence of Non-native Invasive Species	Initial Post-Closure Period and Beyond	Negative	Local	Permanent	Intermittent	Not reversible	Low
V3	Vegetation Health	Uptake of metals by rooted vegetation	Closure Implementation Period and Beyond	Negative	Local	Long-term to Permanent	Long-term to continuous	Not reversible	Negligible to Low
V4	Vegetation Health	Cumulative Deposition of Zinc	Closure Implementation Period and Beyond	Positive	Regional	Permanent	Continuous	Not reversible	Negligible to Low
		Cumulative Deposition of Lead	Closure Implementation Period and Beyond	Positive	Regional	Permanent	Continuous	Not reversible	Negligible to Low
		Annual Deposition of TSP	Closure Implementation	Negative	Regional	Long-term	Intermittent	Reversible	Moderate
		Annual Deposition of TSP	Initial Post-Closure Period and Beyond	Positive	Regional	Permanent	Continuous	Reversible	Moderate

Local Study Area Residual Effects

Impact Statement V1: Borrow source development, stream realignments, infrastructure development, re-sloping of waste rock piles and revegetation of constructed covers will result in losses of native vegetation, creation of new vegetation communities and changes to vegetation diversity in the LSA.

Vegetation Diversity

After the application of mitigation by design and Project-specific mitigation, **negative**, **moderate** magnitude impacts to natural vegetation associations are predicted, particularly for riparian and valley floor associations, from Project activities such as stream realignment and borrow source development. Impacts are assessed as **local** in extent, **permanent** in duration, occurring once during closure implementation.

Progressively developing early seral vegetation covers on substrates that are exposed at baseline and those exposed by Project closure activities will have on balance a **positive**, **moderate** magnitude impact on vegetation cover on a **local** scale in the LSA. The effect will be **continuous**, but **short to long-term** in duration and **reversible**, given the uncertainties of establishing vegetation on mine surfaces and the risks of short-term failures.

Introductions of non-native plants and invasive non-native plant species at **intermittent** intervals during the closure implementation period in seed mixes and through vehicle transfer will have **permanent, negative** impacts of **low** magnitude on vegetation diversity on a **local** scale.

There is potential for project activities to impact rare plant species and their associated habitat, however, surveys have not yet been conducted on all areas of predicted disturbance to native vegetation.

Impact Statement V2: Maintenance, adaptive management and revegetation of exposed substrates will increase vegetation cover, native plant diversity, and vegetation community structure, resulting in stable and self-sustaining vegetation covers.

Stable and self-sustaining vegetation covers on the landscape, consistent with native vegetation communities in the region where possible

The results of ongoing engineering cover trials, reclamation trials and seed trials will inform the design and construction RLUs for the Faro Mine Complex. A great deal will be learned about the best methods to reclaim and revegetate the site during the Closure Implementation Period (years 1-15). With the implementation of intensive monitoring and a responsive adaptive management program in the initial post-closure period (years 16-25), vegetation cover stability and density, native plant diversity and community structure are predicted to incrementally increase. The

establishment of stable and self-sustaining vegetation covers will have a **positive**, **moderate** magnitude effect on a **local** scale. The effects are predicted to be **permanent** and **continuous**.

Further introductions of non-native plants and invasive non-native plant species at **intermittent** intervals are predicted as part of adaptive management during the initial post-closure period. Invasive species introduced in seed mixes and through vehicle transfer will have **permanent**, **negative** impacts of **low** magnitude on vegetation diversity on a **local** scale.

During the mid-term and long-term post-closure periods, monitoring requirements will likely be much reduced and long term objectives for establishing sustainable vegetation covers and establish successional trajectory towards native plant communities consistent with surrounding natural vegetation will likely be achieved. However, there is less certainty in these predictions as long-term risks to revegetating RLUs over time such as landform failure, cover failure, vulnerability to extreme episodic events and climate change are unknown.

Impact Statement V3: Plant species rooted on covers overlying toxic materials may uptake metals and assimilate them into their tissues, thereby transferring them to the surface environment.

Vegetation Health

Uptake of Metals by Rooted Plants

Little uptake of metals from beneath the covers is anticipated by the suite of vegetation species predicted to establish on the covers. The presence of water infiltration barriers within the covers, the ability of plant roots to bind some metals below the surface, relatively neutral soil pH, cold soils and poor nutrient levels of the till materials are predicted to help limit uptake. However, any metals brought to the surface environment can be expected to persist and cycle in the terrestrial ecosystem. Impacts during the closure implementation period and beyond of metal uptake by plants rooted on the metal rich mine wastes are predicted to be **negative, local, long-term to permanent** in duration and **continuous** but of **negligible to low magnitude.**

Regional Study Area Residual Effects

Impact Statement V4: Construction activities, placement of covers and revegetation of exposed substrates will result in changes in the concentrations of TSP and metal-rich dust generated and subsequently deposited on vegetation in the LSA and the RSA.

Vegetation Health

Annual Deposition of Dust (TSP)

During the active closure implementation phase of the Project, large volumes of non-toxic fill material will be moved during resloping of the mine site, development of borrow sources and construction of till covers over mined materials. This activity will produce increased levels of TSP dust relative to baseline levels throughout the 15 year decommissioning phase. Impacts of increasing

TSP dust levels during closure implementation are assessed as **negative** in direction, **regional** in extent, **long-term** in duration, **intermittent** and **reversible** over time. The overall effect of TSP on vegetation during closure is assessed as **negative** and **moderate** in magnitude.

When closure activities are completed and plant material establish on the covers and other exposed substrates, the residual impacts of TSP are expected to be **positive** and **regional**, **permanent** and **continuous** and **moderate** in magnitude. They may be **reversible** if vegetation covers fail over time.

Cumulative Deposition of Metal-rich Dust

Cumulative deposition of zinc, lead and other metals in the form of dust onto soils and vegetation is expected to stabilize after the closure implementation period. Isolation of metal-rich dust from the ground surface will have an immediate effect on further dispersal but it may take many years to detect changes to load levels in vegetation and soils in the LSA and the RSA. Further additions of metals from dust to vegetation and soils will be greatly reduced but since accumulations of these metals are considered permanent in soils, reductions of metal levels in soils in the region beyond the mine site are not predicted. Residual effects of Project activities during closure implementation on future levels of metal-rich dust in the LSA and the RSA, compared to baseline levels, are assessed as **positive, regional** in scale, **non-reversible** and **continuous**, but **negligible to low in** magnitude, given the **permanent** nature of metal contamination in soils. Reductions in metal levels are expected to decrease over the long-term in vegetation as plants die and are replaced. The timing of this reduction will depend on the longevity of the plants and their tissues and whether they absorb metals through their roots or directly through dust on their tissues.

8.8.8 Significance Determination

Impact Statement V1: Borrow source development, stream realignments, infrastructure development, re-sloping of waste rock piles and revegetation of constructed covers will result in losses of native vegetation, creation of new vegetation communities and changes to vegetation diversity in the LSA.

As a result of Project activities, vegetation diversity will shift from areas of mature native vegetation and bare unvegetated mine wastes towards large areas of reclaiming, early seral plant communities dominated by grasses, forbs, and eventually shrubs and young trees. Permanent changes to site conditions will occur on and adjacent to the mine site and introductions of persistent non-native reclamation species are planned. Invasive species introduced in seed mixes and through vehicle transfer will likely have permanent, negative impacts of low magnitude on vegetation diversity on a local scale. There is potential for project activities to impact rare plant species and their associated habitat, however, surveys have not yet been conducted on all areas of predicted disturbance to native vegetation. Mitigation will be developed for any occurrences of rare species found during pre-construction surveys. Overall, changes to vegetation diversity from the Project are predicted to be **not significant.**

Impact Statement V2: Maintenance, adaptive management and revegetation of exposed substrates will increase vegetation cover, native plant diversity, and vegetation community structure, resulting in stable and self-sustaining vegetation covers.

With the implementation of intensive monitoring and a responsive adaptive management program in the initial post-closure period (years 16-25), vegetation cover stability and density, native plant diversity and community structure are predicted to incrementally increase. The establishment of stable and self-sustaining vegetation covers will have a **positive** effect of moderate magnitude that will be **significant** on a local scale.

Impact Statement V3: Plant species rooted on covers overlying toxic materials may uptake metals and assimilate them into their tissues, thereby transferring them to the surface environment.

With the implementation of regular monitoring of plant tissues starting at two years after planting and continuing at 3 year intervals, and a responsive adaptive management program in the initial post-closure period (years 16-25), metal uptake beyond background levels by plants growing on the covers will be identified and managed. The uptake of metals by plants rooted on the covers will have a **negative** effect of negligible to low magnitude that will be **not significant** on a local scale.

Impact Statement V4: Construction activities, placement of covers and revegetation of exposed substrates will result in changes in the concentrations of TSP and metal-rich dust generated and subsequently deposited on vegetation in the LSA and the RSA.

The overall residual impacts of TSP on vegetation are expected to be **positive** and **regional** and not significant.

Residual effects of Project activities on future levels of metal-rich dust in the LSA and the RSA, compared to baseline levels, are assessed as **positive**, but **negligible to low in** magnitude, and **not** a **significant** change from baseline levels.

8.8.9 Monitoring and Follow-up

Monitoring is used to provide information to ensure compliance of government Project approval conditions and to provide environmental management directions to reduce effects during Project phases.

Follow-up assessment is designed to test impact predictions for accuracy. Data is collected and evaluated to determine the extent and nature of actual effects in relation to the prediction of these effects. Follow-up is particularly useful where confidence in impact predictions is low or where effects may be significant. An adaptive management plan (AMP) is a critical component of the FMC closure project and performs the function of follow-up monitoring for vegetation.

Monitoring

Monitoring of vegetation on the FMC closure landscape has three aspects:

- Measurement of metal uptake by plants growing on the engineered covers;
- Routine maintenance and assessment of establishing vegetation; and
- Long-term monitoring of vegetation succession.

Issues identified during monitoring such as vegetation failure or uptake of metals by vegetation on the covers will trigger adaptive management plans (see Section 10) during closure implementation and for the initial post-closure period.

Revegetation Establishment

Annual monitoring surveys to locate and control occurrences of non-native invasive plant species (category #1 Yukon Invasiveness rank) will be conducted during the first three years post-reclamation and as necessary after that.

Regular monitoring of reclaimed landscapes will be linked to short-term (3-5 years post-reclamation) performance criteria for reclamation / revegetation objectives for each RLU. Short-term performance criteria should include measures of:

- Erosion control (short to long-term):
  gullying thresholds;
  minimum live vegetative cover threshold (30% live cover);
  minimum live vegetation plus litter cover threshold; and
  minimum # of live stems per hectare.
- Diversity (resilience):
  minimum number of species per unit area (e.g., >5 sp/ 100 m2 at >2% cover each);
  evenness in species abundance over the treatment area; and
  absence of invasive species (category #1 Yukon Invasiveness rank).

Revegetation Succession

The recent "Environmental Code of Practice for Metal Mines" states that, "monitoring during the mine closure phase is essential to demonstrate compliance with the targeted end land use and to determine whether the use is self-sustaining" (Environment Canada 2009). Long-term performance criteria should include measures of:

- Cover:
  minimum live veg cover threshold (50% live cover); and
  minimum # of live stems per hectare.
- Diversity (resilience):
  minimum number of species per unit area (e.g., >10 sp/ 100 m2 at >2% cover each);

evenness in species abundance over the treatment area; and
e.g., absence of invasive species (category #1 Yukon Invasiveness rank).

- Sustainability:
  e.g., presence of 90% native species;
  presence of 90% long-lived perennial species; and
  evidence of reproducing species (fruit/seed production).

Metal Uptake by Vegetation Species on the Covers

Initial monitoring for trace metals will commence two years after planting and will continue every three years thereafter.

Monitoring will consist of obtaining vegetation samples using standard techniques from a diversity of plant species. Initially, planted species will be targeted, but as the diversity of plants increases on the Covers due to natural in-seeding, additional species will be selected. A minimum of five composite samples from the same plant species will be required from each engineered Cover, revegetation treatment and aspect. Vegetation species to be selected should include samples from grasses, forbs, shrubs and eventually trees. Material from roots, above ground perennial structures, deciduous structures and fruits will be included.

If elevated trace metals are discovered within samples, additional sampling to determine the extent of the issue will be required.

Methods for monitoring metal levels in plants rooted on the covers are further described in the AMP.

Follow-up

Follow-up monitoring for vegetation is described in the AMP. It addresses project activities where confidence in the certainty of the outcome is low to moderate and adaptation to improve project outcomes may be required. Four potential events addressed in the AMP related to vegetation are:

- Short-term establishment of vegetation from revegetation prescriptions (yr 3-5) is insufficient to assure further development of vegetation on the site.
- Long-term establishment of a trend or trajectory towards a diverse, persistent, self-sustaining vegetation cover demonstrating succession towards the surrounding ecosystem.
- Establishment of Yukon Class 1 invasive plant species on reclaiming covers such that revegetation goals are not being met.
- Trace metal uptake by vegetation growing on the engineered covers beyond expected background levels.

8.8.10 Summary and Conclusions

Physical disturbance (new borrow source development, stream realignments, infrastructure development, re-sloping of waste rock piles and habitat changes) during the Faro Mine Complex Closure and Reclamation Project will result in localized, long-term to permanent losses or changes to vegetation.

Given the poor growth medium provided by the rocky substrates and the cold, windy climate of the Faro area, reclamation/revegetation research trials and an intensive adaptive management program will be implemented throughout the closure phase to reduce risks of revegetation failure as well as landform and cover failure.

Sustainable communities of vegetation are expected to re-establish over time on suitable substrates. The age, structure and composition of the resulting vegetation community will be different than pre-disturbance or in surrounding areas for many years or permanently. With the exception of areas seeded to persistent introduced species, the assemblages of plant species are likely to change over time towards those found naturally in the area. Introductions of non-native plants and invasive non-native plant species either accidentally or deliberately during reclamation will have permanent, negative impacts of low magnitude on vegetation diversity in the local area. However, revegetating disturbances at the Faro Mine Complex will have on balance a positive, moderate magnitude impact on vegetation cover on a local scale.

While the proposed covers at Faro have not been engineered to stop metals uptake by vegetation, it is expected that the depth of covers and use of a relatively impermeable layer of clean fill material over more toxic materials, will minimize the availability of trace metals to plant roots. Little uptake of metals is anticipated by the suite of vegetation species predicted to establish on the covers. The uptake of metals by plants rooted on the covers is predicted to be negligible to low in magnitude.

Areas surrounding the mine site, borrow sources and haul road will be affected by increased annual levels of TSP dust deposition during the closure implementation phase. Some dust dispersion will extend beyond the LSA in to the region, however, these impacts will be minimal once the closure activities are completed and vegetation establishes on exposed substrates.

Construction of engineered covers over mine wastes will prevent further increases of metal rich dust loading into the terrestrial environment from these sources. This represents a large positive change in future impacts to the region but given the relatively permanent nature of metals accumulation in soils and vegetation, reductions of current levels in the environment are not predicted for many years.

In summary, implementation of the Faro Mine Complex Closure and Reclamation Project will result in localized, long-term to permanent effects to the ecosystem through changes in vegetation composition and abundance. Positive regional effects to vegetation health and the quality of the substrates that support vegetation will occur. Revegetation progress will be monitored and linked to

performance criteria for reclamation / revegetation objectives. Intensive adaptive management will occur to ensure vegetation cover meets cover design performance requirements and progresses towards stable and self-sustaining vegetation covers on the landscape, consistent with native vegetation communities in the region where possible.

8.9 Wildlife and Wildlife Habitat

8.9.1 Issue Based Approach

As outlined in Section 8.1, an issue based approach was used to identify concerns and issues important to stakeholders in the study area, and how the planned project activities may interact with those concerns and issues, and may be associated with project impacts. Key issues were identified through community meetings and discussions with First Nations (Selkirk First Nation and Ross River Dena Council), the Town of Faro, Government of Yukon biologists, local residents, and scientific opinion of Project scientists.

For wildlife and wildlife habitat, several concerns and issues were identified for a variety of wildlife species centred around the potential impacts of the proposed project activities to species such as Fannin sheep, moose, woodland caribou, grizzly bear, furbearers, migratory birds and small mammals. The concerns and issues were identified in the *Current Environmental Conditions Supporting Document (AECOM 2009)* and are summarized below:

Wildlife Contamination	quality and health of country food sources.
Migratory Birds and Waterfowl	impacts to abundance, distribution and migration of birds.
Species at Risk Impacts	impacts to abundance, distribution and migration of any Species at Risk.
Problem Wildlife Management	mortality risk to grizzly and black bears, wolverine, foxes and wolves.
Fannin Sheep Populations	impacts to abundance, distribution and migration of sheep; as well as mortality risk to sheep.
Woodland Caribou Populations	impacts to abundance, distribution and migration of caribou; as well as mortality risk to caribou.
Moose Populations	impacts to abundance and distribution of moose; as well as mortality risk to moose.
Furbearing Species	impacts to abundance and distribution of furbearing species.
Small Mammals	the impacts to abundance and distribution of small mammals.

The most prominent wildlife concerns identified were related to the Fannin sheep that move through the area seasonally, and the level of contaminants in wildlife, particularly moose. As these concerns and issues were being brought forward, a number of closure options were being developed for the Faro Mine Complex. Based on the concerns and issues, and to guide the review of the closure

options, the Oversight Committee identified a number of closure objectives, some of which relate to wildlife and wildlife habitat:

- Protect and, to the extent practicable, restore the environment including land, air, water, fish and wildlife.
- Return the mine site to an acceptable state of use that reflects pre-mining land use where practicable.

Using the closure objectives and the issues and concerns identified, the following are the wildlife objectives for the remediation of the Faro Mine Complex:

- Reliably prevent mortality to wildlife species due to project activities (e.g., collisions and human/wildlife interactions);
- Reliably prevent changes to habitat use and movements of wildlife species such as Fannin Sheep to and from their traditional habitat use areas;
- Reliably reduce exposure of contaminants to wildlife species; and
- Increase the productivity of affected wildlife habitats from their existing state by reclaiming those areas and developing natural vegetation communities.

These objectives provide direction for mitigating effects to wildlife species during the project implementation phase, including the development of the revegetation objectives and activities that will affect wildlife habitat and wildlife use of the complex.

Valued Ecosystem Components, Indicators and Thresholds

Wildlife and wildlife habitat Valued Ecosystem Components (VECs) were selected that could be affected by Project activities by incorporating information from numerous sources and considering a number of criteria, including:

- the legal status of the species at the Federal and Territorial levels;
- known presence and relative abundance within the study area;
- socio-economic value (hunting, trapping, wildlife viewing, public profile) and regional importance (regional conservation concerns);
- concerns of First Nations, local communities, and regulators;
- the professional judgment of project scientists;
- VECs chosen for previous environmental assessments and current wildlife monitoring programs in the region;
- vulnerability to potential project effects; and
- the role as an indicator species for a specific wildlife group.

The following is a list of VECs considered representative of important wildlife species and the rationale for their selection.

Table 8.43: Rational for Selection of Wildlife VECs

VEC	Rationale for Selection
Fannin sheep	Known to use habitats and move within the LSA, with the potential to interact with project activities; Management concern by First Nations; High socio-economic value for hunting and wildlife viewing.
Furbearers	Species such as wolverine designated as Sensitive by Yukon and Special Concern Federally; Known to use habitats and move within the LSA, with the potential to interact with project activities; Management concern by First Nations; High socio-economic value for trapping.
Grizzly bear	Designated as Special Concern Federally, Known to use habitats and move within the LSA, with the potential to interact with project activities; High socio-economic value for hunting and wildlife viewing.
Migratory birds	Waterfowl and many upland species are migratory and protected under the Migratory Birds Convention Act; Many upland migratory bird species known to use habitats and move within the LSA.
Moose	Known to use habitats and move within the LSA, with the potential to interact with project activities; Management concern by First Nations and Yukon; High socio-economic value for hunting and wildlife viewing.
Small mammals	Known to use habitats and move within the LSA, with the potential to interact with project activities; Management concern by First Nations and Yukon; Potential indicator species for contaminants.
Woodland caribou	Designated as Sensitive by Yukon and Special Concern Federally; Management concern by First Nations; Known to use habitats and move within the LSA, with the potential to interact with project activities; High socio-economic value for hunting and wildlife viewing.

For each VEC; measurable indicators and a baseline case from which to measure change are identified, and thresholds for rating impacts are developed (see Table 8.16). Indicators were chosen to evaluate potential Project effects on each of the VECs selected. Thresholds are measurable parameters of the indicator. For the purposes of this EA, thresholds are defined to be conditions equal to, but not worse than, the existing condition of the chosen indicators. The threshold(s) represents no net change in the existing conditions, either negative or positive.

Table 8.44: Wildlife and Wildlife Habitat VECs, Indicators and Thresholds

VEC	Project Objectives	Indicator	Baseline Case from which to measure change	Threshold
Fannin sheep Furbearers Grizzly bear Migratory birds Moose Small mammals Woodland caribou	Short and long term: Reliably prevent project related mortalities due to project activities (e.g., collisions, nest/den destruction and wildlife/human interactions).	• Number of on-site or project related mortalities	Existing conditions within the Faro Mine Complex LSA	• No increase in mortality from existing conditions
Fannin sheep Furbearers Grizzly bear Migratory birds Moose Small mammals Woodland caribou	Short and long term: Reliably prevent changes to habitat use and movements of wildlife species such as Fannin Sheep to and from their traditional habitat use areas	• Presence or absence of sheep on known use areas • # of sheep crossing events • # hectares of current use habitats within and adjacent to project activities	Existing conditions within the Faro Mine Complex LSA	• No downward trend (> 20% decrease over 3 year running average) in habitat use or # of migratory movements • Less than 20% of currently used habitats classified as disturbed
Fannin sheep Furbearers Grizzly bear Migratory birds Moose Small mammals Woodland caribou	Short and long term: Reliably reduce exposure of contaminants to wildlife species	• Change in trace metal concentrations in wildlife	Existing conditions within the Faro Mine Complex LSA	• No increase in trace metals uptake in wildlife from existing conditions
Fannin sheep Furbearers Grizzly bear Migratory birds Moose Small mammals Woodland caribou	Short and long term: Increase the productivity of affected wildlife habitats from their existing state by reclaiming those areas and developing natural vegetation communities	• # hectares of reclaimed areas showing wildlife use • # hectares of reclaimed area with native vegetation communities	Existing conditions within the Faro Mine Complex LSA	• % of reclaimed areas showing wildlife use increasing by >10%/decade • % of reclaimed area with native vegetation communities increasing by >10%/decade

8.9.2 Impact Assessment

The Project was assessed based on the development of impact statements that were derived from the interaction matrix which identified where Project activities could affect wildlife and wildlife habitat use. These impact statements are tied to the objectives identified for wildlife and provide the basis for assessing effects, identifying mitigation measures and assessing the residual impacts and significance of the impacts.

Within the Project Implementation phase there are a number of Project activities that will affect wildlife and wildlife habitat both positively and negatively. An interaction matrix was developed to identify the Project activities in the various phases of closure that could affect wildlife and wildlife habitat to help focus the impact assessment. Vehicle movements and the noise associated with traffic and machinery pose a risk to wildlife and habitat use through collisions, displacement from habitats or disruption of movements. Increased human presence increases the potential for human/wildlife interactions causing displacement from habitats and wildlife mortality. Vegetation clearing and burial will result in direct loss of wildlife habitats and the clearing activities can affect habitat use in adjacent areas. Revegetation activities during the Project will increase the vegetation cover and the value of wildlife habitat in the area as vegetation communities diversify and natural communities develop. Deposition of dust and metal rich dust will affect vegetation health and can be transferred to wildlife species. Covering the exposed substrates of mine waste will reduce dust contamination of vegetation and wildlife species and will reduce the ability of vegetation to take up these metals.

Local Study Area

As outlined in the Current Environmental Conditions Supporting Document (AECOM 2009), the Local Study Area (LSA) for wildlife species varies by species due to the differences in the area that a species will use. These differences in LSA were considered during the assessment process and are highlighted where appropriate for the various VECs in the following assessments.

Closure Implementation Phase

Impact Statement W1: Project activities will increase road traffic, which will increase the risk of mortality to wildlife species through collisions; machinery use and clearing activities can destroy active nesting or denning sites and the young within them; and, the number of people in the area can cause animals to be destroyed due to human/wildlife interactions.

VEC linkage(s): Fannin sheep, Furbearers, Grizzly bear, Migratory Birds, Moose, Small Mammals, Woodland caribou

The Project Description (SRK 2009, Draft 4) provided estimates for the number of personnel and the number and types of equipment that will be used for the Project from Year 1 to Year 14. Over 60 person years of employment are projected per year between Years 1 and 12, with peak employment

estimated at 115 people. It is expected that workers will travel between the town of Faro and project work sites by pick-up trucks and possibly small buses with the potential for a large number of transits of the site by those vehicles during the Implementation Phase. A conservative estimate of 20 pickup trucks on site traveling between Faro and project worksites and between individual worksites could generate 2,400 round-trips in a month (20 trucks x 4 round-trips/day x 30 days/month) within the Project footprint area. In addition to pick-up trucks, a fleet of up to 20 dump trucks will be used during the project, with over ten trucks being used from Year 1 to Year 10. Estimates of the number of trips these dump trucks could make are difficult due to the complexity of the Project Schedule, but a simple assumption that each dump truck could make at least one trip per hour, generates up to 440 round-trips a month during the peak activity periods in Year 6 (20 dump trucks x 1 trip/hour x 22 hours/day x 30 days/month). Some of these trips are short distances, but others (e.g., moving cover material from Vangorda Overburden dump to Rose Creek and to Faro) are longer distances). Along with the on-site project traffic, lime trucks, fuel trucks and low-bed trucks used to transport equipment will also travel to the Project area, generating a maximum of 600 round-trips/year (Year 2) and over 200 round-trips/year for the first 10 years of the project.

Overall, it is expected that the noise, lights, movements and presence of people and machines associated with the project activities will cause most wildlife species to avoid high use areas, limiting the potential for mortality due to collisions with vehicles. These effects will be localized to the areas of activity, although at times it is possible that significant proportions of the Project area would have activities ongoing. Due to the slow speed of the machines associated with many of the activities (i.e., excavators and bulldozers) it is not expected that collisions with wildlife will occur as the animals will be able to move out of the machine's way. Pickup truck traffic associated with movements of crews and operators, along with movements of dump trucks have a higher likelihood of collisions and mortality due to their higher speed. The limited number of roads and their low speed limits, however, reduce the overall chance that mortality associated with collisions would occur. It is acknowledged however, that climatic conditions such as fog, ice and snow as well as work during the night will increase the potential for collisions.

Project personnel have the potential to interact with wildlife species as they perform activities and potentially enter situations where wildlife may react aggressively or threaten personnel safety. As well, wildlife may become a nuisance to personnel or their activities, by entering buildings or vehicles, damaging equipment or buildings, feeding on food wastes etc. These activities have the potential for wildlife to be seen as problem wildlife and a desire that they be destroyed.

Grizzly bear is the only species for which statistics on mortality due to interactions with humans are maintained. From 1980 to 2001, 22 bears were destroyed within and adjacent to the Project Area for Protection of Life and Property/Problem Bears, with 10 of those bears destroyed in the Vangorda/Grum area between 1990 and 2001.

Assessment Methods

The assessment of effects of increased road traffic and human use on wildlife mortality was qualitative in nature as the ability to predict quantitatively wildlife mortality is not possible with the existing data. A review of the Project Description (Draft 4) (SKR, 2009) provided information on the number of personnel that would be working on the Project, as well as estimates of vehicles and identification of project work areas over time. Assumptions on traffic patterns and anticipated levels of human use were developed qualitatively and compared to known wildlife use areas (e.g., Fannin sheep habitats and movement corridors). As well, a review of the ecosystem mapping provided information on possible high value wildlife habitats (e.g., riparian areas, wetlands, early and mature forests, etc.) and allowed some interpretation of potential nesting, denning and movement areas. In addition, professional experience and available local knowledge was used to help identify potential habitat use areas. Finally, the assessments were conducted assuming that mitigation measures as outlined in Section 8.9.3 would be applied which will lessen the expected effects magnitude.

It is also assumed for this assessment that during the Closure Implementation Period, a year-round No Hunting/No Shooting zone would be imposed upon the Project Area to provide for project workers' safety. This would ensure that wildlife mortality due to hunting would not occur during the Project, reducing the risk of mortality from this source to zero.

Assessment Results

Fannin Sheep

Fannin sheep move through the Vangorda/Grum area in the spring and fall between their seasonal wintering and summering areas. Project activities that will interact with the movements of Fannin sheep and could potentially cause mortality include:

- construction of a new Vangorda Diversion Ditch (Year 1 or earlier);
- moving cover material from Vangorda Overburden dump to Rose Creek (Year 3 to Year 4) and to Faro (Year 6 to Year 9) (assumed as sufficient detail not available in SKR (2009));
- resloping and placing of covers on the Vangorda Dump (Year 10);
- resloping and placing covers on the Grum Dump (Year 10 to Year 12); and
- installing the Grum groundwater collection system (Year 10).

Additional project activities in the Vangorda/Grum areas could also interact with movements of Fannin sheep, but they are more limited in their extent and timing, limiting the interaction. Taking all of the above factors into consideration, the potential for collisions causing mortality to Fannin sheep was assessed as being low due to the sheep likely avoiding traffic areas and the slow speed of the majority of the traffic.

The potential for human interactions with Fannin sheep to cause sheep mortality has been assessed as very low. There was no scenario envisioned where sheep would need to be destroyed due to their danger or perceived danger to people. There is a potential that sheep will forage on revegetated areas, possibly affecting the speed of cover establishment, but means other than destroying the sheep would be used to limit the effects of their foraging on reclaimed vegetation covers.

Furbearers

Furbearers are widespread within the LSA and many species such as marten, ermine, fox, squirrel, lynx, wolverine and wolf have been noted in close proximity or are expected to be found within Project activity areas over the life of the project. Due to the extent of the activities and this overlap of habitat use, it is expected that mortalities due to collisions with vehicles will occur during the project life. Species such as squirrel, ermine, fox and marten are most likely to be involved in collisions due to their higher population density and higher likelihood to be found near project activities. Species such as lynx, wolf and wolverine are more secretive, have lower densities and tend to avoid human use areas more, so are much less likely to suffer mortality due to collisions with vehicles. Other furbearer species such as muskrat, mink and beaver are more closely associated with riparian habitats near streams and have some potential to suffer mortality due to collisions, but the limited number of crossings and limited activities in riparian habitats limits the risk to these species. Overall risk of mortality to furbearers due to vehicle collisions was assessed as low to moderate magnitude, with species such as lynx, wolf, wolverine, muskrat, beaver and mink rated low and marten, squirrel, ermine and fox rated as moderate.

There is also some mortality risk to furbearers as vegetation clearing and cover placement activities occur as the activities may affect dens or sites where the furbearer individual is unable to move out of the way. These effects may be avoided where den sites (e.g., beaver lodges) are obvious and can be avoided, but where dens are more cryptic (e.g., inside hollow trees), identification of sites is more difficult and they may be missed. This mortality risk is more likely for species such as marten, squirrel, ermine, fox and muskrat, but was assessed as low magnitude.

Mortality risk to furbearers due to interactions with humans was assessed as low for all species. Marten and beaver have the highest potential for being trapped and removed if they become a nuisance in camps or buildings as in the case of marten or if riparian revegetation or roads are compromised due to activities of beaver. Although wolves may be targeted for persecution, it is not expected that a real threat to humans would occur in the context of the Project that would require their removal.

Grizzly bear

Grizzly bears are found in the Project area and it is expected that they will interact with all Project activities including traffic as they move across the area and forage in habitats within and adjacent to the Project area. Although the actual number of grizzly bears that would be found in the Project area is unknown, it is not expected to be high. Areas of highest risk for grizzly bear mortality due to

collisions will be where high traffic areas coincide with high use habitats or are adjacent to high value habitats that bears may be travelling to and from. Additional interactions could occur in revegetated areas adjacent to roads if highly palatable species (e.g., red clover, horsetails, fireweed) are used in seed mixes or become established naturally. Due to the difficulty in determining the timing and traffic levels adjacent to high value habitats at this time, the risk of mortality to grizzly bears from collisions was rated as low to moderate.

Grizzly bear den sites have not been identified within the Faro complex area and based on available information, it is not expected that they would be found in those areas. The risk of mortality due to Project activities removing an occupied den site was assessed as nil.

Due to the high number of grizzly bear mortalities in the Project area from 1980 to 2001, for Protection of Life and Property/Problem Bears when previous mining activities were ongoing there is a moderate to high risk of mortality to grizzly bear during the Closure Implementation period. It is unknown what measures were in place during the 1980 to 2001 period to attempt to mitigate the risk of mortality, but it is important that effective measures be used to reduce this risk during the Project.

Migratory Birds

Migratory birds such as warblers, flycatchers, sparrows etc. are found breeding within the Project area and are expected to move through the area during spring and fall migration. During migration and the breeding season, birds have a potential to collide with vehicles causing mortality. Vegetation clearing activities also have the potential for causing mortalities of eggs and nestlings when activities are carried out during the nesting season (i.e., May to August). These mortality risks were assessed to be a low magnitude as the number of mortalities was considered to be limited.

Although some interactions between humans and migratory birds was considered possible (e.g., birds defending nest sites) the risk of mortality due to wildlife/human interactions was assessed to be nil.

Moose

Moose are expected to be found within the Project area year-round, at variable densities, depending on the habitat and time of year. High value habitats that contain forage species such as willow are usually associated with riparian habitats, although upland habitats can also be valuable. The potential for collisions causing mortality increases where high value habitats are adjacent high traffic areas. Due to the difficulty in determining the timing and traffic levels adjacent to high value habitats at this time, the risk of mortality to moose from collisions was rated as moderate.

The potential for human interactions with moose that would cause moose mortality has been assessed as very low. There was no scenario envisioned where moose would need to be destroyed due to their danger or perceived danger to people. As with sheep, there is a potential that moose will forage on revegetated areas, possibly affecting the speed of cover establishment, but it is not expected that moose would be destroyed to limit the effects of their foraging on reclaimed vegetation covers.

Small Mammals

Small mammals are found throughout the Project area and there is a high likelihood that there will be mortalities due to vehicle collisions. The magnitude of this mortality risk was assessed to be low however, as the number of small mammals involved was considered to be small in comparison to the population in the area. Vegetation clearing and cover placement activities were also assessed to have a potential for causing mortality, due to crushing of den sites and associated young or overwintering adults. This mortality risk was assessed as low to moderate magnitude, as some areas such as the Rose Creek tailings areas are relatively large and the mortality could potentially affect local population dynamics.

Although some interactions between humans and small mammals was considered possible (e.g., trapping of nuisance voles in buildings) the risk of mortality due to wildlife/human interactions was assessed to be low.

Woodland caribou

Caribou have not been noted in high concentrations within the Project area and it is expected that the potential for interactions between caribou and Project activities is limited. The risk of mortality to caribou due to vehicle collisions or interactions with humans was therefore assessed to be low.

Discussion and Conclusions

The mortality risk from vehicle collisions was assessed to be low for Fannin sheep, some furbearers (i.e., lynx, wolf, wolverine, muskrat, beaver and mink), migratory birds, small mammals and woodland caribou; low to moderate for grizzly bear; and moderate for some furbearers (i.e., marten, squirrel, ermine and fox) and moose. The mortality risk due to destroying nests or den sites was rated as very low for grizzly bear and low for furbearers, migratory birds and small mammals. The mortality risk from human/wildlife interactions that may require wildlife to be destroyed was rated as low for Fannin sheep, furbearers, migratory birds, moose, small mammals and caribou; it was rated moderate to high for grizzly bear.

Mitigation measures developed as mitigation by design and mitigation for project specific activities or specific wildlife species are expected to reduce the risk of mortality to wildlife. These mitigation measures are outlined in Section 8.9.3.

The uncertainties in the assessment of mortality risk were in the determination of the timing, volume and spatial extent of traffic within the Project area. Although the Project Description outlines the number of vehicles that will be used and the phases and tasks in which they will be used, it is not possible to accurately predict where traffic will occur, the number of trips or timing of that traffic.

Impact Statement W2: Local movements, migration movements (e.g., Fannin sheep) and habitats available for use by wildlife species will be affected by: Project activities that would create noise,

lights, and traffic; increased people on site; and changes to vegetation patterns due to vegetation removal and revegetation activities.

VEC linkage(s): Fannin sheep, Furbearers, Grizzly bear, Migratory birds, Moose, Small mammals, Woodland caribou

Project activities will be diverse, and the machinery that will be used will generate noise, dust, and lights. People using the machines and conducting vegetation removal and revegetation activities will be present at various locations and times within the Project area. Wildlife species will be moving across the Project area, both to access and use habitats within the Project area as well as crossing the Project area to access habitats outside the Project area. The interaction of the Project activities and wildlife use and movements has the potential to affect wildlife to varying degrees. These effects can include causing wildlife to avoid movement routes, increase energy requirements as they avoid Project activities, reduce forage habitats and opportunities, and reduce nesting or denning habitats and opportunities.

Assessment Method

The assessment of effects of Project activities on habitat use and movements was qualitative due the difficulty in completing a quantitative interaction between wildlife habitat use and Project activity timing and extent. A review of the Project Description (Draft 4) (SKR, 2009) provided information on project work activities and areas over during the Closure Implementation Period. Assumptions on traffic patterns and anticipated levels of use were developed qualitatively and compared to known habitat use areas. An analysis of potential noise from machinery, traffic and other activities (Senes 2009) was reviewed to determine the area affected by the proposed activity levels. As well, a review of the ecosystem mapping provided information on possible high value wildlife habitats (e.g., riparian areas, wetlands, early and mature forests, etc.) and allowed some interpretation of potential nesting, denning and movement areas. Professional experience and available local knowledge was also used to help identify potential habitat use areas. Finally, the assessments were conducted using the assumption that mitigation measures as outlined in Section 8.9.3 had not been applied which will lessen the expected effects magnitude.

Assessment Results

Fannin sheep

Fannin sheep will move through the Vangorda/Grum area in the spring and fall and will interact with Project activities from Year 2 to 4, and from Year 6 to 12 (see assessment under Impact Statement W1 for details). The noise and traffic associated with Project activities will affect sheep use of the movement corridor, avoiding machines and using alternate routes around the active areas. Delays in movements may occur, as well as the potential for increased energy expenditures as they avoid affected areas. The Noise Assessment (Senes, 2009) indicates that the sheep habitats on Sheep Mountain and Mount Mye lie outside of the 35 dBA contour, which is the point at which Project

activity noise is expected to fall below background ambient noise. The overall effects to sheep habitat use from the Project activities was assessed to be low to moderate, with higher effects likely occurring during the spring period, when sheep have lower fat reserves and the increased energy expenditures needed to avoid activities could affect them more.

Furbearers

Due to the variety of habitats that furbearers use and the extent of the Project area activities it is expected that some effects to furbearer habitat use will occur over the Implementation Phase. Habitat use by species such as marten, fox and squirrel, which are likely to have the highest densities within and adjacent to the LSA, will be affected more than secretive and low density species such as lynx, wolverine and wolf. Habitat use by muskrat, mink and beaver is also less likely to be affected by Project activities due to the relatively limited amount of riparian habitat within the LSA. Activities along the Haul Road between the Faro and Vangorda/Grum sites such as hauling of borrow/cover materials will generate a large number of vehicle trips at times, which has the potential to disrupt furbearer movements across the haul road, temporarily fragmenting habitats for some species. Effects to furbearer habitat use were assessed to be low overall, however, as the Project activities would not occur over the entire Project area simultaneously and would allow some populations to use habitats without disturbance.

Grizzly bear

Habitat use by grizzly bear is strongly associated with vegetation availability, and in general, lower elevation riparian habitats are used in the spring and mid to upper elevation habitats rich in berries, marmots and ground squirrels used in the summer and fall periods. Project activities that occur during the spring near riparian habitats in Rose Creek Tailings area (Years 3 to 6 and Year 11) and below the Haul Road (Years 3 to 4 and Years 6 to 9) will affect habitat use. The linear nature of the Project area and its orientation between high value riparian habitats along the Pelly River and higher elevation habitats (e.g., Mt. Mye) will affect movements of bears to and from these habitats due to traffic and the noise of Project activities. Only a small number of bears are likely to be found in the Project area at any one time, and the grizzly bear LSA (Game Management subzones [GMS] 4-44 to 4-47, 4-42 and 4-51) is large in comparison to the Project footprint. Due to these factors, the affect to grizzly bear habitat use was assessed to be low.

Migratory Birds

Habitat use by migratory birds will be most affected by the noise of Project activities that take place in the spring and summer during the breeding season. There will be some disturbance as well to foraging habitats from the spring to fall due to vehicles and personnel moving within and adjacent to those habitats. Overall, however, the effects to migratory bird habitat use were rated as low as the area affected were considered to be relatively limited compared to the available habitats within the LSA.

Moose

Noise, vehicle and personnel activities occurring within and adjacent to riparian habitats used by moose within the Rose Creek Tailings area (Years 3 to 6 and Year 11) and below the Haul Road (Years 3 to 4 and Years 6 to 9) are expected to affect moose habitat use. Movements from upland habitats to the extensive riparian habitats along the Pelly River may also be affected by traffic and noise within the Project area. Baseline information indicates a high moose density within the LSA identified for moose (GMS 4-42 to 4-47 and 4-51). Moose is a management concern due to harvesting issues, not habitat use concerns. Overall, the Project was assessed to have a low effect on moose habitat use due to the small proportion of available habitats affected and that the majority of the high value habitat is located outside of the Project footprint in the wetland and riparian habitats adjacent to the Pelly River.

Small Mammals

A wide range of small mammal species have been documented within the Project LSA and use of a variety of habitats has been found, including habitats within the disturbed Project footprint. Project activities such as vegetation clearing, rock dump movements, cover placements, building demolition and revegetation activities will affect small mammal habitats. Vehicle and personnel activities will also affect movements of small mammals between habitats. It is not expected that noise or other disturbance effects will have a great effect on habitat use for small mammals outside of the actual activity area.

Project activities could have a large effect on habitat use by local populations of small mammals due to the small home ranges of these species, these activities will only affect a portion of the Project area at any one time, reducing the overall effect to the small mammal population in the LSA. The effect to overall small mammal habitat use therefore was rated as low.

Woodland caribou

Although woodland caribou have been noted in the vicinity of the Project area, the Tay River herd is primarily located to the east and north of the Project area and ecosystem mapping does not identify large extents of potential high value forage habitats. Project activities will disturb any caribou that are in the area, moving them from foraging habitats due to noise, lights and movements by machines and personnel. The overall effect however to woodland caribou habitat use was rated as low magnitude however due to the small number and extents of the expected interactions.

Discussion and Conclusions

The effects of the Project activities on wildlife habitat use was assessed to be low to moderate for Fannin sheep, and rated low for all other wildlife species. There is some uncertainty that the effects on Fannin sheep habitat use would be moderate, however, as the details regarding the Project activities that would occur during their movements is difficult to determine. Effects could be low if

Project activities do not occur at high levels during the spring and/or fall or if they occur outside of the movement routes.

Mitigation measures developed as mitigation by design and mitigation for project specific activities or specific wildlife species are expected to reduce the effects of project activities on wildlife habitat use. These mitigation measures are outlined in Section 8.9.3.

Closure Implementation and Post-Closure Periods

Impact Statement W3: The increase in natural vegetation communities on the vegetated covers will increase available wildlife habitat for use by wildlife over time.

VEC linkage(s): Fannin sheep, Furbearers, Grizzly bear, Migratory birds, Moose, Small mammals, Woodland caribou.

As outlined in the Vegetation section (see Section 8.8), Reclamation Landscape Units (RLUs) have been developed for the reclaimed areas in the Project area with objectives to:

- Continue to minimize infiltration of water into the covers;
- Continued erosion control;
- Establish sustainable vegetation cover; and
- Establish successional trajectory towards native plant communities consistent with surrounding natural vegetation.

During the development of the RLUs, the objective of utilizing available native species where possible was incorporated into the Revegetation planning. Native shrub and tree cuttings and seedlings are being propagated for use through field trials (EDI 2008) and it is expected that they will be established on RLUs. Long-term goals for revegetation of project areas are to promote vegetation succession, and minimize long term maintenance. An adaptive management plan will be in place for continuous monitoring and maintenance of RLUs when necessary.

Assessment Method

The assessment of the increase in natural vegetation communities on the vegetated covers during the Closure Implementation and Post-Closure periods was qualitative and predictive, based on the conceptual plans for the establishment of the RLUs and the associated monitoring and adaptive management plans of the Faro Mine Complex. It was assumed that the proposed use of native plant species along with the natural infill of native plants and successional processes will cause the revegetated covers to move toward natural vegetation communities over time. Finally, the assessments were conducted using the assumption that mitigation measures as outlined in Section 8.9.3 had not been applied which will lessen the expected effects magnitude.

Assessment Results

Fannin Sheep

Movement corridor habitats for Fannin sheep within the Vangorda/Grum complex will be revegetated primarily to native grass seed and native woody species mixes, which are expected over time to create natural vegetation communities. This change from the current unvegetated state to natural communities is expected to be a positive low magnitude change for Fannin sheep. Other habitats used by Fannin sheep are outside of the RLUs and are not expected to be affected by the revegetation activities.

Furbearers

The LSA designated for furbearers will be affected by the proposed increase in natural vegetation communities in a positive way as there will be a large increase from currently unvegetated to vegetated habitats. It is predicted that the increase in natural grass and woody species will increase furbearer prey species such as voles and small birds, which will provide foraging opportunities. As shrub and tree species grow and diversify, overhead cover will increase, providing for security from avian predators and allow the habitats to be used more effectively by furbearers such as marten.

Grizzly Bear

There is predicted to be a large increase in available spring and summer foraging habitat for grizzly bears due to the increase in available grasses used on the RLUs compared to the current unvegetated state. Areas such as the Rose Creek Tailings Area could see an increase in use as the extensive areas of grass covers become established and native species such as sedges become established. The overall effect however is likely to be a low magnitude positive effect as the revegetation area is limited in comparison to the overall area used by grizzly bears.

Migratory Birds

Migratory bird species that use grassland and shrubland habitats such as sparrows are expected to gain the most benefit from the increase in natural communities during the Closure Implementation and Initial Post-Closure periods. As tree species become more established in the Mid- to Long-Term Post Closure periods, tree-nesting/feeding species such as warblers and fly-catchers would be expected to increase use of the area. The overall impact of the increase in natural vegetation communities is predicted to be a positive effect of low to moderate magnitude.

Moose

It is expected that the effects of the increase in natural vegetation communities for moose will be positive as vegetation species such as willow and balsam poplar, which are important forage species for moose, will be used in riparian RLUs as well as in upland sites. The magnitude of the positive effect will be dependent on the success and extent of the revegetation efforts, but is predicted to be a

low positive effect due primarily to the small area affected within the much larger area used by moose.

Small Mammals

The increase in native vegetation communities, especially the increase in the extent of grassland and shrubland habitats is expected to positively affect small mammals during the Closure Implementation and Post-Closures periods. Species such as voles will benefit from the increase in available forage habitats and could significantly increase in population size if they are able to establish denning sites in the RLUs. Overall a low to moderate positive effect for small mammals is expected due to the increase in native vegetation communities.

Woodland Caribou

The increase in natural grassland and shrubland habitats has the potential to positively affect caribou use of the RLUs during the spring when caribou are more likely to forage in these habitats. The limited extent of the RLUs within areas used by the Tay caribou herd, however, limit the overall positive benefits.

Discussion and Conclusions

The effects of the increase in native vegetation communities was assessed to be a positive effect of low magnitude for sheep, grizzly bear, moose and caribou as the area affected is small compared to available habitats, or there is limited revegetation occurring within habitats used by the species. For species such as furbearers, migratory birds and small mammals, the effects were also predicted to be positive, having a low to moderate magnitude as the proportion of habitat affected is more of their available habitat area.

Mitigation measures developed as mitigation by design and mitigation for project specific activities or specific wildlife species are expected to increase the positive effects of providing native vegetation communities and wildlife habitat. These mitigation measures are outlined in Section 8.9.3.

Impact Statement W4: Project activities will increase dust dispersion and the potential for metals contamination through dusting of vegetation used by wildlife during the Closure Implementation phase, but covers placed on exposed soils will decrease dust and the movements of contaminants into the environment in the Post-Closure periods.

VEC linkage(s): Fannin sheep, Furbearers, Grizzly bear, Migratory birds, Moose, Small mammals, Woodland caribou

Studies of metals contamination have been completed for the Faro Mine Complex area and are presented in GLL (2006) and Gamberg (2008), with a summary of the findings outlined in the *Current Environmental Conditions Supporting Document (AECOM 2009).* Metals contamination

from lead ore and other metals (e.g., arsenic, barium, copper, iron, thallium, nickel, mercury, selenium and zinc) has been found in small mammals, and hunted and trapped animals. The primary method of contamination is by wind transported dust that deposits on vegetation directly or is absorbed through the roots and incorporated into the vegetation. Contamination of wildlife occurs directly through eating the vegetation (e.g., moose, bears, small mammals) or indirectly by eating prey species (e.g., small mammal, birds) that are eaten by wildlife predators (e.g., marten, lynx). The extent of windborne contamination is quite large (see Figure 4.15), which is why a large LSA was chosen for the metals contamination VEC encompassing GMS 4-42 to 4-46. Contamination by wind is ongoing as evidenced by moss-bag studies, with the majority of the contamination occurring during the snow-free periods.

The establishment of covers on the tailings and other waste rock areas is primarily to stop water infiltration and the transportation of metals into the aquatic environment, but will also stop windblown dust contamination. As materials are moved and covers are placed during the Closure Implementation period, however the potential for increased dust dispersion has been identified as having a potential to affect wildlife.

Assessment Method

For the assessment of this effect, the current state of contamination was considered the baseline and effects that caused the metal levels to increase were considered negative, while those that caused the metal levels to decrease were considered positive. The assessment of metals contamination was a qualitative and predictive assessment based on a review of the available information on existing contamination of soils, vegetation and wildlife species outlined in SD B1, GLL (2006) and Gamberg (2008). A review of the Project Description, Draft 4 (SD A1, SKR, 2009) was conducted to determine extent of Project activities that would potentially cause dust. Finally, the assessments were conducted using the assumption that mitigation measures as outlined in Section 8.9.3 had not been applied which will lessen the expected effects magnitude.

Assessment Results

Fannin Sheep

During Years 3 to 6 of the Closure Implementation phase, Project activities related to movement of waste rock dumps in the Vangorda/Grum area have the potential to increase dust dispersion within the sheep movement areas. Windborne dust from these activities may be deposited within foraging areas in the Mount Mye and Sheep Mountain areas. The amount of metals contaminated dust is expected to be limited though, due to the low metals contamination of the waste rock dumps. Once covers are placed within the Vangorda/Grum areas in Years 10 to 12, the potential for dust dispersion will decrease significantly. During the Post-Closure period, uptake of metals in vegetation is expected to be greatly reduced as no new inputs of metals will be available and the depth of covers and impenetrable layer will prevent the uptake of metals through the soil.

Furbearers

Project activities related to the movement, resloping and covering of waste rock dumps in the Faro and Vangorda/Grum areas as well as the covering of the Rose Creek Tailings area will generate dust that is likely contaminated by metals. Due to the close association of the furbearer LSA with these Project areas, there is a potential for increased trace metals contamination of furbearers through direct ingestion of vegetation (e.g., beaver, squirrels) and indirectly through prey species (e.g., small mammals) by marten and others. The placement of covers on the Tailings area (Years 3 to 6), Faro (Years 7 to 9) and Vangorda/Grum (Years 10 to 12) will greatly reduce the potential for windborne contamination once completed. It is expected that metals in vegetation will be reduced during the Post-Closure period as no new inputs of metals to vegetation occurs.

Grizzly Bear

The large size of the grizzly bear LSA in comparison to the Project area and the mobile nature of grizzly bears is expected to limit the exposure of bears to vegetation that may be contaminated by metals due to Project activities. It is unknown at this time the extent of trace metals in bear tissues as no samples were obtained during the previous studies. Any contamination that is occurring, however, will be greatly reduced once covers are in place on the Rose Creek Tailings and the Faro and Vangorda/Grum waste rock areas. Metals in vegetation are expected to reduce during the Post-Closure periods as no new inputs of metals through airborne dust occur.

Migratory Birds

No tissue samples for migratory birds were available for the contamination studies, although many species forage on berries that were shown to have elevated metals levels and there are other pathways (e.g., seeds, insects that eat vegetation) that could cause elevated metals levels in migratory birds. It was assumed that Project activities related to the resloping, movement and covering of waste rock and tailings will produce dust that may have metals contamination and that migratory birds would be affected. The limited time-frame that migratory birds are within the Project area however may limit the potential effects. Once covers are in place over the tailings and waste rock dumps, the potential for contamination is greatly reduced for migratory birds and it is expected that conditions will improve during the Post-Closure period and be reduced from the current conditions.

Moose

Moose are a mobile species with large home ranges that utilize the Project area for foraging and have been shown in the contaminants study to have elevated levels of selenium, cadmium and silver, but not lead in comparison to the Yukon average. Project activities that produce dust may affect vegetation used by moose, but the effects may be limited by the amount of foraging available within the Project area in comparison to the larger moose LSA. As outlined previously, the establishments of covers on the tailings and waste rock dumps will greatly reduce the potential for dusting of

vegetation and metals contamination and will reduce the availability of contaminants in vegetation during the Post-Closure period.

Small Mammals

The Project activities associated with movement, resloping and covering of waste rock dumps and covering the tailing areas will generate dust that may contain metals that would affect small mammals within the Project area. Small mammals currently have elevated metals in their tissues and it is expected that they will continue to be affected until covers have been established upon areas that can produce contaminated dust. Levels of vegetation contamination by metals is expected to reduce during the Post-Closure period.

Woodland Caribou

Caribou are another wide-ranging species that do not appear to use the Faro Mine Complex area extensively, but do occur to the north and east of the Project area, within areas that metals contamination of lichen has been documented. As lichen are a major food source of caribou, the creation of dust during Project activities will increase the potential for elevated metals within the caribou LSA (GMS 4-41 to 4-47 and 4-51). The establishment of covers on the tailings and waste rock dumps will stop additional inputs of metals to the LSA, but as lichen does not shed their leaves they are capable of accumulating and maintaining metals for long periods of time. It is likely that metal levels in lichens will remain elevated during the Post-Closure period. The time required for metal levels to reduce from the baseline condition is unknown at this time, but a gradual reduction over time may occur as metals are no longer available to wildlife (see Walter et. al. 1990).

Discussion and Conclusions

Project activities during the Closure Implementation period related to movement and resloping of waste rock dumps and the covering of the Rose Creek tailings area have the potential to produce contaminated dust that would affect vegetation and the wildlife feeding on it. Covers established on areas will reduce the availability of contaminated dust and are expected to reduce metals in vegetation and wildlife during the Post-Closure period.

Mitigation measures developed as mitigation by design and mitigation for project specific activities or specific wildlife species are expected to reduce the risk of metals contamination of wildlife. These mitigation measures are outlined in Section 8.9.3.

Regional Study Area

Closure Implementation and Post-Closure Periods

No further assessment was completed for the RSA due to use of large LSAs for species that are wide ranging and for the contaminants study (see Section 4.8.2).

8.9.3 Mitigation Measures

Mitigation measures for protection of wildlife and wildlife habitat were developed using information from a variety of sources and are based on regulatory requirements, best management practices, guidelines, professional experience and local knowledge. Mitigation by design was considered early in the Project and provided to Project engineers so that Project activities and methods would reduce impacts to wildlife and wildlife habitat. Mitigation measures specific to wildlife and wildlife habitat were also developed early in the Project planning stages to provide managers and operational staff with methods to decrease impacts to wildlife and their habitats.

Mitigation by Design

To reduce potential wildlife mortality or injury due to traffic, wildlife/human interactions, or hunting a number of mitigation by design features were developed. To protect wildlife and personnel working in the Faro Mine Complex area, a request to establish a No Hunting area during the Closure Implementation period would be made for GMS 4-44 to 4-46 in addition to the current No Hunting area in GMS 4-51. To reduce injuries and mortalities to wildlife from vehicles, low speed limits (e.g., 40 km/hr) would be implemented on roads within the Vangorda/Grum complex and other areas when wildlife are on or near the road. Wildlife Management and Waste Management Plans would be developed and implemented to ensure that Project personnel are aware of the dangers involved in approaching or feeding wildlife as well as ensuring that all food wastes are disposed of correctly (e.g., incinerated). Finally, to reduce mortalities and injuries to wildlife from falls into steep-sided pits (e.g., Faro, Vangorda and Grum pits-) or getting trapped in pits or other structures, berms and/or other barriers to wildlife movements/access will be established in those sites that are identified as dangerous to wildlife.

Several mitigation by design features were incorporated into the Project to reduce effects on wildlife habitats and wildlife use of habitats. These included restricting Project activities to the smallest footprint possible and minimizing disturbance to and removal of currently undisturbed habitats. Minimizing disturbance to riparian areas which are high value habitats for a variety of species was also a mitigation by design feature. The development of the covers and RLU objectives for use of native vegetation was a major mitigation by design feature to reduce impacts and provide eventual improvements to wildlife habitats. The RLUs and vegetation covers will also reduce the availability of airborne contaminated dust to be transported to vegetation and wildlife.

Mitigation of Project Effects on Wildlife

A variety of mitigation measures have also been proposed for specific Project activities that may affect wildlife, wildlife habitats or wildlife use of habitat. These mitigation measures are outlined below in Table 8.17.

Table 8.45: Project Mitigation Measures Related to Wildlife

Impact Statement	VEC Affected	Project Activity	Impact Caused	Discipline-Specific Mitigation	Impact Reduced
W1	All	Traffic related to personnel movements and materials hauling	Increased wildlife mortality/injury due to vehicle collisions	Reduce traffic speeds when wildlife on roads and in identified areas (e.g., Vangorda/Grum) Monitor wildlife use of roads and advise personnel through signs/radio of active areas Ensure snow plowing provides openings and/or low banks to allow wildlife to leave roads	Reduce wildlife mortality/injury due to vehicle collisions
	Migratory birds	Vegetation clearing for new borrows or cover placements	Direct loss of wildlife habitat	Conduct surveys for nesting birds prior to vegetation removal during the breeding season or conduct vegetation removal activities outside of the breeding season	Reduce nest destruction during breeding season
	Furbearers Grizzly bears	Increased personnel on-site conducting Project activities	Increased wildlife mortality due to human/wildlife interactions	Provide wildlife awareness training; establish a Wildlife Response Team trained for deterring wildlife Report and monitor wildlife encounters and outcomes	Reduce wildlife mortality due to human/wildlife interactions
W2	All	Vegetation clearing for new borrows or cover placements	Direct loss of wildlife habitat	Identify and avoid sensitive and important wildlife habitats Conduct surveys for nesting birds prior to vegetation removal during the breeding season or conduct vegetation removal activities outside of the breeding season	Reduce direct loss of wildlife habitat
		Project activities that produce noise, lights, traffic, personnel, etc.	Indirect loss of wildlife habitat through disturbance (e.g., noise, etc.) limiting habitat use	Identify sensitive and important wildlife habitats and avoid activities near them Maintain vegetation as visual/acoustic screens adjacent to activity areas and roads Ensure vehicles have effective muffled exhaust systems and avoid the use of exhaust retarding systems (e.g., Jake brakes) Establish minimum altitudes for helicopter and fixed-wing aircraft over high value habitats, raptor nest sites Establish recommended flight paths for helicopters and fixed-wing aircraft	Reduce indirect loss of wildlife habitat through disturbance
W3	All	Revegetation of covers	Non-native vegetation communities established	Establish a revegetation research program to test local species for suitability Use native seed or non-persistent seed to revegetate exposed erosion-prone soils	Increase in native vegetation communities
W4	All	Handling and transport of waste rock and toxic waste materials	Increased airborne dust containing metals	Suppress dust in construction areas, deposition areas, infrastructure areas and roads	Reduce metals contamination caused by airborne dust
		Revegetation of covers	Exposed soils not revegetated	Establish revegetation research program to test local species for suitability	Reduce dust potential with Increase in vegetation on covers

8.9.4 Significance Determination

Residual Impact Rating

Residual effects of the Project were assessed and are based on those effects that remain when all mitigation options have been incorporated into Project design, and implementation. Criteria identified in Section 8.1 were used to rate the residual effects of Project activities on wildlife and wildlife habitat VECs. Professional judgement was used to determine the residual impact, based on consideration of magnitude in relation to indicator thresholds, geographic extent, duration, frequency and reversibility of the impacts. The applications of these descriptors for each wildlife VEC are provided in Table 8.18.

Table 8.46: Wildlife and Wildlife Habitat Residual Impact Rating

Impact Statement	Wildlife and Wildlife Habitat VEC	Indicator	Project Phase	Residual Impact Rating					
				Direction	Extent	Duration	Frequency	Reversibility	Magnitude
W1	All	Number of onsite or project related mortalities	Closure Implementation and Initial Post Closure Periods	Negative	Local	Medium to Long-term	Intermittent	Reversible	Low
W2	Fannin sheep	Presence or absence of sheep on known use areas	Closure Implementation Period	Negative	Local	Short-term	Intermittent	Reversible	Low
		# of sheep crossing events	Closure Implementation Period	Negative	Local	Short-term	Intermittent	Reversible	Low
	All	# hectares of current use habitats within and adjacent to project activities	Closure Implementation Period	Negative	Local	Short-term	Intermittent	Reversible	Low
W3	All	# hectares of reclaimed areas showing wildlife use	Closure Implementation Period and Beyond	Positive	Local	Short to Long-term	Continuous	Non-Reversible	Low to Moderate
		# hectares of reclaimed area with native vegetation communities	Closure Implementation Period and Beyond	Positive	Local	Short to Long-term	Continuous	Non-Reversible	Low to Moderate
W4	All	Change in trace metal concentration in wildlife	Closure Implementation Period	Negative	Local	Short-term	Intermittent	Reversible	Low
		Change in trace metal concentration in wildlife	Post Closure Period and Beyond	Positive	Local	Medium to Long-term	Continuous	Non-Reversible	Low to Moderate

Local Study Area Residual Effects

Impact Statement W1: Project activities will increase road traffic, which will increase the risk of wildlife mortality and injury through collisions; machinery use and clearing activities can destroy active nesting or denning sites and the young within them; and, the number of people in the area can cause wildlife mortality due to human/wildlife interactions.

All Wildlife VECs

With the implementation of mitigation by design and Project-specific mitigation, the number of onsite or project related mortalities to wildlife during the Closure Implementation and Post-Closure Periods is not expected to increase in comparison to the current conditions. For species such as grizzly bear, the implementation of an effective bear awareness program and management of food-based wastes is expected to decrease the number of human-bear interactions and mortalities. The overall effect will be low to moderate positive impacts within the local area that are expected to occur over the medium to long-term during the Closure Implementation and Initial Post-Closure periods. Interactions between wildlife and project activities are expected to occur intermittently and were considered to be reversible.

Impact Statement W2: Local movements, migration movements (e.g., Fannin sheep) and habitats available for use by wildlife species will be affected by: Project activities that would create noise, lights, and traffic; increased people on site; and changes to vegetation patterns due to vegetation removal and revegetation activities.

Fannin Sheep

Concerns over the effects of Project activities on the movements of Fannin sheep in the Vangorda/Grum complex area has prompted the development of a number of mitigation by design and project specific mitigation measures to ensure that impacts to sheep are minimized. These mitigation measures are expected to reduce impacts to sheep use of habitats and crossings between habitat areas to be a low, negative impact. The impacts will be short-term, intermittent and only affect a local area. Effects are expected to be reversible as they will cease when Project activities have finished in the Vangorda/Grum area.

All Wildlife VECs

The effects of Project activities and associated noise, lights etc., on wildlife habitat use are expected to be a low magnitude, negative impact after being reduced through mitigation by design and project specific mitigation methods. Effects are expected to be short-term, intermittent and localized as Project activities occur at different times and different areas of the Project during the Closure Implementation period. These effects on wildlife habitat use are predicted to be reversible as wildlife are expected to return to using habitats once the project activities have ceased.

Impact Statement W3: The increase in natural vegetation communities on the vegetated covers will increase available wildlife habitat for use by wildlife over time.

All Wildlife VECs

With the establishment of the vegetation covers, both native vegetation communities and wildlife use are expected to increase within the Project area as more habitats provide foraging opportunities. A positive, low to moderate magnitude effect is predicted that will range from short to long-term as different vegetation is established and the areas used by various wildlife species. The effects are expected to be continuous, non-reversible and confined to the local study area.

Impact Statement W4: Project activities will increase dust dispersion and the potential for metals contamination through dusting of vegetation used by wildlife during the Closure Implementation period, but covers placed on exposed soils will decrease dust and the movements of contaminants into the environment in the Post-Closure periods.

All Wildlife VECs

During the Closure Implementation Period, there is a potential for increased dust dispersion which may contain trace metals that could contaminate vegetation that is then eaten by wildlife. This would result in a negative, low magnitude impact to some wildlife species at the local level over the short-term. It is expected that this impact would be intermittent and reversible as covers are established and contaminated soils are no longer available to be dispersed by the wind.

Once covers are established and contaminated soils are no longer available to be transported by the wind, a positive, low to moderate magnitude effect is predicted as it is expected that levels of trace metals in wildlife will decrease. This decrease in trace metals levels would be observed at the local level, be continuous over the medium to long-term and non-reversible if no further disturbance to contaminated soils occurs.

Significance Determination

Impact Statement W1: Project activities will increase road traffic, which will increase the risk of wildlife mortality and injury through collisions; machinery use and clearing activities can destroy active nesting or denning sites and the young within them; and, the number of people in the area can cause wildlife mortality due to human/wildlife interactions.

All Wildlife VECs

The establishment of mitigation by design and the proposed mitigation measures are expected to decrease the potential for wildlife mortalities due to traffic or human/wildlife interactions to a very low level. It is not possible, however to ensure that no mortalities occur, which is why a negative, low magnitude impact to wildlife due to mortalities from Project activities was predicted. Although mortalities may be more likely in species such as small mammals and furbearers than larger specie

such as sheep or grizzly bear, overall the impact is considered to be not significant. The information used to conduct the assessment was considered to be sufficient to be confident in the assessment predictions.

Impact Statement W2: Local movements, migration movements (e.g., Fannin sheep) and habitats available for use by wildlife species will be affected by: Project activities that would create noise, lights, and traffic; increased people on site; and changes to vegetation patterns due to vegetation removal and revegetation activities.

Fannin Sheep

Movements and habitat use by Fannin sheep are predicted to be affected negatively at a low magnitude by Project activities. Some disruption of movements is likely to occur periodically and habitat use patterns may be changed as activities occur in the Vangorda/Grum areas. These effects are expected to be localized, intermittent and short-term and overall not significant to sheep habitat use or movements. Based on the available information it is likely that the predicted effects would be observed. The available information on Fannin sheep habitat use and movements, and the project activities was sufficient to conduct the assessment.

All Wildlife VECs

Habitat use by other wildlife species will be affected by project activities negatively, at a low magnitude. It is predicted that some wildlife species will be sufficiently disturbed by noise or other activities to move out of habitats to areas that have less disturbance, but these movements are expected to be short-term and occur on an intermittent basis within the local area. Overall, it is expected that the impacts will be not significant. These impacts are considered to be moderately likely and there is sufficient data on available habitats and species use patterns from various sources to have a moderate level of confidence.

Impact Statement W3: The increase in natural vegetation communities on the vegetated covers will increase available wildlife habitat for use by wildlife over time.

All Wildlife VECs

The establishment of native vegetation communities on the vegetated covers is predicted to have a positive, low to moderate magnitude effect on wildlife habitat use over the short to long-term. Although this would be considered to be not significant, the potential improvement in wildlife habitats from the current state is considered to be a high probability and the data available to conduct the assessment was sufficient to be moderately confident in the predictions.

Impact Statement W4: Project activities will increase dust dispersion and the potential for metals contamination through dusting of vegetation used by wildlife during the Closure Implementation

period, but covers placed on exposed soils will decrease dust and the movements of contaminants into the environment in the Post-Closure periods.

All Wildlife VECs

The predicted low magnitude, negative impact for trace metals contamination of wildlife during the Closure Implementation period was considered to be not significant. It is possible that some localized, short-term increases may occur, but mitigation measures to reduce dust dispersion are expected to be effective at limiting the potential for trace metals contamination. Ongoing monitoring will be required to test this prediction, however as there is some uncertainty regarding accumulation rates and possible localized effects.

During the Post-closure period and beyond, it is predicted that the trace metals levels in wildlife species will decrease over time due to establishment of the vegetated covers on the contaminated areas. There is an expected positive effect, with a low to moderate magnitude. There is some uncertainty however in how fast the trace metals levels will decrease, so ongoing monitoring will be required.

8.9.5 Monitoring and Follow-up

Monitoring of wildlife mortalities and wildlife habitat use patterns are required to ensure that the assessment predictions were correct and mitigation measures outlined are effective at reducing the predicted effects. Monitoring will be conducted throughout the Closure Implementation phase and into the Post-Closure phase as required. A detailed monitoring plan will be developed prior to project initiation and there will be Adaptive Management components built into that plan to allow changes in management or mitigation to occur as results become available that suggest that changes are required to meet the wildlife objectives. The detailed monitoring plan will also establish the frequency of monitoring and reporting conditions of the monitoring. The following outlines some of the components that are envisioned for the Wildlife Monitoring Plan.

Table 8.47: Components of a Wildlife Monitoring Plan

Project Objectives	Indicator	Monitoring Method(s)
Short and long term: Reliably prevent project related mortalities due to project activities (e.g., collisions, nest/den destruction and wildlife/human interactions).	• Number of on-site or project related mortalities	Document location and reason for wildlife mortality, investigate causes and determine if mitigation method used was effective or if and provide annual summary report of mortalities
Short and long term: Reliably prevent changes to habitat use and movements of wildlife species such as Fannin Sheep to and from their traditional habitat use areas	• Presence or absence of sheep on known use areas • # of sheep crossing events • # hectares of current use habitats within and adjacent to project activities	Use cameras or observers to monitor sheep use of habitats when near project activities and movements through the Vangorda/Grum complex. Conduct ground-based wildlife habitat use assessments in proposed clearing areas and adjacent to other project activity areas to detect level of seasonal wildlife use and determine if project activities should be scheduled to limit effects.
Short and long term: Reliably reduce exposure of contaminants to wildlife species	• Change in trace metal concentrations in wildlife	Continue Trace Metals contamination studies of vegetation and wildlife to determine if changes in trace metals levels are occurring.
Short and long term: Increase the productivity of affected wildlife habitats from their existing state by reclaiming those areas and developing natural vegetation communities	• # hectares of reclaimed areas showing wildlife use • # hectares of reclaimed area with native vegetation communities	Use ground-based surveys to determine wildlife habitat use and establishment of native vegetation communities within the RLUs.

8.10 Cumulative Effects Assessment

8.10.1 Introduction

8.10.2 Projects Included in the Cumulative Effects Assessment

8.10.3 Cumulative Effects

8.10.4 Cumulative Effects Assessment Summary and Conclusions

[i] Senes (2010)

Chapter 9

Socio-Economic Effects Assessment

9 Socio-Economic Effects Assessment

9.1 Scope of Project

Determining the socio-economic scope of a project requires that we:

1. Identify and describe the principal project;
2. Identify and describe any accessory project or projects;
3. Summarize the broad project components and activities that will be included in the assessment; and
4. Describe and document the rationale used to determine the socio-economic scope of the project.[1]

9.1.1 Principal and accessory projects

The principal project consists of the remediation work over fourteen years. There are no accessory projects. The only potential accessory project would be the mining of limestone and burning of lime, but current plans are to purchase the lime. While there is likely to be interest and perhaps proposal to mine limestone in the Yukon and produce the required lime, this will be done by a private enterprise and will be subjected to a separate proposal under YESAA.

9.1.2 Projects components

The project elements that affect VSECs include

- Cost of project
- Employment and employment policies
- Contracting and subcontracting
- Transportation and use of lime
- Project management
- Electric energy use

While the gross employment, cost and major inputs have been identified, much more detailed information on project management is required to complete the socio-economic effects assessment.

The information required to complete the Socio-economic assessment includes:

1. Who is proponent?

[1] Adapted from: Yukon Environmental and Socio-economic Assessment Board. *Guide to Socio-economic Effects Assessments*. June 2006. p.26.

2. The project description should include timeline, employment, location of employees, contracting policies, major supplies required & where they come from, etc.
3. Has YESAB confirmed that any related work, e.g., any road work, municipal infrastructure work in Faro, potential limestone mining & lime kiln will not be treated as an accessory project(s)?
4. What are the reasons for choosing the preferred development timeline (e.g., are there technical or logistical requirements)? What would be the impact on project economics be of extending the construction phase in order to increase local economic benefits?
5. What are the expected capital costs per year of the construction phase of the project?
6. What are the expected operating costs per year of the construction phase of the project?
7. We will need a breakdown of capital costs into categories that will allow us to estimate how much of that spending might possibly be captured in the Yukon.
8. How will construction contracting be handled and how will operations be structured? We assume that the general contractor with overall responsibility must have extensive related experience.
9. How is the proponent planning to manage sub-contracting opportunities?
10. Will subcontractors be subject to the same preferential hiring requirements as may be applied to the general contractor?
11. As much detail as possible on what goods and services will be required during the construction phase
12. What services are anticipated to be provided by the general contractor vs being contracted out to others (e.g. vehicle and heavy equipment maintenance/repair)?
13. What plans, if any, the proponent has for dealing with First Nation, local or Yukon suppliers on a preferential basis.
14. What is the planned timeline for construction? What is the seasonal component? How is "seasonal" defined and how will it vary between construction categories?
15. What are the estimated labour requirements for construction? A detailed annual breakdown of PYs and number of "bodies" per occupation is required, with an indication of seasonality.
16. What are the estimated labour requirements for operations during the construction phase? A detailed annual breakdown of PYs and number of "bodies" per occupation is required, with an indication of seasonality.
17. What is the expected overall labour cost component of construction?
18. How will the construction labour force be housed (Faro, Ross River, camp on site?) and how will they be transported to the site?
19. What are the expected shifts and shift rotations during construction?

20. What are the specific plans/policies relating to worker safety? (e.g. on site health care arrangements, available, injury prevention, return to work, etc.)
21. What are the specific plans/policies relating to human resources, employee assistance programming, employee leave (sick, family, cultural, bereavement etc.), alcohol and drugs, etc. Will these also apply to sub-contractors?
22. Are there any specific plans/policies for recruitment, retention and training for the workforce?
23. Are there any specific plans/policies to deal with local workforce issues (e.g. First Nation concerns such as bereavement leave) and to assist the local communities with negative social effects?
24. What are the expected increased traffic counts on the access road and the Campbell Highway during the construction period? Will there be any dangerous goods?
25. What will be the source(s) of energy for the operation and will it have an effect on overall electricity demand in the Yukon.
26. How will operations be structured.
27. Will the work be seasonal in whole or in part?
28. What are the estimated operating costs (broken down into labour, required goods and services, any further capital investments) per year? Again, we will need as much detail as possible on required goods and services to assess how much may be supplied locally or by Yukon firms.
29. Need detailed data on what kinds of labour will be required and how much by year over the duration of the post closure phase.
30. What are the planned shift rotations, how will workers be moved to and from the site, and how will they be housed?
31. What are the specific plans/policies relating to worker safety?
32. Are there any specific plans/policies for recruitment, retention and training for the workforce?
33. Are there any specific plans/policies to deal with local workforce issues (e.g. First Nation concerns such as bereavement leave) and to assist the local communities with negative social effects?
34. What are the expected increased traffic counts on the access road and the Campbell Highway during the operations phase? Will there be any dangerous goods? Does the proponent have any plans to control or restrict access to the site and/or road?
35. What will be the source(s) of energy for the operation and will it have an effect on overall electricity demand in the Yukon.
36. As much detail as possible on plans and strategies to maximize local and Yukon hiring and worker retention.

37. Similarly, as much detail as possible on plans and strategies to maximize local and Yukon business opportunities.
38. Plans/strategies to help local communities with any negative social effects?
39. What plans are in place to do ongoing socio-economic monitoring and respond to any problems as they arise?
40. Are there any strategies for helping local communities adapt to the post-closure economic and social environment?

9.2 Scope of Assessment

9.2.1 Geographic scope

Canada

The Faro remediation project will not produce socio-economic effects that are significant on a Canada-wide scale. With an estimated capital cost of $455 million and expenditures averaging at about $30 million per year during the 14 year construction period, as well as employment during construction estimated at 80 jobs per year, the project will be statistically imperceptible in a $1.6 trillion economy with 17.2 million people employed.

The federal government will be paying the cost of the remediation work, but the $30-to $40 million dollars a year will also be imperceptible in the federal budget of $240 billion. Canada as a whole, outside of the Yukon, is therefore not included in the assessment of the Faro project.

Yukon

The Yukon as a whole will be affected by the project. Of particular importance will be the territory-wide effects on economic growth, employment, transportation infrastructure, territorial tax revenue, and both workplace and public health and safety.

Ross River & Ross River Dena Council

Like Faro, Ross River is relatively close to the project by road, although it is not directly on the route to it. Nearly all of the VSECs described in Chapter 5 above will be included in the socio-economic effects assessment of Ross River and the RRDC.

Faro & the Town of Faro

The social and economic effects of a project tend to be more concentrated in the communities nearest to the project, and especially those relatively close by road. Faro is not only the closest community to the project, all road traffic to the site must also pass through the community. The Town of Faro has the housing and infrastructure to accommodate a significant population increase and continues in its efforts to attract new residents (and especially families with children). Faro is therefore more likely

than any other community to see a population increase as a result of the project and, if that increase is significant, experience more socio-economic effects.

Selkirk First Nation

Selkirk Dun First Nation has an identified interest in the project because it is downstream of the project and its traditional harvesting activities could be negatively affected by the project. The Selkirk First Nation's likely socio-economic interests in the project include business and employment opportunities and the social issues that arise with an increase in incomes. In addition the SFN has an interest in the effects of downstream water quality on subsistence resource use.

Liard First Nation & Watson Lake

The Liard First Nation and Watson Lake are far from the project but are included in the scope of the socio-economic assessment because of the Liard First Nation's interest in the project through its location on Kaska traditional territory .

For the Liard First Nation and Watson Lake, likely socio-economic interests in the project include: business and employment opportunities, the social issues that arise with an increase in incomes, and perhaps, the economic aspects of subsistence activities.

9.2.2 Temporal scope of assessment

The temporal scope of the project is approximately 25 years, allowing for the current estimated construction schedule of 14-15 years and a monitoring and adaptive management period following reclamation of about 10 years. The number of years coincides with the length of the water license that will be required and with the environmental effects assessment.

9.3 Assessment Methodology

Our assessment method proceeds rigorously from Valued Socio-Economic Components (VSEC) and interests. For each VSEC and interest combination identified in Chapter 5, we ask whether the project has any impact on it. If it has, then we evaluate the effect(s) based on

- Duration
- Extent
- Magnitude
- Reversibility
- Resilience
- Risk
- Frequency
- Probability
- Uncertainty and Direction

We also assess the significance of the effects. For significant negative effects, we identify potential mitigative measures and decide whether the mitigation eliminates or substantially reduces the negative effect. For positive effects, we identify potential enhancement measures and evaluate whether they are worth doing.

The evaluation criteria are presented in the table below.

	1	2	3	4	5
Duration	<1 to 5 years	5 to 10 years	10 to 25 years	25 to 100 years	100 years +
Extent	<1 ha	1 to 75 ha	75 to 200 ha	200 to 300 ha	>300 ha
Magnitude	Negligible effects to socio-economic fabric	Low effects to socio-economic fabric	Moderate effects to socio-economic fabric	Extreme effects to socio-economic fabric	Catastrophic effects to socio-economic fabric
Reversibility	95 to 100%	75 to 95%	60 to 75%	40 to 60%	<40%
Resilience	Very high degree of community resilience to type of change	High degree of community resilience to type of change	Moderate degree of community resilience to type of change	Low degree of community resilience to type of change	Very low degree of community resilience to type of change
Risk	Negligible	Low	Moderate	High	Very high
Frequency	Occurs never or once	Occurs rarely and at sporadic intervals	Occurs on a regular basis and at regular intervals	Continuous	
Probability	None	Low	Medium	High	
Uncertainty	Low level of confidence	Medium level of confidence	High level of confidence		
	+	**-**	**+/-**		
Direction	Positive change	Negative change	Positive and negative change		
	P	**NS**	**S**		
Significance	Positive socio-economic effect	No significant adverse socio-economic effect	Significant adverse socio-economic effect		

9.4 Predicted Effects

[Forthcoming, requires more detailed information as identified above]

9.4.1 Effects on Sustainable livelihood

Traditional economic activities:

hunting,

fishing,

gathering,

trapping.

Employment

Employability

Education

Training

Experience

Infrastructure

Transportation infrastructure

Power & communication infrastructure

Municipal infrastructure

Economic development

Economic growth

Equitable distribution of economic benefits between and within communities

Broad participation in economic development

Government revenues

Economic diversification

Minimizing boom & bust cycles

Healthy business sector

Business opportunities, short & long term

Business capacity

9.4.2 Effects on Community vitality

Community population

Demographics

Housing & land availability

Safety & security

Reduced crime levels

Social cohesion

Social/community events

Volunteerism

Reducing discrimination & racism

Quality of life

Recreation opportunities

Recreation facilities

Community infrastructure & aesthetic

Municipal services

Decent place to live

Governance, political structure and decision-making capacity

9.4.3 Effects on Health & socio-cultural well-being

Best possible health

Individual

Systemic, comprehensive approach to health

Sense of purpose in life

Health and social services infrastructure and programs

Reducing alcohol and drug abuse

Reducing domestic abuse and violence

Public health and safety

Workplace health & safety

Family resilience & self-sufficiency

Intact families

Cohesion of extended family

Food security

Cultural continuity

Heritage sites

Land-based social and cultural activities

Language preservation & restoration

Sharing traditional knowledge and stories

9.5 Mitigation and Enhancement Measures

Without the effects identification, most mitigation and enhancement measured cannot be identified and proposed. However, two mitigation measures have been decided to date:

- Lengthening the construction period to 14 years. This is to avoid the boom and bust situation identified as a negative effect by the communities of Faro and Ross River as well as the Ross River Dena Council.
- Avoidance of the use of a camp for worker accommodation. Camps have been identified as negatively affecting the quality of life in Faro and posing problems in terms of child care for employees responsible for child care (mainly women). It should be possible to have some supervised group accommodation for workers from other communities in Faro, where workers would live during the week and go home when their shift is up. This has been done successfully for workers from Ross River working in the Care and maintenance of the site. As well, some workers may wish to commute from Ross River (less than one hour each way).

9.6 Monitoring and Follow-up

9.7 Cumulative Effects Assessment

Cumulative effects will emerge if any of the currently planned mines go into construction or production. There are a substantial number of projects that currently do or could draw a portion of their labour force from Ross River and Faro. Among the more likely prospects are:

- Yukon Zinc (Finlayson Lake) under construction;
- Mactung (at YESAB);
- Ketza River (active exploration, almost ready to go to YESAB); and
- Selwyn (pre-feasibility, active exploration).

Any of these mines going ahead could on its own draw the entire labour force from Ross River and/or Faro and would presumably have similar effects to the Faro reclamation project. They could also result in a substantial population increase for Faro.

9.8 Significance evaluation

[forthcoming]

VSECs	Effects	Proposed Mitigation or Enhancement Measures	Residual Effects								Significance	Likelihood	
			Direction	Duration	Extent	Magnitude	Reversibility	Resilience	Risk	Frequency		Probability	Uncertainty
Sustainable livelihood													

9.9 Conclusion

[Forthcoming]

Chapter 10

Monitoring and Maintenance Plans

10 Monitoring and Maintenance Plans

10.1 Introduction

Successful implementation of the FMC closure and remediation plan can only be assured by carrying out careful, detailed planning for specific project activities and components. Conceptually the overall approach entails several tiers, each of which plays a pivotal role in achieving satisfactory performance during closure implementation and post-closure phases.

- The closure plan as proposed is designed to achieve environmental and socio-economic objectives.
- Project activities will be carried out in accordance with appropriate best management practices.
- Various environmental management plans define how these best management practices will be applied for the closure and post-closure phases.
- Monitoring will measure environmental and socio-economic performance to confirm expected conditions, provide information about areas of uncertainty, and identify unexpected changes.
- Adaptive management plans anticipate area of uncertainty within the project and describe how monitoring results will be used to trigger appropriate responses to changes in performance.

This chapter describes key management and monitoring plans that will support implementation of the FMC closure and remediation plan. These plans are conceptual at this stage, describing the framework that will be used to achieve the overall environmental and socio-economic objectives of the project. Additional details will be developed at appropriate stages of project planning and implementation. This will include further refinement during project permitting. Because the project entails many components and activities that will be implemented over a period of at least fifteen years, specific environmental and socio-economic management and monitoring plans will continue to be developed and refined for some activities as they approach implementation in the schedule.

10.2 Environmental Management Plans

A series of environmental management plans will describe and guide how the closure implementation and post-closure phases of the project will be carried out to ensure protection of aquatic and terrestrial environmental values. Application of best management practices will be an important component of all environmental management plans. Where necessary, these plans are reinforced by specific events in an environmental adaptive management plan, addressing areas of potential uncertainty.

10.2.1 Water Management Plan

Because potential impacts on aquatic ecosystems are a primary issue for the FMC closure and remediation project, overall water management is one of the main components of the project. Many

of the major project components and activities contribute to accomplishing appropriate segregation and management of water based on its quality. The overall water management goals include:

- Keep clean water clean – provide facilities for uncontaminated water to bypass the site without contact with mine wastes or contaminants.
- Collect and treat water that contains unacceptable levels of contaminants of potential concern (COPCs), e.g. metals like zinc.
- Manage construction-related runoff appropriately with treatment for sediment and/or COPCs as appropriate.
- Because of the focus on protecting the aquatic environment from mine-related contamination, the water management plans related to the first two goals are an integral part of the overall closure plan and are described in the project description (Chapter 7 and the Final Closure and Remediation Plan – Project Description, SD A1). Additional details will be provided in Operations and Maintenance Plans. Summaries of the water management plans are provided below.

Keep Clean Water Clean

- For all areas of the site, diversions will be used to convey clean water around the site, ensuring that it remains segregated from mine wastes that could cause contamination. Bypasses for clean water have been in place throughout mining and continue to function currently. Many of these facilities will require upgrading for long-term performance. In addition, the migration of contaminants in groundwater will require further efforts to maintain segregation of clean water in the long-term in some areas. The following project components are intended to achieve the goal of keeping clean water clean:
- Faro Creek diversion will be upgraded to convey clean water from the Faro Creek catchment into the North Fork of Rose Creek.
- A new lined channel for the North Fork Rose Creek will provide segregation between clean water in the North Fork Rose Creek and contaminated groundwater from adjacent waste rock dumps. A cut-off wall at the upper end of the channel will divert clean groundwater into this lined channel. Establishment of the lined channel will require removal of the North Fork Rock Drain. The lower portion of North Fork Rose Creek will be monitored in accordance with the Adaptive Management Plan to identify any future need to extend the channel lining.
- The Rose Creek Diversion Channel will be maintained and upgraded as necessary to convey clean water from the Rose Creek catchment around the tailings impoundment.
- The North Wall Interceptor Ditch will be maintained to convey clean water from the north side of the Rose Creek Valley around the site.
- The Vangorda Creek Diversion will be upgraded and realigned to safely convey clean water from the Vangorda Creek catchment through the site.

- The Grum Interceptor will be maintained to convey clean water through the site, until it can be shown that contaminant loading conditions would be acceptable for realignment through the Grum Pit Lake.
- In the long-term, the closure and remediation plan envisions that surface runoff from covered areas of the mine will be clean water. This will occur once the covered areas have stable vegetation and slopes. Monitoring will indicate when this water has acceptable quality for direct conveyance into diversion facilities.

Collect and Treat Contaminated Water

- The FMC closure and remediation plan relies heavily on collection and treatment of water that contains unacceptable levels of COPCs. Water treatment has been a fixture at the site since the 1990s and will continue throughout closure implementation and post-closure phases, with a duration expected to last at least several centuries.
- The anticipated flow of contaminated water at the Faro Mine and tailings areas is illustrated in Figure 10.1 and includes the following components:
- Collection of contaminated groundwater and seepage around the waste rock including at S-Wells Area, Zone II Outwash Area, Emergency Tailings Area and Lower Guardhouse Creek.
- Collection of contaminated water from the Zone II Pit, with management of water levels to maintain negative gradients towards receiving waters.
- Collection of contaminated groundwater and seepage from the tailings area including at the Rose Creek Aquifer collection system and at appropriate site-specific locations within the tailings impoundment.
- Conveyance of contaminated water to the Faro Pit for storage during periods when treatment is not operating (e.g. winter).
- Conveyance of contaminated water either directly to the treatment plant, or to the Faro Pit for storage during the water treatment season.
- Conveyance of contaminated water from the Faro Pit to a water treatment plant, with management of Faro Pit water levels to ensure adequate contingency storage and appropriate gradients.
- Treatment of contaminated water using lime amendment in a high-density sludge water treatment plant.
- Discharge of treated water into Rose Creek in accordance with appropriate effluent discharge conditions re: flow rates and water quality.
- The anticipated flow of contaminated water at the Vangorda/Grum area is illustrated in Figure 10.2 and includes the following components:
- Collection of contaminated groundwater and seepage around the Vangorda and Grum waste rock dumps.

- Conveyance of contaminated water from waste rock areas to the Vangorda Pit for storage during periods when treatment is not operating (e.g. winter).
- Conveyance of contaminated water from waste rock areas either directly to the treatment plant, or to the Vangorda Pit for storage during the water treatment season.
- Conveyance of contaminated water from the Vangorda Pit to a water treatment plant, with management of Vangorda Pit water levels to ensure adequate contingency storage and avoid gradients that would lead to release of pit waters.
- Treatment of contaminated water using lime amendment in a high-density sludge water treatment plant.
- Discharge of treated water into Vangorda Creek in accordance with appropriate effluent discharge conditions re: flow rates and water quality.
- Treatment of contaminated Grum Pit water using biological treatment methods, with contingency for additional treatment approaches (e.g. lime amendment in a treatment plant) if needed.
- Management of Grum Pit water levels to provide contingency storage if necessary and/or discharge in accordance with appropriate discharge strategies (water quality and flow rates).
- Modeling of predicted future contaminant loading indicates that very effective collection of contaminated water will be required once water chemistry in waste rock dumps and tailings deteriorates and contaminant migration occurs. The timing for deterioration of water quality and migration of contaminants to receiving water will vary for each potential contaminant source. For example, collection has already been initiated at the S-Wells area while it is not anticipated to be necessary at other areas until many years in the future. Two phased adaptive management plans as described in Section 10.4.11 will be guide decision-making about (1) when to construct collection systems and (2) the need for system upgrades.
- As described above, the current water treatment plan entails the use high-density sludge water treatment plants utilizing lime amendment for the removal of metal contaminants. Treatment in the Grum Pit will rely on interim biological treatment with contingency for lime treatment if necessary. Additional research and site investigations may identify alternative treatment methods for removing COPCs in some circumstances. Should alternative treatment methods prove to be effective for helping to comply with protective discharge conditions, these may be utilized in addition to or as alternatives to the proposed treatment methods.

Construction Water Management

Management of construction-related surface runoff will be a key issue for the implementation of the Faro Mine Complex Closure plan. Surface water management will be needed during both the closure implementation and post-closure phases of the project. Surface runoff water from the site may contain elevated levels of total suspended solids (TSS) and/or elevated concentrations of COPCs. The metals can come from two sources including those associated with the natural chemical

matrix of the TSS and those that have been transformed through time and sulphide oxidation into potential mobile and soluble secondary by-products. In some instances, managing these runoff waters could require advanced treatment processes such as sulphide addition and/or filtration, not only for metals removal but also suspended solids.

To minimize potential aquatic ecosystem effects that could arise from construction activities, a hierarchy of approaches will be followed. Where possible, contact of clean water with sources of contaminant loading will be avoided. Best management practices will be implemented to minimize potential for erosion. Where erosion is possible, erosion control measures will in place to minimize mobilization of suspended solids. Sediment control facilities and measures will be used to control sediment release if necessary. Finally, water treatment facilities will be in place as needed to address removal of TSS and/or COPCs.

For the purposes of the construction surface water management plan, surface water has been grouped into two categories, contact and non-contact water. Contact water is defined as any water that may have been physically or chemically affected by contacting disturbed areas. Contact water includes:

- Surface runoff from oxide fines, low grade ore stockpiles, crusher stockpiles and roadways.
- Surface runoff and shallow drainage from waste rock dumps and sulphide cells.
- Surface runoff and shallow drainage from tailings disposal areas.

All contact water will be intercepted, contained, analyzed, treated if required, and discharged to the receiving environment when water quality meets the discharge criteria. In cases where water is only affected by TSS, treatment will typically be directed to settling ponds for treatment while water that contains elevated levels of COPCs may require treatment in a treatment plant.

Non-contact water is limited to runoff originating from areas unaffected by mining activity that does not come into contact with developed areas. Non-contact water will be intercepted and directed away from developed areas by means diversion channels and allowed to flow to the adjacent creeks untreated.

The effects of erosion can be reduced by protecting the soil from the runoff forces, and by preventing any sediment-laden runoff from leaving the site. Methods for minimizing erosion will include a variety of construction best practices that will vary depending on the types of activities being undertaken. Specific surface water management plans will be developed for individual activities as they arise on the implementation schedule. Erosion control will rely on various best management practices including filter fabric; sediment traps/straw bale filters; riprap; diversion terraces, berms and swales to divert water from construction sites; establishment of cut-and-fill slopes as flat as feasible, consistent with the strength of specific soils and depending on slope length, steepness, moisture content, density, etc.; detention of storm water on the site for release at non-erosive velocities; and temporary sediment control facilities until more permanent structures and/or vegetation are established. These sediment control facilities will provide "treatment" for runoff, discharging sediment-free waters from the site. They will be designed to perform effectively in

appropriate high flow events. In addition to the above measures, construction in sensitive areas will be confined to periods of dry weather, or winter, if possible.

Detail about these general engineering methods for erosion and sediment control are found in Section 12 of the Project Description document (Supporting Document A1).

A conceptual construction surface water management plan is attached as a supporting document (Chapter 12 of SD A1). That plan describes the general water management strategies for Faro Pit area, Rose Creek Tailings area and Vangorda/Grum area including considerations for water management strategies that will be required during construction and post-closure phases. Brief summaries are provided below.

Faro Mine Area

- During waste rock resloping and covering activities at the Faro Mine area, care will be taken to minimize sedimentation and contamination of water. Temporary diversion berms will be constructed up-gradient of the facilities and down-gradient of construction activities. Water falling directly on the exposed dumps and reporting as runoff will be directed into temporary sediment control basins. Temporary sediment control ditches can be placed at the down-gradient toe of the waste rock dumps, outside of the resloped dump toe zone, thereby minimizing seepage entry into receiving waters. Ditches will be designed so that runoff will flow by gravity to sediment control basins. Water quality sampling will determine the fate of this water – direct release, treatment for TSS or treatment for COPCs.
- Surface water that contacts oxide fines, low-grade ores or sulphide cells will be collected and directed to the Faro Pit for subsequent treatment.
- The S-wells and Zone II areas are considered sensitive due to their proximity to Rose Creek. To minimize potential effects, sources of potentially sediment-laden waters will be intercepted as close to the source as possible. It would be appropriate to use sediment control measures such as silt fences, erosion control, or diversion channels and sedimentation basins to control runoff before entering the creek. Sediment basins will be constructed prior to upslope disturbances so as to trap any sediment generated during construction works. Buffer zones around disturbed areas will be established to allow for natural filtering of surface runoff waters that could potentially enter adjacent waterways. If required, silt fences will be placed around the perimeter of disturbed areas to prevent the transport of sediment from the disturbed area or in diversion and perimeter collection ditches.
- In the Emergency Tailings Area surface water interception systems will be installed at both upstream and downstream locations and water will initially be pumped to the Faro Pit. Once the area is cleaned up, monitoring will determine water quality and clean surface water will be diverted to the North Fork of Rose Creek (NFRC) at the upstream end of the Rose Creek Tailings Facility.

- During the post-closure phase of the project, surface water will be managed by lined and unlined plateau channels and a number of armoured slope channels. To minimize erosion, slopes will have berms and sedimentation ponds as necessary and all slopes will revegetated.

Rose Creek Tailings Area

- Water that contacts tailings materials will likely have elevated concentrations of COPCs. Exposed tailings will remain a feature of the site until completion of the tailings cover. During that period, water that ponds on the tailings facility will be pumped to the Faro Pit for subsequent treatment.
- Construction activities associated with the Intermediate Dam raise, spillway and tailings covers will require dewatering of some areas of the tailings. Water from dewatering activities will be pumped to the Faro Pit for subsequent treatment.
- Prior to the completion of flood routing facilities for a PMF, contingency measures need to remain in place to minimize the risks associated with large flood events. Thus the removal or breach of the Cross Valley Dam will be delayed as long as possible so that the facility is available to store flood water in the event of a severe flood.
- Construction activities for breaching the Cross-Valley Dam and constructing the Intermediate Dam raise and spillway may lead to increased TSS concentrations. Erosion and sediment control measures will be developed during detailed planning for these activities and implemented accordingly. For example, temporary diversion berms could be constructed down-gradient of construction activities to divert runoff into temporary sediment control basins. Silt fencing or straw bales can be used to mitigate sediment transport.
- Upgrades to the Rose Creek Diversion Channel and construction of the fuse plug will require management of potential surface water impacts. Depending on the types of specific activities that need to be conducted, some measures to address surface water effects will likely include: construction during dry weather; construction in winter when flows are lower; pumping the creek around construction areas; building silt fences, temporary sandbag sediment barriers and using straw bales to prevent sediment from entering environment; and, armouring the channel well with gravel sized fill to handle silt when channel is opened.
- During the post-closure phase of the project, the tailings will be covered with a vegetated cover and surface water is expected to be clean, allowing discharge directly from the surface of the cover to Rose Creek. Water quality monitoring will determine the acceptability for discharge. Localized collection of surface water seeps (e.g. mouth of old Faro Creek Channel, Lower Guardhouse Creek, Fuse Plug Area) may be necessary to prevent contamination of surface water on the tailings cover.

Vangorda/Grum Mine Area

- During waste rock resloping and covering activities at the Vangorda/Grum Mine area, care will be taken to minimize sedimentation and contamination of water. Temporary diversion berms will be constructed up-gradient of the facilities and down-gradient of construction activities. Water falling directly on the exposed dumps and reporting as runoff will be directed into temporary sediment control basins. Temporary sediment control ditches can be placed at the down-gradient toe of the waste rock dumps, outside of the resloped dump toe zone, thereby minimizing seepage entry into receiving waters. Ditches will be designed so that runoff will flow by gravity to sediment control basins. Water quality sampling will determine the fate of this water – direct release, treatment for TSS or treatment for COPCs.
- Surface water collected during construction activities at the Ore Transfer Pad will be directed to temporary sediment control basins. These basins will be constructed to allow the collected water to infiltrate into the waste dumps thus preventing the exit of potentially contaminated water from site. If the water in the basin begins to rise above the freeboard, the water will be pumped to the Grum Pit because it is likely to be contaminated with COPCs.
- In other locations where there is a danger of clean water contacting highly contaminated material similar procedures will be followed. Water up-gradient will be diverted away from the area either through the use of earthen diversion berms, sand bag structures or equivalent.
- The Grum and Vangorda Waste Dumps will require an internal ditching systems. Surface water coming from the construction efforts can be directed to the Grum or Vangorda Pit catchments or directed to a lined central sump and then pumped to either pit.
- Sedimentation effects could arise during construction of the Vangorda Diversion Channel and other diversion upgrades or changes. Erosion prevention measures such as silt fencing, temporary sandbag sediment barriers, and straw bale berms as well as other best management practices will be used to minimize erosion and sediment release from these activities.

10.2.2 Sludge Management Plan

Because of the need for very long term water treatment at the FMC, sludge management will be an important component of the closure plan. An overview of estimated sludge production and proposed storage plans is provided in Chapter 8 of the supporting document Final Closure and Remediation Plan, Project Description (SD A1). Different approaches for sludge management are required for the sludges produced from existing water treatment plants, and those produced in the proposed HDS water treatment plants.

Long-term sludge management plans are conceptual at this stage and involve storage of sludge at the bottom of existing pits. Adequate work has been completed to confirm that sufficient long-term sludge storage capacity is available in these pits. While long-term pit chemistry could affect sludge stability, the proposed disposal methods will limit these effects. Minor contaminant resolubilization

that may occur will not have adverse environmental effects and can be readily addressed through the water treatment systems.

Sludge production rates have been estimated from lime usage to treat the contaminant loads predicted through the water quality modelling, estimating sludge tonnages and volumes that result when the lime is converted to gypsum and zinc hydroxide. The estimates conservatively assume a sludge density of 15% solids, which should be readily achievable with an HDS system. Sludge densities of 20% solids or higher are more likely.

For the Faro Mine and Tailings areas, sludge from the proposed HDS water treatment plant will be placed in the Faro pit using a tremie system to place the sludge near the pit bottom, and prevent mixing with the water column. The volume available in the pit, without constructing a plug dam, is estimated to be about 35,000,000 m^3 which would provide capacity for over 300 years of sludge production. Higher sludge densities would provide greater capacity. If needed, additional capacity could be obtained by constructing a plug dam in the pit to allow a higher water elevation.

For the Vangorda/Grum Mine area, sludge produced from the proposed HDS water treatment plant will be placed in the Vangorda Pit using a tremie system to place the sludge near the pit bottom, and prevent mixing with the water column. The volume available in the pit is estimated to be about 6,000,000 m3 which would provide capacity for over 1000 years of sludge production. Higher sludge densities would provide greater capacity.

Existing sludge management plans will continue while the current water treatment plants continue to operate. These treatment systems produce much lower density sludge (and thus higher volumes) than the proposed HDS systems. This sludge should not be disposed of in pits because it will consume excess storage volume and will be more prone to mixing with the water in the pit during disposal.

Sludge produced by the existing Faro water treatment plant during the early stages of the closure implementation phase will continue to be stored in impoundments on the tailings surface. During tailings reclamation activities, the sludge material will remain in the tailings area, distributed and/or incorporated under the proposed tailings cover. In this location, any excess alkalinity will serve to neutralize acidity in the tailings. If low-density sludge is produced after placement of the tailings cover, that sludge will be placed in an appropriate location on waste rock where alkalinity can be similarly consumed, and where the material will ultimately be covered.

Sludge produced from the existing Vangorda/Grum treatment system is currently stored in impoundments on the Grum Overburden dump. Storage of sludge at suitable locations on waste rock is expected to continue for the duration of operation of the existing treatment system. The excess alkalinity in the sludge will neutralize some acid potential in the waste rock and the material will eventually be covered as part of the remediation plan.

Detailed sludge management plans for existing facilities are described in the current sludge management plan. Detailed sludge management plans for long-term sludge storage will be prepared in association with water treatment plant design as part of project implementation.

10.2.3 Fish Compensation Plan

TBD - Awaiting information from AECOM.

10.2.4 Dust Abatement Plans

High ambient concentrations of particulate matter (especially fine particles < 30 μm) from fugitive dust could, if not mitigated, have effects on human health and wildlife and vegetation populations. Evaluations of terrestrial and airborne contamination have shown that migration of contamination by dusting has occurred in the past and continues to occur at the FMC. In the long-term, the effects caused by dusting are expected to be negligible because the proposed covers will eliminate contaminant migration for major sources like tailings and waste rock. During the closure implementation phase, however, the increased activities at the site are likely to cause increased mobilization of contaminants by dusting. Potential sources of dust and conceptual control measures are described below. Detailed dust abatement plans will be developed for specific project activities as part of project implementation.

Tailings

The exposed tailings in the Rose Creek Tailings Facility are an existing source of fugitive dust. This occurs during dry summer periods and also when the tailings are frozen due to freeze-desiccation of the surface materials. A chemical dust suppressant was sprayed in a test area on the tailings pond in the summer of 2009 and this was found to be successful in mitigating fine particulate transport. Continued application of a chemical dust suppressant will be used to control dusting from the tailings facility prior to cover placement.

The construction of the tailings cover and Intermediate Dam upgrades will entail construction activities on the tailings. These activities will increase the potential for fugitive dust. Best management practices will be used to avoid dusting during construction. This will include minimizing traffic on exposed, frozen tailings, utilization of chemical dust suppressants, managing activities during windy conditions, utilizing water for dust suppression, and vehicle speed regulations. Specific measures will be identified to address dusting concerns related to sludge that is stored on the tailings surface. Details of a dust abatement plan for tailings reclamation will be completed as part of detailed design for this project component.

Haul Roads

Traffic on site roads can lead to significant mobilization of dust. The phylite material that comprises much of the Vangorda Haul Road for example, can cause significant dust when subjected to heavy traffic in dry conditions. Other roads can also be sources of dust and some roads in the mine area may have elevated concentrations of COPCs. Transport of cover materials will require significant

heavy traffic on site roads which could cause substantial dusting. Traffic speed control, road watering and use of chemical dust suppressants may be required to control dust effects. Monitoring will be required to confirm effectiveness of these measures.

Waste Rock Dumps

At the present time, fugitive dust from waste rock piles appears to be minimal, though some dusting probably occurs, especially in winter conditions. Re-grading and covering of waste rock piles will introduce greater potential for dust release. Monitoring and dust control measures (e.g. dust suppression, vehicle speed regulation) will likely be needed to ensure that unacceptable adverse effects do not occur from these activities. Specific dust abatement plans will be part of detailed design for project components.

Other Activities

Other site activities like building demolition, borrow source development and road reclamation may be sources of fugitive dust. Measures will be taken to monitor, supervise, and control dust from those activities. Possible measures to control fugitive dust emissions include: road watering, vehicle speed regulations, and application of a chemical dust suppressants. These measures would be applied on an as-needed basis based on the results of the ongoing monitoring and supervision.

10.2.5 Operations and Maintenance Plans

Operations and Maintenance Plans for key components of the FMC closure and remediation project will provide detailed guidance about measures to be taken to ensure adequate performance of site facilities. Monitoring plans will confirm conditions and inadequacies can then be addressed in accordance with proposed maintenance approaches. The following components are among those that will be addressed in operations and maintenance plans for the project:

- Covers Operations and Maintenance Plans will describe: expected performance with respect to physical integrity, infiltration control and vegetation, anticipated maintenance activities, approaches for analysis and interpretation of monitoring data, responses to outcomes of analysis, and approaches to water management.
- Dam Operations and Maintenance Plans will describe: expected conditions for dams and appurtenant facilities, anticipated maintenance activities, approaches for water management, and schedules for inspections and safety reviews.
- Diversion Operations and Maintenance Plans will describe: expected conditions for diversions, anticipated maintenance activities, approaches for water management, and schedules for inspections and safety reviews.
- Pit Operations and Maintenance Plans will describe: expected operating conditions for pits including water level management, sludge storage management, stability evaluations, maintenance requirements, approaches for analysis and interpretation of monitoring data (model updates) and schedules for inspections and safety reviews.

- Water Treatment Operations and Maintenance Plans will describe: expected operating conditions for the water treatment systems including sludge production, water quality and flow rates, approaches for evaluation of water treatment performance, and approaches and schedules for analysis and interpretation of monitoring data including modeling updates for overall water and load modeling.

Detailed operations and maintenance plans will be developed as part of detailed designs for specific project components.

10.2.6 Emergency and Spill Response Plans

Emergency and spill response plans currently in place at the site will continue to apply during closure implementation and post-closure phases (SD I15). These overall plans will be updated as necessary for the purposes of the closure and remediation plan. Some specific project components may require more detailed emergency and spill response plans and these will be developed as part of detailed design as needed.

10.2.7 Access and Traffic Management Plan

Some project components will involve significant vehicle traffic, for example transportation of cover materials from Vangorda/Grum Mine area to Faro Mine area, and transportation of materials and reagents to the site. Vehicle traffic both on the site and coming to the site can lead to a variety of potential effects that include dust transmission, wildlife mortality, and wildlife use patterns. Socio-economic effects may also arise, especially from access to the site. A detailed access and traffic management plan will be developed as part of detailed design. This plan will describe methods for minimizing any effects from the proposed vehicle use both on-site and off-site.

10.2.8 Borrow Management Plans

Closure activities for Faro Mine Complex will require large volumes of natural material for construction of elements such as covers and channel protection. Chapter 9 of the Final Closure and Reclamation Plan, Project Description (SD A1) provides some details about the types and quantities of materials required.

Glacial till, granular soils,coarse granular soil, organic soils, waste rock and rip-rap will all be required during the proposed project and will be sourced from a combination of existing sources and new borrow areas. Some general principles have been identified for development of borrow sources, whether existing or new:

- Minimize disturbance area while maximizing volume;
- Avoid developing below grade and creating a crater which will collect and store water;
- Where material is excavated above bedrock maintain 0.5m of overburden for reclamation; and
- Rock quarries used for riprap should be geochemically tested prior to development.

When a borrow source is selected, standard industry practice will apply. Clearing and grubbing will be completed including salvaging the timber or disposing of it according to forestry practice. Topsoil and organics from the grubbing operation will be stockpiled nearby for later reclamation use. Surface water management practices will be adopted around all ground disturbances. The borrow area will be developed in benches according to equipment specifications and landscape. When the borrow/quarry is exhausted or work is completed, the slopes should be flattened to 3H:1V for long-term stability and the surface shaped to encourage natural drainage. A 0.3m lift of organic material from the stockpile would be spread for revegetation according to silvaculture requirements.

Detailed borrow management plans will be developed once quantities from specific borrow areas are finalized during detailed design. These plans will be updated and refined as needed for specific borrow areas and project components.

10.2.9 Wildlife Mitigation Plan

Mitigation measures for protection of wildlife and wildlife habitat were developed through the environmental assessment process and rely on regulatory requirements, best management practices, guidelines, professional experience and local knowledge. The mitigation needs are discussed in Chapter 8 of this Project Proposal and are include activities and methods to reduce impacts to wildlife and wildlife habitat. During project final design, these mitigation methods and activities will be compiled in a wildlife mitigation plan that will provide managers and operational staff with methods to decrease impacts to wildlife and their habitats. Mitigation proposed includes:

- Establishing a No Hunting area during the Closure Implementation period for GMS 4-44 to 4-46 in addition to the current No Hunting area in GMS 4-51.
- Establishing low speed limits (e.g., 40 km/hr) on roads within the Vangorda/Grum complex and other areas when wildlife are on or near the road.
- Development of waste management plans that will minimize potential effects on wildlife.
- Provide wildlife awareness training; establish a Wildlife Response Team trained for deterring wildlife.
- Report and monitor wildlife encounters and outcomes.
- Restrict project activities to the smallest footprint possible and minimize disturbance to and removal of currently undisturbed habitats.
- Minimize disturbance to riparian areas which are high value habitats for a variety of species.
- Ensure snow plowing provides openings and/or low banks to allow wildlife to leave roads.
- Conduct surveys for nesting birds prior to vegetation removal during the breeding season or conduct vegetation removal activities outside of the breeding season.
- Identify sensitive and important wildlife habitats and avoid activities near them.
- Maintain vegetation as visual/acoustic screens adjacent to activity areas and roads.

- Ensure vehicles have effective muffled exhaust systems and avoid the use of exhaust retarding systems (e.g., Jake brakes).
- Establish minimum altitudes for helicopter and fixed-wing aircraft over high value habitats, raptor nest sites.
- Establish recommended flight paths for helicopters and fixed-wing aircraft Establish a revegetation research program to test local species for suitability.
- Suppress dust in construction areas, deposition areas, infrastructure areas and roads.
- Use native seed or non-persistent seed to revegetate exposed erosion-prone soils.

Some key components and approaches in the proposed project will inherently provide mitigation for potential wildlife effects.

- Reduce mortalities and injuries to wildlife from falls into steep-sided pits (e.g., Faro, Vangorda and Grum pits-) or getting trapped in pits or other structures by providing berms and/or other barriers to wildlife movements/access.
- Development of the covers and RLU objectives for use of native vegetation to reduce impacts and provide eventual improvements to wildlife habitats. The RLUs and vegetation covers will also reduce the availability of airborne contaminated dust to be transported to vegetation and wildlife.

10.2.10 Solid and Hazardous Waste Management Plans

Implementation of the FMC Closure and Remediation Plan will require disposal and/or remediation of solid and hazardous waste materials. Waste management is regulated by Yukon Government under its Environment Act and appropriate waste management plans will be required in order to obtain permits for disposal and management of solid and hazardous wastes. These plans will be developed to meet regulatory requirements as part of detailed project planning. Waste management concepts will be as follows:

- Solid waste (exclusive of hazardous waste, special waste) will be disposed of in an on-site landfill facility.
- Hazardous and special wastes will be disposed of on-site or transported off-site, as appropriate for specific waste materials.
- Hydrocarbon contaminated soil materials will be remediated in an on-site landfarm, as described in the Final Closure and Remediation Plan, Project Description (SD A1).

10.2.11 Adaptive Management Plan

An adaptive management approach will be a critical component of any successful closure plan for the Faro Mine Complex. Meeting overall closure objectives related to protection and restoration of the environment, protection of human health, and restoration of land are predicated on performance

of several key project components, especially vegetation/covers, groundwater collection and water treatment.

Comprehensive monitoring, investigation, research and design programs have formed the basis for predictions about future site conditions and performance of closure measures. However, actual site conditions and performance will vary from the assumptions used in the predictions. For all of the noted project components, there are areas of outstanding uncertainty about future conditions where variations from the assumptions could lead to effects on the environment. The Environmental Adaptive Management Plan will be implemented for these areas of uncertainty to detect changes in site conditions or performance in a timely manner and guide appropriate and effective responses that will prevent unacceptable environmental effects. A framework for the Environmental Adaptive Management Plan (AMP) is provided in Chapter 13 of the Final Closure and Remediation Plan, Project Description (SD A1) and is summarized in this section.

The uncertainties addressed by the AMP are limited to those that relate to the overall performance of the closure project. The key events that will be addressed through specified adaptive management plans include the following:

1. Rose Creek Aquifer
   Phase 1 – degradation of aquifer water quality leading to collection and treatment requirements.
   Phase 2 – bypass of water around the Rose Creek Aquifer collection system.

2. Contaminated Groundwater/Seepage
   Phase 1 – degradation of groundwater or seepage quality down-gradient of a mine component, leading to collection or treatment requirements.
   Phase 2 – bypass of water around a mine component collection or treatment system.

3. Receiving Water Quality – degradation of water quality in receiving waters downstream of the mine site.

4. Receiving Water Flow – changes in winter flows downstream of the mine site due to groundwater collection activities (potential effects on fish and fish habitat).

5. Receiving Water Temperature – changes in water temperatures (winter) downstream of the mine site due to groundwater collection activities (potential effects on fish and fish habitat).

6. Water Treatment Source Water Quality/Quantity – ability of treatment systems to function effectively in changing conditions:
   Changes in water quality, water quantity or parameters of concern for water that is being treated.
   Emerging sources requiring treatment.

7. Cover Vegetation Success/Performance – vegetation on soil covers failing to meet objectives (e.g. erosion control, vegetation coverage, invasive species, wildlife habitat, etc.)

8. Terrestrial Effects – effects on the terrestrial environment are different than anticipated.

9. Sludge Management – sludge properties or quantities lead to the need for major changes in approach for sludge management.

To be effective, an AMP must provide an operational structure for detecting changes as well as the development and implementation of timely responses. This structure is provided by several common elements that are included in each specific AMP. These common elements provide the framework that is necessary to ensure that the AMPs will be proactive in detecting changes and implementing responses before unacceptable environmental effects occur. The following common elements form part of each specific AMP.

1. "Event" describes the specific event that is addressed by the AMP.

2. "Possible Environmental Consequences" describes the environmental consequences that could arise if the event were allowed to proceed without appropriate responses.

3. The "Narrative Response Trigger" is a narrative description of the trigger for the AMP event and leads to the development of the specific indicators and thresholds.

4. "Specific Indicators" describe the environmental parameters to be monitored and assessed as part of the AMP. The indicators are selected to provide early detection of relevant changes in environmental conditions or system performance.

5. "Specific Thresholds" define the conditions for specific indicators that would lead to actions being taken. There are often a series of staged thresholds or multiple thresholds for an individual event.

6. "Monitoring Requirements" describes the monitoring (e.g. parameters, locations, frequencies) that will be carried out to support implementation of the AMP. Monitoring requirements may change at various stages of an AMP.

7. "Evaluation of Monitoring Results" describes the methods and processes that will be used to evaluate the monitoring data and determine whether any specific thresholds have been reached or exceeded.

8. "Approach to Development of Response/Mitigation/Intervention" describes the overall approach to responses that will be implemented if any thresholds have been reached or exceeded. In most cases, the responses will include a range of actions that may be taken to address the events. The selection of appropriate responses would depend on the conditions of changed site conditions or system performance.

The Environmental AMP for the Faro Mine Complex is an integral component of the mine closure project. The AMPs will guide decisions in three broad areas: (1) timing for implementation of mine

closure measures (e.g. Rose Creek Aquifer collection), (2) locations for implementation of mine closure measures (e.g. waste rock seepage collection areas), and (3) performance adequacy of closure measures that have been implemented (e.g. vegetation success). Due to these areas of application, without the AMPs the project would cause unacceptable environmental effects. Because of the critical nature of the AMPs, a governance structure must be in place to support effective application of the adaptive management approach.

A detailed adaptive management plan will be developed as part of the detailed design of the project. This will include more detailed specifications of initial thresholds and also identification of an effective governance structure for implementing the AMP. The AMP will need to contain flexibility as some later thresholds and conditions cannot be anticipated at this stage and will need to be refined as conditions at the site change.

10.3 Environmental Monitoring Framework

10.3.1 Overall Monitoring Objectives

Monitoring for a project with the scale and duration of the FMC Closure and Remediation plan is complex and of critical importance. Despite the application of robust science in prediction of potential future conditions and effects, there is still significant uncertainty about the actual outcomes. Monitoring for a variety of purposes will help to ensure that the effects of the project remain within those anticipated and evaluated during the environmental assessment. Monitoring purposes include:

- Evaluating the effectiveness of mitigation measures (MIT).
- Compliance with regulatory requirements (COMP).
- Accuracy of predicted impacts on key ecological values.
- Understanding environmental conditions and changes (EM).
- Adaptive management monitoring needs (AMP).
- Operational needs (OP).
- Addressing social needs for understanding of ecological conditions.

With a project of this scale and duration, monitoring will consume significant resources and create data management challenges. Because of these expenses and challenges, the monitoring program must be an efficient program where monitoring is conducted for distinct purposes. Locations, parameters and frequencies for monitoring of specific environmental values each need to add unique value to the database of information about the site, environment and performance. An efficient program must be established that can meet all of the above monitoring purposes. The program will also need to be flexible to allow changes as environmental and site conditions change and develop.

For all monitoring programs, effective governance structures, monitoring protocols and quality management procedures will need to be in place to ensure that monitoring is conducted and reporting

completed in accordance with appropriate standards and approaches. These structures must be established early in the project implementation phase.

10.3.2 Stages of Monitoring Program

As the FMC closure and remediation project proceeds from the initial implementation phase through to the ultimate post-closure phase, monitoring programs will need to be refined to address specific project needs of those phases. Key phases of the monitoring program are described below.

Closure Implementation Phase

The monitoring program for the closure implementation phase will be the most complex and extensive.

Existing monitoring programs will initially continue with minor refinements. Some additional components will likely need to be added for ecological values that are not currently subject to monitoring. This extensive program provides information about how site conditions are changing and the effects on ecological values. Because no contaminant source controls are yet in place, conditions can change quickly and can lead to immediate effects on ecological values. These conditions will continue to influence the need for short-term mitigation measures and scheduling of permanent closure measures.

As the closure project proceeds, some components of the monitoring program will need to be changed. There may be reductions of monitoring needs in some areas and increases or modifications in other areas. Flexibility needs to be in place to allow these monitoring changes to take place. For example, in the North Fork Rose Creek area, initial programs need to include monitoring and a series of locations to determine whether contaminant loading is problematic from various waste rock zones (e.g. Northeast Dumps, Zone II Outwash, S-wells). Once the North Fork Channel is completed including a channel lining, these monitoring locations will need to be revised. As implementation of the adaptive management plans proceed, monitoring will need to be revised to address the needs of that program.

In addition to the overall monitoring program during the closure implementation phase, there will be additional project-specific and activity-specific monitoring needs (e.g. North Fork Rose Creek Channel, specific cover construction projects, borrow areas). These cannot be finalized at this time because the details will be partially dependent on scheduling and ordering of closure activities. These specific programs will be defined as part of final design for specific project components.

Adaptation Phase

Once physical closure activities have been completed, there will be an interim phase of ongoing adaptation. During this phase, monitoring will still need to be fairly intense to detect changes in the performance of closure components and activities. Much of the monitoring during this phase will be dictated by adaptive management needs.

Post-Closure Phase

The post-closure monitoring program will be implemented once the site has reached a more stable condition. This long-term program will be efficiently focused on identifying changes in site or environmental conditions and responding appropriately including changes in monitoring programs if necessary. Monitoring programs for earlier phases must be designed to provide adequate data for long-term interpretation of site and environmental conditions. Some guidance about proposed long-term monitoring requirements during the post-closure phase is provided in "Aquatic Ecosystem Monitoring Program, Faro Mine, Yukon" prepared by Minnow Environmental (SD B3). This document provide scientific rationale for monitoring programs, though additional considerations will be addressed during development of the final monitoring plan and are included in the framework described below.

10.3.3 Monitoring Framework

Recognizing that details of the monitoring program depend on specific activities, project scheduling and changing site conditions, this Project Proposal presents a monitoring framework that describes the proposed monitoring concepts including values to be monitored, general locations for monitoring, stages for monitoring requirements (e.g. what project phases will this monitoring be relevant for), purpose of proposed monitoring and the general monitoring approach (e.g. parameters, frequencies).

Site/Source

Table 10.1: Site and Source Monitoring Overview

Location	Project Stage(s)	Purpose	Monitoring Approach
Treatment plant discharges	All	OP, COMP	Routine monitoring of all treatment plant discharges for quality and quantity.
Output from collection systems	All	OP, AMP, MIT	Monitoring of water quality and quantity from the output from the various collections systems to track any potential changes in the influent to the treatment plant.
Vangorda and Faro Pit water	All	OP, AMP, MIT	Monitoring of water quality in Faro and Vangorda Pit to assess any potential changes in the influent to the treatment plant and accuracy of predicted pit water quality. Monitoring of pit inflows to provide ongoing data to update pit water balances.
Grum Pit water and/or discharge	All	OP, AMP, MIT, COMP	Monitoring of water quality in Grum Pit to assess performance on in-situ biological treatment, changes in the pit water quality and accuracy of predicted pit water quality. Monitoring of pit inflows to provide ongoing data to update pit water balances.
WR and Pit Wall Seeps	All	AMP, MIT, EM	Monitoring of waste rock and pit wall seepages for trends in water quality and track any potential changes that could trigger collection and ensure protection of the environment. Also provides data for assessment of accuracy of predicted source loadings from the site.
Tailings Seepage	All	AMP, MIT, EM	Monitoring of tailing seepages for trends in water quality and track any potential changes that could trigger collection and ensure protection of the environment. Also provides data for assessment of accuracy of predicted source loadings from the site

Surface Water Receiving Environment

MORE TO COME FROM AECOM

Table 10.2: Surface Water Receiving Environment Monitoring Overview

Location	Project Stage(s)	Purpose	Monitoring Approach
Reference sites in Pelly R., Rose Cr., Anvil Cr., Vanogorda Cr.	All	EM	Monitoring of water quality a key locations identified as reference sites to provide ongoing assessment of "background" conditions and changes in water quality not related to the project.
Aquatic receiving environment sites within the immediate site footprint	All	EM, COMP, AMP	Monitoring water quality at key locations to detect changes in water quality resulting from specific on-site sources. This will support the AMP and be used to refine WQ predictions.
LSA	All	EM, COMP, AMP	Monitoring water quality at key locations to detect changes in water quality resulting from specific on-site sources. This will support the AMP and be used to refine WQ predictions.
RSA	All	EM, COMP, AMP	Monitoring water quality at key locations to detect changes in water quality resulting from specific on-site sources. This will support the AMP and be used to refine WQ predictions.

Ground Water

Table 10.3: Groundwater Monitoring Overview

Location	Project Stage(s)	Purpose	Monitoring Approach
GW levels and WQ for of groundwater extraction systems	All once collection implemented	OP, AMP	Monitoring of groundwater levels and water quality in areas upgradient and downgradient of local groundwater extractions systems will be carried out on a routine basis to provide information for assessment of system effectiveness and optimization.
Monitoring of GW quality and gradients d/g of potential contaminant sources.	All	OP, AMP, EM	Focused groundwater monitoring will be carried out downgradient of areas of potential contaminant sources. This includes wells in footprint of tailings.
GW gradients near streams	Adaptive and Post-closure	OP, AMP, MIT	Groundwater gradients at key locations along the North Fork Rose Creek, Rose Creek Diversion Channel and Rose Creek will be implemented to assess vertical gradients and groundwater discharge or recharge.
General GW monitoring	All	EM, AMP	Annual monitoring, similar to the current program, will be carried out to assess any trends in groundwater quality. This will include key locations within the site, upgradient and downgradient.

Hydrology

Table 10.4: Hydrology Monitoring Overview

Monitoring component	Project Stage(s)	Purpose	Monitoring Approach
Streamflow in key location u/s and d/s of mine facilities	All	EM, AMP, MIT	Stream flows will be monitored at key locations upstream and downstream various components of mine facilities. This information will be used assess the changes in surface water flow as a result of the project. Areas to be monitoring will include upstream stream flows in the Rose Creek and Vangorda Creek drainages, upstream and downstream of the lined portion of North Fork Rose Creek, downstream of the mine site facilities in Rose and Vangorda Creeks.
Stream baseflow in key areas where activities may affect winter flows	All	EM, AMP	Flows in the North Fork Rose Creek, Rose Creek Diversion Channel, Rose Creek and Vangorda Creek (lower) will be monitored for flows during the winter months. This monitoring will include ice thickness and dept of water below ice. This will provide the necessary information to further delineate the winter baseflow conditions prior to, during and post-closure implementation.

Climate and Air Quality

Table 10.5: Climate and Air Quality Monitoring Overview

Monitoring component	Project Stage(s)	Purpose	Monitoring Approach
On-site climate monitoring	All	EM, AMP, MIT	On-site climate monitoring at Faro Mine Area and the Vangorda Mine Area will continue to provide information for update of the site water balances and assessment of overall cover performance.
Air quality monitoring	Implementation	EM, AMP, MIT	Real-time monitoring will be implemented downwind of closure related activities and will focus on contaminants that pose the most significant risks during implementation activities. Snow sampling and vegetation monitoring (including possible use of moss bags) may also be carried out to supplement the air monitoring program.

Aquatic Ecosystem

TBD – AECOM Benthic, fish, fish habitat, temperature, changes in extent/location of open water areas

Post-Closure Aquatic Ecosystem Monitoring

The post-closure aquatic ecosystem monitoring program will generally be conducted in accordance with the "Aquatic Ecosystem Monitoring Program" (Minnow Environmental, 2010, SD ???) with some adjustments to address other considerations. A summary of the long-term approach proposed by Minnow Environmental is provided below.

Benthic Invertebrates

Benthic invertebrates are good, community-level integrators of localized conditions over time, they are important components of aquatic food webs and there are standardized methods for their collection and evaluation. Therefore, benthic invertebrate community monitoring will be an important component of the long-term monitoring program.

Based on recent site-specific investigations for the Faro Mine, a Reference Condition Approach (RCA) sampling design will be most cost-effective for long-term benthic community monitoring. Initially, monitoring should be conducted at six exposure areas reflecting nearfield and far-field conditions in the Rose and Vangorda Creek drainages (X14, R4, V5, V8,VGMAIN, and X2). A previous study involving formal evaluation of habitat characteristics in both exposure and reference areas identified six to 10 reference areas near the Faro Mine that will be suitable for the evaluation of each exposure area (Minnow 2009). However, additional reference areas should be sought to increase the precision and accuracy of the biomonitoring program. Statistical comparisons between exposure and reference areas should be made for a variety of community characteristics (organism abundance, number of taxa, the first three axes from Correspondence Analysis of the data set, and proportions of dominant taxa) to assess benthic invertebrate community health. Surveys should be repeated over time as discussed below. The magnitude of reference exposure area differences should be tracked to determine if conditions are worsening, improving, or remaining stable over time.

Fish Communities

Fish tend to occupy the upper trophic levels of aquatic ecosystems and are often their most visible and valued components. Both population and community-level assessment can be used as indicators of longer-term exposure conditions (e.g., over years). Therefore, fish community composition and relative species abundance should be tracked at key near-field locations near the Faro complex over time (R2, V8, Rose Creek Diversion) and compared to the communities at two or three reference areas possessing similar habitat characteristics (e.g., Anvil Creek well upstream of the Rose-Anvil confluence, the large tributary to Anvil Creek downstream of the Rose-Anvil confluence and/or Blind Creek).

The recommended methods for fish community characterization are similar to those used in previous surveys, including collection of fish by backpack electrofisher and minnow traps. Also, slimy sculpin populations will be assessed using indicators of population health such as mean length, mean weight, weight relative to length (condition), and length frequency distributions for each mine-exposed area compared to reference areas (sample sizes permitting). Survey results should also be compared to past studies. The surveys will be conducted in late August when water levels and velocity are most apt to be low to moderate and fish distributions relatively stable. Analysis of metal content in fish tissues is not recommended at the present time.

Schedules

A five-year monitoring interval is recommended post-closure for monitoring of biological conditions (benthic invertebrates and fish), consistent with the gradual change expected in water quality over time and an appropriate time interval over which measurable biological change may be detectable. If the first few cycles of post-closure monitoring (e.g., 15-20 years of monitoring on a 5-year cycle) indicate that mine-related impacts are minor and that conditions continue to be relatively stable, it would be appropriate to reduce the frequency of comprehensive monitoring (e.g., once every 10 years), with a trigger identified in the site's Adaptive Management Plan to increase the frequency based on specific increases in the loadings/concentrations of key mine-related substances or any biological surveys that clearly show degradation relative to previous surveys.

Future increases or decreases in the scope and/or frequency of aquatic ecosystem monitoring should be based on the findings of Annual Water Quality Monitoring Reports or Comprehensive Aquatic Ecosystem Study Reports. For example, a trigger to expand the spatial extent or frequency of monitoring (i.e., add a downstream station or conduct another study sooner than formerly scheduled) might be predicated on directly observing biological effects or a step-change increase in contaminant concentrations that could be expected to adversely affect biota downstream. Such triggers will be outlined in the long-term Adaptive Management Plan for the site, along with a description of the action to be taken if and when the trigger threshold is exceeded.

Vegetation

Table 10.6: Vegetation Monitoring Overview

Monitoring component	Project Stage(s)	Purpose	Monitoring Approach
Revegetation Establishment	Post-Closure	EM, AMP, MIT	Annual surveys to locate and control non-native invasive species will be conducted focussing on the first three years post reclamation.
Revegetation Establishment	Post-Closure	EM, AMP, MIT	Regular monitoring of reclaiming landscapes will be carried out an linked to the short-term performance criteria for reclamation/revegetation objectives for each RLU.
Revegetation Establishment	Post-Closure	EM, AMP, MIT	Annual surveys to locate and control non-native invasive species will be conducted focussing on the first three years post reclamation.
Metal Uptake by Vegetation Species on Covers	Post-Closure	EM, AMP, MIT	Monitoring for trace metals in vegetation on covers will be carried out, initially focussing on planted species but as the diversity of plants increases, additional species will be added. This information will This will support the AMP.

Wildlife and Wildlife Habitat

Table 10.7: Vegetation Monitoring Overview

Monitoring component	Project Stage(s)	Purpose	Monitoring Approach
Project related wildlife mortalities	All	EM, AMP, MIT	Document location and reason for wildlife mortality, investigate causes and determine if mitigation method used was effective. Will include annual summary report of mortalities
Habitat use and movements of wildlife species	All	EM, AMP, MIT	Use cameras or observers to monitor sheep use of habitats when near project activities and movements through the Vangorda/Grum area. Ground-based wildlife habitat use assessments will be carried out in proposed clearing areas and adjacent to project activity areas. This data will be used to detect the level of seasonal wildlife use and determine if project activities should be schedule to limit effects.
Uptake by wildlife species	All	EM, AMP, MIT	Trace metal contamination studies carried out as part of the Terrestrial Effects Study will be continued including vegetation and wildlife to determine if changes in trace metal levels in terrestrial biota are occurring.
Establishment of wildlife habitats in reclaimed areas	All	EM, AMP, MIT	Use of ground-based surveys to determine wildlife habitat use and establishment of native vegetation communities within the reclaimed areas. Monitoring will be used to determine the number of reclaimed areas showing wildlife use and the number of reclaimed areas with native vegetation communities. This information will be used to assess the productivity of the reclaimed areas.

10.3.4 Physical and Geotechnical Monitoring

Physical and geotechnical monitoring will provide ongoing information to support the Operations and Maintenance Plans described in Section 10.4.5 of this Project Proposal. The physical and geotechnical monitoring framework is summarized in Table 10.1 and described below for key site components.

Table 10.8: Closure and Post-Closure Monitoring Summary

Monitored Facility	Sampling Location	Method of Inspection	Frequency
Tailings Area			
Intermediate Dam		Visual, instrumentation	Annually
Secondary Dam		Visual, instrumentation	Annually
Cross Valley Dam		Visual, instrumentation	Annually
Spillway		Visual	Annually
Erosion Dissipation Structure		Visual	Annually
Tailings Cover		Visual	Annually
Faro Area			
Faro Pit		Visual	Bi-Annual
Safety Berms		Visual	Annually
Faro Covers		Visual	Annually
Sludge Pond		Visual	Annually
Polishing Pond		Visual	Annually
Sedimentation Basins		Visual	Annually
Cut off walls		Visual	Annually
Vangorda/Grum Area			
Grum Pit		Visual	Bi-Annual
Vangorda Pit		Visual	Bi-Annual
Grum Covers		Instrumentation	Annually
Vangorda Covers		Instrumentation	Annually
Cut off walls		Visual	Annually
Sedimentation Basins		Visual	Annually
Safety Berms		Visual	Annually
Haul Road		Visual	Bi-Annual

Visual Monitoring Program

The visual monitoring program will include inspections of the areas listed in Table 1 for signs of instability and erosion. The facilities will be observed on a regular basis by site employees during normal care and maintenance operations, but will also be inspected more rigorously on an annual or bi-annual basis as noted in Table 1. Facilities that will have more formally scheduled monitoring include: the Intermediate Dam and Spillway, the Cross Valley Dam, the Secondary Dam, and the Pit Walls.

Tailings Area

Visual monitoring of the tailings area can be conducted on a weekly basis by care and maintenance staff and noted in weekly logs. Personnel will be instructed to look for unusual signs of settlement, seeps, and erosion in any of the structures. Annual inspections by a qualified engineer-of-record will be completed and documented in a report. Inspections will continue in perpetuity.

Faro Area

The Faro Pit walls and the safety berm will be monitored regularly, on a monthly basis, by care and maintenance personnel and annually by a qualified engineer-of-record. Personnel will be instructed to look for signs of ravelling, erosion, instability and seeps.

The covers do not require regular monitoring, but should be inspected by care and maintenance personnel immediately following freshet. A qualified engineer-of-record will make an annual inspection as needed.

Sedimentation basins, cut-off walls, polishing ponds and the sludge pond will be monitored regularly by on-site personnel who will be instructed to look for seepage, settlement and erosion. A qualified engineer will inspect these sites during an annual inspection.

Vangorda/Grum

The Vangorda/Grum area will be monitored and inspected in the same way as the Faro Area.

The haul road will be monitored regularly as on-site personnel travel the road on a daily basis. Any erosion or settlement will be recorded in a daily log and the engineer of record will be notified.

Geotechnical Monitoring

Geotechnical monitoring of the Intermediate Dam, Cross Valley Dam and Secondary Dam is required periodically to verify stability and ensure operation within geotechnical design parameters.

Tailings Dams

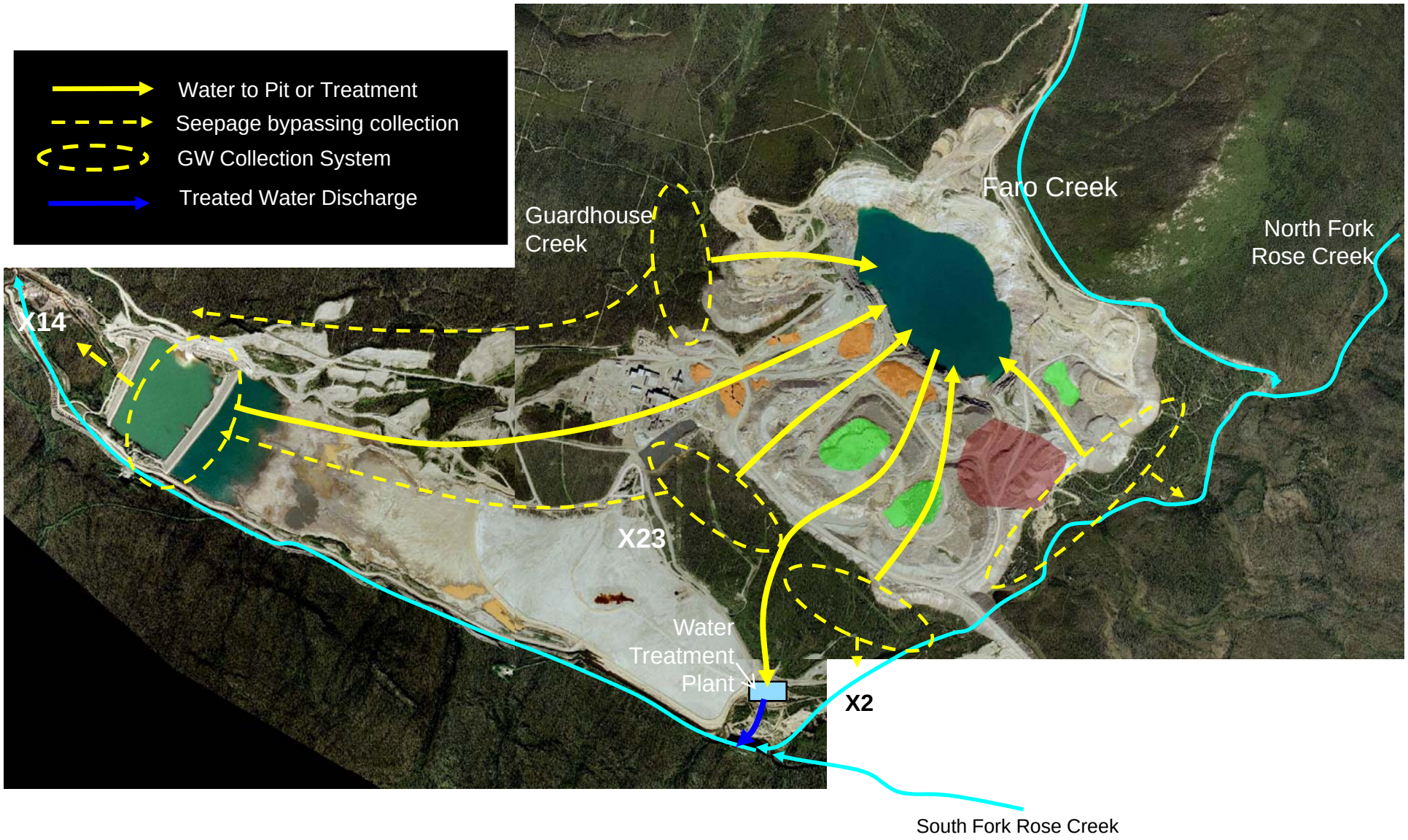
A control station will be located on the north abutment of the Intermediate Dam and monitored regularly by qualified care and maintenance staff. Along with visual inspections, an appropriate level of instrumentation including piezometers, inclinometers, settlement gauges, seepage flow monitors and temperature (permafrost, frost penetration, heating) monitoring systems, will be installed and regularly monitored for changing conditions. Data from the instrumentation will be compiled monthly and sent to a qualified engineer for evaluation based on agreed upon criteria for a monitoring program. The engineer will report annually on the results of the analysis.

TBD SRK Geotechnical Monitoring also needed for other structures.

10.4 Socio-economic Management and Monitoring Plans

Human resources, heritage protection, impact/benefit, blah blah.

Figures



Source: Gomm Environmental Engineering Consulting

Faro Mine Closure
Fermeture de la mine Faro

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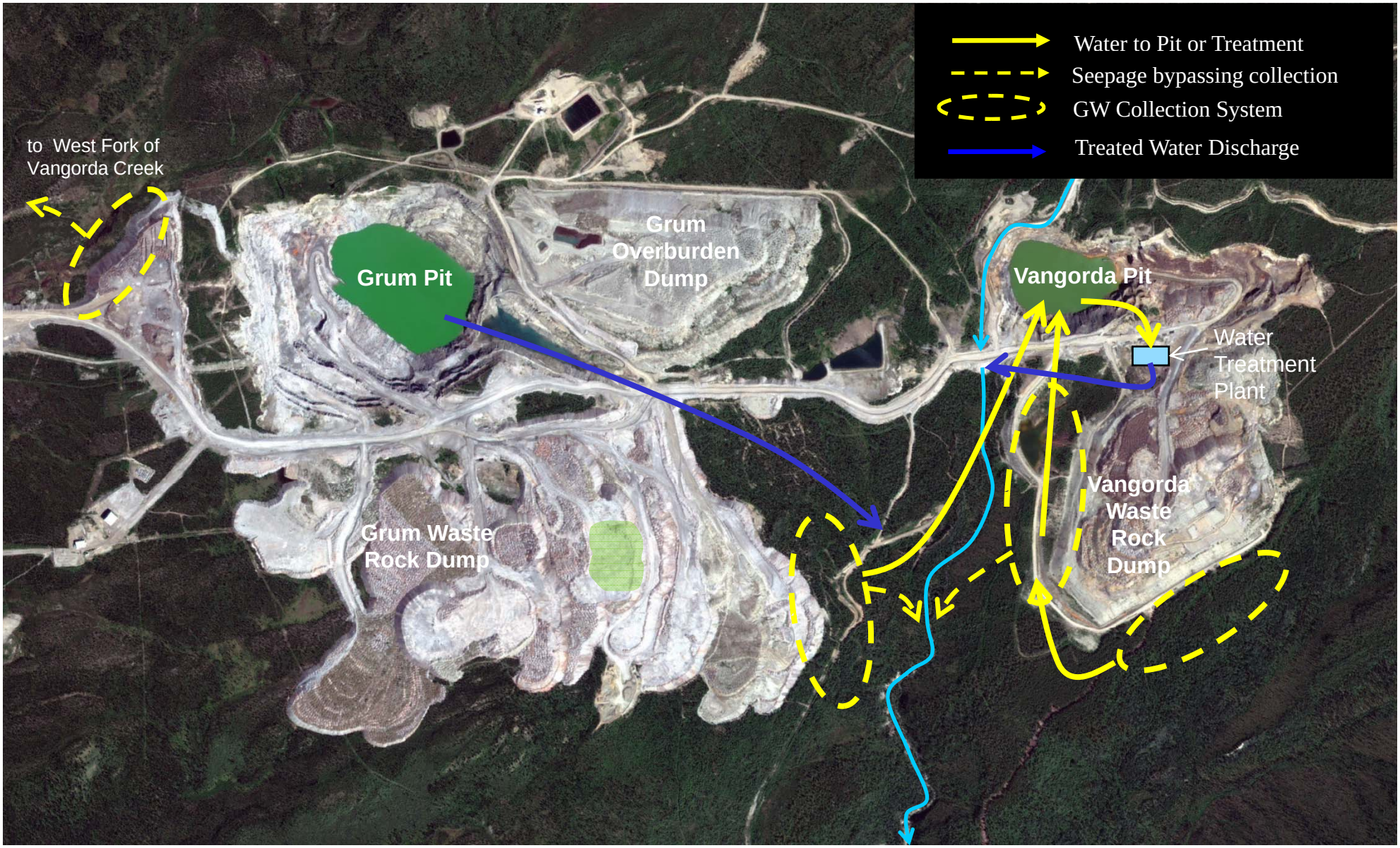
Faro Mine Complex
Closure and Remediation

Project Proposal – Draft 1

Conceptual Schematic of Water Balance Model Faro - Tailings

Date:	Approved:	Figure:
March 2010		10.1



Source: Gomm Environmental Engineering Consulting

Faro Mine Closure
Fermeture de la mine Faro

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Faro Mine Complex
Closure and Remediation

Project Proposal – Draft 1

Conceptual Schematic of Water Balance Model Vangorda

Date:	Approved:	Figure:
March 2010		10.2

Chapter 11

Implementation Assumptions

Chapter 12

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12 References

Chapter 1

Chapter 2

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Chapter 7

Documents referenced in this chapter are listed under "List of Supporting Documents" in the Table of Contents and are available for download from the Faro Mine Complex – Project Proposal FTP site.

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Chapter 10

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Chapter 11

None.