November 25, 2014

INDEPENDENT REVIEW OF 2014 DAM SAFETY INSPECTION REPORT

Huckleberry Tailings Dams

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Reference Number: 051413474-143-R-Rev0-2214

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REPORT

Golder Associates

Executive Summary

Golder Associates Ltd. (Golder) was engaged by Huckleberry Mines Limited (HML) to perform an independent review of the 2014 Dam Safety Inspection report produced by BGC Engineering Ltd. (BGC). The work was commissioned on September 22, 2014, in response to Golder's proposal 051413474-140-P-Rev0-2214.

The independent review was required based on the *Notification of Chief Inspector's Orders – Tailings Dams – Independent Review of Dam Safety and Consequence Classification* from the British Columbia Ministry of Energy and Mines (BC MEM) dated August 18, 2014 (BC MEM 2014).

The scope of the review included the following:

- site visit by Mr. Andy Haynes, P. Eng., on September 29, 2014, to visually observe the status, condition and operating regime of the tailings dams; and
- review of the Draft 2014 Dam Safety Inspection (DSI) report produced by BGC, reference 1193004-01-L, dated November 3, 2014 (BGC 2014).

The findings of Golder's review are as follows:

- The DSI report prepared by BGC addresses the elements required by the BC MEM (2012).
- The dam consequence classification appears appropriate.
- The report provides a comprehensive documentation of the status and performance of the tailings dams.
- The report provides a thorough description of the responses of the instrumentation to changes in the operating regime of the tailings dams. However, the implications to dam safety of the instrumentation data could be clarified.
- The TMF-3 impoundment was operated with the pond level higher than the level of protected filters during 2014, which represents a potential dam safety concern. Mitigation measures were developed by HML and BGC to reduce the pond level in TMF-3 to levels that do not present a dam safety concern. The mitigation plans are considered appropriate.

The following are recommended:

- Maximum allowable pond levels for future construction should be reviewed with BGC.
- Ongoing implementation of the mitigation strategies developed by HML and BGC to address the pond level in TMF-3 (reducing the pond level and raising the filters and rockfill) should be given high priority.
- HML and BGC should review the water management strategy, tailings deposition plan, and dam raise schedule for filter and rockfill placement. This should include review of the sensitivity of the TMF-3 system to changes in water management strategies, such as varying rates of reclaim.
- BGC should review opportunities to incorporate methods of monitoring to assess the deformation of the TMF-3 dams throughout the construction and operation phase.

Study Limitations

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was engaged by Huckleberry Mines Limited (HML) to perform an independent review of the 2014 Dam Safety Inspection (DSI) report produced by BGC Engineering Ltd. (BGC). The work was commissioned on September 22, 2014, in response to Golder's proposal 051413474-140-P-Rev0-2214.

The independent review was required based on the *Notification of Chief Inspector's Orders – Tailings Dams – Independent Review of Dam Safety and Consequence Classification* from the British Columbia Ministry of Energy and Mines (BC MEM) dated August 18, 2014 (BC MEM 2014). This order states:

> *The mine manager must have the DSI reviewed by an independent qualified third party professional engineer from a firm that has not been associated with the tailings dam. The Independent Third Party Review of the DSI must also include a review of the dam consequence classification.*

The scope of the review included the following:

- site visit by Mr. Andy Haynes, P. Eng., on September 29, 2014, to visually observe the status, condition and operating regime of the tailings dams; and
- review of the Draft 2014 Dam Safety Inspection (DSI) report produced by BGC reference 1193004-01-L and dated November 3, 2014 (BGC 2014).

The BGC DSI report includes discussion of the performance of the seepage collection ponds associated with the tailings dams (BGC 2014). As tailings dams are the focus of the BC MEM (2014) order, this independent review is restricted to the HML tailings dams.

The independent review is not a Dam Safety Review as defined in the *Dam Safety Review Guidelines* produced by the BC Dam Safety Section (BC MEM 2012), Section 5 of the Canadian Dam Safety Guidelines (CDA 2013) and in the *Professional Practice Guidelines – Legislated Dam Safety Reviews in BC* produced by the Association of Professional Engineers BC (APEGBC 2014).

2.0 BACKGROUND

2.1 Site Description

Huckleberry is an open pit copper mine located in west-central British Columbia, approximately 120 km south of Houston. The mine is located in mountainous terrain adjacent to the Tahtsa Reach of the Nechako Reservoir and began operation in 1997. The mine layout is shown in Figure 1.

The mine includes the tailings facilities and tailings dams as shown in Table 1.

Table 1: Summary of Huckleberry Tailings Dams

Impoundment	Tailings Dam	Status/Comments
TMF-2	Main Dam	Tailings deposition occurred from 1997 to 2007; currently inactive.
	Orica Saddle Dam	
	East Dam	The East Dam is complete, but will not retain water until closure.
East Zone Pit	East Pit Plug Dam (EPPD)	The EPPD is complete. Tailings are periodically deposited in West Cell. The East Cell is complete and has no active deposition.
TMF-3	Main Dam	Tailings deposition commenced in 2013 and is active. Legacy tailings and waste rock are being removed from the Main Zone Pit and placed in TMF-3. Dams are being actively raised, and construction was in progress at the time of the site visit.
	Saddle Dam	

2.2 Design Engineer

The design engineer for the Huckleberry tailings dams was originally AGRA Inc., which later became AMEC Environment and Infrastructure (AMEC), a division of AMEC Americas Limited. BGC Engineering Ltd. assumed design responsibilities from AMEC in 2013 and BGC is the current Engineer of Record for the Huckleberry tailings dams.

The preparation of this report by Golder does not impact the Engineer of Record role held by BGC.

3.0 INDEPENDENT REVIEW OF DAM SAFETY INSPECTION REPORT

3.1 Compliance with Ministry of Energy and Mines Requirements

The requirements for DSIs are presented in *Guidelines For Annual Dam Safety Inspection Reports* (BC MEM 2012). Table 2 summarizes the compliance or otherwise of the BGC DSI report with the BC MEM requirements.

Table 2: Compliance of Dam Safety Inspection Report with British Columbia Ministry of Energy and Mines Dam Safety Inspection Requirements

Requirement	Included	Comment
Executive Summary Classification of the dam(s) in terms of Consequence of Failure in accordance with Table 2-1 of the CDA Dam Safety Guidelines (2013).	✓	Very High
a. Significant changes in instrumentation and/or visual monitoring records.	✓	
b. Significant changes to dam stability and/or surface water control.	✓	
c. For major impoundments, as defined in Part 10 of the Code, a current Operation, Maintenance and Surveillance (OMS) Manual is required. The annual report shall indicate the latest revision date of the OMS manual.	✓	July 2013
d. For tailings dams classified as High, Very High, or Extreme Consequence, an Emergency Preparedness Plan (EPP) is required. The annual report shall indicate the latest revision date of the EPP document.	✓	July 2013
e. Scheduled date for the next formal Dam Safety Review in accordance with Table 5-1 of the CDA Dam Safety Guidelines (2013). Formal Dam Safety Reviews are required every 5 to 10 years (depending on consequence classification) and differ from annual dam safety inspections. The requirements for Dam Safety Reviews are included in Section 5 of the CDA Dam Safety Guidelines. Dam Safety Reviews may be conducted by the Engineer of Record with third party review, or by an independent third party with involvement of the Engineer of Record.	✓	2015
Summary of past years' construction (if any) with a description of any problems and stabilization	✓	
Plan and representative cross-sections	✓	
Site photographs	✓	
Review of climate data	✓	
Water balance review	✓	
Freeboard and storage availability (in excess of the design flood)	✓	
Water discharge system, volumes, and quality	✓	Water quality reported by HML
Seepage occurrence and water quality	✓	Water quality reported by HML
Surface water control and surface erosion	✓	
Instrumentation review including: (a) Phreatic surfaces and piezometric data (b) Settlement (c) Lateral movement	✓	No instrumentation for settlement and lateral movement of TMF-3

3.2 Dam Consequence Classification

Tailings dams in British Columbia are regulated under the Health, Safety and Reclamation Code for Mines in British Columbia 2008, which references Canadian Dam Association (CDA) Dam Safety Guidelines (CDA 2013).

Consequence categories are based on the incremental losses that a failure of the dam might inflict on downstream or upstream areas, or at the dam location itself. Incremental losses are those over and above losses that might have occurred in the same natural event or condition had the dam not failed. The classification assigned to a dam is the highest rank determined among the four loss categories.

Table 3 presents the dam classification criteria by CDA (2013).

Table 3: Dam Classification in Terms of Consequences of Failure

Dam Class	Population at Risk[(a)]	Incremental Losses		
		Loss of Life[(b)]	Environmental and Cultural Values	Infrastructure and Economics
Low	None	0	Minimal short term loss. No long term loss.	Low economic losses; area contains limited infrastructure or service.
Significant	Temporary Only	Unspecified	No significant loss or deterioration of fish or wildlife habitat. Loss of marginal habitat only. Restoration or compensation in kind highly possible.	Losses to recreational facilities, seasonal workplaces, and infrequently used transport routes.
High	Permanent	10 of fewer	Significant loss or deterioration of important fish or wildlife habitat. Restoration or compensation in kind highly possible.	High economic losses affecting infrastructure, public transport, and commercial facilities.
Very High	Permanent	100 of fewer	Significant loss or deterioration of critical fish or wildlife habitat. Restoration or compensation in kind possible but impractical.	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances).
Extreme	Permanent	More than 100	Major loss of critical fish or wildlife habitat. Restoration or compensation in kind impossible.	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances).

Source: CDA (2013).

a) Definition for population at risk:
None – There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.
Temporary – People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).
Permanent – The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

b) Implications for loss of life:
Unspecified – The appropriate level of safety required a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

A dam breach study has not been reviewed. However, given the proximity of the tailings dams to the Tahtsa Reach of the Nechako Reservoir, it is anticipated that in the potential event of dam failure, potentially acid generating tailings and failure debris would reach Tahtsa Reach and result in negative impacts to fish habitat. The potential impacts on fish habitat are estimated to be in the range covered by the High or Very High consequence categories. Rio Tinto also generates hydroelectric power for its Kitimat operations using water from the Nechako Reservoir. The impact to the hydroelectric operation of potential sediment has not been assessed by Golder. However, for this assessment the economic impacts of potential tailings dam failure were assumed to be high to very high. The consequence classification is likely to be dominated by environmental considerations. On this basis, the dam classifications of the Huckleberry tailings dam are assessed as shown in Table 4.

Table 4: Dam Consequence Classifications

Dam	Population at Risk	Incremental Losses		Dam Consequence Classification
		Environmental and Cultural Values	Infrastructure and Economics	
TMF-2	Temporary Only	Significant loss or deterioration of critical fish or wildlife habitat. Restoration or compensation in kind possible but impractical.	High to very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances).	Very High
East Pit Plug Dam	Temporary Only	Significant loss or deterioration of critical fish or wildlife habitat. Restoration or compensation in kind possible but impractical.	High to very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances).	Very High
TMF-3	Temporary Only	Significant loss or deterioration of critical fish or wildlife habitat. Restoration or compensation in kind possible but impractical.	High to very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances).	Very High

The consequence classification is consistent with that assigned by BGC.

The dam consequence classification typically influences the selection of the design earthquake, design flood event and the frequency for Dam Safety Reviews. The Huckleberry dams have been designed using design earthquakes and flood events that satisfy the criteria for Extreme consequence dams, and it is noted that BGC recommends that a Dam Safety Review be performed every five years, consistent with the CDA recommendations for Very High or Extreme consequence dams. As such, the parameters used for dam design meet or exceed those suggested by the dam consequence.

3.3 Observations from Site Visit

Photographs from the September 29, 2014, site visit are presented in Appendix A.

Observations that present potential dam safety concerns include the following:

- The placement of filters and rockfill is lagging behind the placement of low-permeability core materials in the Main Dam and Saddle Dam of TMF-3. This was noted in the DSI report (BGC 2014). This issue is discussed further in Section 4.3.
- Some cracking of the core has occurred on the TMF-3 Saddle Dam, which extends about 2 m into the core (Photographs 17 and 18 in Appendix A). The lack of rockfill support and potentially lower compaction near the downstream edge of the till are likely to be contributing factors to the cracking. Cracking of this nature was noted in the 2014 DSI report (BGC 2014), and BGC noted that the cracking will be remediated during the fall 2014 construction. This item does not present a dam safety concern provided that the remediation is performed in advance of the pond level reaching the cracked portion of the till.

4.0 FINDINGS AND RECOMMENDATIONS

4.1 General Findings

The general findings of Golder's review are as follows:

- The DSI report prepared by BGC addresses the elements required by the BC MEM (2012).
- The dam consequence classification appears appropriate.
- The report provides a comprehensive documentation of the status and performance of the tailings dams.
- The report provides a thorough description of the responses of the instrumentation to changes in the operating regime of the tailings dams. However, the implications to dam safety of the instrumentation data could potentially be clarified.

4.2 Prioritization of Recommended Action Items

Numerous actions are recommended by BGC to enhance the safety of the HML tailings dams, each with recommended deadlines.

Some of the actions appear to relate to the closure state of the facility, such as installing a seepage weir downstream of the East Dam (which does not currently retain water) in advance of the time at which the dam will impound water. BGC Engineering Ltd. appears to have a rationale for the timeframe of all the actions; however, Golder suggests that articulation of the basis for the rationale and the consequence of potential delays of these actions may assist HML in the prioritization of the recommended actions.

Golder suggests that any recommendations related to immediate dam safety concerns should be identified separately to recommendations that represent improvement opportunities.

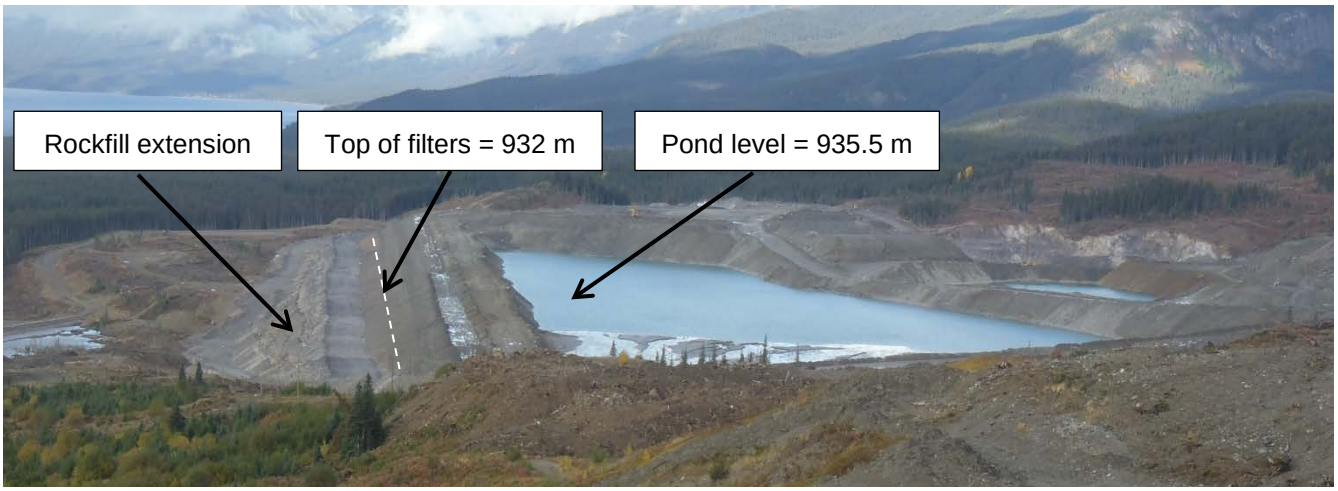
4.3 Filter and Rockfill Placement

At the time of Golder's site inspection, the placement of filters and rockfill to the TMF-3 Main Dam and Saddle Dam was lagging behind the placement of till core.

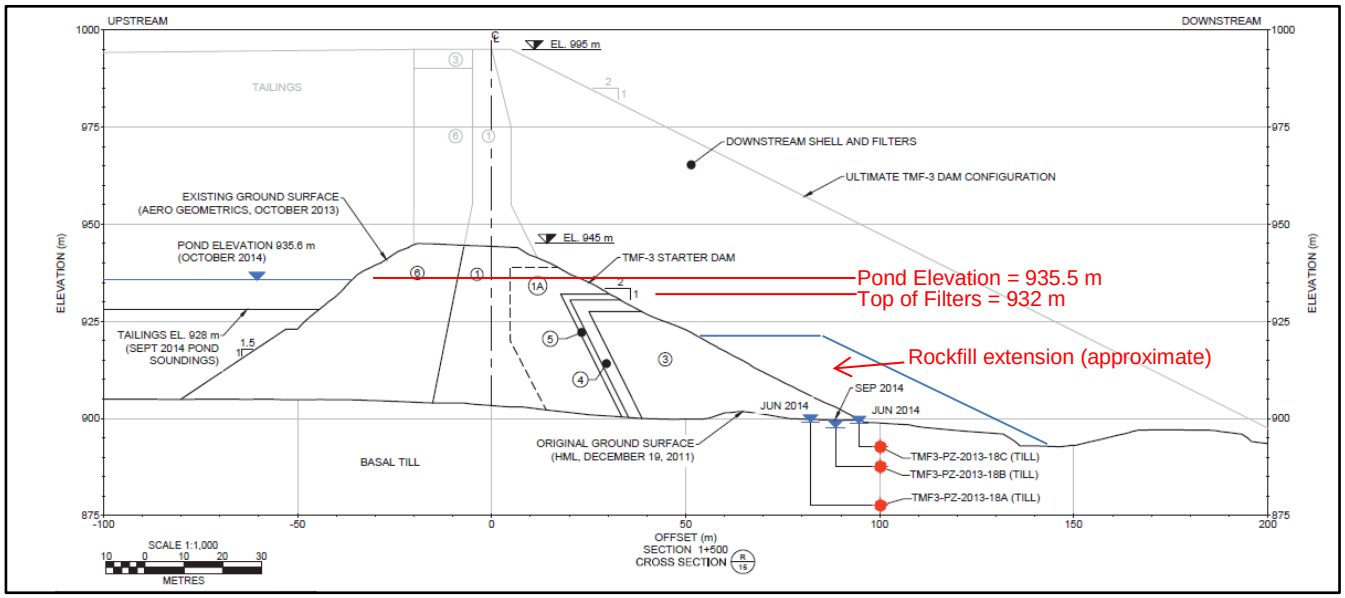
On October 6, 2014, BGC reported the following elevations for the TMF-3 Dam:

- Zone 1 till core 945 m
- top of weighted filter zone 932 m
- pond elevation 935.5 m

This situation (October 6, 2014, data) is shown graphically below and in Photograph 13 in Appendix A.



Photograph Showing Relationship of Pond Level, Till Core, Filters and Rockfill at TMF-3



TMF-3 Cross-Section at Sta 1+500 (modified from BGC 2014)

In October 2014, BGC Engineering Ltd. provided an assessment of the potential dam safety hazard presented by this scenario (Appendix K of BGC 2014) and provided maximum allowable pond levels for filters at El. 932 m. Mitigation measures were developed by HML and BGC to reduce the pond level in TMF-3 to levels that do not present a dam safety concern. The mitigation plans are considered appropriate. It is further understood that raising of the filters and rockfill is in progress at the time of writing, and that filters are expected to be above the pond water level by early December and at about El. 940 m in January 2015. Ongoing implementation of the mitigation strategies (particularly reducing the pond level and raising the filters and rockfill) should be given high priority.

Golder agrees with BGC that impoundment of water above the level of protected filters represents a potential dam safety concern. Sustained operation of the dam with a core not protected by filters and not supported by rockfill may result in the potential for piping failures or unintended downstream movement and cracking of the core. Maximum allowable pond levels for future construction should be reviewed with BGC.

Golder recommends that HML and BGC should review the water management strategy, tailings deposition plan, and dam raise schedule for filter and rockfill placement. This should include review of the sensitivity of the TMF-3 system to changes in water management strategies, such as varying rates of reclaim.

4.4 Survey Monuments on TMF-3

TMF-3 has many piezometers, and additional piezometers are proposed. Seepage from TMF-3 is proposed to be monitored using pumping rates from the seepage collection ponds. These aspects of monitoring appear reasonable.

However, it was not clear from the DSI report whether survey monuments or other methods are proposed to allow monitoring of dam movements during the construction phases. The challenge of maintaining such instrumentation on a structure that is raised annually is noted. However, Golder recommends that the Engineer of Record review opportunities to incorporate methods of monitoring to assess the deformation of the structure throughout the construction and operation phase.

5.0 REPORT CLOSURE

We trust that this Independent Review of the 2014 Dam Safety Inspection Report of the Huckleberry Mines tailings dams (BGC 2014) meets you requirements. Please contact the undersigned if you require additional information regarding this review.

GOLDER ASSOCIATES LTD.

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Reviewed by:

John Cunning, P.Eng.
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AJH/JCC/rs/ls

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BC MEM (British Columbia Ministry of Energy and Mines). 2012. *Dam Safety Review Guidelines.* Version 3. Ministry of Energy and Mines Dam Safety Section. Victoria, BC, November 2012.

BC MEM. 2014. *Notification of Chief Inspector's Orders – Tailings Dams – Independent Review of Dam Safety and Consequence Classification.* Ministry of Energy and Mines Health, Safety and Permitting Branch. August 14, 2014.

BGC (BGC Engineering Ltd.). 2014. *Huckleberry Mine Tailings Management Facilities,* Draft *2014 Dam Safety Inspection Report*. BGC Document 1993004-01-L, dated November 3, 2014.

CDA (Canadian Dam Association). 2013. *Dam Safety Guidelines 2007 (revised 2013)*.

LEGEND

18 APPROXIMATE LOCATION AND DIRECTION OF PHOTOGRAPH FROM SEPTEMBER 29, 2014.

NOTES

1. AERIAL PHOTOGRAPH OCTOBER 2014.

NOT FOR CONSTRUCTION

0 250 500
1:17,500 METRES

CLIENT
HUCKLEBERRY MINES LTD.

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-11-24
PREPARED	JD
DESIGN	AJH
REVIEW	AJH
APPROVED	JCC

PROJECT
INDEPENDANT REVIEW OF DAM SAFETY INSPECTION
HOUSTON, B.C.

TITLE
SITE PLAN

PROJECT No.	PHASE	Rev.	FIGURE
05-1413-474	2214	0	1

APPENDIX A

Photographs

Photograph 1: TMF-2 Impoundment Overview (looking west)

Photograph 2: TMF-2 Dam Downstream Face (looking west)

Photograph 3: TMF-2 Dam Downstream Slope Showing Reclamation (looking east)

Photograph 4: TMF-2 from Seepage Collection Pond 2 (looking north)

Photograph 5: East Zone Pit Impoundment (looking north-east)

Photograph 6: East Pit Plug Dam Downstream Face (looking north west)

Photograph 7: East Pit Plug Dam Downstream Face and Seepage Collection Pond Looking North

Photograph 8: East Pit Plug Dam Downstream Face (looking north east)

Photograph 9: Panorama Showing Location of East Dam Relative to MZO Pit

Photograph 10: East Dam Upstream Face (looking south)

Photograph 11: East Dam Downstream Face (looking south)

Photograph 12: TMF-3 (looking west)

Photograph 13: TMF-3 Dam (looking west)

Photograph 14: TMF-3 Downstream Face (looking west)

Photograph 15: TMF-3 Downstream Face (looking north)

Photograph 16: TMF-3 Saddle Dam (looking north)

Photograph 17: TMF-3 Saddle Dam Tension Crack at Downstream Crest. The crack is above the pond level and does not present a dam safety concern provided that repairs are performed in advance of the pond level reaching the level of the crack.

Photograph 18: TMF-3 Saddle Dam Tension Crack at Downstream Crest. The crack is above the pond level and does not present a dam safety concern provided that repairs are performed in advance of the pond level reaching the level of the crack.

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