

Final

Gap Assessment Report, Faro Mine Remediation Project

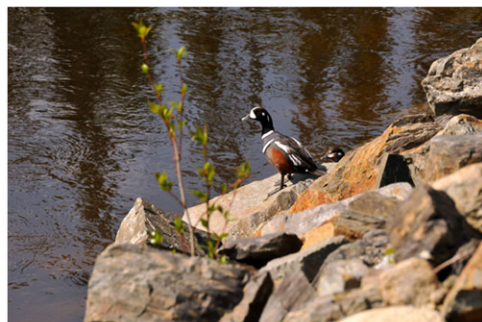
Volume 1: Report

Prepared for
Government of Canada
as represented by Aboriginal Affairs and
the Northern Development Canada and
the Government of Yukon

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CH2MHILL®

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Acronyms and Abbreviations

3D	three-dimensional
AACE	American Association of Cost Engineers
AANDC	Aboriginal Affairs and the Northern Development Canada
ACM	asbestos-containing materials
AMP	adaptive management plan
C&R Plan	<i>Faro Mine Complex Final Closure and Remediation Plan, Project Description – Draft 4A</i>
CAD	Computer-aided design
CH2M HILL	CH2M HILL Canada Limited
COPC	chemical of potential concern
CVD	Cross Valley Dam
DEM	digital elevation map
EA	environmental assessment
EBA	Engineering Consultants Ltd.
ESA	ecosystem services assessment
ET	evapotranspirative
ETA	Emergency Tailings Area
FMC	Faro Mine Complex
FMRP	Faro Mine Remediation Project
GIS	geographic information system
H&H	hydrologic and hydraulic
HDS	high-density sludge
HHERA	human health and ecological risk assessment
IPRP	Independent Peer Review Panel
km ²	square kilometre
LCD	Little Creek Dam
LD/SF	lime demand and solids formed
LGP	low ground pressure
LIDAR	light detection and ranging
m	metre
m ³	cubic metre
MAUA	multi-attribute utility analysis
MCE	maximum credible earthquake
MSA	Master Services Agreement

NF/RO	nanofiltration/reverse osmosis
NFRC	North Fork Rose Creek
O&M	operations and maintenance
PDT	Project Design Team
PM	particulate matter
PM ₁₀	particulate matter less than 10 micrometres in aerodynamic diameter
PM _{2.5}	particulate matter less than 2.5 micrometres in aerodynamic diameter
PMF	probable maximum flood
RCDC	Rose Creek Diversion Channel
RCTA	Rose Creek Tailings Area
SIS	seepage interception system
SRK	SRK Consulting Engineers and Scientists
TA	Task Authorization
TAR	Task Authorization Request
Terra Remote	Terra Remote Sensing, Inc.
TSP	total suspended particulates
WRD	waste rock dump
WTP	water treatment plant
YESAA	<i>Yukon Environmental and Socio-economic Assessment Act</i>
YESAB	Yukon Environmental and Socio-economic Assessment Board
YG	Yukon Government
Zn	zinc

Introduction

1.1 Purpose

Under the Master Services Agreement (MSA) C00010250 (*Project Design Team for Faro Mine Remediation*) dated September, 2011, CH2M HILL Canada Limited (CH2M HILL) is supporting the Faro Mine Remediation Project (FMRP) co-proponents (the Government of Canada, as represented by the Aboriginal Affairs and the Northern Development Canada [AANDC], and the Government of Yukon [YG]) in the remediation and closure planning of the Faro Mine Complex (FMC). CH2M HILL is contracted with the YG to provide technical support in the broad categories of engineering and regulatory approvals support to prepare a submission-ready Project Proposal to the Yukon Environmental and Socio-economic Assessment Board (YESAB).

The second task authorization (TA) under this MSA (TA 002) provided scope and budget for the CH2M HILL Project Design Team (PDT) to initiate technical work activities. The work included the following:

- **Site Visit and Technical Charter** – Gather the Engineering and Regulatory Technical Focus Teams together with representatives of the YG and the Aboriginal Affairs and the Northern Development Canada for a 2-day site visit at the FMC and a 1-day technical chartering meeting in Whitehorse, Yukon Territory. The site visit and meetings were held the week of October 3, 2011.
- **Data Gap Analysis** – Review available reports, data, maps, and analyses previously developed and prepared by other contractors and government entities. Identify and review data or information gaps that may affect or constrain the completion of the Project Proposal, an engineering design (as needed to support the Project Proposal), and an American Association of Cost Engineers (AACE) Class 3 cost estimate. Identify work required to close the data and information gaps.
- **Regulatory Approvals Strategy** – Prepare a regulatory approvals strategy that includes an environmental assessment (EA) and socio-economic assessment methodology workshop, develop and engage a Regulatory Working Group, and prepare a preliminary draft of the consultation and engagement strategy.
- **Preparation of Cost Opinion** – Develop a high-level cost opinion associated with the PDT efforts to prepare the Project Proposal for submission to YESAB.
- **Task Management (Task 02.TM)** – Conduct management activities including coordinating staff and activities for the successful delivery of TA 002.

This final report presents an update to the December 13, 2011 Preliminary Draft Gap Assessment Report by incorporating revisions arising from the January 9–12, 2012 Gap Assessment Review meeting with YG and AANDC.

The other TA 002 activities are addressed in separate documents.

1.2 Initial Gap Assessment

This final report presents the initial gap assessment for closure and remediation of the FMC. It is based on CH2M HILL's current understanding of the proposed project and an initial review of a subset of the available reports, data, maps, and analyses previously developed and prepared by other contractors and government entities. The project description used in this gap assessment was the *Faro Mine Complex Final Closure and Remediation Plan Project Description – Draft 4A* (C&R Plan) (SRK Consulting Engineers and Scientists [SRK], 2010).

1.2.1 Documents Reviewed

Because of the large size and long history of the FMC there is a substantial amount of information that may bear upon the data gaps analysis. To date more than 17,000 files have been received from the YG. To help focus the data gaps assessment Mr. Bill Slater of Bill Slater Environmental Consulting prepared recommended lists of documents that pertain to each engineering discipline. Mr. Slater identified both a comprehensive list as well as a

focused list. Table 1-1 summarizes the number of documents in each list, and Appendix A lists the documents in the focused list. Each of the focused list documents and several comprehensive list documents have been reviewed during this gaps assessment by the respective disciplines.

TABLE 1-1
Document Review Summary
Gap Assessment Report, Faro Mine Remediation Project

Discipline	Comprehensive List	Focused List
Dam Design and Major Structures	70	13
Geochemistry and Water Quality	102	20
HHERA	51	11
Hydrogeology and Seepage Collection	149	23
Hydrology and Surface Water Diversions	53	15
Revegetation and Remediation	99	17
Waste Piles and Tailings	206	21
Water Treatment	22	9
TOTAL	752	129

Note:

HHERA = Human Health and Ecological Risk Assessment

1.2.2 Subsequent Steps

The data gaps presented in this report represents CH2M HILL's first assessment of the information not currently available to complete the engineering design to meet the regulatory requirements to the degree necessary for submission of the Project Proposal to the YESAB. This initial gap assessment will continue to be refined as the project progresses. Subsequent steps include the following:

- Continue to refine the data gaps during the preparation of a final gap assessment report and through subsequent technical evaluations
- Optimize field data needs through further coordination among technical teams
- Plan the field programs to optimize data needs
- Implement the field program late winter through summer 2012
- Refine technical evaluations as new data become available
- Refine existing site-wide models and develop new model components, as feasible
- Initiate design activities for individual components when sufficient data are available
- Conduct baseline evaluations and assessments for the regulatory process

The Project Proposal is scheduled to be submitted to YESAB in October 2014. How this schedule is met is contingent on the level of project definition developed. YG and CH2M HILL will address this uncertainty during a 4-day workshop in January which will evaluate the level of definition to be developed given CH2M HILL's understanding of existing site conditions. The overall project schedule will then be reviewed and updated. This should include an evaluation of the sequence and timing of work so that required information is available in time to support the effects assessment.

1.3 Document Organization

This report includes the following sections and appendices:

- **Section 1, Introduction:** Describes the purpose, objectives, key schedule dates, and organization of this report
- **Section 2, Closure and Remediation Plan:** Provides a brief description of the C&R Plan submittals and scope of the plan.
- **Section 3, Site-Wide Data Gaps:** Provides a summary description from each technical focus team regarding the data gaps identified for the respective technical focus subject areas. To the extent practicable, the descriptions are divided into the principal site areas: Faro, Rose Creek Tailings, and Vangorda/Grum. Where applicable, the description is provided on a site-wide basis. Technical focus areas include the following:
 - Mapping and geospatial
 - Document library
 - Analytical and geotechnical databases
 - Geochemistry/water quality modelling
 - Hydrogeology/seepage collection
 - Hydrology/surface water diversions
 - Waste piles/tailings
 - Water treatment
 - Site civil and mapping
 - Dam design and major structures
 - Revegetation and remediation
 - Human health and environmental risk assessments
 - Mill Area buildings
 - Haul Road
 - Borrow areas
- **Section 4, Engineering Data Gaps:** Describes the engineering data gaps tables presented in Appendix B. The data gaps tables are organized into activity codes presented in Attachment 2-2A of the CH2M HILL June 2011 proposal. These were adopted from the C&R Plan for individual activities, with additional site-wide activities (such as mapping and revegetation trials) included in the CH2M HILL proposal and in this data gaps analysis.
- **Section 5, Regulatory Data Gaps:** Provides an overview of the information requirements for a *Yukon Environmental and Socio-economic Assessment Act* (YESAA) Executive Committee screening and summarizes the high-priority gaps and cross-disciplinary gaps, with details provided in Appendix C (Tables C1 to C6) (see Volume 2 of this report). Tables C1 through C5 are organized into five core environmental and socio-economic assessment activities; Table C6 addresses overarching regulatory gaps:
 - Table C1, Baseline Research and Field Studies
 - Table C2, Baseline Analysis and Interpretation
 - Table C3, Effects Assessment Research and Field Studies
 - Table C4, Effects Analysis and Interpretation
 - Table C5, Mitigation, Adaptive Management, and Monitoring Plans
 - Table C6, Overarching Regulatory Gaps

Closure and Remediation Plan

2.1 Development of Current Closure and Remediation Plan

In 2003, the Government of Canada and the YG accepted responsibility for remediation and closure of the FMC from Deloitte and Touche, the site operator since mining of the site ceased in 1998 and bankruptcy of the mine owner in 1998–1999. In early 2004, a joint agreement was reached between the Government of Canada, the YG, the Selkirk First Nation (on behalf of the Kaska Nation), and the Ross River Dena Council to prepare a closure plan for the site. Senior representatives from these parties formed the Oversight Committee and took a collaborative approach to developing the closure objectives for the FMC. The following five overarching objectives define the desired results of a closure plan, and guide the entire planning and remediation process:

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

From this effort, the Government of Canada and the YG established dedicated internal resources for development of a closure plan and formed the Faro Project Execution Team. Resources were provided to both First Nations to establish community offices for the closure planning. A Technical Advisory Team was engaged to provide technical advice to the Faro Project Execution Team, and the Independent Peer Review Panel (IPRP) was established to review major technical reports and supporting studies.

Beginning in 2002, a series of technical workshops convened to identify and screen closure options. Alternatives were developed and evaluated by SRK, and reviews were conducted by the Technical Advisory Team and the IPRP. This process resulted in development of alternative options for site closure and a draft closure and remediation plan. This section describes the developmental documents.

Options for Closure of the Faro Mine Complex (SRK, 2008a) presented a range of closure options for the Faro Mine Area, the Rose Creek Tailings Area (RCTA), and the Vangorda/Grum Area. These options were evaluated through development of a multi-attribute utility analysis (MAUA) by an 11-member assessment team that compared proposed alternatives with eight objectives (essentially restating the five project objectives identified by the Oversight Committee). The analysis considered short-term and long-term performance and risk (expected and high-risk conditions). The multi-attribute analysis considered the following closure options:

1. For the Faro Mine Area, a single option was evaluated: Regrade all of the waste rock, cover with soil, and revegetate. Design the covers to reduce the amount of water penetrating into the waste rock. Collect contaminated water, store in Faro Pit, and treat the water. Upgrade the Faro Creek Diversion to a stable location.
2. For the RCTA, three options were evaluated:
 - Dry Cover Option: Leave all of the tailings in place and cap with a soil cover; upgrade tailings to withstand the maximum credible earthquake (MCE), upgrade Rose Creek Diversion Channel (RCDC) to pass a 500-year flood event; flood events greater than a 500-year flood, up to a probable maximum flood (PMF) event would be routed onto the tailings and through a newly constructed spillway on the north side of the valley.
 - Complete Relocation Option: Complete relocation of the tailings to Faro Pit, removal of contaminated soil underlying the tailings, and collecting and treating groundwater. At the completion of the groundwater cleanup, Rose Creek would be restored to its original location.

- Partial Relocation Option: Remove the downstream half of the tailings to Faro Pit; upgrade the upstream portion of the Rose Creek Diversion to pass the PMF, and relocate the downstream portion of the creek to its original location after soils and groundwater cleanup.

3. For the Vangorda/Grum Area, two options were evaluated:

- Stabilize in Place Option: Regrade the Vangorda Waste Rock Pile and cap with a soil cover, and reroute Vangorda Creek to a new stable location. Regrade Grum Waste Rock Pile, cover with soil, and revegetate. Collect contaminated water from the waste rock pile, store in Vangorda Pit, and treat.
- Backfill Pit Option: Move the Vangorda Waste Rock Pile into Vangorda Pit and cover. Route Vangorda Creek over the backfilled pit to its original alignment. Regrade Grum Waste Rock Pile, cover with soil, and revegetate.

The *Project Description (Phase 1) Faro Mine Complex* (SRK, 2008b) provided a “preliminary discussion of the Project Description” based on the of the Oversight Committee and their review of the *Options for Closure of the Faro Mine Complex* (SRK, 2008a). This document presented a detailed list of proposed closure activities grouped by the three project areas: Faro Mine Area, RCTA, and Vangorda/Grum Area. Excerpts from reports prepared by various technical groups were provided as an attachment to the report and linked to the assigned activity codes. SRK recognized that many information gaps needed to be addressed to prepare the Project Proposal. The alternatives table included the Dry Cover Option for the RCTA and the Stabilize in Place Option for the Vangorda/Grum Area. The other options were not included in the alternatives table.

The *Project Description (Phase 2) Faro Mine Complex Draft* (SRK, 2009a) provided an update of the Phase 1 report (SRK, 2008b). The Phase 2 report was divided into sections specific to the proposed remedial options for the Faro Mine Area, RCTA, and Vangorda/Grum Area. The closure activities listed in the Phase 1 report were more fully developed, with subsections of the report providing more detailed descriptions of the individual activities. Preliminary design criteria were listed for some of the activities. The document included an example project schedule and preliminary cost estimates.

The *Faro Mine Complex Closure and Remediation Project Description-Draft 3* (SRK, 2009b) provided additional activities including Guard House Creek in the Faro Area, the Polishing Pond in the RCTA, and the Interceptor Ditch to Dixon Creek in the Vangorda/Grum Area. Sections were added to the report pertaining to the project execution strategy and surface water management. Additional design criteria were provided for some activities. The purpose of the document was to provide sufficient data to the EA and socio-economic assessment consultants to complete the assessments for the Project Proposal.

The *Faro Mine Complex Closure and Remediation Project Description-Draft 4* (SRK, 2009c) provided an update of Draft 3. A section specific to design criteria was added to the report. This section provided more detailed descriptions of the proposed covers, groundwater collection strategy based on the adaptive management plan (AMP), surface water management objectives, the site-wide water quality and water balance model, and the AMP. Additional detail was provided in the Surface Water Management section and a new section (Environmental Adaptive Management Plans) was added to the report.

The C&R Plan (SRK, 2010) was the last draft project description prepared by SRK. A water treatment subsection was added to the Design Criteria and Objectives chapter. Additional information pertaining to the environmental AMPs, including long-term and short-term establishment of vegetation, concerns relating to management of invasive species on covers, and trace metal uptake by vegetative covers, was added to the report.

The C&R Plan represents the most current project description. Based on the information contained in the C&R Plan, CH2M HILL estimates that overall, the C&R Plan is between about 1 to 10 percent defined and about a Class 5 estimate in accuracy. Information on the level of project development as related to accuracy of associated cost estimates, as defined by the Association for the Advancement of Cost Engineers (AACE) is presented in Appendix D. To develop a Class 3 estimate that the anticipated level of design is between about 10 and 40 percent depending on the specific component of the design.

2.2 Design and Remediation Uncertainties

There are several technical uncertainties for the project that influence the data gap identification process, including the following:

- The C&R Plan has a range of design levels; in many cases, the level of definition and design identified in the C&R Plan is at the conceptual level.
- Many components of the proposed project present implementation difficulties, and alternatives may need to be considered to develop an effective approach.
- There is uncertainty regarding the water quality goals that will need to be achieved by the project. This results in uncertainty regarding the degree of water treatment that will be required.
- The change in geochemistry of waste rock dump (WRD) and tailings water over time is uncertain. Water quality prediction models have been developed, but the accuracy and timing of these model predictions are uncertain.
- The water quality model (GoldSim) predicts that a very high level of ground water seepage collection efficiency will be needed in the future to meet water quality goals. The ability to meet these collection efficiencies will need to be determined. The IPRP (2010) expressed concerns regarding the reliability of the model to predict future conditions.
- The availability of suitable cover materials having the appropriate properties is uncertain.
- The types of cover systems and final remediation contours to be used in specific locations is only conceptually defined.
- The type of vegetation to be used to revegetate specific locations, and how that vegetation will be established by a designed succession sequence is currently not defined.
- The specific approach to control storm water, snowmelt, and runoff from the covers is currently only conceptually described.
- The IPRP identified several uncertainties that, when resolved, may significantly shape the remedy and result in additional data gaps.

These uncertainties result in additional challenges to identify data gaps and ultimately result in a broader list of data needs.

Site-wide Data Gaps

This section discusses site-wide data gaps and information necessary for development of the Project Proposal and cost estimate.

3.1 Mapping and Geospatial

Topographic and imagery files are available for the FMC and adjacent areas from aerial photogrammetry performed in 2003 and 2009. Computer-aided design (CAD) and geographic information system (GIS) files are available from the 2003 and 2009 mapping and include 2-metre (m)-contour topographic maps with planimetrics for aboveground features at the FMC.

The 2003 data do not overlay the 2009 data. The 2009 mapping is referenced as UTM Zone 8 NAD 83. There was a survey error discovered during the 2003 mapping (SRK, 2009d); the SRK memorandum does not include the source of the error, nor does it provide a resolution. The 2003 mapping is referenced as UTM NAD 83, which CH2M HILL believes to be incorrect. CH2M HILL believes that the 2003 mapping is an approximate UTM Zone 8 North NAD 27 projection. By making this assumption CH2M HILL is able to overlay all of the 2003 CAD and GIS files within approximately 5m of the 2009 mapping. CH2M HILL recommends that an additional field survey be completed to survey an appropriate number of existing monitoring wells. The survey would be used to confirm whether the existing water quality monitoring results can be overlaid accurately onto current light detection and ranging (LIDAR) mapping.

Various reports refer to geotechnical and chemical sampling locations; however, these data are not available in CAD or GIS format. These data would be useful on project maps. To accomplish this, CH2M HILL will request these electronic data. If the data are not available, the data will need to be reproduced by using the coordinate locations listed in the reports for each sampling location.

A GIS database is available for the 2003 survey control points and water quality sampling locations.

The 2003 and 2009 CAD mapping files include horizontal lines for existing pipeline and culverts; however, there does not appear to be any vertical or identifying data available for the pipelines or the horizontal accuracy. A separate utility survey is needed to identify the existing utilities onsite, including horizontal and vertical locations, dispositions, sizes, and materials.

Topographic mapping and digital orthomosaic imagery from 2011 is currently being completed by Terra Remote Sensing, Inc. (Terra Remote), and will be available within the next 2 months for the FMC. The data will be on UTM Zone 8 NAD 83 datum and will include 0.5m interval contours. Stereo photographs are not included in Terra Remote's contract. If these are needed, there will be an additional cost. CH2M HILL has included an additional field survey by a local third party survey firm to confirm the LIDAR mapping accuracy.

The 2003 and 2009 CAD mapping files do not include stereo imagery. Historical and current mapping do not extend to the limits of the watersheds. If additional mapping or imagery is needed outside the project area, it will need to be obtained during the 2012 field investigation.

No site-wide bathymetry data are available electronically. LaBerge Environmental Services prepared bathymetry data for Grum Pit in 2009, but no electronic data are available (SRK, 2009e). Sufficient information has not been located to reproduce these data. The following locations will likely be under water during Terra Remote's updated mapping efforts and will require a bathymetry survey: Faro Pit, Intermediate Pond above Intermediate Dam, Cross Valley Pond, and Vangorda Pit. If the electronic data for Grum Pit is not located, it may need to be included.

If onsite borrow areas are determined to be inadequate in volume or are unsuitable, additional field surveys may need to be preformed. No offsite borrow areas are anticipated at this time.

3.2 Analytical and Geotechnical Databases

After award of the MSA, the YG and various individuals and companies with a history at the FMC provided CH2M HILL with electronic documents including reports (for example, summary reports, field inspection reports, status reports, conceptual design reports, assessment reports, monitoring reports, management plan reports, baseline environmental conditions reports), memorandums, and letters. The data catalogue currently contains approximately 17,000 electronic files including draft and final versions of documents and duplicate copies with various file names. The file formats include PDF and Microsoft Word documents and source files in CAD, GIS, and Microsoft Excel formats.

To use the existing data to the greatest efficacy, the historical reports and data will be reviewed and catalogued. A library will be created that will contain single copies of final reports (or final draft reports if final were not prepared). These reports will be complete and will include electronic copies of appendixes. The raw data used to support the conclusions of these reports will be included in the electronic library.

In some cases, the electronic files do not have readily accessible data files (CAD, GIS, or Excel) that can be uploaded directly into a database. For these files, the data will be converted (by either an electronic scan or manual entry) to enable the data to be uploaded into the database. In other cases, the reports reference appendixes that are not attached to the electronic document. These missing data reports (and the supporting data files) need to be located and uploaded into the database.

The original data will be compiled, extracted, and loaded into a relational database to support technical manipulation and interpretation of the data. Quality assurance testing will be completed for the data transferred into the database so that units, sample identifiers, and physical locations are relevant, representative, and accurate. Additional information will be reviewed, if available, regarding quality of existing data. This will include evaluating whether the data were collected under a quality assurance plan and whether the resulting data underwent a validation process. This will allow the engineering team to use the existing data to support interpretations, create models, identify data gaps, and support the engineering designs used for the remediation activities. In addition to the data contained in these reports, data are being collected as part of the ongoing care and maintenance activities at the FMC. These data are contained in the EmLine database, currently managed by the care and maintenance contractor, Denison Environmental Services. The data contained in the EmLine database will be uploaded into a new database developed by CH2M HILL.

As the technical focus teams fill the data gaps, the new data will be added to the existing database to support interpretation, modelling, and designs.

3.3 Geochemistry/Water Quality Modelling

The water quality modelling data gaps identified for the C&R Plan are site-wide activities that are not categorized by individual area. The geochemistry team has identified four major data gaps: (1) refinement of the existing site-wide water balance model, (2) tying reliable predictive geochemical modelling to the water balance model to generate a site-wide water quality model, (3) continuation of the site-wide, historical seep monitoring program in support of the water quality modelling effort, and (4) incorporation of pit lake modelling to improve water quality predictions of pit water quality and to possibly aid the assessment of biological treatment at Grum Pit.

The current water quality model at the site consists of a GoldSim model and two spreadsheet models (referred to as SRK spreadsheet models). The SRK spreadsheet models provide water quality input for the GoldSim model. One spreadsheet model provides input for contaminant load from the RCTA and the other provides input on the contaminant load from Faro, Vangorda, and Grum waste dump seepage. The GoldSim and spreadsheet models were developed to predict current and future geochemical conditions of the FMC. The two SRK spreadsheet models are not currently available for review and incorporation into an updated model.

The GoldSim model was developed primarily as a risk assessment tool to predict water quality in the receiving environment. The GoldSim model in its current form does not provide information regarding infrequent events that will need to be evaluated in the risk assessment. There would also be a benefit to use the GoldSim model as a

water treatment design tool; therefore, the model needs to be updated and refined so that it can serve the dual purpose of providing predictive data for water treatment design and help assess risks to downstream receptors.

The following main data gaps related to the water quality modelling were identified:

- A detailed review of current model capabilities and the approach taken to model the site-wide water balance is necessary to support refinement of the depiction of the hydrology and runoff components of the water budget. The model currently does not have an overall mass balance check, and addition of this feature would add great value to the model. A mass balance check could potentially identify problems with model operations during the implementation of new features like the tailing areas.
- New hydrological parameters (rainfall and runoff) will be updated in the existing model by using extended data up to the most current date available. A separate model will be used to develop runoff values that will be input into the existing model. Depending on the quality and resolution of the historical hydrological data available to estimate runoff, the model time step could be adjusted or the monthly patterns could be changed (currently the model uses one annual average for runoff and precipitation with a monthly pattern applied to it) to better meet project objectives. AECOM (2009) identified some hydrological data and more recent stations that did not have enough data at the time of their analysis. CH2M HILL assumes that, at minimum, these data will be available to update the runoff estimates.
- New groundwater parameters will be uploaded to the existing model as needed. The current GoldSim model parameters include seepage, groundwater collection efficiency, and groundwater fractions that are discharging into the pits versus other surface water features. The update will be based on new values obtained from the CH2M HILL groundwater modelling team as they find that updates are relevant and important for a more accurate GoldSim model.
- New updated coefficients for the covers will be included in the model. The new coefficients will be based on more recent observed data and associated vadose zone modelling analysis.
- Assuming the SRK spreadsheet models will be made available and must be verified, the data gaps associated with the geochemistry of the waste dumps include (1) seepage water quality predictive tools to predict/update seepage water quality from these facilities during and after closure (that is, with and without covers) and to feed the overall site-wide water quality model, (2) confirmatory acid base accounting testing for a limited number of samples to address the IPRP concerns related to the accuracy of neutralization potential characterization of materials to date, and (3) seepage water quality monitoring to expand the database and respective models (that is, update existing water quality model).
- The geochemical investigations of the Rose Creek tailings materials to date have identified active oxidation of these materials and generation of three fronts of contamination including an acid front, zinc (Zn) front, and total dissolved solids front. A sulphate front may also exist but likely is already in the subsurface. One of the SRK spreadsheet models was developed to predict the generation and advancement of these fronts. Assuming this model will not be available, the data gaps associated with the geochemistry of the tailings include (1) seepage water quality predictive tools to predict/update movement of these contaminant fronts from the Rose Creek Tailings during and after closure (that is, with and without covers) and to feed the overall site-wide water quality model, (2) confirmatory static (acid base accounting) testing on a limited amount of samples, and (3) pore water and seepage sampling and analysis to confirm/update predictions of the different contaminant fronts (that is, update the existing water quality model).

3.3.1 GoldSim Model Improvements

The three main additions to the current water quality model will consist of (1) generating new geochemical spreadsheet input models for GoldSim to replace the SRK spreadsheet models (as described in Section 3.3), (2) adding a contaminant transport model to capture the lag time in mass loading peaks from subsurface components, and (3) coupling the geochemical models to impose equilibrium in the final mass balance around the pits. These two modelling efforts will include an evaluation of the most appropriate software tools to conduct the

modelling assessments. Models that will be evaluated include the GoldSim contaminant transport module, PRHREEQC, and Geochemist Workbench.

Although functional and well organized, the current model lacks user interfaces for input and output. A user friendly input dashboard will be added to accommodate modification of model parameters that will be changed by the user for the scenarios that require evaluation. A few user output dashboards will also be developed to facilitate the interpretation of the model results. The final model should be a self-explanatory tool with respect to inputs and resultant output so that it can be updated and used by decision makers to help evaluate adaptive management options resulting from evolving site conditions.

Other GoldSim model improvements identified include (1) updating the current infiltration data by using updated infiltration rates based on the SRK (2006a) memorandum and updating cover infiltration data based on the proposed final closure design and theoretical cover infiltration data, (2) better handling of extreme hydrological events, (3) better stochastic approach to evaluate model parameters that are considered uncertain, (4) different options to manage and route runoff or pit flows to the water treatment plant(s) (WTP) or possible options that will result in better management of the site runoff (the model should be flexible to evaluate future options that might arise with a better understand of the site), (5) more control of the efficiency (or range of stochastic values) of the groundwater collection system, (6) flexibility in evaluating different options regarding routing of the groundwater collection system, (7) proper estimates of the runoff water quality conditions, (8) an option to include large storage reservoir at the Cross Valley Pond, and (9) an option to connect Vangorda Pit to Faro Pit.

In addition to modelling the geochemical throughputs of the pit lakes, the pit lakes need to be modelled to determine the potential for seasonal stratification as it relates to sludge disposal in Faro Pit, the quantity of transient water storage in Vangorda Pit and Faro Pit, and the potential effects of biological treatment in Grum Pit.

If required, the pit lakes will be modelled by using CE-QUAL-W2, which is a two-dimensional, laterally averaged, hydrodynamic and water quality model. CE-QUAL-W2 can model basic eutrophication processes, such as temperature-nutrient-algae-dissolved oxygen-organic matter and sediment relationships. When coupled to geochemical modelling software, such as PHREEQC, it can predict pit lake behaviour with regards to sludge storage, and seep interception system inputs. Currently, there are insufficient data to characterize basic, year-round lake dynamics (that is, stratification data and seasonal pit dynamics data). It is important to obtain year-round data from each pit lake. Monitoring devices may be installed to collect year-round conductivity, temperature, density, dissolved oxygen, and redox data, or several sampling events may be conducted to collect water quality samples for analytical testing.

3.3.2 Sensitivity Analysis

While the models are being developed (or updated in the case of existing models), a sensitivity analysis will be necessary to understand the importance of assumed key model parameters in model predictions. A specific task will be designated for this modelling effort. Post-processing spreadsheet tools and model output dashboards will be used for the sensitivity analysis.

3.4 Hydrogeology/Seepage Collection

The hydrogeologic data gaps discussed in the following sections are intended to complete the quantitative conceptual models for the high-priority sites where groundwater interception appears warranted to protect downgradient surface water and groundwater quality. These data will be used to facilitate the development of numerical groundwater modelling tools that describe the groundwater conditions in these high-priority areas. The modelling tools will be used to quantify water movement through the aquifer systems at each site, test various configurations of potential groundwater interception facilities, and optimize the design of facilities that are currently operating. These models will be refined as additional data are collected during system installation and modification, and they will be valuable tools to support future groundwater management decisions at the site.

Separate groundwater flow models encompassing the Faro Mine Area and the Vangorda/Grum Area will be prepared. These models will provide estimates of groundwater flow directions, rates, and exchange between the surface water and groundwater systems within the model domain. The groundwater flow models will be used to

estimate contaminant loading from groundwater to surface streams, support the design of groundwater interception systems, and evaluate the sensitivity of the performance of various waste rock cover systems on groundwater flow rates and seepage interception system (SIS) effectiveness.

3.4.1 Faro Area

The primary data gaps in the Faro Area are related to (1) characterization of the subsurface conditions in areas where groundwater interception is planned or currently implemented or (2) the degree of interaction between the surface streams at the site and the underlying aquifer system. Additionally, pre-mining surface topography is a data gap for the Faro Area. This information will aid in determining where future contaminated seepage may occur.

The three areas of interest are the Emergency Tailings Area (ETA), the S-Wells Area, and the Zone II Outwash Area. The primary data gaps for each are summarized in the following sections. In addition, the Rose Creek Tailings Area will be included in the Faro Area Groundwater Model.

3.4.1.1 Emergency Tailings Area

The proposed project recommends removal of the ETA tailings, collection of WRD-affected groundwater and surface water in Old Faro Creek and Mill Canyon upgradient from the ETA, and interim operation of the surface water collection and SIS immediately downgradient from the Mine Road (with planned shutdown after ETA tailings removal and the remedial activities in the Mill Buildings Area and WRD are complete and verified to be effective). Adding a more robust surface water and groundwater collection system downgradient from the Mine Road near the existing SIS as part of the remedial action might be preferable for the following reasons:

- This is a natural groundwater discharge point for the area.
- The upgradient groundwater and surface water collection systems specified in the proposed plan would not likely capture all groundwater contamination associated with the Mill Buildings Area and WRD that flows into and adjacent to the ETA.
- The success of the current ETA SIS (which has about 80 percent seepage recovery when operated [Robertson GeoConsultants, Inc., 2010]) suggests this area can be an effective seepage capture location, and installation of an engineered capture system (that also takes into account potential contaminant flow from the Mill Buildings Area) could significantly increase the overall effectiveness.
- There are more robust options for contingency planning and containment of contaminated seepage discharge in the event of system upsets or temporary suspension of pumping.

To help design the upgradient surface water and groundwater capture systems and to upgrade the SIS downgradient from the Mine Road, the following data gaps need to be filled:

- Better delineate the surface water and groundwater flows that enter the ETA along the Mill Canyon drainage and from the Mill Buildings Area
- Better characterize the upper fractured bedrock surface to facilitate the design of seepage cut-off systems
- Better characterize the aquifer thickness and bedrock topography in Old Faro Creek and Mill Canyon upgradient from the ETA and southwest (downgradient) from the Mine Road
- Characterize aquifer properties west (downgradient) of the Mine Road (in alluvium and weathered bedrock)

3.4.1.2 S-Wells Area

Groundwater collection is also currently being performed in the S-Wells Area through a combination of a shallow permeable collection trench and two deeper groundwater extraction wells screened in the weathered bedrock aquifer. Current estimates of the effectiveness of this system at intercepting contaminated groundwater are on the order of 80 percent. Therefore, data gaps at this site focus primarily on collecting additional information about subsurface conditions to support modifications to the existing system to achieve a higher level of effectiveness. Remaining data gaps at this site include additional characterization of the hydraulic properties of

the weathered bedrock aquifer at the site, improved delineation of the bedrock topography in the vicinity of the existing SIS facility, improved characterization of the alluvial aquifer between the SIS and North Fork Rose Creek (NFRC), and better quantification of the degree of hydraulic interaction between the alluvial aquifer and the NFRC.

3.4.1.3 Zone II Outwash Area

The primary data gaps that remain in the Zone II Outwash Area focus on better delineation of the aquifer properties of both the alluvial and weathered bedrock aquifers in the area, characterization of the saturated thickness of the alluvial aquifer and bedrock topography in the vicinity of the planned SIS, improved understanding of the three-dimensional (3D) distribution of contaminated groundwater requiring capture, and better definition of the spatial and temporal variation in groundwater/surface water interaction between the alluvial aquifer and the NFRC.

3.4.2 Rose Creek Tailings Area

Effective groundwater interception in the RCTA is one of the most critical aspects for implementation of a protective remedy for the Faro Mine Area. All of the surface water and groundwater that originates in the vicinity of Faro Mine naturally drains into the RCTA. Therefore, any contaminated groundwater that by-passes facilities located upstream must be intercepted at the RCTA to prevent continued migration to downgradient receptors. Several locations have been considered for the construction of a groundwater SIS in this area. The location that appears to have the greatest potential for construction of a highly effective groundwater SIS is immediately downstream from the Cross Valley Dam (CVD). The C&R Plan identifies the groundwater SIS in the area between the Intermediate Dam and the CVD. The location immediately downstream from the CVD is at the lower end of the area identified in the C&R Plan. Investigation of areas upstream from the CVD is not planned.

The area immediately downstream from the CVD has undergone significant site characterization with the installation of monitoring wells in the alluvial and bedrock aquifers, aquifer testing, and the construction of a 3D numerical groundwater flow model of the area. However, because of the critical importance of achieving a very high level of effectiveness of groundwater interception at this facility, some further delineation of subsurface conditions is required to support the SIS design. These additional data gaps include further delineation of the bedrock topography across the Rose Creek Valley immediately downstream from the CVD and in the vicinity of a potential cut-off wall included as a contingency measure. Additional characterization of the hydraulic properties of the alluvial and weathered bedrock aquifers in the vicinity of the planned SIS is also required to support system design. Additional monitoring wells are also required downgradient from the proposed facility to improve characterization of the alluvial aquifer geometry and properties, improve understanding of the hydraulic interaction between the alluvial aquifer and Rose Creek, and provide monitoring data to assess system effectiveness during operation.

3.4.3 Vangorda/Grum Area

The bedrock in the Vangorda/Grum Area generally consists of phyllite and schist overlain by glacial till with discontinuous silty sands and gravels near creek channels. Thus, the bulk permeability of the aquifer system is more limited than in the Faro Mine Area, which is located approximately 10 kilometres northwest of the Vangorda/Grum Area. Bedrock in the Vangorda/Grum Area is generally within 30m of the land surface, resulting in a relatively thin distribution of overburden sediments (which further limits the capacity of the aquifer system to transmit groundwater).

No seepage collection system exists along the toe of the Grum WRD; however, a system exists along the toe of the Vangorda WRD. A more robust seepage collection system is currently not required, but the metal loads in seepage from the Vangorda and Grum WRDs are anticipated to increase in the future as acid rock drainage reactions mature. The SIS facilities anticipated for this area will likely rely on the construction of high-permeability trenches excavated into the weathered bedrock. Groundwater extraction wells will be installed at regular intervals along each trench alignment and operated to intercept contaminated groundwater if data resulting from routine groundwater monitoring activities indicate mine-affected groundwater is moving from the WRDs into downgradient areas.

Data gaps identified for the Vangorda/Grum Area are generally classified into two categories: insufficient subsurface characterization and an insufficient groundwater monitoring network. Data gaps identified for areas beneath and downgradient from the Vangorda/Grum WRDs include the following:

- Pre-mining land surface topography
- Bedrock surface topography
- Spatial distribution of hydrostratigraphic units
- Saturated thickness of the aquifer system
- Aquifer properties (overburden and shallow bedrock)
- Groundwater flow directions
- Contaminant groundwater plume extents
- Seasonal gaining versus losing reaches along Vangorda Creek
- Reliable survey location coordinates for existing monitoring and operational infrastructure
- Robust groundwater monitoring network

Metal loads in seepage from the Vangorda and Grum WRDs are anticipated to increase in the future as acid rock drainage reactions mature. A better understanding of the pre-mining land surface topography and bedrock surface topography beneath and downgradient from the WRDs would facilitate identifying potential future seepage pathways that could be targeted for routine monitoring and possibly for subsurface interception. Evaluation of these seepage pathways and their subsurface hydraulic properties is necessary to implement a robust groundwater monitoring network that provides sufficient early warning triggers in accordance with the AMP. Having a more robust groundwater monitoring network would facilitate evaluating seasonal gaining versus losing reaches along Vangorda Creek, groundwater flow directions, and contaminant plume extents downgradient from the Vangorda and Grum WRDs.

Before data gap fieldwork commences, a field reconnaissance of the Vangorda/Grum Area will be necessary to identify access limitations in areas slated for fieldwork. Activities associated with Access Road improvements and construction would need to be completed as early as possible in 2012 to maintain the data gap fieldwork schedule.

3.5 Hydrology/Surface Water Diversions

This section discusses the design basis for the surface water diversions and local surface water conveyance components, and the information required to design diversions and local conveyance projects. The primary basis for design of the surface water diversion alternatives on the mine site has been, to this point, the maximum conveyance capacity required for each of the diversions and the separation of clean water from potentially contaminated water. There has been a considerable effort to assess the infrequent rainfall events associated with maximum required conveyance capacities such as the 500-year rainfall event as well as the probable maximum precipitation event and the potential impacts they have on the design elements of the diversions. There has also been a considerable effort to define the groundwater contaminant contribution to water quality and quantity issues associated with surface water. There is, however, a need to examine the surface water objectives from an overall site-wide management perspective to determine a more comprehensive basis for design. This basis for design developed through a site-wide surface water management plan would incorporate a range of flow regimes in the analysis that have varying impacts on the viability of aquatic habitats, wetland and riparian habitats, water quality, and stream stability. The site-wide water management plan will also focus on water budgets and water quality, from both a surface water and groundwater perspective. The surface water management plan will be part of an overall AMP for surface water, which is the basis for long-term management of surface water on the entire site.

To support the objectives developed through a site-wide surface water management plan, a site-wide hydrologic and hydraulic (H&H) model is the key tool required to (1) define the constraints and opportunities associated with the major components of the existing surface water collection and conveyance system, (2) quantify impacts of proposed site-specific surface water diversion/conveyance alternatives and in relation to an expanded design basis, and (3) quantify impacts of remediation activities on dams and existing conveyance structures. The models

will be used to assess impacts caused by normal and infrequent precipitation events. These are important for developing a comprehensive basis for design and will include the medium- and low-flow conditions that support local ecosystems as well as when groundwater inflows potentially account for a major portion of the flow. Integration with field efforts to fill information gaps and support the development of groundwater/hydrogeological modelling will assess processes required for the surface water modelling efforts. The H&H tool will be used in conjunction with groundwater quantity and quality information and tools developed as part of the hydrogeological tasks.

Outside of the major diversions/conveyance components, several areas on the mine site will require local drainage design components to be developed within the surface water management plan. These areas include waste rock piles, Tailings Areas, and seepage collection areas, as well as locations where the principle design criteria focus is on conveyance of local runoff and seepage across or away from erosion-prone areas and critical seepage areas. These areas may not be integrated into the H&H model to develop a design basis but will require collection of site-specific survey, seepage and basin information that will contribute directly to the designs of local swales and collection ditches/trenches. The primary goal of these efforts is to collect contaminated surface water runoff and seepage, and convey it to treatment facilities rather than allow it to negatively affect receiving surface water systems from an erosion or water quality perspective.

Several specific analyses have been performed, and survey, geotechnical, and hydrological data have been gathered at various times throughout the site to support the development and analysis of the current documented diversion and conveyance alternatives. One goal of the proposed surface water investigation is to supplement existing data with additional information to develop the site-wide H&H tool that includes all major catchments and conveyance elements.

Key data gaps in relation to the H&H tool are classified into two categories: site-wide and site-specific. From a site-wide perspective, meteorological data are a key requirement. A review of existing meteorological and flow monitoring data is required to determine (1) the periods for which data have been gathered, (2) the periods when flow and precipitation data were gathered concurrently, and (3) data gaps and potential data errors.

From a site-specific perspective, there is a need for reliable flow data at key locations in the major diversions. Flow and precipitation data are critical for model development because those data allow calibration and validation of model assumptions based on actual system response. The *Faro Mine Complex Closure and Reclamation – Project Proposal. Current Environmental Conditions Supporting Document* (AECOM, 2009) provides a summary of available existing data. The report shows that continuous flow monitoring data were collected for a relatively short period (2 to 3 years) at many of the sites, and the dates of record are not consistent among the various sites. Therefore, it is important to gather as much concurrent precipitation data and flow data as possible from various stations throughout the site to develop a refined H&H modelling tool capable of predicting system response under various meteorological conditions, and to define baseflow conditions and potential groundwater interactions and impacts. There is also a need for accurate survey data from the major diversions and other conveyance structures. The survey data are critical to the development of a refined H&H modelling tool capable of predicting system response under various design configurations. The H&H tool will be used in conjunction with groundwater quantity and quality tools developed as part of the hydrogeological tasks.

In addition to continued flow and precipitation monitoring at previously established locations, new flow monitoring locations have been identified at key locations throughout the conveyance system. Table 3-1 provides a summary of existing and proposed surface water data collection points throughout the site. In addition, snow surveys and spring freshet flow data may be needed.

Another critical element associated with development of the H&H models is the requirement for detailed topographical and channel condition information. Existing topographic and catchment mapping will be used to delineate the various catchments and subcatchments that will be included in the hydrologic model. Existing topographic mapping (including the 2011 LIDAR mapping) should be sufficient for delineating catchments and developing floodplain cross sections for model development. However, additional site-specific survey information will be required at various locations through the conveyance system to characterize channel reaches. The survey work will define channel cross sections where there are changes in channel form and longitudinal grade,

confluences, expansions, contractions, and hydraulic structures. This information is necessary to properly define unique conveyance elements in the hydraulic model.

TABLE 3-1
Existing and Proposed Data Collection Stations
Gap Assessment Report, Faro Mine Remediation Project

Collection Station ^a	Station Name	Parameters	Description
Faro and Rose Creek Area			
Existing	Faro Dump	Rainfall	Meteorological station on Faro portion of site
Existing	FDU	Flow	Faro Creek East Valley Diversion
Existing	R7	Flow	NFRC
Existing	RCDC	Flow	RCDC
Existing	X14	Flow	Rose Creek downstream from FMC
Proposed		Flow	Rose Creek upstream from the NFRC confluence
Proposed		Flow	Lower Guardhouse Creek
Proposed		Flow	RCDC adjacent to Tailings Area
Proposed		Flow	RCDC adjacent to Tailings Area
Proposed		Flow	RCDC adjacent to Tailings Area
Vangorda/Grum Area			
Existing	Grum Dump	Rainfall	Meteorological station on Vangorda/Grum portion of site
Existing	29BC003	Flow	Vangorda Creek downstream from site
Existing	V1	Flow	Vangorda Creek upstream from Vangorda Pit
Proposed		Flow	Vangorda Creek upstream from Grum Creek
Proposed		Flow	Grum Creek
Proposed		Flow	Dixon Creek

^a Existing sites identified on Figures 3.1-1 to 3.1-3 in the *Faro Mine Complex Closure and Reclamation – Project Proposal. Current Environmental Conditions Supporting Document* (AECOM, 2009)

Groundwater seepage contributes to base flows in several channel and diversion areas, but a primary focus to-date has been on the three areas that potentially contribute significant contaminant levels: the ETA, the S-Wells Area, and the Zone II Pit Outwash Area. Additional groundwater data collected during the groundwater investigations will provide important information for the surface water investigations regarding the relative contribution of groundwater to low-flow conditions in the channels and diversions.

Geotechnical information, soils data, and channel composition are other key components that contribute to the design of the channels and diversions and the development of the surface water models. The geotechnical conditions in the area of existing channels provide an indication of the stability of particular channel sections; in areas where new diversions are routed, this information is required to determine potential permafrost impacts and channel stability. This may require boring samples and possibly thermistor strings installed at regular intervals. The surface water models require channel bed, bank, and floodplain composition to be defined to better estimate the channel conveyance capacity and stability under extreme rainfall events. This information will be collected through field reconnaissance.

To a large degree, the extent to which additional, detailed, cross-sectional and structure survey data are required will be determined on a site-specific basis during the initial field reconnaissance; it is expected to be a significant

effort. The degree to which the hydraulic modelling tool can be used to predict flows under various hydraulic conditions for existing channels and structures is directly dependent on detailed, reach-specific, cross-sectional data; accurate representation of related conveyance infrastructure and conditions related to channel composition; and hydrogeological and geotechnical influences. Also, seasonal factors such as snowmelt, rain on snow, and icing will affect the hydrograph. New channels will be evaluated with the model by using design cross sections superimposed within the native topography.

3.5.1 Faro Area

Faro Area diversions primarily include the Faro Creek Diversion (and West Valley Extension), the North Wall Interceptor Ditch (and Upper Guardhouse Creek), and the Lower Guardhouse Creek upgrades. The East Valley and West Valley extensions are new channel sections that are planned through mostly undisturbed areas that serve to relocate the existing Faro Creek Diversion farther from the Faro Pit Wall. The survey will provide detailed topographic data required to plan the new alignments and determine contributing drainage areas. Previous field efforts have provided general topographic and geotechnical information from test pits at 200m intervals along the planned alignments. Additional geotechnical information will provide the information required for the design of the diversions and the critical alignment of the downstream portion of Faro Creek with the NFRC at the proposed cutoff wall. However, the material available for channel construction and lining needs to be investigated further because it is key to stability and capacity. Flow monitoring has been suggested as part of the field effort recommendations.

The North Wall Interceptor Ditch is an existing channel that accepts uncontaminated flow from Upper Guardhouse Creek. The upgraded North Wall Interceptor Ditch will discharge to Rose Creek downstream from the CVD. There is a lack of detailed cross sectional survey data, geotechnical and soils composition data, and channel capacities for Upper Guardhouse Creek and the North Wall Interceptor Ditch.

Lower Guardhouse Creek, which will not be hydraulically connected to Upper Guardhouse Creek, collects drainage from the Mill Area and crusher stockpile as well as groundwater seepage that will be piped to Faro Pit. Local drainage information from new survey data and groundwater seepage investigations will be used to determine the required capacity for the ditch and associated pipeline to Faro Pit.

Surface water runoff from waste rock piles in the Faro Area will be managed through the use of berms and conveyance ditches to limit erosion and control sediment discharge to creeks.

3.5.2 Rose Creek Tailings Area

Rose Creek in the Tailings Area primarily consists of the NFRC, South Fork Rose Creek, and the RCDC, with associated hydraulic structures including the North Fork Rock Drain and the required RCDC fuse plug. There is a considerable amount of information available for these creek sections, but these areas are perhaps the most hydraulically complicated of the channel and diversion sections at the FMC. In general, the Rose Creek drainage basin requires modification to accommodate the PMF condition. The proposed approach to spill the volume of water from the RCDC section of the basin above a 500-year flood event is to direct the flow exceeding the 500-year flow event over the Tailings Area. This requires a redesigned fuse plug, erosion dissipation design, a design to convey flows over the tailings, and, ultimately, a design for the required spillway at the Intermediate Dam, and potentially the Cross valley Dam. Additional, detailed survey data and a condition assessment are critical for this analysis. Additional survey data in the RCDC to determine channel configuration is also warranted because channel upgrades and seepage estimates are required to determine the necessary upgrades to the channel configuration to accommodate a 500-year flood. Several flow monitors have been suggested as part of the field effort recommendations.

There is also a requirement to construct a fish ladder in the RCDC, which will require additional site-specific surveys and hydraulic and geotechnical data. Upstream from the fuse plug, the RCDC needs to be upgraded to convey the PMF; therefore, additional survey data are critical for this area. Breaching the North Fork Rock Drain also requires a detailed survey and condition information for development of the H&H models. In the RCTA, the objective is to manage contaminated surface water through collection and conveyance to Faro Pit for treatment.

3.5.3 Vangorda/Grum Area

The Vangorda Creek Diversion has experienced stability and conveyance issues under high-flow conditions, and it needs to be redesigned. The H&H models related to the diversions in the Vangorda/Grum Area will require additional survey and flow monitoring data. The interceptor ditch that carries uncontaminated surface water to Dixon Creek also requires an upgrade to accommodate flows. Drainage basin information including survey and runoff/seepage data will also be required for the design. Redesign of the Grum Interceptor Ditch is required to convey flows to Grum Pit. This will also require a site-specific survey, drainage basin information, and runoff/seepage data.

The Vangorda/Grum Area contains waste dump areas that require runoff, sediment, and seepage control because a low-infiltration cover will be installed as part of the closure process. Additional site-specific information including some local areas of topographic survey and geotechnical data will be required.

3.6 Waste Piles/Tailings

The waste piles data gaps discussed in the following sections address the characterization of the waste rock and adjacent foundation soils required to optimize the regrading and capping of the waste rock dumps.

Fundamental data gaps that remain to be addressed for the capping of the waste rock dumps include: geotechnical properties of waste rock to facilitate static and earthquake loading stability assessments and cover design; reactivity of waste rock that will be exposed during regrading of the waste rock dumps; landform design for managing surface runoff, minimizing erosion and supporting self-sustaining vegetated cover; and the anticipated field performance of the various proposed cover designs. In addition, steep waste rock slopes (that is, greater than 4:1 horizontal to vertical) pose several remediation challenges from both a water management and revegetation perspective. Controlling erosion from revegetated slopes will require robust and thoughtful designs for water conveyance and will also need to incorporate a variety of techniques for dissipating energy in surface runoff.

Significant concerns associated with regrading waste rock slopes include sediment control, erosion (during construction and after placement of till), reactivity of freshly exposed fines, water quality of surface runoff, and the ability to revegetate steep slopes. Additional concepts that will be evaluated include benching waste rock slopes and using existing talus slopes to improve geotechnical stability, dissipating runoff energy, and removal of sediments from surface runoff.

The proposed field program developed for the upper surface (plateau) of the waste rock dumps has been designed to provide additional insight into the geotechnical and geochemical characteristics of the various waste rock areas (and other mine waste streams such as oxide and baritic fines) that must be reshaped using land form contouring, relocated, or capped in place (or a combination of these). A test pit investigation has been designed along the top-of-slope for each of the waste rock dumps to provide additional geotechnical (primarily gradation with an emphasis on fines content) and geochemical (primarily evaluating the reactivity of the fines fraction) properties of the waste rock that will be exposed during the regrading and reshaping of the waste rock dumps. Finally, an additional test pit, sampling, and shallow probing program is proposed along the downstream toes of the waste rock dumps, where applicable, to characterize the foundation soils within the expanded footprint of the regraded waste rock dumps.

Other evaluations will be conducted to facilitate design of the grading and cover systems. These will include running static and dynamic slope stability analyses for the various materials and configurations, freeze-thaw analyses, and analyses of candidate covers.

The tailings data gaps discussed below highlights the additional geotechnical and geochemical characterization work and numerical modelling required to design the final closure configuration and to predict long-term performance.

3.6.1 Faro Area

The supplementary field program along the upper surface of the Faro Waste Rock Dump is largely focused on collecting additional geotechnical and geochemical data in areas where significant quantities of material will be relocated, consolidated, or capped with a very-low-permeability cover. The associated test pitting and geotechnical probing program (consisting of hollow stem augers, sonic boreholes, and dynamic cone penetrometers) are designed specifically to enable the evaluation of alternative remediation scenarios, such as the placement of reactive fines for a levelling/cushioning layer above the sulphide waste or consolidation of various reactive wastes in alternative configurations that are more consistent with the desired landform contouring. The test pitting investigation will also provide insight into options for optimizing the landform design of the re-contoured surface. Additional geochemical data will be collected to support the development of health and safety protocols and water management strategies.

Major design constraints associated with reshaping the outer slopes of the Faro Waste Rock Dump includes the proximity of productive and ecologically sensitive streams (for example, NFRC) and the presence of valued terrestrial ecosystems immediately downgradient from the current footprint of the waste rock dumps. These constraints complicate remediation of the waste rock dumps because there is often insufficient room to allow flattening to the desired 3:1 horizontal to vertical slope and the technical challenges associated with capping and revegetating steeper slopes. Where slopes cannot be flattened to 3:1, it will be necessary to either pull portions of the slope up or shift laterally to areas where there is sufficient room downgradient from the existing waste rock footprint to accommodate the additional material.

3.6.2 Rose Creek Tailings Area

The RCTA consists of the Intermediate Dam and the tailings deposited within the basins created by the dam. The supplemental field program must facilitate the design and placement of the final dry tailings cover. It is anticipated that the tailings surface will be capped with an average of 1.5m of till and recontoured to support effective water management.

It is anticipated that the design of the final closure configuration will consider dewatering the intermediate tailings pond and slimes area, backfilling the Intermediate Pond area, regrading the tailings surface to eliminate ponding of water, and placement of a till cover. It is expected that the objective will be to enhance the tailings surface to help control surface runoff and support diverse and self-sustaining cover vegetation.

The requirements for supplementary information vary significantly along the tailings profile. For example, tailings in the original and secondary tailings impoundments are partially drained and are capable of supporting low ground pressure (LGP) equipment, and the sediments adjacent to the Intermediate Dam are fine grained and saturated or below water. In general, the geotechnical characteristics of the tailings within the RCTA vary significantly from east to west. The easternmost tailings beach, which is near the original discharge location, is partially drained and capable of supporting LGP equipment. The sediment in the RCTA becomes progressively finer to the west, toward the Intermediate Dam, where the tailings are the finest (slimes). Sediments in the Intermediate Pond area are unconsolidated or poorly consolidated and incapable of supporting LGP equipment. Most tailings are not trafficable during spring thawing.

Given the significant challenges associated with establishing equipment access over much of the tailings, a program will be evaluated that incorporates amphibious equipment that can support a drilling and piezocone investigation in addition to performing the work when the tailings are frozen. Several piezocone probes are expected to be conducted to characterize the geotechnical properties of the tailings impoundment. Additionally, vane shear data and discrete samples in relatively undisturbed areas will be collected for additional characterization across the tailings impoundment. A sampling and monitoring program will also be implemented in the saturated areas adjacent to the Intermediate Dam. Specialized sampling associated with this program includes collecting frozen core samples for consolidation testing and the installation of thermistor strings (with data loggers).

Additionally, a trafficability study is required over representative sections of the tailings to provide additional insight into the requirements for cover placement, and a few large-scale load tests will provide additional insight

into the anticipated tailings consolidation and differential settlement after loading with the vegetation cover. Use of microblasting for ground improvement will be considered.

It is anticipated that a drainage layer will be required above at least a portion of the tailings to allow expelled pore water to drain to a collection point without making contact with the clean till cover. It is anticipated that this drainage layer will require a large volume of segregated granular materials to function effectively; fine granular material will be required as a filter layer between the tailings, the granular drainage medium, and the final till cover. The source of this granular material remains to be determined, although suitable waste rock could be separated at a large-scale processing operation. Consolidation of the tailings will occur over many years, or even decades; therefore, a drainage system is needed to collect, store, and remove contaminated pore water from the area.

3.6.3 Vangorda/Grum Area

The Vangorda/Grum Area consists of two open pits, two disposal areas for waste rock, and an area of exposed waste rock within Vangorda Pit. The C&R Plan calls for Vangorda Pit and Grum Pit to be actively managed to maintain an operational range sufficient to contain design flood events. Water extracted from the pits will be treated to meet all applicable discharge criteria prior to release to the environment.

The supplementary program for the Grum Waste Rock Dump addresses three principle areas: the main Grum Waste Rock Dump, the Grum Sulphide Cell (already capped), and the Ore Transfer Pad. The Grum Waste Rock Dump will be investigated primarily by using test pits along the upper slope and the toe of the waste rock dumps. The test pits will allow visual inspection and sampling for the geotechnical and geochemical assessments. The current C&R Plan calls for capping the Ore Transfer Pad with a very-low-infiltration cover; however, review of the available data suggests that an alternative closure scenario involving relocation of the affected materials from the Ore Transfer Pad has the potential to reduce or eliminate the need for a very-low-infiltration cap. To that end, a focused investigation of the Ore Transfer Pad (including test pits, sonic boreholes, and discrete sampling for geotechnical and geochemical characterization) is proposed to investigate the potential for either consolidating or relocating (as a capping layer for the Vangorda Sulphide Cell) the thin layer of reactive material that overlies the entire Ore Transfer Pad. Additionally, the Ore Transfer Pad appears to be located on a stockpile of phyllite. The underlying phyllite will be characterized in sufficient detail to evaluate its potential use as a borrow source or growth medium. X-ray fluorescence will be evaluated as a screening tool to help delineate the extent of the contamination associated with the Ore Transfer Pad. X-ray fluorescence is a field method for determining metal concentrations rapidly, which allows for real-time decision making regarding the extent of contaminated materials.

The Grum Sulphide Cell was capped in fall 2010 and subsequently upgraded and retrofitted during the 2011 field season to address performance issues associated with erosion, grading, and water management that were observed during the spring freshet. The design and construction challenges associated with the Grum Sulphide Cell provide excellent information that needs to be incorporated into the future cover design. CH2M HILL recommends that a team of cap design specialists visit the Grum Sulphide Cell during the 2012 spring thaw to observe the performance of the recent upgrades and gain additional insight to optimize waste rock cover designs.

The Vangorda Area includes the Vangorda Waste Rock Dump and the waste rock within Vangorda Pit, which must be recontoured (using land form contouring) and revegetated. The supplementary investigation of the Vangorda Waste Rock Dump includes a test pit and a geotechnical/geochemical sampling program along the upper slopes and downstream toe of the waste rock slopes. A focused investigation of the baritic fines consisting of test pits, numerous dynamic cone penetrometer probes, and multiple hollow-stem auger borings will be completed in the area of the baritic fines to evaluate the potential for either consolidation or complete relocation, potentially as a bedding layer for the Vangorda Sulphide Cell cover. Test pits will also be excavated in the area of the Vangorda Sulphide Cell to visually inspect and evaluate the requirements for a levelling/bedding layer prior to capping with a very-low-infiltration cover. Methods to better delineate the extent of the sulphide cell will be evaluated.

Given the close proximity of the Vangorda Pit waste rock to the pit walls, it is anticipated that a slope stability assessment will be required before mobilizing equipment into the pit. The stability assessment will include

evaluation of the potential for rock fall and pit wall retrogression and will likely involve the installation of several inclinometers to monitor for movement of the pit walls.

3.7 Water Treatment Plant

3.7.1 Site-wide

The following are several site-wide data/information gaps associated with water treatment that need to be addressed before the WTP design and cost estimate can move forward:

- **Optimum number of WTPs (one or two).** The C&R Plan calls for two new WTPs: one in the Faro Area and one in the Vangorda/Grum Area. CH2M HILL believes that one new WTP in the Faro Area with a pipeline and pumping system to convey water from the Vangorda/Grum Area to the Faro Area may be more cost-effective. The IPRP (2010) also made this recommendation. CH2M HILL submitted Task Authorization Request (TAR) 005 to evaluate and compare these two options and identify the better approach. A report documenting the results of the study and the study recommendations is included as a task in TAR 005.
- **Adequacy of existing WTPs to accommodate flows over the next few years (capacity and capability).** The capacity and capability of the existing WTPs, particularly the Faro Area WTP located in the mill building, to accommodate water flows requiring treatment over the next few years is uncertain. The YG has expressed concerns about the effectiveness, reliability, capacity, and safety of the Mill WTP, and has asked CH2M HILL to develop TAR 004 to evaluate this question and determine if there is a need to expedite construction of a new WTP, as recommended in the C&R Plan. TAR 004 includes a focused failure modes and effects assessment.
- **WTP design flows, constituent concentrations, and loads for water treatment.** Flows, contaminant concentrations, and contaminant loads in water conveyed to the WTP(s) for treatment will change over time as sources are either mitigated or captured, and acid generating reaction and mineral weathering rates change. The best estimates of these data are needed for current and future conditions to serve as the basis for establishing design criteria for the WTP(s). The C&R Plan cites average net water accumulation volumes for the three pits, and proposes initial WTP design flows of 5,000 US gallons per minute for the Faro Area WTP and 500 US gallons per minute for the Vangorda Area WTP (excluding water collected in Grum Pit). Estimating current and future flows, concentrations, and loads will require input from several disciplines that involves field sampling and analysis of current and future water sources, laboratory geochemical testing, and mathematical modelling (hydrologic, geochemical, and GoldSim).
- **WTP design lime demand and solids formed (LD/SF) (sludge production).** LD/SF characteristics of the water collected for treatment are essential for WTP design. These values will change over time because they are governed by the water characteristics. They could also change if enhanced treatment processes are needed for some constituents, such as sulphate. Thus, estimates of current and future LD/SF values are needed to develop WTP design criteria. The C&R Plan provides estimates of lime demand based on Zn loading and sludge production based on lime demand. However, the IPRP (2010) states that there are discrepancies in lime dosages between those reported in the C&R Plan and past studies that need to be checked. Estimating current and future LD/SF values will require laboratory testing of current water sources (pit lakes and existing WTP influents) and other potential future water sources.

The estimated sludge production rates developed in the previous task will be used to estimate sludge disposal requirements. Sludge disposal issues include methods for transporting sludge to the pits, the capacity of the pits, and geochemical stability of sludge within the pits. The geochemical stability will be evaluated under the geochemistry task.

- **Discharge limits for treated water including limits for sulphate (if any).** A clear understanding of the discharge limits that may be applied at the site is critical to WTP design. Very stringent limits for metals/elements or limits for sulphate could necessitate inclusion of advanced treatment processes beyond the planned high-density sludge (HDS) lime treatment system with granular media filtration. Establishing discharge limits for the site will likely require the use of existing Canadian Council of Ministers of the Environment guidelines for the protection of aquatic life, determination of protective constituent

concentrations based on risk assessment (which may include bioassays), determination of best practical (achievable) concentrations for different treatment technologies, mass balance modelling of downstream (blended water) concentrations, and consultations with regulators.

- **Water treatability and WTP design and operating parameters.** Water treatment uncertainties include: (1) the effectiveness of treatment achievable by a new HDS/filtration system (that is, the ability to consistently yield effluent constituent concentrations lower than discharge limits) and (2) design and operating parameters for achieving optimum WTP performance. Bench-scale and pilot-scale testing using representative influent water is the best way to address these uncertainties. Bench-scale testing of LD/SF and metals removal at different pH endpoints, and flow-through pilot testing of the HDS process is planned to address this data gap. Pilot testing could be conducted onsite by using selected authentic water blends, or it could be performed at an offsite laboratory by using synthetic water that mimics authentic water in detail.
- **Need for sulphide addition, nanofiltration/reverse osmosis (NF/RO), or other advanced treatment technology.** As previously noted, if the discharge limits for the site require very low effluent concentrations of metals/elements, an advanced treatment process may be required in addition to HDS/filtration treatment. The IPRP (2010) recommends further testing of sulphide addition for this purpose. Similarly, if the sulphate discharge is regulated, NF/RO treatment might be required. Sulphide addition testing could be added to the HDS pilot study. If needed, NF/RO treatment performance would likely be evaluated initially by modelling using one of the existing reverse osmosis modelling packages rather than laboratory or pilot testing.

3.7.2 Faro Area

The C&R Plan identifies the BXL Site at the head of the Rose Creek tailings as the location selected for construction of the new Faro Area WTP. CH2M HILL believes that the Mill Area might be a better location for this WTP, and the IPRP (2010) suggests that a location nearer to Faro Pit than the BXL Site be considered (the Mill Site fits this description). Consequently, the optimum location for the new Faro Area WTP is an information gap that must be addressed at the start of design. A comparative evaluation of prospective Faro Area WTP locations is included in the scope of work for TAR 005.

Another consideration to be evaluated is whether the existing Cross Valley Pond, or a portion of it, should be retained for emergency contaminated water storage. This will be evaluated by using a focused failure modes and effects assessment.

3.7.3 Vangorda/Grum Area

The C&R Plan calls for continuation of nutrient addition for algae treatment of Grum Pit water, contingent on whether that strategy can meet discharge limits. Otherwise, the C&R Plan recognizes that Grum Pit water may require polishing treatment or treatment in a WTP. The IPRP (2010) states that long-term water quality monitoring in Grum Pit has failed to demonstrate that this approach will be effective at achieving dischargeable levels of Zn on a continuous basis and that field evidence does not support continuation of this treatment approach. We concur with the IPRP; algae treatment will not be further considered in the project design.

3.8 Site Civil

3.8.1 Faro Area

The 2003 and 2009 CAD mapping files include horizontal lines for existing pipelines and culverts. However, there does not appear to be any vertical or identifying data available for each pipeline or the horizontal accuracy. A separate utility survey will need to be performed to identify existing utilities, including the horizontal and vertical location, disposition, size, and material for each utility.

Bathymetry data are not available electronically for Faro Pit, and it is likely that some bathymetry work will be necessary.

A field condition survey will be needed for all existing access roads. This survey should include existing surface types and conditions for existing roads and culverts. This survey will be used to identify necessary improvements

to provide safe and reliable access from all three sites and within each site for construction and operations and maintenance (O&M) activities.

Detailed channel cross-section and profile information is required for development of a hydraulic model. Site-specific survey information will be required at various locations through the surface water conveyance system to characterize channel reaches. The extent to which additional survey data are required will be determined on a site-specific basis during future field reconnaissance.

3.8.2 Rose Creek Tailings Area

The 2003 and 2009 CAD mapping files include horizontal lines for existing pipelines and culverts. However, there does not appear to be any vertical or identifying data available for each pipeline or the horizontal accuracy. A separate utility survey will also be needed.

Bathymetry data are not available electronically for the Intermediate Dam Impoundment and the Cross Valley Pond. Bathymetry work may be required for the Intermediate Dam Impoundment and the Cross Valley Pond.

A field condition survey will be needed for all existing access roads (similar to the survey in the Faro Area), as will RCDC channel cross section and profile information. Site-specific survey information will be required at various locations. The extent to which additional survey data are required will be determined on a site-specific basis during future field reconnaissance and after review of the new LIDAR-based mapping.

3.8.3 Vangorda/Grum Area

The 2003 and 2009 CAD mapping files include horizontal lines for existing pipelines and culverts. However, there does not appear to be any vertical data available for each pipeline or the horizontal accuracy of the survey. A separate utility survey will be needed to identify all existing utilities onsite, including the horizontal and vertical location, disposition, size, and material of construction for each utility.

LaBerge Environmental Services prepared bathymetry data for Grum Pit in 2009. However, no electronic data are available and there is insufficient information to reproduce the data (SRK, 2009e). It is likely that some bathymetry work will be necessary for Vangorda Pit and Grum Pit (for example, evaluate sludge storage capacity).

A field condition survey will be needed for all existing access roads. This survey should include existing surface types and conditions of the existing roads and culverts. This survey will be used to identify improvements necessary to provide safe and reliable access from all three sites and within each site for construction and O&M activities.

Detailed channel cross-section and profile information is required for development of a hydraulic model. Site-specific survey information will be required at various locations throughout the surface water system to characterize channel reaches. The extent to which additional survey data are required will be determined on a site-specific basis during future field reconnaissance.

3.9 Dam Design and Major Structures

A major element of the C&R Plan is the long-term stability and safety of the tailings dams and other dams that will remain after closure. Dam safety must be maintained under normal and extreme loading conditions. The MCE and the PMF represent the extreme loading design events. These extreme loading design events are larger loadings than required by the *Canadian Dam Association Dam Safety Guidelines 2007* (Canadian Dam Association, 2007) for high-consequence dams; however, this design approach is considered reasonable and appropriate given that they need to remain safe in perpetuity.

The main dam facilities addressed in this section include the following:

- RCTA
 - Three tailings dams: the Original Dam, the Secondary Dam, and the Intermediate Dam and spillway
 - CVD, which includes a polishing pond downstream from the tailings dams

- Vangorda/Grum Area
 - Little Creek Dam (LCD) (below the Vangorda Waste Rock Dump).
 - Headwork Diversion Dam at the top of the Vangorda Diversion Channel

3.9.1 Faro Area

There are no dams or other major structures in the Faro Area. There are natural channels (such as the NFRC) and diversions (such as the Faro Creek Diversion) that are upstream from the Tailings Area in the Faro Mine study area. The final configuration of these elements will affect the final configuration of the diversions and spillways needed in the Tailings Areas. Changes to the diversions, waste rock dumps, and natural channels will be incorporated into the design for the Tailings Area.

3.9.2 Rose Creek Tailings Area

This section discusses dams and related major structures; however, the design of the RCDC and the required tailings covers are interrelated and integral to the design of the dam. Currently, the RCDC routes the entire flow of Rose Creek around the tailings impoundments and the CVD. The C&R Plan calls for breaching of the CVD. Hydrotechnical studies indicate that the RCDC can currently pass up to a 500-year flood event, but larger floods would spill onto the Intermediate Impoundment (nhc, 2006). It would be necessary, as part of the C&R Plan, to either increase the capacity of the RCDC or to design the Intermediate Dam and the surface of the Intermediate Impoundment to accommodate large floods, including the PMF. This would include raising the Intermediate Dam and potentially the RCDC dike, and construction of a sufficiently large spillway to pass the flood without overtopping the Intermediate Dam.

The hydrotechnical studies and the flood routing concepts for the dams were generally compartmentalized, and a comprehensive unbiased comparison of all the different options for flood routing considered during the approximately 10-year study has not been undertaken. It is reasonable to assume that the current concepts for flood routing presented in the C&R Plan represent the most robust solution; however, it will be prudent to conduct a comparative analysis workshop prior to field work. The comparative analysis would consider the follow options:

- RCDC passing the PMF versus the PMF passing over the tailings
- Options for reducing the PMF:
 - Flood retention dam upstream from the Haul Road embankment
 - Routing of Faro Creek to the north Wall Interceptor Ditch
- Options for reducing the flood flows over the tailings:
 - Long broadcrested overflow weir versus a fuse plug
 - Increase the flow capacity in the RCDC (modest adjustments in geometry)
- Options for increasing spillway flow capacity and minimize the Intermediate Dam raise
 - Drop invert elevation (in C&R Plan); requires regrading the tailings
 - Increase length of spillway overflow (labyrinth or U-shaped spillway; over top-hardened Intermediate Dam embankment); no regrading of tailings

Even in the case that the C&R Plan is implemented, a specific concept for raising the Intermediate Dam and providing a spillway has not been finalized. One approach would be to drop the spillway inlet invert by several metres to limit the Intermediate Dam crest raise to an elevation at or below the elevation of the existing RCDC crest. Lowering the spillway invert elevation will require regrading the tailings surface. Significant data gaps are associated with the tailings properties including their dewatering characteristics, their strength to support construction equipment, liquefaction potential, the associated risk for lateral spreading (causing damage to the covers), and the means to separate groundwater collection versus surface water runoff.

There are also other data gaps that have been identified with the flood routing option presented in the C&R Plan including (1) subsurface information for the proposed closure spillway, (2) interaction of the tailings cover requirements and the over-the-tailings flow requirement, (3) subsurface conditions for the proposed fuse plug, and (4) subsurface conditions along a spillway if it needs to extend below the CVD.

The seismic stability of the dams has been investigated and analyzed in detail (Klohn Crippen, 2004 and 2005). Those studies concluded that the Intermediate Dam would be stable during the MCE, but the Secondary Dam has potentially liquefiable soils in two areas in the foundation that would require upgrading for stability during the MCE (KCB, 2006a and 2006b). The geotechnical properties of the tailings have also been studied, and the conclusion is that they would be subject to liquefaction and localized movement, even in earthquakes smaller than the MCE (Golder Associates 2004, 2006a, and 2006b).

Studies of the stability of the CVD indicate that the underlying soils could liquefy in the MCE, and that substantial upgrades would be required for stability (KCB 2006a, 2006b). This dam is breached in the C&R Plan, although options for retaining it for emergency water storage are to be evaluated.

Data gaps associated with the seismic stability include better definition of the extent of liquefiable conditions at the East Limb of the Secondary Dam, in situ shear wave velocities, and the cyclic shear strength in the clayey soils in the CVD foundation (if the CVD is retained).

To address outstanding conceptual design issues pertaining to the Rose Creek tailings, an Independent Review Board will be convened, consisting of technical experts both internal to CH2M HILL and those we have subcontracted. The project engineering leads will prepare technical analyses pertaining to implementability, effectiveness, risk, and cost associated with alternative design options. Based on feedback from this board, one or more conceptual options will be selected for evaluation in the data gaps field investigation. This Independent Review Board will be convened during the design to review status, provide recommendations for further analyses, and provide concurrence with the design approach.

3.9.3 Vangorda/Grum Area

The C&R Plan indicates that the LCD may be needed to store seepage water, or it may not be needed. It is presumed that the LCD will be needed and that the following will be needed to be established: the design earthquake, design flood, additional drilling and installation of instrumentation at the toe to allow design for stability and earthquake loading, and sizing and design of a spillway. The stability of the Moose and Sheep Pad Pond embankments will also be assessed.

3.10 Revegetation and Reclamation

3.10.1 Introduction

The goal of closure and remediation of the FMC is to create an ecologically functioning (with respect to erosion control, wildlife habitat, surface water quality, carbon sequestration, and aesthetic value) landscape that meets closure objectives identified by the YG and other parties. To describe that functioning landscape, a reclamation plan for the FMC is needed for two key reasons:

- To provide an overall picture of the closure landscape that examines the interconnection between wet and dry landforms and landscape features so that future ecological function can be assessed.
- To provide a tool to complete the EA of closure activities (impacts and residual risks are measured by using the reclamation plan as an endpoint for the assessment of the technical disciplines).

Several aspects of that the C&R Plan are a cause for concern in (1) meeting the terms of the Project Proposal requirements for YESAB (YESAB, 2005), (2) providing a framework for engineering designs that are connected in the reclaimed landscape, and (3) providing landscape information to complete the environmental impact assessment and eventually to inform construction planning for the site. The C&R Plan supplies incomplete landscape remediation detail (for example, surface water drainage from reclaimed waste rock areas are entirely missing), or it provides minimal information on how and under what circumstances reclamation prescriptions might be performed. For example, Table 4.8 notes that “rapid establishment of vegetation to control erosion

during and immediately after construction” is required, but there is no detail regarding what that vegetation will look like or when it will be applied; nor does it describe how it will be coordinated with cover construction activities and whether rapid establishment is feasible. Not only does this make it very difficult to understand how the reclaimed landscape elements will work together, it means that the area-based environmental impact assessment drafted to date either does not accurately calculate hectarages, or it makes assumptions about impacts on end land uses, knowing that the accurate area measurements are not available.

Review of the Proponent’s Guide (YESAB, 2005) and discussions with the Faro Regulatory Leadership Team have highlighted the need to provide levels of detail sufficient to minimize supplemental information requests in the YESAB review process. It is also important that the reclamation plan for the site be a useful tool for site work as it continues into the remediation construction and operations phase, and not a plan that meets regulatory requirements but is otherwise impractical as the basis for construction design.

To date, a reclamation plan has not been available for the FMC, although many studies have been undertaken for parts of the site. A reclamation plan should describe the interdependent closure drainage (surface and groundwater), landforms, cover types (soil and vegetation), and end land use requirements in a single, integrated master plan.

Some of the activities required to provide information for reclamation are specific to particular tasks (for example, completing a revegetation trial on low-infiltration cover waste rock piles on steep final slopes and cool, dry aspects) and some activities require a site-wide focus. Consideration has been given to the timing of these activities. For example, some revegetation trials are necessary to inform vegetation prescriptions, but, if necessary, could be offset until after the time of proposal submission to delay the cost. In this case, existing revegetation trial information and technical experience would be used to plan for the likely vegetation response, and the new revegetation trial information could be underway during YESAB review of the Project Proposal.

In addition to task-specific reclamation and revegetation activities, there are several site-wide activities common to the entire FMC that are required to complete a reclamation plan for the site. These activities need to be addressed soon:

- Mapping of existing conditions on the site
- Examination of cover design features
- Site-wide soils mapping
- Sourcing and planning for revegetation materials
- Site-wide closure drainage planning and revegetation planning

3.10.2 Mapping of Existing Conditions

Considerable data have been collected to map the FMC to date, and a few gaps remain to describe site features so that a reclamation plan can be completed (and the baseline surface can be described for the EA). Existing and new aerial photography, sampling data, and new LIDAR data will allow a review of existing rock cover, surface soil, and surface vegetation on and surrounding the site. This will provide baseline maps and define the underlying layer for reclamation construction. Because conditions and vegetation communities have changed since earlier data were collected (being in an early phase of colonization), data collected in 2012 will assist in evaluating communities and species that are most likely to establish and the probable succession paths under site-specific conditions. In addition, permafrost predictive mapping needs to be performed to provide information to the geotechnical and hydrology teams, to inform landform reclamation activities, and to link back to the EA by providing a mechanism to compare initial permafrost conditions with predicted conditions at closure.

Visual aesthetics depiction will be conducted (which would use baseline surface conditions as an underlying layer) to provide a common point of understanding for all technical disciplines (a picture of the landscape changes makes it much easier to collaboratively plan than do data sets or partial technical drawings) and provides a way to discuss closure plans with interested parties. Plan views of the site and technical specification sheets are not good communication tools for multidisciplinary planning or the engagement of interested parties. Communications tools are a key part of reclamation planning to align results with community values.

3.10.3 Examination of Cover Design Features

There are many sources of information that describe one or more parts of the cover design components; however, to date there has been no overall review of the requirements and applicability of cover features and no examination of how cover features will work together (or not work together) in the reclaimed landscape. Closure drainage planning is entirely missing from cover designs to date, and drainage patterns after closure will be driven by complex interactions between landforms, soil types, vegetation, and other factors. This analysis must be integrated with the early task of reviewing available cover materials and determining where and how they will be used. In this way, CH2M HILL can choose the best combination of cover material types and applications, and revise reclaimed land units to reflect site conditions and reclamation best practices.

Information that needs to be reviewed in detail includes (but is not limited to) the following:

- Cold Regions Hydrological Model infiltration modelling (especially now that the Grum Sulphide Cell can provide field parameters) and potential application of alternative models (such as SVFLUX, SHAW, and VADOSE/W) that may provide better information on unsaturated flows. Slope, aspect, soil type, vegetation type, and leaf area index are critical factors in evaluating infiltration under the extreme conditions at the FMC. The rudimentary cover concept in particular can be considered a type of evapotranspirative (ET) cover or water balance cover, as can the low-infiltration cover concept. ET covers consider environmental conditions (for example, net water loss from soils in the Yukon) and soil and vegetation types. ET covers may provide options for cover designs that provide a sustainable line of infiltration reduction. Bulk density data are critical for ET cover design and only partial data are apparently available for the onsite cover materials.
- Mesotopography and microtopography planning is missing for current reclamation land units but are important for planning closure drainage and a sustainable vegetation cover. Current field trials (and existing regrowth onsite) show that very small topographical changes make a difference in whether vegetation can become established and how moisture is absorbed or shed from the surface. Decisions about how cover surfaces are treated in the reclamation plan are needed to support the long-term health of vegetation covers.
- Coarse woody debris has been cited as a cover treatment, but sources of material and the suitability for cover types have not been examined. Woody debris may be a way to add microtopography for vegetation covers, but its utility on cover types and the steepness of the sites has not been reviewed.
- The role of wetlands and riparian communities within the reclaimed landscape needs to be assessed. These ecosystems can be designed to provide short-term (seasonal or episodic) water storage, maximize ET, minimize dust, and establish low-permeability infiltration barriers over time. Their value relative to landforms and water management on this site may be significant, or the desirable outcome might be to avoid their establishment. This evaluation has not been conducted.
- Resistance of various cover systems to erosion needs to be carefully considered. How the cover systems will function during placement, during the first year, and over the long-term needs to be integrated and evaluated within the design of final design contours, near-term and temporary sedimentation control systems, and during high-intensity rainfall events.

3.10.4 Site-wide Soils Mapping

Data regarding the texture, fertility (major nutrients and required micronutrients), and metals content of potential cover materials exist in different documents and in different formats. Key information in reclamation planning is identifying (and avoiding or planning to mitigate) problem areas (for example, areas with high concentrations of lead arsenic, or Zn or that have pH or texture limitations) and planning to use good cover materials as carefully as possible. New baseline soils data will be needed from cover material and borrow investigations and EA surveys, and these data need to be compiled with existing information. Material balance and movement, can then be considered with respect to cost, location in the reclamation landscape, and cover function.

3.10.5 Sourcing and Planning for Revegetation Materials

Locating, growing, and providing vegetation materials at the right time for large-scale reclamation activities are major challenges. Usually, the provision of planting materials for revegetation is assumed after landforming activities are complete. But, the existing FMC vegetation is adapted to very constrained conditions, with slow growth rates and unpredictable annual growth periods. Revegetation of reclaimed areas will need to happen quickly and efficiently to support landforming and drainage activities, and materials must be ready to be seeded and planted when needed.

For most plant species, a 4- to 5-year lead time will be required to collect seed, grow seedlings, and prepare them for planting. In addition, the large quantities of seed (barley, rye, grass, and potentially legume species) that will be required for initial covers will need to be sourced and produced in bulk. Volume and quality are important with respect to the health of the plants and seeds and the exclusion of weedy species. On this time scale, consideration needs to be given to where and when the plant material will be developed so that it is ready to support reclamation activities on schedule. Key questions include consideration of the location of existing greenhouse and nursery facilities in the Yukon, and ascertaining the interest of First Nations in pursuing this aspect of the reclamation activities.

In addition, there is reference to sourcing some planting material from donor sites around the FMC. Because of the large amount of planting material required, potential donor sites need to be identified, and CH2M HILL must consider the environmental impact on donor sites and perhaps add these donor areas to the EA. The methods of collecting and maintaining large stocks of donor material have not been considered at this scale before, and this also needs to be reviewed and planned.

3.10.6 Site-wide Closure Drainage and Revegetation Planning

As previously discussed, this activity consists of completion of a closure drainage and allied landform plan and then overlaying a soils and revegetation plan. Development of a revegetation plan that shows ecosite types specific to each ecoregion and overlaid on a closure drainage plan is a critical component of planning for the reclamation of the FMC. Although closure drainage is considered in detail in the Hydrology and Hydrogeology Disciplines, the outcome of the drainage planning depends on how landforms are contoured, the cover materials applied (Waste Rock and Tailings Discipline), and where vegetation prescriptions are located (Revegetation and Reclamation Discipline). These disciplines need to individually consider many aspects of design and integrate the designs to form a landscape that functions properly and causes no additional impacts in the EA.

In addition to discipline-specific work, the disciplines need to collaborate through conference calls and focused workshops to review areas of the reclamation landscape, such that the overall site plan meets critical environmental needs and also works as a whole. This is important to demonstrate that reclamation of the FMC does not consist of disparate programs and that the landscape is being designed, planned, constructed, and monitored as a whole functioning system. This will reduce subsequent problems that may arise if a nonintegrated approach were used. This has been experienced at the Grum Sulphide Cell where there is no long-term integration into a reclaimed landscape or determination of how long-term runoff is to be managed.

One of the main issues in landscape function at the FMC will be the interaction of disturbed, reclaimed landforms with adjacent undisturbed natural areas. These areas include the NFRC upstream from the Haul Road, Grum Area, Vangorda Creek Valley between the Grum and Vangorda waste rock piles, and the natural area adjacent to the ETA and down toward the Rose Creek tailings facility. There are many options for how this interaction will occur, and the site-wide drainage and revegetation planning needs tools such as an ecosystem services assessment (ESA) to support decisions regarding the final reclamation landscape. An ESA quantifies ecological services provided by undisturbed areas and by the different options for supporting the reclaimed surface so that the best choice for sustained function and resilience of the whole landscape can be described and rationalized. An ESA analyzes actions that support the function and health of the entire reclaimed landscape when there may be many options for addressing the same issues (for example, installing a slurry wall, lining the NFRC channel, relocating the channel, installing pumping wells, or considering the duration and severity of seepage) that reflect many different

values for parts of the Rose Creek Valley system. An ESA also provides a method for clearly identifying trade-offs in values and benefits.

Completing an ESA involves sourcing quantifiable measures for different services provided by a system (for example, Rose Creek services would include water purification, fish habitat, riparian wildlife habitat, a wildlife movement corridor, and carbon sequestration) and assessing changes to these measures, depending on changes to the system caused by reclamation activities. In some cases, it might be better to leave a system alone to recover rather than interfere and generate further problems. Wet landscapes are often in this category because reclamation techniques can be ineffective, and the ecosystem services are generally numerous and wide in effect.

Finally, the closure drainage and closure vegetation plans provide the long-term vision of the FMC. Integrating different aspects of reclamation planning into closure drainage and revegetation plans for the entire FMC allows assessment of the ability to meet other large-scale integrated needs such as wildlife habitat, forest and resource management, and traditional use requirements for the area. There is a regulatory need to address these items, but this is also a way to describe the positive impact of the reclamation work when the work looks more like further site disturbance while underway.

3.11 Human Health and Environmental Risk Assessment

3.11.1 Faro Area

Data gaps have been identified for the Faro Area with respect to the HHERA. These data gaps can generally be separated by the type of exposure and receptors involved. HHERA data gaps were identified separately for the aquatic and terrestrial environments.

Data are needed for current and future surface water and sediment quality. According to the draft *Probabilistic Human Health and Ecological Risk Assessment of Final Closure and Remediation Plan for Faro Mine Complex* (SENES Consultants Limited, 2010) and the *Faro Project Management Team, Faro Mine Complex Closure and Reclamation – Project Proposal, Current Environmental Conditions Supporting Document* (AECOM, 2009), the surface water quality assessment did not consider implementation of all proposed remedial measures, and older data were used. The HHERA needs to be revised to consider implementation of the full suite of remedial measures, and more recent surface water quality data need to be incorporated into the assessment. New data are required from the existing sampling stations and from at least one new location between Stations R7 and X2 to better characterize baseline conditions in the NFRC.

The *Interim Environmental Monitoring Program: Vangorda Creek (2007) and Rose Creek (2008)* (Minnow Environmental Inc, 2009) indicates that limited surface water chronic toxicity testing has been performed. Chronic toxicity testing more accurately reflects the potential effects on fish, and this testing has not been completed on a salmonid species. Chronic toxicity testing should be conducted to better assess effects on chinook salmon and grayling, which will likely be identified as valued components (VC) in the EA. This type of testing would follow Environment Canada protocols, and testing would be completed on rainbow trout over a 30- to 35-day period to evaluate the embryo to alevin life stages. The assessment of direct effects to aquatic receptors has not been previously well evaluated because limited or no tissue chemistry data have been collected. Site-specific tissue data provide a more accurate assessment of risks than does modelling that uses literature-based values. This data gap should be addressed through tissue analysis of fish, benthic invertebrate, and aquatic vegetation samples.

There is also a lack of sediment quality data; the available data are old. New data are required from the existing sampling stations and from at least one new location between Stations R7 and X2 to better characterize baseline conditions in the NFRC. For the assessment of the effects of contaminants of potential concern (COPC) in sediment on benthic invertebrates, only limited sediment toxicity testing has been completed. Additional testing should be completed to more accurately assess risks under current conditions and to predict the potential for future risks.

Within the Faro Area, there is also the potential for COPC exposure from soils, waste rock, and cover materials and, therefore, risks to humans and terrestrial ecological receptors. This could occur during the construction phase of the project with the relocation and re-grading of the waste rock and over the long-term because of the

quality of the material that will be used to cover the waste rock. To better assess risks from exposure of COPCs in soil, the baseline soil quality description needs to be updated because all of the data are old and there are no data for some areas. The collection of new data, including data from locations not previously assessed, will allow a more accurate assessment of risks under current conditions and in the future. The analysis of soil samples should be conducted for the full suite of COPCs and the chemically bioavailable fraction of those COPCs should be determined. That analysis was never completed. These data will assist in the determination of the fraction available for uptake and exposure to human and ecological receptors. As new site characterization data become available and are added to the existing data set, the current HHRA conclusions can be re-evaluated to select suitable risk mitigation options. New COPCs, if any, that are detected by additional and more complete sampling efforts can also be included in the assessment.

The assessment of direct effects on terrestrial receptors could be better evaluated by collecting and analyzing tissue chemistry data. Existing data are old, and no data have been collected in some of the areas that need to be assessed. Soil organism, terrestrial and riparian plant, and small mammal tissue analysis should be completed in unsampled areas and in areas where updated soil chemistry data will be collected. This information is needed to directly assess effects to these receptors and to assist in the determination of dietary exposure to top predators, all of which will likely be identified as VECs for the EA. The collection of tissue data from larger species of wildlife would also be beneficial for the ecological risk assessment and for assessing dietary exposure and related risks for the HHRA. It may be possible that the YG can arrange to collect and provide this type of data for the HHRA.

The assessment of potential risks associated with the materials proposed for capping the waste rock and other areas needs to be evaluated. No soil toxicity studies have been completed for soil organisms and vegetation. This information is needed to directly assess the effects of soil COPCs on soil organisms (for example, insects such as spiders, beetles, ants, and grasshoppers) and plants. This testing should be conducted in areas where reclamation is currently not proposed and for the cover materials so that there will be no unacceptable long-term effects on terrestrial flora and fauna.

There are currently no data for potential dust associated with remediation and construction activities. As a primary exposure pathway for human health risks, the potential for dust exposure should be evaluated for short-term exposures. A secondary pathway is the distribution and deposition of dust in surrounding areas used by hunters and gatherers. Dust becomes incorporated into surface soil and presents a direct contact risk that needs to be evaluated. Furthermore, COPCs in soil also present a potential food chain exposure pathway, where COPCs are absorbed by plants and animals that are a food source for site users. Dust should be characterized by total suspended particulates (TSP), respirable fraction particulate matter less than 2.5 micrometres in aerodynamic diameter (PM_{2.5}), and COPC concentrations. TSP will be used to assess potential dust deposition and subsequent direct contact exposure, and secondary dietary exposures. PM_{2.5} will be used to determine potential short-term risk and the need for mitigation during remedial activities and construction.

3.11.2 Rose Creek Tailings Area

The issues, receptors, and type of exposures possible for the RCTA are similar to those for the Faro Area. The same types of information are needed; however, the assessment of effects on aquatic receptors will be focused on collecting data from the RCDC.

3.11.3 Vangorda/Grum Area

Similar data, analyses, and testing are required for the Vangorda/Grum Area. One of the differences in the Vangorda/Crum Area is the presence of groundwater seeps. As a result, the assessments described previously must be undertaken to evaluate soil and water quality associated with the seeps and the potential for effects on humans and ecological receptors. Another difference is that the creeks and tributaries located close to Vangorda Pit and Grum Pit are not considered to contain fish or fish habitat; therefore, aquatic sampling and testing are not required. Data collection and testing should be completed downstream from these areas, within Vangorda Creek from Stations V4 to V8 and within the West Fork of Vangorda Creek, near Station V5.

3.12 Buildings

Demolition and decommissioning of the existing site buildings and infrastructure are part of the overall C&R Plan. Numerous buildings are present at the Main Plant Site, including but not limited to the following:

- Administration building
- Shop and garage
- Former mill, including the following:
 - Crusher
 - Concentrate building
 - Concentrate load out
- Outbuildings
- Tank farm
- Several buildings at the Vangorda/Grum Site

To facilitate and support the development of detailed technical specifications and the demolition and decommissioning approach for the FMC, several data gaps require clarification and further information. Information contained within the document library on the state of Mill Area buildings generally does not exist or has not been available for review thus far. At the time of preparation of this report, CH2M HILL has not had an opportunity to review any site drawings or other plans and associated information related to the construction or processing methodology during historical operations. This information is crucial in evaluating the decommissioning risk, execution approach, and associated cost for decommissioning. It will be important to obtain this information.

As a result of the limited information available at this time, CH2M HILL has identified five main categories of information required, either through additional investigation or further research into existing information available regarding the buildings and mill infrastructure. These categories are addressed in the following subsections.

3.12.1 Hazardous Building Material Survey

In October 2011, the YG Energy, Mines, and Resources commissioned EBA Engineering Consultants Ltd. (EBA) to conduct a hazardous materials classification including a building materials assessment at the FMC. Reporting and recommendations resulting from the assessment are due to be released in December 2011. It is expected that the results will fill in many of the gaps that currently exist regarding the approach to decommission site structures. EBA's scope included the following:

- Review of historical reports
- Assessment of asbestos-containing materials (ACM), lead-based paint, mercury-containing equipment, ozone-depleting substances, polychlorinated biphenyls, and mould
- Sampling for ACM, lead-based paint, and polychlorinated biphenyls
- Sampling of containerized process reagents and unlabelled drums
- Inventory labelled chemicals and reagents on the property
- Assessment of structural integrity of buildings
- Interpretation of data and preparation of a final report

One of the main challenges in completing a building materials assessment is being able to obtain enough information to conclusively determine that a specific material does not contain a designated substance. A common example is sampling for ACM in insulation where it is typical for small sections to be replaced (for example, pipe, bends, and elbows) over time using different insulation materials. In this case it is possible to collect samples of material in one area but not necessarily be able to apply that information to like material in a similar or adjacent area. EBA indicated that they would collect up to 100 samples for suspected ACM. It is very

unlikely that this number of samples will be sufficient to quantify the amount of ACM for costing purposes. The consequence of not fully characterizing the hazardous building materials is that similar materials may be treated as hazardous materials, resulting in increased costs.

The follow-up hazardous building material survey will include identification and quantification of common friable ACM such as spray-on fireproofing, thermal pipe and fitting insulation, boiler and duct insulation, duct breeching, and vinyl flooring insulation. Nonfriable ACM will also be surveyed during the follow-up investigation. Common nonfriable asbestos materials may include vinyl floor tiles and mastic, gasket materials, asbestos cement (transite) boards and panels, and ceiling tiles.

3.12.2 Waste Characterization Assessment

Although O&M work at the mill to date may have involved removal of a large number of wastes within and around the buildings, it is likely that additional work will be required to quantify and characterize residual materials for disposal and to mitigate health and safety and environmental risks. During the site walk on October 4, 2011, CH2M HILL staff observed a large quantity of waste in the mill, especially behind the concentrate building. If EBA identifies gaps in the reporting of the scope under their TA, CH2M HILL would suggest additional sampling to address the gap, mitigate the risk, and to gather comprehensive information for disposal costing.

Likewise, a large volume of water is located throughout the mill in various locations; there is a significant amount of water within the crusher. This water needs to be tested and quantified to understand disposal options.

A site visit to identify items that might have been missed by EBA may be warranted.

3.12.3 Structural Assessment

EBA identified the need for an assessment of the structural integrity of buildings for signs of degradation and to identify unsafe working areas. A structural assessment should be conducted on the primary and secondary structures (for example, mezzanines, catwalks, stairs, and walkways). Secondary structures are the first to degrade over time. The integrity of secondary structures is necessary for safe access to collect hazardous building material samples and examine process equipment.

CH2M HILL recommends that a structural engineer complete an assessment of primary and secondary structures for all Mill Area buildings. During a site visit, the structural engineer would identify safe working areas and cordon off unsafe areas to help protect the safety of personnel. In addition, the structural engineer may possibly provide recommendations for repairs or temporary mitigation measures to facilitate access to unsafe areas for material inspections and sampling.

Another benefit of a structural evaluation is to identify appropriate demolition approaches for Mill Area buildings by reviewing and implementing general structural demolition guidelines and requirements for selected structures. Recommendations from this assessment would identify the types of equipment needed for demolition and suggest whether mechanical or explosive demolition of specific building structures would be necessary.

An assessment of the wastes and structures in tanks and tank farms needs to be conducted as separate components of both the waste characterization and structural assessment to fill in data gaps in these areas.

3.12.4 Utilities and Site Survey

Currently, little or no information is available regarding site utilities or surveys of the areas around buildings in the Mill Area or the Vangorda/Grum Area. It is essential that this information be reviewed and possibly supplemented with additional details to determine the demolition scope of work and approach to work around the buildings safely as well as understand demolition sequencing and execution. The required information includes but is not limited to the following:

- Building footprints
- Location of subsurface utilities, vaults, and voids
- Aboveground infrastructure details and locations (for example, fencing and electrical poles)
- Topographic information
- Tree lines

- Roads

CH2M HILL recommends attempting to locate historical site drawings for the facility and consolidating information on a base plan for each of the areas. Interviews with former mine employees would be useful to supplement the available site information. Accepting the fact that the use of geophysics at the FMC may be more problematic than in other applications, its use, including the use of ground penetrating radar and other common subsurface locating techniques, would supplement underground utility information and reduce risks regarding underground utilities.

3.12.5 Preliminary Scrap Value Assessment

At this time, the type of construction materials used in the mill is unknown. During the preliminary site walk on October 4, 2011, CH2M HILL staff observed that some of the buildings were constructed of structural steel and other metals. The salvage value steel and other recyclable materials may be substantial, depending on types and quantities of materials present (ferrous versus nonferrous). Scrap metals currently have high salvage values in commodities markets despite current apprehensions about the health of the global economy. Although many of the buildings must remain as a support base for remedial activities, it may be prudent to conduct a preliminary assessment to determine the possibility of accelerating demolition work in certain specific areas of the Mill Area to benefit from healthy scrap metals markets. The quantification of scrap materials and calculated scrap value is very important as it has the potential to alter the bid structure and how the demolition and decommissioning is executed. To provide a preliminary rough order of magnitude scrap value assessment, CH2M HILL recommends the following:

- Review available site drawings.
- A site visit to investigate construction materials and associated quantities. An important component of this would be to identify and quantify nonferrous recyclable materials (for example, copper, stainless steel, and titanium). A significant portion of the scrap value will derive from nonferrous metal scrap.
- Base assessment of potential contaminants on metals that could negatively affect reimbursement value.

Several parts and material lay down sites exist in the Mill Area. Materials in these areas should be quantified to evaluate additional sources of valuable scrap metal.

3.12.6 Building Reuse

There is the potential for some buildings to be used during site remediation during subsequent care and maintenance. An evaluation of building reuse will be performed.

3.13 Haul Road

The C&R Plan calls for decommissioning the Haul Road. Portions of the Haul Road and associated borrow/dump site and North Fork Rock Drain material have been identified as potential cover material for the Tailings Area and various contouring and regrading uses. Key data gaps include the quantity and quality of material underlying the Haul Road, the potential uses of this material, the constructability issues associated with removing the Haul Road ballast materials prior to full remediation of the mine site, and the final use of the Haul Road area (for example, potential pipeline route).

The Faro-Vangorda Haul Road crosses a watershed divide and several major streams in its approximate 12-kilometre extent. The existing Haul Road borrow/dump site is located adjacent to the Faro-Vangorda Haul Road, near the NFRC Rock Drain outlet. The site potentially contains 150,000 cubic metres (m³) of poorly graded sand and gravel.

The North Fork Rock Drain was reportedly constructed using geochemically benign calc-silicate breccia, stripped from Zone 3 of Faro Pit. The North Fork Rock Drain, which is to be removed in connection with the restoration of Rose Creek, is approximately 70m long and 60m high at the creek crossing; it is estimated to contain 450,000m³ of coarse rock fill material for borrow use. The current plan is to use material extracted from the North Fork Rock Drain excavation as a trafficability layer to support the capping of the Rose Creek tailings. Consequently, detailed

geochemical and geotechnical characterization of the North Fork Rock Drain is not warranted at this time. Additional characterization work would be required if the rock drain material is to be placed directly on the surfaces outside the existing footprint of the Tailings Area and waste rock dumps.

Data gaps for the Haul Road include an understanding of how it was constructed and the materials used. To date, geochemical and geotechnical investigations of the Haul Road and borrow/dump site for use as potential borrow sources have been inadequate. A consistent and systematic field screening program to determine the suitability of Haul Road fill for use as cover material is required. The field program will include boreholes, test pit inspections, and sampling for sieve-hydrometer gradation analyses and applicable metals, leachability, and acid-base accounting analyses.

3.14 Borrow Areas

Preliminary assessments of borrow areas including existing and potential new borrow sources have been completed in connection with the C&R Plan. A more thorough determination of available volumes and geotechnical and geochemical characteristics is required.

Studies considering VECs (such as vegetation and rare plant surveys) have not been completed or are not up-to-date for potential borrow sites. Surface water conveyance studies and hydrogeological evaluations of the potential borrow source areas are also warranted. Most borrow sites have not been evaluated in the EA.

Reclamation of all current and future borrow sources will be a requirement for final site remediation. As such, alternative sources for borrow materials should be considered. All onsite waste products should be investigated for use as potential borrow material, depending on the potential cover requirements and potential source-specific chemical and geotechnical characterizations.

Considerations for borrow development planning should be evaluated and established as standard operating procedures to minimize disturbances in new areas and to maximize volumes to allow more efficient reclamation and revegetation.

3.14.1 Faro Area

Potential borrow sources identified in the FMC are focused primarily on previously disturbed areas in an effort to minimize potential impacts on terrestrial and aquatic habitats or VECs. The few potential borrow materials previously identified on the FMC include granular fill in the tailings borrow area and coarse rock materials from the waste rock dump and the Intermediate Dam spillway. Few potential borrow sources for low-permeability soil were previously identified in the FMC.

The supplementary field programs for the FMC consist of a focused drilling (sonic boreholes), test pits, and sampling to adequately characterize the geotechnical and geochemical properties of each potential borrow area. The granular and coarse rock borrow materials will be evaluated for suitability for a variety of uses including inert cover material, erosion protection, drain material, and concrete aggregate. The drilling investigation will be supplemented by a test pitting and sampling program. Representative samples will be analyzed for gradation, leachability, and water retention characteristics to determine suitability for use in the closure covers or as a growing medium.

Numerous additional potential sources for granular fill were identified during preliminary investigations; however, further investigations will be required to define potential volumes and suitability for use. Surface mapping shows the potential for low-permeability, in situ fill material recovered from future regraded toes of slope toes within the expanded waste rock dump footprint.

In general, potential borrow areas in undisturbed areas will be investigated by using minimally intrusive techniques, if feasible, such as seismic refraction surveys to measure depths and compressive wave velocity tests to evaluate rippability. More intrusive tests may be required.

3.14.2 Rose Creek Tailings Area

The existing Rose Creek Borrow Area could be expanded as a potential granular source (alluvial and glaciofluvial deposits). The C&R Report identified a volume estimate of 1.5 million m³; however, the amount that has been used since these estimates were developed is unknown. If granular borrow is in short supply, it may be possible that coarser tailings could be used as a levelling/cushion layer below a synthetic liner for areas requiring very-low permeability covers.

According to the C&R Report, the Rose Creek Haul Road borrow is a potential source of 800,000m³ of low-permeability material (glacial till).

The supplementary field investigation to evaluate the potential granular and fine-grain borrow within the RCTA would include test pitting, sonic boreholes, and sampling to determine geotechnical and geochemical characterizations.

The existing Rose Creek Diversion Quarry may be expanded as a phyllite riprap source (or potential growth medium). Test pits, drill holes, a suite of geotechnical index property tests and geochemical characterizations are needed to delineate the potential for additional riprap to be excavated from an expanded quarry. The excavation associated with the construction of the proposed Intermediate Dam spillway (specific location to be determined) has the potential to provide additional borrow material.

3.14.3 Vangorda/Grum Area

To minimize potential impacts on terrestrial and aquatic habitats or VECs, potential borrow sources identified in the Vangorda/Grum Area focus primarily on previously disturbed areas. The potential borrow materials previously identified in the Vangorda/Grum Area include low-permeability soils, granular fill, and rock quarries.

The largest potential borrow source in the Vangorda/Grum Area is the Grum Overburden Dump, which is estimated to contain on the order of 8.0 million m³ covering an area 1,000m x 700m to an average depth of 12m. The supplementary field program for the Grum Overburden Dump consists of drilling and sampling to characterize the geotechnical and geochemical properties of the overburden dump and underlying foundation materials. The overburden dump and foundation materials will be evaluated for suitability for a variety of uses including inert fill, incorporation in an ET cover, and a growth medium for revegetation. The drilling investigation will be supplemented by a test pitting and sampling program. Representative samples will be analyzed for gradation, leachability, water retention characteristics, and suitability as a growth medium. The program will also identify areas that are potentially unsuitable for use as final cover.

Numerous additional potential sources for fine-grain and granular borrow fill have also been identified during preliminary investigations; however, further investigations will be required to define potential volumes and suitability for use. In general, potential borrow areas in undisturbed areas will be initially investigated by using minimally intrusive techniques, if feasible, followed by more intrusive tests if required.

Several potential riprap quarries have been identified in the Vangorda/Grum Area and will be investigated in connection with the supplementary field program.

Engineering Data Gaps Table

This section describes the engineering data gaps table presented in Appendix B. This data gaps table is an update of Table 2-2A in the CH2M HILL proposal, *Advanced Engineering Design Team Faro Mine Complex Closure and Remediation* (CH2M HILL, 2011). The engineering data gaps have been identified on a site-wide basis and by activity-levels specific to the principal areas of division defined in the C&R Report. These principal areas of site division included the Faro Mine Area, RCTA, Vangorda/Grum Area, Haul Road, Water Treatment, and Borrow Areas. The first three columns of the table identify the activity code (if applicable), task name, and task description for the site-wide work needs and each closure activity. The remainder of the table's columns are described below.

4.1 Technical Uncertainties

This column in the engineering data gaps table (see Appendix B) provides a brief description of the technical uncertainties associated with remedial design for each closure activity. These uncertainties are based on review of the C&R Report, the documents described in Section 1.2, and the reference materials listed in Appendix A. The technical uncertainties column details the types of information that are not currently known which could affect the remedial design. These technical uncertainties are drivers for identifying the project data gaps. Clarification of these uncertainties will allow refinement of the data gap list and the associated costs.

4.2 Technical Assessments

This column in the engineering data gaps table (see Appendix B) provides a brief description of the technical assessments required to conduct the design. The technical assessments are the types of analyses that need to be performed for each task to generate the basis of design report and are the basis for identifying data gaps for each task. The technical assessment needs are based on a review of the C&R Report, potential options to the components in the C&R Report, and the other documents described in Section 1.2.

4.3 Data Gaps

This column in the engineering data gaps table (see Appendix B) summarizes the data gaps identified for evaluating different options to components for closure, and for the design of each closure activity. The data gaps were identified by reviewing the existing data analysis (using the C&R Report, the documents described in Section 1.2, and the reference materials listed in Appendix A) and comparing that to the data and information requirements to design and implement the remedial actions specified in the C&R Report. The data gaps include key information that is needed to (1) adequately define current conditions, (2) select among potential options for closure components, (3) perform the technical assessments required to generate a basis of design report, and (4) perform remedial design.

4.4 Field Work

This column in the engineering data gaps table (see Appendix B) identifies the fieldwork that needs to be performed to fill the associated data gaps for each task. Field work needs were identified after review of the existing data (using the C&R Report, the documents described in Section 1.2, and the reference materials listed in Appendix A).

Regulatory Data and Analysis Gaps

5.1 Introduction

5.1.1 Scope and Objectives

This section describes data and analysis gaps that need to be addressed specifically to meet the requirements for the Project Proposal for an Executive Committee screening. Some of the gaps are unique to the Project Proposal requirements, while others are similar or related to gaps identified to meet the needs of engineering and design, as discussed in Sections 3 and 4.

The Phase 2B goal for the PDT is to complete a Project Proposal that meets the requirements of the YESAA process. Recognizing these requirements, the regulatory team focused its gap analysis on identifying work and information that will be needed to support the YESAA process. The regulatory team also considered the subsequent regulatory needs for permitting processes, but recognized that most of these will entail additional levels of detail. The regulatory team focused on the need to describe the environmental and socio-economic conditions (baseline) and the potential project effects on VCs. The team structured the gap analysis to systematically identify gaps associated with completing a comprehensive effects assessment, and the need to thoroughly describe the assessment in the Project Proposal. The broad objectives of the regulatory gap analysis were as follows:

- Conduct an initial review of existing information about the project, including assessment-related information and characterize the status of existing information
- Understand information requirements for a YESAA assessment including expectations of YESAB, proponents and reviewers
- Identify areas where the existing information for the FMRP may not meet the information requirements
- Describe approaches and outline schedules for addressing outstanding information and analysis requirements

The regulatory team structured its gap analysis in a consistent way around key steps and components of an effects assessment. Where discipline teams identified gaps, they also characterized the importance of the gap and the proposed timing for addressing the gap. Importance was characterized in three categories as follows: (1) Critical – Must Do, (2) Ideal, and (3) Nice to Have But Not Necessary. Each environmental discipline team evaluated potential gaps in the following areas:

- Baseline research and field studies
- Baseline analysis and interpretation
- Scoping of assessment
- Research and field studies to assess potential effects
- Analysis and interpretation for assessing potential effects
- Reporting of effects assessment and predictions
- Development of mitigation plans
- Development of AMPs
- Development of monitoring plans

The reporting and assessment scoping gaps are not addressed in this report, which focuses on data and analysis gaps. However, the team identified gaps in all of the above areas and the costs for addressing those gaps have been included in the cost opinion.

While conducting the gap analysis, frequent gap overlaps were identified among disciplines on the regulatory team and between the regulatory and engineering teams. As a result, gaps are sometimes identified by more than one discipline. The regulatory team concluded that gaps should be identified for each discipline where they arise.

The completion of the gap analysis has been accompanied by discussions among discipline teams to reconcile how the gaps would be addressed to avoid duplication. Further reconciliation will likely be required during the development of work plans for addressing gaps. Identifying gaps for all areas where they arise highlights the importance of some key cross-disciplinary gaps while recognizing the need for cooperation among the team members when addressing gaps. The regulatory team did not focus on actions needed to address gaps in the description of the proposed project. Although this will be a required component of the Project Proposal, the regulatory team recognized that these information needs will be addressed primarily by the engineering team and has worked with them for inclusion.

5.1.2 Section Organization

The results of the regulatory gap analysis are presented in the remaining subsections of Section 5. Section 5.1.3 briefly summarizes YESAA information requirements. Sections 5.2 through 5.6 summarize gaps; details are provided in Appendix C, Tables C-1 through C-6 (see Volume 2 of this report), as follows:

- Section 5.2; see Table C-1: Baseline Research and Field Studies
- Section 5.3; see Table C-2: Baseline Analysis and Interpretation
- Section 5.4; see Table C-3: Research and Field Studies to Assess Potential Effects
- Section 5.5; see Table C-4: Analysis and Interpretation for Assessing Potential Effects
- Section 5.6; see Table C-5: Development of Mitigation, Adaptive Management, and Monitoring Plans
- Section 5.7; see Table C-6: Overarching Regulatory Gaps

During initial discussions about data and analysis gaps, the regulatory team recognized that there were frequently overlaps among related disciplines. As a result, the discussions about gaps were undertaken in discipline groupings. The groupings were created to combine disciplines with frequent, cross-disciplinary information needs and gaps. For each discipline grouping, Sections 5.2 through 5.6 first identify cross-disciplinary gaps and then discipline-specific gaps. The text of the report highlights high-priority gaps and cross-disciplinary gaps, and the tables provide additional details for each discipline. The following discipline groupings are addressed in this section:

- **Water Resources and Aquatic Ecosystem:** Hydrogeology; hydrology; surface water quality and aquatics; geochemistry; fish habitat compensation; and, ecological and human health risk assessment (aquatic components)
- **Terrain, Landforms, and Terrestrial Ecosystem:** Terrain, geology, geological hazards, and seismicity; vegetation and reclamation; wildlife; and ecological and human health risk assessment (terrestrial components)
- **Air Quality, Climate, and Noise**
- **Socio-economic**

Section 5.7 describes some overarching regulatory gaps and Section 5.8 summarizes gaps that could affect project timelines if they are not addressed in the very near term.

5.1.3 Overview of *Yukon Environmental and Socio-economic Assessment Act* Requirements

The FMRP will trigger an Executive Committee Screening under YESAA, whereby the effects of the project will be assessed by the YESAB Executive Committee. The assessment process will entail a detailed technical evaluation of information provided and work completed including review and input from a wide range of technical experts and regulatory agencies.

The information requirements for the Project Proposal are broadly described in the *Proponent's Guide to Information Requirements for Executive Committee Project Proposal Submissions* (YESAB, 2005). YESAB has initiated the development of several technical guidance documents to provide additional clarification about information requirements. These include guidance about water information requirements (hydrology, water balance, water quality), dams, wildlife baseline data, geochemical characterization, modelling, and climate

change. Some of these guidance documents will be available to support development of the Project Proposal for the FMRP.

The purposes of YESAA are to assess the potential environmental and socio-economic effects of proposed projects, protect environmental and socio-economic values, foster sustainable development, and provide opportunities for participation by First Nations and other individuals and agencies. For Executive Committee Screenings, YESAA (s. 50) requires that the Project Proposal include evidence describing how the proponent has considered the following:

- All stages of the project
- The significance of environmental or socio-economic effects of the project, including effects of accidents and malfunctions
- Alternatives to the project, or alternative ways of undertaking or operating it, that would avoid or minimize any significant adverse environmental or socio-economic effects
- Mitigative measures and measures to compensate for any significant adverse environmental or socio-economic effects
- The need to protect the rights of First Nations people; the special relationship between First Nations people and the wilderness environment; and the cultures, traditions, health, and lifestyles of First Nations people and other residents of Yukon
- The interests of residents of Yukon and of other Canadian residents

YESAA (s. 50) also requires that proponents consult with First Nations and the residents of any community where the project is located or might have significant effects. In addition to these legislated requirements, YESAB encourages proponents to consider and provide information about additional matters like combined effects of other projects, because these matters will be addressed in the assessment.

To achieve the purposes of YESAA and address the information needs, Project Proposals and their supporting documents need to include the following information:

- Description of the proposed project with adequate level of design detail to demonstrate practicality and feasibility, and to assess potential environmental and socio-economic effects
- Description and evidence of consultation undertaken with First Nations and communities
- Description of environmental and socio-economic baseline conditions supported by data, analysis, and interpretation that demonstrates a thorough understanding of those conditions
- Identification of environmental and socio-economic values considered in the assessment, as well as the scopes, factors, and methods utilized in the effects assessment
- Identification and characterization of potential interactions between the project and the identified values, supported by research, data, analysis, and interpretation that demonstrates the rationale for predicted effects, and the degree of uncertainty associated with the predictions
- Identification and characterization of potential combined effects of the project with other projects and activities
- Descriptions of proposed mitigation, monitoring, and adaptive management approaches with sufficient detail to demonstrate effectiveness for addressing potential environmental and socio-economic effects of the project

The need to fulfill these broad requirements guided the regulatory gap analysis.

5.2 Baseline Research and Field Studies Gaps

The Project Proposal must describe the baseline environmental and socio-economic conditions. Understanding baseline conditions requires field investigations and monitoring. Substantial baseline monitoring programs and investigations have been conducted at the FMC in the past, and monitoring programs are continuing. This section identifies areas where the existing information appears inadequate to meet the requirements for the Project Proposal, and where additional research or field investigations are needed to address the gaps. Details of baseline research and field study gaps are identified in Appendix C, Table C-1 (see Volume 2 of this report).

5.2.1 Water and Aquatic Ecosystem

5.2.1.1 Cross-disciplinary Gaps

During meetings, several aquatic teams identified the need to quantify surface water/groundwater interactions including spatial and temporal variability, as well as associated habitat values. The teams recognized that the proposed remediation project will change the groundwater regime because of activities like groundwater collection and cover installation. The extent of future changes in groundwater/surface water interactions could affect hydrology, water quality, and aquatic habitat. Such changes could constitute an important component of habitat loss for the purposes of a fisheries authorization. Quantification of these interactions has been identified as a high-priority data gap. Characterizing winter fish habitat use to understand how it may be affected by changes in groundwater/surface water interactions may be critical to project schedules. Addressing this gap will require installation of monitoring facilities (for example, pressure transducers) and conducting monitoring (for example, stream stage monitoring and surveying) at key locations where habitat or water quality conditions may be affected by changes in groundwater/surface water interactions. Some well installations may be required. Fish habitat usage investigations may also be needed.

5.2.1.2 Hydrogeology Gaps

The hydrogeology team identified high-priority baseline research and field study gaps in the following two main categories:

- Several gaps related specifically to areas where groundwater interception systems are planned. These include delineating properties of aquifer systems, defining bedrock topography and saturated alluvial thickness, and delineating the 3D extent of target areas. Groundwater flow is an important vector between contaminant sources at the site and the aquatic receiving environment. Understanding groundwater properties in areas of contaminant migration (that is, proposed interception areas) will be important for demonstrating a thorough understanding of baseline site conditions and developing defensible predictions of project effects. Addressing these gaps will require field investigations and programs including aquifer testing, seismic or geophysical surveys, and, potentially, well installation/monitoring.
- Delineation of permafrost at the site. Permafrost can have a substantial influence on groundwater flow directions and rates as well as groundwater/surface water interactions. The gap has been identified by several terrestrial disciplines as well. Methods for addressing the gap have been proposed by the terrain team, as described in Section 5.2.2.1, beginning with modelling and proceeding to further field investigations, if needed, in specific areas.

5.2.1.3 Hydrology Gaps

The hydrology team identified several high-priority baseline research and field study gaps related to characterizing baseline flow conditions both at the site and downstream. Addressing these gaps will entail monitoring flows, water elevations, and suspended solids, as well as research about downstream water uses. Detailed information to characterize channel conditions is also a gap, but the information has been identified as a higher priority for engineering needs and will be addressed there. The hydrology team identified the need for continued monitoring of flows and precipitation data throughout remediation planning and implementation.

5.2.1.4 Surface Water Quality and Aquatics Gaps

The surface water quality and aquatics team acknowledged that significant data already exist for understanding baseline conditions, but recommended that some additional data collection would be required to fill gaps and

update existing information. Responding to the information requirements for the Project Proposal, the water quality and aquatics team identified high-priority gaps related to developing and updating information about the following aquatic components:

- Identify and characterize aquatic species at risk by initial research of species and habitat suitability, followed by field investigations, if warranted
- Update benthic invertebrate information with a complete monitoring program in 2012, including adequate reference areas
- Collect periphyton data to characterize reference and exposed areas
- Update and complete information about fish habitat, populations, and utilization (for example, density estimates and gaps involving seasonal utilization patterns and pool/pond habitat characteristics)

Addressing these gaps, which primarily entail updating of existing information, will require a series of field programs in 2012 and 2013. Some investigations must be performed in late winter or early spring and should be conducted in 2012, or they might affect project schedules.

5.2.1.5 Fish Habitat Compensation Gaps

The inadequacy of detailed fish habitat characterization and mapping for affected creeks is a high-priority baseline gap identified by the fish habitat compensation team. There is some good information available about fish habitat (for example, de Graff [2010] discusses reaches of NFRC and the Rose Creek Diversion) but it needs to be augmented by additional field work (for example, characterize deeper pools/ponds that may represent overwinter areas; areas of substantial groundwater upwelling). A 2012 field study focused on quantifying fish habitat would be required to address the gap. Other baseline gaps identified in relation to fish habitat compensation are identified by other water-related disciplines.

5.2.1.6 Geochemistry Gaps

Understanding geochemical conditions at the site will be critical to describing baseline conditions. Although substantial baseline information already exists from seep, groundwater, and surface water sampling, the geochemistry team recognizes the need to continue updating that information because geochemical conditions at the site are continually changing. Therefore, seep, groundwater, and surface water monitoring should be continued during project design. Details regarding information requirements for geochemistry are addressed in the engineering gap analysis.

5.2.1.7 Ecological and Human Health Risk Assessment Gaps – Aquatic

For the aquatic environment, the risk assessment team identified up-to-date water quality data as a high-priority baseline gap. The team identified the need for monitoring consistent with the *Aquatic Ecosystem Monitoring Program, Faro Mine, Yukon* (Minnow Environmental Inc, 2010) so that this information can be used to refine the risk assessment. Discussions with YG suggest that this monitoring is already under way as part of the care-and-maintenance monitoring program. Additional gaps have also been identified in relation to direct toxicity testing and characterization of contaminants in sediment and aquatic biota.

5.2.2 Terrain, Landforms, and Terrestrial Ecosystem

5.2.2.1 Cross-disciplinary Gaps

In gap analysis documentation and during meetings, terrestrial teams identified several cross-disciplinary gaps in baseline data and research. Although the gaps are identified in several disciplines, the methods to address the gaps have been discussed and reconciled by assigning them to appropriate discipline teams.

Several teams in both the terrestrial and aquatic groupings identified the lack of permafrost delineation as a gap in the study area data. Reclamation activities could affect permafrost thermal stability, leading to effects on the performance of remediation measures. Also, long-term thermal stability of permafrost in the study area may affect project components. The terrain team proposes to address this gap in two steps: first by desktop mapping and modelling, followed by groundtruthing the findings if needed in specific areas.

Reclamation and risk assessment teams identified gaps in information related to soil quality, including chemical concentrations, toxicity to organisms, and bioavailability of chemicals. The information will support land classification, an important component of both vegetation and wildlife baseline information. It will also support refinement of the ecological risk assessment. The vegetation and reclamation discipline team has described a field program to address the gap, and will coordinate with the risk assessment discipline team to address their needs.

Reclamation and risk assessment teams identified a gap in information about contamination from dust. The air quality discipline has also identified the need for additional information about airborne contaminant migration at the site. The gap is addressed in more detail in Section 5.2.3.

The wildlife team identified a gap in information about aquatic habitat conditions (for example, benthic invertebrates, vegetation, sediment metal levels) in pits and ponds at the site, specifically in relation to utilization of these water bodies by water birds. Similar information gaps were identified by the reclamation/vegetation discipline, for characterizing wet landscapes as part of baseline and for reclamation planning. The need to update information about aquatic habitat conditions was also identified by some water-related teams, although onsite pits and ponds were not specifically identified. Coordination among disciplines will be required for the field programs.

Wildlife and vegetation/reclamation teams identified a gap related to wildlife utilization of wetland and riparian habitats. The wildlife team has proposed a field study to address this gap.

5.2.2.2 Terrain, Geology, Geological Hazards, and Seismicity Gaps

Although the Proponent's Guide (YESAB, 2005) includes requirements for describing surficial geology, soils, and terrain hazards (including seismicity), the primary driver for information in these areas is to support engineering design. As a result, the Proponent's Guide focuses the information requirements on the project footprint, construction materials, and structural foundations. Gaps related to terrain, geology, geological hazards and seismicity will be refined and addressed in collaboration with the engineering team.

In addition to the cross-disciplinary gap related to permafrost, the Terrain, Geology, and Seismicity Team identified a series of high-priority baseline gaps in three broad categories: (1) aerial photography and mapping, (2) geological information, and (3) seismology information. The engineering sections of this report address aerial photography and mapping needs as well as the seismology information needs

5.2.2.3 Vegetation and Reclamation Gaps

In addition to several cross-disciplinary gaps (permafrost, soil quality, dust, wildlife use of wet landscapes), the vegetation and reclamation team identified a series of baseline gaps related to characterizing vegetation conditions. Detailed field studies to document vegetation are identified as high priorities for some areas that will be directly affected by the project and areas where existing information is not adequate considering the expected level of disturbance or current contamination (for example, ETA, NFRC, Vangorda Creek Valley, and proposed borrow areas). The lack of information about riparian and wetland areas is also a high-priority gap with recommendations for vegetation surveys as well as sampling for contaminant concentrations in soils and vegetation. Understanding wet landscapes is an important part of the baseline and for planning reclamation landscapes. Finally, within this grouping of vegetation characterization gaps, the team recommended additional investigations of rare plant occurrences in undisturbed areas likely to be affected by construction and reclamation activities and, potentially, more broadly within the local study area.

The vegetation/reclamation team identified an overall gap in information about baseline vegetation conditions in the project area. Vegetation data to characterize baseline conditions were collected in 2007 at survey intensity Level 3. The available information does not fully meet the requirements for the Project Proposal: the information is outdated and barely meets the survey intensity requirements for a project of this type and scale. However, the team has assigned Priority 3 to this gap, and recommends a discussion with YESAB and expert reviewers prior to taking action to resolve the gap. The FMC is not a greenfields site, and implementing the remediation project should improve terrestrial conditions, both onsite and in surrounding areas. As a result, the effort required to conduct more detailed and up-to-date vegetation characterization for baseline purposes may not be warranted. Costs for addressing this gap have not been included in the cost opinion.

5.2.2.4 Wildlife Gaps

The wildlife team acknowledged that substantial information already exists to support an effects assessment, but identified some areas where additional information is needed. In addition to the cross-disciplinary gaps, the wildlife team identified a series of gaps related to wildlife presence and utilization within the study area. Current information is not sufficient to demonstrate a comprehensive understanding of baseline utilization by furbearers, grizzly bear, water birds, and moose, all of which are VCs. For some of these species, information is needed for specific or seasonal uses (for example, moose winter use) and, for others, the existing data provide little information to support characterization of baseline uses (for example, furbearers, and grizzly bear). Addressing the gaps will entail a combination of desktop research (for example, habitat suitability modelling) and field investigations. A field survey of furbearer use is required in February–March 2012 to avoid schedule delays.

The wildlife team recognized the importance of designing and conducting field studies so that they meet the needs and expectations of YESAB and expert reviewers, especially wildlife experts at the YG Department of Environment. Therefore, the team has recommended discussions with relevant agencies about the study design prior to implementation.

5.2.2.5 Risk Assessment Gaps – Terrestrial Component

The risk assessment discipline team identified several gaps related to tissue concentrations of contaminants of concern, for example, in soil organisms, vegetation, small mammals, and large ungulates. Gaps related to soil organisms and vegetation were assigned a high priority because this information will be used to assess direct effects on those ecological receptors and is needed to assess effects on wildlife through the food chain. Gaps for other organisms received a medium priority, recognizing that additional information about these receptors will support and corroborate the results of the risk assessment. Discussions with FPET in January 2012 confirmed that collection and tissue concentration data for small mammals and large ungulates presents community and logistical challenges and is not warranted.

5.2.3 Air Quality, Climate, and Noise

As noted in Section 5.2.2.1, the air quality, risk assessment, and reclamation teams identified a baseline gap in information about airborne contaminant release, with the risk assessment and reclamation teams specifically identifying needs for information about the implications of dust transport. To address this gap, the air quality team has identified two options: complete a long-term, multi-contaminant air quality monitoring program, or complete an emissions inventory and air dispersion modelling, in conjunction with existing “pristine” background conditions, to estimate current ambient conditions. Previous air quality monitoring programs have had low success in defining air quality baseline conditions for parameters such as particulate matter less than 10 micrometres in aerodynamic diameter (PM₁₀), TSP, and metals due to various shortcomings including the poor siting of monitors, weather conditions, and laboratory errors. However, an understanding of current conditions for these parameters is needed to interpret results of an emissions inventory for the proposed remediation and post-remediation conditions, including identifying the effects of the project from a human and ecological health standpoint. Because of high costs and several factors that could negatively affect the monitoring program results, the air quality team recommends that the more cost-effective option of developing a robust emissions inventory along with modelling to estimate current ambient conditions be adopted. While the gaps analysis identifies both options, only the more cost-effective option of emissions inventory with modelling is included in the cost opinion. Discussions with FPET in January 2012 confirmed that undertaking an emissions inventory is an appropriate approach for understanding current air quality conditions.

5.2.4 Socio-economic

The socio-economic team identified several high-priority baseline research and study gaps related to the well-being of the First Nations and communities most affected by the FMRP: Ross River Dena Council, Selkirk First Nation, Liard First Nation, the town of Faro, and the community of Ross River.

A robust baseline data set of community conditions is essential to understanding and articulating the positive and negative repercussions of the project, especially on VC such as sustainable livelihoods, employability,

infrastructure, economic diversification, healthy business sector, community vitality, safety and security, quality of life, community infrastructure and aesthetic, and cultural continuity.

The current baseline data are lacking in several key areas, most notably local employment and training statistics, skills assessment, details on local businesses for contracting and procurement opportunities, economic activity and social services such as health, education, and community support information. Addressing these gaps will allow the team to understand and articulate the potential social, economic, and employment impact of the project on local area communities.

As the current descriptions of socio-economic baseline conditions are minimal, addressing socio-economic gaps will require substantial research and data collection efforts including field visits, and community meetings to collect, compile, and groundtruth essential data.

5.3 Baseline Analysis and Interpretation

Using baseline data to understand and describe baseline conditions requires analysis and interpretation of those data, often relying on modelling or statistical analysis. This section identifies areas where additional analysis and interpretation of existing or new data are required. In many cases, the analysis involves updating earlier work by incorporating new data. In other cases, more detailed analysis may be required. Details of baseline analysis and interpretation gaps are provided in Appendix C, Table C-2 (see Volume 2 of this report).

5.3.1 Water and Aquatic Ecosystem

5.3.1.1 Cross-disciplinary Gaps

In gap analysis documentation and during meetings, several aquatic teams highlighted the critical need for more comprehensive overall water and load balance modelling to support remediation planning and effects assessment. At a November 18, 2011, workshop, YESAB stated that modelling to predict potential effects should be part of the Project Proposal, and provided information about the types of documentation needed to support the predictions. Addressing this analysis gap will require a cross-disciplinary approach for the regulatory team and also close integration with the engineering team, as the project design will require similar inputs. The modelling efforts will need to include hydrology, hydrogeology, geochemistry, and water quality components, and integrate these components to provide overall predictions of potential effects on water quality and the aquatic environment. Developing the models will support both the understanding of baseline conditions and the potential effects of the proposed project; thus, it is a gap that corresponds to more than one category of the regulatory gap analysis.

5.3.1.2 Hydrogeology Gaps

High-priority baseline analysis gaps identified by the hydrogeology team are related to developing numerical modelling tools focused on the quantification of the properties of the groundwater aquifers at the site, and the nature of surface water/groundwater interaction, especially in areas of proposed groundwater interception systems.

5.3.1.3 Hydrology Gaps

Several of the high-priority baseline analysis gaps identified by the hydrology team support the development and refinement of hydrologic/hydraulic models. This includes analyzing extreme flood events, channel conditions, groundwater interactions, and cold regions engineering aspects such as snowpack measurements. A second, related category of gaps involves analysis to support the baseline description of hydrologic conditions for the Project Proposal. Additional research and analysis are required to incorporate updated data (for example, recent data, and data from baseline gap programs) about flows and to characterize various flow conditions/events.

5.3.1.4 Surface Water Quality and Aquatics Gaps

Baseline analysis gaps identified by the surface water and aquatics team all entail updating existing analyses to incorporate recent data and data collected in proposed baseline research programs. These updates will be required for all ecological components.

5.3.1.5 Fish Habitat Compensation Gaps

Characterizing existing fish habitat quantities and utilization will require analysis of existing information along with new information collected for proposed baseline research gaps. Baseline habitat analysis and characterization is a high-priority gap as the information will be required to define the extent of required habitat compensation.

5.3.1.6 Geochemistry Gaps

Analysis of geochemistry will be an important input for addressing the cross-disciplinary gap related to overall site water and load balance modelling. Details of geochemistry analysis requirements are addressed as part of the engineering gap analysis.

5.3.1.7 Ecological and Human Health Risk Assessment Gaps – Aquatic

Updating the aquatic risk assessment to incorporate up-to-date data from existing monitoring programs and proposed baseline data gap programs is a high priority for the risk assessment team. The update will include refining exposure models and toxicity reference values where appropriate and utilizing actual measured concentrations to replace modelled concentrations in some circumstances. The analysis needs to be updated for baseline conditions as well as for predicted future conditions. Consequently, the need to update and refine the risk assessment analysis is a gap that corresponds with more than one category of the regulatory gap analysis.

5.3.2 Terrain, Landforms, and Terrestrial Ecosystem

5.3.2.1 Cross-disciplinary Gaps

Several terrestrial-related teams identified a gap related to delineating permafrost conditions, as discussed in Section 5.2.2.1. The terrain/geology/seismicity team recommends that this gap be addressed by modelling to identify expected areas of permafrost, followed by groundtruthing to confirm model results, where needed. Climate data (for example, mean annual air temperatures, degree days freezing/thawing, precipitation [rain versus snowfall], and solar radiation) as well as DEMs, mapping, and thermistor data will be used to develop a permafrost model and generate an initial permafrost distribution map. Groundtruthing will be used to validate the model results.

5.3.2.2 Terrain, Geology, Geological Hazards, and Seismicity Gaps

Baseline analysis gaps in the terrain/geology/seismicity disciplines relate to processing and analyzing data collected in the proposed baseline investigations, including the proposed analysis to model permafrost distribution (cross-disciplinary). Analyzing aerial photography, mapping data, and DEMs will support the preparation of base maps of soil and terrain units as well as geological hazards to address outstanding information needs for describing baseline conditions.

5.3.2.3 Vegetation and Reclamation Gaps

The vegetation/reclamation team identified several site areas that are currently affected by site activities, facilities, and contamination, and where substantial changes will arise during remediation. For these areas, the team has recommended ESA to support the integration between baseline conditions, reclamation planning, environmental assessment, and engineering design.

As described by the vegetation/reclamation team, one of the biggest issues in landscape function on the FMC will be the interaction of disturbed mine reclaimed landforms with “undisturbed” natural areas directly adjacent. Such areas include the NFRC and channel of Rose Creek valley upstream from the diversion; the Grum and Vangorda Creek valleys between the Grum and Vangorda waste rock piles; and the natural area adjacent to the ETA and toward the Rose Creek tailings facility. Many options exist for how this interaction will occur and the site-wide drainage and revegetation planning needs tools, such as an ESA, to support decisions on how the final reclamation landscape will look. ESA provides a method to quantify ecological services provided by these undisturbed areas and by the different options for supporting the reclaimed surface, so that the best choice for sustained function and resilience of the whole landscape can be described and rationalized. Completing an ESA involves sourcing quantifiable measures for different services provided by a system (for example, for Rose Creek, these would include water purification, fish habitat, riparian wildlife habitat, wildlife movement corridor, and carbon sequestration, to name a few) and assessing changes to these measures depending on what is changed within the

system as a result of reclamation activities. Wet landscapes are often in this category, as reclamation techniques can be ineffective and the ecosystem services are generally great in number and wide in effect. For these areas, remediation planning and engineering would best be supported by Ecosystem Services Analysis.

5.3.2.4 Wildlife Gaps

The wildlife team identified two baseline analysis gaps in addition to those that entail evaluating the data collected in the new baseline programs identified in Section 5.2.2.4. Moose populations in the area are currently affected by harvest pressures. Analysis of recent harvest data is needed to understand the current pressures on the population. Water and habitat quality conditions in onsite pits and ponds may have existing effects on water birds. Research and analysis are needed to assess any existing effects. This analysis will rely on existing water quality data as well as information collected about habitat conditions.

5.3.2.5 Risk Assessment Gaps – Terrestrial Component

As with the aquatic component of the risk assessment, updating the terrestrial risk assessment to incorporate up-to-date data from existing monitoring programs and proposed baseline data gap programs is a high priority for the risk assessment team. The update will include refining exposure models and toxicity reference values where appropriate and utilizing actual measured concentrations to replace modelled concentrations in some circumstances. The analysis needs to be updated for baseline conditions as well as for predicted future conditions. As a result, the need to update and refine the risk assessment analysis is a gap that corresponds with more than one category of the regulatory gap analysis.

5.3.3 Air Quality, Climate, and Noise

The climate discipline team identified a baseline analysis gap related to compiling and analyzing climatic baseline conditions (for example, wind, temperature, precipitation, solar radiation, and other parameters). Analyzing these data will support a robust definition of climatic conditions of the study area. This information is required for various regulatory disciplines to support modelling exercises and predict effects. Much of the climate information is available, and older data have been compiled in the supporting document, *Faro Project Management Team. Faro Mine Complex Closure and Reclamation – Project Proposal. Current Environmental Conditions Supporting Document* (AECOM, 2009). This information needs to be revised, reformatted, and updated to support the Project Proposal.

5.3.4 Socio-economic

Associated with the substantial gaps in baseline information, the socio-economic team recognizes an equally important gap with respect to analyzing the data collected. The socio-economic team will undertake analysis of the data gaps identified through the baseline research and field studies. This will entail documenting key socio-economic issues; profiling data; establishing valued socio-economic components through data collection and consultation; predicting and analyzing direct, indirect, and induced effects; and identifying the residual and cumulative effects of the project.

5.4 Research and Field Studies to Assess Potential Effects

The Project Proposal must predict potential effects of the proposed project. This section identifies additional research or field programs that are needed to support predictions of potential effects of the FMRP. Details of effects assessment research and field studies are provided in Appendix C, Table C-3 (see Volume 2 of this report).

5.4.1 Cross-disciplinary Gaps

As previously noted, in gap analysis documentation and during meetings, several aquatic teams highlighted the critical need for more comprehensive overall water and load balance modelling to support remediation planning and effects assessment. A cross-disciplinary approach will be required to provide overall predictions of potential effects on water quality and the aquatic environment. Developing the models will support both the understanding of baseline conditions and the potential effects of the proposed project; thus, it is a gap that corresponds to more than one category of the regulatory gap analysis.

5.4.2 Hydrogeology Gaps

No specific effects assessment gaps were identified for the hydrogeology discipline. Research requirements for understanding and assessing potential effects are addressed through programs to address gaps in other regulatory categories and in the engineering gap analysis.

5.4.3 Hydrology Gaps

No specific effects assessment research gaps were identified for the hydrology discipline. Research requirements for understanding and assessing potential effects are addressed through programs to address gaps in other regulatory categories and in the engineering gap analysis.

5.4.4 Surface Water Quality and Aquatics Gaps

No specific effects assessment research gaps were identified for the water quality and aquatics discipline. Research requirements for understanding and assessing potential effects are addressed through programs to address gaps in other regulatory categories and in the engineering gap analysis.

5.4.5 Fish Habitat Compensation Gaps

Two high-priority effects assessment research gaps have been identified by the fish habitat compensation team. First, expected fish habitat losses over time need to be quantified by integrating information from the proposed project design with data about existing habitat conditions. Second, there is insufficient information about compensation opportunities. Thus, additional research is required to investigate areas unaffected by the project and identify sufficient habitat compensation opportunities to address the expected habitat losses.

5.4.6 Geochemistry Gaps

No specific effects assessment research gaps were identified by the geochemistry team. However, there are substantial geochemistry gaps identified by the engineering team to support overall modelling exercises. Addressing these gaps will provide information to support the regulatory requirements.

5.4.7 Ecological and Human Health Risk Assessment Gaps – Aquatic

No specific effects assessment research gaps were identified for the aquatic component of the risk assessment. Research requirements for understanding and assessing potential effects are addressed through programs to address gaps in other regulatory categories and in the engineering gap analysis.

5.4.8 Terrain, Landforms and Terrestrial Ecosystem

5.4.8.1 Cross-disciplinary Gaps

Terrain/geology, reclamation/revegetation, and risk assessment teams each identified the lack of information about quality (chemical concentrations) of cover and borrow materials as a high-priority gap. Covers are an important component of the remediation plan and will constitute much of the final interaction surface with the environment. Sampling and analyzing cover materials is critical to understanding the long-term effects of the post-closure site. Because the haul road may be a source of borrow material for some closure activities, it should also be included in programs to evaluate quality of borrow materials.

5.4.8.2 Terrain, Geology, Geological Hazards, and Seismicity Gaps

The terrain/geology/seismicity team identified the need to confirm the seismic analyses for the project area. These information needs will be more critical for engineering designs, and the gaps are addressed by the engineering team.

5.4.8.3 Vegetation and Reclamation Gaps

In addition to the cross-disciplinary gap described in Section 5.4.2.1, the Revegetation and Reclamation Team identified high-priority research gaps related to understanding the physical systems that support cover performance. This includes developing an understanding of hydrologic parameters (void spaces, water retention, store/release of water), topography (meso and micro), and differences between tailings and waste rock covers. Vegetation cover types depend on cover depth and microsite variation. Characterizing topography can affect

required cover quantities and landform planning because it may lead to greater cover depths or gentler slopes to allow working of the cover material.

The vegetation/reclamation discipline team assigned a high priority to characterizing effects of dust in areas affected by recent reclamation activities (for example, the Grum Sulphide Cell cover). Completing this research will support prediction of effects associated with future reclamation activities.

5.4.8.4 Wildlife Gaps

No specific effects assessment research gaps were identified by the wildlife team. Research requirements for understanding and assessing potential effects are addressed through programs to address gaps in other regulatory categories.

5.4.8.5 Risk Assessment Gaps – Terrestrial Component

Effects assessment research gaps for risk assessment are described as cross-disciplinary gaps in Section 5.4.2.1.

5.4.9 Air Quality, Climate and Noise

No specific effects assessment research gaps were identified by the air quality, climate, and noise discipline teams.

5.4.10 Socio-economic

Because the current information about socio-economic baseline conditions is very weak and there is no information available about the previous selection criteria or rationale for the stated VC, it is not possible for the socio-economic team to fully predict the socio-economic data gaps. As a result, research gaps have not yet been identified. However, the socio-economic team recognizes that there will be research and studies needed to support the effects assessment. In general, the Socio-economic team will be performing a detailed review of relevant socio-economic information via secondary information sources including existing studies and data, government databases and reports, publicly accessible project applications, and available First Nations and community data.

This information will be augmented with primary data gathered via stakeholder interviews, community meetings, directed surveys, and other public engagement and consultation activities. The socio-economic team will be working with other discipline teams so that collected information can be used to help predict socio-economic effects of the proposed project.

5.5 Effects Assessment – Analysis and Interpretation

Predicting environmental and socio-economic effects for the purposes of the Project Proposal requires systematic approaches to evaluate interactions between VCs and project activities. This section identifies gaps that require further analysis and interpretation to predict the effects of the FMRP. Details of effects assessment analysis and interpretation gaps are provided in Appendix C, Table C-4 (see Volume 2 of this report).

5.5.1 Water and Aquatic Ecosystem

5.5.1.1 Cross-disciplinary Gaps

With respect to analysis gaps for assessing potential effects of the remediation project, several water-related teams highlighted the critical need for a more comprehensive overall water and load balance model. The gap is discussed in Section 5.3.1.1 because the development of the models will support both the understanding of baseline conditions, as well as the potential effects of the proposed project. Modelling is also a gap identified in the engineering gap analysis. Development of models will consider information necessary for both uses.

Several aquatic teams identified the need to assess the effects of the construction phase of the project, which may or may not be addressed by comprehensive site modelling. Previous modelling and effects analysis addressed long-term, post-closure conditions for water quality but did not predict water quality and associated environmental effects during the construction phase. Construction activities can lead to substantial effects, as seen with the Grum Sulphide Cell Cover Project. Further analysis is needed to identify and predict effects from proposed construction activities, whether done through the overall modelling exercise or separately. Where

effects on specific ecological values cannot be predicted with reasonable certainty, robust monitoring, environmental management, and AMPs will be required as part of the Project Proposal to demonstrate that significant adverse effects will not occur.

5.5.1.2 Hydrogeology Gaps

Consistent with the above cross-disciplinary gaps, the hydrogeology team identified the need to more thoroughly assess the effects of construction as well as the longer-term effects of project operations on groundwater. Groundwater flow is a critical vector between source loads and the receiving environment. As a result, it will be important to understand temporal and spatial changes in groundwater conditions.

5.5.1.3 Hydrology Gaps

Consistent with the above cross-disciplinary gaps, the hydrology team identified the need to develop a site-wide hydrologic model based on the existing data set and new monitoring data.

5.5.1.4 Surface Water Quality and Aquatics Gaps

Consistent with the above cross-disciplinary gaps, the surface water and aquatics team identified the need to more thoroughly assess construction and long-term effects using modelling. The need to compile an aquatic impact assessment for closure is also a high-priority gap identified by the surface water and aquatics team. This gap can be addressed by utilizing the modelling results to predict effects on aquatic receptors. This modelling would be completed in cooperation with the risk assessment team.

5.5.1.5 Fish Habitat Compensation Gaps

Developing a fish habitat compensation plan will require analyzing habitat losses over time and identifying proposed compensation approaches, combining the results of programs to address gaps identified in other categories. The analysis will entail determining fish habitat affected by the proposed project and developing strategies to compensate for project impacts on fish and fish habitat. This will require collaboration with other groups (for example, Fisheries and Oceans Canada and YESAB) as necessary. Details about the proposed compensation plan will be needed as part of the Project Proposal to avoid potential requirements for subsequent, separate assessments to address fish habitat compensation activities.

5.5.1.6 Geochemistry Gaps

Consistent with the above cross-disciplinary gap, the geochemistry team will need to provide input to support the development of a site-wide water and load balance model for predicting potential long-term effects. Geochemistry information will also be required to support analysis of potential effects of construction activities. Details of geochemistry analysis requirements are addressed as part of the engineering gap analysis in Section 3.3.

5.5.1.7 Ecological and Human Health Risk Assessment Gaps – Aquatic

Consistent with the above cross-disciplinary gaps, the risk assessment team identified the need to refine site-wide modelling and the associated predictions of contaminant concentrations as these support the risk assessment. Completing an up-to-date risk assessment will also require re-evaluation and revision of exposure models and uptake factors that were used in the previous risk assessment. These changes will form the basis for reassessing risks for many receptors.

5.5.2 Terrain, Landforms, and Terrestrial Ecosystem

5.5.2.1 Cross-disciplinary Gaps

Habitat suitability modelling for the site conditions over time has been identified as a high-priority gap to integrate the requirements/expectations for wildlife habitat with the outcomes and designs for revegetation and reclamation activities. For the vegetation/reclamation team, this modelling is identified as a high priority because it will form the basis for predicting performance of landforms and vegetation in comparison to site objectives. For the wildlife team, habitat suitability modelling will directly support the assessment of potential effects on VC including avian species at risk, grizzly bear, furbearers, moose, and caribou.

The vegetation/reclamation team identified a high-priority effects assessment analysis gap related to understanding effects of interactions between contaminated water (for example, seepage) and vegetation.

Addressing this gap will require integration with the work of aquatic teams, ensuring that the site-wide modelling will provide information needed to support analysis of potential effects on vegetation.

Similar to the above gap issue, water and aquatic habitat quality during remediation and post-closure could affect water birds. Additional research and analysis are needed to assess potential long-term effects on water birds if they use pits and ponds onsite. Addressing this gap, identified by the wildlife team, will require integration with aquatic teams, ensuring that the site wide modelling will provide information needed to support the analysis of potential effects on water birds.

5.5.2.2 Terrain, Geology, Geological Hazards, and Seismicity Gaps

Understanding the net effects of the proposed reclamation project on terrain, as well as potential long-term effects of terrain and geology on the project, will require quantifying natural landforms/terrain units that will be affected by construction activities and new landforms created by mine reclamation activities to assess overall effects after considering mitigation. This assessment would be conducted using a GIS database and has been identified as a high priority to support the assessment of potential effects on VC for the Project Proposal.

5.5.2.3 Vegetation and Reclamation Gaps

Effects assessment analysis gaps for vegetation and reclamation are described as cross-disciplinary gaps in Section 5.5.2.1.

5.5.2.4 Wildlife Gaps

Several effects assessment analysis gaps related to habitat suitability modelling for wildlife are described as cross-disciplinary gaps in Section 5.5.2.1.

5.5.2.5 Risk Assessment Gaps – Terrestrial Component

Completing an up-to-date risk assessment will require re-evaluating and revising exposure models and uptake factors that were used in the previous risk assessment. These changes will form the basis for reassessing risks for many receptors. Also, the lack of future predictions of contaminant transport by airborne migration constitutes a high-priority gap for the risk assessment team. This gap is cross-disciplinary with the air quality discipline and is addressed in Section 5.5.3.1.

5.5.3 Air Quality, Climate, and Noise

5.5.3.1 Cross-Disciplinary Gaps

As noted in Section 5.5.2.5, the air quality and risk assessment disciplines identified a high-priority gap related to analyzing and predicting future air quality conditions. Additional analysis is needed to predict direct environmental effects on VC and as an input to the risk assessment. The air quality team has proposed to address this gap by completing an emissions inventory and air dispersion modelling to predict effects during the construction and post-construction phases of the project. A robust emissions inventory needs to be developed that specifies emission sources used and how the emissions are derived to assess the project's effects on air quality. Dust re-suspension and dispersion of metals should be tied to particular sources. The inventory and modelling should address particulate matter (PM) emissions (including metals content and other contaminants of concern within PM or otherwise) as well as nitrogen oxides, sulphur dioxide, carbon monoxide, and volatile organic compounds. The predictions should also include worst-case 24-hour emissions compared to applicable standards. The results can be used to directly assess effects on air quality and will be an important input for the human health and ecological risk assessments. Air dispersion modelling can be done by using a fully 3-dimensional model capable of estimating concentrations in the near- and far-field from a variety of source types.

The noise team identified the need to update the previously conducted noise assessment, which did not consider the most recent version of the remediation plan C&R Plan (Gomm Environmental Engineering Consulting, 2010). This gap can be addressed in conjunction with the engineering team as the project description is developed and refined. Descriptions of proposed equipment, activity levels, and noise estimates will be needed as inputs for noise propagation modelling.

5.5.4 Socio-economic

The available components of the draft Project Proposal do not include an assessment of potential socio-economic effects of the proposed project.

As a result, this is a significant gap for meeting the requirements of the Project Proposal. The socio-economic team has identified this as a general gap, recognizing that various assessment and modelling exercises, as well as community and stakeholder meetings, will be required to address the gap once baseline condition data and VC are defined and properly analyzed.

Without these scoping exercises, it is not possible to provide specific details about potential gaps.

5.6 Development of Mitigation, Adaptive Management, and Monitoring Plans

Environmental management or mitigation plans are an important component of a project description to develop an accurate understanding of potential effects. AMPs can address project uncertainties by identifying potential failure events, performance indicators, monitoring requirements, thresholds, and adaptive responses. Monitoring plans are important for confirming environmental or socio-economic status/changes, evaluating project performance, and groundtruthing assessment results. Mitigation, adaptive management, and monitoring plans are important components of the Project Proposal because they can significantly influence the prediction of effects and the risks associated with predictions and outcomes. Details of gaps related to mitigation, adaptive management, and monitoring plans are provided in Appendix C, Table C-5 (see Volume 2 of this report).

5.6.1 Water and Aquatic Ecosystem

Aquatic teams identified several gaps related to requirements for mitigation, adaptive management, and monitoring plans. These plans will be required with varying levels of detail to support the Project Proposal including the project description, effects assessment, and evaluation of significance. In some cases, plans have already been developed and will require updates and, in other cases, there appear to be no existing plans. The following actions have been identified to address gaps related to mitigation, adaptive management, and monitoring plans:

- Develop construction monitoring plan
- Develop post-closure monitoring plan
- Update and refine AMPs and associated monitoring plans
- Develop overall site water management plans (groundwater and surface water) for construction and post-closure phases, including mitigation measures, adaptive management, and monitoring
- Develop fish habitat compensation plan and associated monitoring plan
- Develop mitigation, adaptive management, and monitoring plans as appropriate for key aquatic contaminant receptors (for example, fish and aquatic biota)

5.6.2 Terrain, Landforms, and Terrestrial Ecosystem

Terrestrial teams identified several gaps related to the requirements for mitigation, adaptive management, and monitoring plans. The rationale for addressing these gaps is similar to that described for aquatic disciplines. In some instances, both discipline groupings identified the same plans as gaps, recognizing that both groups would contribute to overall plans. The terrestrial-related teams recommended developing the following mitigation, adaptive management, and monitoring plans:

- Construction materials management plan
- Permafrost protection and monitoring plan
- Monitoring and AMPs for climate change effects, geohazards, and extreme events
- Construction and post-closure monitoring plans

- Wildlife management plan including adaptive management and monitoring as needed
- Forest and vegetation management plan including adaptive management and monitoring as needed
- Dust control/mitigation plan
- Sediment management plan

5.6.3 Air Quality, Climate, and Noise

The air quality team identified gaps related to monitoring and AMPs. The draft Project Proposal does not appear to include an air quality monitoring program, and the AMP does not include air emission related action levels or a detailed dust control plan. To address these gaps, the team recommends developing the following:

- Air quality monitoring plan
- Dust control/mitigation plan
- A specific component of the AMP focussing on air quality and identifying trigger levels for specific contaminants (likely PM and metals), appropriate actions to be taken in the event of trigger values being measured, and feedback mechanisms for improving the dust control/mitigation plan

5.6.4 Socio-economic

From the current understanding of baseline conditions, assessment scope, and the proposed project, the socio-economic team identified two high-priority gaps related to mitigation and monitoring plans. These gaps are relevant for the project implementation phase but are also relevant for the planning phase.

Firstly, the team identified the need to develop a socio-economic mitigation and follow-up plan. The socio-economic team expects to identify socio-economic project outcomes that will require mitigation or enhancement activities to address the project consequences. Using the predicted outcomes, the team will design impact mitigation and enhancement plans for the local and regional study areas. As part of this planning, the team will establish a socio-economic monitoring plan that will be implemented by the affected communities. The plans will be developed in conjunction with the affected communities through public consultation and communications.

Secondly, consultation and engagement plans will be important for each phase of the proposed project. That is a well-recognized gap for the current project phase, but consultation and engagement needs will continue through project implementation and post-remediation. The consultation and engagement plan for project implementation will be an important component of the Project Proposal.

5.7 Overarching Regulatory Gaps

In addition to the gaps identified for specific steps and components of the YESAA process, there are three overarching gaps that are not addressed in the existing information. Appendix C, Table C-6, describes these gaps.

First, potential effects of the FMRP in combination with other projects and activities (cumulative effects) have not been addressed. When conducting a Screening, the Executive Committee is obliged to consider cumulative effects (the effects of a proposed project in combination with other existing and proposed projects and activities). Although YESAA does not require proponents to address cumulative effects in the Project Proposal, it is advisable to provide the Executive Committee with sufficient information to allow it to conduct the cumulative effects assessment. Addressing this gap will require compilation of information about other projects and activities, identification of potential overlapping effects on VCs, and assessment of the significance of combined effects.

Second, potential effects of the FMRP on heritage values have not been addressed. The purposes of YESAA and its genesis in First Nation Final Agreements establish a high importance for heritage values which can include moveable objects, records and land that is of aesthetic or cultural value. Assessment of potential effects on heritage values will be particularly important for new areas of disturbance, but may also be relevant for existing disturbed areas. Assessing the potential effects of the FMRP on heritage values will likely require heritage investigations/research to identify specific values, followed by evaluation of potential interactions between project activities and those values.

Third, climate change has not been systematically addressed in the existing information. The Executive Committee and regulatory experts will require evaluation of climate change scenarios as part of the Project Proposal. Global climate change could affect the project via a number of pathways, for example, permafrost thaw/stability, and changes in precipitation/hydrology. Addressing this gap will require a unified identification and evaluation of climate change scenarios so that this information can be used by various technical teams to assess potential effects.

5.8 Near-term Gaps

The regulatory team identified several time-sensitive gaps that may influence the overall schedule for completing the Project Proposal. YG's schedule envisions completion of the Project Proposal in fall 2014. As a result, fieldwork required for baseline characterization and effects assessment must be completed no later than late spring 2013. Therefore, gaps requiring year-round data must be initiated in 2012. Important time-sensitive data gaps that require winter or early spring activities include the following:

- Delineation of areas of surface water/groundwater interactions. These areas may require substantial further investigations through various seasons and need to be initiated in late spring 2012.
- Fisheries surveys, some of which must be initiated in 2012 and which will need to continue in spring 2013.
- Investigations of stream and fish habitat conditions, especially those requiring seasonal data that could include winter low flow conditions which would require investigations to be initiated in 2012.
- Collection of onsite water samples for toxicity testing, which should be collected in late winter 2012.
- Field survey of furbearers, which must be conducted in winter conditions and should occur in February or March 2012.
- Field studies of utilization by water birds. This program includes seasonal components that need to be completed in early spring 2012.
- Defining areas outside of the immediate project footprint that may be affected by the proposed remediation plan, including borrow areas and fish habitat compensation areas. These areas require substantial baseline investigations that need to begin in early 2012.
- Development of a socio-economic mitigation and enhancements planning document to support the effects assessment.
- Development of a consultation and engagement strategy to support the project design phase.

SECTION 6

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Appendix A
Focused Document List for Initial Gap Assessment

Faro Mine Complex – Focused Document List for Initial Gap Assessment

Dam Design and Major Structures

Seismic Stability of Dams

- “Hazard Assessment for Faro, YK” (Atkinson, 2004)
- “Rose Creek Tailings Impoundment Seismic Stability Assessment, Intermediate and Secondary Dams” (Klohn Crippen, March 2006)
- “Rose Creek Tailings Impoundment, Seismic Stability Assessment Addendum – Draft” (Klohn Crippen, April 2006)
- “Rose Creek Tailings Impoundment, Seismic Stability of Cross Valley Dam – 1 in 500 Year Earthquake” (Klohn Crippen, January 2007)

Hydraulic Capacity of Tailings Facilities

- “Faro Mine Hydraulic Capacity Analysis” (northwest hydraulic consultants ltd., June 2006)
- “RCDC Options Analysis Summary” (Memo from northwest hydraulic consultants ltd., February 2006)
- “RCDC Detail Design Issues” (Memo from northwest hydraulic consultants ltd., March 2006)
- “Rose Creek Diversion Canal Hydrotechnical Closure Design” (Draft Report, northwest hydraulic consultants, October 2006)
- “Faro Mine – RCDC Breach Over Intermediate Impoundment” (Memo, northwest hydraulic consultants, November 2006)
- “Rose Creek Tailings Facility, Faro Mine PMF Flood Handling, Phase 1 – Concepts for Passing the PMF over the Intermediate Impoundment” (Klohn Crippen Berger, September 2007)
- “Rose Creek Tailings Facility, Faro Mine, Intermediate Dam Spillway, PMF Flood Handling” (Klohn Crippen Berger, April 2008)
- “Rose Creek Tailings Facility, Faro Mine, Intermediate Dam – Dam Raise and Spillway Options Review” (Klohn Crippen Berger, October 2009)

Tailings Seismic Liquefaction

- Reports and memos by Golder related to the susceptibility of tailings to liquefaction under seismic loading

Geochemistry and Source Water Quality

Waste Rock

- “Water Quality Estimates for Anvil Range Waste Rock” (Draft, SRK, November 2004)
- “Geochemical Studies of Waste Rock, Phase 3 Report” (SRK, June 2004)
- “NP Study Report” (SRK, May 2009)
- Emergency Tailings Area
 - “2005 Seepage Investigation at the Emergency Tailings Area” (SRK, November 2006)
 - “Investigations in Support of Progressive Reclamation of the Emergency Tailings Area” (SRK, September 2006)
- Grum Dump Area
 - “Anvil Range Mining Complex, 2005 Seepage Investigation at the Grum Dump Area” (SRK, January 2007)
 - A number of annual adaptive management plan evaluations, including recommendations for action
- S-Wells Area
 - “2005 Seepage Investigation at the S-Cluster Area Below the Faro Waste Rock Dump” (SRK, November 2006)
 - “2008 S-Cluster Groundwater Investigation and Option Assessment” (SRK, February 2009)
- Zone 2 Outwash Area
 - “Continued Seepage Investigation, Zone 2 Pit Outwash Area” (SRK, January 2007)
- “2009 Groundwater Investigations” (SRK, February 2009)
- “2007 Supplemental Geochemical Studies Report”

Tailings

- “Faro Tailings Source Term Calculations” (Memo, SRK, June 2005)
- “Rose Creek Tailings Deposit, Assessment of Zinc Attenuation” (SRK, July 2006)
- “Bedrock Data and Groundwater Review for the Lower Rose Creek Valley” (SRK, May 2008)
- “Geochemical Assessment of Groundwater Quality in Rose Creek aquifer, Anvil Range Mine, YT” (Robertson GeoConsultants, February 2009)
- “Tracing Contaminant Sources to Groundwater and Surface Water in the Rose Creek Valley” (Robertson GeoConsultants, July 2011)

Pit Lakes

- “Anvil Range Pit Lakes, Assessment of Post Closure Conditions” (Draft Report, SRK, January 2004)
- “Anvil Range Pit Lakes Evaluation of In-Situ Treatment” contains Appendix D – “Updated Estimates of Post-closure Water Quality in Faro, Grum, and Vangorda Pit Lakes” (SRK, January 2006)

Source Water Quality Reviews

- A series of four annual reports addressing trends and conditions of groundwater throughout the site

Site Water and Load Balance Model

- “Site Wide Water Quality Model, Draft 1” (Gomm Environmental, April 2010)

- “Anvil Range Mining Complex: Dump Water Quality Prediction Revisions” (Memo, SRK Consulting, September 2006)
- “Review of Inputs to Task 4.1: Site Water Balance and Load Modelling – FINAL” (Memo, SRK Consulting, April 2010)

Human Health and Environmental Risk Assessment

Aquatic Ecosystem Health

- “Ecological Impact Assessment, Faro Mine, Yukon” (Minnow, May 2007)
- “Faro Background Data Evaluation” (Minnow, December 2008)
- “Aquatic Ecosystem Monitoring Program, Faro Mine, Yukon (Updated 2010)” (Minnow, February 2010)
- “Development of Site-Specific Water Quality Objectives for Faro Mine Complex: Phase I Evaluation” (Minnow, May 2008)
- “Aquatic Impact Assessment Related to Current and Future Zinc, Cadmium, and Sulphate Concentrations at Faro Mine, Yukon” (Minnow, February 2010)

Human Health and Ecological Risk Assessment

- “Probabilistic Human Health and Ecological Risk Assessment of Final Closure and Remediation Plan for Faro Mine Complex” (Draft, SENES, June 2010)

Terrestrial Effects Investigation

- “Anvil Range Mine Complex – Terrestrial Effects Study: Investigation into Metal Concentrations in Vegetation, Wildlife and Soils” (Draft, Gartner Lee Ltd., March 2006)

Baseline Information

- “Faro Mine Complex Closure and Reclamation – Project Proposal Current Environmental Conditions Supporting Document” (AECOM, March 2009)
- “Faro Mine Complex – Final Closure & Remediation Plan Project Proposal – Draft 1, Chapter 4” (March 2010)

Effects Assessment

- “Faro Mine Complex – Final Closure & Remediation Plan Project Proposal – Draft 1, Chapter 8” (March 2010)
- “Chapter 13, Environmental Adaptive Management Plans” (Chapter 13 of Project Description 4a, SRK, March 2010)

Hydrogeology and Seepage Collection

Site Wide Reports

- “Initial Review of Groundwater Quality downstream of Faro, Grum and Vangorda WRDs, Yukon Territory” (Memo, Robertson GeoConsultants, July 2004)
- “2009 Groundwater Investigations” (SRK, February 2009)
- “2008 Groundwater Assessment at Medium Priority Waste Rock Areas” (SRK, May 2009)
- “2007 Supplemental Geochemical Studies Report”
- A series of four annual reports addressing trends and conditions of groundwater throughout the site

Emergency Tailings Area

- “2005 Seepage Investigation at the Emergency Tailings Area” (SRK, November 2006)
- “Investigations in Support of Progressive Reclamation of the Emergency Tailings Area” (SRK, September 2006)
- “Interim Groundwater Capture at the ETA, Faro Mine” (Memo, SRK, April 2006)
- Two performance reports prepared by Robertson GeoConsultants for the interim capture system

Grum Dump

- “Anvil Range Mining Complex, 2005 Seepage Investigation at the Grum Dump Area” (SRK, January 2007)
- Annual adaptive management plan evaluations, including recommendations for action
- “Project Completion Report, V15 Collection System Construction” (Denison Environmental, February 2011)

S-wells Area

- “2005 Seepage Investigation at the S-Cluster Area Below the Faro Waste Rock Dump” (SRK, November 2006)
- “2008 S-Cluster Groundwater Investigation and Option Assessment” (SRK, February 2009)
- Files that describe the implementation, monitoring and modification of the S-Wells collection system installed in 2009

Vangorda Dump

- “As-built Report: Vangorda & Zone II Pumping Wells” (SRK, April 2011)

Zone 2 Outwash Area

- “Continued Seepage Investigation, Zone 2 Pit Outwash Area” (SRK, January 2007)

Tailings

- “Water and Load Balance Study for Rose Creek Tailings Storage Facility, Faro Mine, Yukon Territory” (Robertson GeoConsultants, September 2005)
- “Design of Groundwater Interception System for Rose Creek Tailings Storage Facility, Faro Mine, Yukon Territory” (Robertson GeoConsultants, October 2006)
- “Bedrock Data and Groundwater Review for the Lower Rose Creek Valley” (SRK, May 2008)
- “Geochemical Assessment of Groundwater Quality in Rose Creek aquifer, Anvil Range Mine, YT” (Robertson GeoConsultants, February 2009)
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Hydrology and Surface Water Diversions

Flood Estimation

- “An Analysis of Probable Maximum Precipitation for the Faro Mine Site, Yukon Territory” (Taylor et al., 2006)
- “Rose Creek Probable Maximum Flood” (Water Management Consultants, May 2006)
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Faro Creek Diversion

- “Detailed Comparison of Alternatives for The Relocation of the Faro Creek Diversion” (Golder, February 2004)

Rose Creek Diversion

- “Faro Mine Hydraulic Capacity Analysis” (northwest hydraulic consultants ltd., June 2006)
- “RCDC Options Analysis Summary” (Memo from northwest hydraulic consultants ltd., February 2006)
- “RCDC Detail Design Issues” (Memo from northwest hydraulic consultants ltd., March 2006)
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- “Rose Creek Tailings Facility, Faro Mine, Intermediate Dam Spillway, PMF Flood Handling” (Klohn Crippen Berger, April 2008)
- “Rose Creek Tailings Facility, Faro Mine, Intermediate Dam – Dam Raise and Spillway Options Review” (Klohn Crippen Berger, October 2009)

Vangorda Creek Diversion

- “Alternative Assessment for the Vangorda Creek Diversion” (SRK, 2003)
- “Evaluation of the Vangorda Creek Diversion to Dixon Creek” (SRK, July 2006)
- 2010 design for Vangorda Diversion replacement

Revegetation and Reclamation

Landscape Design

- “Reclamation Land Units” (Memo, SRK, May 2009)
- “Faro Mine Complex Closure and Remediation Plan, Revegetation Plan” (Draft, EDI, November 2009)
- “2008 Reconnaissance-level landform grading field investigation at the Faro Minesite” (SRK and BGC, May 2009)
- “Faro Mine Complex, 2009 Re-vegetation Trials and Monitoring” (EDI, February 2010)

Vegetation Baseline Information

- “Faro Mine Complex Closure Vegetation Baseline” (Gartner Lee Ltd., February 2008)
- “Anvil Range Mine Complex – Terrestrial Effects Study: Investigation into Metal Concentrations in Vegetation, Wildlife and Soils” (Draft, Gartner Lee Ltd., March 2006)
- “Report on Faro Minesite Rare Plant Survey” (AECOM, October 2008)
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Vegetation Effects Assessment

- “Faro Mine Complex – Final Closure & Remediation Plan Project Proposal – Draft 1, Chapter 8” (March 2010)

Covers

- “Soil Covers for Example Alternatives and Short-Listed Options” (Attachment C for the Closure Options Report, SRK, February 2008)
- “Mine Area Cover Optimization and Landform Engineering” (SRK, July 2008)
- “Grum Sulphide Cell Cover Construction – As Built Report” (SRK, May 2011)
- “Probable performance of a cover over the Rose Creek tailings impoundment in response to a large earthquake” (Memo, SRK, April 2006)
- “Waste Rock Cover Trials, Preliminary Performance Report” (Draft, SRK, November 2008)
- Reports presenting monitoring results from cover trials on both tailings
- A series of reports describing results of water balance modelling on existing waste rock and trial covers

Waste Rock and Tailings

Landform Design

- “Reclamation Land Units” (Memo, SRK, May 2009)
- “2008 Reconnaissance-level landform grading field investigation at the Faro Minesite” (SRK and BGC, May 2009)

Covers

- “Soil Covers for Example Alternatives and Short-Listed Options” (Attachment C for the Closure Options Report, SRK, February 2008)
- “Mine Area Cover Optimization and Landform Engineering” (SRK, July 2008)
- “Grum Sulphide Cell Cover Construction – As Built Report” (SRK, May 2011)
- “Waste Rock Cover Trials, Preliminary Performance Report” (Draft, SRK, November 2008)
- Reports presenting monitoring results from cover trials on both tailings and waste rock
- A series of reports describing results of water balance modelling on existing waste rock and trial covers
- “Rose Creek Tailings Impoundment Geotechnical Issues Related to Cover Viability” (Memo, Golder, March 2004)

Borrow Sources

- Three reports on investigation of borrow sources
- Two tables that describe the uses of materials proposed in the current version of the closure plan

Emergency Tailings Area

- “Investigations in Support of Progressive Reclamation of the Emergency Tailings Area” (SRK, September 2006)

Tailings

- A number of memos and reports evaluating liquefaction potential for tailings, and the implications on reclamation activities
- “Assessment of Tailings Outside of Containment” (Draft, Gartner Lee Ltd., December 2004)

Specific Waste Rock Areas

- Haul Road – “Faro-Vangorda Haul Road Reclamation Cost Estimate” (SRK, July 2008)
- Northwest Dump – “Waste Relocation from Northwest Dump to Low Grade Stockpile ‘C’, As-Built Report” (SRK, May 2008)
- Ore Transfer Pad – “Grum Ore Transfer Pad: Evaluation of Near-Surface Geochemical Characteristics” (Memo, SRK, March 2007)
- Oxide Fines and Low-Grade Ore – “Assessment of Select Oxide Fines and Ore Stockpiles” (SRK, July 2006)

Re-vegetation Information

- “Faro Mine Complex Closure and Remediation Plan, Revegetation Plan” (Draft, EDI, November 2009)
- “Faro Mine Complex, 2009 Re-vegetation Trials and Monitoring” (EDI, February 2010)

Terrestrial Effects Investigation

- “Anvil Range Mine Complex – Terrestrial Effects Study: Investigation into Metal Concentrations in Vegetation, Wildlife and Soils” (Draft, Gartner Lee Ltd., March 2006)

Water Treatment

Water Treatment

- “Water Treatment Requirements for the Anvil Range Site.” (Draft, SRK, May 2005)
- “Water Treatment Costs.” (SRK, June 2004)
- “Contaminated Water Treatment Options Evaluation” (Memo, SRK, November 2009)
- “Supplemental Treatment of Grum Pit Water” (SRK, May 2008)
- “Faro Mine Complex, Lime Supply Review” (SRK, October 2008)

Sludge Management

- “Anvil Range Mining Complex, Sludge Management” (SRK, May 2008)
- “Sludge Management at Faro Mine” (Memo, SRK, May 2008)
- “Suitability of Grum Pit Lake for Sludge Disposal” (Memo, SRK, March 2010)
- “Sludge Management Requirements for the Anvil Range Site” (SRK, March 2006)

Final

Gap Assessment Report, Faro Mine Remediation Project

Volume 2: Appendixes B and C

Prepared for
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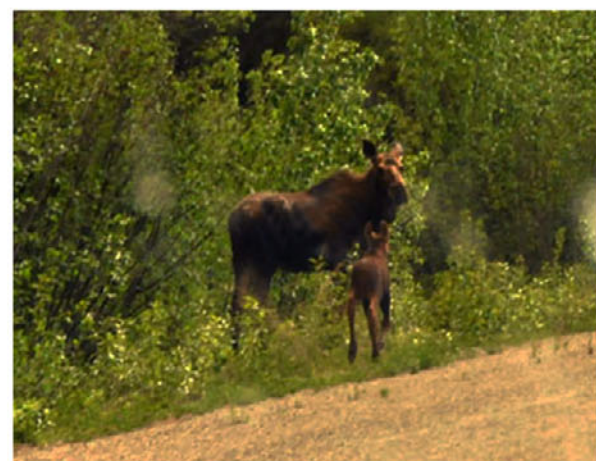
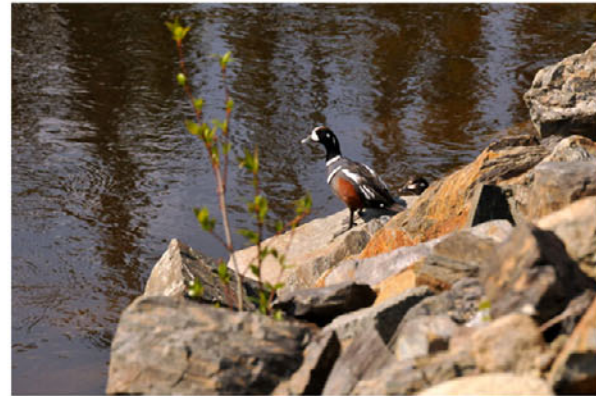


TABLE B-1
Engineering Data Gap Analysis
Gap Assessment Report, Faro Mine Remediation Project – Appendix B

Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
Sitewide						
SW-001	Mapping	Aerial photography and LIDAR acquisition, with color photography, 0.18-m vertical point accuracy/0.3-m contour LIDAR for project area and 2-m contours for outlying drainage basins. Horizontal accuracy equivalent to 12-m/cm mapping and 1.0-m satellite imagery for the project area. Permafrost mapping for geotechnical and reclamation surface planning. Visual aesthetics mapping for reclamation landscape planning.	Accuracy of previous GIS data (mapping and water quality sampling locations). Original ground map. Location of permafrost areas for planning of engineering structures and predicted permafrost locations after reclamation. Existing onsite surface material quality and texture. Existing onsite vegetation status. Multispectral satellite imagery to assist with delineation of wet areas and zones of frozen sediment.	Develop contour maps and digital terrain models from historical mapping showing pre-mining conditions and present conditions. Prepare current surface cover mapping; include layers for particle size distributions, existing vegetation type, and density. Prepare permafrost mapping for site and peripheral areas. Multi-spectral satellite imagery to assist with delineation of wet areas and zones of frozen sediment. Review existing survey control network used to position existing features (wells) and develop new mapping.	Existing utility data. Bathymetry surveys. Geotechnical and chemical sampling location to date. Review of surficial rock types and soil types. Review of vegetation regrowth on Faro, Grum, and Vangorda dump sites. Current data for actual and predicted permafrost locations for planning or reconstruction. Digital terrain model to provide basis for landform reclamation model used in design process and interested party consultation. Original ground map, pre-mine topography. Stereo imagery. Aerial photography and topographic mapping of extended watershed limits. Nested, comprehensive, fertility/texture data along with surface cover.	Confirm ground control and mapping accuracy. Conduct site-wide utility survey. Conduct Bathymetry surveys. Survey new sampling locations. Map surface cover (GIS). Verify surface cover mapping of existing and naturally revegetated areas. Conduct field surveys for use in site-wide SW model; cross sections, floodplains, structures etc. Confirm locations and scope through field reconnaissance.
SW-002	Data Management Chemistry/Environmental Data Compilation and Acquisition	Prepare site-wide data warehouse. Incorporate all available historical electronic analytical and geotechnical data into warehouse. New data added to the database as acquired.	Formatting of available electronic data may require additional processing to incorporate into data warehouse, and data that require processing before being loaded into the database will need QA/QC validation.	Develop data management plan and determine long-term requirements by FPET for data access. Integrate chemical and geotechnical data with GIS for SharePoint lookup. Figures showing all historical (and proposed) boreholes/monitoring wells/test pits.	Uncertain until data compiled and reviewed.	None.
SW-003	Site Access Roads	Design access roads to provide reliable access to critical site locations during large storms events.	Design criteria for Access Road; current capacity. Existing culvert capacities and physical condition.	Design flow for culvert and drainages, loading capacity and use, requirements for all-weather access. Soil properties for corrosion analysis and culvert design.	Condition survey of existing roads for use in short-term and long-term access. Soil conditions and properties at culvert locations.	Conduct Field reconnaissance. Conduct Soil testing. Conduct Detailed topography surveys.
SW-004	Regional Groundwater Flow Modelling	Prepare a site-wide groundwater flow model of the Faro Mine Area and the Vangorda/Grum Area. This may be two separate models, one for each area. These models will provide estimates of groundwater flow directions, rates, and exchange between the surface water and groundwater systems within the model domain. The groundwater flow models will be used to estimate contaminant loading from groundwater to surface streams, support the design of groundwater interception systems, and evaluate the sensitivity of the performance of various waste rock cover systems on groundwater flow rates and SIS effectiveness.	The magnitude of the water budget components of the Faro Mine and Grum/Vangorda systems. The GoldSim model will provide initial estimates of these quantities. The bedrock topography across the site, the spatial distribution of the hydraulic properties of the weathered rock aquifer and alluvial aquifer systems. The spatial and temporal distribution of hydraulic interaction between the surface water and groundwater systems.	Interpretation and integration of existing site water budget data with information collected during the 2012 field effort to develop a quantitative conceptual model of the site and convert that conceptual model into a numerical groundwater flow model.	The bedrock topography across the site, the spatial distribution of the hydraulic properties of the weathered rock aquifer and alluvial aquifer systems. The spatial and temporal distribution of hydraulic interaction between the GW/SW systems.	Collects results of fieldwork for individual areas of interest such as geophysics, drilling, well installation, and aquifer testing to use for the development of a regional GW flow model.

Shaded cells under the Field Work column indicate that a portion of the field work listed for the activity will be completed as part of the final design.

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
SW-005	Surface Water Modelling	Develop site-wide hydrological and hydraulic models including all major conveyance elements and structures. Model subcatchments to be used as tool for site-specific remediation activities (for example, SWM, erosion and sediment control).	Availability of sufficient survey data (that is, cross section development, flow-routing configuration, and existing structures) to develop hydraulic model. Availability of historical flow monitoring data correlated with precipitation data at various locations throughout the site for use in model calibration/validation. Some uncertainties regarding the final configuration of several conveyance components, RCDC, Vangorda Creek, and additional opportunities for Grum Interceptor Ditch.	Integration of GW/SW interactions into hydraulic modelling. Additional flow monitoring at selected locations and acquisition of physical site data that vary by specific location onsite and diversion objectives. Physical site data include ice and snow impact assessments. Documentation indicates that the diversions have been studied at various levels of detail. Site-specific needs are defined on a task-by-task basis.	Detailed cross section survey data and bed and bank material characterizations. Soil data (geotechnical) ice data, flow data, and water profile data (surface elevations). Obtain electronic versions of all previous hydrologic and hydraulic models and associated documentation to assist with model preparation. Collect historical flow and meteorological data for all available locations at the site. Also requires basin delineation data; the drainage basins are not completely defined in some instances.	Overall site reconnaissance; field work for specific areas defined by task. Maintain existing flow monitors and rainfall monitors. Additional meteorological data at existing stations if equipment operational (temperature, wind, snow, and humidity). Precipitation data concurrent with flow monitoring data collection. Collect continuous flow data at newly established monitoring locations as detailed below. Survey for hydraulic model (that is, cross sections, floodplains, structures).
SW-006	Site-Wide Groundwater/Surface Water Management Plan	Develop an overall site-wide strategy that considers the GW/SW objectives and key performance indicators (KPI) required to integrate the various onsite GW/SW activities. The KPIs are required so that the performance of the various GW/SW management activities can be assessed within an adaptive management plan (AMP).	Interactions of the GW and SW components. AMP integration of hydrology/hydraulic, groundwater, aquatics, wetland and terrestrial systems, and socio-economic objectives for water management planning.	Integration of all GW/SW diversion/water quality objectives and KPIs. Integration of aquatics, wetland, terrestrial systems, and socio-economic KPIs.	Objectives and KPIs on a site-wide basis for related disciplines.	None.
SW-007	Cover Design Surface Analysis	Coarse woody debris as erosion control and revegetation cover support has been proposed; however, source, storage, and implementation have not been assessed. CHRM model results used to design and evaluate alternative covers need to be evaluated fully and tested against current performance on Grum Sulphide Cell. Other unsaturated flow models (SHAW and VADOSE/W) need to be evaluated to model flow and snow/snowmelt effects. Cover infiltration descriptions suggest uncertainty regarding how the tailings cover will work with respect to vegetation cover.	Meso- and micro-topography information is missing from the cover type information and is a critical factor for this ecosystem. Resulting suitability for vegetation types and cover volumes needs to be assessed to provide appropriate topographic and planting opportunities. Surface treatments cited in the C&R Plan are not used on maps – DSS, RAS, WDS, and SCS. Must re-evaluate the assumptions for very-low- and low-infiltration covers and locations shown in C&R Plan; compacted till may be adversely affected by freeze-thaw cycles. Consider ET cover design instead of, or in addition to, low-infiltration covers. Moisture beneath the cover within the tailings, and there is only a spatial separation of roots from tailings porewater provided by the cover. This is inherently different to waste rock cover systems (source: C&R Plan, Chapter 8).	Coarse, woody debris usage needs to be assessed for feasibility. Vegetation cover types depend on cover depth and microsite variation. Providing topography may require greater cover depths or gentler slopes to allow working of the cover material, which affects the material balance and landform planning. Need to review surface treatment types and reconcile to current reclamation plan before they become the basis of design for ongoing work. Review of CHRM model results with Grum Sulphide Cell performance. Review of low- and very-low-infiltration cover locations onsite. Application of alternative unsaturated flow model (SHAW or VADOSE/W). ET cover design evaluation as addition to or replacement for low-infiltration covers. The function of cover materials is different for waste rock and tailings. Clarify cover expectations and revegetation planning over tailings for EA.	Assessment of coarse woody debris sources, storage, and application onsite to support this as a basis for reclamation surface design. Reconciliation of surface treatments from C&R Plan to current mapping of the site. Reconciliation of meso- and micro-topography requirements (for different cover types and revegetation requirements) with available cover material volumes. Review of basis of design for Reclamation Landform Unit (RLU) surfaces and amendments, including topography, cover material type, and surface amendments. Check on area application of RLU types in current plan; review for new closure surface including ET covers. Confirmation of very-low-infiltration cover performance and predictions of CHRM model. Application of alternative unsaturated flow model. Review ET cover design implications for very-low- and low-infiltration covers. Bulk density data for proposed cover materials, which are required to relate to soil erosion and vegetation establishment data. Initial soil bulk density is a critical factor in the success of any proposed ET soil cover. Measure soil-water characteristic curves (SWCC) for representative growth media (till and fines).	Field work captured in field trial task. Field trials would be conducted during final design.

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
Combine with 007	Cover Design Infiltration and Texture	CHRM model results used to design and evaluate alternative covers need to be evaluated fully and tested against current performance on Grum Sulphide Cell. Other unsaturated flow models (SHAW and VADOSE/W) need to be evaluated to model flow and snow/snowmelt effects. Cover infiltration descriptions suggest uncertainty how the tailings cover will work with respect to vegetation cover.	Must re-evaluate the assumptions for very-low- and low-infiltration covers and locations shown in C&R Plan; compacted till may be adversely affected by freeze-thaw cycles. Consideration of evapotranspirative cover design instead of, or in addition to, low-infiltration covers. There will be moisture beneath the cover within the tailings, and there is only a spatial separation of roots from tailings porewater provided by the cover. This is inherently different to waste rock cover systems (Source: Chapter 8, C&R Plan).	Review of CHRM model results with Grum Sulphide Cell performance. Review of low- and very-low-infiltration cover locations onsite. Application of alternative unsaturated flow model (SHAW or VADOSE/W). ET cover design evaluation as addition to or replacement for low-infiltration covers. The function of cover materials is different for waste rock and tailings. Clarify cover expectations and revegetation planning over tailings for EA.	Confirmation of very-low-infiltration cover performance and predictions of CHRM model. Application of alternative unsaturated flow model. Review of ET cover design implications for very-low- and low-infiltration covers. Bulk density data for proposed cover materials are required to relate to soil erosion and vegetation establishment data. Initial soil bulk density is a critical factor in the success of any proposed ET soil cover. Measure soil-water characteristic curves (SWCC) for representative growth media (till and fines).	
SW-008	Integrated Site Closure Plan	Completion of a closure drainage and allied landform plan and then overlaying cover materials (soils) and revegetation plan. Required to be basis of closure impact and residual risk analysis for site environmental assessment, and to provide footprint information for drainage, access and landform features of the closure landscape to inform construction activities.	Closure plan for the site does not currently exist. A reclamation landform units plan exists in minimal detail, but it does not integrate drainage (or wet landscape) details or specify soil and vegetation prescriptions.	Completion of integrated closure planning will require input from the following technical disciplines: • Hydrology • Water quality • Hydrogeology • Risk assessment • Waste rock and covers • Revegetation/reclamation	Planning activities will require integrated plan review meetings for all disciplines, focused workshops on key disturbed/ undisturbed interface locations (NFRC, Emergency Tailings Area, Grum Creek Valley) and development of ArcView mapping layers for an integrated drainage plan, overlaid by soil prescription and vegetation (wetland and upland) layers.	Field work captured in task-specific actions.
SW-009	Revegetation Materials Planning and Sourcing	Sourcing revegetation materials will require a 4- to 5-year lead time to grow plant material and prepare the large volumes of planting material for use exactly when required for erosion control. Seeding materials need to be sourced and checked for reliable quality with respect to weedy seed inclusion and large volumes required for native species and proposed agronomic species.	Helicopter seeding has been proposed for steep revegetation areas; this needs to be assessed for feasibility, cost, seed volume, and timed with regrading and cover material sequencing. Some materials are planned to be whips or cuttings; source areas need to be identified for capacity to provide material and whether the areas have been assessed in the environmental assessment. Additional source areas may be required and must be identified. Methods of collection and planting need to be assessed for large areas planned in annual reclamation increments. Use of legume species for soil nitrogenation and revegetation support.	Review of potential vegetation sources, with preference for (1) First Nations greenhousing or propagation facilities and (2) Yukon-based facilities. Assessment of capacity for projected vegetation volumes needs to be performed so that material is grown with a 4- to 5-year lead time prior to revegetation requirements. Not clear if facilities outside the province would be required to provide bulk vegetation volumes for annual reclamation; this should be assessed. Environmental assessment needs to review if vegetation cutting/whip collection areas have been included in assessment.	Identification of potential greenhousing and nursery facilities. Identification of suitable seed sources and cutting/whip sources to be included in the local study area, if required. Identification of seed application methods to be considered in reclaimed surface preparation including helicopter, hydroseeding, or surface application. Assessment of use of leguminous species as nurse crops for reclamation covers. Potential donor sites have not been identified and each donor site will need an EA. Consider establishing greenhouses in the city of Faro or various First Nation communities to supply seedlings for replanting.	Determine donor sites and then perform EA to determine their suitability. This may be a non-starter and may be best to go with nursery-grown materials only. Locate seed and potted/bareroot plant growers and discuss production capabilities. Suppliers must be within the same climatic region. Evaluate areas of proposed new disturbance to optimize recovery of potential growth media material, including vegetation and soil that could be recovered in connection with expansion of the various WR footprints (e.g., flattening of slopes) and access road development.
SW-010	Sitewide Soils Mapping	Soils data are currently dispersed in different formats and documents. Need site-wide database of soil quality to provide basis for material movement and balance, and planned reclamation covers.		Need to categorize data to help identify problematic high or low levels of pH, Pb, As, Zn, and coarse fragments. Consolidation of current soils information needs to be augmented with baseline data collected for new borrow areas.	Production of site-wide soil database to house existing data and new baseline data to be collected for new borrow areas. Identification of problematic pH, metals, and coarse fragment levels to assist in allocation of cover materials to reclaimed surface planning.	Collect additional soils data on existing and potential borrow sources to augment available data (described under the Borrow Sources headings).
SW-011	Update 2004 Site-Specific Seismic Analyses	Perform a desk study to potentially update the 2004 study. Include potential update of seismotectonic models and work performed from 2003–2007 by the USGS.	Updates of seismic information.	Review 2004 report by Atkinson and other background information (papers, reports, etc) to assess needs for updated study.		None

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
SW-012	Identify Additional Areas with a High Probability of Becoming Contaminated Groundwater Discharge Pathways in the Future	Identify additional areas with a high probability of becoming groundwater discharge pathways in the future as ARD reactions continue to accelerate. Support the development of a long-term monitoring network that will identify areas of degrading groundwater quality and potential ARD pathways to be addressed through the AMP.	Implications of new excavations along toe of existing waste rock dumps associated with trenching and borrow source development. May need to design sump areas to collect seepage along the waste rock perimeter and incorporate in GW/SW interaction model.	Perform GIS analysis comparing current topography with pre-mining topography to identify buried drainages that may concentrate groundwater discharge.	Further investigate areas with a high potential to be future contaminant seepage pathways.	Possibly conduct groundwater sampling and install monitoring wells. This will be determined through evaluation of site data.
SW-013	Delineation of Permafrost at Faro Mine and Grum/Vangorda Area	The presence of massive or discontinuous permafrost within the groundwater system has a significant influence on groundwater flow directions, rates, and SW/GW interaction.	The design of an effective SIS requires knowledge of permafrost in the immediate area of the system. Permafrost may also alter contaminant migration pathways and require modification to groundwater monitoring network designs.	Perform detailed literature review to located previous studies or field investigations that delineated permafrost extent at the FMC. Proposed geophysical surveys in the vicinity of SIS installations can be expanded to identify the presence of permafrost in those areas. This is the same permafrost survey identified under the regulatory data gaps.	The potential for permafrost to influence the effective operation of the groundwater interception systems. Evaluate the potential of using multispectral satellite imagery and post-processing to identify areas with a high probability of having near-surface permafrost.	Collect additional geophysical data (such as resistivity) in areas where groundwater interception systems are planned and existing data suggest a high probability of permafrost (for example, frozen wells) A site-wide delineation of permafrost is not practical. Investigate foundation conditions in areas that may be covered by re-graded waste rock slopes.
SW-014	Site-wide Water Balance Model and Piezometer Installation	Develop an integrated GW/SW model that will provide an estimate of the site-wide water balance, contaminant loading, and surface water quality. Install piezometers into the Grum, Vangorda, and Faro waste rock dumps to monitor seasonal groundwater level fluctuations using recording pressure transducers.	Existing model assumptions pertaining to flow/drainage conditions applications and geochemical model for waste rock pumps and tailings. Quality of existing and new data needs to be evaluated and confirmed for appropriate use. Magnitude of fluctuation in groundwater levels driving the geochemical reactions within the waste rock.	Review current model capabilities pertaining to water balance and model functionality. Build mass balance equations in the model to track water throughout the system under different hydrologic conditions and stages of remediation. User interface will be developed that facilitates sensitive studies, summarizes all the user inputs, and promotes tool functionality. Check of the improved model equations and check of model runs at different scenarios. Conduct sensitivity analysis on key parameters that influences the water balance and contaminant loading throughout the system. Develop post-processing tools to report results and summarize results of predictive modelling. Incorporate the observed groundwater level fluctuations into the geochemical analysis performed to estimate future seep and groundwater quality.	Update infiltration and cover infiltration data with more accurate data if available. SRK (2006) provided an update to the infiltration rates, more recent data might be available. Information about the tailings location and how they are connected in the water balance. Need access to the site hydrologic and analytical data and compile site-wide hydrologic and flow data. Calibrate model with existing field conditions from field data. Magnitude of seasonal groundwater level fluctuation within Faro, Grum and Vangorda waste rock dumps.	Install piezometers: in the Grum and Vangorda waste rock dumps and in the Faro waste rock dumps. Instrument each piezometer with a recording pressure transducer.
SW-015	Develop Geochemical Loading Models	Develop individual geochemical models for the waste rock dumps, the Rose Creek Tailings Facility, and the three pit lakes. Integrate into the overall site-wide water balance model to generate a comprehensive predictive water quality model for the site.	Currently do not have possession of geochemical models developed for the waste rock piles and Rose Creek Tailings Facility. Existing modelling did not include three pit lakes. Assume requirement to rebuild geochemical models for waste rock piles, tailings facility, and pit lakes.	Review of the working functions of all current models and submodels. Current model feeds on a series of geochemical submodels for each facility type (that is, WD, pit, TSF), which in turn are based on a series of field and lab tests and assumptions. Field and laboratory tests included oxygen and temperature profiles and static and kinetic laboratory testing. Review additional documents pertinent to the model development may also be necessary (for example, geochemical reports). Spreadsheet database working functions need to be developed and the model needs to be calibrated and compared to the existing geochemical component of the GoldSim model.	Anticipated water quality of surface runoff and seepage from waste rock dumps during construction. Leaching potential and sediment loading potential of freshly exposed (regraded) waste rock from each of the waste rock dumps. Geochemical sub models based on historical and field data to use as inputs to the GoldSim model. Update model with latest data available for each source included in the model (that is, 33+WD, 3 pits, and 2 TSF).	Conduct confirmatory solids sampling around each WD, TSF and pits, and aqueous sampling associated with seepages, porewater, groundwater, and surface water. Install or relocate monitoring points where sources are reconfigured or revised. Monitor at existing and newly installed points to capture evolution of the system with closure activities.

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				Exportable outputs need to be developed to export into the GoldSim model.		
SW-016	Evaluate Pit Lakes Dynamics for Water Treatment Collection and Storage, and Sludge Disposal	The C&R Plan proposes several different uses for the three pit lakes: storage for water treatment and sludge disposal at Faro Pit, storage for water treatment, and possible sludge disposal at Vangorda Pit. Whether the pit lakes are used for water collection and storage in advance of treatment or sludge storage post-treatment, an understanding of basic EPL physical- and chemical-state condition dynamics is required to properly manage inputs and withdrawals from the lakes.	Insufficient physic-chemical data available for pit lake limnology (that is, stratification data). Need fine-grain data to capture seasonal pit dynamics, including under ice data, year-round conductivity, temperature, density, dissolved oxygen, and redox data. Need pit water balance, which will be collected in site-wide water balance. Need field samples for water quality data to corroborate instrumentation data.	In situ data probes with battery power source to permit year round data collection. Conductivity, temperature, density, dissolved oxygen, and oxidation-reduction data at three depths. Pressure sensors at three depths in one or more locations. Pressure level gauge in lake. Obtain samples June through August at depths of in situ redox sensors.	Current data set is insufficiently fine grain to capture potential important dynamic processes; under-ice dynamics critical to understanding year-round lake dynamics because year round performance is not understood. These data are critical to understand stratification. Stratification dynamics are fundamentally important to determine potential of sludge storage in Faro Pit and if algae can fuel sulphide sequestration of zinc in Grum Pit. Year-round oxygen dynamics of pit lakes not understood; must have these data to determine potential reductive dissolution of sludge from WTP or for permanent zinc sequestration from settled algae in sulphide minerals. Redox determines, with corroborating wet chemistry data, the types of biogeochemical processes that occur with loss of oxygen (anoxic conditions). Redox data are essential to determine potential reductive dissolution of iron sludge from the WTP or for sulphide sequestration of zinc in settled algae.	Set probes in June 2012. Collect water samples from pit lakes between June and August 2012.
Faro Mine Area (Activity Code 100)						
101	Faro Pit Safety Berm					
101.2	Safety Berm around the Pit	Construct berm around Faro Pit to restrict physical access.	H&S implications regarding the timing of berm construction. Need to allow for ongoing spalling of pit walls; 5-m offsets proposed can be expected to vary.	Identify borrow materials. Evaluate spalling of pit walls.	Higher resolution mapping	Conduct reconnaissance, review of geologic mapping, and review higher resolution topographic mapping.
102	Surface Water Diversions					
102.1	Faro Creek Diversion (East Valley)	Relocate existing diversion channel to new alignment up hillside; intercept and convey Faro Creek along the eastern slope of Faro Creek Valley above the existing diversion channel. Evaluate design criteria, need for overflow structure where natural creek meets diversion to spill excess floodwater into pit. Address local SW flow to Faro Pit. Consider alternative of building new diversion along the west side that can potentially flow to North Wall Interceptor/Guardhouse Creek.	Discontinuous permafrost, ground conditions, channel seepage losses, interaction of GW and SW, hydraulic analysis, and stability of the pit wall. Management of localized flows captured in existing FCDC drainage area. The existing FCDC will remain but will be revegetated. Local drainage will be captured, but the discharge from the existing FCDC needs to be considered in terms of drainage area and seepage and discharge points for high precipitation events that may overflow the revegetated channel.	Reassess diversion options, preliminary design criteria (C&R Plan, Table 4.1). Geotechnical, water quality, pit wall stability, channel stability, seepage, hydrology, hydraulics, assess current channel design capacity, diversion opportunities, and icing potentials. Determine local SW flow characteristics and drainage area to the existing FCDC and pit area. Overflow structure foundation and stability evaluations.	Detailed cross section survey data including potential alignment of new channel and floodplain. New channel bed and bank material characterizations; additional soils data including more information on permafrost and ice content. Golder report (detailed comparison of alternatives) described test pits along alignment but refusal at shallow depths because of permafrost. Geotechnical data gaps at the new diversion channel alignment include (including for the alternative western alignment): • Depth to bedrock • Soil and rock mass strengths • Presence and extent of permafrost • Permeability of soil and rock • Foundation conditions for potential overflow structure Historical channel ice data, flow monitoring, and water profile data (surface elevations). Flow information from the existing channel, because it is required to be diverted. Existing FCDC will be maintained. Types of vegetation assessment for revegetation opportunities. Assess local flow into pit that will not be captured in the diversion or existing Faro Creek.	Evaluate channel seepage losses and location of permafrost. Survey detailed cross section data, potential bed and bank materials characterizations, and floodplain cover. Determine stabilization requirements and flow for existing FCDC. Identify extent of localized runoff areas tributary to existing FCDC and directly adjacent to Faro Pit. Monitor flow at Stations FDU and R7. Conduct geotechnical field investigation: • Detailed field reconnaissance and seismic refraction along alignment. • Diamond drilling (rock core) borings – Install thermistors – Collect samples and determine ice content – Test permeability in situ (slug tests in ground where not frozen, packer testing in rock), and in laboratory on permafrost soil samples after thawed

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					Additional flow monitoring data collection at station FDU and R7 for model calibration and validation.	Conduct index tests (grading and Atterberg limits) on soil samples and UCS testing on rock core samples as necessary.
102.2	West Valley Extension	Direct clean water from west side of valley around Faro Pit. Minimize seepage losses.	See Activity 102.1. Discontinuous permafrost, ground conditions, channel seepage losses, interaction of GW and SW, hydraulic analysis.	Same as Activity 102.1 above. Evaluate seepage cut-offs to limit flow into Faro Pit.	Same as Activity 102.1.	Conduct geotechnical field investigation: - Detailed field reconnaissance and seismic refraction along alignment - Diamond drilling (rock core) borings - Install thermistors - Collect samples and determine ice content - Test permeability in situ (slug tests in ground where not frozen, packer testing in rock), and in laboratory on permafrost soil samples after thawed - Conduct Index tests (grading and Atterberg limits) on soil samples and UCS testing on rock core samples, as necessary.
102.3	North Wall Interceptor Ditch	Remediate existing North Wall Interceptor ditch (NVID) and discharge to Rose Creek below Cross Valley Dam; improve or construct access. The Upper Guardhouse Creek flows into the NVID. Water from the creek is generally clean but contributes hydraulic load.	Discontinuous permafrost. Amount of GW/SW interaction. Water quality. Little information available for area, need care to separate from Lower Guard House Creek. Design criteria needs to be evaluated in the context of the overall closure. Soil cover and revegetation plan required for remediated ditch area. Discharge design for section below Cross-valley Dam needs to be determined.	Assess remediation options. Geotechnical, water quality, channel stability, seepage, hydrology, hydraulics, design storm flows, and PMF, icing, soil cover, and revegetation options. Limited data have been collected from the UGC and the NVID in terms of site-specific information. The valley slopes are extreme and determining channel capacity and design for erosion control is key. Preliminary information indicates depth of overburden in some areas; uncertain information. Determine impacts of flow on Rose Creek downstream from convergence.	Detailed cross section survey data including channel and floodplain for Upper Guardhouse Creek and NVID for modelling. Channel bed and bank materials characterizations for modelling. Historical channel ice data, flow monitoring, and water profile data (surface elevations). Assess area below Cross Valley Dam for discharge design requirements to Rose Creek – flow management and design requirements. Geotechnical data gaps at the new diversion channel alignment includes the following: - Depth to bedrock - Soil and rock mass strengths - Presence and extent of permafrost - Permeability of soil and rock Soil cover and revegetation plan needs to be assessed for cover volumes and vegetation species in remediated ditch area.	Conduct geotechnical field investigation, borings, and test pits. Evaluate channel seepage losses and location of permafrost. Surveys for detailed cross section data, bed and bank materials characterizations, and flood plain cover characterization. Collect soils data (geotechnical), ice data, flow data, and water profile data (surface elevations). Conduct geotechnical field investigation: - Detailed field reconnaissance and seismic refraction along alignment. - Hollow-stem auger and diamond drilling (rock core) borings. - Install piezometers and thermistors - Collect samples and determine ice content - Test permeability in situ (slug tests in ground where not frozen, packer testing in rock), and in laboratory on permafrost soil samples after thawed - Conduct index tests (grading and Atterberg limits) on soil samples and UCS testing on rock core samples as necessary.
102.4	Lower Guardhouse Creek Water	Intercept seepage from mill and stockpiles. Direct water to Faro Pit by pipeline (ETA Activity 105). Install GW and SW monitoring network. Improve or construct access road to the NW Dump near Upper Guardhouse Creek. Remove waste rock between W8 and W10 on Upper Guardhouse Creek.	Seepage rates, water quality, interception potential, long-term performance of interception. Design criteria provided in the C&R Plan, Table 4.3, require definition and linkage to seepage management and water quality. SW contribution to flows. Hydraulic modelling to contain design flow rates. Establish final PMP and PMF estimates and integrate evaluation of GW and SW.	Hydraulic modelling to determine design requirements to contain design flow rates. Establish final design flow rate estimates and integrate evaluation of GW and SW. Evaluate GW interception based on monitoring results. Potential to route to the ETA rather than pumping.	Detailed cross section survey data including channel and floodplain areas; channel bed and bank materials characterizations; soils data including permafrost; historical channel ice data, flow monitoring, and water profile data (surface elevations). Additional flow monitoring data for model calibration and validation.	Surveys for detailed cross section data, bed and bank materials characterizations, and floodplain cover characterization. Evaluate channel seepage losses, water quality, flow data, and water profile data (surface elevations).

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			Evaluate GW interception based on monitoring results. Seepage losses, water quality, GW and SW interaction, and the location and extents of permafrost.	Seepage rates, water quality, interception potential, and long-term performance of interception. Design criteria provided in the C&R Plan, Table 4.3, require definition and linkage to seepage management and water quality.	Depth to bedrock and aquifer properties in area of planned seepage collection system. No information exists for this channel or its proposed final extension. Geotechnical data gaps includes: • Depth to bedrock • Soil and rock mass strengths • Presence and extent of permafrost • Permeability of soil and rock Effectiveness of current system and need for enhancement.	Conduct routing study and rework channel; establish a flow monitoring station and collect continuous flow data. Conduct seismic survey to determine depth to bedrock in area of planned seepage collection system. Install monitoring wells and collect water level, water chemistry, and aquifer property data. Conduct geotechnical field investigation: • Detailed field reconnaissance with test pitting along alignment • Hollow-stem auger borings: – Install piezometers and thermistors – Collect samples and determine ice content – Test permeability in situ (slug tests in ground where not frozen, packer testing in rock), and in laboratory on permafrost soil samples after thawed • Conduct index tests (grading and Atterberg limits) on soil samples and UCS testing on rock core samples as necessary.
103	Zone II Pit					
103.1	Install Pump in Existing Wells, Piping, Heat Tracing	Reduce effects of contaminant yield from Zone II Pit. Maintain water level in Zone II Pit to maintain gradient towards the pit, away from NFRC.	Access and maintenance of year-round pumping system with minimal O&M costs.	Automate operations.		Continue water level monitoring. Record operating parameters (pumping rate, etc.)
104	Oxide Fines and Low-grade Ore					
104.1	Relocate Oxide Fines to Low-grade Ore Stock Piles (LGSP) C (to be placed below a very-low-infiltration cover)	Reduce contamination from these sources to GW and SW. Alternative – Relocate oxide fines to sulphide cells as a levelling (cushion) layer below the synthetic cover.	Volume of material to be removed and covered. Foundation conditions of LGSP C (water table, and geotechnical properties) Health and safety associated with moving oxide fines. Constructability implications (for example, requirements for specialized equipment or operating procedures). Leachability of fines during construction. Final landform design options – both LGSP C and sulphide cells If alternative: Geochemical compatibility of oxide fines with sulphide waste.	Optimize removal and consolidation to reduce footprint and costs; minimize environmental risk (for example, constructability, minimize disturbance) re-evaluate design criteria in the C&R Plan, Table 4.6.	Geotechnical properties of fines: Material gradation (percentage fines). Geotechnical properties of LGSP C: Foundation stability, material gradation, GW characteristics, trafficability, etc. Geochemical Properties of fines: reactivity. Potential mitigation measures to control sediment mobility and contaminant migration, especially during construction. Water management plan; verification of volume. Final landform evaluation. If alternative: Geochemical compatibility of oxide fines with sulphide waste, final landform design of sulphide cells (footprint, slope angles, and height of capped cell).	Install borings to delineate volume of stockpile to be removed: • Hollow-stem auger boreholes; sampling at regular intervals • DCPT cones and hollow-stem auger boreholes with SPT (including Shelby tubes for consolidation tests). • Heavy equipment trafficability study. Conduct chemical or geochemical testing. Field work (or lab testing) needed to address?

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104.2	Relocate Medium-grade Ore (MGO), Including Brown and Green Oxide Fines (Oxide Fines #1) to LGSP C	Reduce contamination from these sources to GW and SW. Same issue as above. Alternative – Relocate this waste to the sulphide cells as a levelling (cushion) layer below the synthetic cover.	Geochemical compatibility of MGO and Brown/Green Oxide fines with sulphide waste: Leachability and Water EMP. Health and safety issues of moving MGO and brown/green oxide fines. Constructability implications (for example, requirements for specialized equipment or operating procedures). Final landform design.	Optimize removal and consolidation to reduce footprint and costs; minimize environmental risk (for example, constructability, minimize disturbance). Re-evaluate design criteria in C&R Plan, Table 4.6.	Geotechnical properties of fines: Material gradation. Geotechnical properties of LGSP C: Foundation stability, material gradation, GW characteristics, trafficability, etc. Geochemical Properties of fines: Reactivity. Potential mitigation measures to control sediment mobility and contaminant migration, especially during construction. Water management plan; verification of volumes. Final landform evaluation. If alternative: Geochemical compatibility of Oxide fines with sulphide waste, final landform design of sulphide cells (footprint, slope angles, height of capped cell).	Evaluate LGSP C foundation conditions included in Activity 104.1. Delineate volume of MGO stockpile to be removed – hollow-stem auger boreholes. Conduct chemical or geochemical testing. Field work (or lab testing) needed to address.
104.3	Cover and Revegetate LGSP A	Reduce contamination from these sources to GW and SW. Alternative – Relocate this waste to the sulphide cells as a levelling layer for the synthetic cover or consolidate in LGSP C.	Implications for cover design if capped material generates heat. Grum Sulphide Cell is already capped with a very-low-infiltration cover that needs monitoring and possibly instrumentation. Need to maximize benefits by closely monitoring results of existing cover work. Proposed reclamation surface is rough and loose; however, the field investigation concluded that the microtopography is bad for plateau areas because it promotes ponding and infiltration.	Infiltration modelling (cover optimization); VADOSE/W, SLIDE (slope stability); TEMP/W; and re-evaluate design criteria in the C&R Plan, Table 4.6. Evaluate SW management – energy/erosion potential. Field test cover materials and microtopography options for all LGSP surfaces. Geochemical compatibility of low-grade ore with sulphide waste: Leachability. Health and safety issues of moving low-grade ore.	Review RLU planning basis with the Waste Pile and Tailings Discipline Team, and then consider a revegetation trial on this kind of slope/material. Cover and revegetation trial for LGSP reclamation. Existing site water balance versus water balance after final grading needs to be evaluated to determine surface and GW impacts. Water/sediment management plans: Drainage plan, sedimentation ponds/wet landscape options, existing stockpile topography; and final landform design options. Design life reduction of the membrane due to conditions (temperature/caustic gas production). Water table location and fluctuation.	Delineate geotechnical data (If alternative plan of relocating): DCPT (within a grid into underlying soils). Evaluate cover design (if capping in place): Ten test pits for gradations/grain size. Conduct cover field trials; revegetation trials; sediment control plans. Field trials would be conducted during final design.
104.4	Cover and Revegetate LGSP C	Reduce contamination from these sources to GW and SW.	Implications for cover design if capped material generates heat or caustic gas is produced. Grum Sulphide Cell is capped with a very-low-infiltration cover needs monitoring, and possibly instrumentation. Maximize benefits by closely monitoring results of existing cover. Design life reduction of the membrane due to conditions (temperature/caustic gas production). Proposed reclamation surface is rough and loose; however, the field investigation concluded that the microtopography is bad for plateau areas because it promotes ponding and infiltration.	Infiltration modelling (cover optimization); VADOSE/W, SLIDE (slope stability); TEMP/W; and re-evaluate design criteria in the C&R Plan, Table 4.6. Evaluate SW management – energy/erosion potential. Field test cover materials and microtopography for LGSP surfaces.	Review RLU planning basis with Waste Pile and Tailings Discipline; consider a revegetation trial on this kind of slope/material. Cover and revegetation trial for LGSP reclamation. Existing site water balance versus water balance after final grading needs to be evaluated to determine surface and GW impacts. Water/sediment management plans: Drainage plan, sedimentation ponds/wet landscape options, existing stockpile topography; and final landform design options.	Dig test pits for gradations/grain size for cover. Conduct cover field trials, revegetation trials, and sediment control plans. Field trials would be conducted during final design.
105	Emergency Tailings Area					
105.1	Remove Tailings to Rose Creek Tailings Facility	Reduce contaminate loading to GW and SW. Facilitate effective collection of seepage. Prevent contaminated GW from contacting biological receptors. Alternative – Leave the tailings in place and cover; channelize flow of major seeps (for example, X23) in granular trenches to a seepage collection point.	The relative merits of removing tailings is largely dependent on the final location of the SIS. Need to complete an alternative assessment to determine optimal closure configuration. Volume of tailings, extent of impact on underlying surface soil and GW. Geochemical characterization and leachability of materials placed in Rose Creek Tailings. Requirements for fill placement to close area.	Excavation plan that includes sequencing and hydrology and sediment management. Hydrology and GW/SW interaction of closure configuration. Diversion ditch configuration. Alternative design of leaving tailings in place: Require long-term geotechnical/hydro assessment of road.	SW flow calculations. Detailed cross section survey data including potential channel and floodplain areas. Potential channel bed and bank material characterizations and floodplain cover characterization. Integration of SW and GW modelling approaches and results. Final regrading and SW management. Relative merits of removing tailings. Relative merits of removing contaminated soils that underlie the tailings.	Delineate tailings thickness and estimate extent of impacted o/g. Chemical characterization of upper impacted o/g; upgrade monitoring well network. Surveys for detailed cross section data, bed and bank materials characterizations for SW swale(s). Characterize floodplain cover. Install sonic boreholes (below tailings/native contact); DCPT; sieve/hydrometers.

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			If alternative plan of leaving tailings in place: Geotechnical evaluation of Mine Access Road as a (pervious) solids retaining structure.		Relative merits of removing contaminated soils downgradient from the Access Road. Quantify contaminated fill to be removed downgradient from the Access Road. Removal of the tailings could drain the wetland upgradient (SE of ETA).	Develop alternative design of leaving tailings in place: Assume sonic boreholes through mine Access Road and sieve/hydrometers.
105.2	Install GW and SW Collection Systems	Intercept contaminated GW and SW before discharge into the Rose Creek Tailings Area. Determine optimal location for SIS. Evaluate potential to relocate the ETA SIS to the downgradient end of the topographic “funnel” south of the Access Road. Construct diversion ditches, sump, and pumping stations for diversion of waters from ETA during construction. Pipe to Faro Pit.	Define bedrock surface. Define distribution of aquifer properties. Quantify site water budget. Determine number and spacing of extraction wells. Determine permeable trench location. Estimate GW flow and contaminant mass loading from extraction system (average and peak). Three-dimensional numerical GW flow model. Evaluate alternative configurations of SIS design; optimize efficiency and minimize cost. Use GoldSim model, site-specific Feflow model, or other model to provide boundary conditions for the GW flow model. Hydrogeologic assessment: seepage interception (funnel and gate) design options; possible requirement to upgrade monitoring well network.	Use three-dimensional numerical GW flow model. Evaluate alternative configurations of SIS design; optimize efficiency and minimize cost. Use GoldSim or other model to provide boundary conditions for GW flow model. Assessment of optimum SIS location (for example, downgradient of the Access Road channel). Failure modes and effects analysis of various ETA SIS configurations (for example, time for seepage to daylight if active pumping fails). The ETA SIS as presented in the current closure plan requires continuous active pumping to prevent contaminated seepage from ponding and overtopping the Mine Access Road or contaminating the revegetated capping layer. Moving the SIS downgradient from the Access Road would allow GW seepage to gravity drain into a lined channel and pond within the Faro Creek Channel in the event of system disruption (for example, pump failure).	SW flow calculations. Detailed cross section survey data including potential channel and floodplain areas. Potential channel bed and bank materials characterizations and floodplain cover characterization. Integration of SW and GW modelling approaches and results. Rate of GW and SW inflow from Mill Creek Canyon. Aquifer property information in the Mill Canyon area. Bedrock contact delineation in Mill Canyon and Old Faro Creek immediately downgradient from the WRD. Rate of GW and SW inflow from Mill Building Site. Alluvial aquifer thickness and bedrock topography south of the Mine Road. Continuous time-series SIS seepage rates.	Install additional borings to define bedrock surface. Install test wells and test aquifer. Current information includes bore holes and seismic survey; additional data required. Conduct geotechnical field investigation, borings and test pits. Evaluate channel seepage losses and location of permafrost. Surveys for detailed cross section survey data and bed and bank materials characterizations for SW swale(s). Characterization floodplain cover. Install monitoring well pair (one completion in alluvium and one in weathered rock) and a stage gauge along the upgradient reach of Mill Creek. Perform slug testing in the monitoring well pair. Perform surface geophysics survey in Mill Canyon (by the new well pair) and Old Faro Creek (by X23). Install additional monitoring well pairs (completions in overburden and weathered rock) between Mill Buildings Area and the Access Road. Perform surface geophysics survey with confirmation borings (drilled to competent bedrock) to define alluvial thickness and the weathered and competent bedrock surfaces south of the Access Road. If the alluvial aquifer south of the Access Road is substantial, install monitoring well pairs (each with one completion in alluvium and one in weathered rock if possible) and an additional well in competent bedrock. Perform aquifer testing south of the Access Road. Install flow meter and data logger on SIS discharge line.
105.3	Cover and Revegetate ETA	Determine appropriate closure cover for ETA after tailings removal. Tie revegetation plan in to existing adjacent vegetation. This is a high-visibility area adjacent to the site access point and, therefore, requires proactive planning for the reclamation surface.	Closure cover depends on the decision regarding the final disposal of tailings. Existing vegetation needs to be characterized – will be affected by tailings removal. Revegetation footprint could then be larger than the ETA.	Closure surface configuration and capping materials need to be designed (if applicable). Cover soil availability and type needs to be determined. Appropriate vegetation cover to fit in with existing adjacent vegetation. Area needs to be assessed and planned. Failure modes and effects analysis of various ETA SIS configurations (for example, failure of active pumping).	SW flow calculations. Detailed cross section survey data including potential channel and floodplain areas; potential channel bed and bank material characterizations and floodplain cover characterization. Integration of SW and GW modelling approaches and results. Existing vegetation needs to be characterized to assess impact of remediation. Type and quantity of borrow materials required for regarding and revegetation (depends on design alternative selected)	Surveys for detailed cross section data, bed and bank material characterizations for SW swale(s). Floodplain cover characterization. Survey existing vegetation on site and adjacent. Cover soils availability and type assumed to be provided by site-wide soils mapping. Investigate onsite/suitable vegetative species tolerance/translocation of metals and preferred soil cover type/makeup (for example, organics, nutrients), especially those of food chain concern; can be done after input from risk assessment depending on timing from that study.

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106	Waste Rock Dumps					
106.1A	Regrade and Reslope Main and Intermediate Sulphide Cells	Consolidate smaller piles of highly reactive material into larger dumps where practical. Predictive modelling (geochemical, hydrologic, and GW/SW interaction) and monitoring program to provide basis for AMP. Alternative – Consolidate oxide fines on sulphide cells as cushioning layer below liner.	Chemical compatibility of sulphide cells with other fine grained materials to be capped under very low infiltration liners. Use fines as a cushioning layer for the liner.	Optimize regrading plan. Establish sediment control plan. Monitor GW and SW interaction in affected foundation areas. Assess geotechnical stability using SLIDE; Determine depth of freeze-thaw using VADOSE/W and Temp/W; review design criteria in the C&R Plan, Table 4.9. Design evaluations of alternative.	Clear delineation of sulphide cell footprint. Gradation of water rock (necessary to design cushion layer for very low infiltration cover).	Conduct supplementary boring and sampling to support geotechnical, geochemical, and infiltration modelling. Dig test pits to support evaluation of liner constructability. Delineate Sulphide Cell – install sonic boreholes. Survey for detailed cross section and hydraulic feature data and potential bed and bank material characterizations.
106.1B.1	Regrade and Reslope Waste Rock Dumps (upper surfaces)	Maximize ET potential of the cover. Reduce infiltration in the plateaued upper surface of the dumps. Construct geotechnically stable landforms. Minimize energy of runoff from covers and surrounding areas to limit erosion of fine grained sediment. Revegetate disturbed areas in all dump areas. Consider infiltration galleries to manage 100-year flood conditions.	SW, GW, and geochemical modelling are not well integrated. IPR provided recommendations for review; need to evaluate the ability of existing model to estimate the effectiveness of remediation over time and the application of adaptive management principals. Hydraulic modelling of ET cover. Location or application of wet landscape features, such as retention ponds/wetlands to retain flood flows and reduce the hydrograph peakiness. Destination of surface runoff from waste rock plateau. Implications of using infiltration galleries to minimize runoff/sediment erosion.	Update/integrate previous modelling (hydrology, water balance, and geochemical) to optimize ET model and erosion reduction. Hydraulic modelling of diversion channels. Earth-moving plans. SLIDE. Optimize cut/fills to reduce costs. VADOSE/W and Temp/W to assess freeze thaw impact. Borrow materials (till). Potential locations for large scale waste rock processing facilities to generate appropriately graded borrow.	Hydrologic modelling to provide influent SW flow data. Integration of SW and GW modelling approaches and results. Detailed survey data and potential bed and bank material characterizations. Soils data (geotechnical) and nature of the cover material that will be applied. Final landform design. Cut/fill volumes for/from outside sources (that is, need for calc-silicate waste rock for drainage material on tailings; addition of material from Haul Road).	Improve ground survey. Evaluate foundation conditions along perimeter for sediment control structures (dams and retention ponds) and diversion channels). Dig test pits within the waste rock slope perimeter to a depth of the potential cut (to determine the fines content and geochemical kinetics/leachability).
106.1B.2	Regrade and Reslope Waste Rock Dumps (perimeter slopes)	Construct geotechnically stable landforms. Minimize erosion of fine grained sediment. Provide robust means to convey storm flows down slopes (failure modes and effects analysis). Revegetate disturbed areas on waste rock dumps areas, where possible. Alternative: Where possible, use “hybrid” option; combination of talus slopes and revegetated benches. Selective use of infiltration galleries will reduce the potential for erosion (for example, talus slopes).	SW, GW, and geochemical modelling are not well integrated. IPR provided recommendations for review; need to evaluate the ability of existing model to estimate the effectiveness of remediation over time and the application of adaptive management principals. Hydraulic modelling of ET cover. Destination of surface runoff from waste rock plateau. Implications of using infiltration galleries to minimize runoff/sediment erosion. Final landform design. Cut/fill volumes for/from outside sources (for example, need for calc-silicate waste rock for drainage material on tailings; addition of material from Haul Road, etc).	Update/integrate previous modelling (hydrology, water balance, and geochemical). Earth moving plans; hydraulic modelling of diversion channels; SLIDE; optimize cut/fills to reduce costs. Evaluate “hybrid” closure resloping and regrading geometries – combination of leaving existing talus slopes, adding benches, and selective revegetation. Define final footprint of the waste rock dumps (for example, shift WR laterally to areas with a larger buffer zone between the toe of the slope and downgradient water bodies). Consideration for Rose Creek stream realignment. Incorporation of existing talus slopes for energy dissipation.	Geotechnical and geochemical characteristics of waste rock that will be exposed during regrading and resloping. Mitigation measures – Limited space for sediment collection along the toe of the slope in many areas. Assess the potential for using foundation material as borrow in areas where till or organics will be covered by resloped waste pile. Identification of suitable areas for infiltration galleries to help control surface runoff and erosion. Final footprint undefined: Assess impacts of expanding beyond area covered by current EA (for example, lateral shift of some waste rock material to the SW of the S-Wells may result in disturbance outside of current EA footprint). Flattening the waste rock slope upgradient from the S-Wells will cover the seepage interception system and result in the covering Rose Creek (stream realignment considerations). Pulling the material up will be more expensive and technically challenging. If alternative design option: Determine if hybrid combination of talus slopes and benches is suitable for revegetation and if stakeholders will approve.	Dig test pits along the toe of slope (to evaluate geotechnical conditions and potential to supply borrow). Evaluate foundation conditions for sediment control structures (dams and retention ponds) and diversion channels.

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106.2	Cover and Revegetate East Sulphide Waste	Consolidate the smaller piles of highly reactive material into the larger dumps where practical, reduce infiltration, and revegetate. Alternative – Subaqueous deposition of sulphidic wastes in Faro Pit.	Effectiveness, reliability, and performance of covers in short term and long term for stability, erosion protection, and reduction of infiltration. Very high-cost item for project.	Infiltration modelling, impacts to GW and SW. Assess design criteria in the C&R Plan, Table 4.9. Cover optimization; optimization of short- and long-term vegetative performance is critical.	Need to review RLU planning basis to determine cover volume and suitability. A cover trial is required to optimize landforming and grading requirements for the very low infiltration cover on the FMC. Revegetation trial on this slope/material is required to prove the infiltration modelling, microtopography, and vegetation type. Existing site water balance versus water balance after final grading needs to be evaluated to determine surface and GW impacts. Review RLU planning basis with Waste Pile and Tailings Discipline Team, and then need to consider a revegetation trial on this kind of slope/material. Require cover and revegetation trial for low infiltration cover over waste rock reclamation. Evaluate constructability of cover.	Evaluate cover performance. Confirm availability of suitable cover materials (volume and grain size). Initiate cover trial location and initial revegetation cover. Field trials will be conducted during final design. Visually inspect sulphidic rock to determine requirements for levelling/protective base layer under the very low infiltration synthetic membrane Delineate volumes for relocation for alternative design proposal.
106.3	Cover and Revegetate Main and Intermediate Sulphide Cells	Maximize ET potential of the cover. Minimize energy of runoff from covers and surrounding areas to limit erosion of fine grained sediment.	Proposed reclamation surface is rough and loose; however, the field investigation concluded that the microtopography is sub-optimal for plateau areas as it promotes ponding and infiltration.	Field test cover materials and microtopography options on east sulphide waste areas and apply results to all sulphide cell cover plans.	None in addition to East Sulphide Cell cover and revegetation trial (106.2).	Field work covered under Activity Code 106.1A.
106.4/5/6	Place Cover on Remaining Waste Rock and Revegetate	Reduce infiltration in the dumps; construct geotechnically stable landforms; maximize diversion of uncontaminated run off from covers and surrounding areas; and revegetate disturbed areas on all dump areas. Revegetation information for steep waste rock areas with loose cover is not provided; feasibility of applying covers to 2:1 slopes and revegetating needs to be considered to confirm that this is a viable RLU.	Additional technical considerations addressed under 106.1A/B.	Steep (2:1) slopes for waste rock are not workable from a reclamation perspective. Loose cover material faces three issues: how to apply it, how to keep it from working down into the waste rock surface and no longer providing a vegetation support, and how to prevent it from being eroded by SW. Further discussion and planning is required.	Review RLU planning basis with Waste Pile and Tailings Discipline Team to provide basis for access, cover material type and available volume. Cover and revegetation trial is required to prove out the infiltration modelling, microtopography and vegetation type. Existing site water balance vs. water balance after final grading needs to be evaluated to determine surface and GW impacts.	Field work covered under Activity Code 106.1A/B.
106.7	Cover and Revegetate Mt. Mungly (E&W) and Southwest Pit Wall Dump	Apply low-infiltration covers to the Mt. Mungly waste dumps (East and West) and the Southwest Pit Wall Dump. Revegetation information for steep waste rock areas with loose cover is not provided; feasibility of applying covers to 2:1 slopes and revegetating needs to be considered to confirm that this is a viable RLU.		Cover optimization. Detailed regrading plans, Reclamation Landform Unit (RLU) specifications. Steep (2:1) slopes for waste rock are not workable from a reclamation perspective. Loose cover material faces three issues: how to apply it, how to keep it from working down into the waste rock surface and no longer providing a vegetation support, and how to keep it from being eroded by SW. Further discussion and planning is required.	Need to review RLU planning basis with Waste Pile and Tailings Discipline Team, and then need to consider a revegetation trial on this kind of slope/material. Require cover and revegetation trial for low infiltration cover over waste rock reclamation. Constructability of cover. Existing site water balance vs. water balance after final grading needs to be evaluated to determine surface and GW impacts.	Evaluate cover performance. Confirm availability of suitable cover materials (volume and grain size). Initiate cover trial location and initial revegetation cover. Conduct geotechnical evaluation: test pits to evaluate waste rock gradation.

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
107	Faro Groundwater					
107.1A	Upgrade North Fork Rose Creek	Protect North Fork of Rose Creek from potential sources of contamination. Divert from Faro waste rock piles. Increase capacity to 1:500 year event at 81 m ³ /sec and manage the PMF 384 m ³ /sec. Remove the NFRD and build new channel. Divert from Faro waste rock piles. Increase capacity.	Soil and permafrost conditions, geotechnical conditions, seepage rates, channel stability, flow, seepage, seepage management, contaminate source loading. Location of diversion relative to toe of waste piles, stability of piles, and effects on diversion. Uncertain as to final alignment. NFRC noted to be prone to rockfall hazards (Section 4.6.2) but this is not planned for in consideration of moving the creek channel and replacement of floodplain areas. (Source: C&R Plan Chapter 4). In addition, aquatic assessment recommends more structures and features for fish habitat and reclamation of riparian areas and banks, but there are no details in the Source: C&R Plan. (Chapter 8).	Review design criteria, PMP, PMF and water quality estimates. Conduct hydrologic/hydraulic modelling to contain design flow rate. Review final PMP and PMF estimates; integrate evaluation of GW and SW into sitewide model. Channel design needs to provide low infiltration, long-term performance and a floodplain to handle the PMF. Establish final alignment and floodplain characteristics. Rockfall issues appear to be a natural hazard in headwaters area and a construction hazard when working with the Faro Mine waste rock piles. If Rose Creek is planned to be reconstructed with a liner, then consideration needs to be given to where it is best located in the valley to protect it from rock fall and seepage/GW from the waste rock slopes. Riparian areas in the floodplain need to be an integral part of channel planning.	Hydrologic and hydraulic model to provide influent SW flow data and elevations. Integration of SW and GW modelling approaches and results; detailed cross section survey data, bed and bank materials characterizations. Soils data (geotech) ice data, flow data, and water profile data (surface). Additional flow monitoring data collection at Station “R7” for model calibration and validation. Integrated planning required for the NFRC channel and valley area (including riparian and ponded areas), in conjunction with activities to reslope waste rock pile and remove all or part of haul road; need to weigh against possible cut-off wall construction. Ecosystem Services analysis required to quantify creek protection options for cut-off wall, creek liner, remove rock drain, and realign creek. Impact of rerouting creek beds to reduce contaminated GW impact or construction of slurry walls that may cause daylighting of GW.	Evaluate geologic conditions depth to and geometry of bedrock surface in vicinity of proposed cut-off wall and; soil and permafrost conditions along alignment of new channel on the south side of existing NFRC. Monitor GW and SW quality. Surveys for detailed cross section data, potential bed and bank materials characterizations, and flood plain cover characterization. Collect soils data (geotech) ice data, flow data, and water profile data (surface elevations). Collect additional flow monitoring data at Station R7 for model calibration and validation.
107.1B	North Fork Rose Creek Cut-off Wall	Protect NFRC from contamination. Construct cut-off wall and isolate creek from GW interception.	Location for placing wall; effectiveness, requirements for pumping (volume, duration, construction materials, and timing for pumping, and automation). Potential for bypassing cutoff and contaminating GW.	Optimize location for accessibility, short term, and long term performance; evaluate construction materials; reduce cost; and maximize GW cutoff effectiveness.	Hydrologic and hydraulic model to provide influent SW flow data and elevations. Integration of SW and GW modelling approaches and results. Detailed cross section survey data and bed and bank material characterizations. Soils data (geotechnical), ice data, flow data, and water profile data (surface elevations). Bedrock contact delineation.	Conduct geotechnical and geohydrologic investigations to determine location for wall. Surveys for detailed cross section data to determine opportunities for location of new channel, bed and bank materials characterizations, and flood plain characterization. Collect soils data (geotech) ice data, flow data, and water profile data (surface elevations). Conduct geophysical seismic survey in proposed cut-off wall area with confirmation borings.
107.2	Relocate Zone II Outwash Material to Intermediate Sulphide Cell	Move outwash material to Intermediate Sulphide Cell; reduce contaminant loading to NFRC and underlying aquifer; and construct access roads. Alternative: Cap in place.	Stability of upgradient hillslope. Closure geometry of excavated area. Fill requirement. Accessibility. Sediment management during construction. Depth of affected materials.	Volumes to excavate, hydrology to evaluate sediment management; VADOSE/W, SLIDE, and TEMP/W Alternative assessment of cap-in-place versus remove outwash material.	Volume of waste to relocate. Regrading and revegetation plan for reclaimed area.	If relocated: test pits to limit of bucket and geochemical sampling/testing program (field screening [for example, XRF]) Conduct sampling to support geotechnical, geochemical, and infiltration modelling; monitoring wells for AMP for alterative (cap-in-place) proposal.

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
107.3	Install Zone II Outwash Collection System	Intercept seepage from the Zone II Outwash Area; reduce contaminant loading to the NFRC and underlying aquifer.	Configuration of bedrock surface. Distribution of aquifer properties. Extent of GW contamination in the deeper portions of the aquifer. Response of aquifer system to GW pumping. Magnitude of site water budget components. Geochemical conditions within the aquifer and potential for well fouling. Number of wells required for effective interception. Need for permeable trench and cut-off walls. Number and spacing of extraction wells; permeable trench location. Estimate GW flow and contaminant mass loading from extraction system (average and peak).	Develop three-dimensional numerical GW flow model. Investigate various alternative configurations of SIS design to optimize efficiency and minimize cost. Use GoldSim model, or other model, to provide boundary conditions to GW flow model. Define bedrock surface. Define distribution of aquifer properties. Determine three dimensional extent of GW contamination. Quantify site water budget.	Spatial distribution of alluvial aquifer thickness in outwash zone. Spatial distribution of bedrock topography in outwash zone. Hydraulic properties of the backfill materials in Zone II Pit. Spatial and temporal extent of GW/SW interaction between the alluvial aquifer and the NFRC. Horizontal GW flow patterns in the bedrock aquifer. Three-dimensional distribution of contaminants near the proposed GW interception system. Extent of hydraulic connection between the Zone II Pit and the outwash area, and the GW flux originating in the vicinity of the pit.	Install new wells along proposed line of interception system to delineate alluvial aquifer thickness. Conduct aquifer testing on new wells using existing wells in bedrock and alluvium as additional monitoring points. Conduct geophysical survey along SIS alignment to refine bedrock topography. Conduct single well pumping test on existing Zone II pit extraction well to evaluate hydraulic properties of pit backfill. Perform potentiomanometer study along the NFRC to improve characterization of stream/aquifer interaction. Select monitoring well pair/stream gauge locations using these results. Install additional bedrock monitoring wells to refine flow direction in bedrock aquifer and delineate bedrock aquifer properties. Perform aquifer testing in bedrock monitoring wells to improve understanding of bedrock aquifer properties. Perform depth-specific GW sampling during drilling of bedrock wells to refine interpretation of the distribution of contamination within the aquifer.
107.4	Install S-wells GW Collection System	Upgrade and complete existing GW SIS. Provide for permanent pumps, piping, power, and access.	Configuration of bedrock surface. Distribution of aquifer properties. Response of aquifer system to GW pumping. Magnitude of site water budget components. Geochemical conditions within the aquifer and potential for well fouling. Number of wells required for effective interception. Need for cut-off wall.	Develop three-dimensional numerical GW flow model. Investigate various alternative configurations of SIS design to optimize efficiency and minimize cost. Use GoldSim model or other model to provide boundary conditions to GW flow model.	Alluvial aquifer thickness and the hydraulic properties of the alluvial and bedrock aquifers north of the SIS. Aquifer properties of the deep weathered bedrock aquifer in the vicinity of the existing SIS. Alluvial aquifer properties between existing SIS and the NFRC. Bedrock topography in the vicinity of the existing SIS. Spatial and temporal extent of GW/SW interaction between the alluvial aquifer and the NFRC.	Perform aquifer test using the existing deep extraction well as pumping wells and other existing wells in the vicinity as monitoring wells to quantify the hydraulic properties of the weathered bedrock aquifer near the SIS. Install additional alluvial monitoring well near well S3 and perform aquifer testing using well S3 as a monitoring well to estimate alluvial aquifer properties between the SIS and the NFRC. Perform a seismic survey in the area to improve delineation of the bedrock topography near the existing SIS. Perform potentiomanometer study including instrumentation along the NFRC to improve characterization of stream/aquifer interaction. Select monitoring well pair/stream gauge locations using these results. These monitoring wells will also monitor for possible by-pass of contamination through the SIS and subsequent transport to NFRC.

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
107.5	S-Wells GW Collection (part of ADM to capture future concentrated zones near source)	Shallow and deep aquifer interception systems were constructed in 2009. Final component is installation of cut-off wall if monitoring indicates shallow aquifer sump and deep aquifer pumping wells do not provide sufficient capture.	Evaluation of adequacy of shallow and deep aquifer pumping wells to provide sufficient capture of contaminated GW. Method of installation of the cut-off wall; location of bedrock, extent of wall required, and requirements for additional wells.	Three-dimensional GW flow model; incorporate most recent operational data to estimate effectiveness of existing SIS and system enhancements. Conduct optimization study to maximize the capture of contaminated GW flow and cost.	GW seepage will be addressed at this site by the activities recommended under Activity Code 107.4.	Conduct field investigation to determine bedrock conditions along maximum length of the entire S-wells area, from just below the rock drain past the historical S-wells. This is addressed by the activities recommended under Activity Code 107.4
108	Faro Miscellaneous					
108.1	Reclaim Unnecessary Roads	Prevent long-term erosion and breach crossings to prevent blockage.	Road areas will require specific reclamation plans in keeping with required surface drainage plans and surrounding reclamation prescriptions.	Culverts and crossings will be breached and resloped, and drainages restored. Scarify road surfaces and revegetate. Currently no specific prescription for road revegetation or information about road material quality to predict vegetation success.	Require assessment of road material quality. Require assessment for basis of design of road reclamation – revegetation or swale/channel formation as part of surface drainage plan.	Site reconnaissance
108.1a	Reclaim Zone II Outwash Area	Cover and revegetate Zone II Outwash Area after installation of collection system to provide stable creek floodplain. Alternative design: Cap in place.	Configuration of outwash collection system and final placement of NFRC after rock drain is removed will dictate the cover and revegetation plan surface. Revegetation of this area is not currently considered within the reclamation plan but needs to be tailored to location of NFRC (if moved) and to existing valley vegetation.	Once location of reconfigured NFRC is planned; need to assess loss of current vegetation cover and what can be salvaged and moved to other locations for soil and vegetation. Area may be covered by waste rock if NFRC is moved.	Assess current vegetation cover. Assess current soil type and quality. Locate stockpiling or direct placement areas. Confirm availability of suitable cover material. Confirm availability of suitable riparian plant species.	Site reconnaissance/soil and vegetation survey
108.2	Decontaminate and Demolish Buildings	The existing mill, administrative buildings, and surrounding infrastructure will be removed to mitigate potential long-term safety hazards. Stability of structures is unknown. Extent of contamination of surfaces through plant is unknown. A hazardous materials audit by EBA for YG in fall 2011 is not yet complete.	Sampling for ACM and other designated substances may not be substantive enough to be useful for decommissioning purposes. Areas around buildings that are not tested may need to be treated as designated or ACM substances. Extent of process materials (rock and others) in pipelines, equipment, vessels, and holding areas is not documented. Requirement to remove extensive volumes of this material will complicate decommissioning. Site plans, surveys, Material Safety Data Sheets, and other information involving plant construction and makeup are not currently available. A review of laydown areas in close proximity to the plant (boneyards) has not been completed. Implications and cost for decommissioning has not been evaluated. Options to revegetate and reclaim the site as part of the natural landscape after decommissioning need to be evaluated. Site survey required.	Review of the EBA hazardous materials classification and building materials assessment when finalized to evaluate gaps. Depending on EBA scope, obtain a demolition execution approach through a structural engineer. Site visit to identify items that might have been missed. Follow up sampling may be required. Address safety concerns with any of the onsite buildings and to clear areas for safe access to complete other assessments that may be required. Perform site utility surveys. Use ground penetrating radar (GPR) if necessary for decommissioning and to understand H&S risks during work. Retain a demolition contractor to assist in scrap assessment. Determine and obtain permits required to perform demolition. Analyze existing structures (plans if available) to determine less costly design for removal, decontamination, transport, and recycling or placement in a landfill.	Obtain, review, and catalogue site and building as-built plans and other construction documentation. Sufficient sampling to mitigate costs for abatement of materials assumed to contain designated substances due to lack of information to the contrary. Process material quantification. Waste disposal recommendations. Salvage assessment. Utility and site surveys. Confirm availability of suitable cover material. Assess suitable revegetation cover and cover microtopography. A hazardous materials audit has not been completed. Stability of structures and extent of contamination is not certain. Appropriate cover type and revegetation plan needs to be assessed for this area for long-term liability management. Determine if portions of foundations may be covered and revegetated. Determine available cover material types and volumes and appropriate revegetation plan.	Site reconnaissance. Utility and site survey. Hazardous material audit. Cover evaluation.

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
108.3A	Relocate Contaminated Soil from Mill Site Area and Cover (rudimentary)	Remove hazardous materials and contaminated soil from Plant Site Area. Regrade Mill Area, cover, and revegetate.	Volume of material excavation; volume and source of backfill. Concentration threshold criteria for soil removal.	Determine appropriate location for an onsite landfarm for hydrocarbon contaminant treatment. Specific revegetation prescription required, especially because this area is a candidate for an ET cover.	Extent of soil metals and hydrocarbon contamination and acid generating soils (lateral and vertical) near the Vehicle Maintenance Complex, Emergency Generator Area, Mill Diesel Tank, and Waste Oil Tank. GW flow directions. Extent of associated GW contamination. Assess suitable cover material quality. Assess potential for ET vegetation cover, or appropriate revegetation prescription.	Drill additional soil borings near the Vehicle Maintenance Complex, the Emergency Generator Area, the Mill Diesel Tank, and the Waste Oil Tank; collect hydrocarbon, metal, polyaromatic hydrocarbons (PAH), and acid-neutralization potential (ANP) soil samples to delineate contamination. Install shallow GW monitoring wells in a subset of the borings to evaluate GW flow direction in the four areas. Install additional GW monitoring wells after the GW flow direction is better understood to delineate contaminant plumes and provide additional step-out soil sampling locations, if needed.
108.3B	Relocate Contaminated Soil from Faro Lube Shack and Tank Farm Area and Cover (rudimentary)	Remove hazardous materials and contaminated soil from the Plant Site Area. Regrade Mill Area, cover, and revegetate.	Volume of material excavation; volume and source of backfill. Concentration threshold criteria for soil removal.	Determine appropriate location for onsite landfarm for hydrocarbon contaminant treatment. Specific revegetation prescription required, especially because this area is a candidate for an ET cover.	Extent of soil hydrocarbon contamination (lateral and vertical) near the Lube Shack and Tank Farm Area. GW flow directions. Extent of associated GW contamination. Assess suitable cover material quality. Assess potential for ET vegetation cover, or appropriate revegetation prescription.	Drill soil borings near the Tank Farm Area and near the Lube Shack; collect hydrocarbon, metal, PAH, and ANP soil samples to delineate contamination. Install shallow GW monitoring wells in a subset of the borings to evaluate GW flow direction. Install additional GW monitoring wells after GW flow direction is better understood to delineate contaminant plumes and provide additional step-out soil sampling locations, if needed.
Tailings Area (Activity Code 200)						
201	Dams					
201.1/.2/.3 and 202	Dewater Intermediate Tailings Area	Evaluate potential for backfilling the Intermediate Pond with coarse granular (for example, processed waste rock) such that the surface is revegetated and surface runoff is isolated from tailings porewater. Intermediate Tailings Pond would be backfilled with granular material with sufficient volume in the pore space to provide suitable storage capacity (that is, a sump) and allow for emergency storage in the event of pump failure. System to work in connection with active dewatering of expelled tailings porewater.	Geochemical and geotechnical characteristics of tailings slimes and sediments. Volume of sediment. Dewatering characteristics. Sediment control and method of removal. Availability/source of suitable coarse granular and filter-compatible materials.	Evaluation of tailings consolidation and the need for the waste rock trafficability layer to act as a drainage layer. Evaluation of the depth of freezing within the fine zone of the Intermediate Tailings Area and the implications for trafficability. Time for consolidation to occur. Assess need for accelerated consolidation (for example, wick drains or similar). Evaluate slimes to determine if material should be consolidated by surface drying or capped in place.	Rheologic parameters of tailings to evaluate pumpability and thickening characteristic. Geotechnical information for the area within 500m of the Intermediate Dam. Geotechnical parameters (for example, undrained shear strength, depth of tailings, and porewater pressure). Consolidation characteristics of tailings to enable prediction of tailings porewater expelled, rate of consolidation, and total depth of consolidation (to model drainage above tailings) Seepage/water balance to determine design requirements of the backfilled pond area adjacent to the Intermediate Dam and options for actively managing tailings seepage by sump dewatering. Possible requirement for processing waste rock for the trafficability layer to enable function as a drainage layer. Evaluation of freezing profile.	Conduct geotechnical assessment: • Install piezocones (with ball penetrometers or in-situ vane shear testing) extending through the Intermediate Tailings. Unconsolidated soils near tailings dam require amphibious vehicle or barge in summer, or on ice in winter (if possible). • Install thermistor strings and data loggers. • Collect frozen samples from the intermediate tailings for consolidation testing (using either chilled brine or CRREL barrel drilling during the winter). • Complete trafficability study of the tailings surface in the summer using various sized equipment (driving trials). • Conduct bathymetric survey with subbottom geophysics.

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
201.1/.2/.3 and 202	Dewater Cross-valley Dam Pond	Dewater the pond by pumping the water to the Faro Pit. Remove sludge and sediments to (1) facilitate construction of the Intermediate Tailings Dam raise and (2) breach the Cross Valley Dam.	Chemical and physical characteristics of sludge and sediments; volume of sediment; dewatering characteristics; method for controlling surface and groundwater during excavation. Sediment control and method of removal.	Methods of dewatering, treatment as required, and discharge of treated water. Methods of sludge removal, stabilization/drying of sludge, transportation of sludge, and sludge disposal at the existing sludge pond north of tailings impoundment. Stability of Intermediate Tailings Dam (seepage and piping, and drawdown slope stability) after dewatering of the Cross Valley Impoundment.	Volume of sludge and sediment to be removed at Cross Valley Dam Pond. Nature and extent of chemicals in sludge. Rheologic parameters of sediment to evaluate pumpability and thickening characteristics.	Survey sludge and sediment to estimate volume to be removed at Cross Valley Dam Pond: • Conduct bathymetric survey with subbottom geophysics • Install vibrocores • Obtain water and sludge samples for geochemical and treatability testing Conduct geochemical and treatability testing.
201.1	Breach the Cross Valley Dam	Excavate notch in the Cross Valley Dam embankment with minimum base width of 20 metres.	The need to retain the Cross Valley Pond for temporary, emergency storage, and treatment of water, and its effectiveness as a settling pond for removal of suspended solids if retained.	Flood routing (hydraulics) study: • Sizing of notch • Flow velocity • Scour criteria • Incorporate potential for ice flows in flood routing • Flood routing/dissipation in area downstream from Cross Valley Dam before floodwater discharges into Rose Creek Potential for underseepage that can cause piping and uncontrolled breaching and/or widening of notch. Liquefaction potential in the channel subgrade materials.	Need for Cross Valley Pond. Soil conditions at proposed notch location including embankment and foundation conditions. Hydrologic and hydraulic model to provide influent SW flow data and elevations as well as routing and velocity data for spillway to Rose Creek.	Install hollow-stem auger borings to confirm subsurface conditions at proposed notch location and evaluate foundation/underseepage conditions.
201.1/.4/.5	Retain Cross-valley Dam	To allow water to egress from the Intermediate Dam spillway and enter the Rose Creek downstream from the Cross Valley Dam.	Removal of Cross Valley Dam needs to be further evaluated. IRP recommends consideration of Cross Valley Dam to store collected seep water. Requires evaluation of Cross Valley Dam stability, location, and requirements (hydrology, hydraulics, and foundation conditions) for spillway. Location and foundation conditions for downstream SIS will need evaluation.	Identify operational failure scenarios in which the Cross-valley Pond would be used if retained. Evaluate the potential effectiveness of treatment that would be provided under those scenarios. Flood routing (hydraulics) study: • Route flow through pond and spillway at right abutment of Cross Valley Dam. Also, consider alternative of using long spillway that completely bypasses Cross-valley Pond. • Flood routing/dissipation in area downstream from Cross Valley Dam before floodwater discharges into Rose Creek If Cross Valley Dam is retained, dam stability evaluations: • Seepage and slope stability • Liquefaction potential and mitigation • Deformation analyses (seismic) • Slope protection • Geotechnical instrumentation	If Cross Valley Dam is retained, liquefied soil strength for designing the seismic mitigation measures. Hydrologic and hydraulic model to provide influent SW flow data and elevations as well as routing and velocity data for spillway to Rose Creek.	If Cross Valley Dam is retained, install mud rotary borings in Cross Valley Dam foundation (along toe of embankment) with emphasis on silty soil characterization: • Recover undisturbed soil samples • Grading and index testing • Cyclic simple shear testing This would only be for keeping a full pond; for an empty or low-operating pond, eliminate/reduce scope of Cross Valley Dam investigation. If the Cross Valley Dam is retained, conduct additional investigations for spillway area and SIS.

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
201.2	Raise Intermediate Dam (ID) Consider two options: - Significant raise (more than 4.6m; need to raise RCDC dike crest) - Moderate to minor raise (less than 4.6m; does not require raising the RCDC dike; regrading of tailings toward low invert spillway required)	To pass – without overtopping – floods larger than the 500-year return event and route through new spillway. Dam stability.	Dam stability during PMF (flooding) and maximum credible earthquake (MCE) (seismic) events; requirements to modify internal drain and filters (will no longer have Cross Valley Dam water against downstream slope); liquefaction potential and seismic slope stability. Need to determine the amount of raise.	Flood routing (hydraulic) study to determine optimum dam raise in conjunction with spillway configuration and size. RCDC dike and dam stability evaluations: - Seepage and slope stability - Internal filter and drain system adequacy - Liquefaction potential and mitigation - Deformation analyses (static and seismic) - Borrow material considerations - Slope protection - Geotechnical instrumentation Design of dewatering and excavation requirements for regrading tailings.	Subsurface information (foundation conditions) along the RCDC dike. Borrow material sources and borrow material characteristics (dike and dam embankment materials, filter/drain material, slope protection, tailing covers). Assume that Cross Valley Dam will be breached and no tailwater at downstream slope. Tailings permeability for dewatering (assumed to be covered under the Tailings Cover task). Hydrologic and hydraulic model to provide influent SW flow data and elevations as well as routing and velocity data.	Install borings along RCDC dike toe, depending on amount of raise determined appropriate. Perform CPTs for tailings cover constructability along the toe of the RCDC dike (see Tailings Cover task). Conduct laboratory testing including index, permeability and shear strength testing. Investigate borrow material, as necessary. Investigate tailings, conduct CPTs, and perform other fieldwork and related laboratory testing (see Tailings Cover task). Conduct additional geotechnical investigation required, depending on amount of raise determined appropriate.
201.3	Construct Intermediate Dam Spillway	Route the peak flood flows large enough to erode the fuse plug without overtopping the Intermediate Tailings Dam. Construct new spillway in bedrock at the north abutment of Intermediate Tailings Dam. Consider alternative of passing design flood over the top of a hardened embankment. Operational considerations: - SW assumed to be clean (long-term) and gravity drain; SW to be collected initially for monitoring and possible treatment - GW to be collected in waste rock layer underneath till cover and pumped for treatment	Optimize dam raise with spillway design (size, location, invert, overflow length, and location of tailings. Design criteria require review. If concrete is required for spillway, perform seepage analyses to evaluate uplift forces and to design underdrain, uplift, or both. For alternative to pass design flood over the top of embankment, determine design flow velocities. Required measures to provide sheet flow and prevent concentrated flows, energy dissipation/erosion protection at the downstream toe of the Intermediate Tailings Dam.	Flood routing (hydraulics) study: - PMF flood - Flow velocity - Scour criteria - Incorporate potential for ice flows in flood routing - Stability/adequacy of articulating concrete blocks (if flood is passed over the top of the embankment) - Flow routing downstream from Intermediate Dam including channelization and erosion protection - Potential for winter flows and ice blockages	Subsurface conditions for spillway: - Rock mass quality - Erosion resistance - Permeability (to evaluate uplift and underseepage if concrete spillway is constructed) Subsurface conditions for energy structure/modifications downhill from the spillway. Hydrologic and hydraulic model to provide influent SW flow data and elevations as well as routing and velocity data for spillway. PMF handling has been assessed previously and considerable information is available. Flooding information should be incorporated into any new hydraulic models developed.	Conduct additional geotechnical investigation required, depending on final spillway elevation and routing. Evaluate spillway on right abutment: - Survey seismic lines (refraction survey). - Install shallow borings to map depth of bedrock and diamond drill borings for rock coring. - Conduct packer testing to determine rock permeability. If Cross Valley Dam is retained (spillway extended past Cross-valley Pond): - Survey one additional seismic line (refraction survey). - Install an additional shallow borings to map depth of bedrock and additional diamond drill borings for rock coring.
201.4	Stabilize Secondary Dam by Densifying Foundations for East Limb Embankment	Mitigation against liquefaction and dam instability during MCE. Also include embankment stability under all other loading conditions and erosion protection during PMF flooding.	Most cost-effective seismic mitigation: - Extent of liquefaction and slope instability - Appropriate methods of ground improvement	Pseudo-static LE analyses to evaluate different stabilization alternatives. Two-dimensional (FLAC2D) dynamic/seismic analyses to more appropriately determine the cyclic shear stresses in the embankments for liquefaction assessments and mitigation design (shortcoming of the previous liquefaction assessment was using SHAKE91 [a one-dimensional analysis] for two-dimensional geometry). Use FLAC2D to evaluate seismic deformation to optimize mitigation options. Criteria for acceptable deformations must be established first.	Subsurface information covering the full length (for example, filling the gaps, of the East Limb of Secondary Dam) (existing borings tend to be clustered with gaps greater than 500m between clusters). Shear wave velocity (Vs) information. Liquefaction assessments will be more reliable with direct measurement of Vs instead of estimating these values from correlations with SPT blowcounts.	Survey seismic lines (refraction survey) to determine depth to bedrock and measure shear wave velocities. Verify geophysical information by performing downhole shear wave velocity measurements. Collect SPT samples (N values and fine content) Perform sieve analysis and index testing, as appropriate.

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202	Tailings Cover					
202.1/.2/ .3/.4/.5	Cover Intermediate Tailings Pond Construct Swales over the Rose Creek Tailings Area using North Fork Rock Drain Material	Prevent direct contact by wildlife with the tailings and minimize contaminated runoff. The swales will distribute and control flow, decrease flow velocity, and allow flow to pass over the tailings cover without erosion and flow through the spillway into Rose Creek.	The condition of the surface of the tailings within the tailings area varies by season. These conditions limit when and where equipment can successfully work on the tailings surface. The details around the modification of the Intermediate Tailings Pond (upstream from Intermediate Tailings) will require further assessment in the context of (for example, the capacity of the pumps that will be used to transfer water from this pond to the Faro Pit).	Determine settlement/differential settlement predictions; determine stability assessments (for example, edge effects during construction); hydrology, energy dissipation features; TEMP/W drainage, slope stability, and settling assessments; design of basal support layer (waste rock or geogrid); manage risks associated with differential settlement especially in area of energy dissipation features. Determine microtopography features.	Hydrologic and hydraulic model to provide influent SW flow data and elevations as well as routing and velocity data in relation to swales. The erosive and conveyance characteristics of the swales materials and vegetative cover. Source of base granular drainage material, filter compatible layer and final cover. Implications of geochemistry (for example, leachability and decomposition of waste rock above tailings). Determine if material from NFRD the best source or can “less useful” waste rock be used. Thickness of growth media (water balance). Energy dissipation structure design and risks. Ultimate contouring of tailings impoundment and the dynamics of any future intermediate pond (emergent vegetation). Feasibility of sump in WR pore space adjacent to the Intermediate Dam to store tailings porewater covered with till/clay revegetated layer.	Install geotechnical borings to characterize tailings profile; load tests to predict settlement; (included in Activity Codes 201.1/.2/.3, 202) Construct/monitor additional trial cover cells; Constructability assessments. Conduct pilot testing including large lysimeter. surveys for detailed topographic data. Characterize bed and bank materials and flood plain cover.
202.2	Place Covers on Original and Secondary Impoundments and Revegetate	To prevent direct contact by wildlife and birds with the tailings and to minimize contaminated runoff.	Detailed design of capture and conveyance measures; requirements for accessibility; cover stability; and long-term vegetation stability; differential and total settlement. Current revegetation design includes use of agronomic grass species, out of keeping with revegetation of the contiguous Rose Valley area and may be an issue for further revegetation and development of an ET cover. The C&R Plan suggests some potentially contaminated SW flow will discharge to the tailings surface.	Surface hydrology (swales, ditching, and energy dissipation features); GW/SW interaction. Microtopography and mesotopography determination, growth medium characterization in tailings cover material, vegetation type and application method. Integrated assessment of geotechnical and vegetation cover (agronomic or native) issues for the tailings pond is needed to inform cover design.	Need to assess mesotopographic and microtopographic features for tailings cover, and assess available cover material volumes and appropriate vegetation plan. Need to assess optimal cover material types in different areas of tailings cover to facilitate drainage of porewater and separation of clean SW from seepage areas. Lysimeter installation required in dry consolidated and wet unconsolidated (but due to be drained) tailings materials. Cover and revegetation trial required for the tailings surface. Revegetation plan and evapotranspirative aspect of the cover design. Energy dissipation structure and implications for revegetation planning. Microtopography and landforming.	Conduct instrumented cover placement trials to supplement existing cover trials; large lysimeter; characterize cover materials. Install CPT probe holes. Assess trafficability (included in program described under Activity Code 201.1). Conduct full scale load test to determine rate and magnitude of consolidation.

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TABLE B-1
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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
203	Rose Creek Diversion					
203.1	Upgrade Rose Creek Diversion Channel Upstream from Fuse Plug to PMF	The Rose Creek Diversion upstream from the fuse plug and downstream from the convergence of the North and South Forks of Rose Creek currently has capacity for the 674 m³/sec PMF based on the cross-sectional area between the Secondary Dam and the hillside. The upgrade is required to stabilize the existing embankments. Perform modifications to pass the PMF through upstream portion of RCDC, including widening and/or deepening of the channel. Provide erosion protection of channel sideslopes and channel bottom. Consider an alternative to Upgrade Rose Creek Diversion Channel over its full length to pass the PMF without overtopping the RCDC dike.	Stability of the channel banks need to be addressed. Existing fuse plug leaks badly and generates ARD. Must provide materials stable under low-flow conditions, while allowing erosion of the plug during high flow conditions. Rose Creek Diversion Channel needs to increase capacity; stability of the channel banks needs to be addressed. Existing channel carries salmon and is considered a navigable water. Assess changing elevation of channel with respect to tailings and effects on seepage and contamination. Glaciation/icing of channel resulting in reduction of flow capacity during high flow events. Assess glaciation and ice related risks.	Assess geotechnical data, current PMP, and PMF estimates. Erosion potential, water quality, channel stability, hydrology, and hydraulics. Existing channel carries salmon and is considered a navigable water. Assess changing elevation of channel with respect to tailings and effects on seepage and contamination. South slope stability: - Rock cut slope stability - Assess permafrost issues and potential stability issues Assess potential for channel blockages due to the follow: (1) debris flows, or south slope slides, (2) icing/glaciations problems, and (3) minor slope failures (during smaller floods) and vegetation.	Hydrologic and hydraulic model to provide influent SW flow data and elevations. Additional detailed cross section survey data, bed and bank material characterizations. Obtain electronic modelling files and related documentation associated with June 2006 report prepared by northwest hydraulic consultants ltd. (2006). Establishment of flow monitoring station on Rose Creek upstream from the confluence with the NFRC for model calibration and validation. Additional flow monitoring data collection at stations RCDC and X14. Rock mass strengths and soil strengths to assess cut slope stability of south slope Debris flow potential (see note) Potential for icing/glaciation. Quarry sources for large angular riprap. Note: Potential for debris flow and other hazards were performed by BGC in 2006, and documented in memorandum titled <i>Natural Hazard Terrain Assessment – NFRC and South Slope RCDC</i>, dated July 7, 2006.	Conduct geotechnical investigation (surveys have shown permafrost not an issue in area). Review potential use of roadway between secondary dam and channel for use as channel. Surveys for detailed cross section data, bed and bank materials characterizations. Collect soils data (geotech) ice data, flow data, and water profile data (surface elevations). Collect additional flow monitoring data at Station RCDC and X14. Establish new monitoring station in Rose Creek upstream of confluence of Rose Creek and North Fork for model calibration and validation (flows upstream from site). Install hollow-stem auger boreholes, to look for ice (summer program), test pits on the south slope (not needed if expanded to the north on the secondary dam). Conduct index testing and investigate permafrost Investigation geohazards (debris flow).
203.2	Construct Erosion Dissipation Structure	Construct an erosion dissipation layer on tailings cover downstream from the fuse plug. Construct swales in the till cover beyond the erosion dissipation layer so that the flow does not become concentrated. Re-evaluate feasibility of using tailings area to receive flood flows. Potential for sediment erosion is high.	Potential backwater conditions require hydraulic modelling to evaluate whether the flood can pass the lower channel without overtopping the dike or intermediate dam. The erosive energy contained in the overland flow downstream from a breached fuse plug is unknown.	Review of current PMP and PMF estimates. Erosion potential, water quality, stability, hydrology, hydraulics, and construction materials (riprap sources). Assessment of the design of the energy dissipation structures and settlement of underlying material.	Hydrologic and hydraulic model to provide influent SW flow data including velocities, erosive forces, and elevations. Detailed topographic survey data, potential bed and bank material characterizations. Flow data, and water profile data (surface elevations). Foundation strength: natural versus tailings area. Define extent of waste materials (assume it will be removed). Liquefaction potential of tailings underlying the erosion dissipation structure (assumption: finish grade of riprap apron will be near horizontal with small driving stresses). Borrow sources for riprap.	Conduct detailed reconnaissance and review of geologic mapping, to assess conditions and settling characteristics. Review of current site conditions through condition survey. Conduct geotechnical field investigation including borings for area underlying native materials and CPTs in tailings area. Perform CPT in conjunction with the CPT work performed as part of Tailings Cover task.
203.3	Breach North Fork Rock Drain, Create Channel (See Activity Code 107.1)	To restore the North Fork of Rose Creek and protect from potential sources of contamination. Restore the North Fork of Rose Creek and protect it from potential sources of contamination.	Large undertaking will remove primary access route from Faro and Vangorda/Grum sites. Key issues are slope stability, maintenance of access, geochemical conditions, sedimentation, and constructability. Effects on wildlife, including resident grayling must be integrated into design. The extent of effects on fish and fish habitat are unknown.	Geotechnical, hydrology, and hydraulics for passing flow through new channel section and erosion potential. Geotechnical, hydrology, hydraulics, and erosion potential. Fisheries and fish habitat surveys are required to determine the quality and quantity of fish habitat that would be affected by this. This activity is key to obtaining a federal <i>Fisheries Act</i> Authorization for the project. Geochemical assessment. Rock drain may have flood attenuation capacity to be relied upon in the short term.	The extent of effects on fish and fish habitat are unknown. Hydrologic and hydraulic model to provide influent SW flow data and elevations. Detailed cross section survey data upstream and downstream from current rock drain, and potential bed and bank material characterizations. Soils data (geotechnical), ice data, flow data, and water profile data (surface elevations). Geotechnical data along new alignment, including excavatability, permeability, erosion potential, etc. Geochemical properties of Haul Road embankment (rock drain) for use as borrow source at the tailings dam.	Survey fisheries and fish habitat during all seasons. Review current site conditions through condition survey. Surveys for detailed cross section data, bed and bank material characterizations. Collect flow data and water profile data (surface elevations). Conduct geotechnical field investigation: Install hollow-stem auger borings. Install piezometers in a subset of the borings. Dig test pits between the hollow-stem auger borings (previous work shows low blow count material in floodplain near rock drain). Conduct laboratory testing to characterize the foundation including sieve analysis, and Atterberg limits.

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
203.4	Construct Fuse Plug	Replace existing overflow section with material designed to fully breach at design flow. Consider alternatives to a Fuse Plug such as a long Broadcrested Overflow Weir or Fuse Gates.	Design criteria and functionality of the fuse plug. Unpredictability of when fuse plug would breach; Icing or frozen nature delay breaching. Length of fuse plug required. Embankment and foundation conditions for long weir (if used as alternative to fuseplug).	Hydrology, hydraulics, erosion potential, and functional parameters associated with the fuse plug. Design of the fuse plug with construction materials. Hydrology, hydraulics, and erosion potential. Foundation conditions for fuse plug or alternative structure (fuse gate, etc.).	Hydrologic and hydraulic model to provide influent SW flow data and elevations and erosion/load information for the design of the fuse plug. Detailed cross section survey data. Soils data (geotechnical), ice data, flow data, and water profile data (surface elevations). Quarry sources for fuse plug material.	Review current site conditions through condition survey. Conduct detailed reconnaissance and review geologic mapping, to assess conditions. Review current site conditions through condition survey. Install borings to determine foundation conditions at fuse plug structure.
203.5	Upgrade of RCDC Downstream from FP to 1:500 (dike)	Provide adequate freeboard to enable the RCDC to pass the flow of Rose Creek on a year-round basis for all flows up to the 500-year flood event. Provide adequate freeboard to enable the RCDC to pass the flow of Rose Creek on a year-round basis for all flows up to the 500-year flood event.	Significant leakage from the channel in its current configuration – 30% at low flow. Intermediate Dam raise may result in significant additional costs for this item. The relationship defining flows related to the RCDC and the ID spillway. The settlement of the RCDC dike upstream of the Intermediate Tailings Dam.	Geotechnical, hydrology, hydraulics, and erosion potential. Repairs and improvements to the channel and the dike, riprap modifications, steep channel section, portions of the dike may be raised and/or buttressed to mitigate settlement or loss of freeboard.	Hydrologic and hydraulic model to provide influent SW flow data and elevations. Detailed cross section survey data, bed and bank material characterizations. Flow data, and water profile data (surface elevations). Relationship determination between the RCDC flows, water surface elevations, and the raising/flow requirements in the Intermediate Tailings Dam spillway. Seepage losses from RCDC.	Review current site conditions through condition survey. Conduct detailed reconnaissance and review geologic mapping and as-built information. Conduct hydraulic modelling to confirm 500-year flood capacity. Install flow monitoring stations to assess the flow and losses in the channel (three stations with dataloggers) and perform gain/loss flow monitoring.
203.6	Construct a Fish Bypass (ladder)	Replacement of existing drop structures in the downstream portion of the RCDC with a larger fish bypass system.	Need for replacement under review. Poor foundation conditions and thawing permafrost resulting in stability issues. The extent of effects on fish and fish habitat.	Requirements dependent on determination of Cross Valley Dam long-term use. Hydraulics and hydrology. Fisheries and fish habitat surveys are required to determine the quality and quantity of fish habitat that would be affected by the project and that would have to be compensated for or recreated to support a federal <i>Fisheries Act</i> Authorization for the project.	The extent of effects on fish and fish habitat are unknown. Hydrologic and hydraulic model to provide SW flow data and elevations. Soils data (geotechnical), ice data, flow data, and water profile data (surface elevations).	Survey fisheries and fish habitat during all seasons. Review current site conditions through condition survey. Survey for detailed cross section data, and bed and bank material characterizations. Collect soils data (geotechnical), ice data, flow data, and water profile data (surface elevations).
203.7	Revegetate Riparian and High Bank Areas	Erosion control and habitat (fish and wildlife) require vegetated surfaces to work concurrently with engineered diversion structures.		Locate appropriate soils for growth medium. Complete revegetation design for riparian areas and associated wetlands. Design soil and vegetation covers based on engineering design for creek, to enhance geotechnical design.	Characterize source and availability of soil cover materials. Characterize vegetation community for riparian revegetation.	Identify source and availability of soil cover materials. This will be conducted during final design.
204	Groundwater Collection					
204.1	Construct Intermediate Dam Cut-off Wall	Install grout cut-off wall to bedrock in the area of the Intermediate Tailings and Cross Valley dams to direct water either to a central sump or directly into a pipeline; water will be pumped to Faro Pit or directly to the WTP.	Foundation information is not available for the area between the Intermediate Tailings and Cross Valley dams. Data show subsurface at the cross valley and downstream location consist of loose alluvium. Cut-off wall would be located downstream from Cross Valley Dam if Cross Valley Dam is retained.	Assessment of cut-off wall design required. Optimization and detailed design will need to be done during the detailed engineering design phase. Before completion of the cut-off wall and trench, a monitoring system will be installed both upgradient and downgradient from the collector system.	Potential interaction with SW. Bedrock contact delineation.	Conduct geotechnical investigation if the cut-off wall is moved downstream from the Cross Valley Dam. Conduct geophysical seismic survey in proposed cut-off wall area with confirmation borings.

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
204.2	Construct Intermediate Dam Interception Trench	Direct water either to a central sump or directly into a pipeline; 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).	Configuration of bedrock surface. Distribution of aquifer properties. Response of aquifer system to GW pumping. Magnitude of site water budget components. Geochemical conditions within the aquifer and potential for well fouling. Number of wells required for effective interception. Need for permeable trench and cut-off walls. Effectiveness of collector trench and need for additional GW wells extending to bedrock.	Develop three-dimensional numerical GW flow model. Investigate various alternative configurations of GW interception design to optimize efficiency and minimize cost. Use GoldSim model or other model to provide boundary conditions for the GW flow model. Estimate GW flow and contaminant mass loading from extraction system (average and peak). This approach is also required if SIS is constructed downstream from Cross Valley Dam.	Potential interaction with SW. Bedrock topography in the vicinity of the GW interception system downstream from the Cross Valley Dam. Aquifer properties of both the alluvial and weathered bedrock aquifers along the interception system alignment, including areas on the northeast and southwest extents of the valley fill aquifer. Delineation of the alluvial aquifer thickness, bedrock topography, and aquifer properties downgradient from the planned GW interception system. Extent of hydraulic connection between the alluvial aquifer and Rose Creek downstream from the Cross Valley Dam.	Drill additional borings to define bedrock surface. Construct test wells. Perform aquifer testing. Profile seismicity across Rose Creek Valley along the planned interception system alignment to better delineate the bedrock topography. Install new alluvial aquifer monitoring wells along the interception alignment. Perform sequential and long-term aquifer testing for new wells Install additional monitoring wells in the weathered bedrock aquifer along the interception system alignment. Perform aquifer testing in each well. Install alluvial aquifer and bedrock aquifer monitoring wells downstream from the interception system alignment and perform aquifer testing on a subset of these wells (both in alluvium and weathered bedrock) to obtain aquifer properties in this area. These wells will also provide monitoring points to monitor for potential bypass of contaminated GW past the GW interception system. Perform potentiomanometer study including instrumentation along Rose Creek to improve characterization of stream/aquifer interaction. Based on these results, select monitoring well pair/stream gauge locations along Rose Creek and instrument with recording pressure transducers.
205	Miscellaneous Closure Activities					
205.2	Construct New Polishing Pond near the New Faro Area WTP		C&R Plan calls for construction of a new polishing pond to serve as a final discharge point from the new Faro Area WTP. High-density sludge (HDS) treatment plants with filters normally do not require, nor benefit from, a polishing pond; consequently, none is recommended.	CH2M HILL does not believe there is a need for a polishing pond in conjunction with the new Faro Area WTP and does not recommend any technical assessments.	Need for effluent polishing pond for new Faro Area WTP.	None.

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
Vangorda/Grum Area (Activity Code 300)						
301	Vangorda Pit					
301.2	Construct Safety Berms (Vangorda Pit)	Construct the safety berms around Vangorda Pit. Construct an access road along the alignment of the berm.	Construction and design optimization will be completed during the detailed engineering process.	Surface hydrology (drainage ditches) and sediment control (retention/settling ponds).	Higher resolution mapping.	Conduct reconnaissance, review geologic mapping, and review higher resolution topographic mapping.
301.3	Reslope and Cover Vangorda Pit Waste Rock Piles	Regrade smaller waste rock dumps in the southeastern portion of Vangorda Pit. Cover with till – ET cover. Revegetate areas within days of sloping. Construct rock drains/ditches to prevent seeps from daylighting and ponding on revegetated surfaces.	Pit walls are retrogressing in some areas; slope instability issues. Potential of rockfalls. Water level fluctuation in pit (risk of flooding revegetated areas and killing vegetation). Geotechnical and geochemical variability of deposit. Available subsurface information. Location and number of seeps that could daylight on revegetated surface.	Equipment access and foundation conditions. Water level fluctuations, pit wall stability. Appropriate cover material volumes and revegetation planning.	Cover material volumes. Cover microtopography and revegetation plan. Geochemical and geotechnical characterization of waste piles within the open pit. Slope stability study and analysis of pit walls. Evaluate requirements for slope stability monitoring (install inclinometers actively survey pit walls during construction, or bore holes if needed).	Evaluate equipment access, GW water level, foundation conditions. Dig test pits to investigate seeps and design potential drainage collection systems; gradations and visual assessment. Install boreholes/standpipes to below GW table to test for perched water within rock piles. Evaluate slope stability of retrogressing pit walls. Collect sufficient data to carryout modelling analysis.
302	Vangorda Dump					
302.1A	Reslope Vangorda Waste Dump (plateau area)	Decrease infiltration through the dump and to prevent dust migration and direct uptake by wildlife. Control SW runoff.	Geotechnical properties and geochemical variability of waste. Runoff volumes, efficient and reliable control structures.	Cut and fill optimization. Infiltration modelling/cover optimization. VADOSE/W, SLIDE modelling. Sediment control during resloping. Assess available subsurface information.	SW flow direction off plateau and ultimate discharge destination(s). Protection of the stream channel immediately to the south of the toe of the Vangorda WR Dump.	Dig test pits within the waste rock at top of slope to depth of the potential cut to determine the fines content and geochemical kinetics/ leachability.
302.1B	Reslope Vangorda Waste Dump (perimeter slopes)	Construct geotechnically stable landforms that are consistent with long-term revegetation plans.	Options for conveying surface runoff down the dump slopes without eroding cover. Failure modes and effects analysis of water conveyance channels (that is, ice jam). Toe of slope is constrained by creeks in several areas; limited opportunities for downgradient sediment management.	Foundation conditions to allow for sediment collection ditch. Geochemical evaluation of waste rock fines to enable design of sediment mitigation. Optimization of seepage interception along toe of slope (currently appears to be part way up the slope).	Determine if 2.7:1 slope is problematic for revegetation (slope facing creek). Reactivity of regraded waste rock for sediment management and long term revegetation.	Conduct additional investigation to evaluate optimal seepage interception, ditching, and possible cut-off walls. Install new seepage collection wells at toe of slope, and evaluate foundation conditions for sediment management structures. Dig test pits at base of slope to evaluate possible borrow sources if toe of slope is extended.
302.2/.3/.4/.5	Place Low-infiltration Cover on Vangorda Waste Rock and Revegetate	Place low-infiltration cover on Vangorda Waste Rock dump and revegetate.	Allowable infiltration through cover, optimization of cover versus seepage interception and treatment. Proposed reclamation surface is rough and loose; however, field investigation concluded that microtopography is bad for plateau areas because it promotes ponding and infiltration.	Cut and fill optimization. Infiltration modelling/cover optimization. Need to review RLU planning basis with Waste Pile and Tailings Discipline Team, and then require a revegetation trial on this kind of slope/material. Ecosystem services analysis required to assess options for Vangorda Creek undisturbed reaches, with respect to resloping and cover on adjacent waste rock areas and Grum Sulphide Cell.	Revegetation trial required for waste rock covers and slopes. Ecosystem services analysis for Vangorda Creek. Final topography of waste dump. Sediment characteristics (geochemical and geotechnical) of material to be exposed during cut/fill (especially erodible fines). Cover material needs to be identified for source and quality. Existing site water balance versus water balance after final grading needs to be evaluated to determine surface and GW impacts. Evaluate till stockpile as a potential borrow source. Sediment control, especially on freshly covered slopes.	Conduct survey to better characterize material for constructability review and cover material suitability. Visually inspect and document with photographs waste rock gradation to evaluate filter compatibility with till cover.

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
302.6	Place Very Low Cover Over Baritic Fines	Prior to regrading waste rock, cover baritic fines stockpiled on the northeastern side of the dump with a very-low-infiltration cover. Slope waste rock upslope of the fines and cover with a low-infiltration cover. Alternative – Relocate baritic fines to sulphide cell as bedding layer for very low infiltration line. Only feasible if baritic fines have not migrated/leached excessively into the underlying waste rock.	Clear delineation of limits of baritic fines/cover suitability and short-term and long-term performance. If alternative design: Chemical compatibility of baritic fines with material in sulphide cell.	Infiltration modelling/cover optimization. Sediment control and management of contaminated water (primarily surface contact water).	Need geotechnical information for baritic fines to evaluate capping design and possible relocation. Evaluation of possible contamination of waste rock below baritic fines due to leaching of baritic fines. Accurate delineation for baritic fines (conflicting areas and volumes). Sediment control plans during construction (if moved: relocate toward centre of Sulphide Cell rather than toward slope of waste rock pile).	Dig test pits for subsurface investigation to better delineate limits of baritic fines; visual inspection; two gradations. Conduct DCPT; install sonic boreholes to collect samples of waste rock below the baritic fines. Evaluate foundation conditions for sediment management structures.
302.7	Place Very Low Infiltration Cover over Main Dump Sulphide Cell	To decrease infiltration through the dump and to prevent dust migration and direct uptake by wildlife. Alternative 1 – Consider consolidating baritic fines on sulphide cell as finer (cushion) layer at liner contact. Alternative 2 – Design 2:1 slopes for impervious liner and develop 3:1 or flatter slopes outside the liner to facilitate revegetation.	Allowable infiltration through cover; optimization of cover versus seepage interception and treatment. If Alternative 1: Chemical compatibility of baritic fines with material in sulphide cell	Cut and fill optimization and infiltration modelling/cover optimization. Lessons learned from capping Grum Sulphide Cell. Need to monitor processes ongoing in that cover. Need for liner. Merits of very low infiltration cover. Additional monitoring (for example, lysimeters and monitoring wells). Design evaluations of Alternatives 1 and 2.	Cover material volumes need to be assessed for this area. Cover microtopography and revegetation plan needs to be assessed. Gradation of waste rock (relates to necessity for cushion layer below cap).	Conduct cover field trials; revegetation trials; sediment control plans; and pilot testing including large lysimeter. Field trials would be conducted during final design. Dig test pits for visual inspection of material to support liner constructability. Field trails would be conducted in conjunction with the final design.
303	Vangorda Creek Diversion					
303.1/.2	Construct New Vangorda Diversion	Potential revegetation of the diversion and adjacent areas needs to be assessed. To permanently realign Vangorda Creek around Vangorda Pit to minimize leakage into pit and provide a safe setback for the diversion away from the pit slope.	The final design for the permanent realignment of the Vangorda Creek Diversion was performed by others; energy dissipation, erosion prevention measures and intake structure were incorporated into the final design. Potential revegetation of the diversion and adjacent areas needs to be assessed. The technical uncertainties depend on the final alignment option selected. Energy dissipation especially along steep sections. Erosion protection. Seepage losses.	Alignment, energy dissipation, routing, gradient, materials, cost, geotechnical conditions, hydrology, hydraulics, erosion potential, and potential revegetation to manage erosion. The required design storm flows need to be selected and assessed. Impacts on downstream Dixon Creek would need to be considered in the selected alignment. Technical assessments depend on final selected alignment. Revegetation to manage erosion needs to be included in design basis to assess cover materials and vegetation species required.	Hydrologic and hydraulic model to provide influent SW flow data and elevations. Detailed cross section survey data, bed and bank material characterizations. Soils data (geotechnical), ice data, flow data, and water profile data (surface elevations). <i>[Geotechnical information was collected in 2010 by SRK, but this information was not part of the library – BGC is obtaining from YG and will add to the data available – this may remove the need for any site investigation]</i> The final alignment has not been selected. The design storm has not been selected. Dixon Creek characterization is required if the Dixon Creek alignment is selected. Additional flow monitoring data required for Vangorda, Grum, and Dixon Creeks; data to be coincident with precipitation data collected at existing meteorological stations (the Grum Dump) for model calibration and validation. Routing soil conditions. Revegetation planning for channel stabilization and riparian area erosion control.	Conduct detailed reconnaissance and review of geologic mapping to assess conditions. Review current site conditions through condition survey. Continue collecting SW quality data and continuous streamflow gauging at Station V1 on Vangorda Creek. Establish new stream flow gauging sites (1) on Vangorda Creek, upstream from the confluence with Grum Creek and (2) on Grum Creek for model calibration and to provide benchmark data. Collect additional flow monitoring data at Vangorda station 29BC003 (downstream end of Vangorda Creek) for model calibration and validation. Resume collection of continuous rainfall data at Grum Dump station. Conduct geotechnical field investigation: • Detailed field reconnaissance and seismic refraction along alignment • Diamond drilling (rock core) borings – Install thermistors – Collect samples and determine ice content – Test permeability In situ (slug tests in ground where not frozen, packer testing in rock), and in laboratory on permafrost soil samples after thawed.

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						Conduct index tests (grading and Atterberg limits) on soil samples and UCS testing on rock core samples, as necessary.
303.3	Upgrade Runoff Interceptor Ditch to Dixon Creek	Divert uncontaminated surface runoff from the northeast side of the Vangorda to the south and into Dixon Creek via the Dixon Creek Diversion. Upgrade channel to pass the 500-year storm. Place filter material and riprap sized for the flows in the channel, to prevent erosion.	Seepage rates, water quality, interception potential, long-term performance of interception. Design criteria provided in Table 4.3 require definition and linkage to seepage management and water quality.	Geotechnical, hydrology, hydraulics, and erosion potential. Permafrost impacts on design. The GW/SW interaction is particularly important because of the seepage issue. Geotechnical, hydrology, hydraulics, and erosion potential. Prior to the upgrade of the Dixon Creek Diversion, a detailed field investigation will be required to define soil conditions for design purposes, specifically for identification of zone where seepage losses could be a concern. Examination for frozen soil will also be conducted. Depending upon the results of the seepage investigation, the base materials in the channel may also need to be upgraded.	Hydrologic and hydraulic model to provide influent SW flow data and elevations. Detailed cross section survey data, and bed and bank material characterizations. Flow data, and water profile data (surface elevations). Availability of flow data in Dixon Creek upstream from the confluence of Dixon Creek with Shrimp Creek. Subsurface conditions: - Permeability - Permafrost occurrence - Erodability of base material	Conduct detailed reconnaissance and review of geologic mapping, to assess conditions. Review current site conditions through condition survey. Collect additional continuous flow data in Dixon Creek upstream of the confluence of Dixon Creek and Shrimp Creek. Conduct geotechnical field investigation: - Detailed field reconnaissance and seismic refraction along alignment - Diamond drilling (rock core) borings - Install thermistors - Collect samples and determine ice content - Test permeability in situ (slug tests in ground where not frozen, packer testing in rock), and in laboratory on permafrost soil samples after thawed. - Conduct index tests (grading and Atterberg limits) on soil samples and UCS testing on rock core samples, as necessary.
304	Grum Pit					
304.1	Continue In Situ Biological (algae) Treatment for Grum Pit Water	C&R Plan calls for continuation of nutrient addition for algae treatment of the Grum Pit water, contingent upon whether this strategy is capable of achieving water quality in compliance with discharge limits. Our evaluation indicates that this is not a viable option for reliably meeting water quality standards and will not be further considered.				
304.2	Construct Safety Berms (Grum Pit)	Restrict access to human and wildlife for safety purposes.	Effectiveness of biological treatment for the short term and long term, and future water treatment strategies. If the in-situ bioremediation eventually proves to be ineffective, other treatment options will be examined.	Safety berms around Grum Pit; in situ bioremediation, and polishing ponds in the slot. Monitoring and water treatment requirements.	Sufficient resolution mapping and geotechnical data.	Conduct reconnaissance, review geologic mapping, and review higher resolution topographic mapping.
305	Breach Grum Interceptor Ditch					

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
305.1	Divert Grum Interceptor Ditch away from Grum Pit	Interceptor ditch will be diverted away from Grum Pit.	Foundation conditions along Access Road next to the proposed ditch alignment and at the earth dam proposed at headworks. Characteristics of overburden at the trapezoidal interceptor channel and cut slots at pit bench crest and at the south end of Grum Pit.	Geotechnical, hydrology, hydraulics, and erosion potential. Interceptor will be diverted away from Grum Pit.	Hydrologic and hydraulic model to provide influent SW flow data and elevations. Detailed cross section survey data, bed and bank materials characterizations. Soils data (geotechnical), ice data, flow data, and water profile data (surface elevations).	Geotechnical soils.
305.2	Construct Algae Filter at Slot Cut in Grum Pit	This option is not considered a viable, long-term solution.				
306	Grum Dump					
306.1	Reslope and Regrade Grum Waste Dump and Pull Back Crest	Reduce infiltration in the plateaued upper surface of the dumps. Construct geotechnically stable landforms. Minimize energy of runoff from covers and surrounding areas. Revegetate disturbed areas on all dump areas.	SW, ground water, and geochemical modelling are not well integrated. IPR provided recommendations for review. Need to evaluate the ability of the existing model to estimate the effectiveness of remediation over time and the application of adaptive management principals.	Update and integrate previous modelling (hydrology, water balance, and geochemical) to optimize ET model and erosion reduction: - Hydraulic modelling of diversion channels - Earth moving plans - SLIDE; optimize cut/fills to reduce costs - Borrow materials (till) - Consider infiltration galleries to facilitate SW management	Final footprint constraints; evaluate option of expanding the toe.	Improved ground survey; evaluate foundation conditions along perimeter for sediment control structures (dams and retention ponds), and diversion channels. Test pits within the waste rock slope perimeter to depth of the potential cut to determine the fines content and geochemical kinetics/leachability. Test pits at the foundation toe to evaluate geotechnical conditions and clarify potential for borrow through geochemical sampling to assess possible contamination from leachate seepage Evaluate foundation conditions for sediment control structures (dams and retention ponds) and diversion channels.
306.2	Place Very Low Infiltration Cover on Grum Sulphide Cell	Control infiltration to significantly reduce the amount of water entering the surface of the waste (less than 0.5% of the mean annual precipitation). Bottom third of waste pile remains at high slope angle; SW appears contaminated; and need long term plan for SW disposition.	No lysimeters are installed to monitor infiltration. It is difficult (nearly impossible) to determine the effectiveness of the existing cover without installing new instrumentation. Must conduct detailed lessons learned exercise for the Grum sulphide cover to optimize cover design going forward.	Cell already capped. Need to evaluate the performance of the cap for stability, reducing infiltration, and reducing contaminate discharge. Final waste pile geometry and disposition of SW.	High resolution mapping. Soils data for existing cover- distribution of potentially contaminated soils. Plan for overall grading and long-term revegetation of entire hill slope.	Propose additional instrumentation to enable monitoring of cover performance. Detailed visual inspection to evaluate cover performance and revegetation effort. Existing data review and field assessment. Engineering team site visit to assess cover performance during spring freshet.
306.3/.4/.5/.6	Place Vegetative Cover on Grum Dump and Revegetate	Control infiltration and maintain vegetation growth. Cover the Main Dump with a rudimentary cover that has the minimum thickness of soil needed to allow plant growth.	Optimum cover and vegetative materials. Cover layer has been packed smooth, which may contribute to runoff and rilling issues, and create issues for planting and successful growth of shrub and tree species planned for further revegetation activities. Revegetation of drainage-related structures does not appear to be in the plan, but would assist with erosion control. Location and quality of borrow material.	Revegetation trial required for VLIC over dump materials. Evaluate performance of annual rye seeding, root and leaf density, and ability to continue with revegetation of deeper-rooted species/whips and cuttings into surface. Continue evaluation of vegetation performance to provide information for soil cover composition, topography, and vegetation cover on other proposed, very low infiltration covers. Evaluate performance of drainage structures without vegetative cover.	Data on seeding versus barley performance. Review of planned further revegetation efforts. Continued review of vegetation performance over next 5 years. Review of revegetation planning to align with planning for other landforms. Review of soil cover physical and geochemical characteristics.	Multidisciplinary team of design leads visit the Grum Sulphide Cell during the spring freshet to evaluate the performance of the recent retrofit and complete a lessons learned analysis of the cover design and water conveyance structures.

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307	Grum Overburden Dump					
307	Reslope Overburden Dump and Revegetate	The Overburden Dump is the primary source of glacial till borrow material; after all borrow material at the dump has been removed, the area will be regraded and revegetated. Potential integration of final excavated area for use as storage for emergency pit water management.	Appropriate configuration for terrestrial wildlife. Sediment control. Need to understand the contribution of surface texturing (ripping versus vertical or horizontal rilling) to sediment movement off-slope and moisture retention in soils. Current revegetation trial appears to have used graded phyllite (ore) rather than glacial till. Need to understand geochemical and textural impact, because this is not the planned material for other cover areas.	Infiltration modelling; VADOSE/W; SLIDE (slope stability), and TEMP/W (freeze-thaw). Review sediment data from Grum OB Dump toe ditches and review literature regarding rill design. Need to assess geochemical and textural impact of using phyllite rather than glacial till as vegetation cover substrate.		Evaluate foundation conditions along dump perimeter for sediment control structures (dams, retention ponds) and diversion channels. Collection of sediment and water samples from toe ditch area; field evaluation of erosion control on vegetation trial slope areas. Collection of cover material samples for nutrient and metals analysis. Geotechnical field program captured under the borrow source evaluation activity code.
308	Grum Ore Transfer Pad					
308.1/.2/.3	Regrade, Cover and Revegetate Ore Transfer Pad	Cover pad with very low infiltration cover, seed, and allow to revegetate naturally. Construct a temporary sediment collection ditch to divert runoff from the revegetated ore transfer pad away from a nearby stream until the vegetation has established. Alternative – Consider consolidation or complete removal of the geochemically reactive fines (typically less than 1-m thick) and exposure of underlying phyllite waste rock that could be exploited as a potential borrow source	Infiltration rates through cover. Appropriate configuration for terrestrial wildlife. Sediment control. Proposed reclamation surface is rough and loose; however, the field investigation concluded that microtopography is bad for plateau areas because it promotes ponding and infiltration. If the thin layer of sulphidic fines is removed and the underlying phyllite is exploited, it will be necessary to develop appropriate closure scenario. Could potentially include development of constructed wetland.	Infiltration modelling (cover optimization); surface hydrology, energy dissipation swales; and TEMP/W. Need to review RLU planning basis with Waste Pile and Tailings Discipline Team, and plan a revegetation trial on this kind of slope/material. Evaluate the potential for consolidation or complete removal due to limited thickness of geochemically reactive fines. Evaluate phyllite as potential borrow source for low visibility areas or as vegetation growth medium.	Revegetation trial required ore transfer pad covers and slopes, especially where hydrocarbon-contaminated or sludge materials may be applied. Cover material needs to be identified for source and quality. Need to assess impact of ore transfer pad on adjacent pond and wetland complex. Determine rationale for capping without consolidation. Geotechnical characterization of ore transfer waste material (gradations, angularity, and hardness). Thickness of geochemically reactive fines.	Evaluate foundation conditions along ore transfer pad perimeter for sediment control structures (dams and retention ponds), and diversion channels. Pilot testing with lysimeters. Evaluate cover performance; Confirm availability of suitable cover materials (volume and grain size). Initiate cover trial location and initial revegetation cover. Visual inspection to evaluate protective cover requirements. Test pits for investigation along the toe (downstream toe). Test pits on top of ore transfer pad to further delineate extent of reactive fines. Alternative 1: Sonic boreholes to test phyllite as potential borrow source; geochemical screening of representative samples of phyllite for use as growth medium.
309	Vangorda/Grum Groundwater					
309.1/.2/.3/.5	Install Grum GW Collection and Cut-off Walls	Capture contaminated GW seeping from the Grum Waste Rock Dump. Optimization and detailed design will be performed during the detailed engineering design phase. If monitoring indicates insufficient capture of contaminated GW, a cut-off wall and permeable collector trench will be constructed along the Access Road. Pumps would be installed in the collector trench to direct water to the Central Pond.	Pre-mining land surface topography and bedrock topography, subsurface material properties within and beneath Grum WRD, and areas where future seepage from the WRD may occur.	Condition of the Access Road below Grum Dump (construction vehicle access). Pads for pumping wells and clear pipeline alignments. Evaluate central pond foundation in vicinity of Grum Creek crossing. Pump wells and pipelines. House primary discharge pump in a heated enclosure on the side of the central holding pond. Install GW monitoring wells between and downgradient from the pumping wells. Evaluate GW flow directions and GW quality at existing and planned monitoring well and piezometer locations. Develop three-dimensional numerical GW model of the Vangorda/Grum Area to simulate	Bedrock surface topography, pre-mining land surface topography, spatial distribution of hydrostratigraphic units, and saturated thickness within and beneath Grum WRD and along the associated proposed SIS corridor. Reliable XYZ locations of existing monitoring and operational infrastructure in the Grum Area. Seasonal gaining versus losing reaches along Vangorda Creek between Vangorda and Grum WRDs. Robust GW monitoring network in Grum Area to provide sufficient early warning triggers in accordance with the AMP. GW flow directions near proposed SIS corridor and near the Grum WRD toe. Subsurface hydraulic properties along and upgradient from the proposed SIS corridor.	Reconnaissance of Grum Area for access limitations to identify where access roads will be needed to conduct planned GW-related fieldwork. Conduct surface geophysics survey with confirmation drilling atop Grum WRD and along the associated SIS corridor. Conduct XYZ survey of existing monitoring and operational infrastructure in the Grum Area. Drill and install additional monitoring wells and piezometers in and downgradient from Grum WRD to improve the AMP monitoring network. Instrument these wells with automatic data logging pressure transducers. Conduct aquifer (pumping) tests at newly installed monitoring wells and piezometers.

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				GW levels and GW flow directions. This model will also be used to forecast performance of the Grum WRD SIS under different assumed configurations to optimize interception efficiency and minimize cost. This model will aid in forecasting metal loading to the SIS.		Conduct potentiomanometer study along Vangorda Creek to assess gaining versus losing reaches between Vangorda and Grum WRDs. Drill and install stilling wells along Vangorda Creek and instrument these wells with automatic data logging pressure transducers. Conduct GW sampling at existing and newly installed wells, piezometers, and seeps.
309.4	Install VWRD Seepage Collection System	Minimize contaminant loading with covers to decrease infiltration and subsequent seepage. A conceptual design for a GW collection system will be developed.		Seepage collection system in place at the Vangorda Waste Rock Dump consists of French drains to funnel the seepage into a collection ditch that discharges to Little Creek Pond. More active collection of GW seepage from the VWRD is currently not required but may become necessary in the future if contaminant concentrations increase significantly.	Addressed under Activity Code 309.6.	Addressed under Activity Code 309.6.
309.6	Install Vangorda GW Collection System	Capture contaminated GW seeping from the Vangorda WRD.	Pre-mining land surface topography and bedrock topography, subsurface material properties within and beneath Vangorda WRD, and areas where future seepage from the WRD may occur	Evaluate GW flow directions and GW quality at existing and planned monitoring well and piezometer locations. Develop three-dimensional numerical GW model of the Vangorda/Grum Area to simulate GW levels and GW flow directions. This model will also be used to forecast performance of the Vangorda WRD SIS under different assumed configurations to optimize interception efficiency and minimize cost. This model will aid in forecasting metal loading to the SIS.	Bedrock surface topography, pre-mining land surface topography, spatial distribution of hydrostratigraphic units, and saturated thickness within and beneath Vangorda WRD. Reliable XYZ locations of existing monitoring and operational infrastructure in the Vangorda Area. Robust GW monitoring network in Vangorda Area to provide sufficient early warning triggers in accordance with the AMP. GW flow directions near proposed SIS corridor and near the Vangorda WRD toe. Subsurface hydraulic properties along and upgradient from the proposed SIS corridor.	Reconnaissance of Vangorda Area for access limitations to identify where access roads will be needed to conduct planned GW-related fieldwork. Conduct surface geophysics survey with confirmation drilling atop Vangorda WRD and along the associated SIS corridor. Conduct XYZ survey of existing monitoring and operational infrastructure in the Vangorda Area. Drill and install additional monitoring wells and piezometers in and downgradient from Vangorda WRD to improve the AMP monitoring network. Instrument these wells with automatic data logging pressure transducers. Conduct aquifer (pumping) tests at newly installed monitoring wells and piezometers. Conduct GW sampling at existing and newly installed wells, piezometers, and seeps.
310.1/.2	Remove Culverts, Decommission, and Revegetate	Breach all culverts and crossings, and revegetate the disturbed areas. Not yet determined whether haul road should be used as source of cover material; quality needs to be tested.	The flattening and revegetation of the haul road sideslope is currently under review. Will need to develop a sediment control and SW management plan for the work. Possible source material for covers may be incorporated in haul road, but need to core road to check. Removal of haul road across entire Rose Creek valley needs to be assessed.	Remove culverts (includes 10 major culverts in the North Fork River drainage). Decommission embankments. Remove/flatten safety berms. Reclaim by hydroseeding each dump site, breached area, and area of disturbance to eliminate the potential need for hauling and placing topsoil.	Flow requirements for redesigned conveyance components.	Dump or cover materials resulting from the decommission of the haul road is not yet assessed in revegetation and reclamation planning; need to study and report back into waste rock and cover inventory. Revegetation trials on haul road material required.

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Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
311	Vangorda/Grum Miscellaneous					
311.1	Demolish Buildings (treatment plant and the steel culvert over Grum Portal)	Remove existing buildings and infrastructure that will not be required after closure to mitigate potential long-term safety hazards. Stability of structures is unknown. Extent of contamination of surfaces through buildings is unknown. A hazardous materials audit is being conducted by YG subcontractor (EBA) in fall 2011 is not yet complete. Demolish buildings along with their foundations. Only the contaminated foundation components will be removed for proper disposal while the clean foundations will be covered in place (some may be buried within the toe of the Resloped waste rock dump) and revegetated. Prior to any demolition works, a full inspection will be conducted on all site buildings to identify all hazardous waste, salvageable materials, and structural safety concerns. A solid waste management plan will be developed and a list of permits prepared.	Sampling for ACM and other designated substances may not be substantive enough to be useful for decommissioning purposes. Areas around the buildings that are not tested may need to be treated as designated or ACM substances. Site plans, surveys, Material Safety Data Sheets, and other information involving plant construction and makeup are not currently available. Options to revegetate and reclaim the site as part of the natural landscape after decommissioning need to be evaluated. Remove existing buildings that will not be needed after closure and that would be a long-term safety hazard. Revegetate site and reclaim as part of a landscape plan.	Obtain, review, and catalogue site plans and other construction documentation for competitive procurement. Review of the EBA hazardous materials classification and building materials assessment when finalized to evaluate gaps. Depending on EBA’s scope, obtain a demolition execution approach through a structural engineer. Site visit to identify items that may have been missed. Follow up sampling may be required. Address safety concerns with onsite buildings to clear areas for safe access to complete other assessments that may be required. Perform site utility surveys. Use GPR if necessary for decommissioning and to understand H&S risk during work. Retain a demolition contractor to assist in scrap assessment. Determine and obtain permits required to perform demolition.	Sufficient sampling to mitigate costs for abatement of materials assumed to contain designated substances due to lack of information to the contrary. Process material quantification. Waste disposal recommendations. Salvage assessment. Utility and site surveys. Assess suitable cover material quality. Assess potential for ET vegetation cover, or appropriate revegetation prescription. Specific revegetation prescription required, this area is a candidate for an ET cover.	Site reconnaissance. Utility and site survey. Hazardous material audit. Cover evaluation.
311.2	Remove WTP Settling Pond	Construct new treatment plant, making current settling pond (undersized even for current plant) unnecessary. Excavate sludge, remove berms, and rehabilitate footprint.	Geochemical assessment of the most stable disposal option for sludge. Settling ponds have had leakage issues in the past.	Remove and truck existing sludge from the WTP to the Grum Pit for disposal. The sludge should be pumped to the bottom of the pit or tremied so as to not mix the sludge with the pit water or disturb pit bottom sediments. After the water treatment settling pond is cleaned of sludge, the berm should be breached. Breach, riprap, and cover the Water Treatment Settling Pond after the new plant is operational. Breach the dams at the Sheep Pad Ponds (built to capture sediment from the Grum Interceptor Ditch before discharging into Vangorda Creek); the pad ponds do not need to be covered.		
311.3.1	Remove Contaminated Soils (Fuel Lube Station)	Remove hazardous materials and contaminated soil at the site that could cause a long-term impact on the surrounding environment.	Volume of material excavation; volume and source of backfill. Concentration threshold criteria for soil removal.	The C&R Plan, Table 6.13, outlines design criteria.	Extent of soil hydrocarbon contamination (lateral and vertical) near the Lube Shack and Tank Farm. GW flow directions. Extent of associated GW contamination.	Drill soil borings near the Lube Shack and the Tank Farm and collect hydrocarbon, metals, PAH, and ANP soil samples to delineate contamination. Install shallow GW monitoring wells in a subset of the borings to evaluate GW flow direction. Install additional GW monitoring wells after the GW flow direction is better understood to delineate contaminant plumes and provide additional step-out soil sampling locations, if needed.

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311.3.2	Construct Bioremediation Cell	Treat hydrocarbon contaminated soil.	Location of landfarm is to be determined; likely on a waste rock dump near mill buildings.	The C&R Plan, Table 6.13, outlines design criteria.		
311.4	Reclaim Roads	Prevent long-term erosion and breach crossings to prevent blockage. Road areas will require specific reclamation plans in accordance with required surface drainage plans and surrounding reclamation prescriptions.		Culverts and crossings will be breached and resloped and drainages restored. Scarify road surfaces and revegetate. There is currently no specific prescription for road revegetation or information about road material quality to predict vegetation success.	Require assessment of road material quality for use as cover materials or requirements for revegetation. Require assessment for basis of design of road reclamation – revegetation or swale/channel formation as part of surface drainage plan.	Revegetation trial for scarified road surfaces. Road material quality investigation.
	Reconfigure Little Creek Pond (LCP)	The C&R Plan does not provide for the Little Creek Dam, but notes that it may be used. It is assumed that the dam will be used as part of closure.	The need for this structure is undefined and will be determined based on the need for SW and GW collection and storage. The dam is considered a low-hazard dam; therefore, it has a small spillway (500-year event). C&R Plan states that the future of the LCP is yet to be determined, but it will probably not continue to function as a collection pond for seepage from the Vangorda Waste Rock Dump. The C&R Plan suggests that the LCP might be used as a polishing pond for the WTP	Initial review indicates polishing pond in conjunction with a new WTP not required. If retained, review of geologic mapping and as-built information. Engineering analyses: • Spillway capacity • Seepage analysis • Slope stability including pseudostatic (seismic) stability	Embankment and foundation properties (strength and permeability). Piezometric conditions in the dam and the foundation. Erosion protection (riprap) requirements for wave action (assuming that a pond will need to be retained).	Conduct field reconnaissance. Install hollow-stem auger borings: • SPT and undisturbed samples, as appropriate • Piezometers, including monitoring Conduct index tests (grading and Atterberg Limits) on soil samples. Test shear strength (if cohesive soils are encountered).
Haul Road						
310.1/.2	Remove Culverts, Decommission, and Revegetate	Breach all culverts and crossings, and revegetate the disturbed areas. Not yet determined whether the haul road should be used as a source of cover material; quality needs to be tested. The flattening and revegetation of the haul road sideslope is currently under review. Will need to develop a sediment control and SW management plan for the work.	Rockfall issues appear to be a natural hazard in valley areas and are construction hazards in dealing with the Faro Mine waste rock piles and high Haul Road berms. Value of reconstruction of valley areas after Haul Road material removal needs to be assessed. Possible source material for covers may be incorporated in Haul Road, but need to sample road materials to confirm. Removal of Haul Road across entire Rose Creek Valley needs to be assessed.	Remove culverts (includes 10 major culverts in the North Fork River drainage). Decommission embankments. Remove or flatten safety berms. Reclaim by hydroseeding each dump site, breached area, and area of disturbance to eliminate the potential need to haul and place topsoil. Integrated planning required for the NFRC valley area (including riparian and ponded areas), in conjunction with activities to reslope the waste rock pile and remove all or part of the haul road.	Dump or cover materials resulting from decommission of haul road not yet assessed in revegetation and reclamation planning; need to study and report back into waste rock and cover inventory. Revegetation trials on haul road material required. Ecosystem services analysis for haul road reclamation alternatives.	None.
310.3	Construct Haul Road Access from Vangorda to RCT	Breach all culverts and crossings, and revegetate the disturbed areas. The flattening and revegetation of the haul road sideslope is currently under review. Will need to develop a sediment control and SW management plan for the work.		Construct temporary haul roads. Not clear if haul road access alignment has been assessed in the environmental assessment. Need to check if undisturbed areas will be affected by construction; assess and plan for conservation and reclamation of area.	Review of new haul road access area inclusion in environmental assessment, and basis of reclamation design required for affected area.	

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Water Treatment						
101.1	Construct new Faro Water Treatment Plant(s) and Piping	Design and build new WTP and pipelines to treat contaminated water.	C&R Plan includes potential for two new WTPs, Faro Area and Vangorda/Grum Area. Initial review indicates one new WTP in Faro Area with a pipeline and pumping system from the Vangorda/Grum would be more cost-effective and reliable.	Conceptual design and cost estimates (capital and O&M) for the one and two new WTP scenarios.	Optimum WTP scenario (one or two WTPs).	Conduct site reconnaissance and prepare selection studies.
101.1			C&R Plan indicates former BXL Site at Rose Creek for new Faro WTP location. Mill Site should be evaluated. C&R Plan indicates that the Vangorda Area WTP located between Vangorda Pit and Vangorda Creek.	Comparative evaluation of the advantages and disadvantages of the prospective sites. Geotechnical suitability for construction of new WTP(s) and pipelines is unknown. Detailed survey data needed for construction of new WTP(s) and pipelines are not available.	Optimum location(s) for new WTP(s). Identify prospective WTP locations and pipeline routes, and select “best” site(s). Subsurface information for potential WTP locations and pipeline routes. Identify prospective WTP locations and pipeline routes, and select “best” site(s). Survey data for potential WTP locations and pipeline routes.	Conduct field surveys at selected WTP location(s). Conduct geotechnical investigation at WTP location(s). Install Mud rotary borings at WTP location(s). Perform SPT sampling. Conduct index testing (grading, Atterberg limits). Investigate permafrost. Conduct geotechnical investigation for pipelines.
101.1			Lime demand and solids formed (LD/SF) are critical parameters for WTP design, and will change over time with water characteristics.	Determine directly from lime usage records at existing WTPs, LD/SF test data, calculate from chemical analysis data, or a combination of these methods.	Design lime demand and solids formed (current and future).	Test LD/SF on selected samples of pit waters, other WTP source waters, and existing WTP influents.
101.1			Effluent discharge limits is critical to WTP design. Need to consider mixing zones.	Review of current criteria and standards. Evaluation of concentrations based on a risk assessment and treatment technology-specific achievable basis.	Discharge limits for treated water including sulphate/TDS.	None.
101.1			Treatment effectiveness achievable by a new HDS/filtration system (ability to consistently meet discharge limits). Design and operating parameters for achieving optimum WTP performance.	Select representative waters and the expected water qualities to use as influent for testing. Use available data in the CH2M HILL HDS Mass Balance spreadsheet model to develop pilot plant sizing and operating conditions.	Water treatability and WTP design and operating parameters. Bench- and pilot-scale testing using “representative” influent water is the best way to address these uncertainties. Sampling and “complete” chemical characterization of pit waters (needed to develop synthetic water recipes).	Perform laboratory batch testing of LD/SF and dissolved metals removal at selected pHs. Conduct pilot test of flow-through HDS: - Perform onsite at FMC, or in offsite laboratory using synthetic water - Test scenarios (influent water qualities).
101.1			If site discharge limits require very low effluent concentrations, an advanced treatment process may be required in addition to filtration. If sulphate discharge is regulated, NF/RO treatment may be required.	Evaluate discharge limits relative to treatment performance expected for the HDS/filtration process. IPRP (2010) recommends testing of sulphide addition.	Need for sulphide addition, NF/RO, or other advanced water treatment process to meet discharge limits.	Conduct bench or pilot tests (or both) of prospective advanced treatment technologies assuming the following: Perform sulphide addition testing in conjunction with pilot testing above
101.1			Availability of utilities required by the new WTP(s) and pipelines is uncertain.	Assess quantity, quality, and reliability of utilities such as electric power, communications, water, and domestic wastewater management at prospective WTP locations; compare availability versus demands.	Requirements and availability of utilities for new WTP(s).	None.
101.1			Precipitation and scale formation in pipelines is unknown but likely if waters allowed to oxidize or sources waters blended.	Review chemical composition of water to be piped and possible different waters to be combined in pipelines. Geochemical modelling.	Potential for precipitate formation and scaling in water collection and conveyance pipelines. Design features needed to mitigate problems from precipitation and scaling.	Characterize of chemicals in relevant water streams.

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101.1			C&R Plan indicates that the capacities in the pits are more than adequate for water and sludge storage. If a substantial amount of waste rock or other material is placed in the pits, this conclusion might be affected.	Estimate available pit volumes. Calculate annual net water balance of water collected and conveyed to pits (GoldSim modelling). Calculate estimated annual sludge production and solids volume conveyed to the pits.	Quantity requirements and capacities for water and sludge storage in pits. Detailed bathymetric survey data needed for sludge disposal system design may not be available. Identification of prospective locations for pit sludge disposal and selection of the best location.	Survey pit bathymetry at prospective sludge disposal system locations.
101.1			The appropriateness and effectiveness of sludge disposal in the pits.	Assessment of sludge dissolution, fate, and effects on water chemistry.	Geochemical stability of sludge deposited in pits (Faro and Vangorda, or only Faro for the one WTP option).	Conduct geochemical characterization of current pit water conditions. Perform laboratory extraction and analysis of HDS sludge (from pilot study) under geochemical conditions in pit(s).
205.2	Polishing Pond	Construct new Polishing Pond near the new Faro Area WTP. CH2M HILL has determined that a polishing pond is not required following construction of the HDS treatment facilities.				
301.1	Construct Vangorda WTP and Piping	Design and build new WTP and pipelines to treat contaminated water.	See Activity Code 101.1.	See Activity Code 101.1.	See Activity Code 101.1.	See Activity Code 101.1.
Borrow Area Development						
108.4	Develop and Decommission Faro Borrow Sources	Identify all necessary borrow sources and develop plans to rehabilitate borrow areas. Impact on fish and terrestrial habitats, habitat compensation and contamination in Haul Road granular sources.		Some assessments completed on borrow sources. Good quality armour rock is hard to find. Environmental assessment not completed for borrow areas – vegetation and rare plant surveys required. Reclamation planning for borrow sources needs to be included in revegetation plan.	Delineation of sources d/s of tailings area. Environmental assessment not completed for borrow areas – vegetation and rare plant surveys required. Reclamation planning for borrow sources needs to be included in revegetation plan.	
108.4A	Develop and Decommission Faro Borrow Sources – Granular Soil	Identify all necessary granular borrow sources and develop plans to rehabilitate borrow areas. Expand Rose Creek borrow site. New – Intermediate Dam spillway. Potential – east of North Fork of Rose Creek. Could be developed in connection with relocation of NFRC.	Impact on fish and terrestrial habitat and habitat compensation. Quality and quantity of borrow material is undefined or poorly defined. Limiting EA issues associated with various potential sources.	Environmental assessment not completed for borrow areas – vegetation and rare plant surveys required. Reclamation planning for borrow sources needs to be included in revegetation plan. Delineation of sources downstream of tailings area.	Amount and quality/composition of material that has been used since the estimates were developed. Geochemical/geotech parameters Delineation of sources. Environmental assessment not completed for borrow areas – vegetation and rare plant surveys required. Reclamation planning for borrow sources needs to be included in revegetation plan.	Conduct Initial field reconnaissance program: • Dig test pits to explore potential borrows; include field mapping • Map Rose Creek Borrow Site and pionjar survey East of North Fork of Rose Creek
108.4B	Develop and Decommission Faro Borrow Sources – Low Permeability	Identify necessary granular borrow sources and develop plans to rehabilitate borrow areas. Rose Creek Haul Road. Expand tailings borrows.	Potential Areas: • East of North Fork of Rose Creek; could be developed in connection with relocation of NFRC • Between Faro Waste Rock Dump and original Tailings Impoundment: • Impact on fish and terrestrial habitat and habitat compensation • Quality and quantity of borrow material is undefined or poorly defined.	Environmental assessment not completed for borrow areas – vegetation and rare plant surveys required. Reclamation planning for borrow sources needs to be included in revegetation plan. Delineation of potential borrow sources d/s of RCTA.	Amount and quality/composition of material that has been used since the estimates were developed. Geochemical/geotech parameters. Delineation of sources. Environmental assessment not completed for borrow areas – vegetation and rare plant surveys required. Reclamation planning for borrow sources needs to be included in revegetation plan.	Survey vegetation and rare plants. • Conduct initial field reconnaissance program: • Dig test pits (Rose Creek Haul Road, Tailings Borrow, between Faro Waste Rock Dump and original Tailings Impoundment). • Install sonic boreholes to native contact. • Conduct field mapping and pionjar (hand-held drill) surveys of undefined sources.

Shaded cells under the Field Work column indicate that a portion of the field work listed for the activity will be completed as part of the final design.

TABLE B-1
Engineering Data Gap Analysis
Gap Assessment Report, Faro Mine Remediation Project – Appendix B

Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
			Limiting EA issues associated with various potential sources.			
108.4C	Develop and Decommission Haul Road as a Borrow Source	Rehabilitate borrow area. Haul Road material to be used to cover tailings area, contouring, and regarding.	Impact on fish and terrestrial habitats and contamination in Haul Road granular sources. Quality and quantity of borrow material is undefined or poorly defined. Limiting EA issues associated with various potential sources.	Investigations to date on the Haul Road have been minimal and inconsistent.	Need an investigation that includes consistent geochemical/geotechnical testing.	Perform screening-level assessment: Install sonic boreholes along the Haul Road; screening-level geochemical samples (XRF metals and leachability) Install sonic boreholes in Haul Road Borrow/ Dump; collect samples for geotechnical analyses (sieve/hydrometer) and for geochemical analysis (leachability). Dig test pits (shallow) for visual inspection in miscellaneous potential borrow sources.
311.5A	Develop and Decommission Vangorda-Grum Granular Borrow Areas	Identify necessary borrow sources and develop plans to rehabilitate borrow areas. Impact on fish and terrestrial habitats and habitat compensation.	Impact on fish and terrestrial habitats and contamination in Haul Road granular sources. Quality and quantity of borrow material is undefined or poorly defined. Limiting EA issues associated with various potential sources	Some assessment completed on borrow sources. Good quality armour rock is difficult to find. Environmental assessment not completed for borrow areas – vegetation and rare plant surveys are required. Reclamation planning for borrow sources needs to be included in the revegetation plan.	Delineation of sources around Moose Pond and Grum Creek. Environmental assessment not completed for borrow areas; vegetation and rare plant surveys required. Reclamation planning for borrow sources needs to be included in the revegetation plan.	Conduct Initial field reconnaissance program: - Dig test pits in proven borrows (Grum Creek/Moose Pond) - Conduct field mapping and pionjar surveys of undefined sources.
311.5B	Develop and Decommission Grum Overburden Dump Borrow Area (Low Permeability Soils)	Identify volumes, geotech/geochem parameters of Grum OB dump and Grum overburden dump foundation (approximately 8 million m ³ + 1 million m ³ = 9 million m ³).	Grum Sulphide Cell used till from South Till Borrow Area; contractors indicated that Grum overburden pile would require significant effort to sort oversized materials (that is, may be large percentage of boulders in till material). Amount used was 240,227 m ³ Impact on fish and terrestrial habitats and contamination in Haul Road granular sources. Quality and quantity of borrow material is undefined or poorly defined. Limiting EA issues associated with various potential sources.	Volume decline. Geotechnical characterizations. Geochemical characterizations. Foundation Investigations. Reclamation planning for borrow sources needs to be included in revegetation plan. Evaluate Till Stockpile at Vangorda Waste Dump.	Geochemical/geotech parameters. Depth of foundation.	Include reclamation planning for borrow sources in revegetation plan. Initial field reconn program: sonic boreholes and samples. Collect samples to delineate soil distribution. Initial geochemical analysis on representative samples, Test pits for visual assessment for gradations Collect the following samples: - XRF screening level – select samples for further geochemical (for example, kinetic) - Geotechnical (for example, gradations) testing.
311.5C	Develop and Decommission Area Northeast of Grum Pit (Low Permeability Soils)	Identify volumes, geotechnical, and geochemical parameters of low-permeability borrow source. SRK Additional Borrow Studies 2004, Task 11a indicates bedrock ranges from 9 to 18m bgs (based on GPR) with probable overlying till.	Impact on fish and terrestrial habitats and contamination in Haul Road granular sources. Quality and quantity of borrow material is undefined or poorly defined. Limiting EA issues associated with various potential sources.	Volume decline. Geotech characterizations. Geochem characterizations. Foundation Investigations. Reclamation planning for borrow sources needs to be included in revegetation plan.	Determine amount of material used since original estimates were developed. Geochemical/geotechnical parameters. Depth to foundation.	Include reclamation planning for borrow sources in revegetation plan. Conduct initial field reconnaissance program: test pits for visual assessment; sonic boreholes Collect the following samples: - XRF screening level - Select samples for further Geochem (for example, kinetic) - Geotech (for example gradations) testing

Shaded cells under the Field Work column indicate that a portion of the field work listed for the activity will be completed as part of the final design.

TABLE B-1
Engineering Data Gap Analysis
Gap Assessment Report, Faro Mine Remediation Project – Appendix B

Activity	Task	Description	Technical Uncertainties	Technical Assessments Required	Data Gaps	Field Work
311.5D	Develop and Decommission Area Rip Rap Sources (Faro Grum Vangorda Areas)	Identify and develop borrow sources of strong chemically stable rock for use in surface channels and drainage systems. Quarries will need to be excavated from granitic bedrock outcrops. Alternative: Investigate suitability of using cobbles/boulders mechanically separated from till overburden or geochemically inert waste rock during rock processing for other activities (that is, 201.1/.2/.3, 202, which requires large quantities of drainage rock to cover tailings area).	BGC indicates Grum Dump gabbro quarry has been exhausted (personal communication Nov. 2011).	Diamond drill exploration for four potential riprap quarries: - Expanded existing RCDC gabbro quarry. - Possible gabbro quarry site located downstream and uphill from the Cross-valley Dam but unsure of outcrop. - Possible buried granite quarry location at north end of FCDC. No current outcrop noted and location may be outside mine footprint (EA issue). - Possible granite quarry located north of the main haul road and west of the Grum transfer station. Outcrop currently exists.	Total volumes of riprap and rockfill required. Estimate of size ranges for these materials. Location of accessible quarry sites for production of these materials. Quantity and quality of the rock materials in potential quarry sites.	Install diamond drill holes. Collect the following samples: - Density - Point load index - Compressive strength - Abrasion - Freeze-thaw durability - Slake durability - Other soundness tests Perform Geochemical suite of test including ABA, paste pH and leach extraction, followed by possible kinetic tests. Dig test pits at each site.

Sources:

Independent Peer Review Panel (IPRP). 2010. *Comments on Draft 4A of the Project Description for the Faro Mine Complex Closure and Remediation Plan*. August.

northwest hydraulic consultants ltd. (nhc). 2006. *Faro Mine Hydraulic Capacity Analysis*. Prepared for Deloitte & Touche Inc. June.

SRK Consulting Engineers and Scientists (SRK). 2006. *Interim Groundwater Capture at the ETA, Faro Mine*. Internal memorandum prepared for Cam Scott and Daryl Hockley. April 19.

Notes:

%	=	percent	KPI	=	key performance indicator	SIS	=	seepage intercept system
ACM	=	asbestos-containing materials	LCD	=	Little Creek Dam	SPT	=	Standard penetration test
AMP	=	adaptive management plan	LCP	=	Little Creek Pond	SW	=	surface water
ANP	=	acid neutralization potential	LD/SF	=	lime demand and solids formed	SWCC	=	soil water characteristic curve
ARD	=	acid rock drainage	LGSP	=	low-grade ore stock pile	S-Wells	=	
As	=	arsenic	m	=	metre	SWM	=	surface water management
C&R	=	closure and remediation	m bgs	=	metre(s) below ground surface	TDS	=	total dissolved solids
CHRM	=	Cold Regions Hydrological Model	m/cm	=	metre per centimetre	TP	=	Test pit
d/s	=	downstream	m ³ /sec	=	cubic metre per second	UCS	=	uniaxial compressive strength
DCPT	=	Dynamic Cone Penetration Test	MGO	=	medium-grade ore	VLIC	=	very low infiltration cover
DSS	=	direct simple shear	MW	=	monitoring well	V _s	=	shear wave velocity
EA	=	environmental assessment	NF/RO	=	nanofiltration/reverse osmosis	VWRD	=	Vangorda Waste Rock Dump
EBA	=	Engineering Consultants Ltd.	NFRC	=	North Fork Rose Creek	WR	=	Waste Rock
EPL	=	end pit lake	NWI	=	North Wall Interceptor	WRD	=	Waste Rock Dump
ET	=	evapotranspiration	NVID	=	North Valley Interceptor Ditch	WTP	=	water treatment plant
ETA	=	Emergency Tailings Area	O&M	=	operations and maintenance	XRF	=	X-ray fluorescence
FPET	=	Faro Project Execution Team	Pb	=	lead	Zn	=	zinc
GIS	=	geographic information system	PMF	=	probable maximum flood			
GPR	=	ground penetrating radar	QA/QC	=	quality assurance/quality control			
GW	=	groundwater	RAS	=				
HDS	=	high-density sludge	RCDC	=	Rose Creek Dene Council			
ID	=	Intermediate Dam	RCT	=	Rose Creek Tailings			
IPR	=	Independent Peer Review	RLU	=	reclamation landform unit			
IPRP	=	Independent Peer Review Panel						

Shaded cells under the Field Work column indicate that a portion of the field work listed for the activity will be completed as part of the final design.

TABLE C-1
Regulatory Gaps – Baseline Research and Field Studies
Gap Assessment Report, Faro Mine Remediation Project – Appendix C

Activity Code	Data or Information Gap	Rationale	Importance ^a	Actions Required to Address Gap
R05.02.02	Hydrogeology			
R05.02.02a	Delineate the extent of surface water or groundwater interaction at each of the major groundwater seepage sites, including spatial and temporal variability.	This information is critical to improving the understanding of site conditions in the following areas: - Quantify the magnitude of sulphate- and metals-loading from groundwater-seepage sites to target surface streams, such as North Fork/Rose Creek (NFRC), Vangorda Creek, and the Rose Creek Tailings Impoundment - Provide calibration targets for groundwater flow model(s) developed to support design efforts to ensure that the numerical tools adequately replicate the observed stream and aquifer interaction - Support the evaluation of changes in groundwater discharge to streams in winter and the potential effects on fish-rearing conditions - Provide flow data to evaluate the effect that groundwater interception may have on reducing stream flows under low-flow conditions - Provide vertical hydraulic gradient information in the vicinity of steam reaches where lining is being considered, a necessary consideration in development of the liner design	1	Install pressure transducers in monitoring wells adjacent to target stream reaches (preferably monitoring well clusters). Drill additional wells if the existing wells do not exist in critical areas. Establish stream-stage monitoring stations on target stream reaches. Survey elevations of all infrastructure to allow accurate comparison of groundwater elevations and stream-stage conditions. Additional wells will likely be needed in the Vangorda, Grum, and possibly the ETA and Cross-Valley Dam areas. Sufficient wells likely exist in the S-Wells and Zone II outwash areas.
R05.02.02b	Delineate the properties of the aquifer system in the vicinity of the planned groundwater interception systems.	An accurate characterization of site aquifer property distribution is necessary to design a groundwater interception system. This data help determine the geometry of the following interception infrastructure concerns: - Spacing of extraction wells - Need for and extent of permeable trenches - Need for and extent of associated low-permeability barrier systems - Interception flows delivered to a treatment plant	1	Perform long-term (3- to 10-day) aquifer tests in wells in each area where groundwater interception is planned. More data collection will be required in areas, such as the Grum and Vangorda dumps, and the ETA Area, where little data currently exists. Less data will be required at the S-Wells and Zone II outwash areas, as well as the Cross-Valley Dam Area. Operational data will be used in areas where the groundwater extraction system currently operates (S-Wells and ETA) to estimate aquifer properties.
R05.02.02c	Define bedrock topography and saturated alluvial thickness in areas where groundwater interception is planned.	A detailed depiction of the bedrock surface and the thickness of available saturated alluvium are both critical elements to the design of a high-efficiency groundwater interception system. The bedrock topography will define the target extraction well depths and permeable trench configuration, and will influence the design approach of any low-permeability hydraulic barriers that may be included in the design. The saturated thickness of the target aquifer may constrain the operational strategy of the interception system and place limitations on available extraction rates.	1	Perform seismic or other geophysical surveys in the vicinity of the interception system alignments. Drill borings, as necessary, to provide groundtruthing to the geophysical data. The large number of existing wells and amount of borings may provide adequate information in the S-Wells and Zone II outwash areas, but additional data collection is likely needed at the other sites where groundwater interception is planned.
R05.02.02d	Delineate the 3D extent of the target areas for hydraulic capture at each planned groundwater interception area.	A refined delineation of the 3D extent of the site COCs that require hydraulic capture is needed to develop a highly effective groundwater interception system.	1	Drill additional monitoring wells where data gaps exist in the monitoring network. The Vangorda, Grum, and ETA areas will require a greater extent of investigation. The S-wells and Zone II outwash areas have a comparatively greater number of existing monitoring wells and will require fewer additional wells to complete delineation of the target zone. Additional delineation may also be required in the Cross-Valley Dam Interception Area, depending on the selected location.
R05.02.02e	Delineate permafrost at the Faro Mine, Grum, and Vangorda areas.	The presence of massive or discontinuous permafrost in the groundwater system has a significant influence on groundwater flow directions and rates, and the surface water and groundwater interaction. The design of an effective SIS system requires knowledge of permafrost in the immediate area of the system. Permafrost may also alter contaminant migration pathways and require modification to groundwater monitoring network designs.	1	Perform geophysical surveys in the vicinity of SIS installations to identify the presence of permafrost in those areas.
R05.03.02	Hydrology			
R05.03.02a	Conduct cross-section field surveys.	The hydrologic and hydraulic models will require detailed cross-sectional information for all creeks and diversions so that the models can be accurately constructed. This is particularly important since the accuracy of the model is related to the accuracy of water-level predictions, peak flow rates, and erosion potentials, as well as water quality.	1 for engineering; 3 for regulatory YESAB requirements	Perform detailed topographic field surveys. These surveys will be part of the site-wide budget for information gathering and site mapping. The budgets are, therefore, not estimated in either the engineering or regulatory gap budgets.

TABLE C-1
Regulatory Gaps – Baseline Research and Field Studies
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Activity Code	Data or Information Gap	Rationale	Importance ^a	Actions Required to Address Gap
R05.03.02b	Assess creek and diversion (all waterways) bed material and bank material for stability.	The size of the material that comprises the creek or diversion bed and side slopes to the flood levels is integral to proper model calibration (roughness coefficients). The material that makes up the channel has a significant impact on the conveyance capacity and the flow velocities that contribute to erosion potential.	1 for engineering; 3 for regulatory YESAB requirements	The Hydrology team will conduct field surveys. These are estimated in the engineering data gaps budget based on four separate week-long field exercises.
R05.03.02c	Assess soils types in creek and diversion areas.	This is required to better define infiltration components in the hydrology model. The interaction of surface water and groundwater is key to understanding channel base flows and water quality under low-flow conditions.	1 for engineering; 3 for regulatory YESAB requirements	Complete field surveys in test pits and borings to determine surficial soils and local geology. These are estimated in the engineering data gaps budget under geotechnical data gaps.
R05.03.02d	Monitor pre-closure water flow at specific hydrology points in each of the major drainage channels.	Required for the calibration of the hydrology model. Calibration of the model under rainfall conditions is key to the success of extrapolating the model to determine flows under large theoretical events conditions, such as the 500-year-return rainfall and the probable maximum precipitation event. The results are also key to establishing the rates of groundwater seepage or groundwater infiltration, since they indicate the availability of surface water under low-flow conditions to support habitats and vegetation.	1 (YESAB 4.1.10)	Develop a monitoring plan that includes monitoring locations, parameters, and frequency and protocols for sampling.
R05.03.02e	Develop information from downstream of the mine site to establish baseline conditions. This could include hydrology components of flows and water-surface elevations under various return periods, TSS primarily from a hydrology perspective, and socio-economic parameters from a water-use perspective.	Without a baseline, we cannot determine impacts to VC. The project will need to establish the temporal and spatial requirements of the hydrology VCs and potential effects of the project.	1 (YESAB 6.3.2 and 6.3.3 indicate the need for baseline information on effects integrated across VCs; because hydrology was not identified as a VC in the past, this effort may be significant)	Develop field studies and monitoring to augment existing data as part of the engineering exercise. Existing information needs to be put into spatial and temporal context and significantly updated in the Project Proposal documentation.
R05.03.02f	Develop information from the mine site to establish baseline conditions. This could include hydrology components of flows, water-surface elevations under various return periods, total suspended solids (TSS) primarily from a hydrology perspective, and socio-economic parameters from a water-use perspective.	Without a baseline, we cannot determine impacts to VCs. We need to establish the temporal and spatial requirements of the hydrology VCs and the potential effects of the project.	1 (YESAB 6.3.2 and 6.3.3 indicate the need for baseline information and effects across VCs; because hydrology was not identified as a VC in the past, this effort may be significant)	Develop field studies and monitoring to augment existing data as part of the engineering exercise. Existing information needs to be put into spatial and temporal context and significantly updated in the Project Proposal documentation.
R05.03.02g	Monitor the pre-closure downstream TSS outside of the area-wide site. Selected sites should be designated at key locations within the local site areas, as well, to gauge areas for TSS load.	Required to develop a database of baseline suspended solids loading downstream of the mine site and at selected key locations for Faro, Vangorda, and Rose Creek diversions. Other critical areas that have a high risk of slope failure should be monitored. This will allow for performance monitoring later in the maturation of the reclaimed areas and forms part of the AMP triggers.	1 (YESAB 4.1.10)	Develop a monitoring plan that includes monitoring locations, parameters, and frequency and protocols for sampling.
R05.03.02h	Collect rainfall data for Faro and Vangorda sites during all phases of activity and post-closure.	Rainfall data will be required to support the hydrologic model calibration efforts and to correlate rainfall event IDF with concurrent monitored stream flows. Continuation during construction allows monitoring of TSS and flows to be correlated to rainfall events, and triggers to be set for managing water flow or runoff onsite during construction. After construction, the information will be used to continually improve the modelling calibration as part of the AMP.	1 (YESAB 4.15)	Develop a monitoring plan that includes a review of current monitoring sites and protocols and a description of future requirements.
R05.04.02	Surface Water Quality and Aquatic Ecosystem			
R05.04.02a (Task 1) R05.04.02b (Task 2)	Define aquatic species-at-risk.	This is a requirement for the Project Proposal. Previous definitions exist for plants, birds, and wildlife, but are lacking for aquatic species (for example, aquatic plants, fish, invertebrates, and amphibians).	1	Task 1: Review Yukon species-at-risk lists, and identify any species that could be present within the project area based on distribution and preferred habitat. Task 2: If there are any species-at-risk at Faro, undertake a field survey; produce an Aquatic Species-at-Risk Report (primary deliverable); and summarize results for the baseline chapter of the Project Proposal (secondary deliverable).

TABLE C-1
Regulatory Gaps – Baseline Research and Field Studies
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Activity Code	Data or Information Gap	Rationale	Importance ^a	Actions Required to Address Gap
R05.04.02c	Update the benthic invertebrate baseline description and current impacts.	The Executive Committee Project Proposal (Hardrock Mining) requires an inventory of benthic invertebrates and baseline data for affected drainage, including, where applicable, sample site descriptions, species abundance, spatial distribution, taxonomy, and biomass. There are deficiencies associated with the AECOM baseline descriptions and Chapter 4 of the draft Project Proposal that summarizes key baseline information. Also, there is additional information available now that should be incorporated. The benthic invertebrate impact assessment (CABIN approach) by DeGraff (2010) lacked supporting details, such as a statistical model or reference-area characteristics, and the production quality of Appendix 4 is almost illegible. Baseline data should be presented in quantitative format to allow for quantitative future comparisons to baseline conditions. Another benthic survey will be completed in 2012 under the Care and Maintenance Contract.	1	Conduct survey in late August 2012. Ensure recommendations in Minnow (2010a) and Laberge (2010) are implemented in 2012, especially the inclusion of more reference areas and appropriate statistical analyses. Sample up to six stations along the North Fork Rose Creek and Rose Creek diversion for baseline data to support monitoring associated with the fisheries compensation plan (community and biomass analysis) and risk assessment (tissue metals).
R05.04.02d	Prepare periphyton baseline description and current impacts.	The Executive Committee Project Proposal (Hardrock Mining) requires an inventory of periphyton baseline data for affected drainage, including, where applicable, sample site descriptions, species abundance, spatial distribution, taxonomy, biomass, and chlorophyll contents. However, no data or discussions were included in the AECOM baseline or in the draft Project Proposal. Biomass and chlorophylla estimates are also important for fisheries compensation planning and follow-up monitoring. The periphyton community survey was done by DeGraff (2010) but lacked interpretation and supporting details (e.g., explanation of statistical model and reference-area locations and characteristics), and the production quality of Appendix 4 is almost illegible.	1	Collect samples for the periphyton community at same locations as for benthic invertebrates (30 areas) to allow for assessment of current effects through statistical reference-exposure comparisons. Collect periphyton samples from six near-field areas for analysis of tissue concentrations, biomass, and chlorophylla.
R05.04.02e	Update fisheries baseline description, and fill information gaps.	Fish are an important VC. Good baseline information is required to complete a defensible impact assessment and provide a basis for quantitative future comparisons. Past studies largely focussed on fisheries in the immediate mine area only, were not quantitative (densities), are missing information on seasonal utilization patterns, and lack regional context. Little fisheries data exists for Rose and Anvil Creeks downstream of X14.	1	Conduct field survey work to develop density estimates and fill in gaps respecting seasonal utilization patterns and pool and pond habitat characteristics.
R05.06.02	Fish Habitat Compensation			
R05.04.02a	Fill in gaps for detailed fish habitat mapping (e.g., spawning, rearing, and over-wintering areas) and characterization (e.g., substrate composition) information on the creeks, focussing on Arctic grayling and Chinook salmon (likely VCs or indicator species for the EA).	There are types of fish habitat present that are not fully documented or quantified. For example, information is missing about fish overwintering in areas where surface water quality is currently impacted and where winter water quality is worse than at other times of the year. With the fish habitat compensation measures to be implemented, need to study if fish could be impacted if we create areas where opportunity for fish exposure is higher than it is currently.	1	Conduct fish habitat field surveys.
R05.04.02b	Fill in gaps for quantitative information about the determination of seasonal and local fish population densities, habitat use, and migration relative to regional population characteristics and habitat availability and accessibility.	The use of fish habitat is not fully documented or quantified in creeks that may be affected by the FMRP. Further characterization is needed to understand baseline conditions and support development of fish habitat compensation plans. Information regarding nearby unaffected areas is also required to provide context about compensation needs and how compensation efforts are likely to perform.	1	Undertake field surveys as soon as possible, and continue for one full field season.
R05.04.02c	Fill in gaps for information on seasonal surface-water levels, flow patterns and needs, DO and temperature profiling, and groundwater inflow locations and flow measurement in the local study area.	This engineering data is needed for replacement stream design.	1	Undertake field surveys as soon as possible, and continue for one full field season.
R05.10.02	Human Health and Ecological Risk Assessment			
R05.10.02a	Collect recent surface water quality data, including data from new stations, to better characterize baseline conditions and for future monitoring purposes.	The baseline should reflect current conditions. The AECOM baseline was 2005 to 2007. Updated data is available for Faro and Vangorda Areas. The Minnow (2010) aquatic monitoring plan indicated more and newer reference locations are needed for water assessment, at least in the short-term.	1	Collect surface water quality information in 2012 at new stations; this may need to be established based on future monitoring requirements. This will be collected by the surface water and aquatics team.
R05.10.02b	Complete limited surface water chronic toxicity testing.	Chronic testing more accurately reflects the potential effects expected. Testing has not been completed on a salmonid species to better assess the effects on Chinook salmon and grayling, which will likely be identified as VCs for the EA.	2	Collect onsite water quality samples from areas of current and future impact, and conduct testing. This will be collected by the surface water and aquatics team.

TABLE C-1
Regulatory Gaps – Baseline Research and Field Studies
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Activity Code	Data or Information Gap	Rationale	Importance ^a	Actions Required to Address Gap
R05.10.02c	Update old baseline sediment quality data.	The sediment data is old (from 2004 to 2006) and is not available for all required watercourses. Actual measured sediment concentrations are preferable to those that were calculated through the development of site-specific water-to-sediment distribution coefficients.	2	Collect onsite sediment samples. This will be collected by the surface water and aquatics team.
R05.10.02d	Complete limited sediment chronic toxicity testing to directly assess effects on benthic invertebrates, which will be exposed to COCs in sediment.	Chronic testing more accurately reflects potential effects expected and has not yet been conducted.	2	Collect onsite sediment samples from areas of current and future impact, and conduct testing. This will be collected by the surface water and aquatics team.
R05.10.02e	Fill in gaps for tissue chemical analysis data that does not exist or is not present for some aquatic biota.	Tissue data provides a more accurate assessment of risks than modelling.	2	Collect fish, benthic invertebrate, and aquatic vegetation samples for tissue analysis. This will be collected by the surface water and aquatics team.
R05.10.02f	Update baseline soil quality description, as all of the data is old and no information is present in some areas. This information is needed to assess risks to human and ecological receptors.	Data is old and analyses are not completed in all areas of the site or on the full suite of expected COCs.	1	Collect soil samples and conduct testing. This will be collected by the vegetation team.
R05.10.02g	Complete soil toxicity studies on soil organisms and vegetation. This information is needed to directly assess effects to these receptors that will likely be identified as VCs for the EA.	Direct impacts of soil COCs on soil organisms (for example, insects, such as spiders, beetles, ants, and grasshoppers) and plants are not known. This testing is likely needed for the unreclaimed areas of the site to ensure there are no expected long-term effects to terrestrial flora and fauna.	2	Collect soil samples from the site, and submit to laboratory for toxicity testing to assess current risks, which will involve acute testing on two species. This will be collected by the vegetation team.
R05.10.02h	Complete soil-chemical bioavailability analyses. This information will assist in the determination of the bioavailable fraction of each chemical in soil and the potential for uptake or exposure to human and ecological receptors.	The percent of potentially available fraction of a chemical is not known and may be important to determine if biological tissue data is limited.	2	Perform a leaching analyses of select soil samples.
R05.10.02i	Complete soil organism and plant tissue analysis in unsampled areas and in areas where updated soil-chemistry data will be collected. This information is needed to directly assess effects to these receptors and to assist in the determination of dietary exposure to top predators, all of which will likely be identified as VCs for the effects assessment.	This information is needed to assess direct effects on those ecological receptors and for the assessment of effects on wildlife through the food chain.	1	Collect soil organism and plant samples collocated with soil samples and conduct testing. This will be collected by the vegetation team.
R05.10.02j	Collect data on tissue-chemical concentrations in small mammals.	This information is required to address risks directly to these receptors, which will be identified as VCs in the effects assessment, as well as to higher trophic animals.	2	Conduct a field survey to collect red-backed voles or similar small mammals throughout the site. Can be completed while other wildlife programs are being undertaken. Discussions with FPET in January 2012 identified concerns about community sensitivities for this proposed program. The PDT confirmed that lack of information about chemical concentrations in tissue of small mammals is not a significant constraint to completion of the ecological risk assessment. As a result, this gap will not be addressed by field studies and is not included in the Cost Opinion.
R05.10.02l	Collect information related to dust to assess effects to human and ecological receptors. This data will be critical to the assessment of risks during the construction period with the movement of waste_rock.	There is a major exposure pathway during construction.	1	Undertake data collection, modelling, and monitoring. This will be collected by the air quality team.

TABLE C-1
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Activity Code	Data or Information Gap	Rationale	Importance ^a	Actions Required to Address Gap
R05.07.02	Terrain, Geology, Geological Hazards, and Seismicity			
R05.07.02a	Create a DEM for the study area.	The current DEM based on a LIDAR survey covers 67 km ² centered on the immediate mine-impacted area. The study area for the geology, terrain, geohazards, and seismicity will be revised to address engineering and environmental assessment needs.	1	CH2M HILL, through Critigen, will provide the DEM.
R05.07.02b	Provide recent aerial photographs covering the study area.	The most recent aerial photography coverage was flown in 2003 by SRK. It only covers the immediate mine-impacted area at 1:20,000 scale. Aerial photography coverage of the proposed study area is available from YG; however, it is from the 1970s. Other photos only cover portions of the study area.	1	Obtain new aerial photography from the entire study area. The scale will be determined as required to support engineering requirements. CH2M HILL recommends 1:15,000 to 1:20,000.
R05.07.02c	Compile bedrock geology for the site. Yukon geological survey bedrock mapping coverage of the study area exists at a 1:25,000 scale, comprising 17 map sheets and associated reports. Summarize data into one overall baseline document.	The lithology and structure is required for overall site characterization, geohazards, geochemistry, hydrogeology, and quarry locations.	1	Create a desktop summary of site geology and structure, and rock descriptions. Conduct confirmatory field surveys as needed, including collecting representative rock samples of key units for mineralogy/petrology to confirm composition. Complete a tie-in program with engineering. Engineering properties will not be determined under this task item.
R05.07.02d	Compile Quaternary geology for the study area. YGS has 1:25,000 surficial geology maps covering the southern portion of study area. Summarize data into one overall baseline document.	Identify major Quaternary geology units, terrain, soils, and location of bedrock exposures. This provides understanding of geological history to support aerial photography interpretation and forms the base of geohazards mapping and permafrost assessment. Surficial geology and Quaternary aerial photography interpretation will supplement and extend this data across the study area. This is required for overall site characterization, geochemistry, hydrogeology, and borrow areas.	1	Create a desktop summary of Quaternary and surficial geology units. Describe Quaternary geological history and major units. Transfer mapping data onto a new project DEM GIS database. Conduct limited field program, as needed, to groundtruth data..
R05.07.02e	Interpret aerial photographs of geohazards and mapping, and assess the study area.	Within the study area, identify areas of instability, erosion, mass wasting, permafrost degradation, debris flows, and avalanches that may affect closure design or impact the environment.	1	Obtain aerial photography covering the study area. Carry out geohazard assessment, and compile data onto a site DEM topographic GIS database. Carry out field surveys as needed to groundtruth hazards and assess recent activity.
R05.07.02f	Identify permafrost characterization and distribution within the study area.	The site is located in the discontinuous permafrost zone, so it is necessary to identify areas containing permafrost that may be affected by reclamation and closure activities.	1	Obtain aerial photography covering the ~~entire~~ study area. Conduct aerial photography interpretation to note permafrost and periglacial terrain features. Supplement photos with data collected from Quaternary, geohazards, and surficial geology mapping. Carry out separate aerial photography interpretation of vegetation cover characteristics. Derive detailed slope aspect, elevation, and angle data from the site DEM topographic database. Compile local weather station data, preferably from various elevations and other attributes, as input to a permafrost prediction model. Collect regional climate, global warming, and permafrost degradation information. Compile ground temperature data from existing thermistors, and relate to air temperature data.
R05.07.02g	Update seismology study.	Information about seismicity was most recently updated by Atkinson on 2004. Updated analysis is needed to confirm and refine the findings of the 2004 analysis. Engineering requirements for seismic information will surpass those for regulatory and assessment purposes.	1	
R05.08.02	Vegetation and Reclamation			
R05.08.02a	Fill gaps in baseline documentation (Section 4.1.3 YESAB Proponent's Guide) on soil and vegetation classification for disturbed areas.	Existing vegetation in the project footprint needs to be considered for the ETA, NFRC, the Grum/Vangorda Creek Valley, and onsite regrowth areas to assess additional disturbance for revegetation planning. The rationale of using existing condition as baseline needs to be supported, but is not currently in enough detail, so status needs to be checked in disturbed areas. A bioavailable metals assessment needs to be part of screening to check if micronutrient levels are high enough for toxicity or for adverse food-chain impacts (Pb, As, Zn, and B will likely be the main focus).	1	Conduct field studies to document vegetation in: • North Fork Rose Creek Valley • ETA adjacent areas • Grum Creek/Vangorda Valley • Regrowth areas on the mine(s) footprint
R05.08.02b	Update vegetation survey at Survey Intensity Level SIL 3 for the LSA in 2007. This data will be 7 years old by the Project Proposal submission.	Determine if YESAB feels the data needs to be recollected for current conditions. Recommend that vegetation is unlikely to have changed much over this period in the LSA, with the exception of areas proximal to mine disturbance.	3	Recollect SIL 3 vegetation data in the entire LSA.
R05.08.02c	Access the raw field data to determine if soil surveys were collected during the vegetation survey work within the LSA.	Ecological land classification requires a survey of both vegetation and soil to confirm mapping and classification activities. This activity needs to be weighed against a verification of mapping required by YESAB in LSA areas outside the disturbance footprint. This is less important than reporting of soil conditions in disturbed or mine-proximal areas, but the requirement needs to be discussed with YG/YESAB.	2	Collect SIL 3 soils-mapping data within the LSA.

TABLE C-1
Regulatory Gaps – Baseline Research and Field Studies
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Activity Code	Data or Information Gap	Rationale	Importance ^a	Actions Required to Address Gap
R05.08.02d	Fill in information gaps for riparian revegetation details missing from the vegetation section after baseline data. There is almost no data on wetlands or riparian areas at all within the EA or in the closure design it is based on. Even if we do not want wetlands, we will need to plan to ensure that they cannot form (wildlife proximity issue) (Source: Chapter 8 of the draft Project Proposal).	Wet landscape planning has to be included in the revegetation plan to ensure that seepage and ponding areas are included or deliberately excluded. Mapping existing wetland areas within the LSA is a necessary part of the EA, as they are currently treated as a vegetation community, but no wetlands-specific vegetation or soils data has been collected. This is needed to set baseline conditions and as a planning tool for the reclamation surface.	1	Collect wetlands soil and vegetation baseline data within the LSA. Create a map interpretation for RSA.
R05.08.02e	Determine contaminant characterization, load in wetland, riparian vegetation, and food chains.	Determine if the existing wetlands need to be cleaned up (for example, excavated or capped) and re-established, if selected sites can offer transplant options, and which plants are suitable for wildlife habitat wetlands and treatment wetlands. Determine whether and in what form contaminants are sequestered in organics, and if any existing organic soils be used in part for reclamation, what the nutrient status of established wetlands is, and if there is a correlation with the vegetation community. Bioavailable metals assessment needs to check if micronutrient levels are high enough for toxicity or for adverse food-chain impacts (Pb, As, Zn, and B are likely the main focus).	1	Conduct a basic risk assessment in wetland/riparian communities, food-chain sampling (vegetation tissue and soil-fauna samples), and wetland soil toxicity sampling. Compare with other RSA wetlands/riparian areas.
R05.08.02f	Characterize potential borrow and quarry areas in undisturbed locations for: - Vegetation and soils baseline - Rare plants - Actual borrow volumes (and plant and soil salvage volumes) (Source: Chapter 4 of the draft Project Proposal).	Materials and quarry rock should be covered, as riprap and armouring appear to be minimal, and additional borrowing for hard rock and till is potentially required. There is some reference to additional borrow sites for peat and construction materials, but they do not appear to have been included in baseline work or characterized for closure planning. The location of borrow and quarry sites needs to be verified, and baseline soils and vegetation information collected for areas not yet covered in the LSA.	1	Conduct a field program to characterize: - Vegetation and soils baseline - Rare plants - Actual borrow volumes (and plant and soil salvage volumes)
R05.08.02g	Document wildlife use or avoidance of wetland and riparian zones (e.g., moose, sheep, grizzly bear, muskrat, and waterfowl [lesser sand hill crane, trumpeter swan, et al.]).	To identify the appropriate juxtapositions of wetlands according to migration paths and other habitats. This does not appear to have been specifically addressed to date, but this information is important for wetlands planning in the closure landscape.	2	Conduct seasonal surveys documenting specific wildlife use of wetland and riparian zones.
R05.08.02h	Identify permafrost locations not identified in the EA or closure plan (Source: Section 4.1.3 YESAB Proponent's Guide).	Permafrost locations are not noted in the EA or closure plan, either as baseline or as closure features. Not clear how this information is to be handled within the reclamation planning.	1	Map current and potential permafrost areas, and groundtruth permafrost areas onsite. Predictive mapping and groundtruthing carried out in the terrain and geology section.
R05.08.02i	Study dust issue in the Vangorda/Grum Area and as a result of the Grum Sulphide cell sedimentation pond blow-out for baseline (Source: Chapter 4 of the draft Project Proposal).	There may be areas in addition to those in the baseline studies that merit a check on dust or sediment impact on previously undisturbed areas. These should be coordinated with baseline surveys for existing vegetation areas, but also identified as specific responses to dust and sediment issues, as well as for assessment of mitigation and closure landscape design.	1	Discuss with YG and the field program to assess impact of dust and sediment in the areas below the Grum Sulphide Cell and towards Moose Pond.
R05.08.02j	Conduct more extensive rare plant surveys, especially if further borrow areas are required. The impact on undisturbed ETA-adjacent areas and creek channel realignments will also require this (Source: Chapter 4 of the draft Project Proposal).	Currently there is a lack of rare plant information with little data. Only the toe of four waste-rock areas has been surveyed. Any further disturbance in the LSA needs to be surveyed, and there should be a discussion with YG about rare plant surveys in the LSA.	1 for disturbed LSA areas 3 for the entire LSA	Conduct a field program to characterize rare plants in undisturbed areas likely to be impacted by construction and reclamation activities, and potentially within the LSA.
R05.09.02	Wildlife			
R05.09.02a	Review baseline study plan with YG wildlife managers.	Prior to beginning a baseline study program for 2012, prepare a summary of the intended study program to present to YG's wildlife managers. This would provide an opportunity for YG to comment on the program, and also would provide an opportunity to identify potential comments and synergies to improve the program.	1	Organize a presentation with details of the program, and present this to YG wildlife managers (and potentially YESAB).
R05.09.02b	Furbearers Collect data to determine the distribution and abundance of furbearer species within the LSA.	Furbearers were selected as a VC in the existing EA and appear to have high local value; however, there is no data on the actual species occurrences, distribution (according to vegetation type), or abundance of furbearer species. The 2007/2008 data only provides information on small mammal abundance from trapping, which is not relevant to this VC. <i>S. 4.1.9 Describe abundance and distribution of major wildlife species.</i>	1 – Urgent	Conduct a field study to collect information on furbearer abundance and distribution. The required field study is a winter track count that uses track transects arranged by site vegetation type to determine presence and relative abundance.

TABLE C-1
Regulatory Gaps – Baseline Research and Field Studies
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Activity Code	Data or Information Gap	Rationale	Importance ^a	Actions Required to Address Gap
R05.09.02c	Thinhorn Sheep Collect data describing the usage, timing, and location of Thinhorn sheep migration corridors through the Vangorda/Grum Area and potentially the site access road.	Results from YG wildlife key area datasets and other data have established that migration corridors exist through the Vangorda/Grum and access road areas. Corridors are used through the spring and fall, and migration could be impacted by activities onsite, traffic, and habitat changes. Information regarding the use of these corridors is outdated (from 1980); therefore, impacts cannot be accurately assessed. This data will also be used to feed into adaptive management plans for sheep. <i>S. 4.1.9 Describe any transportation corridors and critical, key or sensitive habitats.(YESAB Proponent’s Guide)</i>	1	Discussions with FPET and government wildlife experts in January 2012 concluded that earlier studies combined with ongoing site observations are sufficient to characterize migration corridors through the site and that efforts should focus on maintaining these corridors while protecting sheep from adverse effects.
R05.09.02d	Water Birds and Waterfowl Collect data regarding waterfowl use of pits and ponds in the Faro Mine Complex area, and also data regarding the risks of use of these habitats (the current quality of habitat is water, sediment, and biota).	Waterfowl and water birds are potential seasonal or temporary users of the Faro Mine site on an annual basis. Waterfowl might also use pits and ponds, and as the ponds slowly recolonize with plants and invertebrates over time, the chance of exposure, contamination, or mortality may increase. We have only anecdotal data regarding water bird use at the mine pits and ponds, and there appears to be no data about existing pit and pond sediment quality and biota. <i>S. 6.2.1.3 (YESAB Proponent’s Guide)</i>	1	Address data gap with a field survey of waterfowl and water bird use of pits and ponds in the mine area during staging and breeding seasons.
			2	Investigate habitat, and conduct a desktop study to determine and document conditions in which we can determine the likelihood of feeding or ingestion by waterfowl/water birds. This habitat investigation would investigate the current habitat conditions, including depth, presence of vegetation, sediment metal levels, and existence of any potential feeding sources, such as benthic invertebrates.
R05.09.02e	Grizzly Bear Collect data regarding the potential for Grizzly Bear denning in the LSA and vicinity.	As a species-at-risk at the site, grizzly bears have potential to use the site in a variety of ways, including for -denning (overwintering) at the site. The existing EA in the draft Project Proposal states that this is low potential; however, based on the existing information, we feel this should be revisited. As earthworks are anticipated to occur year-round at the site through the decommissioning period, there is potential for abandonment of den sites, mortality, or other effects. Information regarding the potential suitability of the LSA area for grizzly bear habitat will help to focus the effects assessment, and determine whether further studies (e.g., denning) may be required prior to or during the closure process. <i>S. 4.1.9 (YESAB Proponent’s Guide)</i>	1	Conduct habitat suitability modelling to provide a concept of the likelihood of grizzly bear habitat, including denning habitat. This modelling would use existing datasets (e.g., elevation, vegetation, substrate, slope, and aspect) to determine whether suitable habitats exist, and whether further study is warranted.
			2	Conduct a field survey during the emergence period to determine if denning is occurring at the mine area. Surveys would be conducted during the late winter/early spring from aircraft by a biologist. This survey would ideally build on the HSI.
R05.09.02f	Small Mammal Sampling for Contaminant Data Collect small mammals, and perform laboratory analysis to provide recent contaminants data.	Up-to-date information regarding contaminants data in small mammals is required for local mine areas to feed into the risk assessment process and to determine potential effects on small mammal populations.	2	Collect a limited number of small mammals, and send to the laboratory for analysis; required to fill this data gap. Collections would be performed during the summer and fall of 2012 in conjunction with other wildlife field programs. Discussions with FPET in January 2012 identified concerns about community sensitivities for this proposed program. The PDT confirmed that lack of information about chemical concentrations in tissue of small mammals is not a significant constraint to completion of the ecological risk assessment. As a result, this gap will not be addressed by field studies and is not included in the Cost Opinion.
R05.09.02g	Wetland and Riparian Wildlife Use Document wildlife use or avoidance of wetland and riparian zones (moose, sheep, grizzly bear, muskrat, waterfowl, and migratory birds).	To identify appropriate juxtapositions of wetlands regarding wildlife migration paths and other habitats. This does not appear to have been specifically addressed to date, but is information desirable for wetlands planning in the closure landscape.	2	Conduct seasonal surveys documenting specific wildlife use of wetland and riparian zones. Recommend a combination of plot and transect surveys in riparian areas to record occurrence of wildlife signs (e.g., trails and pellet groups). These would be tied to ELC groupings to allow data to be fed into wildlife modelling for effects and closure works. Winter wildlife riparian habitat use would be captured in furbearer surveys.
R05.09.02h	Moose Late Winter Survey Collect information to add on to fall moose data, but for the critical late winter period, where disturbance effects can be greater for moose.	Generally, surveys of moose are conducted at times and locations that give information relevant to the project and potential impacts. The late-winter period is critical to moose because of low energy reserves and limiting habitat, making them susceptible to disturbance or predation. No information on late-winter distribution in the project area exists.	3	As a first step in addressing this gap, conditions at the FMC will be compared and evaluated for habitat suitability for late winter use by moose (through comparison with regional conditions in known areas of late winter use). Should areas of the site offer suitable habitat conditions, then completion of an aerial survey in March of moose distribution in the study area will be undertaken to fill this gap. This survey would be conducted in the area local to the mine to determine abundance and distribution in relation to project areas, snow load, and habitat areas.

TABLE C-1
Regulatory Gaps – Baseline Research and Field Studies
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Activity Code	Data or Information Gap	Rationale	Importance ^a	Actions Required to Address Gap
R05.11.02	Air Quality, Climate, and Noise			
R05.11.02a	Define air-quality baseline conditions. Previous monitoring results attempted to characterize TSP, PM ₁₀ , and metals, but have not been optimal or successful in defining air-quality baseline conditions. Lack of quality data affects the characterization of background ambient concentrations in the vicinity of the mine, as well in the Town of Faro.	Several air quality monitoring studies had a number of shortcomings, such as low retrieval rate (Senes, 2008), laboratory errors (Senes, 2009), wet conditions leading to low and non-representative baseline concentrations (RWDI, 2006; and Senes, 2008), and poor siting of stations. YESAB’s response to Eagle Gold includes the statement: “Please make sure to include among others information regarding CAC emission inventories and PM monitoring.” YESAB Proponent's Guide, Sections 4.1.6, specifically asks for available background information on existing ambient conditions. However, current data is more indicative of pristine conditions, without the effects of care-and-maintenance activities.	1	An emissions inventory and air dispersion modelling, in conjunction with the available monitoring data, is recommended to characterize the current conditions because of the cost of the air quality monitoring program and possible difficulties in obtaining reliable data from a single monitoring season. Specifically, the current monitoring data, which is more indicative of pristine background conditions, can be added to concentrations predicted from air-dispersion modelling for typical care-and-maintenance activities to characterize current ambient conditions for a number of contaminants. Because of the vast area of the mining site and the multiple emission sites, a significant number of monitoring stations would be required to properly characterize the PM and metal emissions from the site. Also, additional factors, such as heavy precipitation over the course of the summer, could affect the quality of the data and proper characterization of ambient conditions. Option 2 would be more cost-effective than performing another air monitoring program for particulates, metals, and possibly CACs. Since the baseline for this particular project includes some care-and-maintenance activities, an emissions inventory that accounts for these activities, in addition to the estimates of pristine conditions through the previous monitoring programs, should provide a good estimate of current baseline conditions.
R05.12.02	Socio-economic			
R05.12.02a	Collect labour-force information for both Aboriginal and non-Aboriginal population (by industry, occupation, experience, training, wages/earning, participation rates, and employment rates) (LSA and RSA).	Provides information on labour pool and an inventory of statistics to determine impact and possible mitigation methods for anticipated labour-force changes, demands, and wage inflation. Essential for data analysis.	1	Research secondary sources for data and project-relevant statistics, and conduct primary research to complete missing data.
R05.12.02b	Study fishing activity (Aboriginal and non-Aboriginal), including subsistence, commercial (including tourism), recreational, and traditional.	To determine the impact of the Faro project on possible socio-economic fishing and related activities in the LSA. It is an important indicator of community economic use of the land base.	1	Conduct a primarily desktop analysis using secondary sources, and share data with other Faro project technical teams (i.e., the fisheries or aquatics technical focus teams). Augment data with primary research where needed.
R05.12.02c	Collect information on gathering activities (including hunting) for Aboriginal and non-Aboriginal communities, including activities, intensity, and harvest statistics, with a focus on LSA.	To determine impacts of project on existing gathering activities (hunting and land use). It is an important indicator of community economic use of the land base.	2	Research primary data sources and existing traditional knowledge reports for hunting information. Cross-reference with other Faro technical teams. Augment data with primary research where needed.
R05.12.02d	Collect trapping-specific data, including LSA trap activities, registered interests, trapline locations, and economic data (Aboriginal and non-Aboriginal).	To determine baseline conditions for trapping activities in the Faro project area, evaluate potential impacts from the project, and permit the development of possible mitigation methods for adverse project impacts.	2	Contact Yukon Environment for trapping statistics and registered trapline information. Additional communications with primary sources may be required to complete data collection and confirmation.
R05.12.02e	Research education statistics for LSA and RSA, including highest level of education, elementary and high school enrolment, school attendance, relevant skills programs, and training facilities/training capacity (Aboriginal and non-Aboriginal).	To assess the possibility of locally sourcing talent for the project and to determine ability for project to use local facilities for training and education purposes. Also permits analysis of LSA capacity to absorb possible population growth, and affects the funding needs of communities.	2	Collect statistics from primary research sources, augmented where necessary from primary sources.
R05.12.02f	Research occupational breakdown of LSA and RSA labour force, with particular focus on needed project-specific talent.	To assess, evaluate, and maximize deployment of the Yukon labour force on the Faro project.	1	Research secondary labour-force statistics, and confirm with primary sources as needed.
R05.12.02g	Assess opportunities for local employment and training	To determine the ability of local residents to capture employment and possible service contract opportunities. This is of prime importance to project stakeholders and a probable key VSEC.	1	Collect statistics from secondary research sources, augmented where necessary from primary sources.

TABLE C-1
Regulatory Gaps – Baseline Research and Field Studies
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Activity Code	Data or Information Gap	Rationale	Importance ^a	Actions Required to Address Gap
R05.12.02h	Assess municipal infrastructure, such as sewage, parks, power, and telecommunications and services, such as social services and childcare in the LSA communities.	To determine impact of increased population and activity on LSA communities. Important to determine community impact of project.	2	Collect statistics from secondary research sources, augmented where necessary from primary sources.
R05.12.02i	Research traffic volumes in LSA and RSA, including highways, roads, airports, transportation infrastructure, accident statistics, transportation modes, and commuting patterns as relevant to project.	To determine impact of increased population and activity on Yukon communities and transport infrastructure. Essential for community impact analysis.	1	Collect statistics from secondary research sources, augmented where necessary from primary sources.
R05.12.02j	Research income and earnings in the LSA and RSA (Aboriginal and non-Aboriginal), as well as Yukon economic indicators.	Essential to evaluate and determine economic impacts on communities.	1	Collect statistics from secondary research sources, augmented where necessary from primary sources.
R05.12.02k	Conduct a scan of locally owned businesses in the LSA, both Aboriginal and non-Aboriginal.	To understand the local capacity to maximize economic benefits to nearby goods and services suppliers.	1	Research primary sources because of the small size and geographic distribution of population and businesses.
R05.12.02l	Assess taxation revenue impacts for local, territorial, and federal governments.	To provide baseline and analysis information on government revenues.	2	Collect statistics from secondary research sources, augmented where necessary from primary sources.
R05.12.02m	Research population and personal income fluctuations in LSA communities using historical information.	Establish implications for diversification within the project timeline.	1	Collect statistics from secondary research sources, augmented where necessary from primary sources.
R05.12.02n	Collect data on the ability of LSA and RSA business capacity to service the project.	Ensure that Yukon businesses maximize economic benefits from the project.	1	Collect statistics from secondary research sources, augmented where necessary from primary sources.
R05.12.02o	Research the number of business licenses in LSA, and the number of businesses and employees in LSA and RSA.	To determine the ability of Yukon businesses to capture current and ongoing benefits from the project.	1	Research using mostly secondary research sources because of distributed communities.
R05.12.02p	Collect population counts (LSA and RSA), both Aboriginal and non-Aboriginal.	To determine impact of project activities on local communities.	2	Research using mostly secondary research sources because of distributed communities.
R05.12.02q	Collect information regarding community events, including descriptions and numbers.	To determine impact of project activities on local communities.	2	Research using mostly secondary research sources because of distributed communities.
R05.12.02r	Study area mobility status (LSA and RSA, both Aboriginal and non-Aboriginal, where appropriate), including mobility status, age and sex, family size, and marital status.	To build baseline information and allow for project impact analysis.	1	Collect statistics from secondary research sources, augmented where necessary from primary sources.
R05.12.02s	Establish the number of dwelling units; housing prices; land lots for development; number of leasing properties, rental vacancies, or transactions; occupied private-dwelling characteristics; housing sales forecasts; and property values.	To build baseline information and allow for project impact analysis.	1	Research using mostly primary research sources due to distributed communities. Augment data with primary research where needed.
R05.12.02t	Establish community crime rates in LSA, and identify the type of crime and frequency.	To determine impact of project activities and increased population on local communities.	2	Collect statistics from secondary research sources, augmented where necessary from primary sources.
R05.12.02u	Research leisure and recreational activities, including description, type, and nature of use of existing recreation facilities in the LSA, including Aboriginal and non-Aboriginal population centres.	To determine impact of project activities and increased population on local communities.	2	Research using mostly primary research sources because of distributed communities and small sample set.

TABLE C-1
Regulatory Gaps – Baseline Research and Field Studies
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Activity Code	Data or Information Gap	Rationale	Importance ^a	Actions Required to Address Gap
R05.12.02v	Update information on Aboriginal governments (RRDC, LFN, and SFN) and applicable municipal and territorial governments, and identify other relevant major projects in LSA and RSA.	To determine the impact of project activities on local government capacity and services.	2	Interview primary sources (governments, First Nations, and community groups).
R05.12.02w	Research domestic violence occurrences.	To analyze the effects of domestic violence on an increased population in smaller communities.	2	Interview primary sources (governments, First Nations, community leaders, and community support organizations).
R05.12.02x	Describe health and social services.	Assess the ability of local communities to provide services to additional community members.	1	Research using mostly primary research sources because of distributed communities.
R05.12.02y	Research health characteristics, hospitalization rates, medical facilities, medical staff, alcohol and drug use, domestic abuse and violence, and community health characteristics, both Aboriginal and non-Aboriginal (LSA and RSA).	Assess the ability of local communities to absorb additional community members.	1	Collect statistics from secondary research sources, augmented where necessary from primary sources.
R05.12.02z	Research the number of mining-related accidents each year.	Assess the ability of local communities to provide services to additional community members.	2	Collect statistics from secondary research sources, augmented where necessary from primary sources.
R05.12.02aa	Study the quality of life of the Aboriginal population, including measures of health, community life, political stability, climate and geography, job security, and gender equality (RRDC, LFN, and SFN).	Assess the impact of the project on local First Nations well-being and community fabric.	1	Research using mostly primary research sources because of distributed communities. Augment data with primary research where needed
R05.12.02bb	Seek out community input on VSEC priorities.	To ensure that communities support the selected VSECs.	1	Conduct community meetings, discussions, and outreach.
R05.12.02cc	Identify other capacity constraints that may impact community engagement capacity, consultation, and engagement approach (e.g., C&C staffing and labour shortages).	Essential for correct interpretation of data.	1	Assess other major projects in the LSA and the RSA (understand capacity issues, and competition for goods, services, and human resources) as they relate to community capacity and impacts discussions with First Nations and local communities. Comprises primary and secondary research.

^a Importance: 1=Critical – must do; 2=Ideal; 3=Minor – nice to have but not necessary

Notes:

3D = three-dimensional
AMP = adaptive management plan
As = arsenic
B = barium
CAC = criteria of concern
CO = carbon monoxide
COC = contaminant of concern
DEM = digital elevation map
DO = dissolved oxygen
EA = environmental assessment
EDI = EDI Consultants
GIS = geographic information system
IDF = intensity, duration, and frequency
km² = square kilometre
LFN = Liard First Nation
LIDAR = light detection and ranging
LSA = local study area

NFRC = North Fork Rose Creek
°C = degrees Celsius
Pb = lead
PM₁₀ = particulate matter less than 10 micrometres in aerodynamic diameter
PMF = probable maximum flood
RRDC = Ross River Dene Council
SFN = Selkirk First Nation
SIL = survey intensity level
SIS = seepage interception system
TSS = total suspended solids
YESAB = Yukon Environmental and Socio-economic Assessment Board
YG = Yukon Government
YGS = Yukon Geological Survey
yr = year
Zn = zinc

TABLE C-2
Regulatory Gaps – Baseline Analysis and Interpretation
Gap Assessment Report, Faro Mine Remediation Project – Appendix C

Activity Code	Data/Information Gap		Rationale	Importance ^a	Action Required to Address Gap
R05.02.02	Hydrogeology				
R05.02.02f	Develop numerical models of each area where groundwater interception systems are required.	Develop 3D numerical groundwater flow models to quantify the site water budgets; characterize transient groundwater flow directions, velocities, and gradients; quantify the exchange of surface water and groundwater interaction; and quantify how those fluxes vary spatially and temporally. Investigate various alternative configurations of SIS designs for each site to optimize efficiency and minimize cost. These flow models will provide a quantitative basis to prepare a basis-of-design report and will also provide sufficient information to revise the Baseline Conditions section and Potential Environmental Effects section.		1	Construct 3D numerical groundwater flow models of each area where groundwater interception systems will be designed and installed. Utilize the existing GoldSim model and other existing groundwater flow models, such as the FEFLOW model of the ETA Area and the MODFLOW model of the Rose Creek Tailings Area to provide boundary conditions for new, more comprehensive groundwater flow models. Calibrate these models to available groundwater elevation, aquifer testing, and surface water/groundwater interaction data. Utilize these models to develop designs for each groundwater interception system.
R05.02.02g	Delineate permafrost at the Faro Mine and Grum/Vangorda Areas.	The presence of massive or discontinuous permafrost within the groundwater system has a significant influence on groundwater flow directions, rates, and surface water/groundwater interaction. The design of effective SIS systems requires knowledge of permafrost in the immediate area of the system. Permafrost may also alter contaminant migration pathways and require modification to groundwater monitoring network designs.		2	Undertake detailed literature review to locate previous studies or field investigations that delineated permafrost extent at the Faro Site in conjunction with results of proposed geophysical surveys by the terrain and geology focus team to identify the presence of permafrost.
R05.03.02	Hydrology				
R05.03.02a	Update site-wide water-balance model.	Only required if previous model is outdated or inaccurate. There was some review discussion that parts of the GoldSim model should be reviewed, so this is recommended		1 (part of review recommendation)	Review water-balance component in relation to balance accuracy and the water-quality estimates that are derived from the model. This is being carried out as part of the engineering analysis.
R05.03.02b	Examine the baseline precipitation and hydrology/hydraulics data, including PMP/PMF (and other return-period events), flow data, and water-balance information.	Required for setting up the hydrologic/hydraulic models and understanding the inputs and potential model outcomes. Part of the overall truthing of model building and interpretation.		1 (YESAB 4.1.10.1)	Conduct detailed review of all background data is being carried out as part of the engineering analysis. Some effort has been estimated, since the review focus in engineering is on constructability and stability. This regulatory review is required, since we need to take into account VC review objectives.
R05.03.02c	Examine the mapping and topographic data.	Required for setting up the hydrologic/hydraulic models and understanding the inputs and potential model outcomes. Part of the overall truthing of model building and interpretation.		1	Conduct detailed review of all background data. This portion is carried out under engineering review but needs additional effort to review from a regulatory perspective.
R05.03.02d	Examine the composition of creek and diversion bed, as well as bank materials and underlying soils.	Required for setting up the hydrologic/hydraulic models and understanding the inputs and potential model outcomes. Part of the overall truthing of model building and interpretation.		1	Conduct detailed review of all background data and new information collected for hydrology baseline program. This portion is carried out under engineering review but needs additional effort to review from a regulatory perspective.
R05.03.02e	Examine the groundwater information related to surface water hydrology.	Required for setting up the hydrologic/hydraulic models and understanding the inputs and potential model outcomes. Part of the overall truthing of model building and interpretation.		1	Conduct detailed review of all background data is being carried out as part of the engineering analysis. Some effort has been estimated, since the review focus in engineering is on constructability and stability. This regulatory review is required, since we need to take into account VC review objectives.
R05.03.02f	Examine the alternatives that have already been put forward for the Rose/Faro and Vangorda diversions.	Required for setting up the hydrologic/hydraulic models and understanding the inputs and potential model outcomes. Part of the overall truthing of model building and interpretation.		1	Conduct detailed review of all background data is being carried out as part of the engineering analysis. Some effort has been estimated, since the review focus in engineering is on constructability and stability. This regulatory review is required, since we need to take into account VC review objectives
R05.03.02g	Review and report on current flow conditions data. The Project Proposal documentation needs significant update and inclusion of more specific hydrology information from a temporal (seasonal, including ice) and spatial perspective.	Have not found all the base information from flow records needed for model calibration, including information on return-period storms less than the PMF and 500-yr. The YESAB-required data, including peak, minimum, seasonal, and annual average flows, are represented in the AECOM (2009) baseline report. Winter flow conditions need to be described more fully and in relation to VCs.		1 (YESAB 4.1.10.1 does not specifically require any more than peak, minimum, seasonal, and annual average flows, so we may not have to develop more information for reporting than required under YESAB 4.1.10.1. This information needs to be developed for the engineering side.)	Rewrite descriptions using existing information, or develop return-period flow information from the existing rainfall data and flow records. This may be a difficult exercise given the availability of correlated data.

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Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.03.02h	Review and report on current hydrology/hydraulics (return periods) information. This information did not receive good review comments and needs to be updated.	Information is critical to understanding the site hydrology.	1 This is YESAB requirement 4.1.10.1	Collect information and review if covered elsewhere. This effort is to rewrite Project Proposal documentation.
	Review and report on new flow data.	Flow records from existing monitoring will need to be updated, analyzed, and reported.	1	Collect most recent data, and write report.
R05.04.03	Surface Water Quality and Aquatic Ecosystem			
R05.04.03a	Update baseline surface water quality assessment.	Should reflect current conditions – AECOM baseline was 2005 through 2007; Minnow baseline (in Aquatic Effects Monitoring Report) was 2005 through mid-2009.	1	Analyze surface water quality for 2008 through 2011 (confirm time frame). Include temporal trend analysis (2005 through 2011) key variables and locations, relating results to any modifications of water collection and treatment systems (e.g., S-wells collection) during the evaluation period.
R05.04.03b	Update site-wide water-balance model to include groundwater contributions.	Important for management of surface water, fish habitat evaluation (locating groundwater upwellings to surface), and water-quality predictions (source loads divided by volumes).	1	Hydrology team to develop plan and budget
R05.04.03c	Update sediment baseline description.	There are deficiencies associated with the AECOM baseline descriptions and Chapter 4 of the draft Project Proposal.	1	Update sediment quality descriptions using existing information. Additional sediment sampling (benthic invertebrate survey budget) to update baseline and support risk assessment. Incorporate any new sample data into descriptions.
R05.05.06	Fish Habitat Compensation			
R05.05.06a	Gather information on quantity and quality of fish habitat and fish utilization of study area, as current information is lacking; primarily being done by other groups.	Need to know what is present to assess effects and develop compensation plan.	1	Need to populate
R05.10.03	Human Health and Ecological Risk Assessment			
R05.10.03a	Update majority of the ecological risk assessment. As well, the description of risks under current conditions needs to include recent data, some of which will be collected during 2012. It is expected that the exposure models and toxicity reference values (TRV) will have to be revised and that actual measured concentrations can be used to replace modelled concentrations in most circumstances.	Using recent and more comprehensive data will allow a more accurate prediction of risk assessments.	1	Revise risk assessment.
R05.07.03	Terrain, Geology, Geological Hazards, and Seismicity			
R05.07.03a	Prepare summary text and surficial geology (Quaternary geology) map	Need references and legend, as well as description of soil and terrain units in terms of engineering (not agronomic) properties, such as moisture content, grain size, hydraulic conductivity (K), strength, erosion potential, and clay mineralogy (for fine-grained plastic soils).	1	Revise/update mapping data with 2012 field work and ground truthing. Prepare map and legend with soil descriptions. Summarize lab testing data.
R05.07.03b	Prepare shaded slope and watercourse map from DEM.	Serves as base map for geohazard assessment and permafrost characterization, as well as supporting engineering studies.	1	GIS department to process DEM data when available.
R05.07.03c	Prepare summary text and geohazards map.	Need detailed descriptions of each geohazard in terms of location, area affected, current state of activity, consequences, risk, and mitigation measures.	1	Revise/update mapping data with 2012 field work and ground truthing. Identify watershed boundaries, and show major structures.
R05.07.03d	Prepare summary text and permafrost characterization map.	To assess long-term effects of climate change, as well as effects of reclamation activities on permafrost regime.	1	Summarize regional climate data, including mean annual air temperatures, degree days freezing/thawing, precipitation (rain versus snowfall), and solar radiation. Collect and plot thermistor data from existing thermistors, as well as any newly installed instrumentation. Input data into permafrost model, and generate initial permafrost distribution map.

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Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.07.03f	Define baseline conditions in terms of physical, chemical, and thermal stability.	Provides a basis for assessing whether reclamation measures are making a beneficial or detrimental effect on the regional environment. Allows comparison of site reclamation to natural conditions.	2	Compare baseline conditions in currently mine-impacted areas against baseline conditions in adjacent “natural” areas. Compare reclaimed conditions against baseline mine-impacted conditions and natural conditions.
R05.08.03	Vegetation and Reclamation			
R05.08.03a	ETA has potentially large changes to water flow/seepage and elevation planned as mitigation. Understand the risk to the adjacent vegetated area, especially as it appears undisturbed but is likely highly impacted currently. Collect baseline data (as indicated in the Terrain, Geology, Geological Hazards, and Seismicity section), and analyze to determine the best reclamation solution for this area. This will also inform the adaptive management and monitoring plans for the area.	These are aspects of the EA baseline information and mitigation planning, and are best quantified by an Ecosystem Services Analysis to inform the engineering design and EA residual impact analysis.	1	Ecosystem Services Analysis to inform integrated planning for the ETA-adjacent area, all the way to the connection with the Rose Creek Valley.
R05.08.03b	The Grum Creek and Vangorda Creek Area is currently surrounded by higher elevation mine areas (Grum and Vangorda waste rock piles) and is downstream of drainage for the area. Collect baseline data (as indicated in the Terrain, Geology, Geological Hazards, and Seismicity section), and analyze to determine the best reclamation solution for this area. This will also inform the adaptive management and monitoring plans for the area.	These are aspects of the EA baseline information and mitigation planning, and are best quantified by an Ecosystem Services Analysis to inform the engineering design and EA residual impact analysis.	1	Ecosystem Services Analysis to inform integrated planning for the Grum and Vangorda Creek channels, Moose Pond, and valley area.
R05.08.03c	Confirm current water quality and flows – surface-water- and groundwater (seepage) and impacted surface water.	Required to provide basis for integrated terrestrial and wet landscape planning.	2	Review recent data, and compare to historical data. Information to be coordinated with the hydrology team.
R05.08.03d	Conduct Baseline Wetland/Riparian Hydrologic analysis.	To determine surface and groundwater proportional contributions, and to evaluate long-term hydrologic basis, flow paths, and chemistry; examine throughout year.	1	In conjunction with vegetation survey, and working with surface/groundwater and hydrology team, characterize water tables and sources over year; include some paired points upstream/downstream of existing wetlands/beaver ponds.
R05.08.03e	Need to clarify status of Ecological Land Classification requirement for the project, and obtain appropriate mapping information to complete photo analysis prior to field studies.	ELC information is required for wildlife HSI modelling and to complete vegetation/soils impact analysis. Some of this information may already be available from AECOM through YG, but it is not currently present in the data provided. In addition, there is some concern that the coverage of the LSA for terrain may not be wide enough and therefore not cover prospective quarry and borrow areas.	1	Need to request vegetation (and any soils) mapping information from AECOM; raw data and GIS files. Once done, need to assess for missing data or additional areas of coverage.
R05.09.03	Wildlife			
R05.09.03a	Conduct analysis and interpretation of wildlife field program data.	Analysis and interpretation of data from the wildlife field programs proposed is required to prepare this information for reporting and integration into the EA.	1	Data entry, analysis, and interpretation of data from field programs.
R05.09.03b	Gather local harvest records and access information for moose.	The potential overharvest of moose has been and will likely continue to be a topic of concern for the Faro Mine Complex area, particularly if there is the potential for changes to site access. We propose collecting more detailed information on harvest, as well as local access points that may potentially be used for moose hunting. This would allow assessment of the reclamation/closure works and whether these works will add to or reduce access-related hunting concerns (<i>S. 4.1.9, YESAB Proponent’s Guide</i>).	1	Desktop information gathering and mapping exercises, in conjunction with some consultation to tap into local knowledge (e.g., local conservation officer, First Nations).
R05.09.03c	Gather updated information existing water quality in the pits and ponds as relates to local water birds and waterfowl.	Updated information on the existing water quality in the pits and ponds is needed to determine existing effects on water birds and waterfowl.	1	Evaluate existing water quality, as well as existing biota and sediment in pits/ponds at the site, to characterize existing condition impacts on waterfowl.

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Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.11.03	Air Quality, Climate, and Noise			
R05.11.03a	Environmental/climatic baseline conditions for parameters (wind, temperature, precipitation, and solar radiation) and other parameters not well-constructed; many missing or incomplete topics in the current draft baseline section.	These data are required to characterize the general climatic conditions of the area, as well as describing air circulation patterns in and around the project area that may affect air quality. Need current assessment of these parameters to define the climatic conditions of the study area. These were poorly done and/or missing in the draft March 2010 Project Proposal. Proper characterization of current conditions necessary according to Sections 4.1.5 and 4.1.6 in the YESAB Proponent’s Guide. Much of the information is available, specifically in the AECOM (2009) data, as well as from other sources.	1	Update the AECOM (2009) data and present in a manner that will address YESAB requirements from Sections 4.1.5 and 4.1.6 in the YESAB Proponent’s Guide. Collect recent meteorological data from the onsite station, as well as from nearby Environment Canada monitoring stations, as required for update.
R05.12.03 Socio-economic				
No specific baseline analysis and interpretation gaps were identified by the Socio-economic team. However, the team recognizes that the substantial data collection efforts will have associated analysis and interpretation requirements. These activities are assumed to be undertaken as part of the work to address the baseline gaps. Members of the socio-economic team will need to undertake community meetings to verify findings from baseline analysis and interpretation. In addition, the team will propose an overview socio-economic communications plan to provide clarity for all team members regarding data verification methods, limits to communication and consultation, roles and responsibilities, scheduling, etc. The plan will be confirmed with the client before implementation.				

^a Importance: 1=Critical – must do; 2=Ideal; 3=Minor – nice to have but not necessary

Notes:

- ELC = ecological land classification
- K = hydraulic conductivity
- PMP = probably maximum precipitation
- TRV = toxicity reference value

TABLE C-3
Regulatory Gaps – Effects Assessment Research and Field Studies
Gap Assessment Report, Faro Mine Remediation Project – Appendix C

Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.02.03	Hydrogeology			
	Information gaps and needs addressed in other categories.			
R05.03.05	Hydrology			
	Information gaps and needs addressed in other categories.			
R05.04.06	Surface Water Quality and Aquatic Ecosystem			
	Information gaps and needs addressed in other categories.			
R5.06.06	Fish Habitat Compensation			
R5.06.06a	Accurately determine quantity of habitat lost or modified by the project as a result of the harmful alteration, disruption, or destruction of watercourses.	This information is needed for the mid-term (during construction) and long-term time periods. Need to know quantities of habitat lost on a timeline basis to compensate for the loss. Also need to know how the construction work is to proceed.	1	Work with members of the engineering/mapping team to determine this information. No field work needed.
R5.06.06b	Gather sufficient information on areas of, or opportunities for, fish habitat compensation outside of Rose Creek.	Additional areas beyond those within Rose Creek may need to be identified to ensure that there is a sufficient quantity of compensation for the fish habitat that will be impacted by the project.	1	Undertake field surveys involving Department of Fisheries and Oceans Canada (DFO) staff.
R5.10.06	Human Health and Ecological Risk Assessment			
R5.10.06a	Find evidence to support the vegetation assessment, which assumes that all cover materials are clean, but there is no evidence to support this. (Source: Chapter 8 of the Draft Project Proposal)	Clean cover is a critical assumption of the water quality, hydrology, and fish and wildlife assessments, but there is no data shown to support this assumption. If it is not the case, then these parts of the EA would need to be amended. Direct impacts of soil COCs on soil organisms and plants are not known. Toxicity testing on the waste rock cover materials is needed to predict future risks and to determine if that material is acceptable.	1	Review cover materials data, as well as data from areas of the site where reclamation is not currently proposed, therefore representing future conditions; and include missing areas in a field test program.
R5.10.06b	Conduct sequential analysis of soil to determine potentially bioavailable fraction.	Required to assess risks in the long-term.	2	Collect and test cover material samples and soil samples from areas not proposed to be remediated.
R5.07.06	Terrain, Geology, Geological Hazards, and Seismicity			
R5.07.06b	Assess fault activity to support seismology update.	A fault is considered active if it displaces Quaternary aged deposits (i.e., up to about 1.6M years). The 2004 seismology report recommended significantly increased ground acceleration parameters based on evidence that the Tintina Fault was active because Quaternary sediments were displaced.	1	Engineering requirements will drive information needs related to seismology. Actions are addressed in relation to engineering.

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Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R5.08.06	Vegetation and Reclamation			
R5.08.06a	Waste rock and tailings void spaces are noted to store water and release during low-flow periods (Section 4.7.1 of the Draft Project Proposal), but this is not part of revegetation planning for seepage issues for vegetated landforms. Incorporate hydrological model into revegetation and covers planning, as they are critically interlinked areas.	Vegetated landforms require integrated wet landscape/wetlands planning for toes-of-slope and low-lying areas to ensure that reclamation landscape has appropriate moisture regime and/or treatment capacity. Unlikely that tailings void spaces are acting in the same manner as waste rock, and this needs to be separately addressed in planning the tailings cover and revegetation. The closure landscape must integrate hydrology and covers information to provide a closure landscape.	1	Integrate planning for hydrology, wetlands, and wet landscape in revegetation plan, so that closure potential effects can be evaluated.
R5.08.06b	Find evidence to support the assumption from the vegetation assessment that all cover materials are clean, as there is currently no evidence to support this. (Source: Chapter 8 of the Draft Project Proposal)	Clean cover is a critical assumption of the water quality, hydrology, and fish and wildlife assessments, but there is no data shown to support this assumption. If it is not the case, then these parts of the EA would need to be amended.	1	Review cover materials data, and include missing areas in a field test program.
R5.08.06c	Correct cover infiltration descriptions, which suggest a misunderstanding about how the tailings cover will work with respect to vegetation cover.	There will be moisture beneath the cover within the tailings; therefore, there is only a spatial separation of roots from tailings porewater provided by the cover. This is inherently different from waste rock cover systems (Source: Chapter 8 of the Draft Project Proposal). The function of cover materials is different between waste rock (prevent infiltration and, therefore, seepage issues) and tailings (provide infiltration through the cover to keep plant roots spatially separated from the tailings porewater – seepage is still expected). Planning information for the tailings cover design needs to be fed back into the EA process to assess effects on vegetation, wildlife, and water quality.	1	Need to clarify cover expectations and revegetation planning over tailings, and ensure that these are represented properly in the EA for Water Quality and Hydrology sections. Choice of planting material and rooting depth needs to be covered in greater detail.
R5.08.06d	Provide missing meso- and micro-topography (topo) information with the cover-type information, as this is a critical factor for this ecosystem. Assess resulting suitability for vegetation types and cover volumes to provide appropriate topo and planting opportunities (Source: Chapter 8 of the Draft Project Proposal).	Vegetation cover types are dependent on cover depth and microsite variation. Providing topo also may require greater cover depths or gentler slopes to allow working of the cover material, as they impact the material balance and landform planning.	1	Need to work with Waste Rock and Covers team to delineate requirements for cover depths and texture, and then check available source material.
R5.08.06e	Determine placement for Haul Road material removal, which is currently planned as rock drain and perched culverts removed.	This is a substantial amount of material that does not appear to have a destination, and does not consider that it may be necessary to remove more of the Haul Road material (especially that which currently crosses valley areas) (Source: Chapter 8 of the Draft Project Proposal). There is currently not any information on the quality of the road materials or how much material might be desirable for cover requirements. In addition, scarifying and revegetating the road and berms as is has a high likelihood of failure as a self-sustaining closure feature.	1	Require coring program for length of Haul Road. Haul Road needs to be treated as an entire closure feature on the same scale as waste rock dumps so that planning can be completed for removal or regrading of the road materials.
R5.08.06f	Consider impacts of contaminants in dust on treatment wet areas during construction and after closure.	Fallout settling on treatment areas will increase plant tissue concentration. Need to know impacts on plants, as well as foraging wildlife and aquatic organisms. Need to understand whether we want open water on the closure landscape or whether closed-surface treatment wetlands will be required to protect wildlife. Need to also understand uptake of contaminants by wetland vegetation species after closure.	1	Research to determine potential impacts based on current information, and use to inform wet area reclamation planning (and feed back to EA).

TABLE C-3
Regulatory Gaps – Effects Assessment Research and Field Studies
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Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.09.06	Wildlife			
	Information gaps and needs addressed in other categories.			
R05.11.06	Air Quality, Climate, and Noise			
	Information gaps and needs addressed in other categories.			
R05.12.06	Socio-economic			
	No specific effects characterization research gaps were identified by the Socio-economic team. The inadequacy of current descriptions of baseline conditions precludes identification of specific socio-economic research gaps for associated effects assessment. General descriptions of expected activities are provided in the report.			

^a Importance: 1=Critical – must do; 2=Ideal; 3=Minor – nice to have but not necessary

Notes:

- DFO = Department of Fisheries and Oceans Canada
- K = hydraulic conductivity
- PMP = probable maximum precipitation
- TRV = toxicity reference value

TABLE C-4
Regulatory Gaps – Effects Analysis and Interpretation
Gap Assessment Report, Faro Mine Remediation Project – Appendix C

Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.02.03	Hydrogeology			
R05.02.03a	Conduct impact assessment for both construction and long-term operational phases.	Either need to definitively predict impacts during closure phase or, if not possible due to uncertainties associated with future conditions, must explain how effects will be mitigated by providing clear link between AMP and monitoring (e.g., “if we see this type of change at this location, we will do this” to mitigate impacts).	1	Use numerical tools to forecast potential impacts to groundwater resources due to operation of the remedial systems. Also forecast effects on closely related physical systems, such as surface water flows.
R05.03.05	Hydrology			
R05.03.05a	Develop site-wide hydrologic model.	This is a critical, predictive tool that provides potential impacts and can be used to examine mitigation approaches.	1 (for engineering, but for the YESAB requirements, it would be a 2)	Build model based on the collective existing data set and new monitoring data. This effort is included in the engineering gaps and not estimated here.
R05.04.06	Surface Water Quality and Aquatic Ecosystem			
R05.04.06a	Develop site-wide water quality model for key contaminants (e.g., sulphate, zinc, cadmium, nitrate) to predict future surface water concentrations.	IPRP concluded that water quality predictions by Gomm, which served as the basis for the human health and ecological risk assessment (SENES) and an evaluation of impacts specific to Cd, Zn, and SO ₄ , were too conservative (over-predicted concentrations). Serves to highlight priority areas for greatest monitoring/mitigation/remediation attention. Unifies all disciplines into one tool with which the implications of closure plan modification can be followed through to all affected areas.	1	Geochemistry team to develop plan and budget Include both groundwater and surface contributions. Calibrate to current conditions, and use to predict future water quality (use site-wide model that incorporates groundwater and surface water contributions). Predict max and average receiving water concentrations for: (a) construction phase; (b) 10 years post-closure, (c) long-term (100+ years), including seasonal concentration patterns (e.g., winter base-flow versus freshet versus late summer).
R05.04.06b	Determine construction impacts on aquatic environment.	Need to predict potential impacts during closure phase and planned mitigation/control.	1	Determine if construction impacts can be reasonably predicted (e.g., potentially use site-wide water quality model to predict construction impacts under different scenarios of construction sequencing) and/or update AMP to provide clearer link between monitoring and action triggers.
R05.04.06c	Conduct aquatic impact assessment for closure.	Impact assessment must be based on realistic water quality predictions and, if any impacts predicted, need to be specific about where, when, and what species affected.	1	Base on revised WQ predictions, elaborating on outcome of aquatic portion of the HHERA.
R05.06.07	Fish Habitat Compensation			
R05.06.07a	Determine the quantity and quality of habitat that will be affected by modification of the RCDC, removal of the Haul Road rock drain, or other activities on a project timeline basis, and identify compensation measures.	This information is required to ensure that there has been sufficient compensation for any impacts to fish and fish habitat.	1	Determine fish habitat affected and development of strategies to compensate for project impacts on fish and fish habitat. This will require collaboration with other groups as necessary.
R05.10.07	Human Health and Ecological Risk Assessment			
R05.10.07a	Revise GoldSim modelling and predicted surface water COPC concentrations.	Risk assessment is dependent on this data	1	Revise GoldSim modelling.
R05.10.07b	Revise exposure models and uptake factors previously used, and reassess risks.	This is the basis for the assessment of risks for many receptors.	1	Conduct further review and updating of risk assessment.
R05.10.07c	Estimate quantity and quality of fugitive dust emissions.	This is an exposure pathway that has not been well assessed during the mid- and long-term project timelines.	1	Conduct further assessment/modelling by the air quality team.

TABLE C-4
Regulatory Gaps – Effects Analysis and Interpretation
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Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.07.07	Terrain, Geology, Geological Hazards, and Seismicity			
R05.07.07a	Assess net change to terrain units as a result of proposed reclamation activities.	Quantify natural landforms/terrain units that will be impacted by construction activities and new landforms created by mine reclamation activities to assess overall effects after considering mitigation.	1	Superimpose proposed details of mine reclamation activities, including borrow areas excavated, landforms developed, and other areas otherwise impacted. Assess the potential change in the permafrost conditions at each site. Quantify areas of each affected polygon in a GIS database, and assess net effects.
R05.08.07	Vegetation and Reclamation			
R05.08.07a	Make reclamation landscape planning a key objective of habitat suitability modelling. Then integrate habitat areas as key feature of closure landscape.	Quantifiable objectives for the closure landscape with respect to wildlife habitat and forest resources are currently missing. We need to assess what is potentially possible/available onsite to inform the planning and then the effects of the project for the EA.	1	Work with Wildlife section to define appropriate wildlife habitat goals for the closure landscape, and include in integrated closure planning process.
R05.08.07b	Update water quality modelling to take into account inputs that may have not been present in the closure landscape assessment to date.	Inputs from construction period sedimentation and seepage, and dispersed seepage areas not collected in the water treatment system need to be modelled and included in effects assessment.	1	Work with surface water quality section to reflect updated inputs to modelling in the vegetation effects assessment.
R05.09.06	Wildlife			
R05.09.06a	Avian Species At Risk (SAR) Gather data regarding the habitat availability and potential habitat losses and creation for the two primary avian SAR that could occur at the site: Olive Sided Flycatcher and Rusty Blackbird.	Habitat suitability modelling for two key avian SAR will help to describe effects of the project quantitatively. Relatively few species-at-risk occur at the site; however, it is advisable to consider those SAR that do potentially occur on the site. Also, we may see new legislation preventing the destruction of habitat of such SAR in the Yukon within the life of this project. A number of YESAA assessments have recently quantified potential impacts on these two avian species-at-risk. <i>S. 6.2.1.3/4.1.9 Describe any special management requirements for threatened endangered species (YESAB Proponent’s Guide)</i>	1	Desktop habitat suitability modelling is proposed. This modelling will use existing ecosystem land classification data to provide data on current habitat suitability for these species, and also on anticipated habitat losses or gains for these species over the life of the project.
R05.09.06b	Water birds/Waterfowl Gather updated information on the predicted water quality, sediment quality, and biota during and post-reclamation.	Updated information on the predicted water quality, sediment quality, and biota during and post-reclamation in the pits and ponds is needed to determine potential effects on waterfowl and water birds over time at the site.	1	Update water quality models and predictions of the water quality in pits and ponds over time (during closure and post-closure). Conduct modelling to predict associated sediment and biota contaminant levels, and evaluate effects and risks for waterfowl associated with closure and post-closure onsite aquatic habitat.
R05.09.06c	Grizzly Bear Gather data and conduct habitat modelling regarding the current habitat suitability of the site for feeding, and the projected habitat suitability at the site during and post-closure.	Grizzly bears are a federally recognized species-at-risk that are known to occur at the Faro Mine site. The availability of suitable feeding habitat will likely influence the amount of time spent by grizzly bears in the mine area over time; thereby, the potential for interactions between humans and bears (e.g., mortality due to interactions, increases or decreases in habitat availability, etc.). <i>S. 4.1.9 (YESAB Proponent’s Guide)</i>	2	Conduct habitat suitability modelling based on existing vegetation baseline data and landform data, combined with projected changes and proposed vegetation cover for reclamation.
R05.09.06d	Modelling for habitat effects – based on closure objectives – additional VCs. Develop data to quantify changes in wildlife habitat over time for species such as moose, caribou, and furbearers.	Habitat suitability modelling will provide quantitative data on anticipated changes in habitat availability at the Faro Mine site over time, based on habitat objectives for the site. This data will help to support the effects assessment portion of the Project Proposal.	2	Conduct based on existing vegetation baseline data and landform data, combined with projected changes and proposed vegetation cover for reclamation.

TABLE C-4
Regulatory Gaps – Effects Analysis and Interpretation
Gap Assessment Report, Faro Mine Remediation Project – Appendix C

Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.11.07	Air Quality, Climate, and Noise			
R05.11.07a	Clarify emissions inventory regarding what sources are included and what processes are included under which source. Conduct detailed characterization in conjunction with modelling to estimate project effects on air quality. Conduct emission estimates of NOx, SO ₂ , CO, and VOCs. Conduct a comprehensive modelling study.	Presented emissions inventory (Section 8.2.3 of the Draft C&R Plan is somewhat confusing and needs clarification regarding the sources included, and how emissions were derived. Insufficient detail is provided in the draft assessment to follow the logic, and many assumptions are used in the calculations. Dust resuspension and dispersion of metals does not seem to be specific to a particular set of sources, rather is grouped generally under any source-emitting PM. The emissions dealt only with PM emissions, and emissions need to be developed to include metals. Some PM is contaminated with metals and some are not, and these distinctions need to be reflected in the emissions inventory. Also, only annual emissions were derived, perhaps worst-case, 24-hr emissions, as well, should be estimated to better compare to applicable standards. Development of a robust emissions inventory including metals is necessary for study support. Detailed emissions inventory required to fulfill YESAB guideline on project impact assessment according to Section 6.2.1.7 of YESAB Proponent’s Guide. Criteria air contaminants (CACs) have been largely ignored and may affect secondary particulate formation and perhaps ozone generation within LSA and RSA. Table 8.3 of the Project Proposal states CACs are an environmental indicator, but no mention is made of baseline concentrations or expected impacts. These data would be used in conjunction with air dispersion modelling to characterize current ambient conditions and closure impacts of these CACs according to YESAB guidelines. A comprehensive air quality model is usually presented to assess effects, and this was specifically asked for by YESAB in October 2011 in the Eagle Gold Project Proposal review. The assessment is required to augment risk assessment evaluations (i.e., augment deficiencies in monitored data; required to quantify compliance or degree and frequency of noncompliance with appropriate standards/guidelines). The modelling study can help address effects on both local and regional study areas as opposed to monitoring, which addresses mostly the LSA. Can be used to proactively estimate effects of closure activities and add guidance on locations of preferred areas for mitigation. Can also help guide focus of monitoring plans. Can help proactively predict effects of changes to equipment use, duration of use, haulage rates, and various activities associated with closure. Effects assessments would be done using similar emission factors, as appropriate, modelling, and methodology as the baseline study, providing a good comparison between baseline and closure impacts.	1	Gather data, and do a quality assurance (QA) check of previous emissions data; identify activity and timing planned for various areas for current operations and during closure. This study will need to identify all phases of the closure operations that could affect emissions, such as material movement, grading operations, removal or alteration of current sources, and so forth. Identify metals content for various areas where dust is expected to become airborne. Gather available data on particle size distribution and other physical characteristics of soils, fill, and other dust sources. Gather wind speed and precipitation data to identify frequency of wind erosion events from open piles. Gather traffic data for dust resuspension calculations. Gather appropriate emission factors for various activities from recognized sources, and refine and expand (to metals and other COCs according to discussions with risk assessors) the emissions estimates to be used in conjunction with modelling. Gather list of equipment to be used for C&R Plan, including generators, graders, and so forth. Gather appropriate emissions factors for various pieces of equipment and expected usage, fuel characteristics, and timing of equipment. Refine and expand the emissions to other CACs and averaging periods for a more complete assessment of possible project impacts. The modelling task requires prior development of robust emissions inventory. Requires definition of LSA and RSA, as well as possible sensitive receptors in the near- and far-field. Gather background concentrations, and gather and develop data for various input files (emissions, meteorology, terrain, land use, etc). Modelling required for baseline conditions and closure activities for specific, impacted years. Modelling exercise needs to be consistent with activities associated with the latest version of C&R Plan and anticipated schedule. Multiple scenarios and time periods may be necessary if some uncertainty exists in the schedule or plan implementation according to various scenarios developed in the emissions inventory. Deposition modelling of metals will be required to assess short-term and long-term transport of metals for feedback to HHERA. This modelling will entail identification of various phases of similar emissions throughout the closure, and aggregation of the predicted deposition over each of the phases.
R05.11.07b	Update previous noise study (Senes, 2009), which was based on early version of C&R Plan (Gomm Review 2010) and may not be reflective of actual C&R Plan impacts as they currently exist.	The noise effects assessment should be based on current information; therefore, it should reflect the most current version of the C&R Plan, such as equipment, activity data, and noise estimates according to Section 6.2.1.6. of the YESAB Proponent’s Guide.	2	Conduct gap analysis of changes between the most up-to-date version of the C&R Plan with the specific features of the C&R Plan used by Senes. Assign noise-power levels to equipment based on previous studies or other similar equipment from various databases or manufacturer's specifications. Develop input files for noise propagation modelling using CADNA/A to include significant changes, as well as all other sources. Develop worst-case noise-emission scenarios for assessment, which will require consideration of scenarios for several years or phases of the closure period.

TABLE C-4
Regulatory Gaps – Effects Analysis and Interpretation
Gap Assessment Report, Faro Mine Remediation Project – Appendix C

Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.12.06	Socio-economic			
	Conduct impact prediction and analysis (assumptions, direct, indirect, and induced effects), as well as impact analysis.	Evaluation of potential socio-economic effects is a key component of a YESAA assessment and Project Proposal.	1	Analyze interactions between existing conditions in communities and First Nations with the proposed project (e.g., economic analysis).

^aImportance: 1=Critical – must do; 2=Ideal; 3=Minor – nice to have but not necessary

Notes:

- CO = carbon monoxide
- COPC = contaminant of potential concern
- hr = hour
- NO_x = nitrogen oxides
- QA = quality assurance
- SAR = species at risk
- SO₄ = sulphate
- VOC = volatile organic compound
- WQ = water quality
- YESAA = Yukon Environmental and Socio-economic Assessment Act

TABLE C-5
Regulatory Gaps – Mitigation, Adaptive Management and Monitoring Plans
Gap Assessment Report, Faro Mine Remediation Project – Appendix C

Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.02.05	Hydrogeology			
R05.02.05a	Provide clear definition and description of an overall groundwater management plan – complete with strategies for refinement of the monitoring network and frequency as the site matures.	An overall site-wide groundwater monitoring plan is a necessity if all the various groundwater issues, remedial actions, impacts, and related technical interactions are to be considered in conjunction with other discipline areas, such as surface water, geotechnical, geochemistry, aquatics, terrestrial, wetlands, and socio-economic.	1	Use the information developed from the baseline and assessment technical studies described above to write a comprehensive monitoring plan based on what is currently known, along with a clear set of objectives defining preferred management strategies for the future.
R05.02.05b	Update AMP as appropriate and link more specifically to monitoring.	Existing plan is fairly complete but may need to be updated if there are any changes to the proposed treatment, water diversions, and groundwater capture.	1	Update as engineering plan indicates changes relative to previous plan. For each individual AMP, show affected area on a map, along with applicable monitoring stations. Stations should be clearly identified by type (surface, groundwater, seep, pit, treatment, etc.) and relative to mine works (source, perimeter, and receiving environment) with monitoring requirements geared accordingly.
R05.02.05c	Develop construction monitoring plan.	Required element of Project Proposal.	1	Specify how monitoring will be adapted during construction, and explain how monitoring feeds into AMP.
R05.02.05d	Develop post-closure monitoring plan.	Required element of Project Proposal.	1	Specify how monitoring will be adapted during post-closure, and explain how monitoring feeds into AMP.
R05.03.06	Hydrology			
R05.03.06a	Provide clear definition and description of an overall surface water management plan that includes mitigation of impacts.	An overall site-wide plan is a necessity if all the various surface water issues, solutions, and impacts, as well as related technical components, are to be considered in relation to other discipline areas of groundwater, geotechnical, geochemistry, aquatics, terrestrial, wetlands, and socio-economic.	1 (Directly related to YESAB 7.4)	Combine the efforts of previous studies to write an overall plan based on what is known and objectives defined earlier.
R05.03.06b	Define specific performance thresholds for each critical variable in the surface water diversions plan. Critical components include bank erosion, bed scour and deposition, water surface elevations in critical aquatic, wetland habitat areas, and water supply under base-flow conditions to support habitat areas.	This will enable interpretation of triggers and mitigation steps taken. It provides the overall management plan basis for the entire site into the future.	1 (Directly related to YESAB 6.6)	Actual development of the AMP. The triggers are discussed in other areas in the gaps analysis. This effort is to develop the actual AMP that ties them all together. Since hydrology was not considered a VC in the Project Proposal, this is anticipated to be considerable effort.
R05.04.08	Surface Water Quality and Aquatic Ecosystem			
	Develop construction monitoring plan.	Required element of Project Proposal.	1	Need to develop source area monitoring program, perimeter monitoring program, and potentially update aquatic effects monitoring program to deal with potential changes in loads/concentrations and associated aquatic impacts during construction. Monitoring stations, variables, and sampling frequencies need to be rationalized. Specify how monitoring will be adapted during construction, and explain how monitoring feeds into AMP. Necessitates combined input from various disciplines.
R05.04.08a	Update adaptive management plans.	Existing AMPs are fairly complete but need to be updated based on any changes to planned treatment, water diversions, and groundwater capture. Also, AMPs would benefit by describing potential construction effects (aquatic impacts), associated monitoring locations and variables, and decision/action trees (e.g., “if we see this type of change at this location, we will do this” to mitigate impacts).	1	Update as closure plan is modified or developed relative to previous. For each individual AMP, show affected area on a map, along with applicable monitoring stations. Stations should be clearly identified by type (surface, groundwater, seep, pit, treatment, etc.) and relative to mine works (source, perimeter, and receiving environment) with monitoring requirements geared accordingly.
R05.04.09a	Develop post-closure monitoring plan.	Required element of Project Proposal.	1	Largely completed for receiving environment but may need minor updating. Scope and budget for development of source area and perimeter monitoring programs is provided above.

TABLE C-5
Regulatory Gaps – Mitigation, Adaptive Management and Monitoring Plans
Gap Assessment Report, Faro Mine Remediation Project – Appendix C

Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.06.09 Fish Habitat Compensation				
R05.06.09a	Identify appropriate mitigation strategies to be employed during construction and post-construction to minimize effects on fish and fish habitat.	Mitigation strategies will vary depending on project schedule and are required to minimize environmental effects. These will have to be incorporated into the Fisheries Act Authorization process.	1	Consult with the surface water quality and diversion technical focus teams, as well as others, to develop mitigative strategies based on project activities and timing.
R05.06.09b	Supply sufficient information to prepare a Fisheries Habitat Compensation Plan and as material for a Letter of Advice that will be required to support a <i>Fisheries Act Authorization</i> for the project.	A Fisheries Habitat Compensation Plan and possibly a Letter of Advice will be required by DFO to address project impacts with respect to creek realignments, installation of a fish-bypass structure, etc.	1	Develop a Fisheries Compensation Plan and/or material for a Letter of Advice using the information from Chapter 4 of the Draft Project Proposal on fish and fish habitat and in working with the surface water quality and diversion teams. The Fish Habitat Compensation Plan will have to be prepared in consultation with, and must satisfy the requirements of, all regulators and stakeholders.
R05.06.09c	An AMP is not required specifically for the Fisheries Compensation Plan but specific input will need to be provided to the AMPs of the surface water quality team and other disciplines.		1	
R05.06.10a	Develop monitoring plans.	Monitoring plans are required to be developed to ensure that the compensation measures are functioning as designed and required.	1	Develop monitoring plans for the compensation measures.
R05.10.09	Human Health and Ecological Risk Assessment			
R05.10.09a	Develop mitigation plans, including the ones listed, to address potential effects on all site media (e.g., soil, groundwater, surface water, and dust).	This affects the RA because the determination of risk will be based on the predicted concentrations of site media. Mitigation will be required to reduce environmental conditions to acceptable levels.	1	Combine the efforts of previous studies, and consult with all groups to write plans based on what is known and with clear end-use objectives defined.
R05.10.09b	Develop mitigation plans for each receptor group, including vegetation, fish and fish habitat, and wildlife.	If and how mitigation is applied, may affect how those groups use the site, which will affect how risk is assessed.	1	Combine the efforts of previous studies, and consult with all groups to write plans based on what is known and with clear end-use objectives defined.
R05.10.09c	Develop mitigation plans on a project timeline basis.	Different mitigation will be required during construction than during the post-construction period; for example, fish and fish habitat.	1	Combine the efforts of previous studies, and consult with all groups to write plans based on what is known and with clear end-use objectives defined.
R05.10.09d	An AMP is not required specifically for the HHERA but specific input will need to be provided to the AMPs of the surface water quality team and other disciplines.	Adaptive management during and following construction will be key to ensuring there are no unacceptable, adverse, environmental effects.	1	Input to other groups will be required for development of the plans.
R05.10.09e	Conduct monitoring – None specific to the risk assessment but will be for other disciplines	Monitoring will be key to ensuring successful project design and implementation, as well as to ensure that there are no unacceptable, adverse, environmental effects.	1	Input to other groups may be required for development of the plans.
R05.07.09	Terrain, Geology, Geological Hazards, and Seismicity			
R05.07.09a	Provide input to construction (borrow) materials management plan.	Quaternary mapping will be used as a guide for borrow source identification, to be confirmed by engineering needs. Borrow materials may encounter permafrost. Thawing of the permafrost may result in instability, erosion, and water-quality impacts.	2	The terrain assessment will identify potential source areas and potential periglacial terrain units possibly containing ground ice, and thaw-susceptible and problematic soils. The permafrost distribution model will identify potential areas where permafrost may exist.
R05.07.09b	Provide input to water management plan.	Water management structures should be designed to be compatible with the ambient soils and terrain conditions, as well as take into account possible disturbances by geohazards.	2	Coordinate with engineering to ensure that design criteria take into account terrain and geohazard issues.
R05.07.09c	Provide input to EPP. (Note: May need separate permafrost protection plan based on future disturbances and climate change impacts to natural areas.)	The EPP provides guidance for the protection measures required during the construction phase of the reclamation and mitigation program. Permafrost and its related attribute (e.g., vegetation cover) will change in the future due to climate change. Important to note potential site impacts in context of overall site permafrost changes.	2	Identify and develop environmental protection measures based on site-specific designs prepared by engineering.

TABLE C-5
Regulatory Gaps – Mitigation, Adaptive Management and Monitoring Plans
Gap Assessment Report, Faro Mine Remediation Project – Appendix C

Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.07.09d	Set up framework for development of AMPs to address potential climate change effects, potential geohazards, and extreme events.	Climate change effects may result in permafrost degradation, changes in precipitation patterns, and changes in overall site water balance. Geohazards, such as avalanches and debris flows, may block water management structures. Critical structures need to be inspected following seismic events which affect the project area.	2	Using baseline geohazard, terrain, and seismology data, review risks associated with closed mine components. Develop AMPs as required.
R05.07.09e	Develop construction monitoring plan.	Required element of Project Proposal.	1	Coordinate with engineering regarding structure details and site-specific conditions. Specify how monitoring will be adapted during construction, and explain how monitoring feeds into AMP.
R05.07.09f	Develop post-closure monitoring plan.	Required element of Project Proposal.	1	To be developed in further detail based on issues and concerns arising during construction.
R05.08.09	Vegetation and Reclamation			
R05.08.09a	Ensure closure plan shows consistency with Wildlife, Forest Management, and Resource Management Plans – currently, closure objectives are only loosely related (Source: Section 3.5 YESAB Proponent's Guide).	Requirement of proposal not overtly addressed in the closure plan. Need to assess completeness of current plans and changes recommended in EA process, and ensure that they are addressed in closure plan.	1	Reassess closure plan objectives; add reference to these plans as part of assessment documentation.
R05.08.09b	Assess compensatory works for fish habitat, stream restoration, or other habitat compensation.	Compensatory works need to be considered as part of the scope and cost of closure landscape planning. Locations of compensation work need to be identified and agreed upon, as does the method to determine the value of areas to be compensated for and measure of compensation. This scope does not appear to have been addressed in the planning to date.	1	Discuss with YG, appropriate federal bodies (DFO), and YESAB, and ascertain scope of compensation activities. May need to scope design of compensation works, but cannot likely be completed as part of proposal work.
R05.08.09c	Develop dust and sediment management plans which will be central to covers planning, revegetation planning, and wetlands planning in the closure landscape.	Dust and sediment pose a large risk to downwind/downstream areas, and to collection points on the landscape. The management plans need to be aligned with the EA mitigation and adaptive management plans.	1	Review closure landscape for wet landscape features, which may change the outcome of the EA for vegetation, wildlife, water quality, and hydrology sections with respect to sediment capture. Dust control mitigation plans are captured already under the Air Quality discipline.
R05.08.09d	Review Chapter 13 of the Draft Project Proposal adaptive management plans and thresholds for feasibility and applicability to reclamation work and closure plan.	Current adaptive management plan has plenty of content, but need to review and optimize recommended thresholds and mitigating actions based on integrated hydrology, wildlife, fisheries, WQ, and vegetation planning – not as separate disciplines.	1	Review current adaptive management plans, and rework content.
R05.08.11a	Update monitoring plans for vegetation. Need to understand “end point” of monitoring process, besides adaptive management, to define scope of monitoring programs.	The monitoring plan portion in Chapter 8 of the Draft Project Proposal must be rewritten based on new VC selections and new baseline information. Closure landscape changes will need to be evaluated in monitoring plans.	1	Revisit proposal sections and revise based on new information and strategies.
R05.09.08	Wildlife			
R05.09.08a	Develop a wildlife management plan.	A wildlife management plan will be required to outline how some mitigation measures will be implemented and to describe monitoring efforts and adaptive management features. This plan will demonstrate the methods to be used for implementing mitigation measures during closure efforts.	1	Draft plan based on mitigation measures and site features, and include the adaptive management and monitoring components, as outlined in this section.
R05.09.09a	Develop the adaptive management portion of the wildlife management plan.	Adaptive management components are to be included in the wildlife management plan in instances where wildlife mitigations will require a feedback cycle and potential adjustments over the life of the project, depending on performance of mitigations in the field or other unforeseen conditions. This component of the management plan will establish adaptive management strategies based on effect triggers.	1	Include in this component work by a biologist (working with the project team and regulators) to develop adaptive management criteria and actions. This is anticipated to be required for Thinhorn sheep, waterfowl, and potentially grizzly bears.
R05.09.10a	Develop a wildlife monitoring plan.	The wildlife monitoring plan will be a component of the wildlife management plan that feeds into monitoring requirements and adaptive management. This is required to identify how ongoing monitoring is to be completed in the case that it is required onsite. Examples would include monitoring Thinhorn sheep and species-at-risk to feed into the adaptive management plans for site.	1	Develop management plan written by a project biologist. Assess specific values, and develop monitoring criteria tied to adaptive management criteria.

TABLE C-5
Regulatory Gaps – Mitigation, Adaptive Management and Monitoring Plans
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Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.11.09	Air Quality, Climate, and Noise			
R05.11.09a	Develop air-emissions-related action levels, an air monitoring program, and a Detailed Dust Control Plan for the environmental monitoring sections of the adaptive management plan.	Section 8.2.6 of the Draft Project Proposal says an air quality monitoring program will be developed, but no evidence of one was found. Further, the YESAB response to Eagle Gold, in Section 9, R27, states that details of an ambient air quality monitoring plan should be provided. Need a mechanism for determining effectiveness of dust reduction and prioritization to contaminated dust. Modelling (and weather) data to be used to help identify possible areas, time, and frequency of contamination.	1	Identify various components of the C&R Plan, with emphasis on dust-generating activities and further emphasis on metal-containing dust; much of the information would be gathered in the Emissions Inventory development task. Develop an air quality monitoring plan for closure, and develop a dust mitigation plan specific to the activity planned. For the adaptive management plan, identify trigger levels for specific contaminants (likely PM and metals), and identify appropriate actions to be taken in the event of trigger values being measured and feedback mechanisms for improvements of a dust control plan.
R05.12.08	Socio-economic			
R05.12.08a	Develop mitigation and enhancement planning document, LSA community input, and participation.	To document and ensure LSA community input and support of Mitigation and Enhancement Planning document.	1	Need to engage with communities in LSA to solicit advice and comments.
R05.12.08b	Gather public opinions, community aspirations, etc.	Essential for community support of plans.	1	Socio-economic communications plan for consultation and engagement – revised for various project stages. Need to engage with communities in LSA to solicit advice and comments during all project stages.

^a Importance: 1=Critical – must do; 2=Ideal; 3=Minor – nice to have but not necessary

Note:
EPP = environmental protection plan

TABLE C-6
Regulatory Gaps – Overarching Regulatory Gaps
Gap Assessment Report, Faro Mine Remediation Project – Appendix C

Activity Code	Data/Information Gap	Rationale	Importance ^a	Action Required to Address Gap
R05.12.05	Cumulative Effects Assessment	The Executive Committee is obliged to considered effects of the FMRP in combination with the effects of other projects and activities. Although not a statutory requirement, it is advisable as part of a Project Proposal to identify projects and activities with potential cumulative effects, and to characterize those effects.	1	1. Identify projects and activities that may affect the same VCs as the FMRP. 2. Compile information to characterize and predict effects of external projects and activities for consideration in combination with effects predicted for the FMRP.
R05.12.06	Heritage Assessment	YESAA requires consideration of socio-economic effects which includes culture and heritage resources. The Proponent’s Guide (YESAB, 2005), Section 6.2.1.4 describes requirements for addressing effects on heritage resources in a Project Proposal. Existing documentation does not address heritage resources. The need to identify heritage resources and address potential effects will be most critical for areas of new disturbance (e.g., borrow pits, areas affected by re-grading), but may also be important for areas of existing disturbance.	1	1. Completion of a desktop study to identify areas with high potential for heritage resources values. 2. Discussion with community members about potential resource values. 3. Field studies, if needed, to confirm heritage resource values. 4. Characterization of potential effects on heritage resources, and identification of appropriate mitigation measures.
R05.12.06	Characterization of Potential Global Climate Change	Global climate change could affect the performance of structures and facilities that are part of the FMRP. Designs will need to consider global climate change and the Project Proposal should address how the project will address uncertainties related to global climate change. Also, the Project Proposal must address how the environment will affect the project, with global climate change being one factor that requires consideration. Consistent climate change scenarios are needed to support engineering design, risk assessment and environmental assessment. Global climate change is particularly relevant for a project with a duration as long as the FMRP.	1	1. Development of consistent climate change scenarios for utilization in engineering design and effects assessment. 2. Evaluation of potential effects of global climate change on the FMRP. 3. Assessment of risks associated with global climate change.

Appendix D

AACE Cost Estimate Definitions

EXHIBIT B-1. *Classes of Cost Estimates, as Defined by the Association for the Advancement of Cost Engineering*

Estimate Class	Class 5		Class 4		Class 3		Class 2		Class 1	
Level of Project Definition (% of complete definition)	0% to 2%		1% to 15%		10% to 40%		30% to 70%		50% to 100%	
End Usage (typical use of estimate)	Concept Screening		Study or Feasibility		Budget Authorization/Control		Control or Bid/Tender		Check Estimate or Bid/Tender	
Methodology	Capacity Factored, Parametric Models, Judgment, or Analogy		Equipment Factored or Parametric Models		Semi-Detailed Unit Costs with Assembly Level Line Items		Detailed Unit Cost with Forced Detailed Take-off		Detailed Unit Cost with Detailed Take-Off	
Accuracy Range (L=Low, H = High)	L: -20% to -50%	H: +30% to +100%	L: -15% to -30%	H: +20% to +50%	L: -10% to -20%	H: +10% to +30%	L: -5% to -15%	H: +5% to +20%	L: -3% to -10%	H: +3% to +15%
Preparation Effort (relative to least cost index of 1)	1		2 to 4		3 to 10		4 to 20		5 to 100	
Refined Class Definition	Class 5 estimates are generally prepared based on very limited information, and subsequently have very wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systematic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with very little effort expended - sometimes requiring less than 1 hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation.		Class 4 estimates are generally prepared based on very limited information, and subsequently have very wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 15% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems and preliminary engineered process and utility equipment lists. Level of Project Definition Required: 1% to 15% of full project definition.		Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument diagrams, utility flow diagrams, preliminary piping and instrument diagrams, plot plan, developed layout drawings, and essentially complete engineering process and utility equipment lists. Level Of Project Definition Required: 10% to 40% of full project definition.		Class 2 estimates are generally prepared to form a detailed control baseline against which all project work is monitored in terms of cost and progress control. For contractors, this class of estimate is often used as the "bid" estimate to establish contract value. Typically, engineering is from 30% to 70% complete, and would comprise at a minimum the following: Process flow diagrams, utility flow diagrams, piping and instrument flow diagrams, heat and material balances, final plot plan, final layout drawings, complete engineered process and utility equipment lists, single line diagrams for electrical, electrical equipment and motor schedules, vendor quotations, detailed project execution plans, resourcing and work force plans, etc.		Class 1 estimates are generally prepared for discrete parts or sections of the total project rather than generating this level of detail for the entire project. The parts of the project estimated at this level of detail will typically be used by subcontractors for bids, or by owners for check estimates. The updated estimate is often referred to as the current control estimate and becomes the new baseline for cost/schedule control of the project. Class 1 estimates may be prepared for parts of the project to comprise a fair price estimate or bid check estimate to compare against a contractor's bid estimate, or to evaluate/dispute claims. Typically, engineering is from 50% to 100% complete, and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. Level for Project Definition Required: 50% to 100% of full project definition.	