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# Government of Yukon
# Water Resources Branch
# Ketza River Mine
# 2007 Geotechnical Inspections

Prepared by:
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UMA Project No.: 6029 010 00 (4.12.4)

February 2008

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February 12, 2008

UMA Project No.: 6029 010 00 (4.12.4)

Mr. Glenn Ford
Geotechnical Technologist
Water Resources Branch
Environment
Government of Yukon
Box 2703, V-310
Whitehorse, YT
Y1A 2C6

Dear Mr. Ford:

**Re: Yukon Sites – 2007 Geotechnical Inspections
Ketza River Mine**

UMA Engineering Ltd. is pleased to submit our draft report for the above referenced project. This report provides the results of our condition assessment and a qualitative risk assessment based on current operating conditions. Based on the results of the risk assessment, recommendations for follow-up or remedial works are provided.

If you require further information or clarification, please contact Ken Skaftfeld, P.Eng. directly.

Sincerely,

**UMA Engineering Ltd.**

R. Typliski

Ron Typliski, P.Eng.
Regional Manager
Earth and Environmental
KS/dh

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This Disclaimer is attached to and forms part of the Report.

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## List of Appendices

# 1.0 Introduction

## 1.1 Terms of Reference and Scope of Work

This report summarizes the results of our geotechnical inspection of the tailings dams and associated works at the Ketza River Mine. The terms of reference for the inspection were outlined in UMA's letter to Mr. Glenn Ford of the Government of Yukon Water Resources Branch dated September 7th, 2007. The purpose of the inspection was to determine if the existing tailings dams and diversion channels are being operated according to acceptable engineering standards, to identify issues for follow-up and to advise on the adequacy of proposed mitigation measures. Channel armouring along the east bank of the Ketza River where the mine site access road is susceptible to erosion were included in the inspection. In order to achieve these objectives, the program was broken into the following tasks:

1. Review background information provided by the YTG Project Manager including: water license; design documents; past inspection reports; licensee annual and monthly reports, and incident reports; in order to become familiar with the diversion canal and diversion structures and associated potential issues.

2. Inspect the tailings dams, diversion channels and erosion protection measures along the mine access road in the company of the Project Manager.

3. Prepare a site inspection report detailing the condition of the tailings dams and diversion structures, changes from the last inspection (based on the file review), required repairs and /or maintenance and other observed issues. The report should (if applicable) assess the relative risk posed by the structures (dykes and diversion structures) and recommendations regarding the need for and frequency of follow-up site inspections.

4. Include comments on the condition of the erosion protection works installed along the mine access road.

5. Participate, as required, in teleconferences with the owners of the structures and /or their representatives and other government representatives to discuss observations and recommendations, and to assess proposed mitigations.

6. Review the issues noted against proposed mitigations, taken or to be taken, and submit to the Project Manager a follow-up report reviewing the adequacy of mitigations proposed and recommendations regarding any oversight or follow-up work that should be done.

This inspection report is based on a cursory visual inspection and data provided in previous reports by others. Detailed investigations were not carried out and as such, this investigation was not intended to be detailed assessment of their condition. While we have reviewed information from previous reports, there has been no attempt made to corroborate or further analyze information or conclusions presented in past reports.

## 1.2 Site Description

The Ketza River Gold Mine is located within a valley bottom at about 1,400 m above sea level. Surrounding mountains are about 600 m higher than the valley bottom. The mine is located at the head of the Cache Creek drainage basin where Cache Creek was diverted around the tailings pond. Cache

Creek drains to the northeast into the Ketza River. A portion of the mine site access road follows the Ketza River between the confluence of Cache Creek and the Robert Campbell Highway as shown on Figure 01.

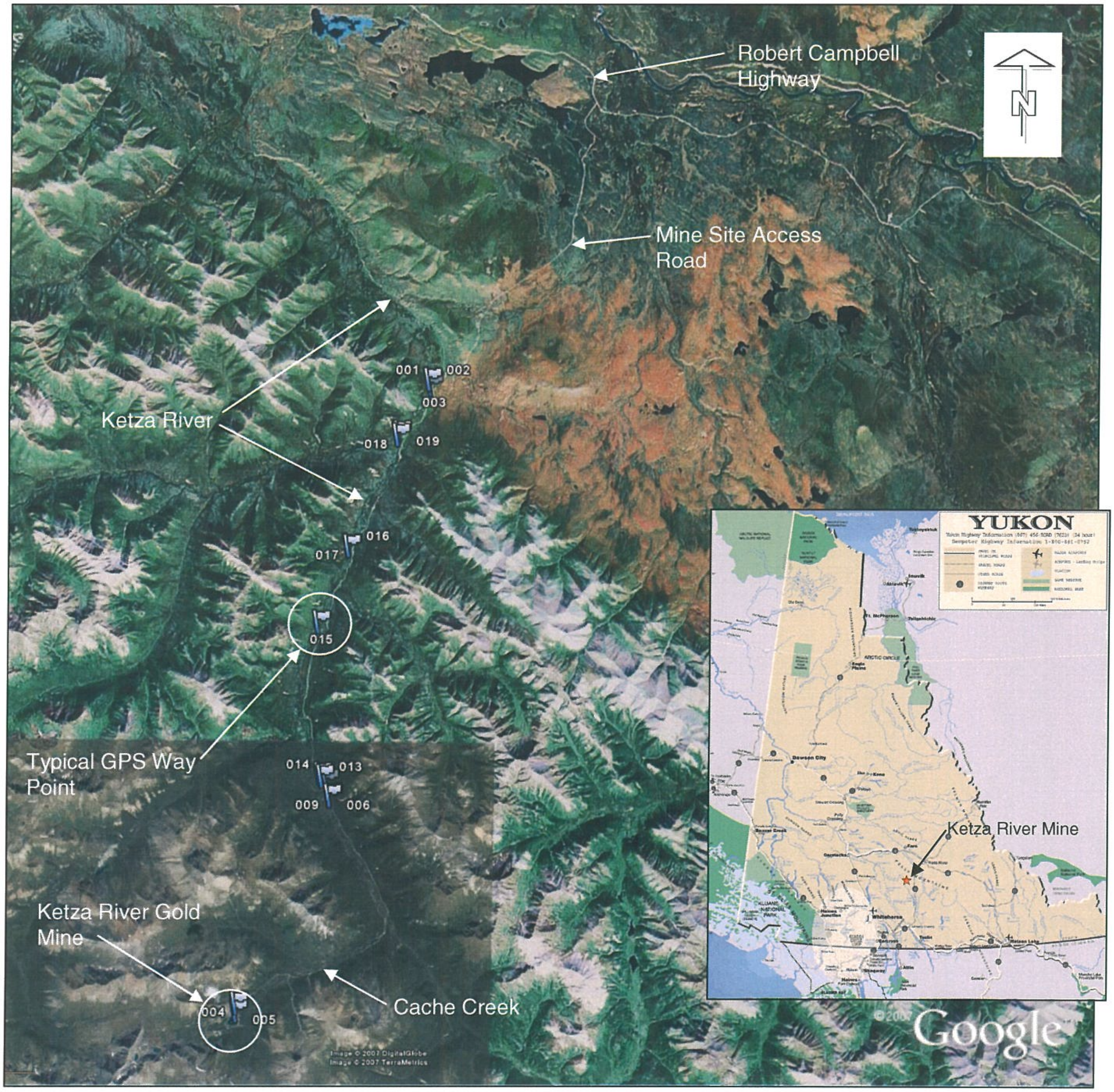


Figure 01 Location Plan

# 2.0 Review of Background Information

Background information provided by the Yukon Government Project Manager prior to the inspection included the following:

- Geo-Engineering (M.S.T.) Ltd. – Ketza River Mine – Report on Geotechnical Conditions of Mine Facilities and Proposed Closure, December 1998.
- Geo-Engineering (M.S.T.) Ltd. – Ketza River Mine – Report on 1999 Inspection, October 1999.
- Geo-Engineering (M.S.T.) Ltd. – Ketza River Mine – Report on 2000 Inspection, August 2000.
- Yukon Government Water Resource Branch – Ketza Mine Inspection, May 2005
- SRK Consulting – Geotechnical Inspection Waste and Water Management Facilities, Ketza River Mine, September 2005.

Subsequent to the inspection of the site, the following additional information was provided by the Yukon Government Project Manager:

- EBA Engineering – 2007 Geotechnical Site Inspection, Ketza River Gold Mine, Yukon, October 2007.

Pertinent findings from these reports are included in the condition assessment (Section 3.0).

# 3.0 Condition Assessment

The condition assessment was carried out on October 2nd 2007 by Mr. Ken Skaftfeld, P.Eng. of UMA Engineering in the company of the Government of Yukon's Project Manager, Mr. Glenn Ford. Light snow was encountered in the morning although it did not impede the inspection work. Temperatures were around zero degrees Celsius. Several photographs and a video were taken during the inspection. These have been included on the compact disc attached to this report as Appendix A. Select photographs have been used throughout the report.

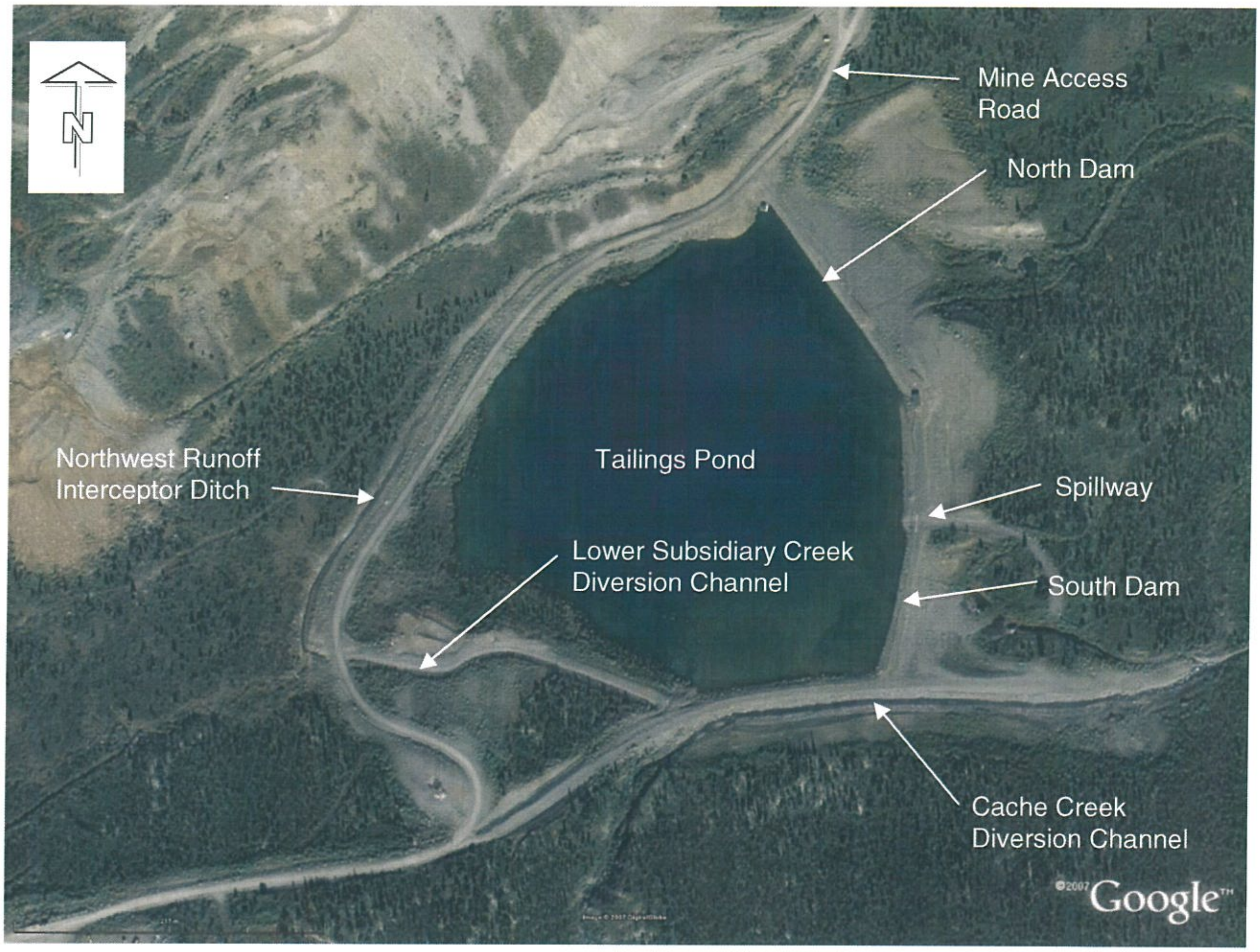


Figure 02 Tailings Management Area

### 3.1 Mine Site

The portion of the overall mine site included in this inspection assignment consists of the tailings impoundment (north and south tailings dams, tailings pond) and diversion ditches. Collectively, these features are referred to in this report as the Tailings Management Area (TMA) as illustrated on Figure 02.

### 3.1.1 Tailings Impoundment

The overall Tailings Impoundment consists of the Tailings Pond, North Dam and South Dam as shown on Figure 03.

#### 3.1.1.1 Tailings Pond

At the time of our inspection, the water level in the tailings pond was estimated to be 2 to 2.5 m below the tailings dam crest level (Figure 04). A staff gauge in the tailings pond read 7 inches. At the current water level, small exposures of tailings beaches were noted along the upstream side of the tailings dams, in particular the South Dam (Figure 05). It was estimated that the water level was approximately 1 m below the invert of the spillway that separates the North and South Tailings Dams. This is approximately the same water elevation reported in the September 2005 inspection by SRK Consulting and probably 0.3 to 0.6 m lower than reported by EBA in their June 26 inspection of this year. It is our understanding that when necessary, tailings pond levels are lowered through pumping via the intake and pumphouse situated on the southwest side of the pond (Figure 06). Water from the pumphouse is discharged via a 150 mm line to the Cache Creek Diversion Channel (Figure 07). The pump was not in operation at the time of our October inspection.

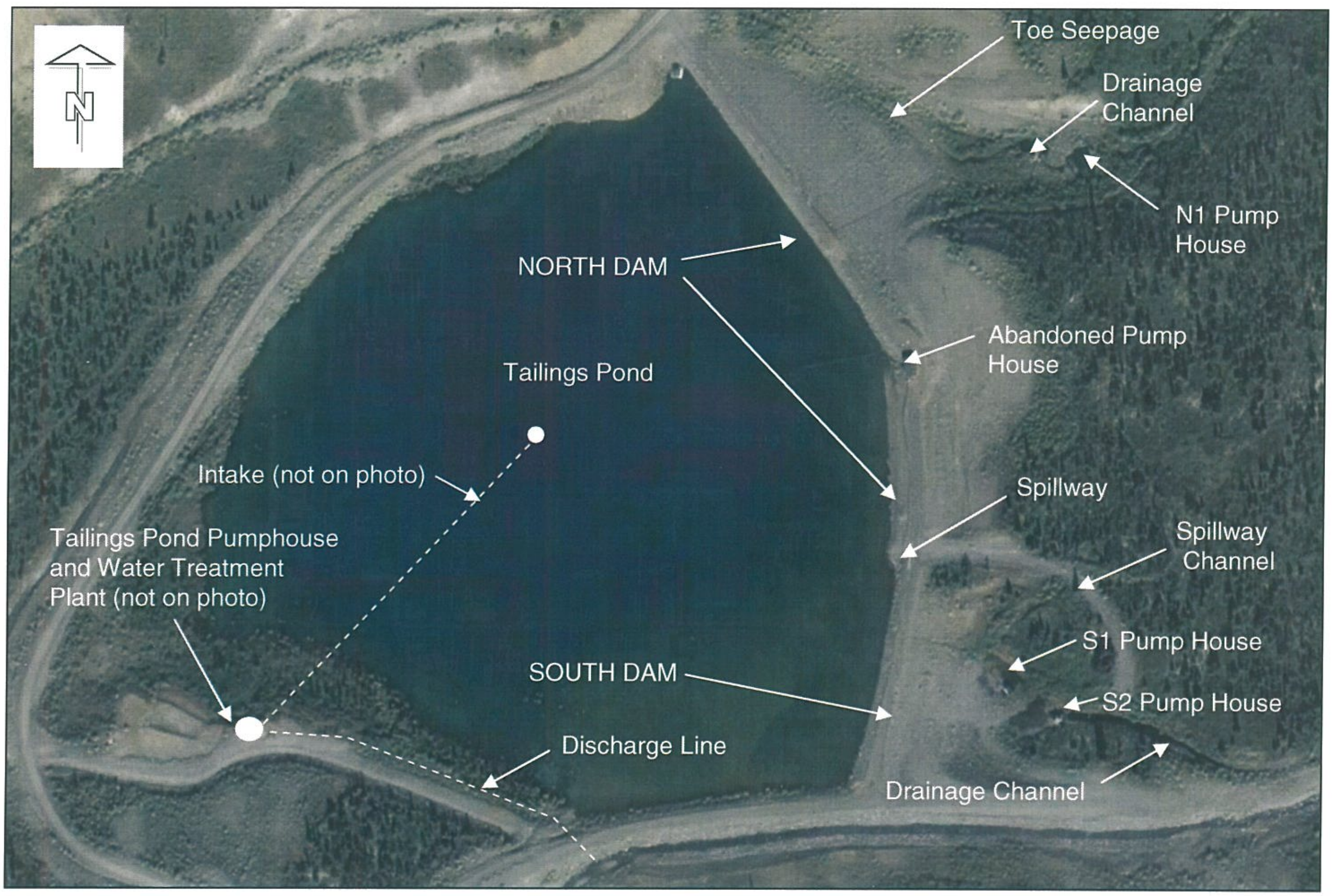


Figure 03 Tailings Impoundment

Figure 04 Upstream Side of North Dam

Figure 05 Exposed Tailings Behind South Dam

Figure 06 Pumphouse, Intake and Discharge Lines

Figure 07 Discharge Line at Cache Cr. Diversion

It is also our understanding that at one time, water from the tailings pond was circulated back to the mill via the abandoned pumphouse just north of the spillway. Seepage water was collected in ponds downstream of the North and South Dams and pumped back over the dams back into the tailings pond via Pumphouses N1, S1 and S2 (Figure 08). None of the pumps are currently operational.

When the tailings pond pumphouse is not operating, water levels in the tailings pond are somewhat self-regulated through seepage losses occurring at the toe of the North and South Dams. Weirs were installed during mine operation to measure seepage flow rates from both the North and South Dams. The V-notch weir installed in the drainage channel immediately upstream of Pumphouse N1 is no longer functional (Figure 09). Two timber weirs downstream of Pumphouse S2 are operational (Figure 10). A water treatment plant located beside the tailings pond pumphouse was not in operation during our inspection (Figure 11). While it is beyond the scope of UMA's assignment to evaluate the environmental impact from seepage effluent, it is our understanding that the seepage water from the tailings pond meets the effluent quality limits established for the site; it is not presently necessary to treat the effluent from the tailings pond.

Figure 08 Pumphouse S1

Figure 09 Pumphouse N1 and Weir

Figure 10 Weirs D/S of South Dam

Figure 11 Water Treatment Plant

#### 3.1.1.2 Tailings Pond Dams

Inspection of the tailings pond dams included a visual assessment of the crest and slopes and seepage conditions at the downstream toe. Only a cursory inspection of the spillway was carried out as this has been routinely been inspected and described in previous reports. It does not appear that any maintenance work or repairs have taken place on the dams since the last inspection by EBA in June 2007.

The dam crest is in generally good condition with no visible tension cracks or tilting. A minor depression of the crest (less than 0.2 m) was noted in the vicinity of Piezometer Nest 11 in the North Dam (Figure 12) and also from the spillway to Piezometer Nest 12 on the South Dam. It appears that the crest was recently surveyed (evidenced by paint marks along the edge), which could provide confirmation of these visual observations. The observation of crest depressions on the South Dam is also supported by apparent settlement of the protective casing at Piezometer P96-12B&C (Figure 13).

Figure 12 North Dam Crest

Figure 13 Piezometer P12B&C on South Dam Crest

The dam slopes are in good condition with no visible signs of bulging or erosion. Vegetative cover is sparse although saplings up to 25 mm in calliper have become established on the upstream and downstream slopes of both dams as seen on Figures 14 and 15.

Figure 14 Saplings on North Dam Slopes

Figure 15 Saplings on D/S Slope of South Dam

Seepage was noted at the toe of the North Dam at several locations along a stretch of about 20 m (Figure 16). Water from these seeps collects into a common drainage channel that runs into the collection pond at Pumphouse N1 (Figure 17). Some fine grained soil has accumulated at the bottom of the drainage channel just upstream of the V notch weir. Although the source of these fines could not be determined they may be from surface erosion of the silty soil beyond the toe since the water seeping from the toe of the dam was clear. The ground is also very soft in the area of the seeps with quicking conditions evident. The soft zone extends up the face of the dam by approximately 1 m. Although seepage was not observed at the toe of the South Dam, water accumulating at the surface of the granular drainage blanket and flow downstream of the pumphouse clearly indicates that seepage losses similar to the North Dam are occurring.

Figure 16 Seepage at Toe of North Dam

Figure 17 Drainage Channel at Toe of North Dam

The spillway located between the North and South Dams is in good condition (Figure 18). As previously noted by others, the granular material across the spillway channel, in particular on the downstream side of the dam centreline is made up of material with a $D_{50}$ less than 75 mm (SRK, 2005). Previous reports have raised a concern with respect to the ability of the spillway to convey large flows without experiencing significant erosion. Although the spillway is located within natural high ground between the two dams, erosion of the spillway channel material could cause weakening of the structure. A small sink hole in the downstream face of the South Dam was noted, however, this feature is related to extraction of a timber utility pole at this location (Photo 19).

Figure 18 Spillway (view D/S)

Figure 19 Sinkhole in South Dam

### 3.1.2 Diversion Channels

The inspection included a visual inspection of the two diversion channels which divert surface water around the tailings impoundment. They are the Cache Creek Diversion that conveys Cache Creek around the south side of the tailings pond, and the Lower Subsidiary Creek Diversion that reroutes flow around the southwest portion of the pond.

#### 3.1.2.1 Cache Creek Diversion

The upstream and middle segments of the Cache Creek Diversion are in good condition (Figure 20). The riprap armouring is stable and no down-cutting of the channel is evident. The far end of the downstream segment (east of the South Dam centreline) is considerably steeper with evidence of ongoing ravelling of riprap along the bank (Figure 21 and 22). Down-cutting of the bedrock through which the channel is founded at the confluence with the drainage channel from the South Dam seepage pond is also evident (Figure 23). The narrow channel width and steep banks of the downstream channel segment makes it more prone to blockages from bank instabilities or ravelling of riprap from the banks.

Figure 20 Middle Segment of Cache Cr. Div.

Figure 21 D/S Segment of Cache Cr. Div.

Figure 22 Ravelling of Riprapped Bank

Figure 23 Bedrock Down-Cutting

### 3.1.3 Lower Subsidiary Creek Diversion

The Lower Subsidiary Creek Diversion is in generally good condition along its length from the mine site access road to its confluence with the Cache Creek Diversion. The 600 mm diameter culvert at the downstream end of the channel is in good condition with no blockages (Figure 24). Based on observations at a weir just upstream of the culvert, the flow is estimated to be in the order of 1 l/sec (Figure 25). Tension cracks and minor slumping of the channel bank about 60 m downstream of the mine access road was noted (Figure 26). Similar observations were made at the road crossing where the channel banks are about 2.5 m high with slopes of about 1 horizontal to 1 vertical (1H:1V). The two 600 mm diameter culverts at the road crossing are in good condition (Figure 27).

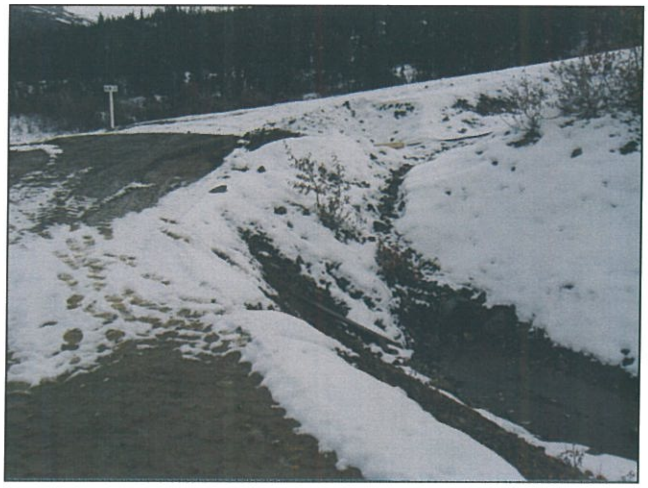

Figure 24 Culvert at End of Diversion Channel

Figure 25 Weir in LSCD, View U/S

Figure 26 Minor Bank Slumping

Figure 27 Culverts at Upstream End of Channel

#### 3.1.3.1 Northwest Interceptor Ditch

The Northwest Interceptor Ditch intercepts and conveys surface water run-off from higher ground to the northwest around the tailings pond. It runs along the northwest side of the mine access road with a high point (drainage divide) about halfway along the edge of the pond. From this point water either runs southwest feeding into the Lower Subsidiary Creek Diversion or northeast along the edge of the road away from the tailings impoundment. The ditch has a bottom width of about 2 m southwest of the drainage divide with sideslopes of about 2H:1V (Figure 28). Northeast of the divide, the channel is V-shaped with steeper slopes estimated to be about 1H:1V (Figure 29).

Figure 28 U/S Segment of Interceptor Ditch

Figure 29 D/S Segment of Interceptor Ditch

### 3.2 Mine Access Road

Channel armouring (riprap) has been placed at eight locations along the east bank of the Ketza River where the mine site access road is susceptible to erosion (Figure 30). Brief inspections were carried out at each of these locations (A to H) with brief descriptions provided as follows:


Figure 30 Channel Armouring Along Mine Access Road

### 3.2.1 Location A

Located on a gentle outside bend, the riprap along this 75 m long segment is in good condition with no evidence of bank erosion (Figure 31). The bank is about 2 m high. Riprap size is up to 900mm with an estimated $D_{50}$ of 300mm.

Figure 31 Riprap at Location A

### 3.2.2 Location B

Location B is at a section of the road that washed out in the spring of 2007 and has since been repaired (Figure 32). Riprap has been placed along the new road alignment leaving the old road bed exposed within the channel where it is being actively eroded (Figure 33). The riprap is in good condition with no evidence of erosion of the new road bed. Some undercutting of the riprap should be expected as the old road bed erodes unless it has been keyed into the channel bottom. The bank is about 3 m high. Riprap size is up to 750 mm with an estimated $D_{50}$ of 250 mm.

Figure 32 Road Washout at Location B

Figure 33 Erosion of Old Roadbed

### 3.2.3 Location C

Location C is a 15 m long section of riprap at a sharp outside bend of the river channel (Figure 34). The bank is about 2 m high with the riprap in good condition with no evidence of active bank erosion (Figure 35). Riprap size is up to 800 mm with an estimated $D_{50}$ of 250 mm.

Figure 34 View D/S at Location C

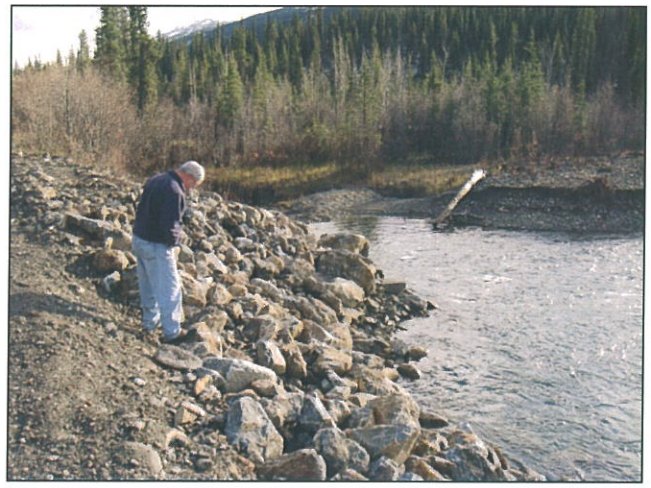

Figure 35 View U/S at Location C

### 3.2.4 Location D

Location D is along a 50 m long stretch at a gentle outside bend of the river channel. The riprap has been in place for many years and is in good condition with no evidence of active erosion. There is a 300 mm diameter culvert crossing the road at this location (Figure 36). The bank is about 1 m high. Riprap size is up to 900 mm with an estimated $D_{50}$ of 250 mm.

Figure 36 Culvert at Location D

### 3.2.5 Location E

Location E is about 50 m long along a gentle outside bend in the channel where the road is flanked on the east side by bedrock (Figure 37). The riprap is in good condition with no evidence of active erosion. The bank is about 1.5 m high. Riprap size is up to 1,500 mm with an estimated $D_{50}$ of 450 mm. Many of the riprap pieces are flat.

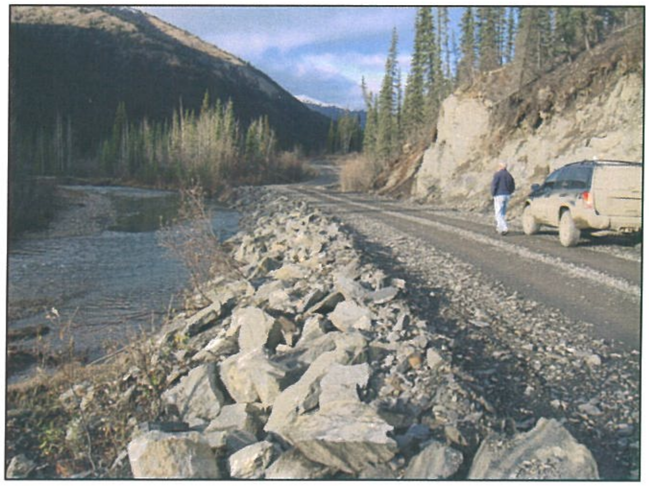

Figure 37 View D/S at Location E

### 3.2.6 Location F

Location F is about 50 m long along a moderate outside bend in the channel (Figure 38). The riprap is in good condition with no evidence of active erosion. The bank is about 2 m high (Figure 39). Riprap size is up to 1,000 mm with an estimated $D_{50}$ of 450 mm. Many of the riprap pieces are flat.

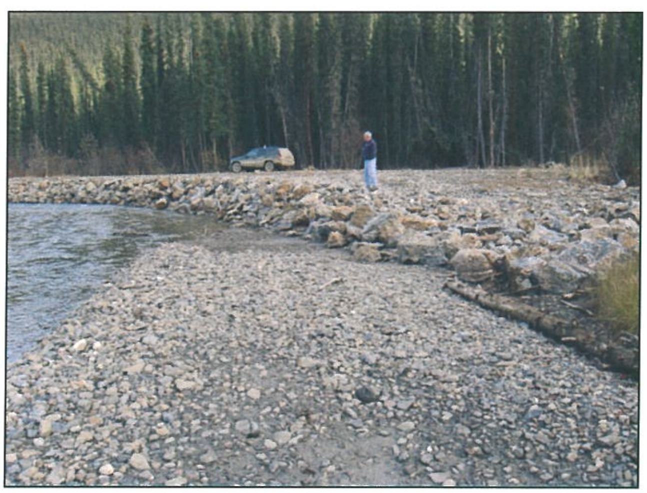

Figure 38 View D/S at Location F

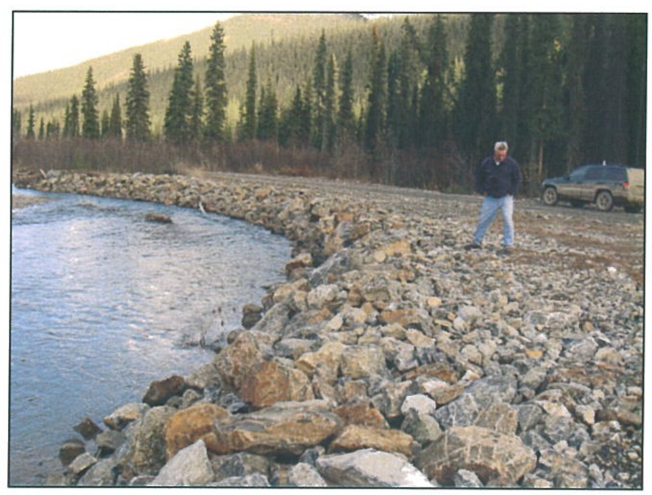

Figure 39 View D/S at Location F

### 3.2.7 Location G

Location G is along a gentle outside bend in the channel where the riprap extends for well over 100 m (Figure 40 and 41). The riprap is in good condition with no evidence of active erosion. The bank is about 2 m high. Riprap size is up to 900 mm with an estimated $D_{50}$ of 450 mm.

Figure 40 View D/S at Location G

Figure 41 View D/S at Location G

### 3.2.8 Location H

Location H is the farthest downstream point just before the road and creek channel diverge. It is located on the outside bend of a channel meander where armouring has been recently placed for a distance of about 100m (Figure 42 and 43). A 400 mm diameter culvert crosses the road from a recently excavated drainage ditch on the opposite side of the road (Figure 44 and 45). Although there was no water flowing in the ditch at the time of our inspection, the bottom $1/3^{rd}$ of the culvert is blocked with sand from previous flows. The bank is about 2 m high. Riprap size is up to 900 mm with an estimated $D_{50}$ of 300 mm. The upstream transition of the armouring with the shoreline is abrupt which may result in scouring towards the road during high flow events (Figure 46). The downstream transition appears adequate (Figure 47).

Figure 42 View U/S at Location H

Figure 43 View U/S at Location H

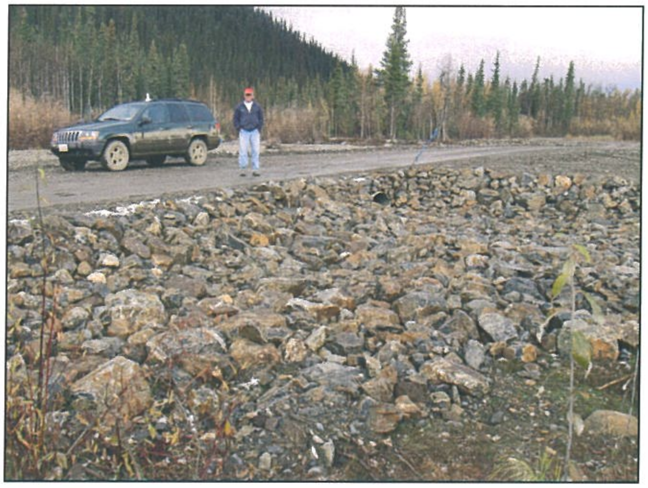

Figure 44 Culvert at Location H

Figure 45 Drainage Channel at Location H

Figure 46 U/S Transition at Location H

Figure 47 D/S Transition at Location H

# 4.0 Structure Classifications

The tailings pond dams, diversion channels and interceptor ditch that are considered to be part of the overall Tailings Management Area (TMA) have been classified using the 2007 CDA Dam Safety Guidelines in terms of the reasonably foreseeable consequences of failure. These classifications are based solely on our cursory inspection and review of available background information with respect to dam and channel stability. A rigorous Dam Safety Review would be required to assess each of the consequence categories more thoroughly to confirm if these classifications are appropriate. It should also be recognized that the classifications have been arrived at without input from the Owner, Regulator or other stakeholders.

The results of the structure classifications are summarized in Table 4-1. The loss of life consequences were evaluated separately from socioeconomic, financial and environmental consequences. While we are aware that the release of tailings pond water is currently acceptable, we have speculated that the environmental impact associated with a dam failure would likely be considerable. Dyke Classifications are taken as the higher of the three consequence categories. Also shown in Table 4-1 are the associated time periods between Dam Safety reviews as recommended in the CDA Dam Safety Guidelines.

**Table 4-1 Structure Classifications**

| Structure | Consequence Category | | | Structure Classification | Maximum Period Between Reviews |
|---|---|---|---|---|---|
| | Loss of Life | Environmental & Cultural Values | Infrastructure & Economics | | |
| North Dam | Low | High | Low | High | 7 years |
| South Dam | Low | High | Low | High | 7 years |
| Cache Creek Diversion | Low | Low | Low | Low | Note 1 |
| Lower Subsidiary Diversion | Low | Low | Low | Low | Note 1 |
| NW Runoff Interceptor Ditch | Low | Low | Low | Low | Note 1 |
| Tailings Pond Pumphouse & Discharge Line | Low | Low | Low | Low | Note 1 |

Note 1: A Dam Safety review is not required for low-consequence dams. However, the consequences of failure should be reviewed periodically, since they may change with downstream development. If the classification increases, a Dam Safety Review is required at that time.

# 5.0 Risk Assessment

## 5.1 Approach

A qualitative risk assessment was carried out for both tailings pond dams and the associated channel diversions and interceptor ditch to assess the risk posed by the structures and identify potential mitigation measures where warranted. The approach considers a number of possible events (e.g. dam failure) for which a risk score can be determined. The risk score is the product of the likelihood, exposure and the possible consequences of the event. The risk scores are then used to determine the risk level for each structure. Recommendations for action (e.g. monitoring or repairs) are based on the risk level. The individual components used in determining the risk score are as follows:

**Likelihood -** Likelihood is the probability of the event occurring. The risk assessment approach for this study uses a ranking of likelihood that is directly related to a failure of the tailings pond dam or containment of the diversion channels. A summary of the risk likelihood categories and associated scores is given in Table 5-1.

**Table 5-1 Likelihood Categories**

| LIKELIHOOD OF DYKE FAILURE | DESCRIPTION | SCORE |
|---|---|---|
| Negligible **(N)** | Practically Impossible | **0.2** |
| Unlikely **(U)** | Conceivable But Very Unlikely | **0.5** |
| Low **(L)** | Remotely Possible | **1** |
| Moderate **(M)** | Unusual But Possible | **3** |
| Probable **(P)** | Quite Possibly Could Happen | **6** |
| Highly Probable **(HP)** | Might as Well Be Expected | **10** |

**Exposure -** For each event in the risk assessment, there is a potential exposure to that risk. The exposure is the frequency that there is a likelihood of the event occurring. A summary of the exposure categories and associated scores is given in Table 5-2.

**Table 5-2 Exposure Categories**

| EXPOSURE | DESCRIPTION | SCORE |
|---|---|---|
| Unlikely **(U)** | Very Rare (Yearly or Less) | **0.5** |
| Very Low **(VL)** | Rare (Few Times Per Year) | **1** |
| Low **(L)** | Unusual (Once Per Month) | **2** |
| Moderate **(M)** | Occasional (Once Per Week) | **3** |
| Probable **(P)** | Frequent (Daily) | **6** |
| Highly Probable **(HP)** | Continuous | **10** |

**Consequences -** Each event may have a number of possible consequences as a result of the event in terms of an impact on operations of the TMA, for example, an injury or fatality or the cost of an environmental clean-up. The environmental impact has been combined with the overall economic consequences of a particular event. The possible consequences and associated scores are given in Table 5-3.

**Table 5-3 Consequence Categories**

| CONSEQUENCES | CATEGORY | SCORE |
|---|---|---|
| ***Minor incident or inefficiency of little or no consequence.***<br>**Operations:** No impact on operations.<br>**Health & Safety:** Near miss or recordable first aid to multiple employees.<br>**Environmental and Economic:** <$10k | VERY LOW<br>**(VL)** | **3** |
| ***Minor incident or inefficiency that may require review and is easily remediated.***<br>**Operations:** Operations delay of up to two weeks<br>**Health & Safety:** Recordable case, minor injuries to multiple employees.<br>**Environmental and Economic:** $10,000 to $100,000 | LOW<br>**(L)** | **7** |
| ***Moderate event that may need some physical attention and certainly review.***<br>**Operations:** Operations delay of up to a few months.<br>**Health & Safety:** Serious lost time injuries to multiple employees.<br>**Environmental and Economic:** $100,000 to $1,000,000 | MODERATE<br>**(M)** | **15** |
| ***Significant event that can be addressed but with great effort.***<br>**Operations:** Significant delay of six months to one year.<br>**Health & Safety:** Serious injuries to multiple employees, possible fatality to an employee.<br>**Environmental and Economic:** $1,000,000 to $10,000,000 | HIGH<br>**(H)** | **40** |
| ***Major uncontrolled event with uncertain and perhaps prohibitively costly remediation.***<br>**Operations:** Operations delay more than one year.<br>**Health & Safety:** Multiple fatalities.<br>**Environmental and Economic:** > $10,000,000. | EXTREME<br>**(E)** | **100** |

The risk level can then be assessed based on the risk score as shown in Table 5-4. Three categories, **I**, **II** and **III** are used for low, moderate and high levels of risk respectively. For example, the risk level associated with a risk score of 100 would be **II** or moderate.

**Table 5-4 Risk Levels**

| RISK LEVEL | DESCRIPTION | RISK SCORE |
|---|---|---|
| **I** | Low Level of Risk | less than 70 |
| **II** | Moderate Level of Risk | 70 to 200 |
| **III** | High Level of Risk | greater than 200 |

Finally, it is necessary to identify the degree of confidence and variability for the Risk Levels as shown in Table 5-5:

**Table 5-5 Confidence Levels**

| CONFIDENCE LEVEL | DEGREE OF CONFIDENCE | DEGREE OF VARIABILITY |
|---|---|---|
| Low **(L)** | Low Confidence | Could Vary Significantly |
| Moderate **(M)** | Moderate Confidence | Moderate Variability |
| High **(H)** | Confident | Low Variability |

### 5.2 Discussion

The Risk Assessment for the Ketza Mine TMA focuses on events involving slope instabilities or overtopping of the Dams resulting in the release of untreated water and tailings to the downstream environment. It must be recognized that this evaluation is based on the current condition and operation of the TMA and does not take into account any alterations to the method of operation or major modifications to structures to accommodate future tailings disposal. The consequences of such events include but may not be limited to environmental damage, property damage, injury or loss of life. The sections below provide a brief description of the pertinent structures which form the TMA and some of the potential events and resulting impacts that could occur in the event of slope instabilities and / or breach.

A deep seated slope instability on either the North or South Dam could trigger a breach resulting in the uncontrolled release of tailings pond water and tailings into the Cache Creek valley. A significant environmental impact would likely result from such an event. The likelihood of loss of life or injury downstream of the dam is low given the limited occupancy in this downstream area. The most likely location for instabilities to occur is in the highest section of the North Dam (in the middle of the valley) where seepage and soft ground are evident at the downstream toe. Previous stability analysis has determined that the stability of the downstream toe is marginal at this location under dynamic (seismic) loading conditions.

Another potential breach location is considered to be the spillway between the dams if it erodes during a significant flow event. Such an event would most likely be triggered by an inflow of water that is normally diverted around the pond. It is our understanding that such an event occurred in the spring of 2007 when an ice dam in the Lower Subsidiary Creek Diversion caused water to flow across the road into the tailings pond. The tailings pond pumphouse and discharge line have also been evaluated since a break at the downstream end of the line could lead to a wash out of the road that could in turn cause water to drain in an uncontrolled manner from the tailings pond into the Cache Creek Diversion.

### 5.3 Risk Assessment Score

For each of the structures which form the TMA, a risk score has been calculated and is presented in Table 5-6. The Risk Assessment Score has been evaluated for large slope movements which would result in a significant loss of tailings and water due to a dam breach. The risk score is the matrix (product) of the likelihood of the event occurring, the exposure to the event occurring and consequences that may result from the event occurring.

**Table 5-6 Risk Assessment Score**

| Structure | Likelihood | Exposure | Consequences | Risk Score | Risk Level | Confidence Level |
|---|---|---|---|---|---|---|
| North Dam | 3.0 | 1.0 | 40 | 120 | II | Moderate |
| South Dam | 0.5 | 1.0 | 40 | 20 | I | Moderate |
| Cache Creek Diversion | 0.5 | 0.5 | 15 | 4 | I | High |
| Lower Subsidiary Creek Diversion | 6.0 | 1.0 | 15 | 90 | II | Moderate |
| NW Runoff Interceptor Ditch | 0.5 | 0.5 | 7 | 2 | I | Moderate |
| Tailings Pond Pumphouse & Discharge Line | 1.0 | 1.0 | 7.0 | 7.0 | I | Moderate |

The North Tailings Pond Dam and Lower Subsidiary Creek Diversion have risk scores that fall within Risk Level II, primarily as a result of the potential environmental consequences that may occur as a result of a slope stability failure of the North Dam or breach of the spillway. The South Dam, Cache Creek Diversion and NW Runoff Interceptor Ditch have risk scores that fall within Risk Level I.

# 6.0 Discussion and Recommendations

The following guidelines for follow-up work are generally associated with the three possible Risk Levels determined in the risk assessment:

**Risk Level I**

- Upgrade deficiencies
- Conduct an annual condition assessment.

**Risk Level II**

- Implement a comprehensive monitoring program.
- Prepare an Emergency Preparedness Plan (EPP).
- Develop an action plan for remedial works.
- Consider the implementation of remedial works to reduce risk.

**Risk Level III**

- Immediate action should take place to reduce/control risk.

Given that no structures have been assigned scores that would place them at a Risk Level of III, immediate action is not considered necessary. However, two structures have scores that fall within Risk Level II. Accordingly, it is recommended that a monitoring program be implemented for these structures. The program should consist of an annual condition assessment but also include monthly monitoring during the spring, summer and fall by Mine Site staff. The monthly checks would act as an early warning system in the event that distress is identified at any of the TMA structures.

An EPP should be prepared to identify the appropriate course of action should events occur that might lead to or be the direct cause of significant environmental consequence, loss of property or personal injury or death. This EPP should include but not be limited to appropriate mitigation measures, evacuation, notification process, and contingency plan.

The following remedial works should be considered:

- Construct downstream toe berm at the North Dam (planned for summer 2008).

- Evaluate the hydraulic capacity and erosion potential for the spillway. Repair/upgrade as required.

- Repair weirs downstream of the North Dam to allow flow measurements to be made.

- Install piezometers near the toe of the North Dam where the toe berm is to be constructed. The piezometers are required to confirm design objectives with respect to seepage are met and to confirm groundwater levels used in previous slope stability analysis.

- Consider an emergency spillway to the Cache Creek Diversion at the downstream end of the Lower Creek Subsidiary Diversion in the event that the culverts are blocked.

- Cut saplings on upstream and downstream dam slopes.
- Survey dam crest and identify any areas below design elevation. Fill low areas as required.
- Repair riprap at the downstream segment of the Cache Creek Diversion.

Once these remedial works have been completed, the risk assessment should be revisited to determine if the scores have been lowered sufficiently to reassign a reduced Risk Level.

Although outside of the TMA, it is recommended that the erosion protection measures along the mine access road also be inspected on a regular basis and maintained as required. In particular, attention should be given to the upstream end of the riprap installed at Location H where scouring is considered likely to occur. Location B should also be closely monitored to determine if additional armouring is required once the old roadbed between the repaired section and the river has eroded.

# 7.0 Closure

The findings and recommendations of this report are based on a review of the available information and the results of the 2007 inspection by UMA. Interpretation of this information has been intended for the sole purpose of assessing stability for the dams and diversion channels within the TMA in order to qualitatively assess the risk posed by these structures. This approach is an engineering reliability technique to systematically identify, characterize and screen risks that derive from the failure to operate as intended.

This review has been based on current operating conditions for the Ketza Mine TMA. Should a revised operation plan for the TMA be considered, the risk assessment should be updated, beginning with any necessary reclassification of the structures. UMA trusts that this information has been of value to the Government of Yukon. Should you have any questions regarding this report, please contact Mr. Ken Skaftfeld, P.Eng. at this office.

Respectfully Submitted,

**UMA Engineering Ltd.**

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Senior Geotechnical Engineer
Earth and Water

PERMIT TO PRACTICE
Signature
Date FEB 12/08.
PERMIT NUMBER: PP066
Association of Professional Engineers of Yukon

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TERRITORY
FEB 12/08.
ENGINEER

# Appendix A
# Site Photographs and Video