TETRA TECH EBA

October 20, 2015

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FILE: W14103376-04
Via Email: josee.perron@gov.yk.ca

Government of Yukon
Department of Energy Mines and Resources
Box 2703
Whitehorse, YT Y1A 2C6

Attention: Ms. Josée Perron. P.Eng.
Senior Project Manager, Assessment and Abandoned Mines

Subject: **Final Updated** Drawdown and Pumping Analysis – Tailings and Seepage Collection Ponds
Mount Nansen Site, YT.

1.0 INTRODUCTION

As requested, Tech EBA Inc. (Tetra Tech EBA) has reviewed the supplied information and combined it with data from our files, to recommend a "trigger" elevation and pumping rate so that untreated water does not discharge over the emergency spillway at the subject site. This report also recommends an allowable pumping rate to draw down the seepage collection pond. This letter is an updated version of previous letters dated March 31 and July 29, 2015, at which time the elevation of a benchmark used in the bathymetric analysis was unknown. It was subsequently surveyed by YG-AAM personnel, which required this report to be updated, followed by a second update to reflect the incorporation of LiDAR data and revised pumping volumes.

2.0 SCOPE OF WORK

The scope of work is summarized as follows:

- Prepare reservoir storage curves for the tailings and seepage collection ponds based on survey data provided in AutoCAD format.
- Calculate inflows to tailings pond based on losses from Dome Creek, and design rainfall/snowmelt estimates.
- Estimate pumping rates required to keep tailings pond elevation below spillway invert, and trigger elevation to start pumping for the tailings pond. In addition, determine the maximum water level/trigger elevation and pumping rate required to prevent seepage pond embankment instability and/or over-topping.
- Calculate the effects of this pumping rate on stability of the tailings and seepage pond and sand slopes around perimeter of reservoir, especially potential effects on Dome Creek diversion separation above tailings dam, and other infrastructure.
- Prepare a summary report.

Tetra Tech EBA Inc.
61 Wasson Place
Whitehorse, YT Y1A 0H7 CANADA
Tel 867.668.3068 Fax 867.668.4349

3.0 AVAILABLE INFORMATION

A Site Plan showing the locations of the tailings pond and seepage collection pond at the site is presented as Figure 1.

Critical elevations of the tailings pond and seepage collection pond are as follows:

Summary of Design and Operating Elevations	
Mount Nansen Tailings Storage Facility, YT	
Tailings Dam:	
Crest of Dam	1099.6 m
Top of Geocomposite Liner	1098.8 m
Emergency Spillway Invert	1097.8 m
Maximum Operating Level	1097.8 m
Water Level (in September 2015)	1095.2 m
Seepage Collection Dam:	
Crest of Dam	1079.1 m
Top of 38 mil Arctic Liner	1078.7 m
Maximum Operating Level	1078.1 m
Water Level (in September 2015)	1077.1 m

The calculated stage-storage curve for each of the ponds is presented in Figures 2 and 3.

4.0 TAILINGS POND

4.1 Storage Volume

Tetra Tech EBA was provided with bathymetric data prepared by Environmental Dynamics Inc. (EDI) in July 2005. The survey was based on a handheld GPS survey of the current water level, relative to a benchmark for which the elevation was provided by Assessment and Abandoned Mines.

The pond depth data from the EDI survey was then converted to geodetic elevations based on the provided benchmark elevation of 1099.9 m – this is summarized in the following Table 1.

Note that we have included the EDI volumes although there is significant variance between the volumes calculated by Tetra Tech EBA and EDI above elevation 1097.2 m. The EDI data above elevation 1097.2 m appears to be based on the survey data available at the time (2005) while our volumes above elevation 1097.2 m are based on the 2012 LiDAR data provided by Assessment and Abandoned Mines.

There also appears to be some error in the EDI data as the high water mark delineated during their survey is actually above the spillway invert. For the purposes of this study, we have only considered the data from the EDI bathymetry survey, and used LiDAR data above this.

Table 1: EDI Volume and Depth Data with Assumed Geodetic Elevations

EDI Data			Tetra Tech EBA Data	
Depth Below Benchmark (m)	**Calculated Geodetic Elevation (m)**	**Volume (m^3)**	**Elevation (m)**	**Volume (m^3)**
1.76	1098.13	155,740	1097.8	75,253
2.73	1097.16	43,870	1,097.4	56,194
2.93	1096.96	37,520	1,097.0	39,867
3.18	1096.71	30,330	1,096.6	27,081
3.43	1096.46	22,790	1,096.2	16,807
3.68	1096.21	17,120	1,096.0	12,433
3.93	1095.96	11,820	1,095.8	8,598
4.18	1095.71	6,880	1,095.4	2,875
4.43	1095.46	3,130	1,094.8	0

The elevations in the following sections are based on the Tetra Tech EBA volumes.

4.2 Design Inflow Volume

The assumed design volume for the tailings pond is based on the 1:200 year two hour event, previously calculated at 30 mm and is presented in the 2013 Dam Safety Review (DSR). Based on a catchment area of 3.07 km^2 (taken from the DSR) and a runoff coefficient of 0.3[1], the rainfall volume for the design event is 27,630 m^3. Assuming that the tailings pond elevation 1096.0 m or less at the start of the design event (it's been about this elevation for the past several years), the design flow will raise the pond to about 1097.0 m.

4.3 Trigger Elevation and Pumping Rate

Once the water in the tailings pond reaches an elevation of 1097.0 m (0.8 m below spillway) it will be necessary to start pumping. The maximum recommended pumping rate is that required to lower the water elevation by not more than one metre per day. To lower the pond to 1096.0 m from 1097.0 m in one day requires a pumping rate of 18,000 L/min – this maximum recommended pumping rate would be very difficult to exceed with the pumps available on site or to rent locally. The risk of an additional 1:200 year event occurring at the site before the initial event can be pumped down is quite low and so the additional stored water from the event could be dealt with using the available equipment at site. Additionally, should a second design event occur before the pond can be drawn down, there will be available storage capacity, based on the initial 1096.0 m starting pond elevation, to store the second event in the pond without releasing water. If a second 1:200 year event were to occur before any water was removed from the pond, it would raise the water elevation to 1097.65 m., which is still 0.15 m below the spillway invert.

[1] Bedient, P.B., Huber, W.C., 2002. Hydrology and Flood Plain Analysis, 3rd Ed. Prentice-Hall Inc.: Upper Saddle River, NJ. P. 396

4.4 Slope Stability

The stability of the upstream slope of a water retention structure is reduced by drawdown of the pond level due to the development of pore pressure gradients and associated seepage. The stability of a slope during and after a drawdown event is generally a function of time and the rate of drawdown relative to the rate of drainage of the slope until steady state seepage conditions become re-established. As a preliminary check of the stability of an embankment's upstream slope under the effects of rapid drawdown it can sometimes be assumed, conservatively, that no significant drainage of the material comprising the embankment slope will occur in the duration of the drawdown event. If stability analyses employing this conservative assumption indicates adequate slope stability, it is usually unnecessary to attempt to assess the potential stabilizing effect of pore pressure reduction as the slope drains.

For the upstream slope of the retention structure, the weakest materials present are considered to be the tailings deposited on the upstream face of the retention structure, which are understood to be present adjacent to the impounded water throughout the range of drawdown under consideration (elevation 1097.0 m to elevation 1095.0 m). The effective-stress shear strength parameters for the tailings have been conservatively estimated to be phi of 26 degrees[2] and cohesion of 0 kPa, indicative of a loose silt.

Review of the topographical information available indicates that the steepest tailings slope along the upstream portion of the tailings retention structure is at a gradient of about 14%. Infinite slope analysis for a material with phi of 26 degrees at a 14% slope gradient with seepage parallel to the slope (considered to be reasonably representative of the condition under consideration) indicates a factor of safety of about 1.7. This factor of safety value would be applicable to a small (localized), shallow failure and factors of safety against larger slumps would be somewhat higher (particularly since the average slope gradient would be reduced if a large slump were to be considered). Dam safety guidance for upstream stability under rapid drawdown conditions generally suggests a target factor of safety in the range of 1.2 to 1.3 so the conservative analysis undertaken confirms that the expected stability of the upstream slope of the tailings retention structure is acceptable under the reservoir drawdown contemplated.

5.0 SEEPAGE COLLECTION POND

5.1 Storage Volume

The available storage volume for the seepage collection pond was obtained from the design documents prepared by Tetra Tech EBA for Aboriginal Affairs and Northern Development Canada[3] and is presented graphically in Figure 3 and is summarized in the following Table 2. The volumes are based on 2013 survey data provided by Yukon Engineering Services and an extrapolated seepage pond bottom elevation of 1076.0 m. No bathymetry data were available at the time of the analysis, other than what could be reached from shore with a survey rod.

[2] Das, B.M., 2005. Fundamentals of Geotechnical Engineering, 2nd. Ed. Nelson: Toronto, ON P. 207

[3] Tetra Tech EBA Inc. 2014. Design Summary Report Seepage Collection Pone Drainage System Mount Nansen Mine, YT. Prepared for Aboriginal Affairs and Northern Development Canada, Edmonton, AB. March 2014. Project Number E14103158-01

Table 2: Seepage Collection Pond Storage Volumes

Elevation (m)	Approximate Storage Volume (m^3)
1076.0	0
1076.5	200
1077.0	475
1077.5	800
1078.0	1,250

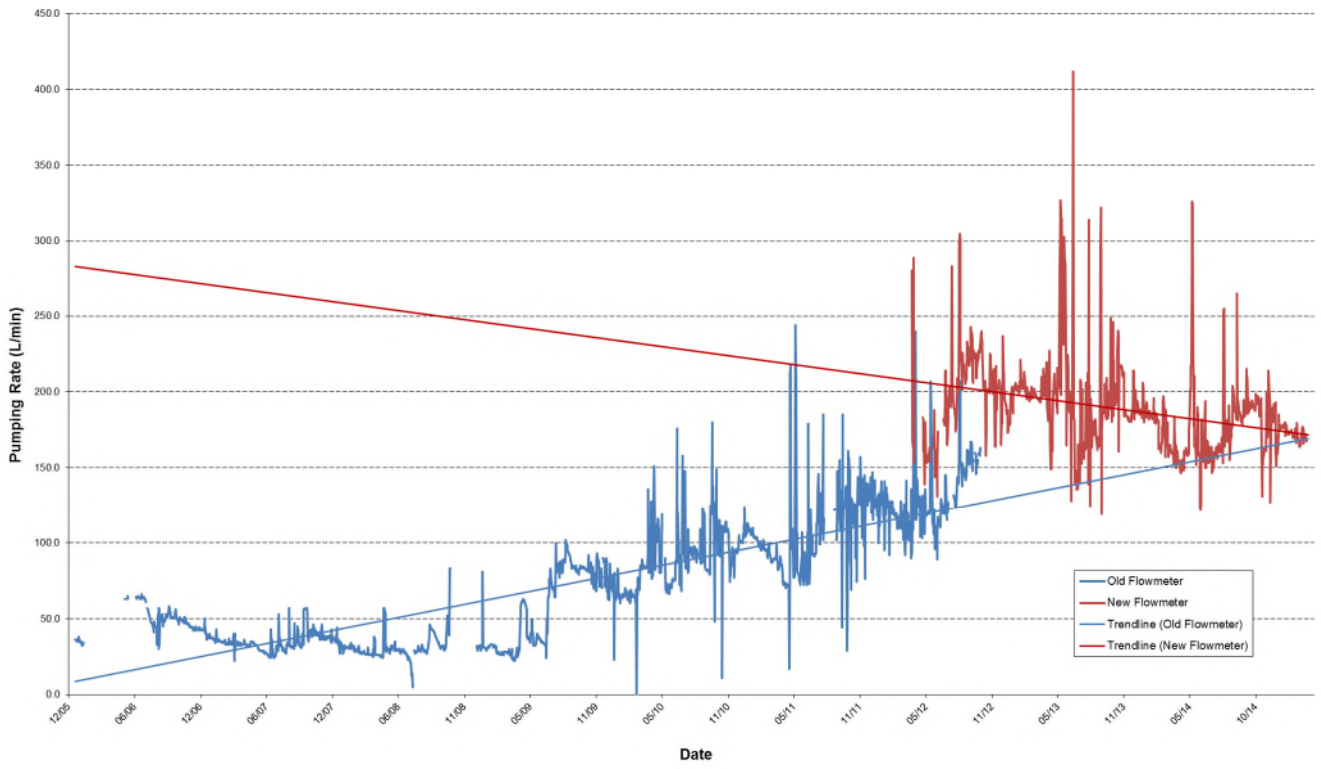
5.2 Design Inflow Volume

Tetra Tech EBA determined a catchment area of 12,000 m^2 for the seepage collection pond, consisting mostly of the downstream slope of the dam. For the 1:200 year two hour rainfall event (as discussed in Section 4.2) the design volume is 108 m^3. This volume of water will raise the water elevation in the seepage collection pond by 0.1 to 0.2 m, to an elevation of about 1077. 5 m assuming a starting elevation of 1077.3 m prior to the event.

5.3 Trigger Elevation and Pumping Rate

In order to store this volume of water, the water level should be maintained below elevation 1077.9 m. If the pond is at this elevation at the time of the design event, the water level in the seepage pond is expected to rise to 1078.1 m, resulting in a free board of 0.6 m.

The historical pumping data from the seepage collection pond has been provided to Tetra Tech EBA and is presented below:



The large spike in 2013 (420 L/min) was when the seepage collection pond was drawn down so that the sides and base could be inspected. There were no stability issues noted during this event. Given the free draining nature of the surrounding soils and the relatively shallow pond depth, the seepage collection pond could be pumped down quickly without compromising the stability. A maximum drawdown rate of one metre per day should be used as the maximum allowable rate, which corresponds to a pumping rate of 550 L/min. This is the maximum recommended pumping rate.

5.4 Slope Stability

The soils surrounding the seepage collection pond are primarily natural and compacted sand, both of which have strength properties that exceed that of the tailings. The pond has also been drained rapidly in the past (2013) and no stability issues were noted.

6.0 SUMMARY AND CONCLUSIONS

The tailings pond is expected to rise about 1.0 m during the design inflow event, based on available data. The recommended "trigger" elevation is 1097.0 m (about 0.8 m below spillway invert) and when the tailings pond water reaches this elevation, pumping should commence. The pond should be pumped down at a rate not to exceed 28,000 L/min to an elevation of 1096.0 m. Pumping at this rate may generate some minor surficial sloughing in the tailings blanket around the interior of the pond, but no deep seated failures affecting the stability of any of the earthwork structures surrounding the pond are expected.

When the seepage collection pond reaches a "trigger" elevation of 1077.9 m, it should be pumped down at a rate not to exceed 550 L/min – this rate will have no effect on stability of the dam or surrounding slopes.

Table 3: Recommended Trigger Elevations and Maximum Pumping Rates

	Tailings Pond	Seepage Collection Pond
Crest (m)	1099.6	1079.1
Top of Liner (m)	1098.8	1078.7
Spillway Invert (m)	1097.8	No spillway
Maximum Operating Level (m)	1097.8	1078.1
Trigger Elevation (m)	**1097.0**	**1077.9**
Maximum Pumping Rate (L/min)	**28,000**	**550**

If greater accuracy of available storage volumes is required, it is recommended that a proper bathymetric survey referenced to geodetic elevations be completed by a geomatics/surveying company.

7.0 CLOSURE

This report and its contents are intended for the sole use of the Government of Yukon, Energy Mines and Resources, Assessment and Abandoned Mines and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Government of Yukon, Energy Mines and Resources, Assessment and Abandoned Mines, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user.

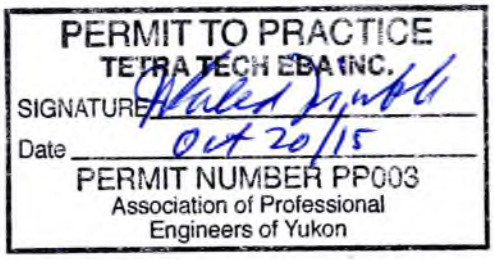
We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech EBA Inc.

Jonathon G. Dixon, P.Eng.
Geotechnical Engineer, Arctic Region
Direct Line: 867.668.9215
jonathon.dixon@tetratech.com

J. Richard Trimble, P.Eng., FEC
Principal Consultant, Arctic Region
Direct Line: 867.668.9216
richard.trimble@tetratech.com

Attachments: Figures (3)



FIGURES

W14103083-01 BH03 (T)

AMEC
BH-T-13-01

AMEC
BH-T-13-02

TAILINGS POND

TAILINGS POND
(ELEV. = 1095.2 m)

AMEC
BH-T-13-03

AMEC
BH-T-13-04

Tailings Dam Crest

APPROXIMATE LOCATION OF DOME CREEK DIVERSION / SPILLWAY

12861-04

W14103083-01 BH01 (T/P)

W14103083-01 BH02 (T/P)

W14103083-01 BH04 (T/P)

12861-07 (T)

GT09-03

GT09-05 (T)

12861-03 (T/P)

GT09-01 (T)

AMEC
BH-TD-13-01

12861-02 (T/P)

12861-06 (T)

12861-08 (T)

12861-05 (T/P)

SEEPAGE COLLECTION
POND (ELEV. = 1077.1 m)

GT09-04 (T)

GT09-02 (T)

12861-01 (T/P)

DH-96-01 (P)

Seepage Collection Dam Crest

14618-BH01 (T)

14618-BH03 (T)

14618-BH04 (T)

LEGEND:

- INSTRUMENTATION BOREHOLE LOCATION
T - THERMISTOR
P - PIEZOMETER
- WATER LEVEL (JUNE 11, 2015)

0 100

Scale: 1 : 1750 (metres)

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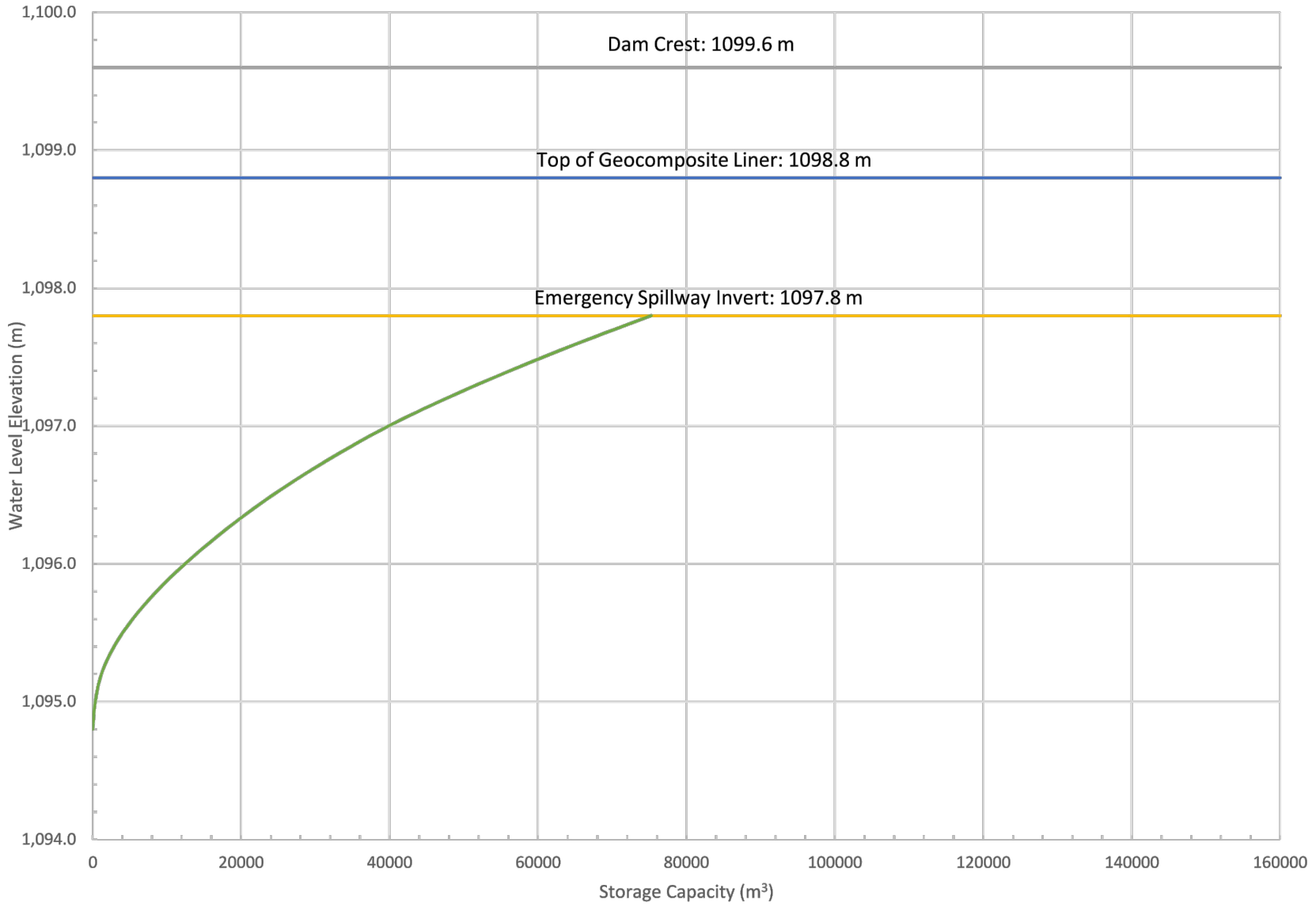
PUMPING RATE & SLOPE STABILITY ASSESSMENT
TAILINGS / SEEPAGE PONDS - MT NANSEN, YUKON

SITE PLAN SHOWING LOCATION OF TAILINGS POND AND SEEPAGE COLLECTION POND AND CROSS-SECTION ALIGNMENTS

PROJECT NO.	DWN	CKD	REV
W14103376-04	CB	JRT	0
OFFICE: EBA-WHSE	DATE: June 28, 2015		

Figure 1

Q:\Whitehorse\Data\0201drawings\Mt Nansen\W14103376-04 Tailings & Seepage Pond Pumping Rate & Slope Stability\W14103376-04 Bathymetry Analysis V2.dwg [FIGURE 1], July 28, 2015 - 3:42:54 pm (BY: BUCHAN, CAMERON)



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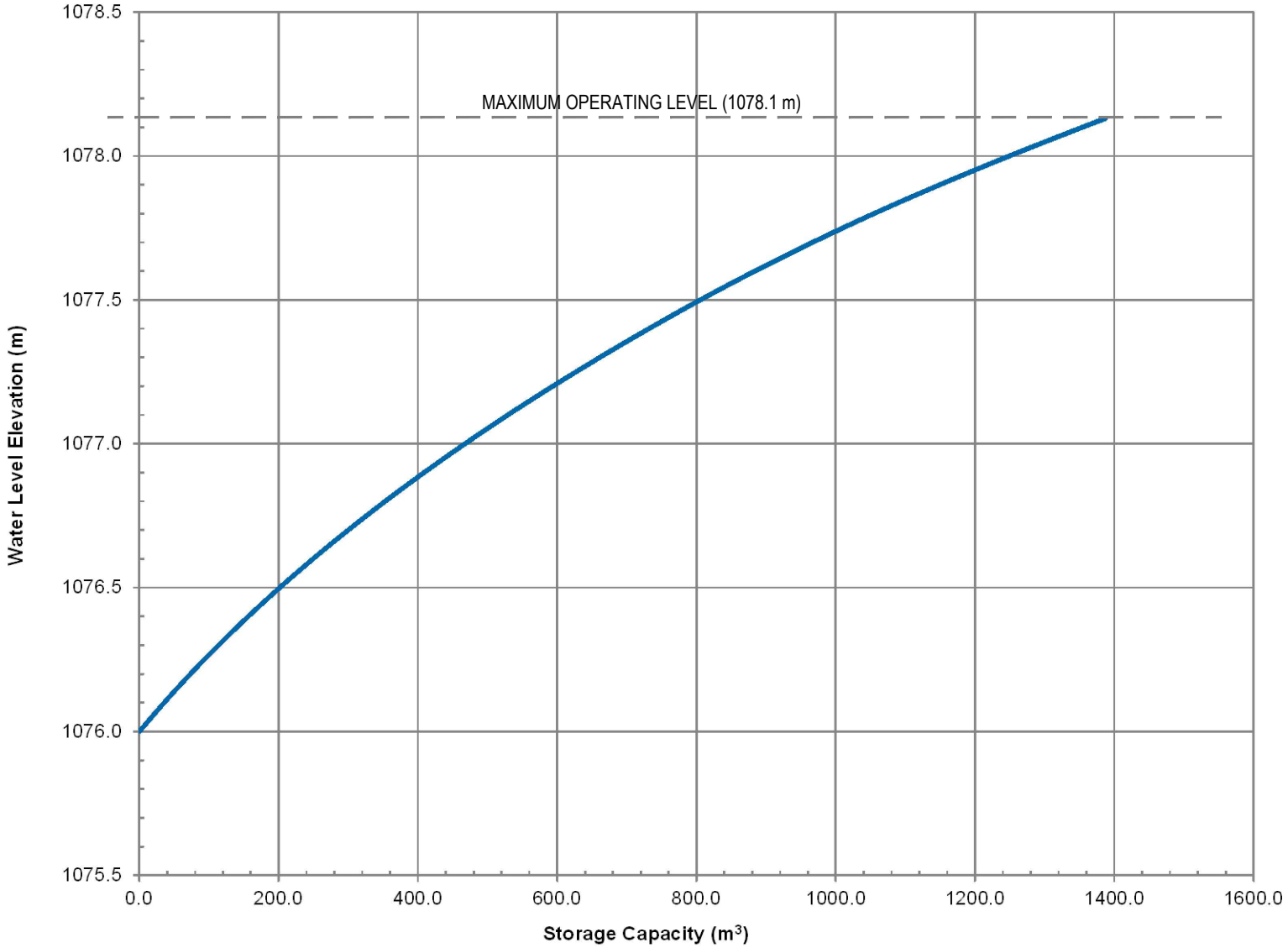
PUMPING RATE & SLOPE STABILITY ASSESSMENT
TAILINGS / SEEPAGE PONDS - MT NANSEN, YUKON

TAILINGS POND
STORAGE CAPACITY CURVE

PROJECT NO.	DWN	CKD	REV
W14103376-04	CB	JRT	0

OFFICE	DATE
EBA-WHSE	March 25, 2015

Figure 2



NOTES

CREST OF DAM = 1079.1 m

TOE OF LINER = 1078.7 m

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PUMPING RATE & SLOPE STABILITY ASSESSMENT
TAILINGS SEEPAGE POND - MT NANSEN, YUKON

SEEPAGE COLLECTION POND
STORAGE CAPACITY CURVE

PROJECT NO.	DWN	CKD	REV
W14103376-04	CB	JRT	0

OFFICE	DATE
EBA-WHSE	March 25, 2015

Figure 3