Yukon Government

Faro Mine Complex

2012 Annual Geotechnical Review

March 2013
M09770A02.730

ISO 9001:2008
REGISTERED FS 62747

Klohn Crippen Berger

March 28, 2013

Yukon Government
Faro Mine Remediation Project
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Y1A 2C6

Karen Furlong, EIT
Project Manager

Dear Ms. Furlong:

Faro Mine Complex
2012 Annual Geotechnical Review

We are pleased to submit the report on Faro Mine Complex - 2012 Annual Geotechnical Review, including Appendix I on 2012 Site Visit Photos, Appendix II on reviewed site data, Appendix III on Site Personnel Training Handout and Appendix IV on TEES 2012 update of site maintenance activities in response to the recommendations given in our 2011 Annual Geotechnical Review report. The current review assesses the geotechnical performance of the water management and waste storage facilities at the Faro Mine Complex, including those at both the Faro and Vangorda Plateau sites. The review is based on our site observations by Robert Lo on September 11 to 13, 2012 regarding the geotechnical aspect, and Arvind Dalpatram on September 19 and 20, 2012 regarding the hydrotechnical aspect, and ongoing review of monitoring data collected by Tlicho Engineering and Environmental Services (TEES).

Yours truly,
KLOHN CRIPPEN BERGER LTD.

Robert C. Lo

Robert C. Lo, P.Eng.
Project Manager

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Yukon Government

Faro Mine Complex

2012 Annual Geotechnical Review

EXECUTIVE SUMMARY

This report assesses the geotechnical and hydrotechnical performance of the water management and waste storage facilities at the Faro Mine Complex, including those at both the Faro and Vangorda Plateau sites. The review is based on our site observations by Robert Lo on September 11 to 13, 2012 regarding the geotechnical aspect, and Arvind Dalpatram on September 19 and 20, 2012 regarding the hydrotechnical aspect, and ongoing review of monitoring data collected by Tlicho Engineering and Environmental Services (TEES).

Sections 2 and 3 of the report present our review of the Faro and Vangorda Plateau site facilities, respectively. For each facility, our site observations are first described, followed by the discussion of TEES site instrumentation monitoring data, and comments and recommendations. Section 4 summarizes our review, making use of summary tables, and Section 5 outlines the main conclusions and recommendations. Representative 2012 site visit photographs are included in Appendix I, and the reviewed TEES monitoring data are organized in Appendix II. Appendix III contains the PowerPoint presentation slides used by Robert Lo on September 12, 2012, and Appendix IV reproduces the TEES 2012 update of site maintenance activities in response to the recommendations given in our 2011 Annual Geotechnical Review report.

The key waste and water management facilities at both the Faro and Vangorda Plateau sites have functioned satisfactorily in 2012 as in the past. The care and maintenance activities, including instrument monitoring and survey measurement, are performed generally following the planned schedules.

According to the Canadian Dam Safety Guidelines (CDA 2007), both the Intermediate Dam and Cross Valley Dam will be due for their third dam safety review in 2014 because of their classification as “high” consequence dams. The current version of the Operations, Maintenance and Surveillance (OMS) Manual and Emergency Response Plan (ERP) for the above two dams and Little Creek Dam is dated in 2008 (BGC 2008a and 2008b). An update of these two documents is being prepared as a joint effort by the Government of Yukon, TEES and Klohn Crippen Berger (KCB) and will be issued by 2014. Moreover, the inundation study for these three dams is being prepared, and will be issued by 2014.

The 2012 pit-wall brim movement monitoring programs at the Faro and Grum Pits indicate that the measured distance changes are within the measurement accuracy. In the summer of 2012, cracks developed in the Grum Pit brim area where the two distance-measurement arrays were located. Safety precautions related to the site personnel were highlighted to prevent accidents.

On September 12 to 14, 2012 Golder (2013) conducted a pit wall slope stability inspection and review at the Faro, Grum and Vangorda Pits, following similar periodical inspections since 2002: for Faro Pit from 2002 to 2010 and for Grum Pit in 2009. These detailed reviews provide the Government of Yukon in-depth overview of the pit-wall stability status of these open pits and recommendations in terms of care and maintenance of infrastructures in the vicinity of these pits. At the Grum Pit installation of survey prisms on the east wall and control of surface drainage above the pit wall were recommended by Golder in light of 2012 crack development.

A flash flood occurred at the Vangorda Creek flume diversion in June 2012. The flume overflowed and the overflow was barely contained by the channel bank slopes outside the flume without spilling into the Vangorda Pit. The flash flood also eroded the riprap and earthfill around the upstream end of the main culvert feeding the flume. It also damaged the half-pipe flume at numerous locations requiring emergency repair. Damage to the flume included dents and holes in half-pipe and bent bracings. There was accumulation of sediments in the flume along the flatter section upstream of the plunge pool. This event was similar to that which occurred in 2004 (SRK 2004). The discharge capacity of the channel outside the flume needs to be checked, and capacity along the reach that barely contained the flow in June, 2012 needs to be enlarged to minimize the potential of spilling flood water into the Vangorda Pit. Moreover, the function of the Vangorda flume needs to be reviewed. We understand that a similar flume was removed from the Faro Creek Diversion Channel in the past with no significant detrimental impact.

The exfiltration function of the Moose Pond in 2012 has been served by seepage through the pond bank slope and bottom. Ongoing monitoring of the exfiltration groundwater flow regime and downstream slope of the esker ridge around the pond are needed to follow the natural recovery process in the area.

Key recommendations regarding both the hydrotechnical and geotechnical aspects are presented in Section 5 for specific facilities reviewed in the report. More detailed recommendations are summarized in Table 4.1. These recommendations deal with ongoing maintenance issues. They could be implemented by the Government of Yukon according to its priority and operational budget, as guided by its long-term closure objectives.

LIMITATIONS AND USE OF REPORT

This report is an instrument of service of Klohn Crippen Berger Ltd. (KCB) and has been prepared for the exclusive use of the Yukon government. The content of this report reflects Klohn Crippen Berger's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it are the responsibility of such third parties. KCB accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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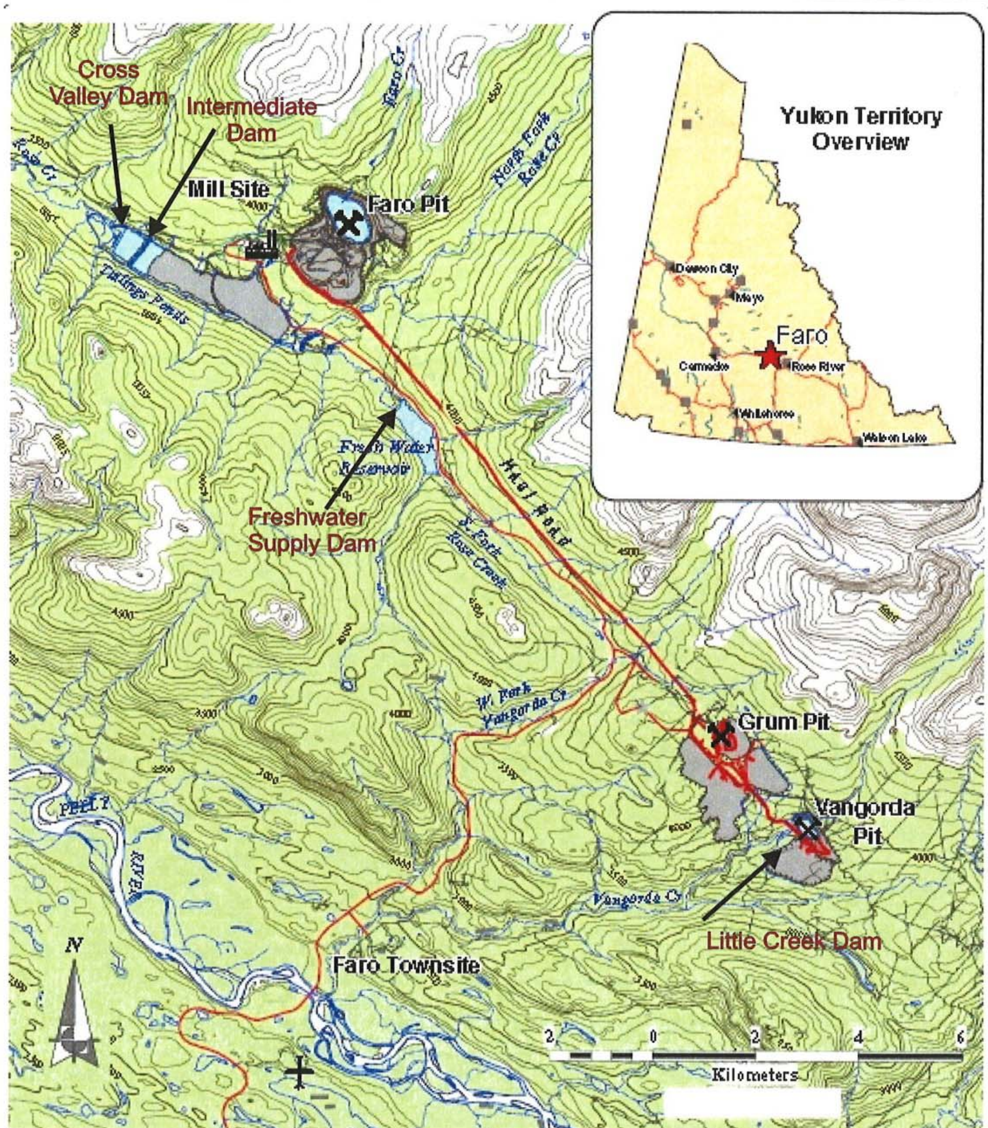
1 INTRODUCTION

1.1 Project Background

The Faro Mine site is located approximately 200 km north-northeast of Whitehorse, Yukon, as shown on the site location plan on page 2. It consists of the Faro Mine which was in production from 1969 to 1992 (with production rates of 5,000 tonnes per day to 9,300 tonnes per day), and the Vangorda Plateau Mine which was in production from 1986 to 1998. From 1998 to 2008, the mine site was under the management of Deloitte & Touche Inc., who were the court-appointed interim receiver. Ongoing care, maintenance, and environmental protection activities have been carried out by Denison Environmental Services (DES) between 2009 and 2011, centered on a seasonal pumping and water treatment program for the Faro and Vangorda open pits, and inspection and maintenance of water retention and water diversion structures. Tlicho Engineering and Environmental Services (TEES) replaced Denison in 2012.

The annual geotechnical review reports for the mine contain a summary of the site observations, provide the instrumentation monitoring data, and note recommendations for operation and maintenance for the coming year. These reports have been prepared by Golder Associates Ltd. (1996 to 1999, 2010, 2011), Geo-Engineering (MST) Ltd. (1999), BGC Engineering Inc. (2000 to 2009), and SRK Consulting Engineers (1996 to 2011). The annual review for 2011 was completed by Klohn Crippen Berger Ltd. (KCB 2012).

According to the Canadian Dam Safety Guidelines (CDA 2007), both the Intermediate Dam and Cross Valley Dam will be due for their third dam safety review in 2014 because of their classification as “high” consequence dams. The current version of the Operations, Maintenance and Surveillance (OMS) Manual and Emergency Response Plan (ERP) for the above two dams and Little Creek Dam is dated in 2008 (BGC 2008a and 2008b). An update of these two documents are being prepared as a joint effort by the Government of Yukon, TEES and Klohn Crippen Berger (KCB) and will be issued by 2014 (KCB 2013a, KCB 2013b). Moreover, the inundation study for these three dams is being prepared, and will be issued by 2014 (KCB 2013c).



Note: Base map figure provided by Gartner Lee Limited.

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SCALE:	As Shown	DESIGNED:	KFM
DATE:	September 2003	CHECKED:	HHH
DRAWN:	SLF	APPROVED:	JWC

CLIENT: Deloitte & Touche

BGC Engineering Inc.
AN APPLIED EARTH SCIENCES COMPANY
Calgary, Alberta. Phone: (403) 250-5185

PROJECT: Anvil Range EPP for Dams & Water Diversion Structures

TITLE: Site Location Plan

PROJECT No.	Figure number	REV.
0257-018-02		0

Site Location Plan of Faro Mine Complex

1.2 Project Scope

This report documents the 2012 annual review of the geotechnical performance of waste and water management facilities at the Faro Mine Complex. For ease of comparing with historical records, we follow the 2011 annual review report format by grouping these facilities into two sites: Faro and Vangorda Plateau sites. Although some of the following facilities are not within the scope of our 2012 task, such as Vangorda Pit, Grum Dump, we have included our observations here for future reference.

Faro Site (see Figures 1 and 2):

- Faro Pit and the Faro Creek Diversion Channel
- North Valley Wall Interceptor Ditch
- Rose Creek Diversion Channel
- North Fork Rock Drain
- K8 Creek Rock Drain
- Secondary Tailings Impoundment
- Intermediate Dam
- Cross Valley Dam

Vangorda Plateau Site (see Figures 3 to 5):

- Grum Pit
- Vangorda Pit
- Grum Dump
- Vangorda Waste Rock Dump
- Grum Interceptor Ditch
- North-East Interceptor Ditch above Vangorda Pit
- Vangorda Creek (Flume) Diversion
- Little Creek Dam
- Sheep Pad Sediment Ponds
- Grum Settling Pond
- V-15 Seepage Ditch and Moose Pond
- Sludge Pond Embankment at Vangorda Water Treatment Plant

The review is based on our site observations by Robert Lo of Klohn Crippen Berger Ltd. (KCB) on September 11 to 13, 2012 regarding the geotechnical aspect, and Arvind Dalpatram of KCB on September 19 and 20, 2012 regarding the hydrotechnical aspect, and ongoing review of monitoring data collected by Tlicho Engineering and Environmental Services (TEES).

On September 12, 2012, a two-hour long PowerPoint presentation was given by Robert Lo to seven members of the TEES site staff for training purposes. Karen Furlong of Yukon Government also attended the presentation. The presentation included the following:

- key structures of Faro Mine Complex;

- instrumentation used at Faro;
- dam inspection; and,
- inspection for problems and checklist for Tailings Dam Inspection.

The exchange of participants' site experiences and observations during their extended stay over the long history of Faro has been invaluable.

1.3 Organization of Report

Sections 2 and 3 present our review of the Faro and Vangorda Plateau site facilities, respectively. For each facility, our site observations are first described, followed by the discussion of TEES site instrumentation monitoring data, and comments and recommendations. Section 4 summarizes our review making use of summary tables, and Section 5 outlines the key conclusions and recommendations. Representative 2012 site visit photographs are included in Appendix I, and the TEES monitoring data are presented in Appendix II. Appendix III contains the PowerPoint presentation slides used by Robert Lo on September 12, 2012, and Appendix IV presents a TEES update of site maintenance activities in response to the recommendations given in our 2011 Annual Geotechnical Review report.

2 FARO SITE FACILITIES

2.1 Faro Pit and Faro Creek Diversion Channel

Faro Pit (see Photos 1 and 2 and Figure 2) and Faro Creek Diversion Channel (FCDC) (see Photos 3 and 4 and Figures 1 and 2)

The Faro Pit is an inactive, inundated open pit structure, roughly elliptical in shape with the major axis oriented to the northwest/southeast. The east wall is, roughly, 375 m high containing two, North and South instability zones separated by a calc-silica rich rock slope.

The Faro Creek Diversion Channel (FCDC) diverts flow from the head waters, north of the Faro Pit around the east side of the mine site and discharges into the North Fork of Rose Creek. The minimum distance between the Faro Pit east wall and the diversion channel are 18.5 m and 93 m, respectively, in the North and South instability zones.

2.1.1 Observations

Faro Pit

Observations of the Faro Pit from the 2012 KCB fall site visit made by R. Lo are as follows:

- No obvious changes on the east pit wall North and South Instability Zones were observed.

Faro Creek Diversion Channel (FCDC)

Observations of the Faro Creek Diversion Channel from the 2012 KCB fall site visit by A. Dalpatram are as follows:

- Moderate flow in channel at time of inspection.
- The channel and side slopes appeared to be stable along most of its length.
- Portions of the channel are lined with rock and geotextile or bentomat. Rock armour has moved in some areas, and geotextile/bentomat is exposed in some areas.

2.1.2 Instrumentation

Faro Pit (see Figure 6 for locations of reference bars and prisms)

Instrumentation at the Faro Pit includes one pond level indicator at the Faro Pit, nine reference bars to monitor pit wall regression and nine prisms to monitor pit wall movements (Golder 2009b and Golder 2011a).

Data provided by TEES on Faro Pit for the year of 2012 is given in Appendix II, and discussed below:

- Pond level (Section II-A.1) – The maximum pit pond level in 2012 is at El. 1142.13 m on May 7, and the minimum level in 2012 is at El. 1140.92 m on September 24, and these levels are compared with historical values in Table 2.1. In general, the pit pond level has been operated in a lowered range varying from 1140.7 m to 1142.1 m since August 2010 as compared with the range of 1141.0 m to 1142.8 m from August 2005 to July 2010.

- Pit wall regression (Section II-A.2) – The measured relative distances between reference bars and the pit wall brim have been similar for four bars (#15352, #15354 to #15356) from 2008 to 2012, and for four newly installed bars (#13908, #15717, #15737 and #15742) from August 2011 to September 2012. Locations of the four new reference bars should be added on Figure 6 to aid interpretation. The apparent difference in readings of about 2 m for #15351 was attributed to potential error in the bearing of distance measurement (Golder 2011a). The ID tag for Reference bar #15353 was destroyed in September 2010. In 2011 Yukon Engineering Services re-tag the Reference bar with ID tag #13908. The reading for reference bar #13908 on May 28, 2012 apparently contains a transcription error. In general, with the exception of bar #15351, all measured distances are practically the same within measurement accuracy. The bearing issue of distance measurement for bar #15351 should be rectified in the field to remove the anomaly.
- Pit wall prism monitoring (Section II-A.3) – The ordinates of change in northing and easting for the prism monitoring plots should be "cm" instead of "m". No survey was conducted in 2012. The scatter of the nine data points for the change in northing and easting plots seems to increase from 2 cm in October 2006 to 3 cm in August 2009. The scatter in the northing-change plot increases further to 5 cm in September 2010 and 2011, and the scatter in the easting-change plot remains at about 3 cm in August 2010 and 2011. It is uncertain whether these changes in scatter are related to prism position/survey accuracy issue or pit wall movement. Moreover, two prisms located uphill of the Faro Creek Diversion Channel (Points #13875 and 13877) were considered by Golder (2011a) not likely to move. However, they experienced "apparent change" of 2 cm to 3 cm in northing and 3 cm to 7 cm in easting from 2006 to 2011. The above observations may indicate that these "measured changes" could reflect the accuracy of these surveys rather than real pit wall movements.

Faro Creek Diversion Channel

Instrumentation at the Faro Creek Diversion Channel includes four staff gauges (FCD-1 to FCD-4) used for flow measurements in the diversion channel. Data provided by TEES on the diversion channel is discussed below:

- Staff gauge flow measurements (see Section II-B of Appendix II) - Historical and 2012 flows in the Faro Creek Diversion Channel are shown in Table 2.1.
- Discharge rating curves for the staff gauges are shown in Section II-B.1. Note all calibration points for the curves are for flows smaller than 700 L/s.
- Channel discharges estimated from the rating curves shown in Section II-B.1 are plotted in Section II-B.2. Since the discharge rating curves have not been calibrated for flows greater than 700 L/s, flows shown in Section II-B.2 that are greater than 700 L/s require confirmation by future calibration of the staff gauges under high flow conditions.

Table 2.1 Water Level for Faro Pit and Flow for Faro Creek Diversion Channel

Structure	Monitor Location	Historical[1]		2012	
		Max	Min	Max	Min
Faro Pit - Pond Level	FP	1143.1 m	1140.7 m	1142.1 m	1140.9 m
Faro Creek Diversion Channel - Flow	FCD-1	2213 L/s	69 L/s	-[3]	153 L/s
	FCD-2[2]	6178 L/s	7 L/s	-[3]	229 L/s
	FCD-3	1366 L/s	47 L/s	-[3]	127 L/s
	FCD-4	6018L/s	47 L/s	-[3]	135 L/s

Notes: 1. Historical data taken from 2011 Annual Geotechnical Review (KCB, 2012). However, it is not known how the high staff gauge was calibrated.
2. Staff gauge FCD-2 was broken during 2011 spring freshet, and was replaced on July 4, 2011.
3. No high flow data is given due to lack of calibration data.

2.1.3 Comments and Recommendations

Comments and recommendations regarding the Faro Pit and Faro Creek Diversion Channel are as follows:

- Continue visual monitoring of pit wall conditions with photos taken at same vantage points.
- Continue monitoring distances between the pit brim and reference bars installed in the North and South Instability Zone as a means to monitor the safety of the Faro Creek Diversion Channel at these strategic locations.
- Continue surveying the prisms installed at the pit wall as a means to monitor the pit wall movements in the North and South Instability Zone.
- Remove the anomaly of reference-bar distance measurement for bar #15351.
- Continue visual monitoring of diversion channel and any seepage from the channel to the Faro Pit wall with photos taken at strategic locations.
- Cover exposed geotextile/bentomat in the diversion channel with rock armour. Replace damaged geotextile/bentomat prior to rock armour placement.
- Faro Pit pond level has been operated in a lower range since August 2010.
- Construct foot bridge at staff gauges to obtain calibration data for the discharge rating curves under high flow conditions.

2.2 North Valley Wall Interceptor Ditch

North Valley Wall Interceptor Ditch (NVWID) (see Photos 5 to 10 and Figures 1 and 2)

The North Valley Wall Interceptor Ditch diverts creek flow from the north valley wall around the tailings impoundment area. It is approximately 3 km long and includes constructed and natural stream channel reaches. The ditch has relatively flat channel gradients along the constructed reaches and steep gradients along the natural stream reaches. The constructed channel reaches include:

- 920 m long upper reach;
- 430 m long middle reach; and,
- 500 m long lower reach.

2.2.1 Observations

Observations of the North Valley Wall Interceptor Ditch during the 2012 site visit by A. Dalpatram are as follows:

- Moderate flow in channel at time of inspection.
- The channel and side slopes appeared to be stable.
- Sedimentation deposition was observed both up and down gradient from the well-access road crossing.
- There was moderate to heavy vegetation growth in upper and middle constructed channel reaches.

2.2.2 Instrumentation

Instrumentation at the North Valley Wall Interceptor Ditch includes one flow monitoring location, NWID, within the diversion channel. Flow data for the NWID is shown in Section II.C.1 of Appendix II. Historical and 2012 flow data for this ditch is shown in Table 2.2.

Table 2.2 Flow in North Valley Wall Interceptor Ditch

Structure	Monitoring Location	Historical[1]		2012	
		Max	Min	Max	Min
North Valley Wall Interceptor Ditch	NWID	32 L/s	1 L/s	40 L/s (Estimated)	25 L/s

1. Historical flow data taken from Geotechnical 2011 Data Review (Golder, 2011c).
2. No indication was given how the flow was estimated; therefore, historical maximum flow value was not changed.

2.2.3 Comments and Recommendations

- Monitor channel sedimentation condition at the well-access road crossing, and remove sediments if the accumulation becomes excessive.
- Clear vegetation along the upper and middle constructed channel reaches. Clearing should also include the access road and berm along the channel to facilitate future inspection.

2.3 Rose Creek Diversion Channel and Canal Dyke

Rose Creek Diversion Channel (RCDC) and Canal Dyke (CD) (see Photos 11 to 16 and Figures 1 and 2)

The Rose Creek Diversion Channel diverts Rose Creek flow around the south side of the tailings impoundment. It is approximately 3.8 km long with, typically flat to moderate channel gradients along the upper reaches and steep gradients along the lower reaches. The upper reach of the diversion channel has three areas that are of geotechnical significance:

- Canal Dyke (CD): The dyke flanks the north side of the channel along the upper reach of the diversion channel and separates the channel from the tailings deposit, the Intermediate Pond, Intermediate Dam, Polishing Pond and Cross Valley Dam, see Figures 1 and 2.
- Spoil Piles: The spoil piles are wastes generated by the construction of the Canal Dyke. They are downslope of the Canal Dyke and located at various spots along the southern periphery of the tailings impoundment.
- Backslope: The backslope is the upper portion of the south excavation slope for the diversion channel above the flowing water.

2.3.1 Observations

Observations of the Rose Creek Diversion Channel during the 2012 site visits by A. Dalpatram and R. Lo are as follows:

- Moderate flow in channel at time of inspection.
- The channel and side slopes appeared to be stable with satisfactory rock armour conditions.
- Moderate vegetation growth in lower channel reaches.
- Minor seepage from the RCDC at base of spoil piles into Polishing Pond was reported previously, but could not be located during the fall inspection.

2.3.2 Instrumentation

Rose Creek Diversion Channel (see Figures 7 and 8)

Instrumentation in the diversion channel consists of one in-stream flow monitoring location (RCSG4). There are three other monitoring locations along the North Fork Rose Creek (NFRC-23, NF2 and X2). Historical data of maximum and minimum flows at these locations are shown on Table 2.3 (Golder 2011c). Staff gauge readings at RCSG4 for 2012, presented in Appendix II-1, vary from a low of 0.133 m to greater than 1.0 m, but the discharge rating curve does not cover readings higher than 0.37 m. A substantial number of staff gauge readings for 2012 are higher than 0.37 m, and five readings are recorded as >1.0 m. Flow measurements at the staff gauge should be made during high flows in order to extend the discharge rating curve beyond 0.37 m. The staff gauge should also be extended such that readings above 1.0 m can be recorded.

Table 2.3 Historical Range of Flow for North Fork Rose Creek and Rose Creek Diversion Channel

Location	Name	Historical[1]		2012	
		Max (L/s)	Min (L/s)	Max (L/s)	Min (L/s)
North Fork Rose Creek	NFRC-23	8000	0	-	-
	NF2	2713	613	-	-
	X2	1538	207	-	-
Rose Creek Diversion Channel[2]	RCSG4/ RCGC-4	38,000	1858	-[3]	289[4]

Notes:
1. Historical data taken from Geotechnical 2011 Data Review (Golder, 2011c). However, it is not known how the high flow data was measured.
2. RCGC-4 is a replacement of RCSG4 in 2012.
3. No high flow data in 2012 is given, because the discharge rating curve for staff gauge readings higher than 0.37 m is not available.
4. Due to uncertainty about minimum flow measured in 2012, no change was made on historical minimum flow value.

Canal Dyke (see Figures 7 and 8)

A summary of existing instrumentation on the Canal Dyke, Spoil Piles and Backslope of the diversion channel is shown in Table 2.4. Plots and recorded data, provided by TEES, for these instruments are given in Appendix II: Section II-E (Piezometers in Section II-E.1, Thermistors in Section II-E.2 and Inclinometers in Section II-E.3). Most of inclinometer readings taken in 2012 are erroneous possibly due to insufficient time being allowed for the probe to adjust to the ground temperature during instrument reading while the probe was being lowered down the inclinometer casing. To confirm correct readings are taken in the field, the site personnel should perform the "checksum" as indicated in the instrument manual. Deformation profiles are presented in Section II-E.3 for only three inclinometers with correct 2012 readings: BGC05-08, BH91-CD-1 and CD-10.

Table 2.4 Instrumentation for Canal Dyke, Spoil Piles and Backslope of Diversion Channel

Structure	Instrumentation (See Figures 6 and 7)
Canal Dyke	Pneumatic Piezometers - 3 single piezometers[1] (CD-7, CD-9, CD-10); and 9 paired piezometers with tips at deep and shallow depths (BH88-7[2], BH88-11[2], BGC05-02/BGC05-03, BGC05-06, CD-13, CD-15, CD-19[2], CD-21[2], CD-26)
	Thermistors - 5 (BGC05-04 and CD-10, CD-15, CD-21 and CD-26)
	Inclinometers - 9 (Borehole_1, BGC05-05, BGC05-08[4], CD-10[4], CD-15, CD-19, CD-21, BH91-CD-1[4] and BH94-CD-1)
Spoil Piles	Thermistors - 3 (SP-2[3], SP-3 and SP-5)
	Inclinometers - 2 (SP-2 and SP-5)
Backslope of Diversion Channel	Pneumatic Piezometers - 2 (BS-5 and BS-9)
	Thermistors - 4 (BS-5, BS-9, BS-10 and BS-12)
	Inclinometers - 3 (BS-5, BS-9 and BS-10)

Notes:
1. CD-7, CD-9 and CD-10 not monitored since 2009.
2. BH88-7, BH88-11 and CD-19 destroyed in 2004, and CD-21 deep piez. destroyed in 2005.
3. SP2 not monitored since 2008.
4. Deformation profiles for BGC05-08, BH91-CD-1 and CD-10 are presented in Section II-E.3.

2.3.3 Comments and Recommendations

Comments and recommendations for the Rose Creek Diversion Channel and Canal Dyke are as follows:

- Continue to check and remove vegetation in the diversion channel periodically.
- Continue to monitor instrumentation on a regular basis.
- Conduct geotechnical inspection of the diversion channel during spring peak flow condition.
- Staff gauge records in flow rate at other Rose Creek Diversion Channel flow monitoring stations were not given. Records in flow rate at these stations should be plotted on charts.
- Construct foot bridge at staff gauge RCSG4 to obtain data for extension of the discharge rating curve above 0.37 m.
- Extend the staff gauge at RCSG4 such that readings above 1.0 m can be recorded.
- Document seepage locations from the diversion channel into tailings impoundment area after fresh snow-fall.
- The piezometric levels either show a downward trend or are in a range consistent with historical variations.
- Seasonal variation of ground-temperature profiles as monitored by the thermistors at monitored locations shows similar historical range.
- Initial readings of inclinometers were obtained from BGC Engineering. However, most inclinometer readings taken in 2012 were erroneous except three. The field personnel need to check the instrument manual for proper procedures, and to perform “checksum” during monitoring in the field to confirm correct readings have been taken.
- There is an indication that thermistors and inclinometers were installed to track the geothermal and deformational development of the discontinuous permafrost present in the original foundation of the structures related to the diversion channel (Golder 1981). Current geothermal profiles seem to indicate that the foundation at depth at many locations of these structures remains frozen. Thus the current frequency of inclinometer and thermistor-readings at two to three times yearly appears to be reasonable. The situation will be reviewed after better inclinometer readings are obtained in 2013 for all functional inclinometers to see whether the frequency of reading could be reduced.

2.4 North Fork Rock Drain

North Fork Rock Drain (NFRD) (see Photos 17 to 18 and Figure 1)

The North Fork Rock Drain is a mine haul road stream crossing constructed of coarse waste rock fill, and drain rock. It functions as a conduit for the North Fork Rose Creek flow to cross the haul road, see Figures 1 and 2. The haul road at stream crossing is approximately 55 m high with a 25 m crest width. Downstream of the haul road, the North Fork Creek crosses the Main Access Road to the mine via a culvert which is supplemented by an auxiliary culvert at a slightly higher elevation.

2.4.1 Observations

Observations of this structure during the 2012 site visit by A. Dalpatram are as follows:

- Stable crest and side slope of mine haul road. Minor slumping of downstream face has occurred but is not a cause for concern at this time.
- Downstream drainage condition is acceptable with three braided channels combined to form one channel at the location of water-level monitoring and water sampling.

2.4.2 Instrumentation

Instrumentation at the North Fork Rock Drain consists of water level readings taken periodically throughout the year to record the pond elevation at both upstream and downstream of the mine haul road. A summary of the historical maximum and minimum values including the most current data (2012) is shown in Table 2.5. Recorded water level plots provided by TEES, are given in Section II-F.1 of Appendix II.

Table 2.5 Water Level at North Fork Rock Drain

Name	Historical[1] (m)		2012 (m)		Comments
	Max	Min	Max	Min	
NF-1	1094.35	1088.83[2]	1093.52	1088.83[2]	Upstream of haul road
NF-2	1089.11	1085.02	1087.58	1085.21	Downstream of haul road

Notes:
1. Historical data taken from 2011 Annual Geotechnical Review (KCB, 2012).
2. Minimum level decreased by 0.14 m from 1088.97 to 1088.83 m on August 20, 2012 for NF-1.

2.4.3 Comments and Recommendations

- The crest and side slopes of the mine haul road appeared to be stable.
- Continue to monitor head pond level and downstream creek level and flow condition, especially during spring freshet season.
- Water elevation at NF-1 has dropped below historical minimum value as indicated in Table 2.5, resulting in the modification of minimum historical value.

2.5 K8 Creek Rock Drain

K8 Creek Rock Drain (K8CRD) (see Photos 19 to 20)

The K8CRD is a mine haul road stream crossing constructed of coarse waste rock fill, and drain rock. It functions as a conduit for the K8 Creek to cross the main mine haul road. The haul road at the creek crossing is approximately 55 m high with a 25 m crest width. There is currently no instrumentation or monitoring program at this creek crossing.

During the 2012 site visit, A. Dalpatram observed the following:

- The crest and side slopes of the mine haul road appeared to be stable.
- Downstream drainage condition is acceptable.

2.5.1 Comments and Recommendations

- Future monitoring should include comments on visual observations from the haul road of the head pond level and downstream flow condition, especially during the spring freshet season.
- Location of the K8 Creek Rock Drain should be shown on site figures.

2.6 Secondary Tailings Impoundment

Secondary Tailings Impoundment (STI) (see Photos 21 to 22 and Figures 1 and 2)

The Secondary Tailings Impoundment is located on the east side of the Down Valley project area. The Secondary Tailings Dam is a perimeter tailings dam that retains tailings, supernatant, and run-off water, and encloses the original tailings impoundment. The dam crest is approximately 1120 m long, 6 m wide, with the crest elevation varying from El. 1060.2 m to El. 1063.3 m along its length. The overall dam height is about 28 m.

2.6.1 Observations

Observations of the geotechnical aspect of this structure during the 2012 site visit by R. Lo are as follows:

- The crest, upstream and downstream slopes appeared to be stable.
- No evidence of seepage along the downstream slope.
- Lower road conditions were satisfactory.
- A row of tailings piles was located on the upstream shoulder of the crest along the southwest portion of the dam. Tailings deposits covering the dam crest in the area were eroded by runoff from this row of tailings piles.
- Cracks that were observed in May 2012 along the downstream road in the vicinity of the upstream end of the Rose Creek Diversion Channel were not seen (see Photo 22), indicating that the temporary presence of cracks in the spring is related to seasonal thawing.

2.6.2 Instrumentation

Instrumentation at the Secondary Tailings Impoundment (see Figure 8) consists of 3 standpipe piezometers installed in 1981 on the dam crest and 4 standpipe piezometers installed in 2003 in the tailings pond (Piezometer P03-4 has not been monitored since September 2008). A summary of the current readings taken from these instruments along with historical maximum and minimum readings are shown in Table 2.6. Individual plots of piezometric levels at these piezometers as provided by TEES, are included in Section II-G.1 of Appendix II. Piezometers P81-6 to P81-8 has been dry, while

P03-1 to P03-3 show a variation less than 1 to 2 m except when blockage occurred. The piezometric levels monitored at these piezometers have been quite steady, about 5 m to 6 m below the ground surface when not dry.

Table 2.6 Historical and Current Water Level at Piezometers Located at Secondary Tailings Impoundment

Location	Piezometer[2]	Historical[1] (m)		2012 (m)	
		Max	Min	Max	Min
Dam Crest	P81-06	Dry	Dry	Dry	Dry
	P81-07	Dry	Dry	Dry	Dry
	P81-08	Dry	Dry	Dry	Dry
Tailings Pond	P03-01	1055.25	1054.29[3]	-[2]	1054.29[3]
	P03-02	1058.35	1053.72	1054.60	1054.04
	P03-03	1060.27	1052.28[3]	-[2]	1052.28[3]

Notes:
1. Historical data taken from 2011 Annual Geotechnical Review (KCB, 2012).
2. Maximum reading near ground level due to blockage.
3. Minimum level decreased by 0.25 m from 1054.54 to 1054.29 m on May 16, 2012 for P03-01, and decreased by 2.2 m from 1054.48 to 1052.28 m on May 16, 2012 for P03-03.
4. P03-04 piezometer has not been monitored since September 2008, but no reason was recorded.

2.6.3 Comments and Recommendations

- Continue to monitor dam performance.
- Continue to monitor piezometer instrumentation.
- Continue to monitor any cracks on the downstream road adjacent to the upstream end of the Rose Creek Diversion Channel, where cracks were observed in the spring of 2012.
- Check vegetation growth on the downstream dam slope periodically and clear vegetation, as required.

2.7 Intermediate Dam

Intermediate Dam (ID) (see Photos 23 to 39 and Figures 1 and 2)

The Intermediate Dam is located at the west end of the Intermediate Pond, just east of the Polishing Pond. It retains tailings, supernatant, and run-off water on the upstream side and polishing pond water on the downstream side. The dam is approximately 650 m long, 7 m wide at the crest and 32 m high. The dam crest elevation is at 1049.2 m, and the spillway invert elevation is at 1047.7 m. It has a downstream berm about 7 m wide, with the berm surface at approximate 1031.7 m. The Starter Dam has a vertical core, which was modified to an upstream sloping core during subsequent dam raises. The rest of dam zones consist of gravel shells and filters.

In 2012, the Government of Yukon experimented with increasing the maximum rate of drawdown of the Intermediate Pond from the historical rate of 25 mm/day to 40 mm/day, and monitors the dam performance in response to this change. No noticeable effect has been observed to date.

2.7.1 Observations

Observations of the dam during the 2012 site visits by R. Lo and A. Dalpatram are as follows:

- Pond level was drawn down.
- Stable crest, upstream and downstream slopes and spillway channel, in general.
- Near south abutment, minor upstream slope fill adjustment was noted (see Photo 30).
- Wave erosion of upstream slope in the vicinity of three markers were closely inspected at different elevations (see Photos 25 to 27 and 29). These markers appear to be reinforcing bars and do not look like the monitoring posts installed by Brodie (2010), see Photo 28. However, no posts similar to that shown on Photo 28 have been observed in our spring and fall visits in 2012. It is unclear whether the 2012 observed reinforcing bars are the 2010 monitoring posts or not.
- Downstream slope is experiencing extensive rill erosion (see Photos 32 to 37), with longitudinal cracks and minor slope slumps developing (see Photos 32 and 33), and eroded materials are depositing on the downstream berm.
- DES placed wooden stakes in 2011 on the downstream slope in the southwest dam segment to assist ongoing monitoring (see Photos 32 to 34).
- Eroded debris from the downstream slope often pushed the above-ground portion of existing instruments (see Photo 37), and the tilted instruments should be restored.

2.7.2 Instrumentation

Instrumentation at the Intermediate Dam (see Figures 7 and 9) consists of a pond level measurement of the intermediate pond; 14 standpipe piezometers at 9 locations; one single pneumatic piezometer and three paired pneumatic piezometers with tips at shallow and deep depths. The piezometers are installed in the embankment zones downstream of the core above, in and below the horizontal drain at the downstream berm elevation as well as in the dam foundation. They are distributed from the northeast dam segment to the southwest abutment (see Figure 9).

A summary of current maximum and minimum pond and piezometric levels as well as corresponding historical maximum and minimum levels are shown in Table 2.7. Plots of piezometric and pond levels are included in Sections II-H.1 and II-H.2 of Appendix II. The 2012 monitored piezometric levels either show a downward trend or are in a range consistent with historical variations.

Table 2.7 Historical and Current Intermediate Pond and Water Level at Piezometers Located at Intermediate Dam

Location	Name	Historical[1] (m)		2012 (m)		Comments
		Max	Min	Max	Min	
Water Level Readings						
Int. Pond	IP	1047.58	1043.47	1046.21	1044.31	Target El. 1043 m
Standpipe Piezometers (Nested piezometers at P01-4, BH96-3 and BH96-4)						
Dam Crest	BH96-1	1031.65	1027.37	1028.43	1027.96	Tip El. At 1027.35 m
	BH96-2	1031.94	1028.87[2]	1028.91	1028.87[2]	Tip El. At 1028.87 m
	BH94-IDC-1	dry	dry	dry	dry	-
	BKS04-06	dry	dry	dry	dry	-
	BKS04-07	dry	dry	dry	dry	-
Dam Toe	P01-3	1030.63	1027.48	1028.74	1028.08	-
	P01-4A	1032.24	1029.27	1030.99	1030.31	Shallow
	P01-4B	1032.17	1029.06	1030.29	1029.55	Deep
	BH96-3A	1031.38	1026.62	1028.67	1027.78	Shallow
	BH96-3B	1031.45	1027.48	1028.7	1027.86	Deep
	BH96-4A[4]	1032.04	1027.61	-	-	No readings for 2012
	BH96-4B[4]	1032.28	1028.39	-	-	No readings for 2012
	BH96-4C[4]	1031.64	1027.74	-	-	No readings for 2012
	BH96-4D[4]	1031.75	1027.62	1028.78	1028.11	-
Pneumatic Piezometers (BH91-ID3 to ID6 are nested piezometers with one tip deep and one shallow)						
South Abutment	BH91-ID3	1039.23	1036.82	1036.96	1036.89	Shallow
		1038.04	1029.95[2]	1032.89	1029.95[2]	Deep
Dam Toe	BH91-ID4	1035.91	1028.28	1029.33	1028.49	Shallow
		1031.85	1026.74	1028.14	1027.65	Deep
	BH91-ID6	1040.9	1026.62	1027.88	1027.39	Shallow
		1034.96	1020.82	1028.8	1028.24	Deep
	BH91-ID7	1035.2	1028.82	-	-	Destroyed in winter 2011/2012

Notes:
1. Historical data taken from 2011 Annual Geotechnical Review (KCB, 2012).
2. BH96-2: Minimum level adjusted to tip elevation 1028.87 m.
3. BH91-ID3 Deep: Minimum level decreased by 0.37 m from 1030.32 m to 1029.95 m.
4. BH96-4: 4 nested piezometers with -4A being the shallowest, and -4D being the deepest.

2.7.3 Comments and Recommendations

- Continue to monitor pond and piezometric levels on a regular basis.
- Continue to monitor upstream slope wave erosion zone because the Intermediate Pond level has been drawn down to below the riprap protection zone since 2010. Moreover, according to Golder 1991 Drawing 912-2402-3 there appears to be a gap between El. 1045.2 and 1046.7 m,

where there is no riprap zone on the upstream face. Remedial measures, such as replacement of riprap, may be required if excessive erosion is observed. However, remedial measures must take into consideration the works required for permanent closure of the pond, which is not expected to occur within the next 10 years.

- Continue to monitor minor damfill adjustment of the upstream slope near the south abutment (see Photo 30).
- Repair minor shoulder erosion of the downstream berm (see Photo 36).
- Monitor ongoing development of rill erosions on the downstream slope and related longitudinal cracks and slope slumps.
- Site staff indicated that re-sloping of the downstream slope has been successfully implemented in 2000s using site dozer equipment working on existing slope material. We recommend that this successful practice be implemented as early as practical to prevent further degradation of the downstream slope by rill erosion.
- Monitor sediment deposition over the discharge face of the drainage zone above the downstream berm surface.
- Review and update, if required, geotechnical stability analyses based on the current planned pond operation range.
- The pond should be pumped down to the targeted drawdown level.

2.8 Cross Valley Dam

Cross Valley Dam (CVD) (see Photos 40 to 49 and Figures 1 and 2)

The Cross Valley Dam impounds the Polishing Pond at the downstream limit of the Rose Creek Tailings Facility. The Polishing Pond is designed for the 60-day retention capacity for seepage from the tailings storage facility and discharge from the Faro Water Treatment Plant. The Cross Valley Dam is 500 m long, 7 m wide at the crest and 17 m high. The dam crest elevation is at 1033.1 m, while the spillway channel invert is at 1031.7 m. The dam has a central silty till core with gravel shells and filters.

2.8.1 Observations

Observations of the dam during the 2012 site visits by R. Lo and A. Dalpatram are as follows:

- The crest, upstream and downstream slopes and spillway channel appeared to be stable.
- Tension cracks previously observed on the dam crest in May 2012 were not observed in the fall. It suggests that the temporary appearance of these cracks in the spring each year seems to be related to the freezing and spring thaw phenomenon.

2.8.2 Instrumentation

Instrumentation at the Cross Valley Dam (see Figures 7 and 10) consists of a pond level measurement, 12 standpipe piezometers, four pneumatic piezometers and two thermistors. Except one piezometer installed in the embankment zone downstream of the core, all other piezometers are installed in the dam foundation at and beyond the downstream toe and beneath the dam crest. One functional shallow thermistor string (BH88-4) is installed in the dam fill zone upstream of the dam core, and one deep thermistor string is installed in the dam foundation underneath the upstream dam crest shoulder (CVDC-6). In addition, four weirs are installed downstream of the dam, Weir X11, X12, X13, and Weir 3.

Plots of piezometric levels, ground temperature profiles, Polishing Pond level and downstream weir flows are included, respectively, in Sections II-I.1 to II-I.4 of Appendix II. A summary of historical and current pond and piezometer levels are shown in Table 2.8. A summary of historical and current maximum and minimum flow weir readings are shown in Table 2.9.

Since 2009, the Polishing Pond level varies in a similar range from about 1027 to 1029 m. The 2012 monitored piezometric levels either show a downward trend or are in a range consistent with historical variations. Thermistor BH88-4 data indicates that the dam fill undergoes seasonal temperature variation from below to above 0^{o} C down to a depth of 4.2 m, while the deep Thermistor CVDC-6 data indicates that the dam foundation is essentially thawed. Thus, the frequency of thermistor-readings for the Cross Valley Dam could be reduced to once a year sometime in June.

Table 2.8 Historical and Current Polishing Pond and Cross Valley Dam Water Level and Piezometer Readings

Structure	Name	Historical[1] (m)		2012 (m)		Comments
		Max	Min	Max	Min	
Water Level Readings						
Polish Pond	PP	1030.33	1026.31	1029.10	1027.27	Target El. 1027 m
Standpipe Piezometers						
Dam Toe	CVDT-1	1018.57	1017.13	1017.92	1017.74	-
	CVDT-2	1019.5	1015.43	1018.65[3] (frozen)	1015.69	-
	P01-02	1018.3	1017.42	-	-	Shallow
		1019.73	1017.86	-	-	Deep
	P01-11	1017.83	1016.57[2]	1016.88	1016.57[2]	-
Dam Crest	CVDC-4	1019.05	1016.72	1018.83	1018.57	Deep
	CVDC-7	1017.74	1015.14	1015.57	1015.25	Shallow
		1019.21	1015.27	1017.82	1017.26	Deep
	94CVDC-1	1024.58	1022.71	1023.12	1022.93	-
	CVDC-9	1024.74	1019.91	1021.01	1020.11	Shallow
		1025.61	1021.18	1022.90	1022.86	Deep
Pneumatic Piezometers						
Dam Toe	CVDP-1	1019.83	1017.38	1018.43	1016.89[5]	-
	CVDP-3[4]	1017.65	1016.11	-	-	-
	CVDP-5	1022.05	1018.13	1020.72	1020.16	-
	CVDP-6	1019.55	1016.99	1017.94	1017.73	-

Notes:
1. Historical data taken from Geotechnical 2011 Data Review (Golder, 2011c).
2. Historical minimum has been reduced by 0.04 m from 1016.61 m to 1016.57 m for P01-11.
3. CVDT-2 frozen for reading on May 9, 2012.
4. CVDP-3 broken in winter 2011/2012.
5. CVDP-1 minimum reading in 2012 is suspicious, hence, not used to change historical record.

Table 2.9 Historical and Current Maximum and Minimum Weir Flow Downstream of Cross Valley Dam

Weir Number	Historical[1] (L/s)		2012 (L/s)	
	Maximum	Minimum	Maximum	Minimum
X11 (North)	20.9	2.56	13.96	4.64[2]
W3 (Central)	7.1	0.13	4.42	1.9
X12 (South)	2.03	0.03	1.10	0.03
X13 (Combined)	43.9	8.08[3]	33.82	8.08[3]

Notes:
1. Historical data taken from 2011 Annual Geotechnical Review (KCB, 2012).
2. The flow measurement of 0.92 L/s on July 12, 2012 could be erroneous. Therefore, it is not considered as the minimum flow in 2012 for Weir X11.
3. X13: Minimum flow decreased by 2.02 L/s from 10.1 to 8.08 L/s on October 4, 2012.

2.8.3 Comments and Recommendations

- Continue to monitor pond, piezometric levels and weir flows on a regular basis.
- The frequency of thermistor-readings for the Cross Valley Dam could be reduced to once a year, sometime in June.
- Monitor potential recurrence of tension cracks in the spring on the dam crest.
- The pond should be pumped down to the targeted drawdown.

3 VANGORDA PLATEAU SITE FACILITIES

3.1 Grum Pit

Grum Pit (GP) (see Photos 50 to 53 and Figures 3 to 5)

The Grum Pit is the northern most major structure at the Vangorda Plateau Site, approximately 12 km southeast of the Faro Pit. It is currently an inundated, inactive open pit with an approximate elliptical shape, extending 850 m in the north/south direction and 600 m in the east/west direction. The dominating wall of the pit is the east pit wall which is 160 m high. Instability of the east wall appears to be still evolving (Golder 2009a, 2013), and ongoing monitoring of potential pit-wall brim movement started in the summer of 2010.

3.1.1 Observations

Observations of the Grum Pit during the 2012 site visits by R. Lo are as follows:

- Crack was observed at the second reference rod from the pit edge along the north array (see Photo 52), and dense vegetation covered along the array interfered with ongoing examination of ground deformation or cracks in the area.
- Ground deformation was observed occurring between the pit edge and the first reference rod along the south array (see Photo 53), and sparse vegetation did not affect ongoing examination of ground deformation in the area.
- TEES removed the vegetation cover along the north array subsequent to the fall site visit to facilitate ongoing monitoring of the ground deformation and cracks in the area.

3.1.2 Instrumentation

Instrumentation at the Grum pit (see Figure 11) involves two sets of monitoring reference rods: 6 rods (GP-N1 to GP-N6) and 4 rods (GP-S1 to GP-S4) along two alignments about 150 m apart (see Figure 11) for monitoring movement on the pit wall brim. Two rods furthest away from the pit wall (GP-N6 and GP-S4) are assumed stationary. Distances from other rods relative to the stationary rod along the same alignment are measured periodically and calculated to detect any relative movements. In addition, there is a pit pond-level measurement point, and two piezometers installed in the Grum Pit cut slot.

Plots showing changes of the distances, measured by TEES from monitoring rods along two arrays to their respective stationary reference rod, are given in Section II-J.2 of Appendix II. A summary of these relative distances measured in 2010 and 2012 are compared in Table 3.1.

Table 3.1 Relative Distances from Monitoring Rods to Reference Stationary Rod on Grum Pit Wall Brim

Location	Rod Name	Distance Measured Relative to Rod GP-S4 or GP-N6, (m)		
		June 24, 2010[3]/ July 29, 2010[2]	December 19, 2012	Comment
South Array				Relative to GP-S4[1]
	GP-S1	29.006[2]	29.01	GP-S1
	GP-S2	23.444[2]	23.441	GP-S2
	GP-S3	15.630[2]	15.636	GP-S3
	GP-S4	0	0	GP-S4
North Array				Relative to GP-N6[1]
	GP-N1	28.738[3]	28.779[4]	GP-N1 (August 28)
	GP-N2	23.356[3]	23.397[4]	GP-N2 (August 28)
	GP-N3	18.130[3]	18.143[4]	GP-N3 (August 28)
	GP-N4	12.004[3]	12.014	GP-N4
	GP-N5	5.740[3]	5.735	GP-N5
	GP-N6	0	0	GP-N6

Notes:
1. GP-S4 and GP-N6 Rods assumed stationary.
2. South array distance measurements initiated on July 29, 2010.
3. North array distance measurements initiated on June 24, 2010.
4. August 28, 2012 is the date when these distance measurements were made by TEES.

Detailed data of pit pond level, monitoring-rod survey and cut slot piezometers, as provided by TEES, are included in Section II-J of Appendix II. As shown on the chart in Section II-J.1, the pit pond level at Grum Pit rose 2.81 m from 1211.45 m on January 3, 2012 to 1214.54 m on December 18, 2012, about 3.54 m above the AMP trigger level at about 1211 m and 1.04 m above the maximum recommended elevation at about 1213.5 m. We understand that a pump barge will be set up in the pit pond to reclaim pond water for treatment in 2013.

3.1.3 Comments and Recommendations

- An error on the record for Rod GP-N5 on January 5, 2012 propagates to calculated distances for other rods on the north array as shown on the plots in Appendix II-J.2.
- Records of two arrays show little change in the relative distances measured to date.
- The calculation and plotting of “velocity of rod’s movement” do not enhance the interpretation of monitored data.
- Continue visual monitoring of pit wall conditions with photos taken from the same vantage points.
- Continue distance measurements of monitoring rods installed on the pit brim. We understand that Golder recommends installation of survey prisms to enhance the current monitoring of the instability zone along the east pit wall. We concur with this recommendation.
- Personnel safety is an important concern with respect to setting up survey prisms in the instability zone and ongoing distance measurements of reference rods. Ongoing monitoring

program should include consideration of other non-technical factors; such as the pit is inactive and site personnel who conduct distance measurement are not geotechnical professional.

- Movement-monitoring survey techniques used for the Grum Pit brim seem to provide more accurate result than those used for the Faro Pit brim. Improvement of survey techniques used at the Faro Pit brim could be considered.
- Piezometric level at both piezometers shows a variation range of about 1 m in the summer months. Significant drop of piezometric level in winter months could be due to the influence of freezing.
- Currently, the Grum Pit pond level is above the maximum recommended level at about 1213.5 m. We understand that a pump barge will be set up in the pit pond to reclaim pond water for treatment in 2013.

3.2 Vangorda Pit

Vangorda Pit (VP) (see Photos 54 to 57 and Figures 3 to 5)

The Vangorda pit is approximately 1.8 km southeast of the Grum Pit, just to the north of the Vangorda Waste Dump, see Figures 3 to 5. It is an inactive, inundated open pit with an approximate elliptical shape, long axis oriented in the northwest to southeast direction. Golder is on site in September, 2012 to evaluate the pit wall stability in light of the potential impact of any instability along the northwest Vangorda pit wall on the adjacent Vangorda Creek Flume Diversion (see Figures 3 to 5).

3.2.1 Observations

There appeared little change in the condition of the Vangorda pit walls since our May 2012 visit.

3.2.2 Instrumentation

There is currently only a pit pond-level measurement point at the Vangorda Pit. Pond-level plot provided by TEES is included in Section II-K of Appendix II.

3.2.3 Comments and recommendations

- Pond water level has been decreasing by about 5 m since 2009 and is well below the maximum recommended elevation at about 1091.8 m. In 2012, the maximum pond level was at 1088.49 m, about 1.05 m above that in 2011.
- Continue to monitor the pond water level on a regular basis.
- Continue visual monitoring of pit wall conditions with photos taken at same vantage points at least at yearly intervals.

3.3 Grum Waste Rock Dump

Grum Waste Rock Dump (GD) (see Photos 58 to 61 and Figures 3 to 5)

The Grum Waste Rock Dump is an old waste dump located just south of the Grum Pit. The dump is currently undergoing reclamation.

Although it is not within the scope of our 2012 work, we recommend that regular visual monitoring be carried out for the Grum Waste Rock Dump, including taking photos.

3.4 Vangorda Waste Rock Dump

Vangorda Waste Rock Dump (VWRD) (see Photos 62 to 75)

The Vangorda Waste Rock Dump, located to the south of the Vangorda Pit and Little Creek Dam, has six transverse base drains installed beneath the glacial till starter dyke to collect dump seepage into a seepage collection ditch. The collected seepage, in turn, drains into a pond retained by the Little Creek Dam, see Figures 3 to 5 (SRK-Robinson 1994).

3.4.1 Observations

Observations of the waste dump and its transverse base drains during the 2012 site visit of A. Dalpatram are as follows:

- Drain No. 1 – was dry. Does not have a weir.
- Drain No. 2 - was dry.
- Drain No. 3 – Staff gauge was tilted and weir plate was delaminated. Flow is usually measured with a bottle and a watch.
- Drain No. 4 – Does not have a weir. Usually only a small trickle flows through the drain, and flow is estimated by eye.
- Drain No. 5 – Weir plate was split into 2 pieces. There are boulders in the pool upstream of the weir and the channel invert downstream of the weir is too high.
- Drain No. 6 – Weir plate and channel is in satisfactory condition for flow measurement. There was evidence of a slump of waste dump slope at the drain in the past.

3.4.2 Instrumentation

Instrumentation at the Vangorda Waste Dump (see Figures 4, 5 and 12) consists of four V-notch weirs, V30 to V33, at transverse base drains 2, 3, 5 and 6 for flow measurement, 16 piezometers and 4 groundwater monitoring wells in the dump area. Detailed data on base drain flows and piezometric levels provided by TEES are included in Section II-L of Appendix II. The weir flow data in 2012 are summarized in Table 3.2. The maximum piezometric level in 2012, and the corresponding date as well as trigger level as provided by SRK (2011b), are shown in Table 3.3.

Table 3.2 2012 Weir Flow Data at Vangorda Waste Dump

Weir No.[1]	Maximum Flow		Minimum Flow	
	Flow (L/s)	Date Measured	Flow (L/s)	Date Measured
V30 (Drain No. 3)	0.33	June 5	0.04	May 11 and July 4
V31 (Drain No. 4)	0.26	July 4	<0.1	In general
V32 (Drain No. 5)	No flow	-	No flow	-
V33 (Drain No. 6)	0.59	June 5	0.017	August 14

Note:
1. Drain number at each weir has been confirmed by TEES.

Table 3.3 2012 Monitored and Trigger Piezometer Level at Vangorda Waste Dump

Groundwater Monitoring Well/ Piezometer		Date of Max. Piez. Level in 2012[3]	Max. Piez. Level, m	Trigger Level[1] m (amsl)	Above Trigger Level
V34	GW-94-01	May 9	1111.25	1115	No
V35	GW-94-02	May 9	1109.56	1115	No
V36	GW-94-03	May 9	1109.21	1113	No
V37	GW-94-04	May 9	1107.22	1109	No
V39	P-94-01A	September 18	1125.39	1131	No
V40	P-94-01B	September 18	1131.24	1133	No
V41	P-94-02A	September 18	1130.7	1133	No
V42	P-94-02B	September 18	1132.32	1134	No
V43	P-94-02C	May 11	1128.75	1125	No
V44	P-94-03A	September 18	1121.38	1126	No
V45	P-94-03B	April 30/May 11	1124.67	1126	No
V47	P-94-04B	September 18	1125.44	1126	No
-	P-2001-02A	May 30	1119.99	1123	No
-	P-2001-02B	May 30	1119.60	1123	No
-	P-2001-03	May 9	1082.02	1120	No
DH1	PW-10-01	September 18	1128.17	1135	No
DH2	PW-10-02	September 18	1127.26	1131	No
DH3	PW-10-03	September 18	1123.29	1130	No
DH4	PW-10-04	April 30/May 11	1132.45	1133[2]	No
DH5	PW-10-05	September 18	1137.83	1139	No

Notes:
1. Trigger levels were taken from SRK (2011b).
2. Trigger level at Piezometer PW-10-04 in Hole DH4 were increased from 1132 to 1133 m by SRK (2011b).
3. Only one reading was taken on May 9, 2012 for piezometers GW-94-01 to GW-94-04, P2001-02A and P2001-02B, and two to three readings were taken for the rest of piezometers.

3.4.3 Comments and Recommendations

Comments and recommendations regarding future geotechnical performance of the Vangorda Waste Rock Dump are as follows:

- Drain No. 3 – Staff gauge and delaminated weir plate should be repaired, if flow is not measured with a bottle and a watch.
- Drain No. 4 – A weir should be installed, if flow increases to measurable levels.
- Drain No. 5 – Weir plate should be repaired. Boulders in the upstream pool should be removed and the channel invert immediately downstream of the weir should be lowered slightly to provide good free flow conditions required for flow measurement.
- Drain No. 6 – Continue to monitor the slump of waste dump slope above the drain observed in the past (see Photo 62).
- Flows at all base drains are consistent with historical data.
- Piezometric level at all piezometers and groundwater monitoring wells in 2012 varies within the historical range, and is below the trigger level provided by SRK (2011b).

3.5 Grum Pit Interceptor Ditch

Grum Pit Interceptor Ditch (see Photos 76 to 79 and Figures 3 to 5)

The Grum Interceptor Ditch diverts water around the Grum Pit and Grum Overburden Dump. It consists of the following three reaches:

- 900 m long ditch upslope of the Grum Pit to divert clean water away from the pit;
- 900 m long ditch along the northeast toe of the Grum Overburden Dump; and,
- 650 m long ditch to convey flow downhill to Tributary B of the Vangorda Creek.

3.5.1 Observations

A. Dalpatram observed the following during the 2012 site visit:

- Stable channel and side slopes.
- Light to heavy vegetation growth, particularly along the upper reaches of the ditch.
- Top of the culvert under the road to Grum Settling Pond (site coordinates 6 905 250N, 592 790E) is deformed approximately 300 mm to 600 mm, and there is sediment deposit in the culvert.
- Top of culvert at site coordinates 6 905 107N, 592 890E is deformed approximately 200 mm to 300 mm.
- The road to the Water Treatment Plant has three culverts: one CSP at the ditch invert; and two HDPE pipe at higher level. The top of the CSP is deformed by approximately 100 mm and its inlet is partially blocked with riprap. Both HDPE pipes are deformed by approximately 20% to 30%.

- Culvert at site coordinates 6 904 990N, 593 035E is slightly deformed, but is considered to be functional.

3.5.2 Comments and Recommendations

There is currently no instrumentation for the Grum Interceptor Ditch. Future monitoring of the ditch should include looking for ditch blockage, slope slump, or increased vegetation growth.

- Clear vegetation from ditch.
- Check capacity of culvert under the road to Grum Settling Pond under its current condition against its design discharge. Replace culvert if capacity is less than design discharge. Alternatively, remove culvert if the road is no longer required. Removal of culvert will improve the conveyance of flow in the ditch.
- Replace the existing culverts under the road to the Water Treatment Plant, if required.
- Remove culvert at site coordinates 6 905 107N, 592 890E if access provided by this culvert is no longer required.
- Continue routine monitoring of ditch and culverts along the ditch.

3.6 North East Interceptor Ditch

North East Interceptor Ditch (NEID) (see Photos 80 to 83, Figures 4 and 5)

The North East Interceptor Ditch diverts surface runoff away from the Vangorda Pit. A. Dalpatram observed the following during the 2012 site visit:

- No flow in ditch along the upper (50%) reach of the ditch; small flow along the downstream reach of ditch.
- Minor ditch side-slope slumps observed along most of the ditch.

There is currently no instrumentation in place to monitor the ditch flow. Future monitoring of the ditch should include:

- Monitor ditch side slopes, especially along reaches with slope slumps during spring freshet.

3.7 Vangorda Creek (Flume) Diversion

Vangorda Creek (Flume) Diversion (see Photos 84 to 95 and Figures 3 to 5)

The Vangorda Creek (Flume) Diversion diverts flow from Vangorda Creek around the Vangorda Pit via a Corrugated Steel Pipe (CSP) half-pipe, or flume. The headworks for the flume include: a main culvert under the road at the upstream end of the flume and a trashrack at the culvert inlet (see Photo 85), and two emergency spillway culverts with a trash rack at a higher level under the road (see Photo 84). At the end of the diversion, the flume discharges to a plunge pool, west of the Vangorda Pit, and the flow is carried across the haul road via a CSP culvert and drop box (see Photo 94) to the Vangorda Creek. There is no instrumentation related to the diversion flume.

We understand that a flash flood occurred in June 2012, and the flume overflowed. The flood flow was barely contained by the ditch bank slopes above the flume without spilling into the Vangorda Pit. This flood and its impact are similar to what occurred in June 2004 (SRK, 2004).

3.7.1 Observations

Observations by A. Dalpatram and R. Lo during the 2012 site visit are as follows:

- The flash flood eroded the riprap and earthfill around the upstream end of the flume main culvert, as well as damaged the half-pipe flume at numerous locations requiring emergency repair. The 2012 and previous damage to the flume includes dents and holes in half-pipe and bent bracings. The flume was still undergoing repairs at the time of the 2012 fall inspection.
- There was accumulation of sediments in the flume along the flatter section upstream of the plunge pool.
- There was approximately 0.5 m of sediment accumulation against the trashrack at the main culvert inlet upstream of the flume.
- Pipe plates at the first and last joints in the main culvert at upstream end of the flume were noted to be separated during the 2011 inspection. When viewed from upstream end, the crown of the main culvert also appeared to have slightly deformed downwards. When viewed from downstream end, the main culvert appeared to have a vertical bend near the upstream end. No discernible change in the condition of the culvert was noted during the 2012 fall inspection.
- The trashrack for the culvert to the drop box was clear of debris and sediments.
- Corrugated steel plates at the first joint in the culvert to the drop box were noted to be separated during the 2011 inspection. The interior of the culvert was not examined during this inspection.

3.7.2 Comments and Recommendations

- Check the drop structure of the flume as early as practical before the 2013 spring runoff season to ensure its proper function.
- Check and enlarge the discharge capacity, as required, of the ditch above the flume, especially along the reach where overflow nearly occurred in June, 2012, to minimize the potential of spilling flood water into the Vangorda Pit.
- Review the function of the flume, and assess the possibility of removing or relocating the flume. We understand from the site staff that the removal of a similar flume at Faro Creek Diversion Channel in the past did not have any significant impact. Also, the relocation of the Vangorda flume is being investigated.

- Remove accumulated sediments from the trashrack at the main culvert inlet upstream of the flume.
- Replace road embankment fill and riprap at the inlet of the flume main culvert which had washed out during the June 2012 flood. Use angular stones for riprap.
- Monitor all trashracks and remove debris and sediment, as required, to maintain discharge capacity.
- Monitor corrosion and abrasion along the culvert inverts.
- Monitor culverts for deformation and separation of plates at joints.
- Monitor condition of the flume. Try to avoid further damage to the flume due to ice removal activities, if possible.

3.8 Little Creek Dam

Little Creek Dam (LCD) (see Photos 96 to 107 and Figures 3 to 5)

The Little Creek Dam was completed in 1991. It is located just northwest of the Vangorda Waste Dump, and currently collects contact water from the Vangorda Waste Dump in the form of seepage and surface runoff. Water collected here is pumped to the Vangorda Pit for treatment at the Vangorda Water Treatment Plant, see Figures 3 to 5.

The Little Creek Dam is a homogeneous embankment dam constructed of local glacial till. It has a cutoff trench and a granular base drains downstream under the downstream slope (see Figure 14 for the dam section). The crest is about 10 m above natural ground, ranging in elevation from 1114.5 m to 1120 m. Side slopes are 2H:1V on the downstream side and 2.5H:1V on the upstream side. A zone of permafrost encountered at the south abutment was excavated prior to till placement. A 900 mm diameter, Corrugated Steel Pipe (CSP) emergency spillway is located at the south abutment (see Photos 101 to 103).

3.8.1 Observations

Observations of the Little Creek Dam by A. Dalpatram and R. Lo during the 2012 site visit are as follows:

- Stable dam slopes with rill erosions developed on the downstream and upstream crest shoulders and slopes.
- A rill erosion began to undermine the foundation of the transformer situated at the downstream crest shoulder (see Photos 99 and 100).
- Pond level drawn down prior to removal of submersible pump in preparation for the winter.
- Culvert spillway in good condition.
- There are cracks in the ground at the downstream end of the spillway outfall channel (see Photos 105 and 106), at the top of bank slope above Vangorda Creek.

3.8.2 Instrumentation

Instrumentation at the Little Creek Dam (see Figures 13 and 14) consists of a pond level measuring point; three pared pneumatic piezometers (P94-LCD-1 to P94-LCD-3) with tips at both shallow and deep depths; three thermistor strings installed in 1994 on the dam crest (94LCD-4T to 94LCD-6T) to a depth ranging from 13 m to 17 m; and seven piezometers (P09-LCD-1 to P09-LCD-7) installed in 2010 along the downstream toe (SRK 2011b). Detailed data of the pond and piezometric levels and ground temperatures, as provided by TEES, are included in Section II-M of Appendix II. The pond level and maximum piezometric level and corresponding date in 2012 for these piezometers are summarized in Table 3.4.

Since mid-2010, the pond level has been lowered by about 2 m from the range of 1109 m to 1111 m to the range of 1107 m to 1109 m. The ground temperature profiles beneath the dam crest monitored in 2012 indicate that the dam fill and foundation is essentially thawed with the exception of the surficial zone down to a depth of 5 m to 7 m undergoing seasonal freezing.

Table 3.4 Historical and Current Little Creek Pond and Water Level at Piezometers at Little Creek Dam

Location	Name	Historical (masl)		2012 (masl)		Comments
		Max	Min	Max	Min	
Water Level Readings						
Pond Level	LCD	1111.70	1106.48	1109.64	1107.10	Licence Limit = 1111.80
Standpipe Piezometers						
Downstream Toe	P09-LCD-1	1093.74	1093.45	1093.67[1]	-	-
	P09-LCD-2	1093.46	1093.26	1093.45[1]	-	-
	P09-LCD-3	1092.10[2]	1091.83	1092.10[1]	-	-
	P09-LCD-4	1091.62	1082.00	1090.13[1]	-	-
	P09-LCD-6	1090.91[3]	1089.46	1090.91[1]	-	-
	P09-LCD-7	1097.41	1096.93	1097.08[1]	-	-
Pneumatic Piezometers (BH94-LCD1 to LCD3 are nested piezometers with one tip deep and one shallow)						
Dam Crest	BH94-LCD1	1105.77	1104.16	1104.58	1104.44	Shallow
		1105.82	1103.79	1104.91	1104.42	Deep
	BH94-LCD2	1101.76	1100.50	1101.20	1101.13	Shallow
		1102.39	1098.54	1099.38	1099.31	Deep
	BH94-LCD3	1106.76	1105.50	Dry[4]	Dry[4]	Shallow
		1108.69	1102.89	1103.72	1103.30	Deep

Notes:
1. Only one reading taken on May 9, 2012 for these instruments.
2. P09-LCD-3: Maximum level increased by 0.06 m from 1092.04 m to 1092.10 m on May 9, 2012.
3. P09-LCD-6: Maximum level increased by 0.34 m from 1090.57 m to 1090.91 m on May 9, 2012.
4. Tip elevation for BH94-LCD3 (shallow) is at 1105.50 m. Therefore, it is assumed that this piezometer is dry.

3.8.3 Comments and Recommendations

- Consider repair of rill erosions on both dam slopes, especially the erosion that began to undermine the transformer foundation.

- Monitor the cracks at the downstream end of the spillway outfall channel.
- For the BH94 series of pneumatic piezometers (LCD-1 to LCD-3 shallow and deep piezometers), the piezometric levels are in a range consistent with historical variations.
- In general, BH94- series piezometers located along the dam crest show piezometric levels fluctuating with the pond level; while P09- series piezometers located along the downstream dam toe only show minor variation of piezometric level, with the exception of P09-LCD-4.
- The details for the installation for P09- series of piezometers are requested for better interpretation of monitored data obtained from these piezometers.
- Since geothermal profiles at the Little Creek Dam indicate that the temperature at depth is essentially thawed, the frequency of thermistor-readings for the dam could be reduced to once a year sometime in June.

3.9 Sheep Pad Sediment Ponds

Sheep Pad Sediment Ponds (see Photos 108 to 111 and Figures 3 to 5).

The Sheep Pad Sediment Ponds are located between the Grum and Vangorda Pits along the main haul road. The facility consists of two ponds which collect surface runoff from upslope areas, including the Grum Overburden Dump. The upstream pond discharges to the downstream pond via a CSP half-round pipe. The lower pond discharges towards the plunge pool for the Vangorda Creek Flume via a riprap lined spillway channel. There is a weir to monitor flow at the sediment ponds.

During the 2012 site visit, A. Dalpatram observed the following:

- Stable pond retaining dyke embankment.
- The upstream section of the spillway channel was noted to have no riprap in the bottom and the underlying geotextile was exposed.

We understand that the geotextile was covered with riprap after our fall 2012 inspection.

3.10 Grum Settling Pond

Grum Settling Pond (see Photos 112 to 113 and Figures 4 to 5)

The Grum Settling Pond, located just northwest of the Grum Pit, functions as part of the water treatment facility at the Vangorda Plateau site. Water from the pond discharges to the Grum Interceptor ditch via a riprap lined spillway channel. There is no instrumentation related to the settling pond.

- During the 2012 site visit, A. Dalpatram observed that the spillway channel appeared to be in good condition, with minor vegetation growth. Future monitoring for the settling pond should include periodic check for erosion and vegetation growth along the spillway channel and dyke embankment integrity.

3.11 V-15 Seep Ditch and Moose Pond

V-15 Seep Ditch (see Photos 114 to 119 and Figures 4 to 5) and Moose Pond (see Photos 120 to 121 and Figures 3 to 5)

The V-15 Seep Ditch is a bentomat lined ditch that diverts Grum Dump seepage water from the V-15 pond to Moose Pond. Both structures are located between the Grum Dump and the Vangorda Waste Dump (see Figures 3 to 5).

Y G (2011a and 2011b) documented the event of excess runoff in the spring of 2011 due to the fact that some of the engineered drainage structures related to the installation of the Grum Sulphide Cell (GSC) cover did not function properly.

3.11.1 Observations

Observations by R. Lo and A. Dalpatram during the 2012 site visit are as follows:

- 2011 excess inflow into Moose Pond caused the following changes: deposition of silt sediment (see Photo 120), raised pond level and slumps of the downstream slope of a retaining esker at the locations of 2011 raised seepage exit.
- Exfiltration from Moose Pond since 2011 has likely changed from the original pond bottom to bank slope at higher elevations. However, this change has not been verified by the comparison of Moose Pond levels before and after the 2011 excess inflow event.
- Significant erosion and slumping of the sides of the V-15 diversion channel was observed at the location where the ditch entered into a steep reach upstream of Moose Pond (see Photos 118 and 119).

3.11.2 Comments and Recommendations

- Prevent future inflow into Moose Pond from extraneous sources not in existence prior to 2011.
- We understand that the V-15 ditch was rehabilitated to minimize further bank erosion and siltation of the Moose Pond after our 2012 fall inspection.
- Determine Moose Pond bathymetry.
- Continue to monitor Moose Pond performance to evaluate new groundwater flow regime related to exfiltration from the Moose Pond, and its exfiltration capacity.
- Continue to monitor seepage flow along the downstream slope of the retaining esker.
- Continue to monitor the downstream slope of the retaining esker to review potential remedial works that may be required to restore the stability and integrity of the esker ridge.

3.12 Sludge Pond Embankment at Vangorda Water Treatment

Sludge Pond Embankment at Vangorda Water Treatment (see Photos 122 to 123 and Figures 3 to 5)

The Sludge Pond Embankment, located just east of the Grum Pit, is a rectangular shaped pond retained by an embankment dyke. During the 2012 site visit, A. Dalpatram observed that the pond had been emptied resulting in a low water level. There is no instrumentation at this pond and its periphery dyke. Regular monitoring and maintenance are required to ensure satisfactory performance of the structure.

4 SUMMARY

Section 4 summarizes our 2012 review in three sub-sections by means of two tables:

- general review in Section 4.1; and,
- review of 2012 TEES Monitoring Plan in Section 4.2.

4.1 General Review

Table 4.1 provides a description of the structures inspected in 2012 and a summary of our observations and recommendations.

Table 4.1 Faro Mine Site Complex – 2012 Summer/Fall Site Visit Summary

Faro Site Facilities			
Structure	**Description**	**Observations**	**Comments and Recommendations**
Faro Pit	▪ An inactive open pit, roughly elliptical shaped, with major axis along northwest-southeast direction. ▪ The east wall is about 375 m high, containing two, North and South, Instability Zones, separated by a calc-silicate rock slope. ▪ Minimum distances between the pit wall and the Faro Creek Diversion Channel are 18.5 m and 93 m, respectively, in the North and South Instability Zone.	▪ TEES data appeared to indicate that no significant changes were measured at reference bars where distances between the pit wall and Faro Creek Diversion Channel have been monitored. ▪ The problem of maintaining consistent distance measurements at reference bar #15351 persisted. ▪ There was no pit-wall prisms survey in 2012.	▪ No obvious changes on the east pit wall North and South Instability Zones were observed. ▪ Golder was on site in September 2012 to conduct periodical review of east pit wall stability. ▪ Continue visual monitoring of pit wall conditions with photos taken at same vantage points. ▪ Continue monitoring distances between the pit wall and Faro Creek Diversion Channel at installed reference bars. ▪ Improve distance measurement at reference bar #15351 to eliminate the survey anomaly persisted there since 2010. ▪ Continue monitoring prisms installed on the pit wall. ▪ Follow any recommendations provided by Golder report. ▪ Continue to have pit slope stability reviewed periodically, especially in case of development of new sizable slumps.
Faro Creek Diversion Channel (FCDC)	▪ Diverts creek flow from head waters north of the Faro Pit around the east side of the mine site, and discharges into North Fork Rose Creek.	▪ Moderate flow in channel at time of inspection. ▪ Staff gauge calibration data is missing for high flow conditions. ▪ Stable channel and side slopes along most of its length. Portions of the channel are lined with rock and geotextile/bentomat. Rock armour has moved and geotextile/bentomat has been exposed in some areas. Exposed geotextile/bentomat might be pulled out under high flow conditions, which might cause additional movement of rock armour.	▪ Continue monitoring of the staff gauges along the diversion channel. ▪ Construct foot bridge at staff gauge locations to obtain rate of flow vs. gauge reading calibration data for high flow conditions. ▪ Continue visual monitoring of diversion channel and any seepage from the channel to the Faro Pit wall with photos taken at strategic locations. ▪ TEES indicated that exposed geotextile/bentomat in the channel will be covered with rock armour by the spring of 2013.
North Valley Wall Interceptor Ditch (NVWID)	▪ Diverts creek flow from north valley wall around tailings impoundment area. ▪ Approximately 3,000 m long, consisting of constructed and natural stream channel sections. Constructed channel sections include: ◆ 920 m long upper reach; ◆ 430 m long middle reach; and ◆ 500 m long lower reach. ▪ Relatively flat channel gradients along constructed sections and steep stream gradients along natural channel sections.	▪ Moderate flow in channel at time of inspection. ▪ Stable channel and side slopes along most of its length. ▪ Sedimentation developing both up and down gradient from the well-access road crossing. ▪ Moderate to heavy vegetation growth in upper and middle constructed channel reaches.	▪ Monitor channel sedimentation condition at the well-access road crossing, and remove sediments if excessive sediment is deposited in the channel. ▪ Clear vegetation along upper and middle constructed channel reaches. Clearing should also include the access road and berm along the channel to facilitate future inspection. We understand that TEES began the recommended clearing after our fall 2012 inspection.
Rose Creek Diversion Channel (RCDC) and Canal Dyke	▪ Diverts creek channel flow around south side of tailings impoundment area. ▪ Approximately 3,800 m long with relatively flat to moderate stream channel gradients along upper reaches and steep gradients along lower reaches.	▪ Moderate flow in channel at time of inspection. ▪ Staff gauge calibration data is missing for high flow conditions. ▪ Stable channel and side slopes, satisfactory rock armour conditions. ▪ Moderate vegetation growth in lower channel reaches. ▪ Seepage from RCDC into tailings impoundment was observed in November 2012 by TEES at two locations: at fuse plug located next to the Secondary Tailings Dam, and about half way between the fuse plug and the Intermediate Dam. ▪ Minor seepage from RCDC at base of spoil piles into CVD Polishing Pond was reported previously, but could not be located during the fall inspection.	▪ Continue to monitor the staff gauge. ▪ Construct foot bridge at staff gauge to obtain rate of flow vs. gauge reading calibration data for high flow conditions. ▪ Clear vegetation along lower channel reaches. ▪ Conduct geotechnical inspection of RCDC next spring during peak flow condition. ▪ Continue to document seepage locations from RCDC into tailings impoundment area after fresh snow fall condition. ▪ The field personnel is to check the instrument manual for proper procedures of taking inclinometer readings, and to perform “cusum check” during monitoring in the field to confirm that correct readings have been successfully taken.
North Fork Rock Drain (NFRD)	▪ Mine haul road stream crossing constructed from coarse waste rock fill and drain rock. ▪ Road embankment is approximately 55 m high, with 25 m crest width. ▪ Downstream of the mine haul road, there is an auxiliary culvert beside the main culvert across the Main Access road to the mine.	▪ Stable crest and side slope of mine haul road. Minor slumping of downstream face has occurred but is not a cause for concern at this time. ▪ Downstream drainage condition is acceptable with three braided channels combined to one channel at water-level monitor and sample location.	▪ Continue to monitor head pond level and downstream flow conditions.

Table 4.1 Faro Mine Site Complex – 2012 Summer/Fall Site Visit Summary (cont'd)

Faro Site Facilities			
Structure	**Description**	**Observations**	**Comments and Recommendations**
K8 Creek Rock Drain (K8CRD)	▪ Mine haul road stream crossing constructed from coarse waste rock fill and rock drain. ▪ Road embankment is approximately 55 m high, with 25 m crest width.	▪ Stable crest and side slopes of mine haul road. ▪ Downstream drainage condition acceptable.	▪ Continue to monitor head pond level and downstream flow conditions. ▪ Show the location of the rock drain on site figures and drawings.
Secondary Tailings Impoundment (STI)	▪ Perimeter tailings dam, retains tailings, supernatant and run-off water. ▪ Encloses original tailings impoundment. ▪ Dam Crest approximately 1120 m long, 6 m wide and, varies from El. 1060.2 m to El. 1063.3 m. ▪ Dam height: 28 m.	▪ Stable crest, upstream and downstream slopes. ▪ No evidence of seepage along the downstream toe. ▪ Lower road conditions are satisfactory. ▪ A row of tailings is located on the upstream shoulder of the crest along the southwest portion of the dam, forming the source of tailings deposited on the dam crest due to runoff erosion. ▪ Cracks that were observed in May 2012 along the downstream road adjacent to the upstream end of the Rose Creek Diversion Channel were not seen. The annual appearance of cracks in the spring and subsequent disappearance of these cracks appear to be related to seasonal freezing and thawing effect.	▪ Continue to monitor dam performance. ▪ Continue to monitor instrumentation. ▪ Continue to monitor any crack appearance on the downstream road adjacent to the upstream end of the Rose Creek Diversion Channel, and seal these cracks by grading to minimize water ingress into the road embankment. ▪ Check vegetation growth on the downstream slope and clear, if required.
Intermediate Dam (ID)	▪ Intermediate tailings/water dam, retains tailings, supernatant and run-off water on upstream side, and polishing pond water on downstream side. ▪ Dam height: 32 m. ▪ Crest approximately 650 m long, 7 m wide at El. 1049.2 m and spillway channel invert at El. 1047.7 m. ▪ Downstream berm: about 7 m wide, berm surface at approximate 1031.7 m. ▪ The Starter Dam has a vertical core, which was modified to an upstream sloping core during subsequent dam raises. The rest of dam zones consist of gravel shells and filters.	▪ Pond level was drawn down. ▪ Stable crest, upstream slope and spillway channel, in general. ▪ Near south abutment, upstream slope fill adjustment was noted. ▪ Wave erosions of upstream slope were closely inspected at different elevations, and the status of three reinforcing-bar erosion markers were checked, and the local erosion conditions at the markers were photographed. Photos of observed 2012 reinforcing bars and marking post installed by Brodie (2010) are shown in Appendix I. It is unclear whether they are the same markers or not, because of different appearance. ▪ Downstream slope was experiencing extensive rill erosion, with longitudinal cracks and minor slope slumps developing, and eroded materials were depositing on the downstream berm. ▪ Denison Environmental Services placed wooden stakes in 2011 on the downstream slope in the southwest portion of the dam to assist ongoing monitoring.	▪ Continue to experiment with the increased maximum drawdown rate of Intermediate Pond at 40 mm/day. ▪ Continue to monitor instrumentation. ▪ Continue to monitor wave erosion along upstream face. Remedial measures, such as replacement of riprap, may be required if excessive erosion is observed. However, remedial measures must take into consideration the works required for permanent closure of the pond, which is not expected to occur within the next 10 years. ▪ Continue to monitor damfill adjustment of upstream slope near the south abutment. ▪ Monitor ongoing downstream slope rill erosions, and resulting slope slumps and longitudinal cracks that occurred due to rapid flow in shallow surficial zone during snowmelt. ▪ Monitor sediment deposition over the discharge face of the drainage zone above downstream berm surface, and restore tilted above-ground portion of existing instrumentation on berm surface. ▪ Piezometric data at P96-2 appeared to show low piezometric level, and not indicating blockage of drainage zone. ▪ Site staff indicated that re-sloping of the downstream slope has been successfully implemented in 2000s using site dozer equipment working on existing slope material. We recommend that this successful practice be implemented as early as practical to prevent further degradation of the downstream slope by rill erosion. ▪ Review and update, if required, geotechnical stability analysis based on current dam conditions, including lowered operating water levels implemented since mid-2010.
Cross Valley Dam (CVD)	▪ Polishing Pond dam is designed for 60-day retention capacity of seepage and discharge water from tailings storage facility and water treatment plant. ▪ Dam height: 17 m. ▪ Crest approximately 500 m long, 7 m wide at El. 1033.1 m and spillway channel at El. 1031.7 m.	▪ Stable crest, upstream and downstream slopes and spillway channel. ▪ Longitudinal cracks that were observed in May 2012 along the dam crest were not seen. The annual appearance of cracks in the spring and subsequent disappearance of these cracks appear to be related to freezing and spring thawing effect.	▪ Continue to monitor instrumentation. ▪ Monitor longitudinal tension cracks on dam crest, and seal these cracks by grading to minimize water ingress to the embankment dam. ▪ Reduce frequency of thermistor-reading to once a year, around June.

Table 4.1 Faro Mine Site Complex – 2012 Summer/Fall Site Visit Summary (cont'd)

Faro Site Facilities			
Structure	**Description**	**Observations**	**Comments and Recommendations**
Grum Pit	▪ An inactive pit, elliptical in shape, extending 850 m in north/south direction and 600 m in east/west direction. ▪ The east pit wall is about 160 m high. ▪ There is no water reclaim facility in the pit.	▪ East wall instability appears to be continually evolving. ▪ New cracks along the pit rim were observed by TEES in August 2012 during monitoring of the north and south arrays of reference rods. ▪ Pit-brim monitoring-reference rods survey since 2010 indicates nominal changes, which could be attributed to random measuring errors. However, since August 2012, surficial cracks and deformation were noticed near the reference rods located closest to the pit brim at both the north and south survey arrays. ▪ Golder on site to conduct periodical review of east pit wall stability.	▪ The ongoing survey monitoring program has been adjusted to stop monitoring the reference rods in areas where cracks have been observed for safety reason. In addition, recommendation was made to remove the vegetation cover along the north survey array that blocking the ongoing observation of surficial ground cracks along the array. We understand that TEES removed the vegetation cover after our fall inspection. ▪ Golder was on site in September 2012 to conduct periodical review of east pit wall stability. ▪ Continue visual monitoring of pit wall conditions with photos taken from same vantage points. ▪ Continue distance monitoring from each survey rod to its respective reference stationary rod along two arrays located on the pit brim, and adjust the monitoring program, as required, to safeguard personnel safety. ▪ The current distance measurement of survey rods does not appear to provide advanced warning of pit-wall displacement. ▪ Golder recommends installation of survey prisms to monitor the instability zone of the east pit wall. We concur with this recommendation. ▪ Golder also recommends a site review of surface ponding in the general area above the instability zone along the Grum Pit east wall with the objective to eliminate sources of surface water that could increase seepage toward the east pit wall. We concur with this recommendation. ▪ Continue to have pit wall slope stability reviewed periodically, especially in case of development of new sizable pit-wall slumps. ▪ Install pump barge at Grum Pit pond to control the rise of pond level.
Vangorda Pit	▪ An elongated, inactive pit, with the long axis oriented in the northwest-southeast direction. ▪ A pump barge pumps water to the treatment plant.	▪ There appeared little change in the condition of the Vangorda pit walls since our May 2012 visit. ▪ Golder was on site to evaluate Vangorda pit wall stability.	▪ Continue visual monitoring of pit wall conditions with photos taken from same vantage points at least at yearly interval. ▪ Follow any recommendations provided by Golder report.
Grum Dump	▪ The dump was not within the current scope of work.	▪ Photos were taken for future reference.	▪ Continue regular monitoring.
Vangorda Waste Rock Dump	▪ Six transverse drains installed beneath the till starter dyke to collect dump seepage into a seepage collection ditch. ▪ Collected seepage drains into a pond retained by the Little Creek Dam.	▪ Drain No. 1 – was dry. Does not have a weir. ▪ Drain No. 2 - was dry. ▪ Drain No. 3 – Staff gauge was tilted and weir plate was delaminated. Flow is usually measured with a bottle and a watch. ▪ Drain No. 4 – Does not have a weir. Usually only a small trickle flows through drain, and flow is estimated by eye. ▪ Drain No. 5 – Weir plate was split into 2 pieces. There are boulders in the pool upstream of the weir and the channel invert downstream of the weir is too high. ▪ Drain No. 6 – Weir plate and channel in satisfactory condition for flow measurement. There was evidence of a slump of waste dump slope at the drain in the past.	▪ Drain No. 3 – Staff gauge and delaminated weir plate should be repaired, if flow is not measured with a bottle and a watch. ▪ Drain No. 4 – A weir should be installed, if flow increases to measurable levels. ▪ Drain No. 5 – Weir plate should be repaired. Boulders in the upstream pool should be removed and the channel invert immediately downstream of the weir should be lowered slightly to provide good free flow conditions required for flow measurement. ▪ Drain No. 6 – Continue to monitor the slump of waste dump slope above the drain observed in the past.
Grum Interceptor Ditch	▪ The Interceptor ditch consists of 3 reaches: ◆ 900 m long ditch upslope of Grum Pit to divert clean water away from the pit; ◆ 900 m long ditch along the northeast toe of Grum Overburden Dump; and ◆ 650 m long ditch to convey flow downhill to Vangorda Creek.	▪ Stable channel and side slopes. ▪ Light to heavy vegetation growth, particularly along the upper reaches of the ditch. ▪ Top of the culvert under the road to Grum Settling Pond (site coordinates 6905250N, 592790E) is deformed approximately 300 mm to 600 mm, and there is sediment deposit in the culvert. ▪ Top of culvert at site coordinates 6905107N; 592890E is deformed approximately 200 mm to 300 mm. ▪ The road to the Water Treatment Plant has three culverts: one CSP at the ditch invert; and two HDPE pipe at higher level. The top of the CSP is deformed by approximately 100 mm and its inlet is partially blocked with riprap. Both HDPE pipes are deformed by approximately 20% to 30%. ▪ Culvert at site coordinates 6904990N; 593035E is slightly deformed, but is considered to be functional.	▪ Clear vegetation from ditch. ▪ Check capacity of culvert under the road to Grum Settling Pond under its current condition against its design discharge. Replace culvert if capacity is less than design discharge. Alternatively, remove culvert if the road is no longer required. Removal of culvert will improve the conveyance of flows in the ditch. ▪ Replace the existing culverts under the road to the Water Treatment Plant, if required. ▪ Remove culvert at site coordinates 6905107N, 592890E if access provided by this culvert is no longer required. ▪ Continue routine monitoring of ditch and culverts along the ditch.

Table 4.1 Faro Mine Site Complex – 2012 Summer/Fall Site Visit Summary (cont'd)

Faro Site Facilities			
Structure	**Description**	**Observations**	**Comments and Recommendations**
North East Interceptor Ditch above Vangorda Pit	▪ Located uphill of the Vangorda Pit. ▪ Diverts surface runoff away from the pit.	▪ No flow in ditch along the upper (50%) reach of the ditch; small flow along the downstream reach of ditch. ▪ Minor ditch side-slope slumps observed along most of the ditch.	▪ Continue to monitor ditch side slopes, especially along reaches with slope slumps during spring freshet.
Vangorda Creek (Flume) Diversion	▪ Diverts Vangorda Creek around Vangorda Pit via a CSP half-pipe (flume). ▪ Headworks for flume include a main culvert and trashrack. ▪ Headworks also include 2 emergency culverts at a higher level, c/w trashrack. ▪ Flume discharges to a plunge pool, and flow is carried across the haul road via a CSP culvert and drop box to Vangorda Creek channel.	▪ A flash flood occurred in June 2012. The flume overflowed and the flow was barely contained by the ditch bank slopes without spilling into the Vangorda Pit. ▪ Flash flood also eroded the riprap and earthfill around the upstream end of the flume main culvert, as well as damaged the half-pipe flume at numerous locations requiring emergency repair. The 2012 and previous damage to the flume includes dents and holes in half-pipe and bent bracings. The flume was still undergoing repairs at the time of the fall inspection. ▪ There was accumulation of sediments in the flume along the flatter section upstream of the plunge pool. ▪ There was approximately 0.5 m of sediment accumulation against the trashrack at the main culvert inlet upstream of the flume. ▪ Pipe plates at the first and last joints in the main culvert at upstream end of the flume were noted to be separated during the 2011 inspection. When viewed from upstream end, the crown of the main culvert also appeared to have slightly deformed downwards. When viewed from downstream end, the main culvert appeared to have a vertical bend near the upstream end. No discernible change in the condition of the culvert was noted during the 2012 fall inspection. ▪ The trashrack for the culvert to the drop box was clear of debris and sediments. ▪ Corrugated steel plates at the first joint in the culvert to the drop box was noted to be separated during the 2011 inspection. The interior of the culvert was not examined during this inspection.	▪ Check the drop structure of the flume as early as practical before the 2013 spring runoff season to ensure its proper function. ▪ Check and enlarge the discharge capacity, as required, of the ditch exterior to the flume to minimize the potential of spilling flood water into the Vangorda Pit. ▪ Review the function of the flume, and assess the possibility of removing or relocating the flume. We understand from the site staff that the removal of a similar flume at Faro Creek Diversion Channel in the past did not have any significant detrimental impact. Also, the relocation of the Vangorda flume is being investigated. ▪ Remove accumulated sediments from the trashrack at the main culvert inlet upstream of the flume. ▪ Replace embankment fill and riprap at the inlet of the main culvert. ▪ Monitor all trashracks and remove debris and sediment, as required, to maintain discharge capacity. ▪ Monitor corrosion and abrasion along the culvert inverts. ▪ Monitor culverts for deformation and separation of plates at joints. ▪ Monitor condition of the flume. Try to avoid further damage to the flume due to ice removal activities, if possible.
Little Creek Dam	▪ Water dam to collect Vangorda Waste Rock Dump contact water to be pumped to the Vangorda Pit Lake.	▪ Stable dam slopes with rill erosions developed on the downstream and upstream crest shoulders and slopes. ▪ A rill erosion began to undermine the foundation of the transformer situated at the downstream crest shoulder. ▪ Pond level drawn down prior to removal of submersible pump in preparation for the winter. ▪ Culvert spillway in good condition. ▪ There are cracks in the ground at the downstream end of the spillway outfall channel, at the top of bank slope above Vangorda Creek.	▪ Consider repair of rill erosions on both dam slopes, especially the erosion that began to undermine the transformer foundation. ▪ Monitor the cracks at the downstream end of the spillway outfall channel.
Sheep Pad Sediment Ponds	▪ Facility consists of 2 ponds which collect surface runoff from upslope areas, including the Grum Overburden Dump. ▪ The upstream pond discharges into the downstream pond via a CSP half-round pipe. ▪ The lower pond discharges towards the plunge pool for the Vangorda Flume via a riprap lined spillway channel.	▪ Stable pond retaining dyke embankment. ▪ The upstream section of the spillway channel was noted to have no riprap in the bottom and the underlying geotextile was exposed.	▪ We understand that the geotextile was covered with riprap after our fall 2012 inspection. ▪ Check the performance of newly placed riprap.
Grum Settling Pond	▪ Pond discharges to Grum Interceptor ditch via a riprap-lined spillway channel.	▪ Spillway channel appeared to be in good condition, with minor vegetation growth.	▪ Continue to monitor spillway channel for erosion and vegetation growth. ▪ Continue to monitor retaining dyke embankment.

Table 4.1 Faro Mine Site Complex – 2012 Summer/Fall Site Visit Summary (cont'd)

Faro Site Facilities			
Structure	**Description**	**Observations**	**Comments and Recommendations**
V-15 Seep Ditch and Moose Pond	▪ Seepage water from Grum Dump daylights at V-15 Pond. ▪ Bentomat lined V-15 ditch diverts water from V-15 Pond to Moose Pond.	▪ 2011 excess inflow into Moose Pond caused the following permanent changes: -- sealing off the pond bottom by silt deposits, raising pond level and slumping of the downstream slope of a retaining esker at the locations of 2011 raised seepage exit. ▪ Exfiltration from Moose Pond since 2011 has changed from the pond bottom to from the pond bank slope at higher elevations. ▪ Significant erosion and slumping of the sides of the V-15 diversion channel was observed at the location where the ditch entered into a steep reach upstream of Moose Pond.	▪ Prevent future inflow into Moose Pond from extraneous sources not in existence prior to 2011. ▪ We understand that the V-15 ditch was rehabilitated to minimize further bank erosion and siltation of the Moose Pond after our fall 2012 inspection. ▪ Determine Moose Pond bathymetry. ▪ Continue to monitor Moose Pond performance to evaluate new groundwater flow regime related to exfiltration from the Moose Pond, and its exfiltration capacity. ▪ Continue to monitor seepage flow along the downstream slope of the retaining esker. ▪ Continue to monitor the downstream slope of the retaining esker to review potential remedial works that may be required to restore the stability and integrity of the esker ridge. ▪ Evaluate the long-term impact of the 2011 excess-inflow incident on the normal exfiltration operation of the Moose Pond, as required.
Sludge Pond Embankment at Vangorda Water Treatment Plant	▪ Rectangular-shaped sludge pond retained by embankment dyke.	▪ Low pond level.	▪ Continue existing monitoring.

4.2 Review of 2012 Monitoring Plan

The Faro Mine Complex is currently under a care and maintenance program. Table 4.2 summarizes our review of the TEES geotechnical - hydrotechnical monitoring frequency in 2012. Our comments are based on our site visit discussions and the data we received since our visits. These preliminary comments are proposed for the review by Yukon Government and TEES. Further discussion and ongoing adjustment of the monitoring program based on the review of obtained monitoring data, actual site conditions and operational and maintenance requirements could make the program more flexible and responsive to both the routine and special needs of 2013.

Table 4.2 Review of TEES 2012 Monitoring Plan

Structure	Type of Record	Monitoring Frequency	
		Current Plan[1]	Actual Schedule and Comments
Faro Pit (FP)	Pit Lake Level	Twice monthly	Weekly to twice monthly
	Pit Wall Surface Movement Monitoring	Twice yearly	Twice yearly
	Pit Wall Prisms Survey	Once yearly	None
Faro Creek Diversion (FCD)	Staff Gauge Reading	Twice monthly from April to October	Twice monthly from April to September (three times in May)
North Valley Wall Interceptor Ditch (NWID)	In-Stream Flow Monitoring	No monitoring program given	Once monthly from May to October (No indication how flow was measured)
Rose Creek Diversion Channel (RCDC)	Staff Gauge Reading	Daily from April to September	Follow schedule closely for RC-SG4 and X14SG and weekly from mid-August to September for X2SG and NFRD-23
North Fork Rock Drain (NFRD)	Water Level	Weekly from May to July Twice Monthly from August to September	Follow schedule closely
Secondary Dam (SD)	Piezometers	3 times yearly	3 times yearly
Intermediate Dam (ID) and Pond	Pond Water Level	Weekly	Once to twice weekly January to October
	Piezometers	3 times yearly	3 times yearly
Cross Valley Dam (CVD) and Pond	Pond Water Level	Weekly	Weekly
	Piezometers	3 times yearly	3 times yearly
	Thermistors	3 times yearly	Propose to reduce to once a year in June or preserve thermistors for future reading[2]
	Weir Readings	Weekly April to October	Weekly April to October
Canal Dyke (CD)	Piezometers	3 times yearly	3 times yearly
	Inclinometers	2 times yearly	2 times yearly[3]
	Thermistors	2 to 3 times yearly	Follow schedule closely except no readings for those at backslope, and once for those at spoil piles[4]
Grum Pit (GP)	Pit Lake Level	No monitoring program given	Weekly to twice monthly
	Pit Wall Surface Movement Monitoring	Monthly	Monthly
	Piezometers	Monthly	Monthly
Vangorda Pit (VP)	Pit Lake Level	No monitoring program given	Weekly to twice monthly
Vangorda Waste Rock Dump (VWRD)	Piezometers Within Dump	Twice yearly	Twice to three times monthly April to May and mid-September
	Weir Readings	Twice monthly from May to October	Twice monthly from May to October
	Monitoring Wells Downstream of Dump	Twice yearly	Twice to three times monthly April to May and mid-September

Table 4.2 Review of TEES 2012 Monitoring Plan (cont'd)

Structure	Type of Record	Monitoring Frequency	
		Current Plan[1]	Actual Schedule and Comments
Little Creek Dam (LCD)	Pond Water Level	Weekly	Weekly to monthly
	Piezometers	Twice yearly	Twice yearly
	Thermistors	Twice yearly	Propose to reduce to once a year in June or preserve thermistors for future reading[2]

Notes:
1. Based on 2011 DES schedule.
2. Since there is no permanent frozen ground at locations monitored by thermistors installed for Cross Valley Dam and Little Creek Dam, the existing thermistors at these two dams should be preserved for future reading or read once a year in June.
3. All inclinometers at Canal Dyke should be read twice a year in 2013 to confirm no recent movement.
4. Continue to monitor thermistors at Canal Dyke according to current schedule, as foundation at depth appears to remain frozen.

5 CONCLUSIONS AND RECOMMENDATIONS

Based on our 2012 fall site visits and ongoing data review, the main conclusions and recommendations are outlined in Sections 5.1 and 5.2.

5.1 Conclusions

Our major conclusions are as follows:

- The key waste and water management facilities at both the Faro and Vangorda Plateau sites have functioned satisfactorily in 2012 as in the past. The care and maintenance activities, including instrument monitoring and survey measurement, are performed generally following the planned schedules.
- The flash flood of June 2012 at Vangorda Creek (Flume) Diversion appeared to be similar to that which occurred in June 2004. The flume overflowed and the flow was barely contained by the ditch bank slopes above the flume without spilling into the Vangorda Pit.
- The pit-wall brim movement monitoring programs at the Faro and Grum Pits indicate that the measured distance changes are within the measurement accuracy.
- At the instability zone along the east wall of Grum Pit, new cracks and ground deformation were observed by TEES in August 2012 during monitoring of the north and south arrays of reference rods.
- The latest dam-safety related documents are as follows:
  - Operations, Maintenance and Surveillance (OMS) Manual for Selected Dams (BGC 2008a).
  - Emergency response plan (ERP) for Intermediate Dam, Cross Valley Dam, Little Creek Dam, Faro Creek Diversion Channel, Rose Creek Diversion Channel and Vangorda Creek Diversion Flume (BGC 2008b).
  - 2007 Dam Safety Review - Cross Valley Dam, Intermediate Dam and Little Creek Dam (KCB 2008).
- In the 2007 Dam Safety Review, both the Cross Valley Dam and Intermediate Dam were classified as “high” consequence dam, while the Little Creek Dam was classified as “low” consequence dam. According to the Canadian Dam Safety Guidelines (CDA 2007), a dam safety review is required every 7 years for a “high” consequence dam, while no review is required for a “low” consequence dam. Thus, both the Cross Valley Dam and Intermediate Dam will be due for their third dam safety review in 2014. Plan is being made by the Government of Yukon to conduct this dam safety review in 2014.
- The current version of the Operations, Maintenance and Surveillance (OMS) Manual and Emergency Response Plan (ERP) for the above two dams and Little Creek Dam is dated in 2008 (BGC 2008a and 2008b). These two documents are being updated together with the preparation of an inundation study for potential dam breach at the Intermediate, Cross Valley and Little Creek Dams (KCB 2013a, 2013b and 2013c). These reports will be issued by 2014.

- The Moose Pond continues to function as the exfiltration pond, although the exfiltration is likely occurring at higher elevations through the bank slope and probably less through the original pond bottom due to silt sedimentation during the excess runoff event in 2011.

5.2 Recommendations

Our main recommendations regarding the hydrotechnical and geotechnical aspects of the site facilities as well as the presentation of site monitoring data are summarized below:

Hydrotechnical Aspects

- Faro Creek Diversion Channel:
  - Construct foot bridge at staff gauge locations to obtain rate of flow vs. gauge reading calibration data for staff gauges under high flow conditions.
  - Continue monitoring of the staff gauges along the diversion channel.
  - Cover exposed geotextile and bentomat with rock armour. Replace damaged geotextile and bentomat prior to placement of armour.
- North Valley Wall Interceptor Ditch:
  - Monitor channel sedimentation at the well-access road crossing, and remove excessive sediments to maintain flow capacity.
  - We understand that TEES began the recommended clearing of vegetation growth along the upper and middle constructed channel reaches after our fall 2012 inspection. We recommend that the access road and berm to be also cleared to facilitate ongoing inspection.
- Rose Creek Diversion Channel:
  - Construct foot bridge at the staff gauge to obtain rate of flow vs. gauge reading calibration data for high flow conditions.
  - Calibrate staff gauges X14SG, X2SG and NFRD-23 in order to convert staff gauge readings to flow rates.
- Intermediate Dam:
  - Continue to experiment with the increased maximum drawdown rate of Intermediate Pond at 40 mm/day.
  - Continue to monitor upstream face wave erosion. Remedial measures, such as replacement of riprap, may be required if excessive erosion is observed. However, remedial measures must take into consideration the works required for permanent closure of the pond, which is not expected to occur within the next 10 years.

- Site staff indicated that re-sloping of existing material on the downstream slope, with a dozer, has been successfully implemented in 2000s. We recommend that this practice be resumed as early as practical to prevent further degradation of the slope by rill erosion.
- Monitor ongoing downstream slope rill erosions, and resulting slope slumps and longitudinal cracks prior to the restoration of the downstream slope.
- Repair shoulder erosion of the downstream berm.

- Grum Pit:
  - Install a pump barge at the Grum Pit pond in order to drawdown the pond level below the maximum recommended elevation at 1213.5 m.
  - As recommended by Golder, review and reduce surface ponding in the area above the instability zone along the east wall to reduce potential seepage toward the pit wall.
- Vangorda Waste Rock Dump:
  - At Drain No. 5 – Weir plate should be repaired. Boulders in the upstream pool should be removed and the channel invert immediately downstream of the weir should be lowered slightly to provide good free flow conditions required for flow measurement.
- North-East Interceptor Ditch above Vangorda Pit:
  - Continue to monitor ditch side slopes, especially along reaches with slope slumps, and repair slumped ditch sections to maintain flow capacity, especially prior to spring freshet.
- Vangorda Creek (Flume) Diversion:
  - In recent years two flash floods occurred at this diversion, in 2004 and 2012. We recommend that the discharge capacity of the ditch exterior to the flume be checked and enlarged to minimize the potential of spilling flood water into the Vangorda Pit, especially along the reach where the flow was barely contained by the ditch bank slopes in June 2012.
  - Review the function of the flume, and assess the possibility of removing or relocating the flume. We understand from the site staff that the removal of a similar flume at Faro Creek Diversion Channel in the past did not have any significant detrimental impact. Also, the relocation of the Vangorda flume is being investigated.
- Little Creek Dam:
  - Monitor ongoing rill erosion along the downstream and upstream slopes.
  - Consider repair or restoration of the dam slopes at the locations of rill erosion, especially in the foundation area of the transformer located on the downstream crest shoulder.
  - Monitor the cracks at the downstream end of the spillway outfall channel.
  - Investigate potential mitigation measures needed to reduce downstream impact of a dam breach of the Little Creek Dam on the Town of Faro as discussed in our inundation study (KCB 2013c).

- Sheep Pad Sediment Ponds:
  - Check the performance of newly placed riprap in the channel between the two ponds.

Geotechnical Aspects

- Faro, Grum and Vangorda Pit Brims:
  - As recommended by Golder, install survey prisms to monitor the instability zone of the east pit wall at Grum Pit, in light of new cracks developed in the pit brim area since the summer of 2012.
  - Continue the current pit-brim potential movement monitoring programs, and watch out for personnel safety while carrying out monitoring work.
  - Continue to check pit slope stability periodically, especially in case of development of new sizable slope slumps.
  - Improve distance measurement at reference bar #15351 at Faro Pit to eliminate the survey anomaly which persisted there since 2010.
- Intermediate Dam:
  - Both the upstream and downstream slope improvements for the Intermediate Dam should be guided by the long-term closure provision for the dam.
  - Monitor the dam performance, and carry out additional analyses, if necessary, to address the issue of lowered operation range and increased rate of drawdown of the Intermediate Pond level.
- Moose Pond:
  - Continue to monitor quality of seepage water downstream of the esker ridge to confirm that the Moose Pond continues to serve adequately its exfiltration function.
  - Monitor the downstream slope of the esker ridge where seepage flow daylights, and implement remedial measures, if required, to maintain the stability and integrity of the esker ridge.

Site Monitoring Data Collection and Presentation

The collection and presentation of site monitoring data by TEES in 2012 has improved considerably. However, the following suggestions are grouped together to serve as reminders for site personnel.

- Data collection:
  - Improve distance measurement at reference bar #15351 to eliminate the error incurred since 2010.

- Leave inclinometer probe down the casing longer to let the probe reach temperature equilibrium with the ground, and perform "checksum" during field monitoring to confirm correct readings have been successfully taken.

- Data Presentation
    - Present Grum Pit distance measurement data for monitoring rods as shown in Section II.J.2 of Appendix II.

We appreciate the opportunity to work on this interesting and environmentally important project, and to exchange information and ideas with you, your colleagues and site personnel during our site visits.

KLOHN CRIPPEN BERGER LTD.

Arvind Dalpatram. P.Eng. (British Columbia)
Senior Project Hydrotechnical Engineer

March 28, 2013

PROFESSIONAL ENGINEER
YUKON
ROBERT C. LO
TERRITORY

Robert C. Lo, P.Eng.
Project Manager

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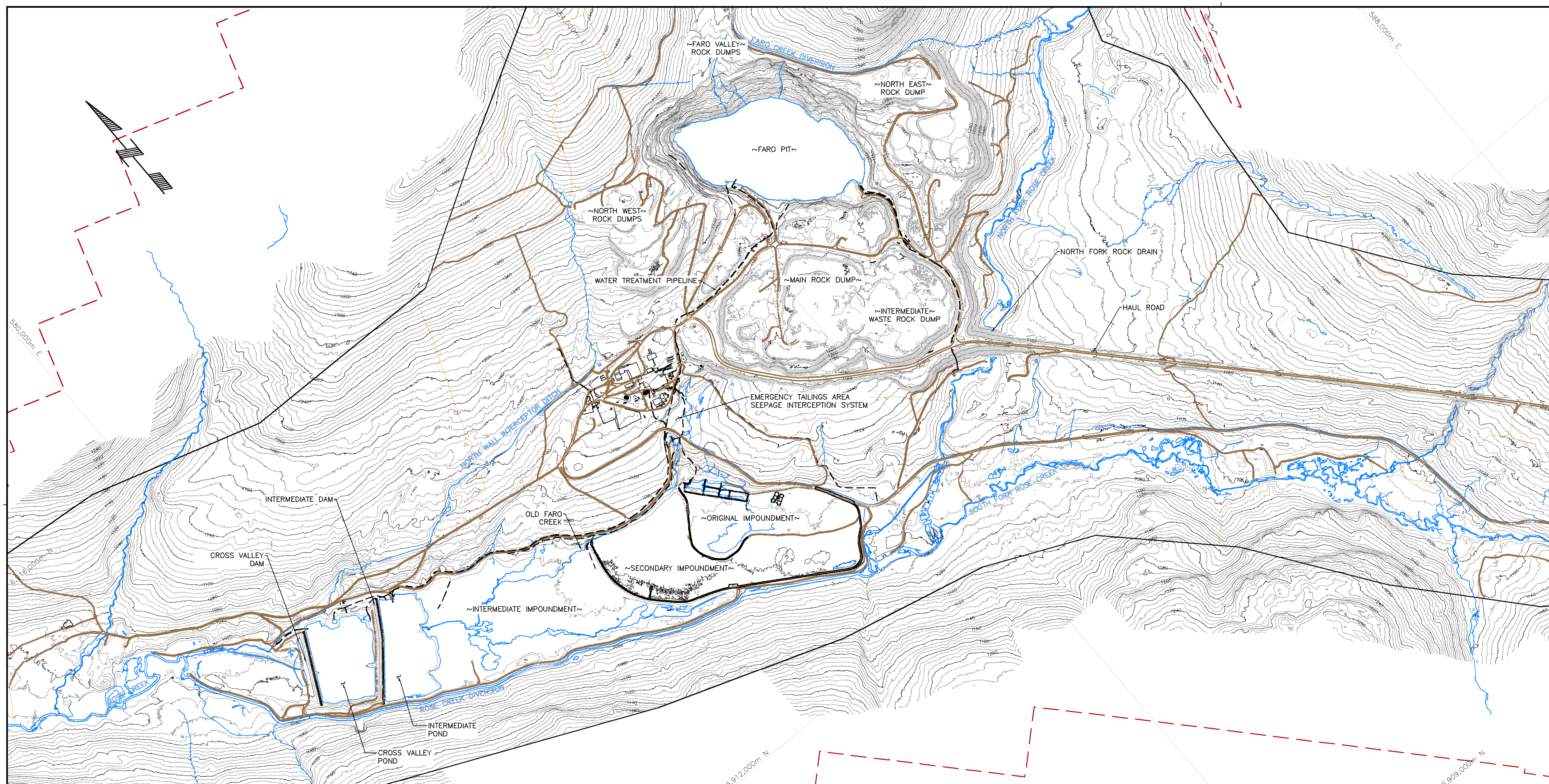
FIGURES



LEGEND

- IMPACTED AREA BOUNDARY
- ACESS ROADS
- STREAMS

NOT FOR CONSTRUCTION

To be read with Klohn Crippen Berger report dated

SCALE 0 — 1000m

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA,STATEMENTS,CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

CLIENT	YUKON GOVERNMENT
	Klohn Crippen Berger
PROJECT	FARO MINE COMPLEX 2012 ANNUAL GEOTECHNICAL REVIEW
TITLE	FARO SITE GENERAL LAYOUT
PROJECT No.	M09770A02 02
FIG. No.	FIGURE 1

KCB-R-MLD

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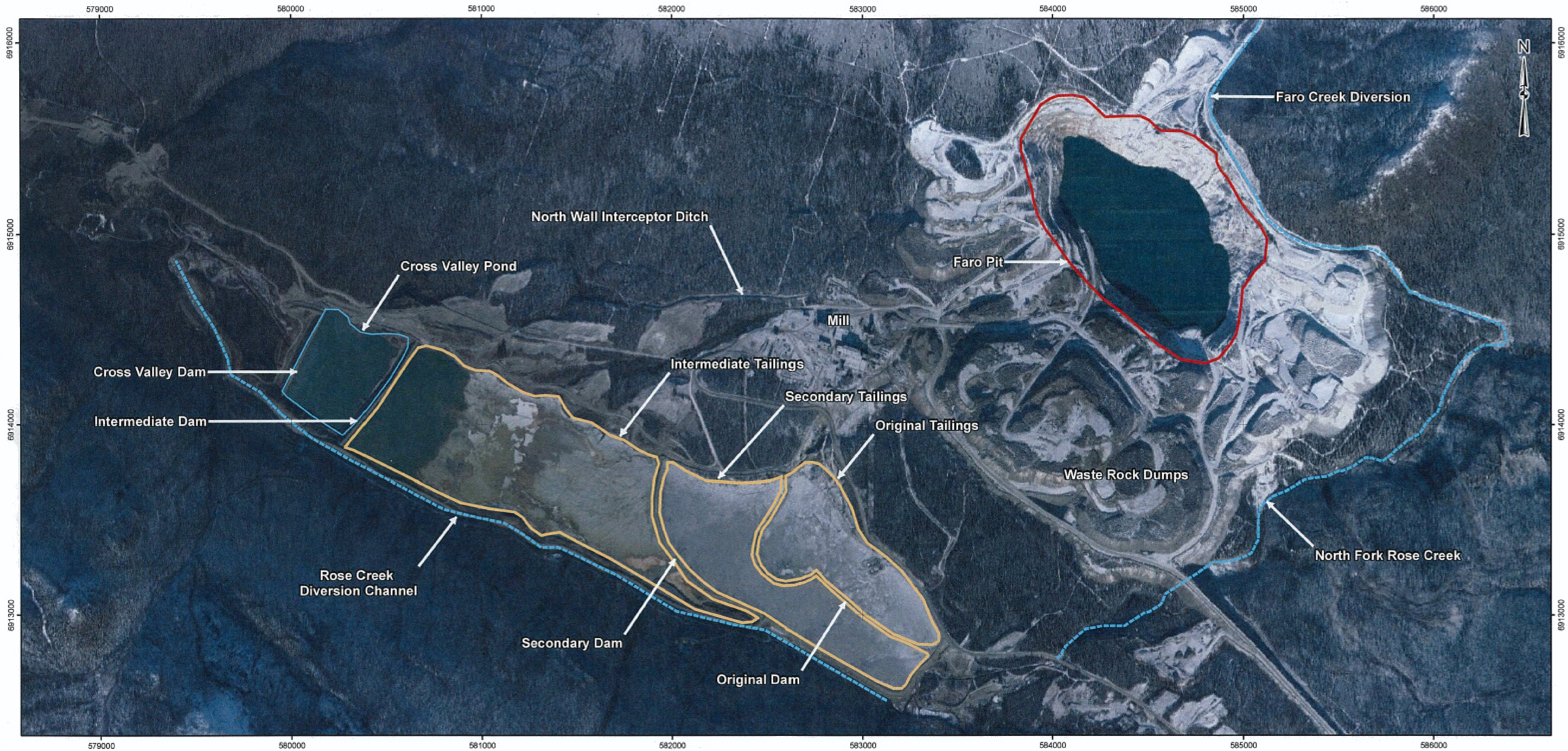

LEGEND

- Pit
- Tailings
- Pond
- Diversion

NOTE

Refer to Figures 3-1 and 3-2 for Down Valley Tailings Containment instrument location details.

REFERENCE

Ortho-image obtained from Google © 2007 Data SIO, NOAA, U.S. Navy, NGA, GEBCO Image © 2011 DigitalGlobe.
Projection: UTM Zone 8 Datum: NAD 83

500 0 500
SCALE 1:20,000 METRES

Fig. 2 Original Source: Figure 2-1 General Arrangement Plan Golder 2011. 2010 Annual Geotechnical Dam Inspection, Faro Mine Complex, Faro, Yukon

FIGURE 2

PROJECT
DENISON ENVIRONMENTAL SERVICES
FARO MINE COMPLEX
YUKON

TITLE
FARO SITE AIR PHOTO

Golder Associates
Greater Vancouver Office, B.C.

PROJECT No. 10-1427-0032			PHASE No. 2000	
DESIGN	WJP	08FEB11	SCALE AS SHOWN	REV. 0
GIS	AL	08FEB11	FIGURE 2-1	
CHECK	WJP	28FEB11		
REVIEW	JAH	28FEB11		

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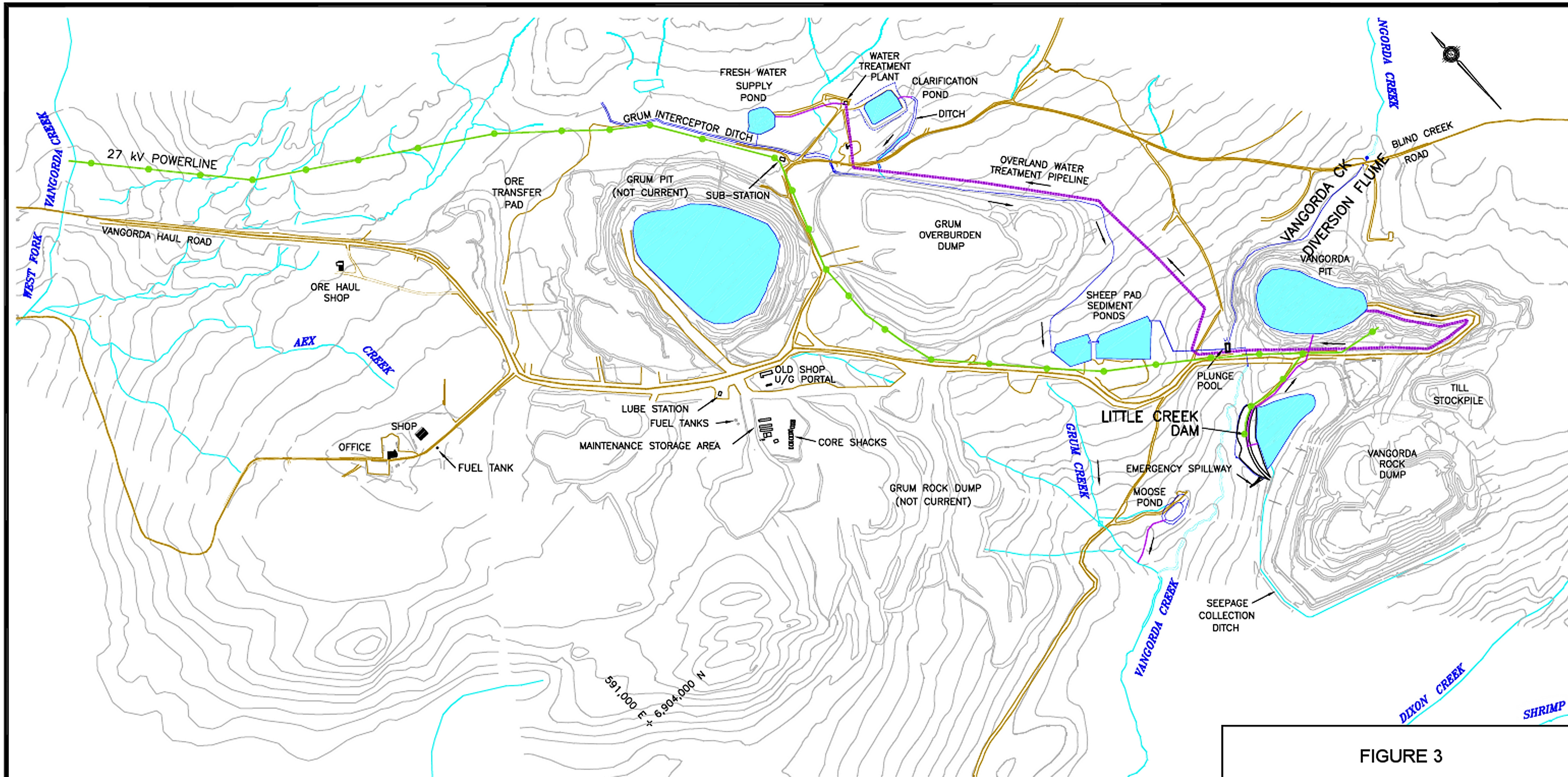


Fig. 3 Original Source: Figure 3 Vangorda Plateau Mine Site – Overview BGC 2003. Report on Emergency Preparedness Plan for Selected Dams and Water Diversion Structures

CLIENT: **Deloitte & Touche**

NOTE: BASE MAP FIGURE PROVIDED BY GARTNER LEE LTD.

LEGEND:
- ROADS
- EXISTING SURFACE DRAINAGE
- PRE-MINE DRAINAGE
- EFFLUENT PIPELINE
- PIPELINE
- POWERLINE
- WATER TREATMENT PIPELINE
- SURFACE WATER

REV.	DATE	REVISION NOTES	DRAWN	CHECKED	APPROVED

SCALE:	AS SHOWN
DATE:	OCTOBER 2003
DRAWN:	GEJ
DESIGNED:	KM
CHECKED:	HHH/JWC
APPROVED:	JWC

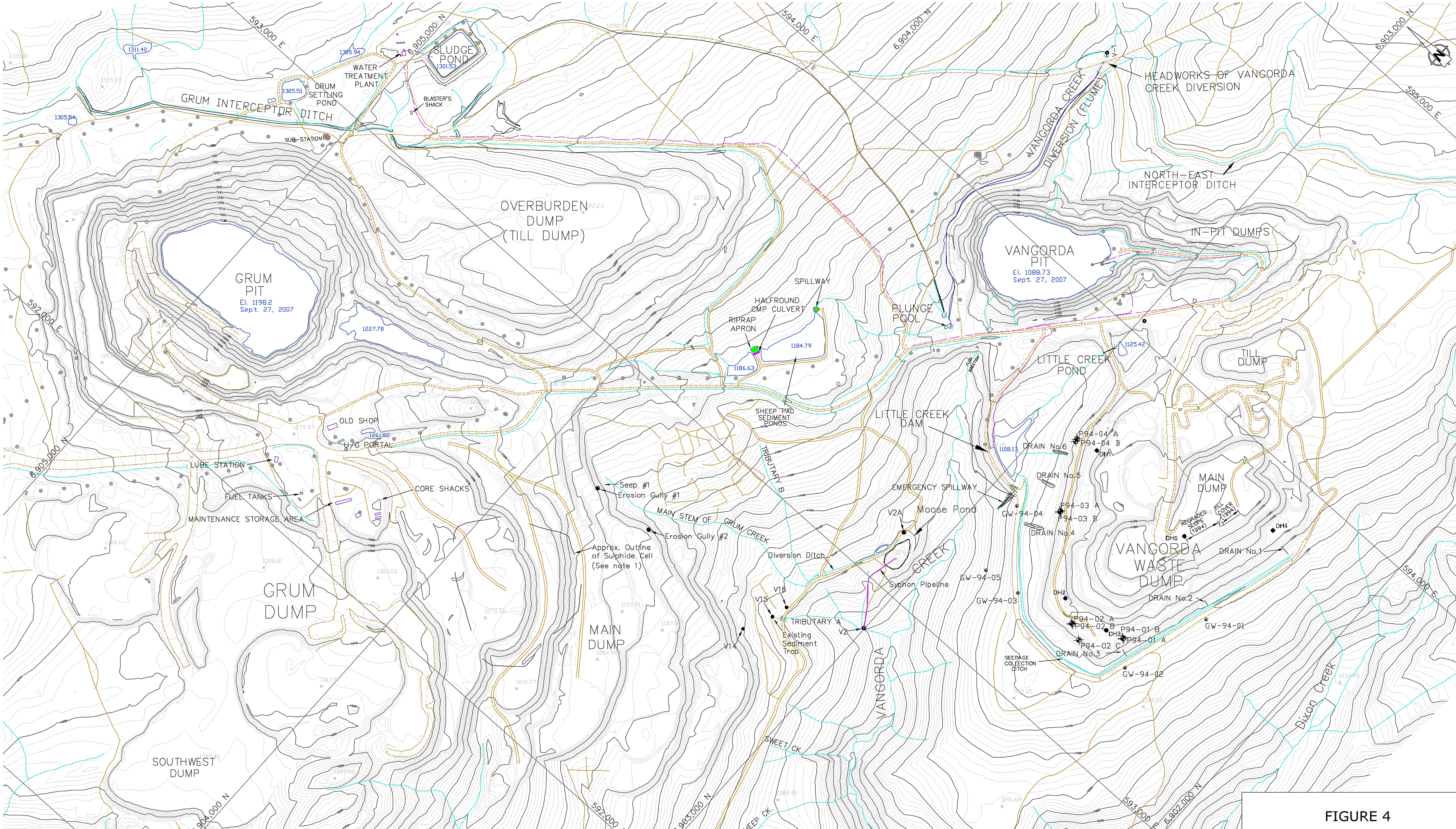
FIGURE 3

PROJECT: ANVIL RANGE EPP FOR DAMS & WATER DIVERSION STRUCTURES

TITLE: VANGORDA PLATEAU MINE SITE OVERVIEW

PROJECT No.	FIGURE No.	REV.
0257-018-02	3	0

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Calgary, AB Phone: (403) 250 5185



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Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

0 100 200 300 400 500
Scale 1:10,000

Fig 4. Original Source: Figure 2 2011 Geotechnical Inspection. Waste and Water Management Facilities Vangorda/Grum

SRK Consulting
Engineers and Scientists
Vancouver

Denison Environmental Services

SRK JOB NO.: 1CD009.003
FILE NAME: site_plan.dwg

FAROMINE COMPLEX

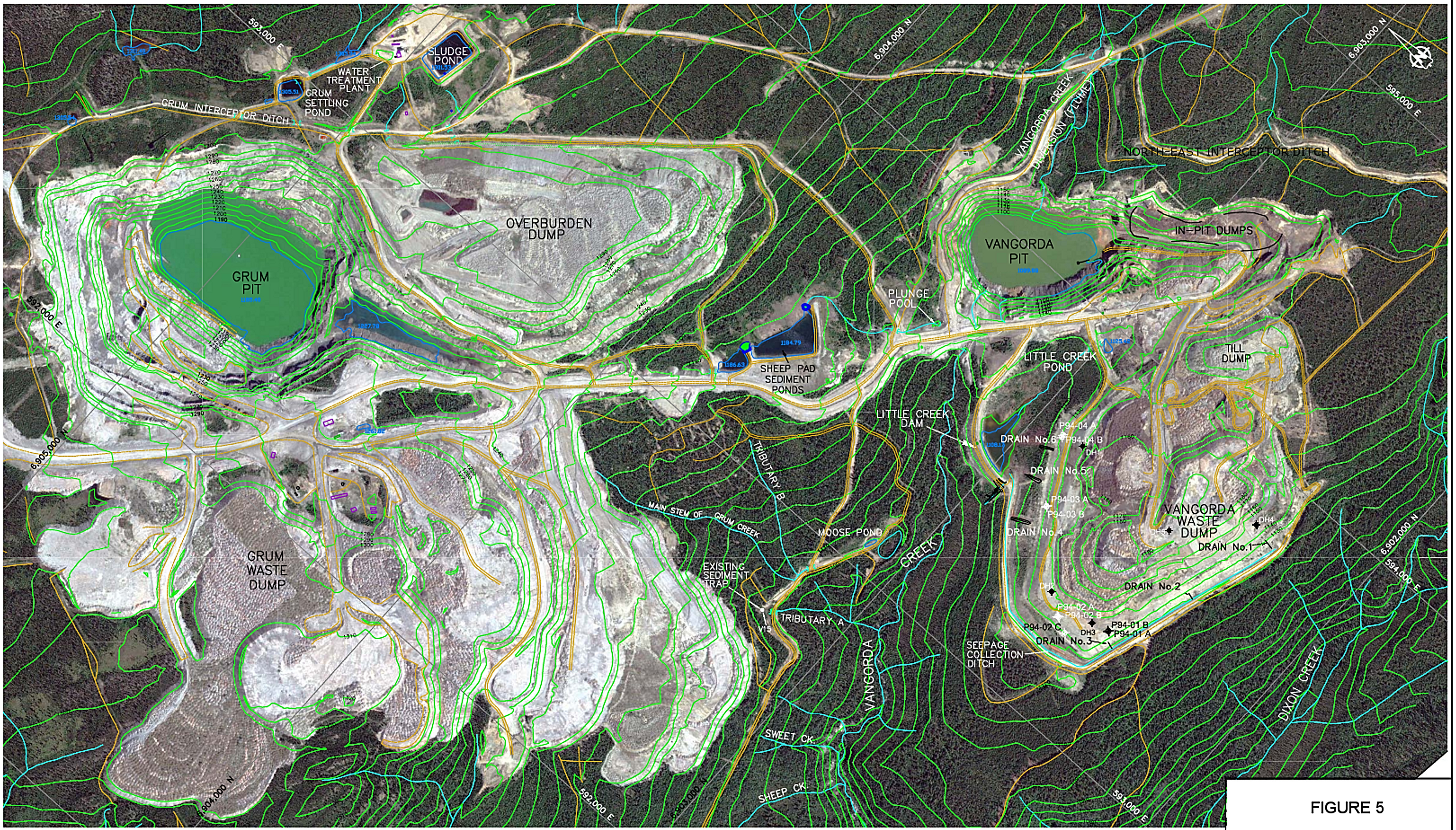
2010 Vangorda Annual Inspection

General Arrangement Plan

DATE:	APPROVED:	FIGURE:
Feb. 2011		2

J:\01_SITES\FARO\1107_1CD009.003_2010 Geot_Insp\040_AutoCAD\site_plan.dwg

Z:\MWCR\M09770A01-GovtYukon-FaroSiteGeotech\300 Design\Figures\GIMP_edited_files\Figure_5_Vangorda_Plateau_Site_Air_Photo.xcf (afischer)



Map Scale: 1:2500
Contour Interval: 2m
Date of Photography: 18/09/09
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27

Fig. 5 Original Source: Figure 3 Photo-Rectified Mosaic, with Contours, of Vangorda Plateau Area SRK 2011. 2010 Annual Inspection – Waste and Water Management Facilities – Vangorda/Grum

srk consulting

Denison Environmental Services

SRK JOB NO.: 1CD009.005
FILE NAME: site_plan_photo.dwg

FAROMINE COMPLEX

FIGURE 5

2011 Vangorda Geotechnical Inspection

VANGORDA PLATEAU SITE AIR PHOTO

DATE:	APPROVED:	FIGURE:
July 2011	PMH	3

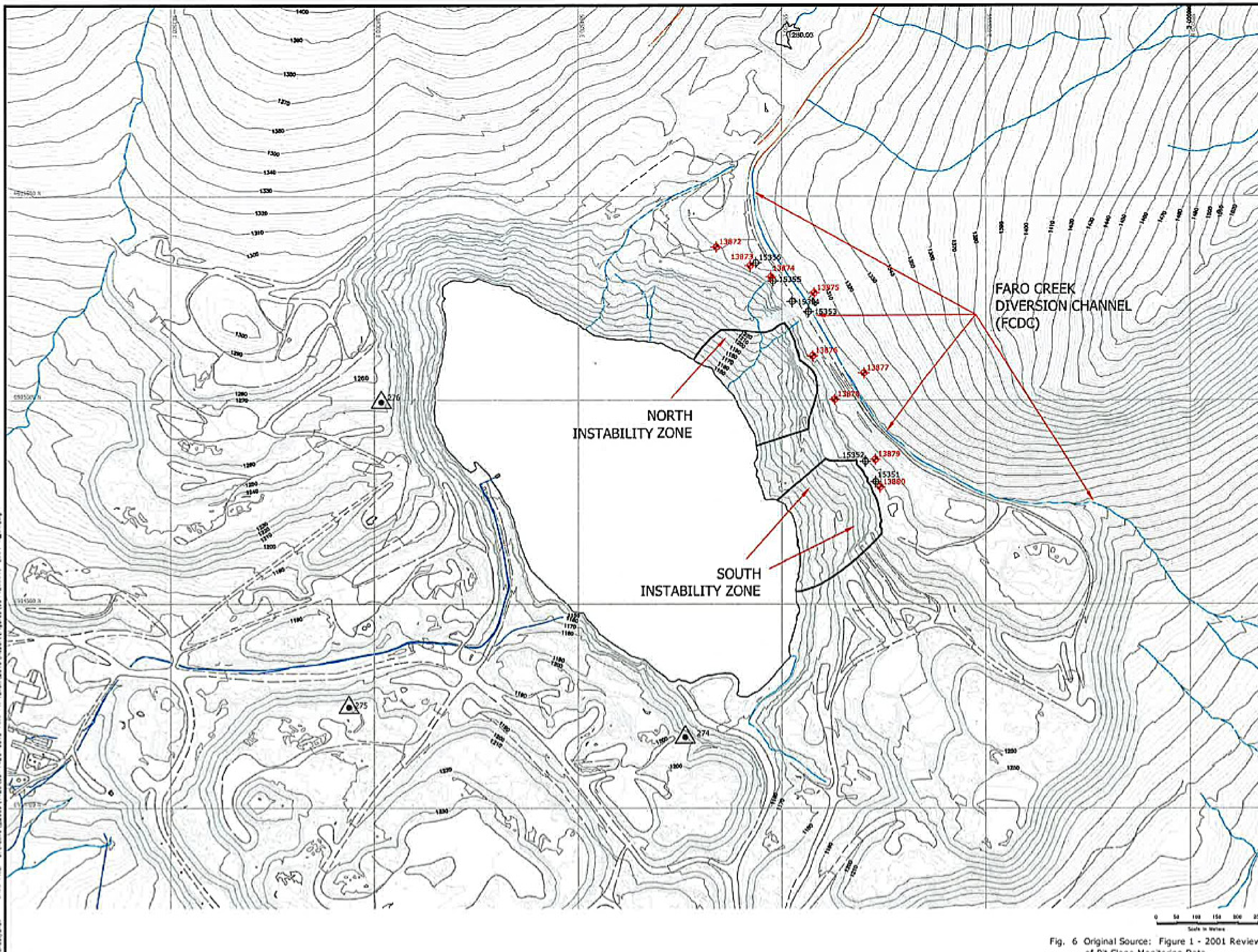


Fig. 6 Original Source: Figure 1 - 2001 Review of Pit Slope Monitoring Data

NOTES:

1) ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE NOTED.

LEGEND:

- 13678 MONITORING SURVEY PRISMS
- 13912 SLOPE MOVEMENT OBSERVATIONS - REFERENCE BARS
- 274 OBSERVATION POINTS FIXED LOCATION

FIGURE 6

PROJECT

DENISON ENVIRONMENTAL SERVICES YUKON, FARO PIT

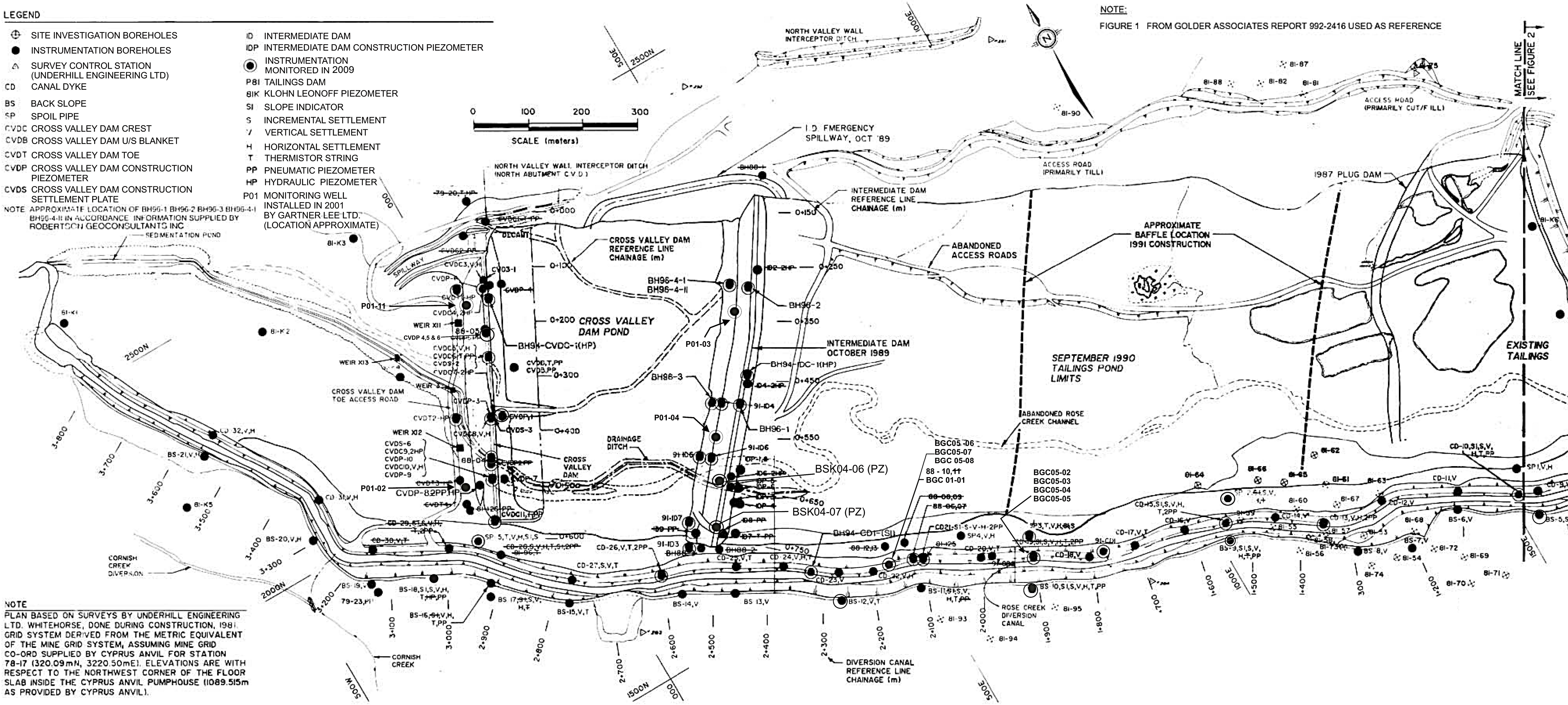
TITLE

REVIEW OF PIT SLOPE MONITORING DATA SITE PLAN

Golder Associates

PROJECT No.		09-1426-0019	FILE No.	0914260019-2001-A_01	
DESIGN	EK	14DEC10	SCALE	AS SHOWN	REV.
CADD	EK	14DEC10	FIGURE 1		
CHECK	EK	14DEC10			
REVIEW	AVC	14DEC10			

DRAWING NO.	REFERENCES	REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW	STAMP



LEGEND

- ⊕ SITE INVESTIGATION BOREHOLES
- ● INSTRUMENTATION BOREHOLES
- △ SURVEY CONTROL STATION (UNDERHILL ENGINEERING LTD)
- CD CANAL DYKE
- BS BACK SLOPE
- SP SPOIL PIPE
- CVDC CROSS VALLEY DAM CREST
- CVDB CROSS VALLEY DAM U/S BLANKET
- CVDT CROSS VALLEY DAM TOE
- CVDP CROSS VALLEY DAM CONSTRUCTION PIEZOMETER
- CVDS CROSS VALLEY DAM CONSTRUCTION SETTLEMENT PLATE
- NOTE APPROXIMATE LOCATION OF BH96-1 BH96-2 BH96-3 BH96-4-I BH96-4-II IN ACCORDANCE INFORMATION SUPPLIED BY ROBERTSON GEOCONSULTANTS INC.
- ID INTERMEDIATE DAM
- IDP INTERMEDIATE DAM CONSTRUCTION PIEZOMETER
- ◉ INSTRUMENTATION MONITORED IN 2009
- P81 TAILINGS DAM
- 81K KLOHN LEONOFF PIEZOMETER
- SI SLOPE INDICATOR
- S INCREMENTAL SETTLEMENT
- V VERTICAL SETTLEMENT
- H HORIZONTAL SETTLEMENT
- T THERMISTOR STRING
- PP PNEUMATIC PIEZOMETER
- HP HYDRAULIC PIEZOMETER
- P01 MONITORING WELL INSTALLED IN 2001 BY GARTNER LEE LTD. (LOCATION APPROXIMATE)

NOTE:
FIGURE 1 FROM GOLDER ASSOCIATES REPORT 992-2416 USED AS REFERENCE

NOTE
PLAN BASED ON SURVEYS BY UNDERHILL ENGINEERING LTD. WHITEHORSE, DONE DURING CONSTRUCTION, 1981. GRID SYSTEM DERIVED FROM THE METRIC EQUIVALENT OF THE MINE GRID SYSTEM, ASSUMING MINE GRID CO-ORD SUPPLIED BY CYPRUS ANVIL FOR STATION 78-17 (320.09mN, 3220.50mE). ELEVATIONS ARE WITH RESPECT TO THE NORTHWEST CORNER OF THE FLOOR SLAB INSIDE THE CYPRUS ANVIL PUMPHOUSE (1089.515m AS PROVIDED BY CYPRUS ANVIL).

FIGURE 7

Fig. 7 Original Source: Figure 2 - 2009 Geotechnical Evaluation and Instrumentation Review, Volume 1

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	N/A
DATE:	FEB 2010
DRAWN:	TMW
DESIGNED:	TMW
CHECKED:	HHH
APPROVED:	GWF

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Denison Environmental Services

PROJECT: 2009 ANNUAL GEOTECHNICAL EVALUATION AND INSTRUMENTATION REVIEW

TITLE: DOWN VALLEY TAILINGS CONTAINMENT INSTRUMENT LOCATION 1 OF 2

PROJECT No.:	FIGURE No.:	REV.:
0762-002-05	2	0

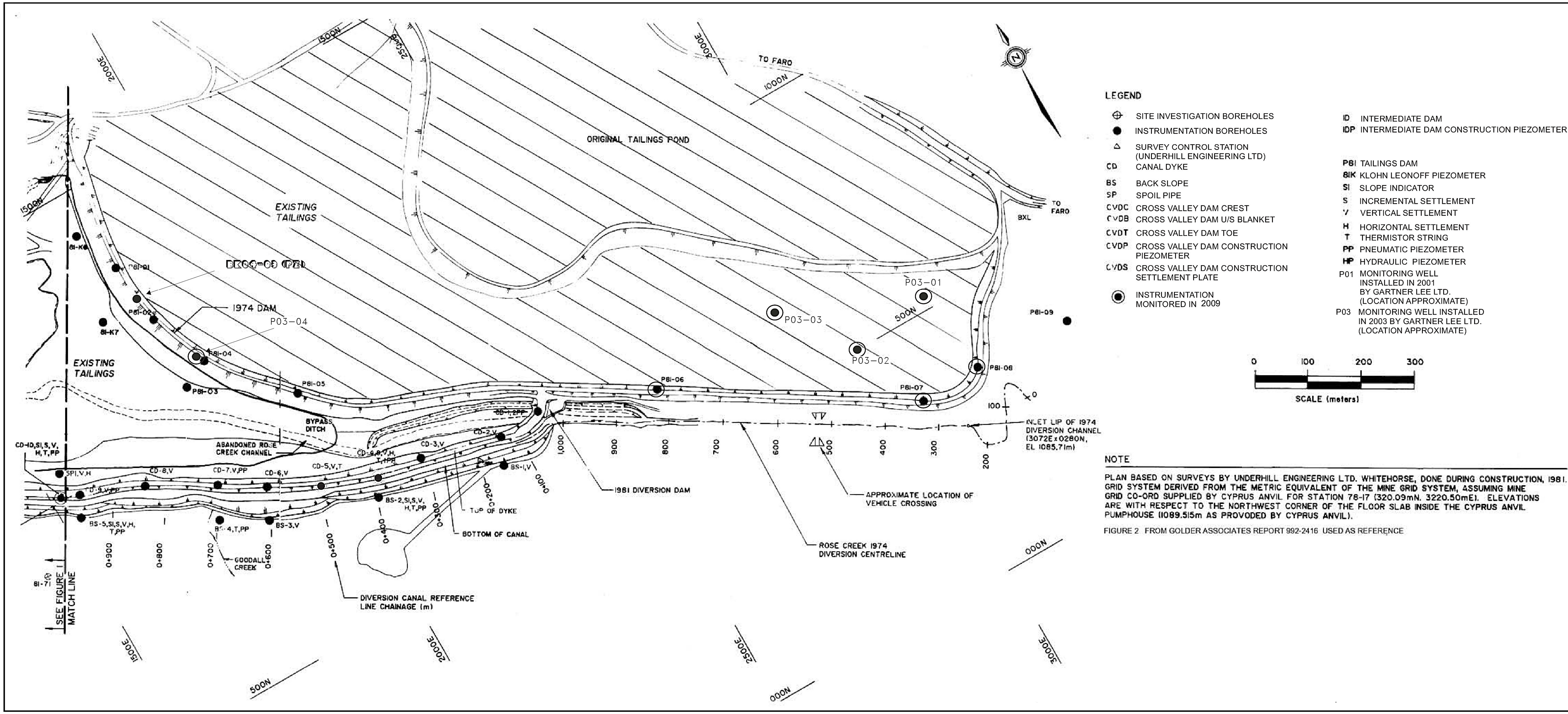


Fig. 8 Original Source: Figure 3 - 2009 Annual Geotechnical Evaluation and Instrumentation Review, Volume 1

FIGURE 8

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	N/A
DATE:	FEB 2010
DRAWN:	TMW
DESIGNED:	TMW
CHECKED:	HHH
APPROVED:	GWF

PROFESSIONAL SEAL:

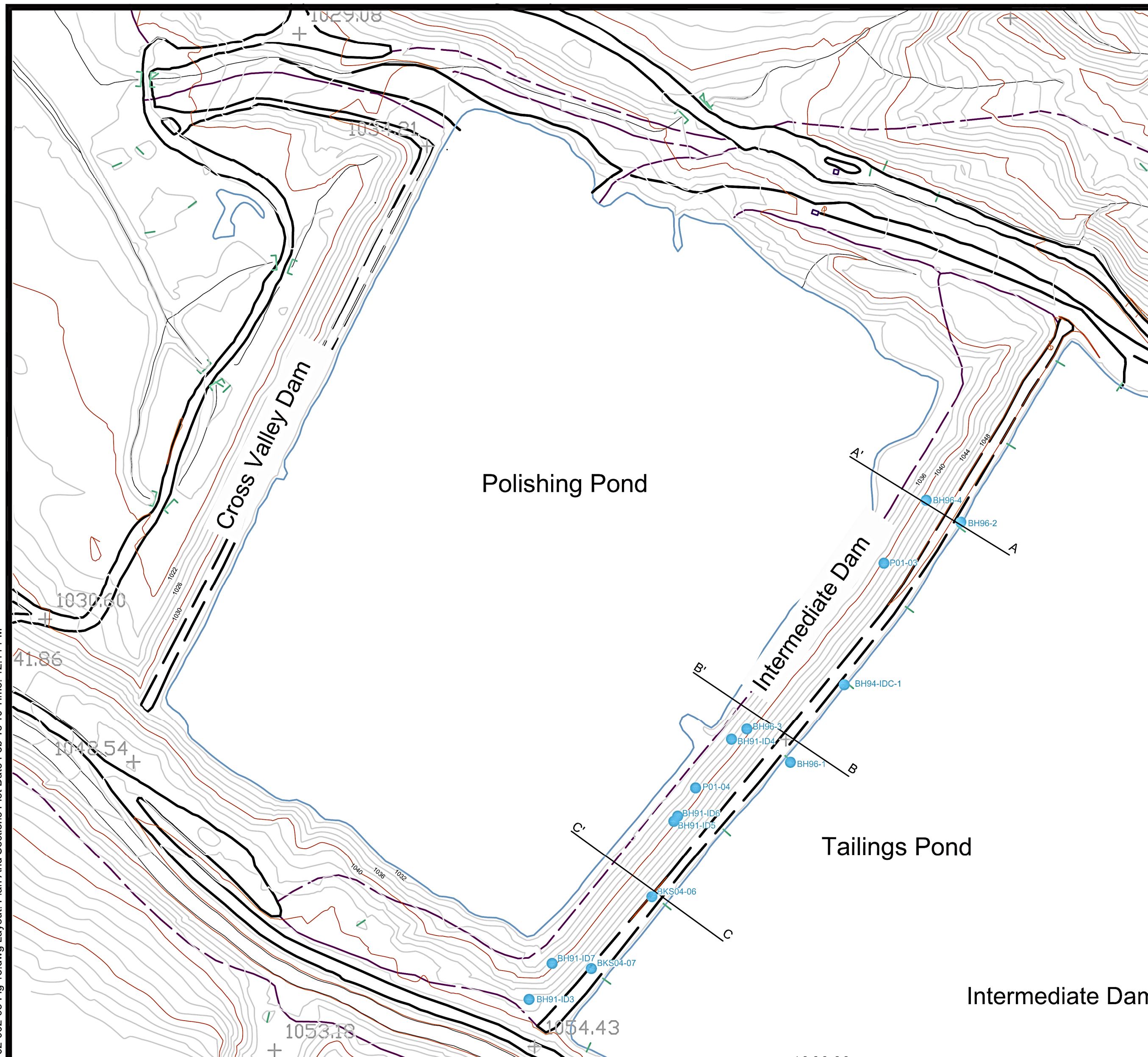
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Denison Environmental Services

PROJECT: 2009 ANNUAL GEOTECHNICAL EVALUATION AND INSTRUMENTATION REVIEW

TITLE: DOWN VALLEY TAILINGS CONTAINMENT INSTRUMENT LOCATION 2 OF 2

PROJECT No.:	FIGURE No.:	REV.:
0762-002-05	3	0

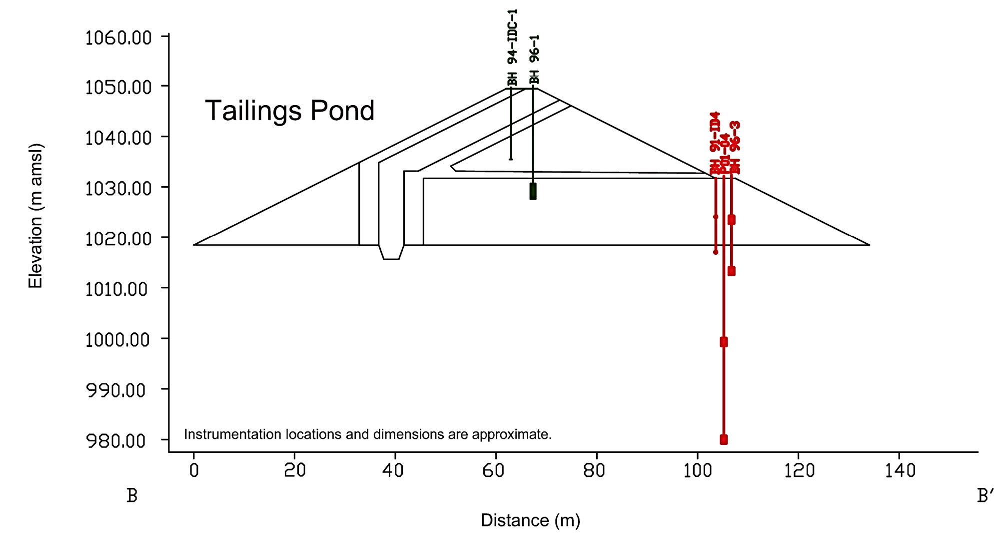


0 50 100 150 200 250 300 m

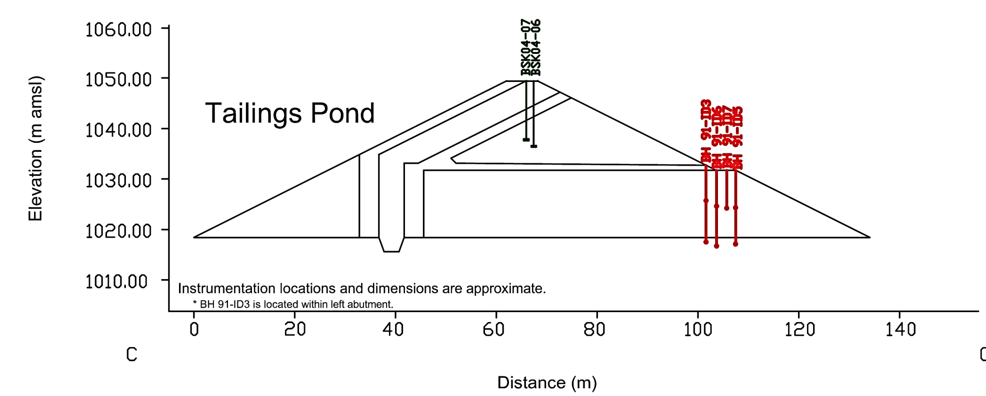
SCALE 1:5000

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

Intermediate Dam - Cross-Section B - B'



Intermediate Dam - Cross-Section C - C'



Intermediate Dam - Cross-Section A - A'

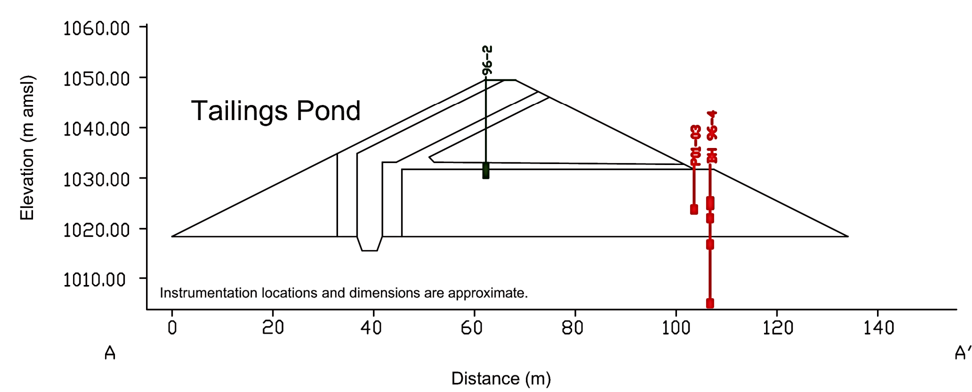


Fig. 9 Original Source: Figure 18 - 2009 Annual Geotechnical Evaluation and Instrumentation Review, Volume 1

FIGURE 9

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	AS SHOWN
DATE:	FEB 2010
DRAWN:	JL
DESIGNED:	TMW
CHECKED:	HHH
APPROVED:	GWF

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Denison Environmental Services

PROJECT: 2009 ANNUAL GEOTECHNICAL EVALUATION AND INSTRUMENTATION REVIEW

TITLE: SECTION VIEW OF INTERMEDIATE DAM

PROJECT No.:	FIGURE No.:	REV.:
0762-002-05	18	0

K:\Projects\0762 Denison Environmental\02 2009 Annual Inspection And Report\05 Reporting\Graphics\Workspace\0762-002-05 Fig 18.dwg Layout: Plan And Sections Plot Date Feb 18 10 Time: 12:11 PM

DWG TO BE READ WITH BGC REPORT TITLED " 2009 ANNUAL GEOTECHNICAL EVALUATION AND INSTRUMENT REVIEW" DATED FEB 2010

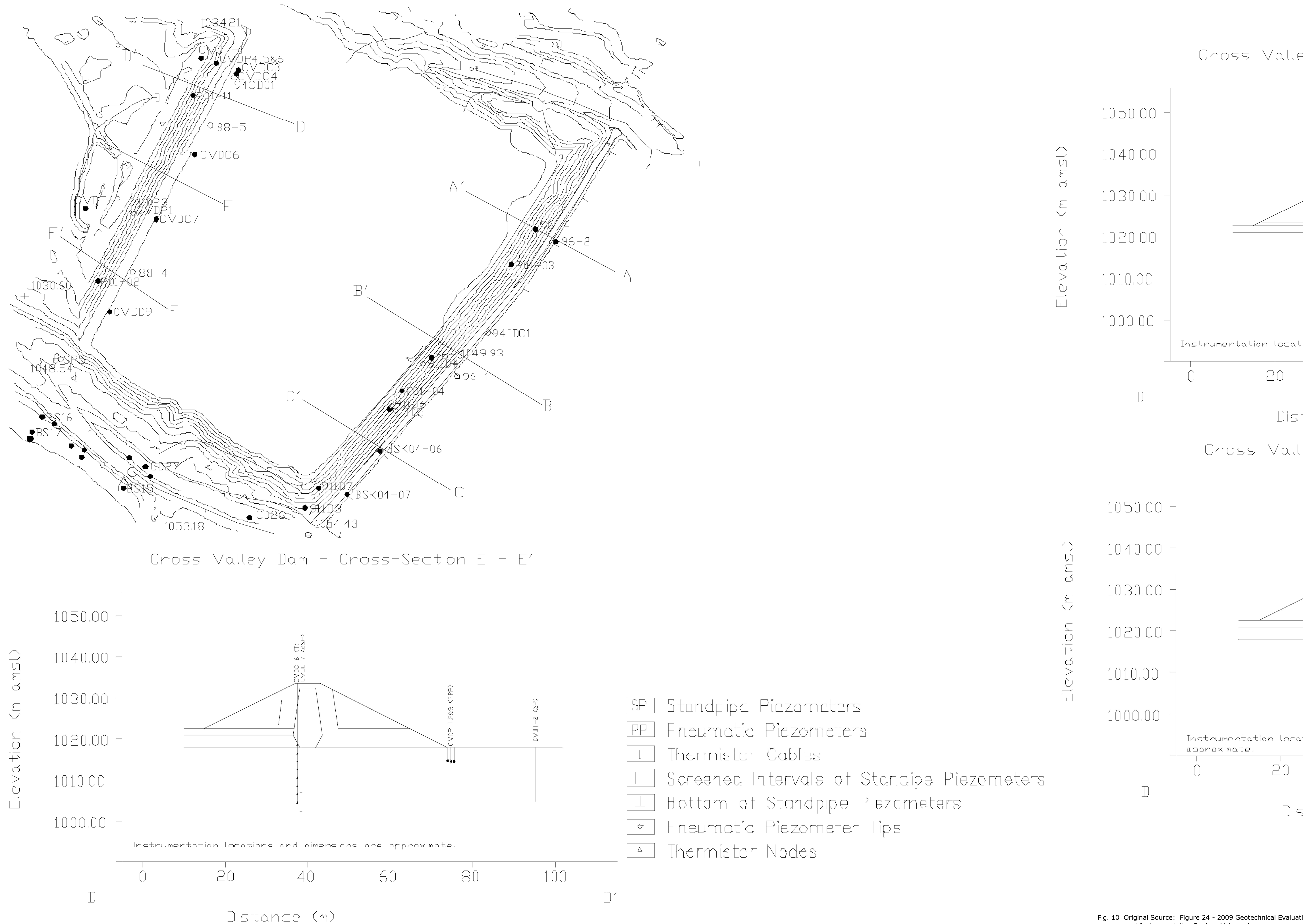


Fig. 10 Original Source: Figure 24 - 2009 Geotechnical Evaluation and Instrumentation Review, Volume 1

FIGURE 10

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	N/A
DATE:	FEB 2010
DRAWN:	TMW
DESIGNED:	TMW
CHECKED:	HHH
APPROVED:	GWF

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Denison Environmental Services

PROJECT: 2009 ANNUAL GEOTECHNICAL EVALUATION AND INSTRUMENTATION REVIEW

TITLE: SECTION VIEW OF CROSS VALLEY DAM

PROJECT No.:	FIGURE No.:	REV.:
0762-002-05	24	0

Denison Environmental Services

Faro Mine Complex: 2010 Geotechnical Monitoring Sites

Fig. 11 Original Source: Figure 2-7 - Denison Environmental Services Working Figure.

FIGURE 11

Figure #:

2-7

Faro Mine Complex:

Inset 5a:

Grum Pit Crest – East Wall

Data Sources & Disclaimers:

Basemap: Orthomapping & Digital Elevation Mapping (1m) Provided by Yukon Government

Projection: UTM Zone 8

Datum: NAD 83

Created By: JP

Reviewed By: JC

Date: February 24, 2011

Revision: 0

Denison Environmental Services

LEGEND

- Piezometer Location
- Monitoring Well Location (1994)
- Monitoring Well Location (2010)
- Monitoring Well Location (2009)

Contour Interval: 2m
Survey control based on: UTM Projection, NAD83
Based on The ORTHOSHOP, Calgary, September 2003

0 50 100 150 200 250
Scale in Metres

Fig. 12 Original Source: Figure 4 - 2011 Geotechnical Inspection Waste and Water Management Facilities Vangorda/Grum

srk consulting

SRK JOB NO.: 1CD009.005
FILE NAME: site_plan nod 83.dwg

Denison Environmental Services

FARO MINE COMPLEX

FIGURE 12

2011 Vangorda Geotechnical Inspection

General Arrangement Plan
Vangorda Waste Rock Dump

DATE:	APPROVED:	FIGURE:
July 2011	JK	4

J:\01_SITES\FARO\1CD009.005_Vangorda 2011 Geotech Inspection\40_AutoCad\site_plan nod 83.dwg

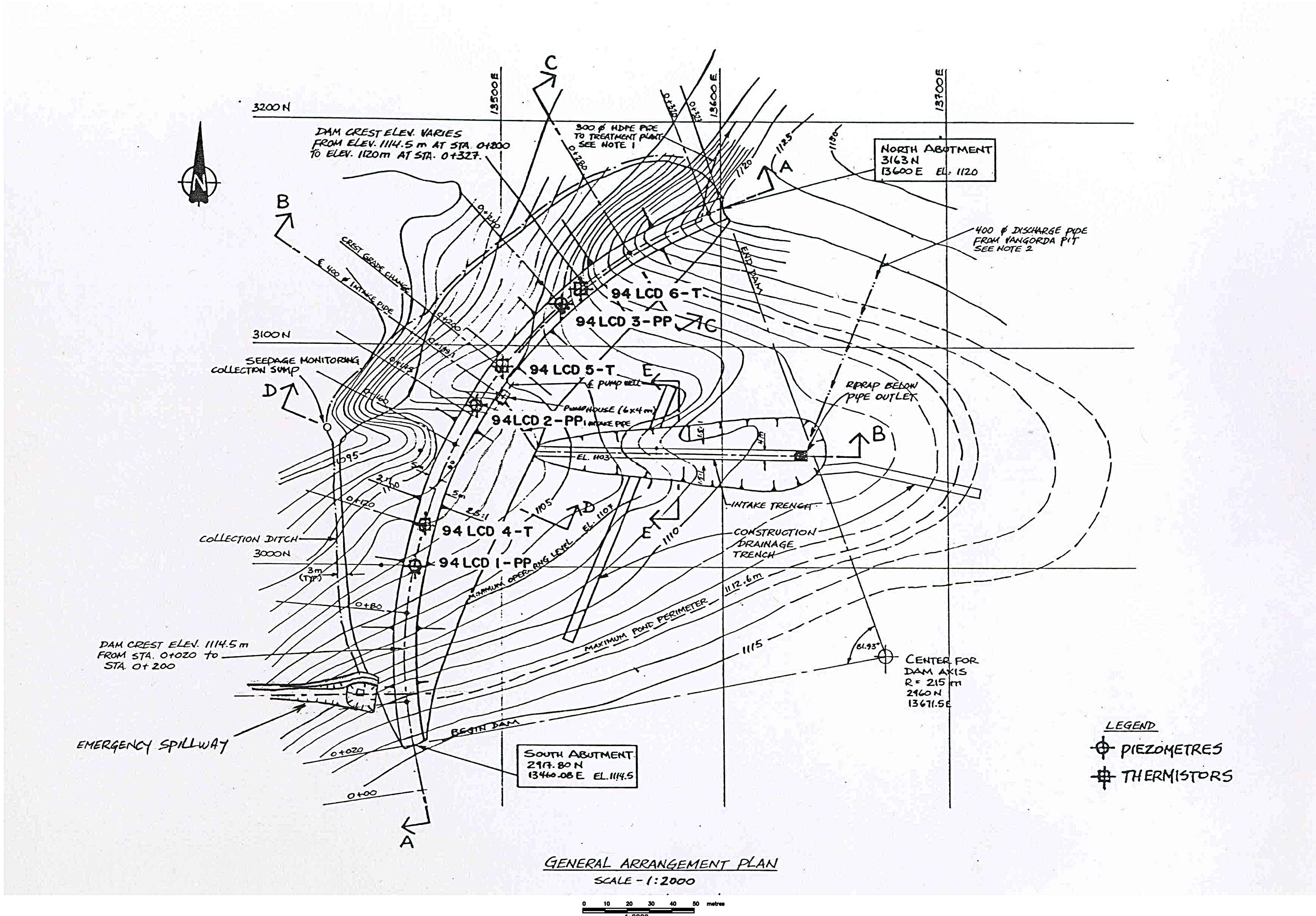


Fig. 13 Original Source: Figure 10 - 2011 Geotechnical Inspection Waste and Water Management Facilities Vangorda/Grum

srk consulting

Denison Environmental Services

SRK JOB NO.: 1CD009.005

FILE NAME: FIG-10.dwg

FAIRO MINE COMPLEX

FIGURE 13

2011 Vangorda Geotechnical Inspection

LITTLE CREEK DAM
GENERAL ARRANGEMENT PLAN

DATE:	APPROVED:	FIGURE:
July 2011	PMH	10

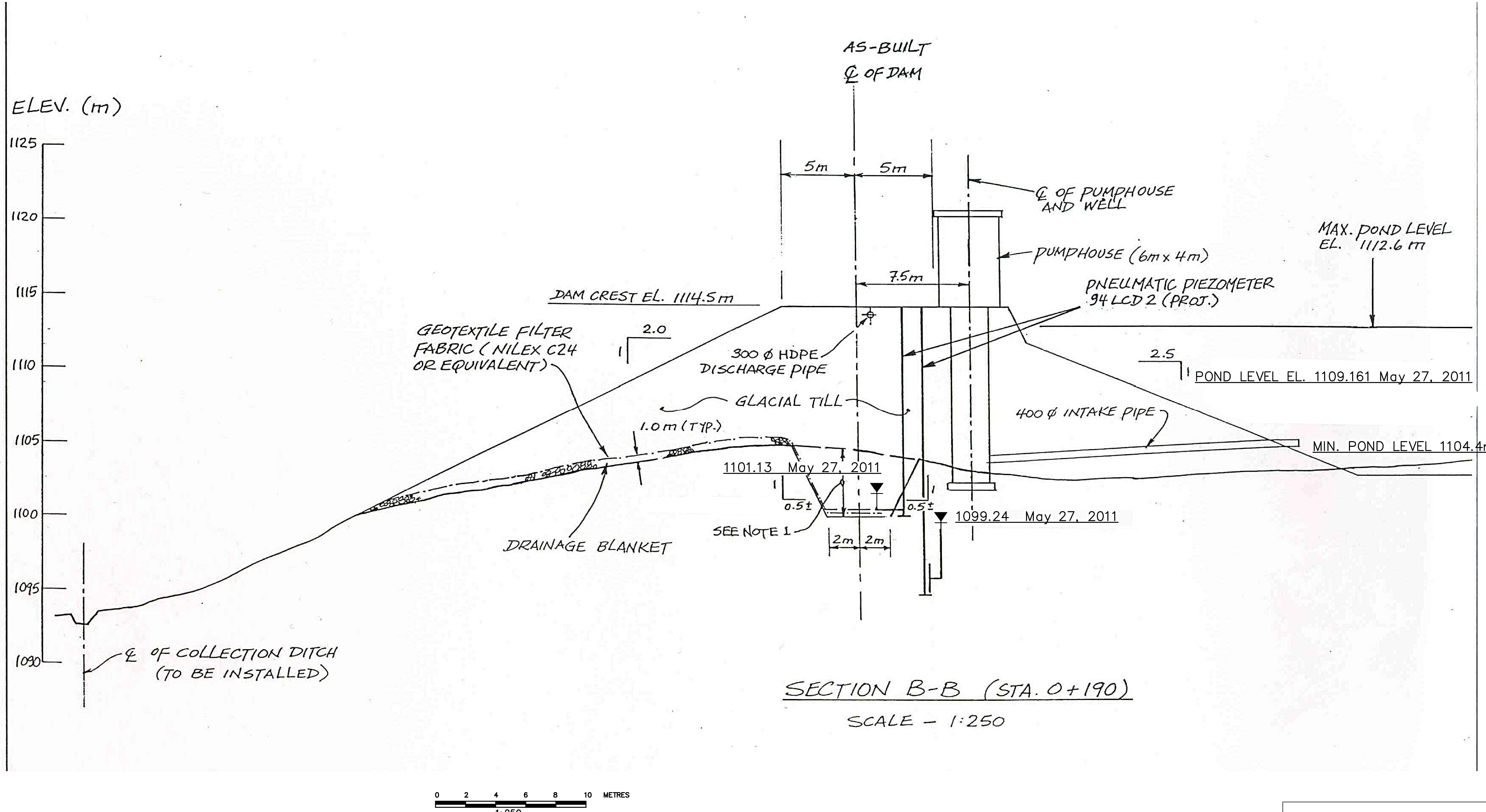


Fig. 14 Original Source: Figure 11 - 2011 Geotechnical Inspection Waste and Water Management Facilities Vangorda/Grum

srk consulting

SRK JOB NO.: 1CD009.005

FILE NAME: FIG-11.dwg

Denison Environmental Services

FARO MINE COMPLEX

FIGURE 14

2011 Vangorda Geotechnical Inspection

LITTLE CREEK DAM
SECTION B-B

DATE:	APPROVED:	FIGURE:
July 2011	PMH	11

J:\01_SITES\FARO\2210_1CD009.005_Vangorda 2011 Geotech Inspection\040_AutoCad\FIG-11.dwg

APPENDIX I

2012 Site Visit Photographs

Appendix I
Site Visit Photos

Faro Pit

Photo 1 Faro Pit east wall as seen from "eye-in-the-sky" (September 11, 2012)

Photo 2 Faro Pit east wall as seen from "eye-in-the-sky" (September 11, 2012)

Faro Creek Diversion Channel

Photo 3 Faro Creek Diversion Ditch above Faro Pit, looking upstream (September 19, 2012)

Photo 4 Faro Creek Diversion Ditch above Faro Pit, looking downstream (September 19, 2012)

North Valley Wall Interceptor Ditch

Photo 5 **Interceptor Ditch upper reach at access road to potable water well upstream end of culverts (September 19, 2012)**

Photo 6 **Upper reach of Interceptor Ditch looking upstream from well access road. (September 19, 2012)**

North Valley Wall Interceptor Ditch

Photo 7 Downstream end of culverts at well access road (September 19, 2012)

Photo 8 Upper reach of Interceptor Ditch looking downstream from well access road (September 19, 2012)

North Valley Wall Interceptor Ditch

Photo 9 Middle reach of Interceptor Ditch above Tailings Impoundment (September 19, 2012)

Photo 10 Lower reach of Interceptor Ditch adjacent to Cross Valley Dam - looking downstream (September 19, 2012)

Rose Creek Diversion Channel

Photo 11 **Rose Creek Diversion Channel fuse plug - looking towards Canal Dyke from Secondary Dam (September 19, 2012)**

Photo 12 **Rose Creek Diversion Channel downstream of fuse plug (September 19, 2012)**

Rose Creek Diversion Channel

Photo 13 **Rose Creek Diversion Channel adjacent to tailings impoundment (September 19, 2012)**

Photo 14 **Rose Creek Diversion Channel (canal) dyke adjacent to Intermediate Dam (September 19, 2012)**

Rose Creek Diversion Channel

Photo 15 Rose Creek Diversion Channel near Cross Valley Dam - looking upstream (September 19, 2012)

Photo 16 Rose Creek Diversion Channel near Cross Valley Dam - looking downstream (September 19, 2012)

North Fork and K8 Rock Drains

Photo 17 North Fork Drain upstream pool at access road between Faro and Vangorda Plateau (September 20, 2012)

Photo 18 North Fork Drain outlet - downstream slope of access road between Faro and Vangorda Plateau (September 20, 2012)

North Fork and K8 Rock Drains

Photo 19 K8 Drain upstream pool (September 11, 2012)

Photo 20 K8 Drain downstream outlet (September 11, 2012)

Secondary Tailings Dam

Photo 21 Southeast corner of Secondary Dam (September 11, 2012)

Photo 22 Downstream berm surface at southeast corner of Secondary Tailings Dam (September 11, 2012)

Intermediate Tailings Dam

Photo 23 Upstream pump barge at northeast abutment (September 11, 2012)

Photo 24 Spillway channel – looking downstream (September 11, 2012)

Intermediate Tailings Dam

Photo 25 Upstream slope of Intermediate Dam – looking southwest (September 11, 2012)

Photo 26 Wave erosion zone on upstream slope – note marker rod installed by Brodie in 2010 in the foreground (September 11, 2012)

Intermediate Tailings Dam

Photo 27 **Wave erosion zone on upstream slope – note second marker rod installed by Brodie in 2010 in the foreground (September 11, 2012)**

Photo 28 **Monitoring post installed on September 14, 2010 (Brodie 2010)**

Intermediate Tailings Dam

Photo 29 **Wave erosion zone on upstream slope – note third marker rod installed by Brodie in 2010 in the foreground (September 11, 2012)**

Photo 30 **Dam crest and upstream slope – note fill adjustment near crest shoulder marked by hard hat (September 11, 2012)**

Intermediate Tailings Dam

Photo 31 Northeast abutment of upstream slope (September 11, 2012)

Photo 32 Rill erosion along lower portion of downstream slope (September 11, 2012)

Intermediate Tailings Dam

Photo 33 Lower portion of downstream slope – looking downslope (September 11, 2012)

Photo 34 Downstream dam slope – looking northeast along toe (September 11, 2012)

Intermediate Tailings Dam

Photo 35 Downstream dam slope – looking up from downstream berm (September 11, 2012

Photo 36 Downstream berm - note rill erosion on berm shoulder in the foreground (September 11, 2012)

Intermediate Tailings Dam

Photo 37 **Southwest portion of downstream slope – note rill erosion at toe and tilted instrument-protection barrel (September 11, 2012)**

Photo 38 **Discharge pipeline of treated water – note separation of pipeline and its intermediate supports)**

Intermediate Tailings Dam

Photo 39 Downstream dam slope – looking from northeast abutment (September 11, 2012)

Cross Valley Dam

Photo 40 Crest and downstream slope - looking southwest (September 11, 2012)

Photo 41 Crest and upstream slope – looking southwest (September 11, 2012)

Cross Valley Dam

Photo 42 Dam crest along southwest segment – looking northeast, note no visible longitudinal cracks on crest surface (September 11, 2012)

Photo 43 Crest and downstream slope - looking northeast (September 11, 2012)

Cross Valley Dam

Photo 44 Cross Valley Pond siphon pipelines intake (September 11, 2012)

Photo 45 Downstream slope and berm – looking from northeast abutment (September 11, 2012)

Cross Valley Dam

Photo 46 Cross Valley Pond siphon pipeline on spillway channel (September 19, 2012)

Photo 47 Cross Valley Pond siphon outlet discharge (September 19, 2012)

Cross Valley Dam

Photo 48 Downstream slope and berm – looking towards northeast (September 11, 2012)

Photo 49 Downstream slope and berm – looking southwest (September 11, 2012)

Grum Pit

Photo 50 Grum Pit as seen from northwest wall – Grum Slot at middle right (September 12, 2012)

Photo 51 Pit east wall as seen from northwest wall (September 12, 2012)

Grum Pit

Photo 52 Reference Rods NP-1 and NP-2 along north array – crack noted at hard-hat location near NP-2 (September 12, 2012)

Photo 53 Reference Rod SP-1 along south array – ground deformation noted at hard-hat location (September 12, 2012)

Vangorda Pit

Photo 54 Pit northwest wall (September 12, 2012)

Photo 55 Pit north wall (September 12, 2012)

Vangorda Pit

Photo 56 Pit northeast wall (September 12, 2012)

Photo 57 Pit southeast wall (September 12, 2012)

Grum Waste Rock Dump

Photo 58 Grum Sulphide Cell water storage pond constructed in 2011 – view in longitudinal direction (September 12, 2012)

Photo 59 Grum Sulphide Cell water storage pond – side view (September 12, 2012)

Grum Waste Rock Dump

Photo 60 Dump side slope, water retention pond on bench and access ramp (September 12, 2012)

Photo 61 Water retention pond on bench – Grum Sulphide Cell in background (September 12, 2012)

Vangorda Waste Dump

Photo 62 Waste Dump previously noted subsidence at the arrow (September 20, 2012)

Photo 63 Waste Dump slope with old scarp and rill erosion (September 13, 2012)

Vangorda Waste Dump

Photo 64 Waste Dump slope with old scarp and rill erosion (September 13, 2012)

Photo 65 Waste Dump slope with rill erosion (September 13, 2012)

Vangorda Waste Dump

**Photo 66	Vangorda Waste Dump Drain No. 6 Weir (September 20, 2012)**

**Photo 67	Vangorda Waste Dump Drain No. 5. Weir – looking upstream (September 20, 2012)**

Vangorda Waste Dump

Photo 68 Vangorda Waste Dump Drain No. 5. Weir – weir plate split into two pieces at the V-notch (September 20, 2012)

Photo 69 Vangorda Waste Dump Drain No. 4 looking downstream - no weir at this drain (September 20, 2012)

Vangorda Waste Dump

Photo 70 Vangorda Waste Dump Drain No. 3 weir (September 20, 2012)

Photo 71 Vangorda Waste Dump Drain No. 3 weir - note delaminated weir plate and crooked staff gauge (September 20, 2012)

Vangorda Waste Dump

Photo 72 Vangorda Waste Dump Seepage Collection Ditch at Drain No. 3 - looking upstream (September 20, 2012)

Photo 73 Seepage Collection Ditch downstream of Drain No. 3 - looking downstream (September 20, 2012)

Vangorda Waste Dump

Photo 74 Vangorda Waste Dump Drain No. 2 weir (September 20, 2012)

Photo 75 Vangorda Waste Dump Drain No. 1 – no weir at this drain (September 20, 2012)

Grump Pit Interceptor Ditch

Photo 76 Interceptor Ditch near upstream end – looking upstream (September 20, 2012)

Photo 77 Interceptor Ditch upstream of Fresh Water Supply Pond - looking upstream (September 20, 2012)

Grump Pit Interceptor Ditch

Photo 78 **Interceptor Ditch near Fresh Water Supply Pond - looking downstream (September 20, 2012)**

Photo 79 **Interceptor Ditch near Grum Water Treatment Plant - looking upstream (September 20, 2012)**

North East Interceptor Ditch above Vangorda Pit

Photo 80 Interceptor Ditch near its upstream end – looking upstream (September 20, 2012)

Photo 81 Interceptor Ditch – looking downstream (September 20, 2012)

North East Interceptor Ditch above Vangorda Pit

Photo 82 Interceptor Ditch – looking downstream (September 20, 2012)

Photo 83 Interceptor Ditch – looking upstream, note slumped road slope (September 20, 2012)

Vangorda Creek (Flume) Diversion

Photo 84 **Flume emergency spillway intake culverts (behind trash rack) (September 12, 2012)**

Photo 85 **Vangorda Flume intake culvert – note considerable embankment toe erosion around culvert (September 20, 2012)**

Vangorda Creek (Flume) Diversion

Photo 86 Vangorda Flume at upstream end (September 20, 2012)

Photo 87 Vangorda Flume (September 20, 2012)

Vangorda Creek (Flume) Diversion

Photo 88 **Flume intake culvert as seen from downstream end - first pipe joint appears to be separated (September 20, 2012)**

Photo 89 **Remnant gravels in Flume (September 20, 2012)**

Vangorda Creek (Flume) Diversion

Photo 90 Pumped inflow of intercepted runoff collected below access road (September 20, 2012)

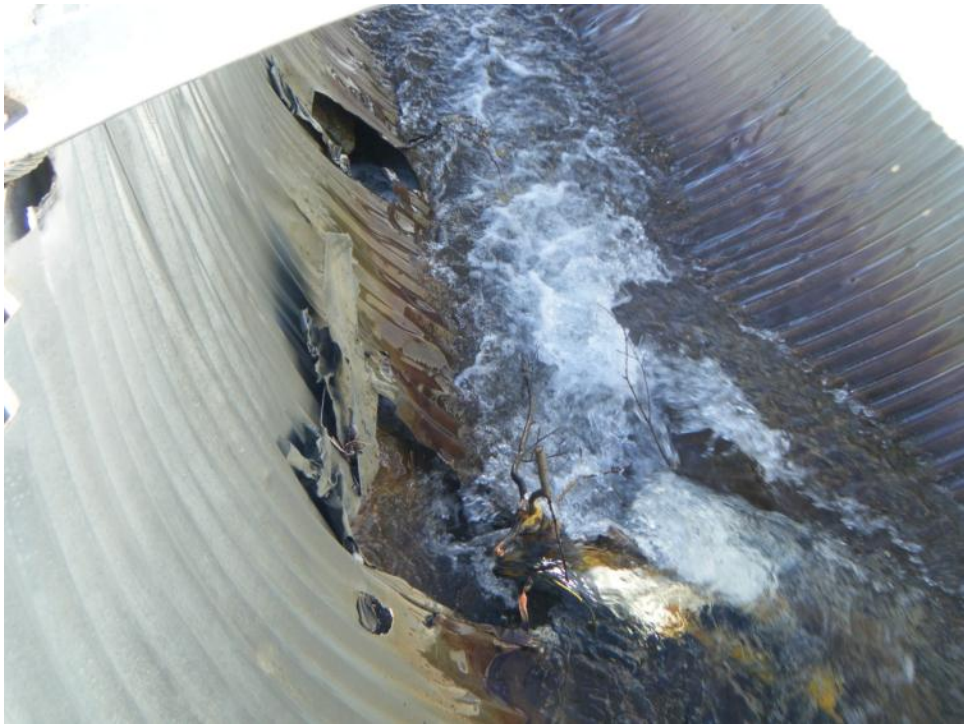


Photo 91 Damaged Flume (September 20, 2012)

Vangorda Creek (Flume) Diversion

Photo 92 Repaired flume segment (September 20, 2012)

Photo 93 Flume plunge pool and culvert to drop box (September 20, 2012)

Vangorda Creek (Flume) Diversion

Photo 94 Flow drop box downstream of Vangorda Flume (September 20, 2012)

Photo 95 Vangorda Creek Diversion outfall at Vangorda Creek downstream of drop box (September 20, 2012)

Little Creek Dam

Photo 96 Dam crest/upstream slope and pond (September 13, 2012)

Photo 97 Dam crest and upstream slope - rill erosions in the foreground (September 13, 2012)

Little Creek Dam

Photo 98 Rill erosions on downstream slope (September 13, 2012)

Photo 99 Rill erosions near transformer on dam crest (September 13, 2012)

Little Creek Dam

Photo 100 Close up of dam crest at base of transformer shown on Photo 98

Photo 101 Upstream end of culvert emergency spillway at left (south) abutment (September 13, 2012)

Little Creek Dam

Photo 102 Downstream end of culvert spillway (September 13, 2012)

Photo 103 Spillway channel with relatively flat invert – looking upstream (September 13, 2012)

Little Creek Dam

Photo 104 Spillway channel with relatively steep invert – looking upstream (September 13, 2012)

Photo 105 Spillway channel downstream end – note deep crack perpendicular to channel (September 13, 2012)

Little Creek Dam

Photo 106 Close up of crack across spillway channel shown on Photo ___ (September 13, 2012)

Photo 107 Downstream dam slope and berm – note piezometer at toe (September 13, 2012)

Sheep Pad Sediment Ponds

Photo 108 Upper Sheep Pad Sediment Pond (September 20, 2012)

Photo 109 Flume connecting Upper and Lower Sheep Pad Ponds (September 20, 2012)

Sheep Pad Sediment Ponds

Photo 110 Lower Sheep Pad Pond (September 20, 2012)

Photo 111 Culvert spillway for Lower Sheep Pad Pond (September 20, 2012)

Grum Settling Pond

Photo 112 Grum Settling Pond (September 20, 2012)

Photo 113 Pond spillway channel, looking downstream towards Grum Interceptor Ditch (September 20, 2012)

V-15 Seepage Collection Ditch

Photo 114 V-15 Pond (September 20, 2012)

Photo 115 V-15 Diversion Ditch to Moose Pond (September 20, 2012)

V-15 Seepage Collection Ditch

Photo 116 V-15 Pumphouse (September 20, 2012)

Photo 117 V-15 Diversion Ditch looking downstream towards Moose Pond (September 20, 2012)

V-15 Seepage Collection Ditch

Photo 118 V-15 Diversion Ditch at its downstream end near Moose Pond (September 20, 2012)

Photo 119 Moose Pond bank slope near V-15 Ditch inflow (September 13, 2012)

Moose Pond

Photo 120 Sediments deposited during 2011 spring excess runoff (September 13, 2012)

Photo 121 Fallen trees caused by excess seepage issuing from esker slope During 2011 spring runoff event (September 13, 2012)

Sludge Pond Embankment - Vangorda Water Treatment Plant

Photo 122 Grum Sludge Pond (September 20, 2012)

Photo 123 Grum Sludge Pond (September 20, 2012)

APPENDIX II

Instrumentation Plots and Data

Instrumentation Plots and Data

Site	Appendix Section: Structure	Data Included Herein	Section Number
Faro	II-A: Faro Pit	Pond Level	A.1
		Pit Wall Regression	A.2
		Pit Wall Prism Monitoring	A.3 (No 2012 data)
	II-B: Faro Creek Diversion Channel	Staff Gauge Calibration	B.1
		Staff Gauge Flow	B.2
	II-C: North Valley Wall Interceptor Ditch	Ditch Flow	C.1
	II-D: Rose Creek Diversion Channel	Staff Gauge Calibration and Flow	D.1
		Staff Gauge Reading	D.2
	II-E: Canal Dyke	Piezometers	E.1
		Thermistors	E.2
		Inclinometers	E.3
	II-F: North Fork Rock Drain	Staff Gauge Measurement	F.1
	II-G: Secondary Tailings Impoundment	Piezometers	G.1
	II-H: Intermediate Dam	Piezometers	H.1
		Pond level (Intermediate Pond)	H.2
	II-I: Cross Valley Dam	Piezometers	I.1
		Thermistors	I.2
		Pond Level (Polishing Pond)	I.3
		Downstream Weir Flow	I.4
Vangorda	II-J: Grum Pit	Pond Level	J.1
		Displacement Monitoring	J.2
		Piezometers (Cut Slot)	J.3
	II-K: Vangorda Pit	Pond Level	K.1
	II-L: Vangorda Waste Rock Dump	Weir Flow Measurement and Drain Visual Monitoring	L.1
		Piezometers	L.2
	II-M: Little Creek Dam	Pond level	M.1
		Piezometers	M.2
		Thermistors	M.3

APPENDIX II-A

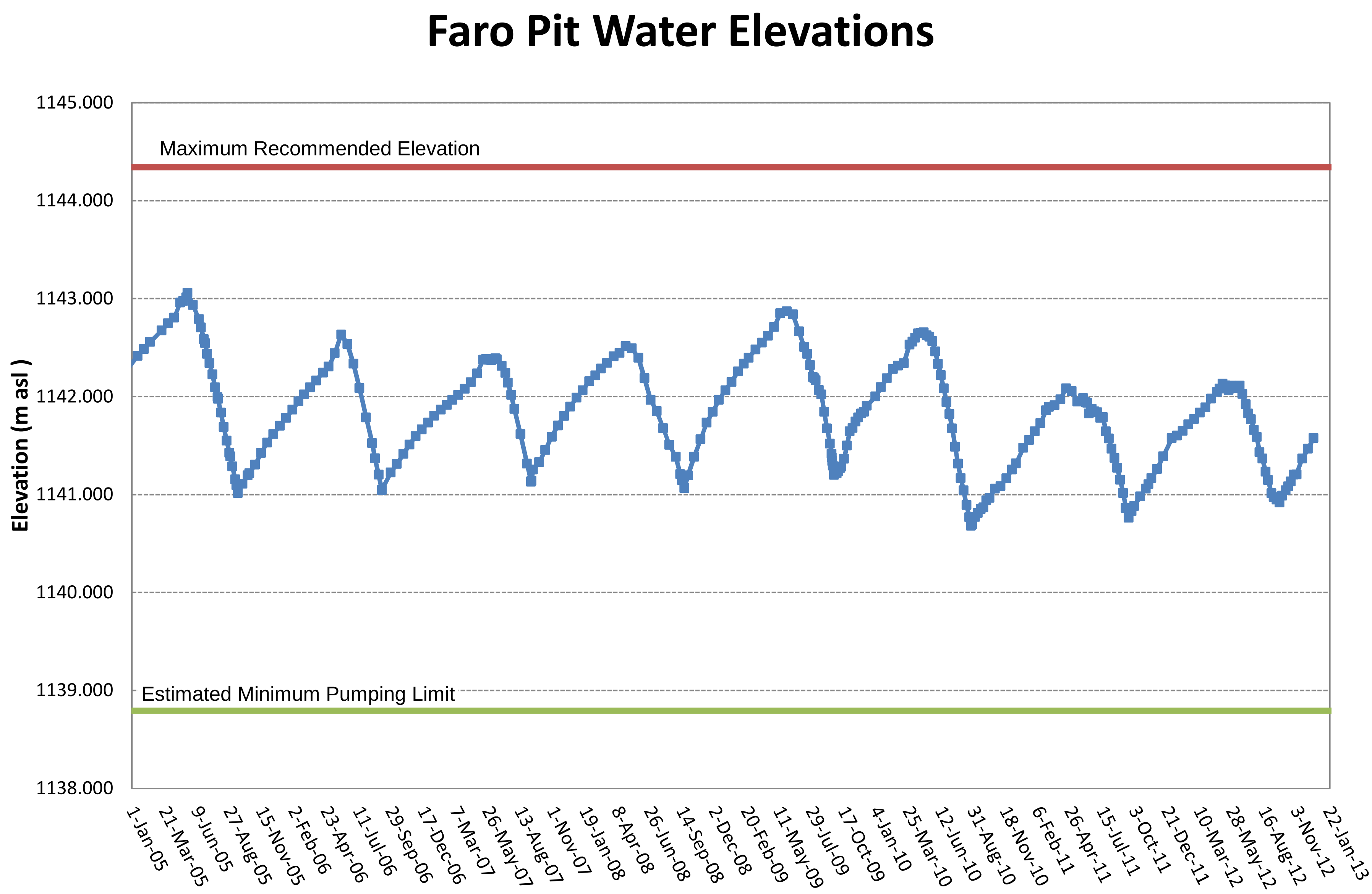
Faro Pit

A.1 - Pond Level

A.2 - Pit Wall Regression

A.3 - Pit Wall Prism Monitoring

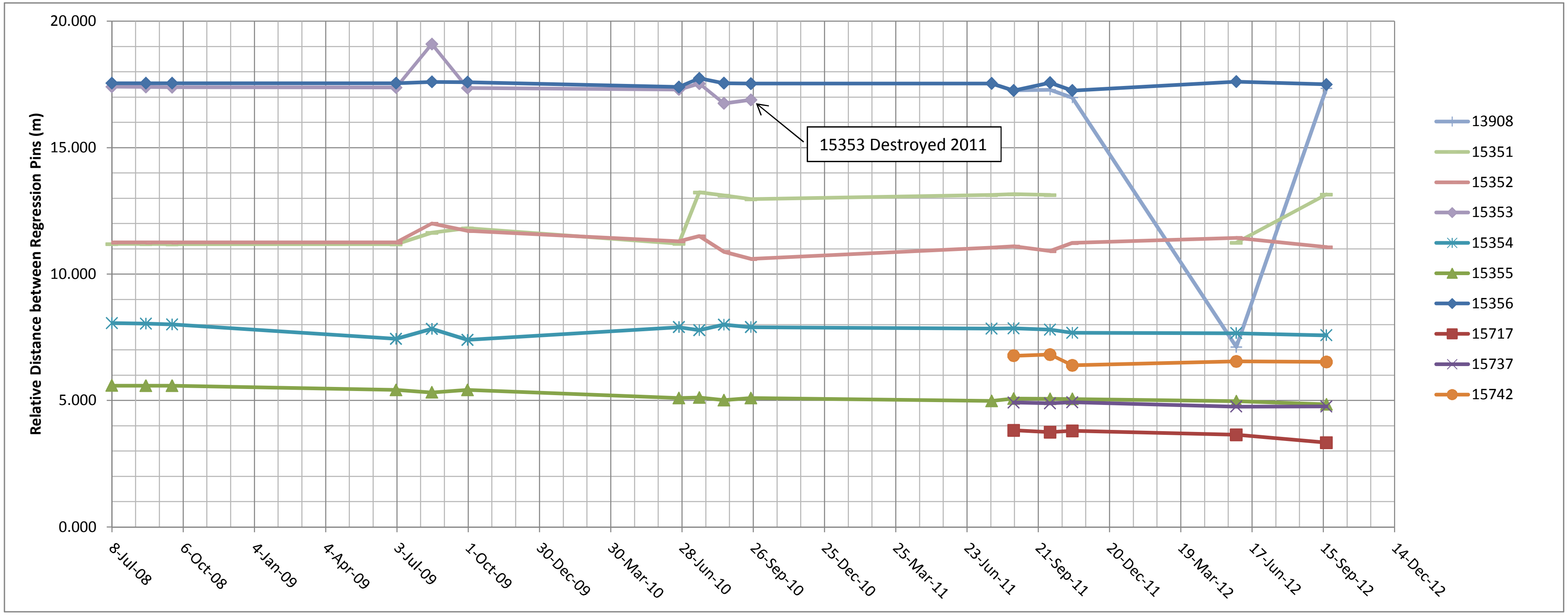
A.1 – Pond Level


Faro Pit Water Elevations
Maximum Recommended Elevation
Estimated Minimum Pumping Limit
Elevation (m asl)
1145.000
1144.000
1143.000
1142.000
1141.000
1140.000
1139.000
1138.000
1-Jan-05
21-Mar-05
9-Jun-05
27-Aug-05
15-Nov-05
2-Feb-06
23-Apr-06
11-Jul-06
29-Sep-06
17-Dec-06
7-Mar-07
26-May-07
13-Aug-07
1-Nov-07
19-Jan-08
8-Apr-08
26-Jun-08
14-Sep-08
2-Dec-08
20-Feb-09
11-May-09
29-Jul-09
17-Oct-09
4-Jan-10
25-Mar-10
12-Jun-10
31-Aug-10
18-Nov-10
6-Feb-11
26-Apr-11
15-Jul-11
3-Oct-11
21-Dec-11
10-Mar-12
28-May-12
16-Aug-12
3-Nov-12
22-Jan-13

A.2 – Pit Wall Regression

2011 Faro Pit Wall
Crest Regression

Pin	8-Jul-08	20-Aug-08	22-Sep-08	2-Jul-09	16-Aug-09	30-Sep-09	24-Jun-10	20-Jul-10	20-Aug-10	23-Sep-10	24-Jul-11	21-Aug-11	6-Oct-11	3-Nov-11	28-May-12	19-Sep-12
15356	17.550	17.550	17.550	17.550	17.600	17.590	17.400	17.740	17.55	17.530	17.540	17.260	17.570	17.260	17.61	17.500
15717												3.820	3.750	3.800	3.65	3.335
15355	5.590	5.580	5.580	5.415	5.320	5.420	5.100	5.120	5.02	5.100	4.980	5.080	5.070	5.060	4.97	4.845
15737												4.920	4.890	4.930	4.76	4.765
15354	8.060	8.040	8.010	7.440	7.830	7.395	7.900	7.780	8.00	7.900	7.840	7.850	7.800	7.680	7.66	7.580
15742												6.770	6.820	6.390	6.55	6.525
13908												17.270	17.290	16.980	7.12	17.350
15352	11.250	11.250	11.250	11.250	12.000	11.710	11.300	11.500	10.89	10.600	11.050	11.100	10.910	11.230	11.43	11.065
15351	11.190	11.190	11.180	11.180	11.640	11.810	11.200	13.230	13.11	12.960	13.130	13.160	13.130		11.24	13.150
15353	17.410	17.400	17.390	17.375	19.100	17.360	17.300	17.530	16.75	16.890	Destroyed 2011					



A.3 – Pit Wall Prism Monitoring

No 2012 Data

Coordinates (Monitoring Points) August 2009

Point #	Northing	Easting	Elevation
13872	6915376.016	584838.717	1289.068
13873	6915330.160	584922.193	1298.200
13874	6915302.306	584972.841	1297.387
13875	6915262.939	585078.500	1303.852
13876	6915108.370	585074.493	1281.030
13877	6915066.804	585200.621	1300.452
13878	6915002.363	585128.755	1280.709
13879	6914854.644	585228.540	1274.949
13880	6914786.552	585240.522	1269.126

1-Aug-09

σ_N (cm)	σ_E (cm)	σ_Z (cm)
0.9	1.0	3.2
0.9	1.0	3.2
0.9	0.9	3.3
1.0	0.9	3.4
1.0	0.8	3.1
1.1	0.8	3.3
1.0	0.8	3.1
1.1	0.7	3.0
1.1	0.7	2.9

Changes Between August 2009 and August 2006

Δ_N(m)	Δ_E(cm)	Δ_Z(cm)
1.48	-1.41	-2.22
1.87	-0.45	-6.03
0.67	-1.55	-4.99
0.30	-2.85	-6.77
-0.16	-0.01	-9.95
1.92	-0.36	-0.77
2.92	-1.37	5.89
1.81	-0.71	-5.09
2.54	-0.26	-3.95

Coordinates (Monitoring Points) September 2010

Point #	Northing	Easting	Elevation
13872	6915376.017	584838.715	1289.073
13873	6915330.162	584922.186	1298.246
13874	6915302.288	584972.853	1297.365
13875	6915262.932	585078.501	1303.913
13876	6915108.383	585074.485	1281.028
13877	6915066.778	585200.616	1300.455
13878	6915002.375	585128.754	1280.727
13879	6914854.642	585228.544	1275.018
13880	6914786.558	585240.513	1269.161

1-Sep-10

σ_N (cm)	σ_E (cm)	σ_Z (cm)
0.81	0.91	2.98
0.85	0.88	2.99
0.87	0.87	3.03
1.11	1.46	4.10
0.89	0.77	2.90
0.98	0.78	3.05
0.91	0.73	2.83
0.97	0.69	2.78
1.23	1.03	3.08

Changes Between September 2010 and August 2006

Δ_N(cm)	Δ_E(cm)	Δ_Z(cm)
1.630	-1.640	-1.680
2.070	-1.060	-1.370
-1.090	-0.290	-7.250
-0.430	-2.670	-0.670
1.090	-0.840	-10.120
-0.680	-0.860	-0.530
4.080	-1.480	7.650
1.600	-0.350	1.780
3.100	-1.160	-0.450

Coordinates (Monitoring Points) September 20 2011

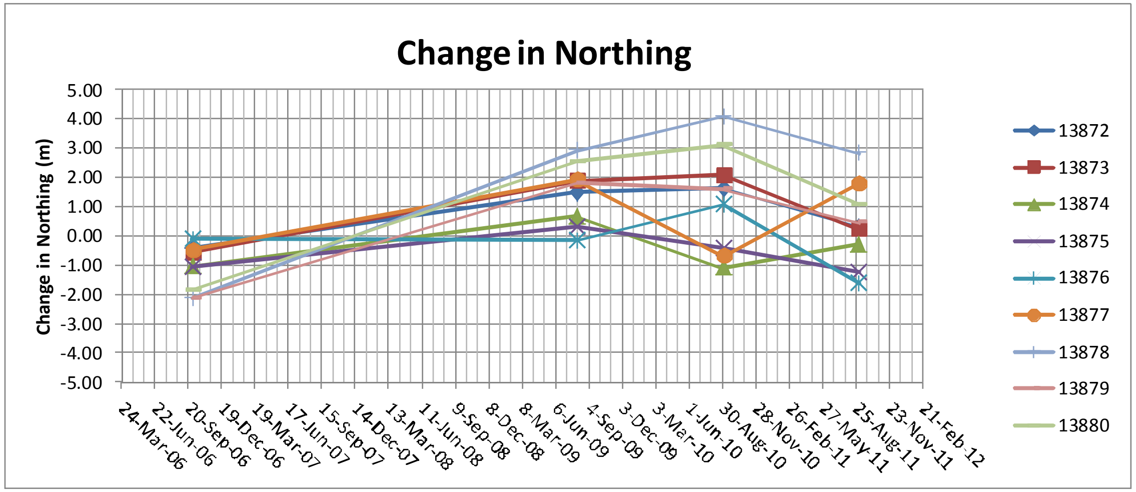
Point #	Northing	Easting	Elevation
13872	6915376.004	584838.718	1289.076
13873	6915330.143	584922.190	1298.250
13874	6915302.296	584972.842	1297.378
13875	6915262.923	585078.492	1303.853
13876	6915108.356	585074.495	1281.032
13877	6915066.803	585200.619	1300.452
13878	6915002.362	585128.751	1280.711
13879	6914854.631	585228.532	1274.975
13880	6914786.538	585240.518	1269.139

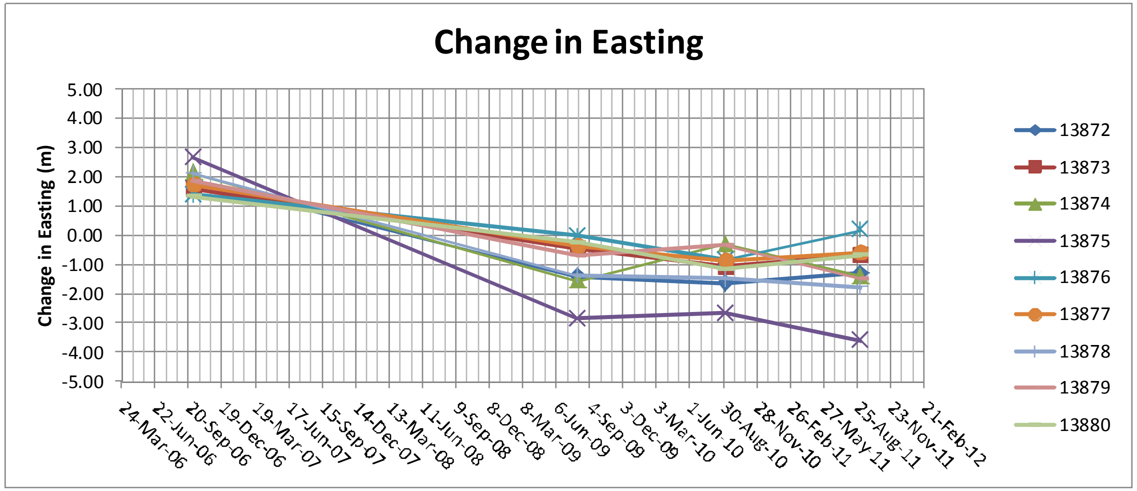
1-Sep-11

σ_N (cm)	σ_E (cm)	σ_Z (cm)
0.604	0.653	1.456
0.621	0.647	1.488
0.632	0.644	1.508
0.660	0.644	1.564
0.642	0.602	1.448
0.682	0.607	1.522
0.651	0.584	1.416
0.673	0.567	1.396
0.673	0.558	1.359

Changes Between August 2011 and August 2006

Δ_N(cm)	Δ_E(cm)	Δ_Z(cm)
0.29	-1.31	-1.44
0.24	-0.68	-1.00
-0.30	-1.40	-5.92
-1.26	-3.60	-6.70
-1.62	0.18	-9.74
1.82	-0.59	-0.82
2.84	-1.78	6.06
0.46	-1.47	-2.46
1.08	-0.68	-2.62


Change in Northing
Change in Northing (m)
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
24-Mar-06
22-Jun-06
20-Sep-06
19-Dec-06
19-Mar-07
17-Jun-07
15-Sep-07
14-Dec-07
13-Mar-08
11-Jun-08
9-Sep-08
8-Dec-08
8-Mar-09
6-Jun-09
4-Sep-09
3-Dec-09
3-Mar-10
1-Jun-10
30-Aug-10
28-Nov-10
26-Feb-11
27-May-11
25-Aug-11
23-Nov-11
21-Feb-12
13872
13873
13874
13875
13876
13877
13878
13879
13880


Change in Easting
Change in Easting (m)
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
24-Mar-06
22-Jun-06
20-Sep-06
19-Dec-06
19-Mar-07
17-Jun-07
15-Sep-07
14-Dec-07
13-Mar-08
11-Jun-08
9-Sep-08
8-Dec-08
8-Mar-09
6-Jun-09
4-Sep-09
3-Dec-09
3-Mar-10
1-Jun-10
30-Aug-10
28-Nov-10
26-Feb-11
27-May-11
25-Aug-11
23-Nov-11
21-Feb-12
13872
13873
13874
13875
13876
13877
13878
13879
13880

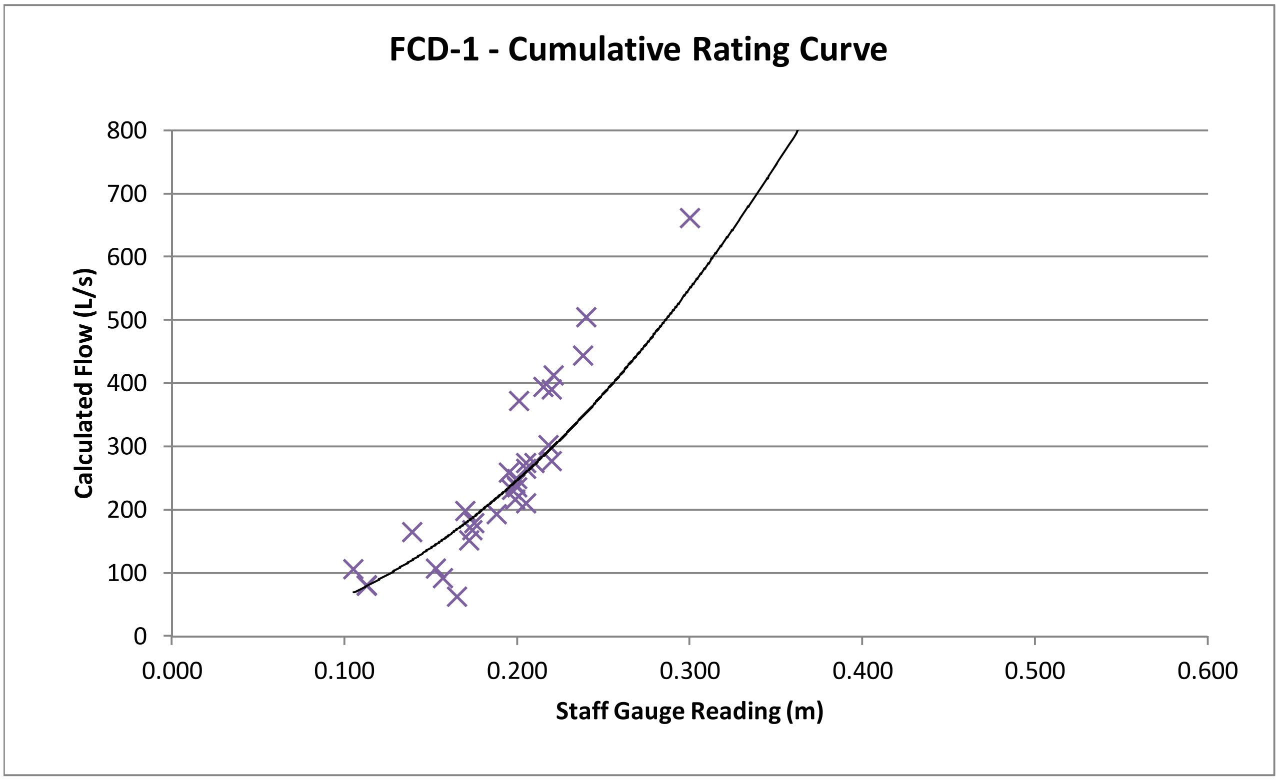
APPENDIX II-B

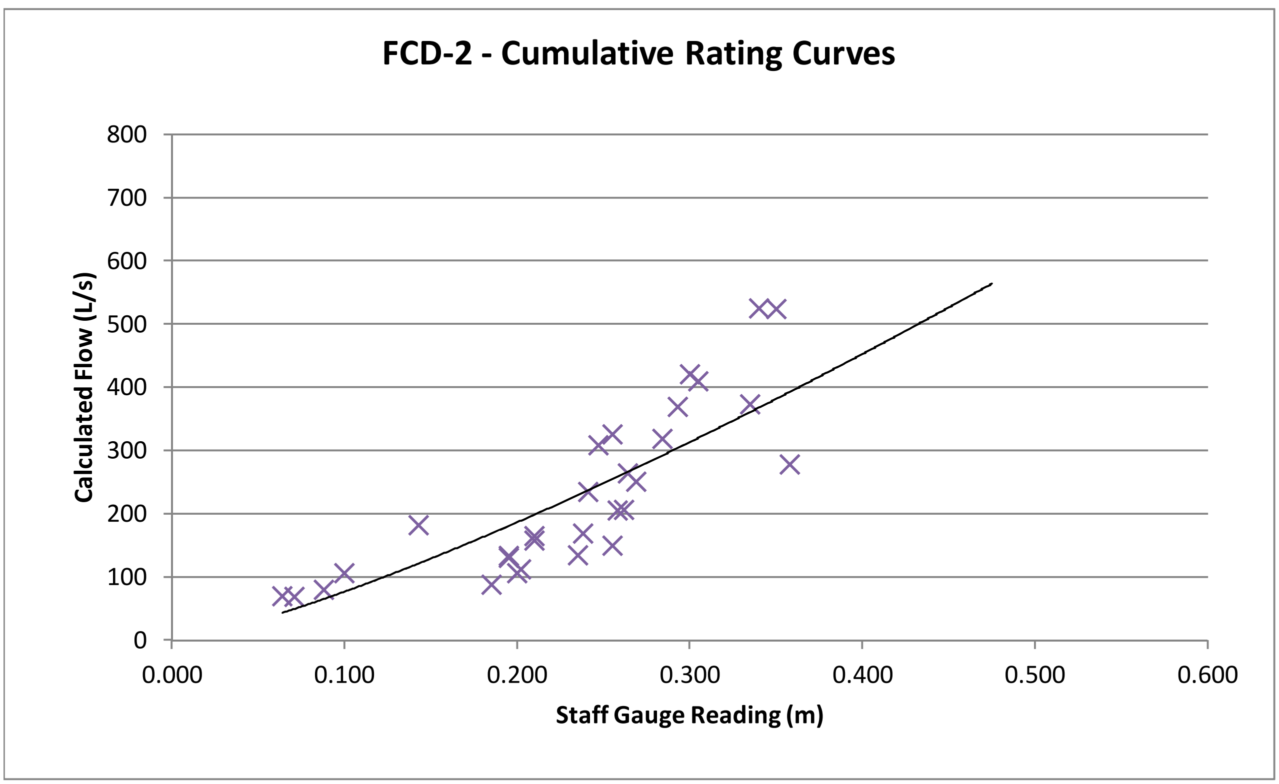
Faro Creek Diversion Channel

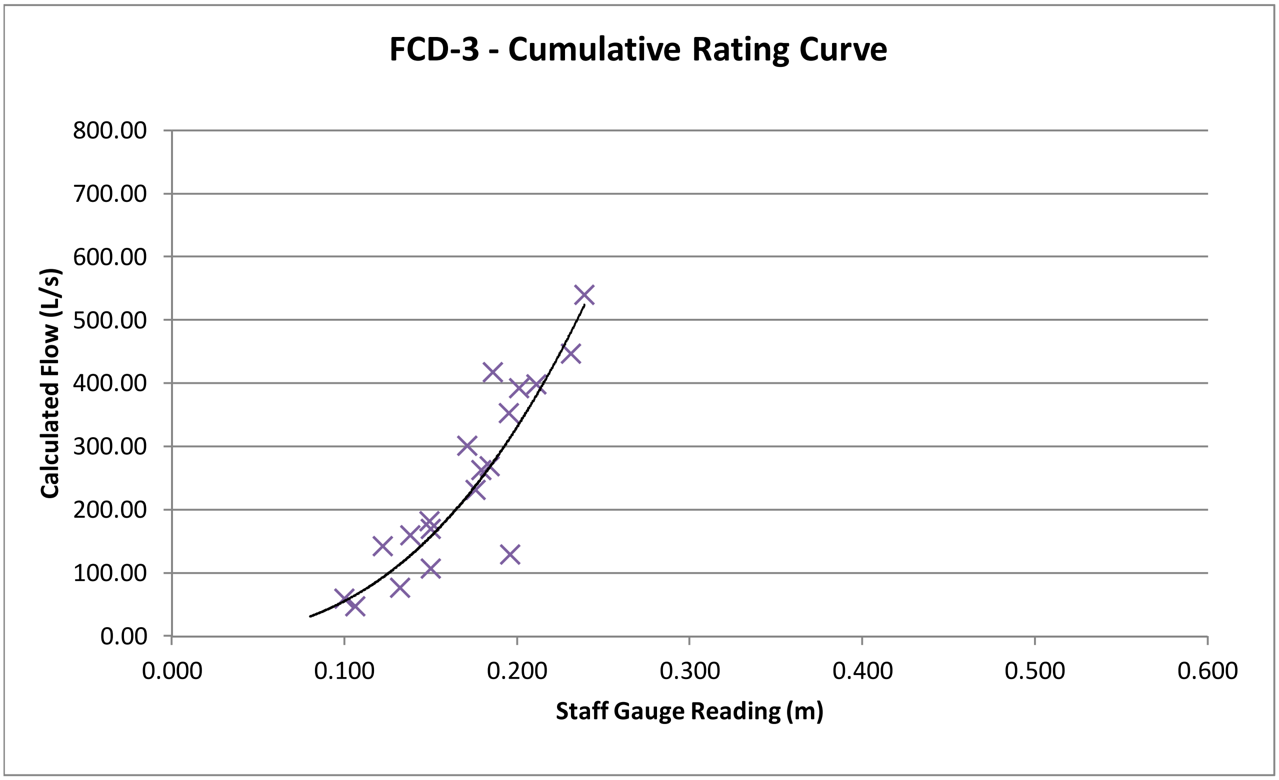
B.1 – Staff Gauge Calibration

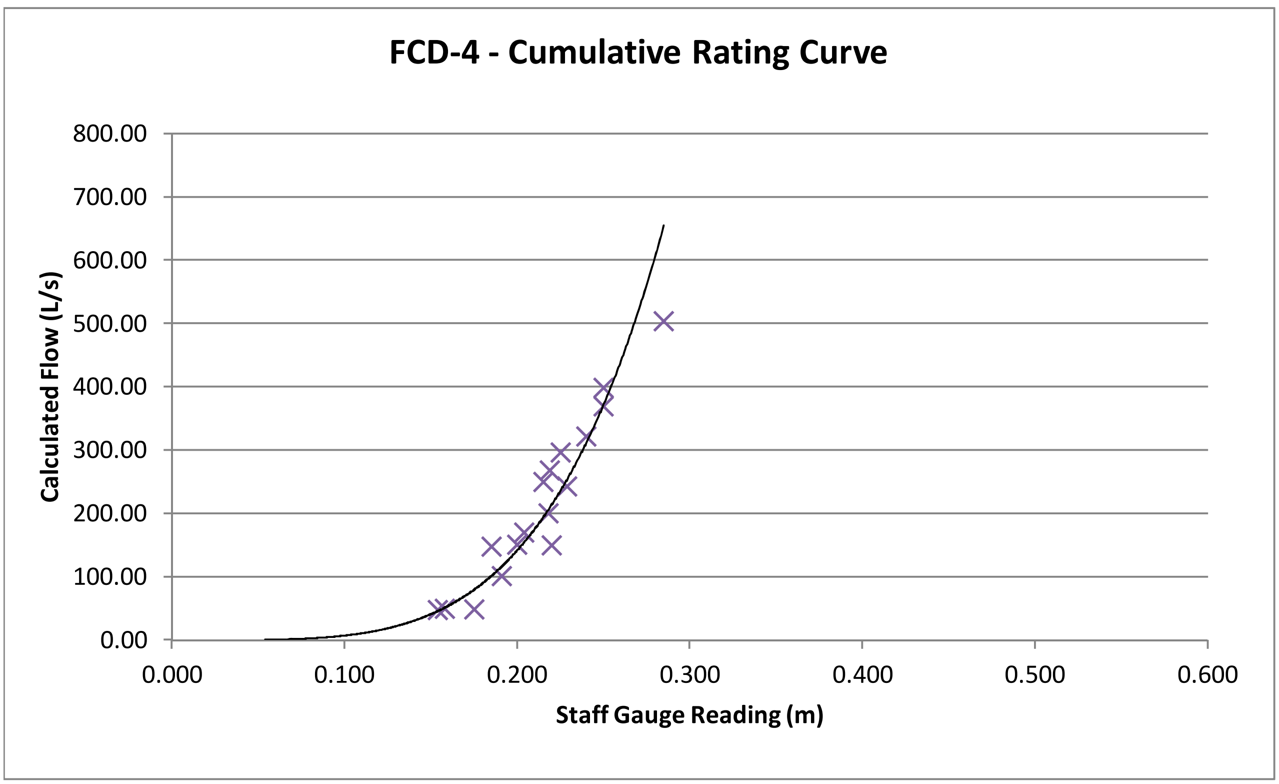
B.2 – Staff Gauge Flow

B.1 – Staff Gauge Calibration

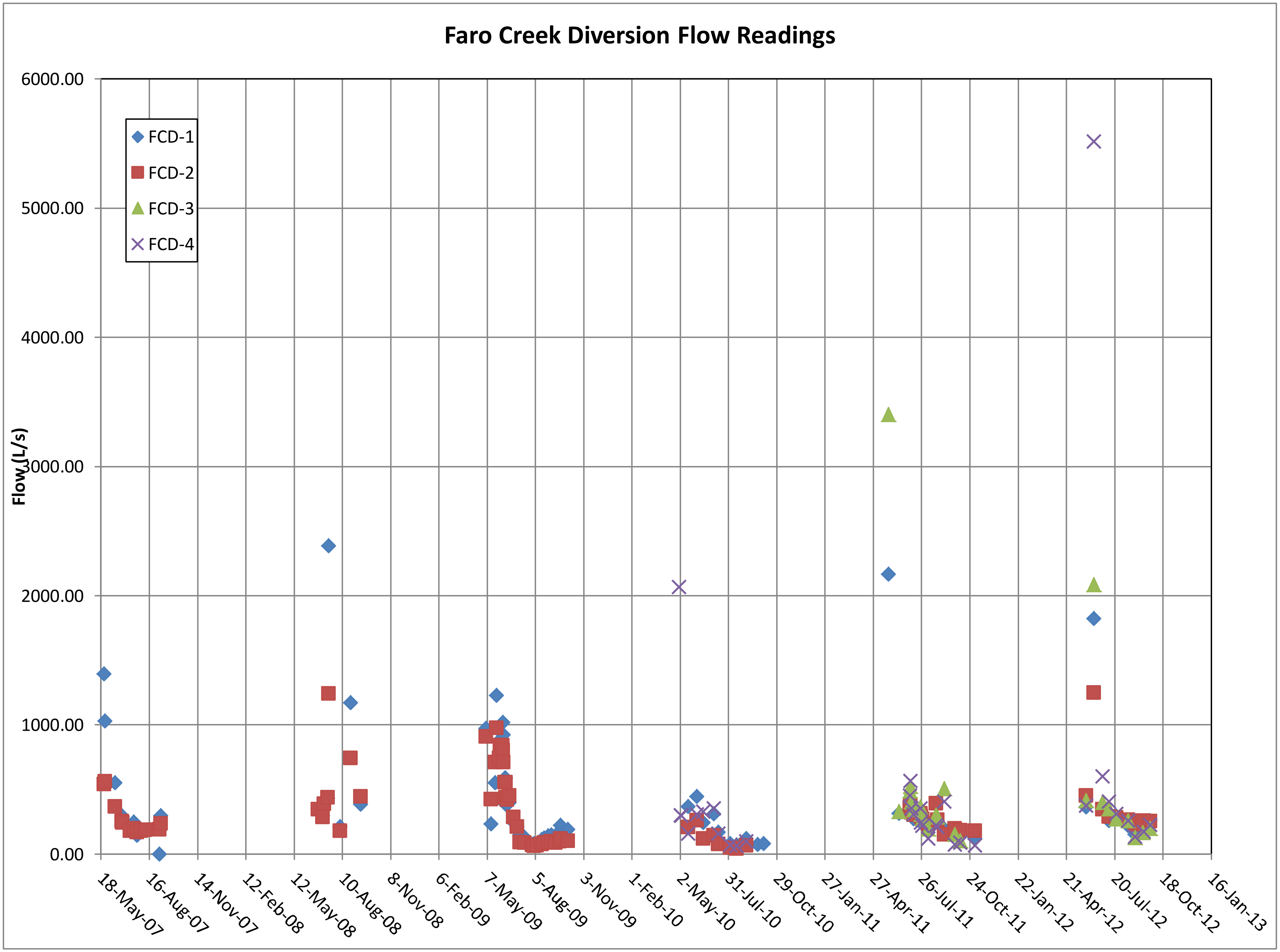

FCD-1 - Cumulative Rating Curve
Calculated Flow (L/s)
0
100
200
300
400
500
600
700
800
0.000
0.100
0.200
0.300
0.400
0.500
0.600
Staff Gauge Reading (m)


FCD-2 - Cumulative Rating Curves
Calculated Flow (L/s)
0
100
200
300
400
500
600
700
800
0.000
0.100
0.200
0.300
0.400
0.500
0.600
Staff Gauge Reading (m)


FCD-3 - Cumulative Rating Curve
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
Calculated Flow (L/s)
0.000
0.100
0.200
0.300
0.400
0.500
0.600
Staff Gauge Reading (m)


FCD-4 - Cumulative Rating Curve
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
Calculated Flow (L/s)
0.000
0.100
0.200
0.300
0.400
0.500
0.600
Staff Gauge Reading (m)

B.2 – Staff Gauge Flow



Faro Creek Diversion Flow Readings
Flow (L/s)
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
FCD-1
FCD-2
FCD-3
FCD-4
18-May-07
16-Aug-07
14-Nov-07
12-Feb-08
12-May-08
10-Aug-08
8-Nov-08
6-Feb-09
7-May-09
5-Aug-09
3-Nov-09
1-Feb-10
2-May-10
31-Jul-10
29-Oct-10
27-Jan-11
27-Apr-11
26-Jul-11
24-Oct-11
22-Jan-12
21-Apr-12
20-Jul-12
18-Oct-12
16-Jan-13

APPENDIX II-C

North Valley Wall Interceptor Ditch

C.1 – Ditch Flow

C.1 – Ditch Flow

2012 NWID
Flows

May 2012						
Site	Water Type	Date	Time	Flow (l/s)	Type of Flow	Comments
NWID	SURFACE	31-May-12	13:45	29.80	In-stream	
NWID	SURFACE	28-Jun-12	16:05	39.10	In-stream	
NWID	SURFACE	25-Jul-12	10:49	40.00	Estimation	
NWID	SURFACE	28-Aug-12	15:30	30.80	In-stream	
NWID	SURFACE	24-Sep-12	13:35	27.20	In-stream	
NWID	SURFACE	30-Oct-12	13:13	25.00	Estimation	Ice covered

APPENDIX II-D

Rose Creek Diversion Channel

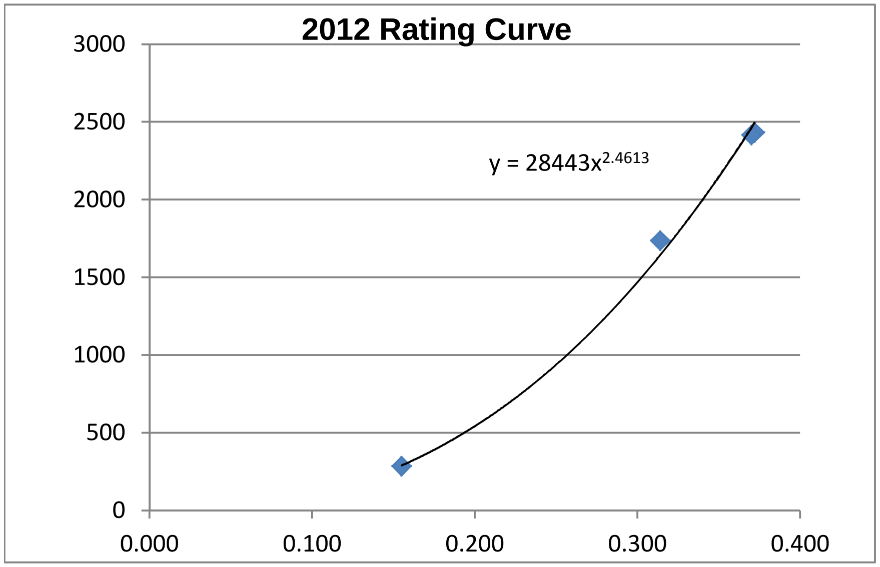
D.1 – Staff Gauge Calibration

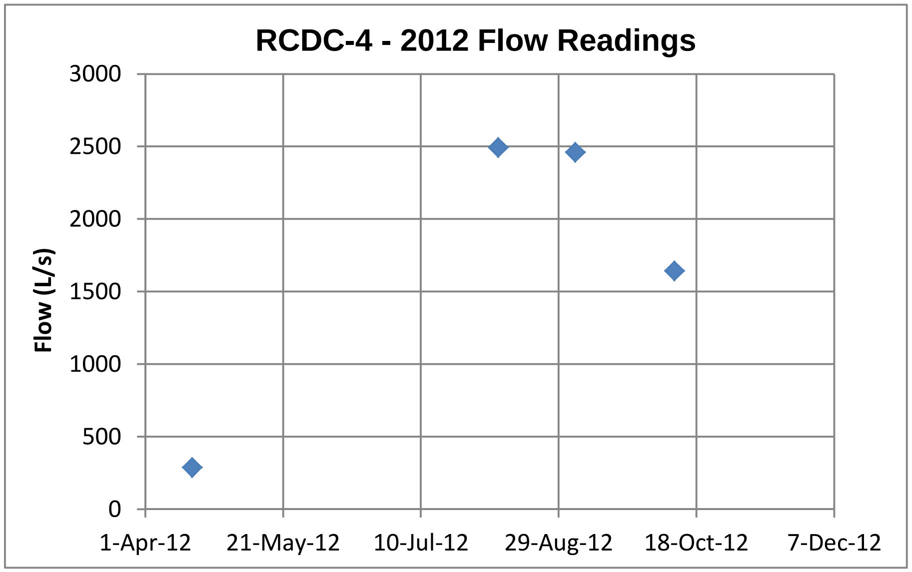
D.2 – Staff Gauge Flow or Reading

D.1 – Staff Gauge Calibration and Flow

RCDC-4 Ratings
Curve and Flow Readings

Date	Time	Staff Gauge (m)	Discharge Q L/sec	Discharge using cumulative rating curve	Error
18-Apr-12	2:17 PM	0.155	286.121	289.1603954	0.010623
7-Aug-12	12:01 PM	0.372	2431.3	2494.323275	0.025922
4-Sep-12	11:29 AM	0.370	2415.8	2461.445956	0.018895
10-Oct-12	1:03 PM	0.314	1735.7	1643.494837	-0.05312
			max	2494.323275	
			min	289.1603954	





D.2 – Staff Gauge Reading

Rose Creek Diversion
Staff Gauge Readings 2012

Date	X2SG		NFRD-23		RCSG-4		X14SG		Comments
	Time	Reading (m)	Time	Reading (m)	Time	Reading (m)	Time	Reading (m)	
5-Apr-12	3:42 PM		3:50 PM		4:00 PM	0.398	4:12 PM	0.381	X2 - Below Staff Gauge NFRD-23 - Unable to read.
9-Apr-12	4:45 PM		4:54 PM	Frozen	4:38 PM	0.338	3:48 PM	0.384	X2 - Below Staff Gauge.
10-Apr-12	2:27 PM		2:25 PM	Frozen	2:38 PM	0.327	2:57 PM	0.387	X2 - Below Staff Gauge.
11-Apr-12	3:38 PM		3:39 PM	Frozen	3:25 PM	0.318	2:56 PM	0.395	X2 - Below Staff Gauge.
12-Apr-12	2:33 PM		2:34 PM	Frozen	2:25 PM	0.313	2:13 PM	0.420	X2 - Below Staff Gauge. X5 discharge started at 11:05
13-Apr-12	3:07 PM		3:07 PM	Frozen	2:57 PM	0.305	8:59 AM	0.421	X2 - Below Staff Gauge.
14-Apr-12	8:36 AM		8:35 AM	Frozen	8:26 AM	0.271	8:11 AM	0.401	X2 -Below Staff Gauge
15-Apr-12	9:40 AM		9:40 AM	Frozen	9:31 AM	0.270	8:50 AM	0.397	X2- Below Staff Gauge X5 discharge stopped overnight
16-Apr-12							11:20 AM	0.465	Flow at X5: 18,800 LPM
16-Apr-12	5:04 PM		5:04 PM	Frozen	4:56 PM	0.202	4:15 PM	0.421	X2 = Below Staff Gauge
17-Apr-12	3:30 PM	below	3:43 PM	Frozen	10:42 AM	0.179	9:10 AM	0.429	X2 below staff gauge
18-Apr-12	11:55 AM	below	12:04 PM	Frozen	2:17 PM	0.155	10:45 AM	0.430	X2 below staff gauge
19-Apr-12	-	below	-	frozen	10:31 AM	0.168	9:23 AM	0.450	X2 below staff gauge
20-Apr-12	10:54 AM	below	10:54 AM	frozen	10:42 AM	0.160	10:10 AM	0.458	RCDC4 is hard to read, rusted
21-Apr-12	9:48 AM	below	9:48 AM	Frozen	9:39 AM	0.158	9:20 AM	0.453	RCDC4 is hard to read, rusted
22-Apr-12	10:22 AM	below	10:22 AM	frozen	10:13 AM	0.228	9:55 AM	0.466	
23-Apr-12	10:21 AM	below	10:22 AM	Frozen	10:13 AM	0.250	9:01 AM	0.458	
24-Apr-12	10:59 AM	below	11:00 AM	Frozen	10:50 AM	0.161	9:37 AM	0.461	Water was getting backed up downstream from RCDC-4 and may be the cause of the fluctuations.
25-Apr-12	9:09 AM	below	9:11 AM	Frozen	9:02 AM	0.163	8:44 AM	0.461	
26-Apr-12	9:28 AM	below	9:28AM	Frozen	9:19 AM	0.133	9:00AM	0.470	
27-Apr-12	7:11 AM	Below	7:10 AM	Frozen	7:26 AM	0.135	7:47 AM	0.465	RCSG-4 hard to read, rusted.
28-Apr-12	9:58 AM	below	10:00 AM	Frozen	9:48 AM	0.138	9:35 AM	0.462	RCSG-4 hard to read, rusted.
29-Apr-12	9:44 AM	below	9:45 AM	Frozen	9:34 AM	0.161	9:15 AM	0.473	RCSG-4 hard to read, rusted.
30-Apr-12	10:22 AM	below	10:20 AM	Frozen	10:11 AM	0.162	9:38 AM	0.499	RCSG-4 hard to read, rusted.
1-May-12	9:58 AM	below	9:59 AM	Frozen	9:50 AM	0.144	9:23 AM	0.480	RCSG-4 hard to read, rusted.
2-May-12	9:32 AM	Below	9:33 AM	Frozen	9:23 AM	0.198	8:57 AM	0.495	
3-May-12	9:14 AM	below	9:17 AM	Frozen	9:07 AM	0.225	8:21 AM	0.500	
4-May-12	8:20 AM	below	8:22 AM	Frozen	8:12 AM	0.319	7:50AM	0.488	
5-May-12	8:23 AM	below	8:23 AM	Frozen	8:12 AM	0.311	7:49 AM	0.487	
6-May-12	8:00 AM	Below	8:01 AM	Frozen	7:51 AM	0.299	7:34AM	0.49	
7-May-12	8:10 AM	below	8:10 AM	Frozen	8:04 AM	0.187	7:47 AM	0.496	RCSG-4 hard to read, rusted.
8-May-12	9:36 AM	Below	9:36 AM	0.327	9:24 AM	0.204	8:46 AM	0.500	NFRD 23- hard to read b/c it's dark
9-May-12	8:28 AM	0.004	8:29 AM	0.332	8:18 AM	0.318	7:58 AM	0.523	
10-May-12	9:50 AM	0.015	9:52 AM	0.358	9:43 AM	0.218	8:25 AM	0.521	X2 Wavy
11-May-12	6:24 AM	0.015	6:23 AM	0.358	7:28 AM	0.210	7:12 AM	0.525	X2 Wavy
12-May-12	6:19 AM	0.020	6:20 AM	0.360	7:27 AM	0.229	7:11 AM	0.545	
13-May-12	6:19 AM	0.047	6:17 AM	0.395	7:26	0.267	7:12 AM	0.582	
14-May-12	9:01 AM	0.048	9:02 AM	0.400	8:55 AM	0.258	8:41 AM	0.572	
16-May-12	8:10 AM	0.020	8:11 AM	0.360	8:53 AM	0.227		0.556	
17-May-12	8:45 AM	0.035	8:44 AM	0.389	8:37 AM	0.346	8:24 AM	0.554	
18-May-12	9:31 AM	0.039	9:31 AM	0.399	9:22 AM	0.262	9:03 AM	0.559	
19-May-12	9:13 AM	0.040	9:13 AM	0.402	9:01 AM	0.271	8:41 AM	0.578	NFRD 23- hard to read
20-May-12	9:03 AM	0.047	9:03 AM	0.458	8:52 AM	0.298	8:34 AM	0.599	
21-May-12	8:44 AM	0.110	8:44 AM	0.500	8:34 AM	0.332	8:20 AM	0.652	NFRD 23- water level was on the part which is "torn" off ergo, an estimation
22-May-12	10:24 AM	0.198	10:26 AM	0.640	10:37 AM	0.422	7:45 AM	0.739	
23-May-12	8:43 AM	0.310	8:43 AM	0.849	8:34 AM	0.599	8:18 AM	0.912	
24-May-12	9:07 AM	0.400	9:07 AM	1.045	8:56 AM	0.688	7:52 AM	1.101	
25-May-12	6:25 AM	0.480	6:25 AM	0.980	7:34 AM	0.772	7:21 AM	1.220	
26-May-12	8:50 AM	0.432	8:49 AM	1.065	8:40 AM	0.718	8:28 AM	1.152	
27-May-12	7:10 AM	0.428	7:11 AM	1.048	8:30 AM	0.792	8:14 AM	1.244	X2 Wavy
28-May-12	9:40 AM	0.424	9:40 AM	1.035	9:45 AM	0.752	8:01 AM	1.200	
29-May-12	9:15 AM	0.420	9:15 AM	1.250	9:08 AM	0.735	8:29 AM	1.168	NFRD23 likely error in reading: probably 1.025
30-May-12	4:35 PM	0.380	4:36 PM	1.030	4:42 PM	0.741	7:50 AM	1.200	
31-May-12	11:56 AM	0.402	11:58 AM	1.034	11:48 AM	0.732	10:57 AM	1.159	
1-Jun-12	7:07 AM	0.365	7:06 AM	1.079	8:21 AM	0.670	8:10 AM	1.078	

Rose Creek Diversion
Staff Gauge Readings 2012

Date	X2SG		NFRD-23		RCSG-4		X14SG		Comments
	Time	Reading (m)	Time	Reading (m)	Time	Reading (m)	Time	Reading (m)	
2-Jun-12	9:13 AM	0.370	9:15 AM	0.940	9:03 AM	0.660	8:47 AM	1.050	X2 and NFRD23 wavy
3-Jun-12	7:45 AM	0.380	7:44 AM	0.970	8:55 AM	0.680	9:04 AM	1.072	
4-Jun-12	8:28 AM	0.490	8:29 AM	1.125	8:19 AM	0.805	7:56 AM	1.229	RCDC-4/NFRD-23/X2SG- WAVY
5-Jun-12	9:12 AM	0.520	9:11 AM	1.355	9:04 AM	0.935	8:03 AM	1.436	RCDC-4/NFRD-23/X2SG- WAVY
6-Jun-12	2:52 PM	0.580	3:54 PM	1.450	3:08 PM	>1.000	8:10 AM	1.490	RCDC-4/NFRD-23/X2SG- WAVY
7-Jun-12	10:19 AM	0.680	10:22 AM	1.735	10:11 AM	>1..000	8:10 AM	1.820	RCDC-4/NFRD-23/X2SG- WAVY
8-Jun-12	6:10 AM	0.720	6:08 AM	NO READ	6:50 AM	NO READ	7:15 AM	NO READ	NFRD-23 RCDC-4 X14SG GAUGES UNDERWATER PHOTOS TAKEN
9-Jun-12	6:22 AM	0.790	6:20 AM	NO READ	7:15 AM	NO READ	7:35 AM	NO READ	NFRD-23 RCDC-4 X14SG GAUGES UNDERWATER PHOTOS TAKEN
10-Jun-12	6:58 AM	0.640	7:08 AM	1.550	3:36 AM	>1.000	7:30 AM	1.625	
11-Jun-12	11:31 AM	0.610	11:30 AM	1.440	11:27 AM	>1.000	9:18 AM	1.552	
12-Jun-12	10:19 AM	0.625	10:20 AM	1.510	10:48 AM	>1.000	8:32 AM	1.579	
13-Jun-12	8:26 AM	0.540	8:25 AM	1.230	8:39 AM	0.860	9:02 AM	1.335	
14-Jun-12	9:20 AM	0.565	9:21 AM	1.396	9:09 AM	0.925	8:22 AM	1.389	
15-Jun-12	9:28 AM	0.531	9:28 AM	1.268	9:15 AM	0.855	9:05 AM	0.855	X2/NFRD-23- Wavy
16-Jun-12	9:10 AM	0.460	9:10 AM	1.098	8:59 AM	0.753	8:38 AM	1.198	X2/NFRD-23- Wavy
17-Jun-12	9:19 AM	0.465	9:19 AM	1.099	9:10 AM	0.763	8:52 AM	1.200	X2/NFRD-23- Very Wavy
18-Jun-12	12:05 PM	0.450	12:05 PM	1.046	11:55 AM	0.740	8:20 AM	1.169	NFRD-23- Wavy
19-Jun-12	12:56 PM	0.449	12:55 PM	0.940	1:06 PM	0.739	8:11 AM	1.168	
20-Jun-12	1:08 PM	0.418	1:09 PM	1.032	1:55 PM	0.724	7:59 AM	1.148	NFRD 23- Wavy
21-Jun-12	11:00 AM	0.430	10:58 AM	0.942	11:11 AM	0.728	11:55 AM	1.500	
22-Jun-12	6:23 AM	0.425	6:21 AM	1.010	7:30 AM	0.719	7:15 AM	1.137	
23-Jun-12	6:22 AM	0.410	6:20 AM	0.997	7:24 AM	0.705	7:06 AM	1.115	
24-Jun-12	6:28 AM	0.405	6:27 AM	0.965	7:28 AM	0.682	7:14 AM	0.987	
25-Jun-12	10:25 AM	0.400	10:26 AM	0.940	10:49 AM	0.650	8:04 AM	1.059	
26-Jun-12	10:41 AM	0.393	10:40 AM	0.890	10:48 AM	0.620	8:52 AM	1.011	
27-Jun-12	8:24 AM	0.470	8:25 AM	0.851	8:16 AM	0.591	8:04 AM	0.976	
28-Jun-12	8:26 AM	0.360	8:27 AM	0.850	9:20 AM	0.590	8:27 AM	0.979	
29-Jun-12	7:45 AM	0.345	7:46 AM	0.802	8:09 AM	0.549	7:55 AM	0.919	
30-Jun-12	8:13 AM	0.361	8:14 AM	0.838	7:57 AM	0.588	7:44 AM	0.961	
1-Jul-12	7:36 AM	0.352	7:37 AM	0.811	7:47 AM	0.555	8:04 AM	0.935	
2-Jul-12	9:41 AM	0.451	9:42 AM	1.003	9:26 AM	0.800	9:06 AM	1.260	
3-Jul-12	3:54 PM	0.443	3:55 PM	1.055	4:04 PM	0.765	7:58 AM	1.310	
4-Jul-12	10:19 AM	0.420	10:21 AM	0.930	10:50 AM	0.745	7:39 AM	1.210	
5-Jul-12	8:18 AM	0.400	8:22 AM	0.950	8:10 AM	0.688	8:00 AM	1.109	
6-Jul-12	6:23 AM	0.360	6:25 AM	0.875	7:19 AM	0.630	7:35 AM	1.040	
7-Jul-12	6:09 AM	0.350	6:07 AM	0.835	6:42 AM	0.598	6:57 AM	0.990	
8-Jul-12	6:13 AM	0.340	6:11 AM	0.820	6:50 AM	0.595	7:07 AM	0.985	
9-Jul-12	9:44 AM	0.345	9:45 AM	0.800	11:43 AM	0.578	7:44 AM	0.962	
10-Jul-12	9:19 AM	0.436	9:19 AM	0.810	9:10 AM	0.590	8:09 AM	0.970	
11-Jul-12	3:55 PM	0.420	3:57 PM	0.840	4:03 PM	0.752	8:06 AM	1.228	
12-Jul-12	12:55 PM	0.440	12:59 PM	1.075	1:15 PM	0.770	8:11 AM	1.268	
13-Jul-12	6:22 AM	0.450	6:21 AM	1.115	7:16 AM	0.783	7:05 AM	1.251	
14-Jul-12	6:22 AM	0.410	6:19 AM	0.995	7:29 AM	0.697	7:19 AM	1.128	
15-Jul-12	6:20 AM	0.405	6:18 AM	0.990	7:17 AM	0.699	7:04 AM	1.124	
16-Jul-12	2:38 PM	0.382	2:38 PM	0.909	2:27 PM	0.649	8:18 AM	1.060	
17-Jul-12	9:59 AM	0.386	10:00 AM	0.925	9:51 AM	0.661	8:10 AM	1.079	
18-Jul-12	8:43 AM	0.402	8:44 AM	0.985	8:25 AM	0.700	8:13 AM	1.129	
19-Jul-12	8:22 AM	0.378	8:23 AM	0.925	8:16 AM	0.665	8:00 AM	1.071	
20-Jul-12	7:10 AM	0.353	7:09 AM	0.867	8:48 AM	0.625	8:37 AM	1.010	
21-Jul-12	7:11 AM	0.344	7:10 AM	0.881	8:03 AM	0.588	7:52 AM	0.983	
22-Jul-12	7:18 AM	0.344	7:17 AM	0.882	8:11 AM	0.553	7:59 AM	0.940	
23-Jul-12	9:37 AM	0.310	9:38 AM	0.751	2:11 PM	0.532	7:43 AM	0.914	
24-Jul-12	11:13 AM	0.315	11:12 AM	0.730	8:35 AM	0.527	8:04 AM	0.898	
25-Jul-12	11:20 AM	0.302	11:21 AM	0.720	11:29 AM	0.501	7:50 AM	0.890	
26-Jul-12	10:14 AM	0.305	10:17 AM	0.712	10:05 AM	0.498	8:10 AM	0.870	
27-Jul-12	7:42 AM	0.285	7:43 AM	0.692	7:34 AM	0.476	7:21 AM	0.850	
28-Jul-12	7:43 AM	0.283	7:45 AM	0.678	7:39 AM	0.475	7:25 AM	0.851	
29-Jul-12	7:19 AM	0.280	7:19 AM	0.673	7:10 AM	0.470	6:51 AM	0.841	
30-Jul-12	1:04 PM	0.260	1:07 PM	0.650	1:25 PM	0.450	7:47 AM	0.816	

Rose Creek Diversion
Staff Gauge Readings 2012

Date	X2SG		NFRD-23		RCSG-4		X14SG		Comments
	Time	Reading (m)	Time	Reading (m)	Time	Reading (m)	Time	Reading (m)	
31-Jul-12	2:10 PM	0.255	2:12 PM	0.630	2:19 PM	0.430	7:57 AM	0.798	
1-Aug-12	11:15 AM	0.250	11:15 AM	0.610	11:05 AM	0.419	8:04 AM	0.880	
2-Aug-12	9:12 AM	0.245	9:11 AM	0.609	9:00 AM	0.405	8:00 AM	0.770	
3-Aug-12	6:42 AM	0.240	6:44 AM	0.605	6:52 AM	0.402	7:05 AM	0.765	
4-Aug-12	5:58 AM	0.240	5:56 AM	0.600	6:32 AM	0.402	6:45 AM	0.765	
5-Aug-12	5:39 AM	0.235	5:37 AM	0.590	6:11 AM	0.390	6:24 AM	0.750	
6-Aug-12	1:21 PM	0.235	1:23 PM	0.580	1:35 PM	0.385	8:00 AM	0.748	
7-Aug-12	2:24 PM	0.210	2:25 PM	0.568	12:01 PM	0.372	2:19 PM	0.832	
8-Aug-12	12:00 AM	0.215	2:39 AM	0.559	2:44 AM	0.370	7:36 AM	0.730	
9-Aug-12							7:42 AM	0.749	
10-Aug-12	7:08 AM	0.338	7:09 AM	0.796	8:11 AM	0.572	8:01 AM	0.950	
11-Aug-12	7:20 AM	0.296	7:21 AM	0.696	8:26 AM	0.479	8:17 AM	0.855	
12-Aug-12	8:32 AM	0.245	8:33 AM	0.619	8:24 AM	0.430	8:14 AM	0.793	
13-Aug-12	1:10 PM	0.250	1:08 PM	0.625	1:26 PM	0.441	7:53 AM	0.818	
14-Aug-12					4:32 PM	0.400	8:22 AM	0.799	
15-Aug-12	8:34 AM	0.290	8:33 AM	0.590	8:25 AM	0.392	8:14 AM	0.775	
16-Aug-12					9:06 AM	0.380	7:51 AM	0.746	
17-Aug-12					7:20 AM	0.376	7:08 AM	0.735	
18-Aug-12					7:22 AM	0.380	7:09 AM	0.741	
19-Aug-12					7:08 AM	0.444	6:55 AM	0.823	
20-Aug-12					7:00 AM	0.405	6:48 AM	0.774	
21-Aug-12	1:48 PM	0.205	1:46 PM	0.656	2:19 PM	0.385	8:20 AM	0.755	
22-Aug-12					8:18 AM	0.376	8:02 AM	0.746	
23-Aug-12					7:40 AM	0.387	7:58 AM	0.750	
24-Aug-12					6:50 AM	0.395	7:04 AM	0.760	
25-Aug-12					6:36 AM	0.380	6:50 AM	0.745	
26-Aug-12					6:39 AM	0.388	6:53 AM	0.748	
27-Aug-12	8:06 AM	0.231	8:09 AM	0.559	7:59 AM	0.377	7:46 AM	0.739	
28-Aug-12					9:06 AM	0.411	8:12 AM	0.765	
29-Aug-12					8:05 AM	0.452	7:46 AM	0.818	
30-Aug-12					11:50 AM	0.405	8:00 AM	0.770	
31-Aug-12					9:15 AM	0.392	9:02 AM	0.754	
1-Sep-12					8:51 AM	0.384	8:38 AM	0.743	
2-Sep-12					8:48 AM	0.375	8:36 AM	0.736	
3-Sep-12					8:44 AM	0.375	8:32 AM	0.732	
4-Sep-12	11:34 AM	0.205	11:36 AM	0.550	11:29 AM	0.370	8:02 AM	0.722	
5-Sep-12					8:15 AM	0.379	8:00 AM	0.738	
6-Sep-12							7:31 AM	0.728	
7-Sep-12					7:24 AM	0.357	7:13 AM	0.686	
8-Sep-12					7:33 AM	0.365	7:23 AM	0.698	
9-Sep-12					8:05 AM	0.407	7:32 AM	0.742	
10-Sep-12	11:40 AM	0.285	11:42 AM	0.700	11:56 AM	0.488	7:57 AM	0.859	
11-Sep-12					8:20 AM	0.431	8:48 AM	0.794	
12-Sep-12					10:11 AM	0.398	7:45 AM	0.770	
13-Sep-12					12:11 PM	0.449	9:33 AM	0.818	
14-Sep-12					7:25 AM	0.506	7:14 AM	0.889	
15-Sep-12					7:11 AM	0.463	7:00 AM	0.845	
16-Sep-12					7:21 AM	0.431	7:10 AM	0.815	
17-Sep-12	11:13 AM	0.245	11:15 AM	0.630	11:32 AM	0.430	8:25 AM	0.808	
18-Sep-12					12:18 PM	0.416	7:52 AM	0.793	
19-Sep-12							8:10 AM	0.782	
20-Sep-12					8:33 AM	0.415	7:53 AM	0.774	
21-Sep-12					6:57 AM	0.406	7:08 AM	0.770	
22-Sep-12					6:44	0.405	6:55 AM	0.770	
23-Sep-12					6:30 AM	0.402	6:41 AM	0.770	
24-Sep-12	8:44 AM	0.202	8:45 AM	0.599	8:36 AM	0.408	7:35 AM	0.753	
25-Sep-12					8:38 AM	0.401	8:13 AM	0.749	
26-Sep-12					8:57 AM	0.407	8:34 AM	0.747	
27-Sep-12					8:08 AM	0.402	7:51 AM	0.748	

APPENDIX II-E

Canal Dyke

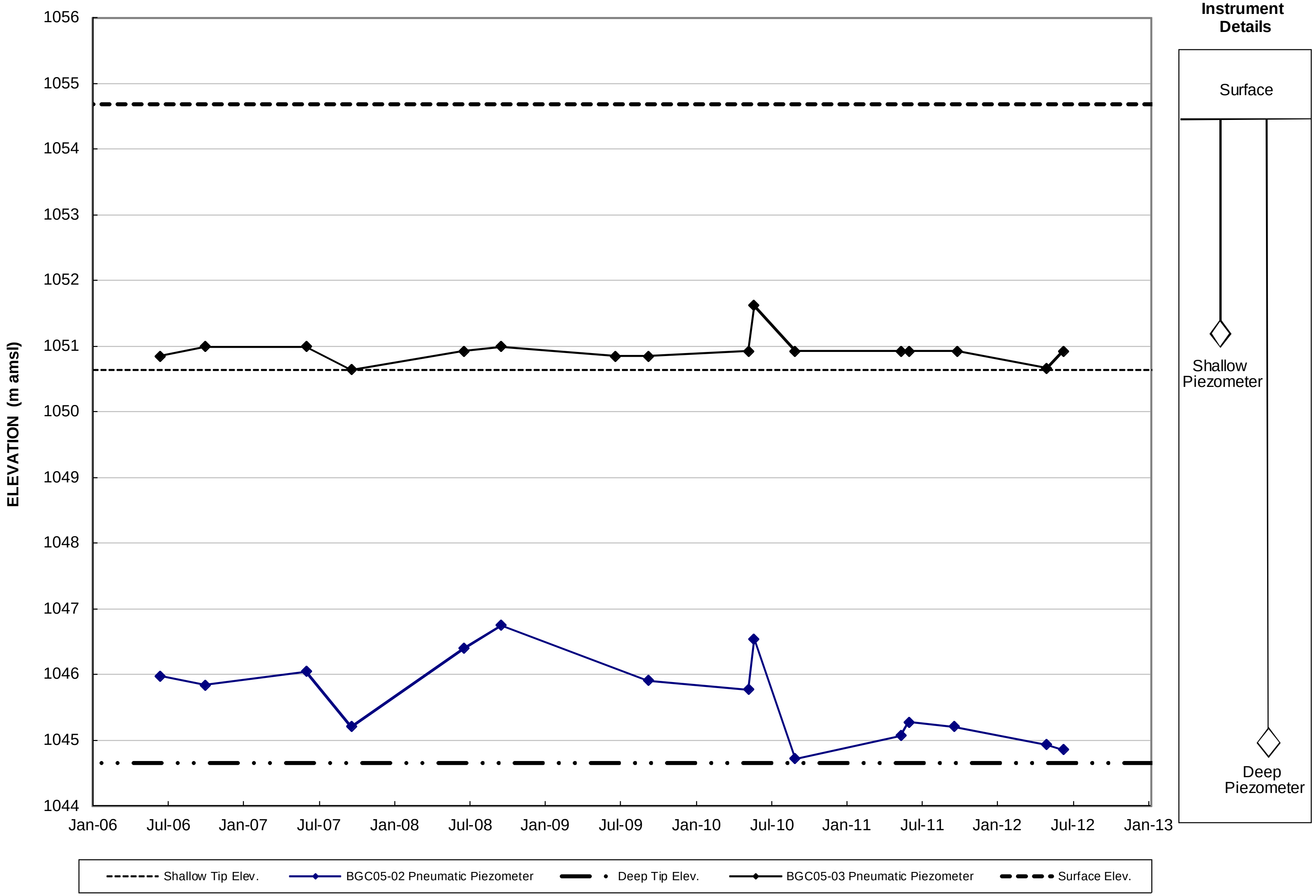
E.1 – Piezometers

E.2 – Thermistors

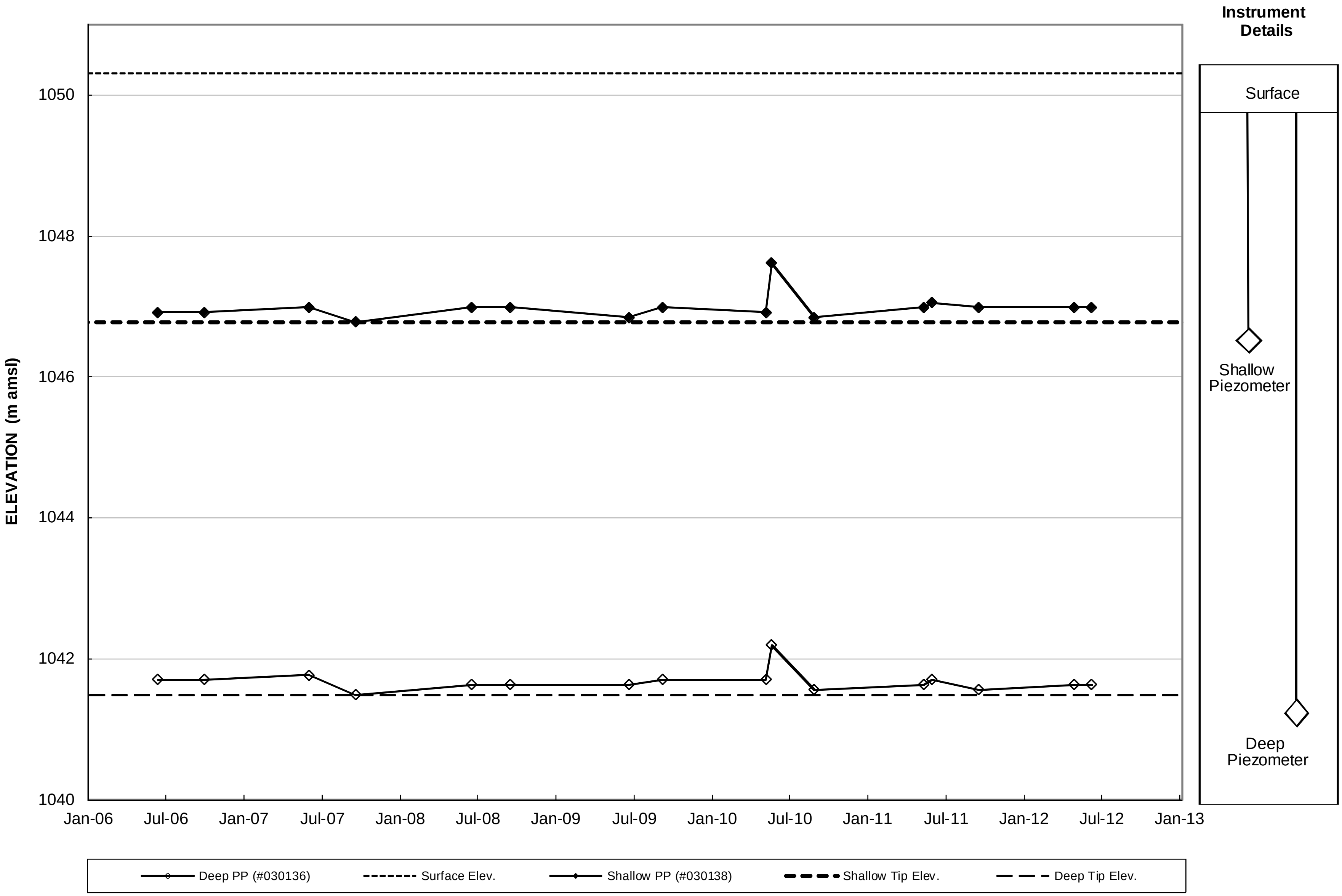
E.3 – Inclinometers

E.1 – Piezometers

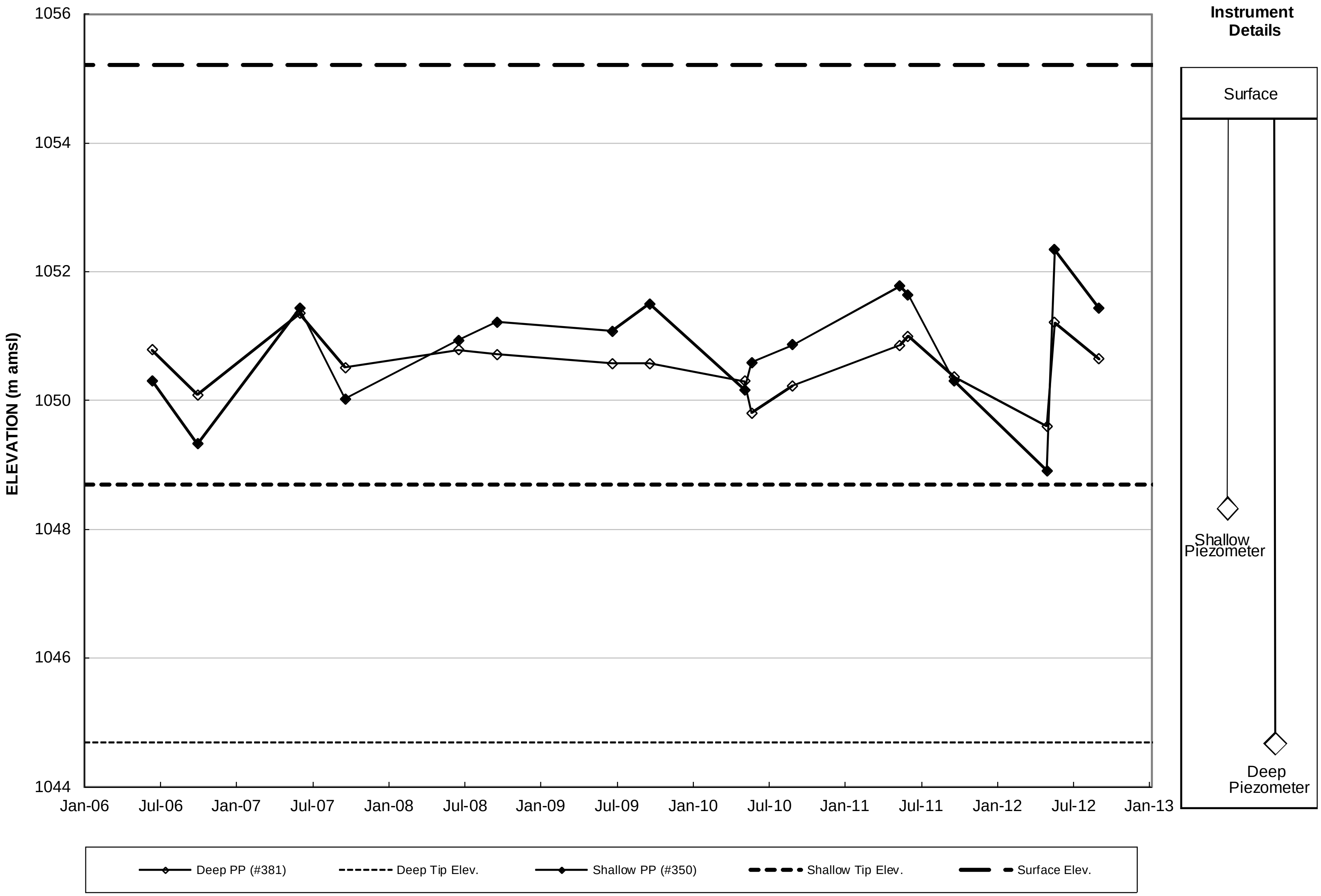
Diversion Canal (Canal Dyke) - Piezometers
BGC05- 02 03



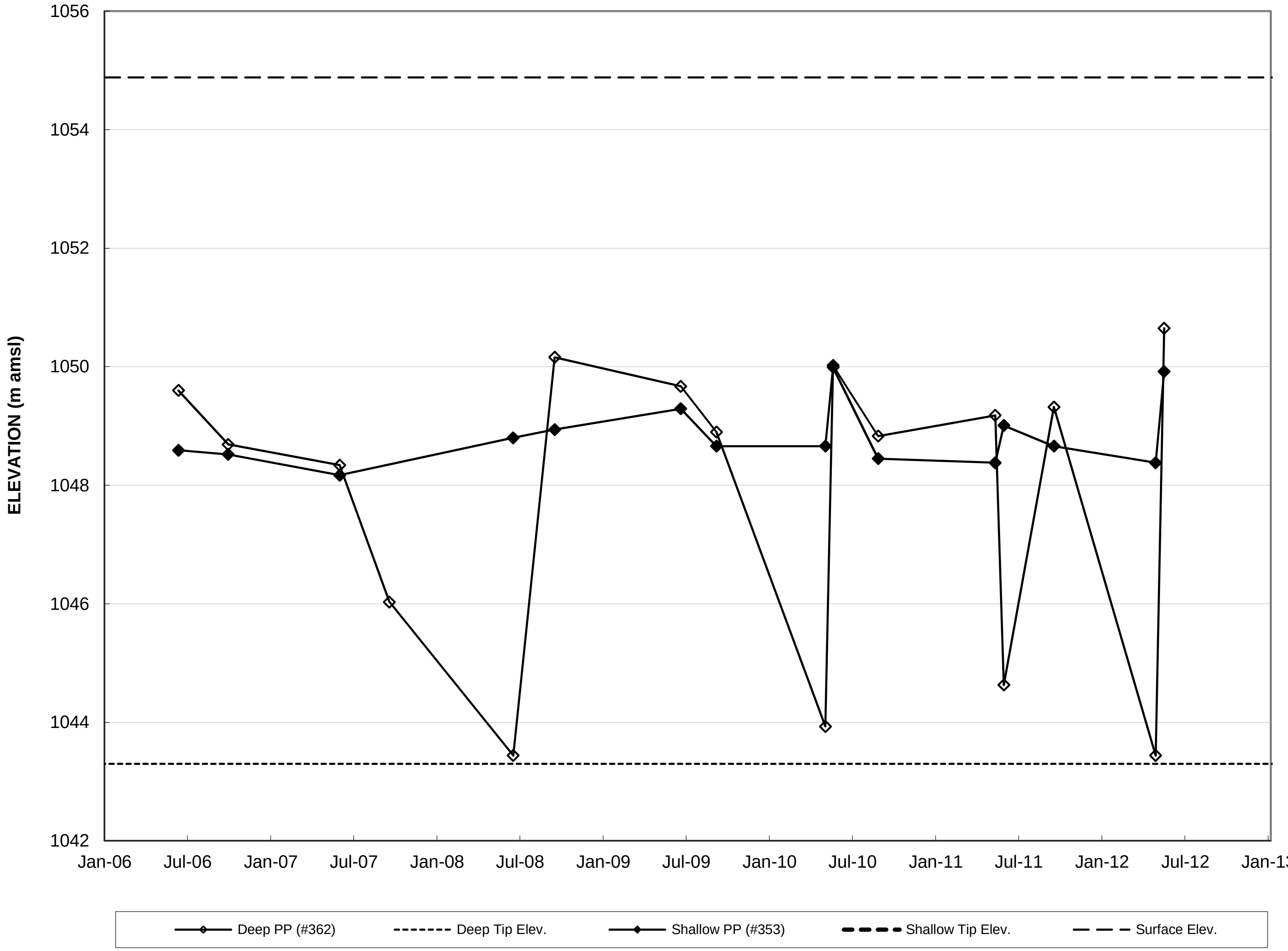
Diversion Canal (Canal Dyke) - Piezometers
BGC05-06 (Both Tips)



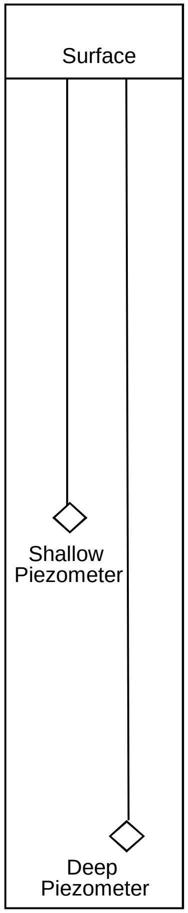
Diversion Canal (Canal Dyke) - Piezometer
CD-13 (Both Tips)



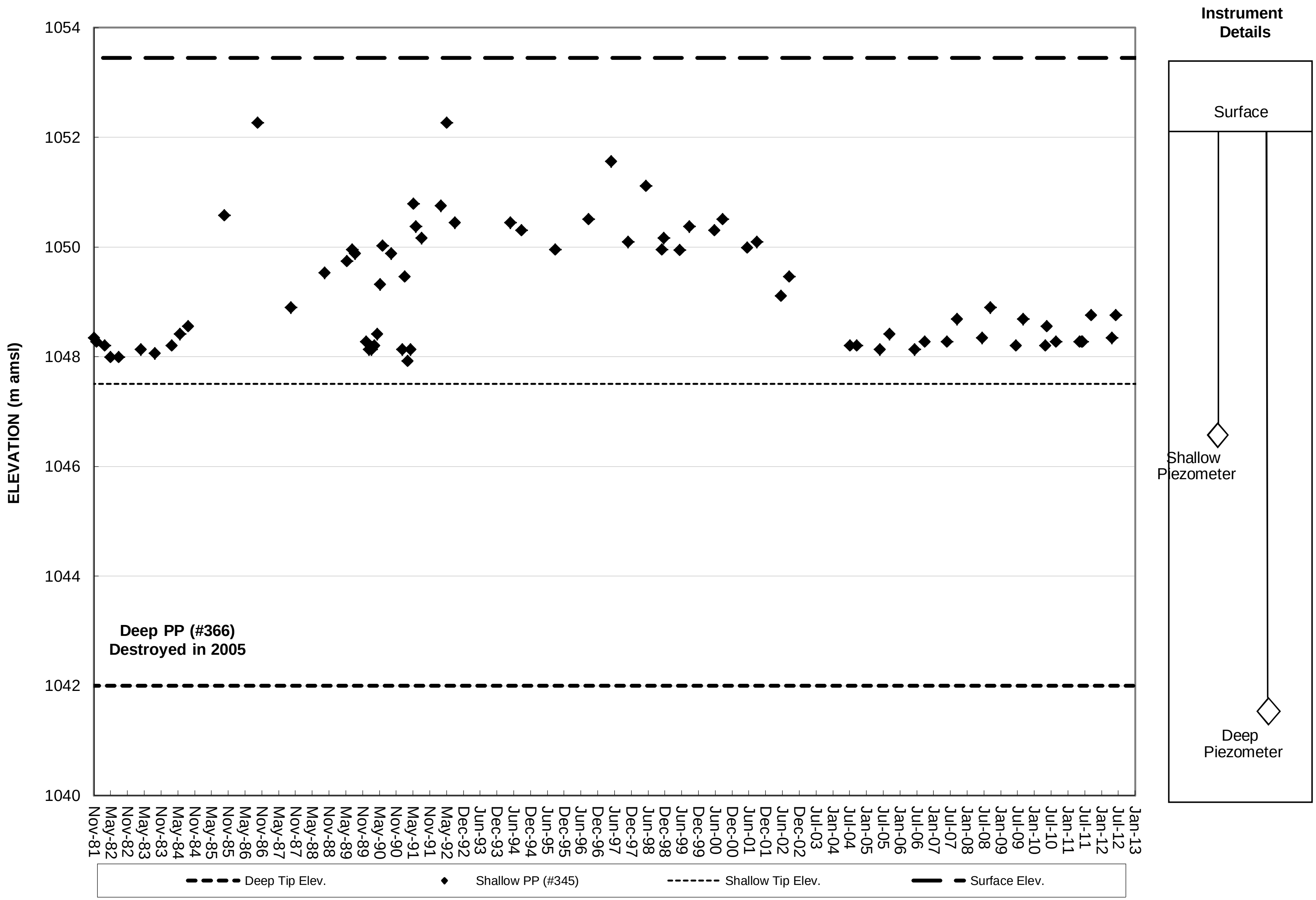
Diversion Canal (Canal Dyke) - Piezometers
CD-15 (Both Tips)



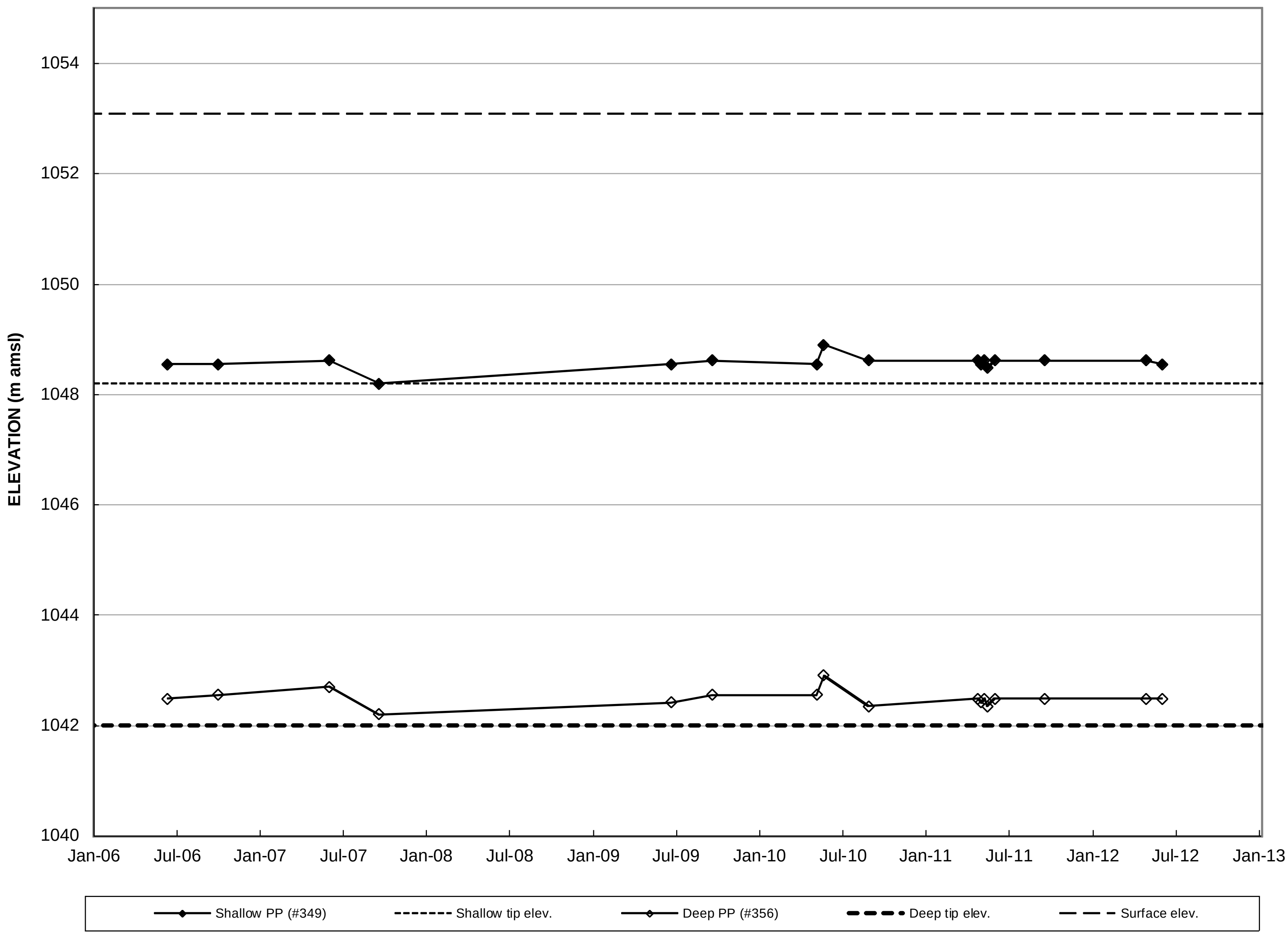
Instrument Details

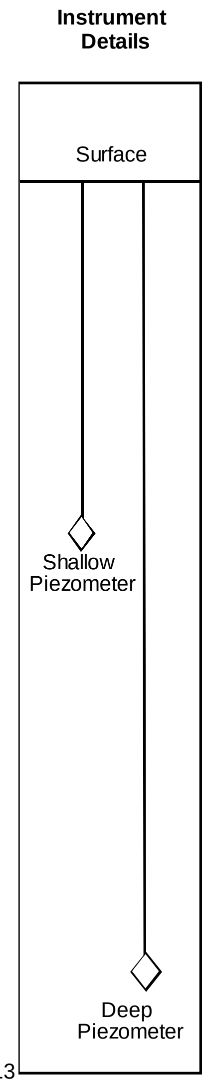


Diversion Canal (Canal Dyke) - Piezometers
CD-21 (Both Tips)



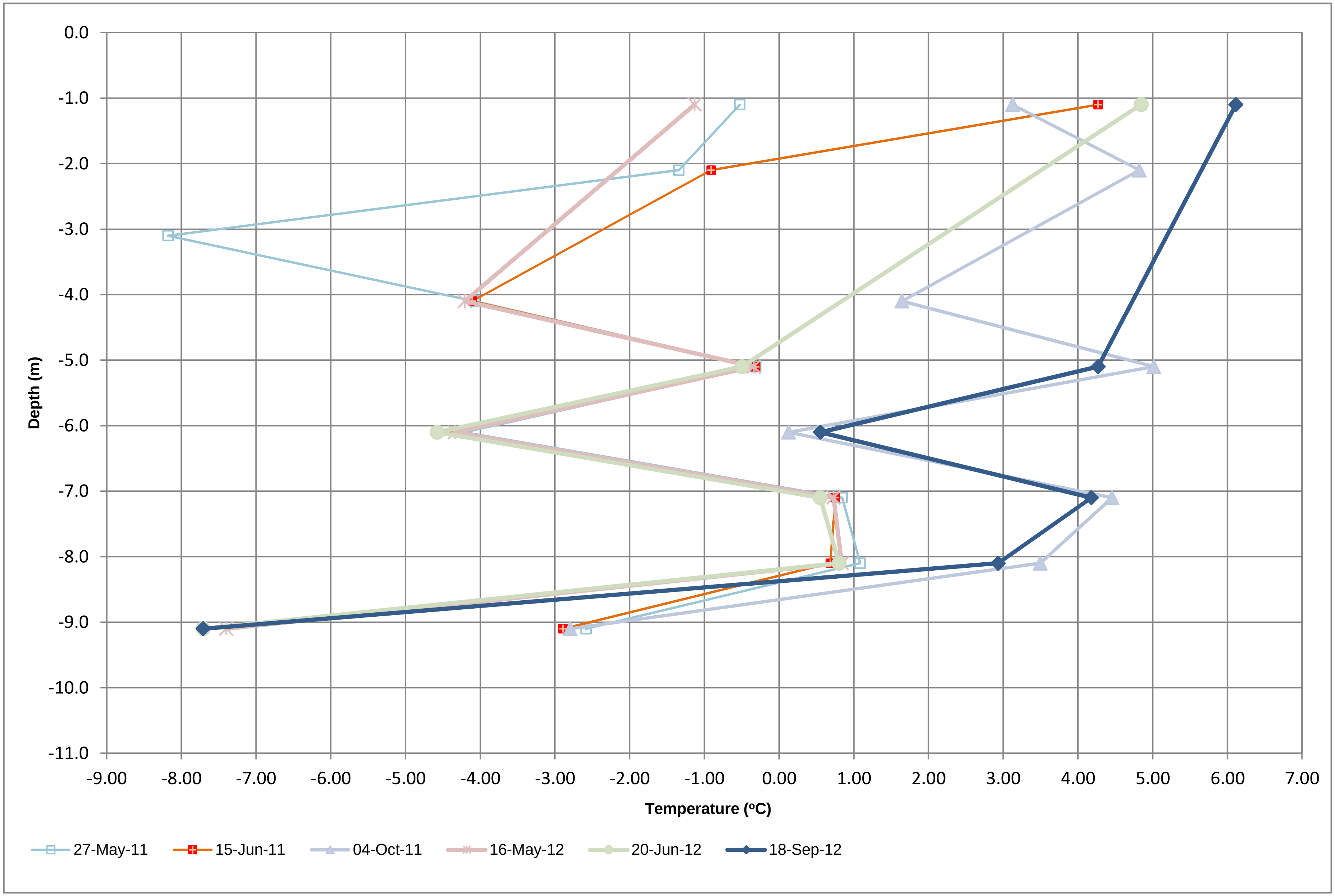
Diversion Canal (Canal Dyke) - Piezometers
CD-26 (Both Tips)



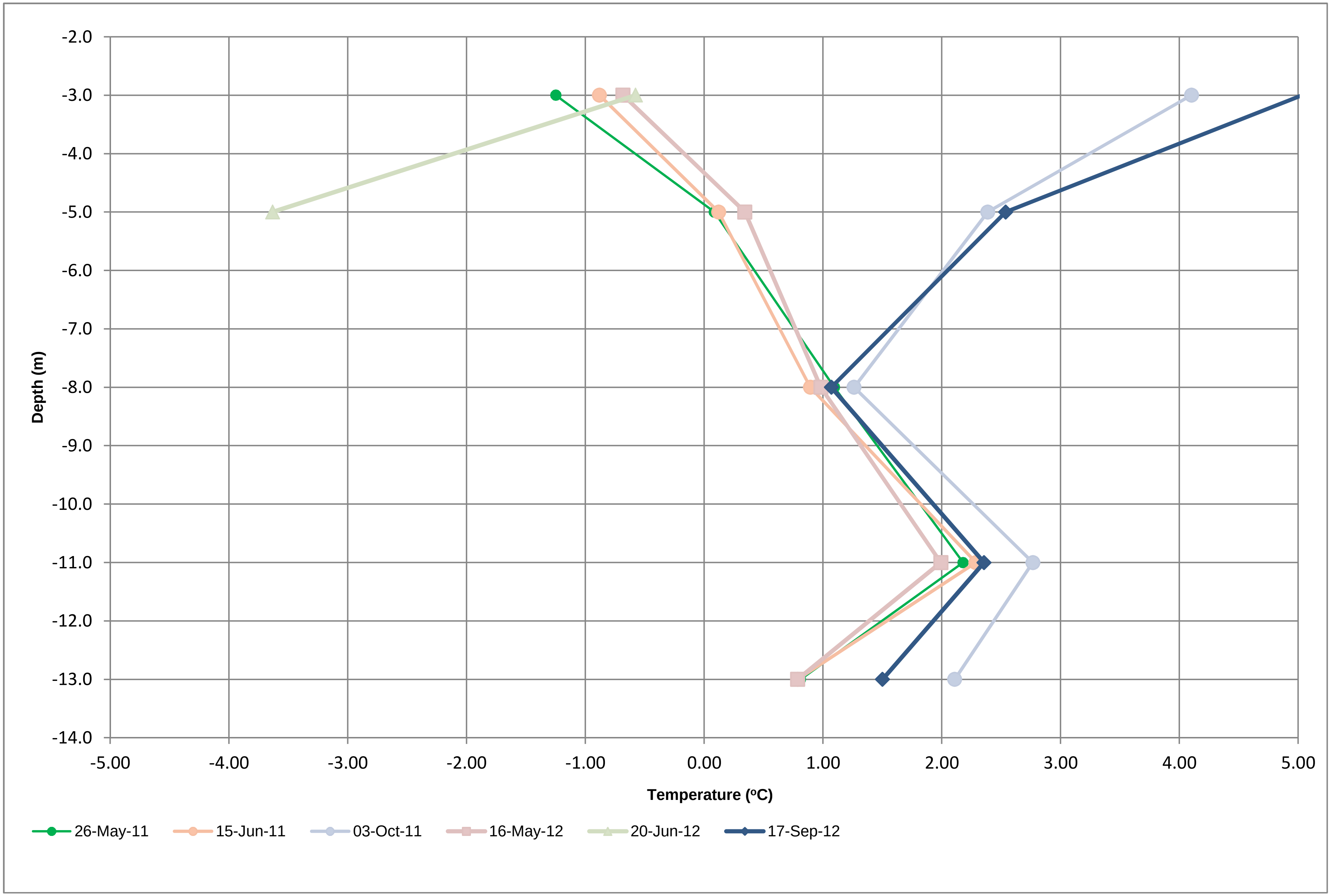


E.2 - Thermistors

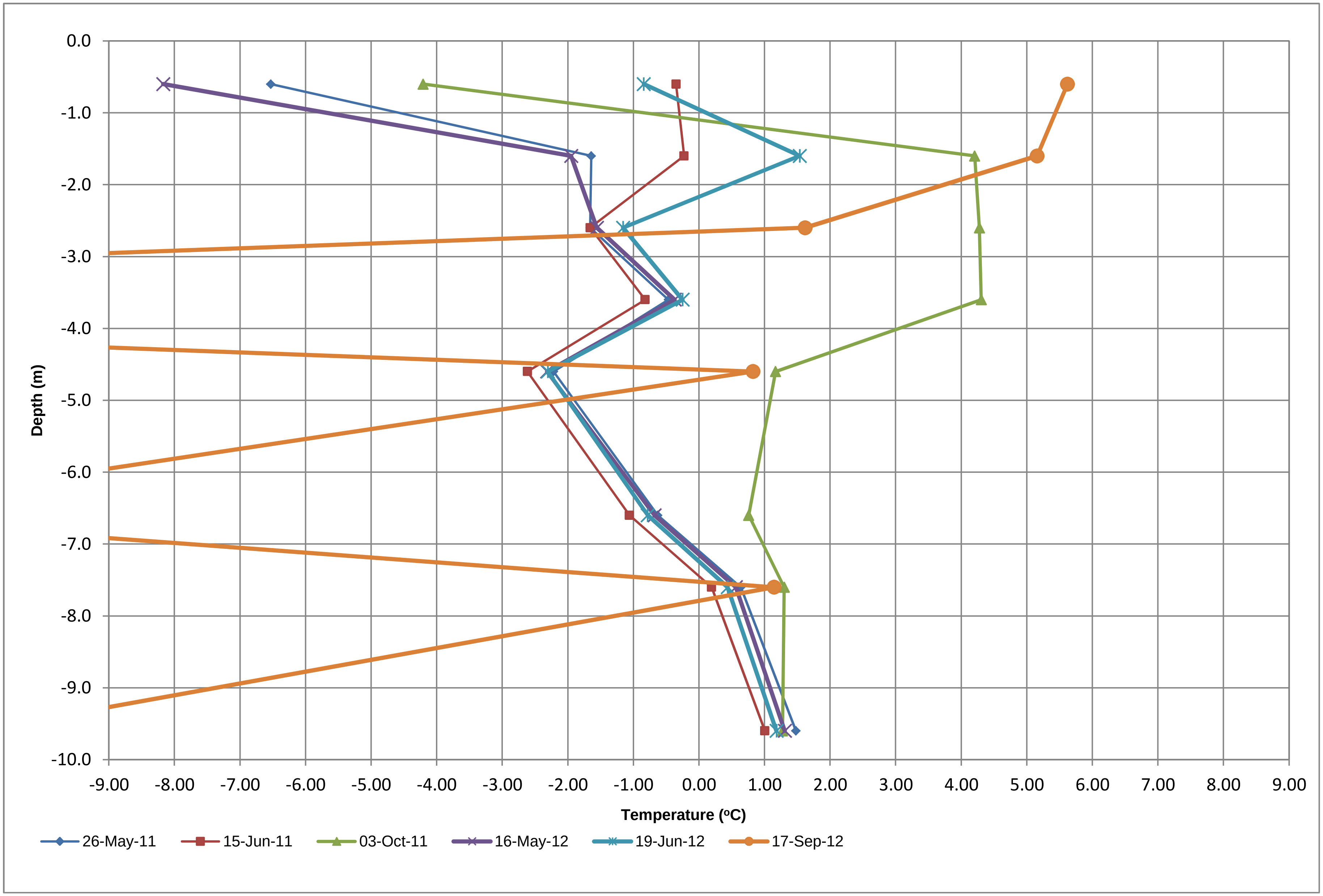
Diversion Canal (Canal Dyke)
Thermistor CD-15



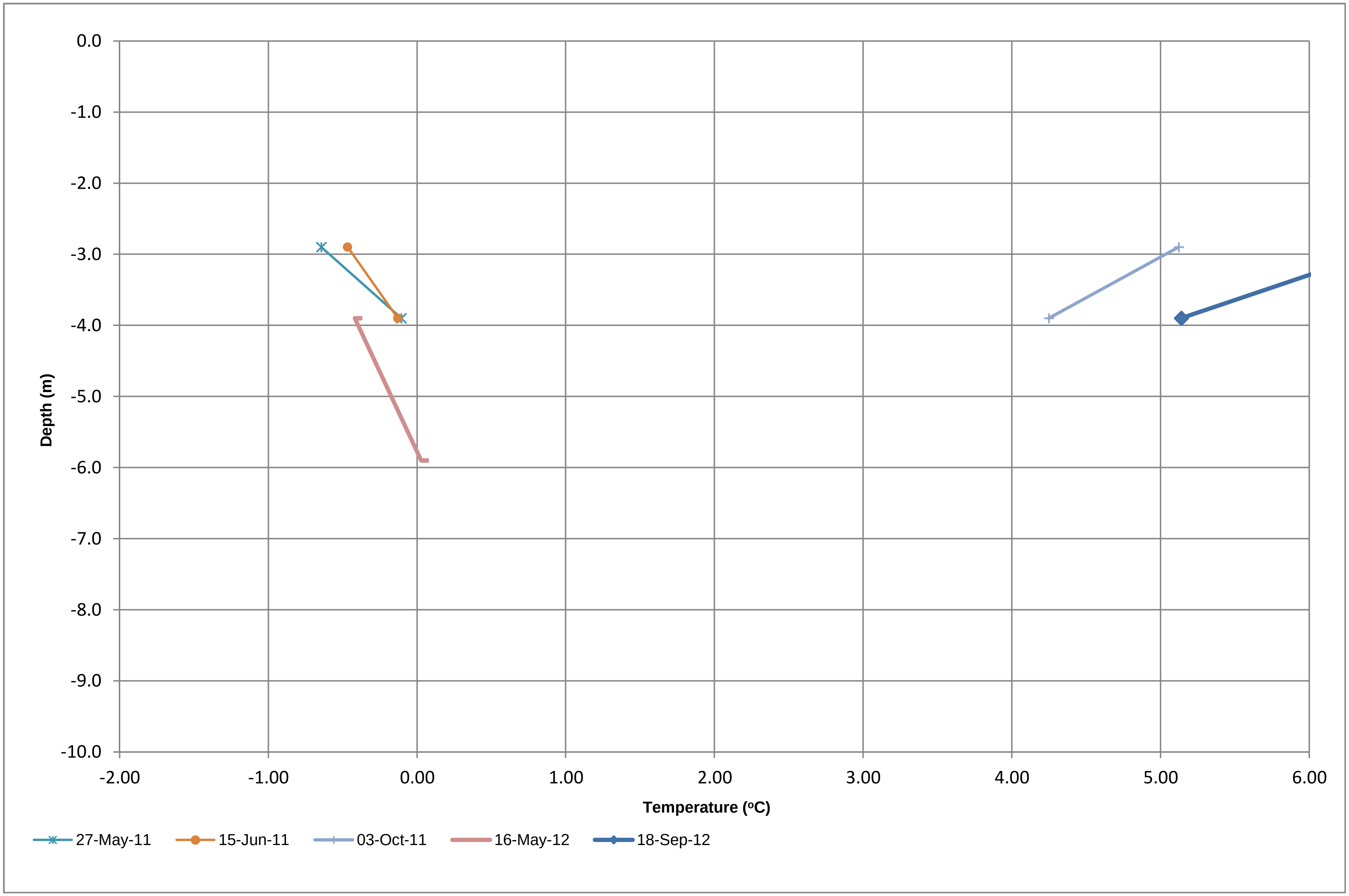
Diversion Canal (Canal Dyke)
Thermistor CD-21



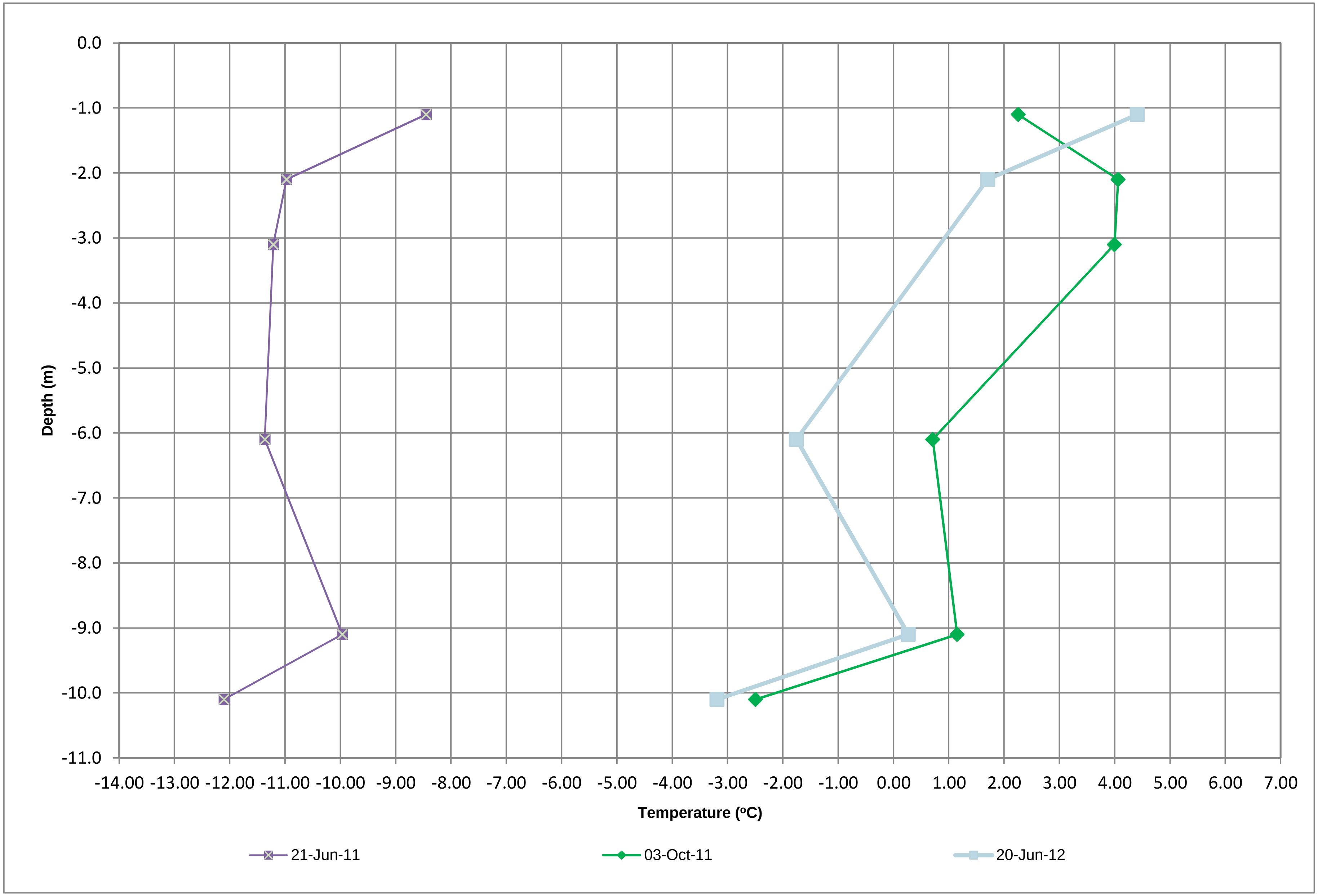
Diversion Canal (Canal Dyke)
Thermistor CD-26



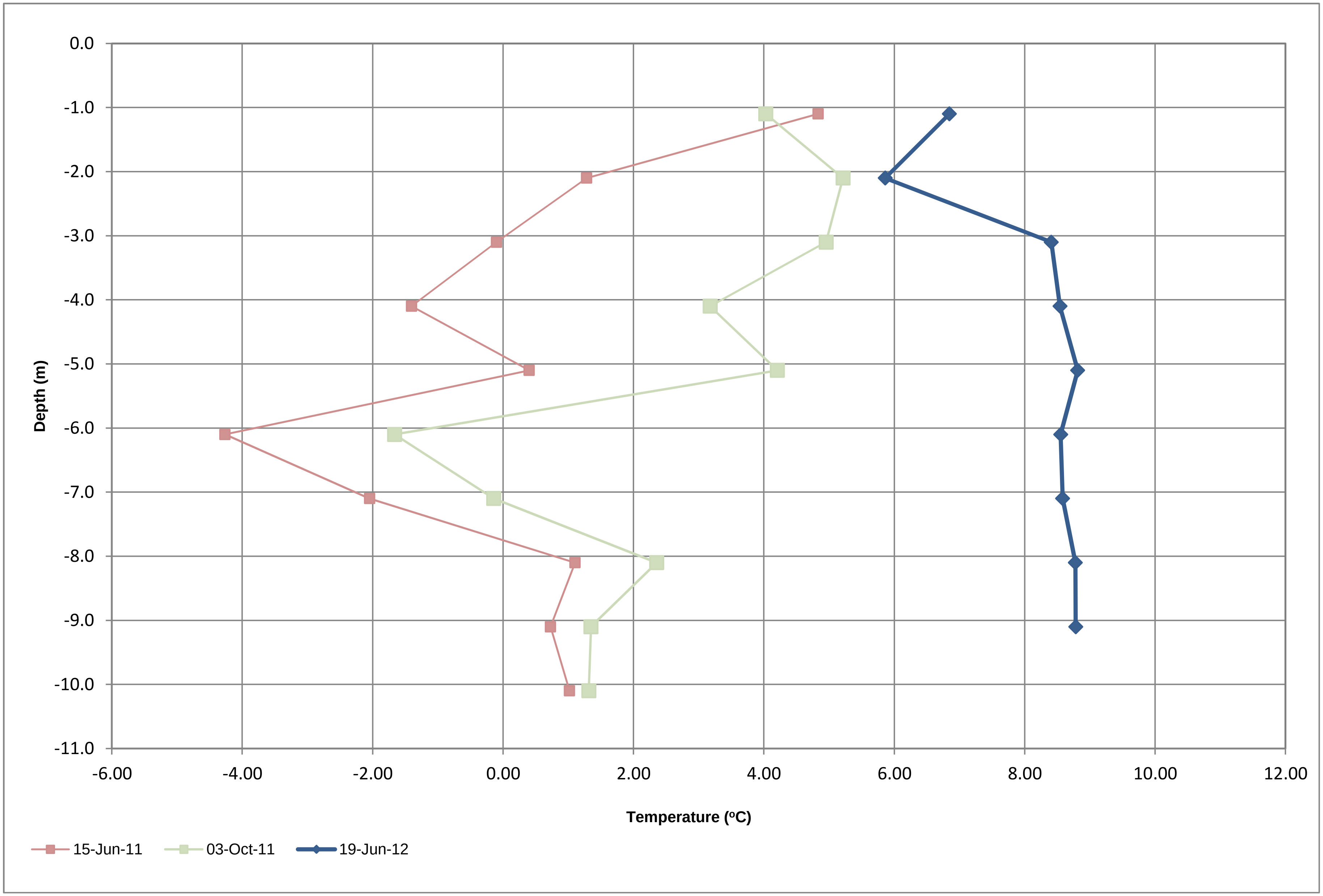
Diversion Canal (Canal Dyke)
Thermistor BGC05-04



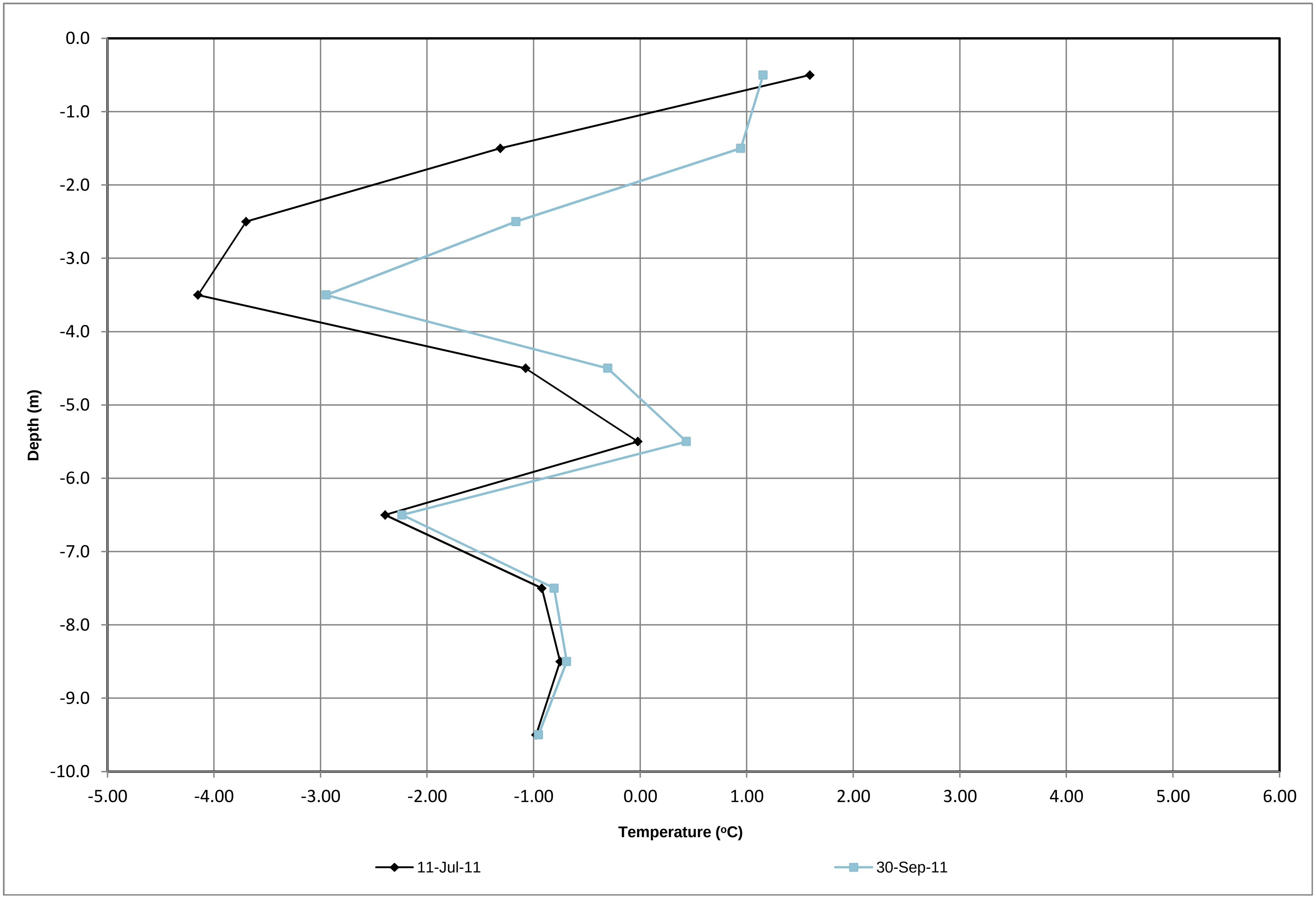
Diversion Canal (Spoil Pile)
Thermistor SP-3



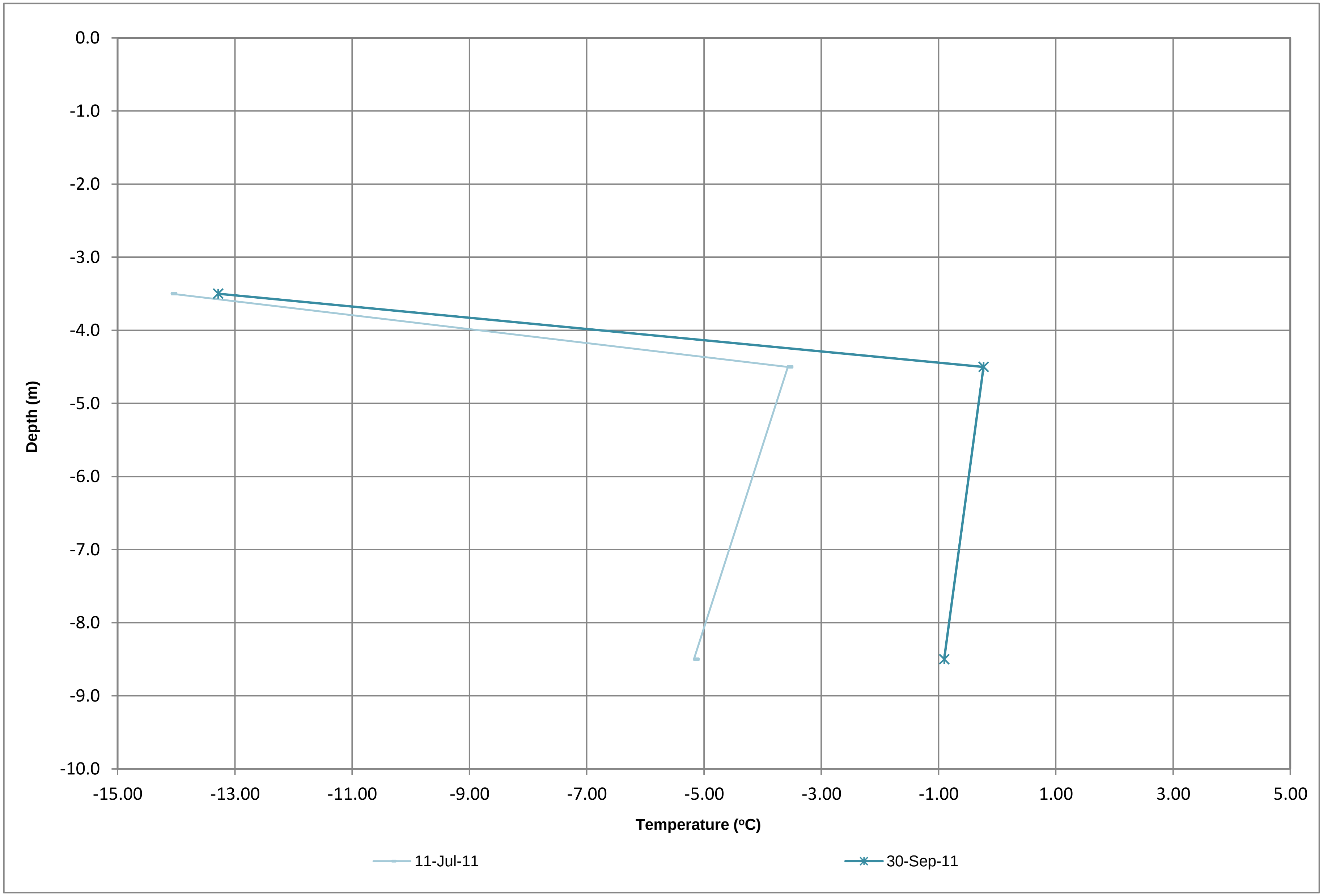
Diversion Canal (Spoil Pile)
Thermistor SP-5



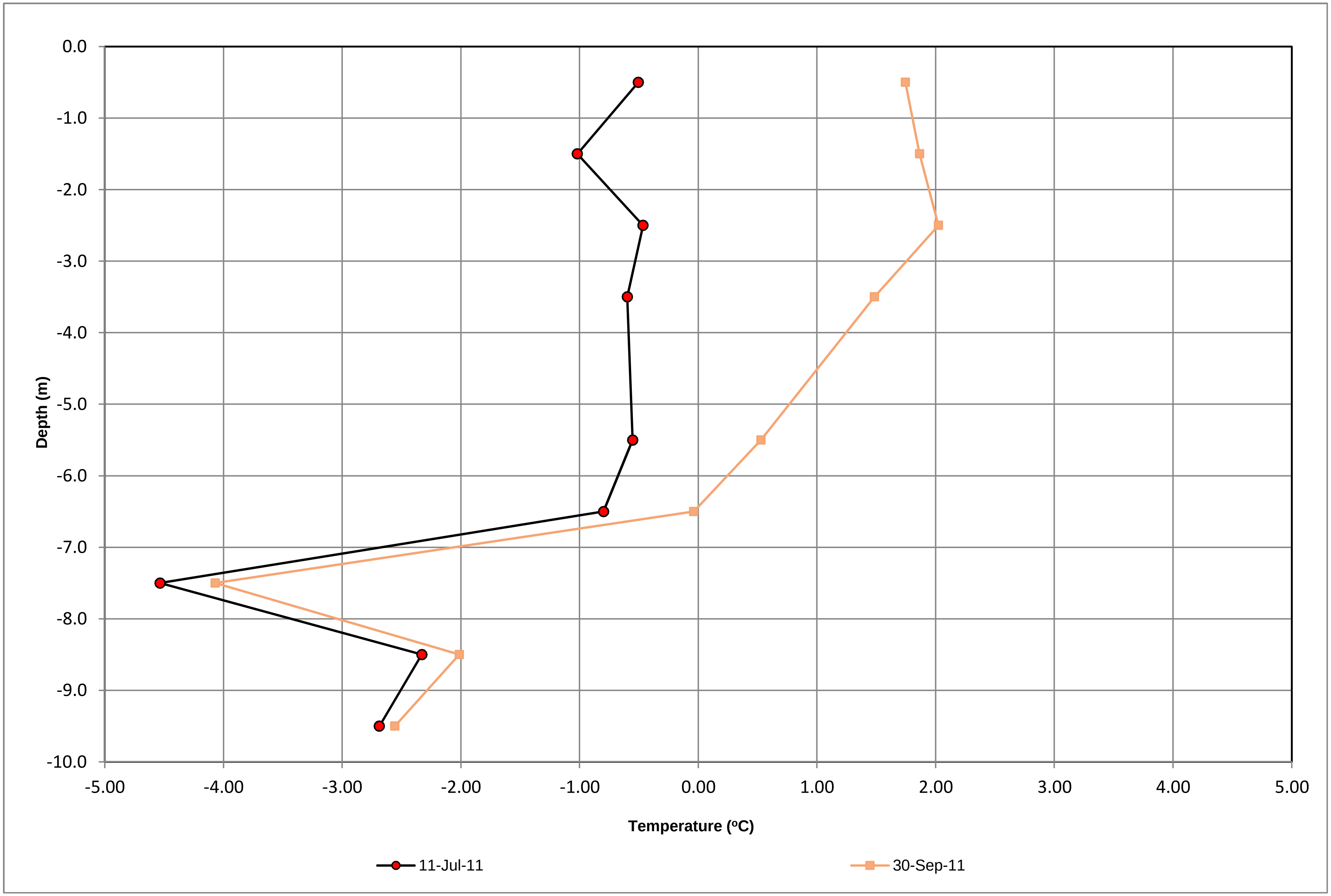
Diversion Canal (Backslope)
Thermistor BS-5



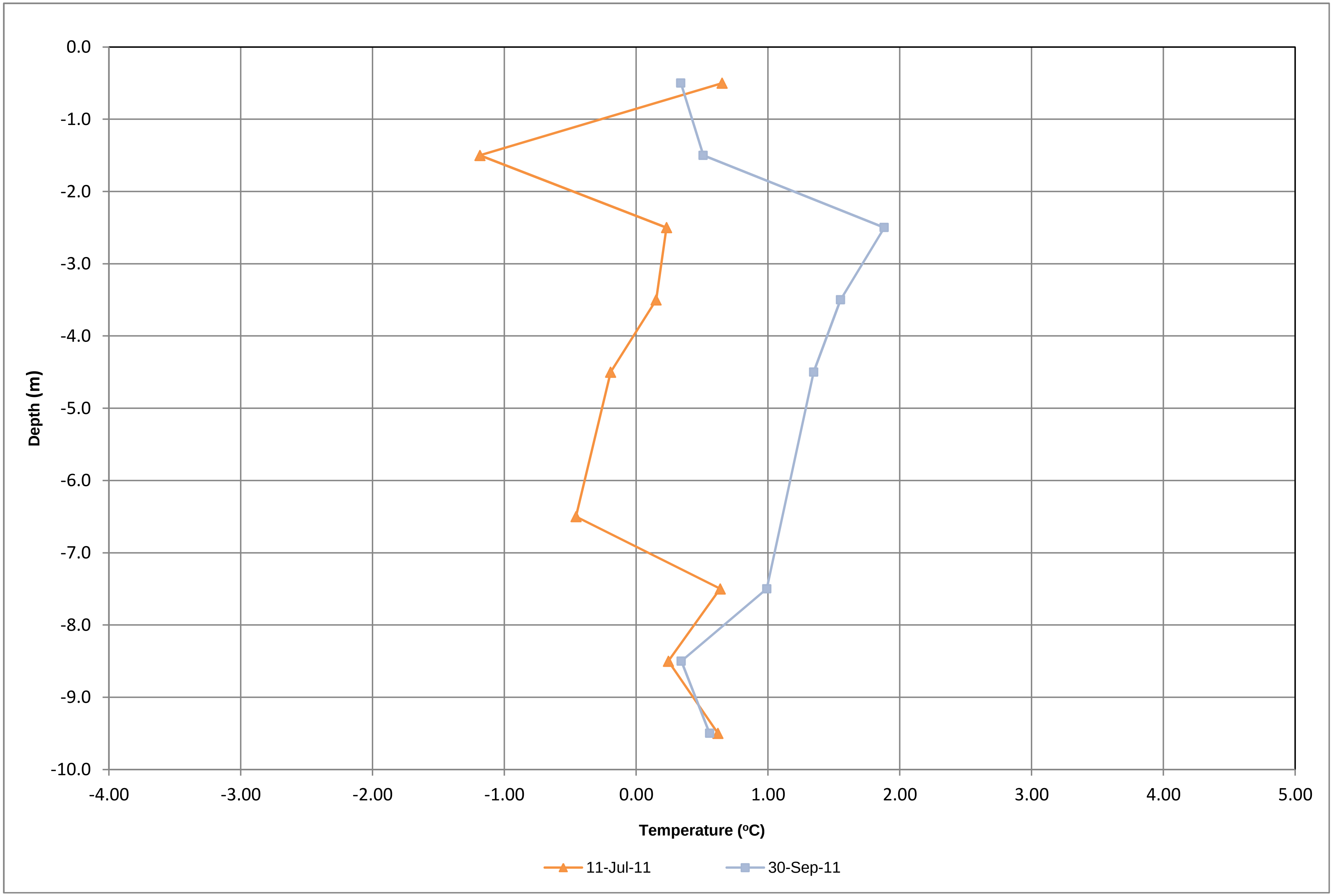
Diversion Canal (Backslope)
Thermistor BS-9



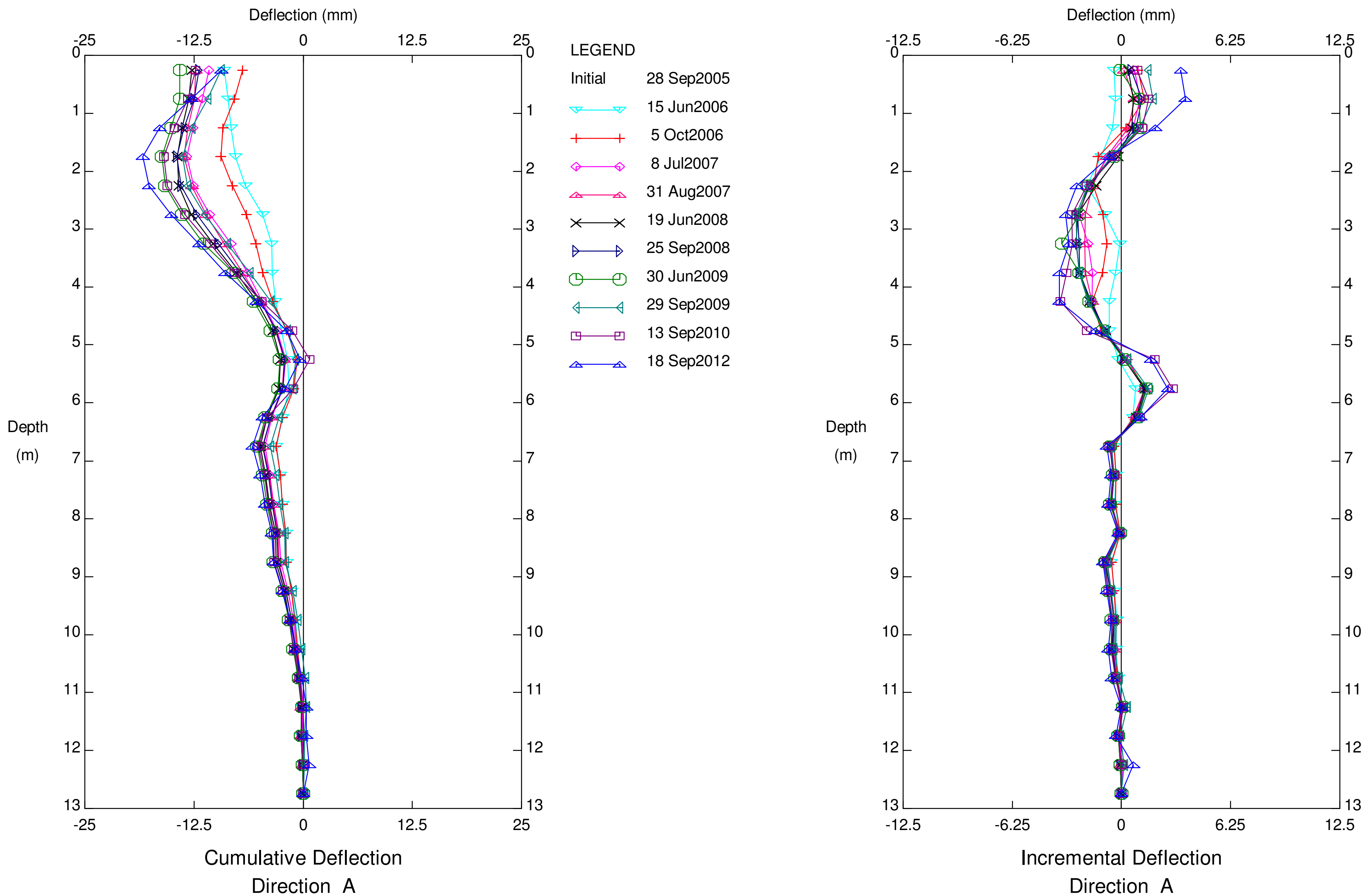
Diversion Canal (Backslope)
Thermistor BS-10



Diversion Canal (Backslope)
Thermistor BS-12

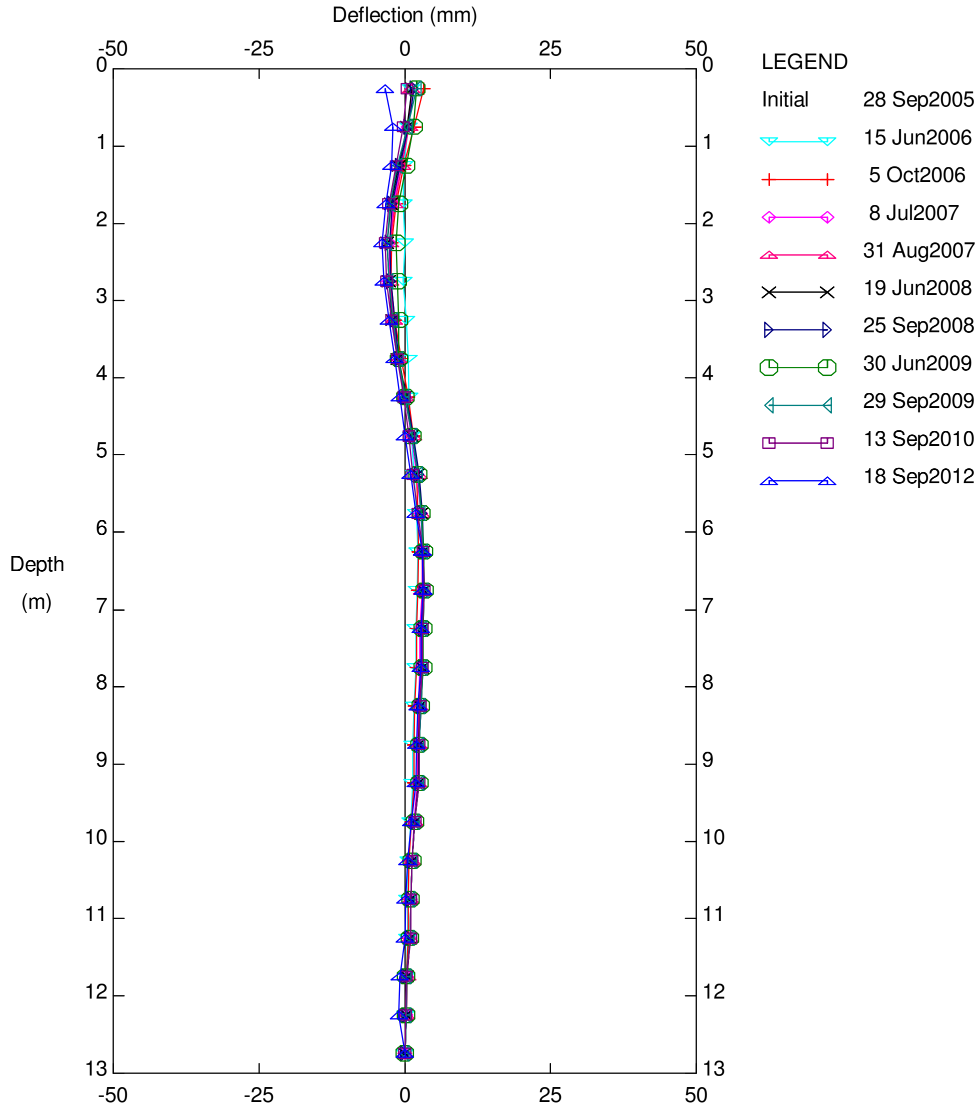


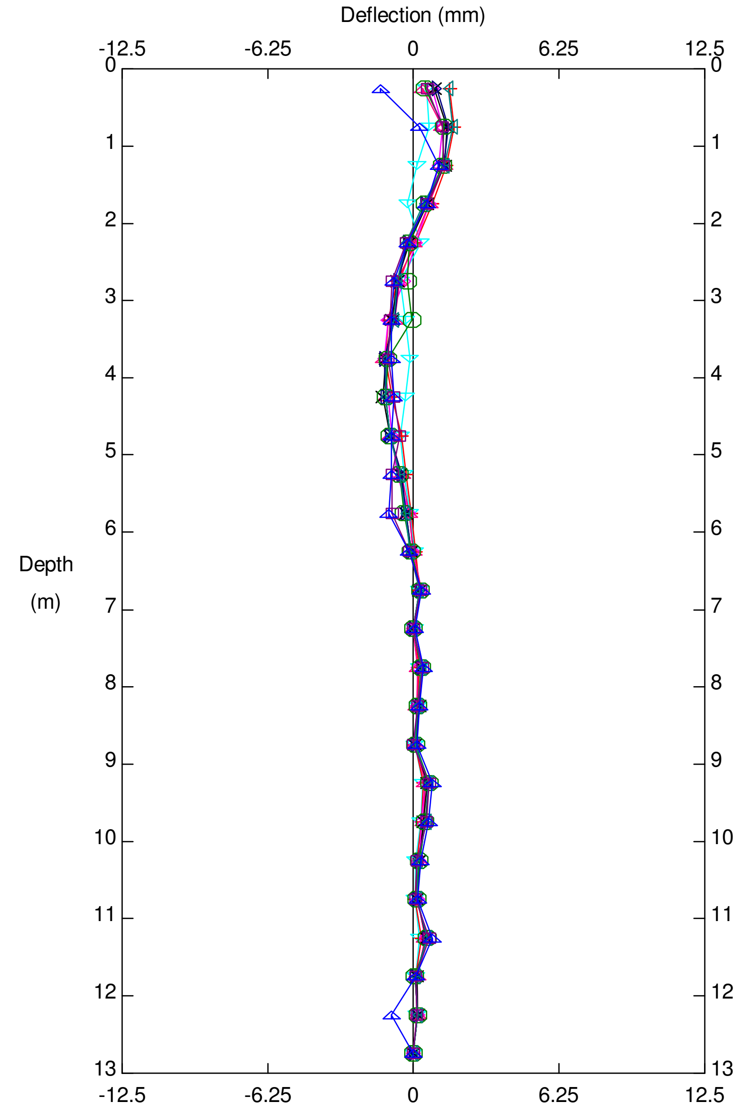
E.3 – Inclinometers



Canal Dike, Inclinometer BGC05-08

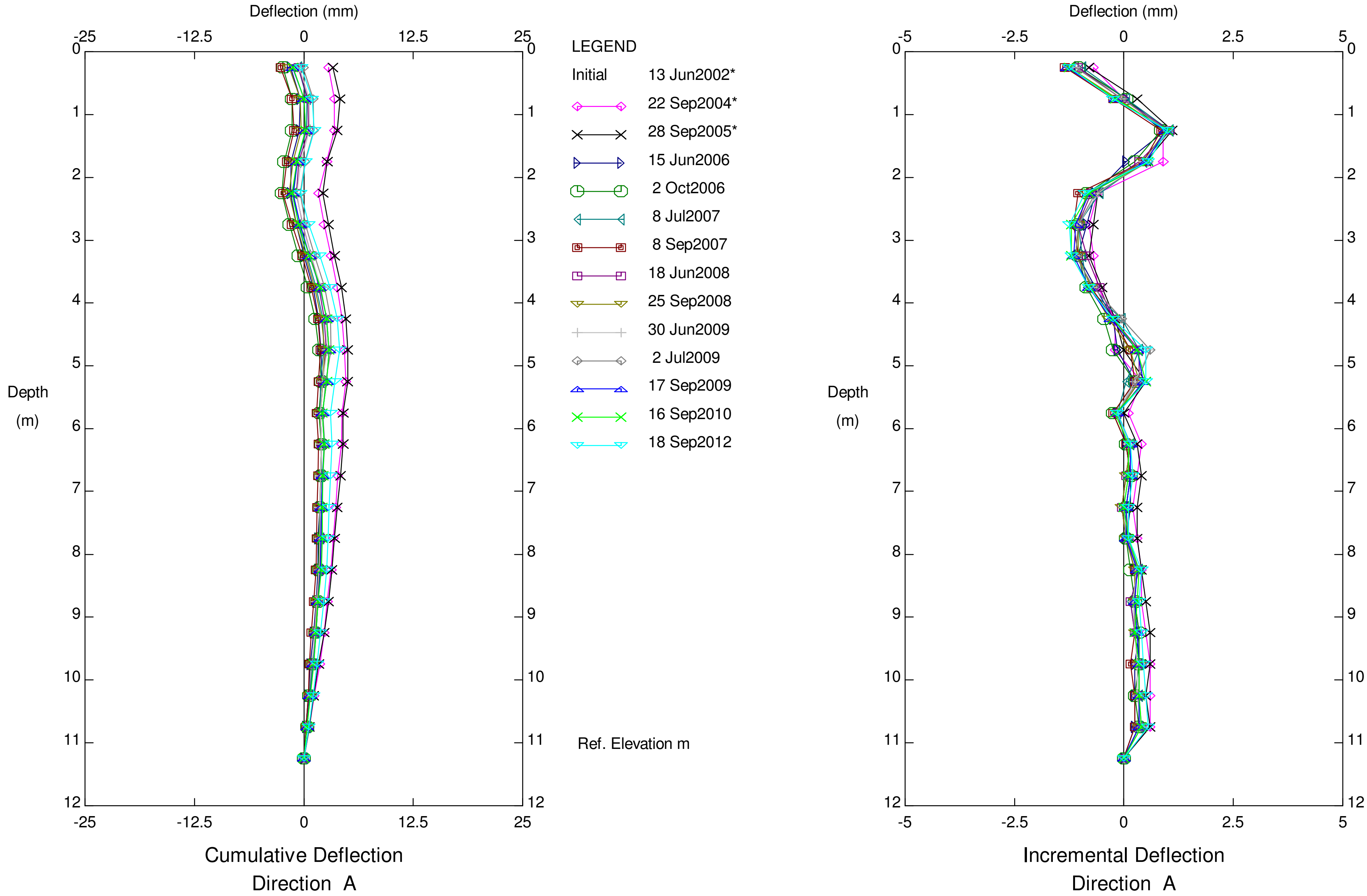
Klohn Crippen Berger Ltd. - Vancouver BC





Canal Dike, Inclinometer BGC05-08

Klohn Crippen Berger Ltd. - Vancouver BC

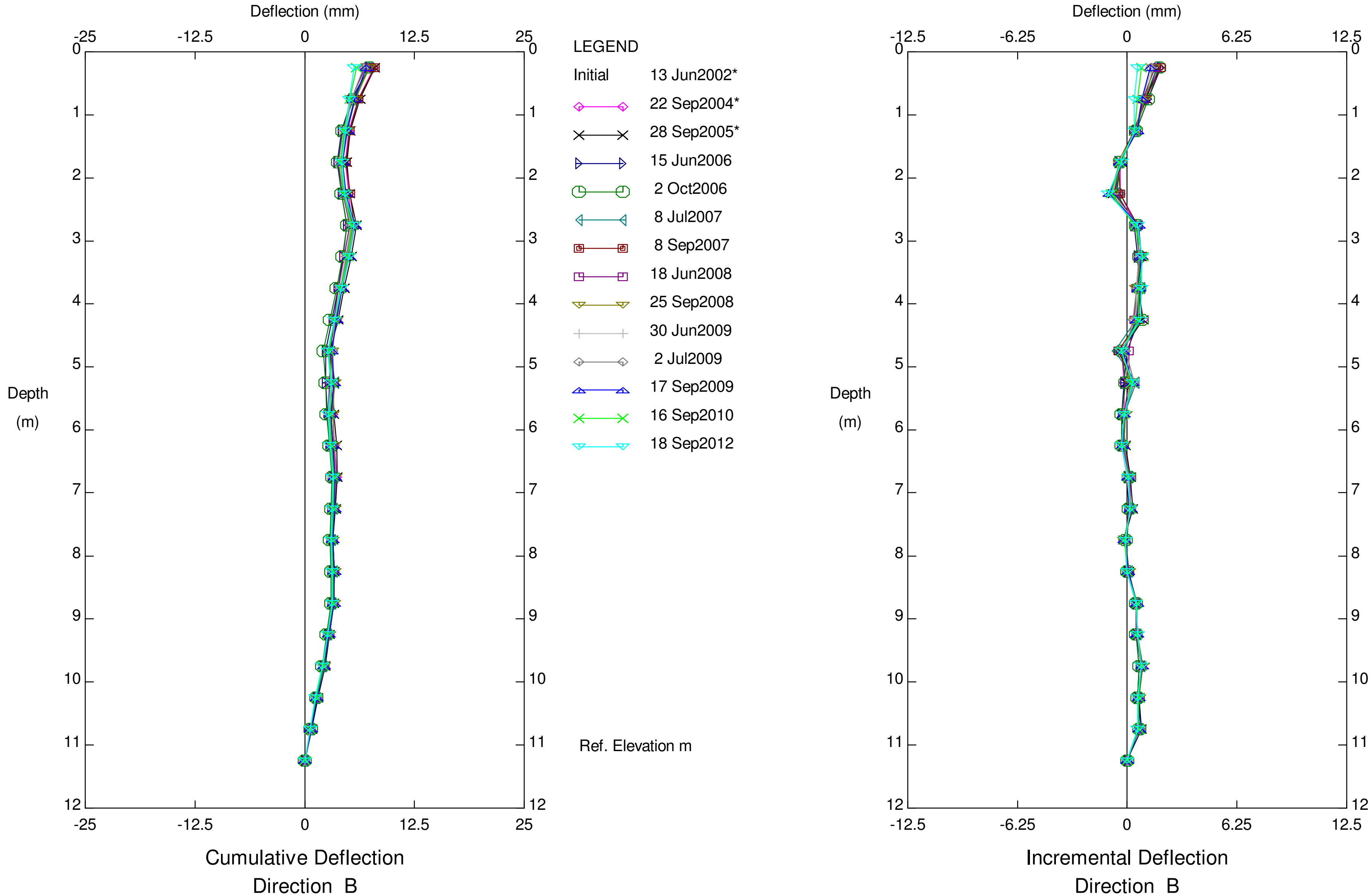


91CD-1, Inclinometer 1+767

Sets marked * include zero shift and/or rotation corrections.

Check-91cd-1.gtl

Klohn Crippen Berger Ltd. - Vancouver BC

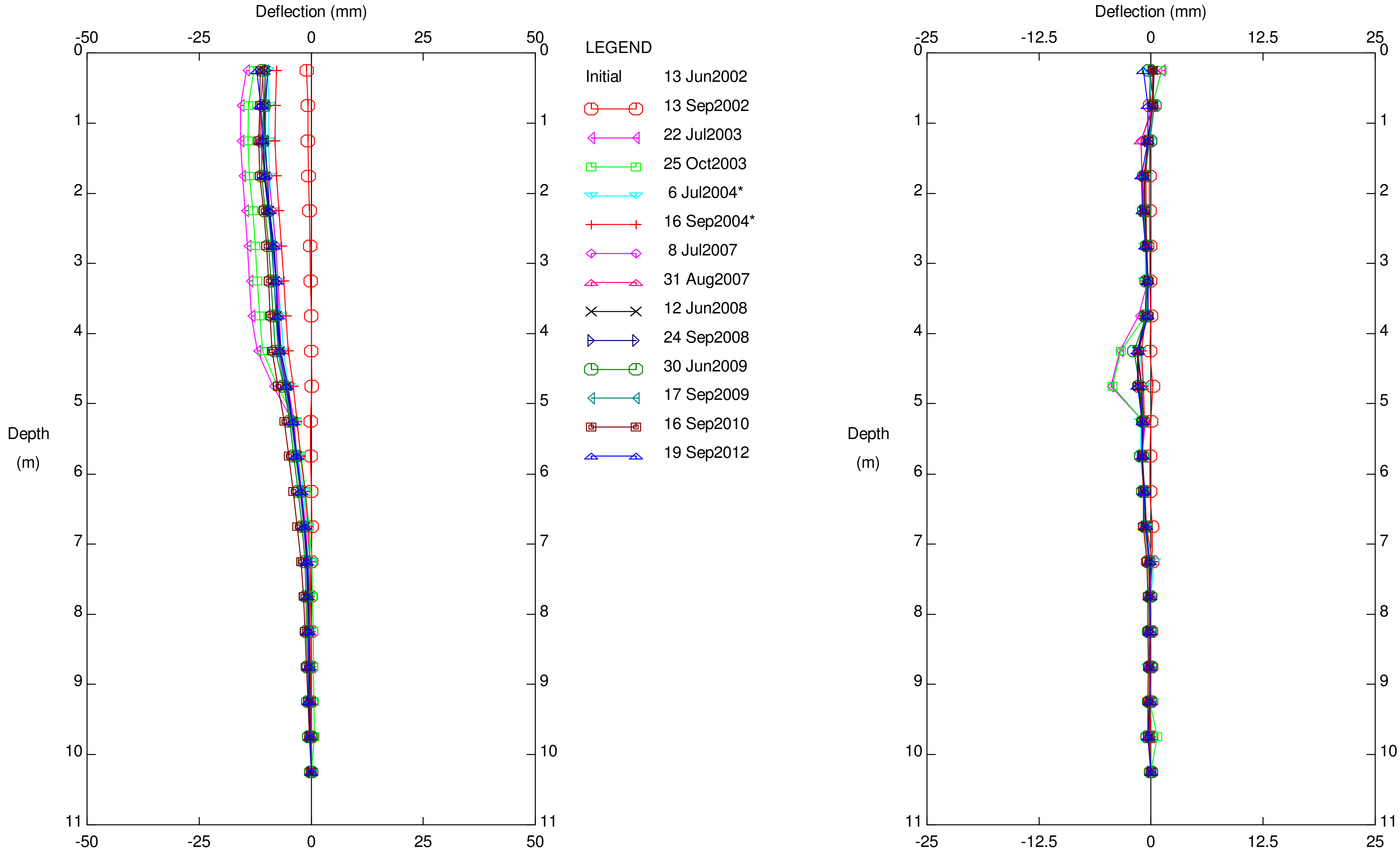


91CD-1, Inclinometer 1+767

Sets marked * include zero shift and/or rotation corrections.

Check-91cd-1.gtl

Klohn Crippen Berger Ltd. - Vancouver BC



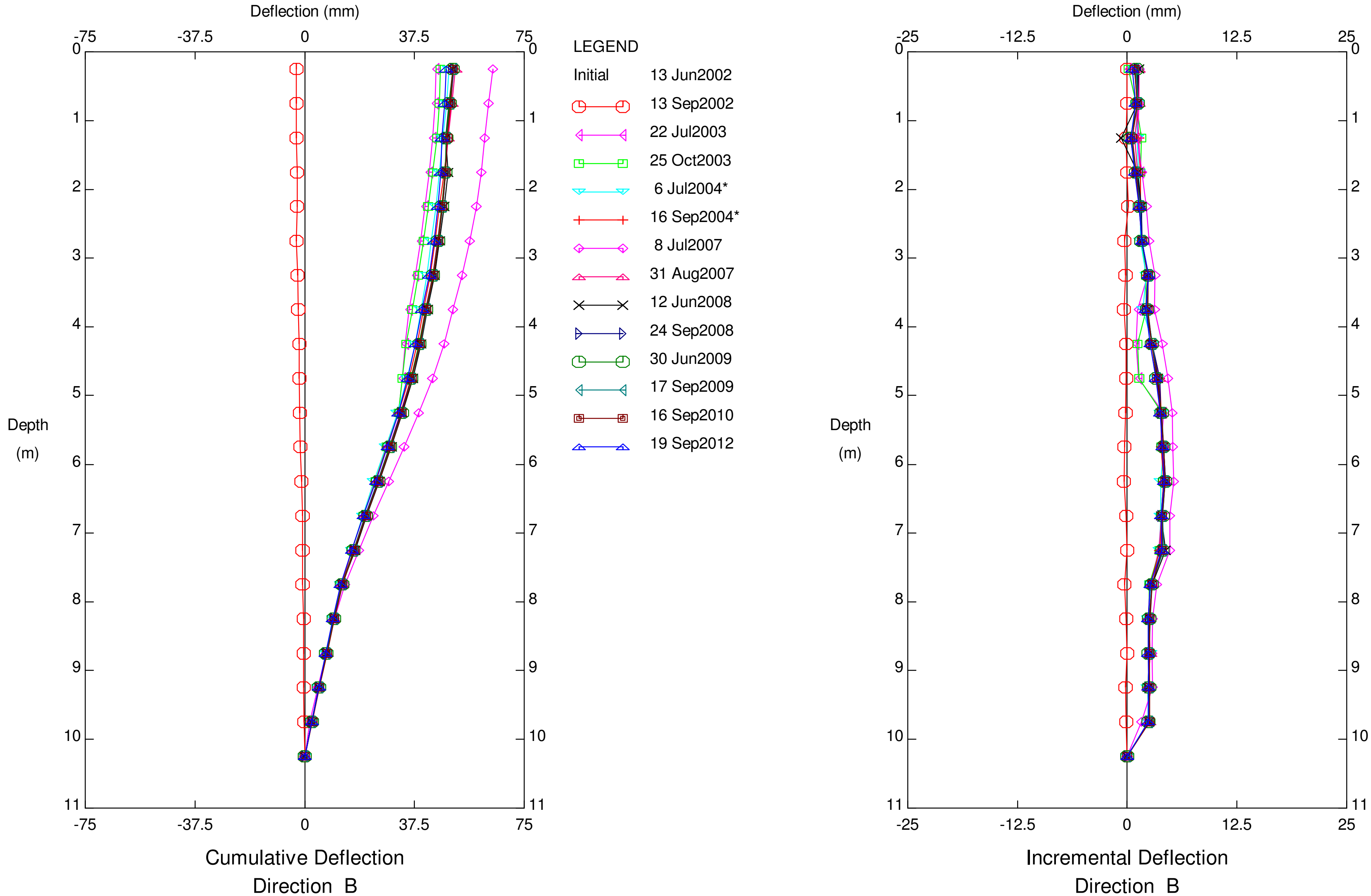
Cumulative Deflection
Direction A

Incremental Deflection
Direction A

CD-10, Inclinometer 0+990

Sets marked * include zero shift and/or rotation corrections.

Klohn Crippen Berger Ltd. - Vancouver BC



CD-10, Inclinometer 0+990

Sets marked * include zero shift and/or rotation corrections.

Check-cd10.gtl

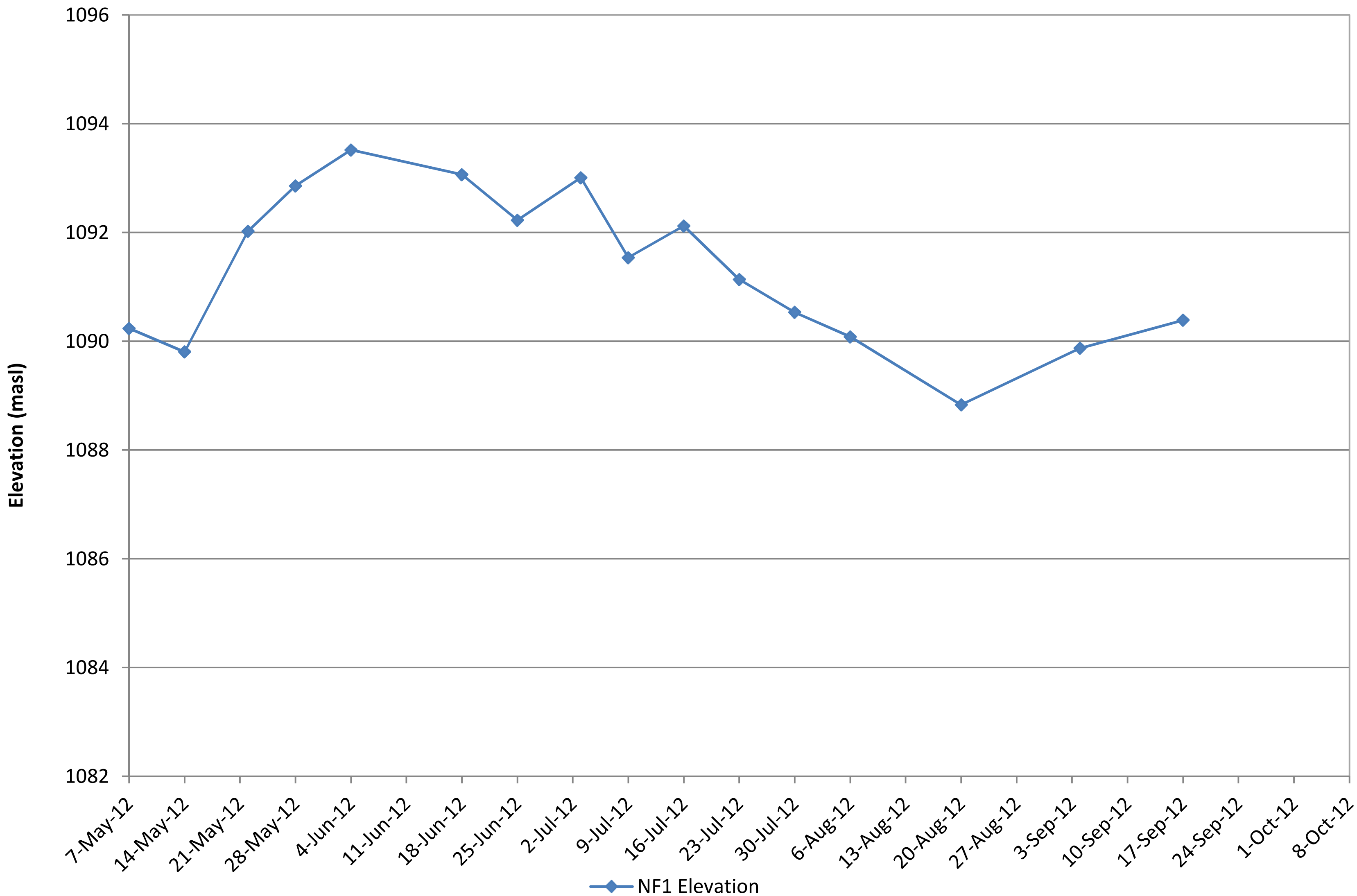
APPENDIX II-F

North Fork Rock Drain

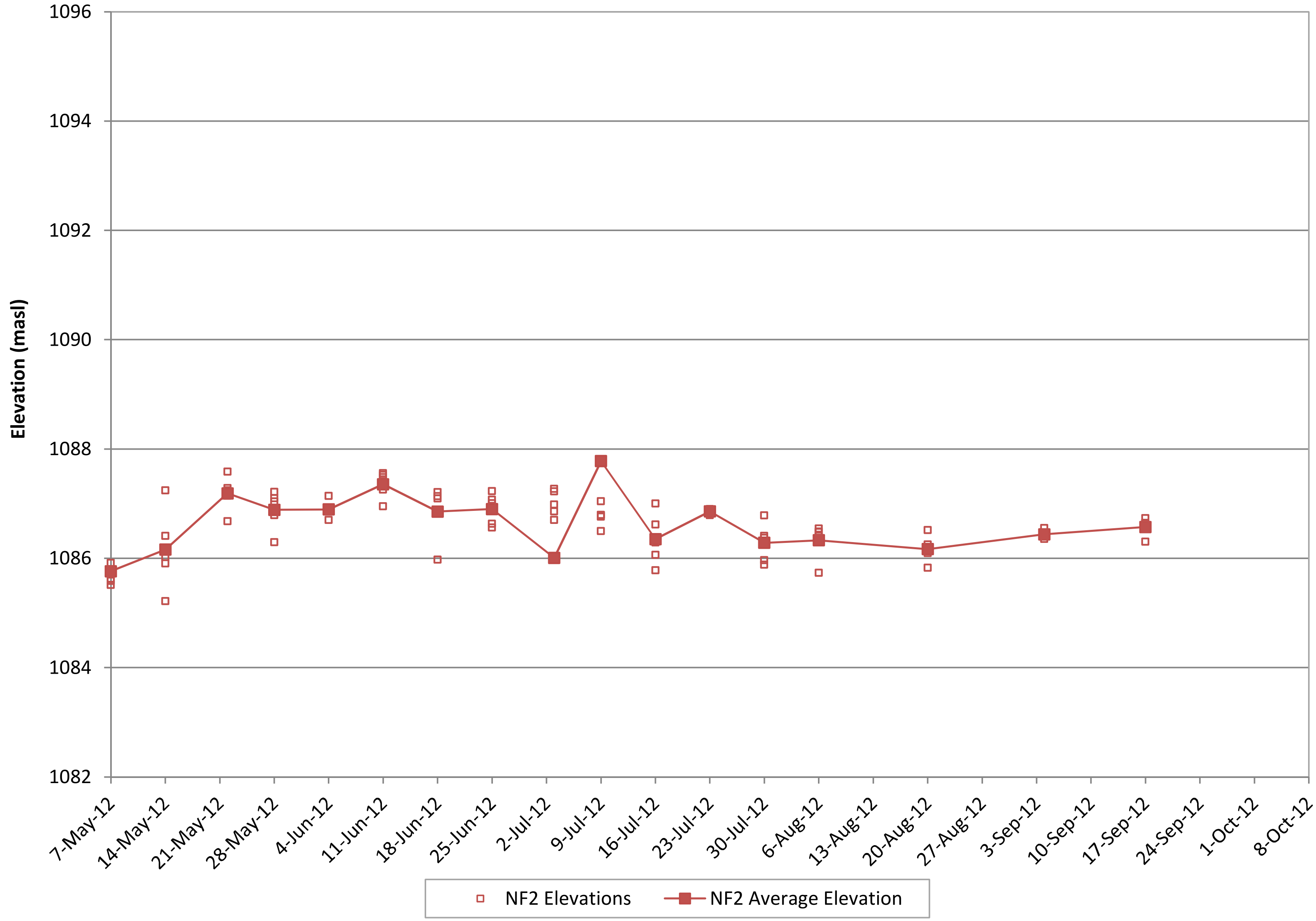
F.1 – Staff Gauge Measurement

F.1 – Staff Gauge Measurement

North Fork of Rose Creek
NF1 Water Elevations



North Fork of Rose Creek
NF2 Water Elevations



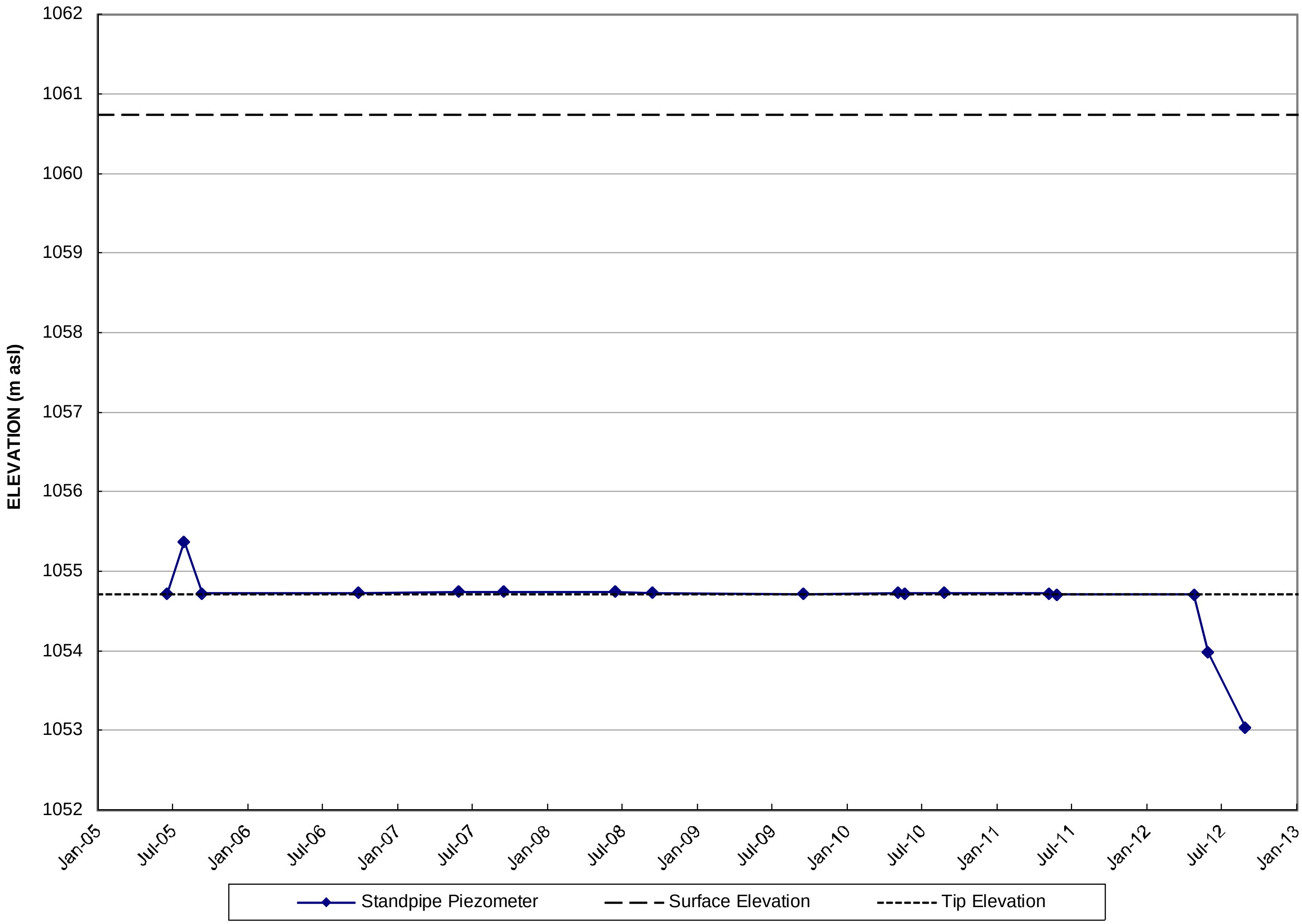
APPENDIX II-G

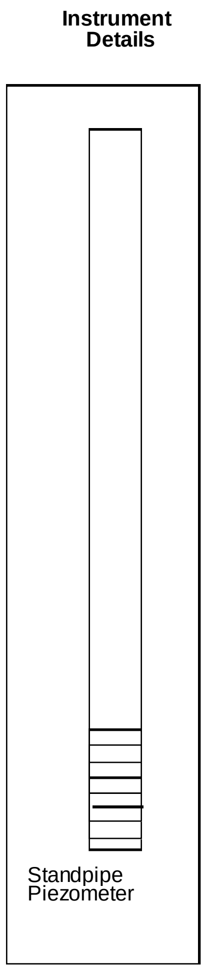
Secondary Tailings Impoundment

G.1 – Piezometers

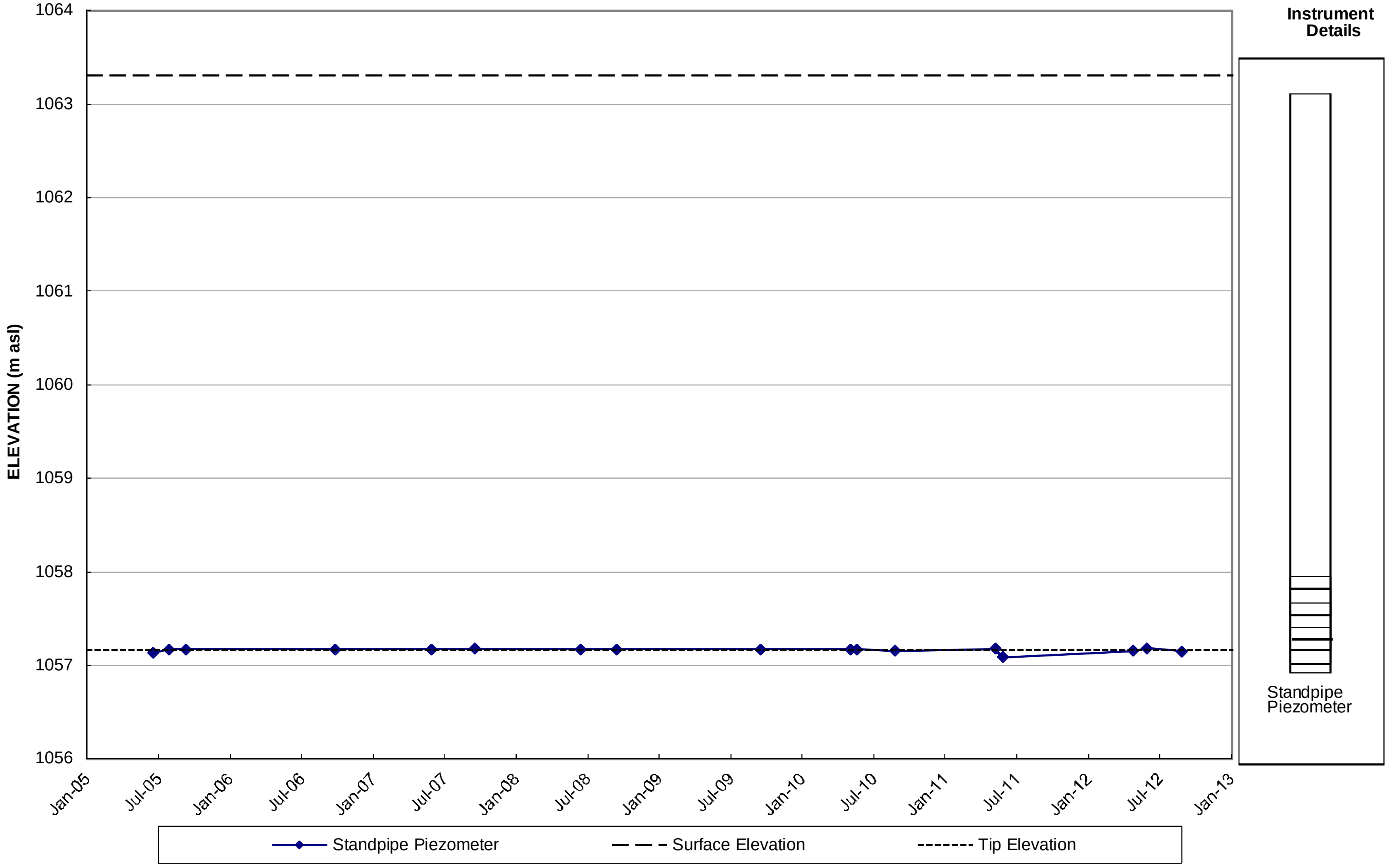
G.1 – Piezometers

Secondary Tailings Dam
Piezometer P81-06

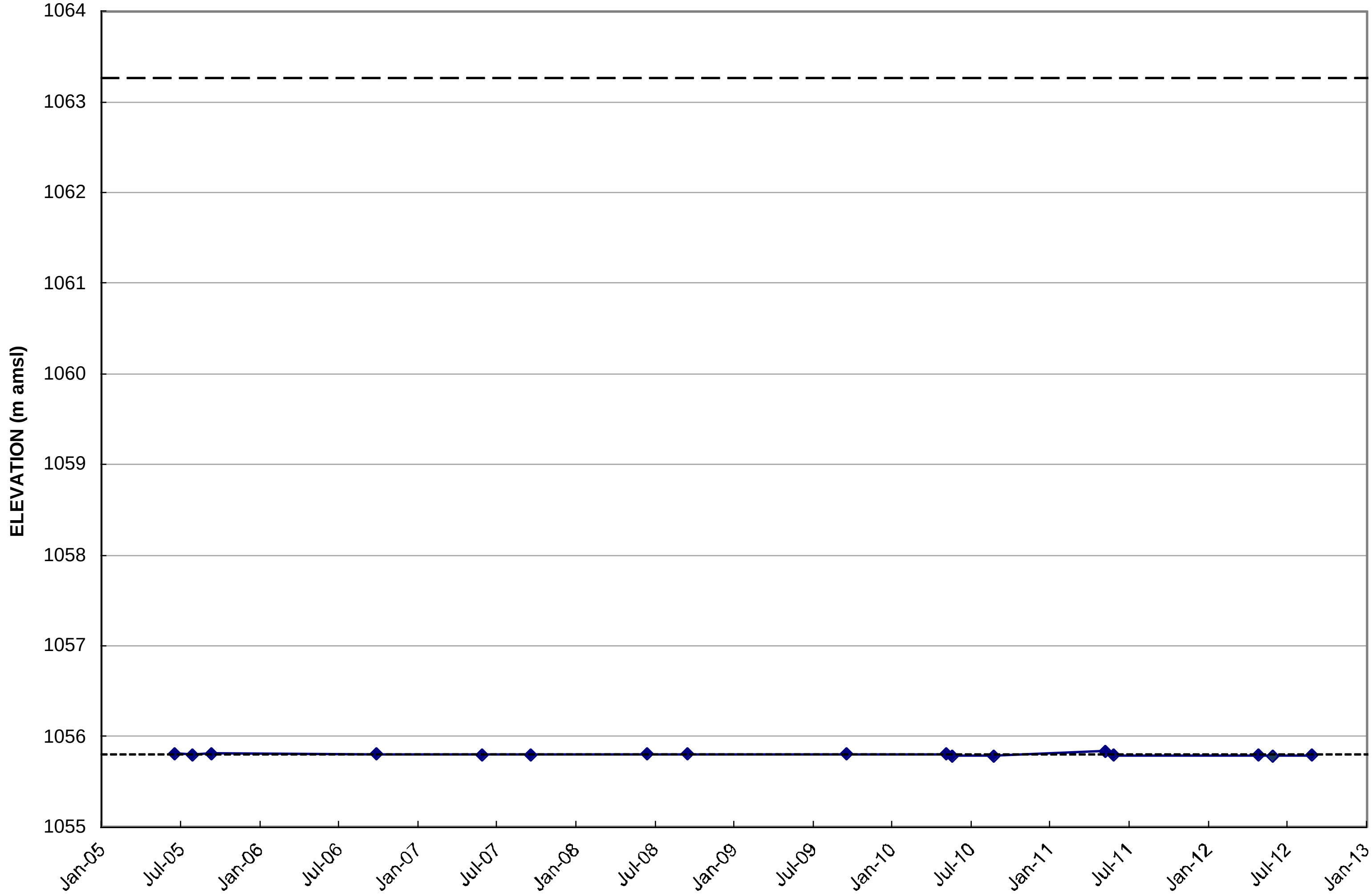


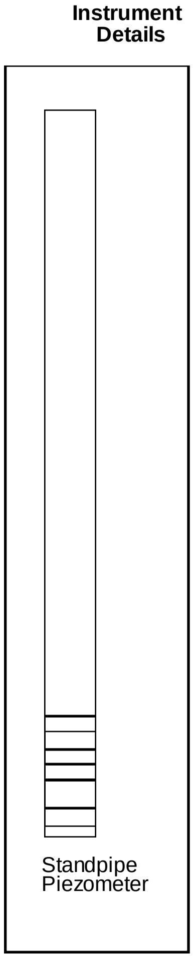


Secondary Tailings Dam
Piezometer P81-07

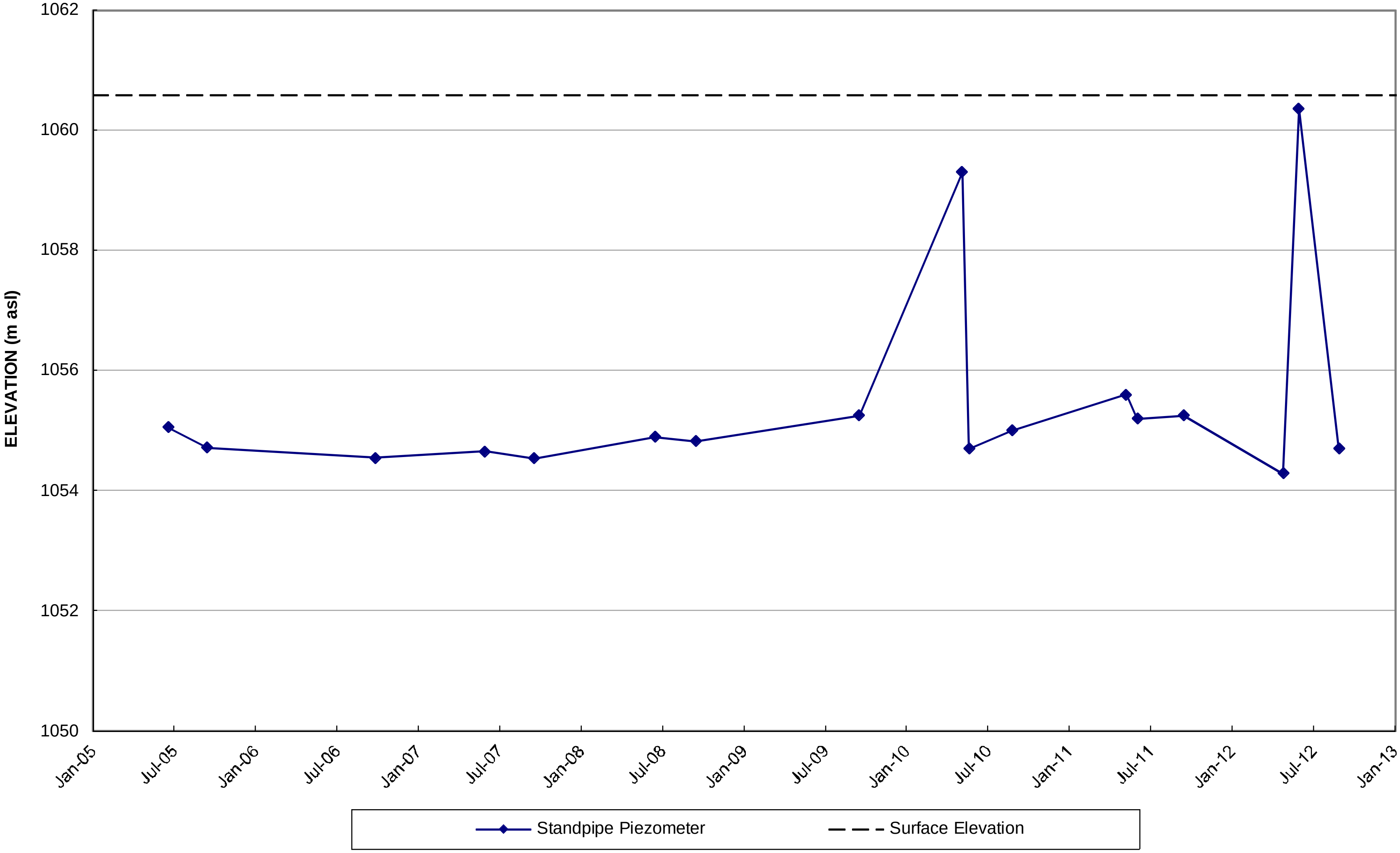


Secondary Tailings Dam
Piezometer P81-08

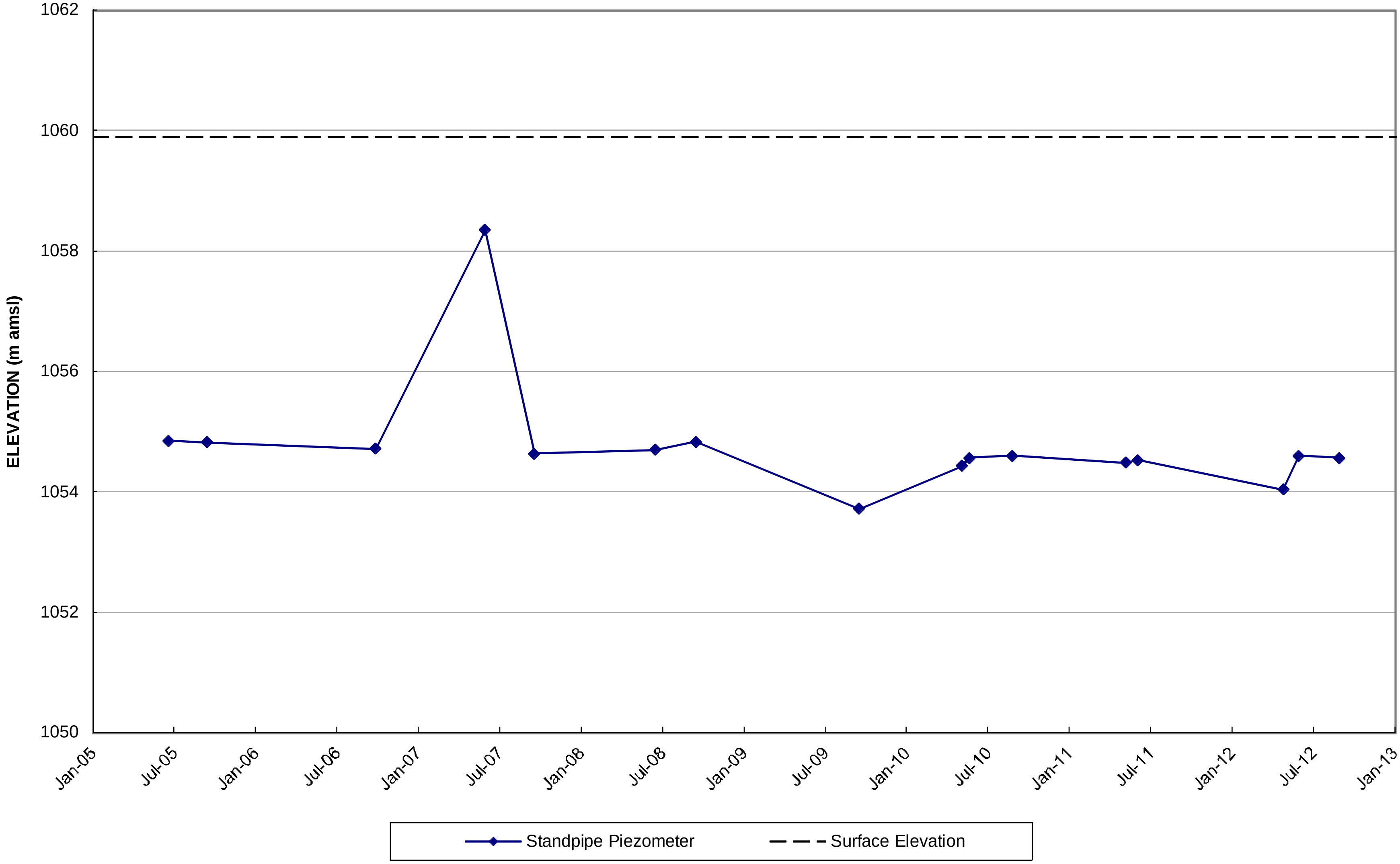




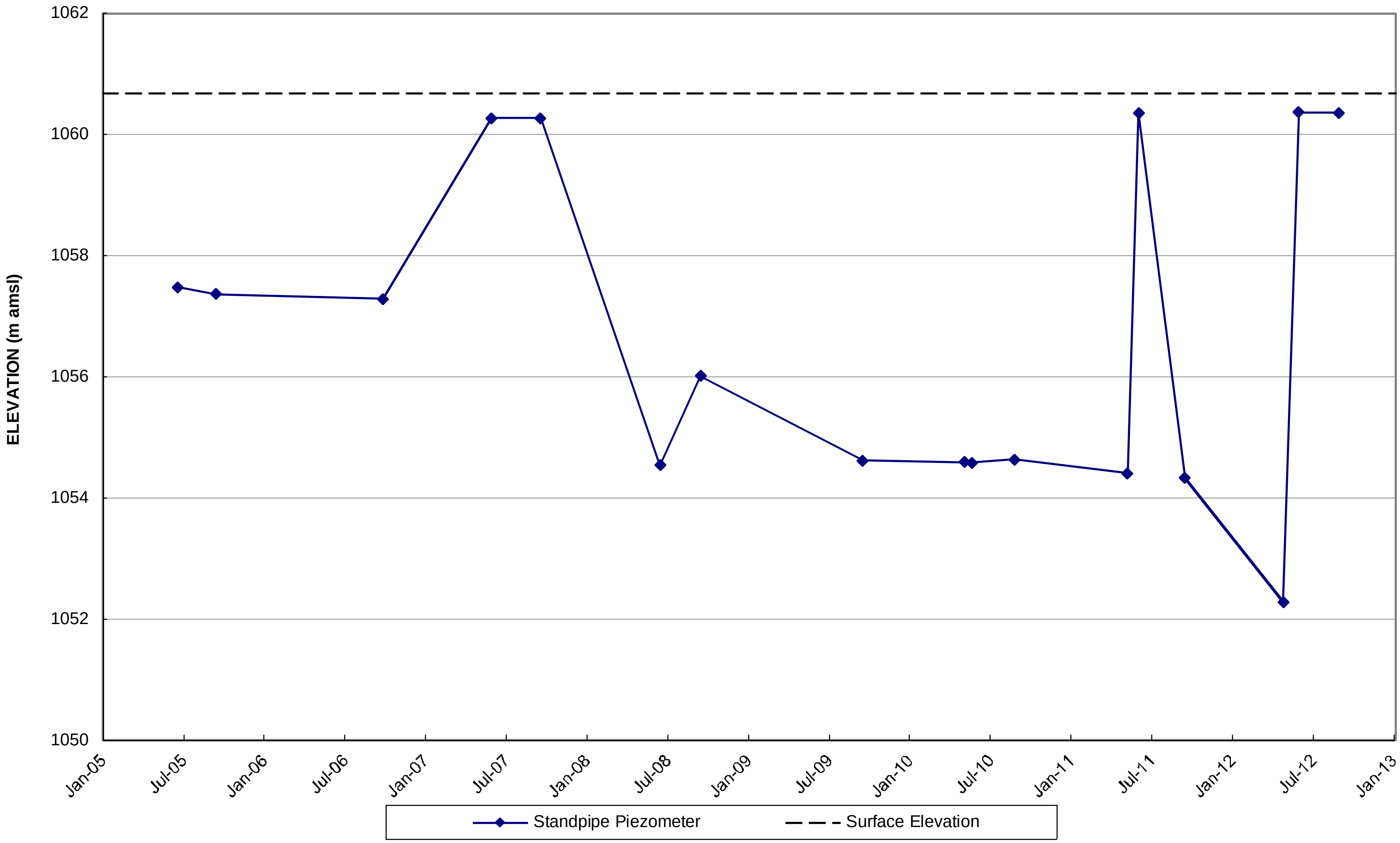
Secondary Tailings Dam
Piezometer P03-01



Secondary Tailings Dam
Piezometer P03-02



Secondary Tailings Dam
Piezometer P03-03



APPENDIX II-H

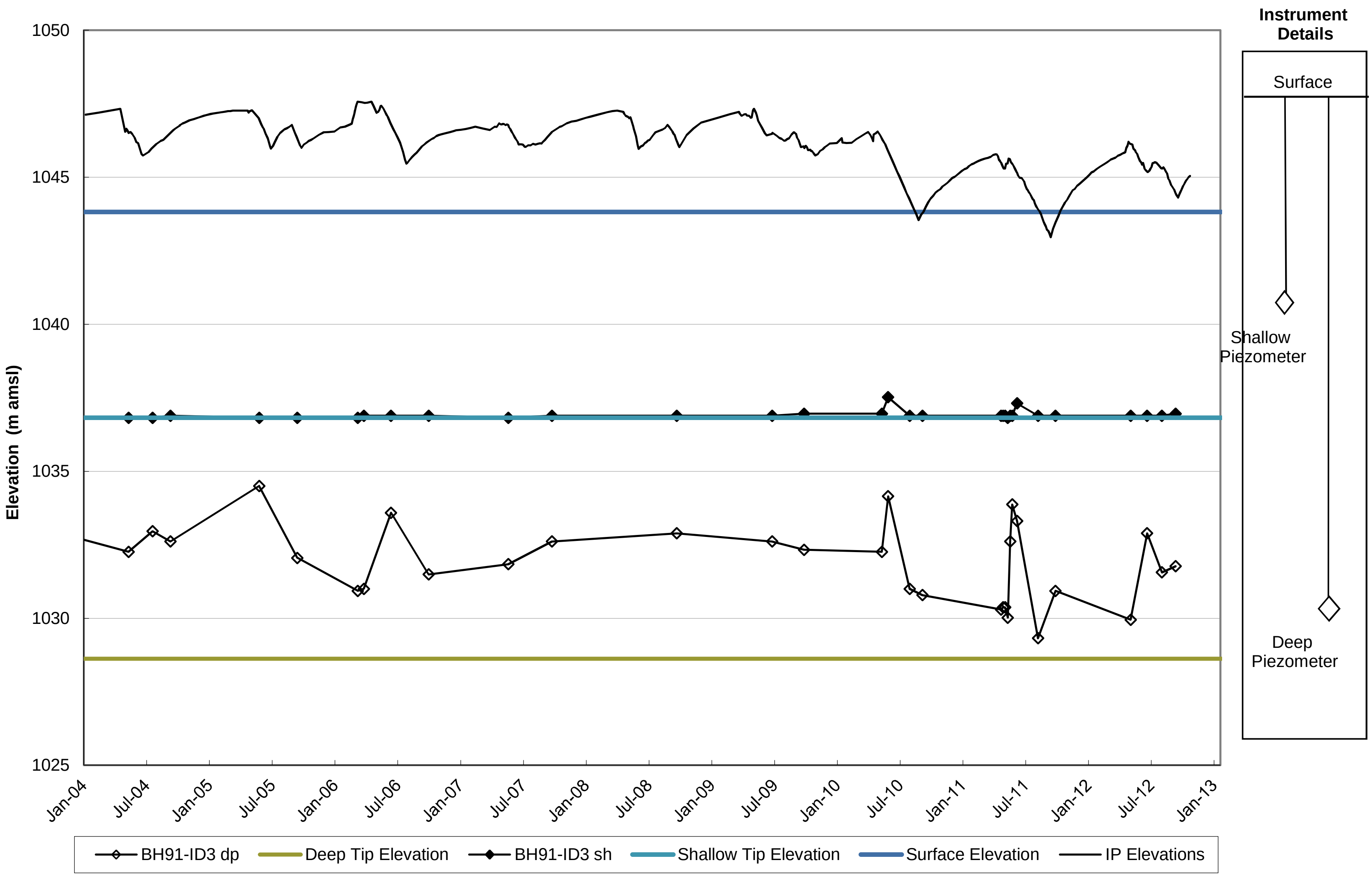
Intermediate Dam

H.1 – Piezometers

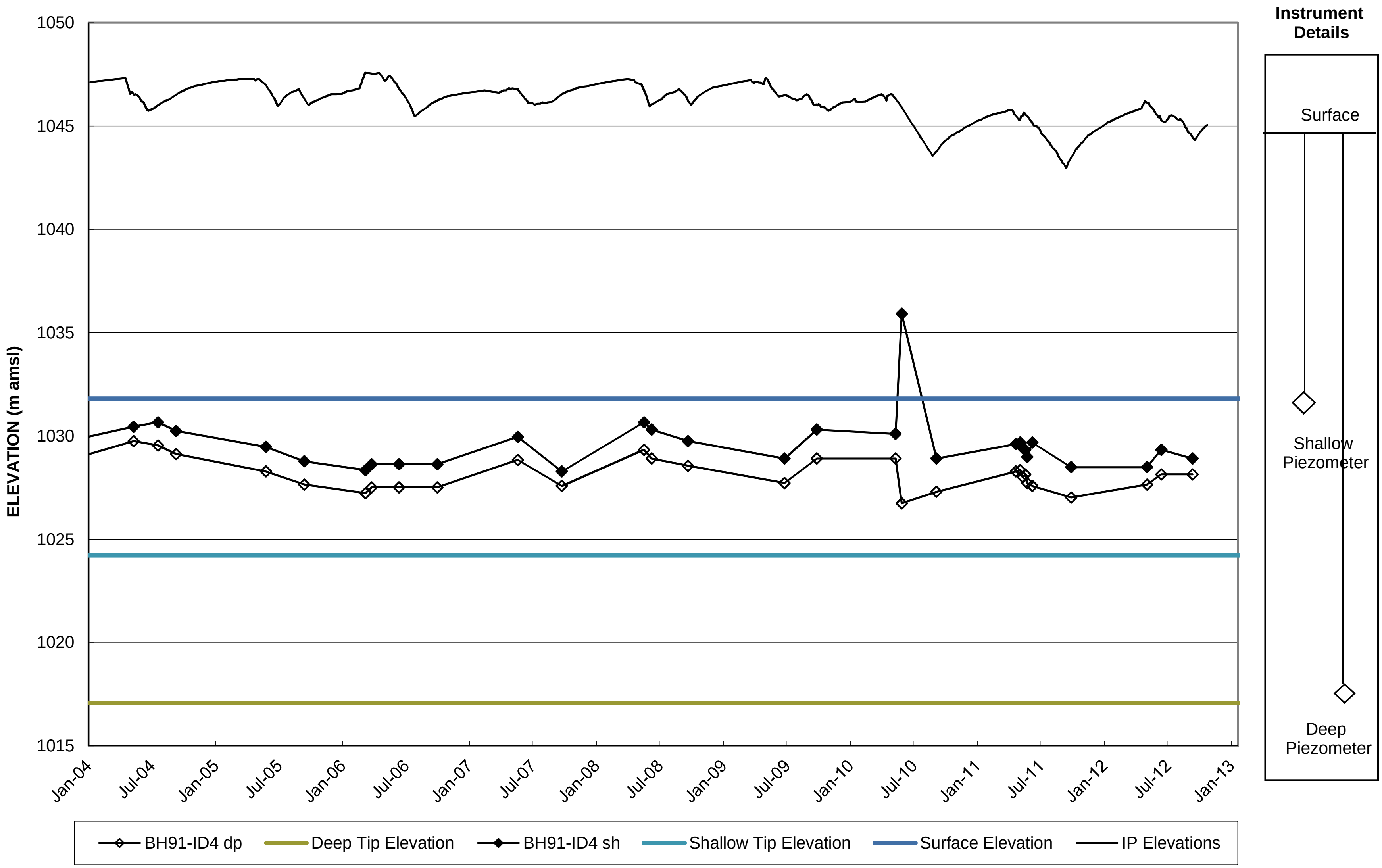
H.2 – Pond Level (Intermediate Pond)

H.1 – Piezometers

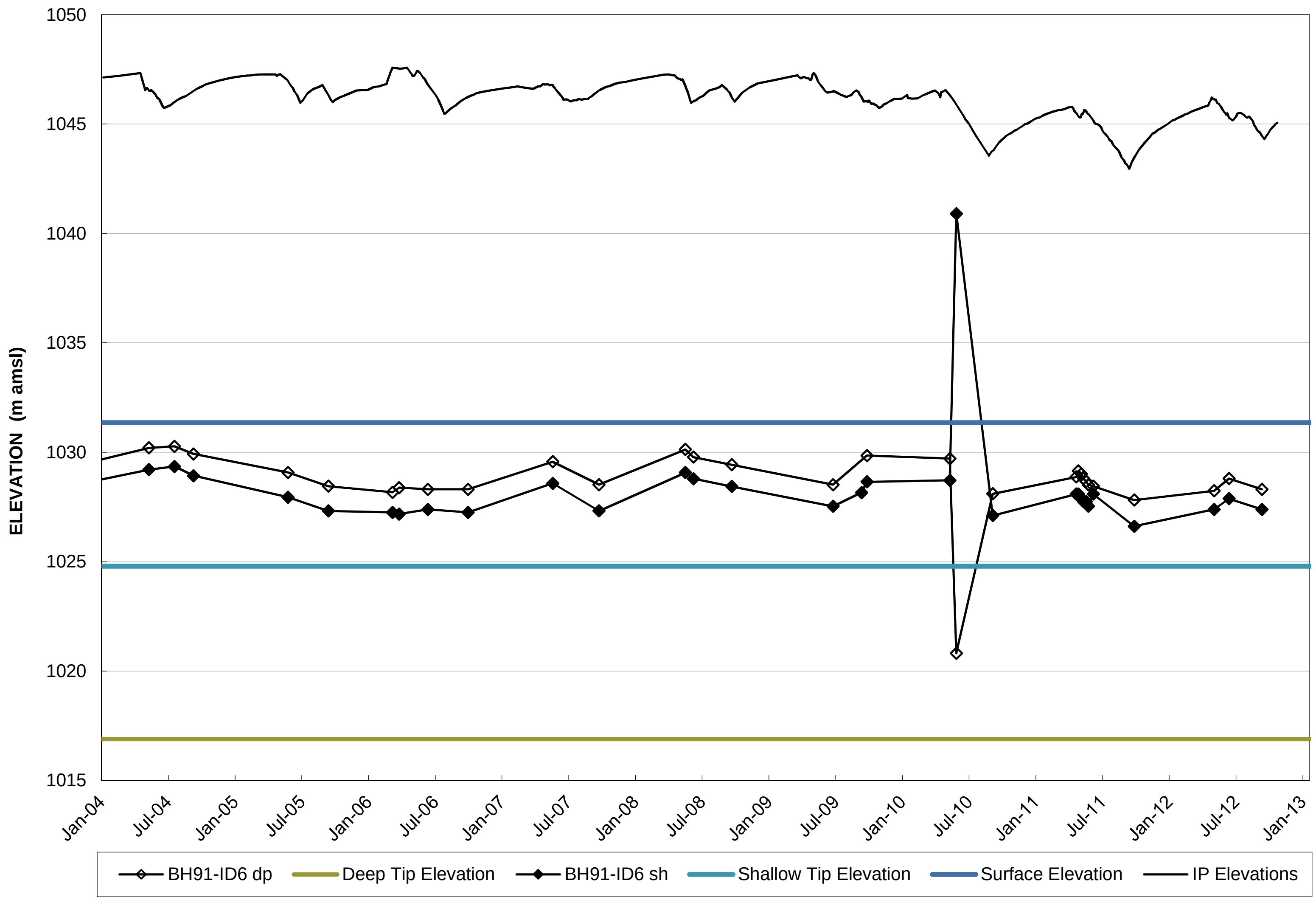
Intermediate Dam
Piezometer BH91-ID3

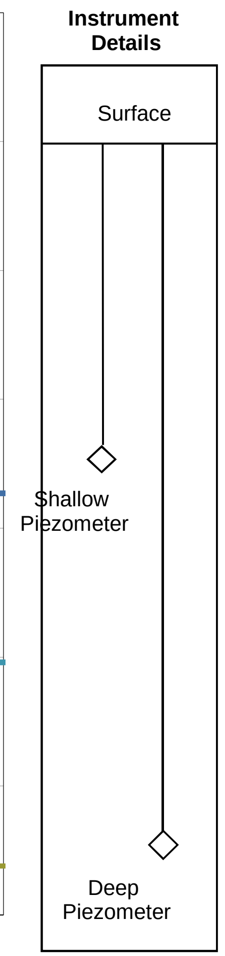


Intermediate Dam
Piezometer BH91-ID4

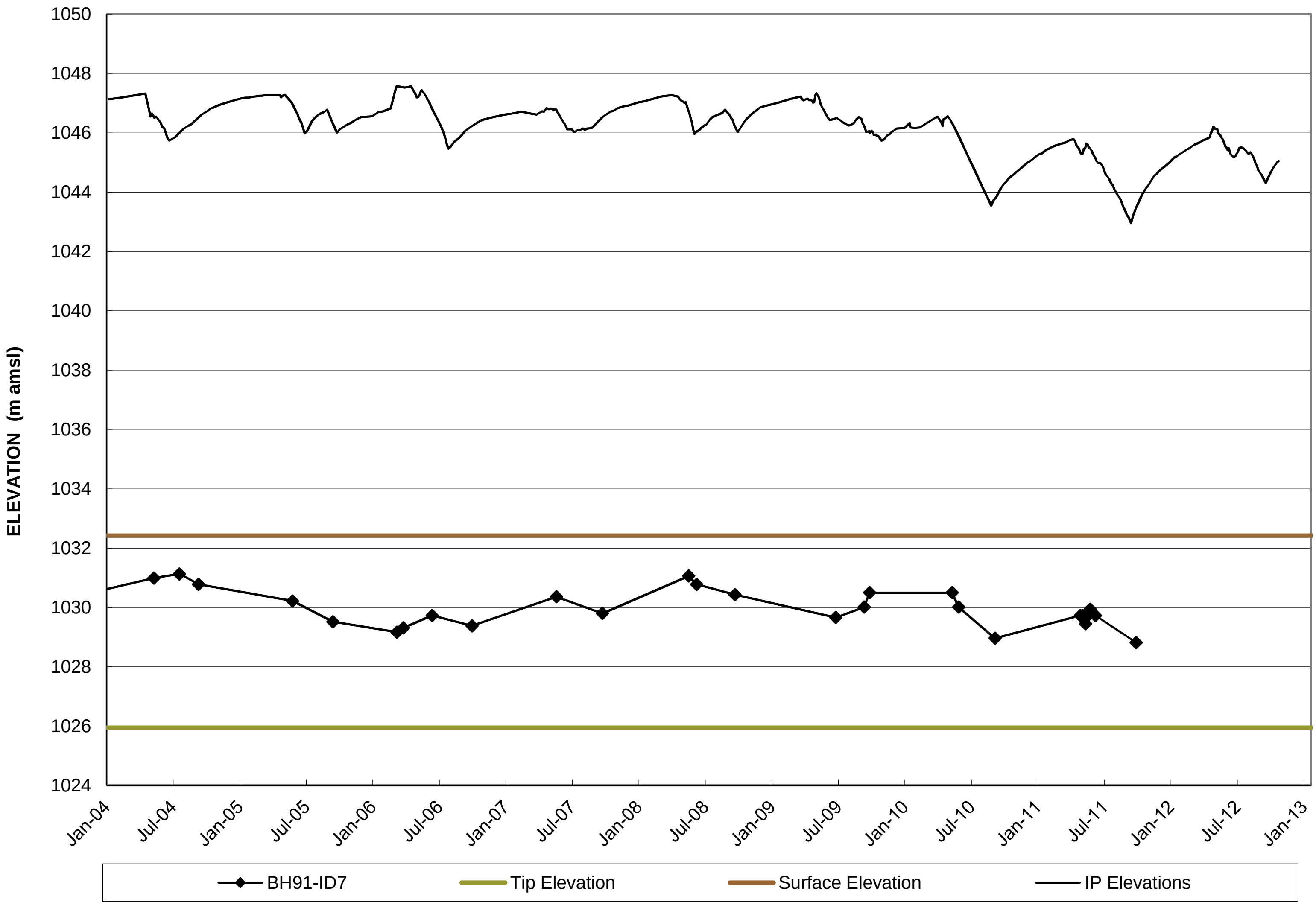


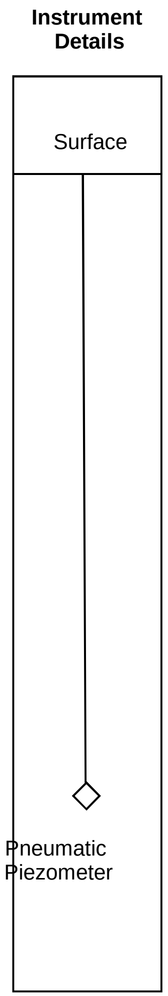
Intermediate Dam
Piezometer BH91-ID6



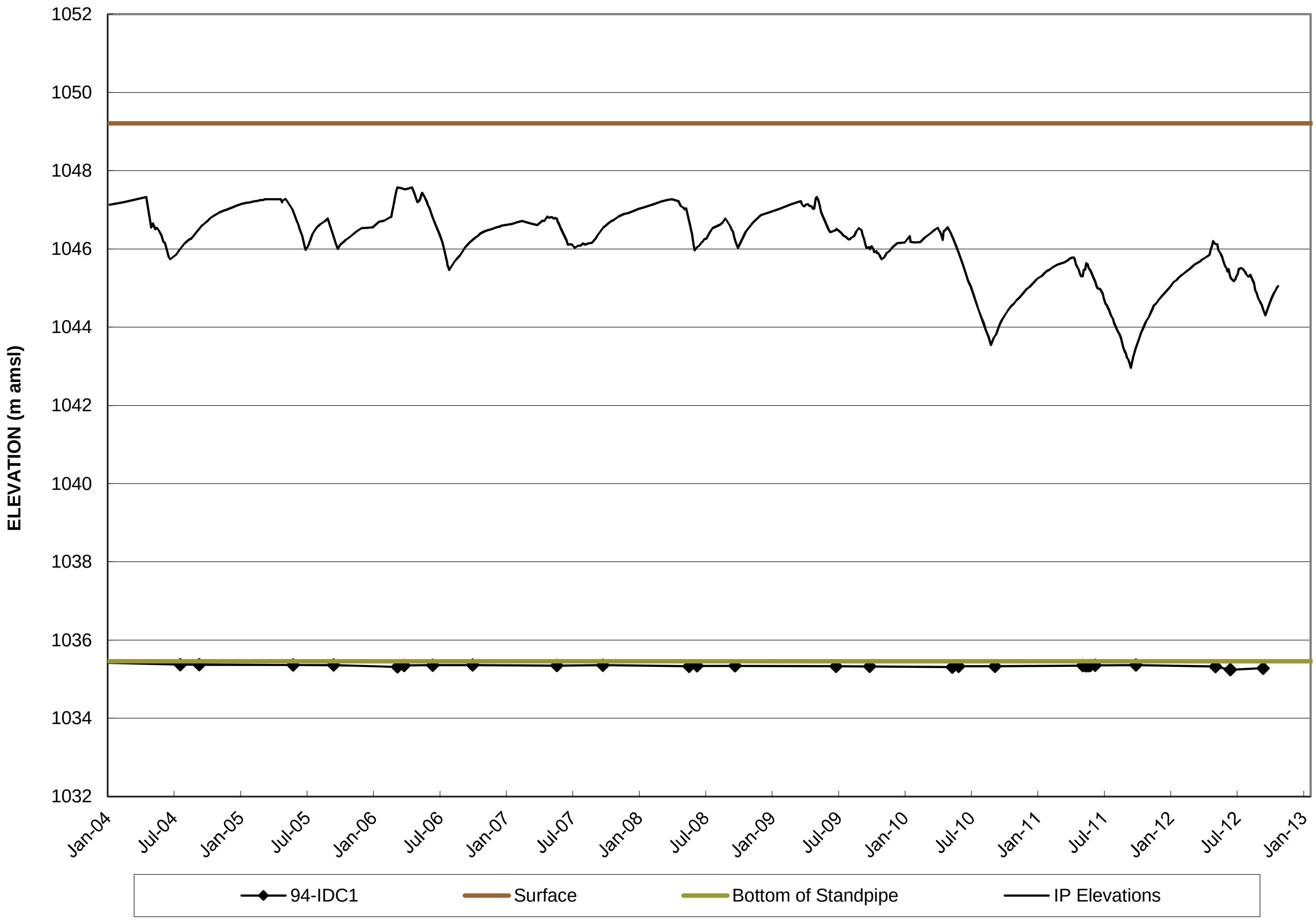


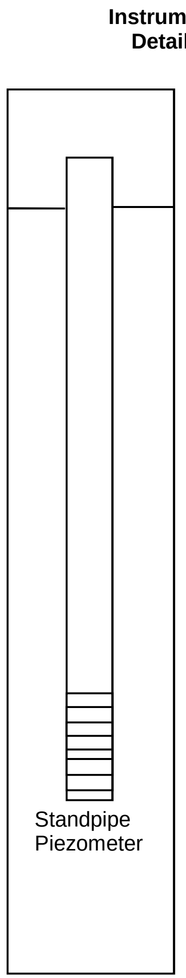
Intermediate Dam
Piezometer BH91-ID7



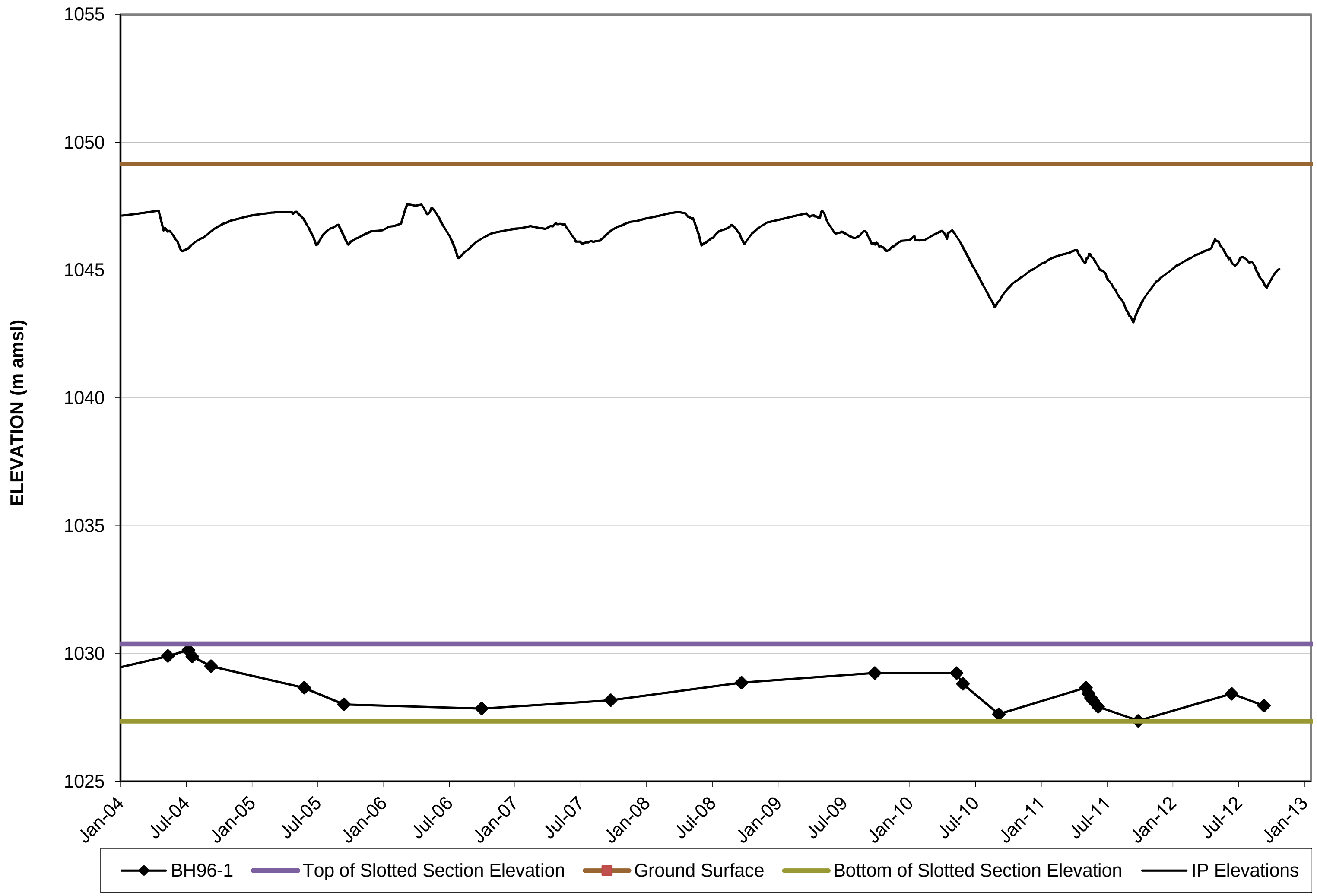


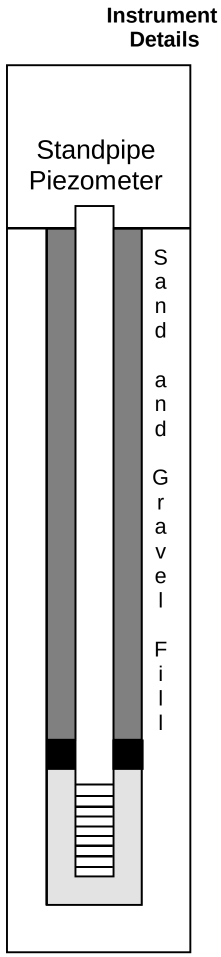
Intermediate Dam
Piezometer BH94-IDC-1



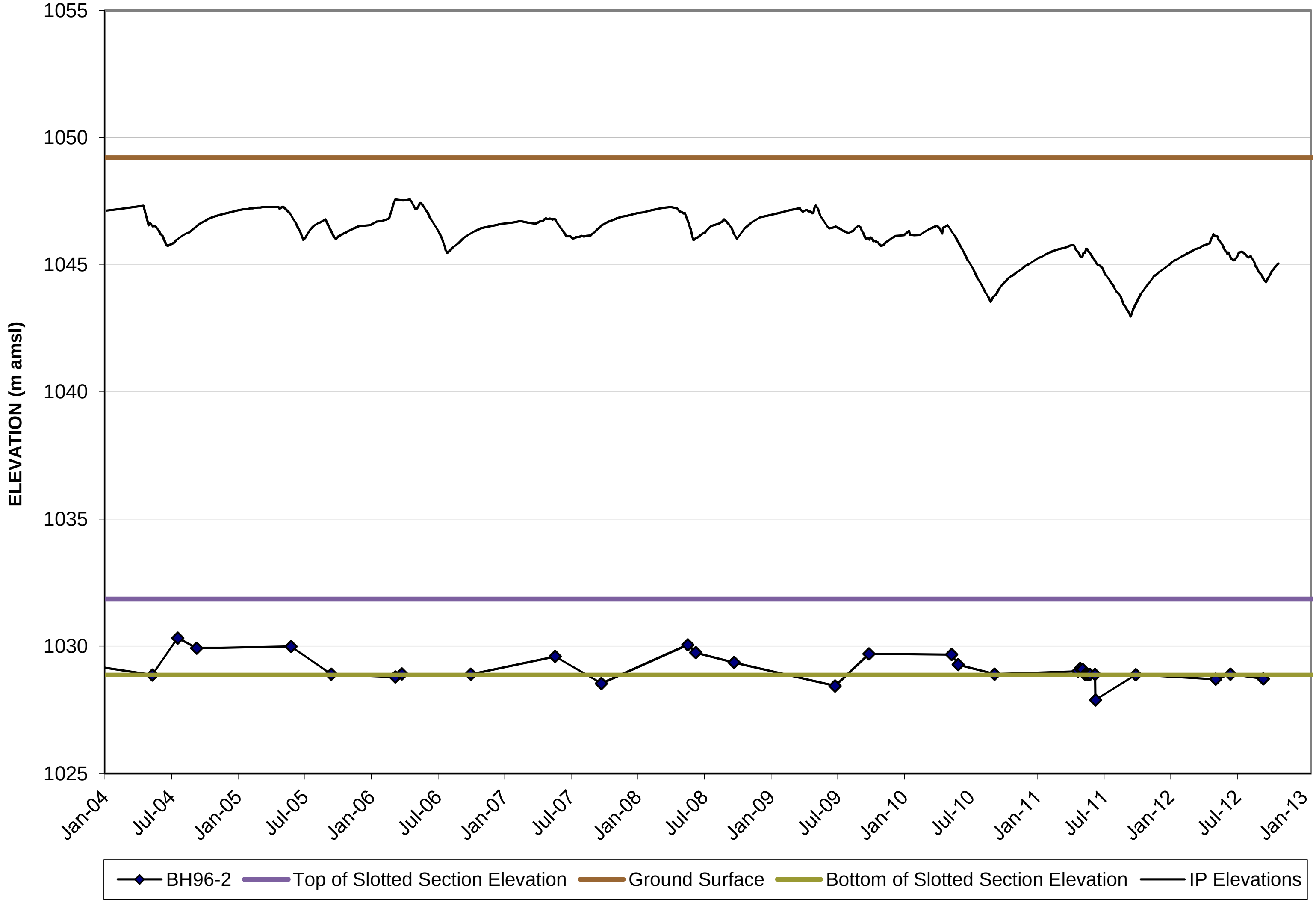


Intermediate Dam
Piezometer BH96-1

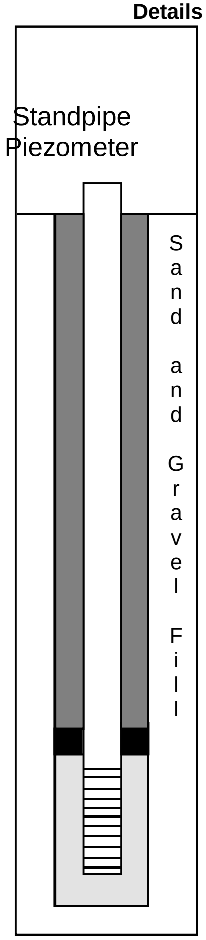




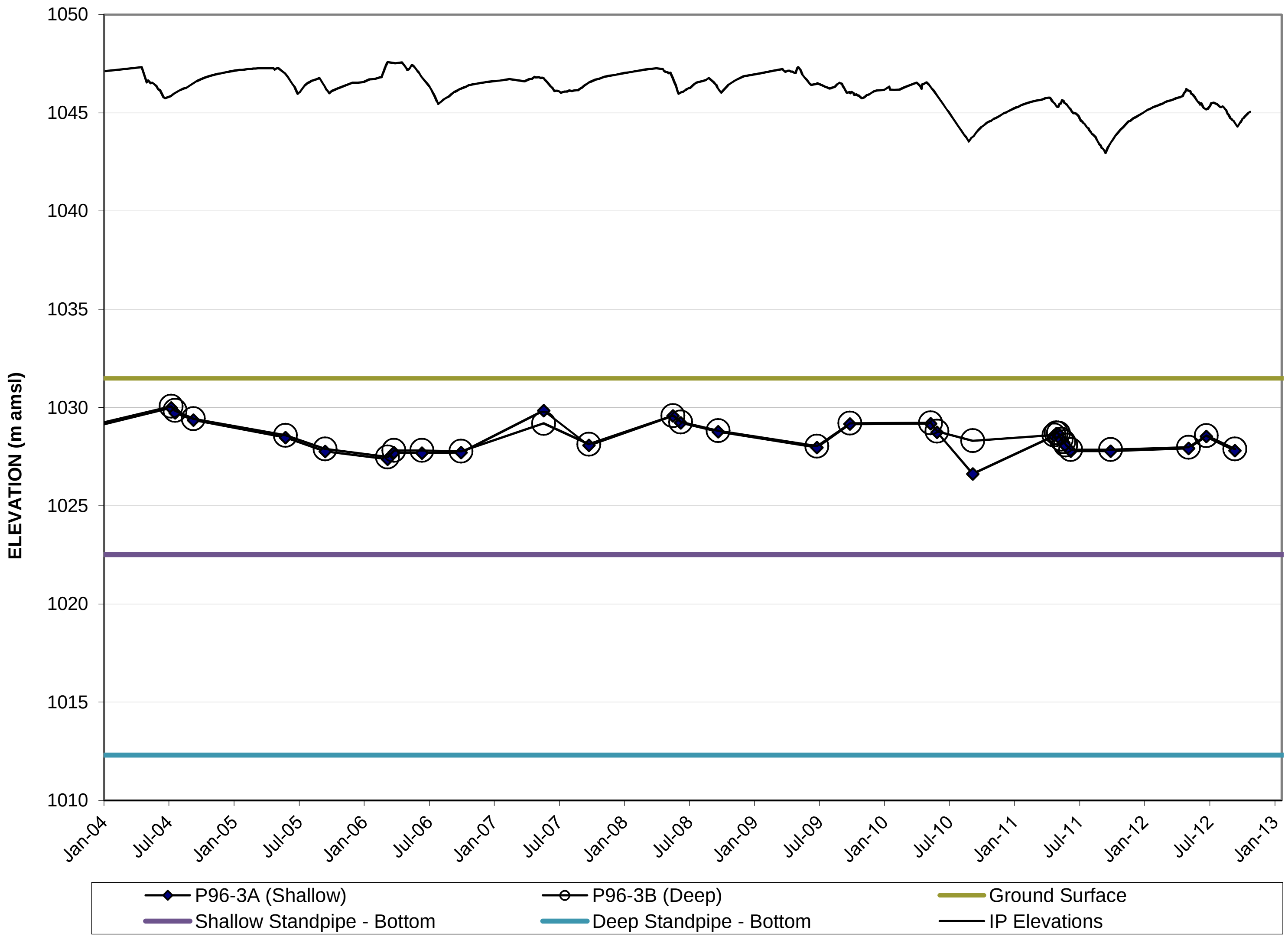
Intermediate Dam
Piezometer BH96-2

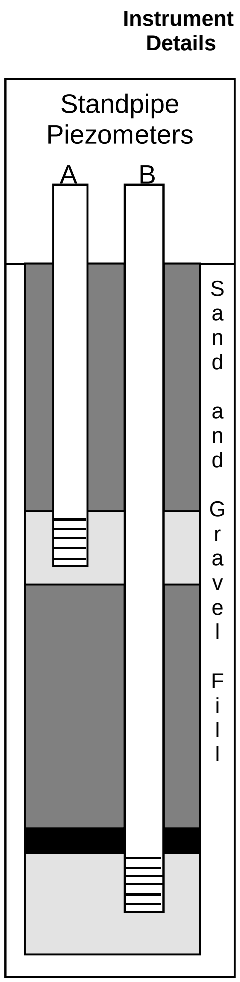


Instrument Details

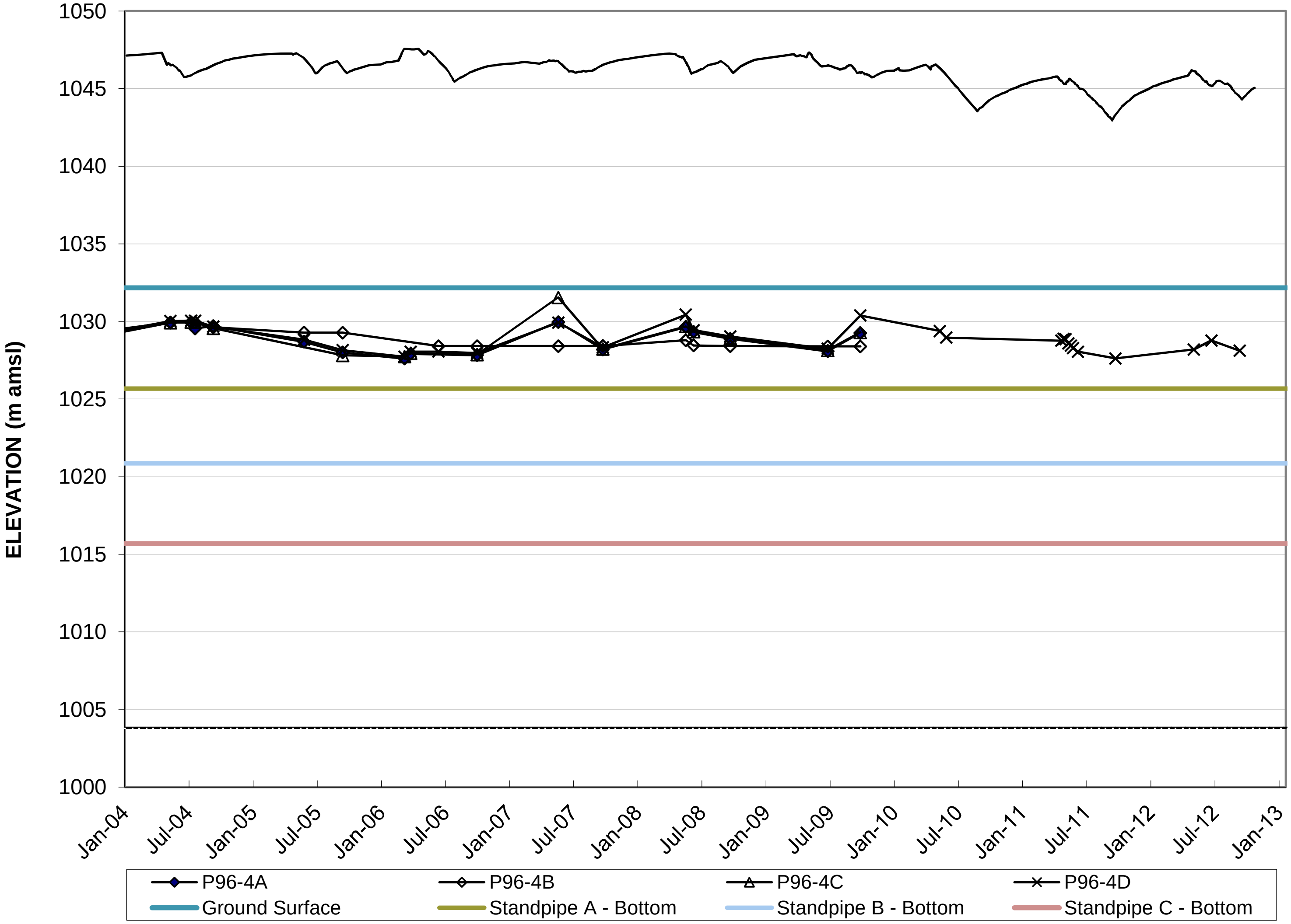


Intermediate Dam
Piezometer BH96-3





Intermediate Dam
Piezometer BH96-4



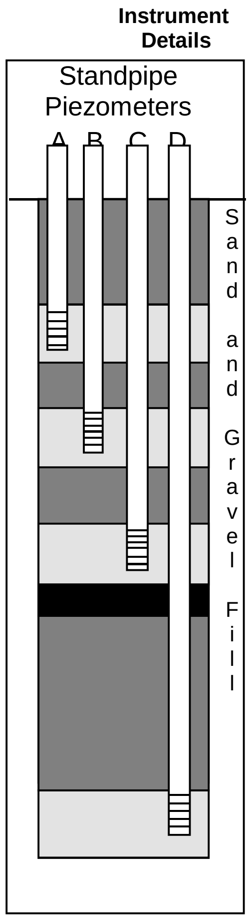
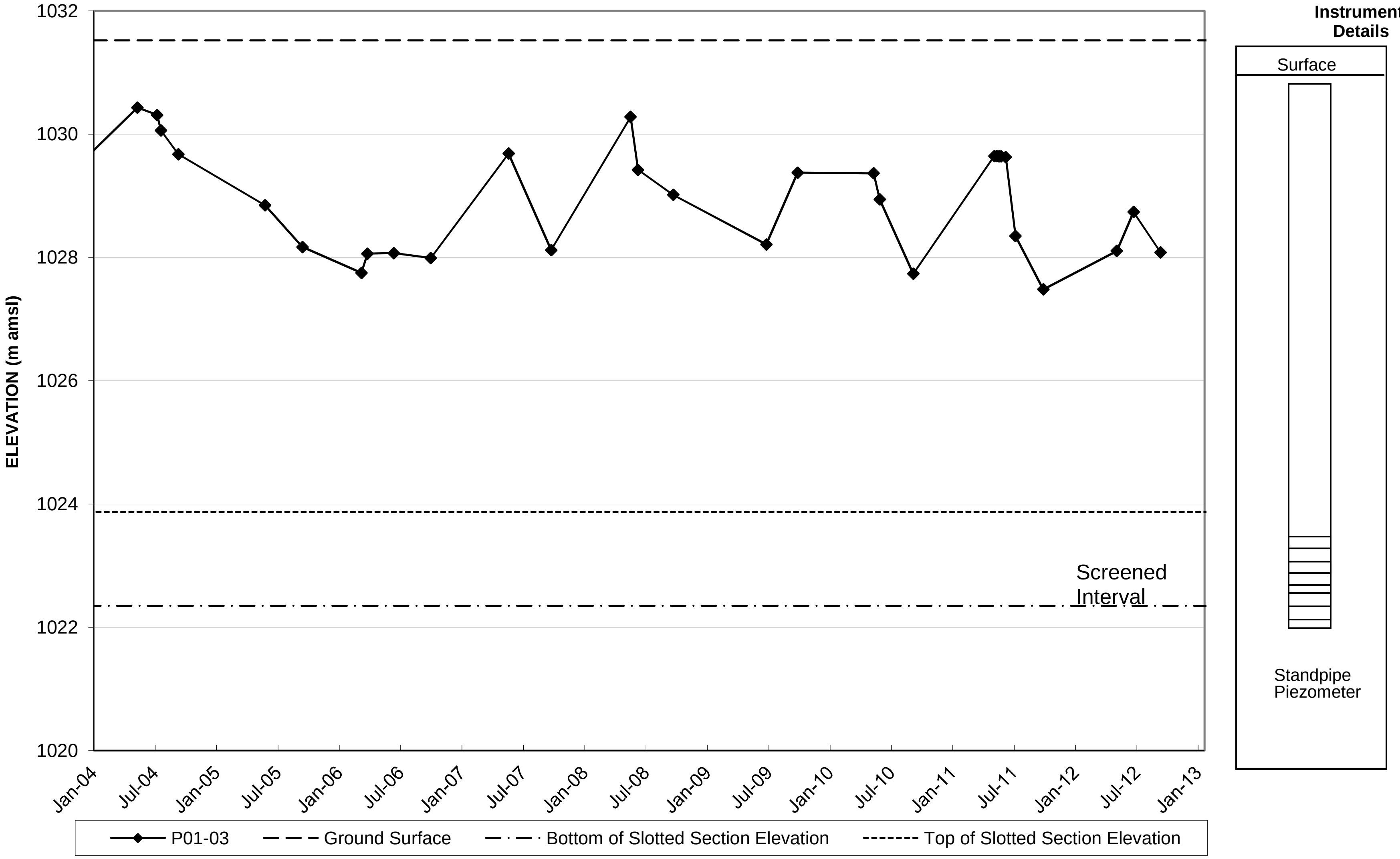
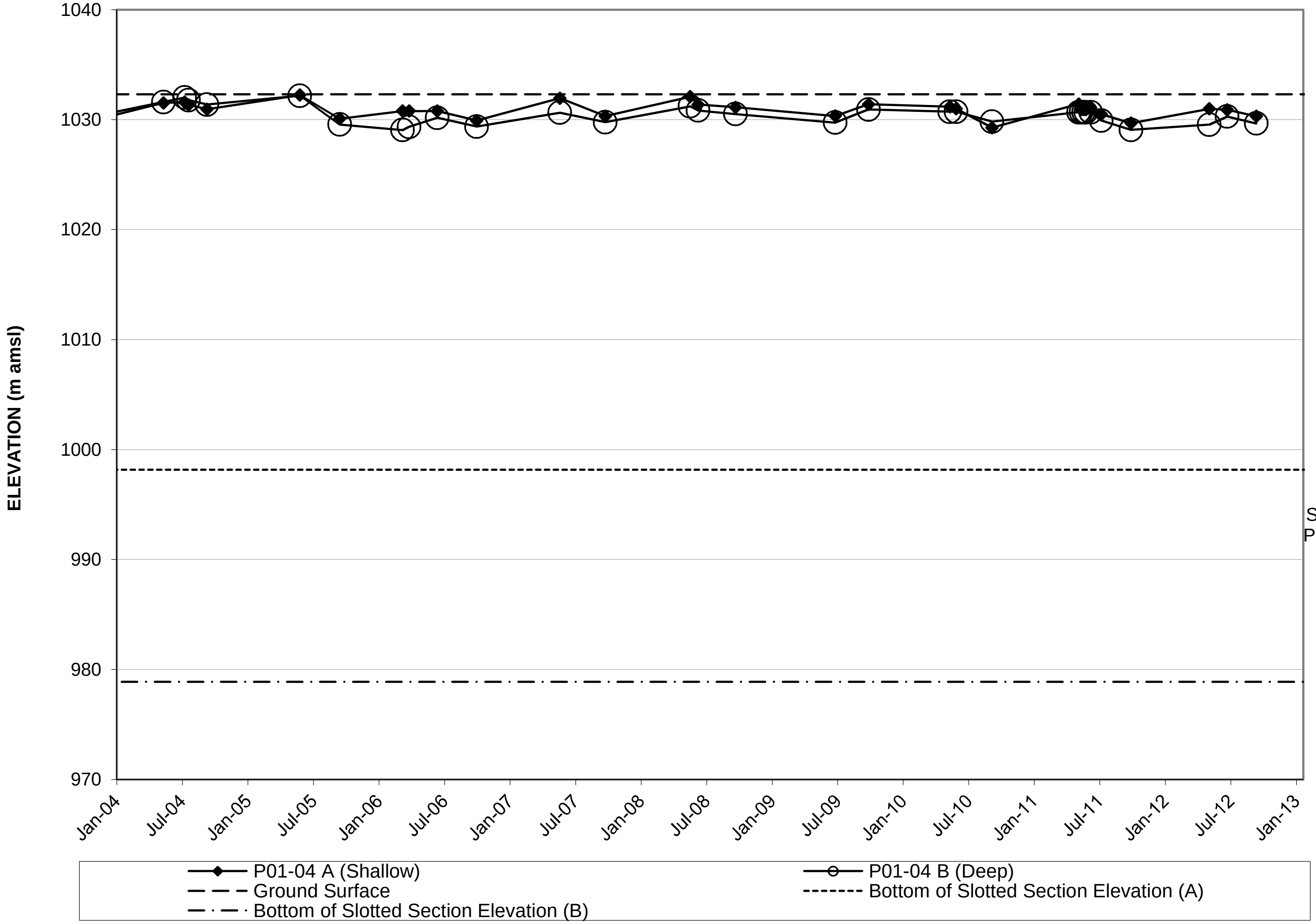
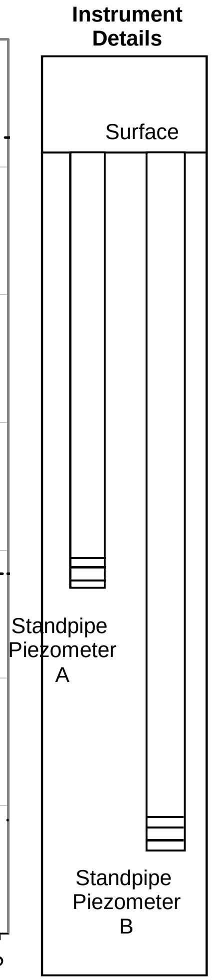


Figure H-34: Intermediate Dam
Piezometer P01-03

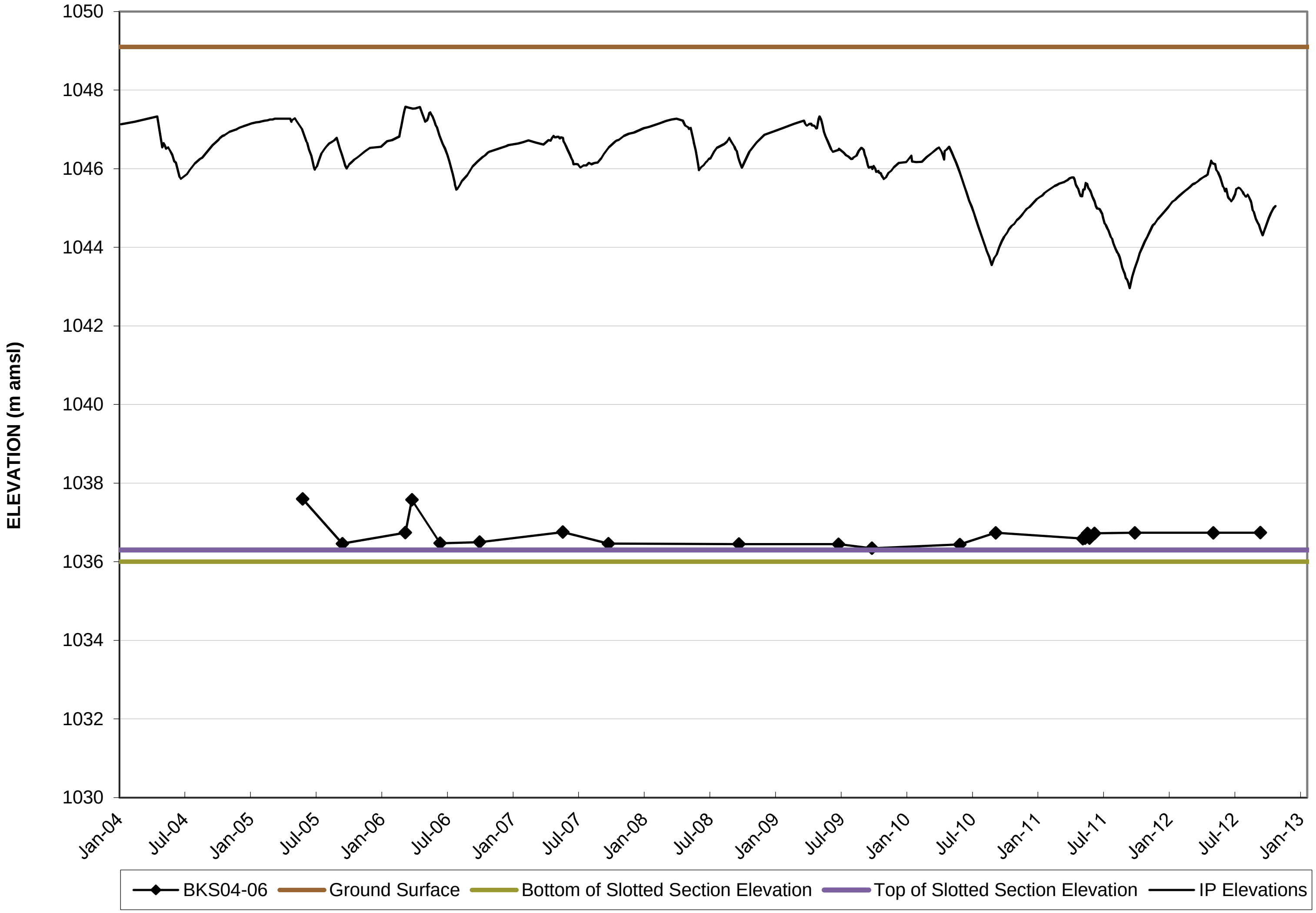


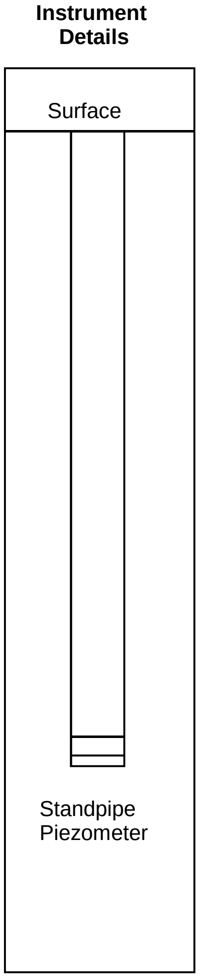
Intermediate Dam
Piezometer P01-04



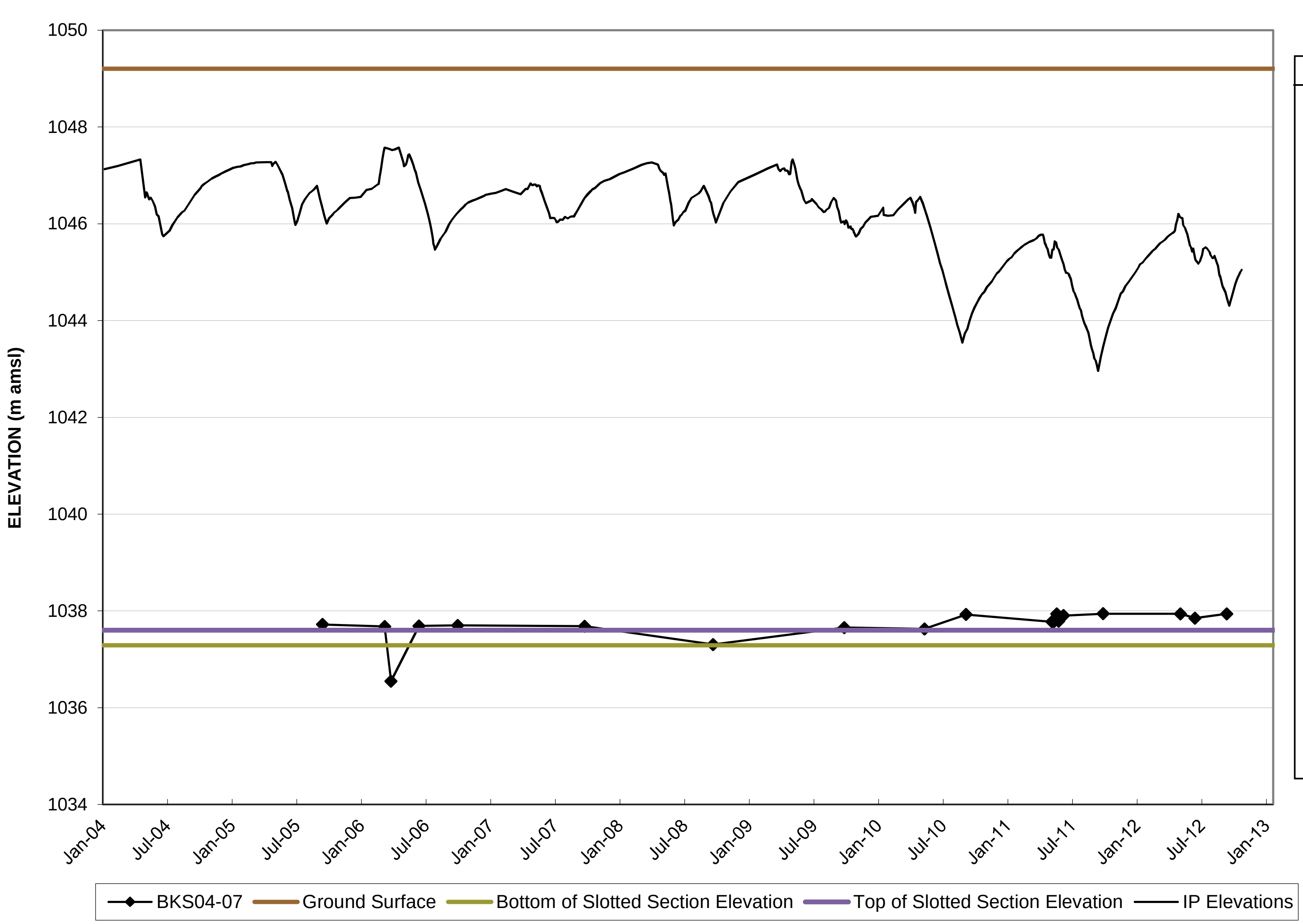


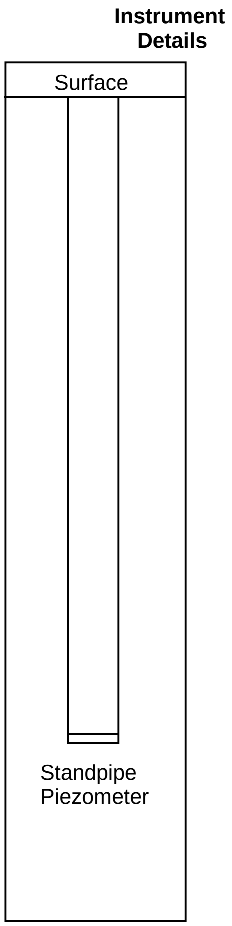
Intermediate Dam
Piezometer BKS04-06



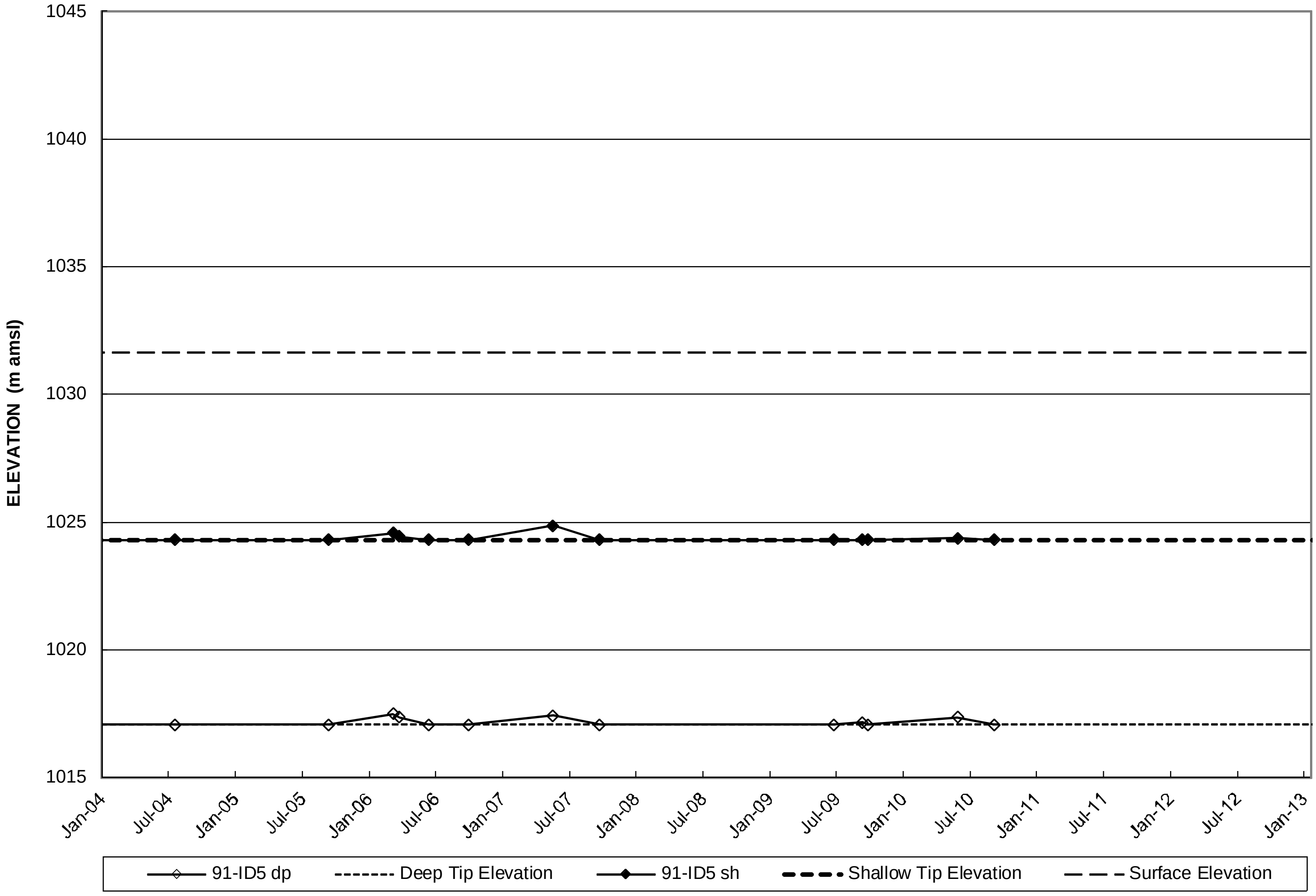


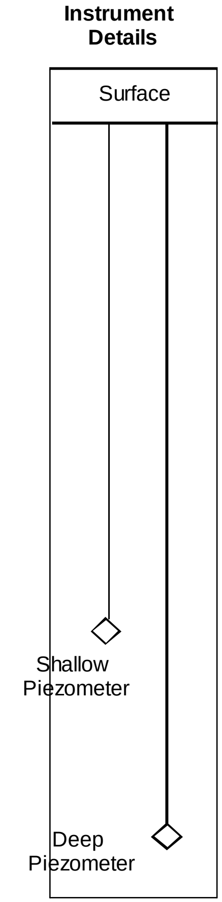
Intermediate Dam
Piezometer BKS04-07





Piezometric Monitoring
BH91-ID5 Pneumatic Piezometer (Both Tips)





Intermediate Dam
Piezometers - Cross Section 'A'

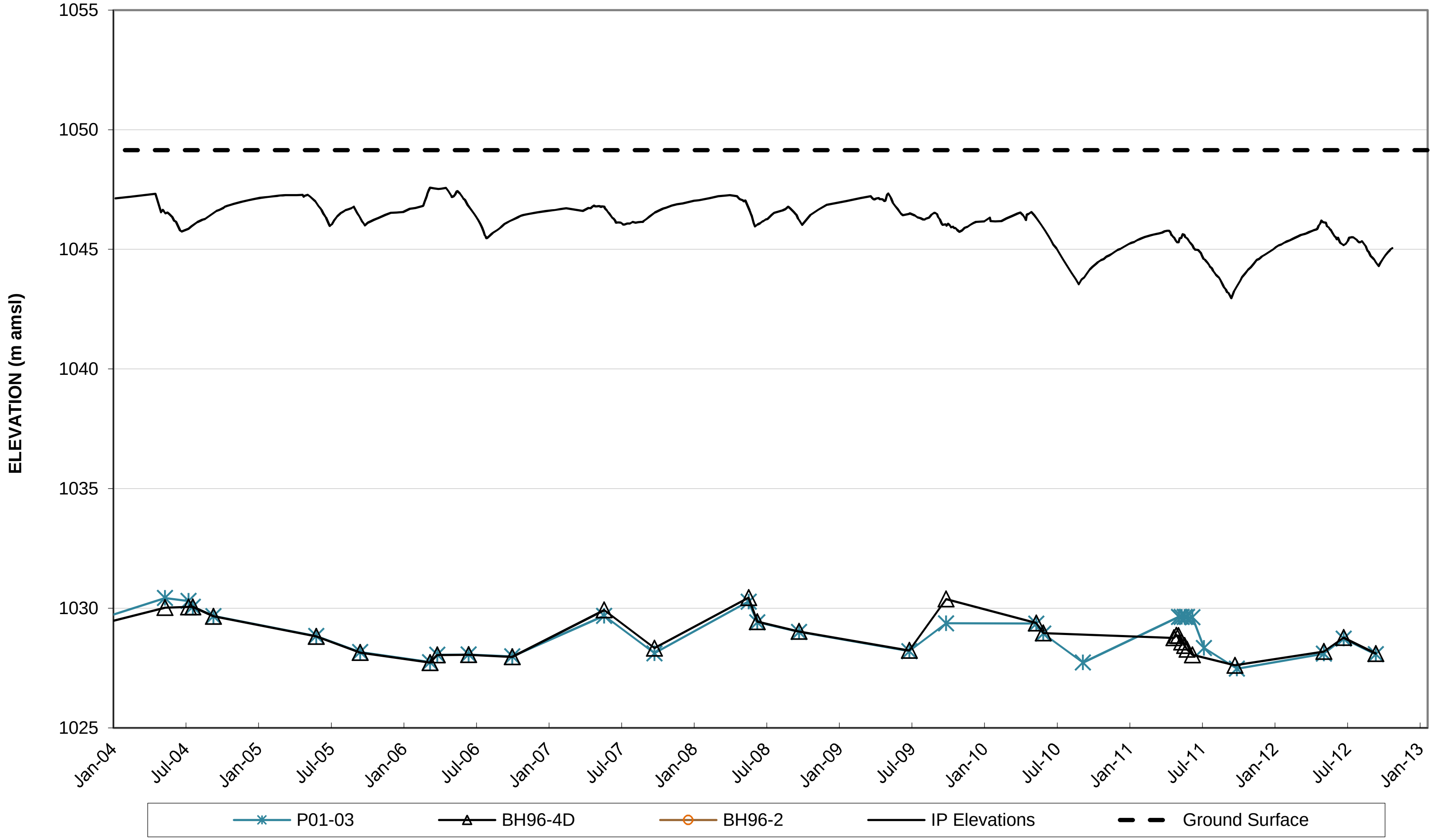
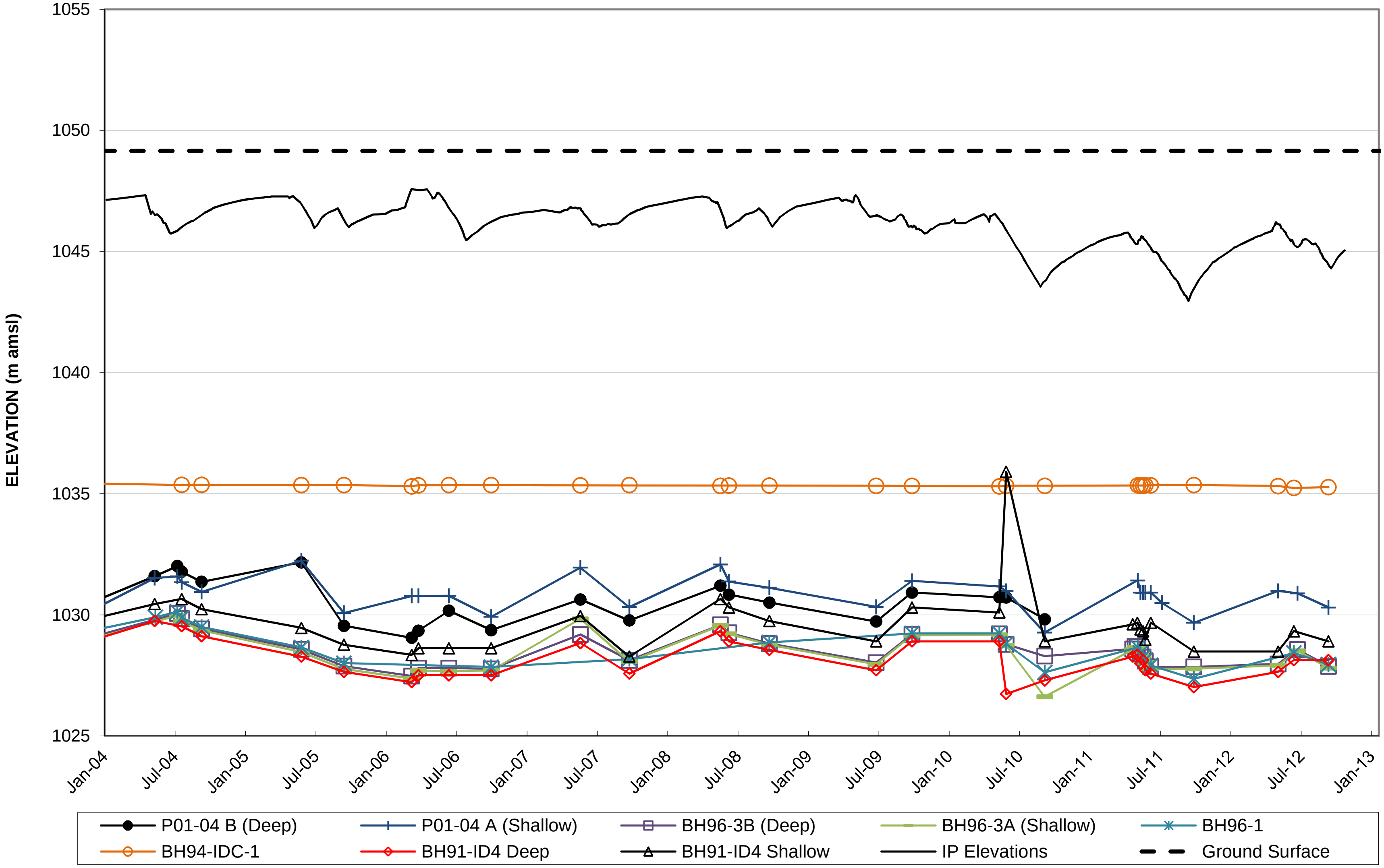
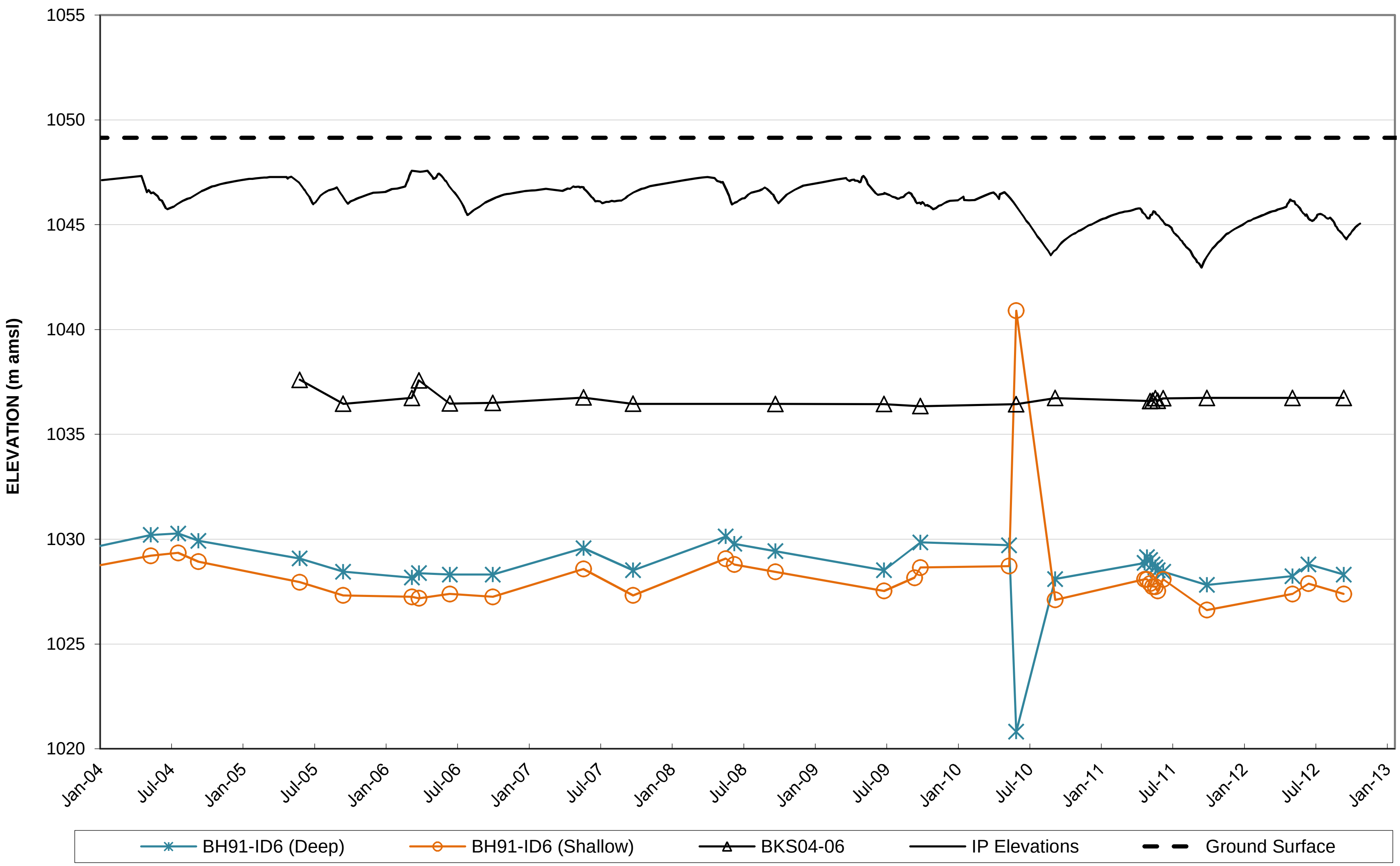


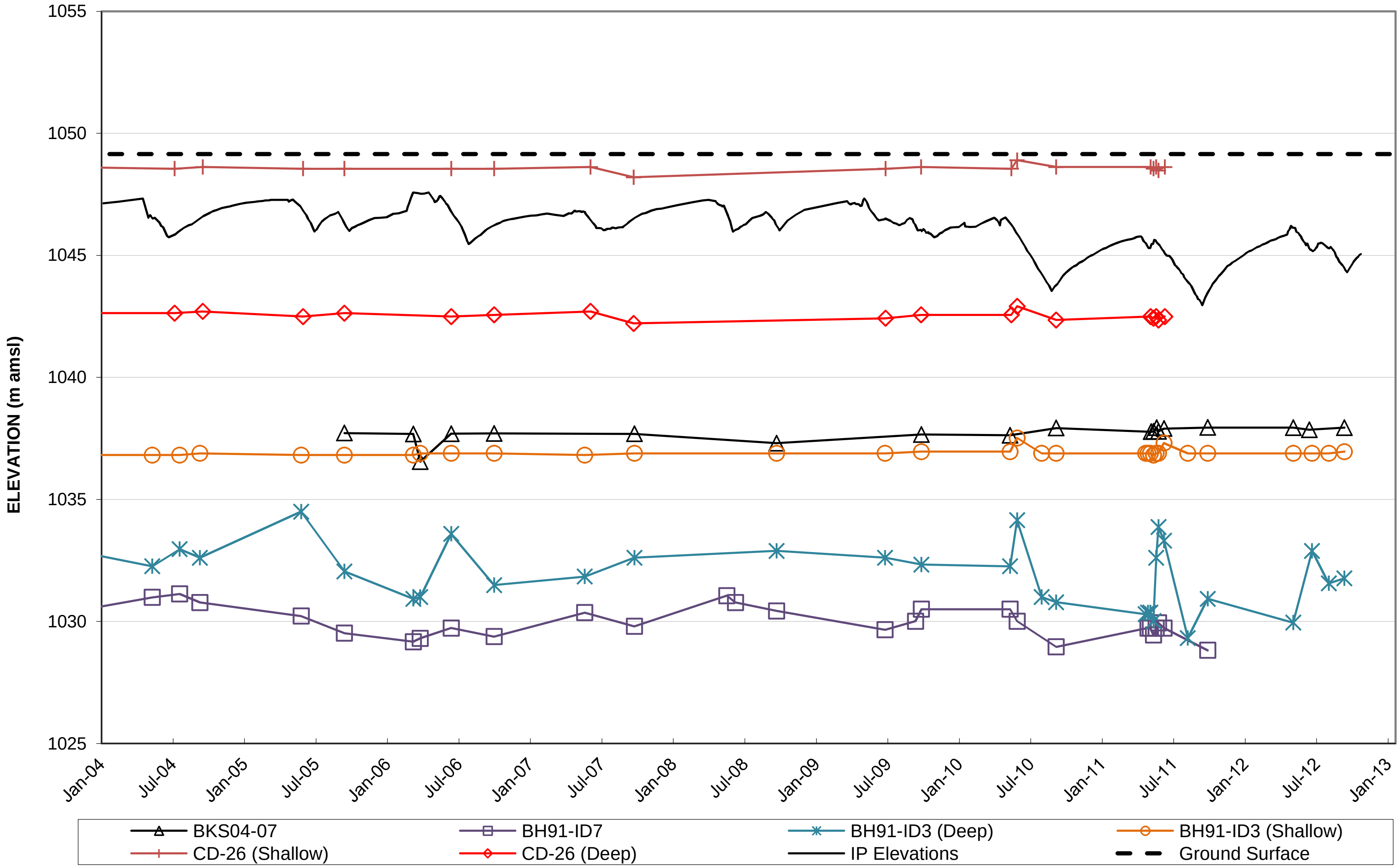
Figure H-39: Intermediate Dam Piezometers - Cross Section 'B'



Intermediate Dam
Piezometers - Cross Section 'C'

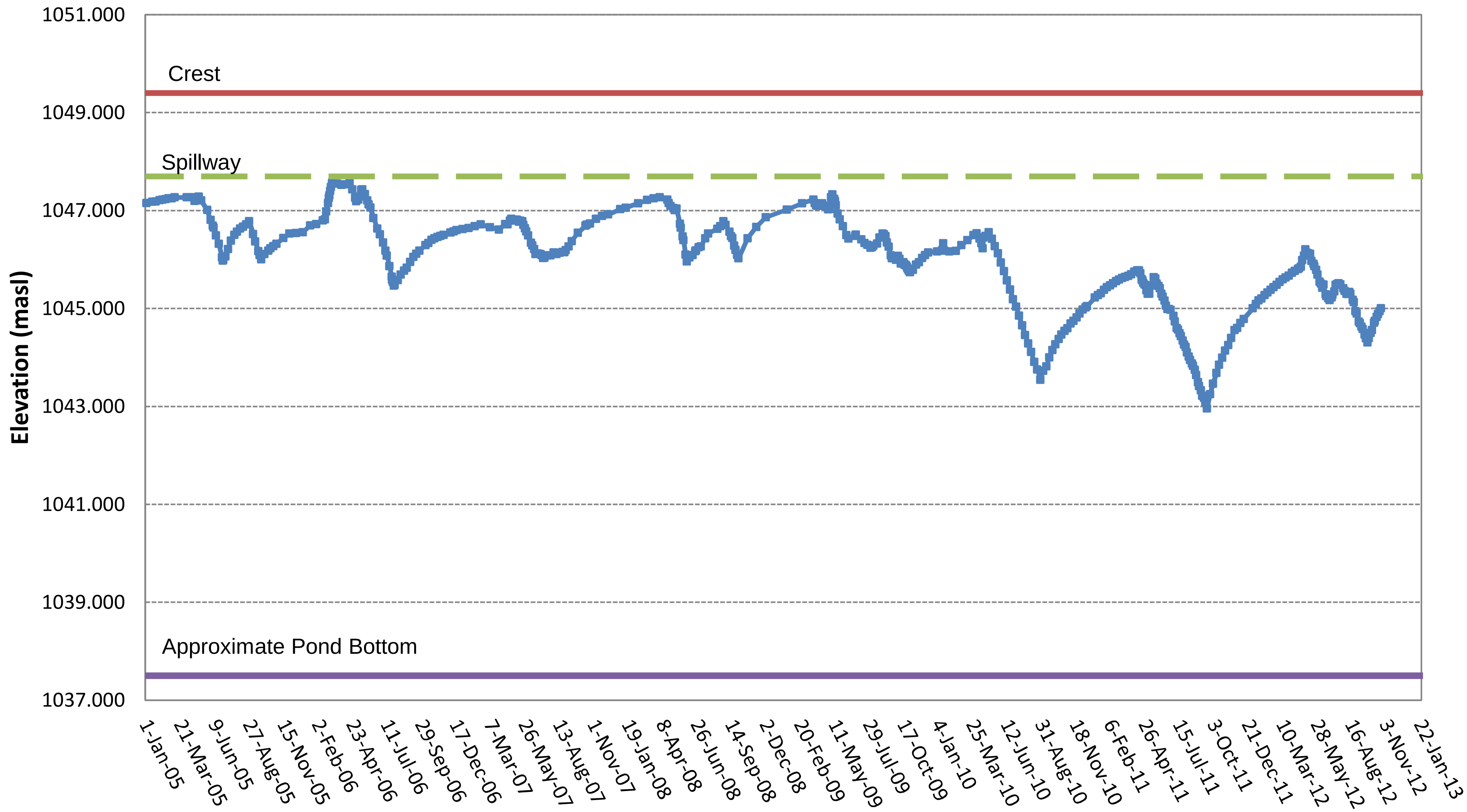


Intermediate Dam
Piezometers Cross Section 'S Abut'



H.2 – Pond Level (Intermediate Pond)

Intermediate Pond Water Elevations



APPENDIX II-I

Cross Valley Dam

I.1 – Piezometers

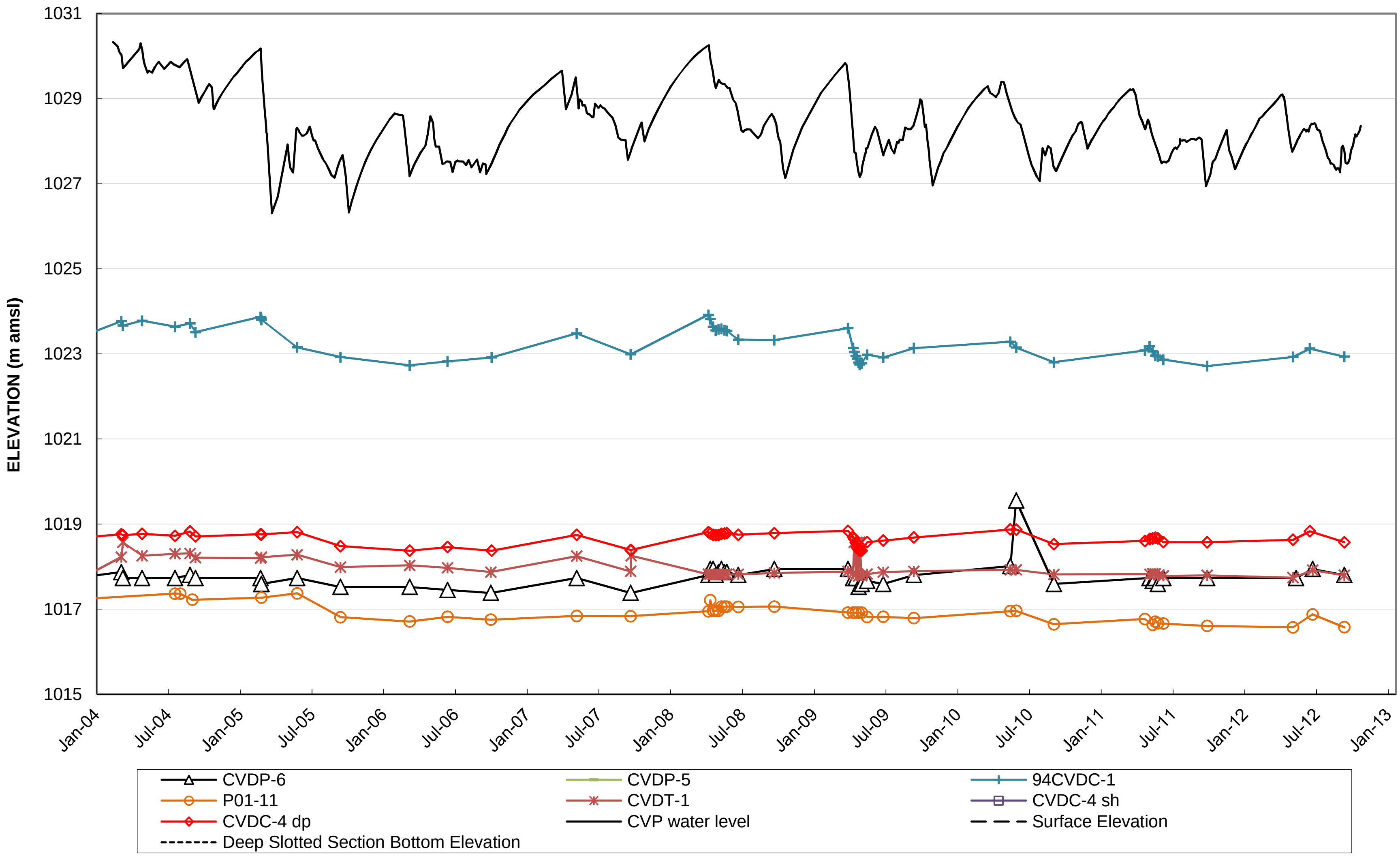
I.2 - Thermistors

I.3 – Pond Level (Polishing Pond)

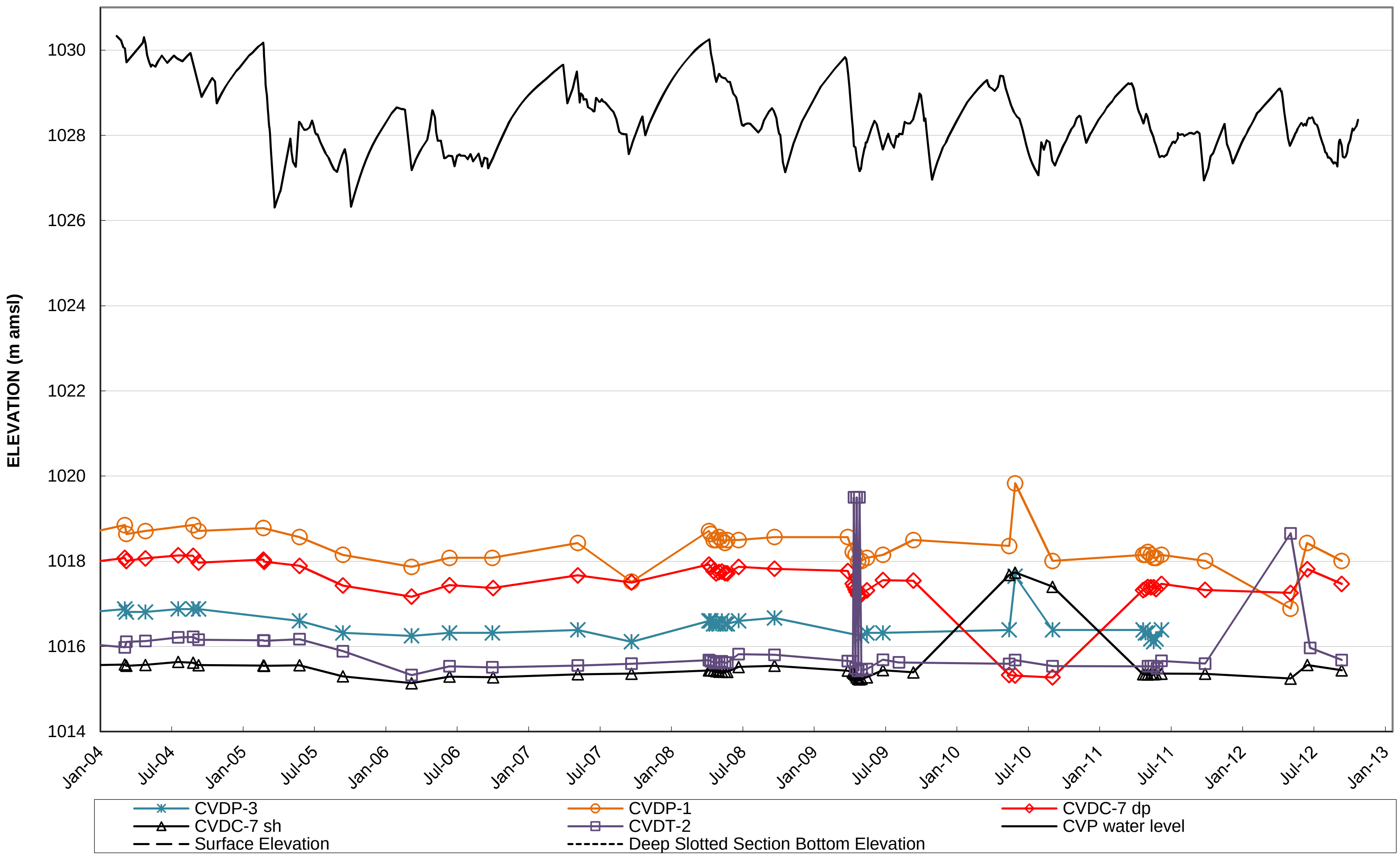
I.4 – Downstream Weir Flow

I.1 – Piezometers

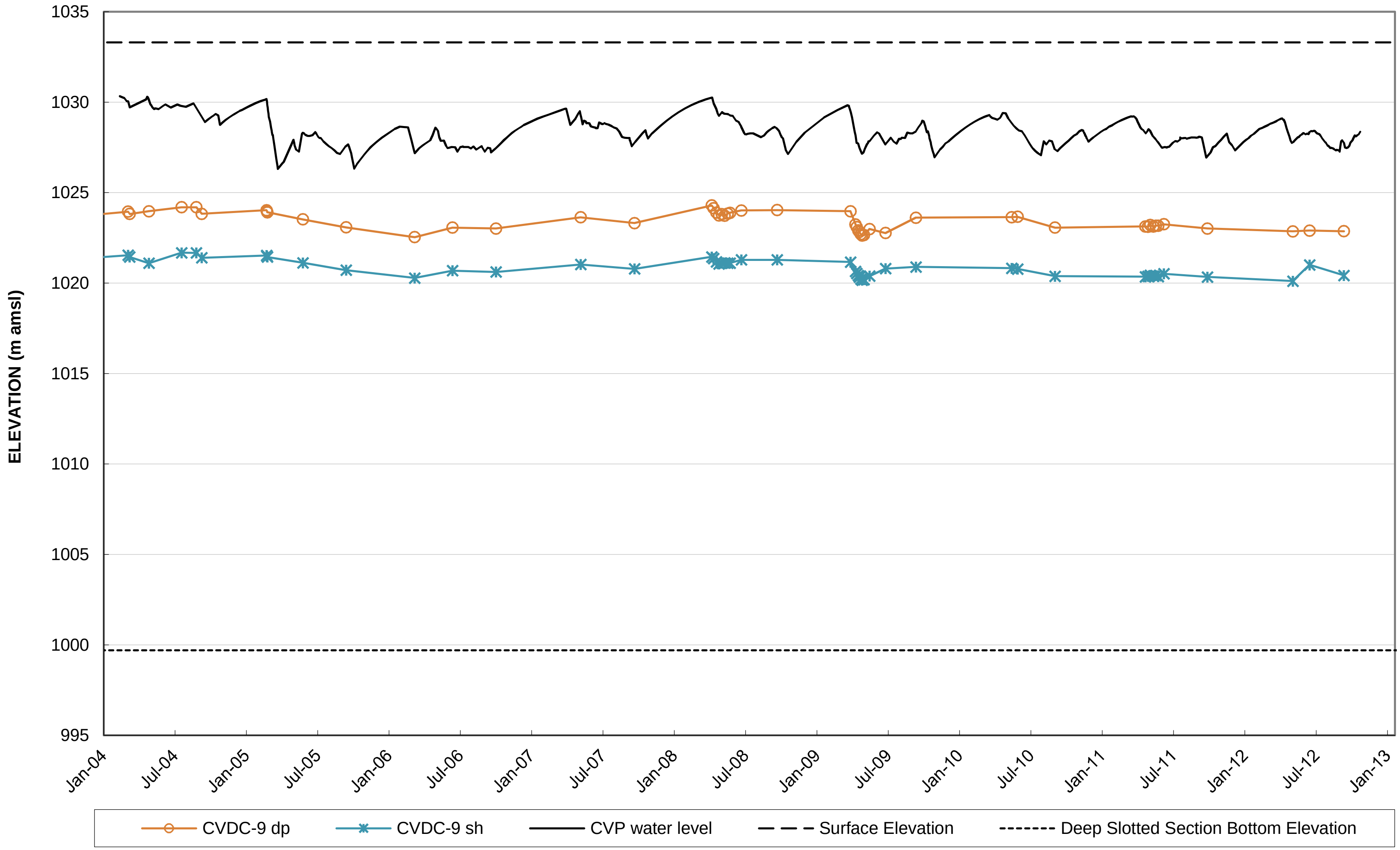
Cross Valley Dam
Piezometers - Cross Section 'D'



Cross Valley Dam
Piezometers - Cross Section 'E'

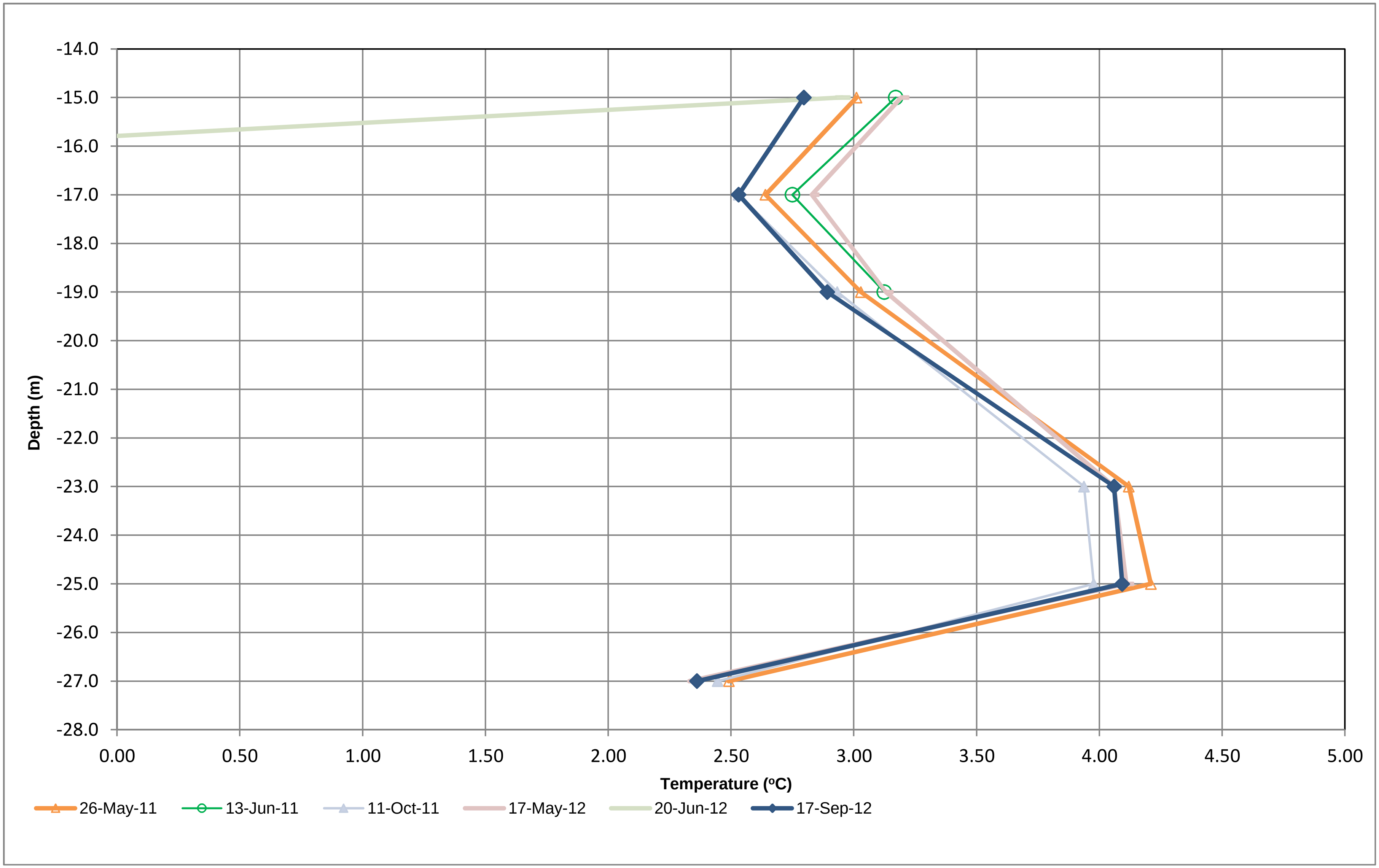


Cross Valley Dam
Piezometers Cross Section 'F'

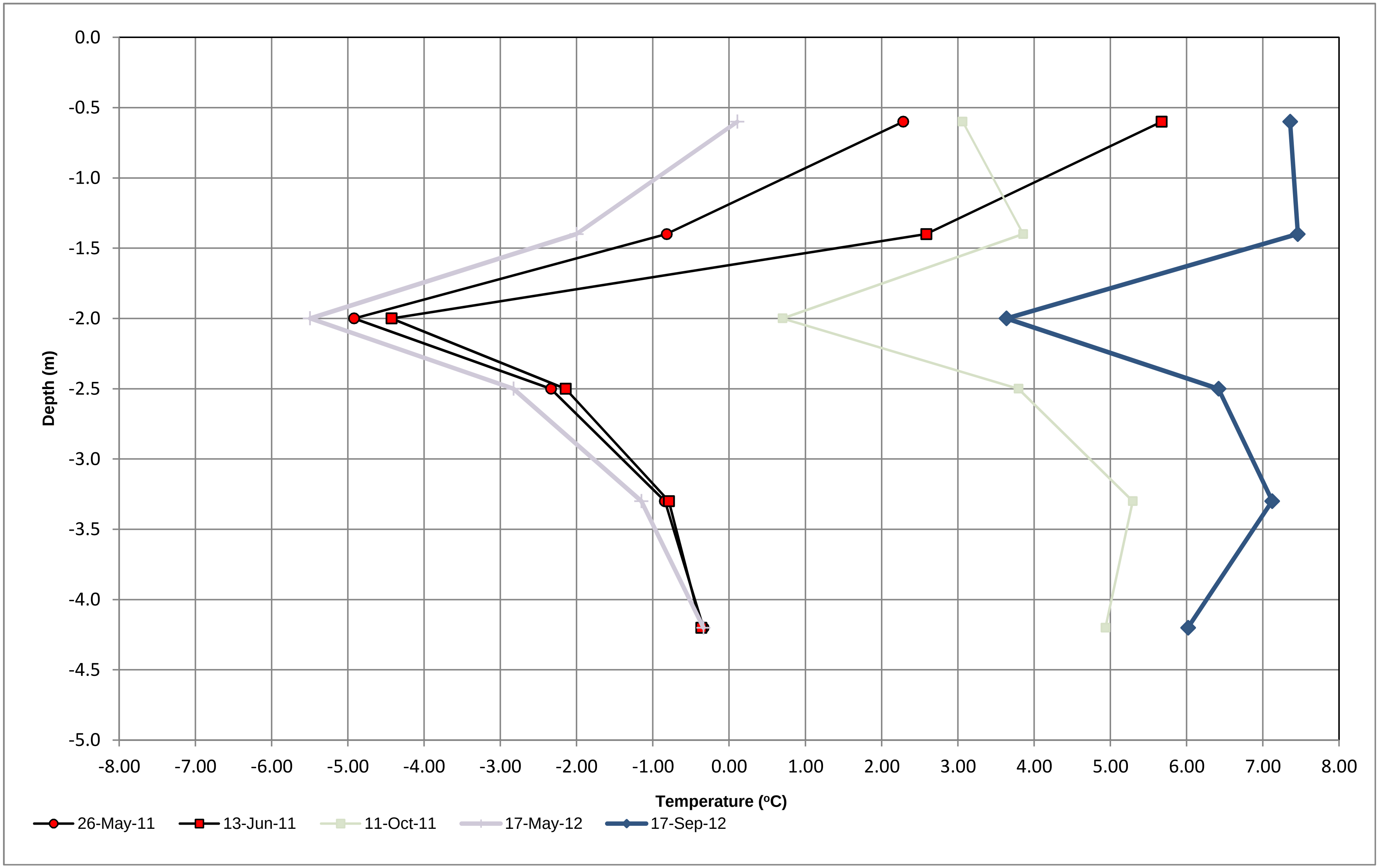


I.2 – Thermistors

Cross Valley Dam
Thermistor CVDC-6



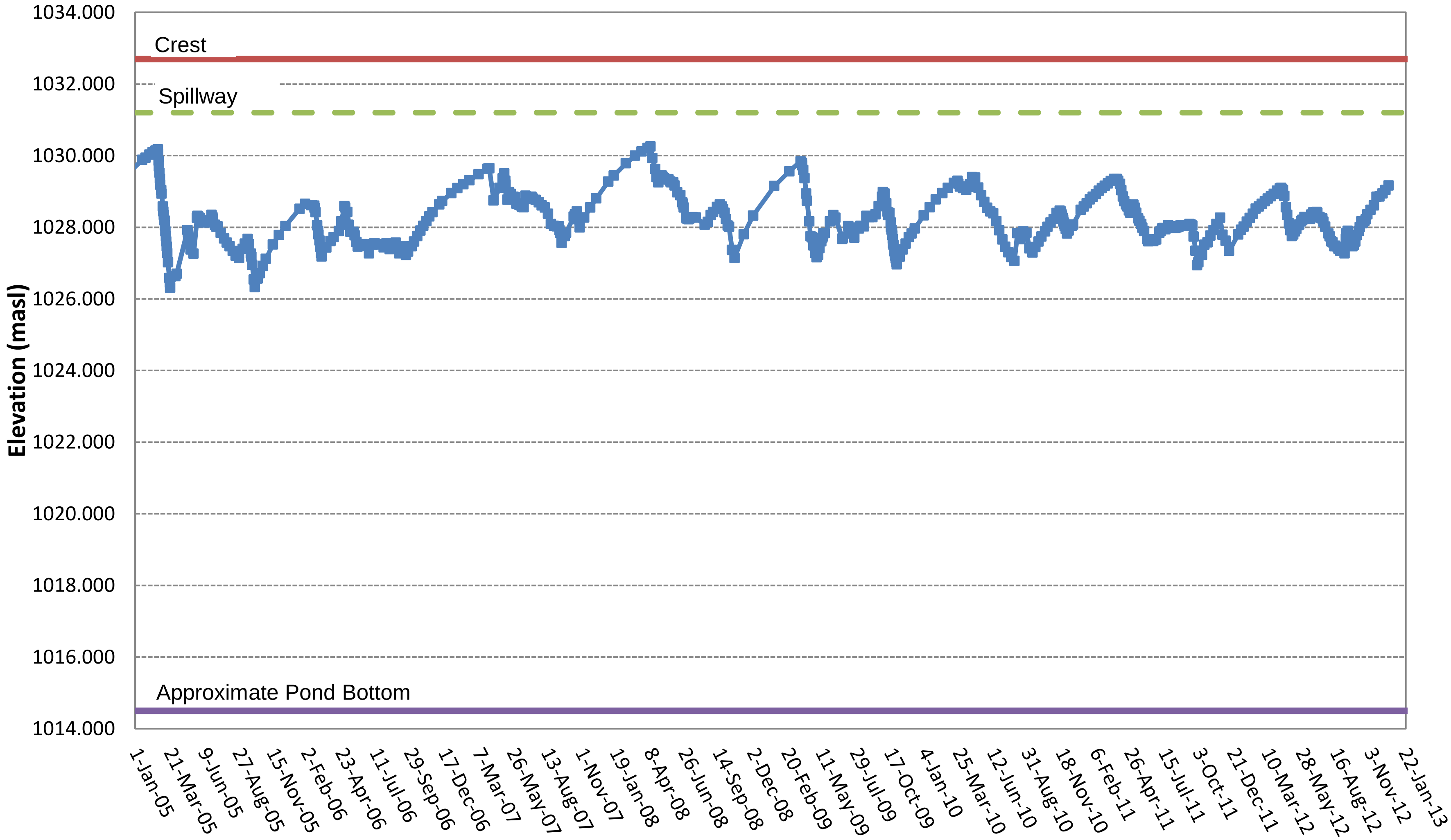
Cross Valley Dam
Thermistor BH88-4



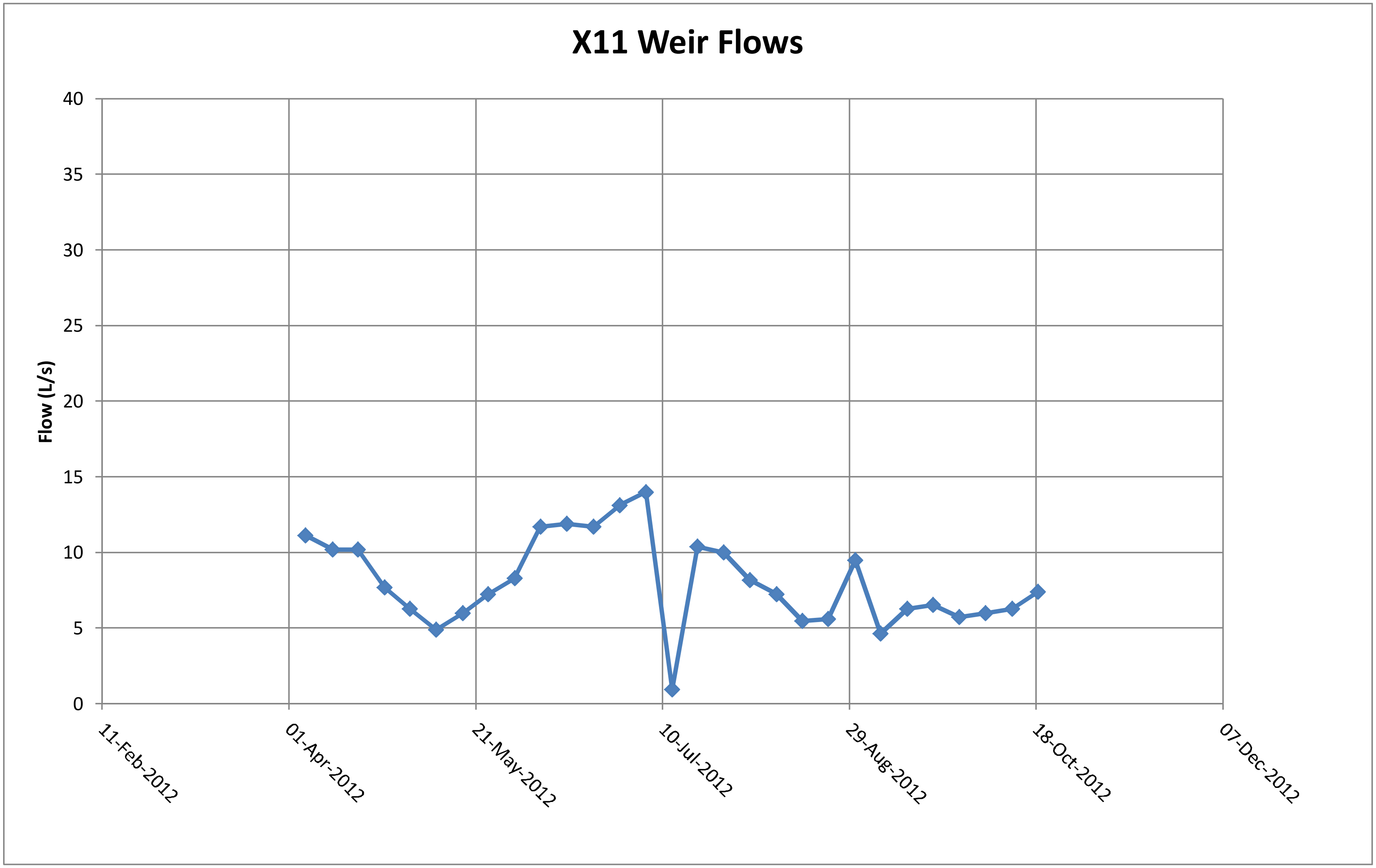
I-2. CVD Thermistors.xlsx
M09770A02.730

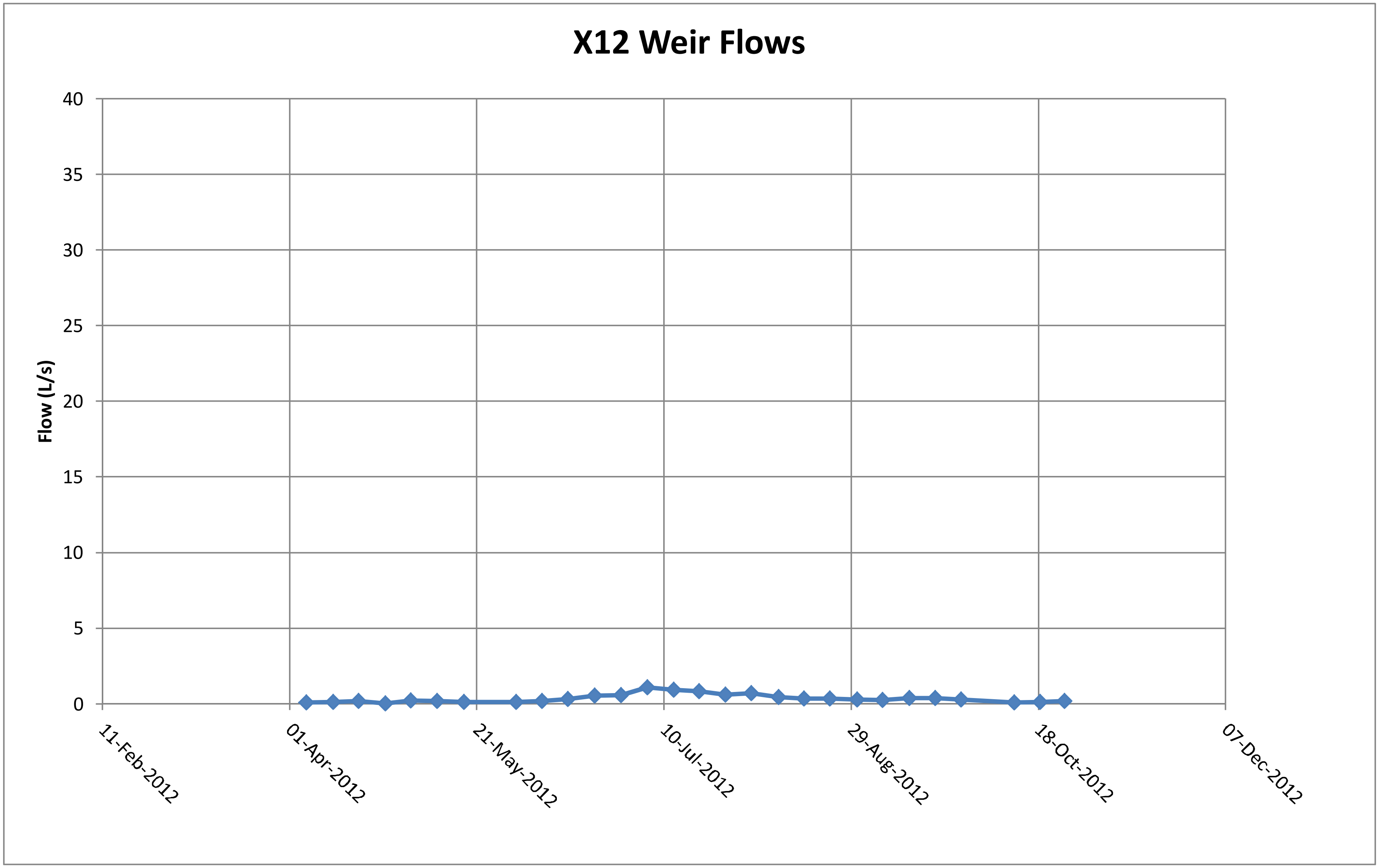
I.3 – Pond Level (Polishing Pond)

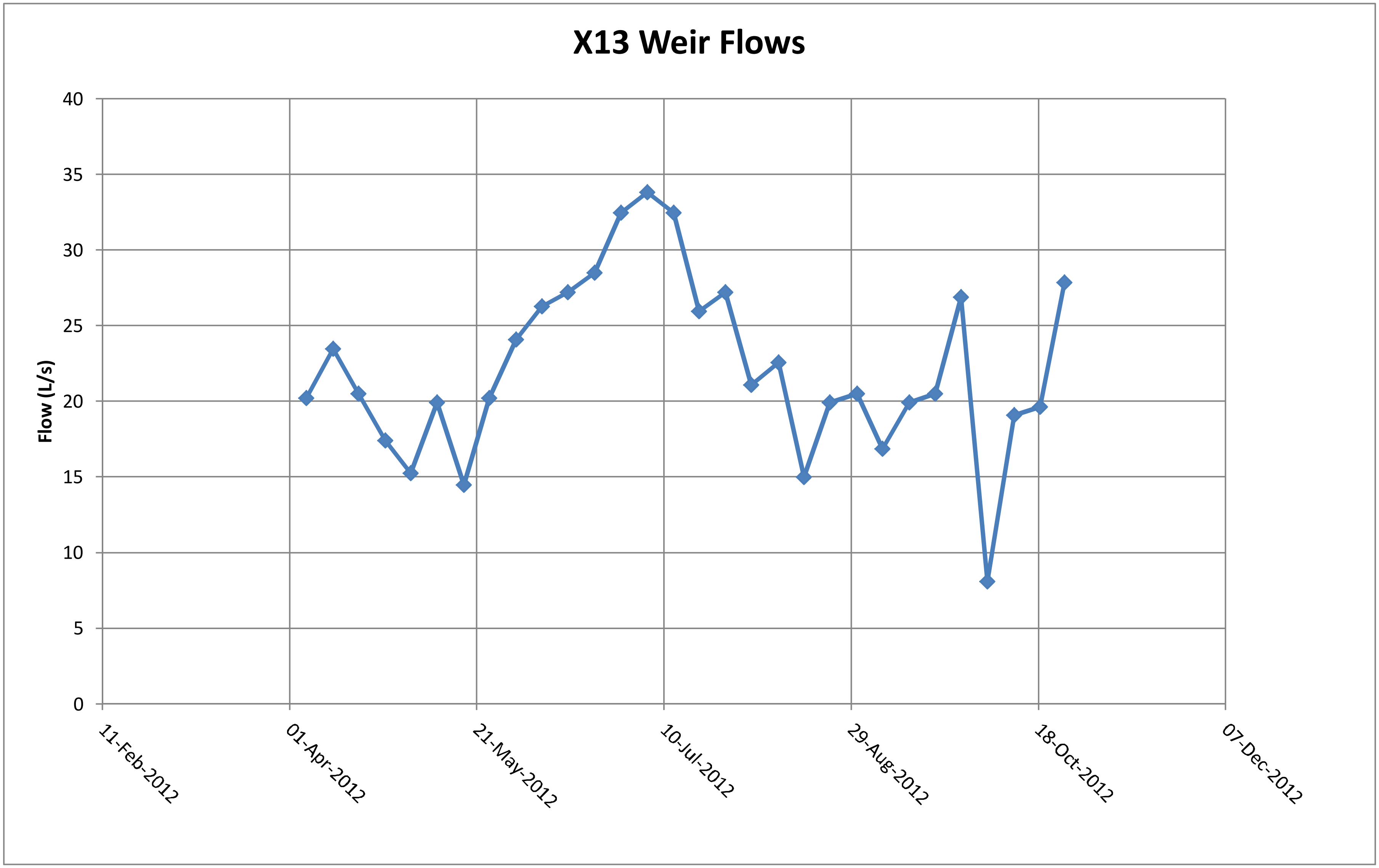
Polishing Pond Water Elevations



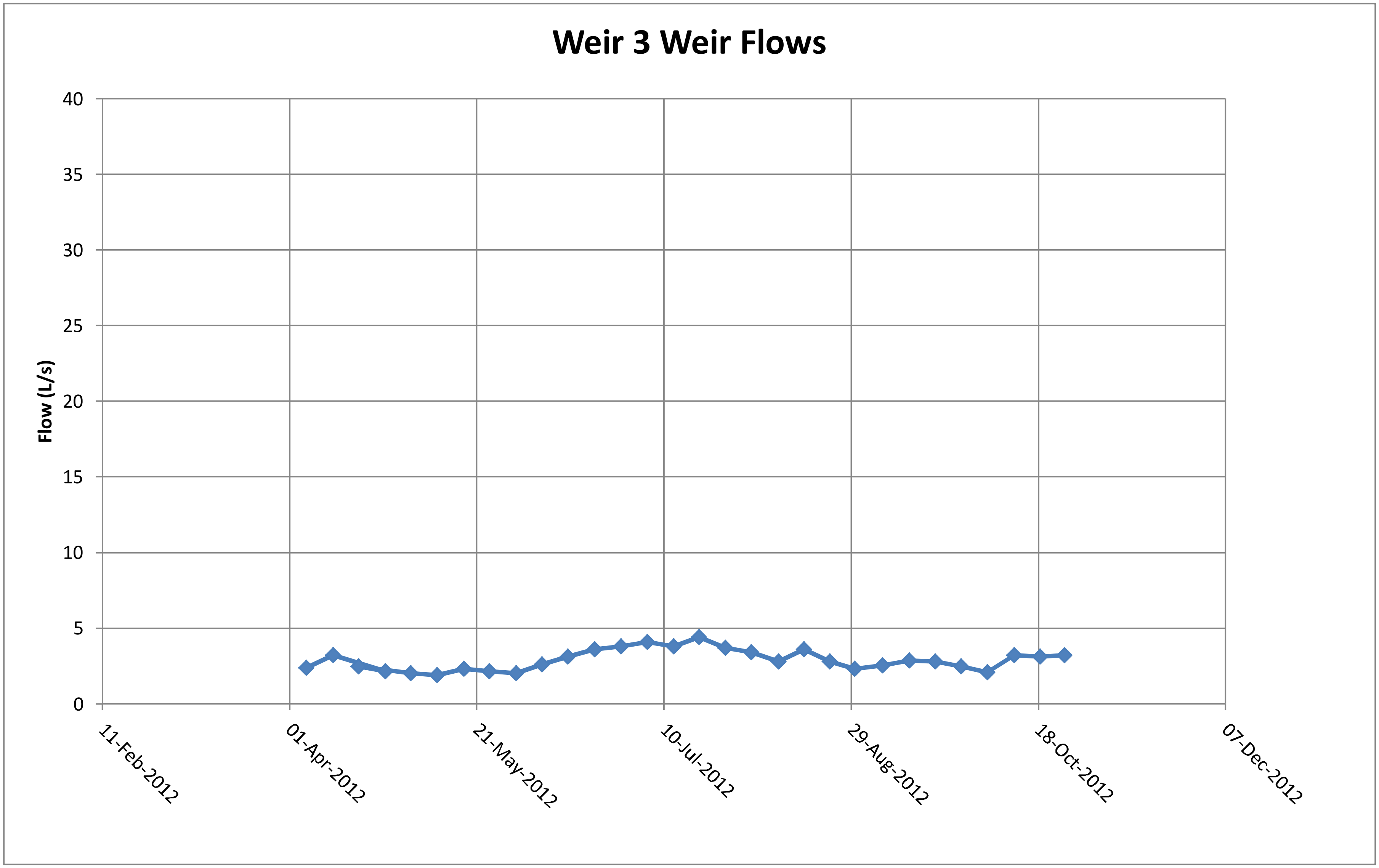
I.4 – Downstream Weir Flow


X11 Weir Flows
Flow (L/s)
40
35
30
25
20
15
10
5
0
11-Feb-2012
01-Apr-2012
21-May-2012
10-Jul-2012
29-Aug-2012
18-Oct-2012
07-Dec-2012


X12 Weir Flows
Flow (L/s)
40
35
30
25
20
15
10
5
0
11-Feb-2012
01-Apr-2012
21-May-2012
10-Jul-2012
29-Aug-2012
18-Oct-2012
07-Dec-2012



X13 Weir Flows
Flow (L/s)
40
35
30
25
20
15
10
5
0
11-Feb-2012
01-Apr-2012
21-May-2012
10-Jul-2012
29-Aug-2012
18-Oct-2012
07-Dec-2012


Weir 3 Weir Flows
Flow (L/s)
40
35
30
25
20
15
10
5
0
11-Feb-2012
01-Apr-2012
21-May-2012
10-Jul-2012
29-Aug-2012
18-Oct-2012
07-Dec-2012

APPENDIX II-J

Grum Pit

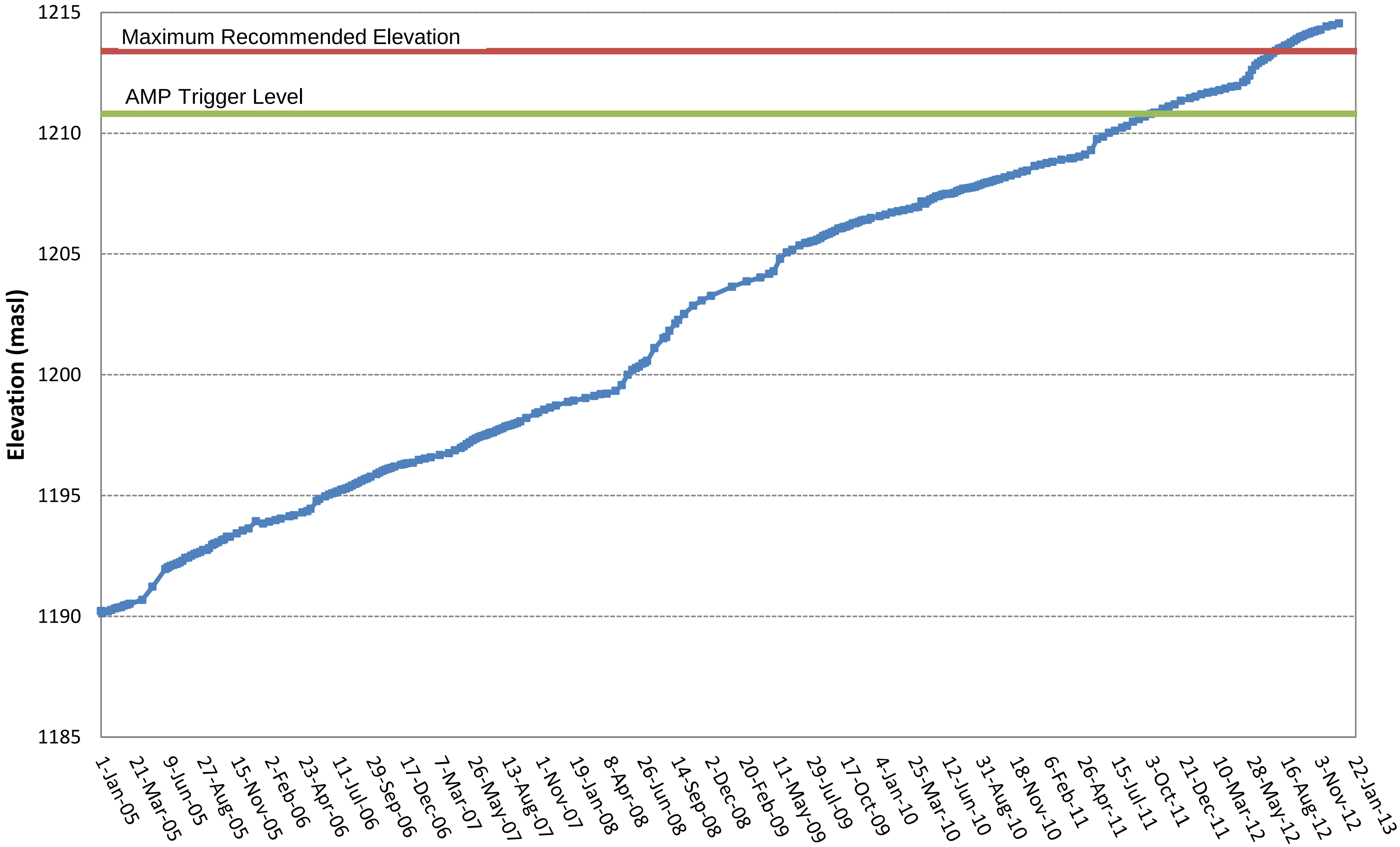
J.1 – Pond Level

J.2 – Displacement Monitoring

J.3 – Piezometers (Cut Slot)

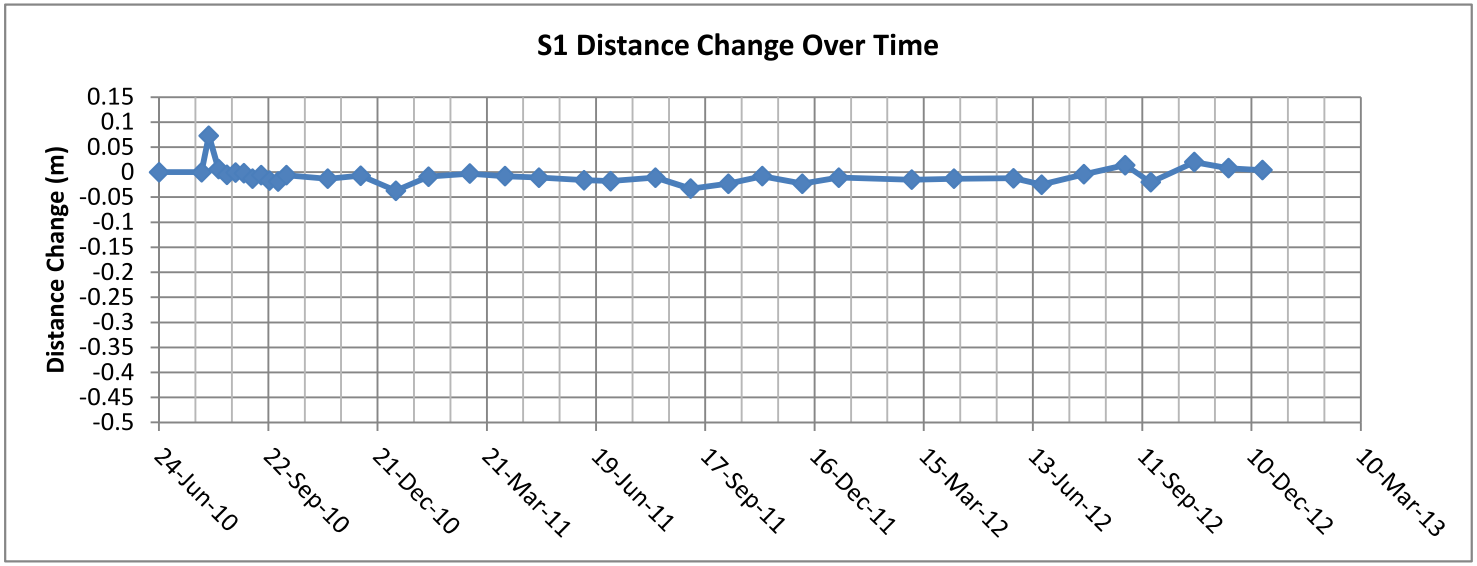
J.1 – Pond Level

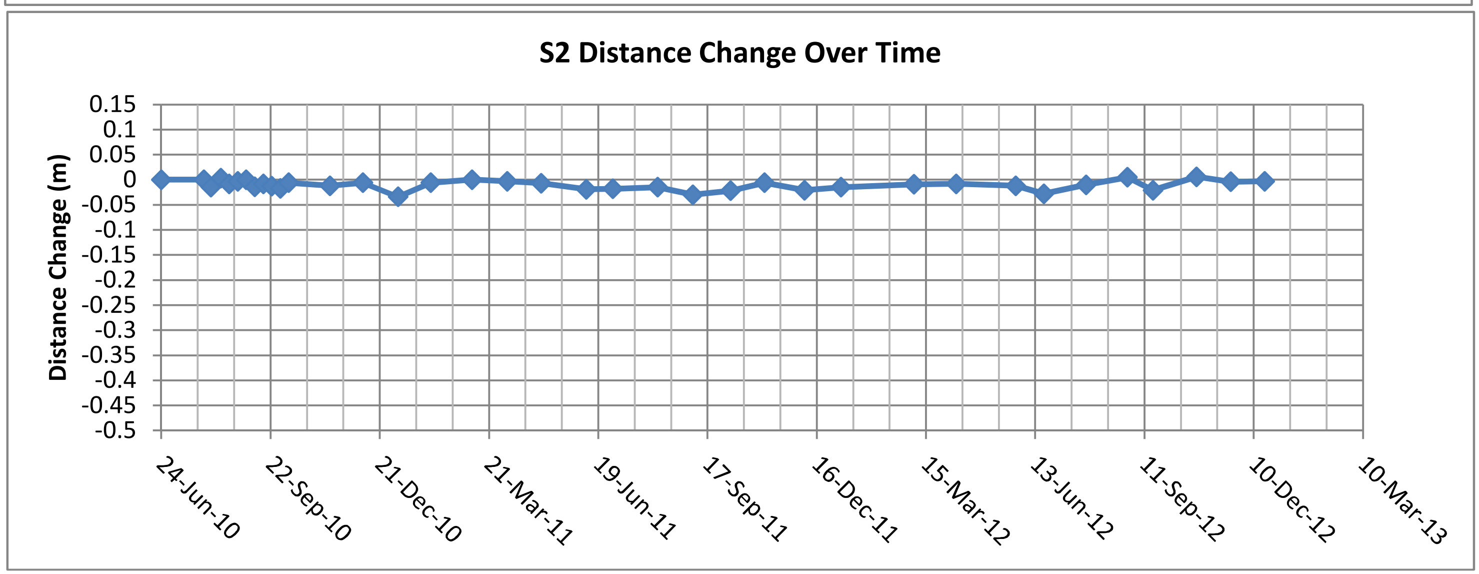
Grum Pit Water Elevations



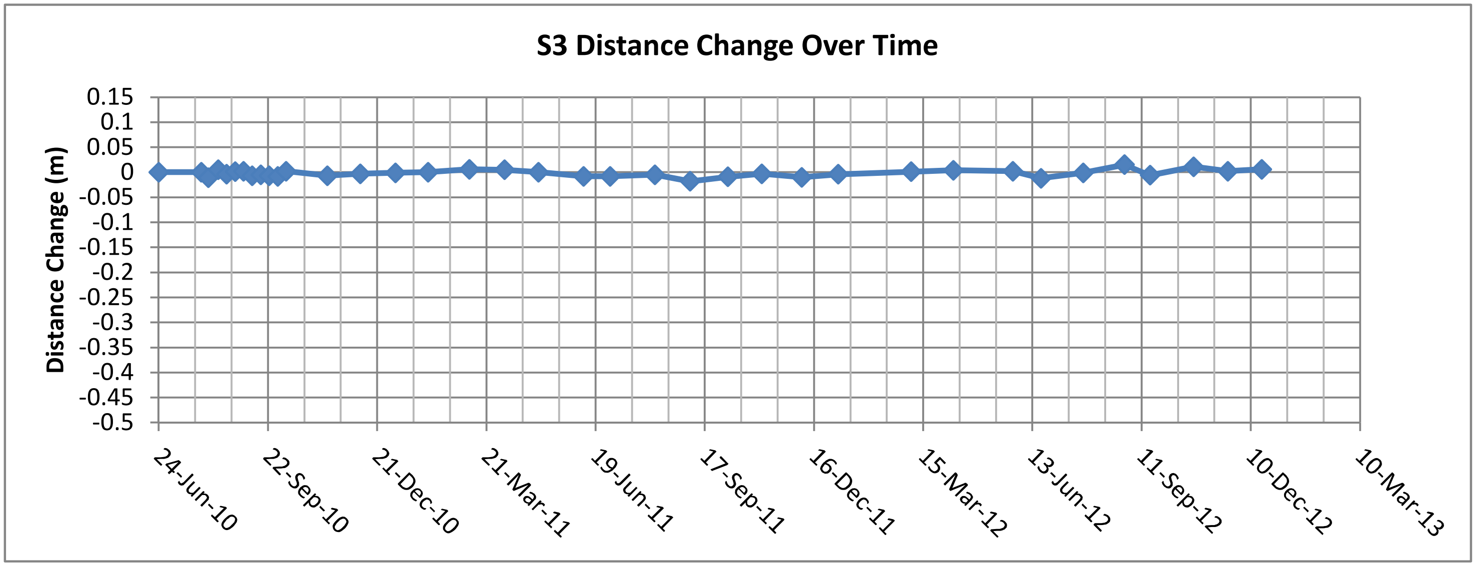
J.2 – Displacement Monitoring

Grum Pit Slope Stability Monitoring

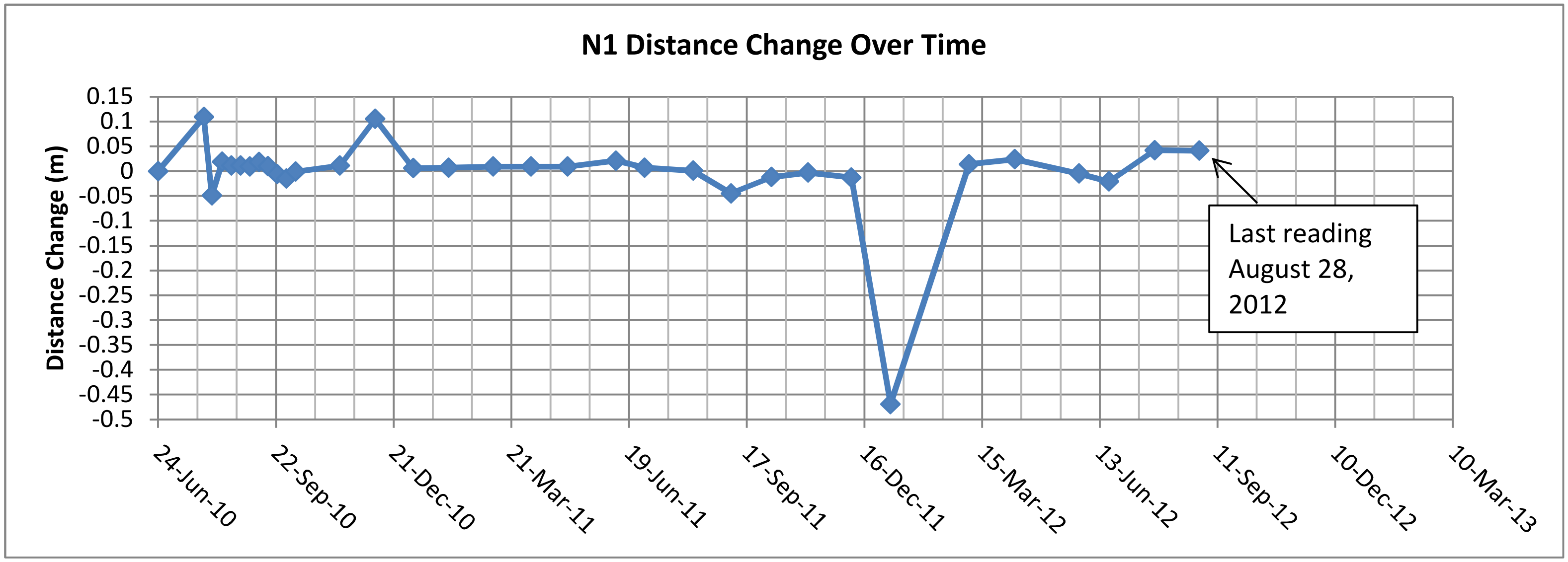


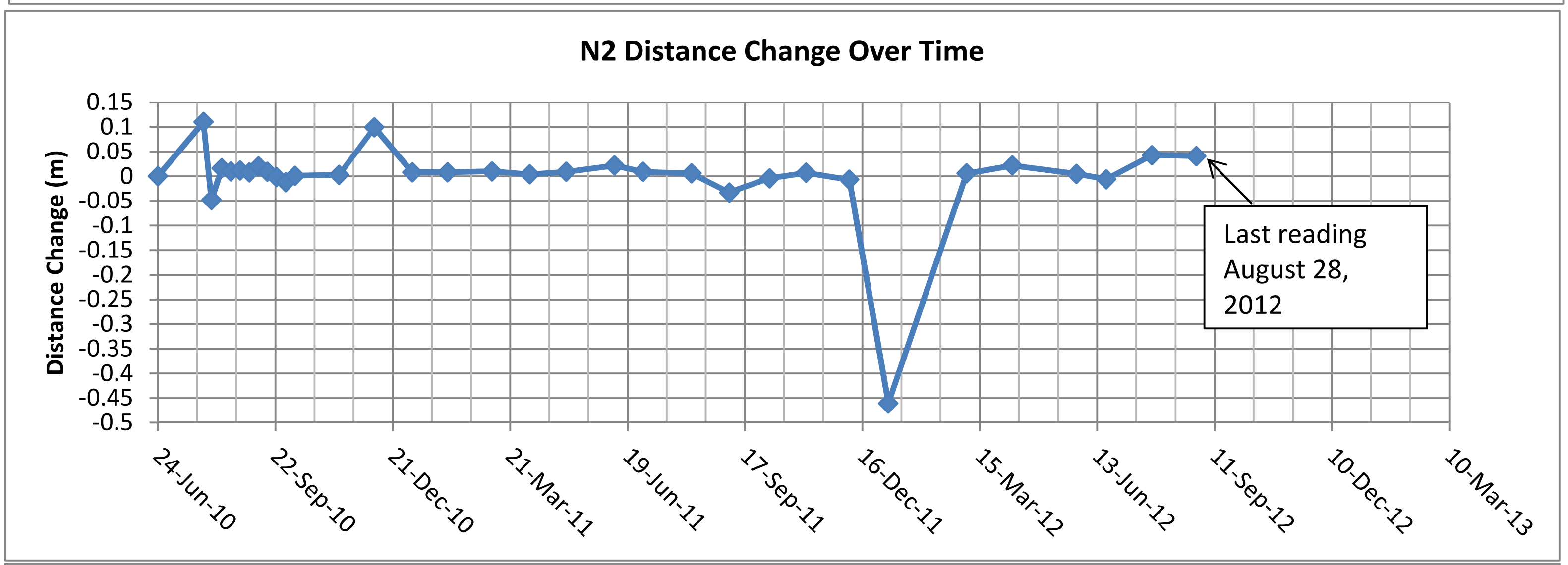


Grum Pit Slope Stability Monitoring

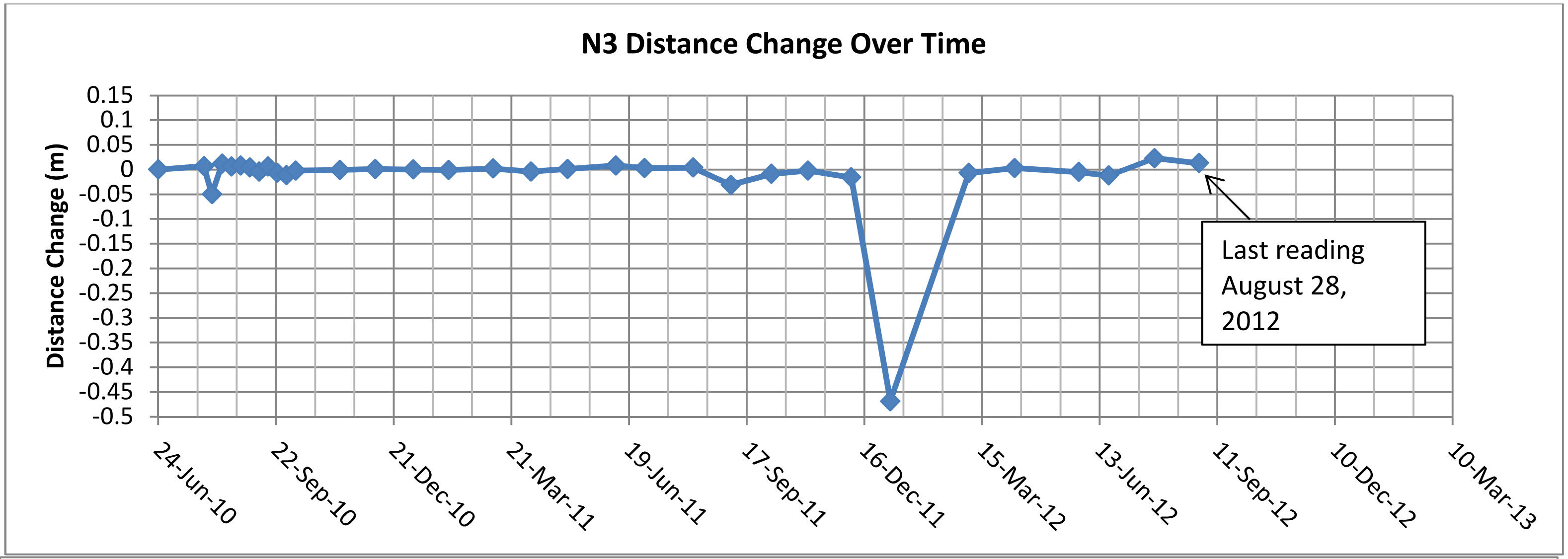


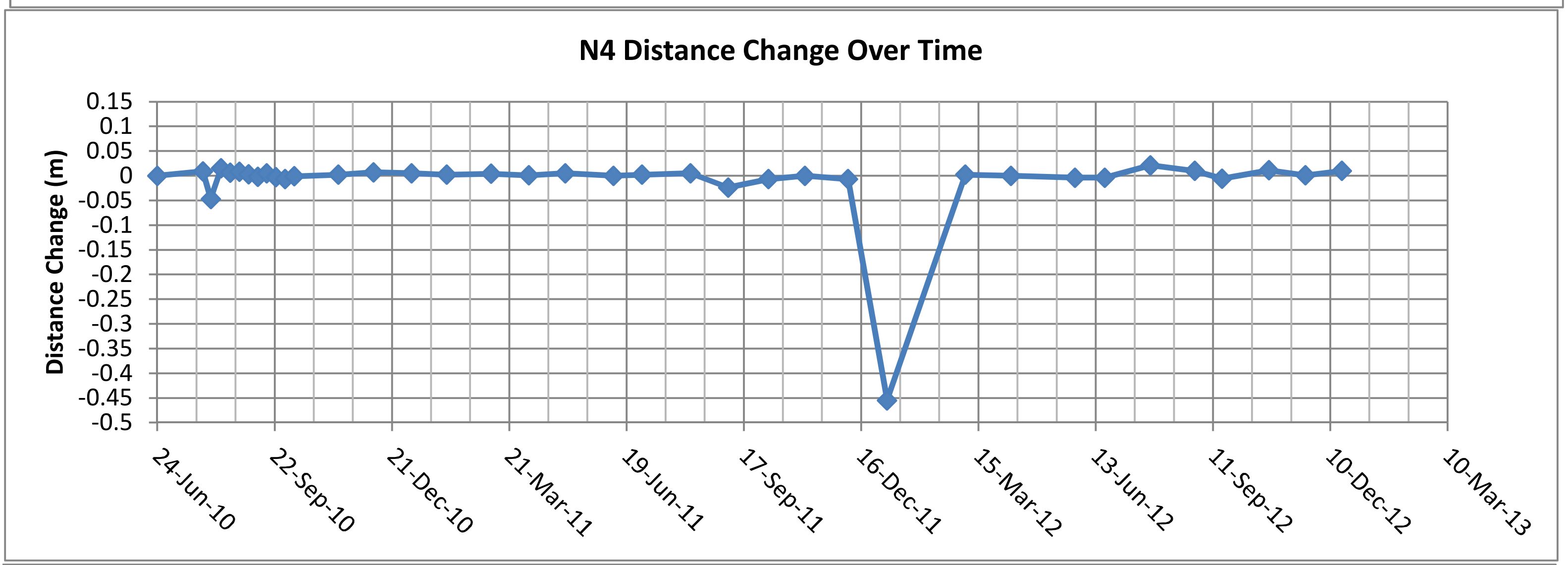
Grum Pit Slope Stability Monitoring



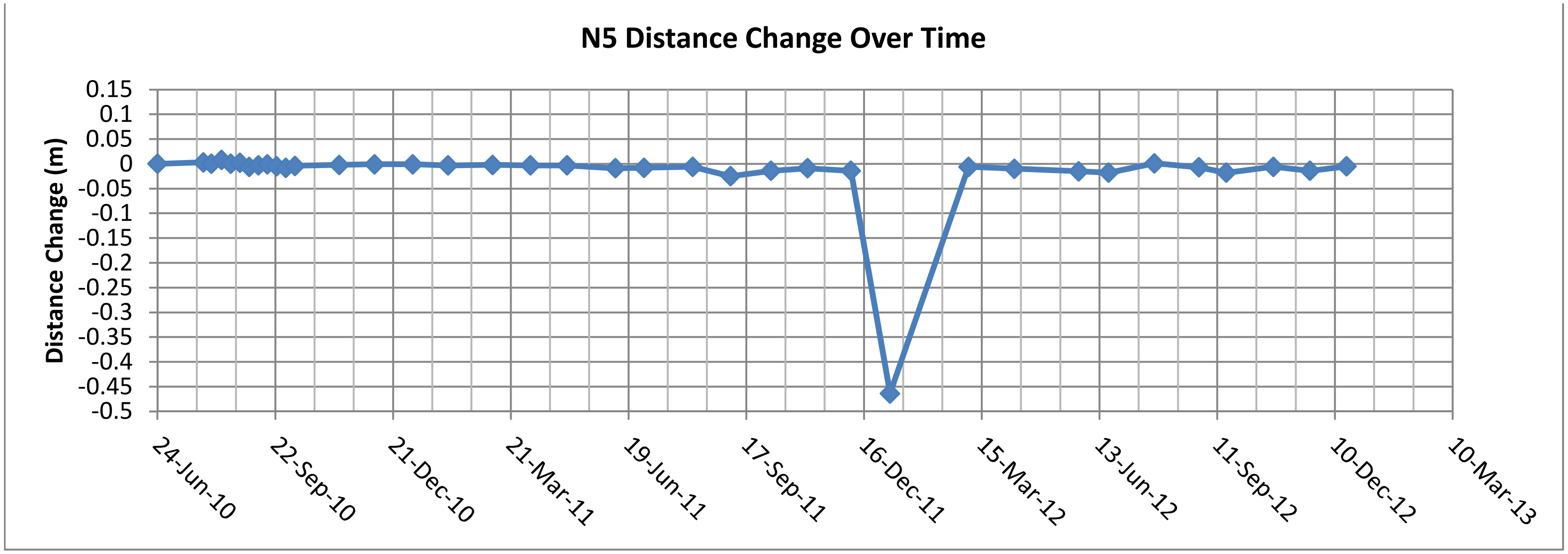


Grum Pit Slope Stability Monitoring



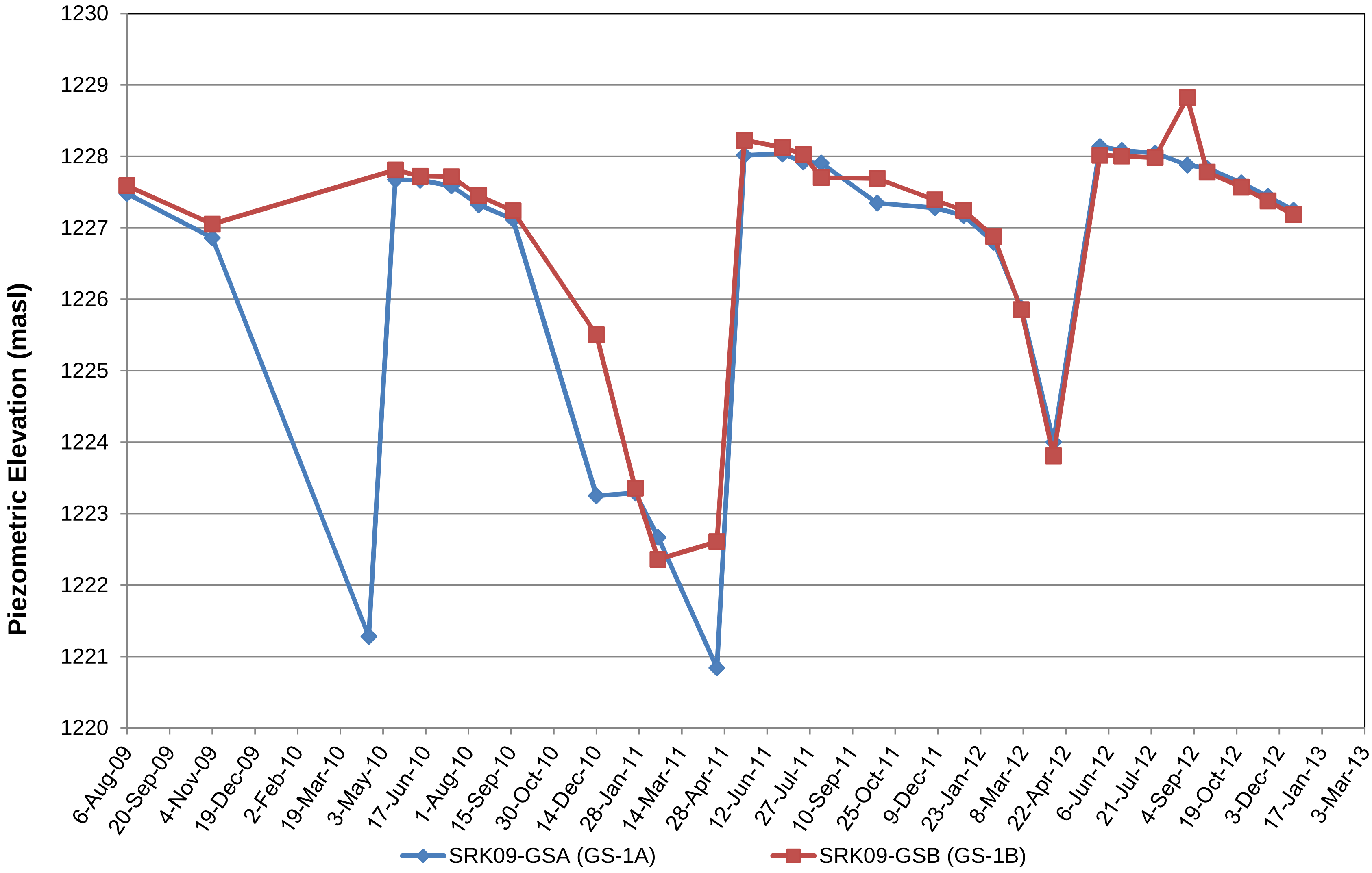


Grum Pit Slope Stability Monitoring



J.3 – Piezometers (Cut Slot)

Water Elevations - Grum Slot Cut Piezometers



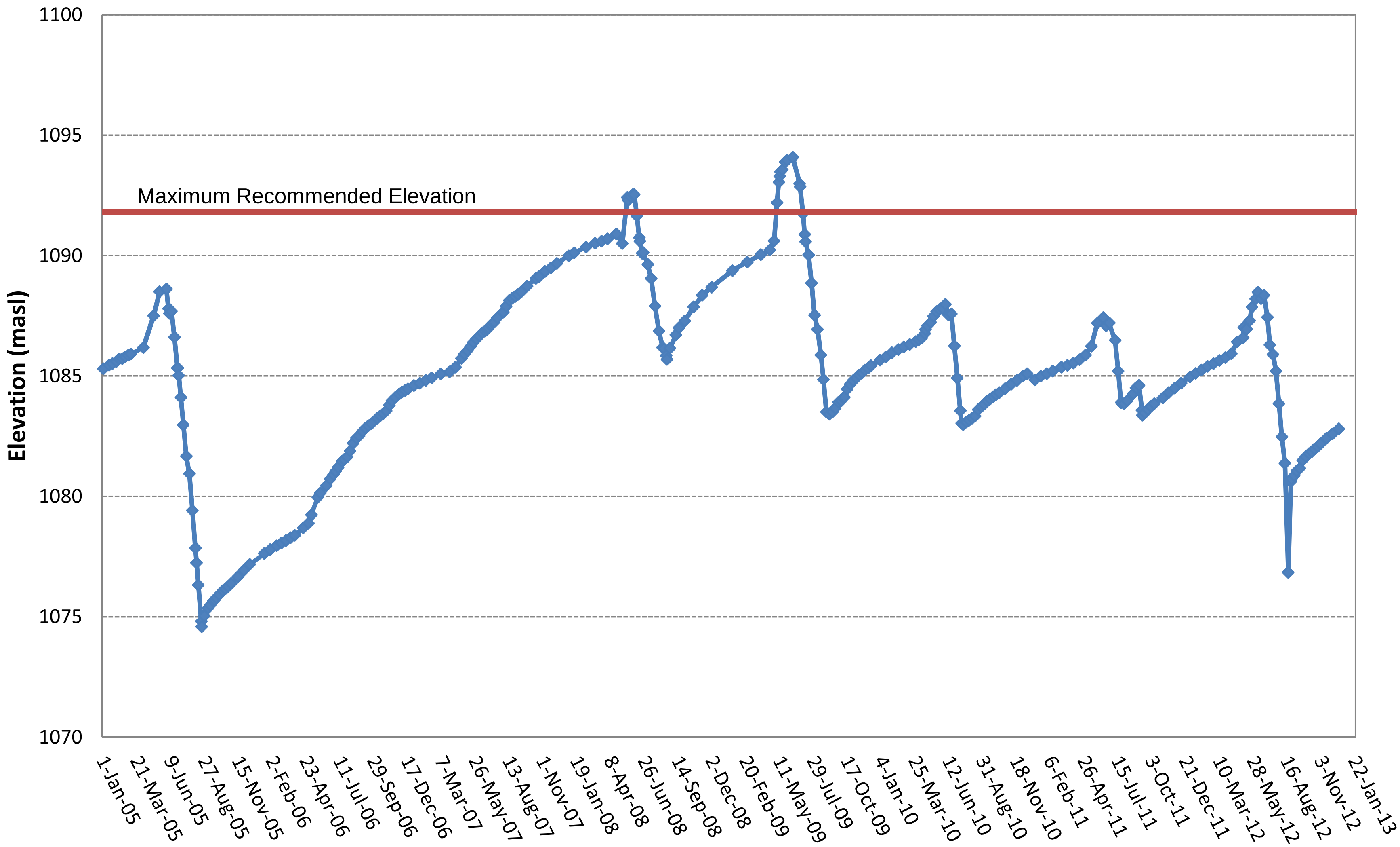
APPENDIX II-K

Vangorda Pit

K.1 – Pond Level

K.1 – Pond Level

Vangorda Pit Water Elevations



APPENDIX II-L

Vangorda Waste Rock Dump

L.1 – Weir Flow Measurement and Drain Visual Monitoring

L.2 – Piezometers

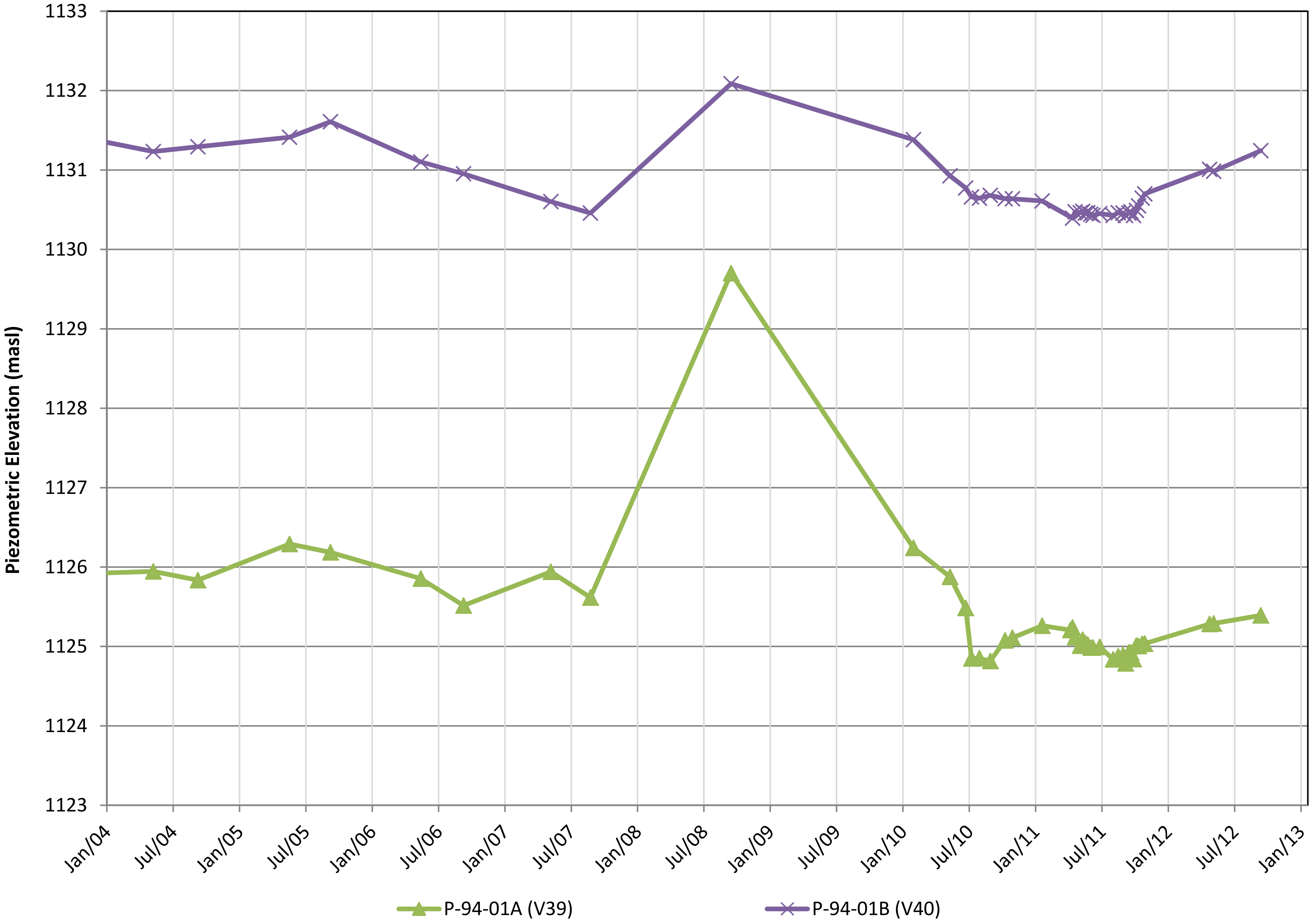
L.1 – Weir Flow Measurement and Drain Visual Monitoring

Data to October 2012

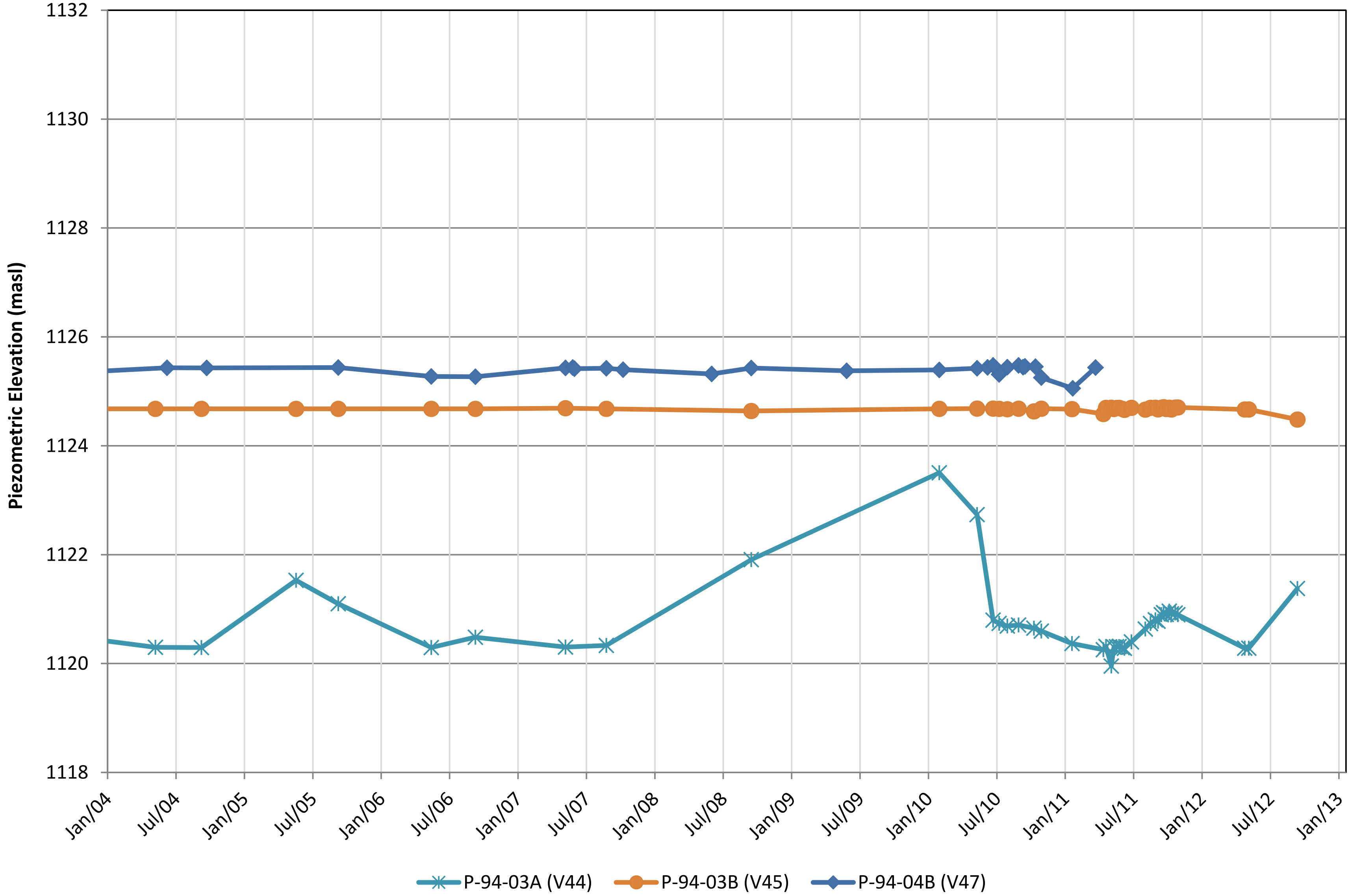
Site	Water Type	Date	Time	Weir Measurement (m)	Flow (l/s)	Type of Flow	Comments
V30	SEEPAGE	11-May-12	12:57		0.04	Estimation	Weir plate tilted; estimated flow of 0.040 L/s. Do not have SD cards for the camera
V30	SEEPAGE	30-May-12	16:00		0.21	Estimation	Weir plate tilted; estimated flow of 0.21 L/s. Photo taken
V30	SEEPAGE	5-Jun-12	13:46		0.33	Estimation	Weir plate tilted; estimated flow of 0.33 L/s. Photo taken
V30	SEEPAGE	20-Jun-12	11:17		0.12	Estimation	Weir plate tilted; estimated flow of 0.12 L/s
V30	SEEPAGE	4-Jul-12	08:20		0.04	Estimation	Weir plate tilted; estimated flow of 0.04 L/s. Photo taken
V30	SEEPAGE	18-Jul-12	16:12		0.06	Estimation	Weir plate tilted; estimated flow of 0.06 L/s
V30	SEEPAGE	1-Aug-12	09:00		0.07	Estimation	Weir plate tilted; estimated flow of 0.07 L/s. Photo taken
V30	SEEPAGE	14-Aug-12	09:20		0.05	Estimation	Weir plate tilted; estimated flow of 0.05 L/s
V30	SEEPAGE	28-Aug-12	13:59		0.12	Estimation	Weir plate tilted; estimated flow of 0.12 L/s
V30	SEEPAGE	11-Sep-12	09:35			Estimation	Samplers measured weir therfore inaccurate flow collected
V30	SEEPAGE	26-Sep-12	13:26			Estimation	Samplers measured weir therfore inaccurate flow collected
V30	SEEPAGE	10-Oct-12	09:13		0.16	Estimation	Weir plate tilted; estimated flow of 0.16 L/s
V30	SEEPAGE	24-Oct-12	10:52			Estimation	Frozen
V31	SEEPAGE	11-May-12	12:50			Estimation	Do not have SD cards for the camera
V31	SEEPAGE	30-May-12	15:52				Photo taken
V31	SEEPAGE	5-Jun-12	14:05		<0.1	Estimation	Photo taken
V31	SEEPAGE	20-Jun-12	11:25		<0.1	Estimation	
V31	SEEPAGE	4-Jul-12	08:40		0.26	Estimation	
V31	SEEPAGE	18-Jul-12	16:25		<0.1	Estimation	
V31	SEEPAGE	1-Aug-12	09:13		<0.1	Estimation	
V31	SEEPAGE	14-Aug-12	09:27			Estimation	Stagnant
V31	SEEPAGE	28-Aug-12	14:18		<0.1	Estimation	
V31	SEEPAGE	11-Sep-12	09:45		<0.1	Estimation	
V31	SEEPAGE	26-Sep-12	13:34		<0.1	Estimation	
V31	SEEPAGE	10-Oct-12	09:28			Estimation	Frozen
V31	SEEPAGE	24-Oct-12	10:57			Estimation	Frozen
V32	SEEPAGE	11-May-12	12:38			Estimation	Do not have SD cards for the camera
V32	SEEPAGE	30-May-12	15:32			Estimation	Photo taken
V32	SEEPAGE	5-Jun-12	14:35		0.00	Estimation	No flow. Photo taken
V32	SEEPAGE	20-Jun-12	11:29		0.00	Estimation	Weir is tilted; no flow
V32	SEEPAGE	4-Jul-12	08:50			Estimation	No flow
V32	SEEPAGE	18-Jul-12	16:18			Estimation	No Flow
V32	SEEPAGE	1-Aug-12	09:20			Estimation	No Flow
V32	SEEPAGE	14-Aug-12	09:35			Estimation	No Flow
V32	SEEPAGE	28-Aug-12	14:09			Estimation	No Flow
V32	SEEPAGE	11-Sep-12	09:55			Estimation	No Flow
V32	SEEPAGE	26-Sep-12	13:38			Estimation	No Flow
V32	SEEPAGE	10-Oct-12	09:35			Estimation	No Flow
V32	SEEPAGE	24-Oct-12	11:00			Estimation	Frozen
V33	SEEPAGE	11-May-12	12:43				Do not have SD cards for the camera
V33	SEEPAGE	30-May-12	15:42		0.17	Estimation	Weir covered in snow; estimated flow of 0.17 L/s. Photo taken
V33	SEEPAGE	5-Jun-12	14:48	0.05	0.59	Weir Measurement	
V33	SEEPAGE	20-Jun-12	11:33	0.03	0.14	Weir Measurement	
V33	SEEPAGE	4-Jul-12	09:05	0.022	0.10	Weir Measurement	
V33	SEEPAGE	18-Jul-12	16:21	0.021	0.087	Weir Measurement	
V33	SEEPAGE	1-Aug-12	09:25	0.023	0.109	Weir Measurement	
V33	SEEPAGE	14-Aug-12	09:40	0.011	0.017	Weir Measurement	
V33	SEEPAGE	28-Aug-12	14:13	0.026	0.149	Weir Measurement	
V33	SEEPAGE	11-Sep-12	10:00	0.023	0.109	Weir Measurement	
V33	SEEPAGE	26-Sep-12	13:42	0.03	0.212	Weir Measurement	
V33	SEEPAGE	10-Oct-12	09:40	0.031	0.231	Weir Measurement	
V33	SEEPAGE	24-Oct-12	11:08	0.029	0.195	Weir Measurement	

L.2 – Piezometers

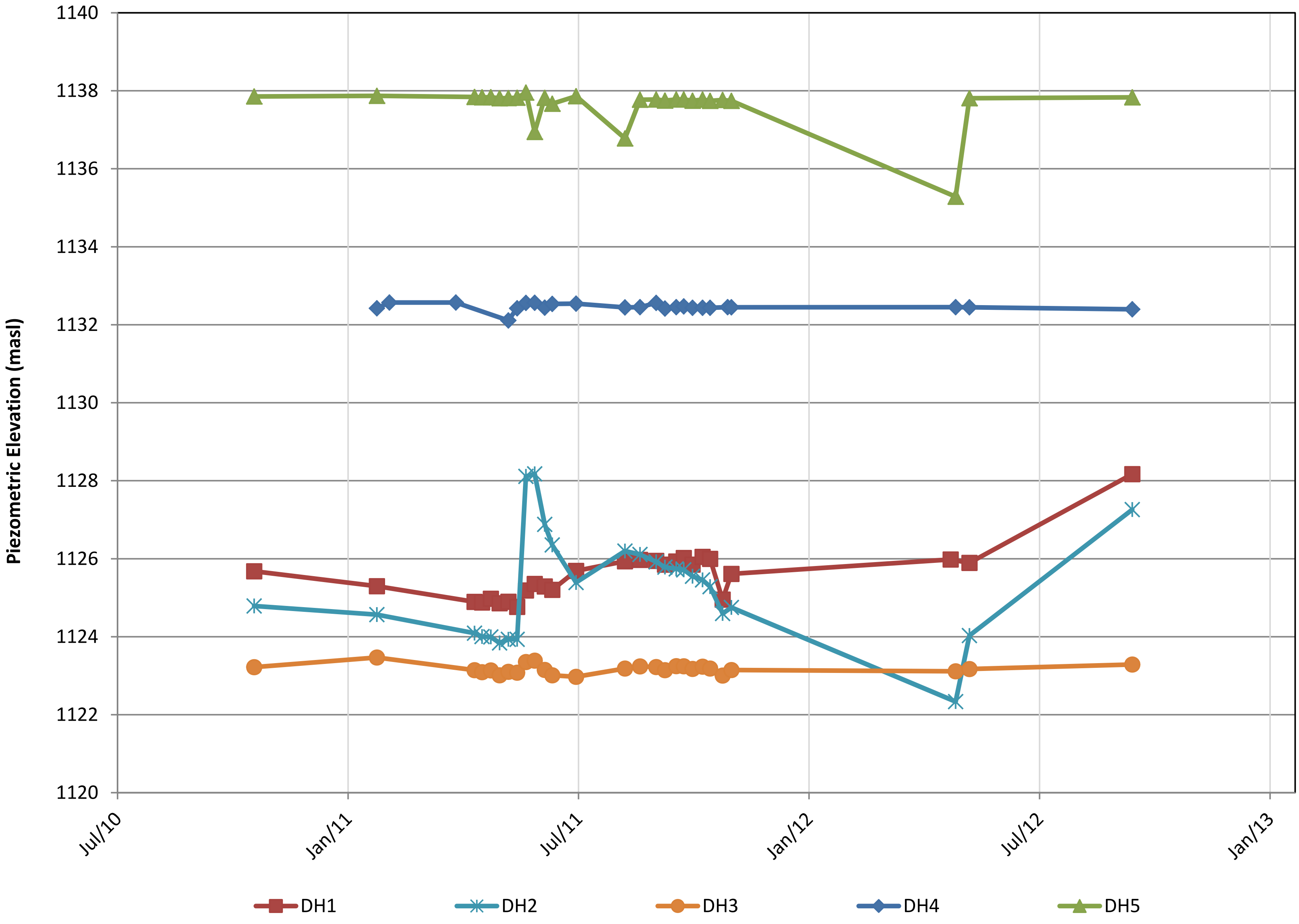
Vangorda Waste Rock Dump
Piezometric Elevations
P94-01A (V39)
P94-01B (V40)



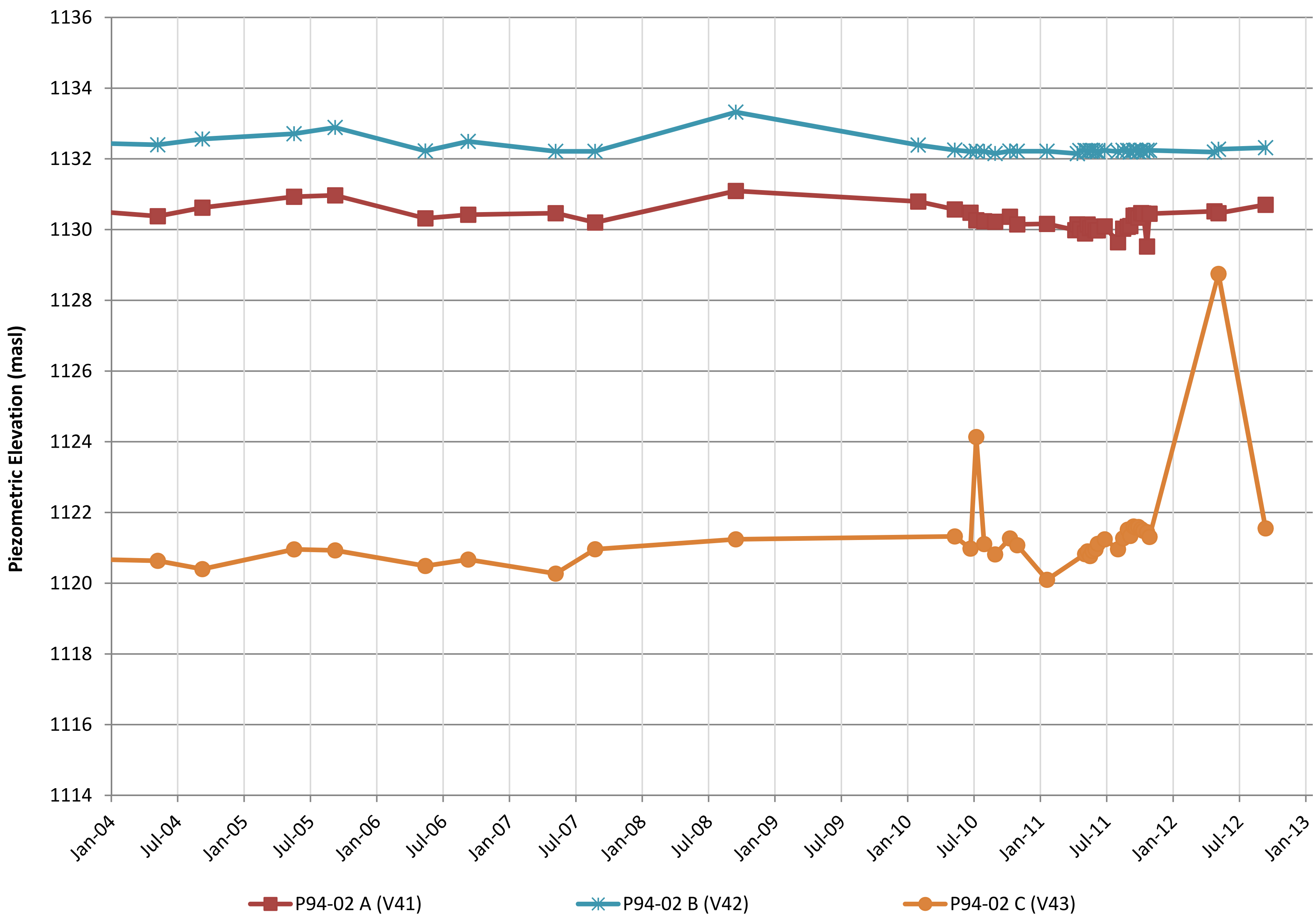
Vangorda Waste Rock Dump
Piezometric Elevations
P94-03A (V44)
P94-03B (V45)
P94-04B (V47)



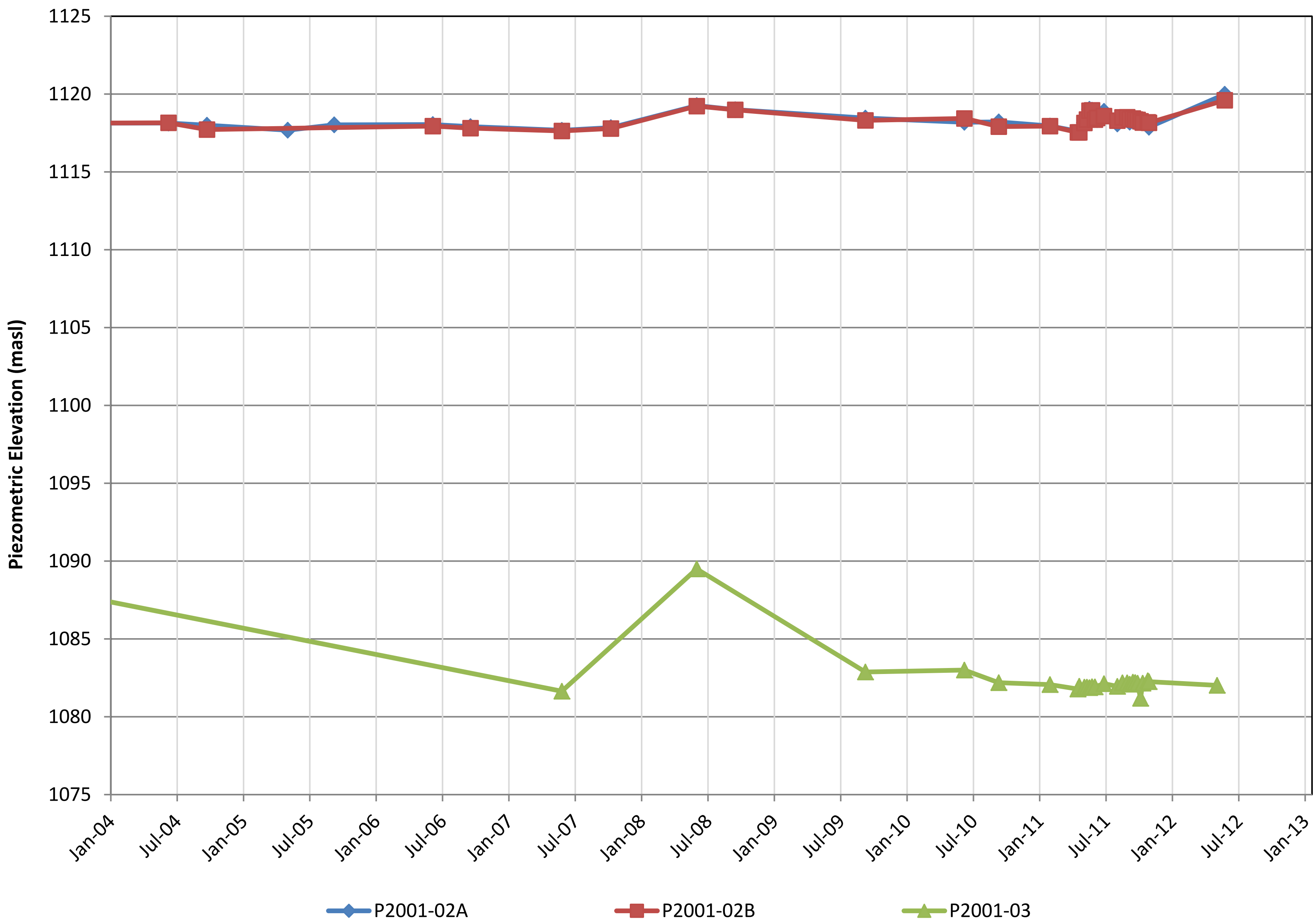
Vangorda Waste Rock Dump
Piezometric Elevations
DH1, DH2, DH3
DH4, DH5, DH6



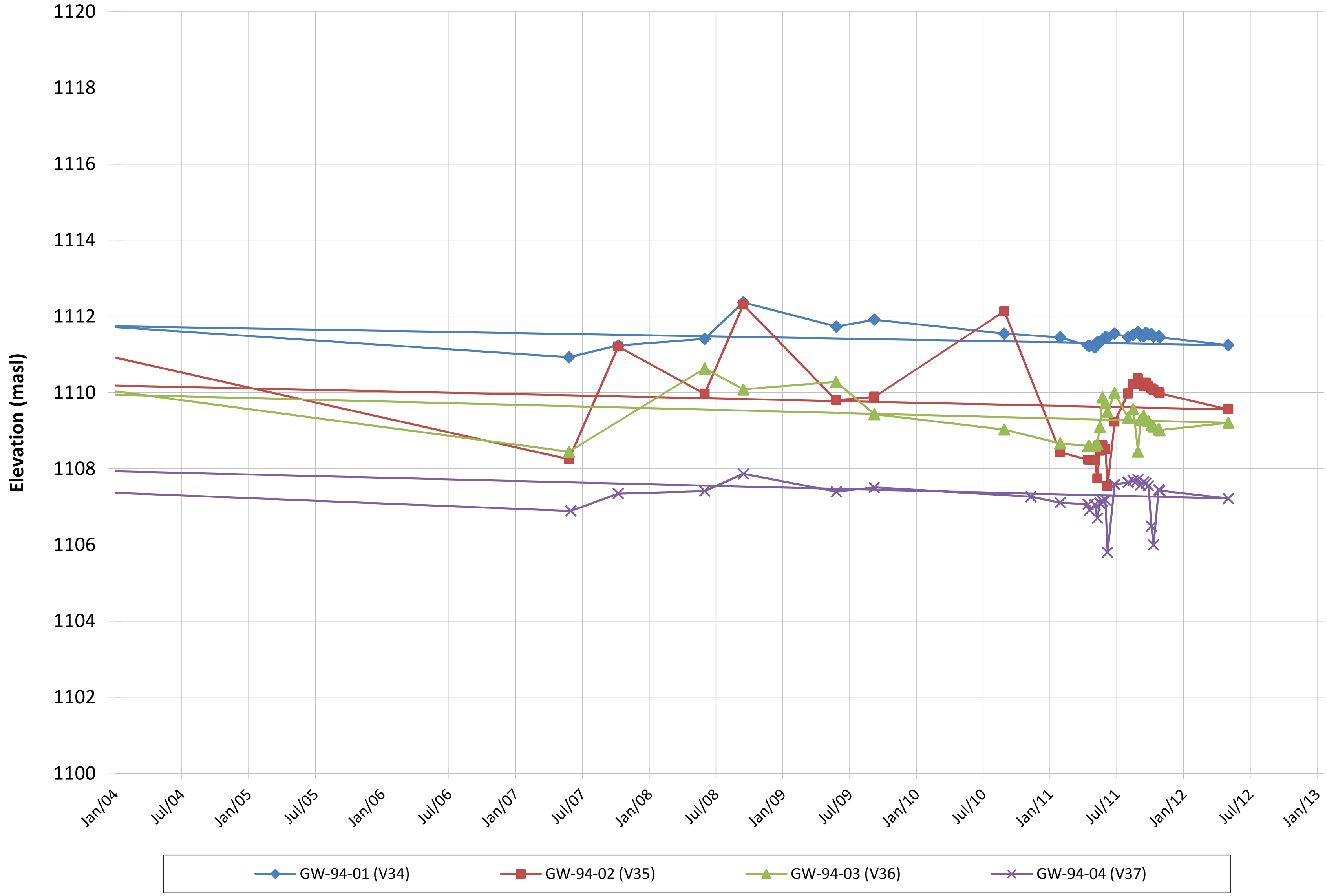
Vangorda Waste Rock Dump
Piezometric Elevations
V41, V42, V43



Vangorda Waste Rock Dump
Piezometric Elevations
P2001-02A, P2001-02B, P2001-03



Vangorda Dump Toe Groundwater Elevations
V34, V35, V36, V37



APPENDIX II-M

Little Creek Dam

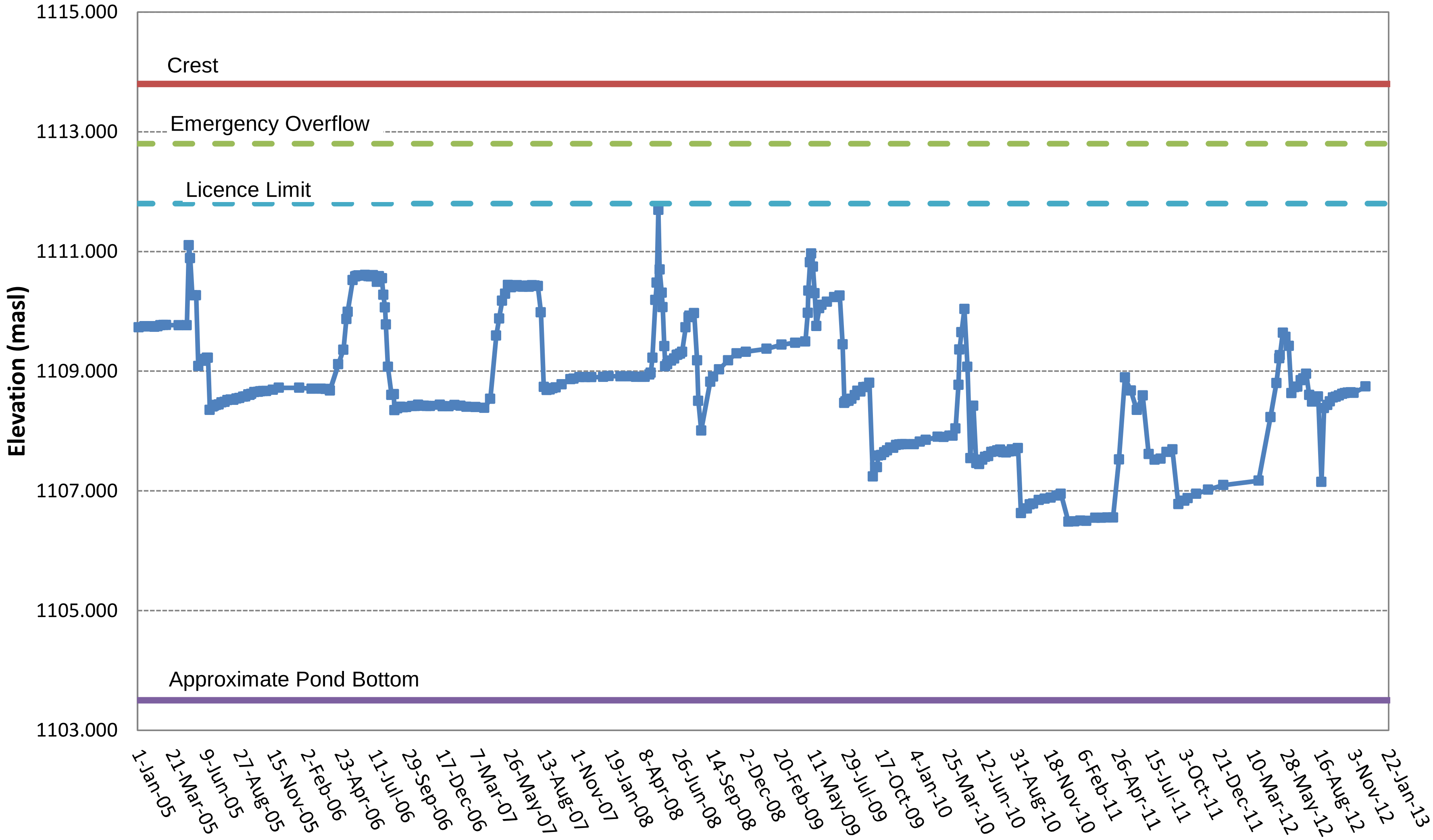
M.1 – Pond Level

M.2 – Piezometers

M.3 - Thermistors

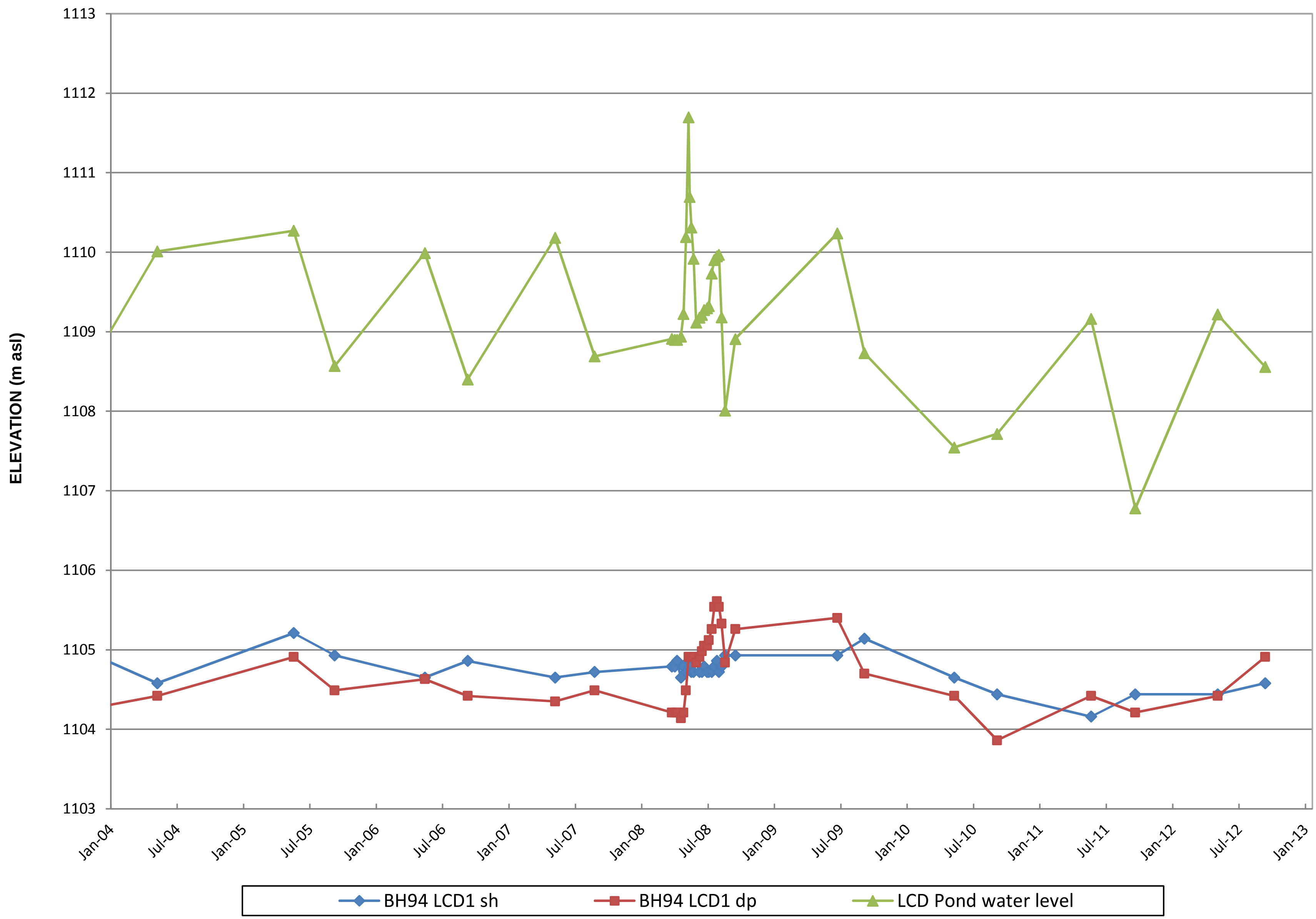
M.1 – Pond Level

Little Creek Dam Water Elevations

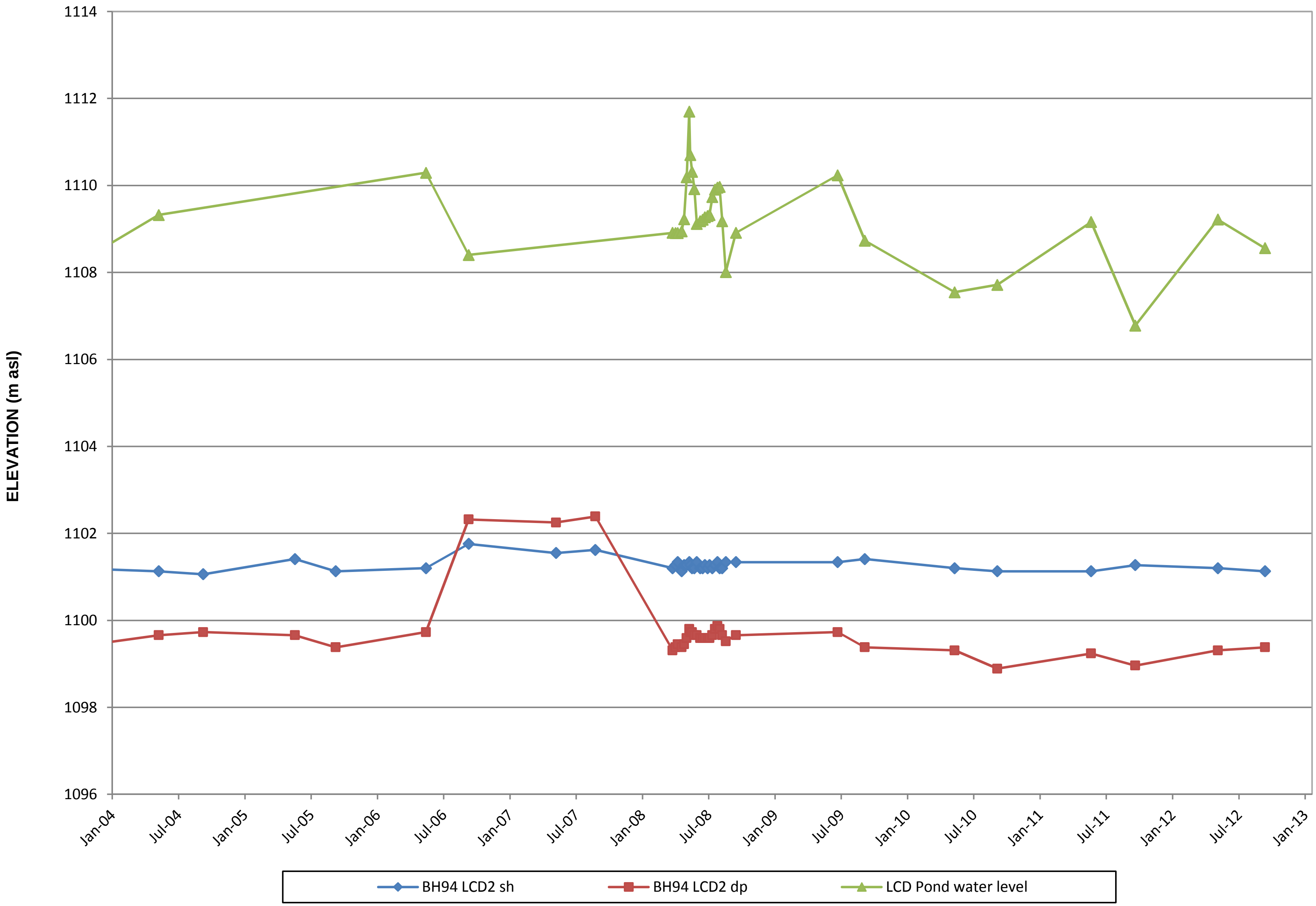


M.2 – Piezometers

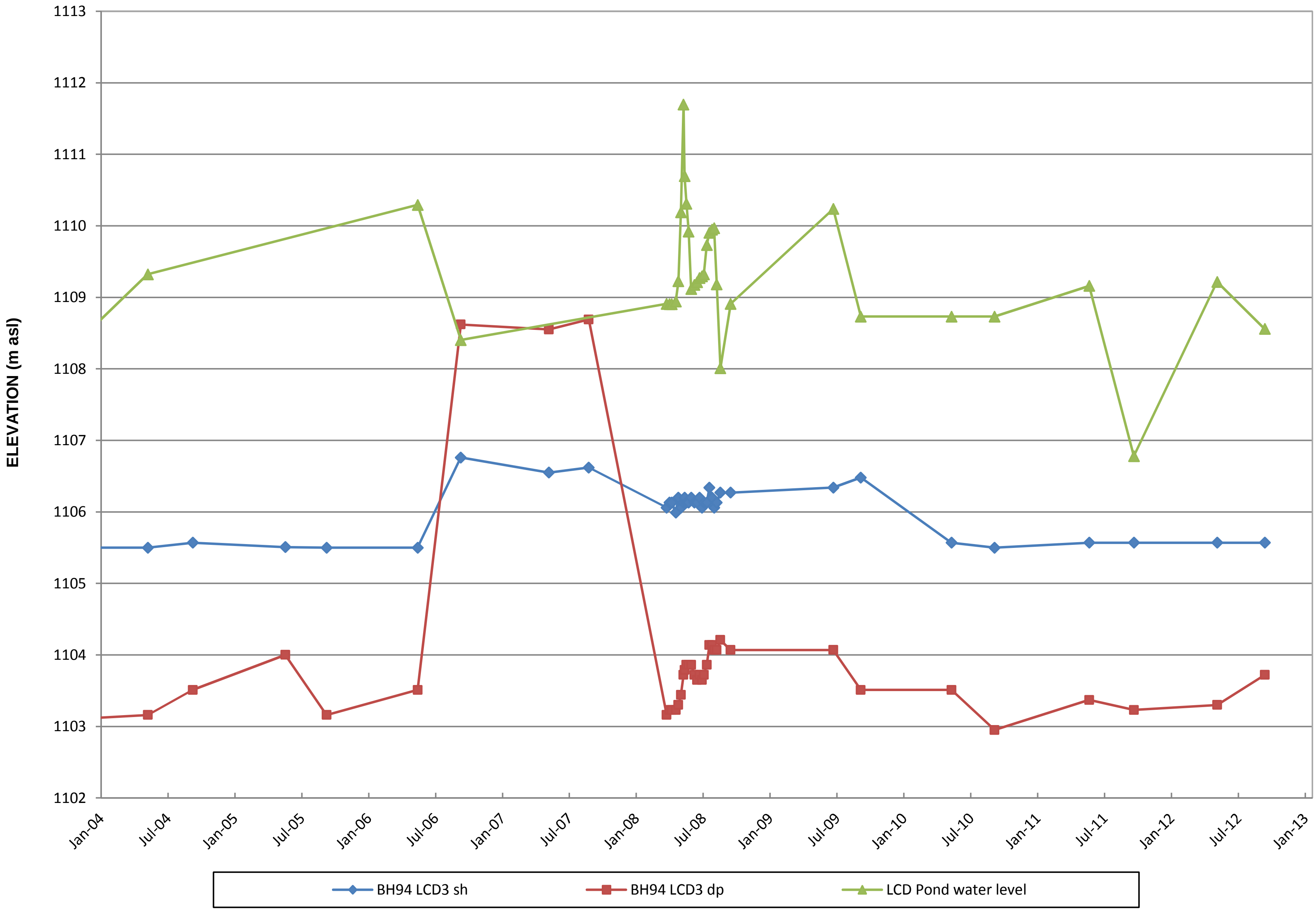
Little Creek Dam
Piezometer BH94 LCD1



Little Creek Dam
Piezometer BH94 LCD2

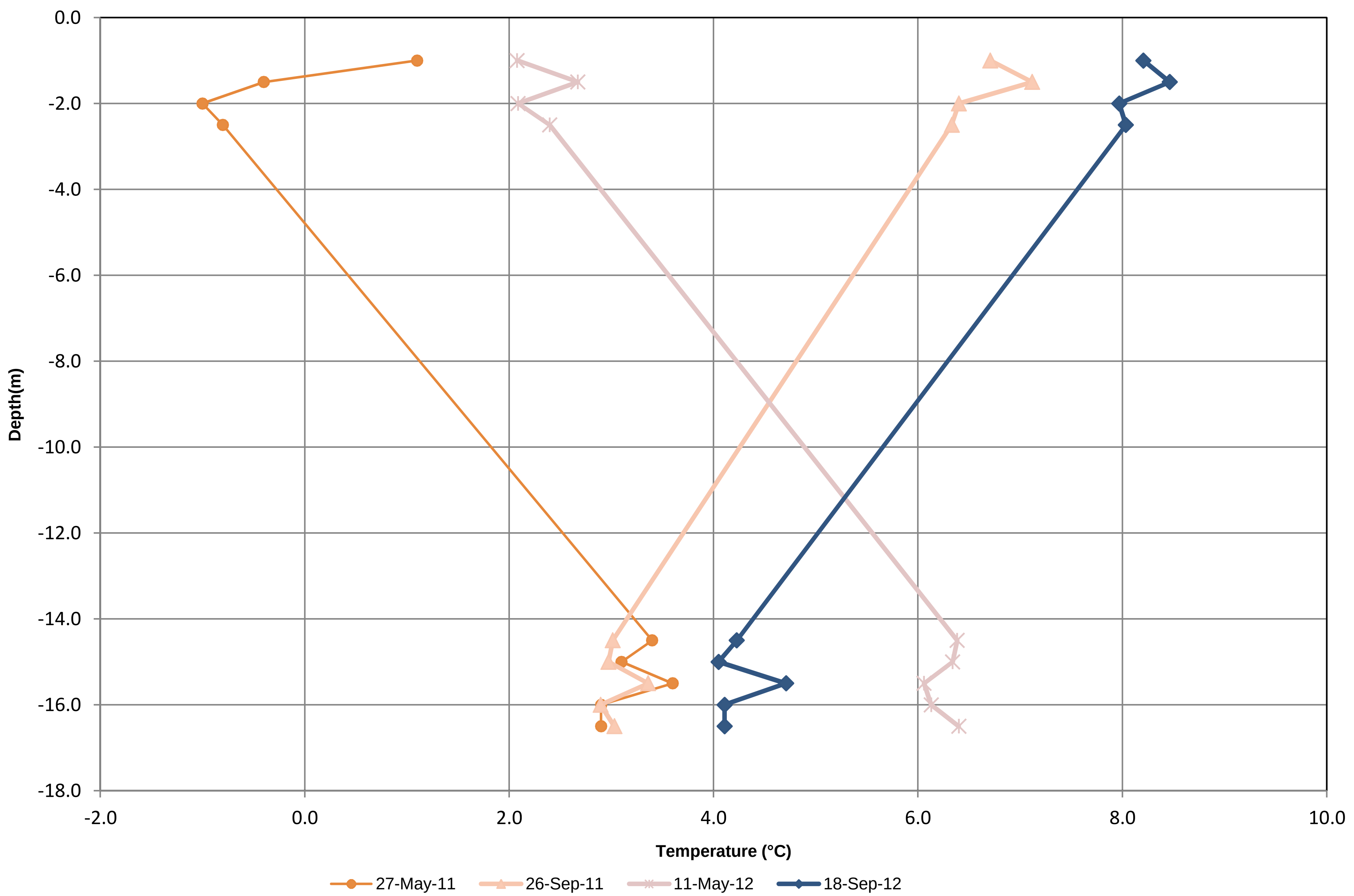


Little Creek Dam
Piezometer BH94 LCD3

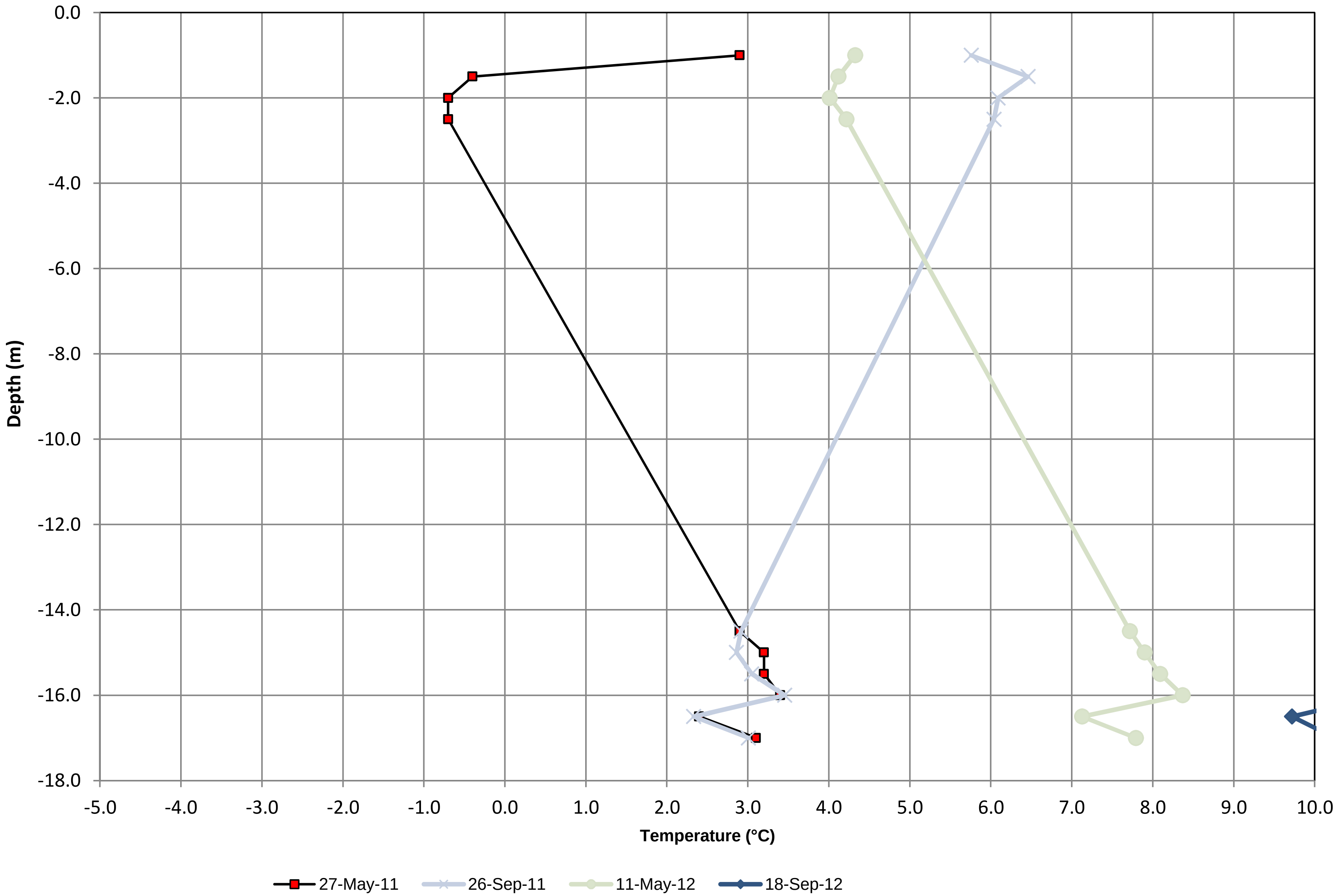


M.3 – Thermistors

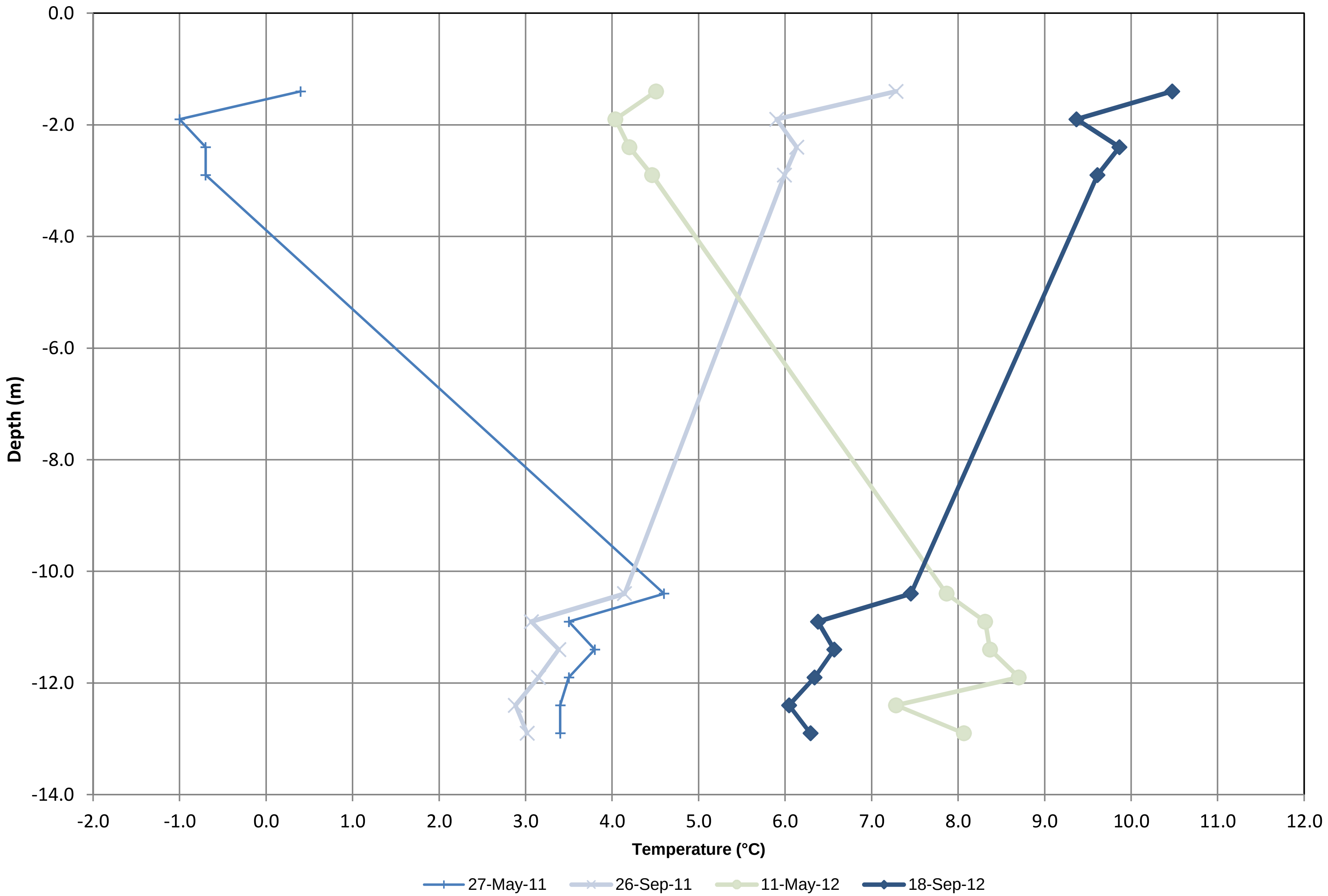
Little Creek Dam
Thermistor BH94 LCD-4



Little Creek Dam
Thermistor BH94 LCD-5



Little Creek Dam
Thermistor BH94 LCD-6



APPENDIX III

PowerPoint Presentation Slides for TEES Staff Training

FARO MINE COMPLEX – STAFF TRAINING

Robert C. Lo, P.Eng. September, 2012

OUTLINES OF PRESENTATION

- **Faro Mine Complex Key Structures**
- **Instrumentation Used on Site**
- **Failure Mechanisms and Inspection for Problems**
- **Inspection & Maintenance of Dams (B.C. Ministry of Environment 2011)**
- **Tailings Dam General Background (Klohn Crippen 1996)**

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60 YEARS

Faro Mine Complex
Key Structures

Klohn Crippen Berger
60 YEARS

Key Structures

Cross Valley Dam

Intermediate Dam

Secondary Tailings Dam

Little Creek Dam

North Valley Wall Interceptor Ditch

Rose Creek Diversion Channel

Faro Creek Diversion

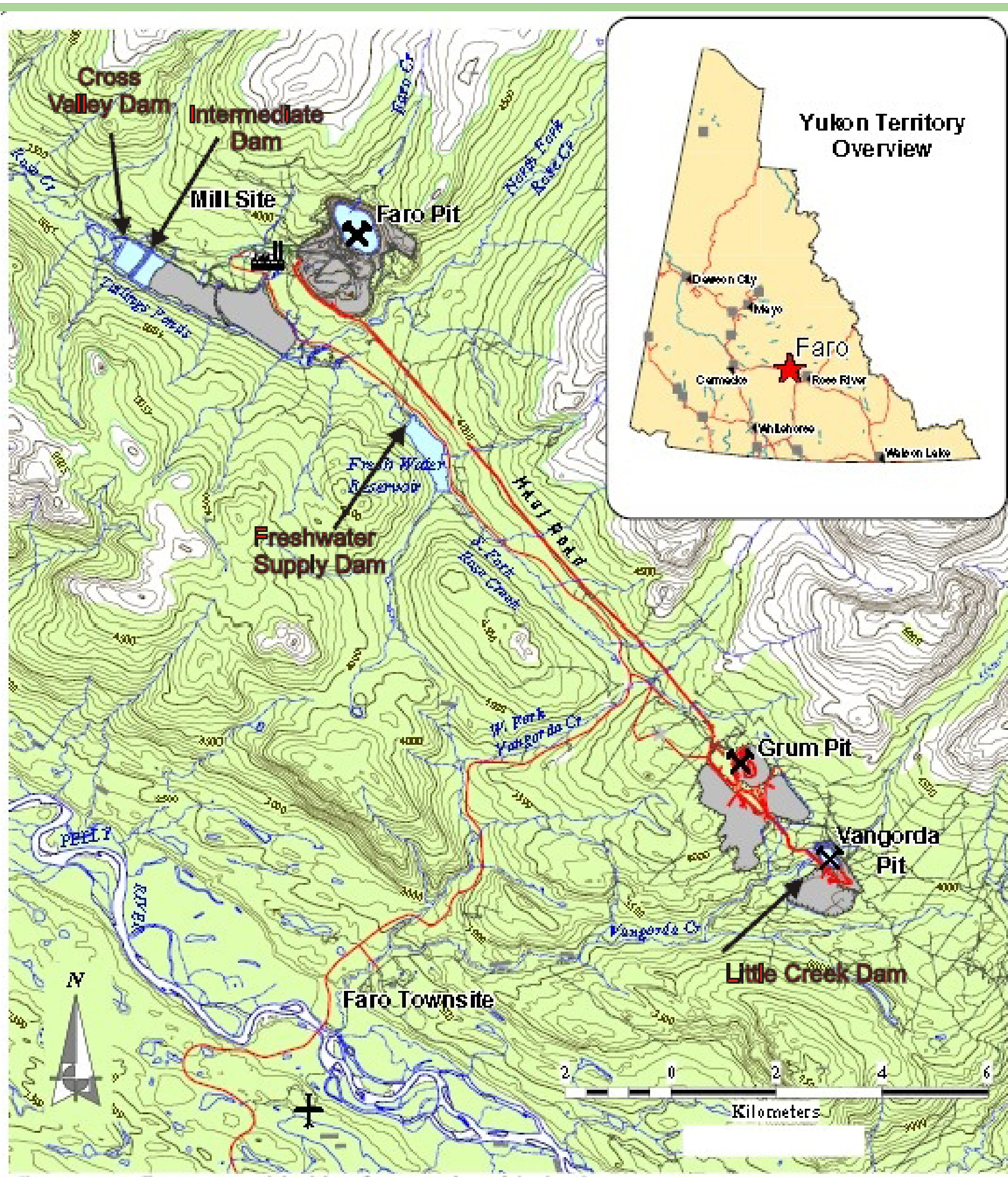
Vangorda Creek Diversion Channel

Moose Pond

Vangorda Waste Rock Pile

Faro Pit

Grum Pit



Note: Base map figure provided by Gartner Lee Limited.

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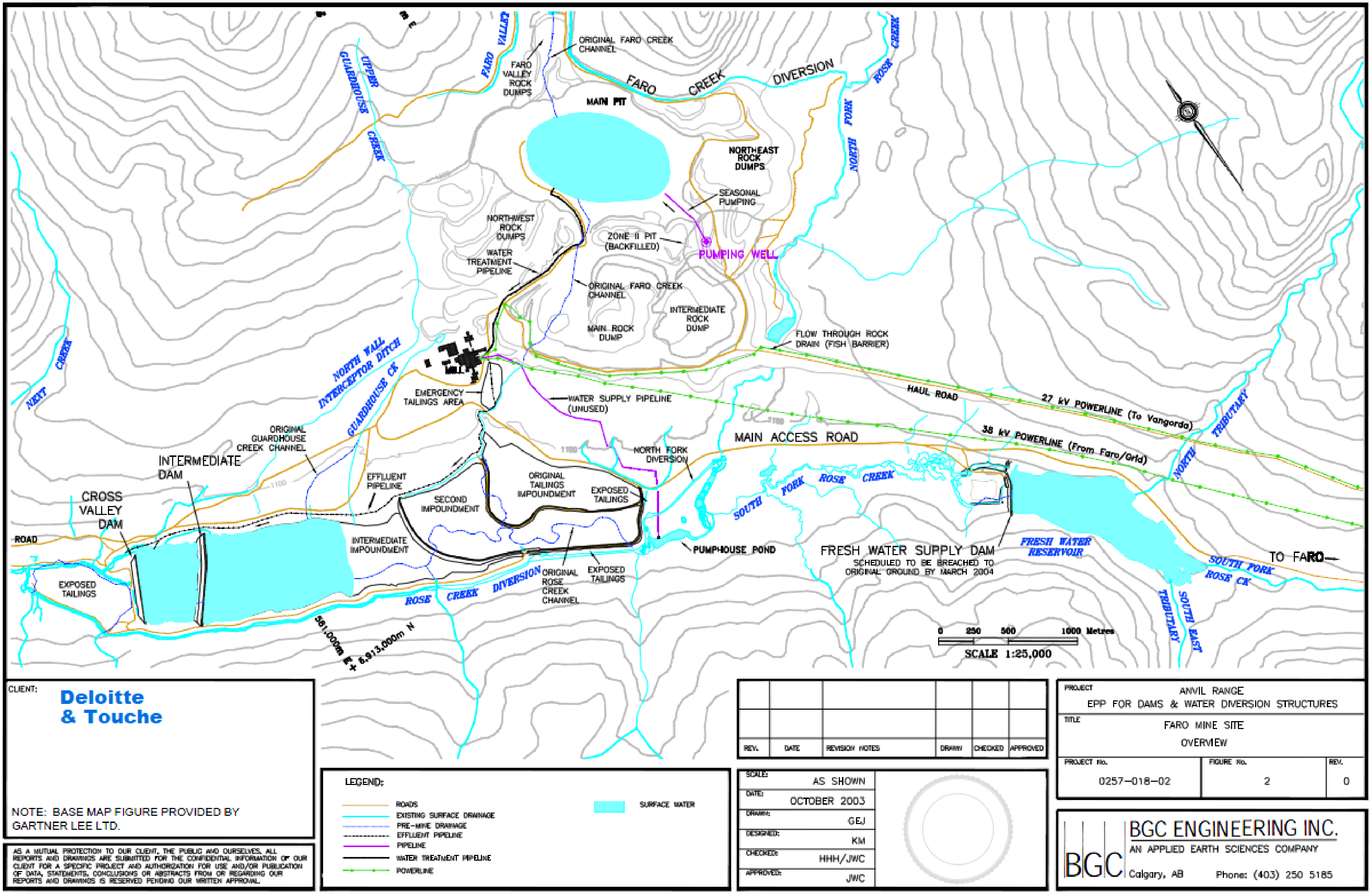

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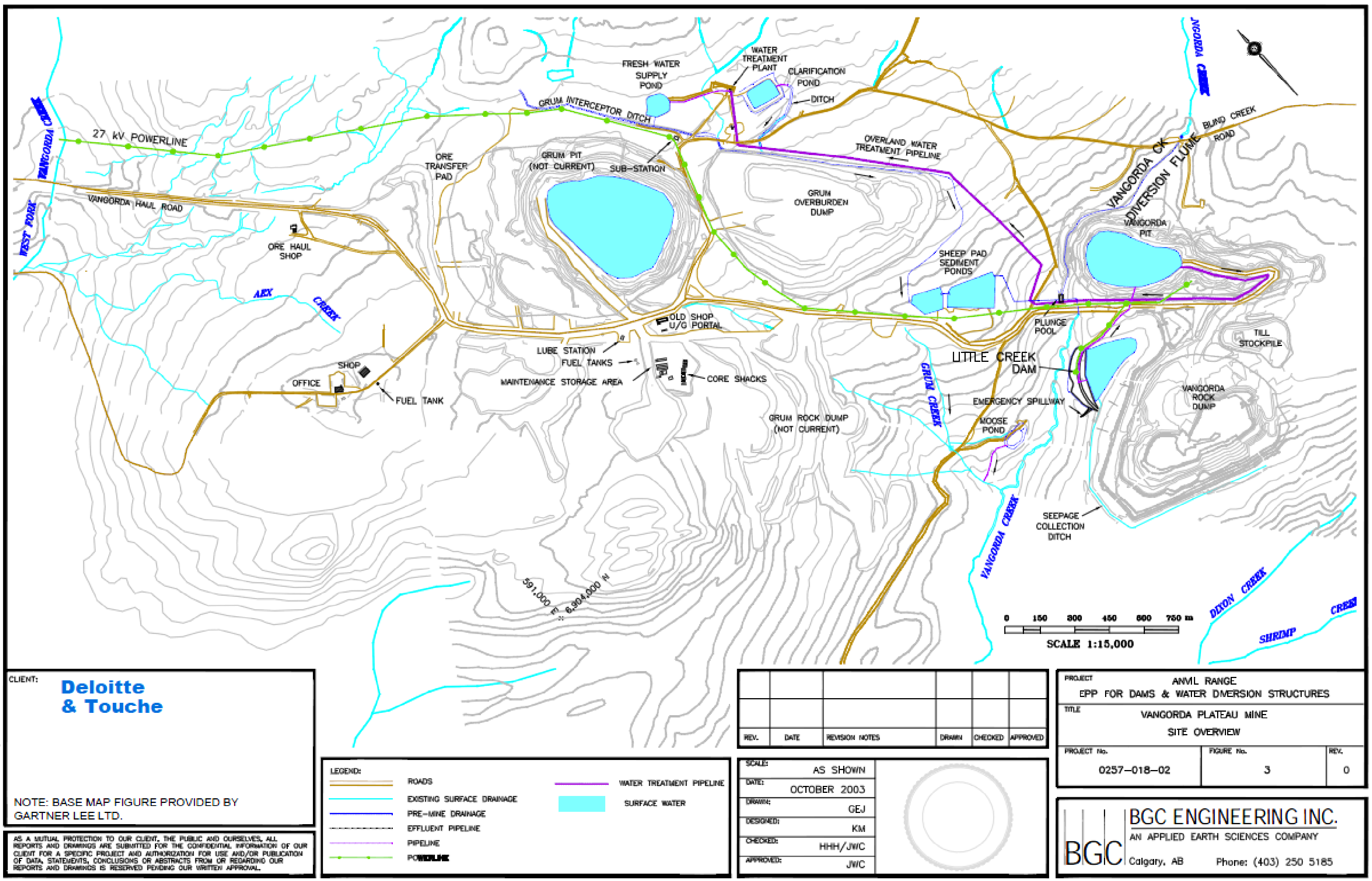

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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

DELOITTE AND TOUCHE INC.

ANVIL RANGE PROPERTY, FARO, YT

OPERATIONS, MAINTENANCE AND SURVEILLANCE MANUAL FOR SELECTED DAMS

INTERIM FINAL
REVISION 2

Klohn Crippen Berger
60 YEARS

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

DELOITTE AND TOUCHE INC.

ANVIL RANGE PROPERTY, YT

EMERGENCY PREPAREDNESS PLAN FOR SELECTED DAMS AND WATER DIVERSION STRUCTURES

FINAL
COPY #7

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Instrumentation Used on Site

Thermistor

Piezometer (Pneumatic and Standpipe)

Inclinometer

Survey

Flow Measurement (To be reviewed by Arvind Dalpatram in September)

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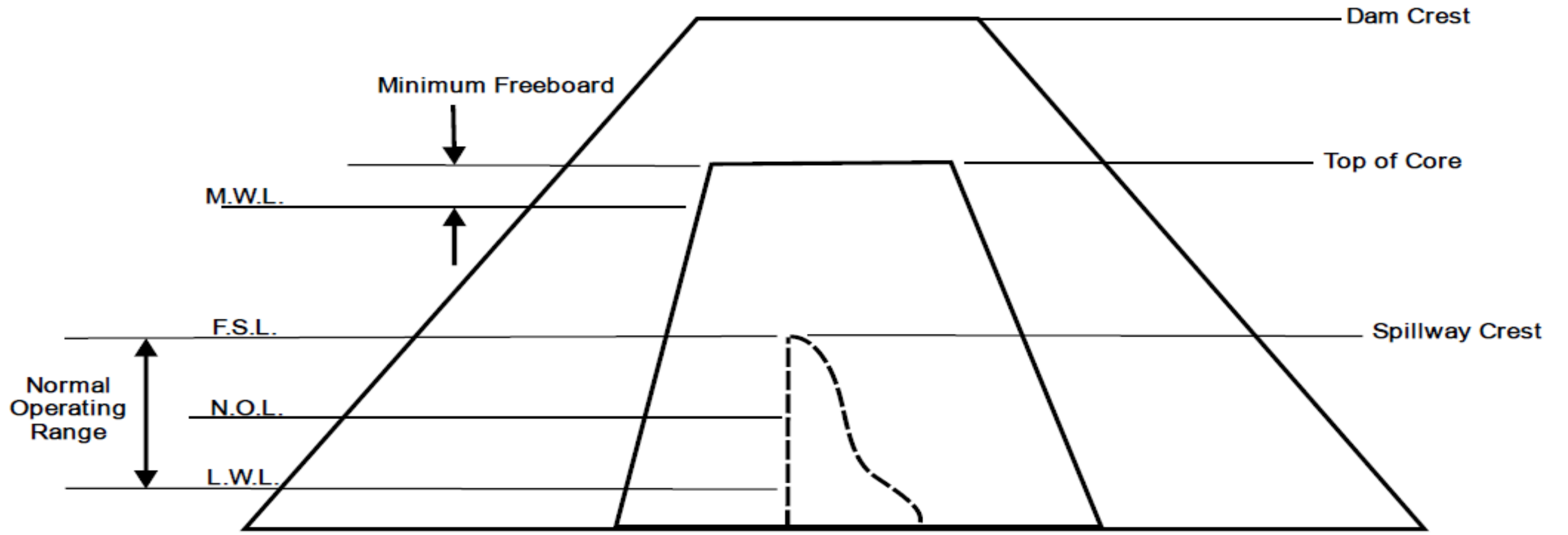
Terminology for Dam Operation



Notes:
M.W.L. Maximum Water Level - This occurs when the spillway is passing the design flood. Surcharge to reservoir above F.S.L. is temporary until end of flood.
F.S.L. Full Supply Level - Headpond level is same as sill level of spillway.
N.O.L. Normal Operating Level - Headpond level used for normal operations. May be the same as F.S.L.
L.W.L. Lowest Water Level - May be constrained by riprap on dam. This is the lowest level the headpond may be operated at. Headpond may be drawn down to this level to increase flood storage capacity.
Normal Operating Range: Headpond may vary in elevation between this range during normal operations.
Freeboard: The vertical distance between the top of the water retaining element of the dam (top of core) and the water level in the reservoir.

DATE: OCT 2003	DRAWN SLF	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY Calgary, Alberta Phone: (403) 250-5185	PROJECT ANVIL RANGE PROPERTY OMS MANUAL FOR DAMS		
REFERENCED DRAWING DESCRIPTION			TITLE TERMINOLOGY FOR DAM OPERATIONS		
		CLIENT Deloitte & Touche	PROJECT No. 0257-018-01	FIGURE No. 4	REV. 0

Faro Mine Complex Dams

Failure Mechanisms
Inspection for Problems

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Failure Mechanisms

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60 YEARS

Summary of RWC Failure Modes for Dams

Dam	Reasonably Worst Case Failure Modes
Intermediate Dam	• Overtopping due to floods (spillway designed for 1:500 year event), blockages and failure of the Second Tailings Embankment. • Static instability including surface sloughing, pore pressure changes and frost effects. • Seismic instability including overall stability and liquefaction. • Piping.
Cross Valley Dam	• Overtopping due to floods (spillway designed for 1:500 year event), blockages and failure of the Intermediate Dam. • Static instability including surface sloughing, pore pressure changes and frost effects. • Seismic instability including overall stability and liquefaction. • Piping.
Little Creek Dam	• Overtopping due to floods (emergency spillway designed for 1:200 year event) or pumping system failure (meant to keep pond down). • Static instability including surface sloughing, pore pressure changes and frost effects. • Seismic instability including overall stability and liquefaction. • Piping.

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Summary of RWC Failure Modes for Channels

Dam	Reasonably Worst Case Failure Modes
Faro Creek Diversion Channel	• Overtopping due to floods or ice/snow blockage. • Slope instability above the channel leading to deformation and/or blockage of the channel. • Instability (including complete failure) of proximal pit wall leading to leakage and/or blockage of the channel. • Leakage from the channel to nearby pit wall, possibly lending to piping in the dike.
Vangorda Creek Diversion Flume	• Overtopping due to floods (designed for 1:100 year event) or ice/snow blockage. • Blockage of the upstream headworks collection dam leading to dam breach. • Slope instability above the channel leading to deformation and/or blockage of the channel. • Instability (including complete failure) of proximal pit wall leading to leakage and/or blockage of the channel. • Leakage from the channel to nearby pit wall, possibly lending to piping in the dike. • Failure of the piping system and drop box below the channel.

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Intermediate Dam Alert Levels

Incident	Alert Level
Dam Overtopping	Reservoir level is at normal operating level and starts to rise to maximum operating level.
Dam Embankment Instability	Appearance of new cracks or the opening of existing cracks in crest or faces of dam. Significant warming trend in thermistors, increasing pore pressures in piezometers or high one-time reading from a single piezometer.
Piping	Small quantities of clear seepage water flowing from the toe or abutment of a dam may be considered normal, but should be recorded as part of the regular visual inspections being carried out. The location and seepage quantity, preferably measured by a weir or by the time required to fill a container of known volume should be monitored. Changes in the location, rate of flow may be related to reservoir levels, precipitation, snowmelt or thawing of ground ice. May be associated with warming trend in thermistors.
Seismic Instability and Large Earthquake Events	Site staff should inspect all dams after a seismic event has been felt at the site, regardless of the size of the event. Pore pressure readings should be taken on all piezometers. Information may be obtained from the PGC website given in the EPP regarding recent seismic events in western and northern Canada and Alaska.

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Cross Valley Dam Alert Levels

Incident	Alert Level
Dam Overtopping	Reservoir level is at normal operating level (See OMS Manual for dam specific reservoir data) and starts to rise to maximum operating level.
Dam Embankment Instability	Appearance of new cracks or the opening of existing cracks in crest or faces of dam. Significant warming trend in thermistors, increasing pore pressures in piezometers or high one-time reading from a single piezometer.
Piping	Small quantities of clear seepage water flowing from the toe or abutment of a dam may be considered normal, but should be recorded as part of the regular visual inspections being carried out. The location and seepage quantities, preferably measured by a weir or by the time required to fill a container of known volume should be monitored. Changes in the location, rate of flow may be related to reservoir levels, precipitation, snowmelt or thawing of ground ice. May be associated with warming trend in thermistors.
Seismic Instability and Large Earthquake Events	Site staff should inspect all dams after a seismic event has been felt at the site, regardless of the size of the event. Pore pressure readings should be taken on all piezometers. Information may be obtained from the PGC website given in the EPP regarding recent seismic events in western and northern Canada and Alaska.

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Little Creek Dam Alert Levels

Incident	Alert Level
Dam Overtopping	Reservoir level is at normal operating level and starts to rise to maximum operating level.
Dam Embankment Instability	Appearance of new cracks or the opening of existing cracks in crest or faces of dam. Significant warming trend in thermistors, increasing pore pressures in piezometers or high one-time reading from a single piezometer.
Piping	Small quantities of clear seepage water flowing from the toe or abutment of a dam may be considered normal, but should be recorded as part of the regular visual inspections being carried out. The location and seepage quantities, preferably measured by a weir or by the time required to fill a container of known volume should be monitored. Changes in the location, rate of flow may be related to reservoir levels, precipitation, snowmelt or thawing of ground ice. May be associated with warming trend in thermistors.
Seismic Instability and Large Earthquake Events	Site staff should inspect all dams after a seismic event has been felt at the site, regardless of the size of the event. Pore pressure readings should be taken on all piezometers. Information may be obtained from the PGC website given in the EPP regarding recent seismic events in western and northern Canada and Alaska.

Diversion Channels and Pond

North Valley Wall Interceptor Ditch

Rose Creek Diversion Channel

Faro Creek Diversion

Vangorda Creek Diversion Channel

Moose Pond

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Waste Dumps

Vangorda Rock Waste Dump

Other Waste Dumps

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Pit Lakes

Grum Pit – East Wall Instability Zone

Faro Pit – East Wall Instability Zones:
North Instability Zone
South Instability Zone

Vangorda Pit

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Inspection for Problems

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Inspection for Problems

Reservoir Problems

Crest Problems

Upstream Slope Problems

Downstream Slope Problems

Downstream Toe Problems

Downstream Abutment Problems

Low-Level Outlet Problems

Spillway Problems

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Minimum Checklist for Tailings Dam Inspections

GENERAL

- ☐ Ensure tailings discharge to pond in accordance with design and good practice - is tailings management plan being followed?
- ☐ Inspect condition of tailings lines, return water line for support, sagging, leaks
- ☐ If staged construction in progress, check for improper construction or operating techniques
- ☐ Inspect for evidence of animals burrowing in slopes of the dam and/or beaver activity near water control facilities
- ☐ Trees should not be allowed to grow on dam slopes as piping failure are possible along the root system - brush and grasses should be encouraged to reduce wind and water erosion and excessive freeze-thaw
- ☐ Check for wet areas on downstream face of dam and other signs of seepage
- ☐ Check the minimum beach width

GEOTECHNICAL

- ☐ Examine tailing impoundment area for potential slope instability that could enter impoundment and result in overtopping of dam
- ☐ Check for longitudinal and transverse cracking of dam
- ☐ Check for sinkholes in dam on the exposed beach and on the dam faces
- ☐ Check for sloughing on the upstream and downstream faces
- ☐ Question large changes in piezometer readings if dam is so equipped
- ☐ Check for heaving at toe of dam
- ☐ Check for horizontal and vertical movement of the dam crest. For larger dams, surface reference markers and/or slope indicators may be present and their data available
- ☐ Check integrity of any membrane or clay liners where exposed above the pond elevation
- ☐ If the dam has a decant culvert, carefully inspect for seepage along the outer walls. Check for collapse of decant structure indicated by increase of volume of discharged water compared with water that enters decant line, or by sinkholes along decant

WATER/ENVIRONMENT

- ☐ Check tailings pond elevation and location relative to design stipulations; adequate freeboard required year-round
- ☐ Is there water against the dam?
- ☐ Inspect diversion ditches for clogging and erosion
- ☐ Check decant system and spillways for proper operation, or readiness for operation
- ☐ Check decant and spillway for appropriate discharge away from toe of dam
- ☐ Check emergency and/or operational spillway for settlement and/or differential movement and integrity of structure
- ☐ If the dam is equipped with underdrains, they must be checked for flow volume and turbidity. Any seepage should be clear. Any flow that becomes turbid indicates a potentially serious condition
- ☐ Clear water or springs that develop on dam downstream face must be corrected. If springs develop turbidity, emergency action must be taken
- ☐ Stream flow or run-off must not be allowed to erode abutments

Klohn C

Inspection & Maintenance of Dams

(B.C. Ministry of Environment 2011)

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60 YEARS

Figure 1 – Principal Parts of an Embankment Dam

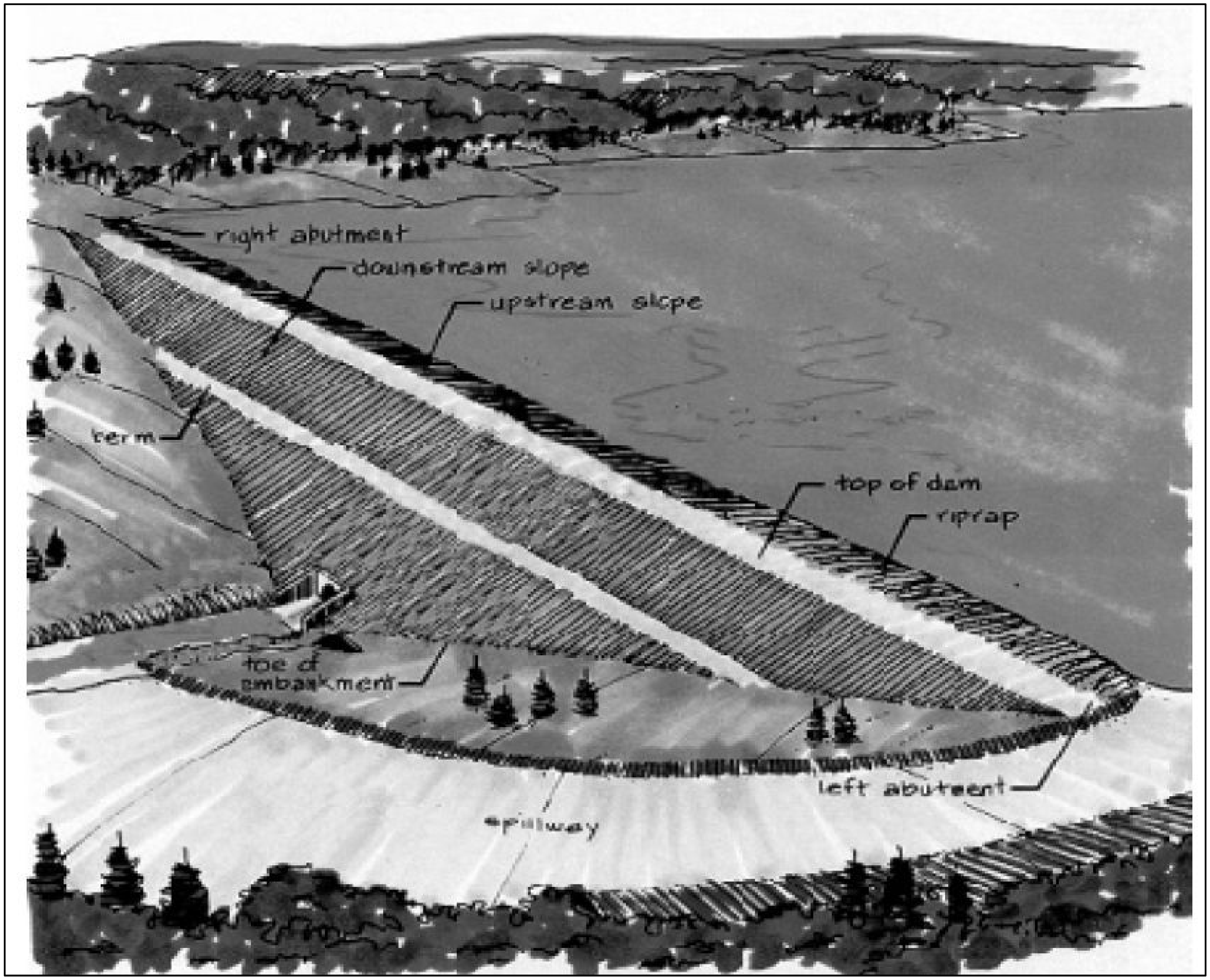

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Figure 2 – Typical Cross Section of an Embankment Dam

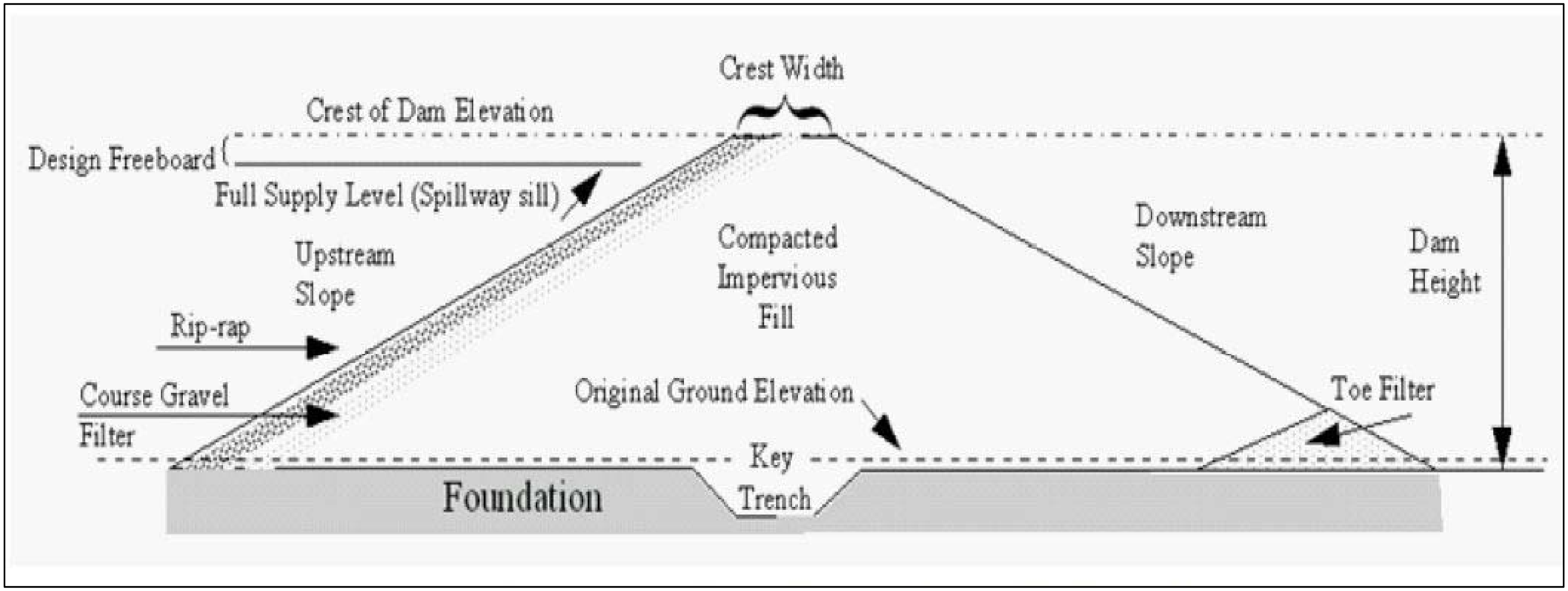

Figure 3 – Typical Catchment Area

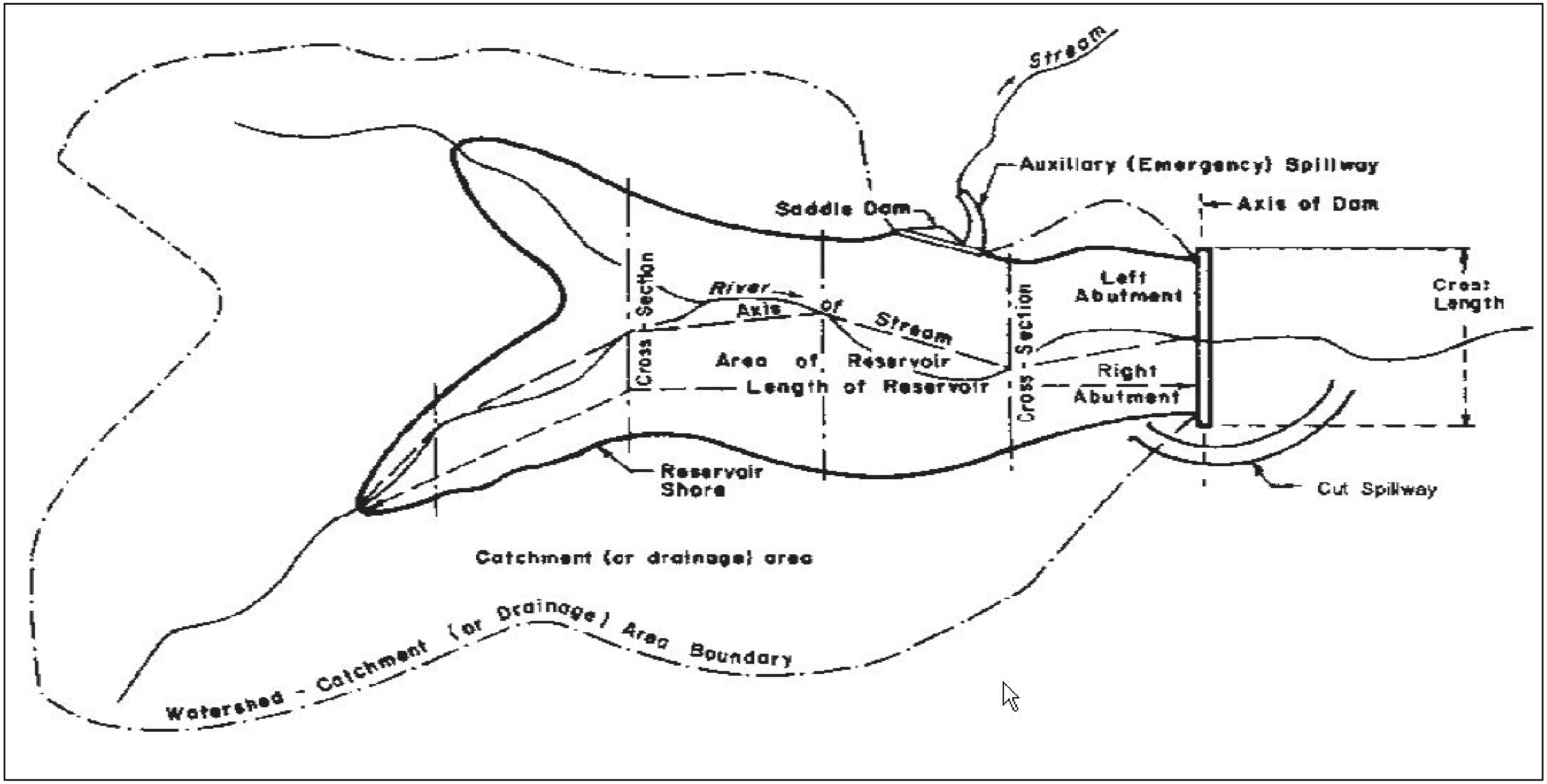

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Figure 4 – Dam Breach caused by Slope Instability

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Figure 5 – Testalinden Dam Failure (near Oliver) June 13, 2010

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Figure 6 – Ellis Creek Dam Failure (near Penticton) 1941

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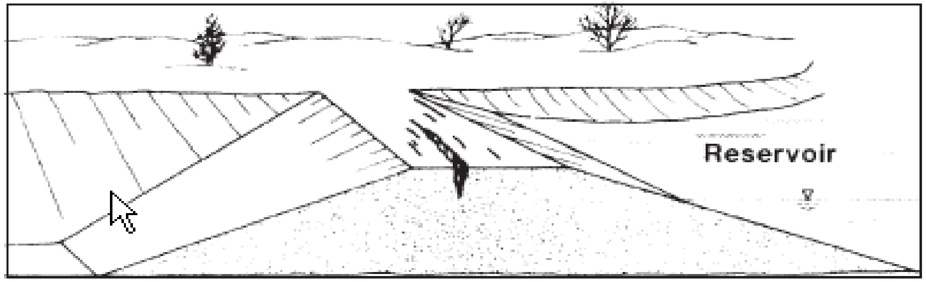
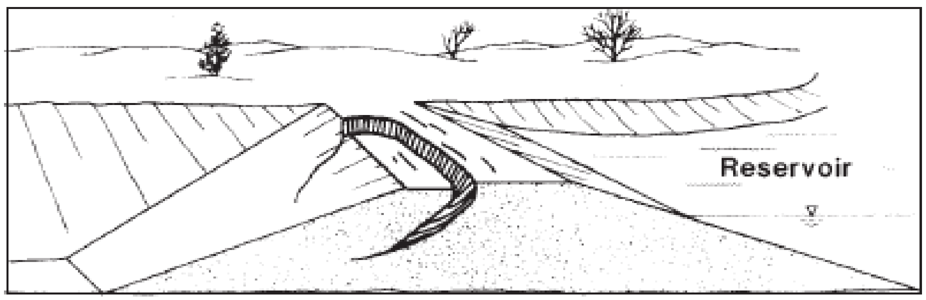
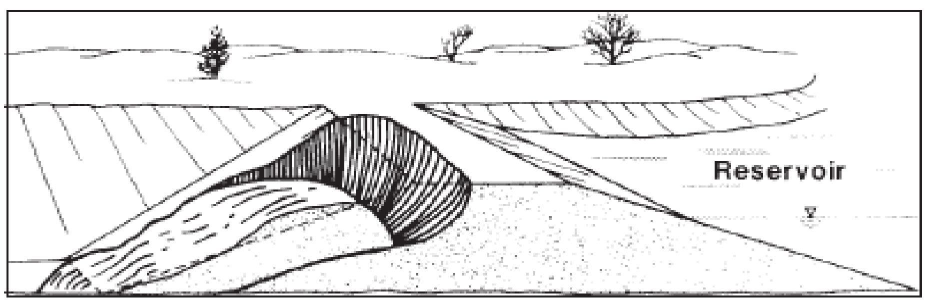
Figure 7 – Development of a Slope Failure from Longitudinal Cracking



A - Longitudinal cracks form and runoff water enters



B - Cracks widen and the ground settles on one side of the crack



C - The slope fails

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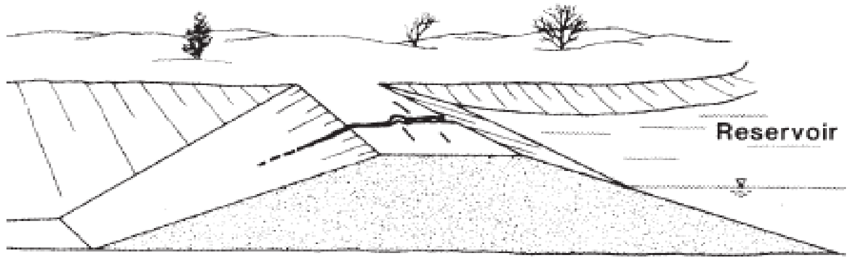
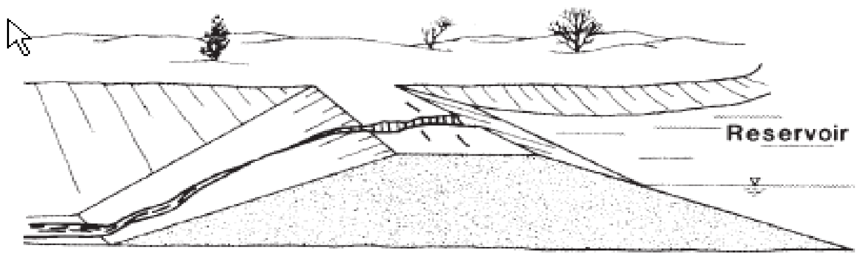
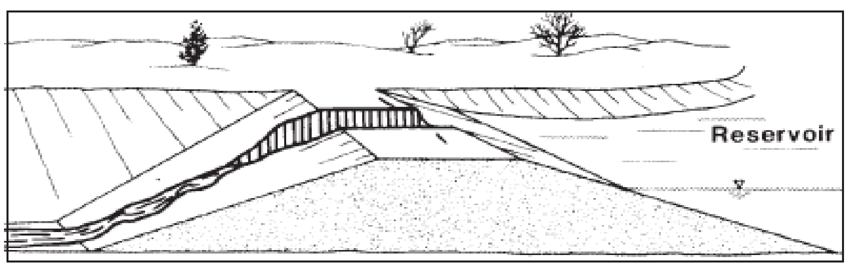
Figure 8 – Development of a Failure from Transverse Cracking



A - Initial Transverse Cracking
Often caused by settlement, foundation problems or placement of fill over steep abutments.



B - Progression of Transverse Cracking to a point below the waterline
Water from the reservoir begins to flow through the crack.



C - Transverse Cracking progressed to an overtopping situation
Condition has progressed to a point of imminent failure.

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Figure 9 – Dam Inspection in Northern B.C.

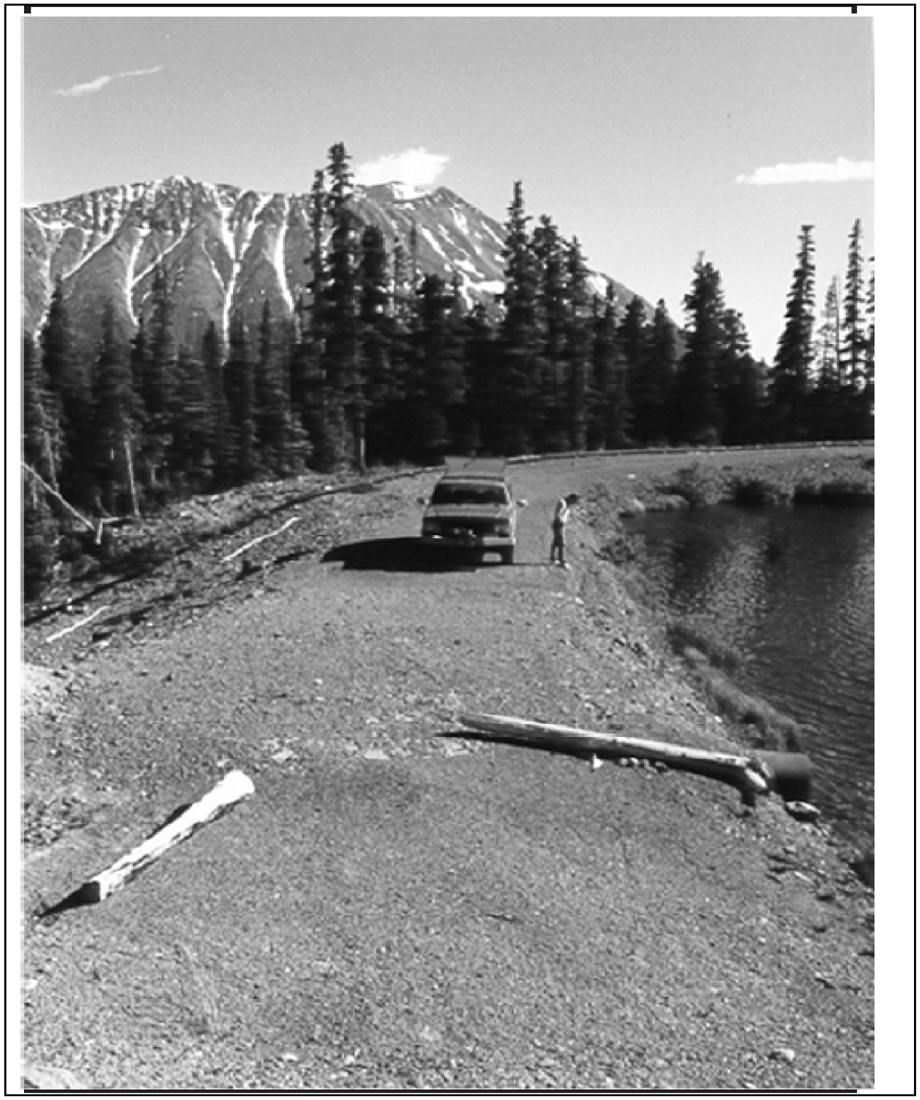

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Figure 10 – Potential Problem Indicators

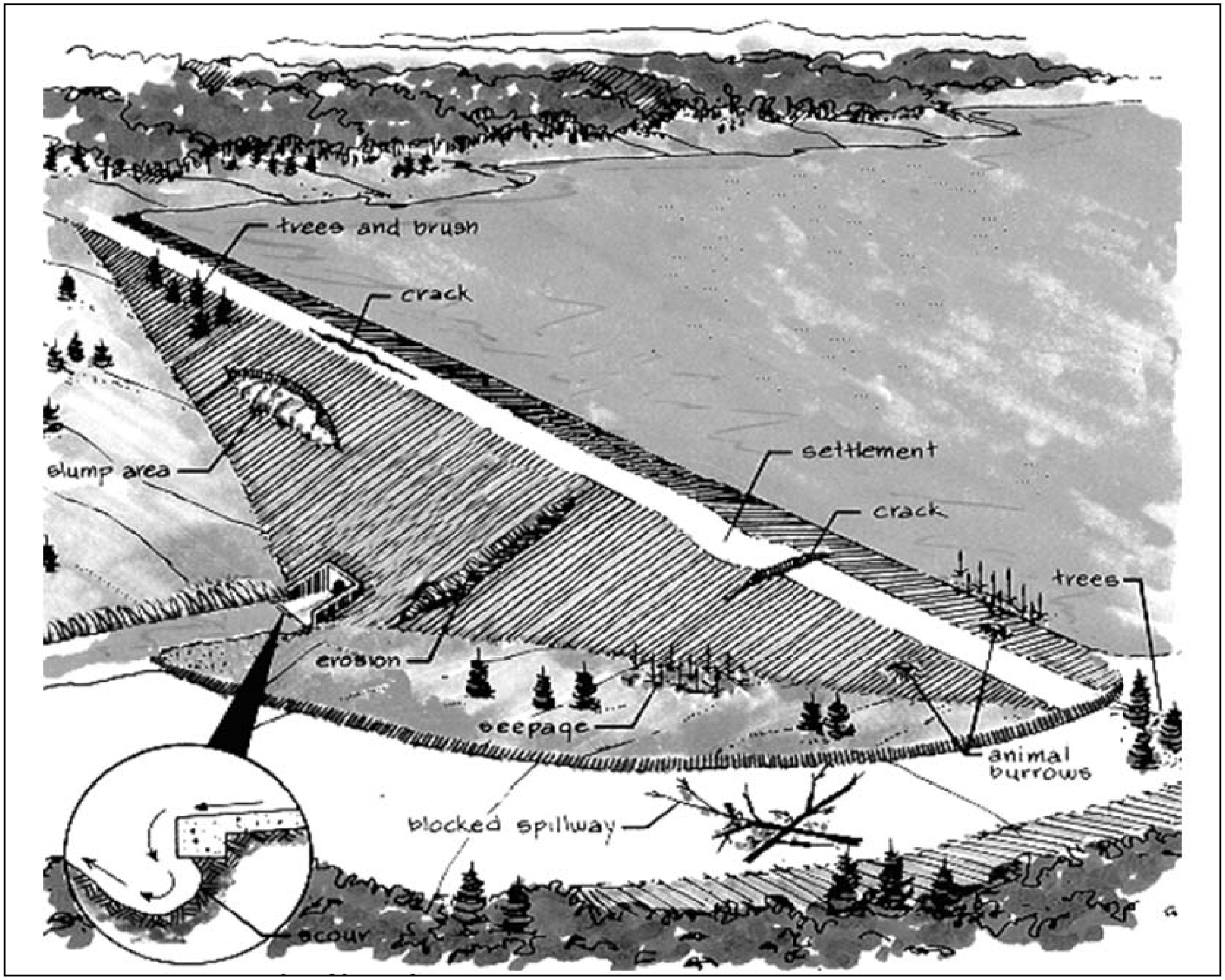

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Figure 11 – Transverse Cracking

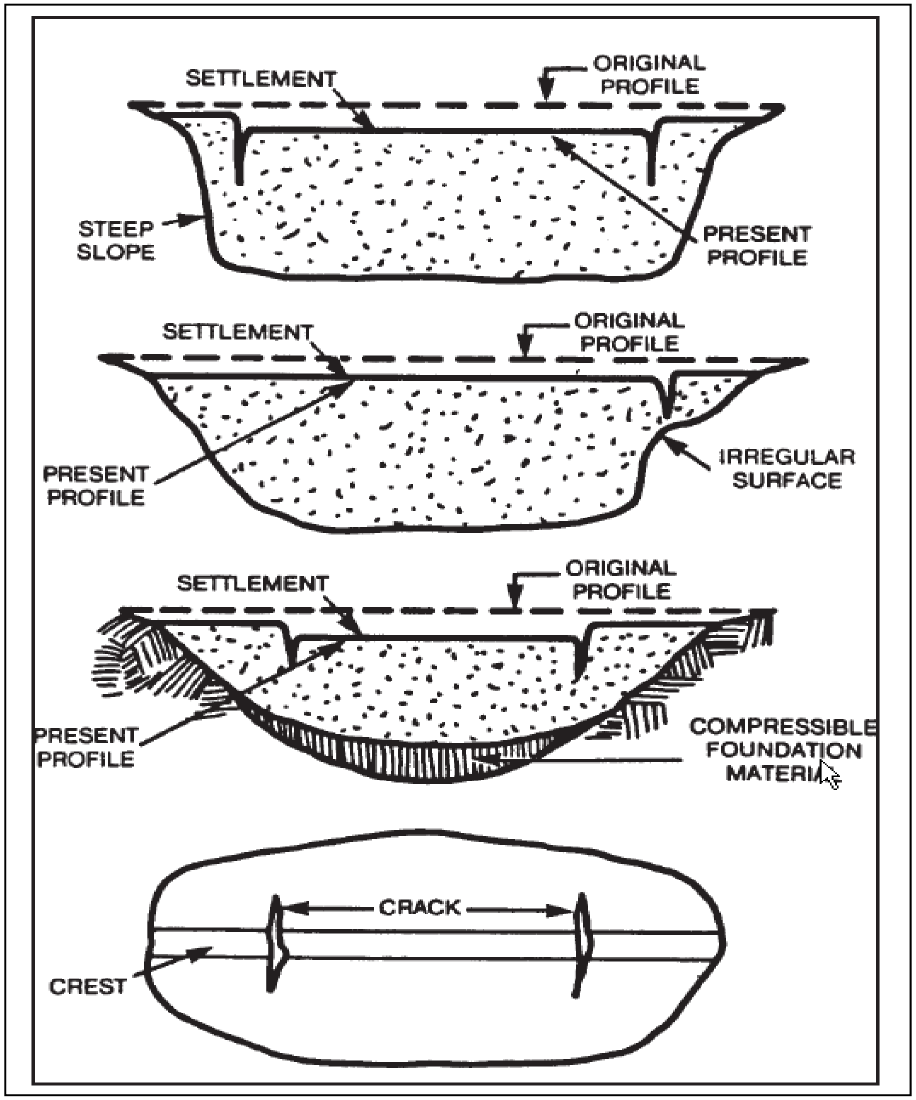

Figure 12 – Longitudinal Cracking

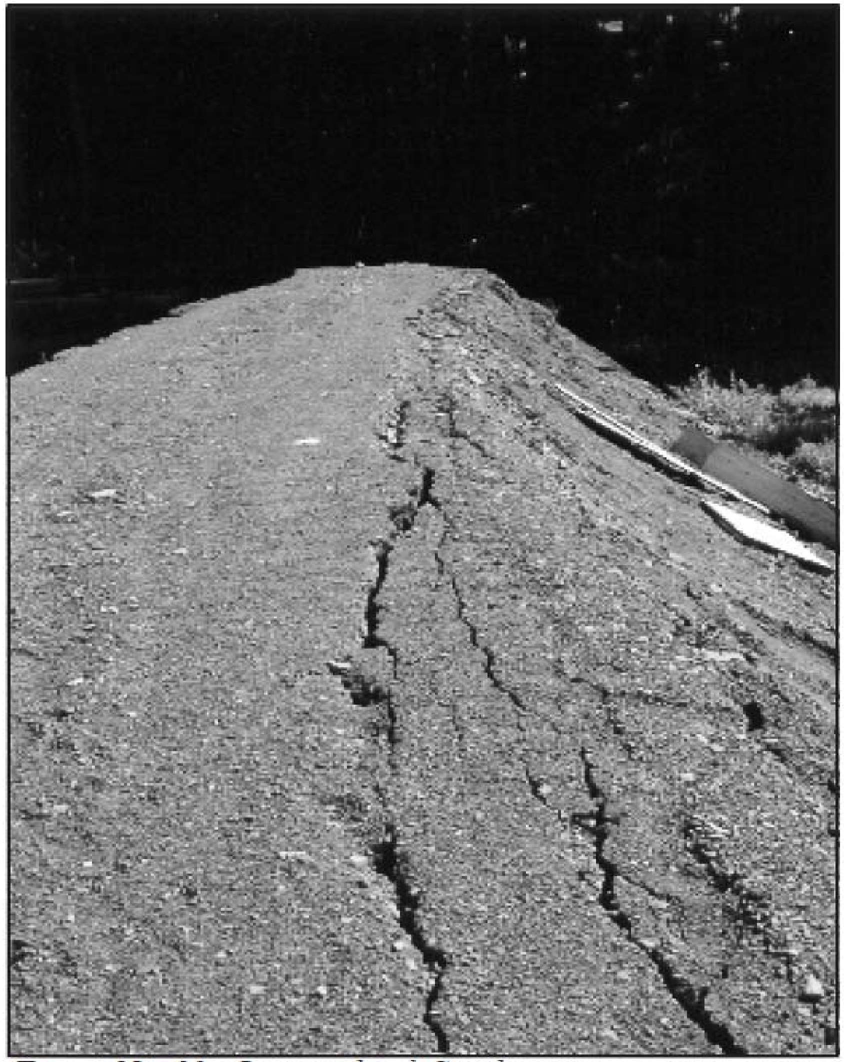

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Figure 13 – Obstructed spillway channel

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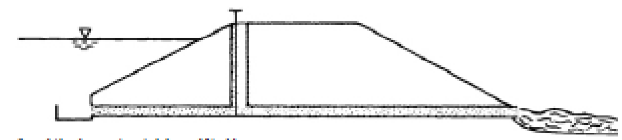
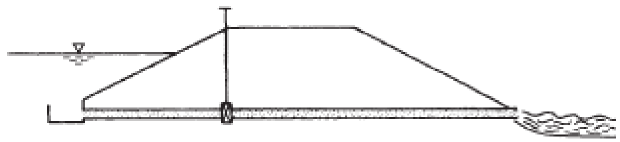
Figure 14 – Most Common Types of Low Level Outlet Controls



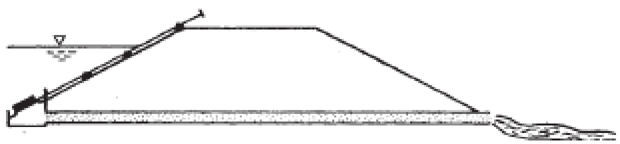
A - Slidegate / Dry Well

Best protection from ice and water damage. The downstream side of the gate can be inspected in the dry. By blocking the inlet, the well and conduit can be drained for maintenance and repairs.



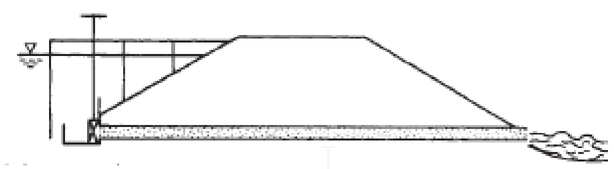
B - Inline Sealed Valve

May be difficult to service unless it is installed in a dry well.
Conduit upstream of valve is under constant pressure from reservoir head.



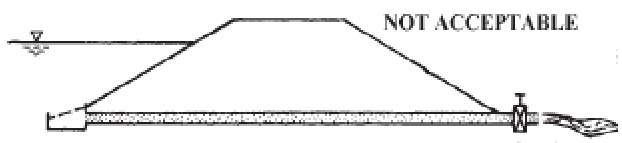
C - Inclined Slidegate

Slidegate and control may be damaged by ice, leaving system inoperable.



D - Vertical Slidegate & Catwalk

Slidegate, control and catwalk may be damaged by ice, leaving system inoperable.
Catwalk requires additional maintence to remain in a safe usable condtion.



E - Downstream Valve

Entire conduit is under constant pressure from reservoir head.
This design would not be allowed on new or replacement outlets.
See potential failure scenario Figure No. 16, page 31.

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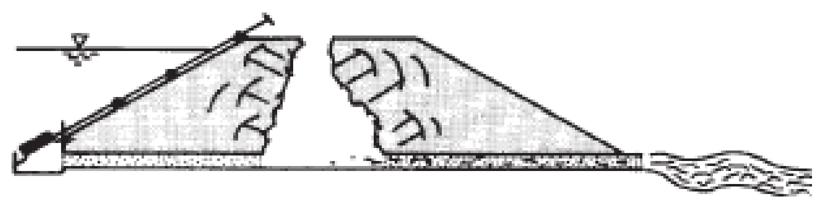
Figure 15 – Development of a Sinkhole and Failure Resulting from a Hole or Joint Separation in the Conduit

A - Hole develops in conduit, eroding embankment

B - Hole in Conduit enlarges, cavity develops.
Debris partially blocks outlet.



C - Sinkhole develops, complete failure is probable.

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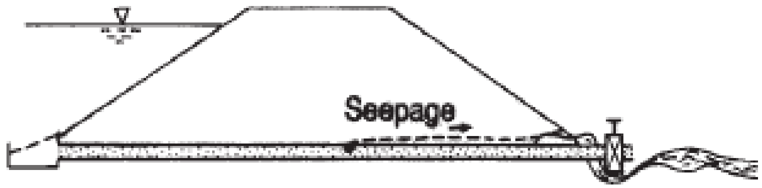
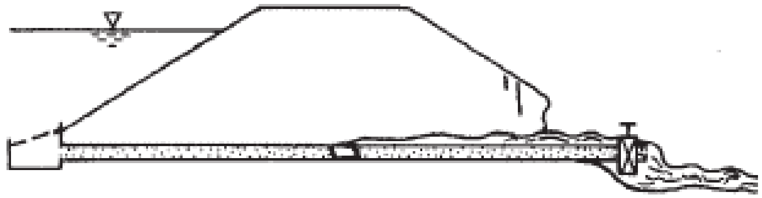
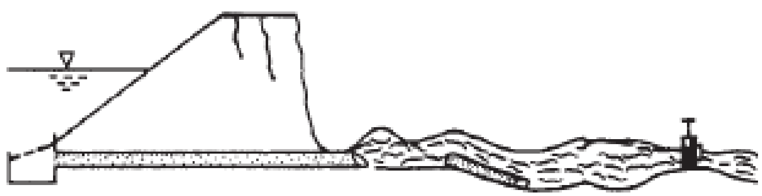
Figure 16 – Development of a Piping Failure Resulting from a Hole in a Conduit with a Downstream Valve



A - Hole develops in conduit with downstream valve which is under constant pressure from reservoir head.



B - Hole enlarges allowing increased flow and a piping failure begins.



C - Reservoir drains through the conduit.

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Figure 17 – Excess growth, broken log boom

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Figure 18 – Properly maintained

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Figure 19 – Intake Control Access Structure Failure

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Figure 20 – Outlet discharge weir

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Figure 21 – Inspecting a spillway training wall

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APPENDIX IV

2012 TEES Maintenance Activities in Response to 2011 Annual Review Recommendations

	Completed
	Not Started
	In Progress

Recommendations from 2011 Annual Geotechnical Review

Short Term (ie/ fall/winter and as time permits):	Comments
• Rob Wren to confirm with site environmental staff that photos of pits taken at same vantage points	Procedure is written map being developed as part of the procedure to identify correct area by which photo's will be taken
• Faro Creek Diversion – Cover exposed geotextile and tarp with rock armour. Replace damaged geotextile and tarp, if any.	The area noted is actually bentomat and is current exposed in the pilot channel of the Faro Diversion. We recommend it not be disturbed but areas where armouring are required this work will be completed in the spring of 2013.
• Rose Creek Diversion Channel – Document seepage locations from RCDC into tailings impoundment area after fresh snow fall condition.	Map developed and GPS locations of seepage areas documented. Information is in the geotechnical file. This is ongoing observations.
• K8 Rock Drain – Rob Wren/Eleni to add flagging tape to the haul road to mark location; environmental staff to continue to monitor head pond level and downstream flow conditions.	All actions completed. Map being developed to identify vantage point for photo's.
• Vangorda Drop Box – Check culverts in drop box to ensure no blockages; to be done during low water levels and all H&S protocols to be followed (confined space etc)	Additional inspection of the drop box will be completed pre freshet 2013. We have completed a visual in 2012 with no clear evidence of drop box being compromised. External support will be needed to complete inspection. This will involve a remote camera of some type. Individual has been contacted and has capacity to do the lengths required.
• Sheep Pad Pond – Replace missing riprap in spillway channel and replace damaged geotextile, if any.	Completed
• Replace erosion-damaged section of the V-15 ditch (V25BSP?) upslope of Moose Pond.	Completed
• Grum Pit monitoring pins, north array – remove vegetation around and near pins to facilitate ability to check potential ground deformation or cracks near rods.	Brush clearing has been completed.

Medium/Long Term (2013 as time permits):	Comments
• North Valley Wall Interceptor Ditch (NVWID) – Clear vegetation along upper and middle constructed channel reaches. Clearing should also include the access road and berm along the channel to facilitate future inspection.	Clearing has begun. Weather dictating progress.
• North Fork Rock Drain – consider contingency measures for the potential flood impact on the main access road (riprap replacement?)	YG (highways) owns these culverts
• Intermediate Dam – Repair shoulder erosion of the downstream berm.	Not started. Will need to develop plan for completing this project
• Repair shoulder erosion of the downstream berm	Not started. Will need to develop plan for completing this project
• Rob Wren to assess Vangorda WRD weirs and weir plates to be repaired or replaced.	All weir locations as well as required repairs have been forwarded to Operation for execution. Additional weir location identified.
• Little Creek Dam – Consider repair of rill erosion on both dam slopes.	Not started. Will need to develop plan for completing this project
• Moose Pond – determine bathymetry.	This is schedule for the summer of 2013

Ongoing:

Regular monitoring of geotechnical/hydrotechnical structures as outlined in recommendations, as well as the following items to make note of:	Comments
• North Valley Wall Interceptor Ditch (NVWID) – Monitor channel sedimentation condition at the well-access road crossing, and remove sediments if excessive sediment is deposited in the channel.	Monitoring plan in place. This is part of our monthly compliance inspections and is reported accordingly.
• IP Dam – Monitor ongoing downstream slope rill erosion and resulting slope slumps and longitudinal cracks – with emphasis during freshet	Monitoring plan in place. This is part of our monthly compliance inspections and is reported accordingly.