Deloitte & Touche

ANVIL RANGE PROPERTY

2002 DAM SAFETY REVIEWS

Report

KLOHN CRIPPEN

PA 3003.01.510

KLOHN CRIPPEN

December 5, 2002

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Mr. Douglas Sedgwick

Dear Mr. Sedgwick:

Anvil Range Property
2002 Dam Safety Reviews
Report

We are pleased to submit our report on the dam safety reviews of the Little Creek Dam at the Vangorda Mine and the Intermediate, Cross Valley and Fresh Water Supply Dams at the Faro Mine.

Please contact us if you have any questions.

Yours truly,

KLOHN CRIPPEN CONSULTANTS LTD.

Brian T. Rogers, P.Eng.
Project Manager

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Deloitte & Touche

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EXECUTIVE SUMMARY

An independent dam safety review report has been prepared for the Little Creek, Intermediate, Cross Valley and Fresh Water Supply Dams at the Anvil Range Property near Faro, Yukon. The Anvil Range lead/zinc mining complex consists of the Faro Mine site which was in production from 1969 to 1992 (production rates of 5000 to 9300 tonnes per day), and the Vangorda Plateau Mine site which was in production from 1986 to 1998. Since 1998, the mine sites have been under the management of Deloitte & Touche Inc., who are the court-appointed interim receiver. Ongoing care, maintenance, and environmental protection activities are centered on a seasonal pumping and water treatment program for the Faro and Vangorda open pits, and inspection and maintenance of water retention and water diversion structures.

The basis of the current review included a site visit by Mr. Brian Rogers, P.Eng., and Mr. Stan Williams, P.Eng. in July 2002, discussions with site staff, an assessment of response data from the instrumentation and background design and construction information contained in selected reports for the project site. The review followed the intent of the CDA Dam Safety Guidelines with the objective of comparing technical design and ongoing care and maintenance operations for the mining complex with good practice.

The dams range in age from the Fresh Water Supply Dam that was constructed in 1968 to provide water storage for the ore processing at the Faro Mine over the winter season, to the Intermediate and Cross Valley Dams that were constructed to form the Down Valley tailings area between 1981 and 1991, and finally the Little Creek Dam that was constructed in 1991 to form a pond for collection of water from the Vangorda open pit and waste dump.

The report presents our findings relative to the design, construction and performance of each dam. We have focused on identifying immediate safety concerns and on assessing the soundness of the approach taken in design, construction and operation, and have only conducted stability design checks for the Intermediate Dam which we consider to be the key long term structure at the mining complex. Much of the original design and construction documentation is not available for this review, and we have not looked at all available information. However, the selected reports that have been reviewed are listed in the references, and give us a good appreciation of the key design aspects of the dams. We also note that annual inspections are completed for both mine sites. The annual inspection reports contain a summary of the site observations, provide the instrumentation response data, and note recommendations for operation and maintenance for the coming year. These reports have been prepared by Golder Associates Ltd. (1996 to 1999), Geo-Engineering (MST) Ltd. (1999), BGC Engineering Inc. (2000 and 2001), and SRK Consulting Engineers (1996 to 2001).

Deloitte & Touche and their consultants are assessing the requirements for the renewal of the Site Water License, and are revising operating procedures for the dams. Considerable work has been completed on an assessment of the Fresh Water Supply Dam following a site inspection of the low level outlet that raised stability concerns. This work has included geotechnical investigations and hydrotechnical analyses of the site, and the assessment of breaking the dam in the 2003/2004 period.

As part of this work, a Qualitative Risk Assessment (BGC 2001c) was completed for the Down Valley tailings area to provide a level of understanding and enhanced awareness of the potential hazards within the tailings containment system. None of the dams have a formal consequence classification. However in this risk assessment, a consequence category of very high was assigned to dam failures of the Fresh Water Supply, the Intermediate, and Cross Valley Dams as this would cause major uncontrolled releases of fluid and tailings from the Down Valley tailings area with downstream surface water contamination for long periods. Consequences include repair, fines and clean-up costs, which were estimated to be in the range of US$10 million to US$100 million.

Therefore, the Intermediate, Cross Valley and Fresh Water Supply Dams are likely classified as Very High Consequence structures under the rating system of the CDA Guidelines. This classification then requires the following:

- Ensure safety of the structures against extreme events such as the Probable Maximum Flood (PMF) and the Probable Maximum Earthquake (MCE);
- Independent safety reviews should be conducted every five years; and
- The dam owner is required to prepare an Emergency Preparedness Plan.

The requirement for ensuring the stability of the dams against extreme events has major implications on the long term operation of the Down Valley tailings area, as currently the tailings area is not designed for PMF conditions or for the Maximum Credible Earthquake. In particular we note that the Intermediate Dam is the key structure for the tailings area, and under the classification of Very High Consequence, will require an assessment of safety under PMF and MCE loading conditions. Therefore, we recommend that a dam breach analysis should be carried out for the Intermediate Dam, to establish the consequence of a breach in terms of both possible loss of life and the socio-economic, financial and environmental impacts and costs, and confirm the hazard classification category.

Our assessment for each dam structure and recommendations for your consideration are included in respective report sections. A highlight of the main conclusions and recommendations for the mine complex dams are as follows:

- Visual inspections did not identify any immediate safety concerns, and all dams appear to be performing satisfactory. Certain maintenance items are recommended, such as repairs to surface erosion on the downstream face of the Intermediate Dam, and infilling and regrade of cracks on the crests of the dams in the Down Valley area.

- We agree with the water management philosophy to reduce the pond levels behind all four of the dams at the site. However, it is recommended that an Operations, Maintenance and Surveillance (OMS) Manual is prepared for the various pond operations and system components. The manual should include current plans and section drawings for each dam showing all elevations in metres above mean sea level, as well as the storage volume curves and the proposed pond operating levels. The OMS Manual would include the current surveillance instrumentation monitoring and annual reporting requirements. The manual should also address trigger levels for pond levels and instrumentation responses at which action is required from site staff.

- We note that the Intermediate Dam is likely classified as a Very High Consequence Structure because of the high costs associated with a dam breach occurrence and the subsequent contamination effects downstream. Therefore, we recommend that a dam breach and inundation study be carried out for the Intermediate Dam to confirm this classification.

- Deloitte & Touche Inc. have qualified consulting companies involved in the maintenance of the dams, and in the assessment of changes to operating procedures, such as the breaching of the Fresh Water Supply Dam in 2003/2004. It is evident that changes to operating conditions must consider the long term safety of all the dams. In particular, attention needs to be given to the capacity of the North Fork Rose Creek rock drain under the Vangorda Mine road, and the main Rose Creek division channel to pass high flood flows. Failure of either of these two components of the system will have major impacts on routing floods passed the Intermediate Dam and its emergency spillway.

- Specifically, there are risks that an extreme flood could be routed onto the tailings area behind the Intermediate Dam, and hence routed down the emergency spillway. It is recommended that the capacity of the emergency spillway at this structure be reviewed, as erosion of underlying native material could cause a dam breach and subsequent loss of tailings.

- It is recommended that the Emergency Response Plan for the Anvil Mine Complex be updated, and that the plan include an Emergency Preparedness Plan to identify the response by site staff to a potential dam breach alert, focusing on the Intermediate Dam which is considered the key structure in the tailings impoundment area.

Since the site visit in July 2002, the assessment of the Fresh Water Supply Dam has resulted in a plan to breach this structure. Preliminary studies are ongoing on the work scope for this dam breach by the spring of 2004. These studies should consider the following recommendations for the Fresh Water Supply Dam made following the July dam safety review site visit:

- There are uncertainties concerning the integrity of the low level outlet pipe at the Fresh Water Supply Dam. Specifically, a recent diver inspection has indicated a potential settlement zone under the dam, and local corrosion of up to 40% of pipe wall thickness. Based on a review of available as-built drawings, we note that the pipe is basically located on bedrock, encased in reinforced concrete, and constructed with 15 collars. Thus it is anticipated that the settlement zone in the pipe results from as-built conditions. We do, however, note that there is a discrepancy between the distance from the intake structure to the valves in the outlet structure as measured by the divers, and as noted on the as-built drawings. This needs to be resolved. It is recommended that a field survey be completed to confirm the location and elevation of the intake structure, and the elevation of the low level outlet pipe both at the intake and outtake structures to compare with the as-built drawings. We also recommend that the valves in the outtake structure be tested to confirm safe operating levels.

- Piping is a serious concern for the Fresh Water Supply Dam. We note that current seepage weirs are not effectively monitoring seepage from this structure. Thus we recommend that separate measurements be made of seepage exiting immediately upstream from the outtake structure, and of the flow from the low level outlet pipe which can be monitored using the overflow weir within the structure.

- It is recommended that high priority be placed on replacing the weir downstream of the outtake structure. During replacement, we would propose to drop the base level of the weir as much as possible to reduce the tail water level adjacent to the outtake structure. This will have the effect of reducing the piezometric level in the rock collector drain under the toe berm.

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1. INTRODUCTION

1.1 General

This report presents the results of the dam safety review of the Little Creek Dam at the Vangorda Mine, and the Intermediate, Cross Valley, and Fresh Water Supply Dams at the Faro Mine. The mines are part of the Anvil Range lead/zinc mine complex which is located approximately 200 km north-northeast of Whitehorse, Yukon, as shown in Figure 1.1. The report has been prepared in accordance with our proposal dated June 25, 2002 and supplementary proposal dated July 17, 2002. Authorization to proceed with the dam safety review was received July 19, 2002. A copy of the Request for Proposal from Deloitte & Touche Inc. dated June 17, 2002 is included in Appendix I for reference.

All units in the report are in the SI system. For clarity, all elevations in the text of the report are given in metres above mean sea level (amsl). It should be noted that this does not apply to many of the base drawings for the mine complex. Often these drawings refer to "Mine Datum" or "Down Valley Datum". The following conversion rules (Robertson Geoconsultants Ltd. 1996) have been assumed for this report:

- To convert from mean sea level to Mine Datum add 33.3 m (109.2 ft)
- To convert from mean sea level to Down Valley Datum add 32.3 m (106.0 ft)

The limitations of this report are described in a Disclaimer after the References.

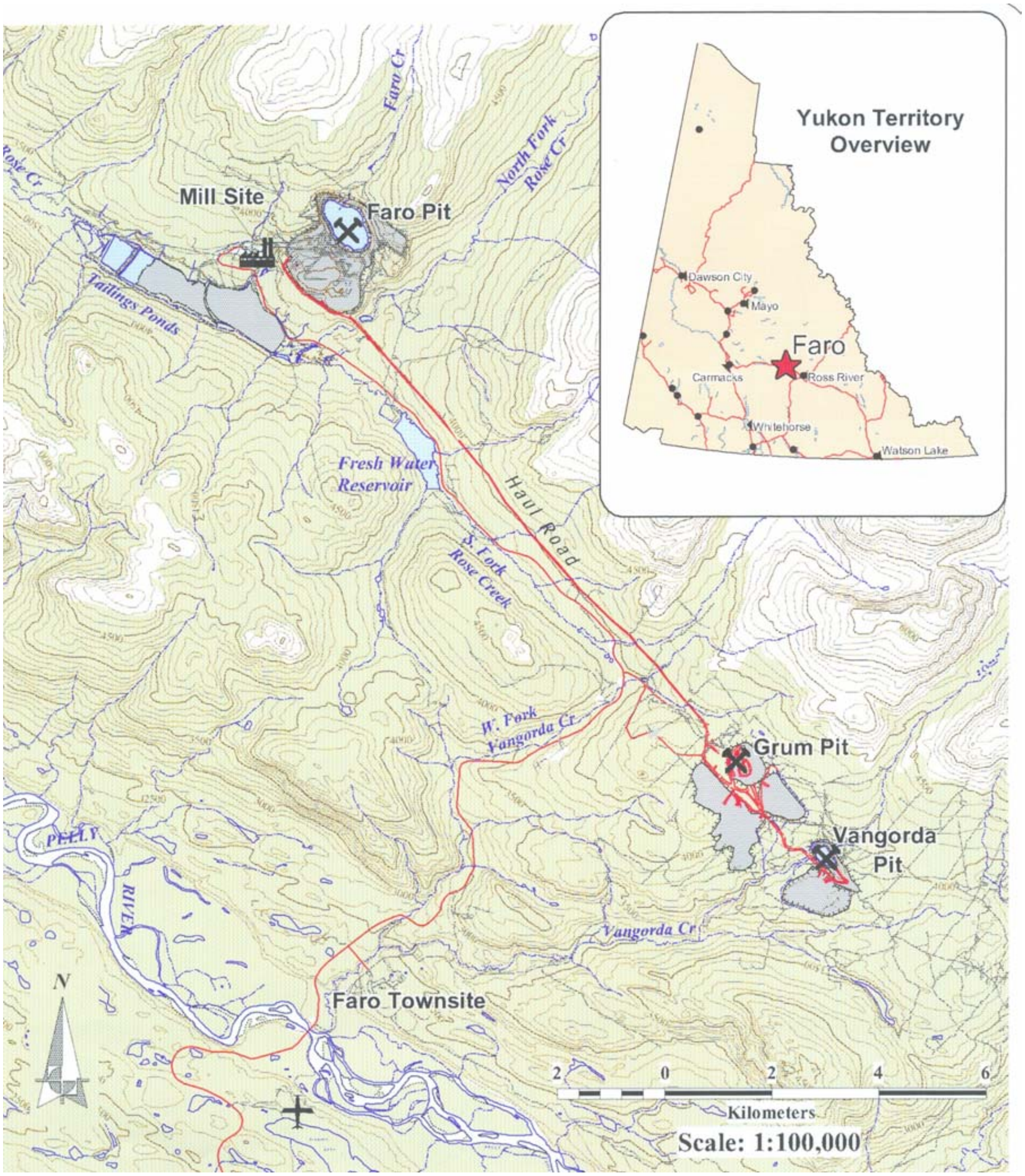

Figure 1.1 Location Plan

1.2 Available Information and Site Visit

A list of the information available and example dam plan and section drawings for the project are included with the Request for Proposal in Appendix I. Our assessment is based on the site visit to the Anvil Range Property on July 23 to July 25, 2002, discussions with site staff and the Deloitte & Touche Inc. engineering consultants, and a review of the instrumentation data and selected reports from the list of available information. The key selected reports are included in the reference list.

Mr. Brian Rogers, P.Eng., and Mr. Stan Williams, P.Eng., together with Mr. Dana Haggar and Mrs. Rhonda Carr of Deloitte & Touche Inc. inspected all four dam sites. Mr. Dana Haggar and Mrs. Rhonda Carr provided site specific background information on operating procedures, surveillance and instrumentation monitoring, and emergency response planning. Our site visit observations are documented in Section 5 for the Little Creek Dam, Section 6 for the Intermediate Dam, Section 7 for the Cross Valley Dam and Section 8 for the Fresh Water Supply Dam. Representative photographs for each dam taken during the site visit are included in Appendix II.

2. SITE CONDITIONS

2.1 Climate

A weather station (elevation 1158 m) was located at the Faro Mine site from 1967 to 1980. The mean annual temperature for that period was –3.4˚C. The mean monthly maximum daily temperature was 17.5˚C in July, and the mean monthly minimum daily temperature was –24.9˚C in January. Months with no mean minimum temperatures below zero were June, July and August.

The mean annual precipitation as recorded at the Faro airport station is 304.7 mm for the period 1978 to 2001. This total comprises roughly equal proportions of rainfall and snowfall as water equivalent. The maximum monthly mean of 58.9 mm occurred in July. The minimum monthly mean of 7.2 mm occurred in April. The accumulation of snow at the tailings impoundment typically begins in October, and the snow is generally melted by the end of April. The prevailing wind direction in the region is from the southeast.

2.2 Geology

The stratigraphy of the Anvil District consists of regionally metamorphosed sedimentary bedrock, ranging in age from late Precambrian to Permian (approximately 900 million to 250 million years ago). The degree of metamorphism ranges from moderate (schist) to low (phylite). The landforms and surficial deposits of the area have been shaped and are attributable to the last ice age which is estimated to have existed in the Yukon between 35,000 and 10,000 years ago.

The surficial geology of the Faro site generally consists of colluvial, glaciofluvial, and morainal (glacial till) deposits forming a discontinuous cover over the bedrock. On the valley sides, bedrock is discontinuously covered with a veneer of moraine and colluvial deposits which increases in thickness towards Rose Creek. A complex assemblage of fan and outwash sand and gravels, dissected by stream channel and lacustrine material fill Rose Creek valley. Terraces and fans are prominent on the north side of the valley, where they in part underlie the existing Down Valley tailings area.

The largest colluvial deposit of the Faro site is described as a colluvial apron and is located on the south slope of the Rose Creek valley upslope from the Cross Valley Dam and extends on the valley wall downstream of the Down Valley tailings area. Another colluvial apron is located at the base of the south slope of the Rose Creek valley about half way between the Fresh Water Supply Dam and the original tailings impoundment. A third major colluvial deposit, described as a colluvial fan, is located east of the upper Rose Creek near the Faro pit.

The majority of the deposits in the area of the Faro site consist of either granular glacial or fluvial deposits. One glaciolacustrine deposit was noted near the location of the Cross Valley Dam and Intermediate Dam. This deposit consists of fine sand to sandy silt. This unit has been measured to be 20 m thick and is frequently buried by a sequence of sand and gravel. The glacial till is a poorly sorted deposit of clay, silt, sand, gravel and angular boulders. Till commonly underlies glaciofluvial deposits in areas of former meltwater drainage.

Discontinuous permafrost is present in the Rose Creek valley. Prior to development of the Down Valley tailings area, most of the south valley wall consisted of frozen coarse glacial till, whereas much of the north valley wall was in similar but unfrozen material.

The area surrounding the Vangorda Mine is characterized by a thick glacial till blanket overlying bedrock.

2.3 Extreme Flood Flows

The Faro Mine site facilities are within the Rose Creek watershed, which is a tributary of approximately 340 km^2 to the Anvil Creek watershed. Anvil Creek is a tributary of the Pelly River.

Rose Creek has two principle tributaries, the North and South Fork, which join upstream of the Down Valley tailings impoundment. Two local streamflow gauging stations at Stn. R7 on the North Fork, and at Stn. X14 on Rose Creek downstream of the tailings have operated seasonally since 1994. The peak daily discharge during the recording periods since 1994 at Stn. X14 was over 14 m/sec in 2000.

The most recent documentation of the flood flows and a Probably Maximum Flood (PMF) estimate have been prepared by Northwest Hydraulics Consultants (2001a). The estimated floods for various locations within the tailings area are summarized in Table 2.1 for the various locations in the Faro Mine site.

Currently the Rose Creek diversion channel and the Intermediate Dam spillway have been sized for flood events less than the PMF. It is understood that preliminary analyses regarding the passing of the PMF are being undertaken by SRK Consulting Engineers Ltd.

Table 2.1 Estimated Floods at Specific Locations at the Faro Mine Site

Mine Site Sub Basins	Drainage Area Km^2	Flood Discharge (Instantaneous)					PMF Peak Discharge m^3/s
		2-year m^3/s	50-year m^3/s	100-year m^3/s	200-year m^3/s	500-year m^3/s	
North Fork Rose Creek at Flow-through Rock Drain	118	9.3	48	59	72	92	920
Fresh Water Supply Dam catchment	67	5.6	31	39	49	63	550
Rose Creek above Tailings Diversion Channel	203	15	71	88	105	135	1480
Rose Creek at Stn 14 Downstream of Tailings Area	230	17	78	96	115	145	1680

From Northwest Hydraulic Consultants (2001a)

2.4 Seismicity

A range of peak ground accelerations have been used for the design of various facilities at the Faro Mine to represent the occurrence of an earthquake.

The design seismic loading criteria used by Golder (1980) in the 1980 design of the Down Valley tailings containment project were a PGA of 0.052 g (100 year return period) and 0.097 g (200 year return period). The determination of these design earthquakes were based on a statistical analysis of historical earthquakes (based on data provided from the Pacific Geoscience Centre) that had a 10% probability of exceedance in 50 years (475 return period event).

In the 1981 abandonment plan, Klohn Leonoff (1981) noted that the design criteria for closure were different from those used for an operating mine. Therefore, they recommended that the MCE be used for the design criteria. The MCE was estimated on the basis two different methodologies; on the basis of potential movements in fault zones located near to the Faro Mine and on the basis of statistical analysis of previous earthquakes. The report noted that the data available at the time was very limited and that a conservative approach was taken.

Based on the historical movement rates within the Tintina Trench it was estimated that an earthquake with the magnitude of 6.5 could occur. Using an empirical formula that included the distance from the site to the location of the earthquake a peak ground acceleration of 0.40 g was estimated as the design horizontal acceleration for the site facilities. Using the same methodology and an estimated 6.0 earthquake within the local faults of the Rose Creek valley a peak ground acceleration of 0.36 g was estimated for the site facilities.

Statistical analysis using earthquake analysis provided by GSC Pacific Geoscience Centre resulted in a peak ground acceleration of 0.32 g for the 10,000 year event. The analysis was also performed to estimate the 475 year return period earthquake, which was determined to be 0.07 g.

Robertson Geoconsultants (1996) included an assessment of the seismic ground motions for the Faro area performed in the Integrated Comprehensive Abandonment Plan report dated November 1996. This was based on historical data and the assumption that earthquake loading would be transmitted through rock. The PGA was estimated as follows:

- 0.05 g for a 475 year return period; and,
- 0.13 g for a 10,000 year return period event.

The 1996 report noted that "there is no evidence of more recent displacement along the Tintina Fault and the fault is not included as an earthquake source zone in either the H or R zonations given in the GSC report, i.e. the fault is not considered active and no maximum magnitude has been defined for the fault. Thus, it is unrealistic to consider a deterministic estimate of seismic ground motions at Faro in which an earthquake is assumed to occur on the Tintina."

In a report by BGC Engineering Inc. (2001b) titled Physical Stability Assessment of the Fresh Water Supply Dam dated November 2001, the design seismic parameters were calculated to be:

- 0.063 g for a 475 year return period; and,
- 0.080 g for a 1,000 year return period event.

This was based on information provided by the Pacific Geoscience Center (a division of the Geological Survey of Canada) which estimated these parameters on the basis of historical earthquake loading and the 1990 NBCC seismic zoning maps. Seismic co-efficients of 0.08g and 0.13g have been used in the most recent analysis of the stability of the Fresh Water Supply Dam.

For this review, the seismic hazard was computed using the computer program EZ-FRISK®. Two seismo-tectonic models were used, as discussed in the Adams et al (1999) GSC open file report. These are labeled as the GSC-R model, based on historical seismicity and regional tectonics, and the GSC-H Model based on historical seismicity.

The resulting peak horizontal ground accelerations (PGA), g, for different return periods are summarized in Table 2.2.

Table 2.2 Seismic Hazard Results – GSC (1999) Tectonic Model

Return Period (Years)	**Faro Mine** (Lat:62.35, Long:-133.27) **PGA(g)***	
	GSC-R	**GSC-H**
1/475	0.05	0.06
1/2,500	0.09	0.11
1/10,000	0.15	0.16

These values are in good agreement with Roberston Geoconsultants (1996), and were used for the assessment of the performance of the Intermediate Dam under seismic load.

3. DAM CONSEQUENCE CLASSIFICATION

Assessing safety acceptance requires the selection of appropriate design loading events that the structures must safely withstand. The CDA Dam Safety Guidelines give exceedance probabilities for design inflow floods and design earthquakes based on loss of life and damage consequences in the event of a dam failure. Loss of life and damage consequences are typically evaluated based on simulated dam breach scenarios to estimate the extent of incremental downstream inundation and damage.

The consequence classification system recommended in the CDA Dam Safety Guidelines (1999) is shown below in Table 3.1:

Table 3.1 Consequence Classification of Dams (CDA, 1999)

Consequence Category	Potential Incremental Consequences of Failure[a]	
	Life Safety[b]	Socioeconomic, Financial & Environmental[c]
Very High	Large number of fatalities	Extreme damages
High	Some fatalities	Large damages
Low	No fatalities anticipated	Moderate damages
Very Low	No fatalities	Minor damages beyond owner's property

[a] Incremental to the impacts which would occur under the same natural conditions (flood, earthquake or other event) but without failure of the dam. The consequence (i.e. loss of life or economic losses) with the higher rating determines which category is assigned to the structure. In the case of tailings dams, consequence categories should be assigned for each stage in the life cycle of the dam.

[b] The criteria which define the Consequence Categories should be established between the Owner and the regulatory authorities, consistent with societal expectations. Where regulatory authorities do not exist, or do not provide guidance, the criteria should be set by the Owner to be consistent with societal expectations. The criteria may be based on levels of risk which are acceptable or tolerable to society.

[c] The Owner may wish to establish separate corporate financial criteria which reflect their ability to absorb or otherwise manage the direct financial loss to their business and their liability for damages to others.

It is understood that no previous classification has been made for the dams at the Anvil Range mining complex. A detailed analysis to quantify the incremental consequences of dam failure is beyond the scope of this review. However, some relevant information is available from the November 2001 report titled Qualitative Risk Assessment of Down Valley Tailings Area by BGC Engineering Inc. (2001c).

The objective of the study was to identify potential failure modes for the Fresh Water Supply Dam and the various other dams, diversion canals and associated structures within the Down Valley tailings area, and to estimate the probability of these failures occurring in order to assess the risk. While no formal CDA rating was assigned to the dam failure modes, a ranking of Very High Consequence was assigned to a number of failure modes for the Fresh Water Supply Dam, the Intermediate Dam and the Cross Valley Dam as these modes could cause major uncontrolled releases of fluids and tailings with resulting surface and groundwater contamination for long periods. The consequences were assessed to have repair, fines and clean-up costs in the range of US$10 million to US$100 million.

Therefore, we consider that under the current operating mode, the Fresh Water Supply Dam, the Intermediate Dam and the Cross Valley Dam are Very High Consequence structures under the CDA rating system. This then mandates that these structures should consider using Probable Maximum Flood (PMF) and Maximum Credible Earthquake (MCE) criteria are appropriate for assessing the future loading conditions. We also consider that the stability of the flow through rock drain for the north fork of Rose Creek under the Vangorda Mine causeway and the Rose Creek diversion channel should be reviewed under PMF conditions, as a failure of this causeway or the diversion channel would have a major impact on the flood routing to the Intermediate Dam.

We consider that a dam breach of the Intermediate Dam is a key consideration that should be studied, and a screening level estimate made of risks and impacts of such a potential failure to establish the consequences in terms of both possible loss of life, and socioeconomic, financial and environmental impacts and costs. The classification of the dam would then be confirmed, also taking into consideration changes in operations proposed now that the mine is closed.

The consequences of failure of the Little Creek Dam is not considered to be in the Very High or High consequence category. Future changes to the Fresh Water Supply Dams and the Cross Valley Dams at closure are expected to reduce their consequence category from Very High.

4. DESIGN AND CONSTRUCTION HISTORY

The Anvil Range mining complex consists of the Faro Mine site, which was in production from 1969 to 1992, and the Vangorda Plateau Mine site, which was in production from 1986 to 1998. The Faro Mine site, which includes the mill and tailings facilities, is located approximately 15 km north of the town of Faro. The Vangorda Plateau Mine site, which includes two open pits and associated mine facilities, is located approximately 9 km northeast of the town of Faro and can be reached by a 12 km haul road from the Faro Mine site.

The Faro Mine was first started by Anvil Range Corporation and began production in 1969 at 5000 tonnes of zinc-lead-silver ore per day. The production increased to 6000 tonnes per day in 1970. In 1974, a mill expansion allowed a further increase in ore production to 9300 tonnes per day. In 1979, Cyprus Anvil purchased the mineral deposits and claims including Grum and Vangorda and then embarked on a program of expansion to bring the Vangorda Plateau deposits (Vangorda and Grum) into production to supplement the Faro Mill feed. Cyprus Anvil ceased production in 1982. The property was shut down and remained idle until the operation was acquired by Curragh Resources in November 1985. The mine facilities were reactivated in December 1985 with a production rate of 13 500 tonnes per day. The deposit was depleted of economic ore reserved in 1992.

Mining of the Vangorda Deposit began in 1990 and 5.7 million tonnes of ore were mined from 1990 to 1993 by Curragh Resources. 52 000 tonnes of ore was mined from the Grum Pit by Curragh Resources prior to the temporary mine shut down in 1993.

Anvil Range Mining Corporation assumed ownership of the mine site in November 1994 and resumed pre-production stripping at the Grum open pit and mining in the Vangorda open pit. By early 1998, mining in the Vangorda open pit was completed, and mining in the Grum open pit was partially completed.

Anvil Range Mining Corporation entered into receivership in April 1998. The mine sites have been shut down and under the management of Deloitte & Touche Inc., acting as the court-appointed interim receiver, since that time.

Since shutdown, care, maintenance and environmental protection activities have been conducted. The activities are centered on a seasonal pumping and water treatment program for the Faro and Vangorda open pits, but also include inspections and maintenance of water retention and water diversion structures.

There is a significant amount of information that has been compiled since the start of operations in 1969. Not all the information could be reviewed within this scope of work, and some of the design and construction information is not readily available. However, the reports made available for this review give a good appreciation of the engineering design work, and as-built features of the dams at the mine complex.

Much of this information has recently been collated for the April 2002 Baseline Environmental Information Document prepared by Gartner Lee (2002). For reference, the following sections from this report have been included in Appendix III.

- Section 2 Faro Mine Site page 21 (Section 2.3.3 Tailings Impoundments) to page 37 (end Section 2.3.6 Dams and Diversions)
- Section 3 Vangorda Plateau Mine Site pages 49 to 51 (Section 3.3.6 Dams and Diversions)

These are accompanied by the respective figures from the report that show the dams in plan and cross-section. Note that there are some inconsistencies between these figures, and similar figures included with the RFP in Appendix I. We recommend preparation of a set of plan and cross-section drawings that show the configurations for each dam, with elevations shown relative to mean sea level for inclusion in an Operations, Maintenance and Surveillance Manual.

The descriptions of the design and construction of each facility provide the background to the current assessments that are presented for each dam in the next sections. The main consultants involved in the design and construction of the dams include the following:

- H.A. Simons International ltd., supported by Ripley Klohn and Leonoff Ltd. for the 1968/1969 construction of the Fresh Water Supply Dam.
- Golder Associates Ltd. for the Down Valley tailings Impoundment that includes the Intermediate and Cross Valley Dams, and the Rose Creek diversion channel.
- SRK Consulting Engineers and Scientists for the Little Creek Dam.

5. LITTLE CREEK DAM, VANGORDA MINE

5.1 Description and Operating Procedures

The Little Creek Dam was completed in 1991 to collect water from the Vangorda open pit and from runoff and seepage at the Vangorda waste dump. The water from the dam was pumped directly to the treatment plant.

Electrical power is supplied by a single line to a transformer located on the dam crest adjacent to the pump house. The pump house has two 35 HP and one 125 HP pumps that were used to pump from the Little Creek pond to the treatment facilities. A 300 mm discharge line runs in the dam embankment to a manhole beyond the right abutment.

Operations have changed at the site. Now only runoff from the Vangorda waste dump collects behind the dam, and this water is pumped in the summer months to the abandoned Vangorda pit. Water from the Vangorda pit is now routed directly to the treatment plant. No water is directed from the Vangorda pit to the Little Creek pond, so it is not expected that the pond level will be operated again at design Full Supply Level.

The dam is a homogeneous embankment section of local glacial till, with a cutoff trench and granular drains under the downstream slope. The crest is about 10 m above natural ground, ranging in elevation from 1114.5 m to 1120 m. Side slopes are 2H:1V on the downstream side and 2.5H:1V on the upstream side. A zone of permafrost encountered at the south abutment was excavated prior to till placement.

The dam is inspected daily during the summer months. Instrumentation includes six pneumatic piezometers and three thermistors, which are read twice a year, typically in the spring and fall. The site is inspected once a week during the winter months.

5.2 Site Inspection

We inspected the dam on July 23, 2002. The water level in the reservoir was at approximate elevation 1108.5 m about 4 m below the Full Supply Level of elevation 1112.6 m. At the time of the inspection, the fall, winter, spring runoff and the waste dump leakage was being pumped from a barge mounted pump directly to the Vangorda pit.

It is planned to use one of the 35 HP pumps in the pumphouse and the buried discharge line to divert water to the Vangorda pit. Use of this buried line while the site is monitored is acceptable. However, it would be prudent to install a surface line for the abandonment plan to allow long term inspection of the pipeline.

Crest, Upstream and Downstream Slopes

The crest, upstream and downstream slope of the dam are in good condition, with no evidence of major settlement, bulging or cracking. There is no riprap on the upstream slope, but it is not required for the small fetch of the reservoir. There is some wood debris at the high water line of the dam. Erosion rills are evident on both the upstream and downstream slopes of the dam. Run off from the crest of the dam has flooded the pump house.

Seepage Discharge at Toe

One seep was noted at the toe of the interface of the drainage blanket and the finger drain at Station 0+220. This is normal and of no concern. The seepage collection ditch and the seepage collection monitoring sump indicated on the drawings were not located in the heavy tree covered area at the toe of the dam.

The trees should be cleared to the toe of the spoil piles that were formed by the original stripping and excavation of permafrost areas. If the seepage collection sump can be located it should form part of the regular monitoring program.

Spillway

The spillway is a 900 mm CMP culvert located near the left abutment (Station 0+040) with an invert elevation of 1112.8 m, about 1.7 m below the crest of the dam. The outfall is a riprap lined plunge pool located in erodible waste material at the left thalweg of the dam.

This type of spillway could easily plug with the debris presently in the reservoir. It is recommended that a “beaver type grillage” be installed on the upstream side of the culvert and the trash removed from the upstream embankment of the dam.

5.3 Dam Safety Considerations

The design and construction history for the dam is included in SRK Consulting (1991). However, a summary of the stability of the dam in terms of factor of safety is not included. The dam is inspected annually by SRK Consulting. The latest inspection report covers 2001 and is dated February 2002. The piezometer data for the dam are presented for reference in Appendix IV as time series plots for the period 1994 to 2002 along with plots showing the thermistor data.

SRK Consulting note that The Little Creek Dam is performing satisfactorily, with a reduced pond level. The piezometric levels are consistent with water levels recorded in the pond. In their 2000 report, SRK Consulting note that the thermistor readings are also consistent. No mention was made of the thermistor readings in the 2001 report.

Based on the current dam performance, and changed operating procedures that result in pond levels 4 m below Full Supply Level, we have not undertaken new stability analysis for the dam. Rather we accept that the design stability factors of safety are being met as there is no indication of movement of the dam. We recommend that SRK Consulting provide a summary of the design stability factors of safety for the dam for inclusion in the OMS Manual.

In summary, we recommend the following:

- Determine and document appropriate target pond levels for the operation of the reservoir and ensure they are maintained. Keep records of pond levels.
- Estimate the PMF waste dump runoff, and the resulting water level and spillway flows that could be expected.
- Clear trees in the area at the toe of the dam.
- Regrade around the pump house and on the west to divert runoff to upstream slope. Repair erosion rills as required.
- Add trash rack on emergency spillway.
- Continue with biannual instrumentation readings, and annual inspection reports. The plot of the pond level should be included on the piezometric time series plots. Trigger levels for action by site staff should be presented in the annual report for the piezometer and thermistor readings.

6. INTERMEDIATE DAM, FARO MINE

6.1 Description and Operating Procedures

The Intermediate Dam was constructed across the Rose Creek valley to contain supernatant water and tailings solids in 1981, and raised in 1988, 1989 and 1991 to a final crest elevation of 1049.4 m amsl, a maximum height of 32 m above the old Rose Creek channel. This is now the main tailings impoundment structure for the Anvil Range mining complex. There are no electrical, mechanical, concrete structures or pipe outlets associated with this dam. There is an emergency spillway channel on the right abutment, constructed as a rock lined channel in natural overburden material. The Cross Valley Dam was also constructed across the Rose Creek valley downstream of the Intermediate Dam to provide a polishing pond for treating tailings effected water prior to discharge back into Rose Creek.

Syphons are typically used to pass water from the water ponded on the tailings to the polishing pond. Water from the Faro pit area now is discharged via a pipeline direct to the downstream polishing pond, bypassing the tailings pond upstream of the Intermediate Dam.

With improved methods for lime treatment of tailings effected water, the pond level in the Intermediate Dam has been dropped in 2002. It is planned to reduce the water level by up to a further 2 m in 2003. The pond water is syphoned in the summer months. Typically the pond level only rises about 0.2 m over the winter and spring runoff period as the catchment area is small.

The dam is a zoned earthfill embankment with a central low permeability core designated as Class VI, and a downstream Class VIII random fill shell. Granular filter zones were constructed on both sides of the core (Class X and Class XI). The initial construction in

1981 raised the ultimate dam footprint to elevation 1031.7 m amsl and made use of natural terrace material present across the valley. A drainage blanket was placed over this footprint downstream of the core and filter zone, extending to the toe of the ultimate height dam. Upstream and downstream slopes are at 2H:1V. Including the 20 m wide berm adjacent to the polishing pond, the overall downstream slope is at 2.1H:1V.

The alluvial terrace under the north portion of the dam comprises sand and gravel. The foundation soils in the vicinity of the Rose Creek channel, under the south portion of the dam, include some zones of sand and gravel, and other zones of silt or silty fine sand. Bedrock is typically more than 30 m below the base of the dam.

The dam is visually inspected daily during the summer months, and weekly during the winter months. Instrumentation includes ten piezometers. The piezometers are read typically twice a year in the spring and fall. Time series plots for the piezometers from 1991 to 2002 are included in Appendix IV. Because the polishing pond inundates the downstream toe there is no way to estimate seepage losses.

6.2 Site Inspection

We inspected the Intermediate Tailings Dam on July 24, 2002. The upstream ponded water was below the monitoring staff gauge, so was estimated at approximate elevation 1047.1 m amsl. This is about 2.3 m below the crest elevation of the dam (1049.4 m amsl). The polishing pond forms the tail water of the Intermediate Dam and was at about elevation 1030.7 m amsl.

The upstream water pond will be maintained at about its current elevation until next year when it is planned to lower it a further 2 m. The current average depth of water at the upstream side of the dam is approximately 4 m.

Crest, Upstream and Downstream Slopes

The upstream slope and riprap appear to be in good condition. It is assumed that the riprap protection is in place from about elevation 1045.2 m to the pre 1991 crest elevation of 1045.7 m. Future pond levels could be aimed to coincide with this riprap protection.

There is longitudinal cracking on the upstream portion of the crest of the dam as noted in previous inspection reports. Most recently the crest has cracked near the emergency spillway towards the right abutment. No serious settlement or bulging was noted on the crest.

The downstream toe of the dam is not visible as it is inundated by the polishing pond. The water level in the polishing pond was about 1 m below the berm on the downstream side of the dam. As noted earlier, this berm represents the top of the 1981 construction. No seepage was visible in the thalwegs or at the immediate toe of the downstream slope at the berm level. However it had been raining and there were puddles on the berm, so it was not possible to determine if there were minor seepage discharges. The bushes growing at the right thalweg of the dam should be cleaned for better visibility of the abutment area.

There has been some ravelling, sloughing and erosion gulleys on the downstream face of the dam, likely from surface runoff. This is particularly evident close to the south abutment. Examination of the dam as built records suggests that the finer Class X filter material daylights on the downstream side of the dam in the area of apparent sloughing and ravelling. The bands of different material are evident in the field. It appears that the

Class X filter material was not protected with coarser shell material. We understand that the site staff intend to cover this area of the slope near the south abutment with more non-erodible material in the near future.

Emergency Spillway

The small berm built across the emergency spillway in 2001 has been removed, and new rock fill placed in the cut channel. The elevation of the spillway crest is likely above the design elevation of 1047.7 m amsl. The left training wall of the channel has little evidence of large rock riprap. The spillway has been constructed in the natural overburden material which appears to be highly erodible. The emergency spillway capacity is stated at 100 m^3/s and exits directly into the polishing pond downstream. It is probably adequate to pass the flows in the immediate drainage area, exclusive of flows from a breach in the Rose Creek diversion canal. The diversion canal is designed to pass the 500-year peak flow of 145 m^3/sec. There is a fuse plug in the Rose Creek diversion than would pass flows directly into the Intermediate Tailings Dam reservoir in the event of an extreme flood flow greater than about 145 m^3/sec.

At this time, we question whether this spillway can pass 100 m^3/sec. It is possible that the higher flows can be concentrated at lower sections of the spillway channel causing the light armouring and riprap to unravel and expose the erodible material at the right abutment, ultimately failing the entire structure. As a case in point, one should examine the out flow of the lower end of the Rose Creek diversion where it drops in the valley. The large riprap and rock weirs have been moved with flows much less than 100 m^3/sec. The records from 1994 through 2000 at gauging station X-14 indicate a maximum in-stream peak flow in the order of 14 m^3/sec (see Figure 3 of the Northwest Hydraulic Consultants (2001a) report titled “Hydrotechnical Assessment for Faro Mine Site”). For reference, the reported flow in the Rose Creek diversion in 1975 was 26.9 m^3/sec.

Failure of this spillway could lead to failure of the Intermediate Dam right abutment area and release of tailings via the Cross Valley Dam to the natural Rose Creek channel.

6.3 Dam Safety Considerations

We have not found any reference to the results of stability assessments completed for the Intermediate Dam. Golder Associates Ltd. (1980) provide reference for the stability of the Cross Valley Dam, which used a 1 in 200 year seismic loading criteria. Golder Associates Ltd. (1992) note that the riprap lined emergency spillway was modified during the 1991 dam raising to allow passage of the 1 in 500 year flood event of 100 m^3/sec.

BGC Engineering Inc. (2002a) prepared the 2001 Annual Geotechnical Evaluation and Instrumentation Review. No reference is made to the current factor of safety assumed for the dam. Their maintenance and repair recommendations included:

- Grading the crest to cover existing cracks, and drain surface water.
- Backfilling of significant erosional gullies on the downstream face, and removal or regrading of debris and slough accumulation that are impeding drainage at the toe of the downstream slope.

We concur with the plan to operate the Intermediate Dam with reduced water levels upstream of the dam. Our specific recommendations for the dam operations in 2003 include:

- Confirm appropriate target pond levels and document in the Anvil Range Property OMS Manual.
- Fill in cracks on crest of the dam, and grade to ensure surface water runoff to the upstream side.

- Confirm elevations of the crest of the dam, and the emergency spillway crest relative to amsl.

- Record pond levels during the seasonal pumping period, relative to amsl. Water levels were below the staff gauge at the time of our site visit.

- Repair and add more stable granular material in the area of sloughing on the downstream slope where the Class X filter material daylights in to the slope, particularly close to the south abutment.

- Clear the trees at the right downstream thalweg of the dam, and grade the berm at elevation 1031.7 m amsl to avoid ponding.

- Continue with annual inspections. Request that all elevations for piezometers in both tables and figures are referenced to amsl.

It is also necessary to address the potential failure of upstream diversion channels. In the case of the Intermediate Dam, flood routing must consider discharge from the Fresh Water Supply Dam, the flow through rock drain on the North Fork of Rose Creek and from a breach of the fuse plug in the Rose Creek diversion channel. Thus it will be necessary to:

- Complete a dam breach analysis for the Intermediate Dam, and prepare an estimate of the consequence of a dam breach in terms of both possible loss of life, and socio-economic, financial and environmental impacts and costs.

- Confirm the hazard classification and the project design criteria for flood and seismic loading. We expect the Intermediate Dam to have a Very High Consequence rating, thus the design flood would be the PMF, and the seismic loading would be based on the MCE.

- Assess the trigger flow for the fuse plug in the Rose Creek diversion due to flood passage, and establish the projected attenuated outflow through the Intermediate Dam emergency spillway in the case of an extreme event. Activation of the fuse plug may be the most significant short term hazard to this dam's performance.

- Investigate and determine the safe capacity of the emergency spillway and modify as required to design for both short and long term requirements as applicable.

- Review the Golder project records to establish the current design factor of safety for the Intermediate Dam, and assess performance under the seismic event. It is expected that the dam is currently designed for a 1 in 200 year seismic event.

Appendix V presents the results of our preliminary assessment of the stability of the Intermediate Dam under seismic loading. The analysis used peak ground accelerations presented in Section 2.4 and conservative strength parameters compatible with previous analysis by Golder for the site. The analyses predicted a permanent deformation of approximately 0.9 m for the 1:10,000 year return PGA of 0.15 g. It was assumed that the foundation materials did not liquefy under the seismic event. This level of permanent deformation would represent serious damage to the dam but would not be likely to cause a release of the impounded water and tailings. The likelihood of fluid release would be further reduced if the water level in the Intermediate Dam pond is lowered as planned. The analysis also considered "base case" strength parameters, and predicted a permanent deformation of approximately 0.1 m for the 1:10,000 year return PGA of 0.15 g, which would represent minor damage to the dam. Minor deformation would occur for the 1:475 year return PGA, for either set of input parameters.

Note that the stability of the Intermediate Dam is also dependent on the downstream pond level. A rapid reduction in the Cross Valley Dam polishing pond elevation would have the effect of removing the supporting water pressure on the downstream face of the Intermediate Dam, without initial lowering the high pore pressures in the dam fill. Limit equilibrium stability analyses predict that instability of the downstream shell of the Intermediate Dam would occur for the condition of rapid drawdown of the Cross Valley pond. It is beyond the scope of this dam safety assessment to provide a detailed procedure for lowering the Cross Valley pond. However, if this pond is to be drained, it should be done slowly so that pore pressures within the Intermediate Dam and foundation can dissipate. The downstream slope of the dam should be closely monitored for any evidence of instability while the pond is drained.

Analyses will need to assess the resistance capability of the natural foundation materials to liquefaction prior to confirming the expected performance under the seismic load. Additional toe berms for the Intermediate Dam would be sized if required in conjunction with closure planning for the polishing pond and the Cross Valley Dam.

7. CROSS VALLEY DAM, FARO MINE

7.1 Description and Operating Procedures

The Cross Valley Dam was completed in 1981 to create a pond for treating water discharged from the Intermediate Dam prior to discharge into Rose Creek. A toe drain was added in 1991. The Cross Valley Dam has two riprap lined emergency spillway channels cut in overburden on the right abutment. The estimated total capacity of 100 m^3/sec is similar to the Intermediate Dam emergency spillway. There are no electrical, mechanical, outlet pipes or concrete structures associated with this dam.

In addition to the treated water from the Faro pit, the polishing pond collects seepage from the Intermediate Dam and the Rose Creek diversion channel, and water is discharged by syphon from the pond on the tailings behind the Intermediate Dam. Now that water treatment facilities have been improved it is planned to operate the pond at a lower level, and it is not expected that the polishing pond will ever be operated again at design Full Supply Level. Water from the polishing pond is discharged by syphon and channelled to Rose Creek. It joins the flow from the Rose Creek diversion channel upstream of monitoring Station X14.

The dam is a zoned earthfill embankment with a vertical low permeability silty fill core designated as Class VI material, and Class VII and VIII random fill shell material. Granular filter zones (Class IX and X) were constructed on both sides of the core. An upstream blanket was placed upstream from the dam. Additional construction activities in 1991 included construction of a toe berm, installation of drains, collector ditches and monitoring weirs. Upstream and downstream slopes, excluding the downstream toe berm are at 2H:1V.

The dam is visually inspected daily during the summer months, and weekly during the winter months. Instrumentation includes seven piezometers, four thermistors, and four seepage weirs, which are read twice a year, typically in the spring and fall. Instrumentation response data is included in Appendix IV.

7.2 Site Inspection

The Cross Valley Dam was inspected on July 24, 2002. The water level in the polishing pond was approximately 1030.7 m amsl down 2.8 m from the crest elevation of 1033.5 m.

At the time of the inspection, there was inflow of water that was being pumped from the Faro pit to the polishing pond for lime treatment. The polishing pond levels are maintained and lowered by a syphon in the emergency spillway.

Crest, Upstream and Downstream Slopes

There is longitudinal cracking on the crest of the dam, as noted in previous annual inspections. Site staff are monitoring recent cracks adjacent to the riprap zone near the left abutment. Generally, the dam crest and visible slopes are in good condition. There is no evidence of major settlement or bulging. The cracks on the dam crest should be filled, and the crest surface re-graded.

The riprap is in good condition. According to the drawings, the riprap extends to Elevation 1029.7 m amsl. If the water levels are lowered below the riprap line for prolonged periods, consideration should be given to extending the riprap lower.

Toe Seepage

There are adequate seepage weirs downstream if the dam is monitored regularly, to indicate any problems with leakage.

Emergency Spillway

As in the case of the Intermediate Dam, the emergency spillway is a riprap lined channel, with a stated capacity of 100 m^3/sec. This is considered the 1 in 500 year event for floods in the Down Valley tailings impoundment area.

The emergency spillway is certainly adequate and capable of passing the flows in the immediate upstream drainage area, exclusive of the flows from Intermediate Dam spillway that would result if a breach occurred in the Rose Creek diversion channel.

The emergency spillway is constructed in a similar manner as the Intermediate Dam and it is recommended that the adequacy and capacity of this overflow structure be re-evaluated to confirm that it is able to pass the 100 m^3/sec without erosional damage.

7.3 Dam Safety Considerations

Stability analyses conducted by Golder Associates Ltd. (1980) have been summarized by Gartner Lee (2002) as follows:

Stability Aspect	Factors of Safety for the Upstream Side	Factors of Safety for the Downstream Side
Static	2.4 to >3	1.46 to 2.0
Pseudo-static (PGA = 0.097g)	1.5 to 2.2	1.05 to 1.6

The PGA of 0.097g was assumed to represent the 1 in 200 year event. Deformation analysis under seismic load events has not been reported.

The initial higher seepage flows evident at the toe of the downstream slope after the construction in 1980 were addressed with the addition of the toe berm in 1991. Based on the performance of the structure, and the operating philosophy to lower the pond level, the stability of the dam under static and 1 in 200 year return period seismic loads is considered adequate.

BGC Engineering Inc (2002a) completed the annual inspection of the Cross Valley Dam in 2001. The report concludes that the dam is performing satisfactorily, and recommend the following maintenance and repair items:

- Grade the crest of the dam to fill in the cracks, and drain surface water.
- Clean out the intake and discharge ends of the culvert located at the south end of the toe berm access road.
- Try to repair piezometer C&DP-3.

We concur with the plan to operate the pond at lower levels. Specific recommendations for 2003 include:

- Determine and document appropriate operating pond levels and ensure they are maintained.
- Confirm elevations for the crest of the dam, and the emergency spillway section relative to mean sea level.
- Fill in cracks and regrade the surface on the crest of the dam.
- Investigate the safe capacity of the emergency spillway. We note that the design criteria for passing floods for both short and long term operation of the Down Valley tailings area, will be reviewed in conjunction with closure planning.
- Continue with the annual inspections. Request that all elevations for pond levels and piezometer levels in both tables and figures are referenced in amsl.

8. FRESH WATER SUPPLY DAM, FARO MINE

8.1 Description and Operating Procedures

The Fresh Water Supply Dam was constructed in 1968 to provide water storage for ore processing in the winter season. A small rock fill toe berm was placed immediately after construction in 1969, and another toe berm placed in 1989. A recycle water system was constructed in 1997 which replaced the Fresh Water Supply reservoir as the primary source of water for the mine. The dam and reservoir are not required for current care and maintenance activities. The dam has a low level outlet pipe in the left abutment, and an overflow spillway on the right abutment. The reservoir was originally designed with a Full Supply Level at the crest of the spillway, elevation 1096 m amsl.

In 1976 stop logs were installed on the spillway to raise the winter water level. Records suggest that the water level was raised to above the level of the internal core of the dam. In 1999 the stop logs were removed, returning the operations to the original design intent. Due to concerns raised following the 2001 diving inspection of the integrity of the low level outlet pipe, plans are in place to breach the Fresh Water Supply Dam.

The dam is a zoned earthfill embankment that includes areas designated as a Zone 1 impervious core and blanket, Zone 2 sand and gravel clean shell material, Zone 3 random material that may or may not meet the requirements of Zone 1 and 2. The sloping Zone 1 impervious core extends as an upstream blanket to a cut-off trench. The upstream slope of the Zone 2 shell material is about 2.5H:1V, and the downstream slope is at about 2H:1V. The 1989 toe berm starts at elevation 1089.7 m amsl, and extends at a slope of 7.5H:1V for about 55 m to a seepage collection trench.

The dam is currently inspected daily. Instrumentation includes ten piezometers, one thermistor and three seepage weirs, which are currently read weekly. Instrumentation response data is included in Appendix IV

8.2 Site Inspection

The dam was inspected on July 25, 2002. The water level in the reservoir was approximately 1096. m amsl, about 3 m below the crest elevation of the dam (Elevation 1099 m amsl). One syphon was installed to lower the reservoir level. It was not working to full capacity as it was partially collapsed. We understand that the riparian outlet at the outlet structure was flowing at 0.2 m^3/s.

Crest, Upstream and Downstream Slopes

The crest of the dam has significant cracks and fissures that have been attributed to ice lenses forming in the core material on a seasonable basis. A review of the operating water levels over the life of the dam indicate that the impervious core of the dam was likely overtopped when stop logs were used in the spillway. The current cracking has been documented in the annual inspection reports. A more complete discussion and recommendations for repair are included in Golder Associates Ltd. (1997) 1996 Annual Inspection Report.

The crest elevation is very uneven, particularly near the curve in the dam, and in areas where the test pits were excavated to examine the cracks. The crest of the dam should be re-graded and levelled to the design level where necessary. All cracks should be filled, following the recommendation in the annual inspection reports.

A bench has formed by wave action near Full Supply Level for almost all of the dam upstream slope. This has caused some downward movement of riprap. Roughly adjacent to the outlet structure, the crest appears narrower, and there is more extensive sloughing in the upstream slope. A cross section was taken after the July 25 inspection. This cross section indicated that there was no indication of sloughing of the upstream slope below the water level. The riprap is considered adequate, but it does not appear to extend too far below Full Supply Level. This will be confirmed during the 6 m drawdown of the reservoir. A survey drawing prepared by YES seems to indicate a "bulge" near the crest of the dam immediately upstream of the curve in the dam near the left side of the spillway. Cross sections should be taken in this area to confirm the contours shown on this plan.

There is an upstream blanket constructed approximately 50 m to 60 m from the toe. Considering the history of the dam, it would be prudent to undertake an underwater inspection to determine if there are any sinkholes evident in this upstream slope. The main area of concern would be in the area of the original Rose Creek channel and near the low level outlet pipe alignment.

The downstream slope is in good condition. Some trees in the right thalweg should be removed. A toe berm was added to the structure in 1989. A further partial berm was located immediately downstream of the curve noted above. No documentation has been found yet as to the reasoning for this partial rock fill placement.

Toe Seepage

There are three weirs set up to measure flows at the toe of the dam. Two are in a channel downstream of the toe berm collecting seepage into the outfall channel. The third weir is located in the outfall channel approximately 120 m downstream of the outlet structure and measures all pipe flow and seepage from the dam. However, this weir is in disrepair and not working correctly. There is also seepage exiting through the backfill at the rear of the outlet structure.

Examination of the H.A. Simons "As Built" construction drawings indicate that there was a toe collection trench exiting to the right of the outlet structure. The 1989 berm buried this collection trench but the seepage will continue to exit at the outlet structure. The phreatic surface in the toe collection trench is controlled by the tail water in the outfall channel as well as the backfill along the right side of the structure. This is evident by the fact the surface seepage behind the valve structure disappeared when the valves were closed for the internal pipe inspection. Consideration should be given to lowering the phreatic water level in the outfall channel by lowering the main seepage weir that is in disrepair.

The outlet structure is constructed with an overflow weir that forms part of the energy dissipater. This weir should be modified to allow accurate measurements of the flow from the pipe, so that this flow is measured separately from the total flow downstream of the dam. We understand a pan type collection system is also under construction to provide a measurement of the seepage behind the outlet structure.

Outlet Structure

The outlet structure is a concrete structure with an access hatch in the roof for maintenance of the valves. The building is insulated and the concrete is in good condition. There is no electrical power at the site.

There is water in the valve chamber to about mid level on the 1067 mm to 610 mm concentric reducer. We understand there are some problems in the piping within the chamber. We currently have limited information on the valves and their operation but understand that the gate valve is typically wide open, and that the plug valve is used for regulating the flow. Tests should be undertaken to determine the safe operating procedures for the valves. The water in the valve chamber should be removed and the pin holes in the pipe examined and repaired. If problems are found upstream of the guard valve, the concentric reducer can be encased in concrete. The valve chamber should be kept dry in the long term.

Low Level Outlet Pipe

A 1067 mm (42 inch) steel pipe extends from the intake structure upstream of the dam to the outlet structure. There is uncertainty with respect to the integrity of the pipe following a diver inspection that indicated a potential settlement area under the centre of the dam, and significant corrosion in the pipe wall thickness. We had questions concerning the results from the pipe inspection as documented by Diving Dynamics (2001). The answers received from Diving Dynamics and our letter request of August 15, 2002 are attached in Appendix VI.

No inspection of the intake structure or low level pipe were made during the July 2002 site visit. However, based on the H.A. Simons as-built drawings, site photographs and the state-of-the-art in engineering dam practice in the late 1960's, we believe that the pipeline is basically located within a rock trench, encased in reinforced concrete with adequate collars to prevent piping of the core material. At this time, we anticipate that there should be further as-built documentation available to confirm that the pipeline is at it's as-built elevation, and that the "sag" recorded by the divers inspection does represent as-built conditions. We note that the divers were not aware at the time of the inspection that the pipe was encased in concrete with extension collars, and primarily located in a bedrock cut.

The apparent internal corrosion up to 40% of the pipe is a concern, but has likely not advanced to a point of structural collapse. The rate of corrosion can be expected to slow down with the build-up of deposits estimated at up to 75 mm in the pipe. Corrosion in the areas of higher velocity in the concentric reducer and valves will probably continue and should be addressed.

A basic unresolved question and concern remains, however, in the discrepancy of some 15 m of pipeline length between the diver inspection (112 m) and the as-built drawing (127 m) as this would cast doubt on the as built drawings.

We recommend the following approach to resolve the pipeline concerns.

- Carry out a surface survey to locate and map the inlet structure location, and the elevations of the inlet and outlet of the pipeline, as well as the elevation of the top of the intake structure and the adjacent soil surface.
- Insert a ROV into the pipeline inlet that can observe the length, azimuth and elevation of the entire length of the pipeline.

If the as-built drawings configuration is confirmed by one of the above methods and the corrosion maintenance recommendations are undertaken, then we consider that the pipeline and outlet valves could be used in the short term prior to the dam breach. However, it is imperative to set up accurate means of monitoring flows from both the low level outlet pipe and seepage exiting at the toe of the dam and upstream of the outlet structure.

Spillway

The concrete in the spillway is in good condition with no undercutting. The spillway channel is cut in rock and in good condition. The supports for the stop logs have been removed. The culverts at the bottom of the spillway channel are not adequate to pass the total capacity of the spillway.

8.3 Dam Safety Considerations

Golder Associates Ltd. (1989) reviewed the stability of the Fresh Water Supply Dam, and subsequently designed and supervised construction of the toe berm in 1989. Their investigations suggested that the zoned dam could be treated as a homogeneous section for the stability assessment and they assigned a soil strength of c = 0, ϕ' = 32º for the fill and bulk density of 22.5 kN/m. The foundation material was assigned a soil strength of c = 0, ϕ' = 30º, and bulk density of 22 kN/m^3. The results of the stability analyses for the dam with the 1989 toe, were summarized by Gartner Lee (2002) as follows:

Stability Aspect	Factors of Safety for the Upstream Side	Factors of Safety for the Downstream Side
Static	1.45 to 2.3	2.0
Pseudo-static (PGA = 0.08g)	-	1.5

Additional stability results have been presented by BGC Engineering Inc. (2002b). Their analyses assumed four cases with varying soil strengths for the different zones. The results are summarized below:

Stability Aspect	Factors of Safety for the Upstream Side	Factors of Safety for the Downstream Side
Static	1.5 to 2.1	1.7 to 1.9
Pseudo-static (PGA = 0.13g)	0.8 to 1.2	1.1 to 1.2

These analyses suggest that the Fresh Water Supply Dam meets target factors of safety under static conditions, and will likely perform satisfactorily under a seismic loading of 0.13g. As noted in the previous sections of this dam safety review report, more work is required to complete dam classifications for closure schemes for both the Intermediate Dam and the Fresh Water Supply Dam, confirm the design flood routing and seismic peak ground acceleration level and assess liquefaction potential of the foundation. The concerns relative to the low level outlet should however be addressed by obtaining further as-built information, completing some site survey work and accurately monitoring seepage.

We understand that studies are now ongoing for the design of a breach of the Fresh Water Supply Dam by the spring of 2004. In conjunction with these studies, consideration should be given to the following recommendations made after our July site visit:

- Undertake a survey to determine the location and elevations of the intake structure and the low level pipe at both the intake and outtake structures, and review cost and feasibility of a ROV survey along the pipe alignment.
- Replace the seepage weir in the channel downstream from the outlet structure, to allow an accurate measurement of total flow. Review lowering the weir to respectively drop the tailwater level at the outlet structure, and under the dam toe.
- Install a weir to measure the seepage behind the outlet structure, and measure flows from low level outlet pipe in the outlet structure.
- Drain the interior of valve chamber and inspect and test the pipe and valve operations. Develop a repair program. Investigate the corrosion regime of the pipe and determine long range protection if required. Investigate methods to keep the valve chamber dry year round.
- Re-install the trash rack on top of the pipeline inlet structure.
- Complete an underwater sinkhole survey of the upstream blanket area.
- Run cross section of the upstream slope at the curve in the dam to determine if the YES site plan contours indicating a possible bulge are correct.
- Fill in the cracks, and regrade the crest of the dam, to the design elevation.
- Clear trees from right thalweg of the dam.
- Continue with annual inspection reports for the Fresh Water Supply Dam.

9. OPERATION, MAINTENANCE AND SURVEILLANCE MANUAL

The Anvil Range Mine complex seasonal pumping and water treatment programs are progressing such that pond levels behind all four dams under this review are being reduced from the design full supply levels. These pond levels will likely reduce further in the coming years.

Currently there does not appear to be any written documentation on site that outlines the current operating procedures for the pond levels. Therefore, we recommend that an Operation, Maintenance and Surveillance (OMS) Manual be prepared for the benefit of operating personnel.

The manual should include the following items:

- Plan and section drawings showing the current configuration of each dam, with elevations in amsl, and the storage-volume curves.
- Plans and section drawings should indicate the extent of the instrumentation and seepage weirs used to monitor performance.
- Operating procedures for maintaining the pond at the target levels.
- Maintenance requirements for such items as the syphons, pumps and valves used for water discharge.
- Surveillance and monitoring schedules. This is already well defined for the site.
- Trigger levels for action by site staff related to changing pond levels, and key instrumentation response for items such as seepage flow rates, and piezometric levels relative to pond levels.

10. EMERGENCY PREPAREDNESS PLAN

10.1 Purpose of Plan

As part of this assignment, the Anvil Range Property Emergency Response Plan has been reviewed. We recommend that this plan be updated to meet current dam safety standards, and that an Emergency Preparedness Plan (EPP) should be prepared that describes the arrangements in place to respond to potential or actual dam breaks. This EPP should focus on a potential dam breach of the Intermediate Dam, which is considered the key structure for the tailings impoundment area.

This plan should specifically address the following:

- What would happen to the stored water and/or tailings behind the various dams at the Anvil Range Property if they were to breach?
- How many people and how much property would be effected?
- What primary and secondary hazards would be created?
- How would emergency responders be notified of any emergencies involving a sudden or potential breach and how would they communicate with each other to effectively integrate their operations where required during an emergency?

To assist emergency responders in developing Emergency Response Plans, this Emergency Preparedness Plan should contain information on:

- The nature of the anticipated inundation and who/what would be affected by it.
- Maps showing the maximum extent of inundation.
- How much time there would be to evacuate.
- What other stakeholders would be doing during an emergency.

Adoption of a single EPP for the Anvil Range Property area is appropriate, provided the reasonably worse case conditions are identified. In this respect, causes and effects from a breach in each dam structure in the property should be evaluated separately, to determine if special concerns or emergency response action is required.

The EPP document should provide a description of the flood inundation and downstream hazards. Details should be provided particularly related to the impact of hazards created by the flood damage. Damage to various components of the infrastructure such as roads, oil and gas pipelines, electrical power or communications may affect emergency response procedures. The EPP document should describe some of the damage impacts that may subsequently affect emergency response procedures.

To date, some dam breach inundation studies for the Freshwater Supply Dam have been completed and we understand work is in progress on other inundation studies for the property. A breach of the Intermediate Dam would have very serious economic damage, with fluids and tailings flowing into Rose Creek. Inundation mapping should be prepared for this scenario. Inundation mapping is also recommended for the Vangorda Creek downstream from dams related to the Vangorda Mine site.

All flood inundation mapping should include tables with flood levels and arrival times since the maps will provide a useful tool during a crisis situation and should contain all of the relevant information.

The organization structure for emergency communications should be clearly defined in the EPP. The EPP document should include the name and position of the representative who is responsible for the Down Valley tailings area, the Faro Mine, and the Vangorda Mine area; the name of the designated EPP coordinator; and an organizational chart for the emergency response team. Contact names may vary during certain hours of work and different seasons and contact personnel names for each period should be listed.

Response procedures for this plan may involve repairs to the dams and/or measures to alleviate potential flooding downstream from the mines and tailings facility. Thus, a list and contact names for provision of construction materials, equipment, emergency power sources, labour and engineering expertise should be included in the EPP and/or Emergency Response Plan.

The EPP should include a listing of standards and conventions that are agreed to by various stakeholders in order to ensure emergency response operations flow smoothly. Communication procedures should include telephone caller verification procedures, message backup procedures and communication logging procedures. Media release procedures and the location of media room facilities should be identified in the EPP.

The EPP should be reviewed every five years and updated as required. A key representative should be assigned responsibility for the execution of this task.

10.2 Hazardous Conditions and Alert Classification

10.2.1 Hazardous Conditions

Conditions, accidents or events which may have implications to the dam's safety should be categorized into potential dam safety problems and other type of emergency situations which do not threaten the safety of dam. Potential dam safety problems are the focus of the EPP. Potential problems which may threaten the various dams at the Faro and Vangorda Mines include:

- Slumping or cracking of the dams
- Springs, seeps or boggy areas;
- Abnormal flows from the drainage areas
- Abnormal instrumentation readings
- Surcharging of the spillways/overtopping due to PMF conditions
- Earthquake events.

In the event any of these situations occur, field staff should follow procedures set out in the Emergency Response Plan for the site. Key procedures include:

- Monitoring and reporting the nature of the problem to head office.
- Obtaining an evaluation of the condition and instructions on mitigative measures from qualified professional engineers.
- If a dam break is likely, advising key stakeholders who will review their own emergency operations plans and staffing situation.

10.2.2 Alert Classification

Upon the discovery of a situation affecting the dams, field staff should classify the situation into alert levels. The two levels of alert can be used to define the increasing potential danger to the safety of the dams, as follows:

- Emergency Alert; and
- Failure Alert

Procedural guidelines and notification systems should be established which are dependent on the declared alert level. The assignment of the Alert levels is the responsibility of the field staff, whom should be trained in the recognition of conditions that would threaten the various dams.

Emergency Alert

An Emergency Alert status would be assigned to an unusual event or condition, which would result in an immediate and significant threat to the safety of the dam. Immediate action would require planning and executing remedial action and repairs, and notification to downstream areas by means of a General Warning System. It is fully expected that the required remedial action could be initiated and completed in sufficient time to eliminate the immediate threat or to prevent it from worsening.

An Emergency Alert would be revised to a Failure Alert, or downgraded, depending on the change in conditions at the dams, or as new information or analysis became available.

Failure Alert

A Failure Alert would be declared upon the failure, impending failure, or delayed but expected failure of any of the dams. A Failure Alert would require immediate notification of downstream area by means of both General Warning System and Local Warning System. Since one of the dams may be failing or about to fail, the Failure Alert classification should be implemented immediately upon direction and verification of the condition. It should be noted that the Failure Alert shall be declared as a precautionary measure when it is not certain whether the dam will fail, but there is a significant probability that it will.

A Failure Alert may develop from such scenarios as uncontrolled overtopping or piping in the dam or its foundations; or slumping and continuing deterioration of the scarp of a slump following an earthquake. Declaration of a Failure Alert and implementation of an evacuation plan does not mean that attempts to save the tailings should be abandoned.

Any emergency repair measure that has some potential to avert, delay or retard the rate of failure should be initiated.

10.3 Review and Testing

On going training of field staff, testing of the communications set up, and a operational test of the plan is required to ensure the effectiveness of the response. It is recommended that field staff complete communications testing on an annual basis.

The results from the training and testing will then be used to update the EPP as required.

11. MAIN CONCLUSIONS AND RECOMMENDATIONS

Klohn Crippen Consultants Ltd. have completed an independent dam safety review of the Little Creek, Intermediate, Cross Valley and Fresh Water Supply dams at the Anvil Range Property. Specific recommendations to meet the intent of the CDA Dam Safety Guidelines have been prepared, and discussed in each section.

The main conclusions for the dams are as follows:

- The dams and associated ponds were designed in conjunction with on-going mine expansions, and are now operated on a care and maintenance basis. New operating procedures will be determined as the mine closure planning continues to be developed. This is resulting in lower pond levels, and the plan to breach the Fresh Water Supply Dam by spring 2004.

- Visual inspections did not identify any immediate safety concerns, and all dams appear to be performing satisfactory. Certain maintenance items are recommended, such as repairs to surface erosion on the downstream face of the Intermediate Dam, and infilling and regrade of cracks on the crests of the dams in the Down Valley area.

- We agree with the water management philosophy to reduce the pond levels behind all four of the dams at the site. However, it is recommended that an Operations, Maintenance and Surveillance (OMS) Manual is prepared for the various pond operations and system components. The manual should include current plans and section drawings for each dam showing all elevations in metres above mean sea level, as well as the proposed pond operating levels.

- The OMS Manual would include the current surveillance instrumentation monitoring and annual reporting requirements. The manual should also address trigger levels for pond levels and instrumentation responses at which action is required from site staff.

- Deloitte & Touche Inc. have qualified consulting companies involved in the maintenance of the dams, and are assessing the plan to breach the Fresh Water Supply Dam by spring 2004. It is evident that closure options must consider the long term safety of all the dams. In particular, attention needs to be given to the capacity of the North Fork Rose Creek rock drain under the Vangorda Mine road, and the main Rose Creek division channel to pass high flood flows. Failure of either of these two components of the system will have major impacts on the Intermediate Dam and its emergency spillway.

- Specifically, there are risks that an extreme flood could be routed onto the tailings area behind the Intermediate Dam. It is recommended that the capacity of the emergency spillway at this structure be reviewed, as erosion of underlying native material could cause a dam breach and subsequent loss of tailings.

- We note that the Intermediate Dam will likely be classified as a Very High Consequence Structure because of the high costs associated with a dam breach occurrence and the subsequent contamination effects downstream. However, we recommend that a dam breach and inundation study be carried out for the Intermediate Dam to confirm this classification. This study is also required for preparation of an Emergency Preparedness Plan for the site.

- It is recommended that the Emergency Response Plan for the mining complex be updated, and that the plan include an Emergency Preparedness Plan to identify the response by site staff to a potential dam breach alert at any of the dams.

Since the site visit in July 2002, the assessment of the Fresh Water Supply Dam has resulted in a plan to breach this structure. Preliminary studies are ongoing on the work scope for this dam breach by the spring of 2004. These studies should consider the following recommendations for the Fresh Water Supply Dam made following the July dam safety review site visit:

- There are uncertainties concerning the integrity of the low level outlet pipe at the Fresh Water Supply Dam. Specifically, a recent diver inspection has indicated a potential settlement zone under the dam, and local corrosion of up to 40% of pipe wall thickness. Based on a review of available as-built drawings, we note that the pipe is basically located on bedrock, encased in reinforced concrete, and constructed with 15 collars. Thus it is anticipated that the settlement zone in the pipe results from as-built conditions. We do, however, note that there is a discrepancy between the distance from the intake structure to the vales in the outtake structure as measured by the divers, and as noted on the as-built drawings. This needs to be resolved. It is recommended that a field survey be completed to confirm the location and elevation of the intake structure, and the elevation of the low level outlet pipe both at the intake and outtake structures to compare with the as-built drawings. We also recommend that the valves in the outtake structure be tested to confirm safe operating levels.

- Piping is a serious concern for the Fresh Water Supply Dam. We note that current seepage weirs are not effectively monitoring seepage from this structure. Thus we recommend that separate measurements be made of seepage exiting immediately upstream from the outtake structure, and of the flow from the low level outlet pipe which can be monitored using the overflow weir within the structure.

- It is recommended that high priority be placed on replacing the weir downstream of the outtake structure. During replacement, we would propose to drop the base level of the weir as much as possible to reduce the tail water level adjacent to the outtake structure. This will have the effect of reducing the piezometric level in the rock collector drain under the toe berm.

12. CLOSURE

Bryan D. Watts, M.Sc., P.Eng., Vice President Engineering, was the senior reviewer for Klohn Crippen Consultants Ltd. for this dam safety review.

Respectfully Submitted,

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HSW/BTR/sh

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1. The report is intended for the exclusive use of the Client and it may not be used or relied upon in any manner or for any purpose whatsoever by any other party.

2. The report is a Dam Safety Review of the Little Creek Dam at the Vangorda Mine, and the Intermediate, Cross Valley and Fresh Water Supply Dams at the Faro Mine (the "Project"). Data required to support detailed engineering assessments have not always been available and in such cases engineering judgments have been made which may subsequently turn out to be inaccurate. There are, therefore, risks inherent in the Project, which are outlined in the report. The Consultant accepts no liability beyond using reasonable diligence, professional skill and care in preparing the report, based on the circumstances the Consultant knew or ought to have known based on the information it had at the date the report was written and after due inquiry based on that information.

3. The Consultant shall not be responsible or liable for any interpretation or recommendation made by others including any determination in respect of any sale by the Client or any purchase by any third party or any valuation in respect of the Project based in whole or in part on the data, interpretations and/or recommendations generated by the Consultant in the report.

4. The investigation described in the report is based solely upon a site visit carried on July 23 to 25, 2002, by the Consultant, and the information received from the Client, which is identified in this report.

5. The report speaks only as of its date and to conditions observed at that time, which conditions may change (or may have changed) by virtue of the passage of time or due to direct or indirect human intervention causing any one or more changes in plans or procedures or due to other factors.

6. The report does not extend to any latent defect or other deficiency in the Project, which could not have been reasonably discoverable or discovered by such observation.

7. The report is to be read in conjunction with all other data and information received and referenced in paragraph 4 and all correspondence between the Client and the Consultant. Except as stated in the report, the Consultant has not made any independent verification of such data and information and does not have responsibility for the accuracy or completeness thereof.

APPENDIX I

Request for Proposal from Deloitte & Touche Inc.

APPENDIX II

Selected Site Photographs from July 2002

APPENDIX III

Background Summary and Drawings of the Dams, Extracted from Gartner Lee (Draft April 2002) Anvil Range Mine Complex 2002 Baseline Environmental Information

APPENDIX IV

Instrumentation Readings

APPENDIX V

Stability Assessment of the Intermediate Dam

APPENDIX VI

Correspondence from Diving Dynamics Related to Fresh Water Supply Dam Low Level Outlet Pipe