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MEMORANDUM

To:	**Deloitte & Touche**	**Fax No.:**	**Via e-mail**
Attention:	**Doug Sedgwick**	**CC:**	**Dana Haggar**
From:	**Ashton Friesen, Gerry Ferris**	**Date:**	**May 15, 2008**
Subject:	**Intermediate Dam Trigger Levels**		
No. of Pages (including this page): 15		**Project No:**	**0257-044-04**

The Intermediate Dam at the Faro Mine retains both tailings and a small pond. This dam was constructed in stages between 1981 and 1991 and is a zoned earthfill dam with gravel shells and a silty till core. As part of on going monitoring and as part of updating the Operations, Surveillance and Maintenance Manual (OMS), a trigger level slope stability analysis has been performed. The scope of work for this study was detailed in a proposal dated May 2nd, 2007. The purpose of the study is to define piezometric readings that would trigger different incident levels for the dam or slope instability in the dam.

Four different incident levels, in terms of factors of safety, were defined as part of the EPP (BGC 2003) and are shown in Table 1. Actions are defined and reporting requirements detailed in the OMS and Emergency Preparedness Plan (EPP) for each of the incident levels.

This memo defines piezometric elevations that would trigger changes to the incident levels. Other trigger mechanisms exist for this dam and are related to other failure modes. The reader should refer to the OMS and EPP for further guidance on triggers for the incident levels due to other failure modes. Of note the EPP and OMS are scheduled for revision in 2008 and the results of this study should be used to update the OMS and EPP documents.

Table 1 Piezometric Incident Levels

Incident Level	Factor of Safety
Normal	1.5 or greater, Piezometric levels below historic maximum
Alert	1.3 or greater, Piezometric levels above historic maximum
Emergency	1.1 to 1.3
Failure	1.0 to 1.1

1.0 INTERMEDIATE DAM DESIGN

The Intermediate Dam is located in the Rose Creek valley, immediately downhill from the mine and milling operations (see Figure 1). It was built as part of the Down Valley development in 1981 with three subsequent dam raises in 1988, 1989 and 1991, to a final crest elevation of 1049.4 m amsl. The Intermediate Dam was built downstream of the original and second tailings impoundments, and provided storage for tailings prior to ceasing operations at the mine.

A list of general characteristics of the Intermediate Dam is provided in Table 2. Figure 2 provides a plan view and a typical cross section of the Intermediate Dam along with the piezometer locations.

Table 2 General Characteristics of the Intermediate Dam

Type	Zoned Earthfill Dam
Fill Details	Gravel shell with a silty till core. Starter Dam with a central core, changing to upstream sloping core at subsequent dam raises
Foundation Cut-off	Partially cut-off
Purpose	Retain tailings solids, supernatant water and run-off water.
Year Constructed	Staged construction between 1981-1991.
Location	See Figures 1 and 2.
Access	Access to south end of dam via dike crest of Rose Creek Diversion Canal. Access to north end via access road to Down Valley area from the Main Mine access road and across the spillway.
Failure Consequence*	High.
Reason for Consequence	Release of non-compliant water and tailings. Qualitative Risk Assessment damages include repair, fines and clean-up with costs estimated between US $10-100 Million.
Reference(s) for Consequence Information	Klohn Crippen Consultants Ltd. 2002. Gartner Lee Ltd. 2002. Klohn Crippen Berger 2008
Emergency Spillway (Y/N)	Y. Rip rap lined earthen channel. Un-gated free overflow into channel.
Operation Spillway	Removable 36 inch diameter PVC siphon
Appurtenances	None.

*CDA 2007 classification, KCB 2008

The overall design criteria and key elevations for the Intermediate Dam are provided in Table 3.

Table 3 Intermediate Dam Design Criteria and Key Elevations

Crest Of Dam			1048.83 m amsl (2003 survey)
Top of Core			1048.5 m amsl (2003 / 2004 survey)
Full Supply Level, FSL			1047.7 m amsl (2005 survey)
Spillway Inlet			1047.7m amsl (2005 survey)
Design Freeboard			0.5 m (Golder 1980)
Actual Freeboard			0.68 m (2005 survey)
Design Seepage			0.22 m^3/s Golder (1980)
Reservoir Area			1,957,000 m^2 Gartner Lee (2002)
Total Storage Capacity			28,600,000 m^3 Gartner Lee (2002)
Design Requirements	**Slope Stability**	Upstream / Downstream, steady state	FS = 1.5
		Upstream, rapid drawdown	FS = 1.2
	Earthquake	Closure Requirement – 1:10,000 year	0.3g (Atkinson 2004)
		CDA Requirement – 1:2,500 year	0.21g (Atkinson 2004)
		Water Licence Requirement – 1:500 year	0.08g (Atkinson 2004)
	Flood	Closure Requirement - PMF	692 m^3/s (WMC 2006)
		CDA Requirement – 1/3 between 1:1,000 year and PMF	342 m^3/s (nhc 2004) (WMC 2006)
		Water Licence Requirement – 1:500 year	11.2 m^3/s (nhc 2006)
Spillway		Type	Earthen Spillway
		Rating Curve	Yes (nhc 2006)
		Capacity	32 m^3/s (nhc 2006)
Earthquake		Comments	Recent work indicates that this dam can withstand the 1:10,000 year earthquake (0.3 g). Thus the dam is stable for both the 500 and 2,500 return periods (KCB 2004)
Slope Stability		Downstream	FS = 1.6
		Upstream	FS = 1.6
		Upstream, rapid drawdown	Varies with initial water level, see Table 10 of this report.

The Intermediate Dam is bordered by the tailings pond on the upstream side and the polishing pond (contained by the Cross Valley Dam) on the downstream side of the Dam. Typical pond levels for both the tailings pond and polishing pond are provided in Table 4.

Table 4 Intermediate Dam Pond Levels (Tailings and Polishing Ponds)

Water Elevations	Tailings Pond (m amsl)	Polishing Pond (m amsl)
2007 Average	1046.49	1028.67
Historic Maximum	1047.94	1026.25
Historic Minimum	1045.53	1031.70
Spillway Invert	1047.70	1031.20

Since 2003 the operating level of the tailings pond has been consistently lower (as low as 1045.53 m amsl) than historically observed. This is due to the rerouting of discharge water from Faro Pit. Prior to 2003 the Faro Pit discharge water was treated at the tailings pond and is now being treated at the Faro Mine treatment plant. This water is then directly or indirectly discharged through the Cross Valley Dam and then into Rose Creek.

2.0 STABILITY ANALYSIS

The purpose of the stability analysis was to define piezometric trigger levels for the Intermediate Dam based on a Factor of Safety criteria (Table 1). The analysis considered a downstream critical failure plane which would, upon failure, release tailings and supernatant from the tailings pond. Similarly on the upstream side the largest possible failure surface, which consisted of a failure plane exiting the dam body above the tailings surface, was analyzed. Shallow surface instabilities of the downstream face were not analyzed in this study. If shallow failures occur they indicate that the dam should be considered within the Alert incident level and treated the same as other Alert level incidences.

The analyses were completed using the Morgenstern – Price method for circular failure surfaces within the slope stability program Slope/W (GEO-SLOPE, 2004). The analysis was conducted under static loading conditions only.

2.1 Material Properties

The material properties used in the analysis are provided in Table 5. These material properties were chosen based on a review of information contained in previous reports on the Intermediate dam and based on typical strength properties for the various material types. The two main references, which included site investigation results and stability analysis were Golder (1980) and Klohn (2004). The friction angles selected are thought to be conservative.

Table 5 Material Properties

Material	Effective Friction Angle (^{0})	Cohesion (kPa)	Unit Weight (kN/m^3)
Shell and Core	34	0	20
Foundation	32	0	20

2.2 Piezometric Readings

The piezometric readings indicate that all the piezometers (except BH91-ID3) can either be classified as a crest or a toe piezometer (BGC 2007), as shown in Table 6. The piezometric elevation measured at all of the crest piezometers were similar, the same situation is encountered at the toe. Thus for the purpose of the slope stability analysis only one cross section was analyzed using a generic crest and toe piezometer. Thus if any of the crest (or toe) piezometers read above the defined elevation, then the appropriate incident level is triggered.

The Intermediate Dam has a total of 14 pneumatic piezometers and standpipes which are located on both the crest and downstream (DS) toe of the Dam, as shown in Figure 2. The historic data associated to these piezometers are provided in Table 6.

Table 6 Intermediate Dam Piezometers

Name or ID	Instrument Type	Location	Historic Water Levels (m amsl)		
			Max	Min	Average
P01-03	Standpipe Piezometer	Toe	1030.63	1027.75	1029.31
P01-04	Standpipe Piezometer	Toe	1031.98	1029.31	1030.69
96-4	Standpipe Piezometer	Toe	1031.93	1027.87	1029.73
96-3	Standpipe Piezometer	Toe	1031.42	1027.43	1029.29
96-2	Standpipe Piezometer	Crest	1031.94	1029.40	1030.41
96-1	Standpipe Piezometer	Crest	1031.65	1027.85	1029.75
94-IDC-1	Standpipe Piezometer	Crest	1035.47	1035.31	1035.42
91-ID7	Pneumatic Piezometer	Toe	1035.20	1029.17	1031.34
91-ID5	Pneumatic Piezometer	Toe	1040.08	1020.69	1022.81
91-ID6	Pneumatic Piezometer	Toe	1033.35	1027.50	1029.86
91-ID4	Pneumatic Piezometer	Toe	1033.22	1027.76	1030.13
91-ID3	Pneumatic Piezometer	Crest (affected by RCDC)	1038.64	1033.88	1035.55
BKSO4-06	Pneumatic Piezometer	Crest	dry	dry	dry
BKSO4-07	Standpipe Piezometer	Crest	1037.72	1037.68	1037.70

The south abutment piezometer (BH91-ID3) has higher piezometric levels due to seepage from the Rose Creek Diversion Canal (RCDC). The RCDC is located just south of the Intermediate Dam, at a higher elevation than the dam crest (Figure 2).

In addition to the piezometers the pond water elevations define the piezometric conditions within the Intermediate Dam. For the analysis, it was assumed that the pond water elevations remained constant. It was assumed that the water elevations in the ponds were at their full supply levels, or at the elevation of the emergency spillways as shown in Table 7. The water levels have been significantly lower over the past five years, but are appropriate for this analysis. The "baseline" piezometric conditions were assumed for the crest and toe piezometers, as the average of the last few years readings, these are shown in Table 7 and graphically on Figure 3.

Table 7 Intermediate Dam Typical Conditions

	Water Elevations (m amsl)
Tailings Pond	1047.7
Polishing Pond	1031.2
Toe Piezometer	1029.7
Crest Piezometer	1030.0

2.3 Stability Analysis Results

A sensitivity analysis was performed by varying the piezometer water elevations (with the ponds at typical levels – Table 7) to determine piezometric trigger levels. Based on the typical ranges of pond water and piezometric elevations the dam is typically operating with a Factor of Safety between 1.5 and 1.6. Table 8 provides factor of safety data corresponding to the various piezometric elevations considered. Table 9 outlines the trigger levels for the piezometers located on the crest and downstream toe, in accordance with the incident levels indicated in Table 1.

Table 8 Intermediate Dam Stability Analysis Results

	Toe Piezometric Elevations (m amsl)					
Crest Piezometric Elevations (m amsl)	1029.7	1031.0	1032.0 (flowing artesian)	1034.0 (flowing artesian)	1035.0 (flowing artesian)	1036.0 (flowing artesian)
1030.0	1.6	1.5	1.5	1.4	1.4	1.3
1030.5	1.6	1.5	1.5	1.4	1.4	1.3
1031.0	1.6	1.5	1.5	1.4	1.4	1.3
1033.0	1.5	1.5	1.5	1.4	1.3	1.3
1035.0	1.5	1.5	1.4	1.3	1.3	1.3
1037.0	1.5	1.4	1.4	1.3	1.3	1.2
1039.0	1.4	1.4	1.3	1.2	1.2	1.2
1041.0	1.4	1.3	1.3	1.2	1.1	1.1
1042.0	1.3	1.3	1.2	1.1	1.1	1.0
1043.0	1.3	1.2	1.2	1.1	1.0	1.0

Table 9 Piezometric Incident Levels

	Toe Piezometric Elevations (m amsl)					
Crest Piezometric Elevations (m amsl)	1029.7	1031.0	1032.0 (flowing artesian)	1034.0 (flowing artesian)	1035.0 (flowing artesian)	1036.0 (flowing artesian)
1030.0	normal	normal	normal	Alert	alert	alert
1030.5	normal	normal	normal	Alert	alert	alert
1031.0	normal	normal	normal	Alert	alert	alert
1033.0	normal	normal	normal	Alert	alert	alert
1035.0	normal	normal	alert	Alert	alert	alert
1037.0	normal	alert	alert	Alert	alert	emergency
1039.0	alert	alert	alert	Emergency	emergency	emergency
1041.0	alert	alert	alert	Emergency	**FAILURE**	**FAILURE**
1042.0	alert	alert	emergency	**FAILURE**	**FAILURE**	**FAILURE**
1043.0	alert	emergency	emergency	**FAILURE**	**FAILURE**	**FAILURE**

3.0 RAPID DRAWDOWN

Another potential slope stability failure mode for this dam is a rapid drawdown of the water within the tailings pond. In this case the slope instability would occur into the tailings impoundment. Similar to the downstream analysis, only critical failure surfaces (defined in this study as a failure surface that would remove more than half of the crest of the dam) were included in this analysis. Smaller, shallower failure surfaces may occur prior to these larger scale failures and should trigger alert or emergency incident levels. The reader is referred to the OMS and EPP for further information on these smaller failures.

The piezometers in the Intermediate Dam are not installed within the core of the dam, and thus no monitoring can be undertaken to help the understanding of the dam's performance during a rapid drawdown event.

In order to assess the potential for rapid drawdown to affect the dam sensitivity analysis was completed. Some of the key information used in the analysis included:

- Strength parameters for the dam as per Table 5.
- Piezometric conditions within the dam's core as per Table 6.
- Water in the pond removed immediately.
- The upstream filter and shell drains just as rapidly as the water in the tailings pond. The piezometric elevation in the core remains unchanged as compared to typical conditions, see Figure 4.

Slope stability analyses were conducted using the Morgenstern – Price method. In this analysis the tailings pond water level was manipulated to simulate different rapid drawdown scenarios. Figure 4 provides the cross section of this analysis.

The results of the analysis are strongly dependent on the average pond elevation prior to the start of rapid drawdown. Two different analysis results are shown in Table 10, when drawdown starts with the pond full, 1047.7 m amsl and a second case when drawdown starts from the 2007 typical pond elevation, 1046.5 m amsl. The incident levels corresponding to normal, alert, emergency and failure stages for the rapid drawdown failure mode at the Intermediate Dam are shown in Table 10.

Table 10 Rapid Drawdown Incident Levels

Incident Level	**Pond elevation range for different incident levels (m amsl) [drawdown from initial elevation m]**	
Starting Tailings pond Elevation (m amsl)	**1047.7**	**1046.5**
Normal	1047.7 to 1047.4 [0 to 0.3]	1046.5 to 1046 [0 to 0.5]
Alert	1047.4 to 1046.8 [0.3 to 0.9]	1046 to 1044.3 [0.5 to 2.2]
Emergency	1046.8 to 1045.8 [0.9 to 1.9]	1044.3 to 1043.5 [2.2 to 3][2]
Failure[1]	1045.8 to 1044.9 [1.9 to 2.8]	

1. Below this elevation the Factor of Safety is less than unity.
2. Entire pond is drained at elevation 1043.5 m amsl.

4.0 CONCLUSIONS

Stability analyses were conducted in order to evaluate the piezometric trigger levels for the Intermediate Dam at the Faro Mine site. The analysis was conducted for a failure plane that would discharge supernatant and/or tailings upon failure. Historically the piezometric levels measured have been indicated that the dam is operating in the normal level (factor of safety of 1.5 to 1.6). This analysis outlines the piezometric levels that would constitute alert, emergency, and failure incident levels. Rapid drawdown of the tailings pond was also considered in this analysis and an alert level breakdown is provided based on tailings pond water levels. The actions to be taken at each of these trigger levels is defined in the EPP. This information along with the previously outlined alert levels based on visual monitoring and other factors are used to understand the performance of the Intermediate Dam. This information is in the process of being included in the updated OMS and EPP manuals for 2008.

5.0 CLOSURE

This report summarizes the physical conditions as observed by BGC and the instrumentation results as collected by site staff on various mine waste facilities and structures at Faro Mine. Thank you for the opportunity to be of service to Deloitte & Touche and Faro Mine. Should you have any questions on this report, please contact BGC at your convenience.

Respectfully submitted,
BGC ENGINEERING INC.
Per:

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Senior Geotechnical Engineer

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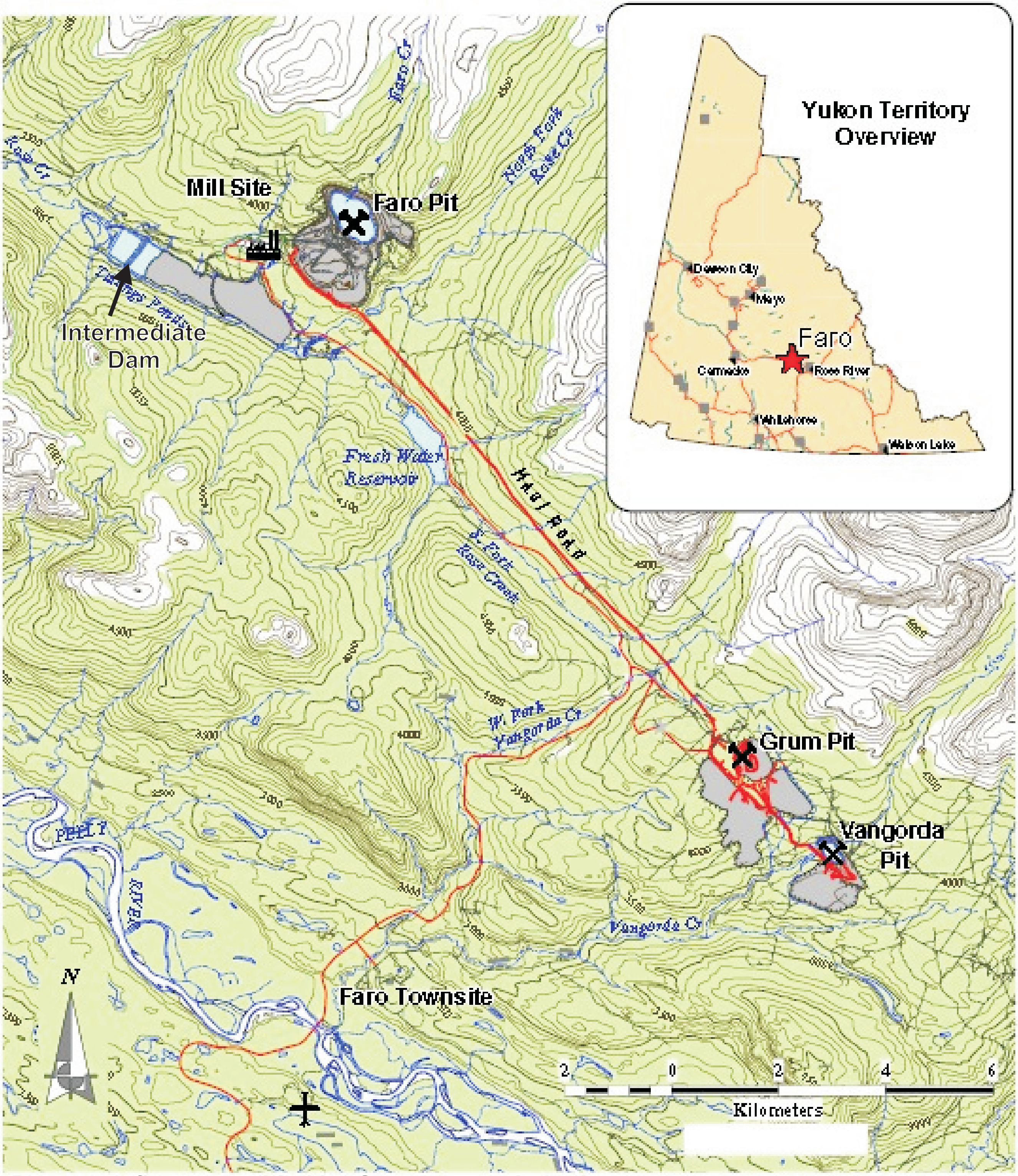
FIGURES



Note: Base map figure provided by Gartner Lee Limited.

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DATE:	MAY 2008	CHECKED:	GWF
DRAWN:	SLF	APPROVED:	JWC

CLIENT: Deloitte & Touche

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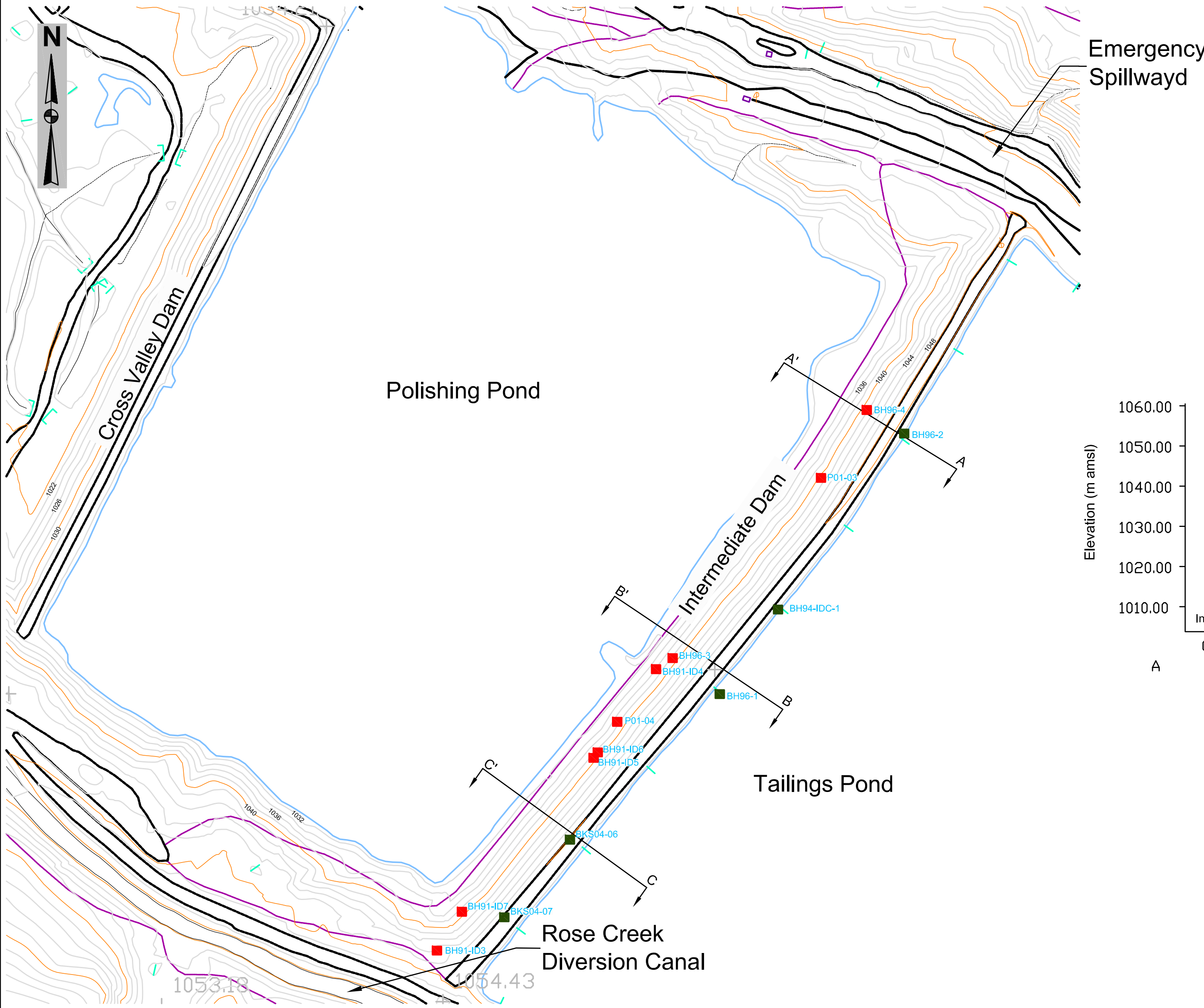
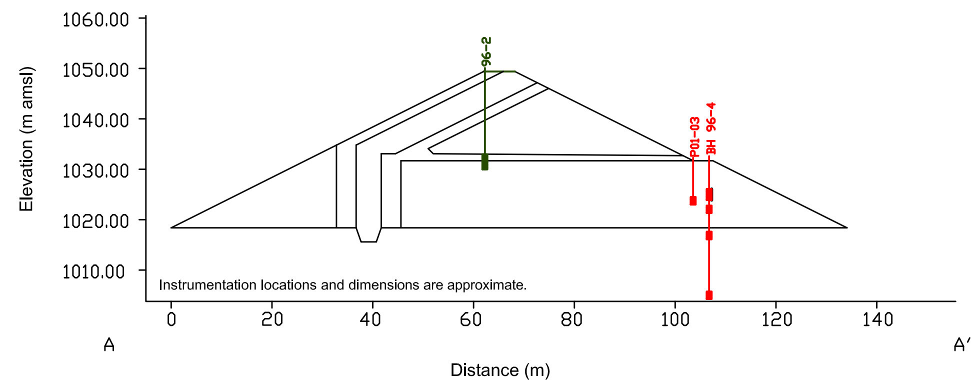
PROJECT
INTERMEDIATE DAM TRIGGER LEVELS

TITLE
SITE LOCATION PLAN

PROJECT No.	FIGURE No.	REV.
0257-044-04	1	0



Intermediate Dam - Cross-Section A - A'



CLIENT:

Screened Intervals of Standipe Piezometers
Bottom of Standpipe Piezometers
Pneumatic Piezometer Tips
Crest Piezometers
Downstream Toe Piezometers

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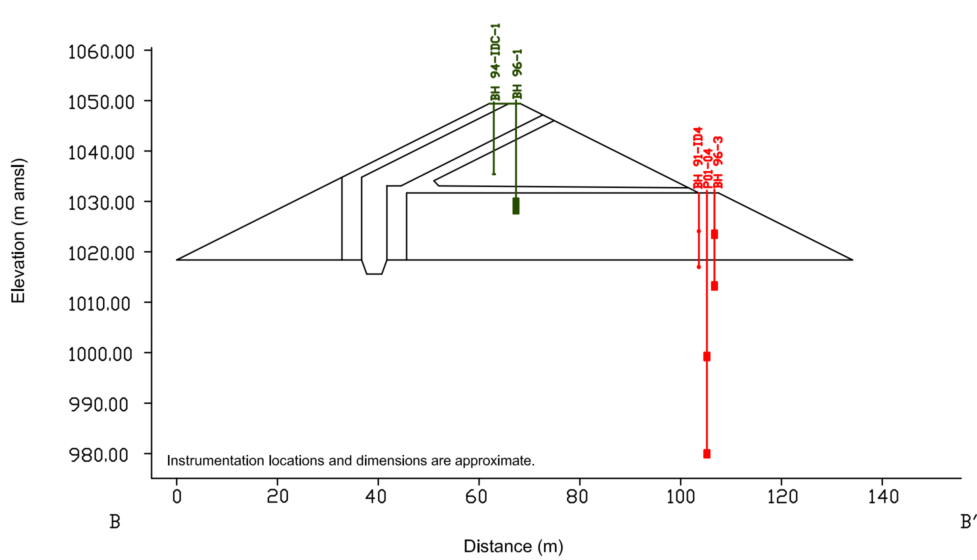
REV.	DATE	REVISION NOTES	DRAWN	CHECKED	APPROVED

Intermediate Dam - Cross-Section B - B'



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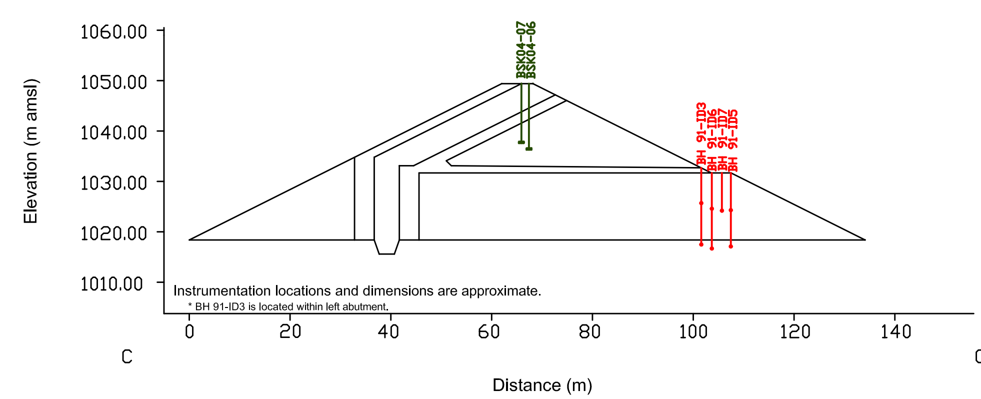

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DESIGNED:	ALF
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APPROVED:	GWF

PROJECT
INTERMEDIATE DAM TRIGGER LEVELS

TITLE
PLAN AND SECTION VIEW OF INTERMEDIATE DAM

PROJECT No.	FIGURE No.	REV.
0257-044-04	2	0

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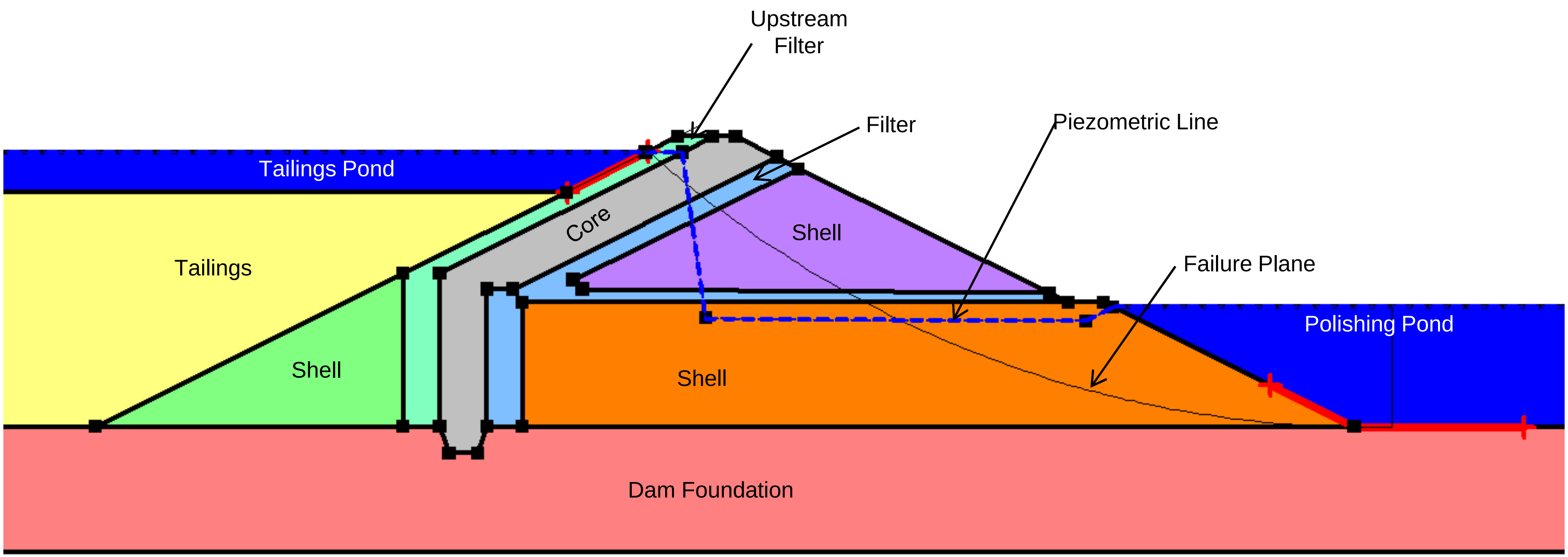
0257-044-04 PLAN AND SECTIONS FOR INTER DAM.dwg



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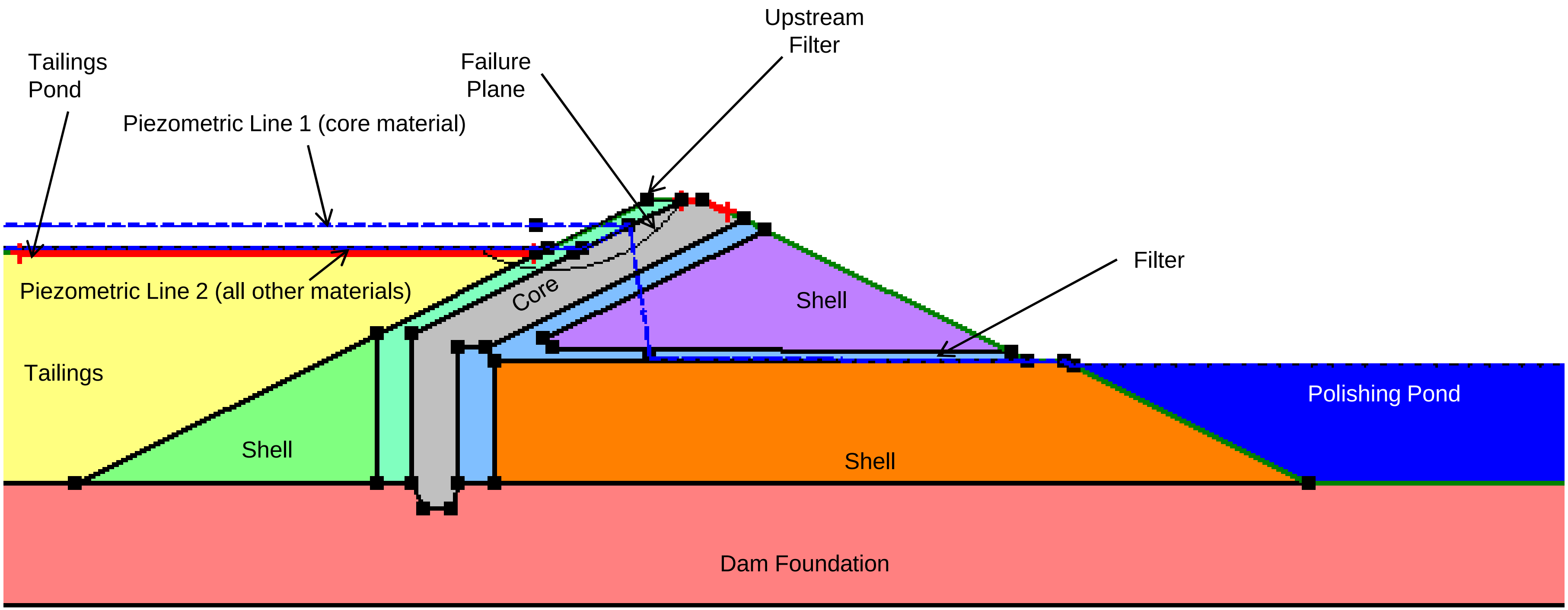
Client: Deloitte & Touche

Project: INTERMEDIATE DAM TRIGGER LEVELS

Title: STABILITY ANALYSIS CROSS SECTION (TYPICAL CONDITIONS)

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
0257-044-04	MAY 2008	NA	ALF	GWF	3



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Project: INTERMEDIATE DAM TRIGGER LEVELS

Title: STABILITY ANALYSIS CROSS SECTION (RAPID DRAW DOWN)

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
0257-044-04	MAY 2008	NA	ALF	GWF	4