PWGSC

Quality in Environmental Services

Phase III Environmental Assessment

Venus Mine Site

Interim Report

Prepared for:

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Phase III Environmental Assessment Big Thing Mine Site

Interim Report

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Executive Summary

A phase II environmental assessment was conducted at the Venus abandoned mine site (60° 01' 12 " N, 134° 37 ' 58" W) in July, 1996 by Environmental Services, Public Works and Government Services Canada for the Action on Waste Program, Indian and Northern Affairs Canada. Based on the findings of the Phase I investigation performed in 1993 by DIAND Technical Services, a phase II assessment was conducted to a) identify potential environmental and human health risks associated with the present condition of the mine site, and b) provide recommendations and preliminary cost estimates for remediation of those risks.

In 1997 a phase III follow-up assessment was performed based on the recommendations of the phase II assessment. The follow-up work included geotechnical evaluations of waste rock slopes ansd supporting structures, waste rock sampling where additional data was required, and water quality monitoring of adit water, seeps, and receiving water bodies and to identify seasonal variations in contaminant loadings upstream and downstream of the main site and waste rock piles. Laboratory leachate extraction tests were completed to characterize the soluble constituents of the waste rock.

Based on interim results the following conclusions have been drawn:

Conclusion 1. Downwards movement of waste rock, impacting the South Klondike highway and posing a safety risk, is imminent due to the eventual failure of the retaining wall structures below Adit 2.

Conclusion 2. Water discharging to Tagish Lake has elevated Arsenic, Aluminum, Selenium, and zinc concentrations. The extent of impact to the environment is uncertain.

Conclusion 3. Water discharge is primarily from the Adit 1 and Adit 2.

Recommendations made in this report are preliminary. Final recommendations will be based on a spring freshet sampling event proposed for April 1998.

Recommendation 1. The two retaining walls below Adits 1 and 2 should be intentionally failed to reduce the risk to the South Klondike Highway below the site. It is recommended that the material behind the retaining walls be relocated to the bench area near Adit 2.

Recommendation 2. Monitoring for potential waste rock slope failure should occur on an annual basis do to the extent of uncertainty inherent in this level of assessment. Alternatively, a more detailed geotechnical analysis can be performed to determine the long term slope stability characteristics.

Recommendation 3. Monitoring adit water and seeps at the Venus Mine should be conducted during the spring freshet. In particular, the base of the waste rock piles should be carefully examined to identify the presence of any new seeps. New seeps and changes in the chemistry of existing seeps may indicate the impact of the waste rock on the quality of water released from the site at high flow conditions.

Recommendation 4. An assessment should be conducted to determine the impact of Venus mine water discharge on Tagish lake in relation to natural seepages and other possible activities which may impact the water quality.

1.0 INTRODUCTION AND BACKGROUND

In 1993, initial assessments (Phase I) of 49 abandoned Yukon mine exploration and development sites were completed under the Arctic Environmental Strategy - Action on Waste program by DIAND Technical Services. These assessments provided a) a general overview of historical activities, b) described site infrastructure, workings and wastes, c) summarized existing environmental or safety concerns on each site, and d) provided general recommendations for remediation or mitigation work. No rock, soil or water samples were collected for these assessments.

A phase II environmental assessment was conducted at the Venus abandoned mine site (60° 01' 12 " N, 134° 37 ' 58" W) in July, 1996 by Environmental Services, Public Works and Government Services Canada for the Action on Waste Program, Indian and Northern Affairs Canada. Based on the findings of the Phase I investigation performed in 1993 by DIAND Technical Services, a phase II assessment was conducted to a) identify potential environmental and human health risks associated with the present condition of the mine site, and b) provide recommendations and preliminary cost estimates for remediation of those risks.

Conclusions of the Phase II assessment were:

1. A potential exists for the physical failure of the upper and lower WR retaining walls structures which may impact a major highway.
2. The Waste Rock is acid generating.
3. There are elevated metal concentrations in the mine waters of openings and seeps, which drain into Tagish Lake.
4. Monitoring is required to determine the impact of high flow conditions and change over time.

The recommendations of the Phase II assessment were to:

1. Conduct a geotechnical assessment of retaining structures and failure impacts.
2. Perform a detailed assessment of receiving water quality.
3. Conduct a water quality monitoring program 3 or 4 times annually.
4. Determine metals in Waste Rock available for transport - leach extraction test.
5. Locate potential borrow source if capping remediation required.

2.0 PURPOSE AND SCOPE OF WORK

This Phase III assessment was carried out by Environmental Services for Indian and Northern Affairs Canada to conduct a follow-up assessment of the environmental impact, or potential environmental impact, of mining and exploration activities conducted at Venus abandoned mine site in the Yukon Territory. The follow-up work included a) waste rock sampling where additional data was required, and water quality monitoring of adit water, seeps, and receiving water bodies and to identify seasonal variations in contaminant loadings upstream and downstream of the main site and waste rock piles; b) laboratory leachate extraction tests were completed to characterize the soluble constituents of the waste rock; and c) slope stability assessment and terrain analysis to provide stabilization options.

Accordingly, the following assessment activities were completed:

- Geotechnical inspection of the waste rock disposal areas, including retaining walls;
- Locating borrow sources for remediation, if required;
- Photo documentation of relevant site features;
- Sampling of waste rock disposal areas, including leachate extraction tests, and surface water (including waste rock seeps and receiving waters);
- Identification of environmental pathways and receptors for site contaminants if required; and
- Assessment of contaminant loadings caused by acid rock drainage at the waste rock disposal area.

Recommendations and preliminary cost estimates were then generated to meet the following remediation/mitigation requirements:

- Physical stabilization of waste rock disposal areas;
- Chemical stabilization of waste rock disposal areas, taking into account onsite resources and accessibility.

3.0 SITE ASSESSMENT METHODOLOGY

3.1 Assumptions

At the Venus mine site, the assessment was limited to the area specifically developed or occupied for mine exploration or mining purposes and off-site environmental resources potentially affected by mine exploration or development activities.

3.2 Assessment Criteria

<u>CCME Criteria</u>

The Canadian Council of Ministers of the Environment (CCME) Interim Canadian Environmental Quality Criteria for Contaminated Sites are numerical limits for contaminants in soil and water intended to protect, maintain or improve environmental quality and human health at contaminated sites in general. For this Phase III mine assessment, Freshwater Aquatic Life criteria were used to assess surface water quality.

<u>Mine Reclamation in Northwest Territories and Yukon (INAC, 1992)</u>

This report defines factors which are to be considered in reclamation of abandoned mine sites operating in northern climates. Factors include:

- open pit and underground mines
- waste rock and tailings disposal
- acid generation and leaching, and
- estimating cleanup costs.

3.3 Methods

3.3.1 Site Assessment Components

A professional geochemist assessed the acid rock drainage and metal leaching potential of the lower/eastern waste rock disposal area by:

- Confirming variations in rock type, mineralization and alteration noted in the Phase II assessment;
- Laboratory leachate testing of selected archived waste rock samples (originally collected during the 1996 site visit).

3.3.2 Sampling Methods and Quality Assurance

Water Sampling

Samples were collected from upstream and downstream of the waste rock disposal areas, and from seeps emanating from the slope. Field pH and conductivity measurements were recorded during the summer sampling period. Samples were collected on 19 August and 18 October 1997 to measure contaminant concentrations during the summer, fall and spring seasons respectively.

250 ml water samples were collected by hand, facing upstream, ensuring that the sample was not contaminated by disturbed sediment, debris and other floating materials. Sample bottles were rinsed three times with water from the sample stream prior to collecting the sample. 2 ml of HNO_3 were immediately added to water samples intended for metals analyses. For analyses of non-metallic parameters, water samples were brim-filled to minimise head space, placed in a cooler, and maintained at 4° C until delivery to the laboratory.

Bottle Roll Tests

To estimate the soluble metal load in the waste rock, large-scale leach extraction tests were conducted on selected samples. These tests involved sieving a waste rock sample to obtain 1 kg of material passing through a 5-mm screen. This material was combined with 1 litre of distilled water and agitated on a rolling device. Every 24 hours the bottle was removed from the roller and allowed to settle. The solution was sampled, and the pH and conductivity measured. Once the pH and conductivity of the solution stabilized, the solution was filtered and analyzed for immediate parameters (e.g. pH, conductivity, acidity, alkalinity, etc.), sulphate, and total metals concentrations. The resulting concentrations represent a measure of the soluble contaminants stored in the waste. A detailed protocol is provided in Appendix A.

Quality Assurance

Quality Assurance (QA) is a set of procedures for ensuring that the results of chemical analyses are (and can be shown to be) accurately representative of field conditions. A complete QA program includes both a field component and a laboratory component.

In addition to the standard sample collection methods outlined above, the field QA measures that were implemented for this assessment study include:

- chain of custody procedures and forms;
- a sample labelling and sample location identification scheme;
- laboratory preparation of all sampling containers;
- laboratory defined sample preservation and shipping procedures; and
- regular maintenance (including re-calibration) and cleaning of field equipment.

4.0 ENVIRONMENTAL SETTING

4.1 Mineralization

Approximately 20 polymetallic, gold-bearing quartz veins are hosted in rock of the mid-Cretaceous Montana Mountain volcanic complex and Montana pluton along an 8 km, northwest trending belt between Windy Arm and Brute Mountain.

The Venus deposit is a gold-silver-lead-zinc bearing quartz vein hosted in the Montana Mountain volcanic complex. The vein has been intruded along a zone of weakness which is the contact between porphyritic andesite to the south and a felsic dike to the north. The Venus vein is a simple, banded fissure-filling containing quartz, arsenopyrite (FeAsS), pyrite (FeS_2), galena (PbS), and sphalerite ((Zn, Fe)S) (Stubens, T.C., 1988).

The country rock in the Venus mine workings consists primarily of pale green to green, competent, cherty andesite breccia, alternating with dark green coloured andesite flows and possibly minor tuff (Hilker, R.G., 1992).

4.2 Surface Hydrology

Both site and regional drainage are to the east down a steep slope across South Klondike

Highway and into Windy Arm of Tagish Lake (see Figure 1). No streams were noted in the immediate area of the North and South claims, however, the Vault claims are located within Pooley Creek canyon to the north.

Seepage from both Adit 1 and Adit 2 was noted at the site. Seep volumes were calculated at approximately 5 L/sec from both adits. Water from the adit seeps flows across the highway and causes icing during winter months. Seepage volumes at the highway were approximately 1 L/sec beneath Adit 1 and less than 1 L/sec beneath Adit 2.

4.3 Climate

The closest climatological information is from the Town of Carcross (60° 11'N, 134° 41'W 663 m above sea level (Environment, Canada, 1990). Total annual precipitation is 211.4 mm. This consists of 118.7 mm of rainfall and 101.3 mm of snowfall. The highest levels of rainfall occur in August and the highest levels of snowfall occur in January. Temperatures range from -19.4°C in January to 12.7°C in July. The mean annual temperature is -1.4°C.

4.4 Vegetation

Venus mine site occurs within the Yukon Stikine Highlands ecoregion. Alpine tundra dominates at higher elevations, with vegetation including scrub heather, dwarf birch, willow, grass and lichens present. At lower elevations, subalpine areas typically consist of white spruce and alpine fir. The mine site is located in an alpine/subalpine transition zone and contains species representative of both ecosystems. Disturbed areas of the site are dominated by fireweed. The waste rock slopes have very little established vegetation as a result of the thin soil colluvium and active mass wasting.

4.5 Fish and Wildlife Resources

Typical mammals in the area include Dall's sheep, moose, grizzly and black bear, porcupine and wolf. Typical bird species include Blue grouse and two species of ptarmigan. A number of raptors hunt and nest in the area including peregrine falcon and golden eagle. Waterfowl, including merganser species are found in lakes and rivers at the lower elevations.

4.6 Site Topography and Soils

The soils within the Yukon Stikine Highlands ecoregion are predominantly brunisolic and regosolic. Occasionally, cryosolic soils, dystric brunisols and eutric brunisols are also found.

The South and North end claims are located on a steep mountain slope (30° to 35°) ending at Tagish Lake approximately 120 m below the site. Drainage is predominantly in that direction. The Vault claims, were not accessible by ground and were located in a steep walled canyon north of the main area of the site. Drainage from this area would also primarily be towards the lake. Waste rock slopes are undergoing constant mass wasting in the form of rock falls, rock slides, debris avalanches, and snow avalanches.

5.0 SITE ASSESSMENT RESULTS

5.1 Surface Water Quality

Results of water quality sample analyses are summarized in Table 5.1. Complete analytical methods and results are provided in Appendix A.

During all three sampling events (August 1996, August 1997, and October 1997) at the Venus Mine, water samples were collected from Adit 1 (VEWQ-A101), Adit 2 (VEWQ-A102), a seep below adit 1 (VEWQ-S101), and from the Adit 2 flow where it intersects the Klondike Highway below the mine site (VEWQ-S201). In August of 1996, a sample (VEWQ-S301) was also collected where the seep S101 intersects the highway. In 1997, samples of the Adit 2 water were collected just above the highway (VEWQ-S2-1). All samples collected had pH values near 8 (range=7.7 to 8.6). Conductivity ranged from 285 µS/cm to 569 µS/cm and sulphate concentrations remained below 200 mg/L. These values indicate that little oxidation is taking place underground, at the source of the water, and that the seeps are not encountering significant soluble constituents (i.e. from the waste rock) once they surface.

The flow from Adit 1 was approximately 10 L/s and pooled outside the adit in a depression lined with a bright orange-brown to bright yellow-orange algae. Drainage from the pool then infiltrated the ground approximately 15 m from the adit. The water had aluminum, arsenic, cadmium, copper, iron, lead, and zinc concentrations above the CCME guidelines. These metals reflect the presence of arsenopyrite, pyrite, galena, and sphalerite in the deposit. No mention of cadmium and copper minerals have been made in reports about the Venus mine, but chalcopyrite is an accessory mineral in both the Arctic Caribou and Big Thing deposits, located in the same district.

The flow from Adit 2 was approximately 5 L/s. Most metal concentrations were lower in the Adit 2 seepage, and only arsenic and aluminum were above the CCME guidelines. The water from Adit 2 was also sampled further down slope where it intercepts the highway. The water quality was not greatly changed from the where it exited the adit.

5.2 Soluble Metals Concentrations

Results of soluble metal concentration analyses are summarized in Table 5.2. Complete analytical methods and results are also provided in Appendix A.

Samples VEWR-P305 and VEWR-P311 were subjected to bottle roll testing to determine soluble metals concentrations. These samples were collected outside of Adits 1 and 2, respectively, and both represent a median acid generating potential and metals concentrations for the waste near each adit.

Table 5.1 Significant Results - Venus Surface Water Samples

Sample ID	Sample Location	Sample Date	pH	Cond. (µS/cm)	Parameters > CCME FAL Criteria
VEWQ-A101	adit 1 seepage	Oct 1997	8.36	285	As, Cd, Cu, Fe, Pb
		Aug 1997	8.1	297	As, Cd, Cu, Fe, Pb
		Aug 1996	7.92	323	Al, As, Fe, Zn
VEWQ-S101	seep below adit 1	Oct 1997	7.99	301	As
		Aug 1997	7.67	319	As, Se
		Aug 1996	7.82	339	As, Al
VEWQ-A102	adit 2 seepage	Oct 1997	8.42	352	As
		Aug 1997	8.2	401	As
		Aug 1996	8.02	439	As, Al
VEWQ-S2-1	adit 2 seepage above highway	Oct 1997	8.56	350	As, Cd, Pb, Zn
		Aug 1996	8.28	399	As, Zn
VEWQ-S201	adit 2 seepage at highway	Oct 1997	8.54	345	As
		Aug 1997	8.32	400	As
		Aug 1996	8.04	435	As, Zn

Notes: FAL = Freshwater Aquatic Life corrected for hardness.

Sample P305 had a laboratory paste pH value of 6.7 and field conductivity of >1900 µS/cm. The NP/AP ratio is 0.25. Sample P311 had a laboratory paste pH of 8 and field conductivity similar to that of sample P305. The NP/AP ratio of sample P311 was 1. Both samples contained >10,000 ppm arsenic, >100 ppm cadmium, >7000 ppm lead, as well as elevated manganese and zinc concentrations.

After six days of testing, the pH of the slurry for samples P305 and P311 were 7 and 8.7, respectively. The conductivity of the first sample increased from 5000 µS/cm to 5800 µS/cm. The conductivity of sample P311 also increased with a final value of 3500 µS/cm. The filtered leachates for both samples contained high concentrations of sulphate and over 100 mg/L alkalinity, indicating that sulphide oxidation is taking place but that the acid produced is being neutralized.

Arsenic concentrations in the leachates were greater than 4 mg/L, and the zinc concentration in sample P305 was 6 mg/L. The presence of these metals reflects the arsenopyrite and sphalerite that are gangue minerals in the Venus vein.

Table 5.2 Summarized Waste Rock ABA and Bottle Roll Test Sample Results

Sample ID	Summary of 1996 ABA Test Results	Summary of 1997 Bottle Roll Test Results
VEWR-P305	Potentially Acid Generating (NP/AP=0.25); paste pH = 5.74; $S0_4$ = 0.39% / Total S = 4.55%;high As, Cd, Cr, Pb, Ag, Zn	Conductivity increased from 5,000 uS/cm to 5,800 uS/cm; acid is generated and neutralized; high arsenic
VEWR-P311	Potentially Acid Generating (NP/AP=1.05); paste pH = 7.08; $S0_4$ = 0.20% / Total S = 3.37%; high As, Cd, Cr, Pb, Mn, Ag, Zn	Conductivity increased from 2,500 uS/cm to 3,500 uS/cm; acid is generated and neutralized; high arsenic and zinc

5.3 Geotechnical Assessment

A detailed geotechnical assessment and determination of suitable remedial actions including a ±25% cost estimate is attached in Appendix B. The following is a summary of this assessment.

Adit 1 Area:

The slope of Adit 1 was inspected for signs of previous slope failures or of active mass wasting. There were no signs of tension cracks near the top of the slope or bulging at the toe which would suggest slope movements. Rather, the extent of downslope movements has been restricted to near surface sloughing. The presence of two horizontal benches downslope of the waste rock pile has restrained the surface sloughing from extending further down the slope. It does not appear that significant mass wasting has occurred in the area of Adit 1 as there were no observed failures related to the waste rock pile in the area.

Adit 2 Area:

In the area of adit 2 the waste rock piles were considered generally stable and did not appear to exhibit evidence of mass wasting. There were no tension cracks at the top of the waste rock pile slope or other signs of failure. There was some surface creep of larger diameter rocks however, did not appear to be extensive since the tracks and structures on top of the waste rock piles have not been undermined as result of a regressive slope. Below the near 80 metres of waste rock slope area switch back roads leading up to the adit and appear to have restrained the loose rock from further down slope movement.

The more significant feature is the presence of unstable retaining walls along the waste rock slope. The walls are constructed with log cribbing and have shown natural degradation over the approximately 25 years of existence. The lower wall showed decay of the log cribbing and some failure at the joints along the edges. There was also extensive sloughing of the waste rock behind the wall, as well as tension cracks parallel to the wall. If the joints along the cribbing continue to fail to a point where the waste rock begins to deform and the strength within the remaining cribbing support is insufficient to restrain the waste rock from mobilizing downslope, it is uncertain that the benches below would prevent this materials from impacting the highway. The rate of failure is uncertain. This material is estimated to be approximately 500 m^3.

The structure retaining the upper waste rock pile does not appear to have decayed as much as the lower wall. There were no noticeable failures of the cribbing joints or evidence of movement within the material behind the wall. However, if failure of the lower wall was to occur, the toe support of the upper wall may fail causing downward mobilization of waste rock from the upper wall. The rate of failure is uncertain. The material is estimated to be approximately 1,500 m^3. The movement of this volume of rock will likely impact the highway below, since the retention capacity of the lower benches is inadequate.

6.0 CONCLUSIONS

Based on interim results of phase III work conducted at the Venus abandoned mine site the following conclusions have been drawn:

Conclusion 1. Downwards movement of waste rock, impacting the South Klondike highway and posing a safety risk, is imminent due to the eventual failure of the retaining wall structures below Adit 2. Two possible options for remedial actions have been presented.

Conclusion 2. The seepage from both Adit 1 and Adit 2 is not representative of Acid Rock Drainage (ARD). Both seepages contain aluminum and arsenic concentrations above the CCME guidelines for freshwater aquatic life. In addition, Adit 2 seepage contains cadmium, copper, iron, lead, and zinc concentrations above the guidelines. The seepage from Adit 1 is little changed after flowing through the waste rock pile, with the exception of occasionally elevated selenium. Adit 2 seepage collected at the highway still has elevated arsenic concentrations, but concentrations of all other metals have dropped below CCME guidelines.

Conclusion 3. Metals concentrations remained relatively constant at each sampling. It is unlikely that the seepage and adit water quality will deteriorate during high precipitation events since most of the water discharging from the site comes directly from the two adits and not from runoff.

7.0 RECOMMENDATIONS

Recommended remediation and management actions are compliant with applicable federal or territorial regulations and criteria, rely upon available technology, and intended to be appropriate for local conditions and sensitivities. Recommendations made in this report are preliminary. Final recommendations will be based on a spring freshet sampling event proposed for April 1998.

Recommendation 1. The two retaining walls below Adits 1 and 2 should be intentionally failed to reduce the risk to the South Klondike Highway below the site. It is recommended that the material behind the retaining walls be relocated to the bench area near Adit 2.

Recommendation 2. Monitoring for potential waste rock slope failure should occur on an annual basis do to the extent of uncertainty inherent in this level of assessment. Alternatively, a more detailed geotechnical analysis can be performed to determine the long term slope stability characteristics.

Recommendation 3. Monitoring adit water and seeps at the Venus Mine should be conducted during the spring freshet. In particular, the base of the waste rock piles should be carefully examined to identify the presence of any new seeps. New seeps and changes in the chemistry of existing seeps may indicate the impact of the waste rock on the quality of water released from the site at high flow conditions.

Recommendation 4. An assessment should be conducted to determine the impact of Venus mine water discharge on Tagish lake in relation to natural seepages and other possible activities which may impact the water quality.

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APPENDIX A

Detailed Geochemical Assessment of Waste Rock and Surface Water

Venus Mine Site

Public Works and
Government
Services
Canada

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YUKON ABANDONED MINE SITES ASSESSMENT REPORT ON 1997 FOLLOW-UP

1CP001.00

YUKON ABANDONED MINE SITES ASSESSMENT
REPORT ON 1997 FOLLOW-UP

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MARCH, 1998

YUKON ABANDONED MINE SITES ASSESSMENT
REPORT ON 1997 FOLLOW-UP

1.0 INTRODUCTION

1.1 Background

In 1993, DIAND Technical Services completed Phase I environmental assessments of 49 abandoned exploration and mine sites in the Yukon Territory as part of the Arctic Environmental Strategy Action on Waste. These initial assessments included a literature review of the historical activities at each site, described the mine infrastructure, workings and waste, summarized environmental and/or safety concerns, and made general recommendations for remediation. No waste rock or water quality samples were collected. The results of this work indicated that an assessment of the environmental impacts of the sites was required before decisions could be made regarding remediation.

In 1996, environmental assessments were conducted by Environmental Services, Public Works and Government Services Canada (PWGSC). These assessments included investigations of the current impacts of mining activities on receiving water, as well as the potential for future impacts on receiving water from waste rock and tailings disposed of on site. Current impacts were assessed by water quality sampling whereas future impacts were estimated by determining the acid generating potential and metal content of the waste. Waste at the site was mapped, described, and representative samples collected. Samples were then analzyed for acid generating potential using Acid Base Accounting (ABA), and for metals concentrations using Inductively Coupled Plasma (ICP). Professional geologists conducted the geochemical investigations. The assessment results were presented in SRK (1997), Norecol Dames and Moore (1997), and Geoviro (1997).

Based on the 1996 work, the PWGSC identified six abandoned mined sites for which additional geochemical or geotechnical information were required in order for decisions to be made regarding reclamation. In 1997, PWGSC retained Steffen, Robertson and Kirsten (Canada) Inc. (SRK) to conduct a follow-up geochemical assessment of the six sites. SRK had conducted evaluations of 15 abandoned sites during the 1996 program and, thus, were familiar with several of the mines requiring additional work (SRK, 1997).

The waste at all of the sites was deposited prior to 1985 and, therefore, has been exposed for more than 10 years. Much of the waste rock at the six sites was already generating acid or, if neutral, had been exposed for sufficient time that acidic conditions would be unlikely to develop in the future. The impact of the waste on receiving waters appeared to be small. However, sampling was conducted in August and September, generally a dry season in the Yukon Territory, when flow in local seeps and streams was low. It was, therefore, recommended that a year of water quality monitoring be conducted in order to measure seasonal variability in metal concentrations. In order to estimate the impact of the waste on receiving waters under high flow conditions, it was also recommended that the soluble metal concentrations associated with the waste rock be measured.

1.2 Objectives

The objectives of the 1997 field program were to conduct a follow-up assessment of the environmental impact, or potential environmental impact, of mining or exploration activities conducted at six abandoned sites in the Yukon Territory. The follow-up work included waste rock sampling where additional data was required, and water quality monitoring of adit water, seeps, and receiving water bodies. Laboratory leachate extraction tests were completed to characterize the soluble constituents of the waste rock.

2.0 FIELD/LABORATORY TECHNIQUES

2.1 Sample Collection

In the 1996 Assessment Reports, water quality monitoring was recommended for the six abandoned mine sites that were revisited. Samples were collected from adits, seeps, and receiving water upstream and downstream of the mine in August and in October of 1997. The sampling protocol used was provided in SRK (1997).

Waste samples were only collected during the August 1996 and 1997 visits. Waste rock sampling protocols were provided in the SRK (1997).

2.2 Flow Measurement

During the August 1997 field trip, flow in streams and seeps were measured using a Price Current meter. Stream depth and velocity measurements are taken at several locations across the stream, and averaged to obtain a value for the stream.

2.3 Analytical Techniques

Water samples were analyzed for immediate parameters (pH, electrical conductivity, hardness, alkalinity, ionic balance, and total dissolved solids), and sulphate, chloride, bicarbonate, nitrate, nitrite, and metals concentrations.

To estimate the soluble metal load in the waste rock, large-scale leach extraction tests were conducted on selected samples. These tests involved sieving a waste rock sample to obtain 1 kg of material passing through a 5-mm screen. This material was combined with 1 litre of distilled water and agitated on a rolling device. Every 24 hours the bottle was removed from the roller and allowed to settle. The solution was sampled, and the pH and conductivity measured. Once the pH and conductivity of the solution stabilized, the solution was filtered and analyzed for immediate parameters (e.g. pH, conductivity, acidity, alkalinity, etc.), sulphate, and total metals concentrations. The resulting concentrations represent a measure of the soluble contaminants stored in the waste. A detailed protocol is provided in Appendix A. Results of bottle roll tests are presented in Tables 1 and 2.

3.0 ASSESSMENT CRITERIA

The freshwater aquatic criteria of the Interim Canadian Environmental Quality Criteria for Contaminated Sites (CCME, 1995) were used to assess impacts to surficial receiving waters. These criteria provide numerical limits that are designed to protect, maintain, or improve environmental quality and human health at contaminated sites.

9.0 VENUS

9.1 Background

The Venus Mine site is located on a steep slope above the Windy Arm of the Tagish Lake, and discharge from the adits flows into the lake. The 1996 site visit and analytical testwork indicated that the waste rock at the Venus mine site is generally neutral, but has the potential to generate acid. Of concern at this site is the potential for metals to enter the lake.

The Venus deposit is composed of gold-bearing quartz veins hosted in the mid-Cretaceous volcanic complex and Montana pluton. Veins associated with the deposit contain arsenopyrite (FeAsS), pyrite (FeS2), galena (PbS), and sphalerite ((Zn,Fe)S).

9.2 Observations

No new seeps were seen at the Venus Mine during the 1997 visits (Photograph 8). Water continues to flow from Adits 1 and 2.

9.3 Water Quality

During all three sampling events at the Venus Mine, water samples were collected from Adit 1 (VEWQ-A101), Adit 2 (VEWQ-A102), a seep below adit 1 (VEWQ-S101), and from the Adit 2 flow where it intersects the Klondike Highway below the mine site (VEWQ-S201). In August of 1996, a sample (VEWQ-S301) was also collected where the seep S101 intersects the highway. In 1997, samples of the Adit 2 water were collected just above the highway (VEWQ-S2-1). Water quality data is presented in Table 9.

All samples collected had pH values near 8 (range=7.7 to 8.6). Conductivity ranged from 285 µS/cm to 569 µS/cm and sulphate concentrations remained below 200 mg/L. These values indicate that little oxidation is taking place underground, at the source of the water, and that the seeps are not encountering significant soluble constituents (i.e. from the waste rock) once they surface.

The flow from Adit 1 was approximately 10 L/s and pooled outside the adit in a depression lined with a bright orange-brown to bright yellow-orange algae. Drainage from the pool then infiltrated the ground approximately 15 m from the adit. The water had aluminum, arsenic, cadmium, copper, iron, lead, and zinc concentrations above the CCME guidelines. These metals reflect the presence of arsenopyrite, pyrite, galena, and sphalerite in the deposit. No mention of cadmium and copper minerals have been made in reports about the Venus mine, but chalcopyrite is an accessory mineral in both the Arctic Caribou and Big Thing deposits, located in the same district.

The flow from Adit 2 was approximately 5 L/s. Most metal concentrations were lower in the Adit 2 seepage, and only arsenic and aluminum were above the CCME guidelines. The water from Adit 2 was also sampled further down slope where it intercepts the highway. The water quality was not greatly changed from the where it exited the adit.

9.4 Soluble Metals Concentrations

Samples VEWR-P305 and VEWR-P311 were subjected to bottle roll testing to determine soluble metals concentrations. These samples were collected outside of Adits 1 and 2, respectively, and both represent a median acid generating potential and metals concentrations for the waste near each adit. Sample locations are shown in Figures 6 and 7.

Sample P305 had a laboratory paste pH value of 6.7 and field conductivity of >1900 µS/cm. The NP/AP ratio is 0.25. Sample P311 had a laboratory paste pH of 8 and field conductivity similar to that of sample P305. The NP/AP ratio of sample P311 was 1. Both samples contained >10,000 ppm arsenic, >100 ppm cadmium, >7000 ppm lead, as well as elevated manganese and zinc concentrations.

Results of bottle roll testing of these two samples are listed in Tables 1 and 2. After six days of testing, the pH of the slurry for samples P305 and P311 were 7 and 8.7, respectively. The conductivity of the first sample increased from 5000 µS/cm to 5800 µS/cm. The conductivity of sample P311 also increased with a final value of 3500 µS/cm. The filtered leachates for both samples contained high concentrations of sulphate and over 100 mg/L alkalinity, indicating that sulphide oxidation is taking place but that the acid produced is being neutralized.
Arsenic concentrations in the leachates were greater than 4 mg/L, and the zinc concentration in sample P305 was 6 mg/L. The presence of these metals reflects the arsenopyrite and sphalerite that are gangue minerals in the Venus vein.

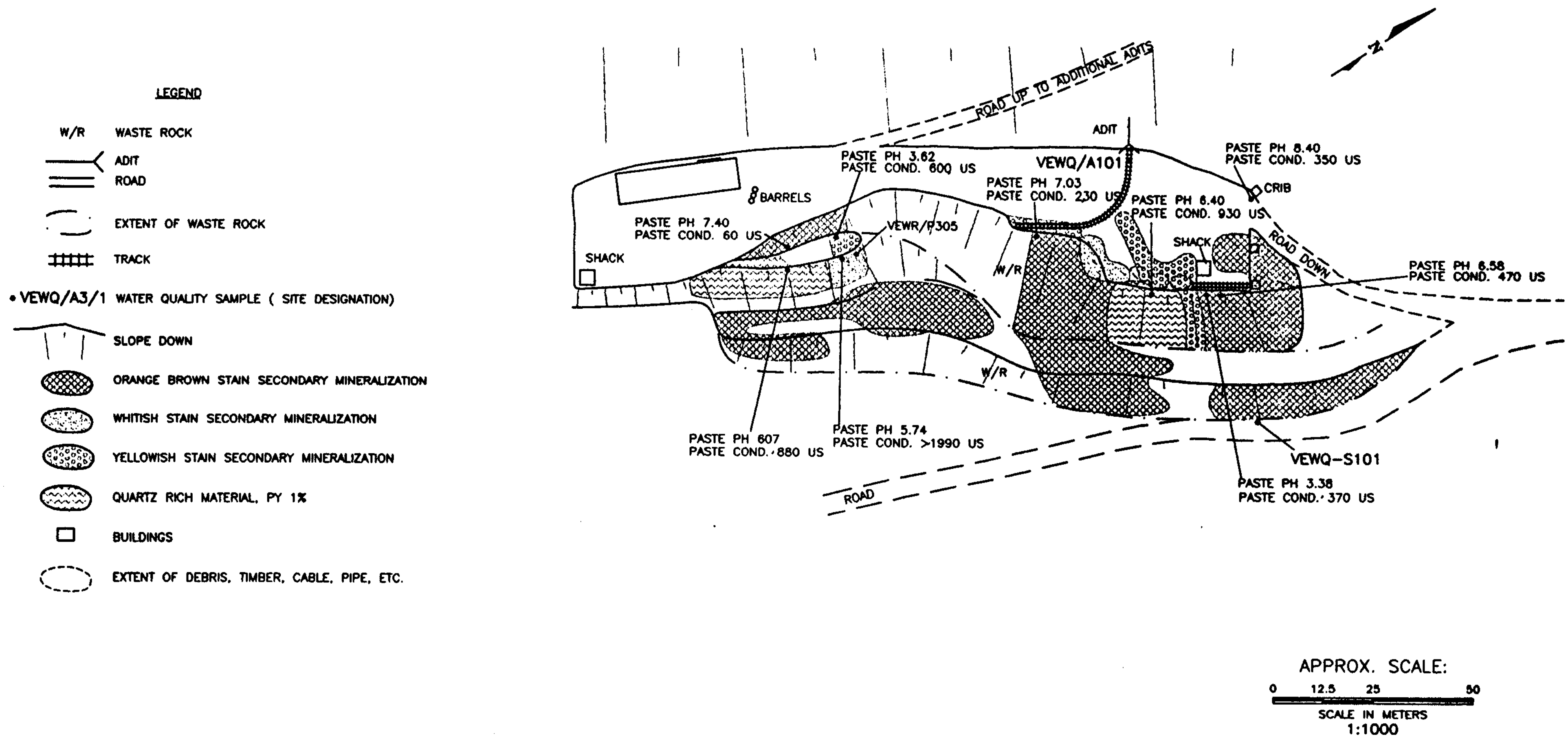
9.5 Discussion

The seepage from both adits is not representative of Acid Rock Drainage (ARD). However, both contain aluminum and arsenic concentrations above the CCME guidelines for freshwater aquatic life. In addition, Adit 2 seepage contains cadmium, copper, iron, lead, and zinc concentrations above the guidelines. The seepage from Adit 1 is little changed after flowing through the waste rock pile, with the exception of occasionally elevated selenium. Adit 2 seepage collected at the highway still has elevated arsenic concentrations, but concentrations of all other metals have dropped below CCME guidelines.

Metals concentrations remained relatively constant at each sampling. It is unlikely that the seepage and adit water quality will deteriorate during high precipitation events since most of the water discharging from the site comes directly from the two adits and not from runoff.

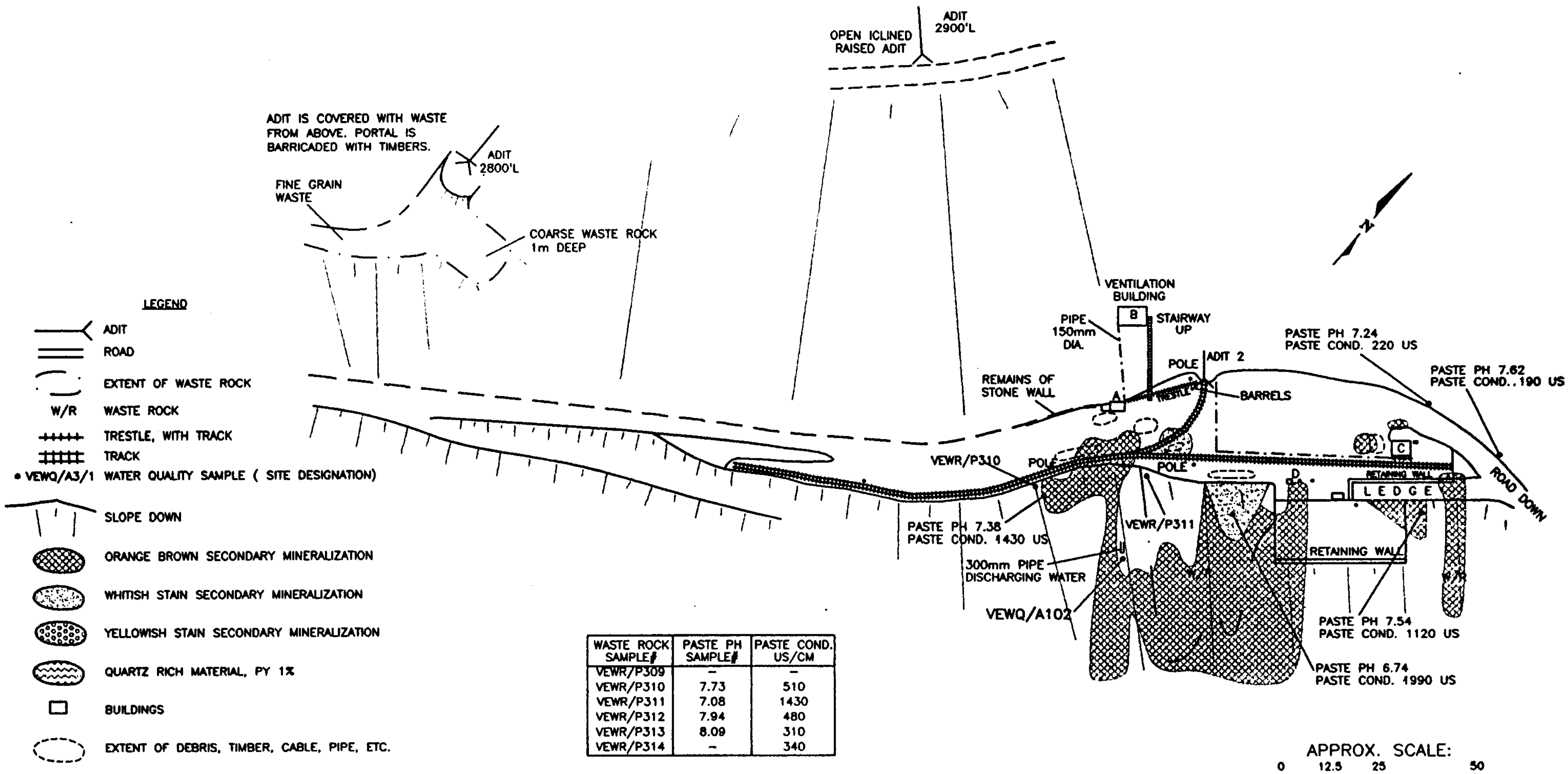
9.6 Recommendations

Monitoring adit water and seeps at the Venus Mine should be conducted during the spring freshet. In particular, the base of the waste rock piles should be carefully examined to identify the presence of any new seeps. New seeps and changes in the chemistry of existing seeps may indicate the impact of the waste rock on the quality of water released from the site at high flow conditions.



STEFFEN ROBERTSON & KIRSTEN (CANADA) Consulting Engineers & Scientists			**FIGURE 6** VENUS MINE SITE 1997 INVESTIGATION ADIT 1
PROJECT NO.	DATE	REVISION	
1CP001	02/98	A	

• STA.43 • J:\1CP001\FIG6.DWG • FEB 26, 1998 • 4:59:44 PM •



WASTE ROCK SAMPLE#	PASTE PH SAMPLE#	PASTE COND. US/CM
VEWR/P309	–	–
VEWR/P310	7.73	510
VEWR/P311	7.08	1430
VEWR/P312	7.94	480
VEWR/P313	8.09	310
VEWR/P314	–	340

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PROJECT NO.	DATE	REVISION
1CP001	02/98	A

FIGURE 7

VENUS MINE SITE
1997 INVESTIGATION
ADIT 2

Table 1
Results of Physical Parameters in Bottle Roll Test Leachates

SAMPLE	SOLID			SLURRY										FILTERED LEACHATE									
	pH	Conductivity (µS/cm)	NP/AP	pH (Hours)					CONDUCTIVITY (uS/cm) (Hours)					pH	COND. (uS/cm)	REDOX POT. (mV)	ACIDITY (mg/L CaCO3)		ALKALINITY pH 4.5 (mg/L CaCO3)	SULPHATE (mg/L)	BICARBONATE CaCO3 (mg/L)	CARBONATE CaCO3 (mg/L)	CHLORIDE mg/L
				48	72	120	144	216	48	72	120	144	216				pH 4.	pH 8.3					
STU-WR-P3-1	7.8	270	2.5	–	7.3	6.9	6.8	6.7	–	1410	2250	2700	2900	7.97	4450	280	0.0	10.5	289.0	3160	303	<1	5.5
STU-WR-P4-1	6.6	840	<0.1	–	6.2	6.4	6.1	–	–	2650	4000	4200	–	7.10	5350	290	0.0	7.5	21.0	4070	1	<1	96.8
PAD-WR-1-1	7.7	81	5	–	8.0	7.7	7.5	7.3	–	780	1490	1880	2400	8.31	3260	285	0.0	0.0	304.5	1930	320	<1	4.5
PAD-WR-2-1	7.6	77	5.3	–	8.3	8.1	8.0	8.1	–	670	1290	1590	1900	8.28	2760	288	0.0	0.5	104.0	1470	110	<1	4.2
FO-WR-P302	7.8	180	0.49	–	7.8	8.0	8.1	–	–	2300	2800	3000	–	7.52	4180	282	0.0	5.0	32.0	2140	<1	<1	754
FOR-WR-P307/	4.6	–	<0.1	–	4.0	4.3	4.3	–	–	4500	3900	3800	–	4.60	5280	365	0.0	1300.5	1.0	4570	<1	<1	5.9
GV206PAD1-3*	4	–	<0.1	4.5	4.7	–	–	–	375	420	–	–	–	5.02	623	387	0.0	31.0	10.0	208	51	<1	388
GV206PAD1-16	3	–	<0.1	2.9	2.9	–	–	–	1520	1560	–	–	–	3.10	2400	375	315.0	1500.0	0.0	1710	<1	<1	9.2
BT-WR-P302	3	750	<0.1	–	3.1	3.4	3.4	3.7	–	3900	4600	5000	4300	3.85	5750	352	58.0	1266.0	0.0	4070	123	<1	3.1
BT-WR-P305-1	8	140	1	–	8.9	9.1	9.2	9.2	–	750	1065	1240	1580	9.03	2250	242	0.0	0.0	56.5	785	129	<1	104
VE-WR-P305	6.7	>1990	0.25	–	6.6	6.7	7.0	–	–	5000	5400	5800	–	7.93	5820	252	0.0	13.0	133.5	3860	<1	<1	1.2
VE-WR-P311	8	>1990	1	–	8.5	8.6	8.7	–	–	2500	3200	3500	–	8.40	3610	257	0.0	0.0	119.5	1840	<1	<1	4.6

*500 g sample was used with 500 ml of distilled solution.
– = not analyzed for this element.

Table 2
Dissolved Metals Concentrations in Bottle Roll Test Leachates

Sample No.		STU-WR-P3-1	STU-WR-P4-1	PAD-WR-1-1	PAD-WR-2-1	FO-WR-P302	FOR-WR-P307/2	GV206PADI-3	V206PADI-1	BT-WR-P302	BT-WR-P305-1	VE-WR-P305	VE-WR-311
Lab. Samples No.		4062	4063	4064	4065	4067	4066	4072	4073	4069	4068	4071	4070
Aluminum	mg/L	<0.2	<1	<0.2	<0.2	<0.2	5	1.8	67.2	53.9	0.2	<0.2	<0.2
Antimony	mg/L	0.2	<1	<0.2	<0.2	<0.2	<1	0.3	0.7	<0.2	0.3	<0.2	<0.2
Arsenic	mg/L	0.309	0.593	0.0335	0.0104	0.0133	0.0124	0.129	3.4	38.1	2.9	4.3	7.4
Barium	mg/L	0.04	<0.05	0.07	0.04	0.09	<0.05	0.09	0.03	0.08	0.07	0.04	0.03
Beryllium	mg/L	<0.005	<0.03	<0.005	<0.005	<0.005	<0.03	<0.005	0.015	0.007	<0.005	<0.005	<0.005
Bismuth	mg/L	0.2	0.7	0.1	<0.1	<0.1	0.6	<0.1	0.1	0.1	<0.1	0.3	<0.1
Boron	mg/L	0.1	<0.5	<0.1	0.1	1.0	0.8	0.4	2.0	0.2	0.1	0.1	<0.1
Cadmium	mg/L	<0.01	<0.05	<0.01	<0.01	0.02	11.2	<0.01	0.421	0.346	<0.005	0.04	<0.005
Calcium	mg/L	689	513	261	130	614	488	13	33.3	296	53.1	432	200
Chromium	mg/L	<0.01	<0.05	<0.01	<0.01	<0.01	<0.05	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
Cobalt	mg/L	0.04	0.27	0.01	<0.01	<0.01	0.41	0.11	0.12	0.47	<0.01	0.04	<0.01
Copper	mg/L	0.04	0.07	0.01	0.02	0.03	0.12	0.23	2.57	0.4	0.023	0.02	<0.01
Iron	mg/L	<0.03	<0.2	<0.03	<0.03	<0.03	167	1.58	431	352	<0.03	<0.03	0.007
Lead	mg/L	0.09	3.9	0.1	0.013	0.22	3.7	0.10	0.30	0.77	<0.05	<0.02	<0.02
Lithium	mg/L	0.09	0.09	0.14	0.07	0.06	0.82	0.07	0.12	0.21	<0.01	0.19	0.06
Magnesium	mg/L	221	556	131	44.7	78.4	433	7.08	17.0	19	6.35	369	49.1
Manganese	mg/L	15.5	405	0.681	0.175	1.09	97.7	7.57	19.2	3.54	0.021	22.6	0.07
Mercury	mg/L	<0.00005	0.00009	<0.00005	<0.00005	0.00008	0.00032	0.0001	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenu	mg/L	<0.03	<0.2	<0.03	0.1	<0.03	<0.2	<0.03	<0.03	<0.03	0.87	<0.03	0.07
Nickel	mg/L	0.06	0.8	<0.02	<0.02	<0.02	1.2	0.03	0.32	0.04	<0.02	0.07	<0.02
Phosphorus	mg/L	<0.3	<2	<0.3	<0.3	<0.3	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Potassium	mg/L	66	99	36	24	93	20	28	<2	173	52	111	74
Selenium	mg/L	0.0015	0.0028	0.0046	0.0041	<0.2	<1	<0.2	<0.2	0.0015	0.0085	<0.2	<0.2
Silicon	mg/L	10.2	7	7.99	8.04	3.19	30.3	52.1	66.2	104	19.3	25.9	23.4
Silver	mg/L	<0.01	<0.05	<0.01	<0.01	0.004	0.008	<0.01	<0.01	<0.01	0.02	<0.01	<0.01
Sodium	mg/L	320	134	360	486	290	132	82	66	764	377	543	552
Strontium	mg/L	2.33	0.3	0.879	0.625	0.396	0.045	0.077	1.04	0.754	0.329	5.32	3.09
Thallium	mg/L	<0.1	<0.5	<0.1	<0.1	<0.1	<0.5	<0.1	0.3	0.2	<0.1	<0.1	<0.1
Tin	mg/L	<0.03	<0.2	<0.03	<0.03	<0.03	<0.2	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Titanium	mg/L	<0.01	<0.05	<0.01	<0.01	<0.01	<0.05	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	0.0031	<0.0001	0.0087	0.006	<0.0001	0.0007	0.0005	0.0062	0.0152	0.0042	0.0038	0.0085
Vanadium	mg/L	<0.03	<0.2	<0.03	<0.03	<0.03	<0.2	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	mg/L	0.175	1.06	1.18	0.057	0.524	702	0.686	57.7	6.76	0.015	6.01	0.055

Table 9
Water Quality Data
Venus Mine

PARAMETER	Units	D.L.	VEWQ-A101	97VEWQ-A101	VEWQ-A101	VE-WR A102	97-VE-WR A102	VE-WQ-A102	VE-WQ-S101	97-VE-WQ S101	VE-WQ-S101
Sampling Event			Aug-96	Aug-97	Oct-97	Aug-96	Aug-97	Oct-97	Aug-96	Aug-97	Oct-97
Location			Adit 1			Adit 2			seep below Adit 1		
pH		0.1	7.92	8.1	8.36	8.02	8.2	8.42	7.82	7.67	7.99
Electrical conductivity	uS/cm	0.1	323	297	285	439	401	352	339	319	301
Hardness	mg/L	0.1	–	173	182	–	237	247	–	189	203
Alkalinity	mg/L	1	118	121	122	173	166	165	123	126	132
Sulphate	mg/L	0.3	48.8	<0.5	59.8	72.7	71	77.3	57.4	62.5	67.6
Aluminum	mg/L	0.00005	[illegible]	0.045	0.0215	[illegible]	0.012	0.00394	[illegible]	0.047	0.0163
Antimony	mg/L	0.005	<0.2	<0.005	<0.005	<0.2	<0.005	<0.005	<0.2	<0.005	<0.005
Arsenic	mg/L	0.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cadmium	mg/L	0.00006	<0.01	[illegible]	[illegible]	<0.01	0.00172	0.00111	<0.01	0.00028	0.00023
Calcium	mg/L	0.002	46.6	46	49.3	49.5	46.8	48.8	49.5	49.9	51.4
Chromium	mg/L	0.00006	<0.01	<0.00006	0.00023	<0.01	<0.00006	0.00027	<0.01	<0.00006	0.00017
Cobalt	mg/L	0.00003	<0.01	0.00024	0.00014	<0.01	0.00011	<0.00003	<0.01	<0.00003	<0.00003
Copper	mg/L	0.00003	<0.01	[illegible]	[illegible]	<0.01	0.00043	0.00016	<0.01	0.00072	0.00037
Iron	mg/L	0.003	[illegible]	[illegible]	[illegible]	<0.03	0.103	0.0254	<0.03	0.094	0.0127
Lead	mg/L	0.0003	<0.05	[illegible]	[illegible]	<0.05	<0.0003	0.0017	<0.05	<0.0003	0.0008
Lithium	mg/L	0.00006	<0.01	0.0075	0.00937	0.01	0.0146	0.0174	<0.01	0.00557	0.00678
Magnesium	mg/L	0.005	11.7	11	11.2	26.9	23.5	23.5	12.2	11.6	11.5
Manganese	mg/L	0.00002	0.008	0.0145	0.0133	<0.005	0.00386	0.00207	<0.005	0.00073	0.00059
Mercury	mg/L	0.0001	–	<0.0001	<0.0001	–	<0.0001	<0.0001	–	<0.0001	<0.0001
Molybdenum	mg/L	0.00007	<0.03	0.00969	0.00849	<0.03	0.0121	0.00830	<0.03	0.0106	0.00604
Nickel	mg/L	0.0001	<0.02	<0.0001	0.0002	<0.02	0.0003	0.0001	<0.02	<0.0001	<0.0001
Selenium	mg/L	0.003	<0.2	0.005	<0.003	–	0.005	<0.003	<0.2	[illegible]	<0.003
Silver	mg/L	0.00005	<0.01	0.00014	<0.00006	<0.01	<0.00005	<0.00006	<0.01	<0.00005	<0.00006
Zinc	mg/L	0.0002	[illegible]	[illegible]	[illegible]	0.023	0.0599	0.0379	<0.005	<0.0002	0.0045

– not analyzed for this parameter.
* Detection Limit for analyses of 1997 samples.
CCME = Canadian Council of Ministers of the Environment, Canadian Water Quality Guidelines
(black shading) Exceeds the guidelines.

Table 9
Water Quality Data
Venus Mine

PARAMETER	Units	D.L.	VE-WQ-S301	VEWQ-S201	VEWQ-S201	VE-WQ-S201	VE-WQ-S2-1	VE-WQ-S2-1
Sampling Event			Aug-96	Aug-96	Aug-97	Oct-97	Aug-97	Oct-97
Location			seep S101 drainage where it intersects hwy.	Adit 2 seep where it intersects hwy.			Adit 2 seep above highway	
pH		0.1	7.84	8.04	8.32	8.54	8.28	8.56
Electrical conductivity	uS/cm	0.1	569	435	400	345	399	350
Hardness	mg/L	0.1	–	–	238	246	239	247
Alkalinity	mg/L	1	189	170	165	160	165	162
Sulphate	mg/L	0.3	121	72	73.1	78.8	72.4	78.4
Aluminum	mg/L	0.00005	<0.2	<0.2	0.015	0.0234	0.012	0.0341
Antimony	mg/L	0.005	<0.2	<0.2	<0.005	<0.005	<0.005	<0.005
Arsenic	mg/L	0.01	<0.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cadmium	mg/L	0.00006	<0.01	<0.01	0.00047	0.00049	0.00134	[illegible]
Calcium	mg/L	0.002	84.1	44.6	46.7	47.9	46	48.4
Chromium	mg/L	0.00006	<0.01	<0.01	<0.00006	0.00035	<0.00006	0.00026
Cobalt	mg/L	0.00003	<0.01	<0.01	<0.00003	0.00010	<0.00003	0.00021
Copper	mg/L	0.00003	<0.01	<0.01	0.00021	0.00019	0.00061	0.00064
Iron	mg/L	0.003	<0.03	0.28	0.044	0.0129	0.029	0.1131
Lead	mg/L	0.0003	<0.05	<0.05	<0.0003	0.0007	0.0014	[illegible]
Lithium	mg/L	0.00006	<0.01	0.02	0.0149	0.0166	0.0143	0.0174
Magnesium	mg/L	0.005	21.6	24.8	23.6	23.2	23.1	23.3
Manganese	mg/L	0.00002	<0.005	0.031	0.00048	0.00238	0.00117	0.0161
Mercury	mg/L	0.0001	–	–	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.00007	<0.03	<0.03	0.00666	0.00618	0.0129	0.00606
Nickel	mg/L	0.0001	<0.02	<0.02	<0.0001	<0.0001	<0.0001	0.0003
Selenium	mg/L	0.003	–	–	0.007	<0.003	0.004	<0.003
Silver	mg/L	0.00005	<0.01	<0.01	<0.00005	<0.00005	<0.00005	<0.00005
Zinc	mg/L	0.0002	<0.005	[illegible]	<0.0002	0.0062	[illegible]	[illegible]

Table 10
Summary of DINA Water Chemistry Analysis (1975)
(mg/l unless otherwise stated)

Analysis	Station 1		Station 2			Station 3		Station 4	
	9-Jun	Sept. 4	3-May	9-Jun	Sept.4	9-Jun	4-Sep	3-May	Sept. 4
Temp. @ Sampling oC	3.0	5.0	1.0	8.0	7.0	3.0	8.9	1.0	7.8
pH: Laboratory	7.4	7.7	7.8	7.6	7.6	7.8	7.6	6.2	7.7
Turbidity (Turb. Units)	0.26	0.18	2.6	0.53	0.53	0.38	0.23	4.0	0.34
Colour (Rel. Units)	32.0	25.0	43.0	30.0	10.0	<5.0	<5.0	<5.0	10.0
Sp. Conductance (pmho/cm)	56.3	59.6	142.0	57.8	49.9	63.2	60.0	11.4	57.1
Total Diss. Solids (calc'd)	-	-	7.0	-	-	-	-	29.0	-
Residue: N. F. (105o)	-	-	2.0	-	-	-	-	24.0	-
Residue: Fixed N.F. (550o)	-	-	5.0	-	-	-	-	5.0	-
Alkalinity: Phenol, CaCO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alkalinity: Total, CaCO3	22.6	27.0	58.4	25.8	20.8	25.1	23.8	3.09	24.2
Hardness: Total, CaCO3	26.2	28.6	55.9	26.8	22.4	28.4	26.9	1.8	25.9
Calcium (Ca): Dissolved	-	9.0	-	-	7.3	-	9.3	-	8.1
Sulphate (SO4): Dissolved	2.3	2.0	14.2	3.1	3.2	5.9	5.4	0.9	4.0
Nitrogen (N): NO2+NO3	0.002	<0.002	-	0.002	<0.002	0.010	0.076	-	0.045
Carbon (C): Total Organic	7.9	7.7	4.1	6.2	4.9	4.2	2.5	2.0	4.9
Carbon (C): Total Inorganic	4.7	6.2	12.4	6.2	4.4	6.0	4.7	1.2	4.7
Iron (Fe): Extractable	0.36	0.26	1.1	0.31	0.16	0.047	0.028	0.11	0.17
Manganese (Mn): Extractable	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper (Cu): Extractable	<0.001	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	0.007	<0.001
Zinc (Zn): Extractable	<0.001	<0.001	0.002	0.009	<0.001	<0.001	<0.001	0.046	<0.001
Lead (Pb): Extractable	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001
Mercury (Hg): Extractable	0.11	<0.05	0.17	0.11	3.8	<0.05	<0.05	0.15	<0.05
Arsenic (As): Extractable	0.0004	0.0005	0.0188	0.0044	0.0078	0.0004	0.0008	0.0009	0.0052
Silver (Ag): Extractable	0.008	<0.005	<0.005	0.005	<0.001	0.007	<0.005	<0.005	<0.005
Barium (Ba): Extractable	0.04	0.03	-	0.03	0.02	0.03	-	-	0.02
Cadmium (Cd): Extractable	<0.0002	<0.0002	-	<0.0002	<0.0002	<0.0002	<0.0002	-	<0.0002
Carbon (C): Particulate	0.094	0.024	-	0.15	0.098	0.072	0.12	-	0.14
Nitrogen (NH3)	0.004	0.007	-	0.004	0.002	0.003	0.005	-	0.006
Cyanide (CN): Total	<0.001	-	-	<0.001	<0.005	<0.001	<0.005	-	<0.005
Molybdenum (Mo): Extractable	<0.005	0.001	-	-	-	-	-	<0.002	0.002
Nickel (Ni): Extractable	<0.001	<0.001	-	-	-	-	-	0.002	<0.001
Nitrogen (N): Particulate	-	-	-	0.016	0.011	0.007	0.011	-	0.014
Nitrogen (N): Total Dissolved	-	-	-	0.25	0.123	0.25	0.110	-	0.163
Selenium (Se): Extractable	-	<0.0001	-	-	<0.0001	-	-	<0.0001	<0.0002
pH: Field	7.1	-	-	7.3	-	7.4	-	-	-
Dissolved Oxygen	1.5	-	-	1.0	-	6.0	-	-	-
Flow: cfs	10.0	8.0	-	10.0	-	10.0	-	-	-
Residue: Filterable (105oC)	81.0	-	-	66.0	-	62.0	-	-	-
Residue: Fixed Filt. (550oC)	62.0	-	-	36.0	-	30.0	-	-	-
Boron (B): Dissolved	0.01	-	-	0.01	-	0.005	-	-	-
Phosphorus (P): Total	0.0035	-	-	0.008	-	0.006	-	-	-

(from Environment Canada, 1975)

APPENDIX B

Geotechnical Services, Yukon Abandoned Mine Sites

Venus Mine Site

FINAL REPORT

GEOTECHNICAL SERVICES
YUKON ABANDONED MINE SITES

Venus Mine Site
south of Carcross, Yukon

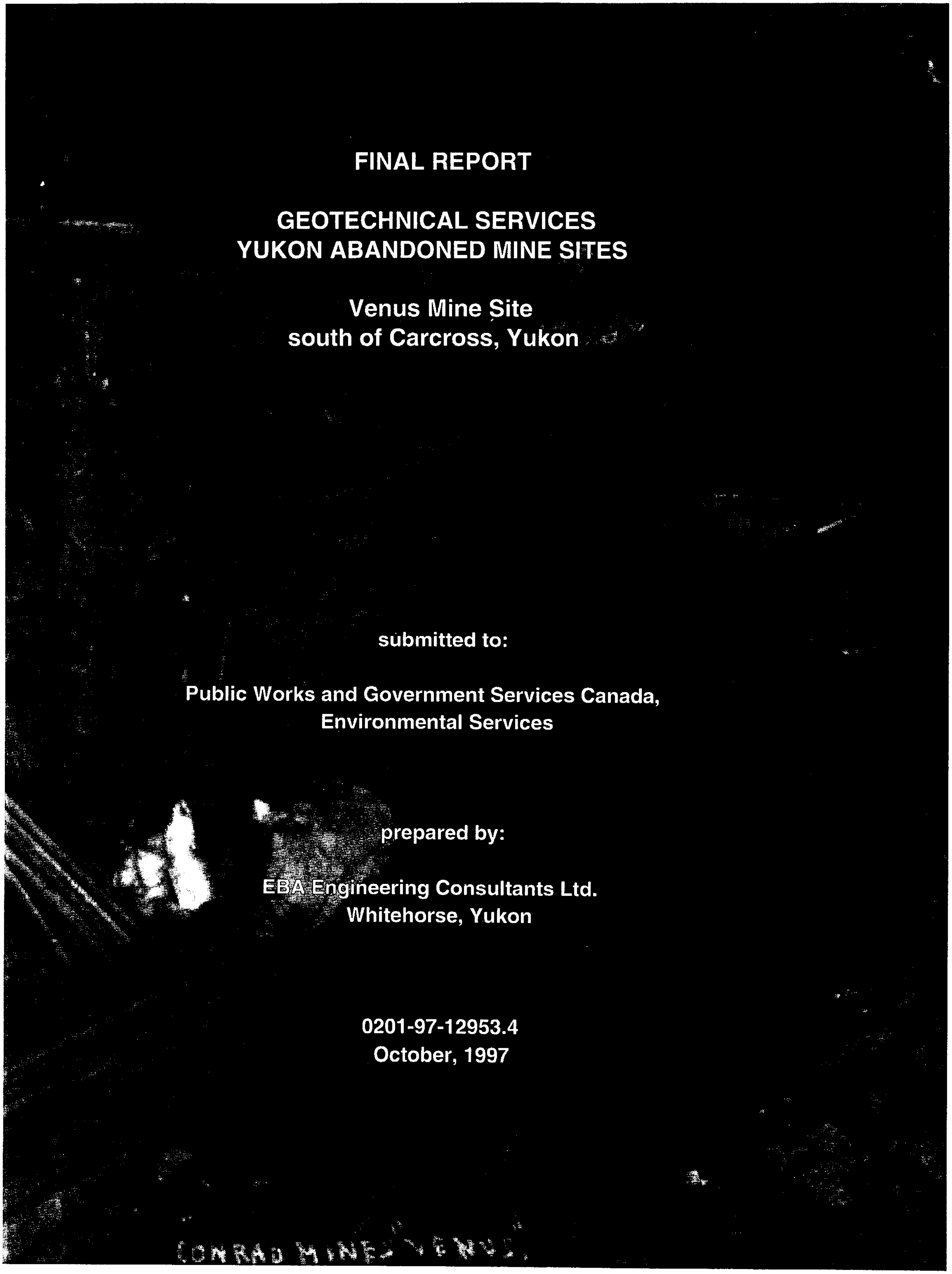
submitted to:

Public Works and Government Services Canada,
Environmental Services

prepared by:

EBA Engineering Consultants Ltd.
Whitehorse, Yukon

0201-97-12953.4
October, 1997



EXECUTIVE SUMMARY

Public Works and Government Services Canada (PWGSC), Environmental Services retained EBA Engineering Consultants Ltd. (EBA) to perform geotechnical services in relation to the restoration of the Venus Mine Site. In brief, the geotechnical aspect of the restoration study involved a field work component and a terrain analysis component. The purpose of the field work program was to visually observe and assess slope conditions at each site and to provide information for site specific slope stabilization options. The purpose of the terrain analysis work was to perform the necessary air photo interpretation and review of existing borehole data in order to identify potential sources of borrow materials for site restoration purposes.

Of the two adit locations which were inspected at the Venus Mine Site, the majority of the waste rock material deposited along the slope of Montana Mountain did not appear to be unstable or at risk of failure. This is based on the lack of visual evidence of mass wasting or signs of failure during a single site visit and the fact that the waste rock material has been relatively stable in its current location for at least 25 years. In order to provide more certainty as to the stability of the waste rock piles through more conclusive data, it is recommended that a detailed survey and regular monitoring activities of the waste rock slopes at theVenus Mine Site be undertaken.

The primary concern with respect to slope stability is the area of the two retaining walls near Adit 2. These retaining walls are constructed of log cribbing and have shown signs of degradation. It is unavoidable that further decay of these retaining walls will occur and that they will eventually fail which may lead to adverse impacts on the South Klondike Highway. It is recommended to intentionally fail these structures to reduce the risk of a future uncontrolled failure. Two options to demolish these retaining walls has been provided. The first option would involve dismantling the retaining walls and mobilizing the waste rock downslope to a catchment area where it could be disposed of off site. The second option would involve relocating the material behind the retaining walls to the level bench area in the vicinity of adit 2 and reshaping the slope to an acceptable grade. Class "D" cost estimates for each of these restoration options have been provided under separate cover.

There are no fine grained borrow sources which could be used as a low permeability cover in the immediate area of the Venus Mine Site. However, there are suitable fine grained morrainal till deposits in the area of the Arctic Caribou Tailings Site which could be used for this purpose. It is recommended to proceed with a ground truthing and test pitting excercise at this location for borrow quality and quantity verification purposes.

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Appendix A: Response from PWGSC of draft report.

1.0 INTRODUCTION

Public Works and Government Services Canada (PWGSC), Environmental Services retained EBA Engineering Consultants Ltd. (EBA) to perform geotechnical services in relation to the restoration of five abandoned mines near the communities of Elsa and Carcross, Yukon. The subject property considered in this report is known as the Venus Mine Site which is located on the South Klondike Highway approximately 22 km south of Carcross.

The terms and conditions of the agreement for the project, including the scope of work and the basis for payment, was outlined in the fax by Tim Sackmann of PWGSC dated August 11, 1997. In brief, the geotechnical aspect of the restoration study involved a field work component and a terrain analysis component. The purpose of the field work program was to visually observe and assess slope conditions at each site and to provide information for site specific slope stabilization options. The purpose of the terrain analysis work was to perform the necessary air photo interpretation and review of existing borehole data in order to identify potential sources of borrow material for site restoration purposes.

It is understood that this report was intended to cover strictly the geotechnical aspects of the restoration work and as such, that it would be appended to a comprehensive document describing the overall restoration study. Therefore, to avoid redundancies, the writer has not described in detail the location, site access, climate, or other extraneous details of each site. Rather, the report contains the results of the field work program, the slope stabilization options with cost estimates, and the results of the terrain analysis. Brief conclusions and recommendations have also been prepared in consideration of the findings.

2.0 SITE CONDITIONS

2.1 General

The purpose of the field work program was to visually observe the slope conditions at the Venus Mine Site in order to develop recommendations for site specific slope stabilization options. The field work was conducted on August 21, 1997 and was performed with representatives from PWGSC and Steffen, Robertson, and Kirsten (SRK).

The methodology of the field work program essentially consisted of performing lateral surveys to verify site sketches taken from previous reports, visually observing the slope conditions for signs of instability or mass wasting, and excavating test pits (hand dug) in order to get an indication of the near surface soil or waste rock profile for geotechnical considerations.

Those areas inspected at the Venus Mine Site included the works surrounding Adit 1 and Adit 2 as labelled in the PWGSC project report 668724. The location of each adit is depicted on the air photo enclosed as Drawing 12953-10. Each adit traverses the slope of Montana Mountain at an elevation of approximately 945 m above sea level. The mine is approximately 245 m higher in elevation than the South Klondike Highway and 300 m above the Windy Arm of Tagish Lake. The mine site falls within a steep slope ranging from 30° to 35° which is undergoing constant mass wasting in the form of rockfalls, rock slides, debris avalanches, and snow avalanches. The slopes are covered in rubble deriving from various fall and slide activities and there is very little established vegetation as a result of the thin soil colluvium and the active mass wasting. The lack of vegetation is particularly evident in areas of high avalanche activity such as the immediate area of the Venus Mine Site which is subjected to avalanches on average once in every five years[1].

[1] Chris Stethem & Assoc. and EBA Engineering Consultants Ltd. 1986. Klondike Highway Avalanche Atlas. Unpublished Contract Report prepared for Yukon Department of Community and Transportation Services.

2.2 Area of Adit 1

Adit 1 was located at a bench constructed along the slope where tracks were established along the edge for the purpose of depositing waste rock during the mine operation. The site conditions during the investigation at Adit 1 are essentially as described in the Site Plan enclosed as Drawing 12953-11 and in Photo #V1. The waste rock pile below Adit 1 was approximately 100 m long and extended approximately 30 m to 35 m down the slope. There was a bench established mid-way down the waste rock pile as is evident in Photo #V1. As seen in Drawing 12953-11, there is another bench where the access road exists. The relatively steep slope angle of 33° to 35° which was observed for the waste rock pile is due to the well graded, free draining nature of the material and due to its adesitic igneous origin. A sample was retained of the near surface waste rock for the purpose of laboratory testing. As seen on the Venus 1 lab results, the waste rock is composed primarily of gravel and sand with only a trace of silt and has a moisture content of less than 1%. This type of material has a high internal angle of friction and a very low pore water pressure which relates to a high shear strength against slope failure.

The slope was thoroughly inspected for signs of previous slope failures or of active mass wasting. There were no signs of tension cracks near the top of the slope or bulging at the toe which would suggest slope movements. Rather, the extent of downslope movements has been restricted to near surface sloughing from disturbances such as avalanches and other slides. This is particularly evident at the south portion of the waste rock pile where surface sloughage has undermined the tracks leading from Adit 1 as seen in Drawing 12953-11. The presence of two horizontal benches downslope of the waste rock has restrained the surface sloughing from extending further down the slope. It does not appear that significant mass wasting has occurred in the area of Adit 1 as there were no observed failures related to the waste rock pile in this area.

2.3 Area of Adit 2

The site conditions at Adit 2 are essentially as described in the Site Plan enclosed as 12953-12 and in Photos #V2 to V4. In the area of Adit 2, the waste rock piles were considered generally stable and

Photo #V1: Looking east down slope from adjacent to shack at north portion of area near adit 1. Note lower benches of waste rock and of access road. Note fallen pipes.

Photo #V2: Looking north along tracks at area of adit 2. Note culvert along waste rock pile s slope; note lower retaining wall built of log cribbing.

EBA Engineering Consultants Ltd.	PROJECT GEOTECHNICAL SERVICES, YUKON ABANDONED MINES PROJECT
CLIENT PUBLIC WORKS AND GOVERNMENT SERVICES CANADA	TITLE **VENUS MINE PHOTO SHEET #1**

DATE	DWN.	CHKD.	FILE NO.	DWNG.	REVISION
97 10 09	MEB		0201-97-12953	12953-PHTO7	0

Photo #V3: Looking west at log cribbing retaining structure. Note log cribbing construction; note shack fallen over at top right;

Photo #V4: Looking south east at lower retaining wall. Note sloughing of waste rock material; note poor condition of log cribbing supports.

EBA Engineering Consultants Ltd.		PROJECT	GEOTECHNICAL SERVICES, YUKON ABANDONED MINES PROJECT
CLIENT: **PUBLIC WORKS AND GOVERNMENT SERVICES CANADA**		TITLE: **VENUS MINE PHOTO SHEET #2**	
DATE 97 10 09	DWN. MEB	CHKD.	FILE NO. 0201-96-12953
DWNG. 12953-PHTO8	REVISION 0		

did not appear to exhibit evidence of mass wasting. There were no tension cracks at the top of the waste rock pile slope or other signs of failure. The particle size of the near surface waste rock material was composed of gravel and some sand as noted in the grain size analysis results of sample Venus 2. If sample Venus 2 is indicative of the full depth of material in the pile, the waste rock mass is considered stable at the existing slope of 35° to 37° which was observed at the time of the field work. The material also appears to be very well drained since the water deriving from the culvert located along the waste rock slope has not compromised the stability of the waste rock pile at this location.

As with the waste rock pile at Adit 1, there was some surface creep of the larger diameter rock material which is most likely attributed to avalanche activity. However, the sloughage did not appear to be extensive since the tracks and other materials at the top of the waste rock slope have not been undermined as a result of a regressing slope. The waste rock appeared to extend approximately 80 metres downslope. As seen in the air photo enclosed as Drawing 12953-10, the switchback roads leading up to the adit have served as benches in restraining the loose rock from further downslope movement. It appeared that these benches had been reworked by constructing berms in order to enhance the affect of the benches in preventing loose rock from impacting the Klondike Highway.

The most significant feature in the area of Adit 2 was the presence of relatively unstable retaining walls along the waste rock slope. These are illustrated in plan drawing 12953-12 and profile 12953-13 as well as in photos #V3 and #V4. Of particular note were the two retaining walls built in series along the waste rock pile slope shown as section B-B on drawings 12953-12 and 12953-13. These have been constructed with log cribbing and have shown natural degradation over their 25 or more year existence. With respect to the lower wall, the log cribbing itself showed some natural decay and there were some failures noted at the joints along the edges. There was also extensive sloughing of the waste rock behind the wall and tension cracks parallel to the wall. As the integrity of the wall and waste rock mass is undermined by natural decay and slight movements, a sudden failure may eventually occur leading to a large mass of waste rock mobilizing downslope. This could occur if the joints along the cribbing continue to fail to the point where the waste rock begins to deform and the strength within the remaining cribbing support is insufficient to restrain the waste rock mass from mobilizing downslope. If mobilization of a large portion of the rock were to occur, whether it be as a gradual process or as a sudden event, it is uncertain if the benches located at the access roads downslope would prevent the fallen waste rock from negatively impacting the highway. The maximum volume of waste rock restrained by the lower wall is estimated at between 400 m^3 and 500 m^3.

With respect to the upper retaining wall, the log cribbing did not appear to have decayed nearly as much as the lower wall. This is most likely due to the apparently coarse, free draining nature of the waste rock which was retained by this wall as compared to the finer grained material of the lower wall. This free draining nature of the waste rock has ensured a dry environment immediately surrounding the log cribbing which has retarded natural biological decay. There were no noticable failures of the cribbing joints or evidence of movement within the material behind the wall. Although this retaining wall is subject to natural decay and would eventually exhibit more active failure in the future, the affect of the lower wall on the instability of the upper wall is considered to be more significant. If such a failure of the lower wall was to occur, this could undermine the toe support of the upper wall which may result in failure and downslope mobilization of waste rock from the upper wall. However, the rate of this failure is uncertain. The maximum volume of waste rock restrained by the upper wall is estimated at between 1300 m^3 and 1500 m^3. The mobilization of this amount of rock would likely impact the South Klondike Highway below since the slope angle remains in excess of 28° to 30° along the run-out path and there is not sufficient retention capabilities of the lower benches to restrain such a volume of rock from mobilizing down to the highway.

3.0 SITE SPECIFIC SLOPE STABILIZATION OPTIONS

3.1 Description of System - Option 1

As noted in Section 3.5, the waste rock piles which have been deposited along the existing slopes in the areas of Adit 1 and Adit 2 are considered stable due to the lack of visual signs of mass wasting. It appears that insignificant movement of the waste rock has occurred since it was deposited during the original development in 1901 or during the subsequent development in 1969[2]. The fact that the waste rock piles have remained stable for at least 25 years despite their location within an area of active rock falls, rock slides, and avalanche activity suggests that the existing physical and environmental conditions will not be greatly altered such that future instabilities are probable. In fact, it should be noted that the existing waste rock material and the associated risk of failure should be considered in the context of the already inherent risk associated with slope failures which are characteristic of steep mountainous terrain such as with Montana Mountain.

However, the risk of slope failure is considered more probable in the area of the two retaining walls as previously discussed in Section 2.3. To avoid the sudden failure of these retaining walls in the future and the associated risk of downslope movement of waste rock to the South Klondike Highway, it is recommended to intentionally fail these structures and to grade the waste rock to a slope which is naturally stable for this type of material. The method of destroying the wall would have to be sensitive to the possibility of disturbing the surrounding waste rock material. For example, blasting of the walls may cause a massive failure of the extensive waste rock material adjacent to the retaining structures. With this in mind, it is recommended to construct a catchment area downslope of the retaining walls, demolish the walls gradually with the use of various heavy machinery such as a dozer and a backhoe, and then dispose the fallen rock material to a suitable waste dump location. The proposed reclamation program is described in detail below.

[2] Lundberg, M. 1996. Fractured Veins & Broken Dreams, Montana Mountain and the Windy Arm Stampede, Pathfinder Publications, Whitehorse, Yukon.

The demolition of the retaining walls and grading of the waste rock material will obviously result in downslope movement of the waste rock material. In order to determine the quantity of waste rock which will be mobilized downslope and to gather existing plan and profile information for the design of the catchment area, a more accurate survey of the area will be necessary. The results of the survey would be used in the design of the catchment area.

Due to the hazardous work conditions at the subject site, it is recommended to perform a hazard assessment prior to construction in order to identify the necessary measures which must be in place to reduce the risk of injury during construction. This would include determining a suitable safety protocol while performing the construction work, identifying the specific responsibilities of the work party members, and ensuring that an emergency plan is in place.

At the outset of construction, the roads leading up to the area of Adit 2 would have to be repaired to allow access by the machinery. Following this, the existing benches at the locations of the two access roads which are directly below the retaining walls (refer to Drawing 12953-10) would be reconfigured to act as catchment areas for rubble mobilizing downslope as a result of the demolition activities. This would include widening the roads and building a berm at the downslope edge of each road. Ideally, the size and shape of the catchment areas would be determined using a mass balance approach where the volume capacity of the catchment area would equal or exceed the estimated quantity of material which would be mobilized downslope. However, due to the shallow bedrock and the risk of undermining the toe of the waste rock slope by performing excessive cuts on the upslope side, it will be difficult to construct a catchment area of sufficient size. It is envisioned that the catchment area would be designed to accommodate a maximum quantity of waste rock and that the demolition activities would be designed in a stepwise fashion to allow for the catchment area to be cleared in between successive grading activities. If desired, the catchment area could extend further along the existing access road below the full extent of the waste rock pile near Adit 2 to act as a long term catchment area to restrain future near surface mass wasting, rock falls, rock slides or avalanche slides from impacting the Klondike Highway.

The demolition would essentially consist of dismantling the load out structures and the retaining wall with the backhoe. As necessary, subexcavation of material behind the retaining wall would be performed to construct a ramp for the dozer to push the remaining material downslope to the catchment area and to reshape the slope to an acceptable final grade. The extent of activity by machinery on the slope in the vicinity of the retaining walls would have to be determined following detailed survey information and consultation with qualified contractors who typically work on extreme slopes of this nature.

During the demolition activities, a backhoe would be available to sort the waste rock and the fallen timber cribbing at the catchment area and to load the dump truck for transport to a suitable waste location at the toe of Montana Mountain. The material would be hauled using the existing access road leading south down to the Klonkike Highway. The most efficient waste location would be at the alluvial fan located near Pooly Creek Canyon approximately 0.6-0.7 km north of the mine site. This was the former construction camp location during the reclamation of the Venus Tailings Site by PWGSC, Environmental Services in 1995. Alternately, the waste rock could be placed at the location of the Venus Tailings Site which is approximately 2.5-2.7 km north of the mine site. Following sorting activities, the timber cribbing would be hauled and burned at the waste disposal location.

3.2 Description of System - Option 2

Following a review of the EBA draft report for the Venus Mine Site, PWGSC provided comments which identified alternate approaches to decommissioning the retaining structures. For a detailed description of these approaches, the reader is referred to the response prepared by PWGSC which is included in Appendix A. However, in brief, each approach essentially consisted of excavating and moving the material from behind the retaining walls to the level bench area in the immediate vicinity of the adit rather than mobilizing the material downslope and removing it from the site as discussed in Option 1, above. In order to incorporate this idea into our final report, the following 'Option 2' describes this approach of placing the material on the bench area.

In general, the idea of placing the rock material on the existing bench is considered problematic since it would mean adding a surcharge load to the existing adjacent waste rock pile which would cause a decrease in the safety factor against slope failure. It is beleived that the current waste rock slopes are at a safety factor equal to or just greater than 1.0 due to the method of deposition. This means that the average shear strength within the rock mass which prevents failure is just slightly above the driving forces which act to mobilize that shear strength. An increase in surcharge load would increase these driving forces which may result in a slope failure. Therefore, if this option is considered further, it may be necessary to illustrate that the relocation of waste rock from behind the existing retaining walls to the bench would not compromise the slope stability of the adjacent waste rock slope.

This could be accomplished by confirming the existing geometry of the area through a detailed survey and by performing a test pit program to determine the subsurface profile along that bench area. The subsurface investigation would essentially consist of excavating two trenches perpendicular to the existing rock face to the edge of the slope to determine the thickness of the waste rock and the native colluvium overburden and the depth to bedrock. The information gained in the survey and test pit program could be used in more accurate volume determinations and in verifying that the bench consists of competent material on which the waste rock could be safely relocated. It would also be useful in verifying the depth to bedrock to ensure that the subcut which would be required to establish a 1.5H:1V slope behind the retaining wall could proceed without hitting bedrock.

Initially, the work would involve preparing the access road leading up to the area of Adit 2. This would include widening that section of the access road which traverses the slope immediately below the two retaining walls so that the area could act as a catchment area for fallen debris. Following this, the loadout structures which occur above the retaining walls would be gradually dismantled to allow for subexcavation of the material behind the retaining wall using a backhoe. The excavated material would be pushed with the dozer to the area adjacent to the rock slope just north of the adit entrance. Concurrent with this subexcavation, the wall would be demolished with the backhoe and segregated from the waste rock using a 'thumb' attachment on the bucket. This excavation would continue with successively lower benches being formed where the backhoe could be perched in order to extend its reach downslope. Once the reach of the hoe is not sufficient to place the rock on the level surface for removal by the dozer, the dozer would prepare a ramp for use in the removal of material. Some back blading by the dozer would initially be required to relocate the material up to the bench, however, as the slope is eventually prepared to an adequate grade and width to allow the dozer to turn and push the material up slope, the dozer would be used more effectively. This process would continue until both retaining walls are removed and the final slope is prepared to a 1.5H:1V grade for long term stability. The segregated wood from the two walls would be burned at the bench during site cleanup work.

The effectiveness of this option would be carefully scrutinized following the detailed survey and investigation and consultation with and selection of an appropriate contractor who has experience with working on such steep scree-type slopes. However, following conversations with local contractors and researching equipment capabilities with the Caterpillar Performance Handbook (Caterpillar, Ed.28, October, 1997), it is beleived that either of the above options are feasible.

3.3 Cost Estimates

As requested, the "Class D" cost estimates to implement each of the above two reclamation programs have been detailed under separate cover.

3.4 Schedule

In regards to scheduling, if the reclamation work is intended for the summer of 1998, it is advised to proceed with the surveying aspect of the work as soon as possible. If option 2 is to be followed, the surveying work should roughly correspond with the test pit investigation work. This would provide sufficient time to perform the engineering design and to develop construction specifications, to obtain the required permits, and to solicit and select a contractor prior the 1998 construction season.

4.0 FINE GRAINED BORROW SOURCES

Aerial photography of the study area with an approximate scale of 1:20,000 was reviewed for terrain analysis considerations in order to determine the location of a fine grained borrow source. This was necessary so that fine grained material could be identified for potential use as an low permeability cap over the existing waste rock piles at the subject property. The results of the terrain analysis was cross referenced with available borehole information and with a Geological Survey of Canada surficial geology map of the study area.

There are no fined grained borrow source locations within the immediate study area. The area of the Venus Mine Site is dominated by a thin veneer of colluvial material over bedrock. As seen in the air photo in Drawing 12953-10, there is extensive exposed bedrock at the upper reaches of the slope as well as along the slope itself. The soil cover is less than 0.3 m throughout the majority of the slope, including along the lower reaches near Windy Arm. Exception to this is at canyon locations along the mountain which are associated with the development of alluvial fan deposits at the shore of Windy Arm. These deposits are composed of coarse grained sand and gravel material and are not suitable as a low permeability cover.

The closest fine grained borrow material to the subject site would be near the community of Carcross where the general near surface geology is dominated by ancient glacio-lacustrine deposits at or near the elevation of Lake Bennett and where there is morainal till along the more gentle slopes of Montana Mountain. Specifically, fine grained till material appears to be located in the area of the Arctic Caribou Tailings Area as identified in Drawing 12953-14 which is approximately 25 km from the Venus Mine Site. This would be an appropriate source for borrow material since there is a sufficiently thick, fine grained deposit as evidenced by pronounced gully formations in this area. Further, since the area has been previously developed and is road accessible, the approval for the land use permit would be a less onerous process than with other undisturbed areas near Carcross.

There is no specific borehole information available for the proposed borrow source area near the Arctic Caribou Tailings Site. However, the results of the terrain analysis are consistent with the surficial geology maps for the study area. It is recommended to proceed with a ground truthing and test pitting excercise in order to verify the quality and quantity fine grained borrow material prior to further design consideration. Further, if it is determined that the waste rock at the Venus Mine Site is net acid generating to the extent that the material has to be isolated through the use of a low permeability cover, it is not considered feasible to construct such a containment system at the Venus Mine Site. This is due to the steep slopes and to the limited area at the site to construct such a system. As such, it may be necessary to consider moving the waste rock to an alternate area such as the Arctic Caribou Tailings Site where there is ample space and fine grained material and where a more effective containment system could be developed.

5.0 CONCLUSIONS

The following conclusions can be drawn from this study:

1. Of the two adit locations which were inspected at the Venus Mine Site, the majority of the waste rock material deposited along the slope of Montana Mountain did not appear to be unstable or at risk of failure. This is based on the lack of visual evidence of mass wasting or signs of failure during the site visit and the fact that the waste rock material has been relatively stable in its current location for at least 30 years despite being within an active area of rock falls and avalanche slides. Mass wasting appears to have been restricted to surface movements of coarse fractions which is most likely attributed to disturbances caused by avalanche related activity.
2. The primary concern with respect to slope stability is the area of the two retaining walls near Adit 2. These retaining walls are constructed of log cribbing and have shown signs of degradation. It is unavoidable that further decay of these retaining walls will occur and that they will eventually fail leading to downslope movement of waste rock. Although the rate of failure is uncertain, the potential for a sudden, massive failure is considered to be a significant health and safety risk due to the location of the South Klondike Highway directly below the waste rock pile.
3. There are no fine grained borrow sources which could be used as a low permeability cover in the immediate area of the Venus Mine Site. However, there are suitable fine grained morrainal till deposits in the area of the Arctic Caribou Tailings Site which could be used for this purpose. Regardless, it is not considered feasible to construct a containment system using a low permeability fine grained soil cover at the Venus Mine Site. If such a containment system is necessary for the waste rock, serious consideration should be given to move the waste rock to an alternate location such as the Arctic Caribou Tailings Site where the terrain is more suitable and there is a fine grained borrow source in the immediate area.

6.0 RECOMMENDATIONS

The following recommendations have been formulated in consideration of the project objectives and results of the study:

1. In regards to the two retaining walls located in the area of Adit 2, it is recommended to intentionally fail these structures to reduce the risk of a future impact on the South Klondike Highway. This could be accomplished by implementing option 1 which involves constructing a catchment area to restrain the fallen waste rock from extending to the highway during the demolition. The fallen waste rock would be moved from the catchment area in a stepwise fashion and hauled to a suitable disposal site within a close proximity to the Venus Mine Site. A second option to demolish these retaining walls would involve relocating the material behind the retaining wall to the bench area near adit 2. As requested, Class 'D' cost estimates to an accuracy of +/- 25% has been prepared and is enclosed under separate cover.
2. In regards to the waste rock piles leading downslope from Adit 1 and Adit 2, it is not anticipated that a sizable failure will occur in the future. However, this conclusion has been drawn from limited observations made during a single site visit and inferences based on the historical stability of the waste rock piles. In order to provide more certainty as to the stability of the waste rock piles through more conclusive temporal data, it is recommended that a detailed survey and future monitoring activities of the slope conditions be undertaken at theVenus Mine Site. This would involve an annual site visit by a qualified geotechnical engineer to identify and detect visual clues of instability so that appropriate action could be taken to avoid future failures. Alternately, if such a monitoring program is not suitable due to the time requirements before abandonment and closure could be realized, a more extensive geotechnical analysis could be conducted to determine the long term slope stability characteristics. Briefly, this could involve one or more of the following measures: performing a detailed survey of the existing slopes, conducting geophysical surveys to determine the profile of the waste rock and bedrock interface, performing a drilling and sampling program, and conducting a slope stability modelling excercise to determine the factor of safety against failure. The extent of this analysis would be commensurate with the extent of certainty of the

risk of slope failure which is required.

3. If a fine grained borrow source is required as a low permeability cover, it is recommended to proceed with a ground truthing and test pitting excercise at the proposed borrow location in the vicinity of the Arctic Caribou Tailings Site once this site has been confirmed as being suitable from a land use perspective. At this time, the quality and quantity of the proposed borrow source could be determined and samples could be retained for the purpose of laboratory verification testing.

7.0 LIMITATIONS

Recommendations presented herein are based on a geotechnical evaluation following the scope of work described in Section 1.0 of this report. The conditions encountered during the field work are considered to be reasonably representative of the site. If, however, conditions other than those reported be noted during subsequent monitoring activities or otherwise, EBA should be notified and given the opportunity to review our current recommendations in light of new findings.

This report has been prepared for the exclusive use of Public Works and Government Services Canada, Environmental Services for the specific application described in Section 1.0 of this report. It has been prepared in accordance with generally accepted geotechnical engineering practices. Engineering judgement has been applied in developing the recommendations in this report, in an attempt to strike a reasonable balance between risk of failure and economic factors. No other warranty is made, either expressed or implied. For further limitations, reference should be made to the General Conditions enclosed immediately following the text of this report.

8.0 REPORT CLOSURE

We trust this draft report meets your present requirements. Once you have had a chance to review the contents of the report, we would be pleased to answer any questions or comments you may have. We would be pleased to provide any further services needed for the design and to advise on the geotechnical aspects of specifications for inclusion in contract documents. Should you require any additional information, please do not hesitate to contact our office.

Respectfully submitted,
EBA Engineering Consultants Ltd.

Michael E. Billowits, M.Sc., P.Eng.
Project Engineer

J. Richard Trimble, M.Sc., P.Eng.
Project Director, Yukon Region

MEB/meb

EBA Engineering Consultants Ltd. (EBA)
GEOTECHNICAL REPORT
GENERAL CONDITIONS

This report incorporates and is subject to these "General Conditions"

A.1 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's client. Any such unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request. This report should be read in its entirety.

A.2 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

A.3 LOGS OF TEST HOLES

The test hole (test pit, borehole) logs are a compilation of conditions and classification of soils and rocks interpreted from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

A.4 STRATIGRAPHIC AND GEOLOGICAL SECTIONS

The stratigraphic and geological sections indicated on drawings contained in this report are evolved from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of exact locations of geological units is necessary, additional investigation and review may be necessary.

A.5 GROUNDWATER CONDITIONS

Groundwater conditions represented in this report refer only to those observed at the times recorded on logs of test holes and/or wells, and/or within the text of this report. These conditions may vary with geological detail between test holes and/or wells; annual, seasonal and special meteorologic conditions; and with construction activity. Where instruments have been established to record groundwater variations on an ongoing basis, the records will be specifically referred to. Interpretation of groundwater conditions from observations and records is judgemental and constitutes an evaluation of circumstances as influenced by geology, meteorology and construction activity. Deviations from these observations may occur.

A.6 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

A.7 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Preservation of adjacent ground and structures from the adverse impact of construction activity is required. Therefore support of excavation walls, of ground adjacent to anticipated construction and of structures adjacent to the construction must be provided.

A.8 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity may affect structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

A.9 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgemental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein to the benefit of the project.

A.10 DRAINAGE SYSTEMS

Where temporary and permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

A.11 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

A.12 SAMPLES

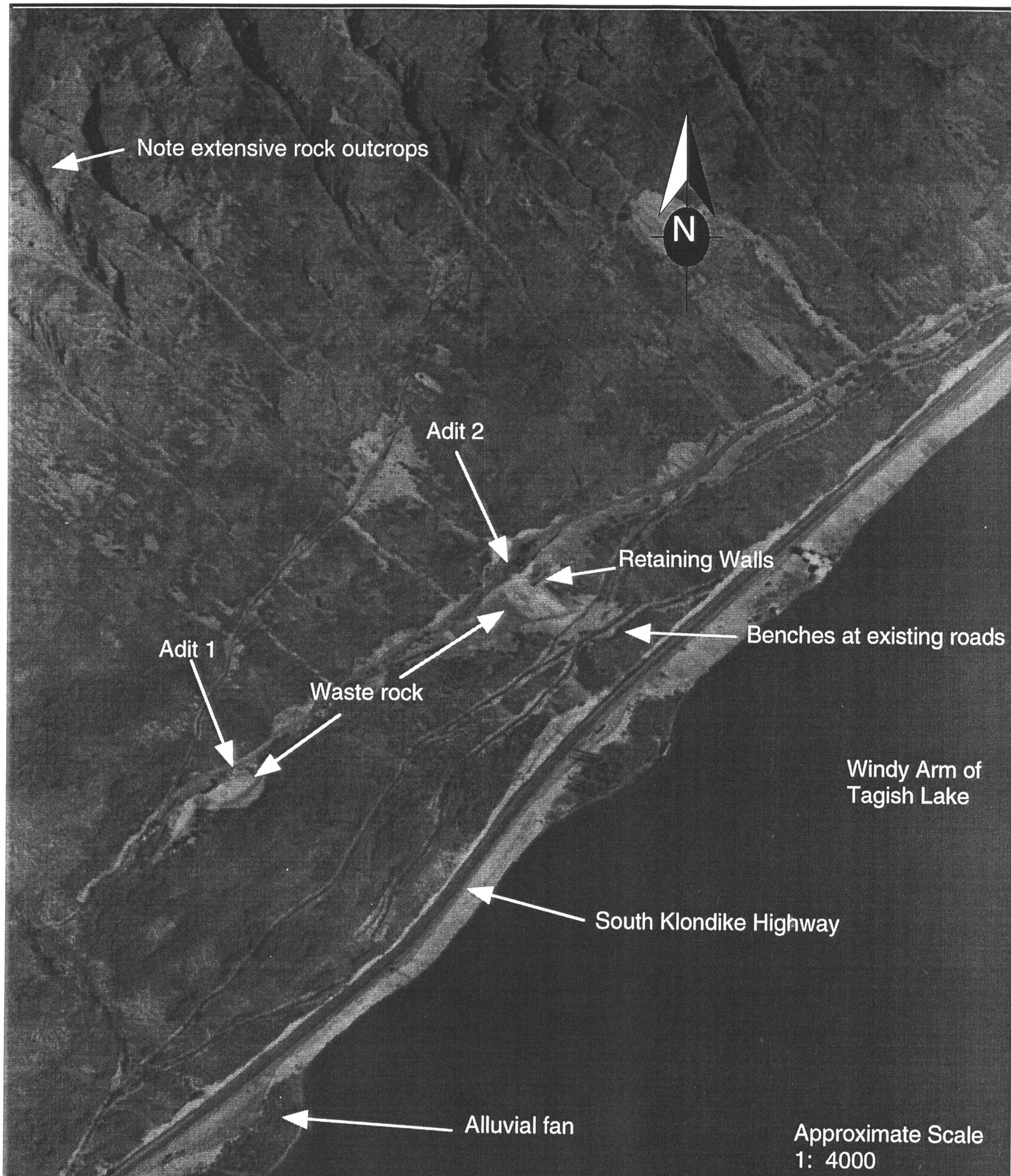
EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the client's expense upon written request, or samples will be discarded.

A.13 STANDARD OF CARE

Services performed by EBA for this report are conducted in a manner consistent with that level and skill ordinarily exercised by members of the profession currently practising under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made, concerning the test results, comments, recommendations, or any other portion of this report.

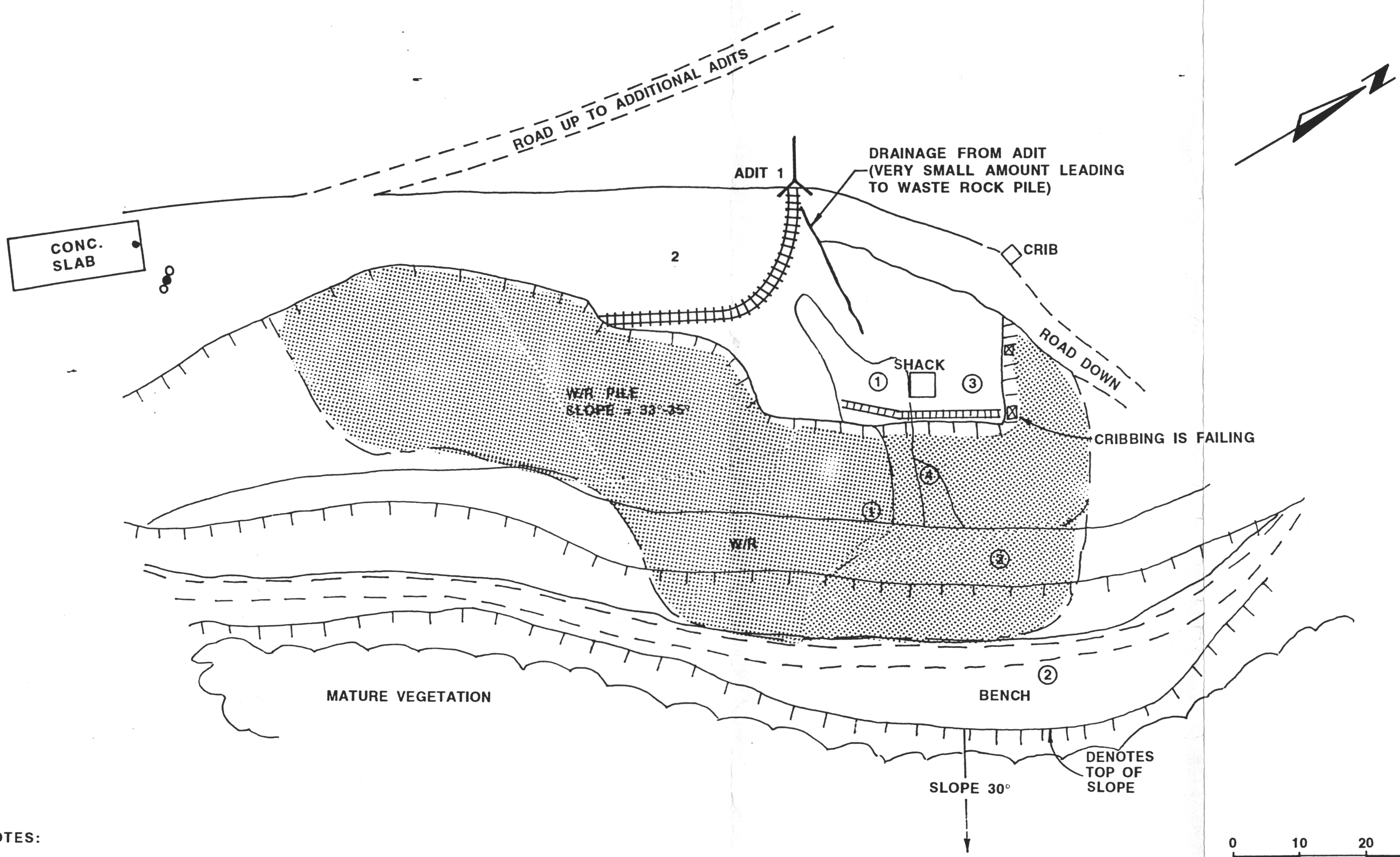
A.14 ENVIRONMENTAL AND REGULATORY ISSUES

EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site, unless otherwise specifically indicated in the report.



eba EBA Engineering Consultants Ltd.	PROJECT GEOTECHNICAL SERVICES, YUKON ABANDONED MINES PROJECT
CLIENT PUBLIC WORKS AND GOVERNMENT SERVICES CANADA	TITLE Air Photo Depicting Features of Venus Mine Site Study Area

DATE 97 10 20	DWN. MEB	CHKD.	FILE NO. 0201-97-12953	DWNG. 12953-10	REVISION 0

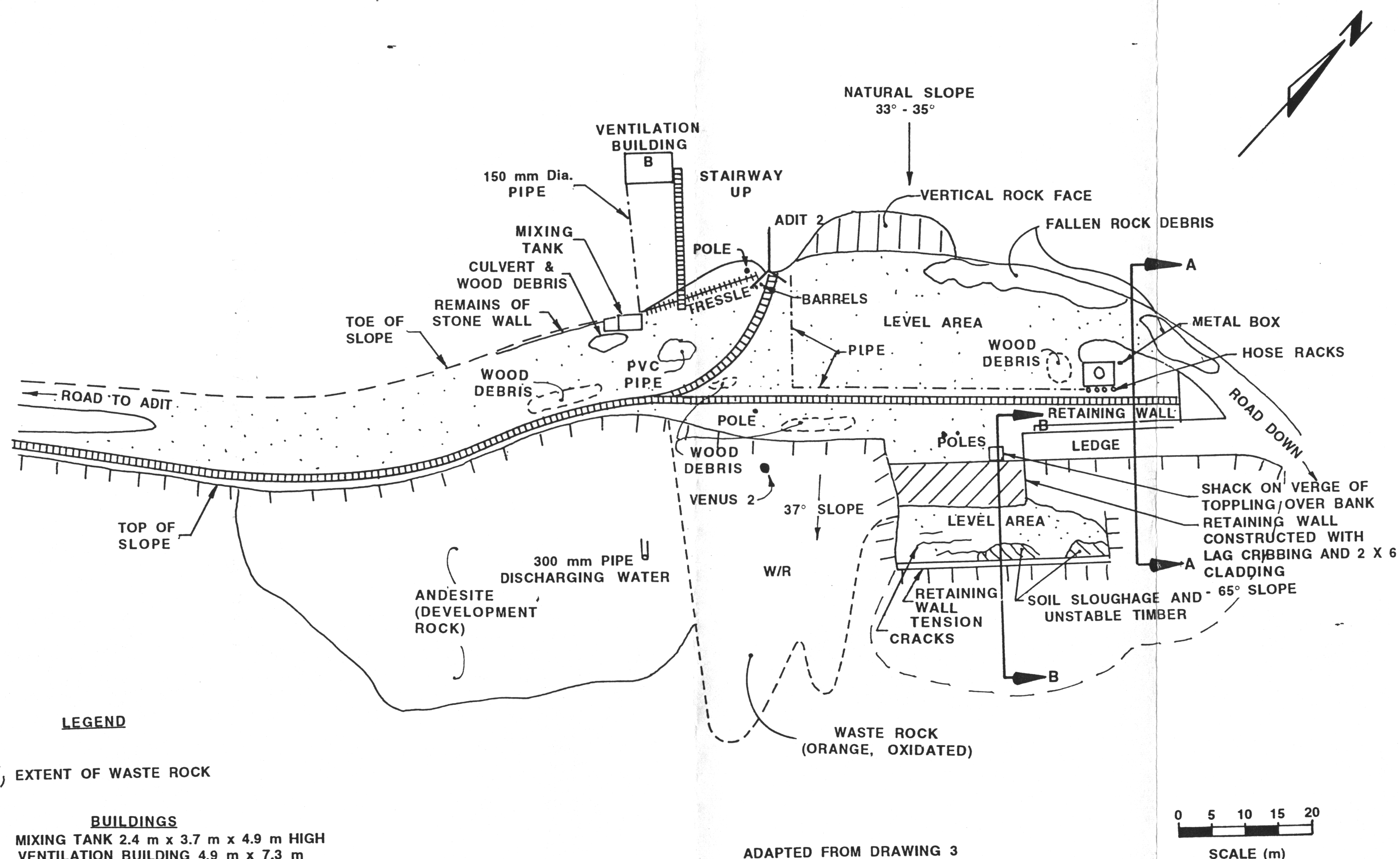


NOTES:

1. STOCKPILED PIPE AND RAIL TRACKS.
2. BENCH (FLAT AREA).
3. NO EVIDENCE OF EXTENSION CRACKS AT TOP OF SLOPE, WASTE ROCK SLOPE APPEARS STABLE.
4. SAMPLE VENUS 1 TAKEN 10.0m DOWN SLOPE FROM EDGE OF TRACKS DIRECTLY BELOW SHACK.

ADAPTED FROM DRAWING 2 PW & GSC
REPORT PROJECT NO. 668724

EBA Engineering Consultants Ltd.				PROJECT	GEOTECHNICAL SERVICES YUKON ABANDONED MINES SITES
CLIENT	PUBLIC WORKS & GOVERNMENT SERVICES CANADA			TITLE	SITE PLAN OF VENUS MINE SITE AREA OF ADIT 1
DATE 97/10/08	DWN. MEB	CHKD. MEB		FILE NO.	12953-11 — 0201-97-12953



LEGEND

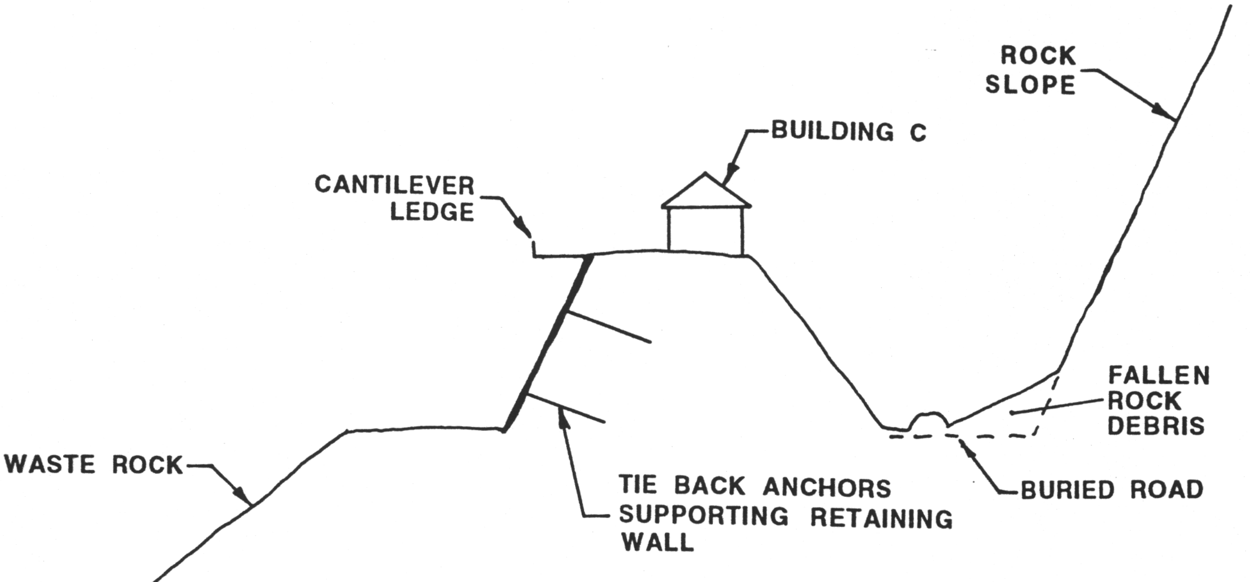
EXTENT OF WASTE ROCK

BUILDINGS

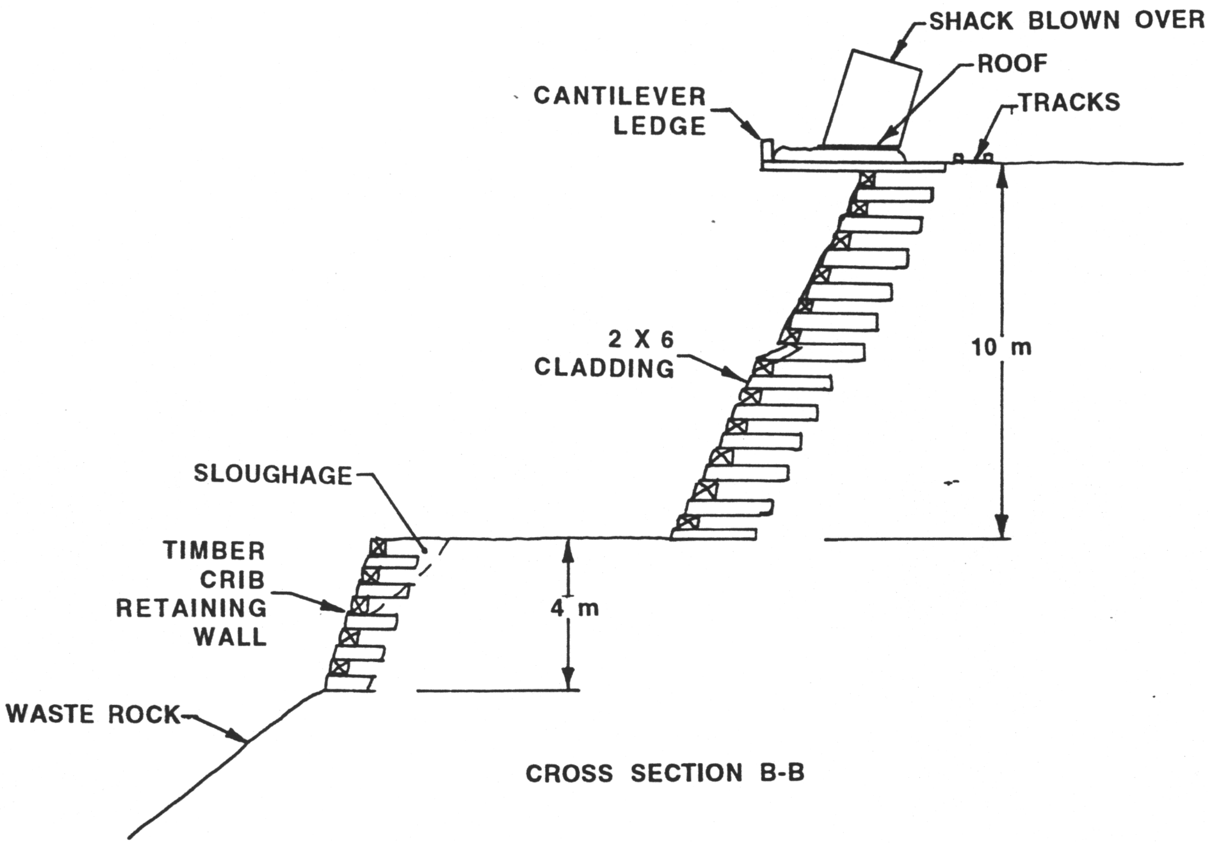
A. MIXING TANK 2.4 m x 3.7 m x 4.9 m HIGH
B. VENTILATION BUILDING 4.9 m x 7.3 m
C. STORAGE BUILDING 3.7 m x 4.9 m
D. SHACK 1.2 m x 1.2 m PLYWOOD SHACK

ADAPTED FROM DRAWING 3
PW & GSC REPORT,
PROJECT NO. 668724

EBA Engineering Consultants Ltd.				PROJECT: GEOTECHNICAL SERVICES YUKON ABANDONED MINES SITES	
CLIENT: PUBLIC WORKS & GOVERNMENT SERVICES CANADA				TITLE: SITE PLAN OF VENUS MINE SITE - AREA OF ADIT 2	
DATE 97/10/08	DWN. MEB	CHKD. MEB		FILE NO. 0201-97-12953	12953-12



CROSS SECTION A-A



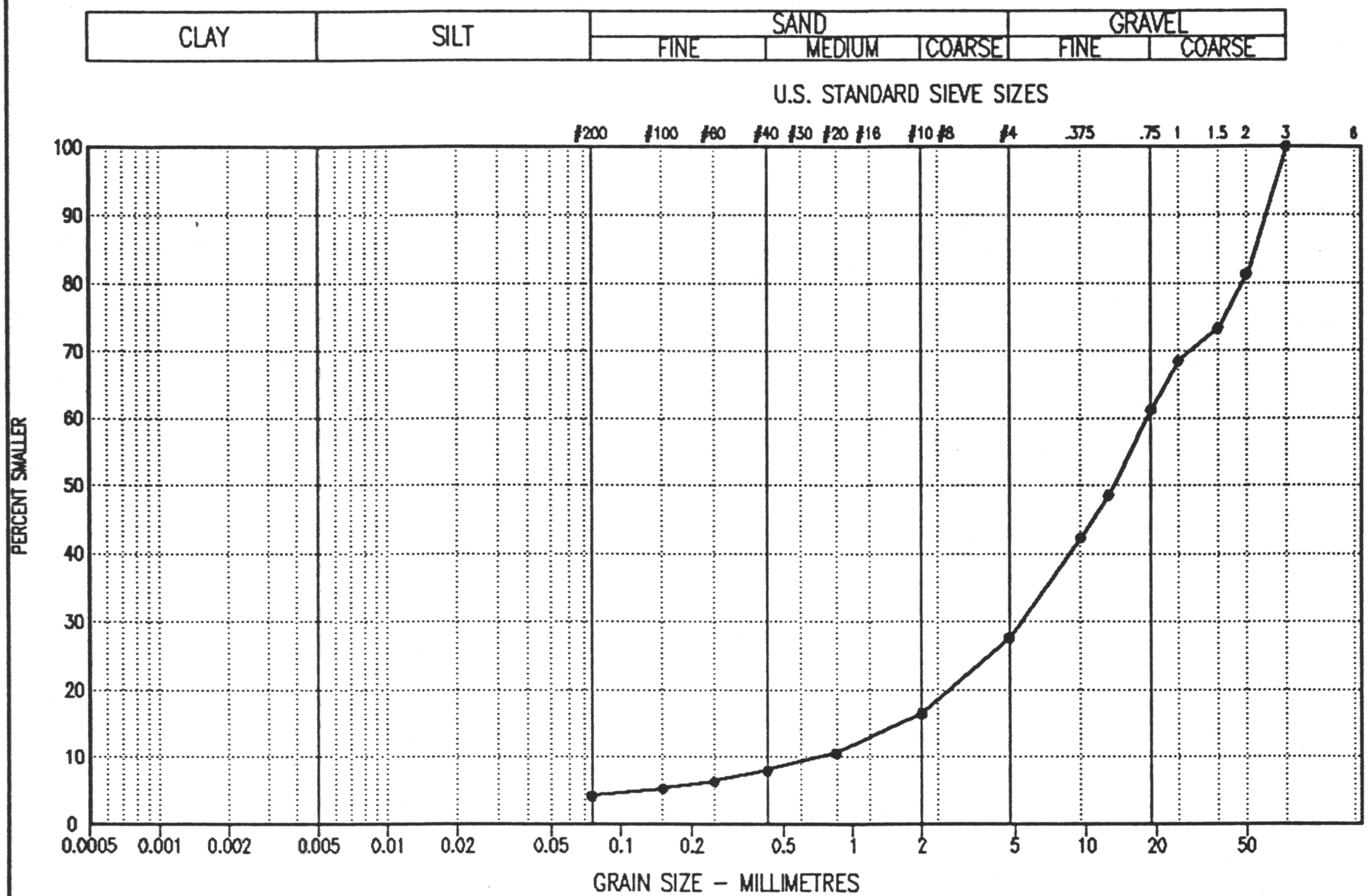
CROSS SECTION B-B

SCALE = 1:200

EBA Engineering Consultants Ltd.			PROJECT: GEOTECHNICAL SERVICES YUKON ABANDONED MINE SITES		
CLIENT: PUBLIC WORKS & GOVERNMENT SERVICES CANADA			TITLE: PROFILE DRAWINGS OF CROSS SECTIONS A - A, & B - B VENUS MINE SITE, ADIT 2		
DATE 97/10/08	DWN. MEB	CHKD. MEB	DRWG NO. 12953-13		FILE NO. 0201-97-12953

EBA Engineering

PARTICLE SIZE – ANALYSIS OF SOILS



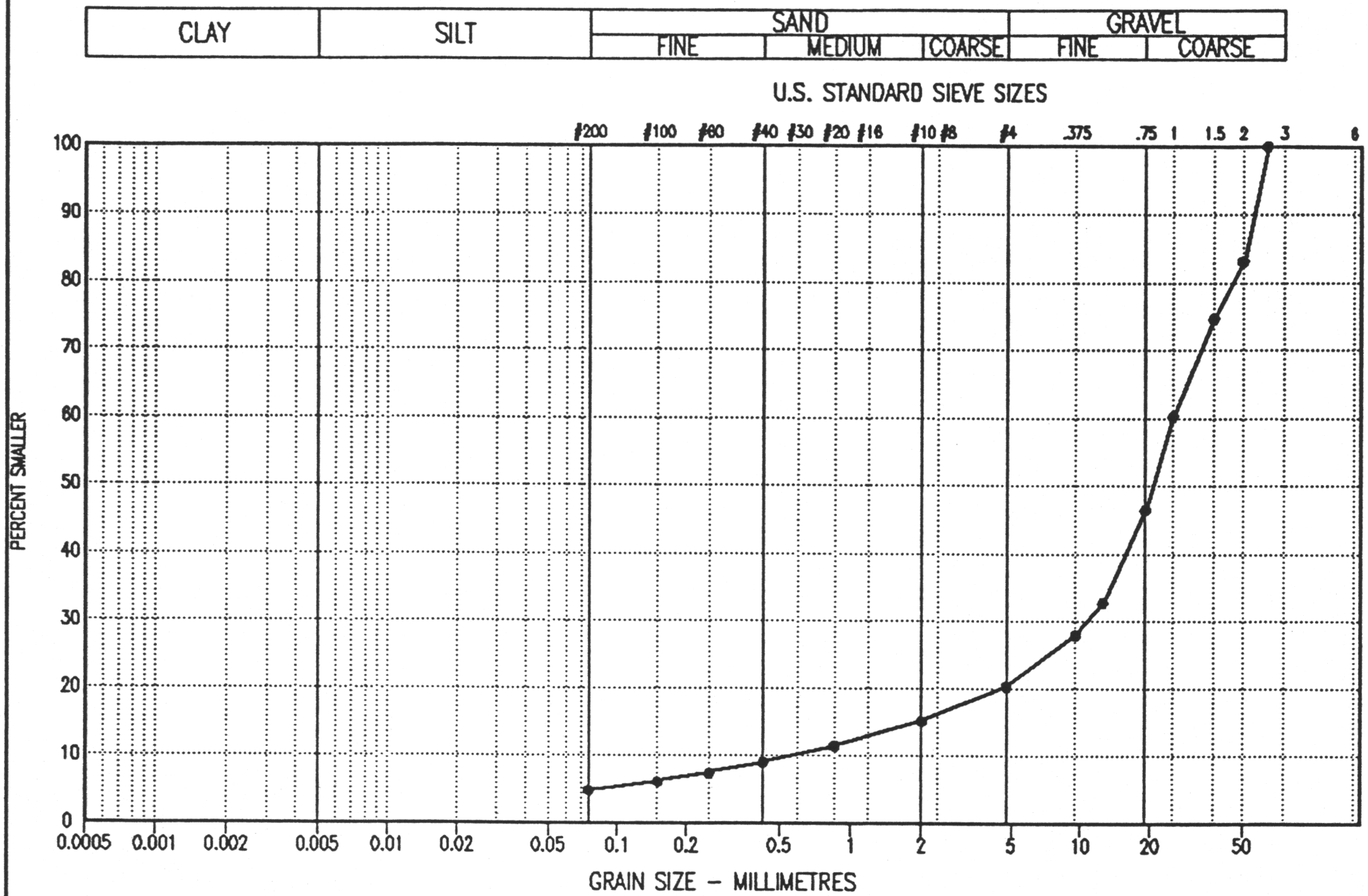
SYMBOL	BOREHOLE NUMBER	DEPTH (ft)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
•——•	VENUS1	0.00	4.2	23.4	72.4	24.2	2.2	GW

Project: 0201–97–12953 Date Tested: 97/09/16 BY: JSB

Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (ft)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●——●	VENUS2	0.00	4.8	15.5	79.7	41.6	7.8	GP

Project: 0201-97-12953

Date Tested: 97/09/16

BY: JSB

Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

February 12, 1998

Environmental Services
Public Works and Government Services Canada
1330-800 Burrard Street
Vancouver, B.C.
V6Z 2V8

EBA File No.: 0201-97-12953.4

Attention: Mr. Tim Sackmann, Manager
Contaminated Sites & Assessment

Dear Sir:

Subject: Class 'D' Cost Estimate for Site Restoration
Venus Mine Site
Montana Mountain near Carcross, YT

EBA Engineering Consultants Ltd. (EBA) is pleased to submit the following Class 'D' Cost Estimates for the slope stabilization options for the Venus Mine Site. The cost estimates have been prepared in consideration of the two different site restoration approaches described in detail in the EBA final report entitled "Geotechnical Services, Yukon Abandoned Mine Sites, Venus Mine Site, Montana Mountain near Carcross, YT".

The Class 'D' cost estimate to an accuracy of 25% has been presented in Table 1 and 2, below, for restoration options 1 and 2 as presented in the referenced report. Briefly, option 1 involved mobilizing the material retained by the walls downslope to facilitate removal off site and option 2 involved moving the material up to the level bench near the adit. The following assumptions have been applied in the preparation of this cost estimate:

- A consultant will be retained to perform the survey, design, development of construction drawings and specifications, and on-site supervision aspects of the work program rather than PWGSC forces.
- The work program will be conducted while the ground is not frozen.
- The existing access road will be adequate to mobilize equipment to the area of adit 2.
- If option 1 is followed, the waste location for the rock will be within a 3 km distance from the mine site and will not require a containment system to mitigate acid rock drainage generation.
- A construction camp will not be required (daily mobilization to the site from Whitehorse).
- The Klondike Highway will not suffer extensive damage as a result of the reclamation work.

eba
Calcite Business Centre
Unit 6, 151 Industrial Road, Whitehorse, YT Y1A 2V3
•Phone (403) 668-3068 • FAX (403) 668-4349•

ITEM	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	AMOUNT
2.1	Survey for quantity estimation and	hr	20	$ 125.00	$ 2,500.00
	design of restoration system				
2.2	Test pit investigation	LS	1	$ 2,300.00	$ 2,300.00
2.3	Design of restoration system, develop	LS	1	$ 9,500.00	$ 9,500.00
	construction drawings and specs,				
	obtain permits, contractor selection				
2.4	Mob/demob equipment to site	km	480	$ 2.50	$ 1,200.00
2.5	Prepare access road and catchment	hr	10	$ 95.00	$ 950.00
	area				
2.6	demolition of retaining structures	hr	60	$ 115.00	$ 6,900.00
		hr	60	$ 95.00	$ 5,700.00
	(daily mob demob charges and lunch)	PD	6	$ 220.00	$ 1,320.00
2.7	Final grading of catchment area and	hr	10	$ 95.00	$ 950.00
	waste disposal area, clean site/hwy				
	(labourers to assist in site cleanup)	PD	2	$ 300.00	$ 600.00
2.8	Project Engineer, mob/demob and	PD	8	$ 1,000.00	$ 8,000.00
	on-site supervision and inspection				
2.9	Traffic management - Klondike Hwy	PD	8	$ 500.00	$ 4,000.00
2.10	Summary report	LS	1	$ 2,500.00	$ 2,500.00
	Subtotal				$ 46,420.00
	Contingency	15%			$ 6,963.00
	G.S.T.	7%			$ 3,736.81
	TOTAL ESTIMATED COST				$ 57,119.81

Notes: PD= per diem (based on 12 hr work day including mob/demob to site and lunch)
LS= lump sum
-necessity of traffic management to be assessed during final design
-equipment assumes D4 dozer @ $95.00/hr and 225 hoe @ $115/hr

Table 2. Class "D" cost estimate for the proposed restoration work for option 2 at the Venus Site.

We trust this information is suitable for your present requirements. If you have any questions or comments on the information presented herein, please do not hesitate to contact our office.

Respectfully submitted,
EBA Engineering Consultants Ltd.

Michael E. Billowits, M.Sc., P.Eng.
Project Engineer

J. Richard Trimble, M.Sc., P.Eng.
Project Director, Yukon Region

VENUS MINESITE

MONTANA MOUNTAIN NEAR CARCROSS, YUKON

STABILITY OF THE TWO RETAINING WALLS

NEAR ADIT 2

EBA Consultants Ltd. of Whitehorse YT undertook an inspection of slope stability at the Venus Minesite in October , 1997. Their conclusions read, in part as follows:

> "The primary concern with respect to slope stability is the area of the two retaining walls near adit 2. These retaining walls are constructed of log cribbing and have shown signs of degradation. It is unavoidable that further decay of the retaining walls will occur and that they will eventually fail leading to potentially adverse impacts on the South Klondike Highway. It is recommended to intentially fail these structures to reduce risk of a future sudden and uncontolled failure. A class "D" estimate of $70,000.00 has been identified to complete this reclamation work"

The accompanying report was reviewed by Dennis Cook, Senior Highways Engineer, Lawrence
Borowski, Project Manager, and Michael Nahir, Environmental Engineer. Findings of the review and subsequent meeting are detailed below.

It is not believed that decay of the retaining walls in itself would lead to a catastophic failure of the structures. Most likely, decay of the retaining walls would lead to noticeable failures which probably would not reach the South Klondike Highway. However, a catastrophic failure could occur if triggered by a landslide, earthquake or avalanche. Accordingly, it is concurred that remedial action, in some form, should be undertaken.

Several possible methods of addressing the problem were discussed. Intentionally failing the structures could be undertaken. The South Klondike Highway could be closed to traffic, the retaining walls "failed", material allowed to slide down the mountain side, the highway cleaned up and reopened to traffic.This would probably be the quickest method of addressing the problem. However, intentionally failing the structures may result with wood debris strewn down the embankment along with boulders which didn't roll all the way down. This would require activity on the slopes to remove this material. This approach therefore is not considered acceptable.

A second approach would be to remove material from behind the upper structure by means of a backhoe pearched on the ledge above the structures. This would require systematically dismantling the load out structure to obtain clearance, then excavating material from behind the retaining wall. This would be an economical approach, but may not fully resolve the problem. The success of this method would be dependent on the reach of the backhoe. Certainly, the lower retaining wall structure and any material retained by this structure would be inacessable. Prior to making any recommendations regarding this procedure a detailed site survey would be required.

The third method of addressing the problem involves the use of three pieces of equipment including a dozer (D4), a backhoe, and a boom truck. As with the second option, the loadout structure would be systematically dismantled. The dozer would then move down into the area where the load out structure was located and push material contained by the upper retaining wall to a location which could be reached by the backhoe. As this material is moved, the retaining wall itself can be gradually dismantled and lifted to the upper ledge using the boom truck. It should also be possible to remove any material retained by the lower retaining wall and dismantle this structure as well.

	Project Budget	
Item	Description	Estimated Cost
A	Mobilization:	
	a) Truck to mobilize and demobilize dozer/backhoe 400 kilometers @ $2.50	$1,000.00
	b) Mobilize and demobilize boom truck 400 kilometers @ $1.50	$600.00
	c) Mobilize crewcab and pickup 400 kilometers @ $0.50	$200.00
B	Construction:	
	a) Dozer 60 hours @ $110.00	$6,600.00
	b) Backhoe 60 hours @ $80.00	$4,800.00
	c) Boom truck 60 hours @$65.00	$3,900.00
	d) Labourers 2 @ 60 hours @ 20.00	$2,400.00
	e) Superintendent 60 hours @ $50.00	$3,000.00
	f) Service truck 60 hours @ $75.00	$4,500.00
C	Overhead:	
	a) Rental of crew cab and pickup 5 days @ 200.00	$1,000.00
	b) Commute to Whitehorse (2 vehicles) 1,600 km @ $0.50	$800.00
	c) Meal allowances (lunch) 7 persons for 5 days @ $20.00	$700.00
	Subtotal direct costs:	$29,500.00
	Overhead and profit @20%	$5,900.00
D	**Construction costs:**	$35,400.00
E	Engineering Costs:	
	a) Site survey:	

	- Survey Crew 12 hours @ $125.00	$1,500.00
	- Survey crew travel time 2 hours @ $125.00	$250.00
	- Vehicle rental 1 day @ 100.00	$100.00
	- Survey equipment 1 day @ $100.00	$100.00
	- Office time 20 hours @ $50.00	$1,000.00
	- Meals 2 @ $20.00	$40.00
F	**Sub Total survey crew costs**	$2,990.00
	b)Design:	
	- Consultant 60 hours @$60.00	$3600.00
	- Cad presentation 10 hours @ $50.00	$500.00
	- Tender and evaluation 10 hours @ $60.00	$600.00
G	**Subtotal Design:**	$4,700.00
	c) Supervision:	
	- Site time 50 hours @ $60.00	$3,000.00
	- Travel time 10 hours @ $60.00	$600.00
	- Meal allowances 5 @ $20.00	$100.00
	- Vehicle rental 5 days @ 100.00	$500.00
	- Mileage 1000 @ $0.30	$300.00
	- Fuel 1000 km @ $0.10	$100.00
	- Office wrapup 20 hours @ $60.00	$1,200.00
	- Miscellaneous disbursements	$200.00
H	**Subtotal Supervision:**	$6,000.00
I	**TOTAL ENGINEERING COSTS**	$13,690.00
J	Total all costs	$49,090.00
K	Contingency @ approx 10%	$4,910.00
L	**T.E.C. (Budget)**	$54,000.00

APPENDIX C

Laboratory Reports

NORWEST LABS
EDMONTON PH. (403) 438-5522 FAX (403) 438-0396
CALGARY PH. (403) 291-2022 FAX (403) 291-2021
LANGLEY PH. (604) 530-4344 FAX (604) 534-9996
LETHBRIDGE PH. (403) 329-9266 FAX (403) 327-8527
WINNIPEG PH. (204) 982-8630 FAX (204) 275-6019

DATE 28 AUG 97 10:06
P.O. NO.
W.O. NO. 3 138316
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ENVIRONMENTAL SERVICES
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MIKE NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

SAMPLE		1 97VEWQ-A101	2 97-VE-WR A102 VENUS	3 97-VE-WQ S101
ROUTINE WATER				
pH		8.10	8.20	7.67
ELECTRICAL COND	uS/cm	297	401	319
CALCIUM	mg/L	48.6	50.4	53.3
MAGNESIUM	mg/L	12.5	27.0	13.5
SODIUM	mg/L	3.9	5.6	3.9
POTASSIUM	mg/L	<0.60	<0.60	<0.60
IRON	mg/L	<0.04	<0.04	<0.04
MANGANESE	mg/L	0.010	0.006	<0.003
SULPHATE	mg/L	54.0	71.0	62.5
CHLORIDE	mg/L	<0.5	<0.5	<0.5
BICARBONATE	mg/L	148	203	153
T ALKALINITY	mg/L	121	166	126
HARDNESS	mg/L	173	237	189
T DIS SOLIDS	mg/L	193	255	210
IONIC BALANCE	%	~102	~104	~103
WATER NUTRIENTS				
NO2&NO3-N	mg/L	0.11	0.14	0.23
TOTAL, COLD VAPO				
MERCURY	mg/L	<0.0001	<0.0001	<0.0001
TRACE ICP,TOTAL				
ALUMINUM	mg/L	0.045	0.012	0.047
ANTIMONY	mg/L	<0.005	<0.005	<0.005
ARSENIC	mg/L	1.23	0.24	0.26
BARIUM	mg/L	0.0309	0.0263	0.0235
BERYLLIUM	mg/L	<0.00001	<0.00001	<0.00001
BISMUTH	mg/L	0.0008	<0.0004	<0.0004
BORON	mg/L	<0.002	<0.002	0.007
CADMIUM	mg/L	0.0270	0.00172	0.00028
CALCIUM	mg/L	46.0	46.8	49.9
CHROMIUM	mg/L	<0.00006	<0.00006	<0.00006
COBALT	mg/L	0.00024	0.00011	<0.00003
COPPER	mg/L	0.00579	0.00043	0.00072
IRON	mg/L	1.89	0.103	0.094
LEAD	mg/L	0.0547	<0.0003	<0.0003

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MIKE NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

SAMPLE		1 97VEWQ-A101	2 97-VE-WR A102 VENUS	3 97-VE-WQ S101
TRACE ICP, TOTAL				
LITHIUM	mg/L	0.00750	0.0146	0.00557
MANGANESE	mg/L	0.0145	0.00386	0.00073
MAGNESIUM	mg/L	11.0	23.5	11.6
MOLYBDENUM	mg/L	0.00969	0.0121	0.0106
NICKEL	mg/L	<0.0001	0.0003	<0.0001
PHOSPHORUS	mg/L	0.023	<0.006	0.014
POTASSIUM	mg/L	2.80	0.88	1.25
SILVER	mg/L	0.00014	<0.00005	<0.00005
SELENIUM	mg/L	0.005	0.005	0.005
SILICON	mg/L	3.77	3.75	3.80
STRONTIUM	mg/L	0.651	0.990	0.641
SODIUM	mg/L	3.42	5.22	3.56
THALLIUM	mg/L	<0.001	<0.001	<0.001
SULPHUR	mg/L	17.3	22.7	19.8
TITANIUM	mg/L	0.00027	<0.00002	0.00079
TIN	mg/L	<0.0002	0.0003	<0.0002
VANADIUM	mg/L	<0.00003	<0.00003	0.00027
ZINC	mg/L	0.520	0.0599	<0.0002

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MIKE NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

SAMPLE		4 VEWQ-S201	5 VE-WQ-S2-1 VENUS MINE AUDT 2 WP PILE BELOW	6 BTWQ-STR-102 YUKON MINE PHIII 500M DOWSTREAM
ROUTINE WATER				
pH		8.32	8.28	7.23
ELECTRICAL COND	uS/cm	400	399	31.3
CALCIUM	mg/L	50.3	50.3	2.8
MAGNESIUM	mg/L	27.2	27.4	1.0
SODIUM	mg/L	5.7	5.6	0.8
POTASSIUM	mg/L	<0.60	<0.60	<0.60
IRON	mg/L	<0.04	<0.04	<0.04
MANGANESE	mg/L	<0.003	<0.003	<0.003
SULPHATE	mg/L	73.1	72.4	4.6
CHLORIDE	mg/L	<0.5	<0.5	<0.5
BICARBONATE	mg/L	201	201	26
T ALKALINITY	mg/L	165	165	21
HARDNESS	mg/L	238	239	11.1
T DIS SOLIDS	mg/L	256	256	23
IONIC BALANCE	%	~104	~104	~50.2
WATER NUTRIENTS				
NO2&NO3-N	mg/L	0.06	0.14	<0.05
TOTAL, COLD VAPO				
MERCURY	mg/L	<0.0001	<0.0001	<0.0001
TRACE ICP,TOTAL				
ALUMINUM	mg/L	0.015	0.012	0.023
ANTIMONY	mg/L	<0.005	<0.005	<0.005
ARSENIC	mg/L	0.32	0.32	0.01
BARIUM	mg/L	0.0279	0.0257	0.00158
BERYLLIUM	mg/L	<0.00001	<0.00001	<0.00001
BISMUTH	mg/L	0.0005	<0.0004	<0.0004
BORON	mg/L	<0.002	<0.002	0.008
CADMIUM	mg/L	0.00047	0.00134	<0.00006
CALCIUM	mg/L	46.7	46.0	3.42
CHROMIUM	mg/L	<0.00006	<0.00006	<0.00006
COBALT	mg/L	<0.00003	<0.00003	<0.00003
COPPER	mg/L	0.00021	0.00061	<0.00003

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MIKE NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

SAMPLE		4	5	6
		VEWQ-S201	VE-WQ-S2-1 VENUS MINE AUDT 2 WP PILE BELOW	BTWQ-STR-102 YUKON MINE PHIII 500M DOWSTREAM
TRACE ICP,TOTAL				
IRON	mg/L	0.044	0.029	0.024
LEAD	mg/L	<0.0003	0.0014	<0.0003
LITHIUM	mg/L	0.0149	0.0143	<0.00006
MANGANESE	mg/L	0.00048	0.00117	0.00024
MAGNESIUM	mg/L	23.6	23.1	0.836
MOLYBDENUM	mg/L	0.00888	0.0129	0.00443
NICKEL	mg/L	<0.0001	<0.0001	<0.0001
PHOSPHORUS	mg/L	<0.006	0.059	0.038
POTASSIUM	mg/L	2.04	<0.60	<0.60
SILVER	mg/L	<0.00005	<0.00005	<0.00005
SELENIUM	mg/L	0.007	0.004	0.007
SILICON	mg/L	3.36	3.66	1.76
STRONTIUM	mg/L	0.995	0.988	0.0199
SODIUM	mg/L	5.25	5.31	0.796
THALLIUM	mg/L	<0.001	<0.001	<0.001
SULPHUR	mg/L	22.7	22.4	1.67
TITANIUM	mg/L	<0.00002	<0.00002	0.00028
TIN	mg/L	<0.0002	<0.0002	<0.0002
VANADIUM	mg/L	<0.00003	<0.00003	0.00018
ZINC	mg/L	<0.0002	0.0355	0.0226

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MIKE NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------	---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------
pH	27Aug97	DARREN CRICHTON	ELECTRICAL COND	27Aug97	DARREN CRICHTON
CALCIUM	27Aug97	LANG QUE TRAN	MAGNESIUM	27Aug97	LANG QUE TRAN
SODIUM	27Aug97	LANG QUE TRAN	POTASSIUM	27Aug97	LANG QUE TRAN
IRON	27Aug97	LANG QUE TRAN	MANGANESE	27Aug97	LANG QUE TRAN
SULPHATE	27Aug97	LANG QUE TRAN	CHLORIDE	27Aug97	THERESA LIEU
BICARBONATE	27Aug97	DARREN CRICHTON	T ALKALINITY	27Aug97	DARREN CRICHTON
HARDNESS	28Aug97	LANG QUE TRAN	T DIS SOLIDS	28Aug97	LANG QUE TRAN
IONIC BALANCE	28Aug97	LANG QUE TRAN	NO2&NO3-N	27Aug97	THERESA LIEU
MERCURY	27Aug97	LANG QUE TRAN	ALUMINUM	27Aug97	LANG QUE TRAN
ANTIMONY	27Aug97	LANG QUE TRAN	ARSENIC	27Aug97	LANG QUE TRAN
BARIUM	27Aug97	LANG QUE TRAN	BERYLLIUM	27Aug97	LANG QUE TRAN
BISMUTH	27Aug97	LANG QUE TRAN	BORON	27Aug97	LANG QUE TRAN
CADMIUM	27Aug97	LANG QUE TRAN	CALCIUM	27Aug97	LANG QUE TRAN
CHROMIUM	27Aug97	LANG QUE TRAN	COBALT	27Aug97	LANG QUE TRAN
COPPER	27Aug97	LANG QUE TRAN	IRON	27Aug97	LANG QUE TRAN
LEAD	27Aug97	LANG QUE TRAN	LITHIUM	27Aug97	LANG QUE TRAN
MANGANESE	27Aug97	LANG QUE TRAN	MAGNESIUM	27Aug97	LANG QUE TRAN
MOLYBDENUM	27Aug97	LANG QUE TRAN	NICKEL	27Aug97	LANG QUE TRAN
PHOSPHORUS	27Aug97	LANG QUE TRAN	POTASSIUM	27Aug97	LANG QUE TRAN
SILVER	27Aug97	LANG QUE TRAN	SELENIUM	27Aug97	LANG QUE TRAN
SILICON	27Aug97	LANG QUE TRAN	STRONTIUM	27Aug97	LANG QUE TRAN
SODIUM	27Aug97	LANG QUE TRAN	THALLIUM	27Aug97	LANG QUE TRAN
SULPHUR	27Aug97	LANG QUE TRAN	TITANIUM	27Aug97	LANG QUE TRAN
TIN	27Aug97	LANG QUE TRAN	VANADIUM	27Aug97	LANG QUE TRAN
ZINC	27Aug97	LANG QUE TRAN			

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MIKE NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

The following published METHODS OF ANALYSIS were used:

10301L pH
Electrometric (pH meter)
Ref. APHA 4500-H+
02041L ELECTRICAL COND
Conductance meter
Ref. APHA 2510 B
20103 CALCIUM
ICP spectroscopy @ 317.9 nm
Ref. APHA 3120 B
12102L MAGNESIUM
ICP spectroscopy @ 285.2 nm
Ref. APHA 3120 B
11102L SODIUM
19111 POTASSIUM
Diss.,ICP Spectroscopy, Ref. APHA 3120 B
26304L IRON
16306L SULPHATE
ICP spectroscopy @ 180.7 nm
Ref. APHA 3120 B
17203L CHLORIDE
Automated colorimetry, Thiocyanate
Ref. APHA 4500 Cl-,E
06201L BICARBONATE
Potentiometric titration with standard
acid to pH 8.3 and pH 4.5
Ref. APHA 2320 B
10101 T ALKALINITY
Potentiometric titration with standard
acid to pH 4.5 & pH 8.3. Report as CaCO3
Ref. APHA 2320 B
10602 HARDNESS
Calculation from 2.5*Ca + 4.1*Mg
Reported as CaCO3
Ref. APHA 2340 B
00203 T DIS SOLIDS
SUM OF IONS CALCULATION
Ca + Mg + K + Na + SO4 + Cl + 0.6*T Alk
Ref. APHA 1030 F
NWL4994 IONIC BALANCE
00100 IONIC BALANCE 2
%Diff=(Sum Cations-Sum Anions)/
(Sum Cations+Sum Anions)*100
Ref. APHA 1030 F
07105L NO2&NO3-N
Automated colorimetry Cadmium reduction
Ref. APHA 4500-NO3-,F

Method References:

1. APHA Standard Methods for the Examination of Water and Wastewater, American Public Health Assoc., 17th ed.
2. EPA a. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, 3rd ed., US EPA, 1986
b. Methods for Chemical Analysis of Water and Wastewater, US EPA, 1983
3. MSS Manual on Soil Sampling and Methods of Analysis, Cdn. Soc. of Soil Science, J. A. McKeague, 2nd ed.

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MIKE NAHIR

WATER ANALYSIS REPORT

SAMPLE		10 PAD-WQ-ST1-3	11 VE-WA, A101	12 VE-WQ-A102
ROUTINE WATER				
pH		8.15	8.36	8.42
ELECTRICAL COND	uS/cm	562	285	352
CALCIUM	mg/L	114	51.3	52.0
MAGNESIUM	mg/L	23.6	13.2	28.5
SODIUM	mg/L	2.3	4.3	6.8
POTASSIUM	mg/L	0.89	0.60	<0.60
SULPHATE	mg/L	220	59.8	77.3
CHLORIDE	mg/L	<0.5	<0.5	<0.5
CARBONATE	mg/L			4.64
BICARBONATE	mg/L	189	148	192
P ALKALINITY	mg/L			4
T ALKALINITY	mg/L	155	122	165
HARDNESS	mg/L	381	182	247
T DIS SOLIDS	mg/L	454	203	265
IONIC BALANCE	%	~101	~104	~107
WATER NUTRIENTS				
NO2&NO3-N	mg/L	0.10	0.16	0.17
ICP METALS, EXTR				
IRON	mg/L	0.06	1.63	0.03
MANGANESE	mg/L	0.107	0.013	<0.003
DISS, COLD VAPOR				
MERCURY	mg/L	<0.0001	<0.0001	<0.0001
METALS, DISS, AAS				
SELENIUM	mg/L	<0.0001	<0.0001	<0.0001
TRACE ICP, DISS				
IRON	mg/L	0.0508	1.554	0.0254
ALUMINUM	mg/L	0.00447	0.0215	0.00394
ANTIMONY	mg/L	<0.005	<0.005	<0.005
ARSENIC	mg/L	<0.01	1.27	0.23
BARIUM	mg/L	0.0488	0.0333	0.0280
BERYLLIUM	mg/L	<0.00001	<0.00001	<0.00001

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MIKE NAHIR

WATER ANALYSIS REPORT

SAMPLE		10 PAD-WQ-ST1-3	11 VE-WA, A101	12 VE-WQ-A102
TRACE ICP,DISS				
BISMUTH	mg/L	<0.0004	0.0006	<0.0004
BORON	mg/L	<0.002	<0.002	<0.002
CADMIUM	mg/L	0.00205	0.0229	0.00111
CALCIUM	mg/L	105	49.3	48.8
CHROMIUM	mg/L	0.00016	0.00023	0.00027
COBALT	mg/L	<0.00003	0.00014	<0.00003
COPPER	mg/L	0.00041	0.00597	0.00016
LEAD	mg/L	0.0008	0.0500	0.0017
LITHIUM	mg/L	0.00809	0.00937	0.0174
MANGANESE	mg/L	0.104	0.0133	0.00207
MAGNESIUM	mg/L	19.6	11.2	23.5
MOLYBDENUM	mg/L	0.00020	0.00849	0.00830
NICKEL	mg/L	0.0012	0.0002	0.0001
PHOSPHORUS	mg/L	<0.006	<0.006	<0.006
POTASSIUM	mg/L	0.89	0.60	<0.60
SILVER	mg/L	<0.00005	<0.00005	<0.00005
SELENIUM	mg/L	<0.003	<0.003	<0.003
SILICON	mg/L	3.25	3.79	3.83
STRONTIUM	mg/L	0.218	0.716	1.10
SODIUM	mg/L	1.39	3.28	5.11
THALLIUM	mg/L	<0.001	<0.001	<0.001
SULPHUR	mg/L	67.1	18.1	23.1
TITANIUM	mg/L	<0.00002	<0.00002	<0.00002
TIN	mg/L	0.0014	0.0013	0.0016
URANIUM	mg/L	0.0029	0.0144	0.0063
VANADIUM	mg/L	<0.00003	<0.00003	<0.00003
ZINC	mg/L	0.256	0.376	0.0379
ZIRCONIUM	mg/L	<0.00004	<0.00004	<0.00004

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MIKE NAHIR

WATER ANALYSIS REPORT

SAMPLE		13 VE-WQ-S2-1	14 VE-WQ-S101	15 VE-WQ-S201
ROUTINE WATER				
pH		8.56	7.99	8.54
ELECTRICAL COND	uS/cm	350	301	345
CALCIUM	mg/L	51.5	57.6	51.5
MAGNESIUM	mg/L	28.6	14.5	28.4
SODIUM	mg/L	6.7	4.9	6.4
POTASSIUM	mg/L	0.97	1.73	1.59
SULPHATE	mg/L	78.4	67.6	78.8
CHLORIDE	mg/L	<0.5	<0.5	<0.5
CARBONATE	mg/L	7.39		8.59
BICARBONATE	mg/L	182	161	178
P ALKALINITY	mg/L	6		7
T ALKALINITY	mg/L	162	132	160
HARDNESS	mg/L	247	203	246
T DIS SOLIDS	mg/L	264	226	263
IONIC BALANCE	%	~107	~106	~108
WATER NUTRIENTS				
NO2&NO3-N	mg/L	0.17	0.26	0.14
ICP METALS,EXTR				
IRON	mg/L	0.10	<0.02	<0.02
MANGANESE	mg/L	0.013	<0.003	<0.003
DISS, COLD VAPOR				
MERCURY	mg/L	<0.0001	<0.0001	<0.0001
METALS,DISS,AAS				
SELENIUM	mg/L	<0.0001	<0.0001	<0.0001
TRACE ICP,DISS				
IRON	mg/L	0.1131	0.0127	0.0129
ALUMINUM	mg/L	0.0341	0.0163	0.0234
ANTIMONY	mg/L	<0.005	<0.005	<0.005
ARSENIC	mg/L	0.38	0.29	0.35
BARIUM	mg/L	0.0282	0.0232	0.0285
BERYLLIUM	mg/L	<0.00001	<0.00001	<0.00001

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MIKE NAHIR

WATER ANALYSIS REPORT

SAMPLE		13 VE-WQ-S2-1	14 VE-WQ-S101	15 VE-WQ-S201
TRACE ICP,DISS				
BISMUTH	mg/L	0.0009	<0.0004	<0.0004
BORON	mg/L	<0.002	<0.002	<0.002
CADMIUM	mg/L	0.00209	0.00023	0.00049
CALCIUM	mg/L	48.4	51.4	47.9
CHROMIUM	mg/L	0.00026	0.00017	0.00035
COBALT	mg/L	0.00021	<0.00003	0.00010
COPPER	mg/L	0.00054	0.00037	0.00019
LEAD	mg/L	0.0168	0.0008	0.0007
LITHIUM	mg/L	0.0174	0.00678	0.0166
MANGANESE	mg/L	0.0161	0.00059	0.00238
MAGNESIUM	mg/L	23.3	11.5	23.2
MOLYBDENUM	mg/L	0.00805	0.00804	0.00818
NICKEL	mg/L	0.0003	<0.0001	<0.0001
PHOSPHORUS	mg/L	<0.006	<0.006	<0.006
POTASSIUM	mg/L	0.97	1.73	1.60
SILVER	mg/L	<0.00005	<0.00005	<0.00005
SELENIUM	mg/L	<0.003	<0.003	<0.003
SILICON	mg/L	3.81	3.94	3.51
STRONTIUM	mg/L	1.08	0.673	1.07
SODIUM	mg/L	5.07	3.21	5.03
THALLIUM	mg/L	<0.001	<0.001	<0.001
SULPHUR	mg/L	23.9	20.7	23.3
TITANIUM	mg/L	0.00022	0.00017	<0.00002
TIN	mg/L	0.0019	0.0015	0.0017
URANIUM	mg/L	0.0072	0.0026	0.0060
VANADIUM	mg/L	<0.00003	<0.00003	<0.00003
ZINC	mg/L	0.0614	0.0045	0.0062
ZIRCONIUM	mg/L	0.00015	<0.00004	<0.00004

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LETHBRIDGE PH. (403) 329-9266 FAX (403) 327-8527
WINNIPEG PH. (204) 982-8630 FAX (204) 275-6019

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T5J 4E2

MIKE NAHIR

WATER ANALYSIS REPORT

note pH — pH REPORTED AT ROOM TEMP

note ELECTRICAL COND — 'ELECTRICAL COND' (EC) is in microsiemens/cm and is a measure of solids in solution
E.C. CORRECTED TO 25C

note T ALKALINITY — 'ALKALINITY' is CARBONATE/BICARBONATE expressed as CALCIUM CARBONATE

note HARDNESS — 'HARDNESS' is calcium and magnesium expressed as CALCIUM CARBONATE

note NO2&NO3-N — is expressed as nitrogen

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WATER ANALYSIS REPORT

---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------	---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------
pH	21Oct97	DARREN CRICHTON	ELECTRICAL COND	21Oct97	DARREN CRICHTON
CALCIUM	22Oct97	LANG QUE TRAN	MAGNESIUM	22Oct97	LANG QUE TRAN
SODIUM	22Oct97	LANG QUE TRAN	POTASSIUM	22Oct97	LANG QUE TRAN
SULPHATE	22Oct97	LANG QUE TRAN	CHLORIDE	21Oct97	THERESA LIEU
CARBONATE	21Oct97	DARREN CRICHTON	BICARBONATE	21Oct97	DARREN CRICHTON
P ALKALINITY	21Oct97	DARREN CRICHTON	T ALKALINITY	21Oct97	DARREN CRICHTON
HARDNESS	0	LANG QUE TRAN	T DIS SOLIDS	0	LANG QUE TRAN
IONIC BALANCE	0	LANG QUE TRAN	NO2&NO3-N	21Oct97	THERESA LIEU
IRON	21Oct97	LANG QUE TRAN	MANGANESE	21Oct97	LANG QUE TRAN
MERCURY	23Oct97	LANG QUE TRAN	SELENIUM	22Oct97	LANG QUE TRAN
IRON	22Oct97	LANG QUE TRAN	ALUMINUM	22Oct97	LANG QUE TRAN
ANTIMONY	22Oct97	LANG QUE TRAN	ARSENIC	22Oct97	LANG QUE TRAN
BARIUM	22Oct97	LANG QUE TRAN	BERYLLIUM	22Oct97	LANG QUE TRAN
BISMUTH	22Oct97	LANG QUE TRAN	BORON	22Oct97	LANG QUE TRAN
CADMIUM	22Oct97	LANG QUE TRAN	CALCIUM	22Oct97	LANG QUE TRAN
CHROMIUM	22Oct97	LANG QUE TRAN	COBALT	22Oct97	LANG QUE TRAN
COPPER	22Oct97	LANG QUE TRAN	LEAD	22Oct97	LANG QUE TRAN
LITHIUM	22Oct97	LANG QUE TRAN	MANGANESE	22Oct97	LANG QUE TRAN
MAGNESIUM	22Oct97	LANG QUE TRAN	MOLYBDENUM	22Oct97	LANG QUE TRAN
NICKEL	22Oct97	LANG QUE TRAN	PHOSPHORUS	22Oct97	LANG QUE TRAN
POTASSIUM	22Oct97	LANG QUE TRAN	SILVER	22Oct97	LANG QUE TRAN
SELENIUM	22Oct97	LANG QUE TRAN	SILICON	22Oct97	LANG QUE TRAN
STRONTIUM	22Oct97	LANG QUE TRAN	SODIUM	22Oct97	LANG QUE TRAN
THALLIUM	22Oct97	LANG QUE TRAN	SULPHUR	22Oct97	LANG QUE TRAN
TITANIUM	22Oct97	LANG QUE TRAN	TIN	22Oct97	LANG QUE TRAN
URANIUM	22Oct97	LANG QUE TRAN	VANADIUM	22Oct97	LANG QUE TRAN
ZINC	22Oct97	LANG QUE TRAN	ZIRCONIUM	22Oct97	LANG QUE TRAN

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WATER ANALYSIS REPORT

The following published METHODS OF ANALYSIS were used:

10301L pH
Electrometric (pH meter)
Ref. APHA 4500-H+

02041L ELECTRICAL COND
Conductance meter
Ref. APHA 2510 B

20103 CALCIUM
ICP spectroscopy @ 317.9 nm
Ref. APHA 3120 B

12102L MAGNESIUM
ICP spectroscopy @ 285.2 nm
Ref. APHA 3120 B

11102L SODIUM

19111 POTASSIUM
Diss.,ICP Spectroscopy, Ref. APHA 3120 B

16306L SULPHATE
ICP spectroscopy @ 180.7 nm
Ref. APHA 3120 B

17203L CHLORIDE
Automated colorimetry, Thiocyanate
Ref. APHA 4500 Cl-,E

06301L CARBONATE
Potentiometric titration with standard
acid to pH 8.3 and pH 4.5
Ref. APHA 2320 B

06201L BICARBONATE
Potentiometric titration with standard
acid to pH 8.3 and pH 4.5
Ref. APHA 2320 B

10151 P ALKALINITY
Potentiometric titration with standard
acid to pH 8.3. Report as CaCO3
Ref. APHA 2320 B

10101 T ALKALINITY
Potentiometric titration with standard
acid to pH 4.5 & pH 8.3. Report as CaCO3
Ref. APHA 2320 B

10602 HARDNESS
Calculation from 2.5*Ca + 4.1*Mg
Reported as CaCO3
Ref. APHA 2340 B

00203 T DIS SOLIDS
SUM OF IONS CALCULATION
Ca + Mg + K + Na + SO4 + Cl + 0.6*T Alk
Ref. APHA 1030 F

NWL4994 IONIC BALANCE

00100 IONIC BALANCE 2
%Diff=(Sum Cations-Sum Anions)/
(Sum Cations+Sum Anions)*100
Ref. APHA 1030 F

07105L NO2&NO3-N
Automated colorimetry Cadmium reduction
Ref. APHA 4500-NO3-,F

26321 IRON
Acid extr.,ICP Spectro. Ref. APHA 3120 B

25321 MANGANESE
Acid extr.,ICP Spectro. Ref. APHA 3120 B

80016 MERCURY
Dissolved, cold vapor atomic absorption
spectroscopy, with H2SO4/K2S208 digest
Ref. EPA 245.2

34102 SELENIUM
Dissolved, perchloric acid digest, auto.
hydride atomic absorption spectroscopy

Method References:

1. APHA Standard Methods for the Examination of Water and Wastewater, American Public Health Assoc., 17th ed.
2. EPA a. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, 3rd ed., US EPA, 1986
   b. Methods for Chemical Analysis of Water and Wastewater, US EPA, 1983
3. MSS Manual on Soil Sampling and Methods of Analysis, Cdn. Soc. of Soil Science, J. A. McKeague, 2nd ed.

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