Government of Yukon

Water Resources Branch

United Keno Hill Mine, YT

2007 Geotechnical Inspections

Prepared by:
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UMA Project No.: 6029 010 00 (4.10.4)

February 2008

D R A F T

February 7, 2008 UMA Project No.: 6029 010 00 (4.10.4)

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
United Keno Hill Mine, YT

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 studies or remedial works are provided.

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

Sincerely,

UMA Engineering Ltd.

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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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 United Keno Hill Mine (UKHM), YT. 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 structures within the Elsa Tailings Management Area (TMA) are being operated according to acceptable engineering standards, to identify issues for follow-up and to advise on the adequacy of proposed mitigation measures. 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 TMA structures in the company of the Project Manager.

3. Prepare a site inspection report detailing the condition of the TMA 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. Participate, as required, in teleconferences with the owners of the structures and/or their representatives, other government representatives to discuss observations and recommendations, and to assess proposed mitigations.

5. 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 United Keno Hill Property is located near the community of Keno in the Mayo Mining District, approximately 452 km north of Whitehorse (Figure 01). This part of the central Yukon is characterized by rolling hills and mountains rising to about 1,200 m above sea level. There are a number of old mining operations spread out over three mountains (Keno, Sourdough, and Galena Hills). The Elsa tailings are located in the Flat Creek valley over permafrost affected soils.

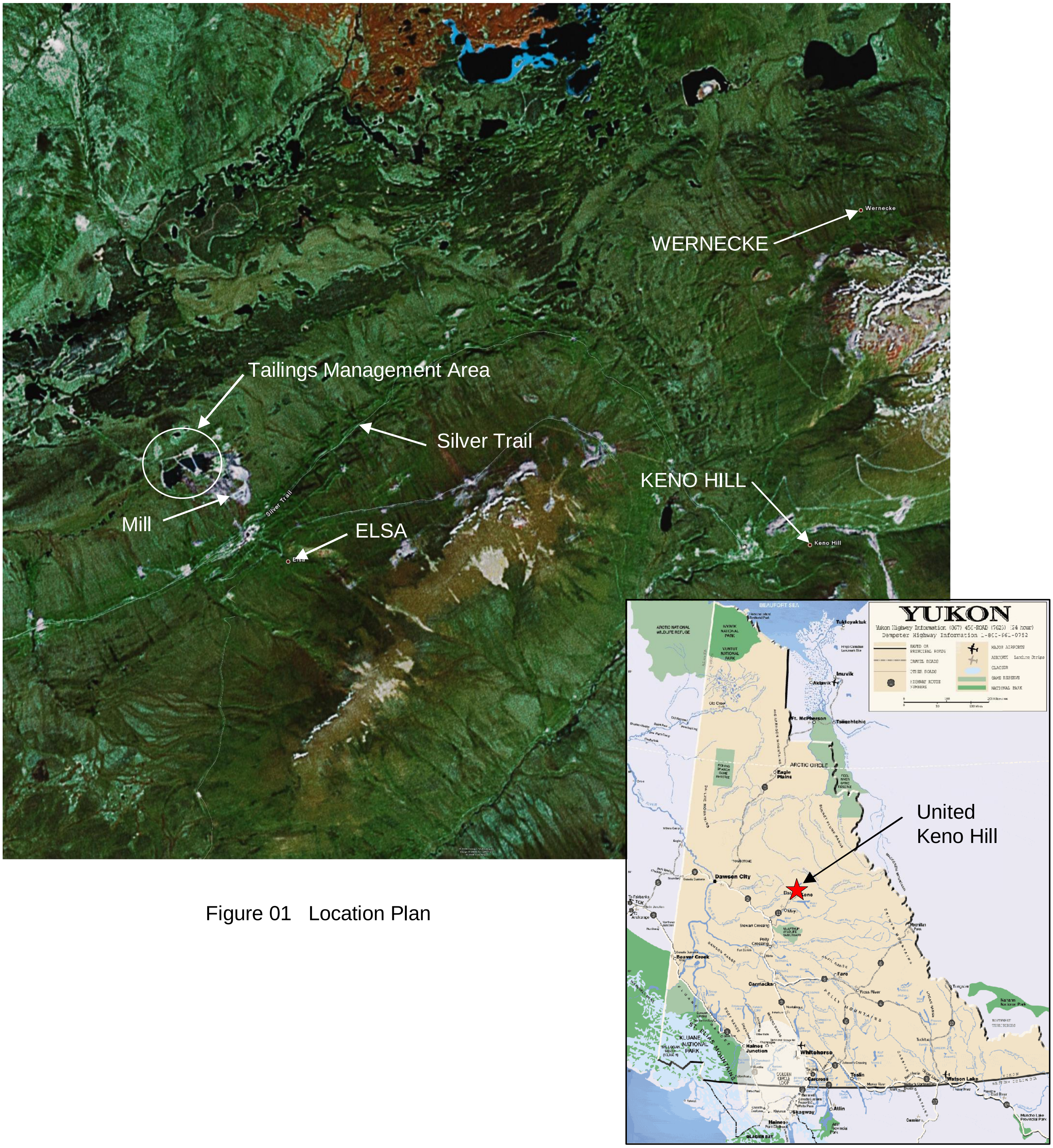

Figure 01 Location Plan

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. – United Keno Hill Mines Limited – Review of Proposed Closure plan For Current Conditions, October 1996.

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

- Miscellaneous Mine Site Drawings including Tailings Dam Drawings from UKHM dated 1972.
- The Department of Indian Affairs and Northern Development – Screening report Under the Canadian Environmental Assessment Act, United Keno hill Mines reopening and Closure – March 1997.
- Excerpts from Report No. UKH/96/04 Water Licence Specifications (Pgs. 6 to 13).
- SRK Consulting – Draft Preliminary Environment Baseline Assessment, United Keno Hill Mines – December 2005.

It is our understanding that thaw-settlement of the permafrost affected soils beneath the dams has been problematic since their construction and regular raising of the crests are required. Two dam failures, believed to be associated with separation and/or collapse of culverts through the dams have been reported since 1972 (DIAND, 1997). At least one of these failures occurred on Dam 2. It is also believed that previous dam failures have resulted in tailings depositions as far downstream as Dam 3.

3.0 Condition Assessment

The condition assessment was carried out on October 3rd 2007 by Mr. Ken Skaftfeld, P.Eng. of UMA Engineering in the company of the Government of Yukon's Project Manager, Mr. Glenn Ford and Mr. Frank Patch of the Government of Yukon, Department of Energy, Mines and Resources. Temperatures were around zero degrees Celsius. Several photographs and a video were taken during the inspection. These have been included on the CD (photographs) and DVD (video) attached to this report as Appendix A. Select photographs from the photo set have been used throughout the report.

3.1 Tailings Management Area

The Elsa Tailings Management Area is located in the Flat Creek valley below the Elsa mill. It consists of three Dams, (Dam 1, Dam 2 and Dam 3) as shown on Figure 02, 03 and Drawing 01. Dam 1 provides the majority of tailings impoundment while Dams 2 and 3 provide retention areas for water treatment and the deposition of lime sludge. Pond 2 and Pond 3 are situated on the east side of each respective dam. The Porcupine Creek diversion channel diverts water around the TMA. A seepage collection ditch along the edge of the tailings area directs tailings seepage water into Pond 3.

Figure 02 Overall Tailings Management Area

Figure 03   Dams 1 (right) and 2 (left)

3.1.1 Dams

Inspection of the dams included a visual assessment of the crest and slopes and where accessible, the downstream toe area.

Dam 1

Dam 1 is rock fill structure about 5 m in height and about 800 m long. The freeboard at the time of our inspection was estimated to be 2 m. Two culverts originally installed through the base of Dam 1 have since been abandoned although the discharge end of the most northerly culvert is still visible. Downstream side slopes are estimated to range from 1.5 horizontal to 1 vertical (1.5H:1V) to 2H:1V. The crest elevation is uneven and it appears that fill has recently been added along the top of the dam at several locations to restore the design crest elevation. An 8 m wide toe berm, about 1.5 m high has been added on the downstream side of the dam (Figure 04). Sections of the toe berm that have apparently settled have been filled with darker coloured granular material. Iron staining visible on the downstream slope above the top of the toe berm is indicative of a seepage flow path exiting above the toe berm, although no seepage was noted during the inspection (Figure 05).

Figure 04 Downstream Toe Berm

Figure 05 Iron Staining

Water from Pond 1 was being siphoned over Dam 1 at the time of our inspection through a 150 mm diameter pipe (Figure 06). A larger pipe on the toe berm conveyed water into Pond 2 (Figure 07). A decant weir consisting of a steel box with stop-log gates located near the south abutment is in good condition although not in use at the time of our inspection (Figure 08). There are three openings in the structure fitted with stop log guides. A 900 mm diameter corrugated metal pipe (CMP) discharges water from the decant weir through the dyke to a lime addition plant on the downstream side (Figure 09). Two steel pipes inside of the CMP are likely for heating. The water level in Pond 1 was well below the base of the decant weir although corrosion on the lower half of the structure provides an indication of previous pond elevations.

Figure 06 Siphon Over Dam 1

Figure 07 Siphon Discharge into Pond 2

Figure 08 U/S Decant Weir in S Abutment of Dam 1

Figure 09 Decant Weir Discharge Culvert Inlet

A 900 mm diameter corrugated metal pipe connects the decant weir to a lime addition plant consisting of an insulated slurry tank, mixer and discharge chute (Figure 10). The plant is in some disrepair and it appears that the inlet culvert through the dyke has settled relative to the inlet to the lime plant (Figure 11). Armouring on the upstream side of the dam is sparse for the first 30 m north of the south abutment and was limited to coarser dyke fill material up to 250 mm diameter exposed from wave action (Figure 12). Between the siphon and middle of the dam, the armouring consists of riprap with an estimated maximum size of 250 mm and a D_{50} of 150 mm. The armouring along this stretch is in good condition (Figure 13) with the high water mark (evidenced by iron staining) visible about 1 m below the crest. The upstream slopes in this stretch are in the order of 1.5H:1V to 2H:1V. A staff gauge in Pond 1 read 0.81 m.

Figure 10 Lime Addition Plant

Figure 11 Settlement of Lime Plant Inlet Pipe

Figure 12 Upstream Slope at Siphon

Figure 13 Upstream Slope at Staff Gauge

The upstream slope of the northern half of the dam are at about somewhat flatter at about 3H:1V with heavier armouring material up to 750 mm in diameter (Figure 14). The downslope side is at about 2H:1V with saplings up to 3 m high becoming established (Figure 15). A 150 mm diameter polyethylene line shown in Figure 14 is used to pump water back from Pond 3 into Pond 1. No water was being pumped during the site inspection.

Figure 14 Upstream Armouring Along N Half

Figure 15 Saplings at toe of D/S Slope

The discharge end of an abandoned culvert is visible on the downstream side of Dam 1 (Figure 16). Gravel washed into Pond 2 and crest settlement are evident immediately south of the culvert where it appears that the crest has been raised by about 0.75 m and the downstream slope at the toe berm area has been recently filled (Figure 17 & 18). Iron staining on the downstream slope surface is also visible. There is also minor longitudinal cracking (about 7 m long) along the downstream edge of the crest at this location (Figure 19).

Figure 16 Abandoned Culvert

Figure 17 Toe Repair Area

Figure 18 Crest Settlement Repair

Figure 19 Longitudinal Cracking

Dam 2

Dam 2 is about 3 m high and about 420 m long. Design drawing F-128-A indicates the dam was to be constructed using local esker material with a waste rock drainage blanket and cover on the downstream slope. The freeboard at the time of the inspection was estimated to be in the order of 3 m. Upstream and downstream slopes are steep, ranging from about 1H:1V to 1.5H:1V (Figure 20). Slopes below the water level in Pond 2 were estimated to be in the order of 6H:1V or flatter. Rilling (erosion gullies) of the downstream slope is occurring about 30 m north of the south abutment (Figure 21). Riprap armouring on the upstream slope from the toe to the high water line has a maximum size of about 900 mm with a D_{50} of

400 mm. There is also ponding of water at the downstream toe in this proximity. Minor erosion of the upstream slope was noted for a distance of about 90 m south of the decant weir.

Figure 20 View N Along Dam 2 and Pond 2

Figure 21 Rilling on D/S Edge of Crest

Lateral spreading along the upstream edge of the crest and upstream slope begins about 165 m south of the decant outlet. At the south end of this area, the tension cracks appear old and are up to 75 mm wide (Figure 22). More recent (active) cracking is apparent in a northerly direction along the dam towards the decant outlet where they have extended to within 2 m of the centerline of the dam (Figure 23). Vertical slumping in this area is estimated to be up to 300 mm. Riprap along the upstream toe may be associated with previous repair measures.

Figure 22 Tension Cracks and Slumping

Figure 23 Tension Cracks Extending to CL

A decant outlet (weir) and lime addition system are located near the middle of the dam (Figure 24). The timber decant outlet is in very poor condition and on the verge of collapse (Figure 25). A 150 mm diameter polyethylene line siphons water from pond 2 into Pond 3 at this location, although it was not in operation at the time of our inspection (Figure 26). There are stop log guides on the upstream side of the structure but it does not appear that they have been used in the recent past. During higher water levels in Pond 2, it appears seepage flow occurs beneath the structure as evidenced by staining and a void beneath the downstream discharge apron. A small channel has been excavated at the discharge point into Pond 3 (Figure 27).

Figure 24 View S at Decant Weir and Lime Mixer

Figure 25 Upstream Side of Decant Weir

Figure 26 D/S Side of Weir Showing Siphon

Figure 27 Channel/Pond D/S of Weir

A secondary containment dyke is visible on the downstream side of Dam 2 at the weir (Figure 28). It is believed that it was an emergency dyke built sometime before the construction of Dam 3 (SRK, 2005). The dyke is about 1 m high with a 900 mm diameter culvert installed near the north end (Figure 29). The toe of Dam 2 was noticeably soft and wet at the junction of the secondary containment dyke.

Figure 28 Water Behind Secondary Dyke

Figure 29 Culvert Through Secondary Dyke

The armouring along the upstream edge extends for about 15 m north of the weir beyond which, there is no upstream erosion protection until about 15 m from the north abutment (Figure 30). Erosion of the unprotected dam slope in this stretch is minor. The maximum rock size visible is in the order of 100 mm. Downstream slopes are steep at about 1H:1V (Figure 31).

Figure 30 U/S Side N of Weir (view S)

Figure 31 D/S Side N of Weir (view N)

Dam 3

Dam 3 consists of two segments separated by naturally high ground. The total length including the high ground is in the order of 425 m. An abandoned culvert crosses the south segment of Dam 3 where the dam has also been considerably widened (Figure 32). The upstream end of the culvert has collapsed and the downstream side is not visible (Figure 33). Significant settlement of the crest over a 40 m stretch is evident just north of the culvert crossing where up to 1.2 m of fill has been added (Figure 34). A granular pad has been placed on the downstream side of the dam at this location although the function of the pad is unclear (Figure 35). Iron staining on the granular pad indicates active seepage at this location. The upstream shoreline is grassy with little to no active erosion.

Figure 32 Widened Section of Dam 3

Figure 33 Abandoned Culvert

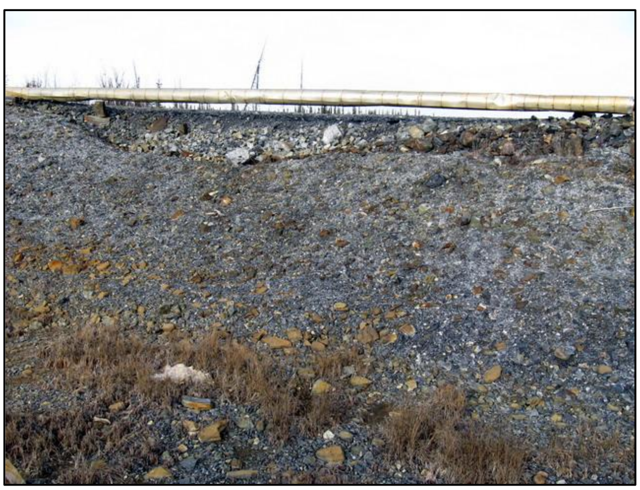

Figure 34 Crest Fill on DAM 3

Figure 35 Granular Blanket on D/S Side of Dam 3

A 900 CMP culvert is located near the south end of the north segment of Dam 3 (Figure 36). The culvert looks relatively new with no deformation or deflections visible throughout its length. The bottom of the inlet is partially blocked with timbers, likely to regulate upstream water levels. A non-woven geotextile cover has been cut open. The purpose of the geotextile is unclear but it may be for sediment control. Erosion of the downstream slope has occurred where the end of the culvert is recessed (Figure 37). The culvert is believed to be an emergency spillway for Dam 3 (SRK, 2005).

Figure 36 Culvert Inlet

Figure 37 Erosion at Culvert Outlet

The main control structure for Dam 3 is located at about mid-point along the north dam segment where the upstream slope has been widened to about 18 m (Figure 38). The structure consists of a steel decant box with stop-log guides on the inlet end (Figure 39). The wooden gate (not in use at the time of our inspection) fits into the stop-log guides. A 750 mm diameter steel pipe fastened to the box runs through the dam exiting about 1.5 m above the toe (Figure 40). A flow rate of 0.2 litres per second was measured using a 5 gallon pail. A scour hole has developed at the unprotected toe of the dam (Figure 41).

Figure 38 View N at Decant Structure Location

Figure 39 Decant Structure Inlet

Figure 40 Pipe at Inlet End of Decant Structure

Figure 41 Decant Structure Outlet Pipe

A gravel pad has been placed on the downstream side of the dam for about 25 m north of the decant structure, possibly in an area of seepage (Figure 42). Iron staining on the downstream slope just above the toe in this vicinity suggests that seepage through the dam occurs but probably only visibly during higher water levels in Pond 3. The upstream shoreline is grassy and stable (Figure 43).

Figure 42 Gravel Pad N of Decant Weir

Figure 43 Upstream Shoreline (view N)

3.1.2 Porcupine Creek Diversion

The Porcupine Creek Diversion diverts water around the TMA. The headwater for the diversion is along the natural creek channel between the mill and tailings impoundment referred to as Brefalt Creek on the Plant Site Drawing. A gravel berm or dyke diverts water into the diversion channel, preventing it from entering Pond 3. The author did not inspect the diversion channel itself but observations provided by Mr. Glenn Ford indicated it was flowing with no visible channel blockages. Previous inspections indicated that the channel is cut through natural ground, comprised of stratified silts and sands covered with muskeg. These deposits are apparently ice-rich and thawing continues resulting in sloughing of the bank (Geo-Engineering, 1996). The channel upstream of the diversion is cut through what appears to be natural material. Water first appears in the channel as ice (Figure 44) where the diversion channel banks are about 2 m high (Figure 45). From this point, the creek channel runs westerly until joining the diversion at the gravel dyke (Figures 46-48). Iron staining is visible at numerous locations along the diversion (Figure 49).

Figure 44 Ice at Upstream end of Cr. Channel

Figure 45 Creek Channel Bank

Figure 46 Gravel Dyke

Figure 47 View U/S From Start of Div. Channel

Figure 48 View D/S At Start of Div. Channel

Figure 49 Iron Staining in Creek Channel Bed

3.1.3 Seepage Collection Ditch

A seepage collection ditch has recently been excavated through the tailings north of the Porcupine Creek Diversion. It appears to have been constructed to intercept tailings seepage water before it enters the adjacent creek channel. The ditch starts in the tailings close to the road as shown on Figure 50 and Drawing 01, ending on the flood plain at the edge of the tailings in Pond 3. Water first enters the ditch as groundwater seepage at the location shown on Drawing 01, with flow gradually increasing towards the tailings ponds. The ditch in the upper reaches is V shaped with steep sideslopes. Farther downstream the banks are still very steep but the channel bottom is wider. Instabilities and slumping of the ditch banks are evident throughout its length (Figure 51). The ditch enters a grassy channel before entering into the flood plain at the edge of Pond 3 (Figure 52 and 53).

Figure 50 U/S End of Seepage Collection Ditch

Figure 51 Water in Seepage Collection Ditch

Figure 52 Seepage Collection Ditch at Gravel Dyke

Figure 53 Flood Plain at end of Seepage Collection Ditch

4.0 Structure Classifications

The tailings pond dams, diversion channel and seepage collection ditch are structures considered to be part of the overall tailings management area (TMA). Using the 2007 Canadian Dam Association (CDA) Guidelines in terms of the reasonably foreseeable consequences of failure, these structures have been classified. The results are summarized in Table 4-1. The loss of life consequences were evaluated separately from socioeconomic, financial and environmental consequences. The Dyke Classification in Table 4-1 is 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 2007 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		
Dam 1	Low	Low	Significant	Significant	10 years
Dam 2	Low	Low	Low	Low	Note 1
Dam 3	Low	High	Significant	High	7 years
Porcupine Cr. Diversion	Low	Low	Low	Low	Note 1
Seepage Collection Ditch	Low	Significant	Low	Significant	10 years

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.

Several limiting assumptions were taken into consideration when determining the appropriate structure classifications. These include:

- The tailings and tailings water, released untreated into the environment, could cause considerable environmental impact on downstream habitat, fisheries, etc.
- Dam 3 does not fail if there is a failure of either upstream dam or the Porcupine Creek Diversion.

5.0 Risk Assessment

5.1 Approach

A risk assessment was carried out for the three tailings pond dams and the Porcupine Creek Diversion and seepage collection ditch to assist in determining an appropriate risk management strategy. 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 consequence 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. **Operations:** No impact on operations. **Health & Safety:** Near miss or recordable first aid to multiple employees. **Environmental and Economic:** <$10k	VERY LOW **(VL)**	**3**
Minor incident or inefficiency that may require review and is easily remediated. **Operations:** Operations delay of up to two weeks **Health & Safety:** Recordable case, minor injuries to multiple employees. **Environmental and Economic:** $10,000 to $100,000	LOW **(L)**	**7**
Moderate event that may need some physical attention and certainly review. **Operations:** Operations delay of up to a few months. **Health & Safety:** Serious lost time injuries to multiple employees. **Environmental and Economic:** $100,000 to $1,000,000	MODERATE **(M)**	**15**
Significant event that can be addressed but with great effort. **Operations:** Significant delay of six months to one year. **Health & Safety:** Serious injuries to multiple employees, possible fatality to an employee. **Environmental and Economic:** $1,000,000 to $10,000,000	HIGH **(H)**	**40**
Major uncontrolled event with uncertain and perhaps prohibitively costly remediation. **Operations:** Operations delay more than one year. **Health & Safety:** Multiple fatalities. **Environmental and Economic:** > $10,000,000.	EXTREME **(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 United Keno Hill Mine TMA focuses on the potential failure of a structure that results 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 following sections 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 overtopping (breach).

DAM 1

Dam 1 contains the majority of the tailings. It appears that over the years, a number of repairs and modifications to Dam 1 have been completed including the construction of a toe berm, the addition of fill to maintain the design crest elevation and the installation of a decant structure at the south abutment. Although water is presently being siphoned over Dam 1, the decant structure provides the only point of controlled discharge from Pond 1. There does not appear to be any provision for an emergency spillway. Overall, the current condition of Dam 1 is good.

A failure of Dam 1 would result in the uncontrolled release of tailings and water into Pond 2. While there would not be any direct significant environmental impact form such an event, there could be a significant impact on the operation of the TMA. There may also be a concern with respect to the available storage capacity of Pond 2 and 3. In a worst case scenario, the failure of Dam 1 could result in the subsequent overtopping of one or both downstream dams and the uncontrolled release of untreated water into the downstream environment.

DAM 2

Dam 2 contains lime sludge and serves as a primary settling pond to polish the water before it is released into Pond 3. The necessity for the dam in the overall operation of the TMA has been previously questioned and at one point, its abandonment has been considered (INAC, 1997). There is presently only one discharge point that being the decant weir at about the mid-point of the dam. The widened section near the south abutment is believed to be the location of a previous failure (SRK, 2005). There does not appear to any provision for an emergency spillway. Significant deformation of the dam is evident in particular south of the decant weir where lateral spreading and settlement of the crest is evident. Based on the current condition of the decant weir, it is unlikely that the safe passage of water would be provided under normal or extreme operation conditions.

The stability of the dam, in particular where significant deformations are occurring is considered marginal. A failure of Dam 2 could have a significant environmental consequence if Pond 3 cannot safely store the volume of water released from Pond 2.

DAM 3

Dam 3 is the last downstream retention structure and provides final polishing of effluent water before release through the decant structure to the downstream environment. A 900 mm diameter culvert just south of the decant structure is believed to be an emergency spillway. It is believed likely that a failure of the south leg of the dam may have occurred in the past as evidenced by a granular downstream blanket and recently added fill material up to 1.2 m thick in this area. As well, previous inspections noted tension cracks along the dam in this area (SRK, 2005).

Overall, the current condition of Dam 3 is reasonably good. Dam 3 must provide containment not only for routine release of water from Pond 3 but also the uncontrolled release of water from Ponds 1 or 2 or the possible failure of the Porcupine Creek Diversion. In this regard, it is considered the most important structure from a consequence perspective when completing the risk assessment.

PORCUPINE CREEK DIVERSION

Failure of the gravel dyke could cause Porcupine Creek to be diverted into Pond 3 resulting in a significant rise in water levels upstream of Dam 3. From a risk management perspective, it is essential that Dam 3 have a spillway capacity sufficient to pass this flow should such a failure occur. It is unclear as to what flows could be expected in the creek at the time of the inspection since the only contribution to existing flow is groundwater discharge at the upstream end of the existing channel.

Overall the creek channel between the road and the diversion ditch is functional although the banks are over-steepened in some cases and the channel width varies considerably. Vegetation is becoming well established along the creek channel. The channel bed appears to be well armoured with cobble sized material. The gravel dyke at the entrance to the diversion channel is in good condition although over-steepened and because of the fine grained material used to construct the dyke, it is susceptible to erosion.

SEEPAGE COLLECTION DITCH

A failure of the seepage collection ditch would not have a significant impact since the contribution of water is already accounted for in routine operation of the TMA. A blockage could however, contribute tailings water directly into the Porcupine 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 failures that could result in the release of untreated water and/or tailings. 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
Dam 1	3	1	15	45	**I**	Moderate
Dam 2	10	1	7	70	**II**	Moderate
Dam 3	3	1	40	120	**II**	Moderate
Porcupine Cr. Diversion	3	1	40*	120	**II**	Moderate
Seepage Collection Ditch	6	1	7	42	**I**	Moderate

* Assumes worst case scenario where flow into Pond 3 exceeds discharge capacity of decant weir and emergency spillway.

6.0 Discussion and Recommendations

Dam 2, Dam 3 and the Porcupine Creek Diversion have risk scores that fall within Risk Level II. The score for Dam 2 is primarily a result of the likelihood of a failure of the dam or decant weir. The score for Dam 3 and the Porcupine Creek Diversion are primarily a result of the consequences of a failure of Dam 3 or the Porcupine Creek Diversion. As noted in Table 5-6, the worst case scenario has been assumed for a failure of the Porcupine Creek Diversion whereby the release of water into pond 3 exceeds the discharge capacity of the decant weir and emergency overflow on Dam 3 i.e. a failure of Dam 3 is triggered. Dam 1 and the seepage collection ditch have scores that fall within Risk level I.

The following guidelines for follow-up work are provided for the three levels associated with 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 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, three components of the TMA 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 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 should be considered if all of the existing components of the TMA are expected to operate under current conditions:

- Consider the need for an emergency spillway on Dam 1 and 2 in accordance with Canadian Dam Safety Guidelines.

- Evaluate the hydraulic capacity of the emergency spillway on Dam 3, in particular with respect to failure of upstream dam(s) or the Porcupine Creek Diversion.
- Evaluate the need for Dam 2.
- Evaluate the stability of all of the dams and structures and identify appropriate improvements.
- Evaluate condition and extent of armouring on upstream dam slopes and add material where necessary.
- Cut saplings on upstream and downstream dam slopes.
- Survey dam crests to identify low areas (below design crest elevation) and fill as required.
- Armour the gravel dyke at the headwater for the Porcupine Creek Diversion Channel.
- Repair scouring of dam slope and toe at downstream ends of culverts through Dam 3. Extend 900 mm emergency spillway culvert and construct spill pads to dissipate energy at culvert ends.

Once 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.

7.0 Closure

The findings and recommendations of this Risk Based Dam Assessment are based on a review of the available information and the results of the 2007 inspection by UMA. Interpretation and analysis 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 determine risk. 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 Elsa 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 at this office.

Respectfully Submitted,

UMA Engineering Ltd.

Reviewed By:

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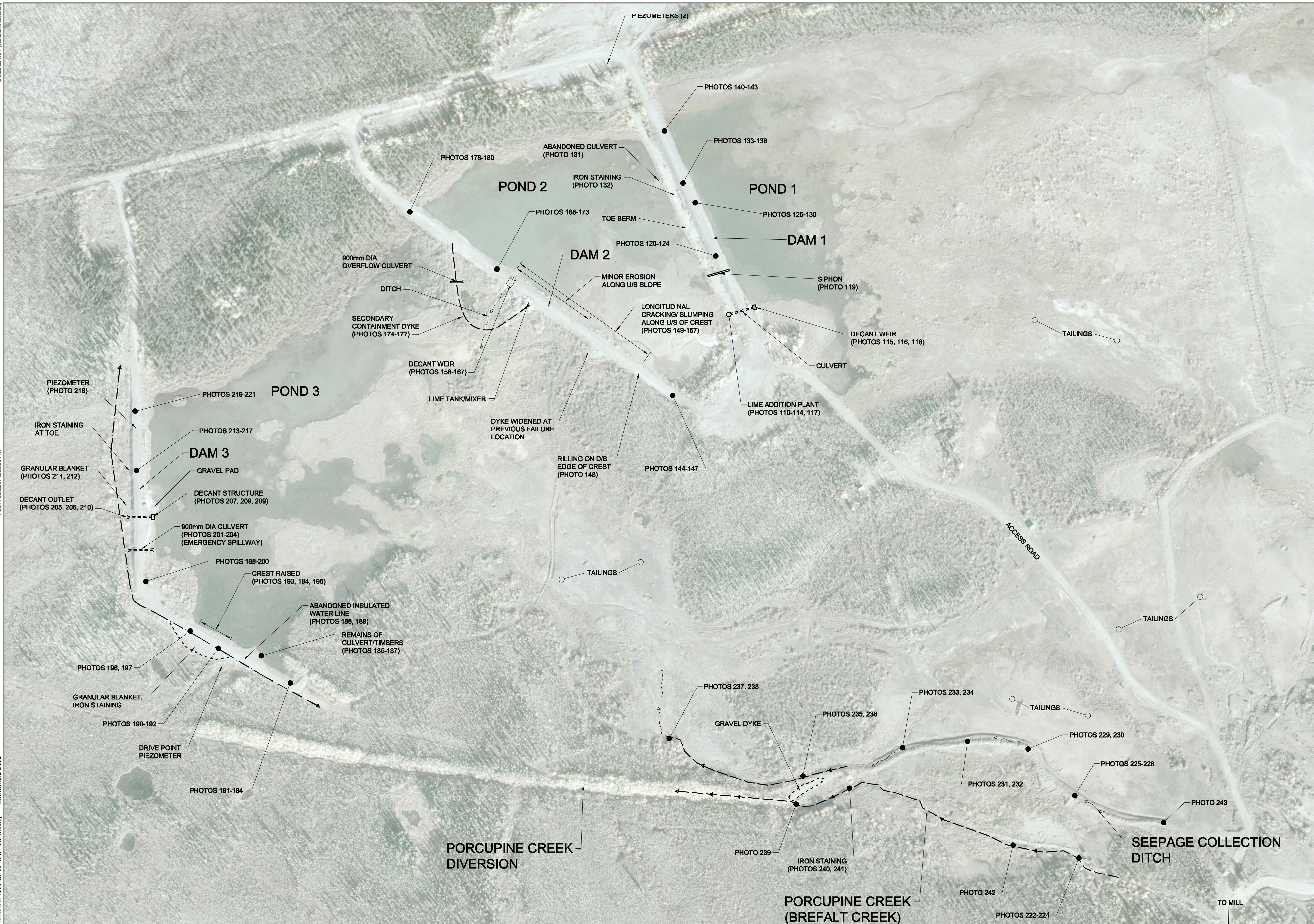

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DRAFT

PLAN

0 20 40 60 m

SCALE 1:2000 (22"X34")
1:4000 (11"X17")
APPROX.

Government of Yukon
United Keno Hill Mine
2007 Geotechnical Inspections

Site Plan

UMA | AECOM

Drawing - 01

Appendix A
Site Photographs and Video