Deloitte & Touche

# Anvil Range Mine Complex

## Closure Planning Workshop June 2003

Anvil Range Mining Corporation
(Interim Receivership)

October 2003

# Anvil Range Mine Complex

# Closure Planning Technical Workshop Report

Organized by the
**Type II Mines Project Office**
on June 24-26 2003

October 2003

Produced with the assistance of:

SRK Consulting
Engineers and Scientists

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# 1 Introduction

A workshop was held on June 24-25 2003 to identify and develop scopes for technical work related to planning the closure of the Anvil Range Mine Complex located in Faro Yukon. The workshop was organized by the Type II Mines Project Office and Deloitte & Touche Inc. (Deloitte & Touche Inc. was appointed Interim Receiver of Anvil Range by an order of the Ontario Court on April 21, 1998.)

The workshop was held at Yukon College, Whitehorse, Yukon. Invited participants are listed below, with those who attended indicated by an asterisk. All attendees were also invited to an additional working session held on June 26 2003, and about two-thirds of the group were able to attend.

| | |
|---|---|
| Anvil Range Mining Corp. | Dana Haggar* |
| Technical Consultant | Ron Nicholson (Stantec)* |
| Technical Consultant | Jim Cassie (BGC)* |
| Technical Consultant | John Brodie* |
| Technical Consultant | Milos Stepanek (Geo-Engineering Ltd.)* |
| Technical Consultant | Eric Denholm (GLL)* |
| Technical Consultant | Wim Veldman (Northwest Hydraulics)* |
| Technical Consultant | John Chapman (SRK)* |
| Technical Consultant | Daryl Hockley (SRK)* |
| Technical Consultant | Cam Scott (SRK)* |
| Deloitte & Touche Inc. | Valerie Chort* |
| Deloitte & Touche Inc. | Shannon Glenn* |
| Deloitte & Touche Inc. | Wes Treleaven* |
| Dept. of Fisheries and Oceans | Herb Klassen |
| Dept. of Fisheries and Oceans | Sandra Orban* |
| DIAND | Joanna Ankersmit (HQ)* |
| DIAND | Chris Cuddy (HQ)* |
| DIAND | Brett Hartshorne (Yukon Region)* |
| Environment Canada | Vic Enns* |
| Environment Canada | Benoit Godin |
| Environment Canada | Eric Soprovich* |
| Kaska Dena Council | Chairperson David Porter |
| Liard River First Nation | Chief Daniel Morris |
| Ross River Dena Council | Chief Jack Caesar (represented by Jason Acklack and George Smith)* |
| Selkirk First Nation | Chief Lucy McGinty (represented by Styde Klugie)* |
| Town of Faro | David Power* |
| Town of Faro | Mayor Mel Smith |
| Type II Mines Office | Hugh Copland (YTG)* |
| Type II Mines Office | Marg Crombie (YTG)* |
| Type II Mines Office | Bud McAlpine (DIAND)* |
| Type II Mines Office | Dave Sherstone (DIAND)* |

| | |
|---|---|
| Yukon Government | Lois Craig (EMR) |
| Yukon Government | Bill Dunn (EMR)* |
| Yukon Government | Leslie Gomm (ECO)* |
| Yukon Government | Rod Hill (EMR) |
| Yukon Government | Bryan Levia (Env) |
| Yukon Government | Bengt Pettersson (Env)* |
| Yukon Government | Bill Slater (Env)* |

# 2 Workshop Preliminaries

## 2.1 Welcoming address

On the morning of June 24, 2003, each participant introduced themselves. In the interest of creating a team environment, participants were requested to identify their areas of technical interest without reference to their organizational affiliation.

*Focus of the workshop is technical and is a component of the overall closure planning process*

Dave Sherstone then made introductory comments on behalf of the Type II Mines Project Office. A Type II Mines Project Office has been formed, which is currently small in size and directed by a Steering Committee. This committee is lead by the Deputy Minister of Energy Mines and Resources for YTG and the ADM, Northern Affairs Program for DIAND.

There is a need to know, by 2008, how the property will be abandoned. The objective for this workshop is to look for technical solutions relating to this challenge. It was cautioned that the overall management of the site is still uncertain and will evolve over time. The Type II Project Office is currently taking the lead on developing a Final Closure and Reclamation Plan, and this workshop was intended to contribute to that effort. The Type II Project Office is also responsible for consultation issues, but these will not be part of the workshop discussions. Currently, day-to-day management of the site and care and maintenance are the responsibility of the Interim Receiver.

## 2.2 Overview of Agenda

*Next steps for the tailings and the mine areas will be developed through group exercises.*

Following the introduction, the agenda for the workshop was reviewed. The first morning would include introductions and the development of concepts that would be used in the remainder of the workshop. Technical questions related to the tailings would be the focus of the first afternoon and technical questions related to the three mine areas would be examined in the morning of the second day. Identification of priorities for additional studies would be the focus of the second afternoon. The third day of the workshop was described as an 'overflow day' and as time to work on detailed scopes for any high priority investigations.

The detailed agenda was presented as follows:

Tuesday Morning – Getting Started

- Introductory comments
- Overview and Objectives
- Identifying possible closure methods
- Listing evaluation factors

Tuesday Afternoon – Tailings Area

- Methods
- Example Alternatives
- Evaluations to identify information needs
- Design of investigations/studies/etc.

Wednesday Morning – Mine Areas

- Methods
- Example Alternatives
- Evaluations to identify information needs
- Design of investigations/studies/etc.

Wednesday Afternoon – Next Steps

- Review of investigation designs
- Prioritizing investigations/studies/etc.
- Constructing network diagram

Thursday

- Overflow from Tuesday & Wednesday
- Detailed scopes of work for this year's investigations

## 2.3 Closure Planning Process

***Most closure "alternatives" require a combination of several " methods".***

Two definitions were proposed to facilitate communication:

- The term "methods" would be used to refer to individual steps in the process of closing a mine
- The term "alternatives" would be used to refer to a combination of methods necessary to complete the closure.

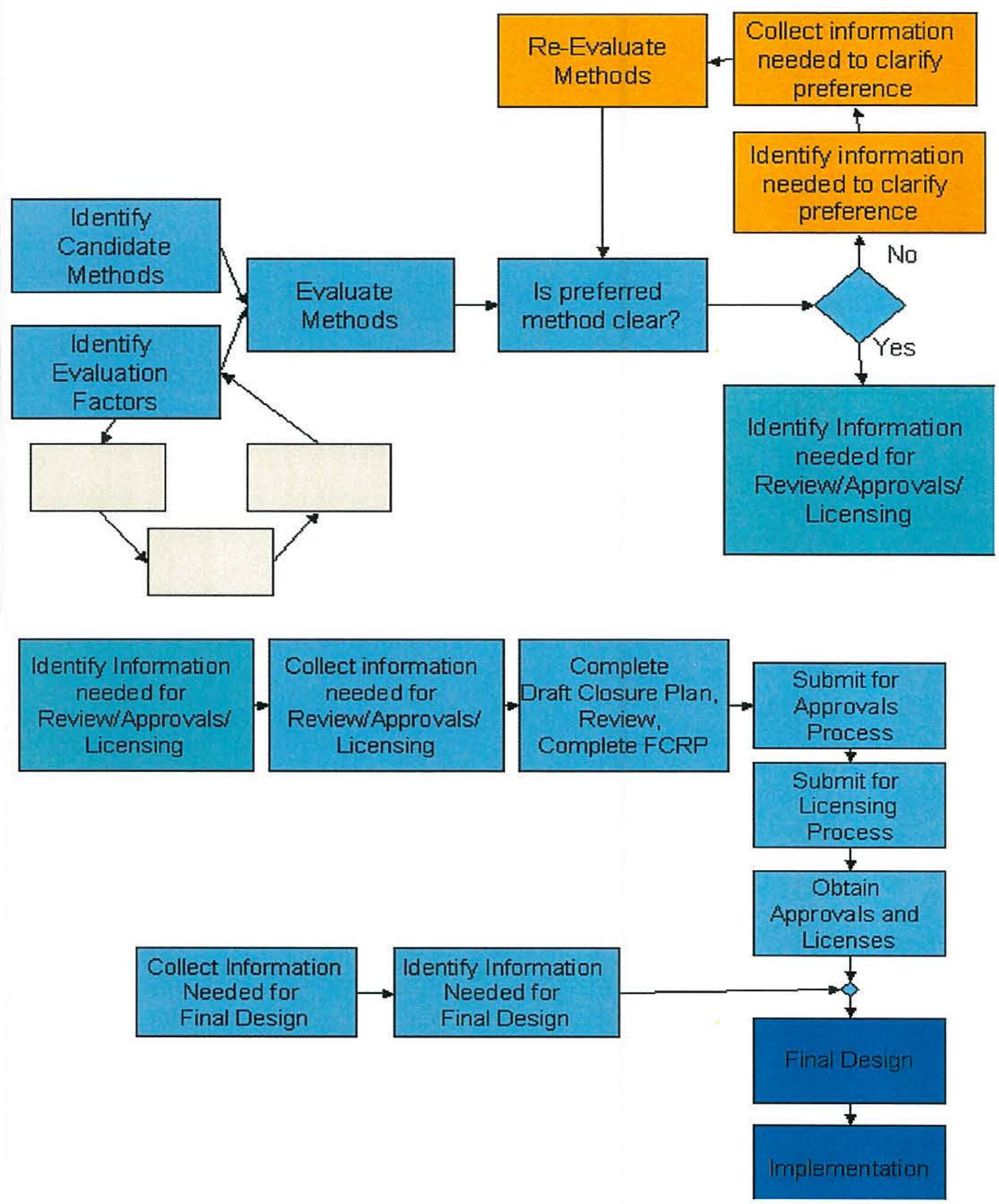
The generic closure planning process shown in the diagram below was reviewed. The starting point of the closure planning process is the identification of candidate methods and evaluation criteria. This, in turn, allows an initial evaluation of methods. In some cases, a clear preference will be identifiable. In other cases, the initial evaluation will result in identification of information gaps. Once the missing information is gathered, the candidate methods can be re-evaluated. This evaluation loop needs to be repeated until a complete closure alternative is selected. The workshop would focus on this loop.

The generic review and approval process shown in the second diagram below was also discussed briefly. The diagram is simplified, even with current legislation, and there could be many changes to this process as the new legislation comes into play. The diagrams were used to show how the outcomes of this workshop would fit into the bigger picture. The workshop would be one iteration in a long process, and there would be many opportunities for further input as the process moves forward, However, workshop participants were urged to get as many issues and methods as possible on the table now, to minimize the need to backtracking in subsequent iterations.

The first diagram also shows an iterative loop for the development of the "evaluation factors" by which closure methods would be selected. The identification of evaluation factors involves consultation with local stakeholders and regulatory agencies. That consultation process is one of the key objectives for the Type II Mines Project Office, but would not be a major theme of this workshop.

***Evaluation factors will be determined in a process other than this workshop***

The point was raised that the regulatory requirements and the existing licence contain evaluation factors, which should either override other factors or provide a minimum standard. The response was that individuals are likely to have different sets of evaluation factors that they consider to be over-riding, and that workshop participants would have the opportunity to develop a list of example evaluation factors later in the workshop.



## 2.4 Group Thinking Methods

*Thinking styles can be convergent or divergent. Both styles would be used during the workshop.*

Two thinking styles were reviewed. "Divergent" thinking is wide open, free-wheeling and creative. "Convergent" thinking is analytical, considered and accurate. Both types of thinking are needed in mine closure planning. Two examples from projects elsewhere were reviewed to illustrate how divergent thinking can lead to identification of new mine closure methods, and convergent thinking can allow them to be efficiently implemented.

The use of "mind mapping" as a divergent thinking tool was introduced and participants were asked to complete an introductory mind mapping exercise. The individual mind maps were reviewed. Participants were asked to observe how single "dominant thoughts" could get in the way of creative thinking. The use of branches of the mind-map was suggested as a means to record dominant thoughts, and then allow the mind to move on to other ideas.

*To practice group mind-mapping, elements of the property were defined and closure methods for each were identified.*

The application of mind mapping in group thinking was then explained, and the group worked through an example. The elements of the Rose Creek, Faro and Grum/Vangorda areas were defined and group mind-maps were created to identify candidate closure methods for each. The elements within each area were:

- Rose Creek Area: tailings solids, tailings water, original and secondary dams, Intermediate Dam, Cross Valley dam, Rose Creek diversion and North Wall Interceptor ditch.
- Faro Mine Area: waste dumps, water treatment system, main pit, zone 2 pit, Faro creek diversion, North Wall Interceptor ditch, haul road and rock drain, mill building, ore stockpiles.
- Vangorda Mine Area: Vangorda flume, pit, waste dumps, barite dumps (similar to oxide fines), in-pit waste dumps, till stockpile and Little Creek Dam.
- Grum Mine Area: Grum pit, overburden dump, main dump, Southwest Dump, haul road, water treatment system, ore transfer pad, sheep pad sediment ponds.

Two groups of the technical consultants were then asked to organize the lists of closure methods. The results of their work are described in Section 3.

## 2.5 Example Evaluation Factors

*Evaluation factors help decide what needs to be investigated and the review of closure plans. The identification of evaluation factors is not the focus of the technical workshop.*

Although the final evaluation factors for the project will be identified through the consultation process being initiated by the Type II Mines Project Office, a set of example evaluation factors was needed for the purposes of subsequent steps in the workshop. After the technical consultants had left the room, the remaining participants developed a list of example evaluation factors.

First, a slide reviewing the role of evaluation factors was presented:

Important role in making decisions about what needs to be investigated

- Guides technical thinking to key issues
- Much broader than "design criteria"

Generally subject of lengthy consultation

- Type II Project Team and stakeholders
- But these will develop as project proceeds

Today's example evaluation factors are for this workshop only

*Examples of evaluation factors used on other projects*

Then, examples of evaluation factors developed for other projects were presented:

WISMUT project (Germany):

- Cost: alternative cost, water treatment, land value
- Risk: human health, worker health, institutional risk
- Acceptance: local public, regulatory agencies, funding agency

Giant Mine (NWT):

- Short/long term risk of arsenic release
- Human health
- Cost

Colomac (NWT):

- Environmental protection
- Human health and safety
- Dogrib acceptance
- Other public acceptance
- Cost
- Long-term effectiveness
- Permitting schedule
- Implementation schedule
- Technical certainty
- Corporate (DIAND) objectives

Each participant was then asked to imagine receiving a freshly printed copy of a "Final Closure and Reclamation Plan" for the Anvil Range complex. The participants were asked what they would be looking for when they first opened the document. An example was given that some people would turn immediately to the section on costs. Each person was then asked to make a mind map listing the things that they would be looking for in the completed plan.

The mind maps were then circulated around each table and discussed. Each table was also asked to identify 'drop-dead factors' which, if not met, would make the plan unacceptable.

Each table then contributed suggestions to a consolidated list of example evaluation factors. The table on the following page show the consolidated list.

| Example Evaluation Factor | Working Definition |
|---|---|
| Technical certainty | Appropriate design criteria and level of conservatism<br>Availability of contingencies and monitoring |
| Human Health | First Nation, public and worker health and safety<br>Acute and chronic<br>Commensurate with established guidelines, best-practices or acceptable risk levels |
| Ecological | Protect ecosystem health and integrity<br>Based on existing license, CCME, established guidelines, best practices, and/or a risk assessment approach<br>Incorporates Traditional Knowledge<br>Protection of wildlife population integrity<br>Protection of traditional food sources |
| Government acceptance | Compliance with Federal, Yukon, First Nations and Municipal laws<br>Meets the requirements of the DTA, meets regulatory obligations, meets financial and policy requirements, meets long-term minimum risk/cost goals<br>Meets regulatory obligations<br>Meets financial and policy requirements<br>Meets long-term minimum-risk and minimum-cost goals |
| First Nations acceptance | |
| Community acceptance | Broad Yukon public, Chamber of Commerce and Mines, businesses, contractors, NGO's, local community |
| Maximize local and economic social benefits | Local is Faro/Ross River; employment, capacity building, schools, services, infrastructure for the workforce, long term employment |
| Cost | Comprehensive and accurate cost with appropriate contingency (cost certainty)<br>Cost above minimum are justifiable on basis of human health, ecological risk and/or economic and social benefits<br>Sunk cost vs. liability reduction<br>Balance of short and long term costs, capital investments and long-term costs |

# 3 Identification of Methods and Uncertainties

The workshop then began the process of examining the closure methods that could be applied at each area of the site, and identifying key technical uncertainties. The areas were grouped as follows:

- Rose Creek Tailings Area (Tuesday afternoon)
- Faro Mine Area (Wednesday morning)
- Vangorda/Grum Mine Areas (Wednesday morning)

For each area, methods that had been identified during the earlier exercise (Section 2.4) were first reported back to the workshop. A limited number of alternatives were then selected and groups were asked to develop very rough "designs". The designs were then presented to the workshop and discussed. The key technical uncertainties associated with each design were identified and recorded.

The results are presented in the following sections.

## 3.1 Rose Creek Tailings Area

### 3.1.1 Identification of Methods

Jim Cassie presented the collated list of candidate methods for closure of the Rose Creek Tailings area.

*Methods identified for the tailings area were reviewed.*

**Methods for Tailings Solids**

Relocate to Faro Pit

- All or Partial
- Hydraulic,
- Slurry
- Dredge
- Drag Line
- Truck and Shovel,
- Conveyor

Cover

- All (cover as is or re-contoured)
- Partial
- Status Quo of present system
- Soil
- Geo-synthetics
- Water
- Combination
- Iron Oxide

External Re-processing (metal value +/- chemical alteration of tailings)

- All or Partial
- Faro Pit,
- Down Valley or
- other location

*In-situ* treatment (and/or processing)

- All or Partial

- Leaching
- Neutralizing
- Permafrost Aggradation (Stabilization)

**Methods for Tailings Dams**
Upgrade
Remove/Breach
Enlarge (similar to upgrade)
Leave as is

**Methods for Clean Water Diversions**
Upgrade
Remove
Relocate

**Methods for Water Treatment**
Surface water, Groundwater, and/or porewater
- Status Quo – in plant
- Wetland Treatment
- In-pit treatment
- Passive Barriers for groundwater
- Collect/Treat groundwater
- New Water Treatment Plant
- Nutrient Addition
- Sludge Management

### 3.1.2 Development of Example Alternatives

***Themes were selected for further evaluation.***

It would be necessary to combine several of the above methods to develop a complete closure alternative for the Rose Creek tailings. However, it was recognized that, if one were to first choose the method to be applied to the tailings solids, most of the other methods would either be a necessary add-on or one of several options for ancillary structures. The candidate methods for tailings solids were then discussed and the following consolidated list was developed:
- Relocate to Faro Pit
- Cover
- Leave as is
- Relocate/cover/leave-as-is Combination
- Other *in situ* containment
- Chemical stabilization
- Reprocessing
- Water cover
- Relocate as dry tailings

Four "example alternatives" were then selected for further discussion. The selection at this point was not meant to exclude other possibilities, only to cover a wide range so that key technical uncertainties could be identified. The example alternatives were:
1. Relocation of the Tailings
2. Covers, including soil and water
3. Leave as is with water quality management
4. Relocate/Cover/Leave-as-is Combination

*The status quo option provides a basis for estimating the benefits associated with other alternatives.*

A discussion took place regarding the need to continue having the *status quo* on the list. It was explained that some form of "do nothing" or "do as little as possible" alternative would be helpful in that it would provide a basis for assessing the benefits of other approaches.

Each of the example alternatives was then assigned to a team to develop the rough "design". The following subsections present the results and summarize the discussion that ensued upon their presentation to the workshop.

#### 3.1.2.1 Tailings Relocation

Two example alternatives involving tailings relocation were presented: relocating the tailings to Faro Pit, and re-stacking the tailings on the side of the valley. The first was "designed" in more detail.

**Relocation to Pit**

Tasks:

- Treat tailings porewater
- Treat groundwater (temporary): assume removing contaminated soils
- Water Management in pit: assumption that this is required
- Remove sludge (Cross Valley): currently being used as a settling pond
- Capture and treat waste rock seeps: will need to be capture and require information about sub-surface loading
- Alternative Sludge Management: CV dam is currently used as a polishing pond.
- Remove Contaminated Soils: from the valley

Variants:

- Pit-focused water treatment
- Temporary in-valley treatment: may be a temporary need for this. It does not have to be pump and treat wells.
- Dam removal (breach):
- Rose Creek returned to original channel
- Capture/treat waste rock seepage
- Define groundwater load from waste rock dumps
- Sludge management: this will be an issue with almost every alternative
- Feasibility reprocessing: need to update a study done in the past

**Relocation to Valley Walls**

- Complete containment or,
- Treat Rose Creek.

In subsequent discussion of these example alternatives, it was explained that the option of relocating tailings to the valley walls would require construction of new dams along the length of the valley, and therefore was not given much consideration. Other issues raised were whether it would be possible to collect all of the tailings without significant over-excavation, and whether it would be necessary to treat groundwater in the valley during or after the tailings relocation.

#### 3.1.2.2 Tailings Covers

Two alternatives for covering the tailings were presented: covering with soil materials and covering with water. The proposed major components within each alternatives were as follows:

**Soil Cover**

**Tailings** Solids
- Re-contour
- Cover design (all soil or soil/geosynthetic)
- Quarry
- Surface ditch and runoff
- Vegetation management strategy

Tailings Water:
- Remove surface contaminated water
- Possible downstream capture and treatment of groundwater

Intermediate Dam:
- Consider buttress
- Consider lowering spillway

Cross Valley Dam:
- Possible removal/probable lowering

Rose Creek
- Upgrade to PMF or less (cover design)

North Wall Interceptor Ditch
- Upgrade

**Water Cover**

Tailings Solids
- Re-contouring
- Possible lime addition (because of having to move tailings around to mitigate acidity in materials)

Tailings Water
- Medium term collection and treatment of groundwater

Intermediate Dam
- Raise crest
- Revise spillway

Cross Valley Dam
- Possible removal/probable lower
- Could be raised instead of the Intermediate Dam

Rose Creek
- Upgrade to PMF in existing or alternative alignment

North Wall Interceptor Ditch
- Breach

In discussion of the soil cover alternative, questions were raised regarding liquefaction of tailings, and the treatment of groundwater. The consensus was that liquefaction would damage the cover, but the damage could be repaired. However, there was more concern about the effect of liquefaction on the Original and Secondary Dams. The question about groundwater treatment was whether the cover would prevent or significantly reduce the leaching of contaminants to groundwater, and what would be the effect on long-term groundwater collection and treatment needs.

Another issue raised was the choice between a water and soil cover. It was pointed out that water covers can completely stop oxidation, and are therefore best applied before oxidation has any chance to occur. Once oxidation has proceeded for many years, as in this case, there is already a high loading of contaminant available in the tailings. A water cover could increase the downward flow of water and could thereby increase the leaching of contaminants to groundwater. Also, in this case, a permanent water cover would require significant upgrading of the existing dams. Soil covers can also achieve some reduction in oxidation rates, but the most important effect on contaminant loadings is by reducing infiltration. It was pointed out that soil covers can have other functions as well, such as preventing dust, preventing direct contact between wildlife and tailings, and reducing the contact between the tailings and surface runoff.

#### 3.1.2.3 Leave Tailings Facility As-Is

The leave-as-is alternative was assumed to require perpetual water quality management. The major components of the "design" were as follows

Tailings Solids

- Leave as is except for regrading of original tailings area (consider combinations with dam upgrade)

Tailings Water

- Treat and release tailings surface and groundwater water
- Perpetual surface and groundwater collection required
- Include groundwater collection wells at toe of Cross Valley Dam
- Move water treatment plant below Cross Valley dam and consolidate with Faro Mine water treatment
- Install High Density sludge system and manage sludge in cells constructed in tailings solids

Intermediate Dam

- Upgrade for MCE and PMF at spillway

Cross Valley Dam

- Upgrade for MCE (maybe) and PMF at spillway

Rose Creek Diversion Channel

- Upgrade to PMF or possibly route some of flow through armoured channel over top of tailings

North Wall Interceptor Ditch

- Upgrade to PMF along the Cross-Valley dam abutment

General requirements

- Maintenance and monitoring of dams and remaining structures
- Aquatic monitoring
- Vegetation monitoring for tailings dusting

In discussion, it was suggested that the "leave as is" alternative could be designed to be protective of the environment, and the question was raised whether tailings relocation or covering could achieve a significant additional benefit.

#### 3.1.2.4 Combination Alternative

This alternatives was intended to represent various possible combinations of the above. The alternative selected for analysis included partial relocation, and covering the remaining tailings. Key components were as follows.

Tailings Solids

- Lower tailings level to around 4m below the Intermediate Dam.
- Hydraulic monitor (likely most cost effective), dredge or mechanical (dragline)
- Pump tailings to Faro pit
- Include lime amendment to counteract acidity

Tailings Water

- Water cover over remaining tailings to prevent further oxidation
- Pump and treat groundwater aquifer at source, as required (closer to the source, where the contamination presently is within the facility)

Intermediate Dam

- Raise and/or upgrade to create water cover

Rose Creek Diversion

- Construct new spillway to carry entire Rose Creek flow
- Direct Rose Creek flow to tailings

Cross Valley Dam

- Breach

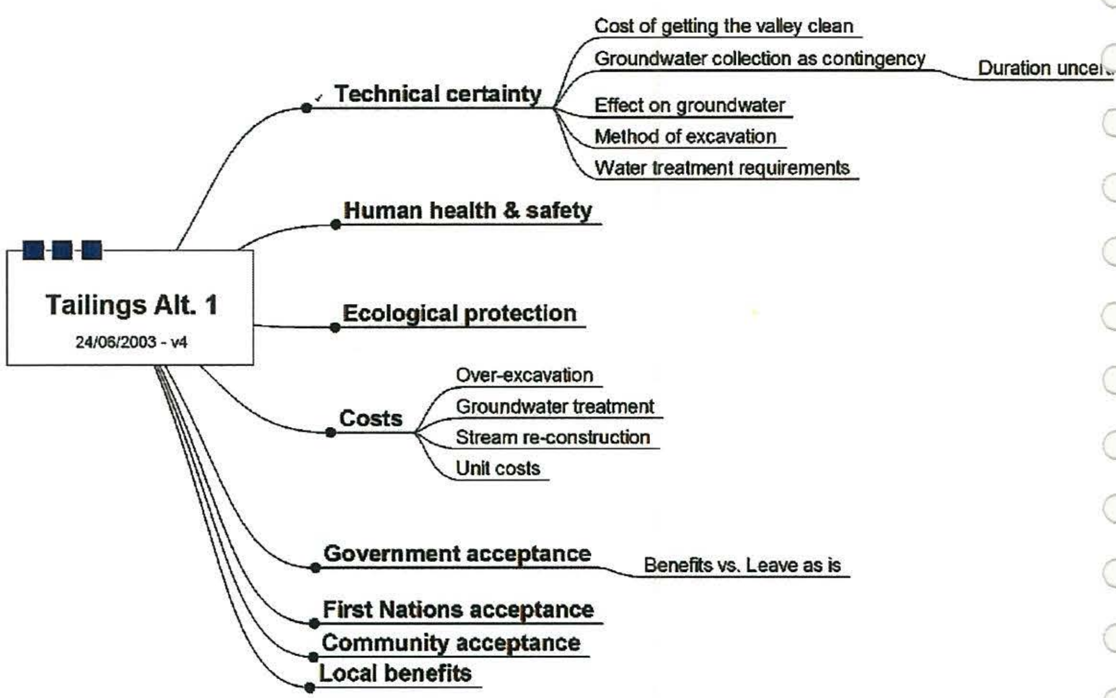
In discussion of the example combination alternative, it was pointed out that lowering the tailings to 4m below the Intermediate Dam would allow the preservation of the existing structure with much less upgrading than the 100% water cover option. One question raised was whether it would be justified from a cost perspective to keep the dam structures for the remaining tailings, especially since 80% of the soluble zinc is above the current water table. It was agreed that the tailings volumes and zinc numbers would all need to be checked in a complete assessment of any combination alternative to see if there is an "optimum" combination of relocation and covering.

### 3.1.3 Evaluation of Example Alternatives

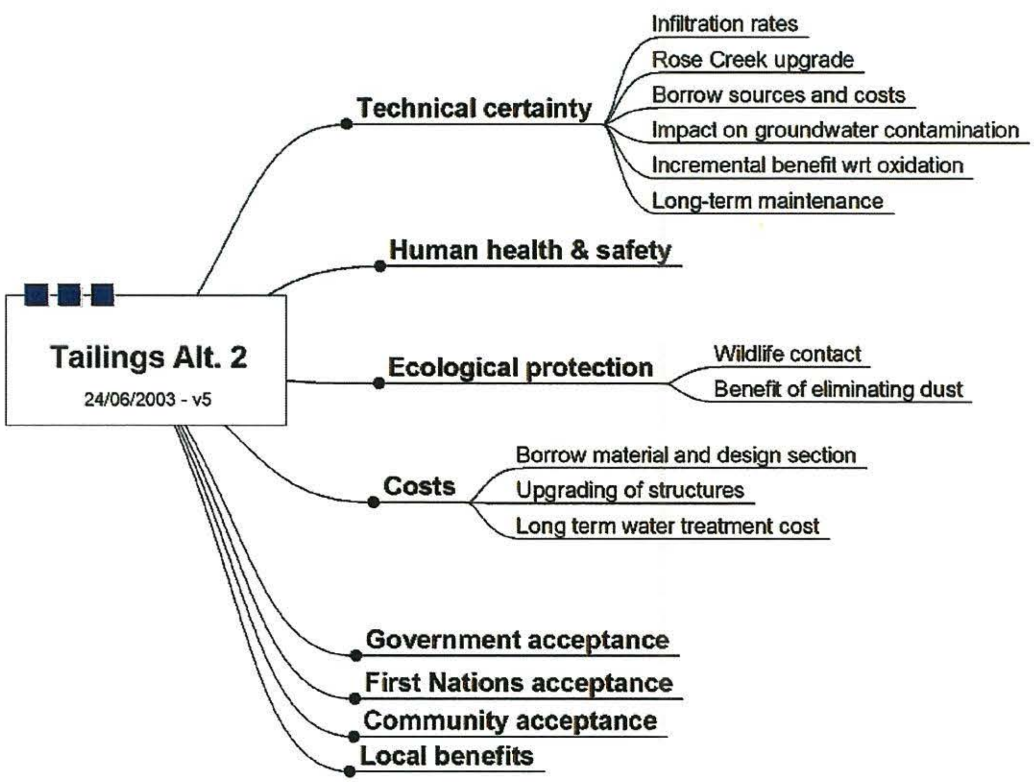
***Options were evaluated using the example evaluation factors to help identify uncertainties***

Individuals were then asked to compare each of the alternatives to the evaluation factors developed in the morning. Results were then discussed by the group and summarized in the mind-maps shown on the following pages.

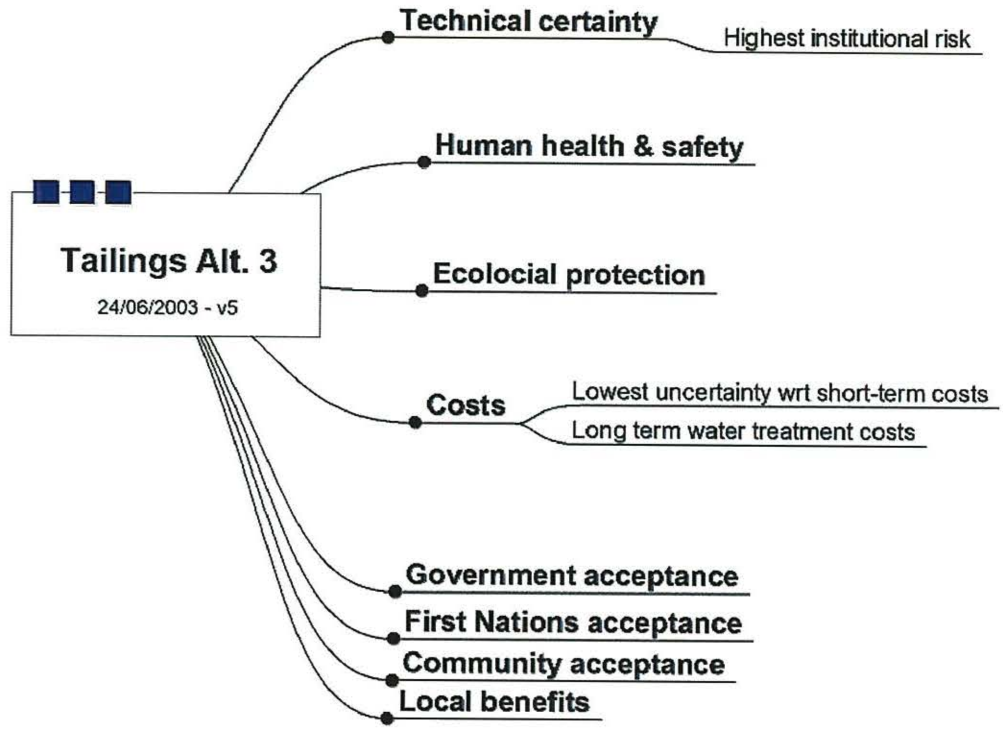
Several trends were common to all of the evaluations. First, it was difficult to assess the categories "Government acceptance", First Nations acceptance", "Community acceptance" and "Local benefits". All of those evaluation factors would need to be assessed through a consultation process. Second, all of the alternatives appeared to be protective of human health and safety, and could be designed for ecological protection. Third, there were a number of cases where technical uncertainties could be resolved with increases in cost. In other words, there is a trade-off between technical certainty and cost.

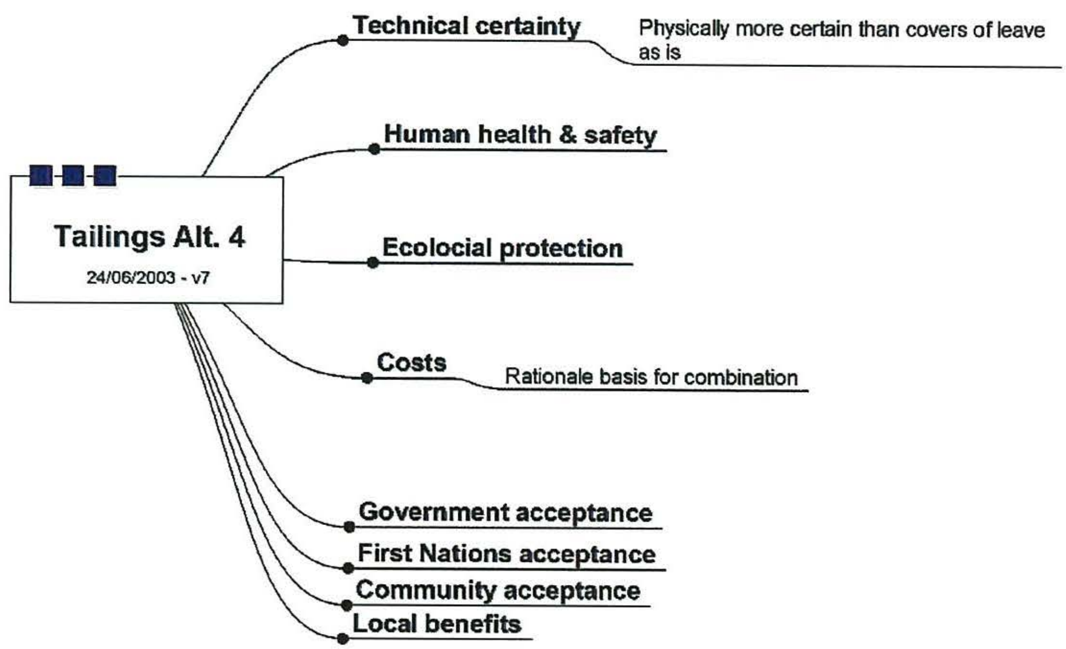


Tailings Alt. 1
24/06/2003 - v4
Technical certainty
Cost of getting the valley clean
Groundwater collection as contingency
Duration uncer...
Effect on groundwater
Method of excavation
Water treatment requirements
Human health & safety
Ecological protection
Costs
Over-excavation
Groundwater treatment
Stream re-construction
Unit costs
Government acceptance
Benefits vs. Leave as is
First Nations acceptance
Community acceptance
Local benefits

Tailings Alt. 2
24/06/2003 - v5
Technical certainty
Infiltration rates
Rose Creek upgrade
Borrow sources and costs
Impact on groundwater contamination
Incremental benefit wrt oxidation
Long-term maintenance
Human health & safety
Ecological protection
Wildlife contact
Benefit of eliminating dust
Costs
Borrow material and design section
Upgrading of structures
Long term water treatment cost
Government acceptance
First Nations acceptance
Community acceptance
Local benefits


Tailings Alt. 3
24/06/2003 - v5
Technical certainty
Highest institutional risk
Human health & safety
Ecolocial protection
Costs
Lowest uncertainty wrt short-term costs
Long term water treatment costs
Government acceptance
First Nations acceptance
Community acceptance
Local benefits


Tailings Alt. 4
24/06/2003 - v7
Technical certainty
Physically more certain than covers of leave as is
Human health & safety
Ecolocial protection
Costs
Rationale basis for combination
Government acceptance
First Nations acceptance
Community acceptance
Local benefits

The evaluation exercise led to further discussion of the technical issues and uncertainties. In the further discussion of the two relocation alternatives, it was agreed that relocation to the Faro Pit would be preferable. Several uncertainties were identified, most of which relate to costs. The identified uncertainties included:

- Feasibility and cost: to remove all the contaminant, including any contaminated soil below the tailings
- Requirement and timing for treating groundwater that is already contaminated
- Requirement for residual groundwater collection and treatment
- Effects of hydraulic monitoring on groundwater
- Method of excavation could differ for top and bottom of the tailings
- Reprocessing feasibility

In the further discussion of the tailings cover alternatives, it was noted that some of the possible cover functions would be much easier to accomplish than others. For example, preventing dust generation would be relatively easy, whereas preventing infiltration would be very difficult. Once the function of the covers is defined, cover costs would be easier to estimate than relocation costs,. Uncertainties included:

- Ability to upgrade Rose Creek Diversion Channel to PMF
- Borrow materials and cost
- Impact of further oxidation and the incremental benefit to water treatment cost
- Long-term maintenance and performance
- Costs for water treatment.

In the further discussion of the leave-as-is alternative, it was suggested that it would present the lowest uncertainty related to short-term cost but the highest institutional risk because of the perpetual care requirements. The further discussion of the combination options showed that they would suffer from all of the technical uncertainties identified in the other options.

### 3.1.4 Key Uncertainties

The discussion of tailings alternatives ended with a summary of the key uncertainties that would need to be resolved before a final selection of a tailings area closure alternative could be made. The summary list was as follows:

- Results of consultation with First Nations and local communities
- Cover function and performance
- Tailings physical properties
- Feasibility of capture/treat waste rocks seeps
- Availability and cost of borrow materials
- Impact on Faro pit water and treatability if tailings are moved
- Better prediction of water treatment costs
- Tailing relocation methods
- Design parameter: PMF/MCE, fish passage
- Seismic stability of the Intermediate Dam
- Groundwater contamination below tailings
- Water quality and receiving environment objectives: VECC, risks
- Cost estimates and cash flows

Other uncertainties include the need for a water cover, optimal volumes for partial relocation, and the nature of contaminant attenuation in groundwater and tailings.

## 3.2 Faro and Vangorda/Grum Mine Areas

### 3.2.1 Identification of Methods

John Chapman presented the collated list of candidate methods for closure of the Faro and Vangorda/Grum mine areas. Most of the identified methods could be applied to any of the sites. Exceptions are noted in the list.

**Water Treatment Methods**

Pump and treat

- HDS (lime)
- New/upgrade technology
- Expand collection system
- Increase capacity

Wetland and biological (passive): perhaps at seepage locations around the dumps

In-pit treatment

- Sulphate reduction (bacterially produced sulphide precipitates base metals)
- Lime
- Biological: similar to the Island Copper pit

Underground workings

- Sulphate reduction

Do Nothing

- Relocate to tailings area and use gravity feed

Sludge disposal

- In-pit
- Lined facility

**Methods for Mill Site and Buildings**

Do nothing

Leave or upgrade for alternate use: training, community, heritage site, other

Remove hazardous materials

Salvage items with re-sale or scrap value

Demolish remainder

Dispose of non-hazardous materials

- Landfill
- Pit

Soil remediation

Ore stockpiles

- Process
- Backfill

**Methods for Water Retaining Structures/Ponds**

Do nothing

Continue maintenance and current use

Upgrade

- Enhance fish habitat: stocking the ponds with fish

Breach

- Removing the entire dam
- Breaching and re-vegetating the remainder of the dam
- Enhance fish habitat

**Methods for Creeks and Diversions**

Do nothing
Upgrade in current alignment
Re-align

- Relocate on land: take a different route for the diversion and maximize the water captured by the diversion
- Tunnel
- Through-pit/over-pit: over the pit if the pit is backfilled
- Pump

Generate hydro-electricity as energy recovery
Expanded or new (increase freshwater diversion)

**Methods for Haul Road and Rock Drains**

Do nothing
Breach

- Remove
- Create fish passage/habitat

Upgrade to water-retaining dam
Remove and replace with culvert/bridge (alt. creek crossing)
Cover, re-slope and vegetate
Maintain for continued use
Partial breaching (for wildlife corridors)

**Methods for Faro, Grum and Vangorda Pits**

Do nothing
Flow-through (remove diversion)

- Clean pit
- Dirty pit
- In pit treatment (stratification/lime)

Fence/Berm
Backfill

- Rock (using layering according to properties and lime addition)
- Tailings
- Cover of the backfill pit
- Road is another source of material to put into the pit

Plug Dam: identified for the Faro pit to raise the water level in the pit
Discharge water from the pits

- Tunnel
- Slot Cuts
- Existing overflow areas

Pump and treat contaminated water to maintain water below the overflow level
Clean and cover pit walls and the benches to remove the acid generating materials
Water storage facility (for seasonal treatment)

**Methods for Waste dumps (including transfer pads, ore sulphides, till dumps)**

Do nothing

Collect seepage and treat

- Removal (partial (acid generation))
- For use in reclamation
- All
- Pit/Tailings area

Re-grade and cover (Partial/all)

- Till
- Complex (multiple layers)
- Compact surfaces
- Geo-synthetics
- Re-vegetate
- Water

Fence/Berm

Permafrost aggradation

Classification & segregation

Consolidate

Process or selling

**Methods for Zone 2 Pit**

Do nothing

Pump and treat

Water management

- Divert inflows
- Cut-off

Cover and seal

Reactive barrier wall

Allow overflow and treat downstream

Treat *in situ*

- Sulphate reduction

Remove acid generating of rock above water table to main pit

Use as storage (containment pond)

A question was asked about the amount of soluble zinc in the waste rock dumps, and whether it is of a similar order of magnitude as in the tailings. The simple answer was yes, the amounts are similar. In both cases, however, the key question is not how much zinc is present, but how much is leaching out. It was explained that the dumps currently do not release as much acidity as one would predict based on the rock's geochemical properties. The explanation may be related to the dump water balance and the complex nature of water flow into and through the dumps.

Another question concerned the potential consequences of placing tailings in the Faro Pit. One impact would be a limitation of the options for the waste rock, as the volume of tailings would use up much of the available storage capacity. One way to mitigate this impact would be to place tailings at the bottom and waste rock above, to force the tailings to consolidate. Another means of increasing storage capacity in the Faro Pit would be to build a plug dam across the ramp that is currently the lowest point in the pit wall.

From a water quality perspective, another impact would be the release of soluble contaminants to the pit lake water (which then creates a requirement for treatment). To mitigate this effect, lime could be added to the tailings as they were relocated.

Another discussion centred on the partial removal of the waste rock dumps. In two examples of waste rock relocation elsewhere, the reactive materials were distributed throughout the dumps and it was necessary to relocate the entire dump, sorting it during the process. However, in cases where the reactive material has been isolated in one area, it could be possible to remove it without dealing with all of the other rock. The sulphide cell on the Grum Dump might be a good example.

A final point of discussion concerned the advantages and disadvantages of adding freshwater into the pit lakes. At the Grum pit, the current water quality is quite good. Routing clean water through the pit lake might bring the water quality to within CCME guidelines. In the Vangorda pit, however, the water is so contaminated that freshwater addition would not help. In fact, it would be better to continue treating smaller volumes of water at higher concentrations.

### 3.2.2 Development of Example Alternatives

"Example alternatives" were identified for further discussion.

Participants discussed some of the challenges and assumptions that would need to be taken into account when developing "example alternatives" for the mine areas.

One question is whether it could be assumed that all of the mine areas would require perpetual water collection and treatment programs. After much discussion, it was concluded that opportunities to minimize water treatment requirements should be explored in some of the example alternatives, if only to highlight uncertainties that would need to be examined before a perpetual treatment alternative is selected.

It was also questioned whether the Vangorda/Grum areas should be considered separately from the Faro area. There is certainly logical linkage between some alternatives at both sites. For example, if the alternative adopted for the Faro area required perpetual care and maintenance, the Faro manpower could be leveraged towards Vangorda/Grum alternatives that also require long-term care and maintenance. However, it was concluded that such linkages should not constrain the exploration of alternatives. For example, a 'walk-away' closure that could return the entire Vangorda/Grum side to other uses would probably be very attractive to First Nations and other local stakeholders, even if the Faro area required a long-term site presence.

Some participants asked for further information that might be helpful in designing example alternatives. To address questions about the current understanding of waste rock geochemistry, results of the acid rock drainage study undertaken during the summer of 2002 were briefly reviewed. Maps showing the key results were distributed. On the Faro side, segregation of sulphidic rock had been planned but not implemented, with the result that acidic rock was distributed throughout the Faro dumps. The waste rock at Vangorda varies from extremely reactive to moderately reactive, again with the result that acidic conditions are widespread. The Grum rock dump appears to have been much more carefully segregated, resulting in an identifiable sulphide cell and no evidence of acid generation in the remainder of the dump. It was asked whether the Grum dumps only looked good because they were relatively fresh, only eight years old, and if acidic conditions could be expected in the future. The response was that the age of the dumps had been taken into account in the study, and that the Grum dumps really were significantly better than the Faro or Vangorda dumps.

Other questions were raised, for example about the volume available within each of the pits. It was pointed out that much of that information was available in study reports circulated prior to the meeting, and that each of the groups assigned example alternatives would include participants familiar with the study details.

A short list of example alternatives was then developed and the following were selected for "design" by individual groups:.

**Faro Mine Area**

1. Long-term collection and treatment
2. Capital intensive

**Vangorda/Grum Mine Area**

3. Eventual no active treatment
4. Long-term treatment with improvements (justifiable on cost-recovery basis)

Other 'example alternatives' discussed included the segregation of reactive material and the *status quo*. The above selection was not intended to rule out these or other approaches, only to result in a wide range of designs for the subsequent discussion. In order to force groups to focus on important specifics of each alternative, the groups were asked to include rough cost estimates in their "designs".

#### 3.2.2.1 Faro - Treatment Intensive

The group designing the Treatment Intensive" alternative for Faro assumed that there would be as few major capital improvements as possible, relying instead on long-term collection and treatment of water.

| Tasks | |
|---|---|
| Relocation of Faro Diversion | \$3-8M |
| Remove (Notch) rock drain | \$3-5M |
| Upgrade/Construction-NE rock dump | |
| • Groundwater collection | |
| • Seepage collection | |
| Prioritize fines removal | \$1M |
| Water treatment capital | \$10-15M |
| Water treatment operating | \$12-25M |
| Option - move Faro Valley dump (not included in total) | \$6M |
| **Total:** | **\$35-60M** |

Relocation of the Faro Valley dump was included as an option because it was thought that the resulting reduction in zinc loadings might be readily recoverable in terms of treatment cost savings. There would no relocation or covering of the other Faro dumps. The only clean water management improvement would be relocation of the Faro Creek diversion for long term stability. Other ditches and collection systems, including the Zone II pit groundwater pumping systems, would be maintained as is. It was estimated that the amount of water requiring treatment would be about 2 million $m^3$/year. Ranges of treatment capital and operating costs were included to show the uncertainty associated with long-term water quality.

#### 3.2.2.2 Faro - Capital Intensive

The 'capital-intensive' alternative for the Faro mine was intended to be an example of alternatives where significant up-front expenditures would be made in order to reduce the requirements for long-term water collection and treatment. The group designing this example alternative decided that such an intent would best be met by a program that involved turning Faro pit into a flow-through system. That in turn would require removal or remediation of most of the sources contributing contaminant to the pit. There is currently considerable uncertainty about whether such an approach would be successful. So the "design" was presented as a series of core tasks and a number of possible contingencies.

| | | |
|---|---|---|
| <u>Tasks</u> | | |
| Move reactive material and/or dumps that drain to pit | | |
| • Fare Valley dump: | $7M | |
| • Ranch dump: | $5M | |
| • Low grade ore stockpile: | $10M | $22M |
| Cover remaining dumps with HDPE cover | | $50M |
| Construct plug dam and grout curtain | | $3M |
| Construct ditch to downstream of Intermediate Dam | | $3M |
| Re-establish Faro Creek and create 2 interception ditches | | $1M |
| Demolish mill, bury materials, and remediate soils | | $4M |
| **Subtotal** | | **$86M** |
| | | |
| <u>Contingencies</u> | | |
| In-pit treatment capital | | $6M |
| In pit treatment cost NPV | | $6M |
| New Faro Creek Diversion | | $4M |
| Separate seepage collection and treatment | | |
| • Collection system (wells) | $3-20M | |
| • Water treatment capital | $5M | |
| • Water treatment operating (NPV) | $25M | |
| **Subtotal** | | **$49-$66M** |

The plug dam was included in the design to eliminate the need for routing the water flowing out of the pit over any waste rock. The assumption is that the outflow would be re-directed through a ditch constructed through the mill area. The contingencies would not necessarily be required.

#### 3.2.2.3 Vangorda/Grum – Eventual No Active Treatment

The group designing the first Vangorda/Grum alternative focused on a method to mitigate pit and waste rock water quality problems on the Vangorda site. It was assumed that some form of passive treatment will be required. The selected concept was to backfill waste rock into the Vangorda pit and create a "pervious surround" where water could flow around the edges of the backfill and be passively treated by sulphate reduction. Organic matter would be added at the top. The Vangorda Creek inflow would flow down into the pit and would re-emerge on the other side.

**Tasks**

| | |
|---|---|
| Vangorda Creek: Major new channel | $10M |
| Vangorda pit: Selective backfill with lime/cover/mounded | $30M |
| In-pit and barite dumps: Dispose in pit (cost included above) | |
| Vangorda Dump: all in pit (costs included above) | |
| Till stockpile: contour material, re-vegetate | $0.5M |
| Little Creek Dam: medium term use/removal | $0.1M |
| Grum Pit allowed to flood with *in-situ* treatment | $1M |
| Overburden dump: use as construction material or re-vegetate | $1M |
| Grum Main & SW dumps | |
| • Cover only sulphide cell | |
| • Contour & revegetate | $3M |
| Water treatment | |
| • Capital - New small plant at Little Creek Dam | $3M |
| • Operating (NPV) | $10M |
| Ore transfer pad: cover in place | $0.5M |
| Sheep Pad Pond: remove | |
| **Total:** | **$58M** |

Even if the backfilled pit were covered, a continuing flow of water would enter through the walls (which are acid-generating) and eventually flow out of the system. The passive treatment system was intended to deal with this flow. But the passive system would be experimental (at best) and therefore would need to be tested and developed over several years. In the interim, water treatment would be continued. As a result, some time would be required before Little Creek Dam could be removed.

#### 3.2.2.4 Vangorda/Grum – Long-term Treatment with Improvements

The idea behind the Vangorda/Grum 'long-term treatment with improvements' alternative was that a water collection and treatment system would be built, and other work would only be carried out if it could be shown to result in a proportional reduction in water treatment costs.

**Tasks**

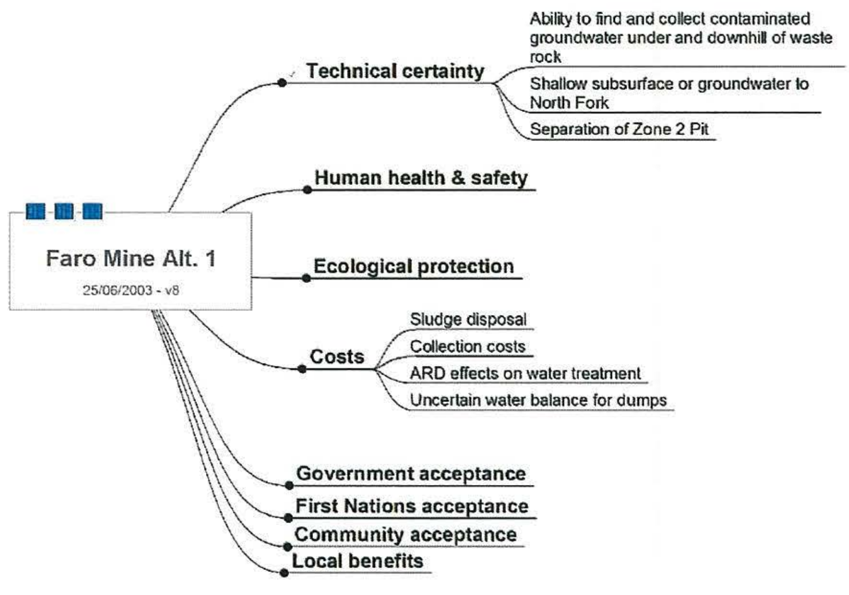
| | |
|---|---|
| Water treatment capital | $7M |
| Water treatment operating (Vangorda only) | $20M |
| Grum re-sloping | |
| • 250,000m2@$3/m2 | $0.75M |
| Grum Diversion Channel | |
| • 1000 m @$500/m | $0.5M |
| Grum Top diversion | |
| • 1000m@$300/m | $0.3M |
| Grum Toe collection | |
| • 1000 m@$500/m | $0.5M |
| Grum wetlands treatment | $0.5M |
| Relocation of ore transfer pad to Vangorda pit | |
| • 300x400x3=260,000m3@$4/m3 | $1.5M |
| Breach stream crossings on haul road | $0.6M |
| Decommission old WTP and pipes | $0.1M |
| Sludge management in cells in O/B Dump | $3.0M |
| • Grum slot cut | |

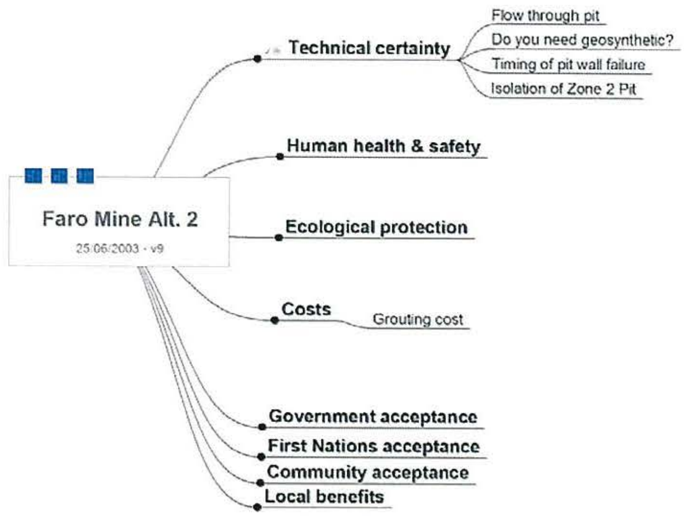
| | |
|---|---|
| • 90,000m³x$15/m³ | |
| Vangorda Diversion to Shrimp Creek | $2.5M |
| Barite Dump to Vangorda Pit | |
| • $735,000t/@$2/t | $1.5M |
| In-pit waste dump | |
| • 70,000t/@$1/5 | $0.1M |
| Upgrade Vangorda drains | $0.3M |
| Little Creek Dam maintenance | $3.M |
| **Total** | **$44M** |

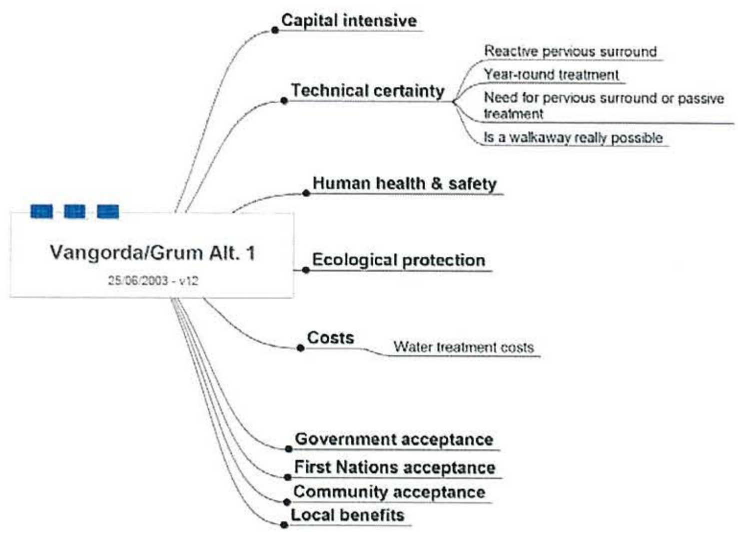
It was assumed that water from the Grum pit and dumps would not require active treatment, but the water would be collected and routed through a passive treatment system. Also, the Vangorda treatment plant would be located downhill of the Grum collection system. Therefore, if active treatment of the Grum water were to become necessary, it would require only an increase in the treatment plant operating costs.

### 3.2.3 Evaluation of Example Alternatives

Each of the example alternatives was then presented to the workshop and discussed. The example evaluation factors developed earlier were used as a checklist to ensure that all uncertainties were addressed.







#### 3.2.3.1 Faro - Treatment Intensive

The Treatment Intensive example for Faro was generally agreed to present fewer technical uncertainties than the Capital Intensive alternative. However, there were questions about the ability to collect all contaminated water. For most of the contaminated water, collection was agreed to be feasible, although potentially costly. However, it was not yet certain how much of the contaminated water would need to be collected to eliminate downstream impacts. If the proportion requiring collection is very high, the technical feasibility could be questionable. In this regard, a particular information gap was identified, namely the quantity and quality of groundwater and surface water inflows to Rose Creek downhill of the mine area.

Regarding cost uncertainties, it was noted that sludge disposal was not explicitly considered. The options for sludge disposal include placing it in the pit or in a disposal cell constructed on land. The costs of water collection were considered uncertain. In addition, long-term changes in acid generation may impact water treatment costs. The trade-off between treatment volumes and concentrations was discussed.

It was also noted that the water balance of the dumps is not well understood, but there appears to be more water falling on the dumps than is coming out the bottom. Possible explanation include higher than expected evaporation, sublimation or wind-removal of snow; seeps percolating downwards to groundwater; seeps resurfacing at some distance from the dump toes; and, storage of water within the dumps either as saturated mounds or taken up by the weathering of the rock. Some of the explanations are worrisome because they suggests that there could be sudden increase in seepage rates in future.

No major concerns about human health, safety and/or ecological protection were identified with this alternative.

#### 3.2.3.2 Faro - Capital Intensive

The presentation of the Capital Intensive example for Faro led to a lengthy discussion about the technical uncertainties associated with covering the dumps with a plastic liner. The ability to place liners on an area as large as the Faro dumps was questioned. However, it was explained that large scale liner installations were common in other areas, and that modern quality control methods make it possible to predict a successful outcome with a fair amount of certainty. The long-term durability of plastic materials is a more difficult question. Recent projects have been assuming over 100 years of useful life. Furthermore, when the plastic degrades, the failure is incremental rather than catastrophic. It was also questioned whether HDPE material is really required for the liners, and it was agreed that further investigations would be needed to show the performance of soil covers and whether the additional barrier would provide significant benefits. Finally, the need to re-slope the dumps before placing an HDPE liner was identified as a significant cost uncertainty. The use of plastic liners generally requires flatter slopes than soil covers, and some of the dumps have no room at the toe for re-sloping. Therefore, some participants thought re-sloping costs could be much higher than the "design" suggested.

The impact of pit wall stability was discussed and it was agreed that wall failures could interfere with the timing of some of the work. However, because there will be a flow-through pit, the impact of wall failures on the Faro Creek would not be as significant as in other alternatives. The ravelling of the wall would continue but would not result in catastrophic failure.

The idea of routing the pit lake outflow through the mill area was discussed and it was agreed that such a routing would be hydraulically feasible, but costs were uncertain.

The feasibility of isolating the Zone II pit was questioned, given the multiple points of water entry through fractured rock and waste rock. The plug dam, on the other hand, was thought likely to be feasible, although costs might be higher than anticipated if additional grouting were required

Finally, it was agreed that there would be a need for contingencies for the event that the flow-through pit water quality is unsuitable for discharge. It was noted that the second contingency re-establishes the Faro Creek diversion, which is in effect the *status quo*.

#### 3.2.3.3 Vangorda/Grum - Eventual No Active Treatment

Discussion of the technical uncertainties of the Eventual No Active Treatment example for the Vangorda/Grum areas started with the requirements for adding lime to the waste rock. It was pointed out that experience at other sites shows that it is possible to achieve a very high density and low permeability if the material is placed in thin lifts. If that were the case in the Vangorda pit, it might not be necessary to have a pervious surround or passive treatment system. The group that developed the alternative responded that seepage from the pit wall would continue to enter the backfill. There was discussion as to whether that seepage could be reduced by upstream cut-offs, and, eventually, agreement that the quality and quantity of water in the pit backfill was a significant uncertainty.

The feasibility of 'walk-away' was questioned. If the covers work well, it is conceivable that a small volume of water could all be collected in one place. However, the possible need for long-term active treatment represents a significant cost uncertainty.

#### 3.2.3.4 Vangorda/Grum - Long-Term Treatment with Improvements

The Long-term Treatment with Improvements alternative was generally agreed to present fewer technical uncertainties than the Eventual No Active Treatment example. The ability to collect seepage from the Grum waste rock was raised as one uncertainty. The dump is partially situated on sand and gravel, and the concern was that seepage collection would require wells and pumping. The need to collect Grum seepage was raised as a fundamental uncertainty. Despite favourable results to date, there remains concern that the Grum dump seepage could become more contaminated over time. The Grum Pit water quality was also identified as an uncertainty. Designing the system so that Grum water could eventually be treated, if required, was agreed to be a wise approach.

The most significant cost uncertainties in this alternative relate to water treatment, and the potential for increased contaminant loadings in future.

### 3.2.4 Key Uncertainties

The discussion of mine area alternatives ended with a summary of the key uncertainties that would need to be resolved before a final plan could be selected. The summary list was as follows:

- Waste dump hydrology and contaminant loadings from the dumps
- Grum pit water quality: what is it going to be in the future
- Requirements, feasibility and costs of lining and grading dumps
- Plug Dam design requirements: grouting, etc…
- In-pit treatment performance

- Collection and treatment requirements: sizing; batch or year-round treatment
- Seepage chemistry: as it relates to the uncertainty of the capture of the rock dump
- Pit lake water quality
- Clean pit scoping study
- Faro diversion design criteria
- Vangorda Diversion design criteria
- Little Creek dam future requirements
- Sludge disposal location costs
- Grum dump extent of sulphide cells (i.e. need for seepage collection)
- Escape of seepage at Faro down into the valley from dumps in general
- Water quality objectives
- Terrestrial quality objectives
- Site meteorology

An additional uncertainty identified in later discussions was the value of the ore remaining below the Grum Pit, and whether alternatives should be designed to allow future underground access to the ore.

# 4 Initial Investigation Designs

The key uncertainties identified through the examinations of closure methods and alternatives were then reviewed by the workshop. The lists presented in Section 3.1.4 and 3.2.4 above were posted at the front of the room and participants were asked to collate the uncertainties into a series of investigations. Groups of participants were then asked to prepare scopes of work and rough cost estimates for specific investigations. The resulting initial investigation designs are described in the following subsections.

## 4.1 Tailings Area

<u>T1 - Tailings physical properties (T1)</u>

The objective would be to determine physical properties of tailings relevant to both *in-situ* and removal options. The major tasks would include review of the existing data, and, undertaking a drill programme (involving cone penetrometer testing for density, strength, trafficability, sonic drilling and sampling for laboratory testing). The laboratory analysis would include Atterberg Limits, cohesion, strength, density, moisture content and grain size. Piezometers could be installed in the drilled holes. Fifteen to twenty bore holes would be required. The cost for this study is estimated at $250K and would take about six months to seven months to complete (three weeks of field work and six months to complete the project).

<u>Discussion:</u> It was noted that sonic drilling would not provide any information regarding *in-situ* density, but would provide samples for laboratory testing. The 1992 programme characterized grain size at 1 m intervals. However, grain size is known to a certain extent already because it was constrained by milling. Cone penetrometer testing (CPT), and supporting this type of investigation with occasional boreholes and thermistors would more efficiently characterize variability within the tailings. Frozen zones would need to be identified and considered for evaluating relocation strategies. Thermistors would provide temperature profiles. Pore water pressure as related to tailings trafficability was discussed.

The use and need of this information in the context of a relocation scenario was discussed. For slurrying and truck and shovel relocation, CPT would provide useful information. Using the CPT, many holes can be completed relatively quickly (est. for $40K; 15 to 20 holes can be completed). However, that information can also be obtained through other programmes.

The need for 15 to 20 holes was questioned, as well as the cost. It was noted that this proposed programme would complete drill holes only in the tailings and not the aquifer. The primary questions that arose was: "Is this number of holes required to understand the stability of the dams?" Some participants favoured a small volume of good quality data. i.e fewer drill holes.

An assessment of the seismic stability of the tailings is required at this point, with a focus on *in-situ* stability of the tailings. The need for seismic information related to the secondary impoundment is also required. There was however disagreement as to the consequences of a failure of the dam at the secondary impoundment. It was questioned whether 20 holes would be required to meet this objective. Seismic stability in the context of covers was also discussed. The comment was made that in the case of an earthquake (e.g. 1:475), which may lead to a cover failure, the cover would simply be repaired. The impact of an earthquake on covers is not catastrophic.

Vic Enns quoted the opinions of Andy Robertson regarding the 1974 dam, which highlighted his concern with liquefaction of the impoundment. The understanding of the concept of liquefaction (particularly static) has evolved and risks are now understood. Milos Stepanek indicated that it is not necessary to complete a $250K programme to address the issue; he estimated that more than 3 but fewer than 20 holes would be required. Cam Scott indicated that the data required to evaluate relocation could be generated quickly using the CPT, for about $40K.

**Borrow materials for covers (T2)**

The objectives would be to locate, quantify and characterise (grain size, moisture retention, etc.) of suitable material for cover construction. The major tasks would include Phases I and II assessments, which have already been completed. A Phase III field investigation would be required to 1) complete additional detail/delineation of borrow areas, and, 2) fill any information gaps in the Phase I and II investigations. There is also a need to look for additional riprap material. The cost for this study was estimated (provisionally) at about $50K and would take two months to complete.

Discussion: There is a need to know whether there would be enough volume available for the construction of the covers and exactly where it would come from. Borrow material estimates are also used for cost estimation. A question was asked as to the whether these previous phases had included looking at "off road" (further a field) locations. In response, there was consensus that sufficient cover materials have not yet been identified if the tailings are also to be covered and that incremental areas would need to be developed. There is a need to identify whether there are well defined quantities of borrow materials suitable for cover construction readily available. Reasonable information is available to indicate potential borrow areas, but these areas are poorly defined. Riprap may be borrowed from select areas of the dump, but the material properties would need to be defined. In particular for the Faro area, if the need for a lot of till is identified, further areas of borrow material would need to be identified and characterised.

**Water treatment and sludge disposal (T3)**

The objectives would be to determine the unit treatment costs for various influent chemistries, or water qualities, to identify the most appropriate treatment technology(ies) and to estimate long-term sludge production and disposal requirements. A desktop component would be required to estimate unit treatment costs for various influent chemistries. Some treatment options to be examined would include the current treatment strategy, low-density conventional lime treatment and high-density sludge treatment (HDS). The tasks could also include possible bench scale treatability and pilot scale testing. The sludge production scenarios could be assessed as a desktop study and sludge stability prediction would be modelled. The cost for this study was estimated at about $25K (+25K depending on bench scale testing requirements; and $75K for pilot plant testing if required). Two parallel studies would be undertaken comprising i) unit treatment costs, and ii) sludge disposal and cost. These studies would be expected to take about three months each.

Discussion: The discussion centered on the fact that unit costs would be required to allow comparisons between types of treatment methods. Since (water) treatment of the pore water would be integral to relocation, it would also be essential to the decision of whether or not to relocate tailings. The discussion also addressed identification of the most appropriate location of the treatment plant (e.g. to minimise pumping requirements by utilizing gravity flow systems), and included discussion of groundwater interception requirements as they relate to volume and quality of water to treat as function of interception location (e.g. Cross Valley Dam interception point would result in a lot of water being treated). Consensus was reached on the fact that pilot testing would be required only after the exact water quality that would need to be treated has been defined.

**Rose Creek Diversion (T4)**
The scope and objectives of the study would depend on whether the tailings would be remediated *in-situ* or whether all or some would be relocated to the open pit. If the tailings remained in place, the objective would be to design a channel to pass the PMF. The study would be undertaken in a phased approach. The major tasks would include reviewing the PMF magnitude, examination of various channel alignments, assess the possibility of multiple channels, completing the hydraulic design with respect to thermal conditions and seepage (e.g. icing, freeboard/risks which would require field data) and assessing borrow sources (including the potential need for riprap). The energy dissipation drops would be an issue (however, failure of the drop area would not affect the tailings) and would need to be examined with respect to hydraulics and fish passage. The schedule should be phased and synchronised to start as soon as input to other studies would be required. The cost for this study was estimated at \$50K-\$250K and would take six months to one year to complete.

Discussion: This study would include the possibility of placing a channel over the top of the tailings (including the design of the spillway). This would include an assessment of the possibility to upgrade the channel in its current alignment. The need for designing to the PMF in Rose Creek, and the magnitude of the PMF would need to be determined. This should also be coupled with the level of maintenance that could be tolerated. The magnitude would not be as important if the channel was on the bottom of the valley (as a suitable floodplain could be designed).

The availability of the geotechnical information was questioned. More data is available now than was available in 1979.

It was estimated that a \$50K study would generate design sections for the channel, and would provide information to answer questions such as "would the channel need to be relocated?".

Estimation of the PMF would represent about half of the scoping study. Another question raised concerned the appropriateness of designing to the PMF if the flow was across the tailings surface. The reason for a reduction in the design criteria is that the flow channel could be made wide, and that it could be vegetated.

The effect of climate change in the estimate of PMF was questioned. There were no examples of anyone else accommodating this in their designs. It appears that intense storm events in small basins are not affected by climate change. In addition, freeboard would always be more than the level of uncertainty caused by climate change.

**Engineering Design criteria (T5)**
The objective would be to determine the extreme design criteria for long-term stability of structures, i.e. maximum credible earthquake (MCE) and probable maximum flood (PMF). Several estimates of the MCE have been completed, with more than four

estimates in existence. The MCE depends on whether the Tintina Trench is active. The major tasks would include 1) assessing the uncertainty of the PMF estimates recently identified for the Faro site (the Vangorda side needs work); 2) reviewing previous MCE estimates and assessment of the Faro tectonics; 3) identifying and assessing geological structures proximal to dam sites (deterministic, field mapping: unlikely); 4) estimating (deterministic/probabilistic) values for the MCE; and 5) developing a technical understanding of values lower than the MCE.

Some work to estimate the PMF has recently been completed for Faro, and tasks related to the PMF were eliminated. The cost for this study was estimated at $70K but revised to $40K and would take about three to four months to complete (revised to two).

Discussion: Estimation of the PMF would be completed as part of the Rose Creek Diversion study (T4). One of the current estimates of the MCE is very high compared to the others. The need for an accurate number was discussed as well as whether a deterministic approach would be appropriate. The MCE number would drive the upgrades to the water retaining structures and would determine the incremental costs. The importance of MCE was also discussed in the context of tailings relocation; it could be one of the reasons to relocate the tailings. There was consensus that it was important to know whether the MCE estimates are within a reasonable range. To put the level of certainty required into context, it was estimated that buttresses would cost in the tens of thousands of dollars.

The timing for the completion of this study was discussed; it would need to be completed in time to allow comparison of cost implications for various closure alternatives.

**Waste rock seeps to tailings (T6)**

The objective of this study would be to assess other sources that may contribute contaminants to the tailings and the Rose Creek aquifer. The study would require an analysis of Guardhouse Creek water quality for determine potential impacts on the Down Valley water quality. There appears to be a pathway by which groundwater may be contaminated (requires a pathways analysis; desk top study). A recent seep survey has been completed by SRK and could be used as a starting point. The cost for this study was estimated at about $70K. The task would include analysis of existing data ($10K), Guard House Creek field study ($20K), identification of contaminant pathways ($15K), post excavation seep field survey ($25K) and would take four months for tasks 1 to 3 and two months after excavation to complete.

Discussion: This study might be separated into pre- and post (tailings) excavation phases and should be linked to the waste rock hydrology and contaminant release study.

**Tailings relocation methods (T7)**

The objective would be to develop a better understanding of costs and methods for tailings relocation. The relocation methods that would need to be evaluated would include hydraulic monitoring, dredging and mechanical (dragline). Water management would be a primary focus because any water introduced would be contaminated and establishing of ponded water (e.g. for a dredge) would increase hydraulic heads and porewater displacement rates (i.e. water flow through the tailings to the aquifer would be increased). The tasks would include an assessment of the impact ponded water, evaluating water management requirements, acquiring contractor input; and, establishing water treatment requirements. The cost for this study was estimated at $30-50K and it was estimated that it would take two months to complete.

Discussion: Other factors that may be worth considering would include water balance per method and looking at energy recovery from gravity flow return water. The cost of the study might be underestimated. There was consensus that paying a contractor to do a bid would be an effective approach to completing the relocation component of the study.

The timing of this study in the decision making process was questioned; the T1 study would be a feeder study to this (T7) study. Since it would be a large component of the costs and would be fundamental to evaluating overall costs, it would need to be completed sooner rather than later.

Water management and quality within the pit lake was raised as a significant component of this study and would need to be addressed as part of the water management strategy for each method/approach.

It was questioned whether the estimation of cost of treatment is also addressed elsewhere in the studies. The need to refine the costs associated with relocation and potential risks was parallel to the MCE discussion. The major costs would be the lime and the energy (for pumping). The use of the pit lake to manage lime costs was discussed as well as the amount of alkalinity that may be released by the tailings.

**Impact on Faro pit from tailings (T8)**

The objective of this study would be to determine the impact on pit lake water quality and assess treatment requirements for the relocation of the tailings to the open pit. The major tasks would include estimation of the storage available volume, establishing the maximum level to which tailings could be placed and the need for a cofferdam, evaluating pit water quality and treatment requirements (lime requirements), and developing a cost-benefit analysis for various pit lake management strategies, including evaluating water quality objectives. An options analysis would results from these tasks. The cost for this study was estimated at about $20-30K for engineering and potentially $20K for laboratory work, for a range of $40 to $50Kand would take 3 months to complete.

This study relates back to study T7.

**Groundwater contamination below tailings (T9)**

The objective would be to define the extent of the groundwater contamination below the tailings deposit. The major tasks would include a drilling program (sonic), installation of instrumentation, sampling, laboratory testing and reporting. The cost for this study was estimated at $110K for the drilling and an additional $110K for engineering and would take three months to complete.

Discussion: This study was based on the proposed Gartner Lee Ltd. study currently in progress. During the discussion it was established that other study objectives could be addressed as part of the proposed study, including the collection of additional information regarding the physical properties of the tailings. Nine holes have been proposed, including six or seven within the tailings deposit. Drilling would be completed with a sonic drill rig, which may not be suitable for other purposes.

The study would provide an improvement over the database from 2001. The drill holes have been targeted to address hot spots identified previously. During the discussion it was pointed out that zinc solubilization in the tailings has lead to elevated porewater concentrations, however, zinc concentrations in the aquifer remain low and the reason for this is not understood. The study would be designed to determine the reason for this.

Concern was expressed in that, while there are only low levels of contamination in the aquifer, it is possible that the contamination may soon increase to levels where it may be too late to benefit from tailings relocation (i.e. once contaminated the contaminants may persist for some time in the aquifer).

The study would also provide water quality information, which would be required irrespective of whether or not the tailings would be relocated. The information is relevant to planning for possible contaminated water interception strategies and assessing the travel time through the aquifer. The possible level of contamination in the aquifer after tailings relocation was also discussed. A focused geochemical study examining why the zinc is attenuated more than the sulphate could be undertaken. Further discussion also brought into questions the benefit of drilling due to the scale of the tailings deposit and the length of the aquifer; a 'hit or miss' situation could arise which could lead to misleading results.

**Seismic stability/upgrade requirements (T10)**

The objective would be to determine the seismic stability of the tailings containment structures and assess the potential for liquefaction. The focus would be on the Secondary and Intermediate tailings dams. The major tasks would include i) review of MCE estimates, ii) determining the tailing properties (*in-situ* density (see T1)), iii) modeling the physical stability and assessing the potential for liquefaction. The cost for this study was estimated at about $50K and would take six months to complete. The study would need to be completed prior to final selection and design of the preferred option(s).

Discussion: The scope of the study would need to focus on the Intermediate dam and Secondary impoundment and their foundations. The importance of the foundation conditions for the Intermediate dam was debated.

The need for Phase II was questioned. However, drilling may be required if it cannot be demonstrated that there would be no cause for concern at either embankment.

This study is partly linked to Study T1.

**Fish passage (T11)**

The objective would be to determine whether there is a regulatory requirement for a fish passage along the Rose Creek diversion. The task would require that the regulators be consulted. The cost for this study was estimated to be negligible. It would need to be completed prior to preliminary design of preferred options.

An issue that may arise could relate to potential compensation.

**Soil Cover Assessment (T12)**

The objectives of the study would include determining the physical properties of borrow materials that would be considered for cover construction, developing feasible cover designs based on likely performance criteria and field testing cover components to provide the basis for final design and performance assessment. Two strategies were considered for developing the testing approach namely 'top down' and 'bottom up'. The study tasks would first require a screening model assessment of the system to understand the performance objectives and develop suitable design criteria for the covers (e.g. low infiltration cover rather than oxygen barrier). Second, available materials would be identified and laboratory testing of the materials would be undertaken to establish their hydraulic and construction properties (e.g. particle size distribution, moisture retention profiles, compaction, etc.). Third, performance modelling would be undertaken to determine the infiltration reduction that could be achieved and to establish the construction requirements which provide the basis for developing final designs. A decision to proceed would be required at this stage. On the basis of proceeding, the availability of suitable cover materials would be established and field testing of one or two options would be undertaken. The output is cost, construction methods and infiltration performance. The cost for this study was estimated to be about $60K for Phase I (desk top study and laboratory components). Phase II was estimated to be about $200K for construction and about $60K/year for operations. Phase I would take 1 to 6 months (compressible to 2) and it was estimated that Phase II would take about 5 years to be completed.

Discussion: Ideally, five years would be required to conduct the cover test plots but final decisions may be required before they could be completed. Consensus was reached that the desktop study should be completed as soon as possible. Following the completion of the desktop study (including the laboratory investigations) a decision would be made whether or not to commence with the field test plot programme. It was pointed out that large uncertainties are likely to remain as to long-term cover performance even if 4 to 5 years of operation could be completed. It was however concluded that it was certain that some or other component(s) at the site would be covered at closure, and that the investigation should proceed irrespective.

The discussion elaborated on the mechanisms and performance of various cover options, including store and release covers, low infiltration covers etc. The discussion also addressed specific requirements for each of these options including climate, material types etc.

Consensus was reached that the cover investigations and design approach for the waste rock and tailings area should be combined to avoid duplication.

**Cost estimates and cash flow possibilities (T13)**

This task was not explicitly defined in a working session but was kept as something that requires definition. It would be undertaken every six months as new estimates become available.

## 4.2 Mine Areas

**Grum Collection Requirements (M1)**

The objective would be to identify systems that would be needed to collect groundwater seepage. An important focus of this study would be to determine the risk for seepage loss and its potential impacts on the receiving environment. The major tasks would include defining the hydrogeology at the base of the Grum Dump (the cost was estimated to be $60 to 80K) and identifying a preferred collection system to intercept contaminated seepage (The cost for this task was estimated to be about $15K). The total cost for this study was estimated to be about $75 to $95K. It was suggested that the study be undertaken in the summer of 2004.

Discussion: The discussion questioned if the pathways for seepage loss could be identified. It was considered that drilling would be required. The focus of this hydrogeological study would be to establish the collection system requirements for this area, which has three tributaries of varying sizes. The feasibility of bringing in a drill rig without suitable road access was also questioned, as well as the appropriateness of costs relative to the significance of the potential seepage. This study would not determine the closure requirements for the Grum dumps; it would only assess the ability to collect seepage from the dumps.

**Grum Seepage Chemistry (M2)**

The objectives of this study would be to determine future seepage water quality and contaminant loads, and, to identify the need for collection and treatment (uncertainty of the capture of the rock dump) of seepage. A geochemical study of the waste rock is currently under way (SRK). The major tasks would include i) monitoring surface water, and, i) integrating the data with the geochemical assessment to define potential treatment requirements. The cost for this study was estimated to be about $10-15K and could take to 2-3 months to complete (potentially in 2004).

The discussion was focused on making sure that these issues would not be forgotten within other studies. The key outcome would be contaminant loading predictions.

**Estimated Treatment Requirements (M3)**

The objective of the study would be to define the volume of water requiring treatment at Grum/Vangorda (need for continuous treatment vs. seasonal or intermittent). The major tasks would include i) reviewing the existing water balance and ii) developing estimates flows that would require treatment (including seepage from Grum dump). The study would consider identification of the most appropriate treatment strategy (batch or year-round treatment). The cost for this study was estimated to be about $5-10K and would take about 1 month to complete.

**Clean Pit Feasibility (M4)**

The objective would be to assess at a scoping level whether a clean pit would be feasible for any of the pits. The major tasks would include completing a review of point source inputs to each pit (flows and loads form streams etc.), estimating inputs from non-point sources (e.g. pit walls, adjacent rock, etc.) and completing a review of mitigation strategies that may lead to a clean pit. Based on the assumption that load estimates were available, the cost for this study was estimated to be about $50K. Because the study would not include a field investigation, it was estimated that it would take about 4 months to complete.

During the discussion it was concluded that there may be some duplication within the 'pit lake water quality' assessment. It was also noted that if hot spots were present in the pit, the body of water may be high in zinc. A field component to evaluate pit walls would increase the cost of the study.

**Seepage loadings at Faro (M5)**

The objective of this study would be to identify potential seepage pathways that would require treatment. The focus in general would be on pathways from dumps down into the valley. The two key issues that were identified were protection of the North Fork of Rose Creek and the south side, where water could potentially seep down into Rose Creek. The major tasks would include 1) identifying priority areas based on a desktop study, by reviewing the hydrogeology (sub surface) and water balance to identify areas of potential seepage loss (was estimated to be about $15K); 2) developing and conducting a field programme to install monitoring wells to refine the hydrogeology (~100-200K); 3) developing preferred options for a collection system at priority areas \to protect downstream water quality (~15K); and 4) completing a post excavation seepage survey.

The total cost for this study was estimated to be between $130 and $230K and would be scheduled for 2004 (four months for tasks 1 to 3 and two months for task 4).

1. Analyze existing data: $10K
2. Guardhouse creek field survey $20K
3. Linkages/contaminants pathway $15K
4. Post excavation seep field survey/analysis $25K

During the discussion it was questioned whether this study had already been completed. The discussion focussed on the specific pathways i.e. seepage within a thin layer near surface, or at depth from waste rock that has been placed in the Zone 2 pit, with the primary source of contaminants as the rock dumps. Monitoring wells on the south side of the dump provide useful data, but this well is in the Faro valley.

One idea that was raised was to investigate from the emergency tailings valley to the rock drain to determine various seepages and to assess the feasibility of collection. There is evidence of surface water contamination at X2. A series of monitoring stations also exist up the North Fork of Rose Creek, and four or five have been installed above the rock drain. X2 is below the rock drain. There is an approximately ten year history of erratic total and dissolved zinc concentrations, but not a consistent trend. These numbers are not observed above the rock drain and it was considered a possibility that inflow to Rose Creek may be linked to shallow subsurface flow.

The concern was related to the risk once the pathway is completely developed. However, it was concluded that looking for pathways in this type of terrain is expensive. It was noted that trenching might represent a cost effect alternative to drilling. It was also pointed out that breakthrough would not occur as a catastrophic event, but likely occur incrementally, and as a result, could be detected in sufficient time to install and appropriate collection system.

**Waste dump hydrology and contaminant loadings from the dumps (M6)**

The objective of this study would be to address the issues surrounding the water balance of the waste rock dumps, in particular the lack of seepage. The major tasks would include i) undertaking a meteorological study, ii) installing large scale lysimeters, iii) completing a drilling program for Rose Creek, iv) sampling at select high ARD dump areas during their removal (program to relocate the most acid generating material into the pits); v) excavating groundwater interceptor trenches; vi) irrigating select areas of rock piles; and vii) installing continuous monitoring instrumentation at selected seeps. The cost for this study was estimated at between $250 to 500K and would take a minimum of 1 year to complete.

During the discussion it was questioned as to whether this study would generate any additional useful information. The primary concern was that insufficient information is available at this time, and that it might be more efficient if there were 3 areas that could be identified, where there is a likely expectation for seepage to occur, that could be investigated systematically. The investigation could then be approached in steps according to a scoping study. Drilling would be the most expensive component. It might also be worth considering a study to measure runoff directly, by establishing an area on a waste rock dump that could be monitored during rainfall events (as opposed to trying to determine directly how much infiltration occurs). The discussion however concluded that large scale lysimeters might be used to measure infiltration.

**Vangorda/Faro Diversion design criteria (M7)**

The objective of this study would be to compute the design flows and to establish design criteria for diversion channels.

Notes: route alternatives are dependent on waste dumps/pit issues etc. This study would not address alternate routings. Existing licences do not specify design criteria. Meteorological data would be collected on site. A PMF review would be completed for the Rose Creek Diversion.

The major tasks would include 1) measurement of flows in both creeks and correlation with Rose Creek available flow monitoring results ($20K over two years). Flows would be measured monthly in summer using staff gauges. Crest gauges would be used to establish peak water levels; 2) a regional hydrologic analysis would be undertake for up to a 1:200 yr flood (correlated to Rose Creek flows upstream of Faro Creek; correlated to major rainfall events (if they occur during the study period)($10K); 3), the 1:200 to PMF values would be calculated from Rose Creek PMF values ($5K); and, 4) recommended design criteria would be developed considering "what if" scenarios ($5K). The total cost of this project was estimated at about $40K and would take six months to a year to complete task one and an additional six months for completion of the remaining tasks. Monthly flow measurements would be made for six months each year.

**Feasibility/costs of lining and grading dump (M8)**

The objective of this study would be to establish the feasibility of, and costs for, grading and covering the waste rock dumps. The study would primarily be focus on Faro but would be applicable to the Vangorda waste rock dumps as well. Infiltration objectives would need to be determined as described in Study T12, to establish the primary function of the covers, i.e. infiltration barriers or store-and-release covers. The major tasks would include estimation and characterization of available construction materials (quantity and quality), and, evaluation of dump stability. It would also be important to assess at long-term performance (as related to cold climate). The cost for this study was estimated at $25K because it would be completed as a desktop study and would take 3 months to complete.

During the discussion it was concluded this study would be equivalent to the tailings covers study (T12). The Phase II would be completed in that study and this study represent only the desktop component of the covers evaluation. The discussion identified various components of the cover that would need to be evaluated, including the extent to which a bedding layer would be required and the limitation of slope angle on cover design and durability. The discussion also identified the possibility of utilising the test cover sections that have been constructed on the on Vangorda waste rock pile, and the possibility of completing in-situ measurements on the till and overburden piles, which have been exposed to weathering conditions for many years.

**Little Creek dam future requirements (M9)**

The objective of this study would be to determine the need to upgrade and/or maintain the dam and estimate associated costs for long-term use of the dam (long term criteria – MCE/PMF). The major tasks would include 1) assessing of current condition and performance of Little Creek Dam and current design criteria (see Klohn Dam Safety Review?); 2) determining long-term stability criteria (MCE/PMF) and compare to 'as built', 3) evaluating rehabilitation needs and costs (likely no field work), and, 4) reporting with cost summary. The cost for this study was estimated to be about $35K (for two person months) and would take to about three months to complete.

**In-pit Dam Design (M10)**

The objectives of this study would be to i) determine whether or not the Zone II pit could be isolated from the main pit, and, ii) develop a design and cost estimate for the plug dam. The study would be completed to a pre-feasibility level. The major tasks would include 1) compilation of existing geological and geotechnical data, including viewing rock cores, to assess the structural geology, including faulting and fracturing; 2) completing basic fieldwork by drilling and Packer testing the bedrock; 3) competing a preliminary dam design with seepage/grouting assessment; 4) estimating construction quantities and developing a cost estimate and 5) preparing a final report. The overall cost for this study was estimated to be about $80K (three person-months with drilling and field work) and would take 4 to 5 months to complete. A lay-out map and topography has already been prepared, and it was anticipated that the first step of the study (a scoping level study) could be completed for about $10K.

During the discussion, grouting was identified as major component of the success of the plug dam. In particular, the feasibility of grouting, given a set of pressures, was questioned. It was concluded that the hydraulic head would not be significant, nor the extent of the area (i.e. the base and abutments could easily be grouted). The permeability however would need to be determined through Packer testing. It was estimated that the grouting costs could be in the range of about $100K to $250K.

The discussion group question the need for this study to understand whether or not the plug dam would be feasible. However, it was concluded that field testing (Packer testing) would be required to assess the feasibility of the structure. As to the need for the plug dam, it was concluded that it would be required to enable gravity discharge from pit. The potential consequences of failure (i.e. if the plug leaks) were discussed, and it was concluded that seepage would likely report to the Zone 2 pit. The potential impacts would likely depend on the rate of seepage.

**Water and terrestrial quality objectives (MT1)**
The objective would be to develop site-specific aquatic and terrestrial receiving environment objectives. The major tasks would include 1) reviewing existing available guidelines (which would require a jurisdictional review); 2) consulting with stakeholders for determination of key receptors (VECC including Traditional Knowledge); 3) completing baseline investigations to determine metal levels in vegetation; 4) conducting wildlife monitoring, including contaminants in food chain (liver, meat, etc…); 5) analysing contaminant pathways; 6) carrying out an ecological risk assessment; 7) developing site specific aquatic receiving water criteria; 8) completing a human health risk assessment to determine mitigation requirements (if applicable); 9) completing public consultation. Appropriate discharge standards would be back-calculated from the baseline conditions and the risk assessment. All the above should incorporate existing data (*i.e.* available benthic, water quality etc.). The tasks could be summarized in the following studies:

1) Completing a ecological risk assessment;
2) Completing a human health risk assessment (both 1 and 2 would include consultation for VECC and Traditional Knowledge, fish tissue study, etc.)
3) Conducting a Baseline metals uptake by vegetation;
4) Determining discharge standards.

The cost for this study was estimated to be about $425K and would take two years to complete.

During the discussion it was established that more data are available for fish than for wildlife. It was concluded that the study could be phased over two years and that the risk assessment could be postponed to later in the study as it would rely on data that would be generated by other components of the study that would need to be completed first.

Renewable Resources on the site were discussed, which included the existing moose country food testing. Habitat and moose counts have been done and the study would tie in with the socio-economics of the region.

**Sludge disposal location and costs (M11)**
The objective of this study would be to determine best methods of permanent storage of water treatment sludges. The major tasks would include 1) determining volumes of sludge that are likely to be generated; 2) estimating the chemistry and the long term stability of the sludge; 3) examining potential locations for developing storage areas and prioritizing these areas; 4) matching potential locations to various abandonment alternatives; 5) designing storage facilities and 6) developing cost estimates. The cost for this study was estimated to be about $40K and would take six months to complete.

The discussion identified the potential for utilizing the findings from this study to benefit current care and maintenance requirements and water treatment costs.

**Grum pit future water quality (M12)**
The objective of this study would be to determine the long-term trend of water quality and establish potential requirements for water treatment. The major tasks would include 1) reviewing existing data, 2) completing additional field sampling and analysis, 3) conducting a pit wall seep survey (field 3 months, once per year for three years); 4) completing a data analysis and compiling a final report. The cost for this study was estimated at about $320K and would take about 48 months to complete.

During the discussion it was inquired as to whether it would be possible to obtain a definitive answer regarding a clean pit. It was concluded that this would not be likely, however, the extent of contamination in the case of a dirty pit might be easier to establish. A possible overlap link with the *in-situ* treatment study was identified.

**Seepage Chemistry – Waste rock dumps (M13)**

The objective of this study would be to provide medium and long-term predictions of water quality from the waste dumps for the Faro, Grum and Vangorda areas. The major tasks would include seepage surveys, instrument monitoring, kinetic testing, continued laboratory testing, and predictive modeling. Some of these tasks have already commenced. Some additional sampling would be completed this year. The cost for the remainder of this study was estimated at about $200K and would take about 1 year to complete.

During the discussion it was established that the kinetic tests represented the bulk of the remaining laboratory testing programme to be completed. The kinetic testing is being done on the rock samples that were taken as part of the test pit investigation. It as also established that leach tests have been completed on the samples. With respect to the earlier work completed by Linda Broughton, it was considered that the additional testing would lead to a better understanding of the waste rock geochemistry, and in particular the of the Grum dump which was poorly characterised. The continuing seep surveys represented a small portion of this budget.

**In-pit treatment performance (M14)**

The objective of this study would be to determine the technical feasibility and performance of in-pit treatment methods. The study would focus on available biological (algal), and chemical (lime addition; bench tests) technologies that have been used elsewhere. The biological methods would require consideration of lake turnover, algal performance under field conditions and might require laboratory testing. The study would determine fertilization requirements, phytoplankton growth, metal removal capacity and lime requirements. The cost for this study was estimated at $90K for each of the Faro and Vangorda pits, for a total of $180K, and would take three to six months to complete.

During the discussion it was established that the Grum pit was is not included because it would likely be proved to be a clean water body that would not require treatment. It was determined that the Colomac tailings and pit lakes are examples where algae have been used in a northern environment to treat contaminated water. At that site, metals were removed as a result of biological activity that was stimulated in the pit and tailings lakes. It will however need to be determined if it would work at the metal levels present at the Anvil Range site. Another example mentioned was the Equity Silver Pit where ongoing investigations are under way. However, it was cautioned that the biological treatment system is still an emerging technology.

**Pit lake water quality (M15)**

The objective of this study would be similar to M12, expanded to include a mixing model to evaluate the effects of turnover. The objective would be to predict water quality and develop load balances for the Faro and Vangorda pits. The major tasks would include i) completing seep and load surveys (walls and other sources (~$30-40K)), ii) developing and/or compiling the hydrology for sources and inflows for flow-through options

(~$10K), and, iii) developing mixing models to assess effects of turnover and seasonal discharge (~$40-50K). A shorter-term programme is possible, which would look at a fall/spring freshet monitoring programme, and would be completed as a scoping study. The cost for this study was estimated to be about $80-90K (including $30K for field work) and would take about nine months to complete (mainly determined by seasonality of seeps).

During the discussion it was established that the cost identified were total, and that this study was linked to the clean pit feasibility study; it was considered that it would be more efficient if the scopes of the two studies could be blended.

# 5 Prioritized Investigation Designs

## 5.1 Prioritization of Investigations

After the initial investigation designs were presented to the workshop and discussed, participants were asked to assign priorities. The method of prioritization was as follows:

- Participants were divided into four groups, with each group including individuals who had worked on each of the initial investigation designs;
- Each group was then given $2,075,000 of play money, and told that they could "spend" $1,025,000 in this fiscal year and the remaining $1,050,000 in the next fiscal year.

The table on the following page shows the results, along with the initial cost estimates for each investigation. As shown on the bottom row, the total of the initial cost estimates for ranged from about $2,600,000 to $4,000,000, so that it was be impossible for groups to fund all of the investigations.

## 5.2 Discussion of Schedule and Re-Grouping of Tasks

To assist with the further prioritization of investigations, there was a limited discussion of schedule constraints. The overall schedule for the project remains under discussion, but it was generally agreed that this year and next year, *i.e.* fiscal years 2003-04 and 2004-05, are where most of the technical issues need to be resolved. Although it is likely that some technical investigations would continue longer, workshop participants were asked to focus on resolving all of the key uncertainties in that time frame.

With that schedule in mind, results of the initial priority setting exercise were reviewed. Each group was asked to defend their "spending" plan. It quickly became apparent that groups had taken slightly different approaches to dealing with tasks that were overlapping, and the re-grouping of the investigations allowed the real agreements and disagreements to be better highlighted.

The table on the second page below shows the re-grouped investigations:

Tasks T1, T5, and T10 – All groups funded the investigations of tailings physical and seismic stability, and all agreed that the "big ticket" item, T1, could be done for much less than the initial estimate. There was some disagreement about whether the work should be done in this year or next.

Investigation T2 – All groups agreed that further work on borrow sources was not a high priority in the next two years.

Investigations T3 and M11 – All groups gave some funding to the study of water treatment needs, but, as indicated by the low amounts, the general opinion was that 'paper studies' would be sufficient and that large scale pilot testing was unnecessary at this time.

| Area and Initial Investigation | | Initial Estimates | Group 1 | | Group 2 | | Group 3 | | Group 4 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tailings Areas** | | | This Year | Next Year | This Year | Next Year | This Year | Next Year | This Year | Next Year |
| T1 | Tailings physical properties | 250 | 20 | 100 | 40 | | 40 | 40 | 60 | |
| T2 | Borrow materials for covers | 50 | | | | | | | | |
| T3 | Water treatment and sludge disposal costs | 25-100 | 40 | | 20 | | 20 | 20 | 20 | 20 |
| T4 | Rose Creek diversion | 50-250 | | 40 | 20 | | 60 | | | 40 |
| T5 | Deterministic seismic design criteria | 40 | | 40 | 40 | | 40 | | | 40 |
| T6 | Waste rock seeps to tailings area | 50-70 | 80 | | 20 | | | | | 60 |
| T7 | Tailings relocation methods | 30-50 | | | 40 | | 40 | | 20 | 40 |
| T8 | Impact of tailings on Faro Pit | 40-50 | 60 | | 60 | | | 40 | | 40 |
| T9 | Groundwater contamination below tailings | 220 | 140 | | 100 | 100 | | 100 | 200 | 60 |
| T10 | Seismic stability & upgrade reqmts | 50 | | | | | 40 | | 20 | 40 |
| T11 | Fish passage | | | | | | | | | |
| T12 | Soil cover assessment | 60-400 | | | 100 | 100 | 200 | 100 | 100 | 100 |
| T13 | Cost estimates and cash flow | | 25 | 50 | 25 | 50 | 25 | 50 | 25 | 50 |
| MT1 | Water & terrestrial quality objectives | 425 | 120 | 140 | 120 | 120 | 140 | 200 | 100 | 100 |
| **Mine Areas** | | | | | | | | | | |
| M1 | Grum Dump collection requirements | 75-75 | | | | 40 | | 100 | | |
| M2 | Grum Dump seepage chemistry | 10-15 | | | | 20 | | | | |
| M3 | Estimated Vg/G treatment requirements | 5-10 | 20 | 20 | | | | | 20 | |
| M4 | Feasibility of clean Faro Pit | 50 | 40 | 100 | | | 40 | | | 100 |
| M5 | Assess seepage loss at Faro | 15-230 | | 20 | | 100 | | | | 100 |
| M6 | Waste dump hydrology | 250-500 | 40 | 300 | 40 | 200 | 100 | 100 | 100 | 100 |
| M7 | Faro/Vangorda Creek Flows | 20-40 | | | | 120 | | 20 | 20 | 20 |
| M8 | Grading and covering dumps | 25 | 60 | | 20 | | 20 | 40 | | |
| M9 | Little Creek dam requirements | 35 | | | | | | | | |
| M10 | In-Pit plug dam design | 10-80 | 20 | 100 | | 40 | 80 | | 60 | |
| M11 | Sludge disposal | 40 | | 40 | | 100 | | 40 | 20 | |
| M12 | Grum Pit water quality | 320 | 200 | | 20 | | 100 | 40 | | |
| M13 | Seepage chemistry of waste rock dumps | 200 | 140 | | 200 | 60 | 100 | 100 | 200 | 40 |
| M14 | In-pit water treatment | 180 | 20 | 100 | 120 | | | | 60 | 100 |
| M15 | Water and load for Faro and Vangorda Pits | 80-90 | | | 40 | | | 40 | | |
| | | 2605-3945 | 1025 | 1050 | 1025 | 1050 | 1045 | 1030 | 1025 | 1050 |

| **Area and Re-Grouped Investigations** | | **Initial Estimate** | **Group 1** | | **Group 2** | | **Group 3** | | **Group 4** | | **Average** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Tailings Area** | | | This Year | Next Year | This Year | Next Year | This Year | Next Year | This Year | Next Year | This Year | Next Year |
| T1 | Tailings physical properties | 250 | 20 | 100 | 40 | 0 | 40 | 40 | 60 | 0 | 40 | 35 |
| T5 | Deterministic seismic design criteria | 40 | 0 | 40 | 40 | 0 | 40 | 0 | 0 | 40 | 20 | 20 |
| T10 | Seismic stability & upgrade reqmts | 50 | 0 | 0 | 0 | 0 | 40 | 0 | 20 | 40 | 15 | 10 |
| | Subtotals | 340 | 20 | 140 | 80 | 0 | 120 | 40 | 80 | 80 | 75 | 65 |
| T2 | Borrow materials for covers | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| T3 | Water treatment and sludge disposal costs | 25-100 | 40 | 0 | 20 | 0 | 20 | 20 | 20 | 20 | 25 | 10 |
| M11 | Sludge disposal | 40 | 0 | 40 | 0 | 100 | 0 | 40 | 20 | 0 | 5 | 45 |
| | Subtotals | 65-100 | 40 | 40 | 20 | 100 | 20 | 60 | 40 | 20 | 30 | 55 |
| T4 | Rose Creek diversion | 50-250 | 0 | 40 | 20 | 0 | 60 | 0 | 0 | 40 | 20 | 20 |
| T6 | Waste rock seeps to tailings area | 50-70 | 80 | 0 | 20 | 0 | 0 | 0 | 0 | 60 | 25 | 15 |
| M1 | Grum Dump collection requirements | 75-95 | 0 | 0 | 0 | 40 | 0 | 100 | 0 | 0 | 0 | 35 |
| M5 | Assess seepage loss at Faro | 15-230 | 0 | 20 | 0 | 100 | 0 | 0 | 0 | 100 | 0 | 55 |
| M6 | Waste dump hydrology | 250-500 | 40 | 300 | 40 | 200 | 100 | 100 | 100 | 100 | 70 | 175 |
| | Subtotals | 390 | 120 | 320 | 60 | 340 | 100 | 200 | 100 | 260 | 95 | 280 |
| T7 | Tailings relocation methods | 30-50 | 0 | 0 | 40 | 0 | 40 | 0 | 20 | 40 | 25 | 10 |
| T8 | Impact of tailings on Faro Pit | 40-50 | 60 | 0 | 60 | 0 | 0 | 40 | 0 | 40 | 30 | 20 |
| T9 | Groundwater contamination below tailings | 220 | 140 | 0 | 100 | 100 | 0 | 100 | 200 | 60 | 110 | 65 |
| T11 | Fish passage | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| T12 | Soil cover assessment | 60-400 | 0 | 0 | 100 | 100 | 200 | 100 | 100 | 100 | 100 | 75 |
| M8 | Grading and covering dumps | 25 | 60 | 0 | 20 | 0 | 20 | 40 | 0 | 0 | 25 | 10 |
| | Subtotals | 85-400 | 60 | 0 | 120 | 100 | 220 | 140 | 100 | 100 | 125 | 85 |
| T13 | Cost estimates and cash flow | | 25 | 50 | 25 | 50 | 25 | 50 | 25 | 50 | 25 | 50 |
| M3 | Estimated Vg/G treatment requirements | 5-10 | 20 | 20 | 0 | 0 | 0 | 0 | 20 | 0 | 10 | 5 |
| | Subtotals | 5-10 | 45 | 70 | 25 | 50 | 25 | 50 | 45 | 50 | 35 | 55 |
| **Mine Areas** | | | | | | | | | | | | |
| M2 | Grum Dump seepage chemistry | 10-15 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 5 |
| M13 | Seepage chemistry of waste rock dumps | 200 | 140 | 0 | 200 | 60 | 100 | 100 | 200 | 40 | 160 | 50 |
| | Subtotals | 210-225 | 140 | 0 | 200 | 80 | 100 | 100 | 200 | 40 | 160 | 55 |
| M4 | Feasibility of clean Faro Pit | 50 | 40 | 100 | 0 | 0 | 40 | 0 | 0 | 100 | 20 | 50 |
| M12 | Grum Pit water quality | 320 | 200 | 0 | 20 | *100* | 100 | 40 | 0 | 0 | 80 | 35 |
| M14 | In-pit water treatment | 180 | 20 | 100 | 120 | 0 | 0 | 0 | 60 | 100 | 50 | 50 |
| M15 | Water and load for Faro and Vangorda Pits | 80-90 | 0 | 0 | 40 | 0 | 0 | 40 | 0 | 0 | 10 | 10 |
| | Subtotals | 630-640 | 260 | 200 | 180 | 100 | 140 | 80 | 60 | 200 | 160 | 145 |
| M7 | Faro/Vangorda Creek Flows | 20-40 | 0 | 0 | 0 | *20* | 0 | 20 | 20 | 20 | 5 | 15 |
| M9 | Little Creek dam requirements | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M10 | In-Pit plug dam design | 10-80 | 20 | 100 | 0 | 40 | 80 | 0 | 60 | 0 | 40 | 35 |
| **Combined Areas** | | | | | | | | | | | | |
| MT1 | Water & terrestrial quality objectives | 425 | 120 | 140 | 120 | 120 | 140 | 200 | 100 | 100 | 120 | 140 |

Investigation T4 – All groups funded the initial phase of the Rose Creek Diversion investigation. There was minor disagreement about timing.

Investigations T6, M1, M5 and M6 – All groups funded the investigations of waste rock seepage. The funding levels were within the range of the initial estimates, indicating agreement that these are high priority items.

Investigation T7 – All groups except Group 1 funded further investigation of tailings relocation. There were disagreements about timing.

Investigation T8 – All groups funded further investigation of the impact of tailings on Faro pit, again with disagreements about timing only.

Investigation T9 – All groups funded the further investigation of groundwater contamination below the tailings. There was considerable disagreement about the scope and timing, with some groups feeling that there was no need for immediate field work, and others seeing it as a high priority.

Investigation T11 – All groups agreed that deterring the fish passage requirements for the Rose Creek was a priority, but that it cold be done with little or no cost.

Investigations T12 and M8 – All groups provided some level of funding to investigations of covers, but there was significant disagreement about the scope. Group 1 felt that any investigation of covers for the tailings area was unwarranted.

Investigation T13 and M8 – All groups provided some level of funding to these tasks, which were grouped because they both lead to improved estimates of closure costs (including water treatment costs).

Investigations M2 and M3 – All groups provided a high level of funding to investigations of waste rock seepage chemistry, with the Grum Dump work seen as a subset of the overall program.

Investigations M4, M12, M14 and M15 – All groups provided a high level of funding to assessments of future water quality in the pit lakes, and what might be done to mitigate the problems and allow flow through conditions to develop.

Investigation M7 – Further investigation of flow in Faro and Vangorda Creeks was seen as a low priority for this year. Three of the groups provided some funding for next year.

Investigation M9 – All groups agreed that investigations of Little Creek Dam are not a priority.

Investigation M10 – Although all groups funded some level of effort on the Faro Pit plug dam, there was significant disagreement about the scope and timing, with some groups wanting a detailed field investigation and design and others suggesting more limited investigation only.

Investigation MT1 – All groups agreed that further definition of water and terrestrial quality objectives is a high priority.

## 5.2 Detailed Scopes for High Priority Investigations

The re-grouping of the initial designs led to a much smaller number of investigations. The discussion of priorities and re-grouping indicated that there was either substantial interest or significant disagreement in the following (grouped) investigations:

- Tailings physical stability (T1, T5, T10)
- Pit water quality (M4, M12, M15, M15)
- Waste rock hydrology and seepage (T6, M6, M5)
- Tailings geochemical and groundwater (T8, T9)
- Soil covers (T12, M8)
- Sludge disposal (T3, M11).

Workshop participants were then asked to develop detailed scopes of work for the above. The detailed scopes were then presented to the entire workshop and questions were answered, although the time for discussion was limited. Results are presented in the following subsections.

### 5.2.1 Tailings Physical Stability Studies

A combined program for the investigation of the tailings liquefaction potential was presented. The scope was expanded to include final engineering analyses based on the new field data. It was pointed out that the field program could be carried out in winter, if necessary, and that in fact a winter program might allow easier access to softer parts of the tailings, which are likely to be of most interest.

| Title | Tailings Physical Stability Studies<br>(Combination of TI, T5 and T10) | |
|---|---|---|
| Objective | Evaluate performance of Down Valley tailings structures in response to maximum credible earthquake (MCE) | |
| Activities | Description | Est. Cost |
| 1 | Review existing data<br>Compile and review data for 3 dams plus tailings. Identify data gaps | $10K |
| 2 | Field program to investigate tailings properties | |
| | CPT in Tailings - 5 drill rig days for density, pore pressure dissipation, liquefaction potential | $38K |
| | BDT at Cross Valley - drilling of dam foundations (if needed – next year only) | $55K |
| 3 | Define MCE | |
| | Review of existing assessments by independent expert. Definitive opinion on MCE, based on available information. Recommendation for site specific studies, if required. | $20K |
| | Additional studies (if needed – next year only) | $50K |
| 4 | Engineering Analyses<br>Screening level tailings liquefaction study, pseudo-static dam | $65K |

| Title | Tailings Physical Stability Studies (Combination of TI, T5 and T10) | |
|---|---|---|
| | analyses and third party review for three dams and deformation analyses for two dams. | |
| | **Total**: | $238K |

### 5.2.2 Soil Covers

A combined program to investigate the potential for soil covers on the tailings and waste rock was presented. The program shown below was discussed at length. With respect to the tailings, it was suggested that the program should include consideration of water covers and soil covers intended only for erosion and dust control. It was also agreed, after much discussion, that full-scale field tests were not warranted this year but that limited field experiments would be beneficial.

| Title | Soil Covers (Combination of T12 and M8) | |
|---|---|---|
| Objective | Desktop and field technical feasibility and cost of waste rock and tailings covers | |
| Activities | Description | Est. Cost |
| 1 | Data review | $15K |
| 2 | Deconstruct existing tailings plots (chemistry), Vangorda cover, overburden piles | $22K |
| 3 | Lab testing of borrow materials | $35K |
| 4 | Consultation and Design - identify characteristics of the covers | $25K |
| 5 | Construct cover optimization experiments / test | $100K |
| | **Total**: | $200K |

### 5.2.3 Plug Dam Design – Phase I

An investigation of the feasibility of a plug dam was presented. Phase I could be undertaken this year. Phase II, which is the field program, could be undertaken next year.

| Title | Plug Dam Design – Phase I (Combination of T12 and M8) | |
|---|---|---|
| Objective | Conceptual design and costing of In-Pit Dam (between Zone I and II pits) | |
| Activities | Description | Est. Cost |
| 1 | Review existing topography and develop height-volume curve for dam (1 person-week)<br>Review foundation and abutment geology from existing information (2 person-week)<br>Field reconnaissance to look/map at rock mass on abutment and | $30K |

| Title | Plug Dam Design – Phase I (Combination of T12 and M8) | |
|---|---|---|
| | foundation, detailed assessment of drill accessibility (including review of 1993 or 1994 SRK drill programme data). (1 person-week)<br>Conceptual design and planning of future dam and costing, quantities, costing and constraints, specs for field program (specifications for site investigation programme) (3 person-week) | |
| 2 | The field programme would include 5 boreholes (drilling and logging and Packer tests). The need for thermistors was discussed. | $50K |
| 3 | Design to final level (seepage/grouting/quantities; stability) | $40K |
| | **Total**: | $120K |

### 5.2.4 Waste Dump Hydrology and Seepage – Phase I

A program to better define waste dump water balances was presented. The first three steps would be executed as Phase I this year (for a cost of $150K) and the last step as Phase II next year (for a cost of $100 to 200K).

| Title | Waste Dump Hydrology and Seepage – Phase I (Combination of T6, M5 and M6) | |
|---|---|---|
| Objective | The primary focus is to define water balance and flow patterns. A secondary objective would be to link to the geochemical and contaminant loading study and to interface with the water quality studies. | |
| Activities | Description | Est. Cost |
| 1 | Compilation and review existing data | $15K |
| 2 | Select, supply and install met stations at Faro, Grum dumps | $40K |
| 3 | Flow scenarios and desktop characterization of water balance scenarios and literature search | $100K |
| 4 | Define objectives, plan and implement field program | $100-200K |
| | **Total**: | 250-350K |

### 5.2.5 Water Treatment and Sludge Disposal T3 M11

A combined study of water treatment and sludge disposal was presented. The need to examine preferred options for sludge disposal was highlighted. It was noted that Yukon government has regulations regarding sludge disposal.

| Title | Water Treatment and Sludge Disposal (Combination of T3 and M11) |
|---|---|
| Objective | Identify the unit costs for new treatment system and selection of preferred sludge storage / disposal options |

| Title | Water Treatment and Sludge Disposal (Combination of T3 and M11) | |
|---|---|---|
| Activities | Description | Est. Cost |
| 1 | Review of existing systems, selection options for further assessment | $5-10K |
| 2 | Lab and pilot studies as required | $20-30K |
| 3 | Review existing sludge stability (existing data) and identify storage / protection requirements | $5-10KK |
| 4 | Determine volumes | |
| 5 | Assess disposal options | $25-35K |
| 6 | Determine disposal locations | |
| 7 | Preliminary design / costing | $5-10K |
| 8 | Reporting | $10K |
| | **Total**: | $70-105K |

### 5.2.6 Impacts of Tailings on Faro Pit

A revised plan for investigating the impacts of tailings on the Faro Pit was presented. The plan included testing of geochemical impacts on the pit lake as well as possible control or mitigation measures.

| Title | Impacts of Tailings on Faro Pit (Revised T8) | |
|---|---|---|
| Objective | Determine/Assess potential source concentrations from deposited tailings on pit water and effect/possible influences of deposition options on contaminant concentration / treatment | |
| Activities | Description | Est. Cost |
| 1 | Define deposition strategies | $5-10K |
| 2 | Testing programme– lime demand, pH-metal relationship; solute release under different conditions (anoxic) – column tests | $20-35K |
| 3 | Define source terms for selected options | $15-20K |
| 4 | Evaluate solute transfer to the pit lake and pit lake quality | $10-15K |
| 5 | Assess treatment requirements | $5-10K |
| 6 | Select preferred strategy and reporting | $10-15K |
| | **Total**: | $55 – 95K |

### 5.2.7 Groundwater Contamination Below Tailings

A revised scope for the Phase II characterization of groundwater contamination below the tailings was presented. The proposed schedule is 6 to 9 months, with a potential for a

Phase III. Ron Nicholson commented that there may be an advantage to do the study in the winter. One hole could go through the Intermediate Dam. An item to consider is on site lab testing.

| Title | Groundwater Contamination Below Tailings (Revised T9) | |
|---|---|---|
| Objective | Refine and verify extent of groundwater contamination (Zn) below the tailings and timing for contaminants getting into the groundwater | |
| Activities | Description | Est. Cost |
| 1 | Lay out calculations as to costs x and y | $100-150K |
| 2 | Drilling program (7-9 holes down to bedrock with samples) | |
| 3 | Testing program<br>Tailings – field screening – pH and conductivity of solids<br>Selected leach tests (extractions on tailings (shake flask)<br>Selected grain size<br>Selected permeameter (lab)<br>Selected Kv – neutral tails, aquifer | $30-50K |
| 4 | Monitoring (SWL/ Water Chemistry) | $20-30K |
| 5 | Supplemental Program (keep sample for availability for T8) | $5K |
| 6 | Reporting | $40-60K |
| | **Total**: | $195–295K |

### 5.2.8 Pit Lake Water Quality

A combined study of pit lake water quality was presented. There was no time for discussion of this program, but comments received later suggested that there was a need for a more limited "phase 1" to establish whether in-pit treatment was at all feasible.

| Title | Pit Lake Water Quality (Combination of M4 M12 M13 M15) | |
|---|---|---|
| Objective | Assess feasibility of flow through. | |
| Activities | Description | Est. Cost |
| 1 | Review existing evaluation and data ($15 to 20K)<br>Compile data (hydrology, hydrogeology and seep data) ($10-15K)<br>Prepare preliminary water and load balance and conduct gap analysis ($20-25K and $5K)<br>Design and implement field program/investigation ($50 to 150K)<br>Prepare Mixing model and select to proceed or not ($15-20K)<br>Decision Point: continue only selected | $115-250K |
| 2 | Select potential mitigation measures ($10K)<br>Field investigation mitigative measures ($180K) | $220K |

| Title | Pit Lake Water Quality<br>(Combination of M4 M12 M13 M15) | |
|---|---|---|
| | Sensitivity analysis (evaluate mitigative performance) and<br>Prepare proposed strategies for closure ($30K plus peer review)<br>Peer review | |
| | **Total**: | $325–470K |

### 5.2.9 Other High Priority Investigations

Three other investigations were on the re-grouped list but did not receive further attention in the workshop. The investigations of tailings relocation (T7) and waste rock seepage quality (M13, M2) were not re-scoped because there was little disagreement about the initial ideas. A lumped investigation called "cost estimates" was proposed to allow for development of a cost database for the site and ongoing refinement of closure cost estimates. That task would also incorporate initial investigations T12 and M3.

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October 8, 2003

To: Distribution List:

**Anvil Range Mining Corporation ("Anvil Range") – June 2003 Technical Workshop Report**

We are pleased to circulate a report documenting the Technical Workshop that was held in Whitehorse on June 24-26, 2003.

As announced at the January 2003 Technical Advisory Committee meeting, the responsibility for closure planning for the Anvil Range mining complex has been assumed by a joint government project team. The Type II Mines Project Office has since been established. The purpose of the June 24-26 workshop was to provide guidance to the Type II Mines Project Office in their work toward the development of a Final Closure and Reclamation Plan for the Anvil Range mining complex. The workshop was organized by Deloitte & Touche Inc., on behalf of the Type II Mines Project Office.

Specific objectives for the workshop included:

- Identifying the key factors that stakeholders will use to evaluate any closure and reclamation options that are developed;
- Identifying closure and reclamation options that are worthy of evaluation;
- Preparing the scope of work for any investigations needed to support such options; and
- Preparing a broad schedule for the investigations.

The Type II Mines Project Office and Deloitte & Touche Inc. would like to extend our thanks to the workshop participants for their attendance and for their contributions to an open discussion about the long-term challenges presented by the Anvil Range property. The enclosed report is intended to serve as a record of the workshop activities and of the discussions that took place during the workshop.

The workshop was instrumental in shaping the programme of studies for the remainder of this year. Following the workshop, the 2003-2004 study plans were revised to reflect priorities identified by the workshop participants.

If you have any questions regarding the content of the report or next steps, please contact the Type II Mines Project Office (Mr. Dave Sherstone, DIAND at 867-667-3360 or Ms. Marg Crombie, YTG at 867-393-7098) or myself at 416-601-6147.

Yours very truly,
**DELOITTE & TOUCHE INC.**
in its capacity as Interim Receiver of
ANVIL RANGE MINING CORP.

Valerie Chort

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National Practice Leader, Environmental Services
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