Klohn Crippen Berger

Yukon Government

Faro Mine Complex

2014 Annual Geotechnical Review

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Klohn Crippen Berger

September 18, 2015

Yukon Government
Faro Mine Remediation Project
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Karen Furlong, EIT
Project Manager

Dear Ms. Furlong:

Faro Mine Complex
2014 Annual Geotechnical Review

We are pleased to submit the report on Faro Mine Complex - 2014 Annual Geotechnical Review, including Appendix I on 2014 select site photos, Appendix II on reviewed site monitoring data, Appendix III on instrumentation status and monitoring schedule and Appendix IV on 2014 site staff training PowerPoint presentation. The current review covers the geotechnical and hydrotechnical aspects 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 site observations by Ben Olsen and Robert Lo on June 10 to 12, 2014 and by Kate Patterson and Robert Lo on September 9 to 11, 2014 and ongoing review of monitoring data collected by Tlicho Engineering and Environmental Services.

Golder conducted a pit wall slope stability inspection and review at the Faro, Grum and Vangorda Pits on August 19 to 22, 2014. They concluded that the slopes of all three pits are exhibiting adequate overall stability. WorleyParsons conducted a dam safety review for the Intermediate, Cross Valley and Little Creek Dams with a site visit on September 25 and 26, 2014. They concurred that all three dams can be classified as "high" consequence dams.

The critical issues at Faro in 2014 include: continued rise of pit lake level at the Faro and Grum Pits, ongoing development of slope slumps on the hillside of Rose Creek Diversion Channel, ongoing pit wall deformation in the East Instability Zone at the Grum Pit and the implementation of a plug dyke and seepage collection program on the Faro Creek North Fork. Measures taken in 2014 to deal with these issues are discussed in the report. In 2015 these issues will be followed closely in order to reduce their impact on the normal care and maintenance activities at Faro.

Yours truly,
KLOHN CRIPPEN BERGER LTD.

David Willms, P.Eng. (YT)
Project Manager

DW/RL:dl

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Yukon Government

Faro Mine Complex

2014 Annual Geotechnical Review

EXECUTIVE SUMMARY

Notice: The Executive Summary is provided solely for purposes of overview. Any party who relies on this report must read the full report. The Executive Summary omits a number of details, any one of which could be crucial to the proper application of this report.

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 site observations by Ben Olsen and Robert Lo on June 10 to 12, 2014 and by Kate Patterson and Robert Lo on September 9 to 11, 2014 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. 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.

Representative 2014 site photographs taken by KCB and TEES are included in Appendix I, and the reviewed TEES monitoring data are organized in Appendix II. Appendix III summarizes the current status of instrumentation monitored by TEES and presents 2014 geotechnical/hydrotechnical monitoring schedule with minor adjustment for 2015. Appendix IV shows PowerPoint slides used for the training session held on June 12, 2014 for staff in TEES environmental group.

The following highlights some of the current and general issues for the site facilities at Faro Mine Complex:

Dam Safety Aspect

- According to the Canadian Dam Safety Guidelines (CDA 2007), both the Intermediate Dam and Cross Valley Dam were due for their third dam safety review in 2014, because of their classification as “high” consequence dams. Moreover, a dam breach and inundation study completed by KCB (2014a) confirmed the “high” consequence classification of these two dams, and raised the Little Creek Dam classification from “low” to “significant” or “high” pending on a more refined future inundation study.
- The Operations, Maintenance and Surveillance (OMS) Manual and Emergency Response Plan (ERP) for the Intermediate, Cross Valley and Little Creek Dams were updated as a joint effort by the Government of Yukon (YG), Tlicho Engineering and Environmental Services (TEES) and Klohn Crippen Berger (KCB), and issued in 2014 (KCB 2014b and 2014c). The updated ERP document also included three diversion channels: Faro Creek Diversion Channel, Rose Creek Diversion Channel and Vangorda Creek Diversion Flume.

- WorleyParsons (2015) conducted a dam safety review for the Intermediate, Cross Valley and Little Creek Dams with a site visit on September 25 and 26, 2014. They concurred that all three dams can be classified as "high" consequence dams.
- In response to the dam safety review by WorleyParsons, the Government of Yukon (YG), Tlicho Engineering and Environmental Services (TEES) and Klohn Crippen Berger (KCB) updated the Emergency Response Plan (ERP) in draft (KCB 2015b), and plan to issue the update of both the ERP and Operations, Maintenance and Surveillance (OMS) Manual by March 2016.

Water Treatment Aspect

- In 2014, a temporary lime treatment plant was set up at the north abutment of the Cross Valley Dam in early August to treat and release water from the Polishing Pond via North Valley Interceptor Ditch, when water quality is in compliance with discharge criteria. In addition, excess water in the Intermediate Pond was pumped back to the Faro Pit. The interim water treatment plant was constructed at the Faro plant site, and had been used briefly to treat water from Faro Pit Lake in October.
- In 2014 water was pumped from the Grum Pit Lake, via Vangorda Pit Lake and treated at Vangorda Water Treatment Plant from June to September.
- In 2014 the lake levels at the Faro and Grum open pits have risen above the respective recommended levels as follows:
- Faro Pit Lake – lake level on December 29 to El. 1152.4, about 8.1 m above the recommended maximum level; and
- Grum Pit Lake – lake level on December 29 to El. 1216, about 2.6 m above the recommended maximum level

  The current lake levels at the two pits are in the overburden and/or weathered surficial bedrock zones that may be more pervious than the sound bedrock at depth. Thus, the raised lake levels could cause increased groundwater quality degradation in the pit rim region and/or reduced local pit wall stability at the toe, especially during rapid drawdown of the lake level.

Spring Freshet Aspect

- No excess inflow into Moose Pond occurred during the 2014 spring freshet due to the improved interception of surface runoff from the Grum Waste Rock Dump to the Vangorda Pit Lake.

Pit Wall Stability Aspect

- Golder (2014) conducted a pit wall slope stability inspection and review at the Faro, Grum and Vangorda Pits on August 19 to 22, 2014. They concluded that the slopes of all three pits are exhibiting adequate overall stability.
- We understand that YG (2015) intends to strengthen the Faro Pit East Rim Slope Stability Monitoring program carried out by TEES during the current period of elevated Faro Pit lake

level. The concern is due to the decreased storage capacity of the pit lake. Should an event, such as blockage of the Faro Creek Diversion Channel, a larger flood or a pit wall failure at the Faro Pit East Rim causing water in the diversion channel to flow into the pit, the amount of response time to the event before the pit is overtopped would be reduced. The objective of an intensified monitoring program is to gain as much lead time as possible to take mitigation measures under current circumstances (KCB 2015a).

- The 2014 pit-wall rim movement monitoring programs at the Faro and Grum Pits indicate that the measured distance changes are within the measurement accuracy. At the Grum Pit, cracks that developed in the summer of 2012 at Reference Rod GP-N2 in the north array continued to grow in width and depth in 2014. Additional crack was also observed between Reference Rod GP-N2 and GP-N3. Safety precautions related to site personnel working in the area were highlighted to prevent accidents. We recommend that YG prepares a contingency plan with a specified time frame to relocate the existing power lines and transformer station located on the east pit rim of the Grum Pit that are subject to the impact of a rapid pit wall failure (KCB 2014d).

Facility Maintenance Aspect

- The deformed segments of the hillside channel slope of the Rose Creek Diversion Channel (also called Back Slope) were examined by KCB in our spring and fall site visits in 2014, both on the Back Slope and from the Canal Dyke crest. The deformed Back Slope segments initially observed by TEES personnel in 2013 were marked: the primary deformed area to the west, in the vicinity of Instrument Cluster BS-10 was flagged; while the secondary deformed area to the east, in the vicinity of Instrument Cluster BS-5 was staked during our spring visit to facilitate ongoing monitoring (see Figure 7). Slope slump activities appeared to progress more in the primary than secondary area from June to September 2014. In addition, signs of slope slump seemed to also initiate in two other areas: one west of the primary and the other east of the secondary area as observed from the crest of the Canal Dyke in September 2014.
- Available project records indicated that the current slumping activities on the Back Slope are recurrent events that were active in the past at various locations and at different time. Two mechanisms could contribute to these activities: surficial saturation effect due to precipitation and runoff, and weakening effect of the newly thawed subsoil at depth.
- Our preliminary review suggested that non-functional existing thermistors on the Back Slope need to be repaired or replaced and monitored in 2015 after the Back Slope can be accessed in late spring. Close visual inspection of the Back Slope should continue in 2015 to confirm whether the slumping activities will accelerate/expand or stabilize/decelerate.
- Back slope maintenance strategies include: monitoring and repair in select area as required, installing instrumentation on the Back Slope through existing earthfill thermal liner and installing Styrofoam insulation board on an experimental basis to slow down the downward thawing process. We expect that monitoring and repair in select areas, as required, would be the preferred approach in 2015, unless slumping activities accelerates significantly (KCB 2014f). We request for the following missing annual review reports by Golder (1983 to 1999)

and BGC (2000, 2001 and 2003), especially for those early years when repair works in the Back Slope area were conducted:

The objective of seeking these project records is to learn from past experiences:

- How the past repairs were carried out? and
- How effective were various repair methods.

These past successful experiences would provide valuable guidance for ongoing current and future care and maintenance activities in the Back Slope.

- A small rill erosion of the Rose Creek Canal Dyke south shoulder near the Cross Valley Dam south abutment observed in 2013 fall was repaired satisfactorily.
- At the North Valley Wall Interceptor Ditch, the access road to the potable well was repaired and three culverts embedded in the roadfill were cleared of cumulated sediments. The channel bottom was slightly over-excavated at both the culvert inlet and outlet to create a sediment trap and to minimize sediment deposition inside the culverts.
- We understand that the Interim Water Treatment Plant at Faro operated briefly in the late fall of 2014 for about one month, treating about 3000 m^3 of Faro Pit Water. In 2015, the goal of water treatment at Faro is to draw down the level of Faro Pit Lake by at least 4 m, and aiming at a target level of 1149 m by April 1, 2016. At the Grum Pit, the lake level is expected to be lowered further in 2015 than that in 2014.
- At Moose Pond, 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. To recover the pond bottom's exfiltration capacity, careful removal of excess silt sediments accumulated during the 2011 and 2013 spring freshets using a small backhoe with low bearing pressure could be attempted, if the pond is allowed to dry during late summer.
- Flash floods in 2004 and 2012 overflowed the Vangorda Flume (i.e., CSP half pipe). The flood flow was barely contained by the channel slopes above the flume without spilling into the Vangorda Pit. The CSP lining has holes or is torn at several locations, and many of the cross braces are bent. We understand that the installation of a replacement flume and/or channel along a different route is being studied. The replacement structure should be installed as early as practical.

In general, the key water and waste management facilities at both the Faro and Vangorda Plateau sites have functioned satisfactorily in 2014 as in the past. The care and maintenance activities, including instrument monitoring and survey measurement, also generally followed the planned schedules.

CLARIFICATIONS REGARDING THIS 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

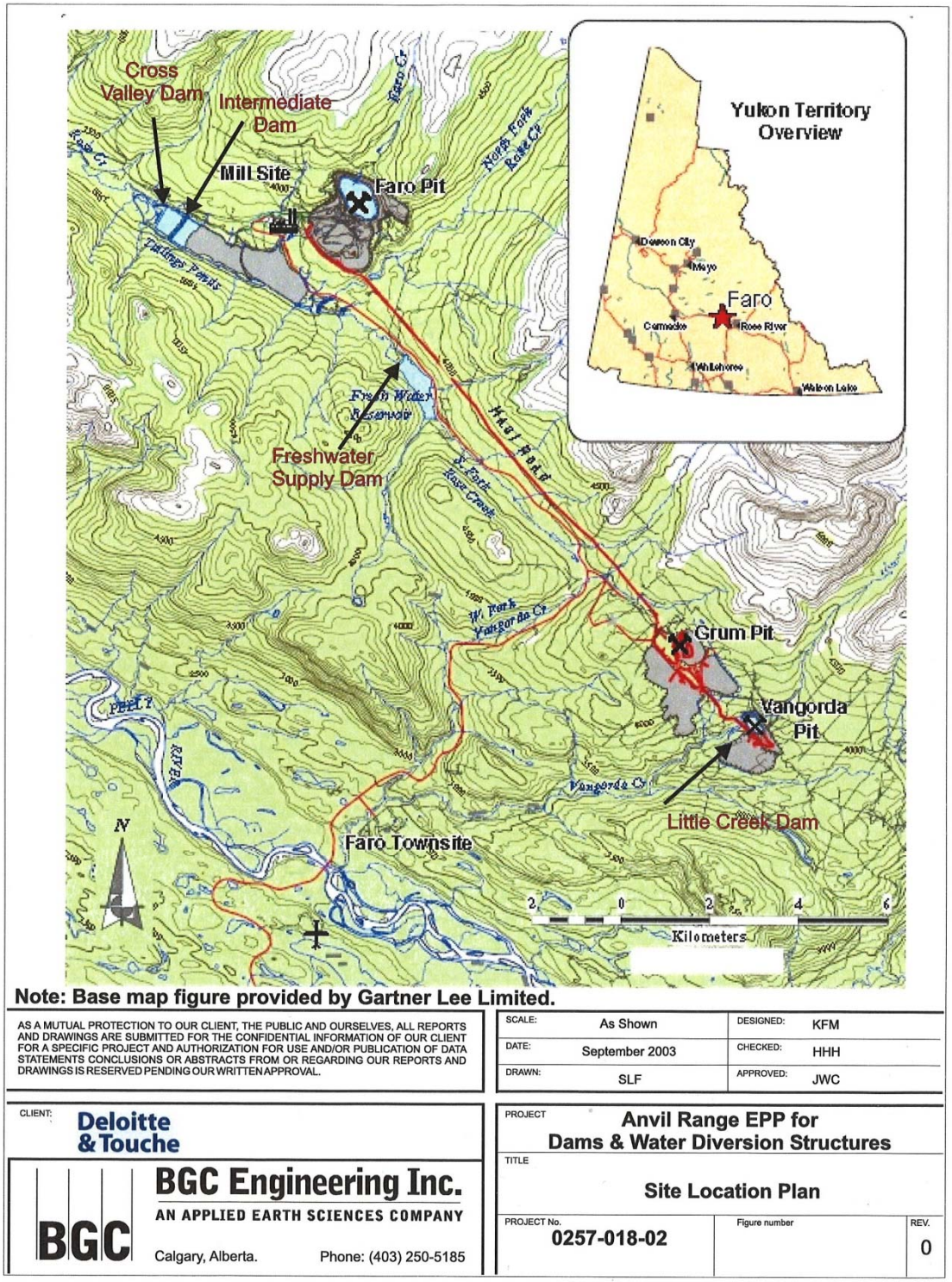
The Faro Mine site is located approximately 200 km north-northeast of Whitehorse, Yukon, as shown on the site location plan on page 2. It consists of the Faro Mine which was in production from 1969 to 1992 (with production rates of 5,000 tonnes per day to 9,300 tonnes per day), and the Vangorda Plateau Mine which was in production from 1986 to 1998. From 1998 to 2008, the mine site was under the management of Deloitte & Touche, who were the court-appointed interim receiver. From 2009 to date, the Yukon Government has actively managed the mine complex. 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 and waste retention and water diversion structures. Tlicho Engineering and Environmental Services (TEES) replaced Denison in 2012.

There are three main waste and water retention dams, Intermediate, Cross Valley and Little Creek Dams, in the Faro Mine Complex covered in the Operations, Maintenance and Surveillance (OMS) Manual (KCB 2014b), while in addition to these three dams, three water diversion structures, Faro Creek and Rose Creek Diversion Channels and Vangorda Creek Diversion Flume, are included in the Emergency Response Plan (ERP) (KCB 2014c). The Intermediate and Cross Valley dams are located in the Rose Creek Valley and were constructed between 1981 and 1991 to form the Down Valley tailings area (Golder 1980, 1981, 1982, 1983, 1990a, 1990b and 1992). The Little Creek Dam, constructed in 1991 with a spillway added in 1998, is located adjacent to Vangorda Creek to capture water discharging from the Vangorda Waste Rock Dump (SRK 1990 and 1998).

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) (1999), BGC Engineering (2000 to 2009), and SRK Consulting Engineers (1996 to 2011). The annual reviews for 2011-2013 were completed by Klohn Crippen Berger (KCB 2012-2013 and 2014d).

According to the Canadian Dam Safety Guidelines (CDA 2007), both the Intermediate Dam and Cross Valley Dam were due for their third dam safety review in 2014, because of their classification as “high” consequence dams. Moreover, a dam breach and inundation study completed by KCB (2014a) confirmed the “high” consequence classification of these two dams, and raised the Little Creek Dam classification from “low” to “significant” or “high” pending on a more refined future inundation study. The Operations, Maintenance and Surveillance (OMS) Manual and Emergency Response Plan (ERP) for the Intermediate, Cross Valley and Little Creek Dams were updated as a joint effort by the Government of Yukon (YG), Tlicho Engineering and Environmental Services (TEES) and Klohn Crippen Berger (KCB), and issued in 2014 (KCB 2014b and 2014c). The updated ERP document also included three diversion channels: Faro Creek Diversion Channel, Rose Creek Diversion Channel and Vangorda Creek Diversion Flume. WorleyParsons (2015) conducted a dam safety review for the Intermediate,

Cross Valley and Little Creek Dams with a site visit on September 25 and 26, 2014. They concurred that all three dams can be classified as “high” consequence dams. In response to the dam safety review by WorleyParsons, the Government of Yukon (YG), Tlicho Engineering and Environmental Services (TEES) and Klohn Crippen Berger (KCB) updated the Emergency Response Plan (ERP) in draft (KCB 2015b), and plan to issue the update of both the ERP and Operations, Maintenance and Surveillance (OMS) Manual by March 2016.



Site Location Plan of Faro Mine Complex

1.2 Project Scope

This report documents the 2014 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 2013 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 2014 task, such as Vangorda Pit, Grum Waste Rock Dump, we have included our observations or headings here for future reference.

Faro Site (see Figures 1 and 2):

- Faro Pit and 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 Waste Rock Dump
- Vangorda Waste Rock Dump
- Grum Interceptor Ditch
- Vangorda Northeast Interceptor Ditch
- Vangorda Creek Diversion Flume
- 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 Ben Olsen and Robert Lo on June 10 to 12, 2014 and by Kate Patterson and Robert Lo on September 9 to 11, 2014 and ongoing review of monitoring data collected by Tlicho Engineering and Environmental Services (TEES).

1.3 Related Reports by Others

Golder (2014) was onsite between August 19 and 22, 2014 to conduct their 2014 review of pitwall stability at the Faro, Grum and Vangorda Pits, and Worley Parson (2015) was on site on September 25 and 26, 2014 to conduct their dam safety review for the Secondary Tailings Dam, Intermediate Dam, Cross Valley Dam and Little Creek Dam. BGC (2014) presented a plan to implement a plug dyke and

seepage collection program in the Faro Creek North Fork Rock Drain area to remedy water quality of North Fork Rose Creek flow. References of these reports are listed at the end of this report, and relevant comments related to these reports are in appropriate sections of this report.

1.4 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. 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.

Representative 2014 site photographs taken by KCB and TEES are included in Appendix I, and the reviewed TEES monitoring data and Faro Airport climate data are organized in Appendix II. Appendix III contains three summary tables outlining the status of instrumentation, the 2014 geotechnical/hydrotechnical monitoring schedule and our proposed schedule in 2015 with minor adjustment. Appendix IV shows PowerPoint slides used for the training session held on June 12, 2014 for staff in TEES environmental group.

2 FARO SITE FACILITIES

2.1 Faro Pit and Faro Creek Diversion Channel

Faro Pit (see Photos 1 to 4 and Figure 2) and Faro Creek Diversion Channel (FCDC) (see Photos 5 and 6 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

The 2014 observations of the Faro Pit are as follows:

- No obvious changes in the North and South Instability Zones of the east pit wall were observed, except minor erosion by runoff.
- Pitwall Photos 3 and 4 were taken by TEES on December 15, 2014 showing the seepage exit area in Photo 1. Golder indicated that there has always been seepage at this location, just below the overburden/bedrock contact. These photos most likely reflect the fact that the weather has warmed up in mid-December allowing groundwater to daylight. Subsequent rapid freezing caused the seepage to freeze on the wall. We understand that YG plans to engage a consultant to investigate in 2015 whether ice plucking may contribute to pitwall degradation at this location. The source of this seepage is likely to derive from farther behind the slope where snow is melting and infiltrating into the bedrock, and the meltwater is flowing along the overburden/bedrock contact until it is discharged at the face of the slope. Continued monitoring by TEES of seepage condition after December 15, 2014 did not find anything unusual in the buffer zone between the pitwall and the Faro Creek Diversion Channel behind the access road.

Faro Creek Diversion Channel (FCDC)

Our 2014 observations of the Faro Creek Diversion Channel are as follows:

- The channel and side slopes appeared to be stable along most of its length.
- During spring freshet, minor side slope slumps due to surface runoff erosion occurred at some locations.
- Cross-channel overhead wire was installed in 2014 at Staff Gauges FCD-1, FCD-2 and FCD-4 to facilitate flow measurement under high flow conditions.

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 2014).

- Data provided by TEES on Faro Pit for the year of 2013 and survey data on Faro Pit reference bars and prisms by YES (2013a) are presented in Appendix II, and discussed in our 2013 annual review report. 2014 monitoring data by TEES and YES were reviewed by Golder (2014). The detailed review by Golder seemed to indicate that a review in the field by Golder and YES may potentially clarify some of the survey details and improve the survey results.

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 Appendix II-B) - Historical and 2014 flows in the Faro Creek Diversion Channel are shown in Table 2.1. Since the values shown in the table are based on spot measurements, they might not show the lowest or the highest flows the channel experienced during the reporting period.
- Discharge rating curves for the staff gauges are shown in Section II-B1 of Appendix II. Two rating curves are shown for FCD-3 and FCD-4: one for the period 2008 to 2010; and the other for the period 2011 to 2014. Different staff gauge calibration equipment was used during these two periods, and it is believed that the equipment used after 2010 is more accurate.
- Plots of channel discharges estimated from the rating curves shown in Section II-B1 are presented in Section II-B2 (Appendix II). Since the discharges shown are based on spot measurements, they might not show the lowest or the highest flows the channel experienced during the reporting period. Furthermore, the high flows shown in the plots are based on the extrapolation of the rating curves beyond their calibrated range therefore they are likely not reliable. These flows should be re-calculated when additional data for the extension of the rating curves is collected.

Table 2.1 Faro Pit Lake Level and Faro Creek Diversion Channel Flow

Structure	Monitor Location	Historical[1]		2014	
		Max	Min	Max	Min
Faro Pit - Pond El.	FP	[2]1152.4 m	1140.7 m	[2]1152.4 m	1148.2 m
Faro Creek Diversion Channel - Flow	FCD-1	2213 L/s	69 L/s	1230 L/s	75 L/s
	FCD-2	6178 L/s	7 L/s	210 L/s	70 L/s
	FCD-3	1366 L/s	47 L/s	1080 L/s	60 L/s
	FCD-4	6018 L/s	47 L/s	1020 L/s	80 L/s

Notes:
1. Historical data was taken from 2013 Annual Geotechnical Review (KCB, 2014). However, it is not known how the high staff gauge reading was calibrated.
2. The maximum pit lake level was increased by 4.3 m from 1148. 1 m to 1152.4 m due to high lake level measured on December 29, 2014.
3. Values shown in the table are based on spot measurements; therefore, they might not show the lowest or the highest flows experienced during the reporting period.

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 (see Photos 1 and 2).
- Due to Health and Safety concerns, YG discontinued as of September 23, 2014 distance monitoring by TEES staff between the pit wall and reference bars installed in the North and South Instability Zone. However, the annual survey by YES of monitoring prisms installed in the two instability zones will be maintained (Golder 2015).
- Continue visual monitoring of diversion channel and any seepage from the channel to the Faro Pit wall north and south instability zones with photos taken at strategic locations.
- Repair slumps on the hillside slope of the channel under safe conditions, if practical.
- Starting from 2015 take flow measurements across the diversion channel at staff gauge stations using the newly installed cross-channel overhead wire to collect flow data for calibrating flow vs. staff gauge level under high flow condition.
- Continue flow calibration measurements for the diversion channel in order to improve the stage/discharge rating curves.
- Continue to have pit slope stability reviewed periodically, especially in case of development of new sizable slumps.
- During current period of high pit-lake level, consider to have geotechnical or geological specialist check East Pit Rim slope stability condition, including the hillside slope crest along the Faro Creek Diversion Channel to confirm no cracks are present.

2.2 North Valley Wall Interceptor Ditch

North Valley Wall Interceptor Ditch (NVWID) (see Photos 7 to 16 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

Our 2014 observations of the North Valley Wall Interceptor Ditch are as follows:

- The channel and side slopes appeared to be stable.
- Sedimentation accumulated both up and down gradient from the potable-water-well access road culverts and inside the culverts was cleared, and the access road repaired in 2014. Photo 9 shows the condition of partially blocked culverts prior to clearance, while Photos 10 to 14 show the cleared conditions of the access road and culverts in the fall and winter.
- There was moderate to heavy vegetation growth in the upper and middle constructed channel reaches. Vegetation clearance started from the upstream end of the upper reach in the fall of 2012 and 2013 and to be continued in 2015.
- The installation of a weir in the ditch near the beginning of the upper constructed reach has been included in TEES maintenance planning schedule.

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-C1 of Appendix II. Historical and 2014 flow data for this ditch is shown in Table 2.2.

Table 2.2 North Valley Wall Interceptor Ditch - Flow

Structure	Monitoring Location	Historical[1]		2014	
		Max (L/s)	Min (L/s)	Max (L/s)	Min (L/s)
North Valley Wall Interceptor Ditch	NWID	554	0.1	87.27 (Measured)	0.5 (Estimated)

Notes:
1. Historical data was taken from 2013 Annual Geotechnical Review (KCB, 2014).
2. Values shown in the table are based on spot measurements; therefore, they might not show the lowest or the highest flows experienced during the reporting period.

2.2.3 Comments and Recommendations

- Continue vegetation clearance along the upper and middle constructed channel reaches. Clearing should also include the access road and berm along the channel to facilitate future inspection.
- Install a weir near the beginning of the upper constructed reach according to TEES planned schedule.

2.3 Rose Creek Diversion Channel and Canal Dyke

Rose Creek Diversion Channel (RCDC) and Canal Dyke (CD) (see Photos 17 to 24 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.
- Back Slope: The Back Slope is the hillside slope of the Diversion Channel excavation.

2.3.1 Observations

Our 2014 observations of the Rose Creek Diversion Channel are as follows:

- The channel and side slopes appeared to be in general stable condition with satisfactory rock armour protection.
- The deformed segments of the hillside channel slope of the Rose Creek Diversion Channel (also called Back Slope) were examined by KCB in our spring and fall site visits in 2014 (on the Back Slope as well as from the Canal Dyke crest). Two areas of the deformed Back Slope initially observed by TEES personnel in 2013 spring were flagged (primary area to the west, in the vicinity of Instrument Cluster BS-10) and staked (secondary area to the east, in the vicinity of Instrument Cluster BS-5) during our spring visit to facilitate ongoing monitoring (see Figure 7). Slope slump activity appeared to progress more in the primary than the secondary area since June as checked in September, 2014. In addition, signs of slope slump seemed to appear in two other areas: one west of the primary and the other east of the secondary area as observed from the crest of the Canal Dyke in September.
- A small washout of the Rose Creek Canal Dyke south shoulder near the Cross Valley Dam south abutment observed in 2013 fall was repaired satisfactorily.
- Moderate vegetation growth in lower channel reaches.

- Seepage was not observed from RCDC into tailings impoundment at time of our inspections, but presence of seepage prior to the spring visit was inferred by our site observation.
- Minor seepage from the RCDC at base of spoil piles into the Polishing Pond was reported previously, but could not be located during the 2014 inspections.
- Cross-channel overhead wire was installed in 2014 at Staff Gauges NFRD-23 and RCDC-4 to facilitate flow measurement under high flow conditions.

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 (RCDC4). There are three other monitoring locations along the North Fork Rose Creek (NFRD-23, NF2 and X2), and two monitoring locations (X10 and X14) in Rose Creek downstream of the Rose Creek Diversion Channel.

- Historical and 2014 data of maximum and minimum flows for the stream flow stations are shown in Table 2.3. Since the values shown in the table are based on spot measurements, they might not show the lowest or the highest flows the channel experienced during the reporting period.
- Discharge rating curves for the staff gauges are shown in Section II-D1 of Appendix II-D.
- Plots of channel discharges estimated from the rating curves shown in Section II-D1 (Appendix II) are presented in Section II-D2. Since the discharges shown are based on spot measurements, they might not show the lowest or the highest flows the channel experienced during the reporting period.

Table 2.3 Flow in North Fork Rose Creek and Rose Creek Diversion Channel

Location	Name	Historical[1]		2014	
		Max (L/s)	Min (L/s)	Max (L/s)	Min (L/s)
North Fork Rose Creek	NFRD-23	8000	0	2,730	300
	NF2	2713	613	Flow not measured	Flow not measured
	X2	1538	207	-	-
Rose Creek Diversion Channel	RCSG4/ RCDC4[2]	38,000	1858	26,900	620
Rose Creek	X14[3]	-	-	-	-

Notes:
1. Historical data was taken from 2013 Annual Geotechnical Review (KCB, 2014).
2. RCDC4 is a replacement of RCSG4 in 2012.
3. No data was provided for X14.
4. Values shown in the table are based on spot measurements; therefore, they might not show the lowest or the highest flows experienced during the reporting period.

Canal Dyke (see Figures 7 and 8)

A summary of existing instrumentation on the Canal Dyke, Spoil Piles and Back Slope 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-E1, Thermistors in Section II-E2 and Inclinometers in Section II-E3). Many of inclinometer readings taken in 2014 are erroneous probably due to insufficient training for some personnel. To confirm correct readings are taken, the site personnel should perform the "checksum" as indicated in the instrument manual in the field. Deformation profiles are presented in Section II-E3 for six inclinometers with correct 2014 readings: 91CD-1, BGC05-08, CD-21, BS-5, BS-9 and BS-10.

Table 2.4 Instrumentation for Canal Dyke, Spoil Piles and Diversion Channel Back Slope

Structure	Instrumentation (See Figures 6 and 7)
Canal Dyke[1,2,3]	5 paired pneumatic piezometers[2] with tips at deep and shallow depths (BGC05-02/BGC05-03, BGC05-06, CD-13, CD-15 and CD-26) and one pneumatic piezometer[2] (CD-21 shallow)
	Thermistors - 4 (BGC05-04, CD-15, CD-21 and CD-26)
	8 Inclinometers - (BGC05-05, BGC05-08, CD-10, CD-15, CD-19, CD-21, BH91-CD-1 and BH94-CD-1)
Spoil Piles[3]	2 Thermistors - (SP-3 and SP-5)
	2 Inclinometers - (SP-2 and SP-5)
Back Slope of Rose Creek Diversion Channel	2 single pneumatic piezometers - (BS-5 and BS-9)
	4 Thermistors[4] - (BS-5, BS-9, BS-10 and BS-12)
	3 Inclinometers - (BS-5, BS-9 and BS-10)

Notes:
1. 3 single pneumatic Piezometers: CD-7, CD-9 and CD-10 are removed from the table, as no data is given for them.
2. 3 paired pneumatic Piezometers: BH88-7, BH88-11 and CD-19, and CD-21 deep pneumatic piezometer are removed from the table, as they were destroyed.
3. 2 thermistors: CD-10 and SP-2 are removed from the table, as no data is given for them.
4. Most thermistors in BS-5, BS-9, BS-10 and BS-12 are not functioning in 2014 and need repair.

2.3.3 Comments and Recommendations

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

- Continue monitor condition of longitudinal cracks and slope slump scarps at the Back Slope of Diversion Channel in 2015.
- Explore permit requirements regarding ongoing monitoring, investigation and repair of the above slope slumps, starting with obtaining a permit to allow easier personnel and light amphibious vehicle access to the Back Slope. RCDC is the main diversion channel at the Faro site, and prevention of a major slump and blockage is a high priority.
- Continue to document seepage locations from RCDC into tailings impoundment area after fresh snow fall.
- Clear vegetation along lower channel reaches as required.
- Continue to monitor instrumentation on a regular basis.
- Conduct geotechnical inspection of the diversion channel during spring peak flow condition.

- Continue to monitor the staff gauges. Take readings during high flows such that the discharge rating curves can be extended beyond the current calibrated limits.
- The piezometric levels either show a downward trend or are in a range consistent with historical variations.
- Many inclinometer readings taken in 2014 were erroneous. 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.
- Back Slope maintenance strategies include: monitoring and repair in select areas as required, installing instrumentation on the Back Slope through the existing granular earthfill thermal liner or installing Styrofoam insulation board on the deformed slope on an experimental basis to slow down the downward thawing process. We expect that monitoring and repair in select areas, as required, would be the preferred approach in 2015, unless slumping activities accelerate significantly. We request for the missing annual review reports by Golder (1983 to 1999) and BGC (2000, 2001 and 2003), especially for those early years, when repair works in the Back Slope area were conducted. Past successful repair experiences could provide guidance for current and future care and maintenance activities in the Back Slope area.

2.4 North Fork Rock Drain

North Fork Rock Drain (NFRD) (see Photos 25 and 26 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

Our 2014 observations of the North Fork Rock Drain are as follows:

- Stable crest and side slopes of mine haul road in general.
- Washouts occurred on the upstream and downstream slopes starting from the road shoulder observed in 2013 have been successfully repaired in 2014.
- Downstream drainage condition is acceptable with three braided channels combined to form one channel at the location of water-level monitoring and water sampling.
- Minor earth work related to the implementation of a plug dyke and seepage collection program in the Faro Creek North Fork Rock Drain area has been carried out in the fall and winter of 2014, resulting no significant change on the upstream side of the rock drain.

2.4.2 Instrumentation

Instrumentation at the North Fork Rock Drain consists of water level readings taken periodically throughout the year to record the upstream pond and downstream discharge elevation at the mine haul road. A summary of the historical maximum and minimum values including the most current data (2014) is shown in Table 2.5. Recorded water level plots provided by TEES, are given in Section II-F1 of Appendix II.

Table 2.5 North Fork Rock Drain - Water Level

Name	Historical[1]		2014		Comments
	Max (m)	Min (m)	Max (m)	Min (m)	
NF-1	1094.35	1088.83	1093.63	1089.21	Upstream of haul road
NF-2	1089.11	1085.02	1088.3	1085.7	Downstream of haul road

Notes:
1. Historical data was taken from 2013 Annual Geotechnical Review (KCB, 2014).
2. Values shown in the table are based on spot measurements; therefore, they might not show the lowest or the highest water levels experienced during the reporting period.

2.4.3 Comments and Recommendations

- The crest and side slopes of the mine haul road appeared to be stable.
- Some changes may be expected at the North Fork Rock Drain in 2015 due to any work related to the implementation of a plug dyke and seepage collection in the area. We recommend TEES to document both physical changes as well as changes in the flow condition at the Rock Drain, especially during the spring freshet season.

2.5 K8 Creek Rock Drain

K8 Creek Rock Drain (K8CRD) (see Photos 27 and 28)

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.

Our 2014 observations of the K8 Creek Rock Drain are as follows:

- The crest and side slopes of the mine haul road appeared to be stable in general.
- Washouts occurred on the upstream and downstream slopes starting from the road shoulder observed in 2013 have not been repaired as yet in 2014.

2.5.1 Comments and Recommendations

- Add coarse rockfill at two low spots of the road berm on both side slopes of the haul road in 2015 prior to the spring freshet, similar to that placed at the North Fork Rock Drain in 2014, to allow drainage of surface runoff without losing fine roadfill down the slopes.
- Continue to monitor the head pond level and downstream flow condition from the haul road, especially during the spring freshet season.

2.6 Secondary Tailings Impoundment

Secondary Tailings Impoundment (STI) (see Photos 29 to 32 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

Our 2014 observations of the Second Tailings Impoundment are as follows:

- The crest, upstream and downstream slopes appeared to be stable.
- No evidence of seepage along the downstream slope.
- The condition of the Lower Road, which also serves as the Rose Creek Canal Dyke, was satisfactory.
- A row of tailings piles was located along the upstream shoulder of the crest in the southwest portion of the dam. Tailings deposits covering the dam crest in the area appeared to have been derived from these upstream tailings piles.
- The annual appearance of longitudinal cracks along the downstream berm road surface in the spring and their subsequent disappearance seemed to be related to seasonal freezing and thawing effect. This phenomenon repeated in 2014.

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-G1 of Appendix II. Piezometers P81-6 to P81-8 have been dry, while P03-1 to P03-3 show a variation less than 1 m 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 Secondary Tailings Impoundment – Pond and Piezometer Levels

Location	Piezometer	Historical[1]		2014	
		Max (m)	Min (m)	Max (m)	Min (m)
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	1054.95	1054.76
	P03-02	1058.35[2]	1053.72	1054.49	1054.37
	P03-03	1060.27[2]	1052.28	1054.58[3]	1054.58[3]

Notes:
1. Historical data was taken from 2013 Annual Geotechnical Review (KCB, 2014).
2. Maximum historical reading near ground level due to blockage.
3. Only one good reading taken.
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 surface adjacent to the upstream end of the Rose Creek Diversion Channel, where cracks were usually observed in the spring. The cracks, when discovered, should be sealed by grading to minimize ingress of runoff into the road embankment.
- Check vegetation growth on the downstream dam slope periodically and clear vegetation, as required.

2.7 Intermediate Dam

Intermediate Dam (ID) (see Photos 33 to 40 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.

Since 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 of this increased drawdown rate has been observed to date.

2.7.1 Observations

Our 2014 observations of the Intermediate Dam are as follows:

- Pond level was relatively high as compared with 2013, and was not lowered to its target level as in the past.
- Stable crest, upstream/downstream slope and spillway channel, in general.
- Steps along the upstream slope near the crest shoulder were observed. Until the fall of 2014, only one such a step was observed near the south end. It appeared that more of these steps were observed in the middle of the dam in the fall (see Photo 34). The nature of these steps is uncertain. It could be remnant features left during dam construction. It could also be caused by potential downward movement of the upstream slope.
- The status of downstream slope rill erosion is similar to that observed in 2013.
- Eroded fill material from the downstream slope often pushed the above-ground portion of existing instruments to lean toward downstream.
- Vegetation growth on the downstream slope was not even. In the area with dense shrubbery growth, root structure tends to retard rill erosion process. In addition, the vegetation cover tends to make rill erosion less pronounced visually.
- Minor rill erosions on downstream berm shoulder (see Photo 38).

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 pond and piezometric levels are included in Sections II-H1 and II-H2 of Appendix II. The upper range of pond level in 2014 was about 0.3 m lower than that in 2013, while the lower range was about 0.6 m higher than that in 2013. The monitored piezometric levels were in a range consistent with historical variations.

Table 2.7 Intermediate Dam - Pond and Piezometer Levels

Location	Name	Historical[1]		2014		Comments
		Max (m)	Min (m)	Max (m)	Min (m)	
Water Elevation Readings						
Int. Pond	IP	1047.58	1043.47	1046.72	1044.9	Target El. 1043 m
Standpipe Piezometers (Nested piezometers at P01-4, BH96-3 and BH96-4)						
Dam Crest	BH96-1	1031.65	1027.37	1029.65	1028.58	-Tip El. At 1027.35 m
	BH96-2	1031.94	1028.87	1030.1	1029.08	-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	-
Downstream Berm	P01-3	1030.63	1027.48	1029.43	1029.24	-
	P01-4A	1032.24	1029.27	1031.62	1031.1	Shallow
	P01-4B	1032.17	1029.06	1031.05	1030.54	Deep
	BH96-3A	1031.38	1026.62	1029.62	1028.33	Shallow
	BH96-3B	1031.45	1027.48	1029.63	1028.17	Deep
	BH96-4A[3]	1032.04	1027.61	1030.19	1029.24	No readings for 2012/2013
	BH96-4B[3]	1032.28	1028.39	1030.23	1029.26	No readings for 2012/2013
	BH96-4C[3]	1031.64	1027.74	1029.35	1029.29	No readings for 2012/2013
	BH96-4D[3]	1031.75	1027.62	1030.02	1029.3	No Reading for 2012
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	1036.33	Shallow
		1038.04	1029.95	1033.66	1029.95	Deep
Downstream Berm[4]	BH91-ID4	1035.91	1028.28	1030.8	1030.31	Shallow
		1031.85	1026.74	1029.26	1028.7	Deep
	BH91-ID6	1030.95	1026.62	1029.07	1028.51	Shallow
		1034.96	1020.82	1029.92	1029.43	Deep
	BH91-ID7[2]	1035.2	1028.82	1029.94 (2011 Reading)	1028.82 (2011 Reading)	Destroyed in winter of 2011/2012

Notes:
1. Historical data taken from 2013 Annual Geotechnical Review (KCB, 2014).
2. BH91-ID7 was destroyed in winter of 2011/2012.
3. BH96-4: 4 nested piezometers with -4A being the shallowest, and -4D being the deepest.
4. BH91-ID5: No data since 2011.

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.
- Ongoing monitoring of the development of steps on the upstream slope near crest shoulder especially after the maximum drawdown to guard against excessive slope deformation.
- Continue to monitor ongoing development of rill erosions on the downstream slope and related longitudinal cracks and slope slumps.
- Site staff indicated that re-grading the downstream slope has been successfully implemented in 2000s using site dozer equipment working on existing slope material. YG and TEES could potentially experiment with different strategies of maintaining the downstream slope: in the

segments with poor or no vegetation growth, try re-grading the slope with bulldozer, while in the segments with good vegetation growth, try improving vegetation cover with no re-grading.

- Tilted above-ground portion of existing instrumentation on the berm surface to be restored in the re-graded segments of the downstream slope, after completion of slope re-grading work.
- Repair shoulder erosion of the downstream berm.
- Review and update, if required, geotechnical stability analyses based on the current planned pond operation range.
- The pond level should be drawn down to the targeted drawdown level by pumping, once normal water treatment operation resumes at the Faro Site.

2.8 Cross Valley Dam

Cross Valley Dam (CVD) (see Photos 41 to 46 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, an upstream impervious blanket and a downstream drainage blanket.

2.8.1 Observations

Our 2014 observations of the Cross Valley Dam are as follows:

- The crest, upstream and downstream slopes and spillway channel appeared to be stable.
- The annual appearance of longitudinal cracks along the dam crest in the spring and their subsequent disappearance seemed to be related to seasonal freezing and thawing effect. This phenomenon repeated in 2014.
- Water stored in the Polishing Pond was treated in the summer of 2014 in a temporary lime treatment plant installed at the north shore of the Cross Valley Pond. Treated water in compliance was released through the North Valley Wall Interceptor Ditch.
- In addition, the Interim Water Treatment Plant was constructed on the Faro Plant Site and started operation in the fall of 2014 for a brief duration with treated water discharged into the Cross Valley Pond.

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 for 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. In addition, four weirs are installed downstream of the dam, Weir X11, X12, X13, and Weir 3.

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). As permafrost condition no longer exists at these locations, thermistor data is not reviewed.

Plots of Polishing Pond and piezometric levels, ground temperature profiles, and downstream weir flows are included, respectively, in Sections II-I1 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 m to 1029 m. In 2014, the maximum pond level was 0.3 m higher than that in 2013 and the minimum pond level was 0.42 m higher than that in 2013. The 2014 monitored piezometric levels were in a range consistent with historical variations.

Table 2.8 Cross Valley Dam – Pond and Piezometer Levels

Structure	Name	Historical[1]		2014		Comments
		Max (m)	Min (m)	Max (m)	Min (m)	
Water Elevation Readings						
Polishing Pond	PP	1030.33	1026.31	1029.73	1027.92	Target El. 1027 m
Standpipe Piezometers						
Dam Toe	CVDT-1	1018.57	1017.13	1017.92	1017.86	-
	CVDT-2	1019.5	1015.40	1015.72	1015.54	-
	P01-02[2]	1018.3	1017.42	-	-	Shallow
		1019.73	1017.86	-	-	Deep
	P01-11	1017.83	1016.17[3]	1016.69	1016.17[3]	-
Dam Crest	CVDC-4	1019.05	1016.72	1018.84	1018.79	Deep
	CVDC-7	1017.74	1015.14	1015.37	1015.29	Shallow
		1019.21	1015.27	1017.77	1017.61	Deep
	94CVDC-1	1024.58	1022.71	1023.67	1023.55	-
	CVDC-9	1024.74	1019.91	1020.92	1020.77	Shallow
		1025.61	1021.18	1023.99	1023.79	Deep
Pneumatic Piezometers						
Dam Toe	CVDP-1	1019.83	1016.82[5]	1018.36	1016.82[5]	-
	CVDP-3[4]	1017.65	1016.11	1016.39 (2011 Reading)	1016.11 (2011 Reading)	-
	CVDP-5	1022.05	Dry[6]	1020.86	Dry[6]	-
	CVDP-6	1019.55	1014.86[7]	1017.94	1014.86[7]	-

Notes:
1. Historical data was taken from 2013 Annual Geotechnical Review (KCB 2014).
2. No readings for Piezometers P01-02 were given.
3. P01-11: Minimum historical level reduced by 0.4 m from 1016.57 m to 1016.17 m on June 16, 2014.
4. CVDP-3 broken in winter 2011/2012.
5. CVDP-1: Minimum historical level reduced by 0.56 m from 1017.38 m to 1016.82 m on June 16, 2014.
6. CVDP-5: Minimum readings in 2013 and 2014 appeared to indicate that the piezometer tip was dry.
7. CVDP-6: Minimum historical level reduced by 2.13 m from 1016.99 m to 1014.86 m on September 22, 2014.

Table 2.9 Cross Valley Dam - Weir Flows

Weir Number	Historical[1]		2014	
	Maximum (L/s)	Minimum (L/s)	Maximum (L/s)	Minimum (L/s)
X11 (North)	22.01[2]	2.56	22.01[2]	5.59
W3 (Central)	7.1	0.03[3]	6.38	0.03[3]
X12 (South)	2.03	0.02	0.84	0.02
X13 (Combined)	59.63[4]	7.45	59.63[4]	10.65

Notes:
1. Historical data was taken from 2013 Annual Geotechnical Review (KCB 2014).
2. X11: Maximum flow increased from 20.9 L/s to 22.01 L/s on June 12, 2014.
3. W3: Minimum flow decreased from 0.13 L/s to 0.03 L/s on January 16, 2014. Weir plate was corroded through the v-notch after September 11, 2014; therefore, no measurements could be taken since then.
4. X13: Maximum flow increased from 43.9 L/s to 59.63 L/s on September 11, 2014.
5. Values shown in the table are based on spot measurements; therefore, they might not show the lowest or the highest flows experienced during the reporting period.

2.8.3 Comments and Recommendations

- Continue to monitor pond, piezometric levels and weir flows on a regular basis.
- Replace the corroded weir plate at flow monitoring station W3 (see Photo 46).
- Since geothermal profiles at the Cross Valley Dam indicate that the temperature at depth is essentially thawed, Thermistor reading at the dam should be stopped, and instrumentation protected for potential future use.
- Continue to monitor longitudinal tension cracks on dam crest in the spring, and seal these cracks by grading to minimize water ingress to the embankment dam.
- The Polishing Pond level should be drawn down to the targeted level, once normal water treatment operation resumes at the Faro Site.

3 VANGORDA PLATEAU SITE FACILITIES

3.1 Grum Pit

Grum Pit (GP) (see Photos 47 to 54 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 2014), and ongoing monitoring of potential pit-wall rim movement started in the summer of 2010.

3.1.1 Observations

Our 2014 observations of the Grum Pit are as follows:

- Since August 2013, a pump barge was used in the summer and fall to transfer water from Grum to Vangorda Pit for treatment.
- The pond level has been in a range close to the contact level between overburden and bedrock (see Section II-J1 of Appendix II).
- East wall instability appears to be continually evolving, with wet streaks of groundwater daylighting the pit wall (see Photo 51).
- Longitudinal crack at GP-N2 survey rod on the north array increased in width and depth since August 2012, and a new crack appeared between Rods GP-N2 and GP-N3 (see Photo 50). A slump occurred at the pit rim in the general area since 2013.
- Ground deformation along the south array remains similar to that in 2013.

3.1.2 Instrumentation

Instrumentation at the Grum pit east wall (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 rim. 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 lake-level measurement point, and two piezometers installed in the Grum Pit cut slot.

Following Golder's recommendation, CH2MHILL (2013a) established 14 locations of survey prisms for ongoing monitoring of Grum Pit wall and rim movement. YES (2013b) installed and surveyed the initial 4 prisms, MP005 to MP008, in September 2013 and provided installation details for additional prisms for TEES to complete the installation work in 2014 (see Figure 11). Due to Health and Safety concerns no additional survey prisms were installed in 2014. Moreover, YG discontinued distance monitoring by TEES staff after September 14, 2014 of reference rods installed at the north and south arrays along the Grum Pit east wall.

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-J2 of Appendix II. A summary of these relative distances measured in 2010 and 2014 are compared in Table 3.1.

Table 3.1 Grum Pit - Wall Movement

Location	Rod Name	Distance Measured Relative to Rod GP-S4 or GP-N6, (m)		
		June 24, 2010[3]/July 29, 2010[2]	September 17, 2014	Comment
South Array				Relative to GP-S4[1]
	GP-S1	29.006[2]	28.996	GP-S1
	GP-S2	23.444[2]	23.426	GP-S2
	GP-S3	15.630[2]	15.625	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 (up to August 28, 2012)
	GP-N2	23.356[3]	23.397[4]	GP-N2 (up to August 28, 2012)
	GP-N3	18.130[3]	18.129	GP-N3
	GP-N4	12.004[3]	11.999	GP-N4
	GP-N5	5.740[3]	5.715	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 lake level, monitoring-rod survey and cut slot piezometers, as provided by TEES, are included in Section II-J of Appendix II. A pump barge was set up in the pit lake to pump water from Grum to Vangorda Pit in the summer and fall since 2013. As shown on the chart in Section II-J1, the pit lake level at Grum was at 1216.0 m on December 29, 2014 near the overburden/bedrock contact elevation.

3.1.3 Comments and Recommendations

- An error on the record for Rod GP-N5 on January 5, 2012 (prior to TEES presence on site) was corrected as shown on the plots in Appendix II-J2.
- Records of both north and south arrays show little change in the relative distances measured to date.
- Continue visual monitoring of pit wall conditions with photos taken from the same vantage points (see Photo 47).
- Piezometric level at both piezometers at the Grum Slot Cut 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 lake level is near the contact elevation between overburden and bedrock at El. 1216 m. Drawdown below this contact level is needed to prevent potential increase in seepage from the Grum Pit as well as pit wall toe instability.

3.2 Vangorda Pit

Vangorda Pit (VP) (see Photos 55 and 56 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, with the long axis oriented in the northwest to southeast direction. Water pumped from Grum Pit entered Vangorda Pit via a pipeline located on the northwest pit wall, while sludge pumped from Vangorda Water Treatment Plant Sludge Pond entered Vangorda Pit via a pipeline.

3.2.1 Observations

Our 2014 observations are as follows:

- There appeared little change in the condition of the Vangorda pit walls since 2013.

3.2.2 Instrumentation

There is currently only a pit lake-level measurement point at the Vangorda Pit. Pit lake-level plot provided by TEES is included in Section II-K1 of Appendix II.

3.2.3 Comments and recommendations

- The maximum pit lake level in 2014 was at 1089.9 m on June 2 about 1.9 m below the recommended maximum elevation of 1091.8 m.
- Continue to monitor the pit lake level on a regular basis.
- Continue visual monitoring of pit wall condition with photos taken at same vantage points at least at yearly interval (see Photo 55).

3.3 Grum Waste Rock Dump

Grum Waste Rock Dump (GD) (see 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. Due to time constraint, we did not visit Grum Waste Rock Dump in 2014.

Grum Waste Rock Dump has been the source of excess inflow into Moose Pond in the spring freshets of 2011 (YG 2011a and 2011b) and 2013 (YG 2013). However, it appeared that no problem occurred at the Grum Waste Rock Dump in 2014.

Although it is not within the scope of our 2014 work, we recommend that regular visual monitoring of the Grum Waste Rock Dump be carried out by TEES including taking photos for record purposes. This precaution is to prevent uncontrolled release of surface runoff from the waste dump to Vangorda Creek and/or Moose Pond, especially during the spring freshet season.

3.4 Vangorda Waste Rock Dump

Vangorda Waste Rock Dump (VWRD) (see Photos 57 and 58)

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 the Little Creek Pond retained by the Little Creek Dam, see Figures 3 to 5 (SRK-Robinson 1994).

3.4.1 Observations

Our 2014 observations of the Vangorda Waste Rock Dump and its transverse base drains are as follows:

- Drain No. 1 – was dry. Does not have a weir.
- Drain No. 2 - was flowing at a trickle. Has a v-notch weir.
- Drain No. 3 – was flowing. Staff gauge was tilted and the v-notch weir plate was delaminated. Flow is usually measured by TEES 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. TEES has excavated a small hole at the drain to collect seepage water. A weir could be installed at the drain to measure the flow.
- Drain No. 5 – was flowing at a trickle. Has a v-notch weir, but the 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 – was flowing. Weir plate and channel are in satisfactory condition for flow measurement.

3.4.2 Instrumentation

Instrumentation at the Vangorda Waste Dump (see Figures 4, 5 and 12) consists of four V-notch weirs, V29 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 2014 are summarized in Table 3.2. The maximum piezometric level in 2014, and the corresponding date as well as trigger level as provided by SRK (2011b), are shown in Table 3.3.

Table 3.2 Vangorda Waste Dump - 2014 Drain Flow

Drain[1]/Weir No.	Maximum Flow		Minimum Flow	
	Flow (L/s)	Date Measured	Flow (L/s)	Date Measured
Drain No. 1 (V28)	No flow	During monitoring visits	No flow	During monitoring visits
Drain No. 2 (V29)	0.004	June 11	No flow	During monitoring visits
Drain No. 3 (V30)	0.8	June 11	0.09	October 8
Drain No. 4 (V31)	0.19	September 10	No flow	During monitoring visits
Drain No. 5 (V32)	No flow	During monitoring visits	No flow	During monitoring visits
Drain No. 6 (V33)	0.52	May 29	0.07	June 12

Note:
1. Drain number has been confirmed by TEES.
2. Values shown in the table are based on spot measurements; therefore, they might not show the lowest or the highest flows experienced during the reporting period.

Table 3.3 Vangorda Waste Dump - 2014 Piezometer Levels

Groundwater Monitoring Well/ Piezometer		Date of Max. Piez. Level in 2014[3]	Max. Piez. Level (m)	Trigger Level[1] (m)	Above Trigger Level?
V34	GW-94-01	September 26	1111.49	1115	*No*
V35	GW-94-02	September 26	1110.72	1115	*No*
V36	GW-94-03	May 22	1110.40	1113	*No*
V37	GW-94-04	September 26	1107.64	1109	*No*
V39	P-94-01A	May 28	1125.93	1131	*No*
V40	P-94-01B	May 28	1131.03	1133	*No*
V41	P-94-02A	May 28	1130.44	1133	*No*
V42	P-94-02B	September 26	1132.23	1134	*No*
V43	P-94-02C	September 26	1121.61	1125	No
V44	P-94-03A	September 26	1124.59	1126	No
V45	P-94-03B	May 28	1124.69	1126	No
V47	P-94-04B	September 26	1125.45	1126	No
-	P-2001-02A	May 22	1120.58	1123	No
-	P-2001-02B	May 22	1119.47	1123	No
-	P-2001-03[2]	-	-	1120	-
DH1	PW-10-01	September 26	1130.82	1135	No
DH2	PW-10-02	May 28	1128.76	1131	No
DH3	PW-10-03	September 26	1123.49	1130	No
DH4	PW-10-04	May 22	1132.44	1133[3]	No
DH5	PW-10-05	September 26	1138.03	1139	No

Notes:
1. Trigger levels were taken from SRK (2011b).
2. P-2001-03: No data since October 2000.
3. Trigger level at Piezometer PW-10-04 in Hole DH4 was increased from 1132 to 1133 m by SRK (2011b).

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.
- Flows at all base drains are consistent with historical data.

- Piezometric level at all piezometers and groundwater monitoring wells in 2014 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 59 to 62 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

Our 2014 observations of the Grum Pit Interceptor Ditch are as follows:

- Stable channel and side slopes.
- Light to heavy vegetation growth, particularly along the uppermost and lowest reaches of the ditch.
- There appeared to be no change in condition of culverts since 2013 fall site visit:
  - 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. The following recommendations from the 2012 Annual Geotechnical Review remain valid:

- 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 63 and 64, Figures 4 and 5)

The North East Interceptor Ditch diverts surface runoff away from the Vangorda Pit. Our 2014 observations of the ditch are as follows:

- Relatively small flow in ditch along the upper (50%) reach of the ditch; increased flow along the reach downstream of the tributary confluence.
- Four ditch side-slope slumps were observed in the fall of 2012 along the lower reach: one at the road embankment slope was partially repaired with large boulders during 2013 freshet, and remaining slumps are to be repaired as required to provide adequate drainage during spring freshets, including two on the bank slope on the opposite side from the road.

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

- Continue to monitor ditch side slopes, especially along reaches with slope slumps during spring freshet, when the side slope material is saturated by snowmelt.
- When slope slumps are repaired, filter materials are to be placed between the existing slope and newly added riprap materials. Installation of filter fabric at the contact between material zones of different grain sizes would also be useful.
- The maintenance activity should focus on ensuring the adequate flow capacity of the Interceptor Ditch during the next spring freshet.

3.7 Vangorda Creek Diversion Flume

Vangorda Creek Diversion Flume (see Photos 65 to 70 and Figures 3 to 5)

The Vangorda Creek Diversion Flume 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 66), and two emergency spillway culverts (see Photo 65) with a trash rack at a higher level under the road. 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 (see Photo 70) and drop box to the Vangorda Creek. There is no instrumentation related to the diversion flume.

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. During repair after the flood, the road surface adjacent to the flume ditch was raised in the area to help contain the flood flow. This flood and its impact were similar to what occurred in June 2004 (SRK 2004). No flash flood occurred in 2014 at the Vangorda Creek Diversion Flume.

3.7.1 Observations

Our 2014 observations of the Vangorda Creek Diversion Flume are as follows:

- One broken bar on the large main steel trashrack located in the creek slightly upstream of the flume culvert, observed in the fall of 2012, remained to be repaired (see Photo 66).
- At the upstream end of the flume main culvert, large boulders were added in 2012 as riprap but no filter materials appeared to be present between the riprap and road embankment fill. An auxiliary steel trashrack (see Photo 67) was also installed at the entrance of the culvert downstream of the main trashrack to prevent unravelling of the boulders over the culvert entrance.
- Some sediments were observed at the bottom of the twin emergency culverts, and channel invert downstream of the culverts appeared to be slightly too high.
- Some flume braces appeared to buckle under stress.
- The CSP flume has holes or is torn at several locations.
- The steel canopy that was used to weigh down the flume after 2012 repair has been removed in 2014.
- Replacement of the flume along an alignment upslope of the existing alignment is being investigated/designed by CH2MHILL. However, no concrete plan has been made regarding when to construct the replacement.

3.7.2 Comments and Recommendations

- At the upstream flume intake, repair the broken bar of the main steel trash rack and replace the auxiliary steel trash rack, which is tied to boulders with ropes (see Photo 67), with a permanent installation, as required. Lower the spillway channel invert at the exit of the twin emergency spillway culverts as well as remove sediments deposited in the culvert inverts.
- Where flume braces were buckled, add additional stronger braces to stiffen the flume in local areas.
- 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.
- Replace the flume with a new structure as early as practical.

3.8 Little Creek Dam

Little Creek Dam (LCD) (see *Photos* 71 to 74 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 located at the south abutment was added in 1998 to route through the 1 in 200-year flood.

3.8.1 Observations

Our 2014 observations of the Little Creek Dam are as follows:

- Stable dam slopes with rill erosions (see Photos 71 to 74) developed on the downstream and upstream crest shoulders and slopes.
- A rill erosion appeared in the vicinity of the foundation of the transformer situated at the downstream crest shoulder.
- Culvert spillway in good condition, and a relatively low pond level.
- There are cracks in the ground at the downstream end of the spillway outfall channel, 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; and seven piezometers (P09-LCD-1 to P09-LCD-7) installed in 2010 along the downstream toe for monitoring groundwater quality (SRK 2011b). Detailed data of the pond and piezometric levels as provided by TEES, are included in Section II-M of Appendix II. The pond level and maximum piezometric level and corresponding date in 2014 for these piezometers are summarized in Table 3.4.

Three thermistor strings were installed in 1994 on the dam crest (94LCD-4T to 94LCD-6T) to a depth ranging from 13 m to 17 m. As permafrost condition no longer exists at these locations, thermistor data is not reviewed.

Since mid-2010, the pond level has been lowered by about 1 m from the range of 1108 m to 1111 m to the range of 1107 m to 1110 m.

Table 3.4 Little Creek Dam - Pond and Piezometer Levels

Location	Name	Historical[1]		2014		Comments
		Max (masl)	Min (masl)	Max (masl)	Min (masl)	
Water Elevation Readings						
Pond Level	LCD	1111.70	1106.48	1110.09	1108.7	Licence Limit = 1111.80
Standpipe Piezometers						
Downstream Toe	P09-LCD-1	1094.23[2]	1093.45	1094.23[2]	1093.82	-
	P09-LCD-2	1095.40[3]	1093.26	1095.40[3]	1093.50	-
	P09-LCD-3	1092.10	1091.83	1092.03	1092.00	-
	P09-LCD-4	1091.98	1082.00	1091.78	1082.37	-
	P09-LCD-6	1090.91	1089.46	1090.51	1090.45	-
	P09-LCD-7	1097.50[4]	1096.93	1097.50[4]	1097.08	-
Pneumatic Piezometers (BH94-LCD1 to LCD3 are nested piezometers with one tip deep and one shallow)						
Dam Crest	BH94-LCD1	1105.77	1104.02[5]	1105.0	1104.02[5]	Shallow
		1105.82	1103.79	1105.26	-[6]	Deep
	BH94-LCD2	1101.76	1100.50	1101.41	1100.92	Shallow
		1102.39	1098.54	1099.66	-[6]	Deep
	BH94-LCD3	1106.76	Dry	1106.06	1105.99	Shallow
		1108.69	1102.89	1104.21	-[6]	Deep

Notes:
1. Historical data taken from 2013 Annual Geotechnical Review (KCB 2014).
2. P09-LCD-1: Maximum level increased by 0.39 m from 1093.84 m to 1094.23 m on September 25, 2014.
3. P09-LCD-2: Maximum level increased by 1.89 m from 1093.51 m to 1095.40 m on September 25, 2014.
4. P09-LCD-7: Maximum level increased by 0.09 m from 1097.41 m to 1097.5 m on September 25, 2014.
5. BH94-LCD1 shallow piezometer: Minimum level decreased by 0.14 m from 1104.16 m to 1104.02 m on September 22, 2014.
6. The September 22, 2014 readings for all three deep piezometers in BH94-series appeared to be in error, and should be checked and removed.
8. P09-LCD-5: No data for this piezometer since 2009.

3.8.3 Comments and Recommendations

- Consider repair of rill erosions at the dam crest on both dam slopes, including the erosion in the vicinity of 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. The September 22, 2014 readings for all three deep piezometers appeared to be in error, and should be checked and removed.
- 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 of P09- series of piezometers are needed for better interpretation of monitored data obtained from these piezometers.

- Since geothermal profiles at the Little Creek Dam indicate that the soil at depth is essentially thawed, no monitoring of thermistors is needed for the Little Creek Dam, and existing instrumentation should be preserved for potential future use.
- Consider to construct a surface runoff collection ditch at the downstream toe to prevent the toe area getting wet and soft after snowmelt and/or heavy rain.

3.9 Sheep Pad Sediment Ponds

Sheep Pad Sediment Ponds (see Photos 75 and 76 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.

Our 2014 observations of the Sheep Pad Sediment Ponds are as follows:

- Freeze-and-thaw longitudinal cracks observed along dyke crest and upstream slope in the spring were subdued in the fall (see Photo 75).
- Large boulders, weighing down the half-round CSP between the Upper and Lower Ponds near the entrance, restricted flow. There are no stiffening braces across the top of the half-round CSP (see Photo 76) and the CSP sections are not tied together. The entrance CSP section appeared to have shifted.
- At the spillway of the Lower Pond, geo-fabric under riprap boulders was exposed in places. The dyke slope above the inlet of the spillway channel showed signs of lateral spread (i.e., squeezing in the channel).

We recommend the following monitoring and maintenance measures:

- Monitor freeze-and-thaw dyke cracks in the spring and repair the dyke as required to prevent leakage and/or spill of pond water.
- Consider to Re-position the rotated entrance section of the CSP, and reduce the size of large boulders there. Add stiffening braces to the top of the CSP to prevent further pipe deformation due to lateral pressure from riprap materials around the pipe.
- Check and cover exposed geo-fabric, as required, with riprap materials at the Lower Pond spillway, and monitor lateral spreading of the dyke slope at the Lower Pond spillway channel.

3.10 Grum Settling Pond

Grum Settling Pond (see Photos 77 and 78 and Figures 4 to 5)

The Grum Settling Pond, located just northwest of the Grum Pit, is used to clarify water for the use in the water treatment facility at the Vangorda Plateau site. Water from the pond spillway discharges to

the Grum Interceptor ditch via a riprap lined spillway channel. There is no instrumentation related to the settling pond.

Our 2014 observations are as follows:

- Spillway channel appeared to be in good condition, with minor vegetation growth.
- Vegetation growth on dyke was relatively dense.

We recommend the following monitoring and maintenance measures:

- Continue to monitor spillway channel for erosion and vegetation growth.
- Continue to monitor retaining dyke embankment and clear vegetation growth, as required.

3.11 V-15 Seep Ditch and Moose Pond

V-15 Seep Ditch (see Photos 79 to 80 and Figures 4 to 5) and Moose Pond (see Photos 81 and 82 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).

Excess inflow and sediments entered Moose Pond during 2011 and 2013 spring freshets due to release of surface runoff from the Grum Waste Rock Dump.

Figure 4 shows a siphon pipeline from Moose Pond to V2 Sediment Trap. We understand that it was used to draw down water from Moose Pond in the past.

3.11.1 Observations

Our 2014 observations of the Moose Pond are as:

- In the spring of 2014 a new pump and pipelines were installed in the upper reach of V15 ditch to transfer excess water during the spring freshet to Vangorda Pit. Thus, no excess flow entered in Moose Pond in 2014.
- The steep reach of the ditch upstream of the Moose Pond is in satisfactory condition in 2014 (see Photo 81).
- Pond level at Moose Pond in the fall of 2014 was higher than that in the fall of 2013, as normal flow from the V-15 Ditch continued to enter Moose Pond in the summer of 2014.

3.11.2 Comments and Recommendations

- Prevent future inflow into Moose Pond from extraneous sources not in existence prior to 2011.
- Determine Moose Pond bathymetry using latest survey information obtained in 2013.
- Continue to monitor pond level variation at Moose Pond and its exfiltration performance under current groundwater flow regime.

- Suggest YG to confirm the status of the siphon pipeline from Moose Pond to V2 Sediment Trap as well as to investigate the potential use of this siphon pipeline as an emergency spillway for Moose Pond and the ramifications of this use.
- Continue to monitor seepage flow along the downstream slope of the retaining esker.
- Continue to monitor the downstream slope of the retaining esker ridge to review potential remedial works that may be required to restore the stability and integrity of the esker.
- Evaluate the long-term impact of the 2011 and 2013 excess-inflow incidents on the normal exfiltration operation of the Moose Pond, as required.
- Consider removing sediments accumulated in the pond bottom during 2011 and 2013 excess inflow incidents to restore the exfiltration capacity of the Moose Pond as required, if the pond can be operated to become dry during late summer.

3.12 Sludge Pond Embankment at Vangorda Water Treatment

Sludge Pond Embankment at Vangorda Water Treatment (see Photos 83 and 84 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. There appears to be no instrumentation at this pond and its periphery dyke.

Our 2014 observations of the Sludge Pond Embankment are as follows:

- Freeze-and-thaw longitudinal cracks observed on the dyke crest in the spring were less obvious in the fall.
- Pond level in the fall of 2014 was relatively high due to the change of sludge removal from mechanical excavation in the winter to hydraulic dredging in the summer since 2014.

We recommend the following monitoring and maintenance measures:

- Monitor freeze-and-thaw dyke cracks in the spring, and repair the dyke as required to prevent leakage or spill of pond water.
- Continue existing monitoring and maintenance of the retaining embankment dyke.

4 SUMMARY

Section 4 summarizes our 2014 annual review in two sub-sections by means of Table 4.1 and Table 4.2:

- general review in Section 4.1; and
- proposed 2015 Faro Mine Complex geotechnical monitoring program in Section 4.2.

4.1 General Review

Table 4.1 provides a description of the structures inspected in 2014 and a summary of our observations and recommendations.

Table 4.1 Faro Mine Site Complex – 2014 Annual Review 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 Zones.	▪ Pit wall conditions similar to that observed in 2013, except with a higher lake level. ▪ YES and 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 distance measurement at reference bar #15351 seemed to be improving in 2013 in terms of consistency, however no 2014 data for this reference bar was given by Golder (2014). ▪ Faro pit is currently used to store water pumped back from Intermediate Pond. ▪ As treatment of water stored in the Faro Pit was suspended in 2013 and most of 2014, pit-lake level has risen above the maximum recommended level, and is within the range of the overburden/bedrock contact elevation (see Section II-A1). ▪ Glaciation of seepage from groundwater flow out of Faro East Pit Wall was observed by TEES in the winter of 2014-2015 (see Photos 3 and 4).	▪ Continue visual monitoring of pit wall stability condition including seepage of groundwater flow with photos taken at same vantage points. ▪ Golder and YES to review current site survey details in the field to clarify prism survey results reviewed by Golder (2014). ▪ Continue to have pit slope stability reviewed periodically, especially in case of development of new sizable slumps. ▪ As water treatment operation resumes at the Faro site in 2015, slowly lower the pit-lake level to minimize the potential of triggering pit wall instability. ▪ Continue monitoring East Pit Rim for any sign of pit wall instability during the period of high lake level to provide more time for emergency response in case of pit wall failure.
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.	Faro Creek Diversion Channel (FCDC) ▪ Moderate flow in channel at time of inspections. ▪ Some cracking, likely related to annual freeze-thaw condition, was noticed near the top of the channel hillside slope during spring 2014 visit. This cracking was not evident in fall of 2014. ▪ Minor vegetation growth along channel. ▪ Overhead wires were installed across the channel by TEES in 2014 at staff gauges FCD-1, FCD-2 and FCD-4 for measurements of high flows for calibration of the gauges. ▪ No repair of slumps that occurred on the hillside channel slope in recent years due to safety concerns.	▪ Continue monitoring of the staff gauges along the diversion channel. ▪ TEES to initiate calibration flow measurements at staff gauges in 2015 during high flows, using the newly installed overhead wires. ▪ Consider alternative safe means to repair and maintain channel slopes and flow capacity from the adjacent road, if practical. ▪ Continue visual monitoring of diversion channel and any seepage from the channel to the Faro Pit wall with photos taken at strategic locations.
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 inspections. ▪ Stable channel and side slopes along most of its length, except a minor slope slump was observed by TEES in the fall (see Photo 16). ▪ Heavy vegetation growth observed in the upper and middle constructed channel reach (see Photos 8 and 15). ▪ Access road to the potable water well was repaired and accumulated sediments upstream and downstream as well as inside of three culverts were removed (see Photos 9 to 12).	▪ Continue vegetation removal along upper and middle constructed channel reaches, including the adjacent access road. ▪ Install a weir in the ditch near the beginning of the upper constructed reach for measuring flow.
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 channel gradients along upper reaches and steep gradients along lower reaches.	▪ Moderate flow in channel at time of inspections. ▪ Generally stable channel and side slopes, satisfactory rock armour conditions. ▪ Moderate vegetation growth in lower channel reaches. ▪ Overhead wires were installed across the channel by TEES in 2014 at existing staff gauges for measurements of high flows for calibration of the gauges. ▪ The repair of 2013 dyke shoulder erosion of the Canal Dyke near the Cross Valley Dam seemed to perform well. ▪ Seepage was not observed from RCDC into tailings impoundment at time of inspections, but presence of seepage prior to spring visit was inferred. ▪ Two areas of the deformed Back slope were flagged (primary area to the west) and staked (secondary area to the east) during 2014 spring visit to facilitate ongoing monitoring (see Figure 7). Slope slump activity appeared to progress more in the primary than the secondary area since spring as checked on the Back Slope. In addition, signs of slope slump seemed to appear in two additional areas: one west of the primary and the other east of the secondary area as observed from the crest of Canal Dyke.	▪ Continue to monitor the staff gauge. Extend staff gauge, if required, such that it can be read during high flows. ▪ TEES to initiate calibration flow measurements at staff gauges in 2015 during high flows, using the newly installed overhead wires. ▪ Rehabilitate or replace malfunctioning thermistors installed along Back Slope. ▪ Monitor condition of longitudinal cracks and slope slump scarps at the Back Slope of Diversion Channel, and continue instrumentation monitoring along the Back Slope. ▪ Explore permit requirements regarding investigation and repair of the above slope slumps. RCDC is the main diversion channel at the Faro site, prevention of a major slump and blockage is a high priority. ▪ Improve access trail/road condition for personnel and vehicle/equipment from landing sites to the slope slump areas on the Back Slope. Explore the use of Argo or equivalent vehicle to cross the channel at an existing ford under permit. ▪ Clear vegetation along lower channel reaches. ▪ Continue to document seepage locations from RCDC into tailings impoundment area after fresh snow fall condition.

Table 4.1 Faro Mine Site Complex – 2014 Annual Review Summary (cont'd)

Faro Site Facilities			
Structure	**Description**	**Observations**	**Comments and Recommendations**
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.	▪ Generally stable crest and side slope of mine haul road. ▪ 2013 erosion washouts of upstream and downstream road shoulder and embankment slope have been remediated and road berm constructed. ▪ Construction activity for the North Fork Rock Drain Plug-Dyke project, which is aiming to improve water quality monitored along Rose Creek North Fork, was observed mainly in the downstream right bank area. ▪ 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 with photos. ▪ Monitor the effect of constructed North Fork Rock Drain Plug-Dyke work on the performance of the rock drain during 2015 spring freshet.
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.	▪ Generally stable crest and side slopes of mine haul road. ▪ Downstream drainage condition acceptable. ▪ Road surface runoff drained from the breach in road berm on both upstream and downstream slopes with the loss of roadfill fines down the haul road slopes.	▪ Continue to monitor head pond level and downstream flow conditions with photos. ▪ Add coarse rockfill at two low spots of the road berm on both side slopes of the haul road similar to that placed at the haul road above North Fork Rock Drain to allow drainage of surface runoff without losing fine roadfill down the slopes.
Secondary Tailings Impoundment (STI, including Original Tailings Impoundment)	▪ 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 and no evidence of seepage along the downstream toe. Lower downstream-berm road conditions are satisfactory; repairs have been done on the shoulder section. ▪ The annual appearance of longitudinal cracks along the downstream berm road surface in the spring and their subsequent disappearance appear to be related to seasonal freezing and thawing effect. This phenomenon was repeated in 2014 with only barely visible signs of spring cracks in the fall.	▪ Continue to monitor dam performance. ▪ Continue to monitor piezometer instrumentation. ▪ Continue to monitor any crack appearance on the downstream-berm road surface adjacent to the upstream end of the Rose Creek Diversion Channel in the spring, and seal these cracks by grading to minimize water ingress into the road embankment. ▪ Check vegetation growth on the downstream slope and clear, as 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 relatively high as compared with 2013. ▪ Stable crest, upstream slope and spillway channel, in general. ▪ Downstream slope rill erosion condition similar to that in the 2013 fall, with longitudinal cracks and minor slope slumps, and eroded materials depositing on the downstream berm. Over time, the head of rill erosion appeared to have moved up the slope (see Photos 36, 37 and 40). ▪ Vegetation growth on the downstream slope was not even. In the area with dense shrubbery growth, root structure tends to retard rill erosion process. In addition, the vegetation cover tends to make rill erosion less pronounced. ▪ Steps along the upstream slope near the crest shoulder were observed (see Photo 34). Until 2014 fall, only one such a step was observed near the south end. It appeared that more of these steps were observed in the middle of the dam in the fall. The nature of these steps is uncertain. It could be remnant features left during dam construction. It could also be caused by potential downward movement of the upstream slope.	▪ Continue to experiment with the increased maximum drawdown rate of Intermediate Pond at 40 mm/day, and observe any unfavourable dam response, such as signs of horizontal deformation, settlement, seepage and slope slump, etc. Draw down the pond to the targeted drawdown level, once normal water treatment operation resumes at the Faro Site in 2015. ▪ Continue to monitor piezometer instrumentation. ▪ Continue to monitor wave erosion along upstream face and rill erosion along downstream face. ▪ YG and TEES could potentially experiment with different strategies of maintaining the downstream slope: in the segments with good vegetation growth, try improvement of vegetation cover with no re-grading, while in the segments with poor or no vegetation growth, try re-grading the slope with bulldozer. In the area where re-grading is carried out, efforts should be taken to minimize the damage to the existing vegetation cover on the slope and to restore tilted above-ground portion of existing instrumentation on the berm surface. ▪ Ongoing monitoring of the development of steps along the upstream slope near the crest shoulder, especially after maximum drawdown to guard against excessive slope deformation.
Cross Valley Dam (CVD)	▪ Cross Valley Dam (or 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. ▪ The annual appearance of longitudinal cracks along the dam crest in the spring and their subsequent disappearance seem to be related to freezing and spring thawing effect. This phenomenon was repeated in 2014 with only barely visible signs of spring cracks in the fall (see Photo 41). ▪ A temporary lime treatment plant was being dismantled at the north shore of the Cross Valley Pond (see Photo 45). Water stored in the Polishing Pond received lime treatment in the summer. Compliance water was then released to the environment via the North Valley Wall Interceptor Ditch. ▪ Rill erosions occurred on the downstream slope near the dam crest shoulder (see Photos 42 and 43). ▪ Repair of the shoulder erosion of the north access road near Cross Valley Dam was not completed (see Photo 44). ▪ Downstream Weir No. 3 was corroded in September (see Photo 46).	▪ Continue to monitor piezometer and weir instrumentation. ▪ Continue to monitor longitudinal tension cracks on dam crest in the spring, and seal these cracks by grading to minimize water ingress to the embankment dam. ▪ Repair rill erosions in local areas of the downstream slope near the dam crest as required. ▪ Monitor the repair of the north access road shoulder above the north abutment of the dam, which is being used by the public. ▪ Trim vegetation growth on the dam as required. ▪ Repair downstream Weir No. 3.

Table 4.1 Faro Mine Site Complex – 2014 Annual Review 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.	▪ East wall instability appears to be continually evolving, with wet streaks of groundwater daylighting the pit wall (see Photo 51). ▪ Longitudinal crack at N2 Survey Rod on the north array increased in width and depth since 2013, and a slump occurred at the pit rim in the general area was progressing. Additional crack was also observed between N2 and N3 Survey Rods (see Photo 50). ▪ Several nearby power poles seemed to tilt towards the pit. We understand that this line of poles no longer carry live wires. ▪ A wire fence encloses a former deep-well site near the transformer station and the south survey road array. The fence closest to the pit rim showed significant distortion as compared to that furthest from the rim. ▪ Pit lake level started to drop from the maximum 2014 level in July. However, the level in December was still above the maximum recommended level as well as near the overburden/bedrock contact elevation (see Section II-J1). ▪ A pump barge was in operation to transfer water from Grum Pit to Vangorda Pit for treatment. There were signs of some rock fall on the nearby pit wall. Personnel working in the general area should monitor potential rock fall to ensure safe working condition. ▪ Access road on the north pit rim was partially flooded. We understand that TEES plans to deactivate this road for safety reasons.	▪ Continue to have pit slope stability reviewed periodically, especially in case of development of new sizable slumps. ▪ Continue visual monitoring of pit wall conditions with photos taken from same vantage points. ▪ Contingency planning regarding power supply in the area is needed relative to the impact of potential progressive failure of the pit wall on the remaining two rows of power poles carrying live wires. ▪ Safely monitor surface runoff ponding in the area west of the access road if practical, and pump any water standing in an existing east-west ditch adjacent to the access road to the Grum Interceptor Ditch. ▪ Avoid rapid drawdown of pit-lake level, during water treatment period to mitigate the potential of slope instability. ▪ Mark set back area from the pit wall near the pump barge access road to warn the personnel against rock-fall hazard. ▪ Cover the exposed large drill holes (see Photo 54) on the north pit rim with steel plates and mark the locations with red paint or block access to the area for protection of personnel and wild animal.
Vangorda Pit	▪ An elongated, inactive pit, with the long axis oriented in the northwest-southeast direction. ▪ The pit is about 1.100 m long, 350 m wide with a maximum height of 150 m. ▪ A pump barge pumps water to the treatment plant.	▪ Pit lake level started to drop from the maximum 2014 level in June. ▪ Cracks were observed by CH2MHILL in 2013 and Golder in 2014 in the face and crest of the glacial till slope in the northwest corner of the pit.	▪ Continue to have pit slope stability reviewed periodically, especially in case of development of new sizable slumps. ▪ Continue visual monitoring of pit wall conditions including the glacial till slope at the northwest corner of the pit with photos taken from same vantage points at least at yearly interval.
Grum Waste Rock Dump	▪ The dump is not within the current scope of work. ▪ The dump was visited due to excess surface runoff occurred during spring freshet in 2011 and 2013.	▪ Due to time constraint, Grum Waste Rock Dump was not visited in 2014.	▪ Continue regular monitoring. ▪ Prevent the escape of excess surface runoff from the Grum Waste Rock Dump during spring freshet and flowing into Vangorda Creek or Moose Pond.
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 Little Creek Pond retained by the Little Creek Dam.	▪ As noted in previous reports, the steel weir plate at Drain 5 is split. The weir plate at Drain 3 is delaminated and the staff gauge has tipped over. ▪ A small hole has been dug at Drain 4 to collect seepage water. A weir could be installed at the drain to measure the flow.	▪ Repair damaged weirs at Drains 3 and 5. ▪ Install a weir at Drain 4, if flow increases.
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 uppermost and lowest reaches of the ditch. ▪ Rill erosion was present on Till Overburden Dump slope. ▪ No change in condition of culverts since 2013 fall site visit.	▪ Clear vegetation from ditch. ▪ Continue routine monitoring of ditch and culverts along the ditch. ▪ For recommendations on culvert maintenance/repairs see Table 4.1 in the 2012 Annual Geotechnical Review report.
Vangorda North East Interceptor Ditch	▪ Located uphill of the Vangorda Pit. ▪ Diverts surface runoff away from the pit.	▪ Small flow in ditch along the upper (50%) reach of the ditch; increased flow along the reach downstream of the tributary confluence. ▪ Four ditch side-slope slumps were observed along the lower reach: one at the road embankment slope was partially repaired in 2013 with large boulders, and remaining slumps are to be repaired as required before spring freshet including two on the bank slope on the opposite side from the road.	▪ Continue to monitor ditch side slopes, especially along reaches with slope slumps during spring freshet. ▪ When slope slumps are repaired, filter materials are to be placed between existing slope and newly added riprap materials. Addition of filter fabric at the contact between material zones of different grain sizes would be useful. ▪ The maintenance activity should focus on ensuring the adequate flow capacity of the Interceptor Ditch during the next spring freshet.

Table 4.1 Faro Mine Site Complex – 2014 Annual Review Summary (cont'd)

Faro Site Facilities			
Structure	**Description**	**Observations**	**Comments and Recommendations**
Vangorda Creek Diversion Flume	▪ 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.	▪ At the upstream end of the flume main culvert, large boulders were added as riprap but no filter materials appeared to be present between the riprap and road embankment fill. A small steel trashrack, tied to a few boulders by ropes, has been installed to prevent unravelling of the boulders over the culvert entrance (see Photo 67). ▪ One broken bar on the large trash rack at the entrance of the flume culvert remained to be repaired (see Photo 66). ▪ Some sediments were observed at the bottom of twin emergency culverts (see Photo 65); channel invert downstream of the culverts appeared to be slightly too high. ▪ Galvanized flume braces appeared to be undersized and buckled under lateral pressure from riprap around the flume. Flume was deformed in places as the result.	▪ Clear the entrance of the twin emergency spillway culverts and lower the spillway channel invert at the discharge end of the culverts. ▪ Repair the broken rod of the large trash rack at the culvert inlet to the flume. ▪ Consider replacing the steel trash rack, which is tied to boulders with ropes (see Photo 67), with a permanent installation. ▪ Where flume braces were buckled, add additional stronger braces to stiffen the flume in local areas. ▪ 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. ▪ Replace the flume with a new structure as early as practical.
Little Creek Dam	▪ Water dam to collect contact water from Vangorda Waste Rock Dump for pumping it to the Vangorda Pit Lake.	▪ Stable dam slopes with rill erosion developed on the downstream and upstream crest shoulders and slopes as well as downstream berm slopes. ▪ Ground appeared wet along downstream toe. ▪ Rill erosion is present at the foundation of the transformer situated at the downstream crest shoulder. ▪ Culvert spillway in good condition, and a relatively low pond level. ▪ There are cracks in the ground at the downstream end of the spillway outfall channel at the top of bank slope above Vangorda Creek.	▪ Repair rill erosions on both dam slopes near the dam crest, as needed. ▪ Plan to incrementally repair rill erosions on the downstream berms from bottom up. ▪ Consider to construct a surface runoff collection ditch at the downstream toe to prevent the toe area getting wet and soft after snowmelt and/or heavy rain. ▪ Monitor the cracks at the downstream end of the spillway outlet channel. ▪ Trim vegetation on dam slopes, as required.
Sheep Pad Sediment Ponds	▪ Facility consists of 2 ponds, the upper and lower pond, which collect surface runoff from upslope areas, including the Grum Overburden Dump. ▪ The upper pond discharges into the lower 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.	▪ Freeze-and-thaw longitudinal cracks observed along dyke crest and upstream slope in the spring were subdued in the fall (see Photo 75). ▪ Large boulders weighing down the half-round CSP between the Upper and Lower Ponds near the entrance restricted flow. There are no stiffening braces across the top of the half-round CSP (see Photo 76) and the CSP sections are not tied together. The entrance CSP section appeared to have shifted. ▪ The dyke slope above the inlet of the spillway channel showed signs of lateral spread (i.e., squeezing in the channel).	▪ Monitor cracked and deformed dyke crest and upstream slope and repair the dyke as required to prevent leakage and/or spill of pond water. ▪ Reduce the size of large boulders there. Add stiffening braces to the top of the CSP to prevent further pipe deformation due to lateral pressure from riprap materials around the pipe. ▪ Cover exposed geofabric, as required, with riprap materials at the Lower Pond spillway. ▪ Monitor lateral spreading of the dyke slope at the Lower Pond spillway channel, and repair cracked slope as required.
Grum Settling Pond	▪ Pond discharges to Grum Interceptor Ditch via a riprap-lined spillway channel.	▪ Spillway channel appeared to be in good condition, with considerable vegetation growth (see Photo 78). ▪ Vegetation growth on the dyke crest and downstream slope was overgrown in places (see Photo 77).	▪ Continue to monitor spillway channel for erosion and vegetation growth. ▪ Continue to monitor retaining dyke embankment and clear overgrown vegetation, as required.

Table 4.1 Faro Mine Site Complex – 2014 Annual Review Summary (cont'd)

Faro Site Facilities			
Structure	**Description**	**Observations**	**Comments and Recommendations**
V-15 Seep Ditch and Moose Pond	▪ Seepage water from Grum Waste Rock Dump daylights at V-15 Pond. ▪ Bentomat lined V-15 ditch diverts water from V-15 Pond to Moose Pond, and, in turn, water exfiltrates from Moose Pond to the environment. ▪ Figure 4 shows a siphon pipeline from Moose Pond to V2 Sediment Trap. We understand that it was used to draw down water from Moose Pond in the past.	▪ 2011 and 2013 excess spring runoff inflows into Moose Pond contributed to the following 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 2011⁄2013 raised seepage face. ▪ Exfiltration from Moose Pond potentially has changed from occurring at the pond bottom to from the pond bank slope at higher elevations since 2011. ▪ The steep reach of the V-15 Ditch above the Moose Pond appeared to be in good shape (see Photo 81). ▪ A pumping station has been installed in the upper reach of V-15 ditch in the spring of 2014 to control the flow to the Moose Pond. ▪ Pond level dropped significantly in the summers of 2013 and 2014 due to the blockage of V-15 Ditch to facilitate pumping the ditch flow to Vangorda Pit.	▪ Prevent future inflow into Moose Pond from extraneous sources not in existence prior to 2011. ▪ Determine Moose Pond bathymetry using latest survey information obtained in 2013 to obtain the storage capacity of the Moose Pond. ▪ Continue to monitor pond level variation at Moose Pond and its exfiltration performance under current groundwater flow regime. ▪ Suggest YG to confirm the status of the siphon pipeline from Moose Pond to V2 Sediment Trap as well as to investigate the potential use of this siphon pipeline as an emergency spillway for Moose Pond and the ramifications of this use. ▪ Continue to monitor seepage flow along the downstream slope of the retaining esker. ▪ Continue to monitor the downstream slope of the retaining esker to determine 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 and 2013 excess-inflow incidents on the normal exfiltration operation of the Moose Pond, as required. ▪ Consider removing sediments carried by 2011 and 2013 excess inflow and accumulated in the pond bottom to restore its exfiltration capacity as required. This could be done by first drying the pond in late summer, and using light excavation equipment with low bearing pressure.
Sludge Pond Embankment Dyke at Vangorda Water Treatment Plant	▪ Rectangular-shaped sludge pond retained by embankment dyke. ▪ Accumulated sludge created by treating water from Vangorda Pit Lake has been removed mechanically during winter until 2013. ▪ Hydraulic dredging of sludge has been initiated during summer and fall of 2014 to dredge increased sludge created by treating water from both Vangorda and Grum Pit lakes.	▪ Freeze-and-thaw longitudinal cracks observed on the dyke crest in the spring of 2013 and 2014 were less obvious in the fall. ▪ Hydraulic dredge was shown in operation (see Photo 84).	▪ Monitor freeze-and-thaw dyke cracks in the spring, and repair the dyke as required to prevent leakage and/or spill of pond water. ▪ Continue existing monitoring of the embankment dyke.

4.2 Proposed 2015 Faro Mine Complex Geotechnical-hydrotechnical Monitoring Program

The Faro Mine Complex is currently under a care and maintenance program. Table 4.2 presents our proposed 2015 Faro Mine Complex geotechnical - hydrotechnical monitoring program, which is the same as Table III.3 in Appendix III. As outlined in Appendix III, the 2014 site instrumentation monitoring program essentially followed the recommendations given in our 2013 Annual Review report (KCB 2014) as given in Table III.2 of Appendix III. The status of 2014 instrumentation monitoring is summarized in Table III.1.

As discussed in Appendix III, the minor adjustment proposed in Table 4.2 (Table III.3) essentially applies only to the thermistors and inclinometers located on the Back Slope of the Rose Creek Diversion Channel. We recommend that Thermistors: BS-5, BS-9, BS-10 and BS-12 be rehabilitated or replaced to provide correct in situ ground temperature profiles in 2015. In addition, all other thermistors located on the Back Slope should also be checked to see whether they can be rehabilitated or replaced for ongoing ground temperature monitoring at depth in other reaches of the Back Slope. Since no excessive horizontal movement is indicated in the movement profiles obtained in 2014 for Inclinometers BS-5, BS-9 and BS-10, we recommend that only one set of reading of these inclinometers be taken in 2015.

Due to Health and Safety concerns, programs of distance monitoring by TEES at the pit rim of the Faro Pit east wall and Grum Pit east wall were discontinued in September 2014.

Table 4.2 Proposed 2015 Faro Mine Complex Geotechnical – Hydrotechnical Monitoring Program

Faro Mine Complex Geotechnical Program 2015	January	February	March	April	May	June	July	August	September	October	November	December
Rose Creek												
Thermistors												
Canal Dyke: CD-15, CD-21, BGC05-04, BGC05-07, CD-26					Monthly	Monthly			Monthly			
Spoil Pile: SP-3, SP-5						Monthly						
Backslope: BS-5, BS-9, BS-10, BS-12						Monthly			Monthly			
Slope Indicators	If blocked in May attempt in June											
Canal Dyke: CD-10, CD-15, CD-19, CD-21, BH94CD-1, BH91-CD1, BGC05-05, BGC05-08					Monthly				Monthly			
Spoil Pile: SP-2, SP-5						Monthly						
Backslope: BS-5, BS-9, BS-10						Monthly			Monthly			
Piezometers												
Canal Dyke: CD-13, CD-15, CD-21, BGC05-02, BGC05-03, BGC05-06, CD-26					Monthly	Monthly			Monthly			
Backslope: BS-5, BS-9						Monthly			Monthly			
Staff Gauges												
RCDC-4				Daily	Daily	Daily	Daily	Daily	Daily			
NFRD23, X2				Daily	Daily	Daily	Weekly	Weekly	Weekly	Weekly		
Data loggers												
NFRD23				Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly		
Elevations												
NF1, NF2					Weekly	Weekly	Weekly	TAM	TAM			
Observations												
NF1, NF2	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Cross Valley Dam												
Thermistors												
CVDC-6, BH88-4						Monthly						
Piezometers												
CVDC-4, CVDC-7, CVDC-9, CVDT-1, CVDT-2, CVDP-1, CVDP-3, CVDP-5, CVDP-6, 94 CVDC-1					Monthly	Monthly			Monthly			
Weir Flows												
X11, X12, Weir 3	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
X13	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Elevations												
Polishing Pond	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Intermediate Dam												
Piezometers												
91ID-4, 91-ID-6, 91-ID-7, 94-IDC-1, 96-1, 96-2, 96-3, 96-4, P01-03, P01-04, BKS04-06, BKS04-07					Monthly	Monthly			Monthly			
914-ID3					Monthly	Monthly		Monthly	Monthly			
Observations												
Seepage observations near south abutment					Monthly	Monthly		Monthly	Monthly			
Elevations												
Intermediate Pond	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Secondary Tailings Dam												
Piezometers												
P81-6, P81-7, P81-8, P03-01, P03-02, P03-03					Monthly	Monthly			Monthly			
North Wall Interceptor Ditch												
Flows												
NWID	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Faro Creek Diversion Channel												
Staff Gauges												
FCD-1, FCD-2, FCD-3, FCD-4				TAM	TAM	TAM	TAM	TAM	TAM	TAM		
Flows												
FCD-1, FCD-2, FCD-3, FCD-4				TAM	TAM	TAM	TAM	TAM	TAM	TAM		
Faro Pit												
Observations												
Faro Pit	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Haul Road												
Observations												
K8 Rock Drain	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Grum Pit												
Observations												
Grum Pit Wall	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Piezometers												
SRK09-GSA, SRK09-GSB	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Vangorda Pit												
Observations												
Vangorda Pit Wall	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Vangorda Waste Rock Dump												
Observations												
V28, V29, V30, V31, V32, V33					Monthly	Monthly	Monthly	Monthly	Monthly	Monthly		
Drainage Ditch						Monthly						
Northeast Dump Crest						Monthly						
Flows												
V29, V30, V31, V32, V33					TAM	TAM	TAM	TAM	TAM	TAM		
Piezometers												
V39, V40, V41, V42, V43, V44, V45, V46, V47, PW-10-01, PW-10-02, PW-10-03, PW-10-04, PW-10-05					Monthly				Monthly			
Data loggers												
PW-10-01, PW-10-02, PW-10-03, PW-10-5					Monthly				Monthly			
Little Creek Dam												
Piezometers												
BH94 LCD-1, BH94 LCD-2, BH94 LCD-3					Monthly				Monthly			
Thermistors												
BH94 LCD-4, BH94 LCD-5, BH94 LCD-6					Monthly							
Observations												
Dam Crest						Monthly						
Inlet of Culvert Spillway						Monthly						
Vangorda Creek Diversion												
Observations												
Trash Rack at Headworks						Monthly						
Seepage Collection Pond						Monthly						
Sideslopes Above Plume						Monthly						
Sludge Pond Embankment												
Observations												
Downstream slopes and Embankments						Monthly						
Grum Settling Pond												
Observations												
Spillway from Grum Settling Pond to Grum Inteceptor Ditch						Monthly						
Grum Interceptor Ditch and Sheep Pad Pond												
Observations												
Outlets / Inlets to Ditch						Monthly						
Sheep Pad Pond Dyke						Monthly						
Moose Pond												
Observations												
Kaori's Seep	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
						Monthly						
Elevations												
Moose Pond	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly

5 CONCLUSIONS AND RECOMMENDATIONS

Based on our 2014 annual review including spring and fall site visits, ongoing review of TEES monitoring data and periodical discussions with YG and TEES, the main conclusions and recommendations are presented 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 in general functioned satisfactorily in 2014 as in the past. The care and maintenance activities, including instrument monitoring, survey measurement and surveillance / maintenance, are performed generally following the planned schedules.
- The pit-wall rim movement monitoring programs at the Faro and Grum Pits indicate that the measured distance changes are within the measurement accuracy.
- At the instability zones along the east wall of Grum Pit, cracks and ground deformation observed by TEES in August 2012 continued to develop in 2014. In response, YG initiated installation and survey of prisms along the pit rim in the fall of 2013 (CH2MHILL 2013a and YES 2013b). We understand that YG is also reviewing with Golder to look for an alternative cost-effective and safe monitoring program at Grum and Faro east pit rim to track the ongoing pit wall deformation (Golder 2015).
- The latest dam-safety related activities carried out for the Faro Mine Complex included the following:
  - WorleyParsons (2015) conducted a dam safety review for the Intermediate, Cross Valley and Little Creek Dams with a site visit on September 25 and 26, 2014. They concurred that all three dams can be classified as “high” consequence dams.
  - In response to the dam safety review by WorleyParsons, the Government of Yukon (YG), Tlicho Engineering and Environmental Services (TEES) and Klohn Crippen Berger (KCB) updated the Emergency Response Plan (ERP) in draft (KCB 2015b), and plan to issue the update of both the ERP and Operations, Maintenance and Surveillance (OMS) Manual by March 2016.
- In 2014, a temporary lime treatment plant was set up at the north abutment of the Cross Valley Dam in early August to treat and release water from the Polishing Pond via North Valley Interceptor Ditch, when water quality is in compliance with discharge criteria. In addition, excess water in the Intermediate Pond was pumped back to the Faro Pit. The interim water treatment plant was constructed at the Faro plant site, and had been used briefly to treat water from Faro Pit Lake in October.
- In 2014 water was pumped from the Grum Pit Lake, via Vangorda Pit Lake and treated at Vangorda Water Treatment Plant from June to September.
- In 2014 the lake levels at the Faro and Grum open pits have risen above the respective recommended levels as follows:

- Faro Pit Lake – lake level on December 29 to El. 1152.4, about 8.1 m above the recommended maximum level; and
- Grum Pit Lake – lake level on December 29 to El. 1216, about 2.6 m above the recommended maximum level

The current lake levels at the two pits are in the overburden and/or weathered surficial bedrock zones that may be more pervious than the sound bedrock at depth. Thus, the raised lake levels could cause increased groundwater quality degradation in the pit rim region and/or reduced local pit wall stability at the toe, especially during rapid drawdown of the lake level.

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:
  - Initiate calibration flow measurements at staff gauges in 2015 during high flows, using the newly installed overhead wires.
- North Valley Wall Interceptor Ditch:
  - Continue vegetation clearance along the upper and middle constructed channel reaches. Clearing should also include the access road and berm along the channel to facilitate future inspection.
  - Install a weir in the ditch near the beginning of the upper constructed reach for measuring flow.
- Rose Creek Diversion Channel:
  - Initiate calibration flow measurements at staff gauges in 2015 during high flows, using the newly installed overhead wires.
  - Clear vegetation along lower channel reaches.
- Grum Pit:
  - In the 2015 spring freshet season, pump any snowmelt water collected in a short east-west running ditch north of the North Array of Reference Rods across the access road and discharge the water to the Grum Interceptor Ditch. In addition, mark on a topographical map other ponding water accumulated in low spots on the pit rim for possible transfer to the Grum Interceptor Ditch by pumping in future.
- Vangorda Waste Rock Dump:
  - Repair damaged weirs at Drains 3 and 5.
  - Install a weir at Drain 4, if flow increases.
- Vangorda Northeast Interceptor Ditch above Vangorda Pit:

- Repair slumped ditch sections to maintain flow capacity, especially prior to spring freshet.

- Vangorda Creek Diversion Flume:
  - Check and maintain freeboard of the CSP flume and its containing channel to prevent flow spilling into the adjacent Vangorda Pit across the access road during flood events similar to those occurred in 2004 and 2012.
  - Add additional stronger braces to stiffen the flume in local areas, where existing braces are buckled.
- Little Creek Dam:
  - Investigate potential mitigation measures 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 2014a).
- Moose Pond:
  - Suggest YG to confirm the status of the siphon pipeline from Moose Pond to V2 Sediment Trap as well as to investigate the potential use of this siphon pipeline as an emergency spillway for Moose Pond and the ramifications of this use.

Geotechnical Aspects

- Faro, Grum and Vangorda Pit Rims:
  - Conduct periodical pit wall stability inspections as directed by the pit wall stability consultant.
  - Golder and YES to review survey details in the field to improve the accuracy of survey results at the Faro East Pit Rim, subject to due diligence regarding personnel safety.
  - YG and Golder to implement an alternative cost-effective pit rim stability monitoring program at Faro and Grum Pits.
  - Make a contingency plan regarding power supply in the Grum East Pit Rim area relative to the impact of potential progressive failure of the pit wall on the existing two rows of power poles carrying live wires and a transformer station.
- Faro and Grum Pit-Lakes:
  - Monitor pit wall slope stability of the Faro and Grum Pits, especially at the toe, during drawdown of lake level from the current elevated stage.
  - Monitor potential deterioration of groundwater quality in areas affected by the Faro and Grum Pit Lakes during the current period of elevated lake levels.
- Rose Creek Diversion Channel:
  - Rehabilitate or replace malfunctioning thermistors installed along the Back Slope.
  - Monitor condition of longitudinal cracks and slope slump scarps as well as instrumentation at the Back Slope.

- Explore permit requirements regarding investigation and repair of the local slope slumps at the Back Slope.
- Improve access trail/road condition for personnel and vehicle/equipment from landing sites to the slope slump areas on the Back Slope. Explore the use of Argo or equivalent vehicle to cross the channel at an existing ford under permit.

- Intermediate Dam:
  - Continue to experiment with the increased maximum drawdown rate of Intermediate Pond at 40 mm/day.
  - Continue to monitor wave erosion along upstream face and rill erosion along downstream face.
  - Monitor the development of steps along the upstream slope near the crest shoulder, especially after maximum drawdown to guard against excessive slope deformation.
  - YG and TEES could experiment with different strategies of maintaining the downstream slope: in the segments with good vegetation growth, try improvement of vegetation cover with no re-grading, while in the segments with poor or no vegetation growth, try re-grading the slope with bulldozer. In the area where re-grading is carried out, efforts should be taken to minimize the damage to the existing vegetation cover on the slope and to restore tilted above-ground portion of existing instrumentation on the berm surface.
  - Repair shoulder erosion of the downstream berm.
- Cross Valley Dam:
  - It would be desirable to construct a secondary access road to the crest of the Cross Valley Dam through the south abutment from the Rose Creek Diversion Channel access road as discussed in the updated Emergency Response Plan (KCB 2014c).
- Moose Pond:
  - Prevent extraneous surface runoff entering into the Moose Pond to compromise its exfiltration capacity and damage the stability and integrity of the downstream esker ridge that retains the pond.
  - 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.
  - Consider removing sediments accumulated in the pond bottom during 2011 and 2013 excess inflows with equipment of low bearing pressure as required, if the pond is allowed to dry in the late summer.

Site Monitoring Data Collection and Presentation

The collection and presentation of site monitoring data by TEES in 2013/2014 has improved considerably. We understand that TEES environmental group is going through some personnel changes. The following suggestions are grouped together to serve as a reminder for site personnel.

- Data collection:
  - Inclinometer data - The collected data in 2013/2014 suggests that TEES may need to improve some of its personnel's capability to obtain correct inclinometer data. There are still significant portion of the collected data unusable.
  - Piezometer data – Piezometric data should be reviewed by TEES personnel to remove erroneous data such as showing piezometric level at the level of a probe blockage, or piezometric level lower than the level of the piezometer tip.
  - Staff gauge flow calibration - KCB provided 2013/2014 flow calibration presented in Section II-B1 and II-D1 for staff gauges located in Faro Creek Diversion and Rose Creek Diversion, respectively. Further discussion between KCB and TEES personnel may be useful for site personnel to update the calibration in the future.
- Data Presentation
  - We suggest that TEES to review all data presented in Appendix II, and to confirm that future data presentation by TEES will produce similar plots as those shown in Appendix II after 2015. The objective would be that data presented by TEES for the annual review will not require further work by KCB with the exception of inclinometer data. Further discussion between KCB and TEES personnel on this regard may be needed to ensure that KCB personnel's time is focused on technical interpretation of collected monitoring data rather than data presentation.

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.

KLOHN CRIPPEN BERGER LTD.

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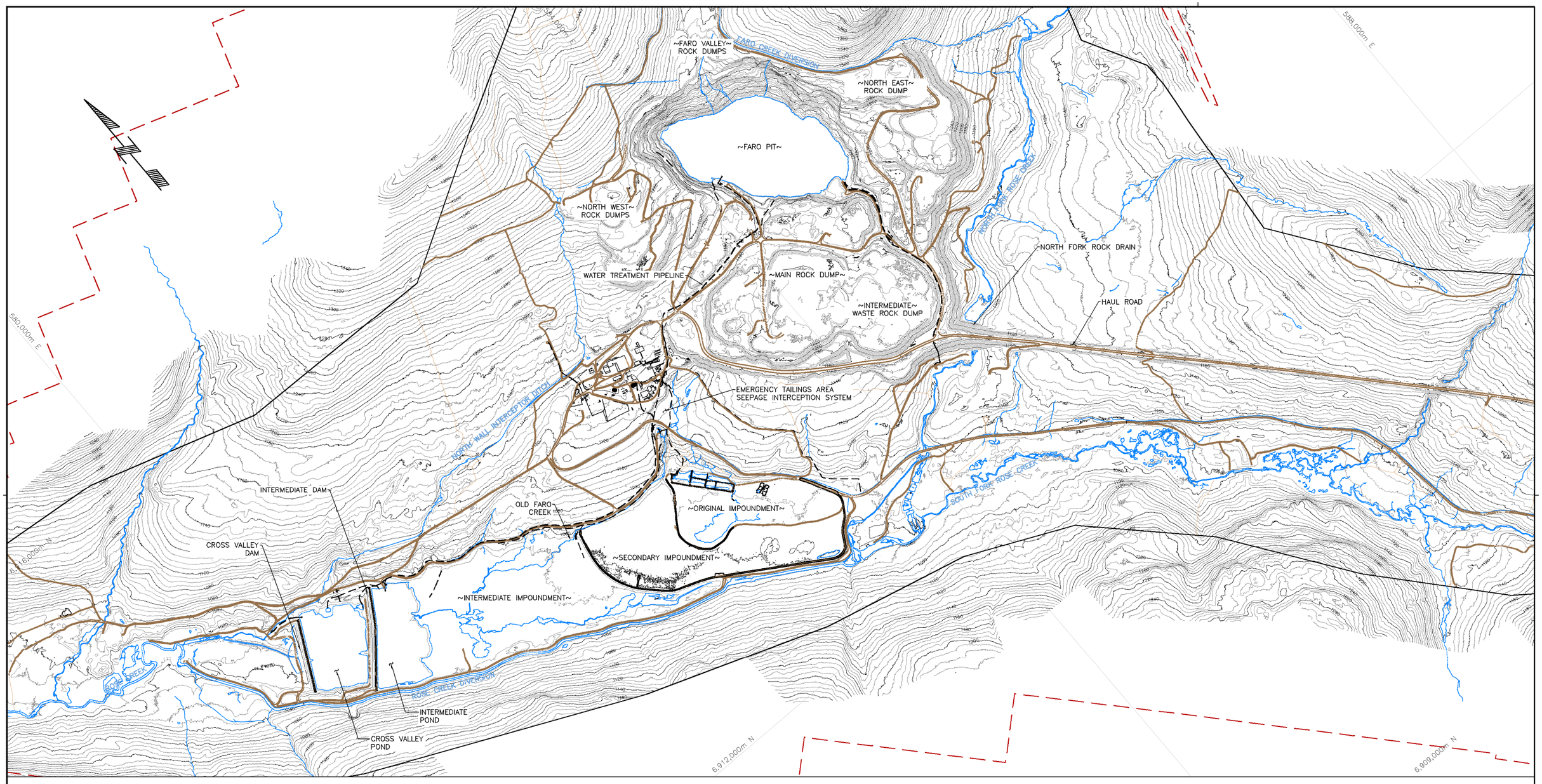
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FIGURES

Figure 1	Faro Site – General Layout
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Figure 13	Little Creek Dam – General Arrangement Plan
Figure 14	Little Creek Dam – Section B-B



LEGEND

- IMPACTED AREA BOUNDARY
- ACESS ROADS
- STREAMS

NOT FOR CONSTRUCTION

To be read with Klohn Crippen Berger report dated

SCALE 0 1000m

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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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Image File(s):

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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

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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		
CHECK	WJP	28FEB11	FIGURE 2-1	
REVIEW	JAH	28FEB11		

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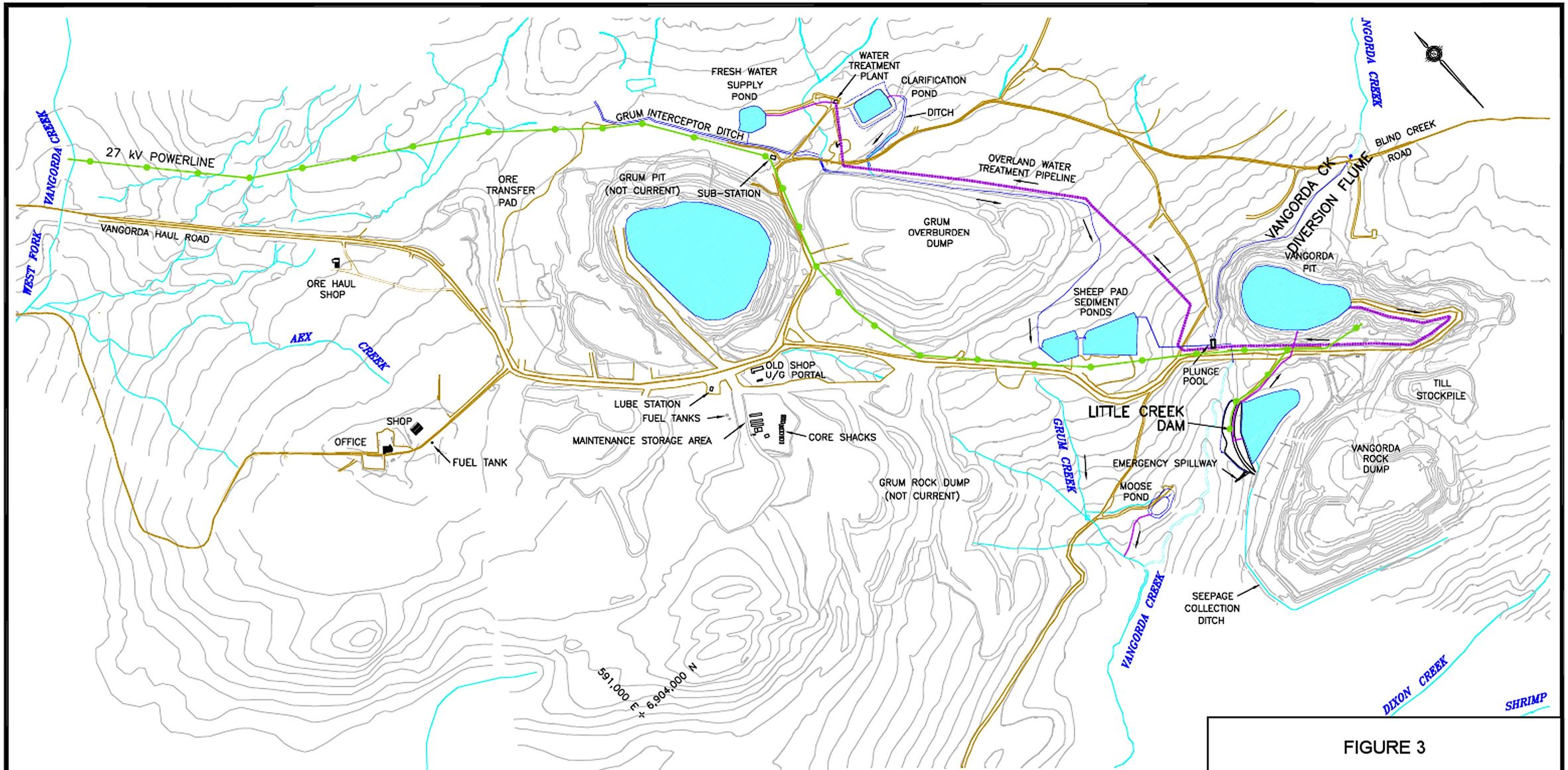


Fig. 3 Original Source: Figure 3 Vangorda Plateau Mine Site – Overview BGC 2003. Report on Emergency Preparedness Plan for Selected Dams and Water Diversion Structures

CLIENT: **Deloitte & Touche**

NOTE: BASE MAP FIGURE PROVIDED BY GARTNER LEE LTD.

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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

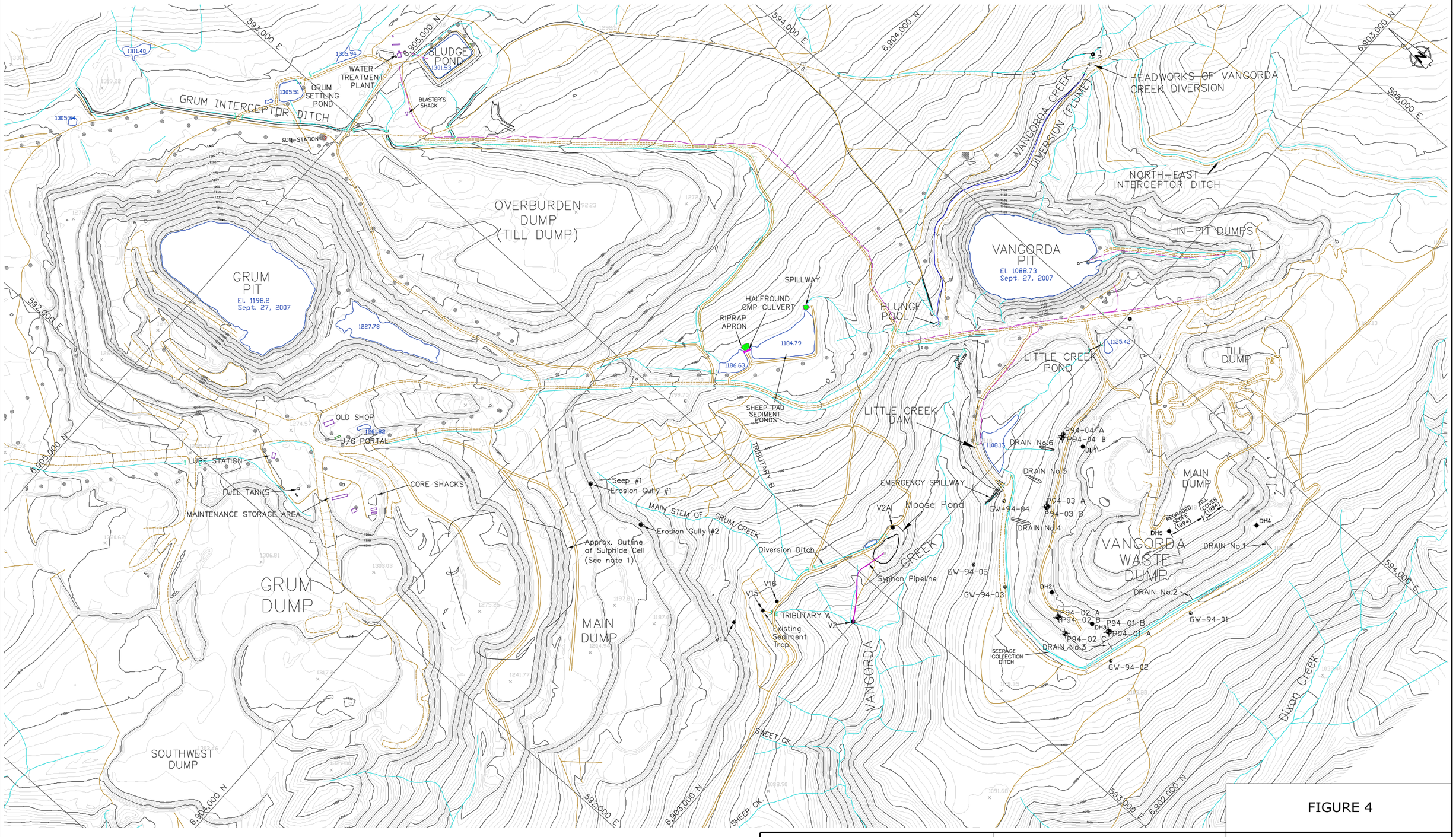
FIGURE 3

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



Map Scale: 1:2500
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

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

Denison Environmental Services

FARO MINE COMPLEX

FIGURE 4

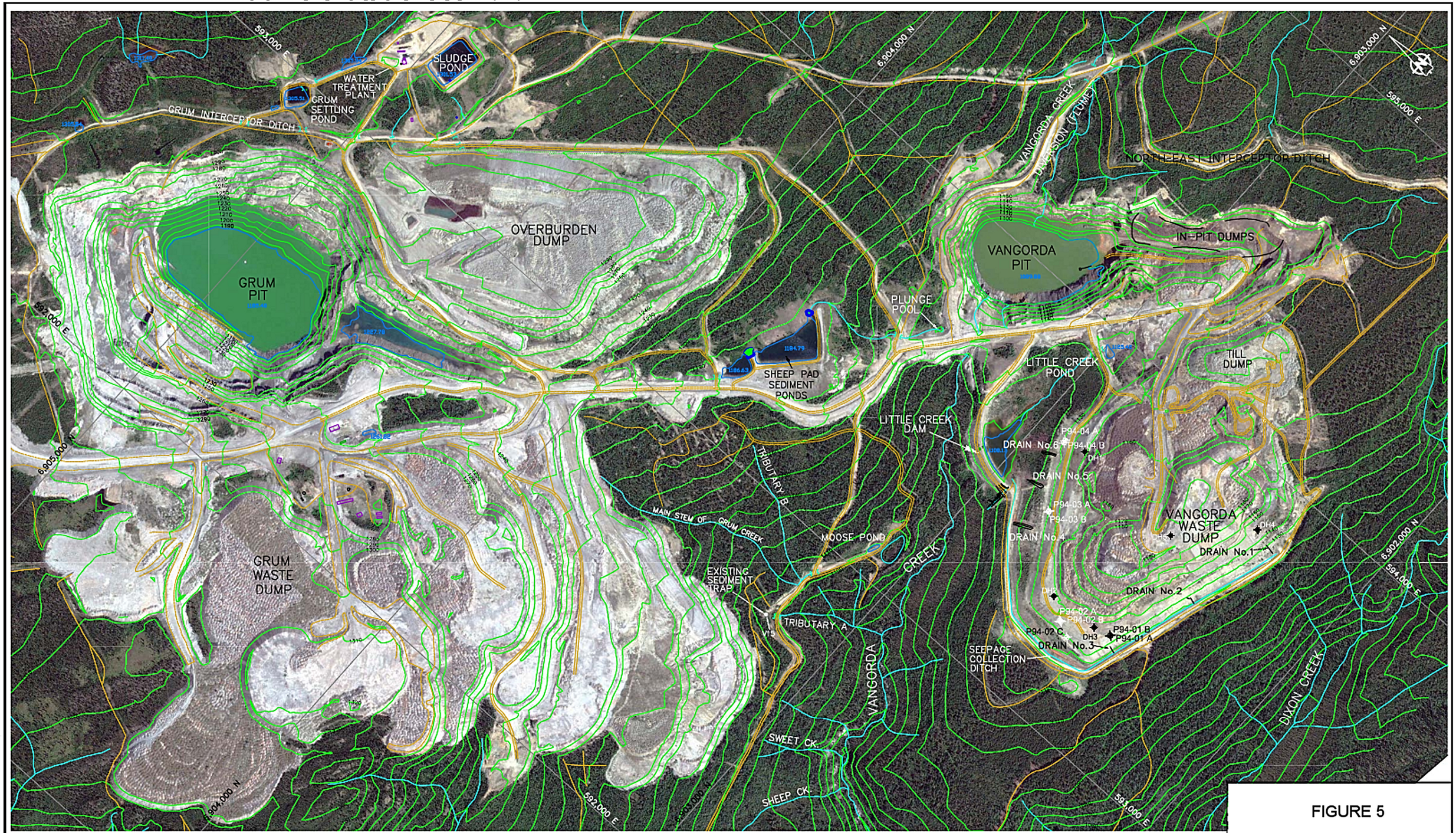
2010 Vangorda Annual Inspection

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:\M\WCR\M09770A01 - Gov't Yukon-FaroSiteGeotech\300 Design\Figures\GIMP_edited_files\Figure_5_Vangorda_Plateau_Site_Air_Photo.xcf (arischer)



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

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

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

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

Denison Environmental Services

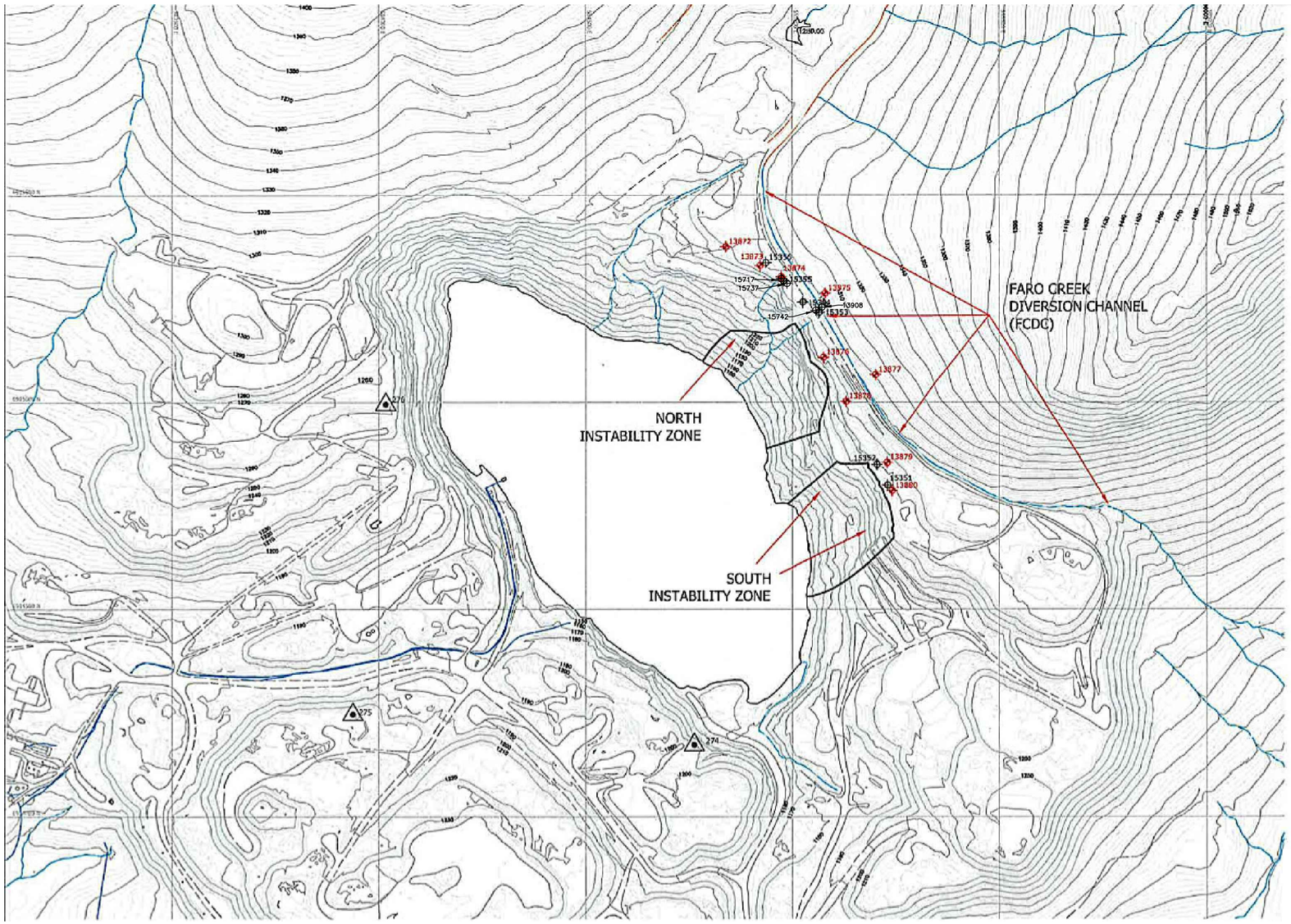
FARO MINE COMPLEX

FIGURE 5

2011 Vangorda Geotechnical Inspection

VANGORDA PLATEAU SITE AIR PHOTO

DATE:	APPROVED:	FIGURE:
July 2011	PMH	3



NOTES:

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

LEGEND:

- 13878 — MONITORING SURVEY PRISMS
- 13912 — SLOPE MOVEMENT OBSERVATIONS - REFERENCE BARS
- 274 — OBSERVATION POINTS-FIXED LOCATION

NOTES:
1. ORIGINAL FIGURE PROVIDED BY GOLDER ASSOCIATES.
2. SLOPE MOVEMENT OBSERVATIONS 15717, 15737, 15742 AND 13908 APPROXIMATELY LOCATED.

To be read with Klohn Crippen Berger report dated

SCALE

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CLIENT: Yukon Government

Klohn Crippen Berger

PROJECT: FARO MINE COMPLEX
ANNUAL REVIEW

TITLE: FARO PIT BRIM
REFERENCE BARS AND SURVEY PRISMS

PROJECT No.: M09770A03 01

FIGURE 6

KCB-R-MLD

Date:1/29/2013 Time:13:25:10 Scale:1:2,585
Filename:\\INT.KLOHN.COM\PROJDATA\VA\VCR\M09770A03-GOVTYUKON-2013 FARO\400 DRAWINGS\ANNUALREVIEW\FIG_6_FAROPIT.DWG

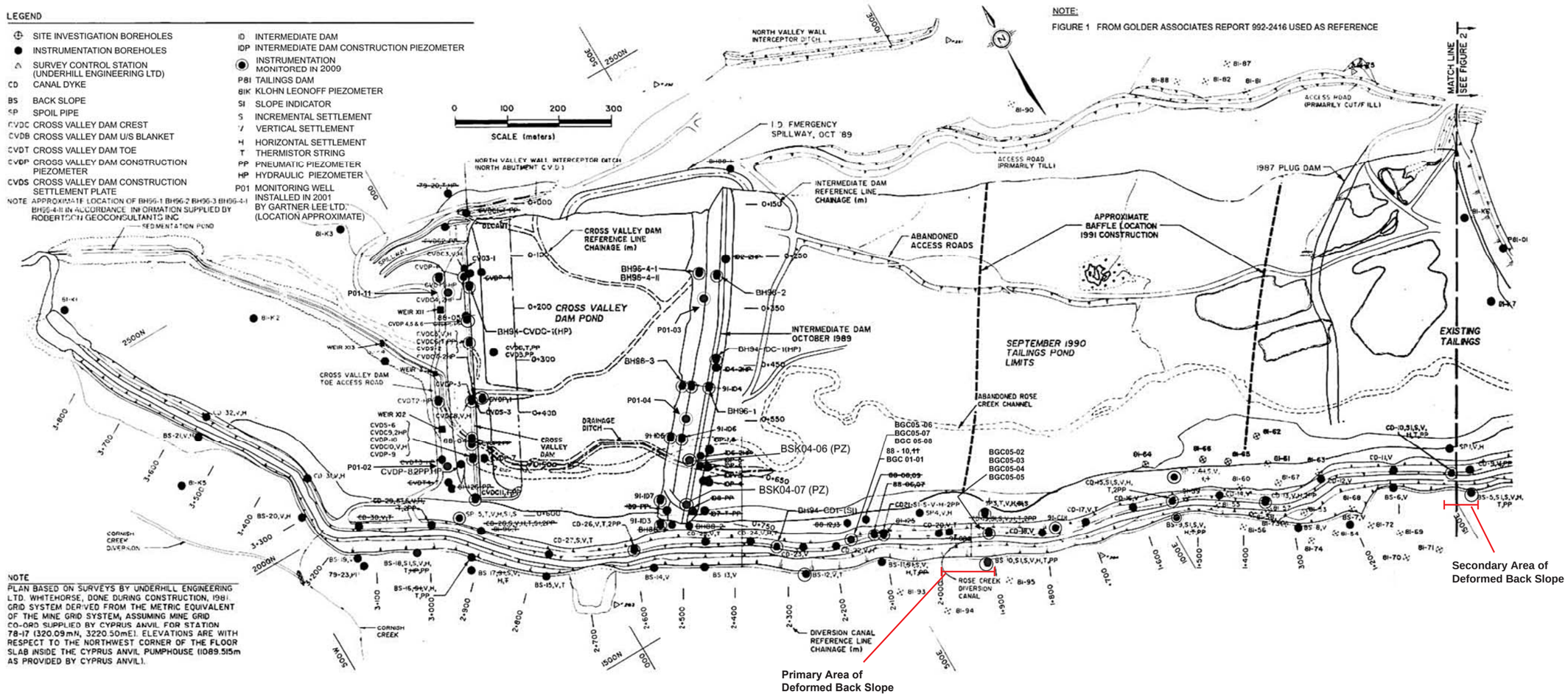


Fig. 7 Original Source: Figure 2 - 2009 Geotechnical Evaluation and Instrumentation Review, Volume 1

FIGURE 7

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REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

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

PROFESSIONAL SEAL:

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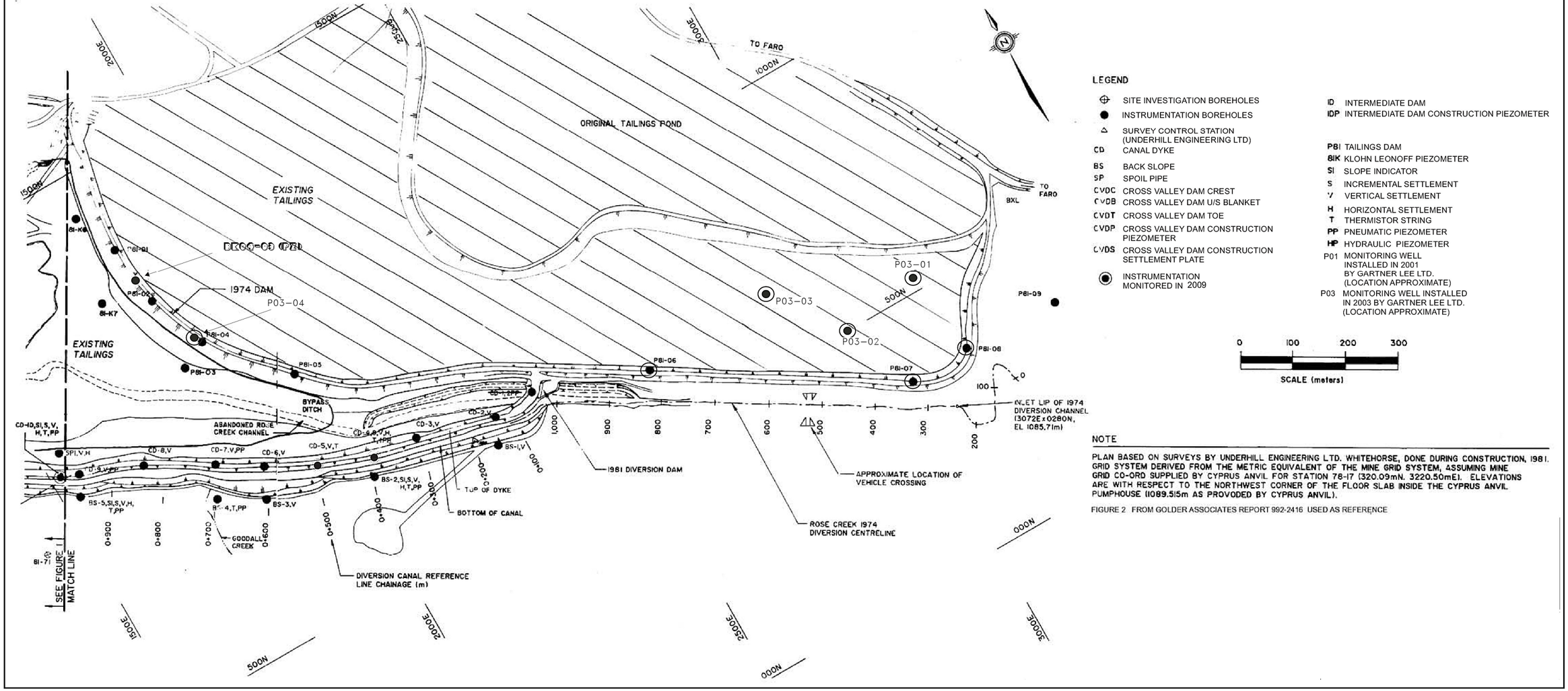
CLIENT: Denison Environmental Services

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

Z:\M\VCR\M09770A01 - Gov't Yukon-FaroSiteGeotech\300 Design\Figures\GIMP_edited_files



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
- INSTRUMENTATION MONITORED IN 2009
- ID INTERMEDIATE DAM
- IDP INTERMEDIATE DAM CONSTRUCTION PIEZOMETER
- PBI TAILINGS DAM
- BIK 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)
- P03 MONITORING WELL INSTALLED IN 2003 BY GARTNER LEE LTD. (LOCATION APPROXIMATE)

0 100 200 300

SCALE (meters)

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 PROVODED BY CYPRUS ANVIL).

FIGURE 2 FROM GOLDER ASSOCIATES REPORT 992-2416 USED AS REFERENCE

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

FIGURE 8

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CHECKED:	HHH
APPROVED:	GWF

PROFESSIONAL SEAL:

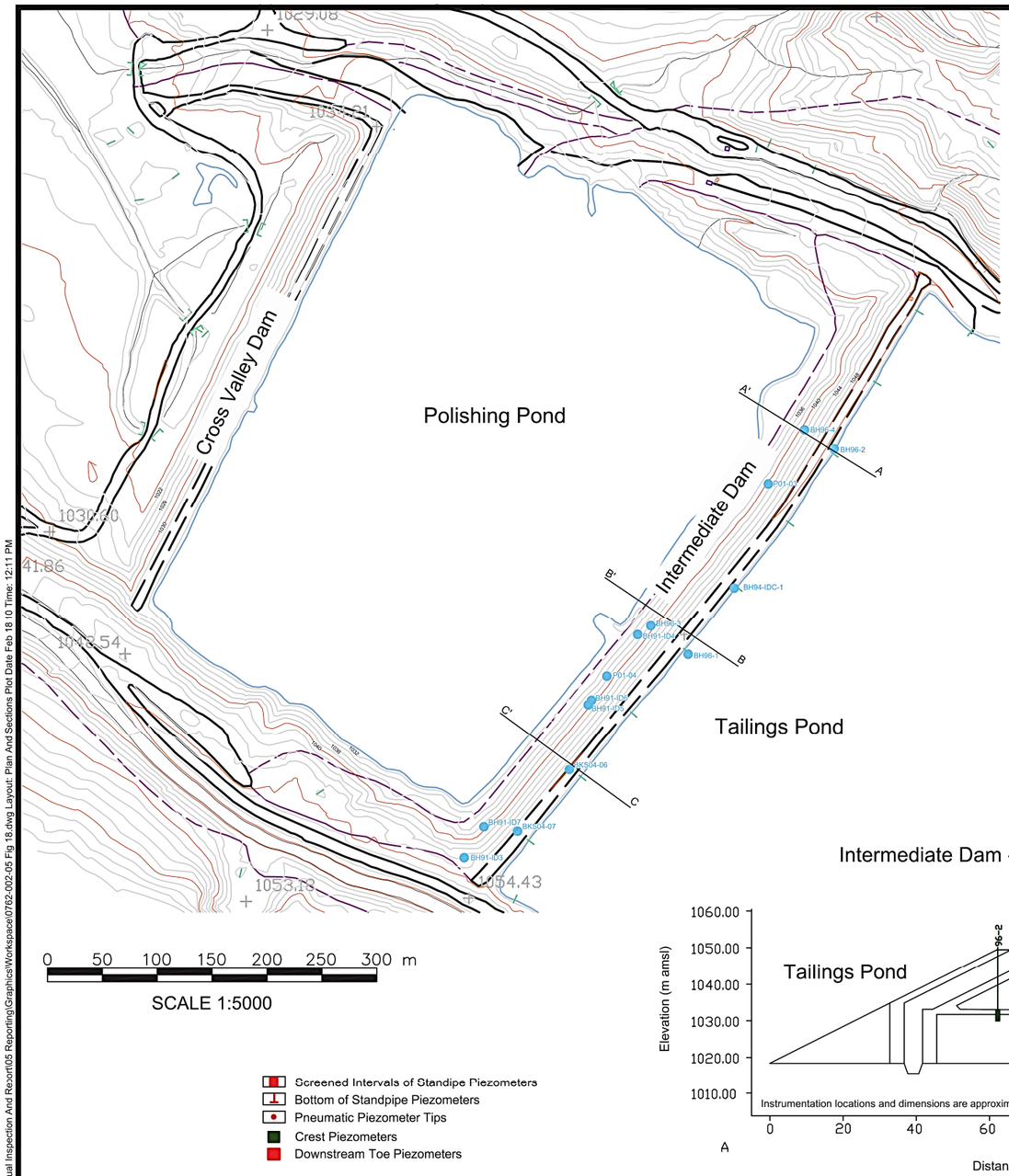
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Denison Environmental Services

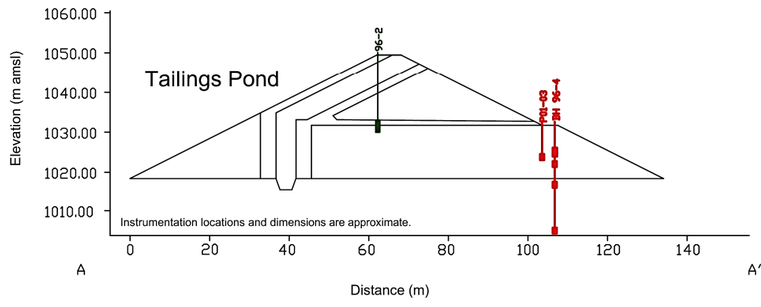
PROJECT: 2009 ANNUAL GEOTECHNICAL EVALUATION AND INSTRUMENTATION REVIEW

TITLE: DOWN VALLEY TAILINGS CONTAINMENT INSTRUMENT LOCATION 2 OF 2

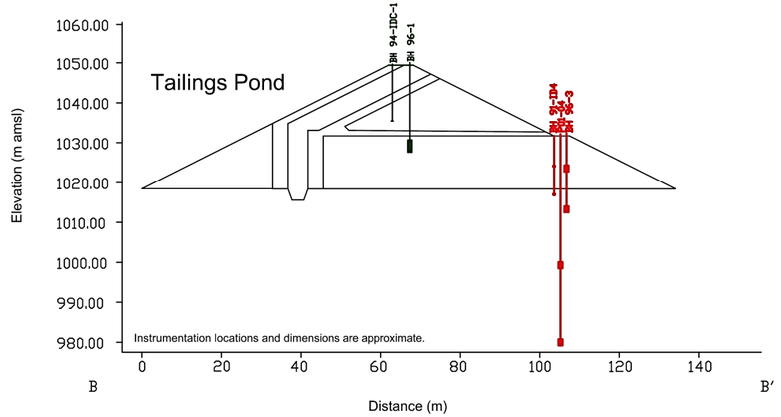
PROJECT No.:	FIGURE No.:	REV.:
0762-002-05	3	0



Intermediate Dam - Cross-Section A - A'



Intermediate Dam - Cross-Section B - B'



Intermediate Dam - Cross-Section C - C'

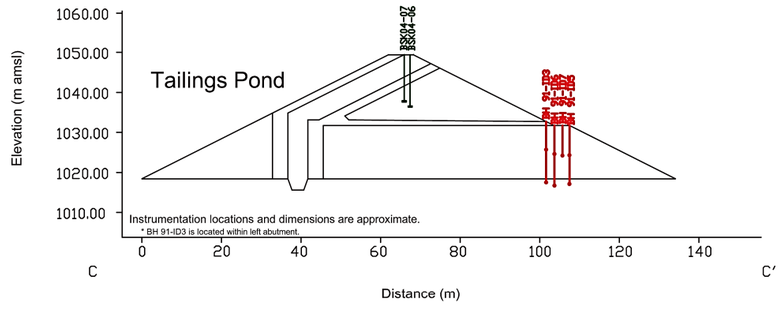


Fig. 9 Original Source: Figure 18 - 2009 Annual Geotechnical Evaluation and Instrumentation Review, Volume 1

FIGURE 9

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. AUTHORIZATION FOR ANY USE AND/OR PUBLICATION OF THIS REPORT OR ANY DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS, THROUGH ANY FORM OF PRINT OR ELECTRONIC MEDIA, INCLUDING WITHOUT LIMITATION, POSTING OR REPRODUCTION OF SAME ON ANY WEBSITE, IS RESERVED PENDING BGC'S WRITTEN APPROVAL. IF THIS REPORT IS ISSUED IN AN ELECTRONIC FORMAT, AN ORIGINAL PAPER COPY IS ON FILE AT BGC ENGINEERING INC. AND THAT COPY IS THE PRIMARY REFERENCE WITH PRECEDENCE OVER ANY ELECTRONIC COPY OF THE DOCUMENT, OR ANY EXTRACTS FROM OUR DOCUMENTS PUBLISHED BY OTHERS.

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

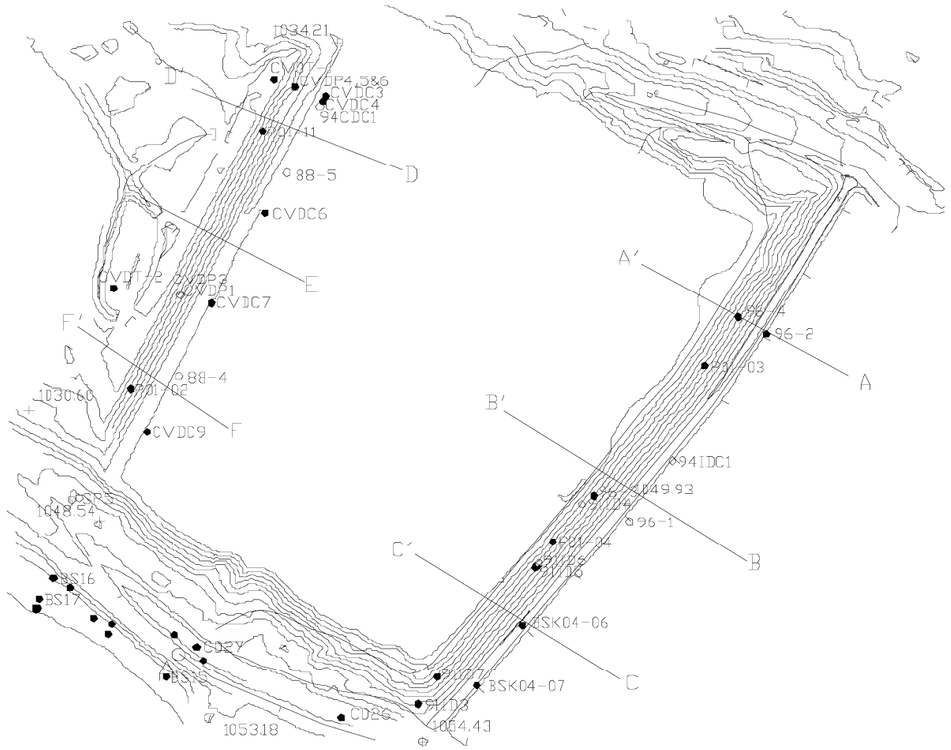
PROJECT: 2009 ANNUAL GEOTECHNICAL EVALUATION AND INSTRUMENTATION REVIEW

TITLE: SECTION VIEW OF INTERMEDIATE DAM

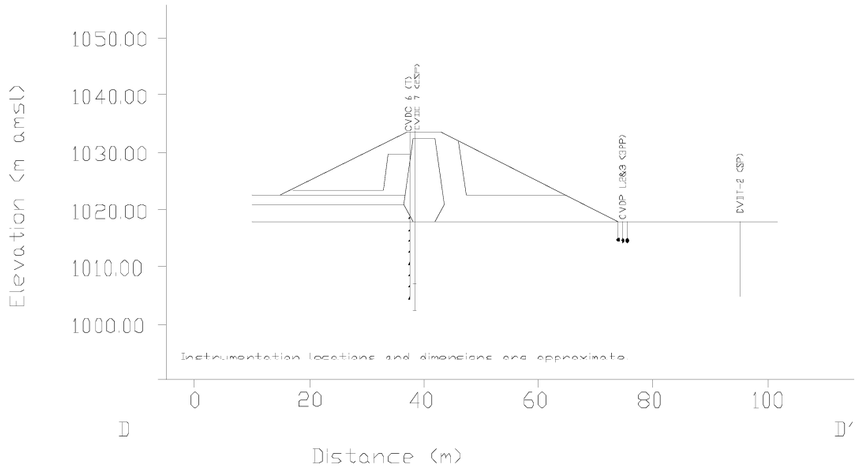
PROJECT No.:	FIGURE No.:	REV.:
0762-002-05	18	0

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

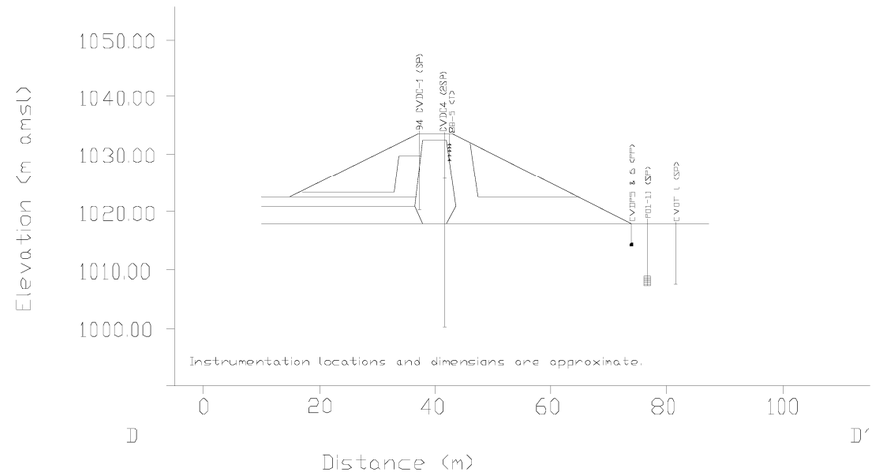
DWG TO BE READ WITH BGC REPORT TITLED " 2009 ANNUAL GEOTECHNICAL EVALUATION AND INSTRUMENT REVIEW" DATED FEB 2010



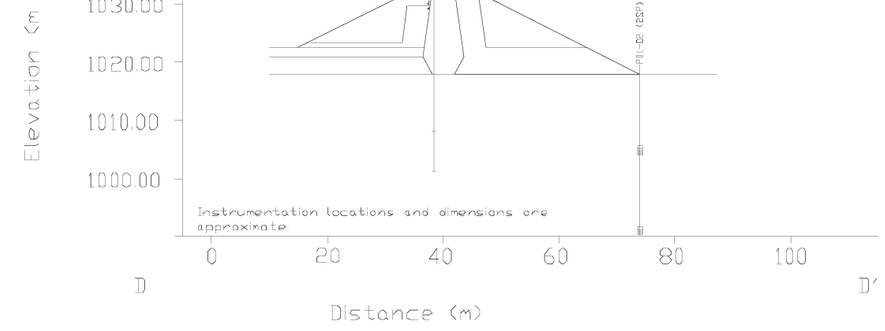
Cross Valley Dam - Cross-Section E - E′



Cross Valley Dam - Cross-Section D - D′



Cross Valley Dam - Cross-Section F - F′



SP Standpipe Piezometers
PP Pneumatic Piezometers
T Thermistor Cables
Screened Intervals of Standpipe Piezometers
Bottom of Standpipe Piezometers
Pneumatic Piezometer Tips
Thermistor Nodes

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

FIGURE 10

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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.
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CLIENT: Duncan 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

592,500m E
593,000m E
593,500m E
592,000m E
6,905,500m N
6,905,000m N
6,904,500m N
6,904,000m N

GRUM SETTLING POND
SLUDGE POND
OVERLAND WATER TREATMENT PIPELINE
~GRUM OVERBURDEN DUMP~
~GRUM PIT~ (NOT CURRENT)
~VANGORDA PIT~
SLOT CUT
LITTLE CREEK POND

GP-N1
GP-N2
GP-N3
GP-N4
GP-N5
GP-N6
GP-S1
GP-S2
GP-S3
GP-S4

MP001
MP002
MP003
MP004
MP005
MP006
MP007
MP008
MP009
MP010
MP011
MP012
MP013
MP014

LEGEND

- ACESS ROADS
- STREAMS
- POWER POLE
- MP014 — 2014 SURVEY PRISM
- MP005 — 2013 SURVEY PRISM
- GP-N1 — REFERENCE ROD

To be read with Klohn Crippen Berger report dated

SCALE 0 750m

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CLIENT: Yukon Government

Klohn Crippen Berger

PROJECT: FARO MINE COMPLEX ANNUAL REVIEW

TITLE: GRUM PIT BRIM REFERENCE RODS AND SURVEY PRISMS

PROJECT No. M09770A03 01

FIGURE 11

KCB-F-MD

Date: 1/29/2013 Time: 13:25:10 Scale: 1:2,585
Filename: \\NT.KLOHN.COM\PROJDATA\M\VCR\M09770A03-GOVTYUKON-2013 FARO\400 DRAWINGS\ANNUALREVIEW\FIG_11.DWG



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 nad 83.dwg

Denison Environmental Services

FARO MINE COMPLEX

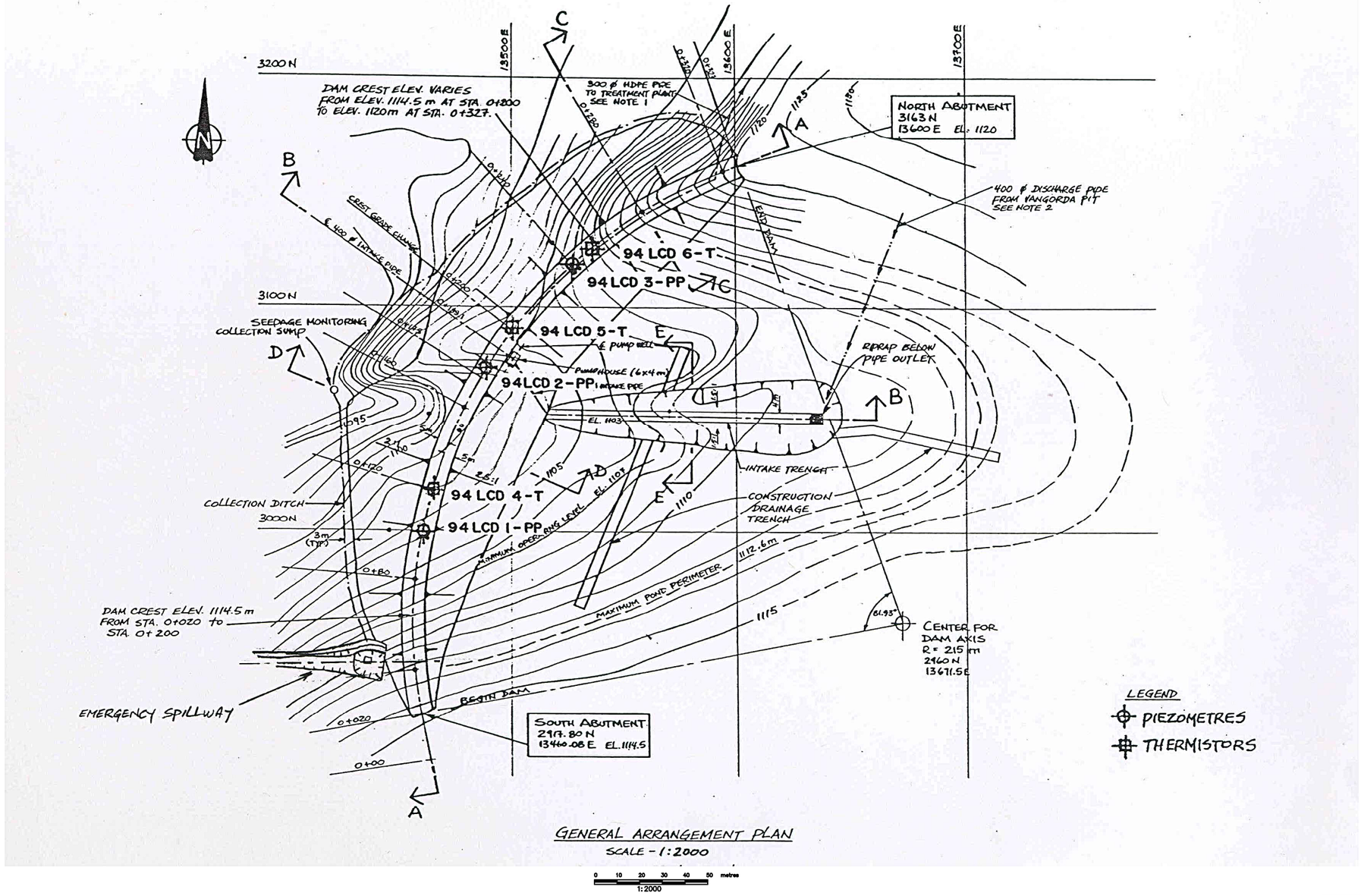
FIGURE 12

2011 Vangorda Geotechnical Inspection

General Arrangement Plan
Vangorda Waste Rock Dump

DATE:	APPROVED:	FIGURE:
July 2011	JK	4

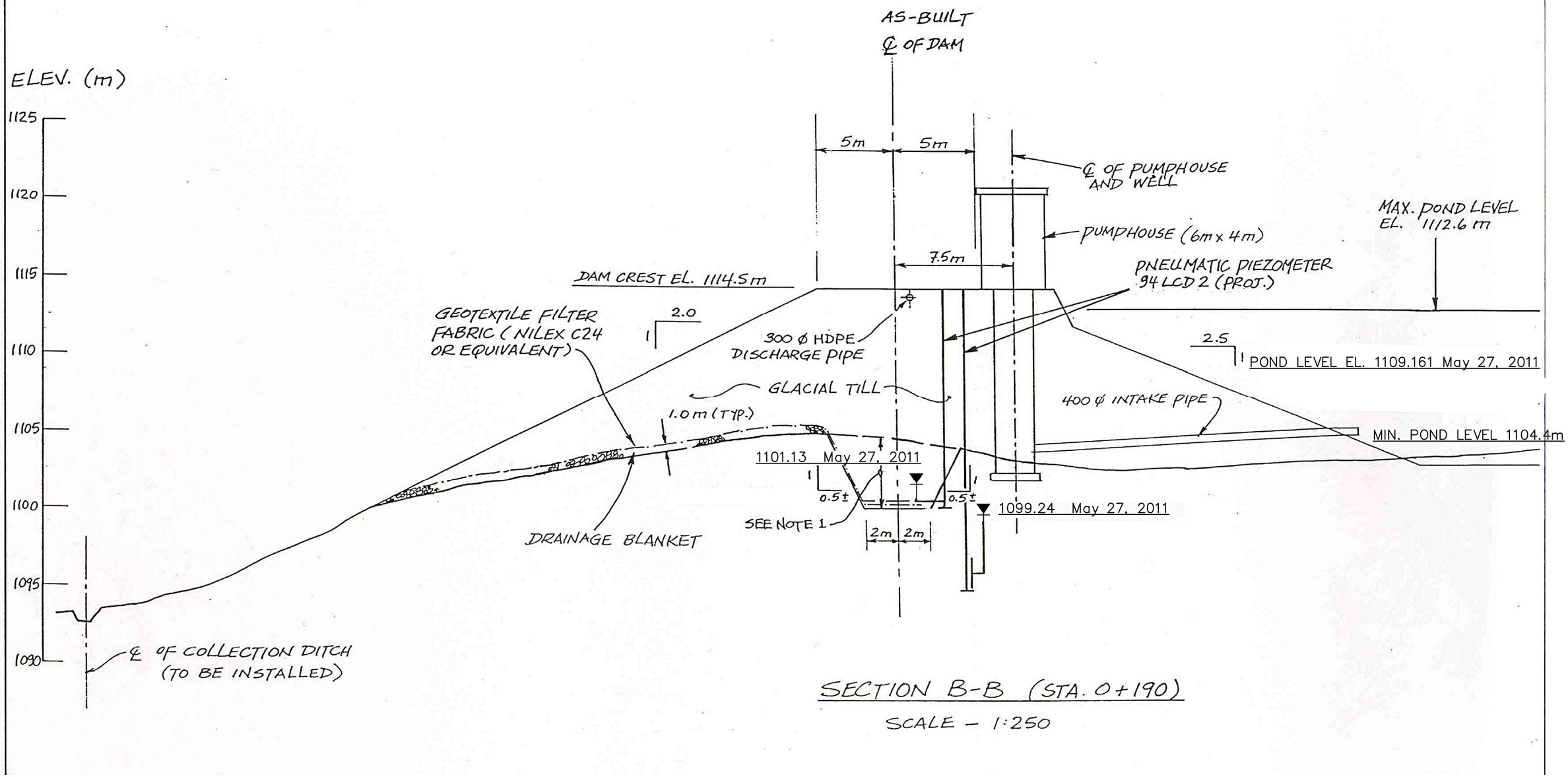
J:\01_SITES\FARO\22I0_1CD009.005 _Vangorda 2011 Geotech Inspection\C40_AutoCad\site_plan nad 83.dwg



GENERAL ARRANGEMENT PLAN
SCALE - 1:2000

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

srk consulting	Denison Environmental Services	FIGURE 13
SRK JOB NO.: 1CD009.005	FARO MINE COMPLEX	2011 Vangorda Geotechnical Inspection
FILE NAME: FIG-10.dwg		LITTLE CREEK DAM GENERAL ARRANGEMENT PLAN
		DATE: July 2011 / APPROVED: PMH / FIGURE: 10



SECTION B-B (STA. 0+190)

SCALE – 1:250

0 2 4 6 8 10 METRES

1:250

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

J:\01_SITES\FARO\2210_1CD009.005 _Vangorda 2011 Geotech Inspection\340_AutoCad\FIG-11.dwg

srk consulting	Denison Environmental Services	FIGURE 14
SRK JOB NO.: 1CD009.005		2011 Vangorda Geotechnical Inspection
FILE NAME: FIG-11.dwg	FARO MINE COMPLEX	LITTLE CREEK DAM SECTION B-B
		DATE: July 2011 / APPROVED: PMH / FIGURE: 11

APPENDIX I

2014 Select Site Photographs

Faro Creek Diversion Channel

Faro Pit



Photo 1 **Faro Pit north segment of east wall as seen from "eye-in-the-sky"**



Photo 2 **Faro Pit south segment of east wall as seen from "eye-in-the-sky"**

Faro Creek Diversion Channel



Photo 3 **Faro Pit north segment of east wall – note melting of groundwater seepage in upper middle of photo (TEES 2014)**



Photo 4 **Close-up of groundwater seepage area in Photo 3 (TEES 2014)**

Faro Creek Diversion Channel



Photo 5 **Faro Creek Diversion Channel erosion on hillside bank**



Photo 6 **Faro Creek Diversion Channel Staff Gauge FCD 4 – note newly installed channel-crossing overhead wire for flow calibration during high flow**

North Valley Wall Interceptor Ditch



Photo 7 **Interceptor Ditch upstream of upper man-made reach at proposed weir location**



Photo 8 **Interceptor Ditch upper man-made reach - vegetation clearance in 2013 to be continued further downstream**

North Valley Wall Interceptor Ditch



Photo 9 **Interceptor Ditch upstream of well access road – note sediment accumulation inside and outside culverts**



Photo 10 **Interceptor Ditch upstream of well access road – note accumulated sediment removed (from TEES 2014, September 26)**

North Valley Wall Interceptor Ditch



Photo 11 **Interceptor Ditch upstream of well access road – note sediment removed from both inside and outside of culverts (from TEES 2014, September 26)**



Photo 12 **Interceptor Ditch downstream of well access road – note sediment removed from both inside and outside of culverts (from TEES 2014, September 27)**

North Valley Wall Interceptor Ditch



Photo 13 **Interceptor Ditch upstream of well access road (from TEES 2014, December 17)**



Photo 14 **Interceptor Ditch downstream of well access road (from TEES 2014, December 17)**

North Valley Wall Interceptor Ditch



Photo 15 **Middle reach of man-made ditch – overgrown vegetation along ditch and dyke**



Photo 16 **Middle reach of man-made ditch - Minor Bank Slope Slump (TEES 2014, September 14)**

Rose Creek Diversion Channel



Photo 17 **Back-slope longitudinal cracks and slope slump scarps – photo taken from the primary deformed area**



Photo 18 **Back Slope – photo taken from the secondary deformed area**

Rose Creek Diversion Channel



Photo 19 Lowered probe in inclinometer casing at Back Slope



Photo 20 Reading Thermistor String at Back Slope

Rose Creek Diversion Channel



Photo 21 Reading Pneumatic Piezometer at Back Slope



~ tailings ~

Photo 22 Canal Dyke toe seepage area, downstream of Secondary Tailings Dam fuse plug – no sign of recent seepage

Rose Creek Diversion Channel



Photo 23 Rose Creek Diversion Channel near Cross Valley Dam, looking upstream



Photo 24 Downstream end of Rose Creek Diversion Channel – looking upstream

North Fork and K8 Rock Drains



Photo 25 **North Fork Rock Drain upstream pool at access road (from TEES, 2014, October 15)**



Photo 26 **Channel downstream of North Fork Rock Drain (from TEES, 2015, January 19)**

North Fork and K8 Rock Drains



Photo 27 K8 Drain upstream pool



Photo 28 K8 Drain downstream outlet, looking down - note rill erosion of the road embankment in middle of photo

Secondary Tailings Dam



Photo 29 **Secondary Tailings Dam and upstream tailings – looking northwest**



Photo 30 **Barely visible sign of downstream berm freeze-thaw longitudinal crack at southeast corner of Secondary Tailings Dam**

Secondary Tailings Dam



Photo 31 **Crest and downstream slope of Secondary Tailings Dam and downstream berm at southeast corner**



Photo 32 **Fuse plug of Canal Dyke, looking downstream**

Intermediate Dam



Photo 33 Reclaim pump barge in Intermediate Pond



Photo 34 Dam crest and upstream slope, looking north – note a slight slope break at the location of the hard hat

Intermediate Dam



Photo 35 **Dam crest after rain, looking north (from TEES 2014, September 25)**



Photo 36 **Downstream slope – looking northeast from southwest abutment**

Intermediate Dam



Photo 37 Rill erosion along downstream slope – looking down slope



Photo 38 Rill erosions along downstream berm shoulder, looking southwest

Intermediate Dam



Photo 39 Spillway channel adjacent to dam crest – looking downstream



Photo 40 Rill erosion along downstream slope

Cross Valley Dam

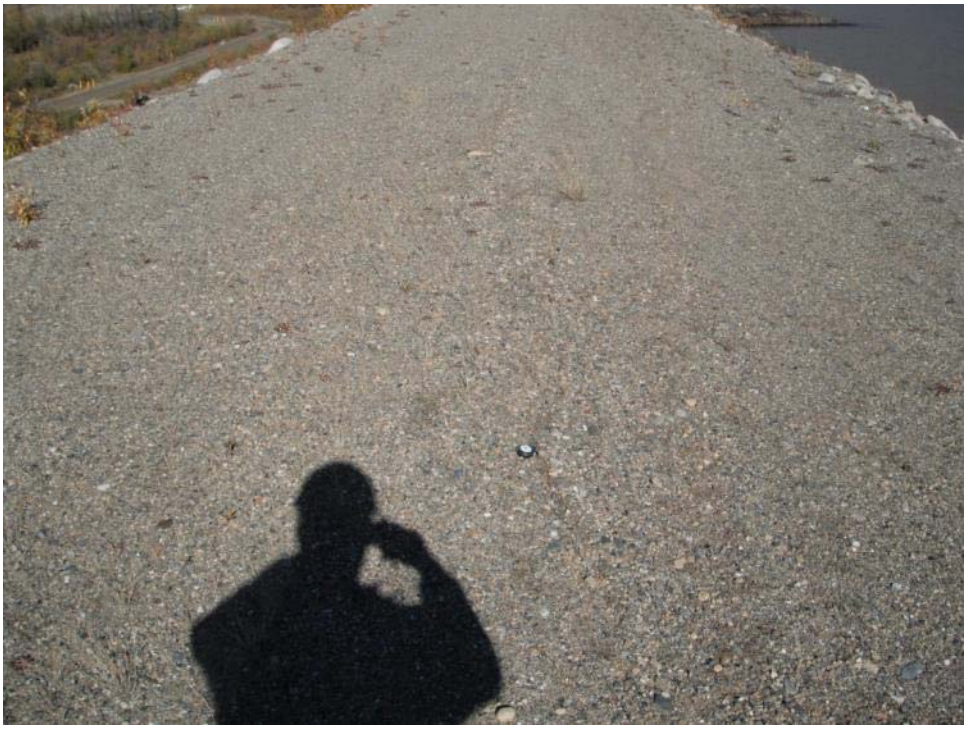


Photo 41 **Barely visible sign of freeze-thaw longitudinal crack along dam crest, looking north**



Photo 42 **Rill erosion at downstream crest shoulder near north abutment - looking down slope**

Cross Valley Dam



Photo 43 **Rill erosion at downstream slope near crest shoulder (from TEES 2014, September 14)**



Photo 44 **North access road near Cross Valley Dam – note shoulder erosions near hill top**

Cross Valley Dam



Photo 45 **Lime treatment plant being dismantled from the north shore of Cross Valley Pond**

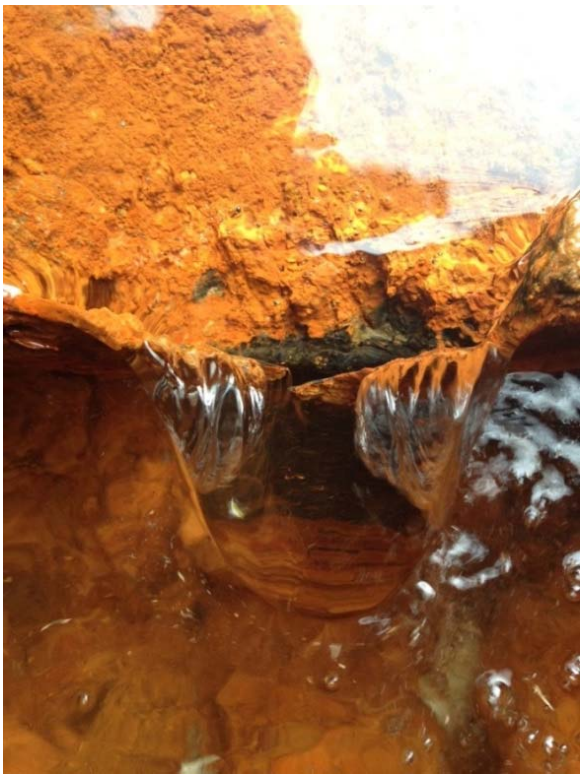


Photo 46 **Corroded Downstream Weir No. 3 (from TEES 2014, September 18)**

Grum Pit



Photo 47 East pit wall along instability zone



Photo 48 East pit wall Reference Point installed by YES in 2013 at south end of instability zone – photo taken in June, 2014

Grum Pit



Photo 49 **North array of pit wall movement survey rods – note vegetation cover to be removed to facilitate observation of ground cracks**



Photo 50 **Widened longitudinal crack passing through second Rod NP-2 along north array – note left of the rod ground elevation dropped further since spring**

Grum Pit



Photo 51 Ongoing slump of east pit wall



Photo 52 Pit wall slope above pump barge area – note red cones placed to warn of rock fall hazard

Grum Pit



Photo 53 Pit East Wall (from TEES 2014, October 15)



Photo 54 Exposed drill hole on north pit rim

Vangorda Pit



Photo 55 **Northwest pit wall adjacent to Vangorda Diversion Flume - note discharge line from Grum Pit shown on left**



Photo 56 **Vangorda pump barge**

Vangorda Waste Dump



Photo 57 Waste dump slope and toe seepage collection ditch



Photo 58 Waste dump rill erosions and sediment deposits in seepage ditch

Grump Pit Interceptor Ditch



Photo 59 Ponded water pumped to upstream reach of Interceptor Ditch



Photo 60 Vegetation on Grum Till Overburden slope above Interceptor Ditch - note rill erosions along slope

Grump Pit Interceptor Ditch



Photo 61 **Downstream reach of Interceptor Ditch with a steep gradient**



Photo 62 **Downstream end of Interceptor Ditch – note erosion of access road surface due to ditch overflow**

Vangorda Northeast Interceptor Ditch



Photo 63 **2013 repair of road-side bank slope near top of photo to be completed**



Photo 64 **Slumped bank slopes of Interceptor Ditch**

Vangorda Creek (Flume) Diversion



Photo 65 Flume emergency spillway culverts entrance area



Photo 66 Vangorda Flume intake culvert upstream trashrack with a bent rod

Vangorda Creek (Flume) Diversion



Photo 67 Auxiliary trash rack downstream of Main Rack at Culvert Entrance



Photo 68 Flume deformed with buckled braces

Vangorda Creek (Flume) Diversion



Photo 69 Steel braces across two new flume sections



Photo 70 Diversion Flume water entering downstream culvert at plunge pool

Little Creek Dam



Photo 71 Upstream slope and pond – note submersible pump in lower left corner



Photo 72 Dam crest and slopes

Little Creek Dam



Photo 73 Downstream slopes and berms



Photo 74 Rill erosions along downstream crest shoulder and slope

Sheep Pad Sediment Ponds



Photo 75 **Subdued longitudinal cracks on dyke slope of Upper Sediment Pond**



Photo 76 **Upstream end of flume between Upper and Lower Ponds – note slumped side slope and shifted flume section**

Grum Settling Pond



Photo 77 Dyke crest and slopes – note overgrown vegetation



Photo 78 Pond spillway channel, looking downstream towards Grum Interceptor Ditch

V-15 Seepage Collection Ditch



Photo 79 Ponded V-15 Ditch adjacent to pump house



Photo 80 Last reach of V-15 Ditch along access road above Moose Pond

Moose Pond



Photo 81 Descending V-15 Ditch above Moose Pond



Photo 82 Moose Pond with staff gauge for monitoring pond level

Sludge Pond Embankment Dyke - Vangorda Water Treatment Plant



Photo 83 **Pond, dyke crest and slopes**



Photo 84 **Hydraulic dredging of sludge in action (from TEES 2014, September 27)**

APPENDIX II

Instrumentation and Climate Data Plots

Instrumentation and Climate Data Plots

Site	Appendix Section: Structure	Data Included Herein	Section Number
Faro	II-A: Faro Pit	Pond Level	A1
		Pit Rim Reference Bars	A2
		Pit Rim Prisms	A3
	II-B: Faro Creek Diversion Channel	Staff Gauges Calibration	B1
		Staff Gauges Flow	B2
	II-C: North Valley Wall Interceptor Ditch	Ditch Flow	C1
	II-D: Rose Creek Diversion Channel	Staff Gauges Calibration	D1
		Staff Gauges Flow	D2
	II-E: Canal Dyke	Piezometers	E1
		Thermistors (Thawed ones not included)	E2
		Inclinometers	E3
	II-F: North Fork Rock Drain	US and DS Water Levels	F1
	II-G: Secondary Tailings Impoundment	Piezometers	G1
	II-H: Intermediate Dam	Pond Level (Intermediate Pond)	H1
		Piezometers	H2
	II-I: Cross Valley Dam	Pond Level (Polishing Pond)	I1
		Piezometers	I2
		Thermistors (Not included)	I3
		DS Weirs Flow	I4
Vangorda Plateau	II-J: Grum Pit	Pond Level	J1
		Pit Rim Reference Rods	J2
		Pit Slot Cut Piezometers	J3
	II-K: Vangorda Pit	Pond Level	K1
	II-L: Vangorda Waste Rock Dump	Weirs Flow	L1
		Piezometers	L2
	II-M: Little Creek Dam	Pond Level (Little Creek Pond)	M1
		Piezometers	M2
		Thermistor (Not included)	M3
	II-N: Moose Pond	Pond Level	N1
Faro Airport	II-O: Faro Airport Climate	Monthly Precipitation/Temperature	O1

APPENDIX II-A

Faro Pit

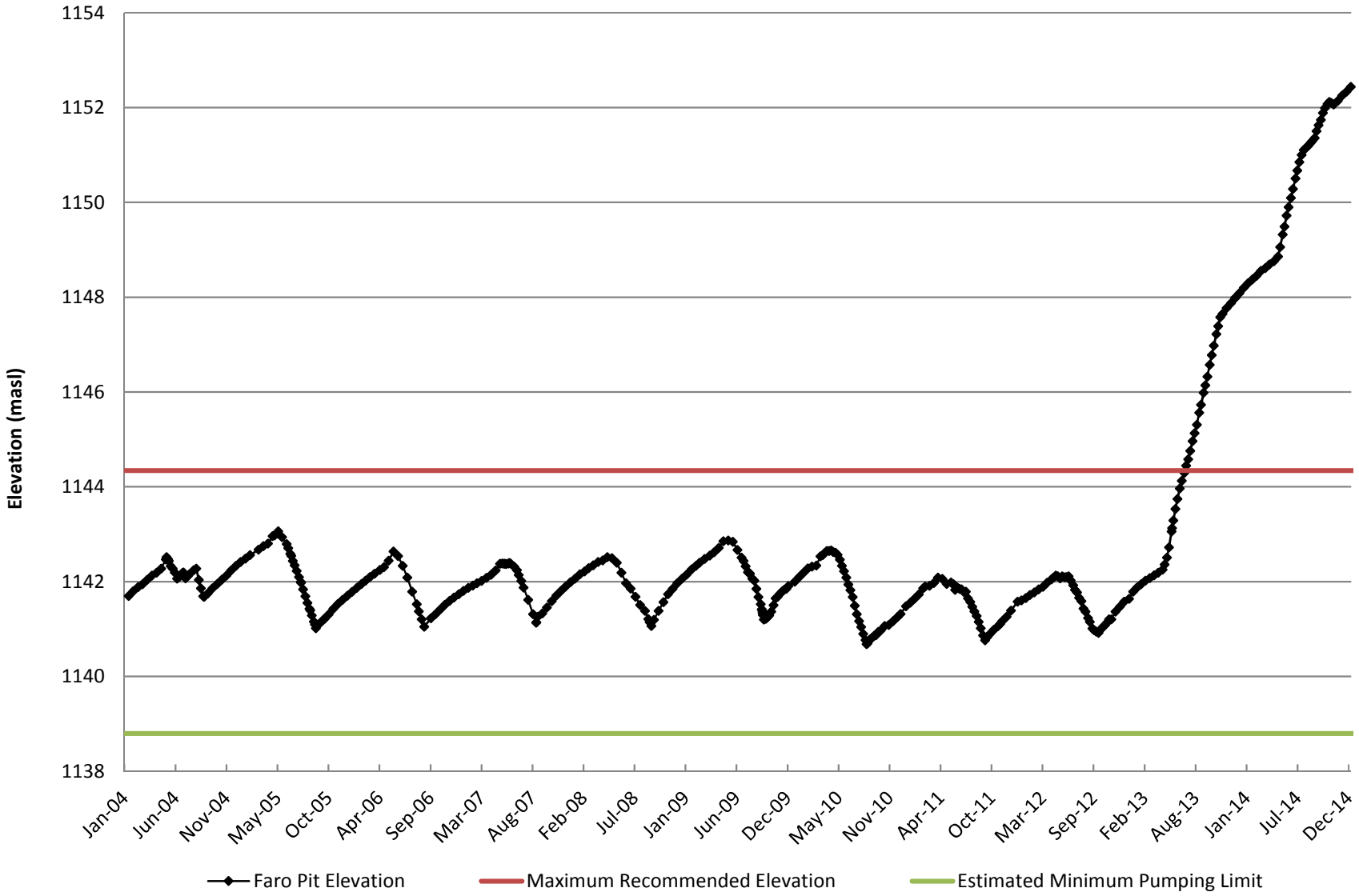
A1 - Pond Level

A2 - Pit Rim Reference Bars

A3 - Pit Rim Prisms

A1 – Pond Level

Faro Pit Water Level



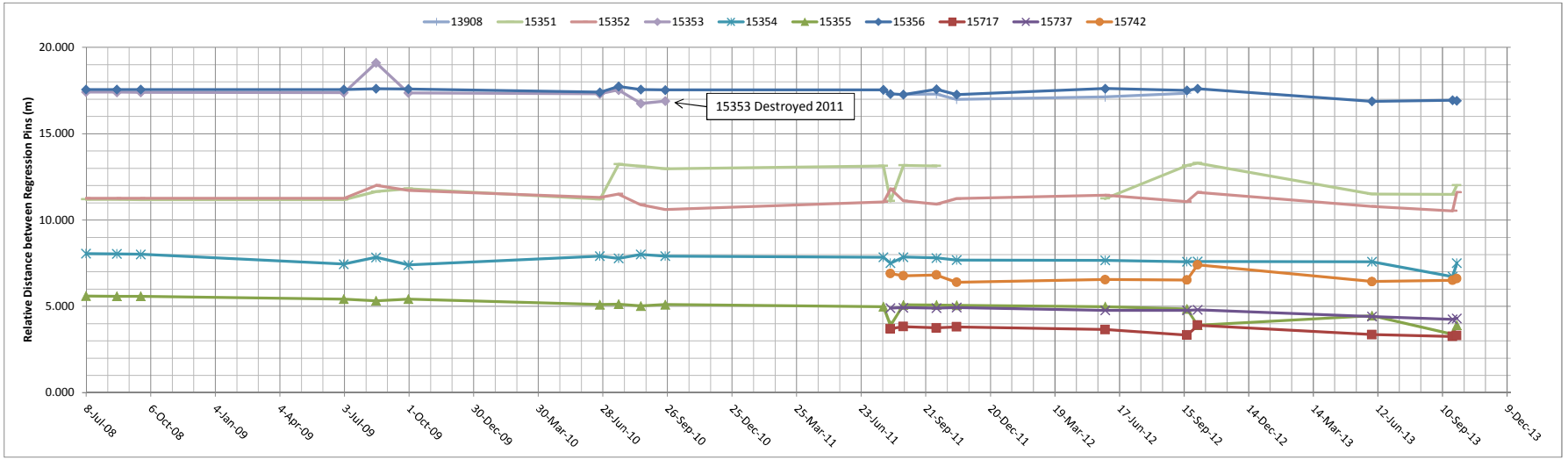
A2 – Pit Rim Reference Bars

2008 to 2013 Faro Pit Rim Regression Pins Survey Summary
DES/TEES Plus YES Data

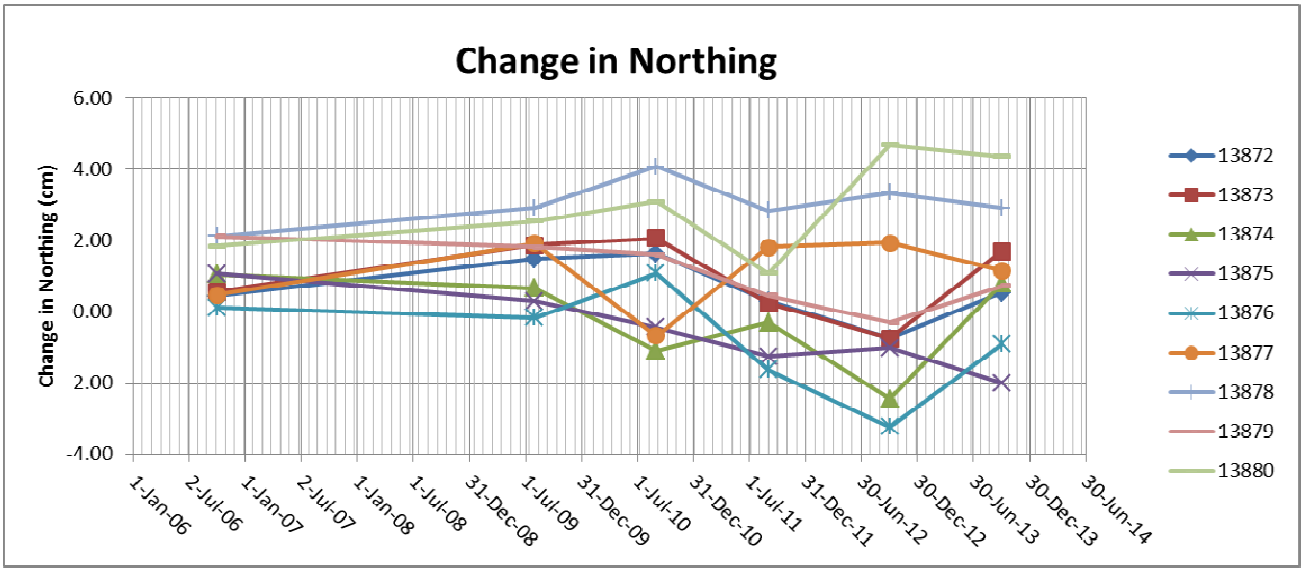
Faro Pit Rim Regression Pins Survey Data (DES/TEES Plus YES)

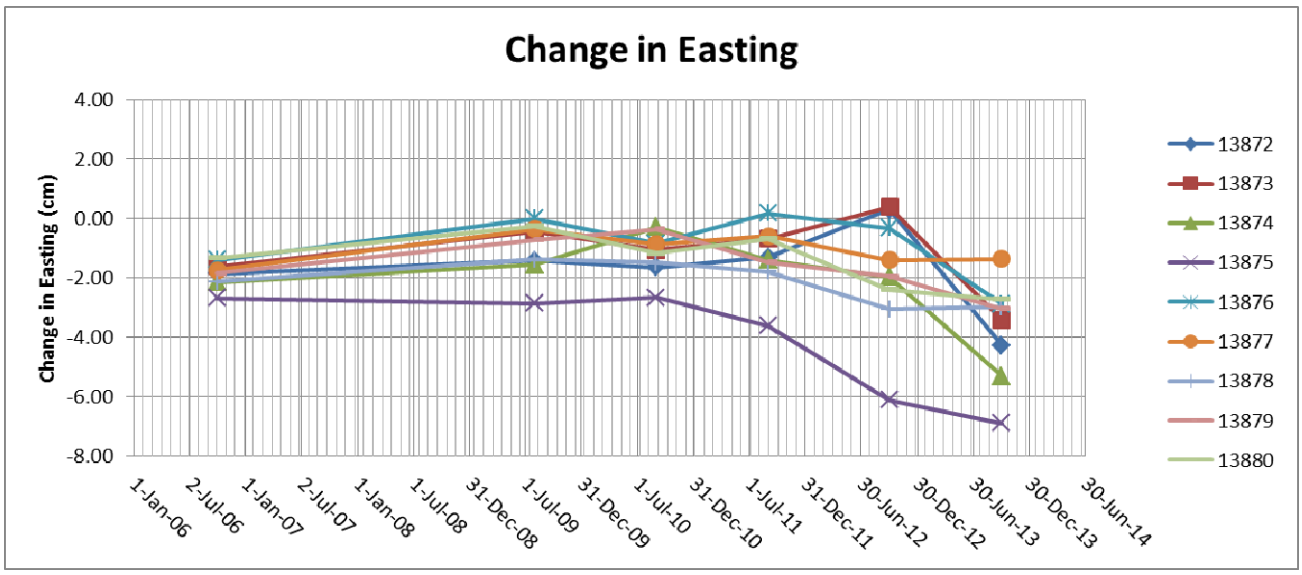
												YES						YES			YES
Pin	8-Jul-08	20-Aug-08	22-Sep-08	2-Jul-09	16-Aug-09	30-Sep-09	24-Jun-10	20-Jul-10	20-Aug-10	23-Sep-10	24-Jul-11	3-Aug-11	21-Aug-11	6-Oct-11	3-Nov-11	28-May-12	19-Sep-12	4-Oct-12	4-Jun-13	24-Sep-13	30-Sep-13
	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
15356	17.550	17.550	17.550	17.550	17.600	17.590	17.400	17.740	17.55	17.530	17.540	17.300	17.260	17.570	17.260	17.61	17.500	17.60	16.877	16.935	16.900
15717												3.700	3.820	3.750	3.800	3.65	3.335	3.90	3.355	3.259	3.300
15355	5.590	5.580	5.580	5.415	5.320	5.420	5.100	5.120	5.02	5.100	4.980	3.900	5.080	5.070	5.060	4.97	4.845	3.90	4.455	3.378	3.900
15737												4.900	4.920	4.890	4.930	4.76	4.765	4.80	4.405	4.241	4.300
15354	8.060	8.040	8.010	7.440	7.830	7.395	7.900	7.780	8.00	7.900	7.840	7.500	7.850	7.800	7.680	7.66	7.580	7.60	7.575	6.722	7.500
15742												6.900	6.770	6.820	6.390	6.55	6.525	7.40	6.432	6.504	6.600
13908													17.270	17.290	16.980	17.12	17.350		16.915	17.004	
15352	11.250	11.250	11.250	11.250	12.000	11.710	11.300	11.500	10.89	10.600	11.050	11.800	11.100	10.910	11.230	11.43	11.065	11.60	10.785	10.523	11.600
15351	11.190	11.190	11.180	11.180	11.640	11.810	11.200	13.230	13.11	12.960	13.130	11.100	13.160	13.130		11.24	13.150	13.30	11.503	11.474	12.000
15353	17.410	17.400	17.390	17.375	19.100	17.360	17.300	17.530	16.75	16.890	Destroyed 2011										

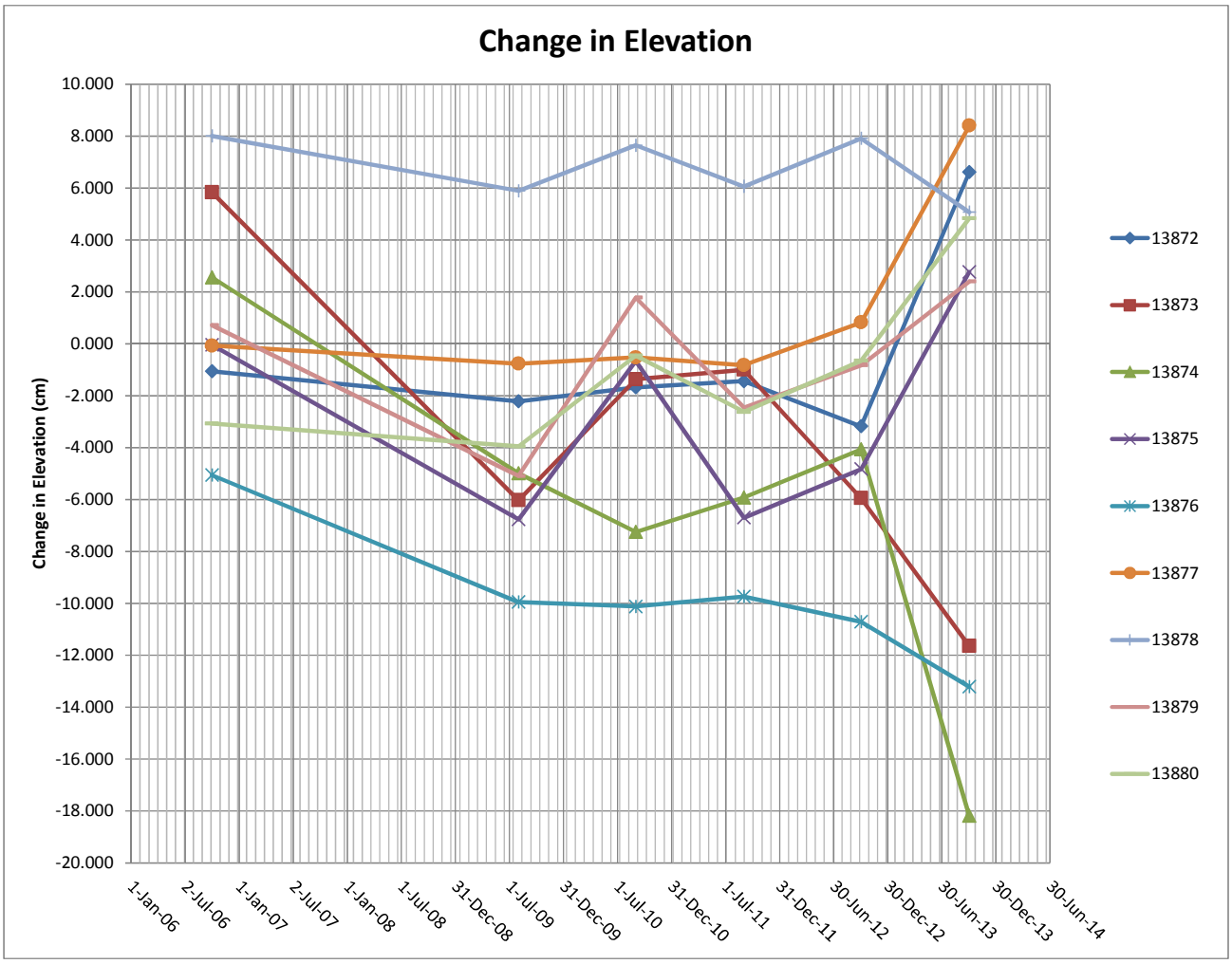
Faro Pit Rim Regression Pins Survey Summary Plot (DES/TEES Plus YES)



A3 – Pit Rim Prisms


Change in Northing
Change in Northing (cm)
6.00
4.00
2.00
0.00
2.00
-4.00
1-Jan-06
2-Jul-06
1-Jan-07
2-Jul-07
1-Jan-08
1-Jul-08
31-Dec-08
1-Jul-09
31-Dec-09
1-Jul-10
31-Dec-10
1-Jul-11
31-Dec-11
30-Jun-12
30-Dec-12
30-Jun-13
30-Dec-13
30-Jun-14
13872
13873
13874
13875
13876
13877
13878
13879
13880


Change in Easting
Change in Easting (cm)
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
1-Jan-06
2-Jul-06
1-Jan-07
2-Jul-07
1-Jan-08
1-Jul-08
31-Dec-08
1-Jul-09
31-Dec-09
1-Jul-10
31-Dec-10
1-Jul-11
31-Dec-11
30-Jun-12
30-Dec-12
30-Jun-13
30-Dec-13
30-Jun-14
13872
13873
13874
13875
13876
13877
13878
13879
13880


Change in Elevation
Change in Elevation (cm)
10.000
8.000
6.000
4.000
2.000
0.000
-2.000
-4.000
-6.000
-8.000
-10.000
-12.000
-14.000
-16.000
-18.000
-20.000
1-Jan-06
2-Jul-06
1-Jan-07
2-Jul-07
1-Jan-08
1-Jul-08
31-Dec-08
1-Jul-09
31-Dec-09
1-Jul-10
31-Dec-10
1-Jul-11
31-Dec-11
30-Jun-12
30-Dec-12
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13877
13878
13879
13880

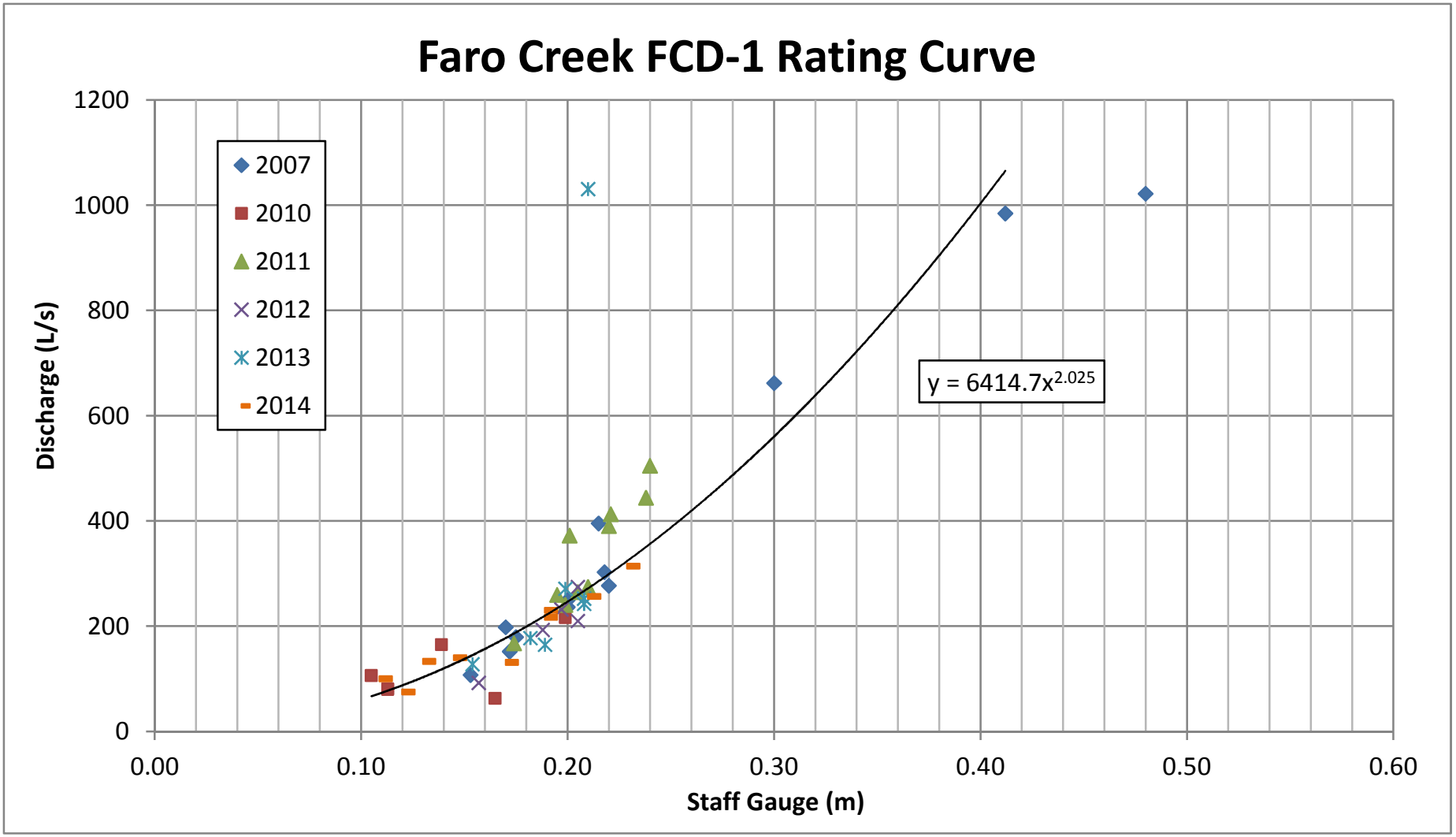
APPENDIX II-B

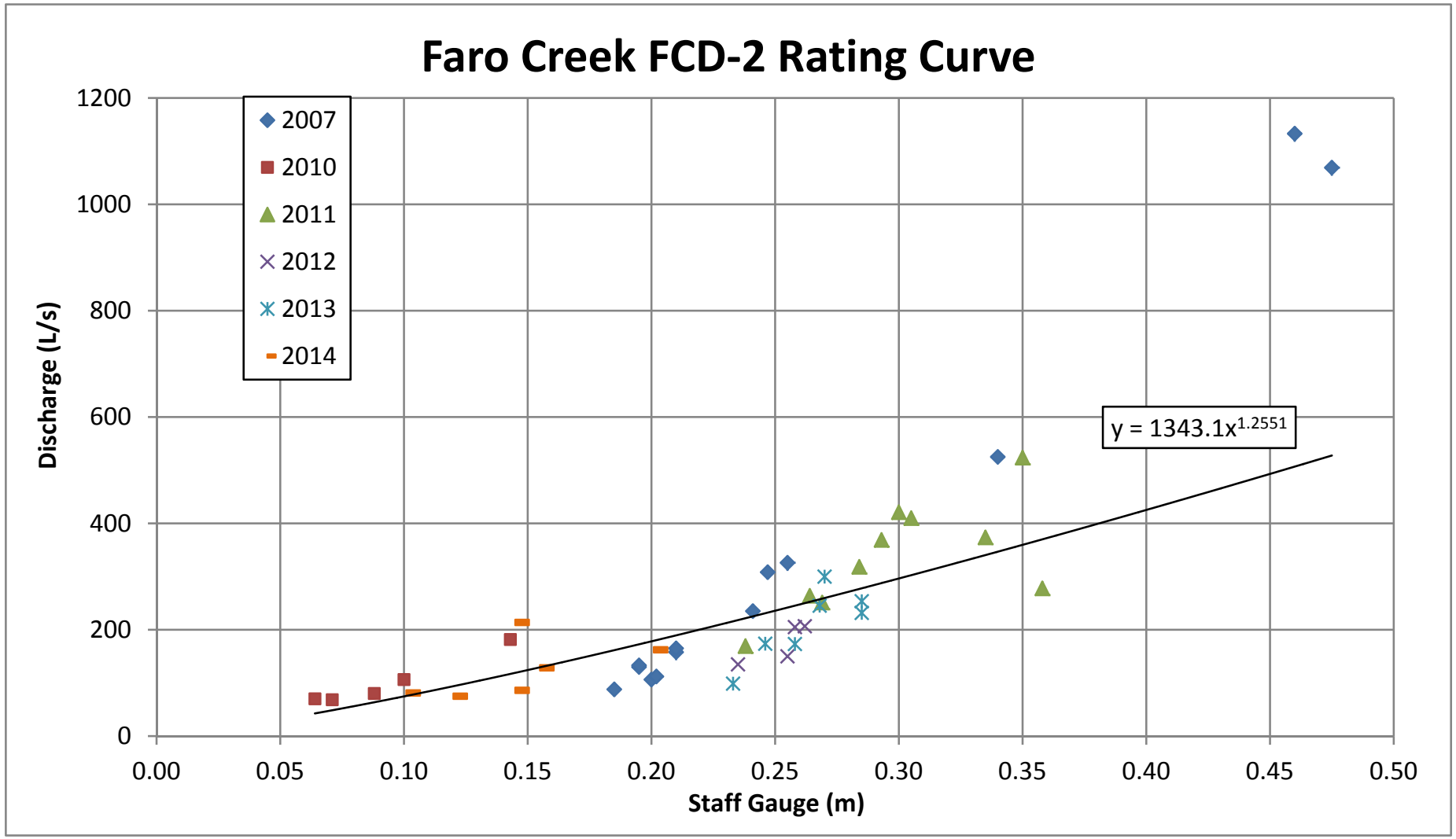
Faro Creek Diversion Channel

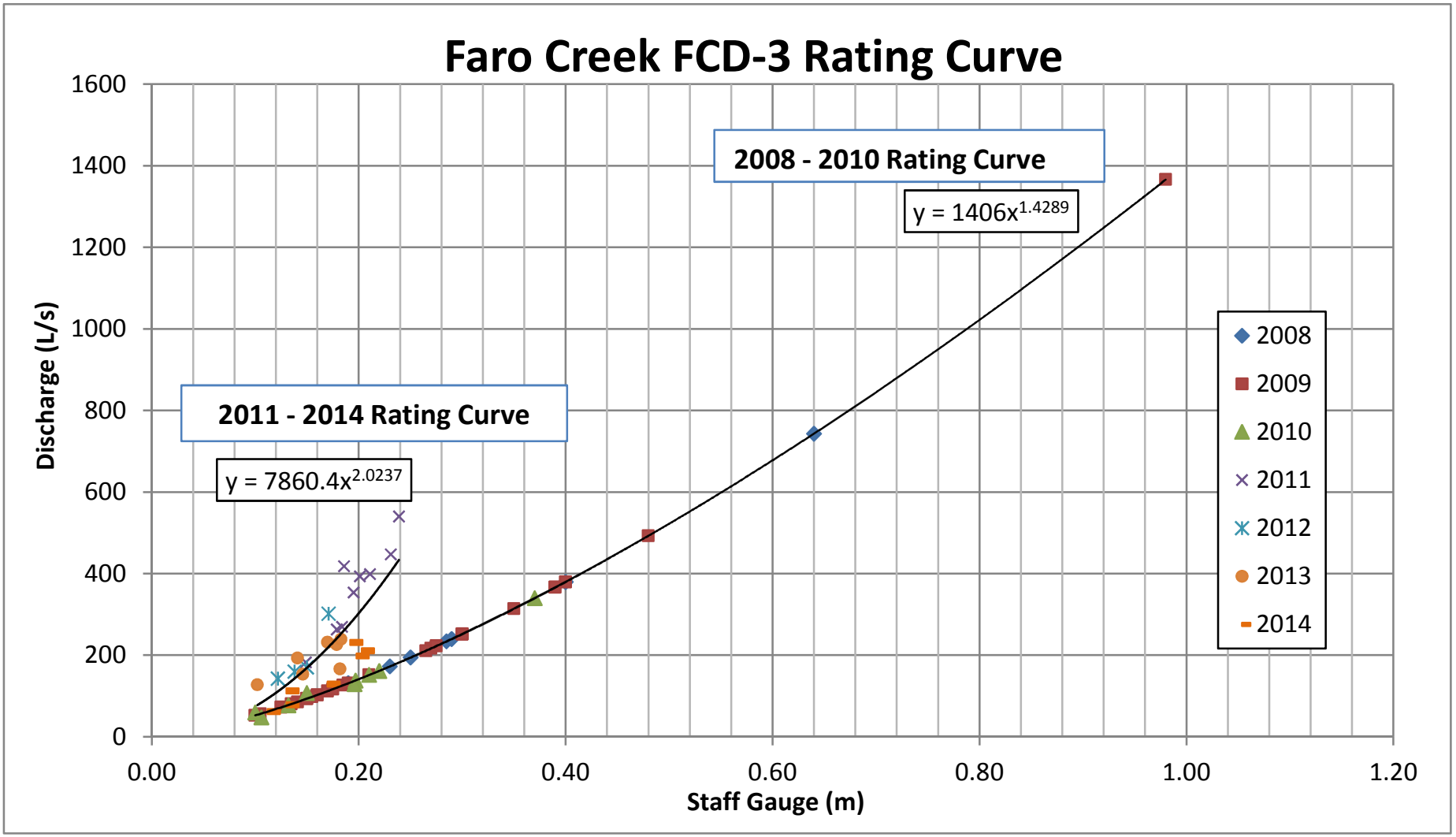
B1 – Staff Gauges Calibration

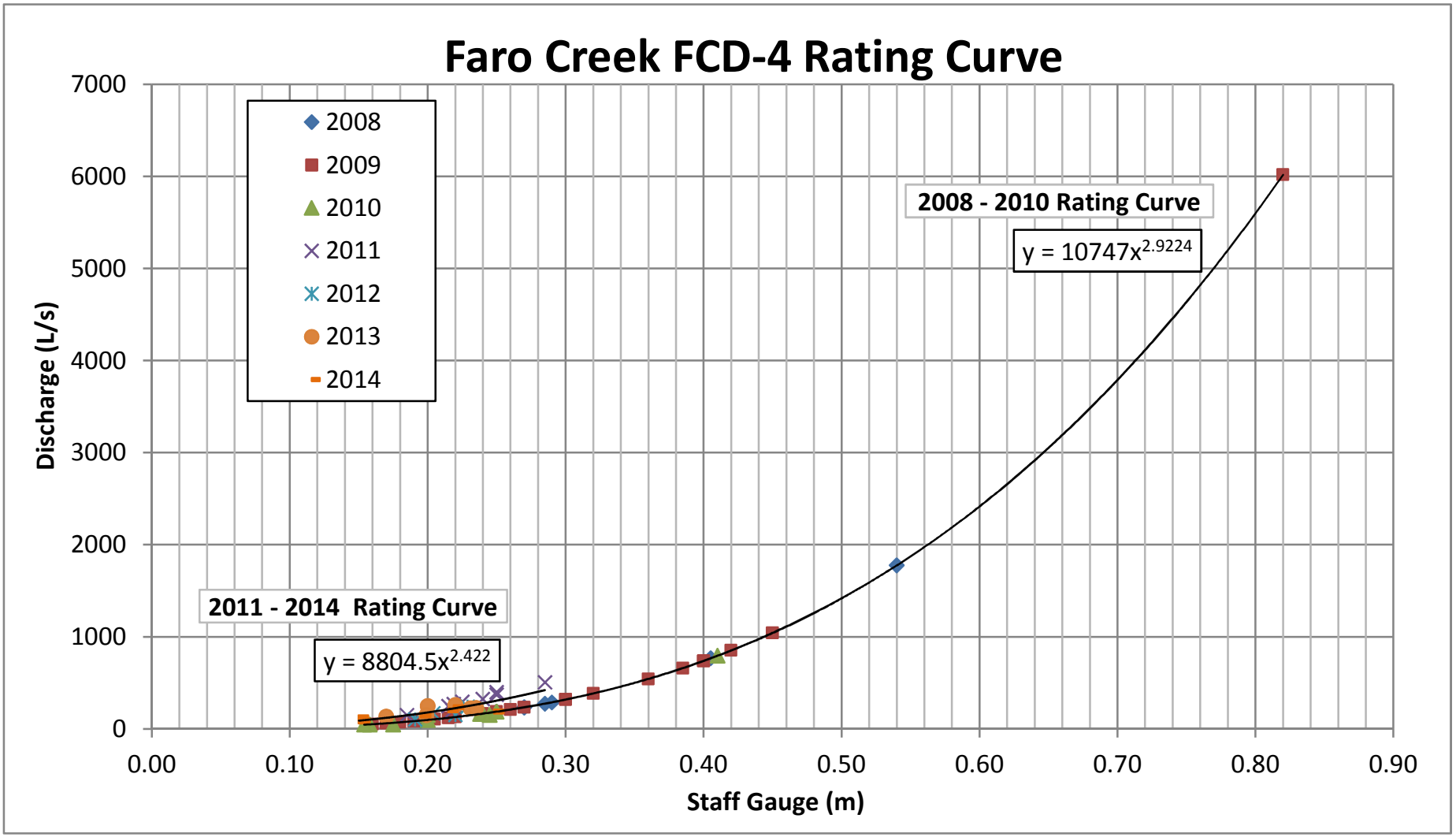
B2 – Staff Gauges Flow

B1 – Staff Gauges Calibration

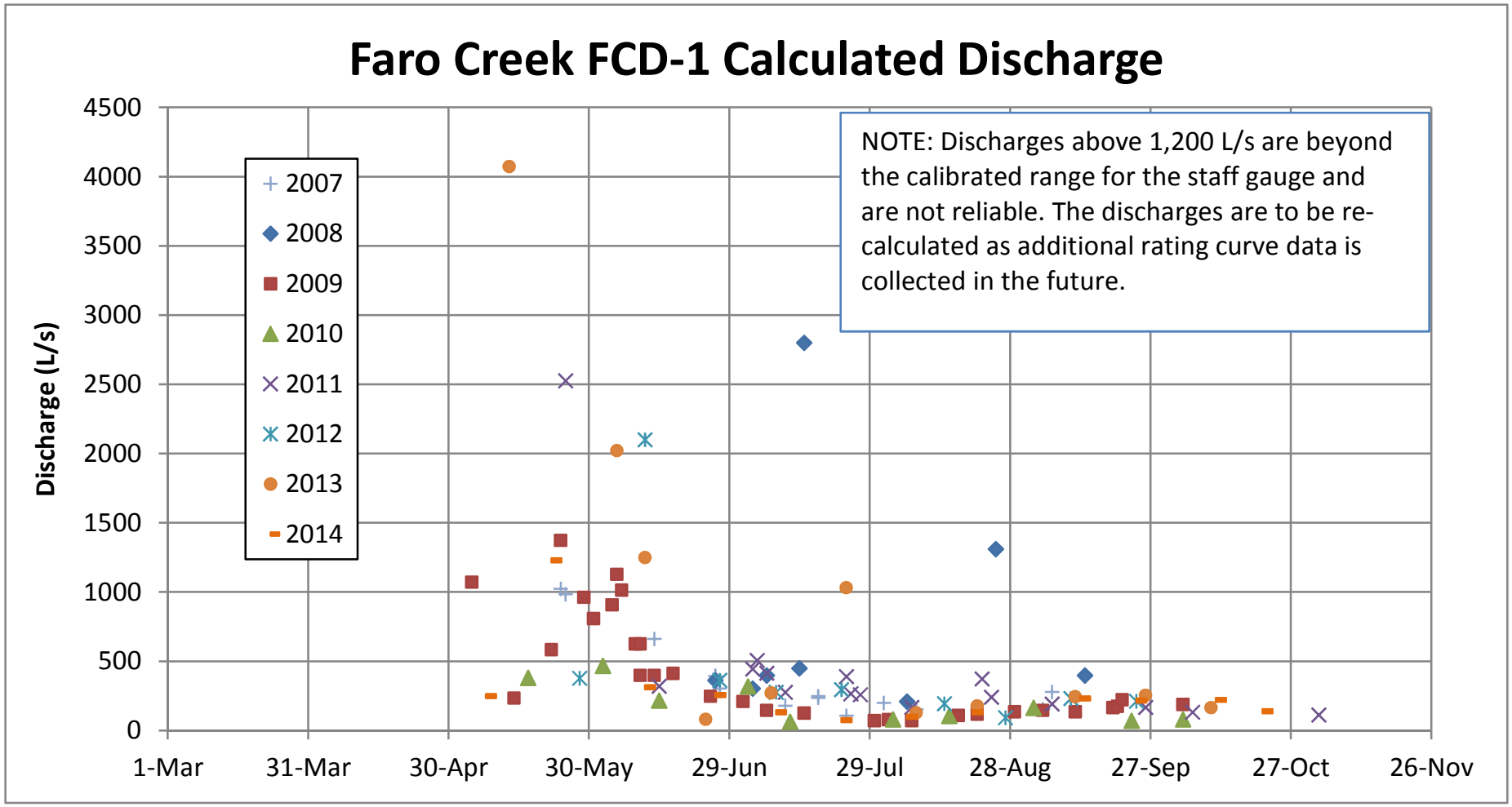

Faro Creek FCD-1 Rating Curve
Discharge (L/s)
Staff Gauge (m)
2007
2010
2011
2012
2013
2014
y = 6414.7x2.025
0
200
400
600
800
1000
1200
0.00
0.10
0.20
0.30
0.40
0.50
0.60

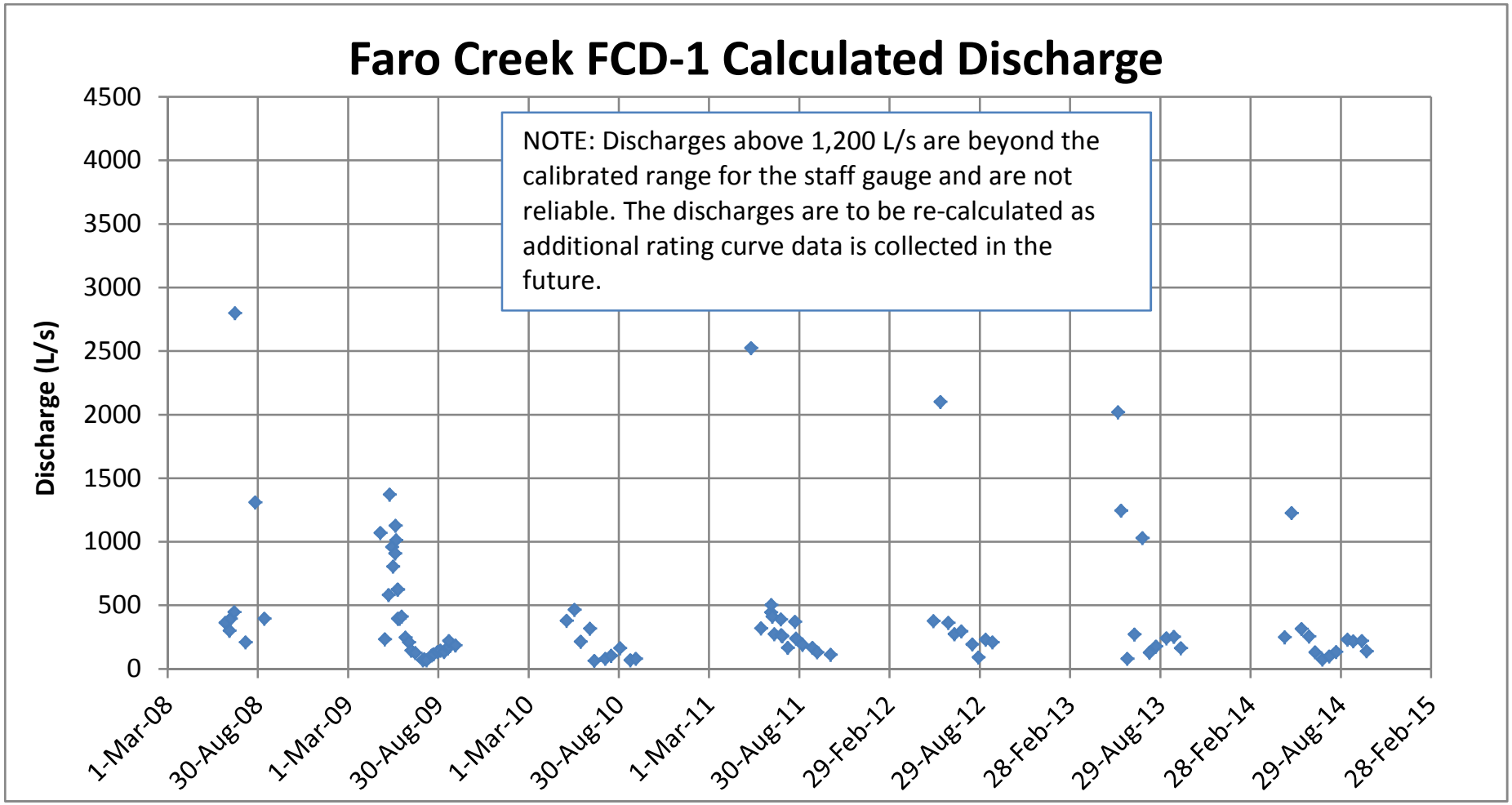

Faro Creek FCD-2 Rating Curve
Discharge (L/s)
Staff Gauge (m)
2007
2010
2011
2012
2013
2014
y = 1343.1x^1.2551
0
200
400
600
800
1000
1200
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50

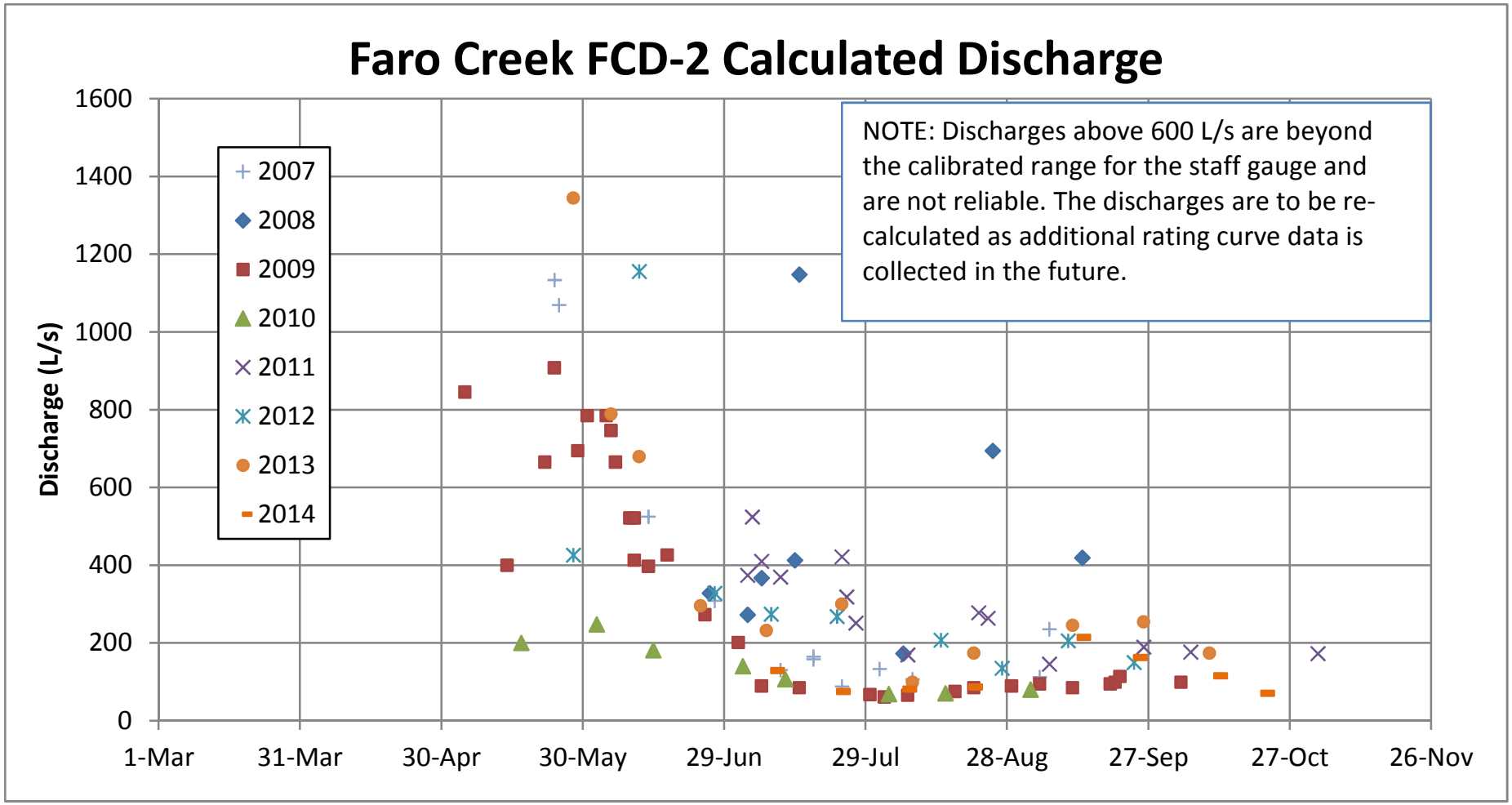

Faro Creek FCD-3 Rating Curve
2008 - 2010 Rating Curve
y = 1406x^1.4289
2011 - 2014 Rating Curve
y = 7860.4x^2.0237
Discharge (L/s)
Staff Gauge (m)
0
200
400
600
800
1000
1200
1400
1600
0.00
0.20
0.40
0.60
0.80
1.00
1.20
2008
2009
2010
2011
2012
2013
2014

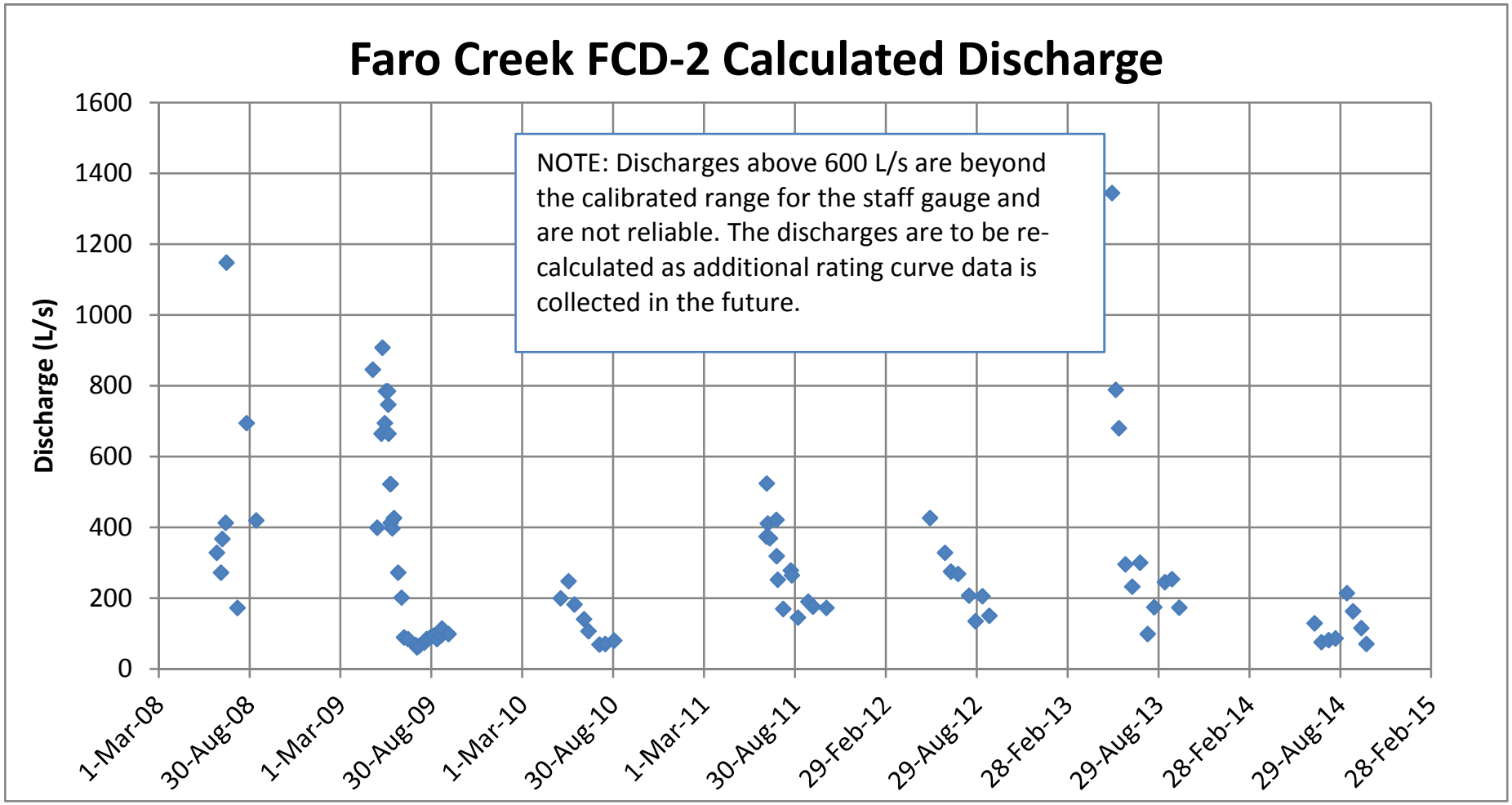

Faro Creek FCD-4 Rating Curve
Discharge (L/s)
Staff Gauge (m)
2008
2009
2010
2011
2012
2013
2014
2008 - 2010 Rating Curve
y = 10747x2.9224
2011 - 2014 Rating Curve
y = 8804.5x2.422
7000
6000
5000
4000
3000
2000
1000
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90

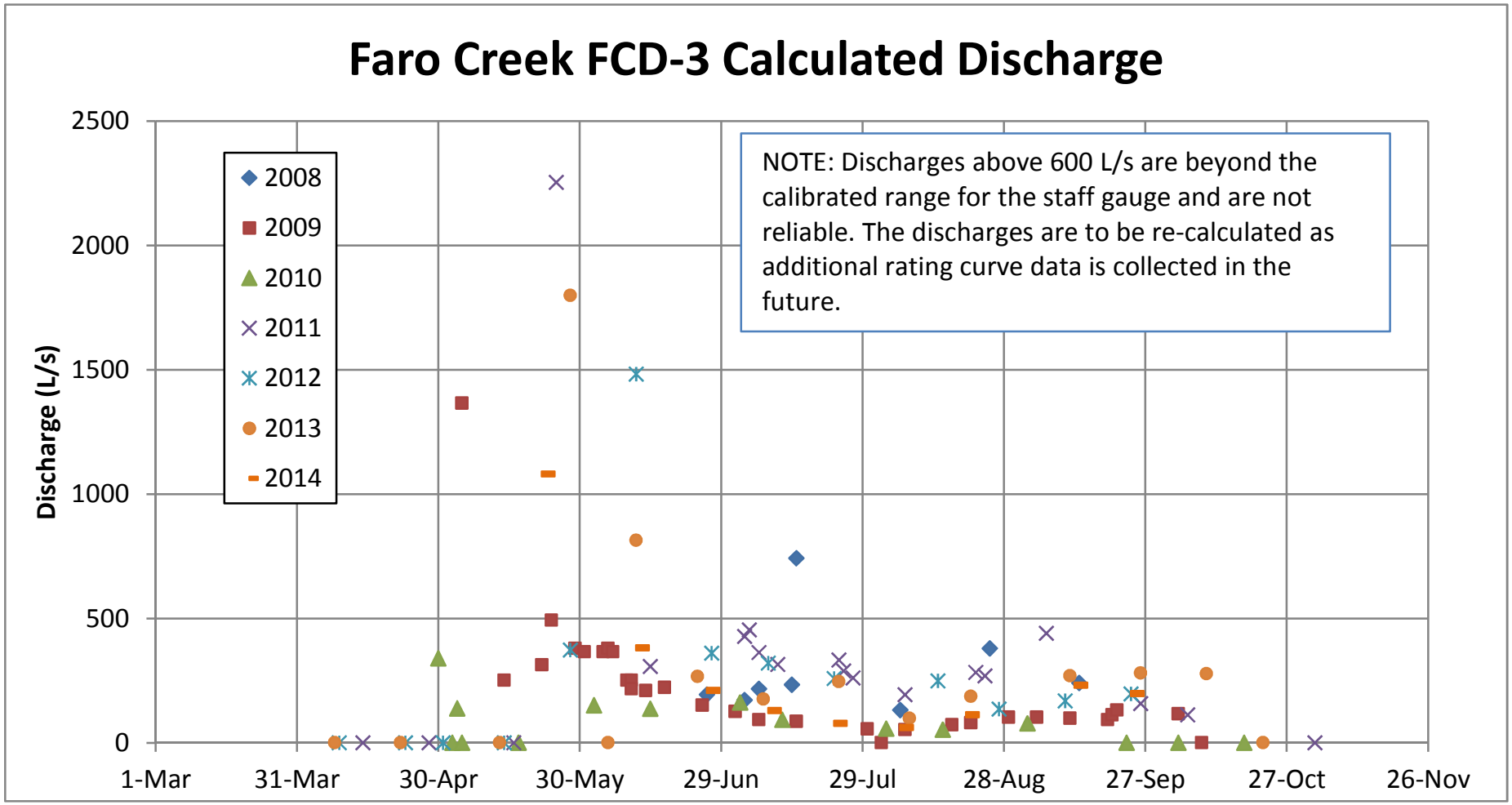
B2 – Staff Gauges Flow

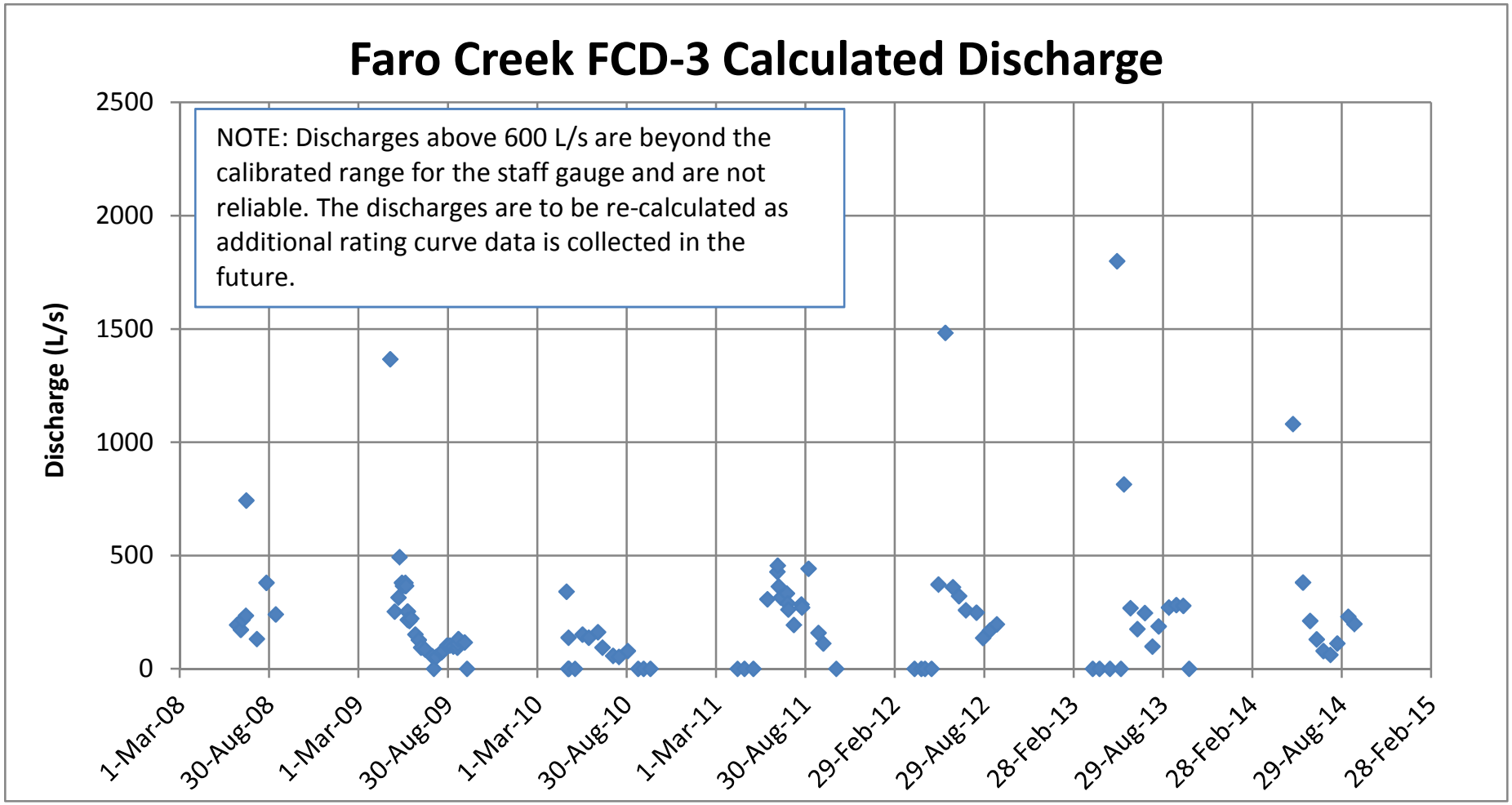

Faro Creek FCD-1 Calculated Discharge
Discharge (L/s)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1-Mar
31-Mar
30-Apr
30-May
29-Jun
29-Jul
28-Aug
27-Sep
27-Oct
26-Nov
2007
2008
2009
2010
2011
2012
2013
2014
NOTE: Discharges above 1,200 L/s are beyond the calibrated range for the staff gauge and are not reliable. The discharges are to be re-calculated as additional rating curve data is collected in the future.

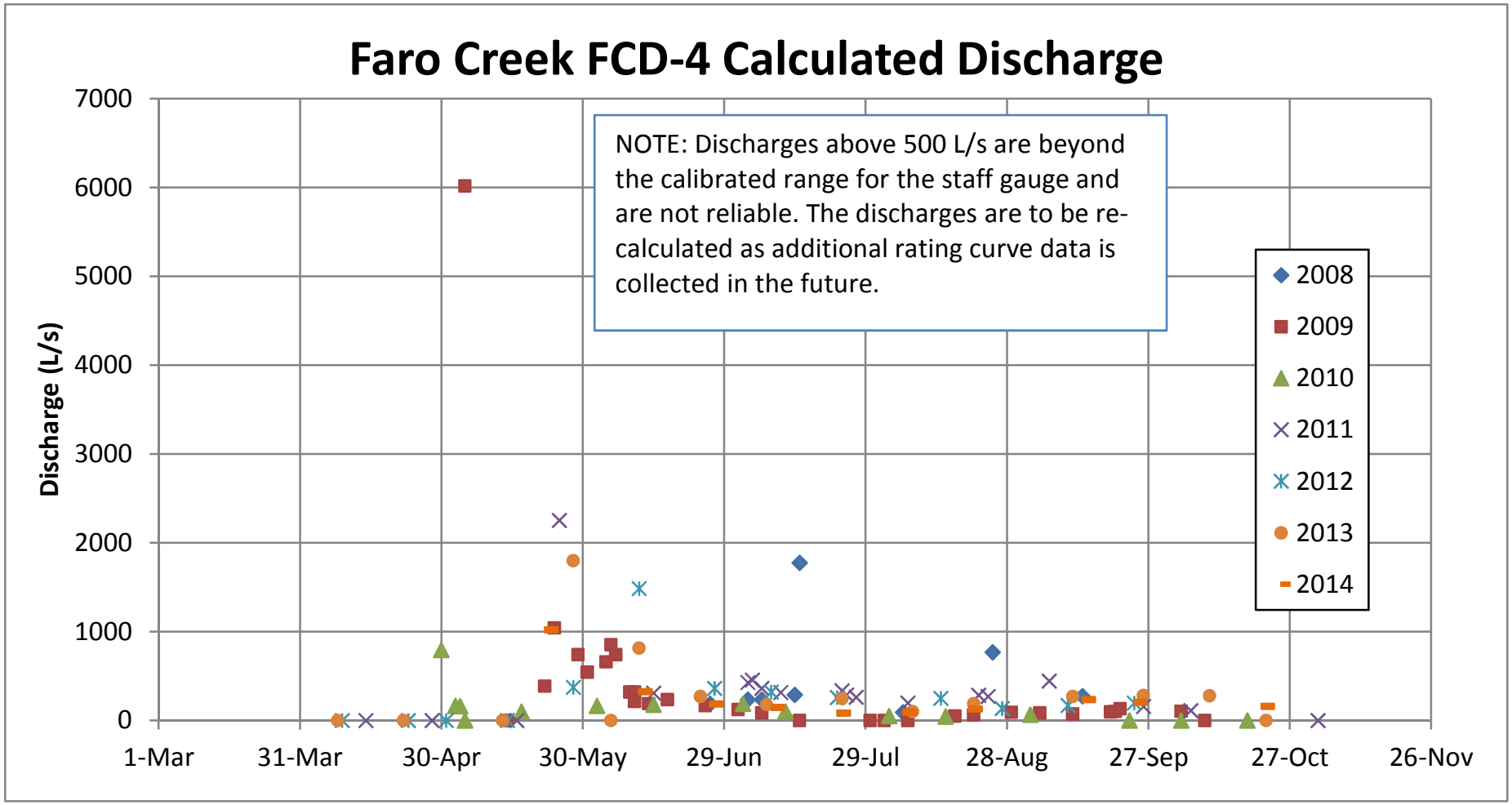

Faro Creek FCD-1 Calculated Discharge
NOTE: Discharges above 1,200 L/s are beyond the calibrated range for the staff gauge and are not reliable. The discharges are to be re-calculated as additional rating curve data is collected in the future.
Discharge (L/s)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1-Mar-08
30-Aug-08
1-Mar-09
30-Aug-09
1-Mar-10
30-Aug-10
1-Mar-11
30-Aug-11
29-Feb-12
29-Aug-12
28-Feb-13
29-Aug-13
28-Feb-14
29-Aug-14
28-Feb-15

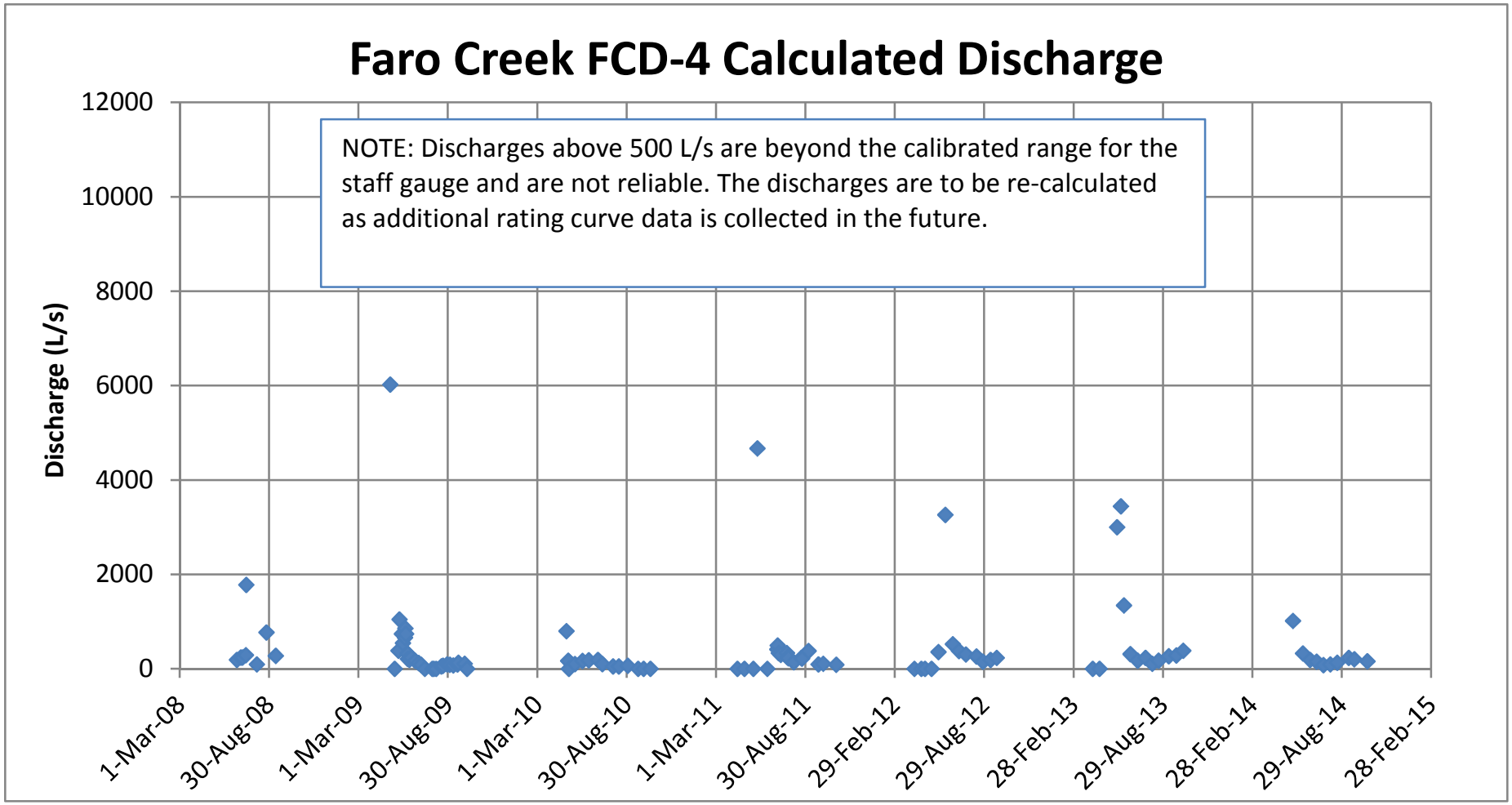

Faro Creek FCD-2 Calculated Discharge
Discharge (L/s)
1600
1400
1200
1000
800
600
400
200
0
1-Mar
31-Mar
30-Apr
30-May
29-Jun
29-Jul
28-Aug
27-Sep
27-Oct
26-Nov
2007
2008
2009
2010
2011
2012
2013
2014
NOTE: Discharges above 600 L/s are beyond the calibrated range for the staff gauge and are not reliable. The discharges are to be re-calculated as additional rating curve data is collected in the future.


Faro Creek FCD-2 Calculated Discharge
Discharge (L/s)
1600
1400
1200
1000
800
600
400
200
0
1-Mar-08
30-Aug-08
1-Mar-09
30-Aug-09
1-Mar-10
30-Aug-10
1-Mar-11
30-Aug-11
29-Feb-12
29-Aug-12
28-Feb-13
29-Aug-13
28-Feb-14
29-Aug-14
28-Feb-15
NOTE: Discharges above 600 L/s are beyond the calibrated range for the staff gauge and are not reliable. The discharges are to be re-calculated as additional rating curve data is collected in the future.


Faro Creek FCD-3 Calculated Discharge
Discharge (L/s)
2500
2000
1500
1000
500
0
1-Mar
31-Mar
30-Apr
30-May
29-Jun
29-Jul
28-Aug
27-Sep
27-Oct
26-Nov
2008
2009
2010
2011
2012
2013
2014
NOTE: Discharges above 600 L/s are beyond the calibrated range for the staff gauge and are not reliable. The discharges are to be re-calculated as additional rating curve data is collected in the future.


Faro Creek FCD-3 Calculated Discharge
NOTE: Discharges above 600 L/s are beyond the calibrated range for the staff gauge and are not reliable. The discharges are to be re-calculated as additional rating curve data is collected in the future.
Discharge (L/s)
2500
2000
1500
1000
500
0
1-Mar-08
30-Aug-08
1-Mar-09
30-Aug-09
1-Mar-10
30-Aug-10
1-Mar-11
30-Aug-11
29-Feb-12
29-Aug-12
28-Feb-13
29-Aug-13
28-Feb-14
29-Aug-14
28-Feb-15


Faro Creek FCD-4 Calculated Discharge
NOTE: Discharges above 500 L/s are beyond the calibrated range for the staff gauge and are not reliable. The discharges are to be re-calculated as additional rating curve data is collected in the future.
Discharge (L/s)
7000
6000
5000
4000
3000
2000
1000
0
1-Mar
31-Mar
30-Apr
30-May
29-Jun
29-Jul
28-Aug
27-Sep
27-Oct
26-Nov
2008
2009
2010
2011
2012
2013
2014


Faro Creek FCD-4 Calculated Discharge
NOTE: Discharges above 500 L/s are beyond the calibrated range for the staff gauge and are not reliable. The discharges are to be re-calculated as additional rating curve data is collected in the future.
Discharge (L/s)
12000
10000
8000
6000
4000
2000
0
1-Mar-08
30-Aug-08
1-Mar-09
30-Aug-09
1-Mar-10
30-Aug-10
1-Mar-11
30-Aug-11
29-Feb-12
29-Aug-12
28-Feb-13
29-Aug-13
28-Feb-14
29-Aug-14
28-Feb-15

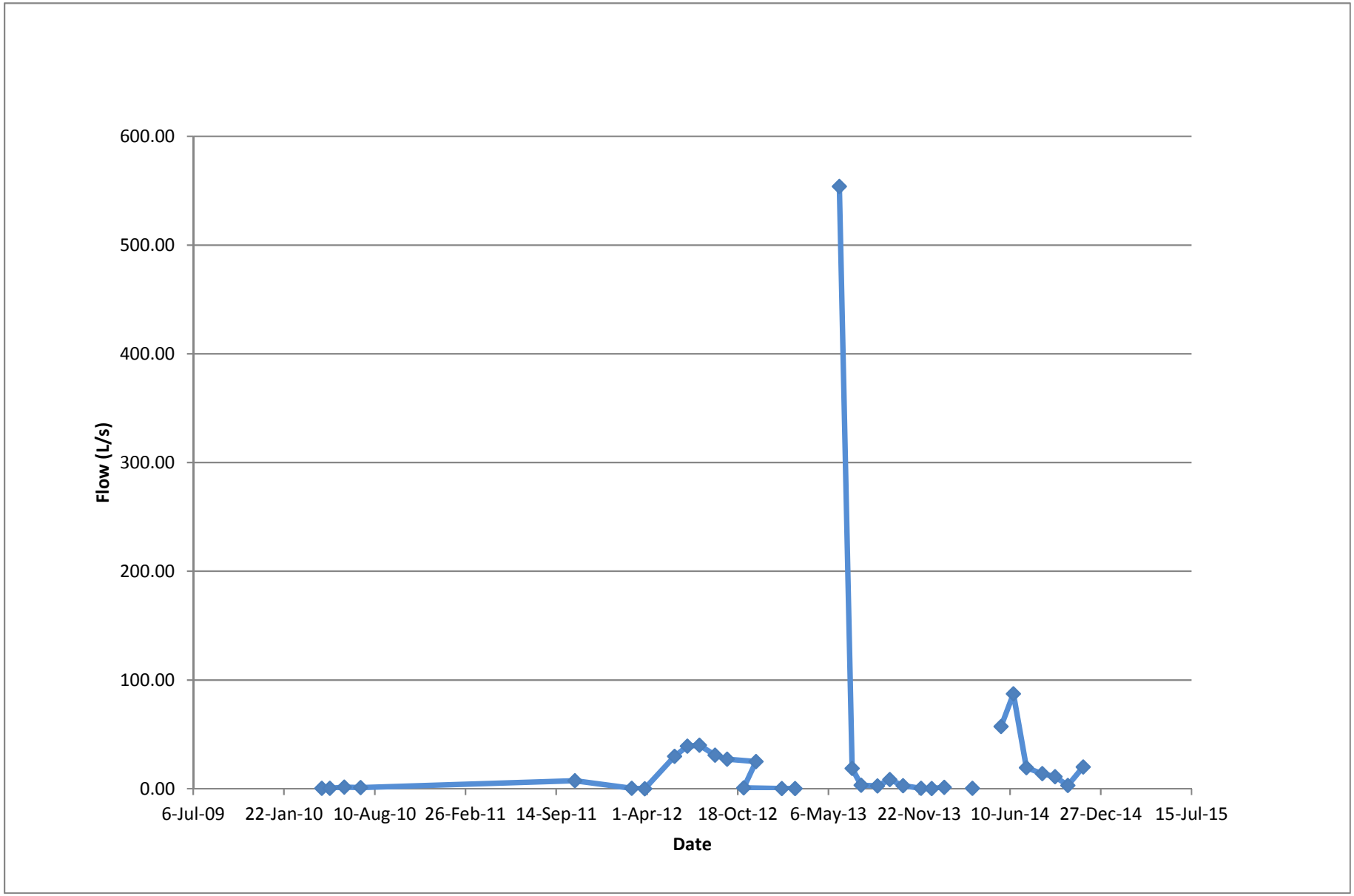
APPENDIX II-C

North Valley Wall Interceptor Ditch

C1 – Ditch Flow

C1 – Ditch Flow

NWID Flow Summary



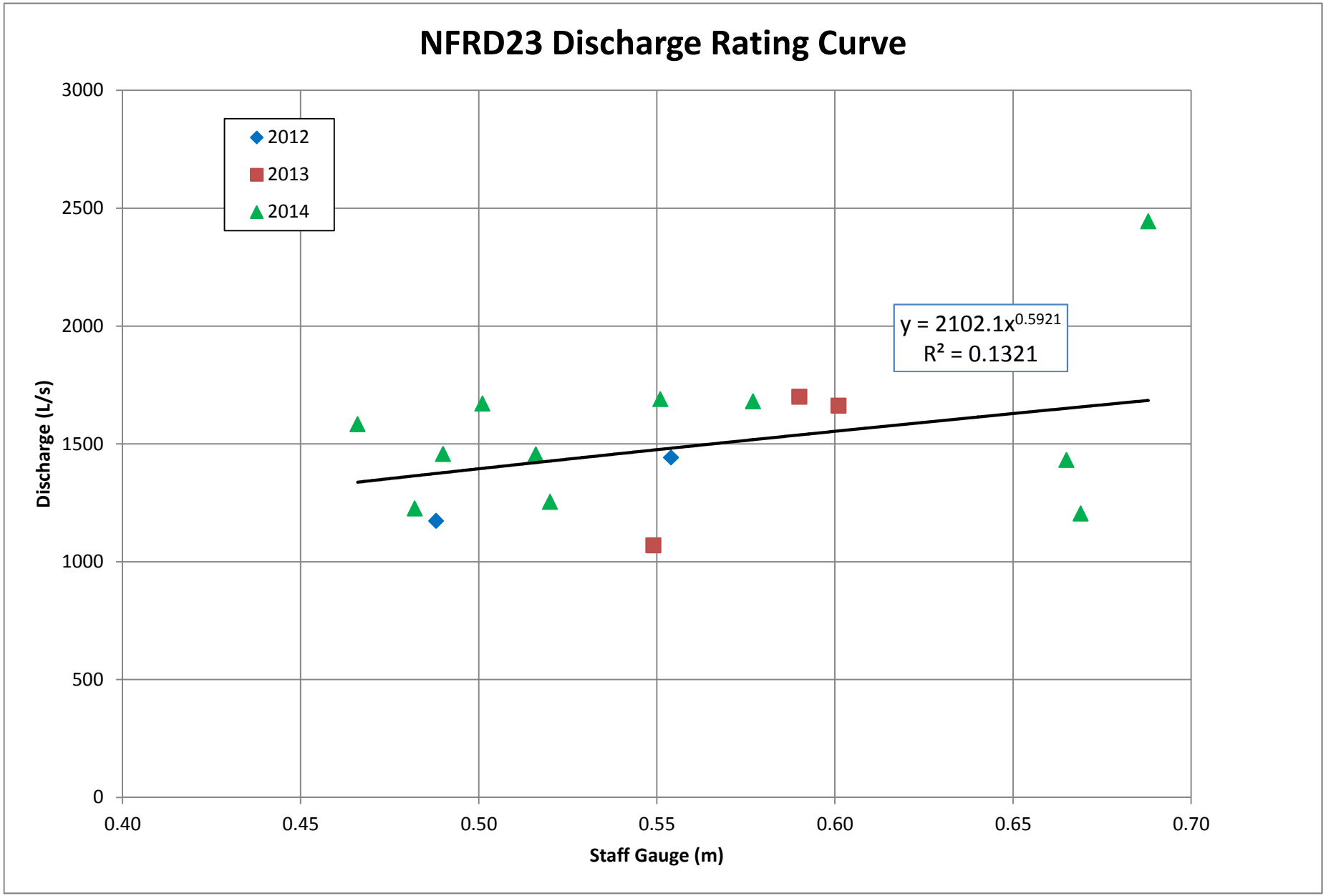
APPENDIX II-D

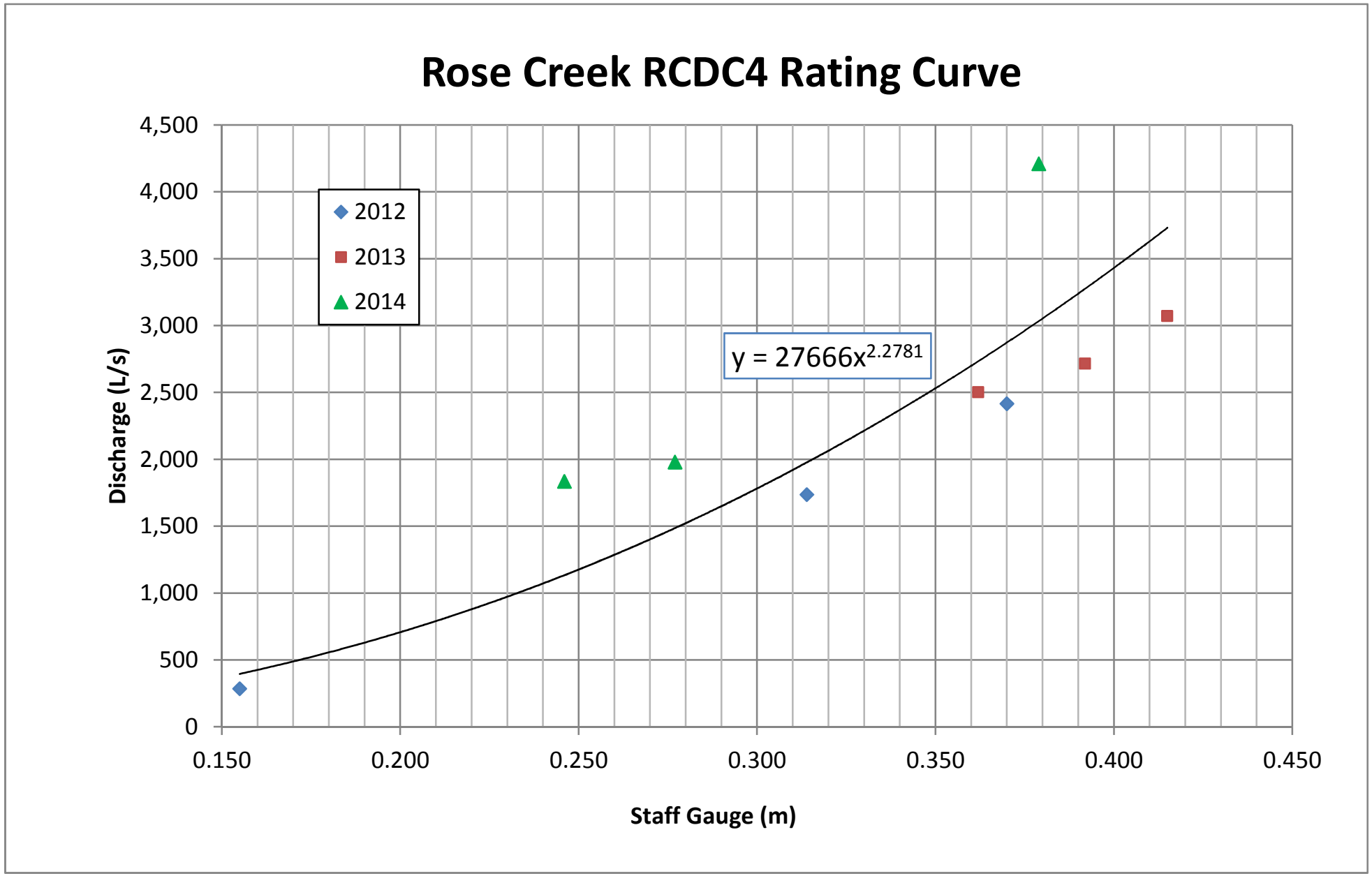
Rose Creek Diversion Channel

D1 – Staff Gauges Calibration

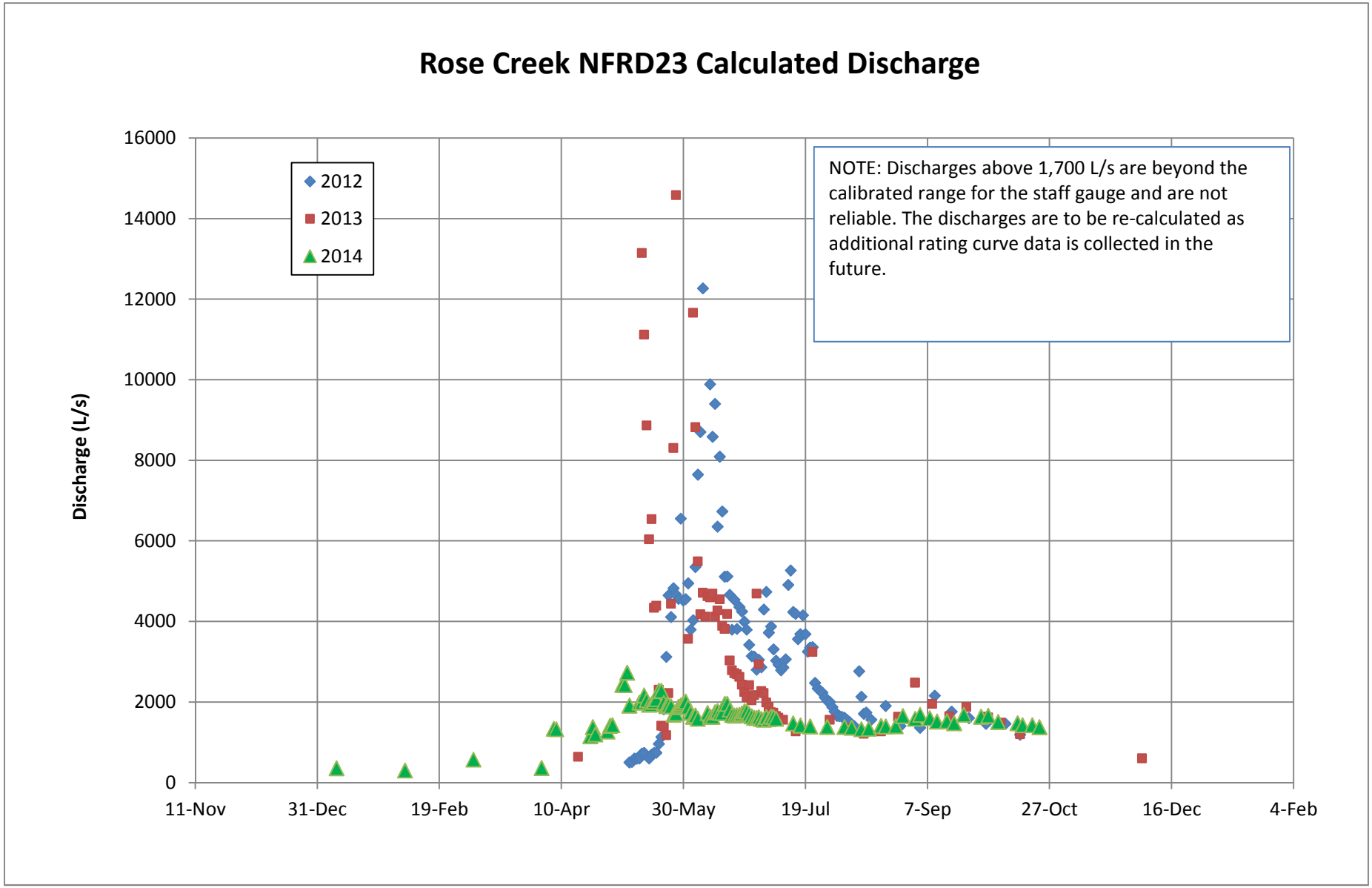
D2 – Staff Gauges Flow

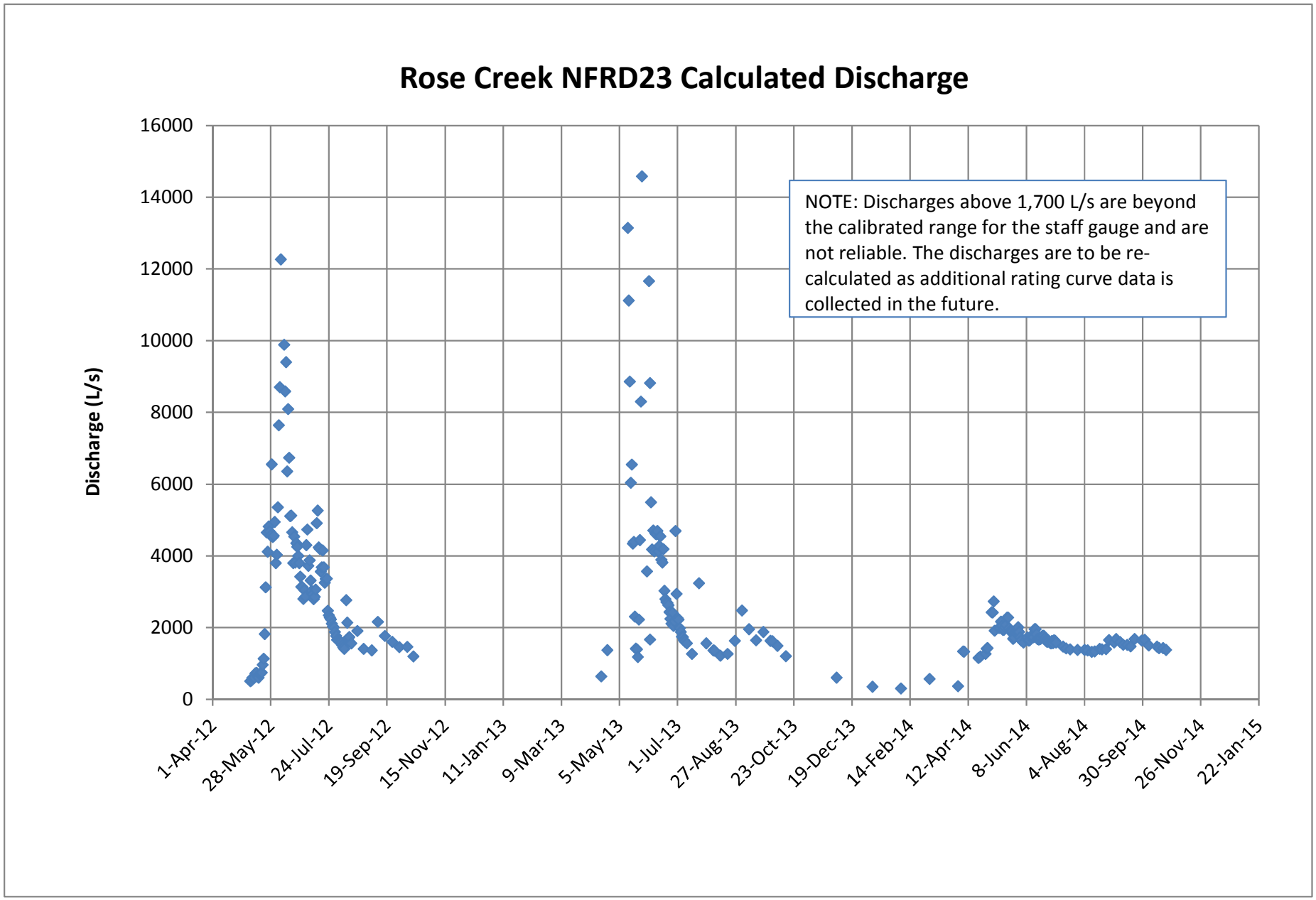
D1 – Staff Gauges Calibration

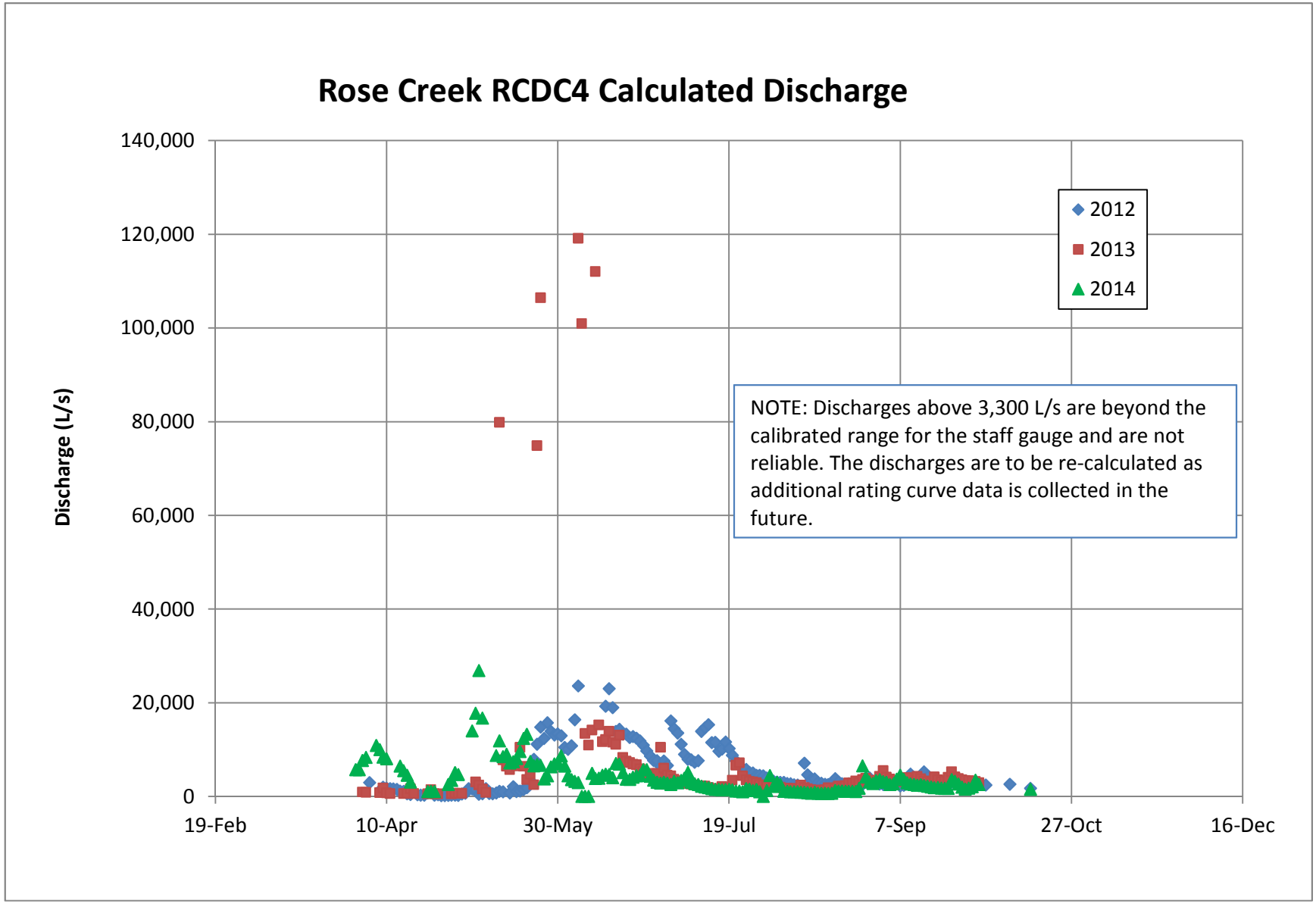

NFRD23 Discharge Rating Curve
3000
2500
2000
1500
1000
500
0
Discharge (L/s)
0.40
0.45
0.50
0.55
0.60
0.65
0.70
Staff Gauge (m)
2012
2013
2014
y = 2102.1x^0.5921
R² = 0.1321

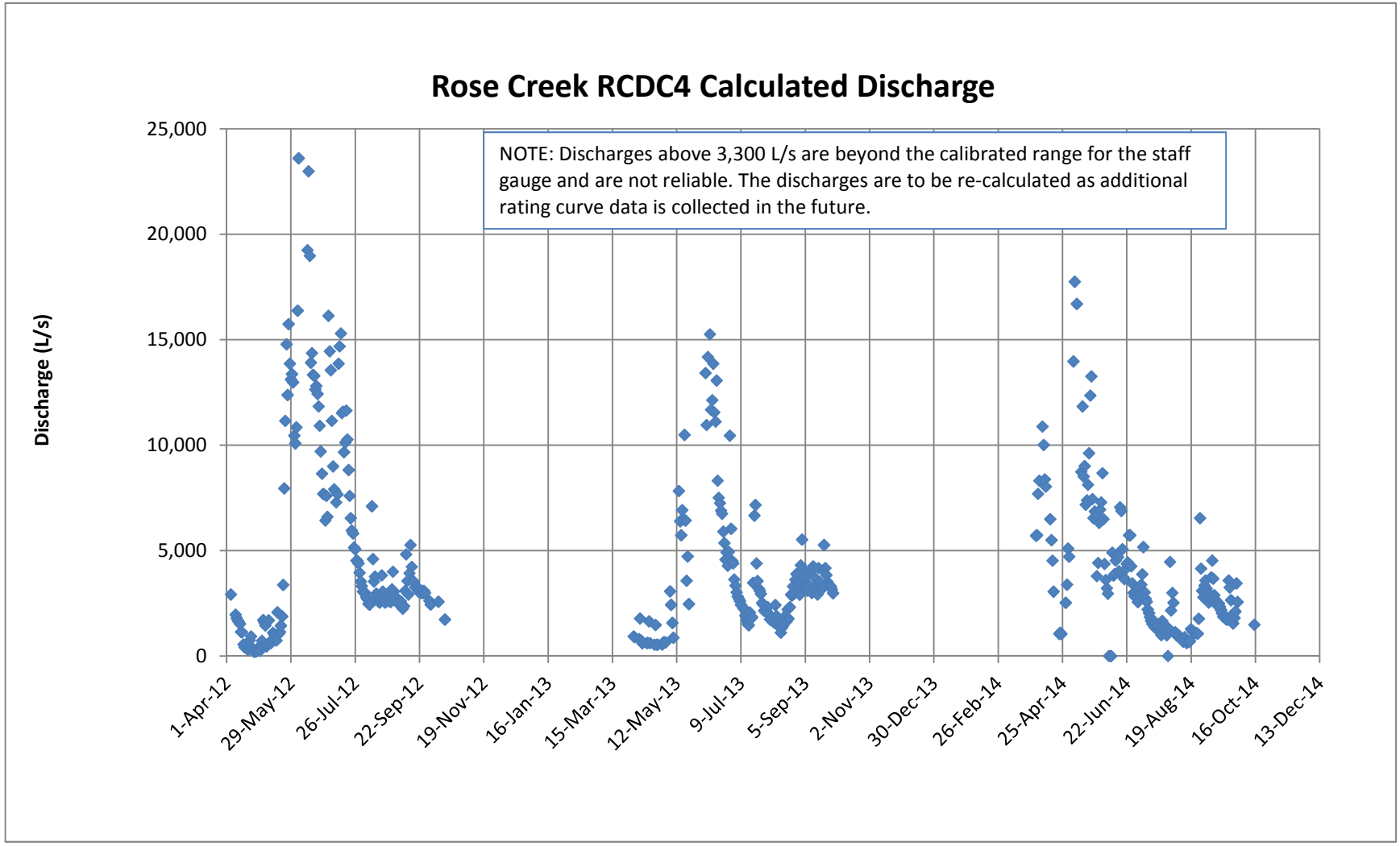

Rose Creek RCDC4 Rating Curve
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Discharge (L/s)
2012
2013
2014
y = 27666x2.2781
0.150
0.200
0.250
0.300
0.350
0.400
0.450
Staff Gauge (m)

D2 – Staff Gauges Flow


Rose Creek NFRD23 Calculated Discharge
Discharge (L/s)
16000
14000
12000
10000
8000
6000
4000
2000
0
11-Nov
31-Dec
19-Feb
10-Apr
30-May
19-Jul
7-Sep
27-Oct
16-Dec
4-Feb
2012
2013
2014
NOTE: Discharges above 1,700 L/s are beyond the calibrated range for the staff gauge and are not reliable. The discharges are to be re-calculated as additional rating curve data is collected in the future.


Rose Creek NFRD23 Calculated Discharge
Discharge (L/s)
16000
14000
12000
10000
8000
6000
4000
2000
0
1-Apr-12
28-May-12
24-Jul-12
19-Sep-12
15-Nov-12
11-Jan-13
9-Mar-13
5-May-13
1-Jul-13
27-Aug-13
23-Oct-13
19-Dec-13
14-Feb-14
12-Apr-14
8-Jun-14
4-Aug-14
30-Sep-14
26-Nov-14
22-Jan-15
NOTE: Discharges above 1,700 L/s are beyond the calibrated range for the staff gauge and are not reliable. The discharges are to be re-calculated as additional rating curve data is collected in the future.


Rose Creek RCDC4 Calculated Discharge
Discharge (L/s)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
19-Feb
10-Apr
30-May
19-Jul
7-Sep
27-Oct
16-Dec
2012
2013
2014
NOTE: Discharges above 3,300 L/s are beyond the calibrated range for the staff gauge and are not reliable. The discharges are to be re-calculated as additional rating curve data is collected in the future.


Rose Creek RCDC4 Calculated Discharge
NOTE: Discharges above 3,300 L/s are beyond the calibrated range for the staff gauge and are not reliable. The discharges are to be re-calculated as additional rating curve data is collected in the future.
Discharge (L/s)
25,000
20,000
15,000
10,000
5,000
0
1-Apr-12
29-May-12
26-Jul-12
22-Sep-12
19-Nov-12
16-Jan-13
15-Mar-13
12-May-13
9-Jul-13
5-Sep-13
2-Nov-13
30-Dec-13
26-Feb-14
25-Apr-14
22-Jun-14
19-Aug-14
16-Oct-14
13-Dec-14

APPENDIX II-E

Canal Dyke

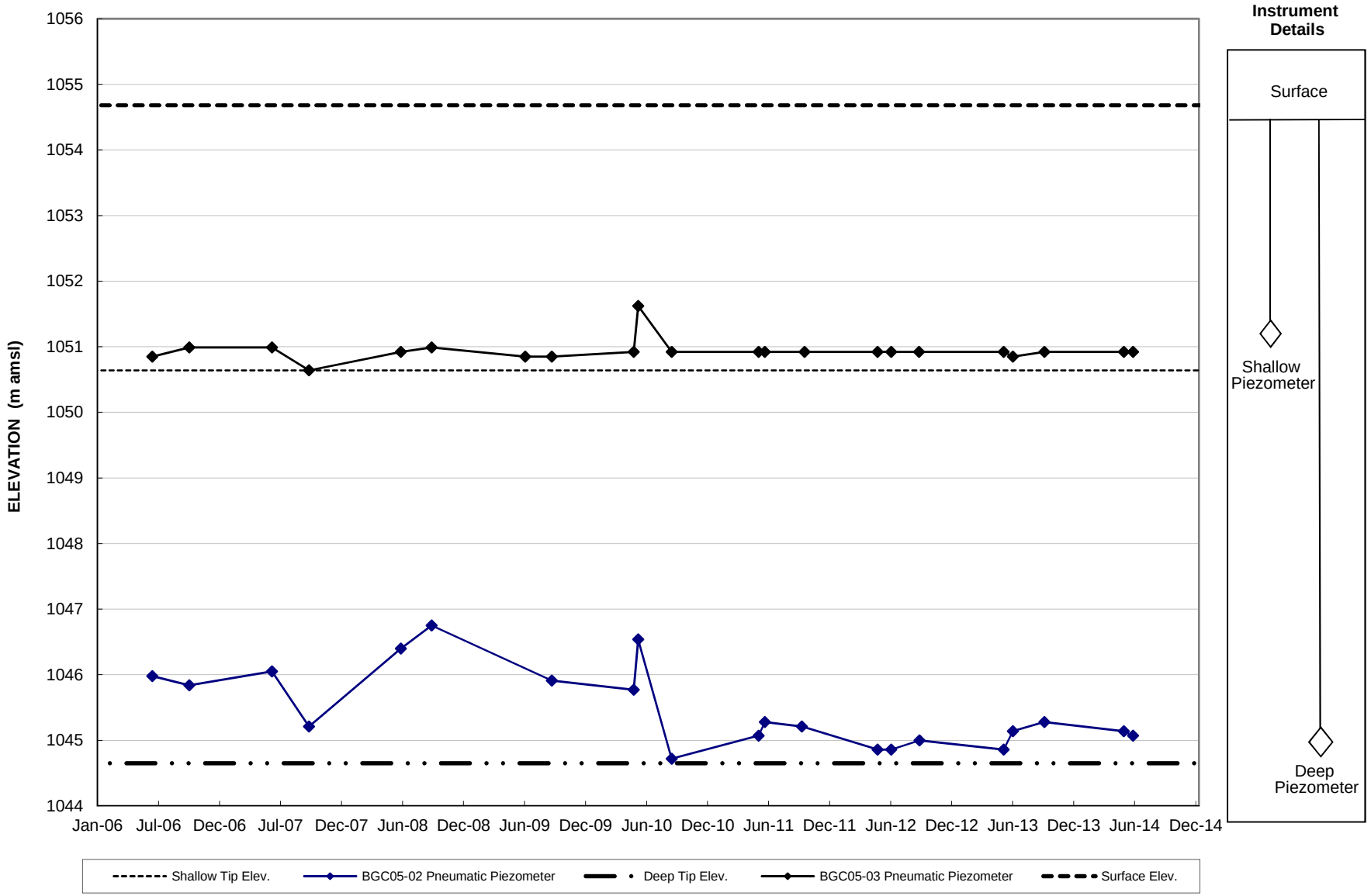
E1 – Piezometers

E2 – Thermistors (Thawed ones not included)

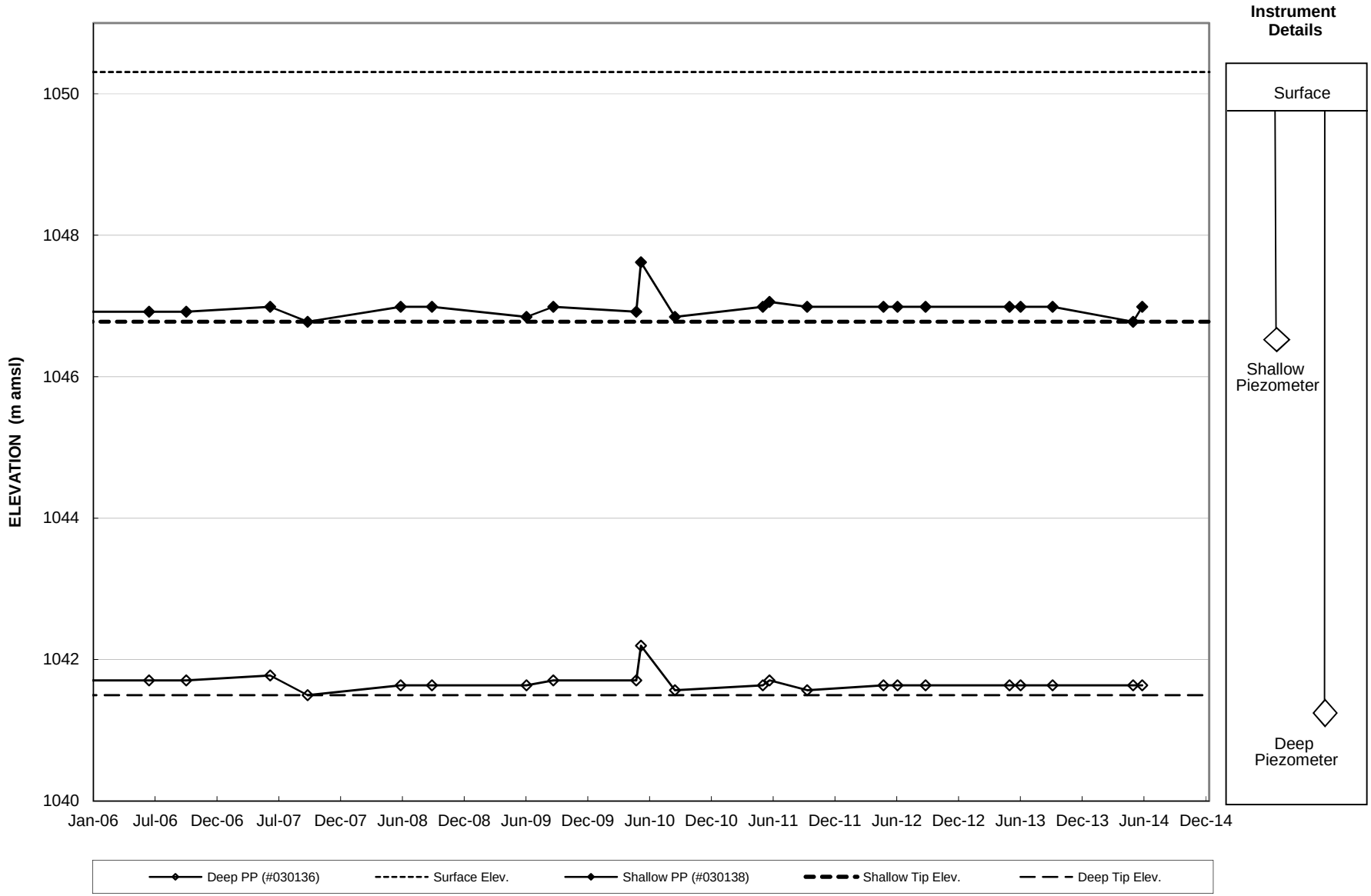
E3 – Inclinometers

E1 – Piezometers

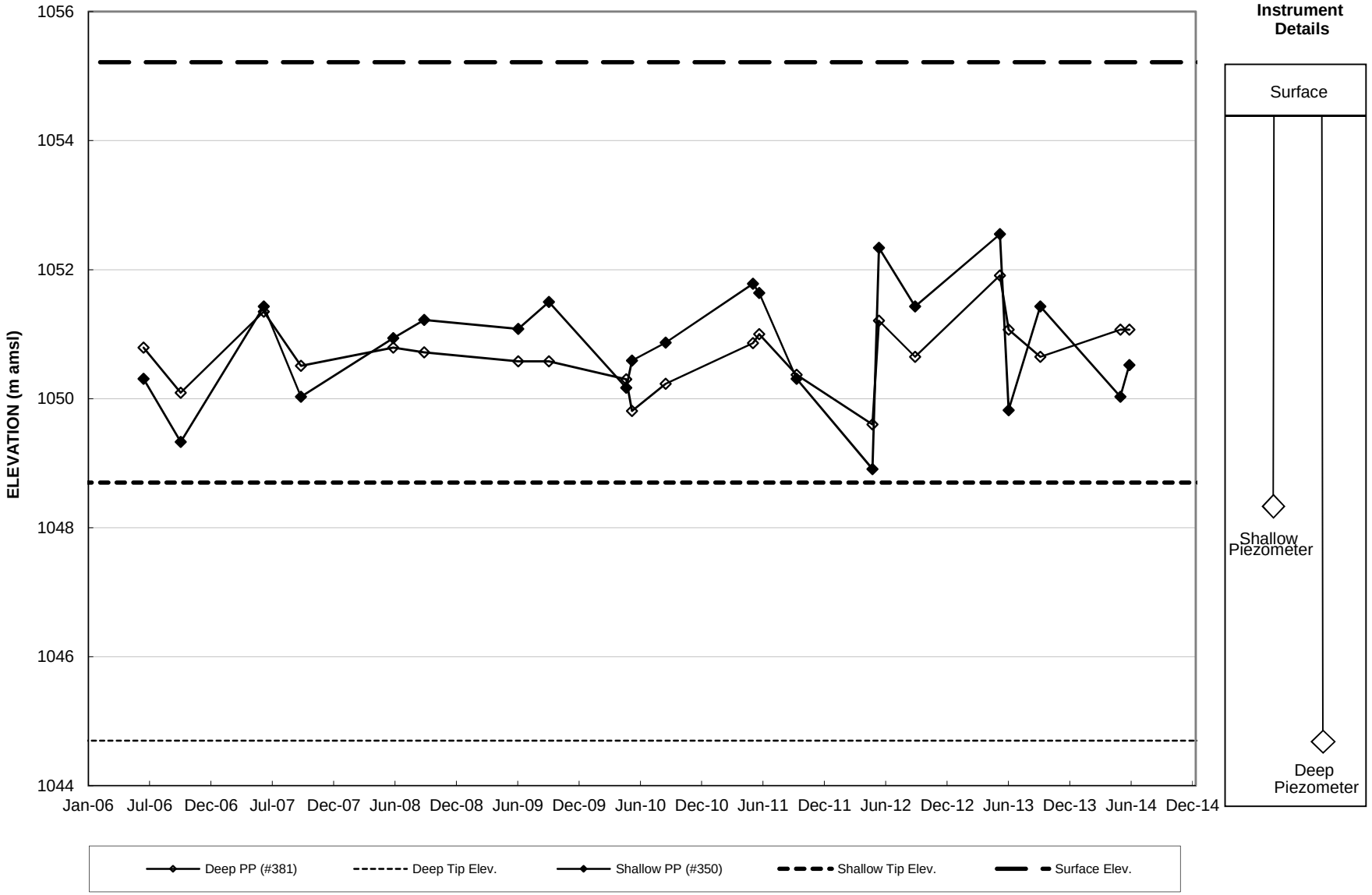
Diversion Canal (Canal Dyke) - Piezometers
BGC05- 02 03



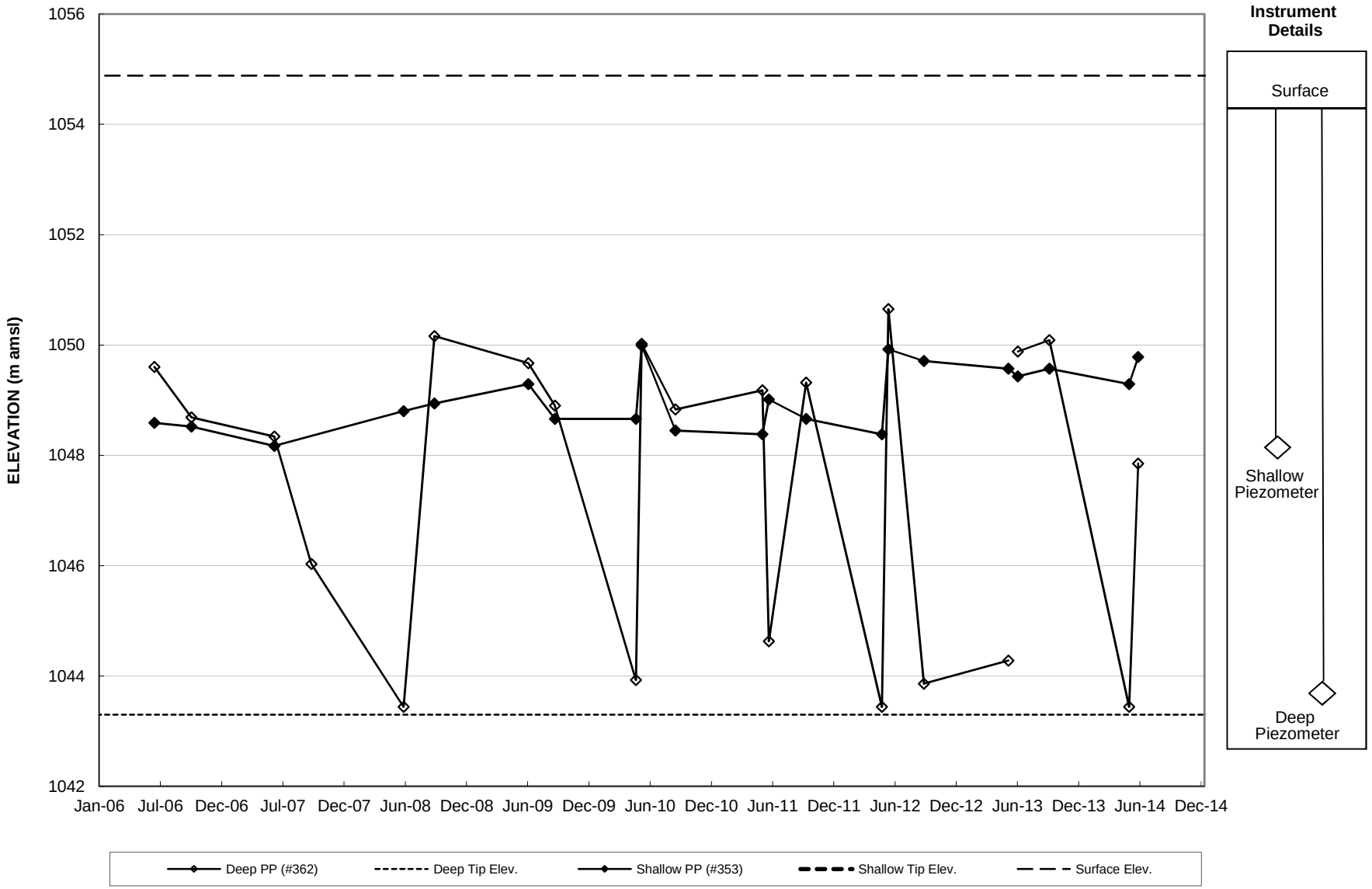
Diversion Canal (Canal Dyke)
Piezometers BGC05- 05-06 (Both Tips)



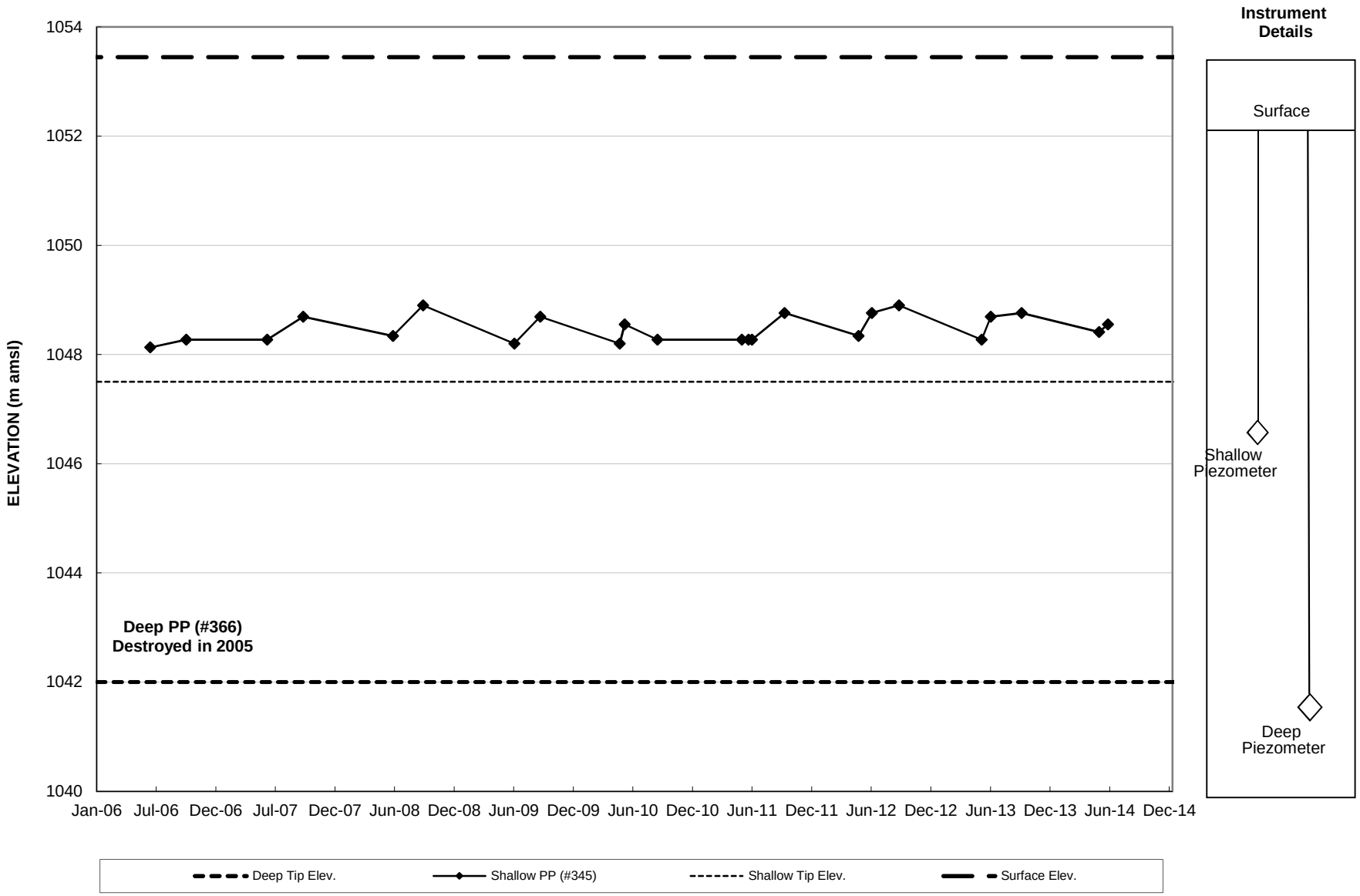
Diversion Canal (Canal Dyke)
Piezometers CD-13 (Both Tips)



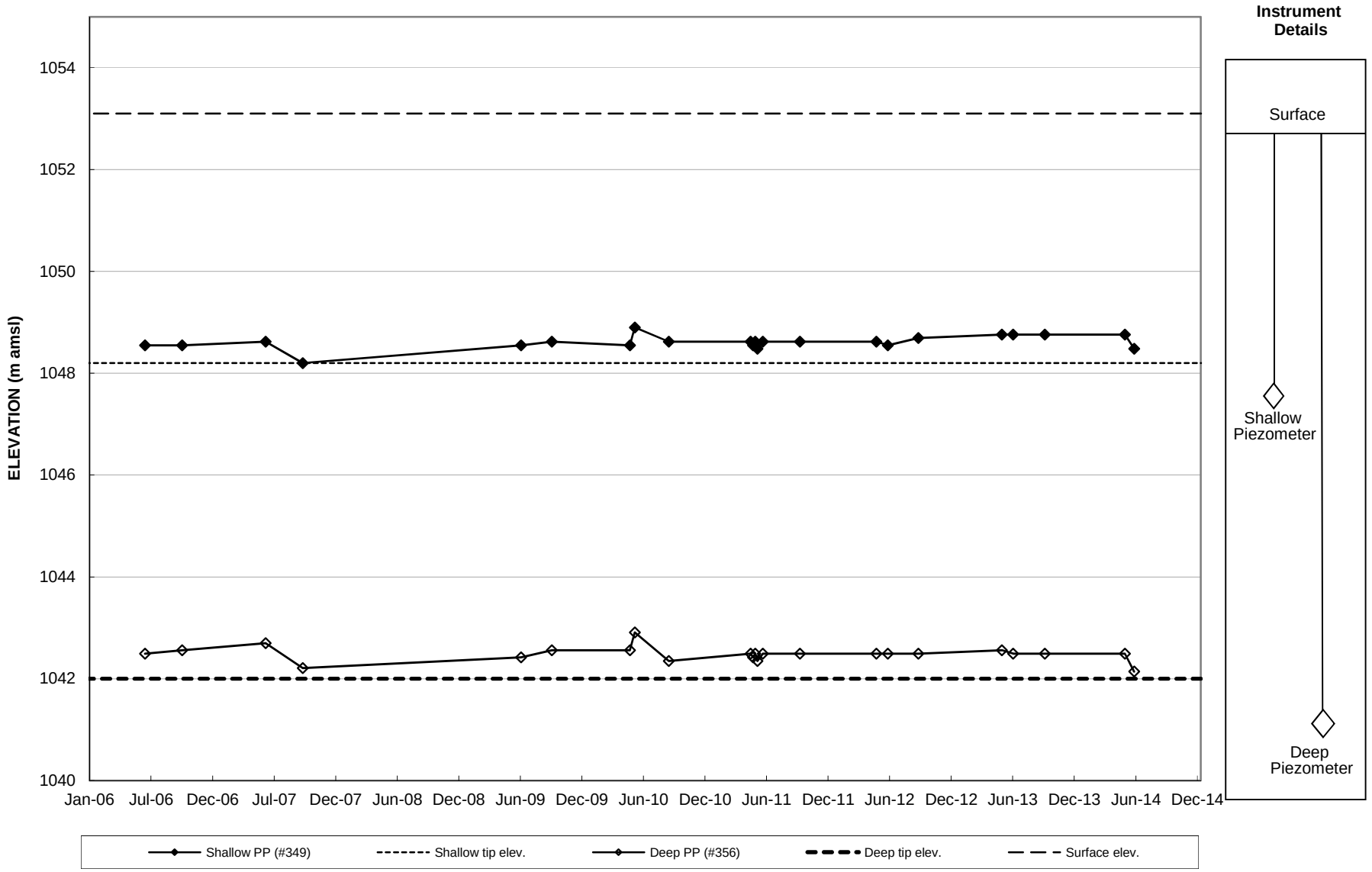
Diversion Canal (Canal Dyke)
Piezometers CD-15 (Both Tips)



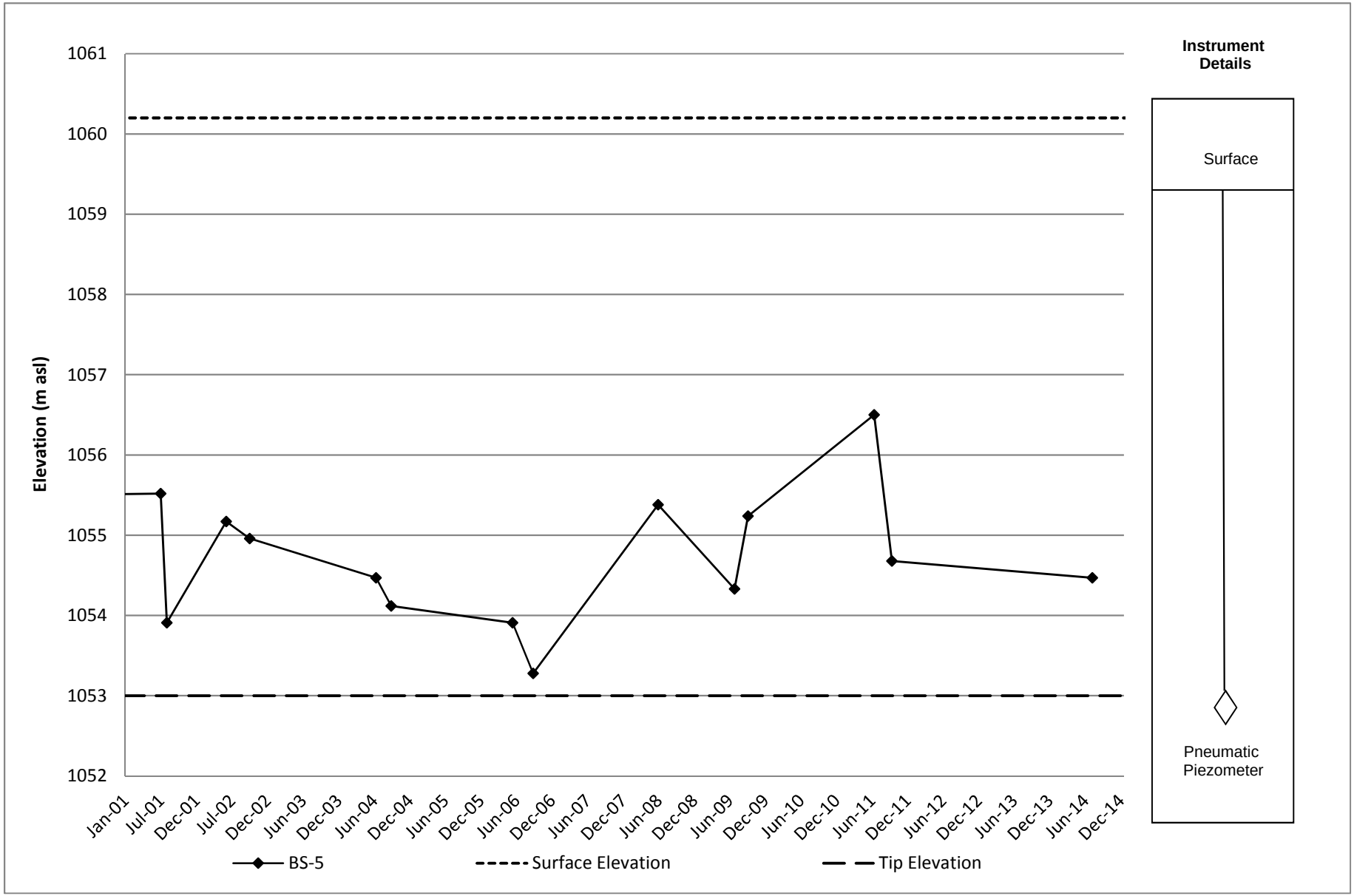
Diversion Canal (Canal Dyke)
Piezometers CD-21 (Both Tips)



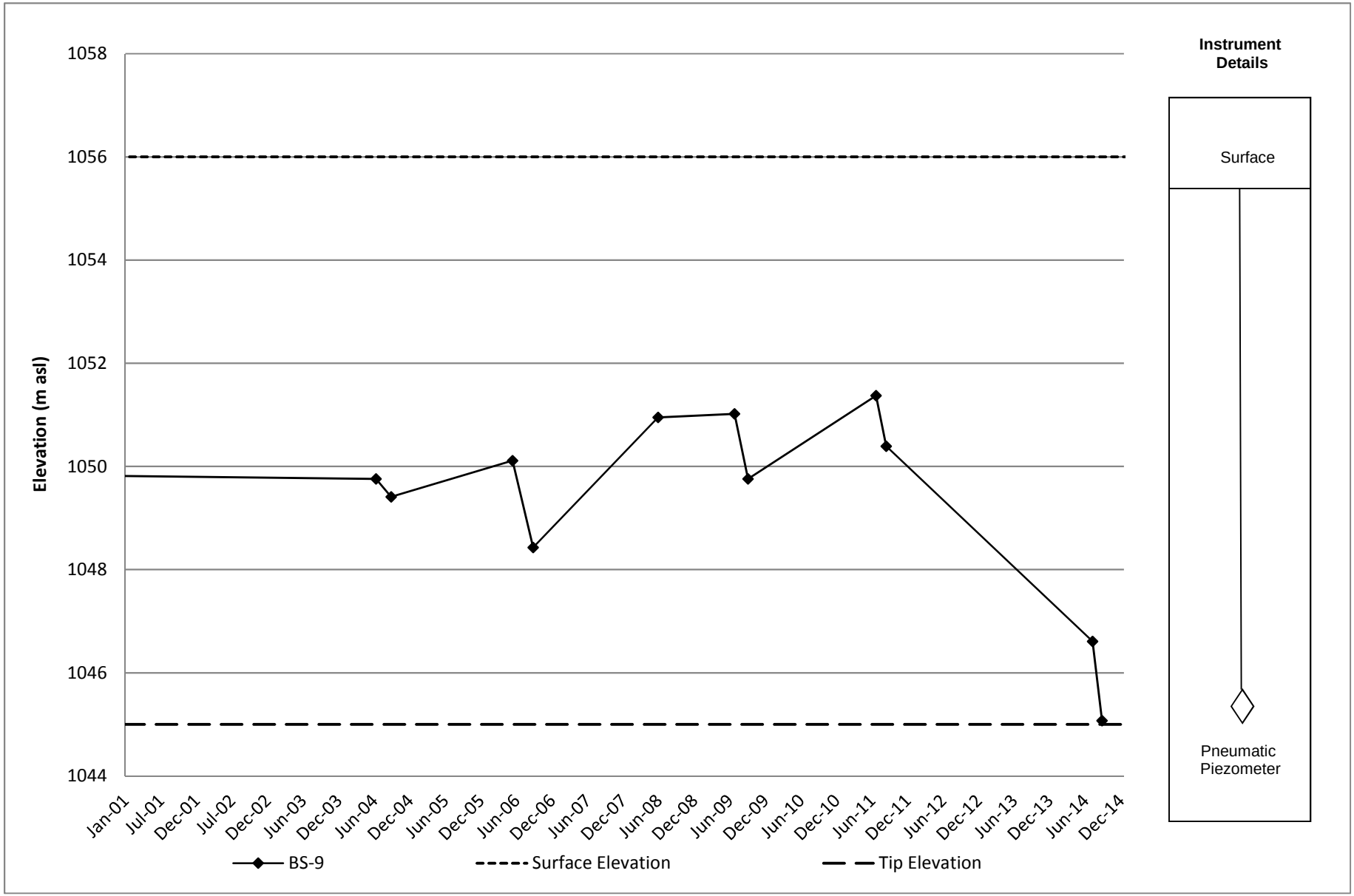
Diversion Canal (Canal Dyke)
Piezometers CD-26 (Both Tips)



Diversion Canal (Backslope)
Piezometers BS-5



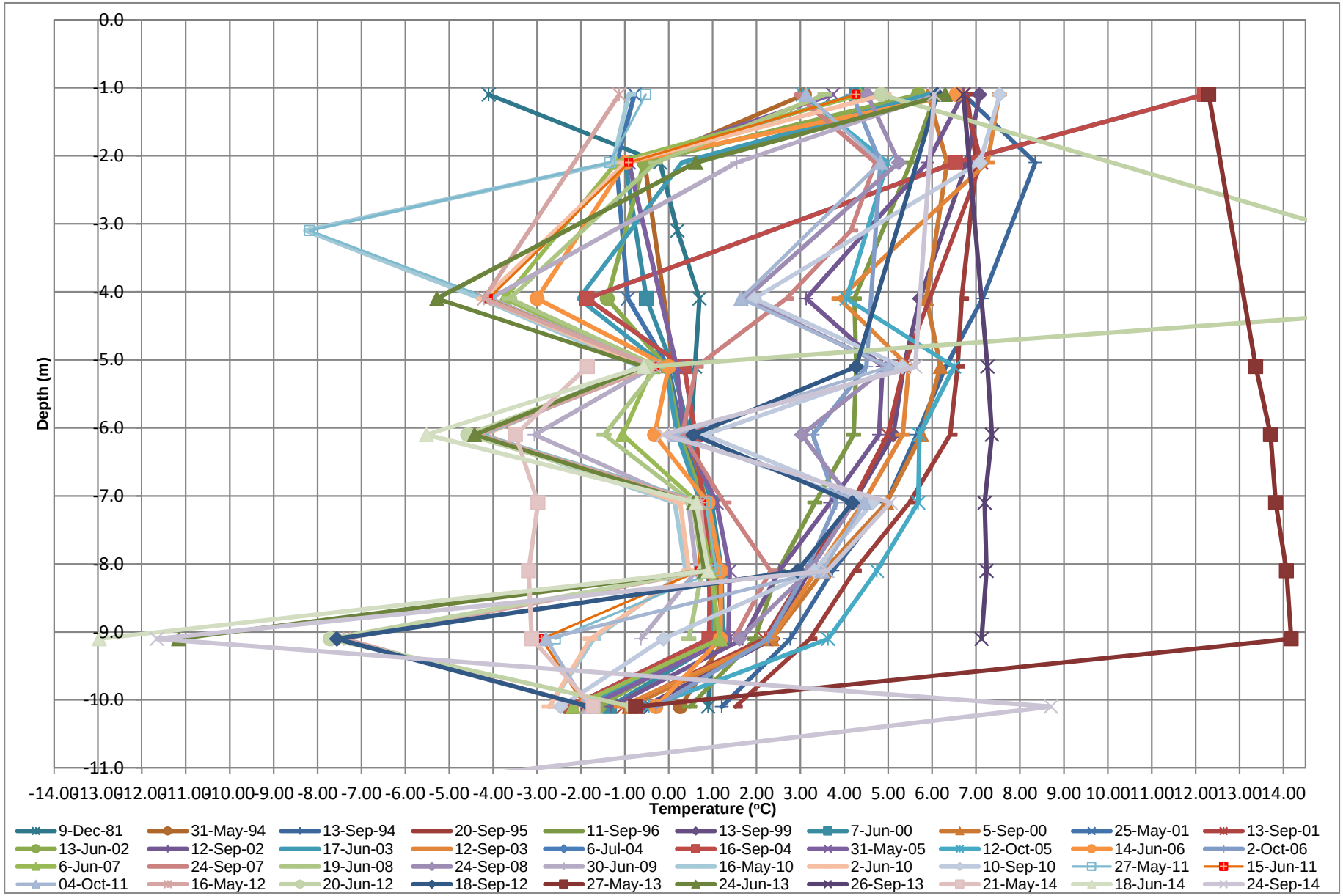
Diversion Canal (Backslope)
Piezometers BS-9



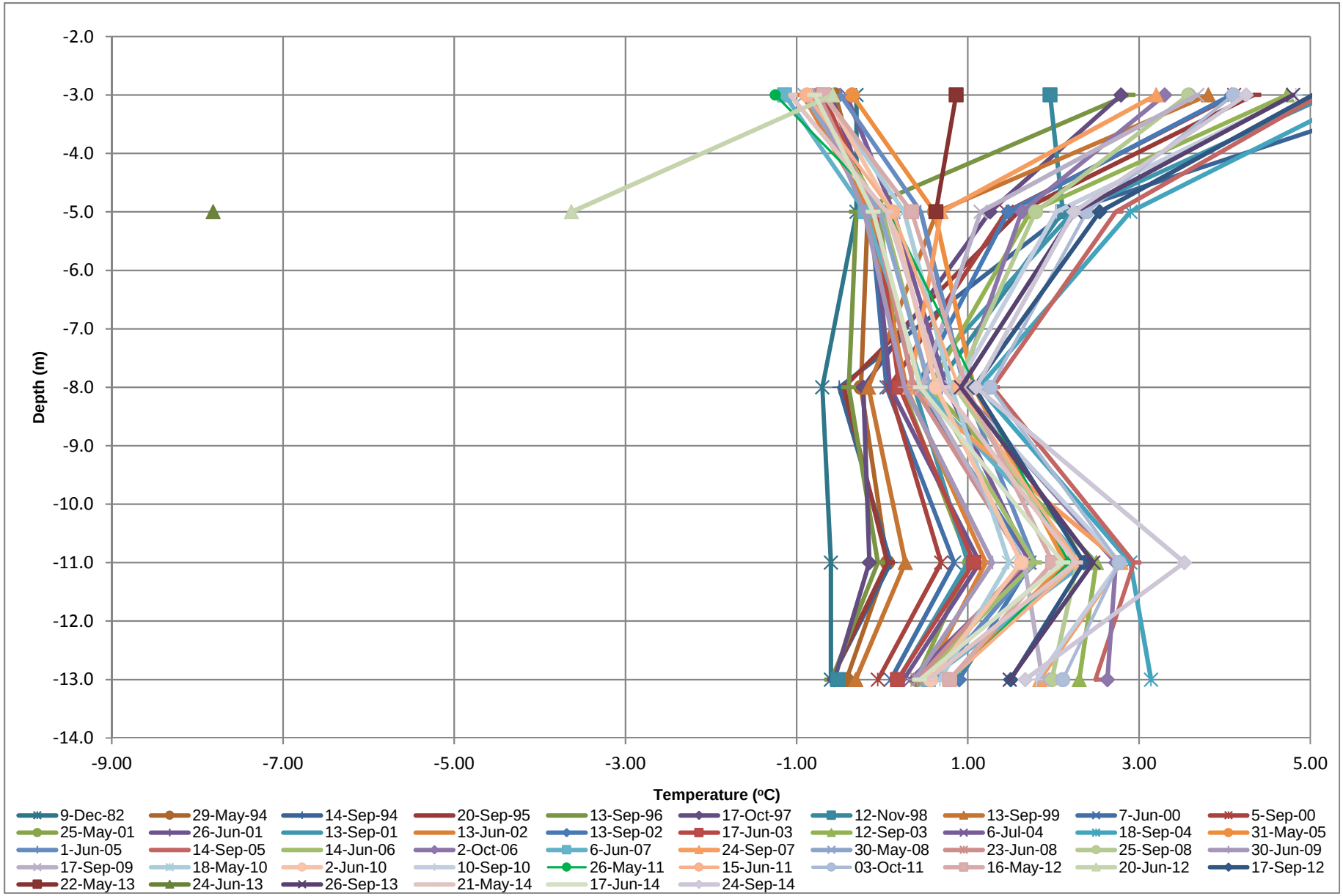
E2 - Thermistors

Thawed ones not included

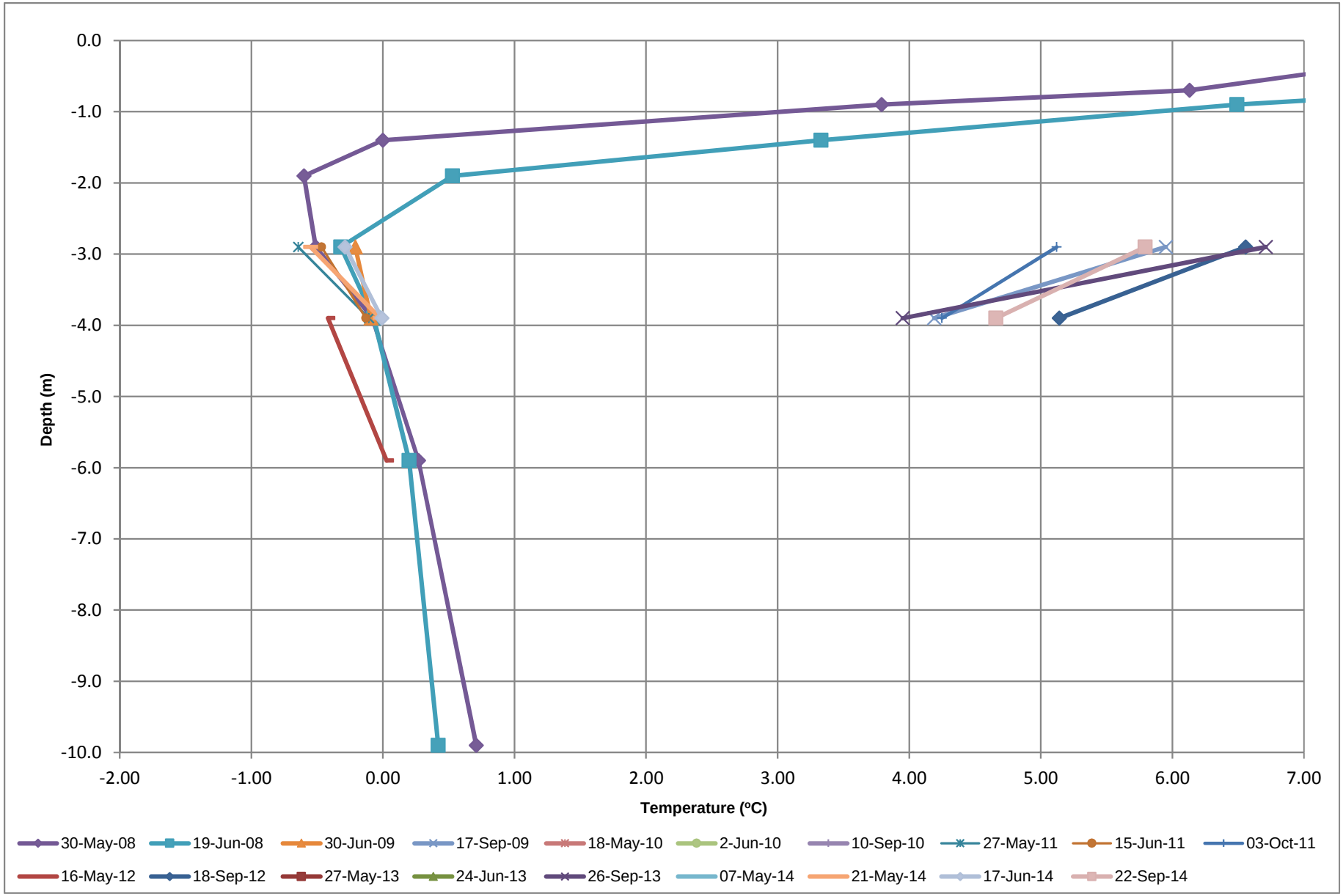
Diversion Canal (Canal Dyke)
Thermistor CD-15



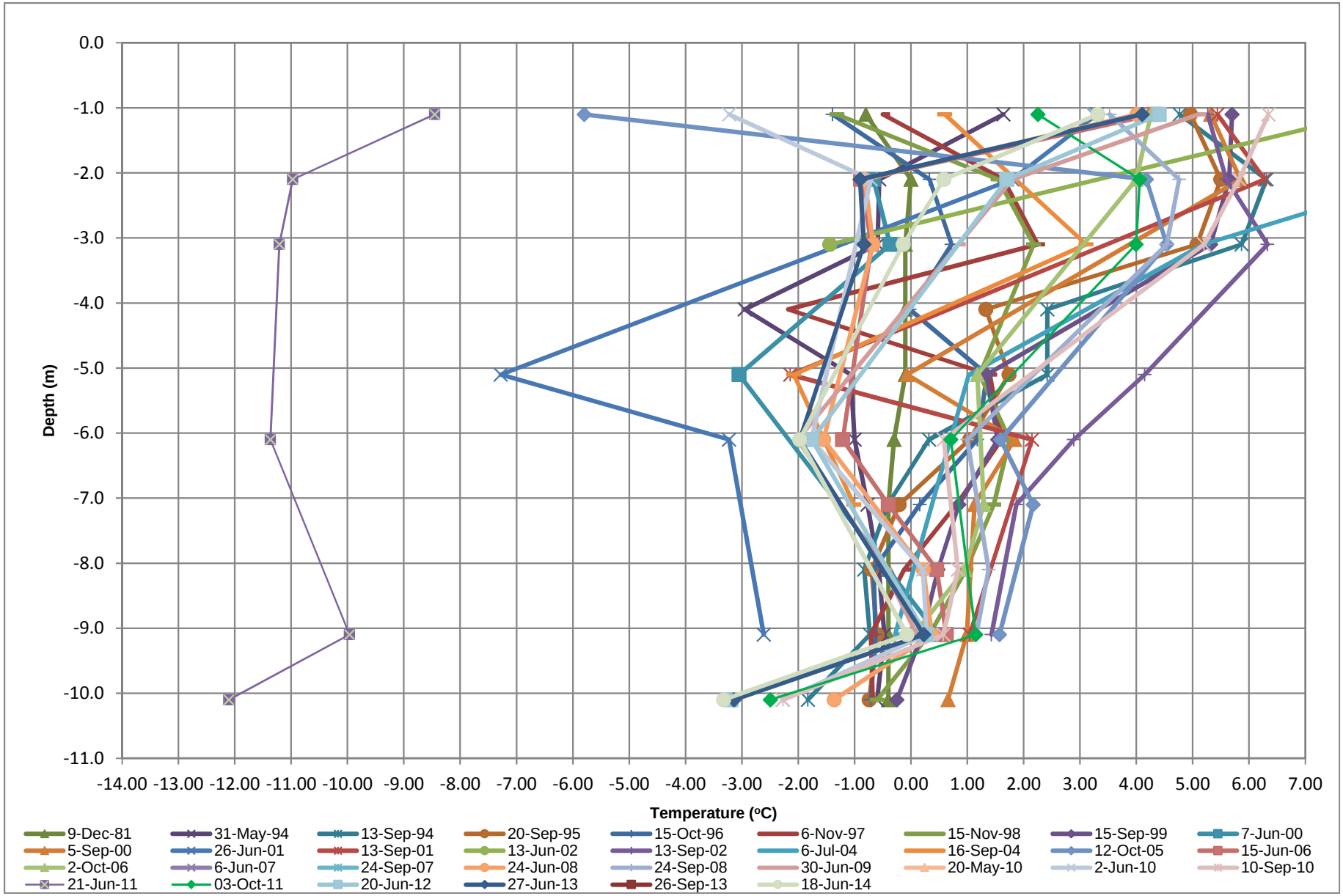
Diversion Canal (Canal Dyke)
Thermistor CD-21



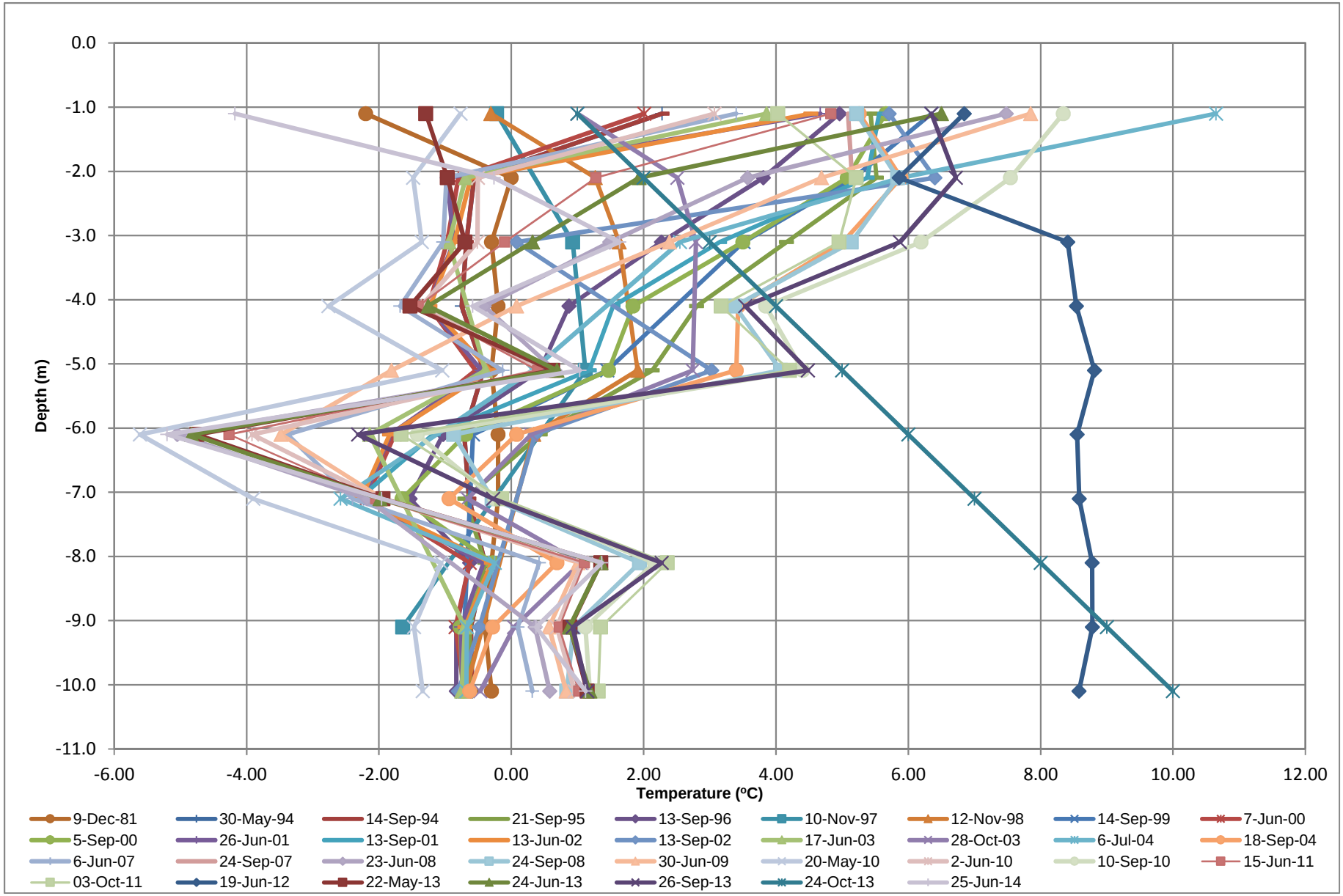
Diversion Canal (Canal Dyke)
Thermistor BGC05-04



Diversion Canal (Spoil Pile)
Thermistor SP-3

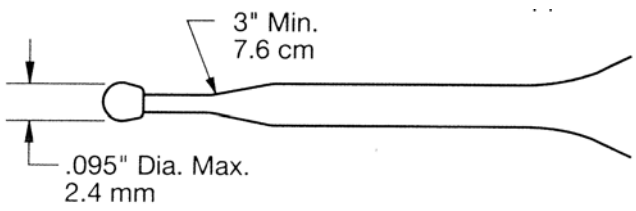


Diversion Canal (Spoil Pile)
Thermistor SP-5



44007RC Precision Epoxy NTC Thermistor

MECHANICAL DETAILS



RESISTANCE V TEMPERATURE TABLE

Temp °C	K-Ohms
-55	482.200
-54	447.900
-53	416.300
-52	387.100
-51	360.200
-50	335.300
-49	312.300
-48	291.000
-47	271.300
-46	253.000
-45	236.200
-44	220.500
-43	205.900
-42	192.500
-41	180.000
-40	168.300
-39	157.500
-38	147.500
-37	138.200
-36	129.500
-35	121.400
-34	113.900
-33	106.900
-32	100.300
-31	94.220
-30	88.530
-29	83.220
-28	78.260
-27	73.620
-26	69.290
-25	65.240
-24	61.450
-23	57.900
-22	54.580
-21	51.470
-20	48.560
-19	45.830
-18	43.270
-17	40.860
-16	38.610

Temp °C	K-Ohms
-15	36.490
-14	34.500
-13	32.630
-12	30.880
-11	29.230
-10	27.670
-9	26.210
-8	24.830
-7	23.540
-6	22.320
-5	21.170
-4	20.080
-3	19.060
-2	18.100
-1	17.190
0	16.330
1	15.520
2	14.750
3	14.030
4	13.340
5	12.700
6	12.090
7	11.510
8	10.960
9	10.440
10	9.951
11	9.486
12	9.046
13	8.628
14	8.232
15	7.857
16	7.500
17	7.162
18	6.841
19	6.536
20	6.247
21	5.972
22	5.710
23	5.462
24	5.225

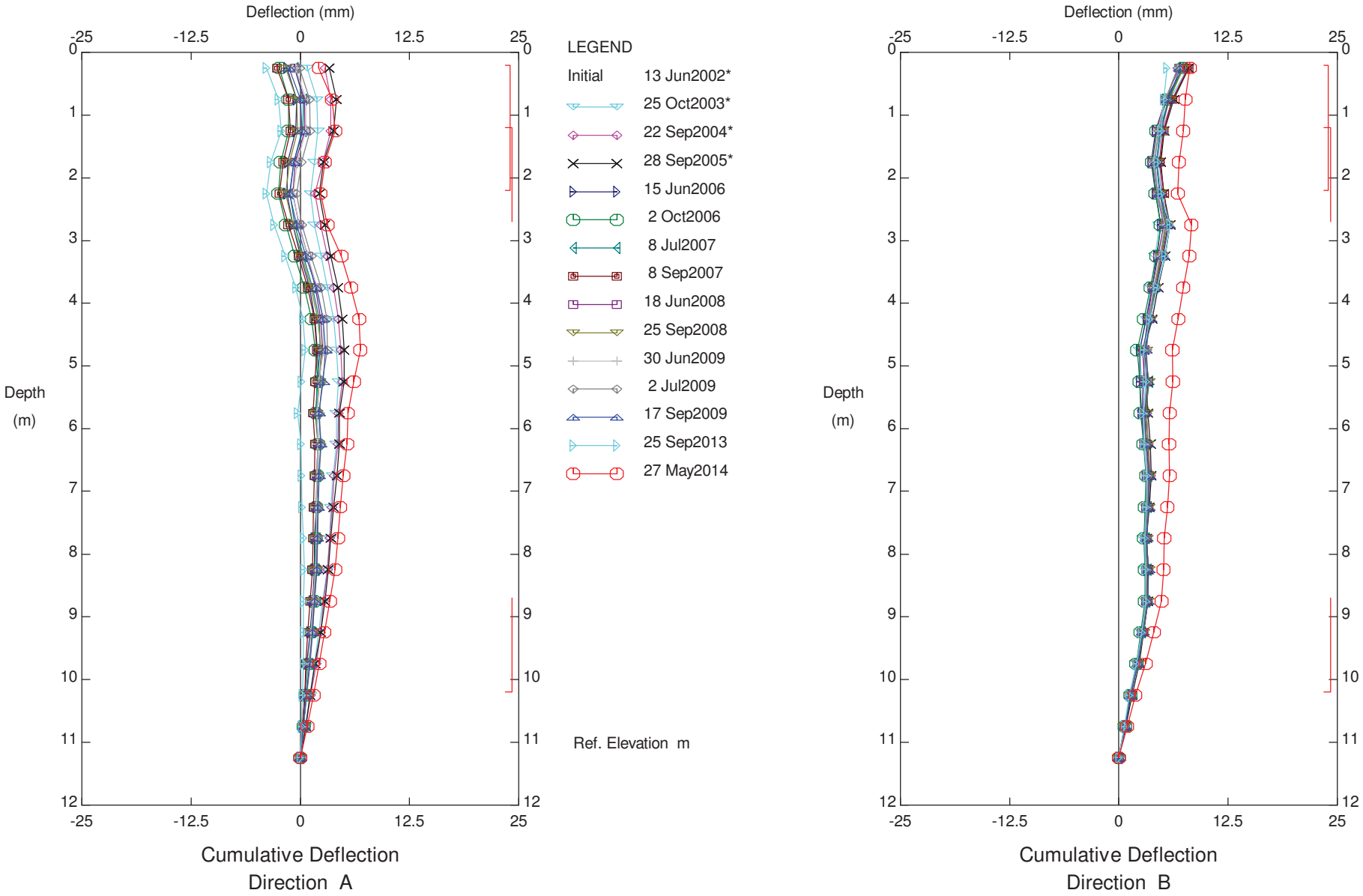
Temp °C	K-Ohms
25	5.000
26	4.787
27	4.583
28	4.389
29	4.204
30	4.029
31	3.861
32	3.702
33	3.549
34	3.404
35	3.266
36	3.134
37	3.008
38	2.888
39	2.773
40	2.663
41	2.559
42	2.459
43	2.363
44	2.272
45	2.184
46	2.101
47	2.021
48	1.944
49	1.871
50	1.801
51	1.734
52	1.670
53	1.608
54	1.549
55	1.493
56	1.439
57	1.387
58	1.337
59	1.290
60	1.244
61	1.200
62	1.158
63	1.117
64	1.079

Temp °C	K-Ohms
65	1.0410
66	1.0060
67	0.9711
68	0.9380
69	0.9063
70	0.8757
71	0.8464
72	0.8183
73	0.7912
74	0.7651
75	0.7400
76	0.7159
77	0.6927
78	0.6703
79	0.6488
80	0.6281
81	0.6082
82	0.5889
83	0.5704
84	0.5526
85	0.5354
86	0.5188
87	0.5028
88	0.4874
89	0.4726
90	0.4582
91	0.4444
92	0.4310
93	0.4182
94	0.4057
95	0.3937
96	0.3821
97	0.3709
98	0.3601
99	0.3497
100	0.3396
101	0.3298
102	0.3204
103	0.3113
104	0.3025

Temp °C	K-Ohms
105	0.2940
106	0.2857
107	0.2778
108	0.2701
109	0.2626
110	0.2554
111	0.2484
112	0.2416
113	0.2351
114	0.2287
115	0.2226
116	0.2167
117	0.2109
118	0.2053
119	0.1999
120	0.1947
121	0.1896
122	0.1847
123	0.1799
124	0.1753
125	0.1708
126	0.1664
127	0.1622
128	0.1581
129	0.1541
130	0.1503
131	0.1465
132	0.1429
133	0.1394
134	0.1360
135	0.1326
136	0.1294
137	0.1263
138	0.1232
139	0.1203
140	0.1174
141	0.1146
142	0.1119
143	0.1092
144	0.1067
145	0.1042
146	0.1018
147	0.0994
148	0.0971
149	0.0949
150	0.0927

E3 – Inclinometers

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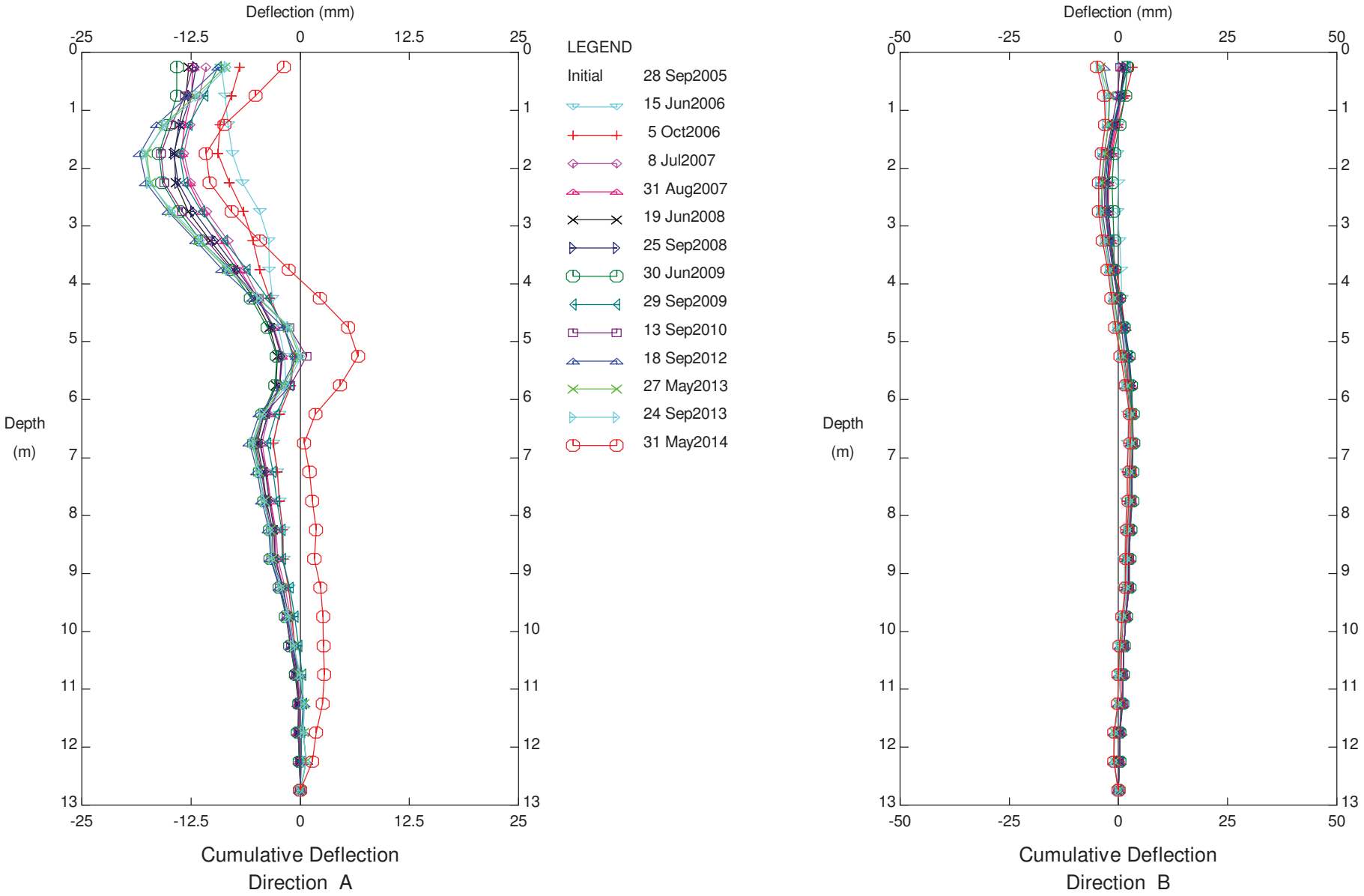


91CD-1, Inclinometer 1+767

Canal Dyke 91CD-1 Sta 1+767 A+ direction is 90

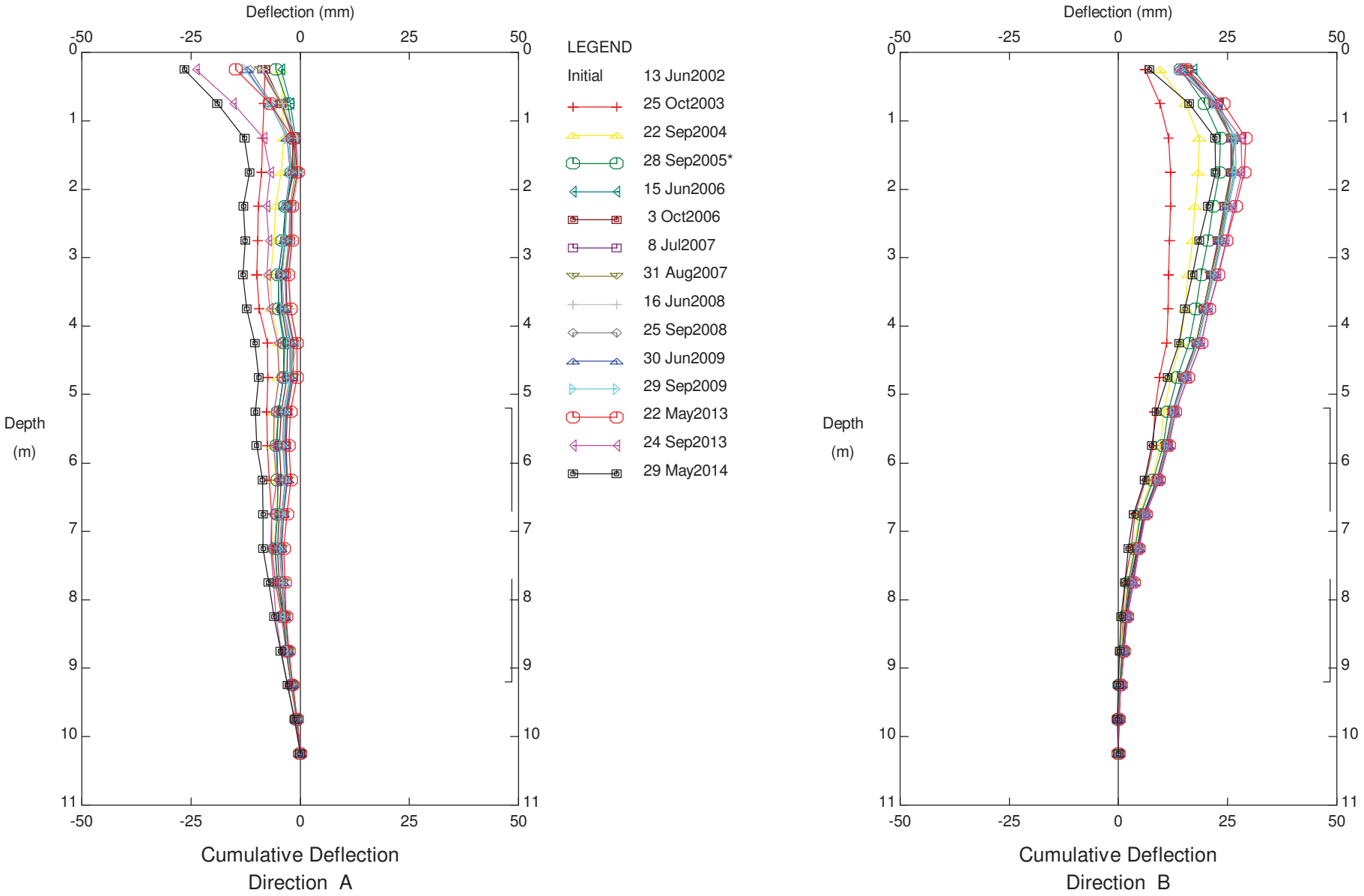
Sets marked * include zero shift and/or rotation corrections.

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Canal Dike, Inclinometer BGC05-08

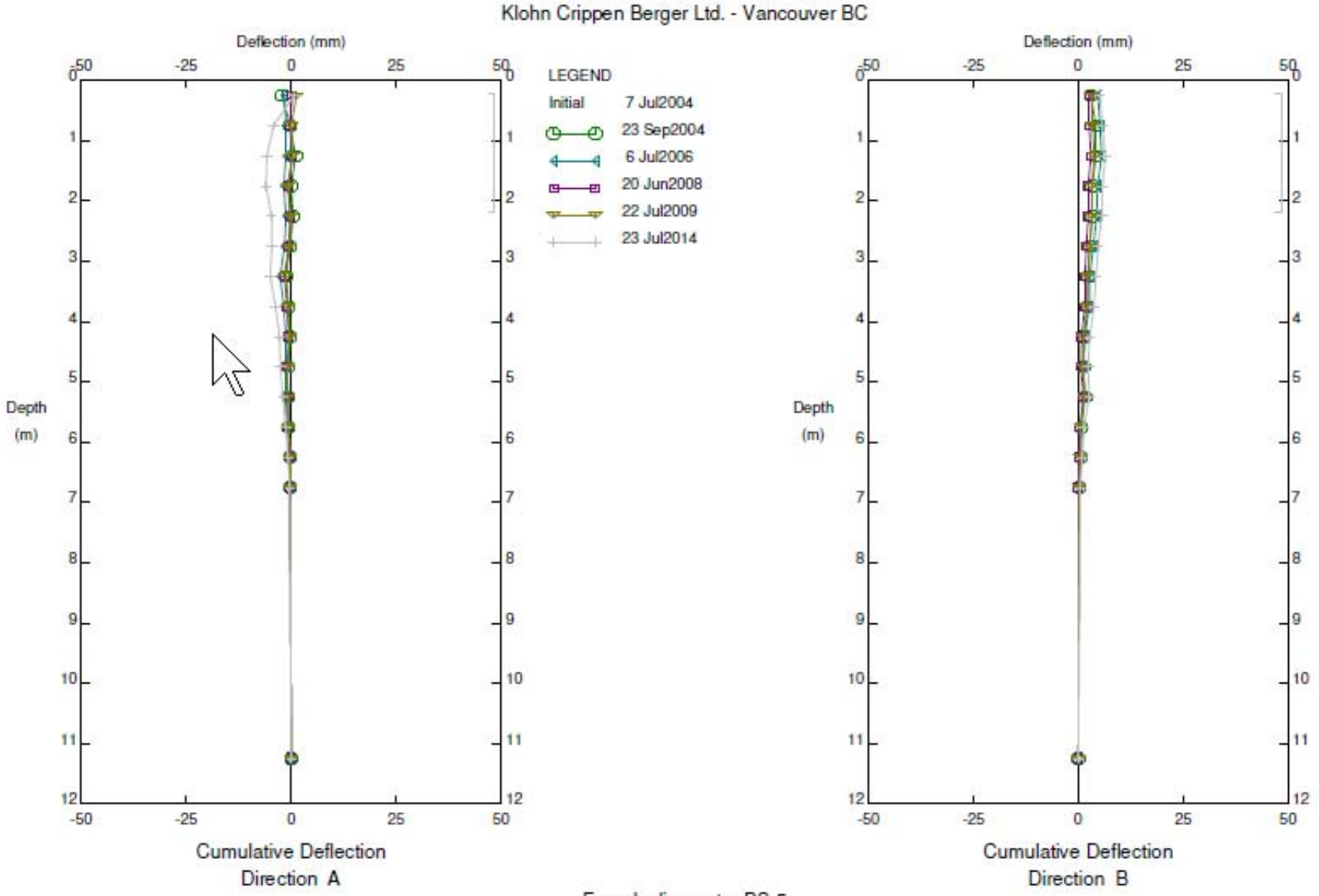
Klohn Crippen Berger Ltd. - Vancouver BC



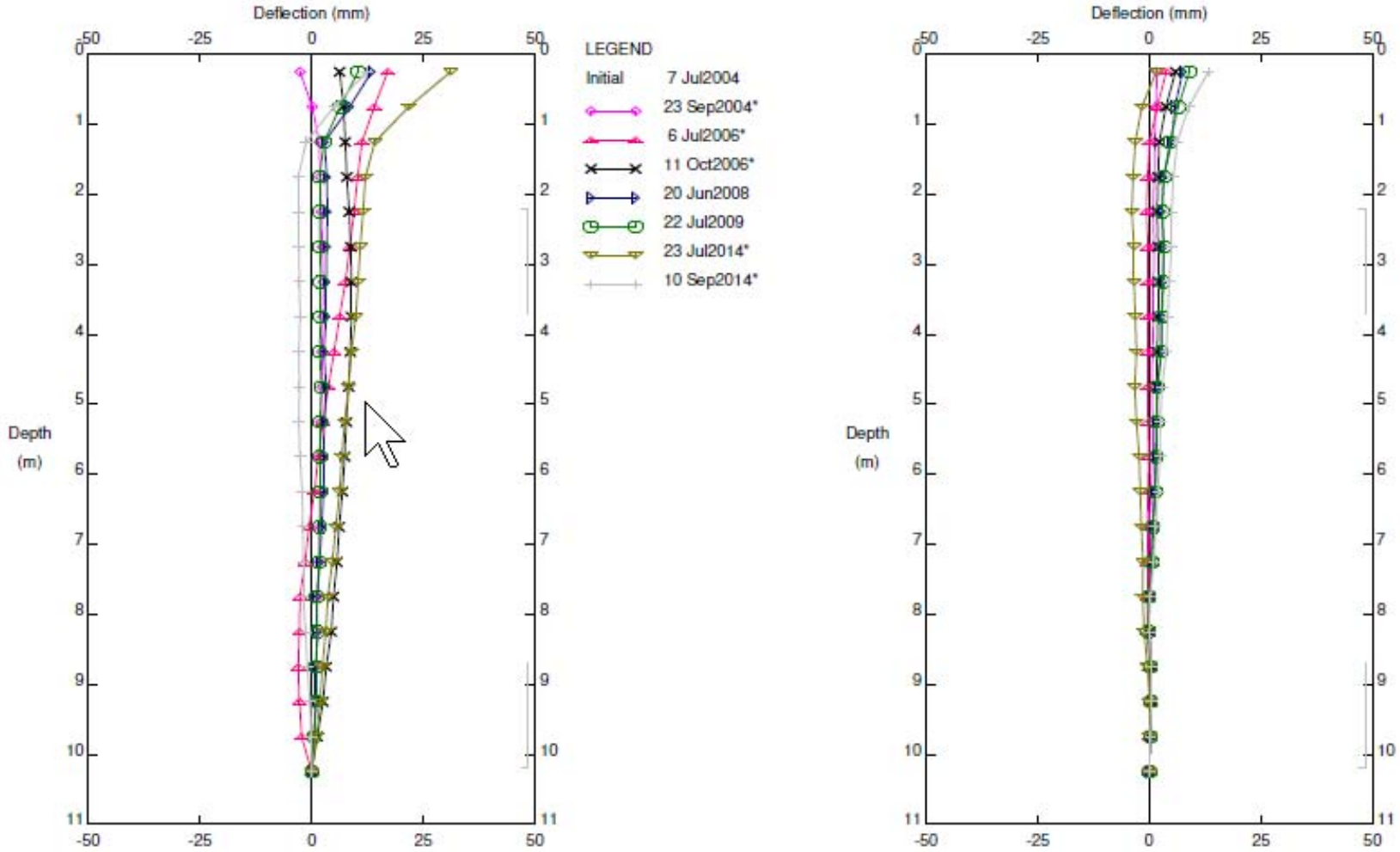
CD-21, Inclinometer 2+100

Canal Dyke CD-21 Sta 2+100 A+ direction is 50

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


Klohn Crippen Berger Ltd. - Vancouver BC
Deflection (mm)
-50
-25
0
25
50
LEGEND
Initial 7 Jul2004
23 Sep2004
6 Jul2006
20 Jun2008
22 Jul2009
23 Jul2014
Depth
(m)
0
1
2
3
4
5
6
7
8
9
10
11
12
Cumulative Deflection
Direction A
Deflection (mm)
Depth
(m)
Cumulative Deflection
Direction B
Faro, Inclinometer BS-5
Denison Environmental Service
Backslope of Canal Dyke

Klohn Crippen Berger Ltd. - Vancouver BC

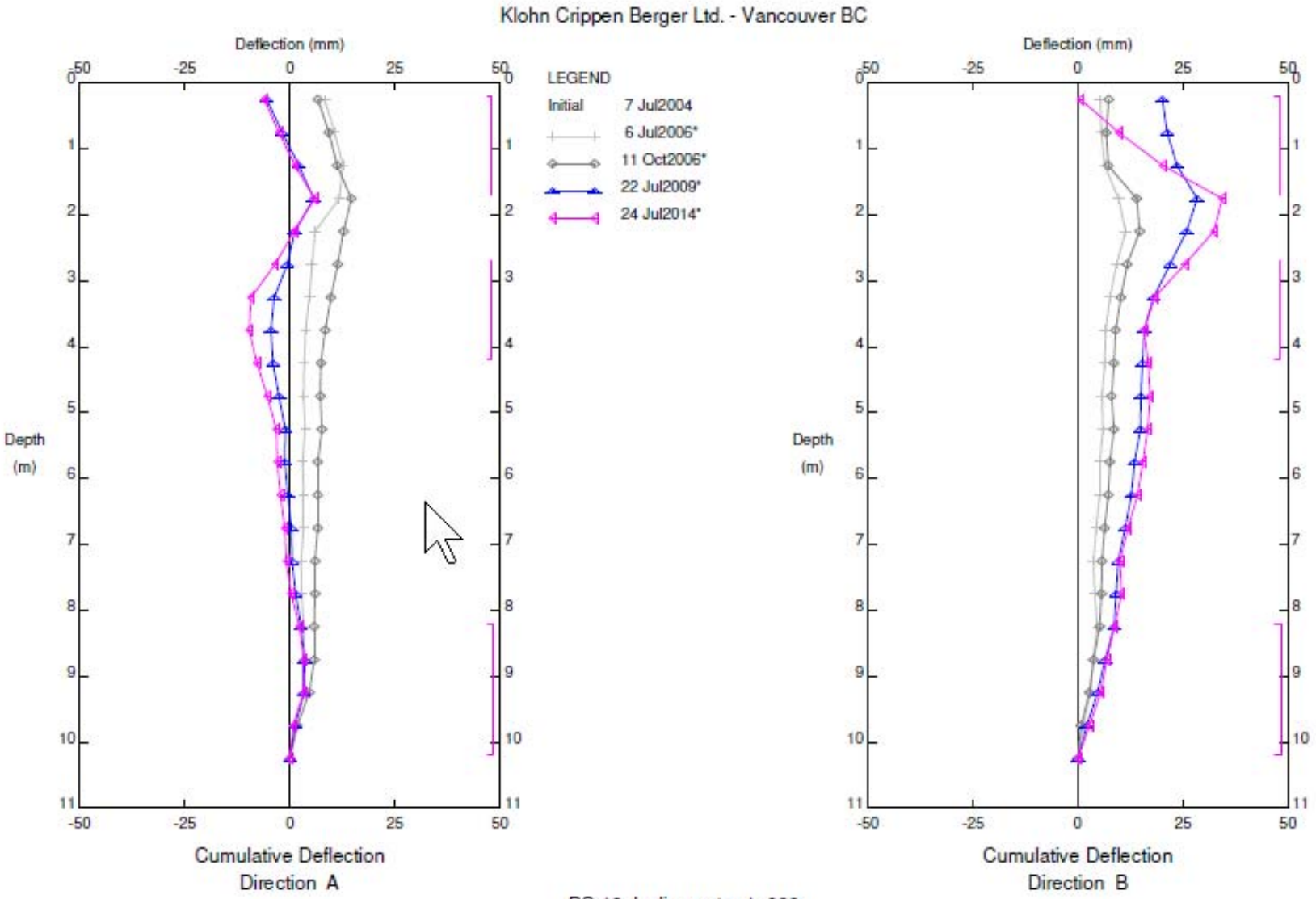


BS-9, Inclinometer 1+530

Denison Environmental Service

Back Slope BS-9 Sta 1+530 A+ direction is 110

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



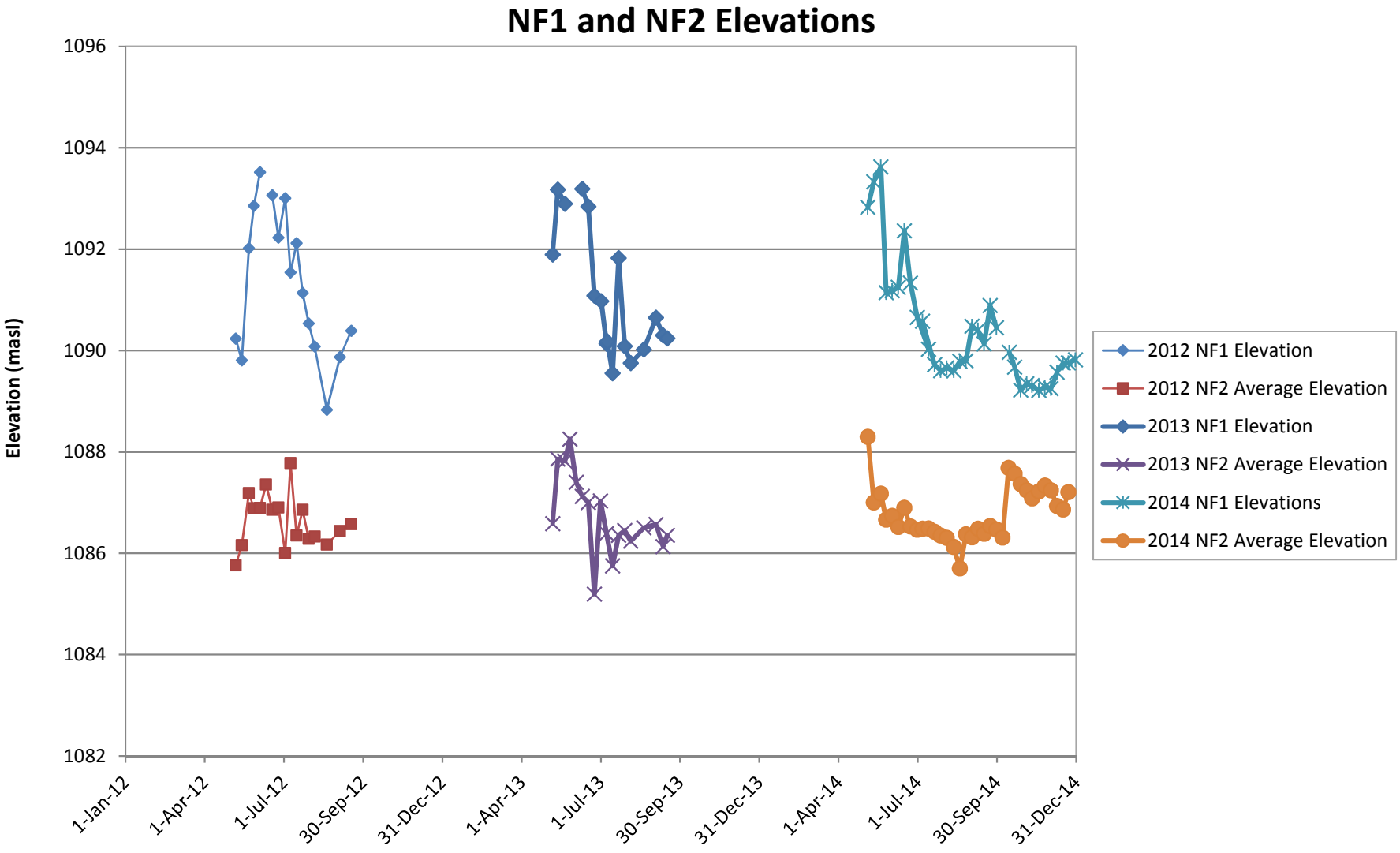
Backslope Subsoil Horizontal Deformation Profiles at Inclinometers BS-5, BS-9 and BS-10

APPENDIX II-F

North Fork Rock Drain

F1 – US and DS Water Levels

F1 – US and DS Water Levels


NF1 and NF2 Elevations
Elevation (masl)
1096
1094
1092
1090
1088
1086
1084
1082
1-Jan-12
1-Apr-12
1-Jul-12
30-Sep-12
31-Dec-12
1-Apr-13
1-Jul-13
30-Sep-13
31-Dec-13
1-Apr-14
1-Jul-14
30-Sep-14
31-Dec-14
2012 NF1 Elevation
2012 NF2 Average Elevation
2013 NF1 Elevation
2013 NF2 Average Elevation
2014 NF1 Elevations
2014 NF2 Average Elevation

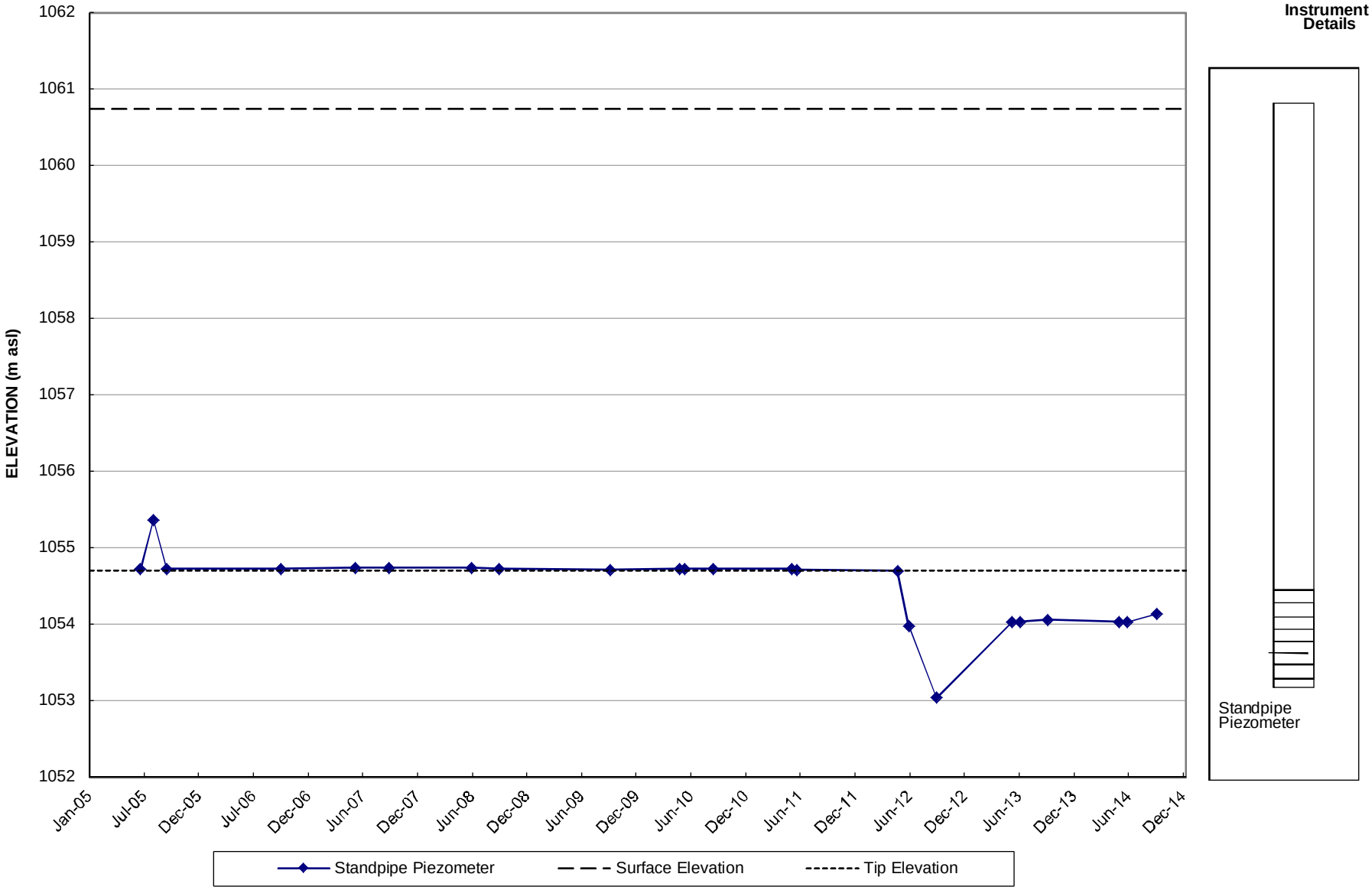
APPENDIX II-G

Secondary Tailings Impoundment

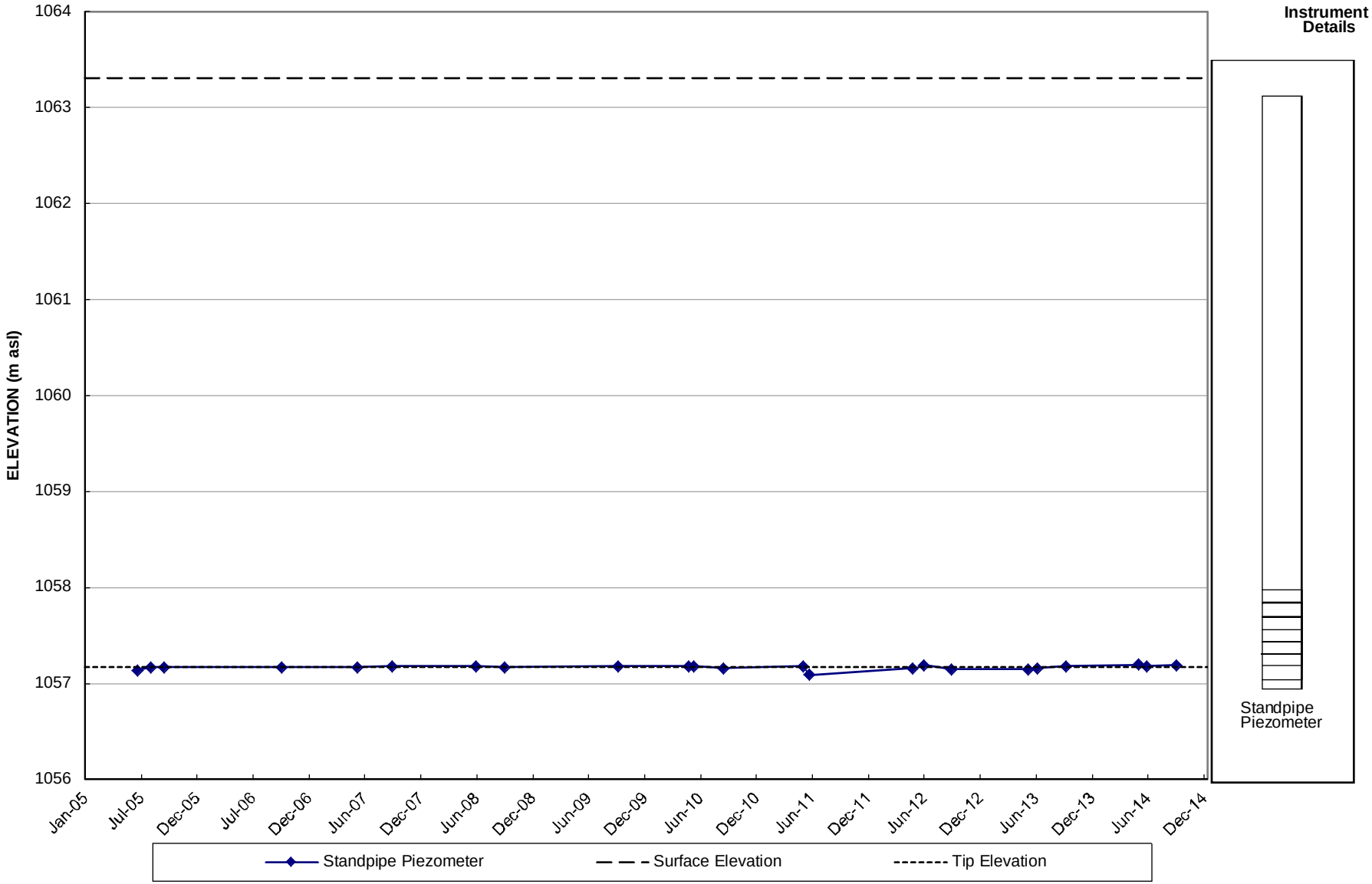
G1 – Piezometers

G1 – Piezometers

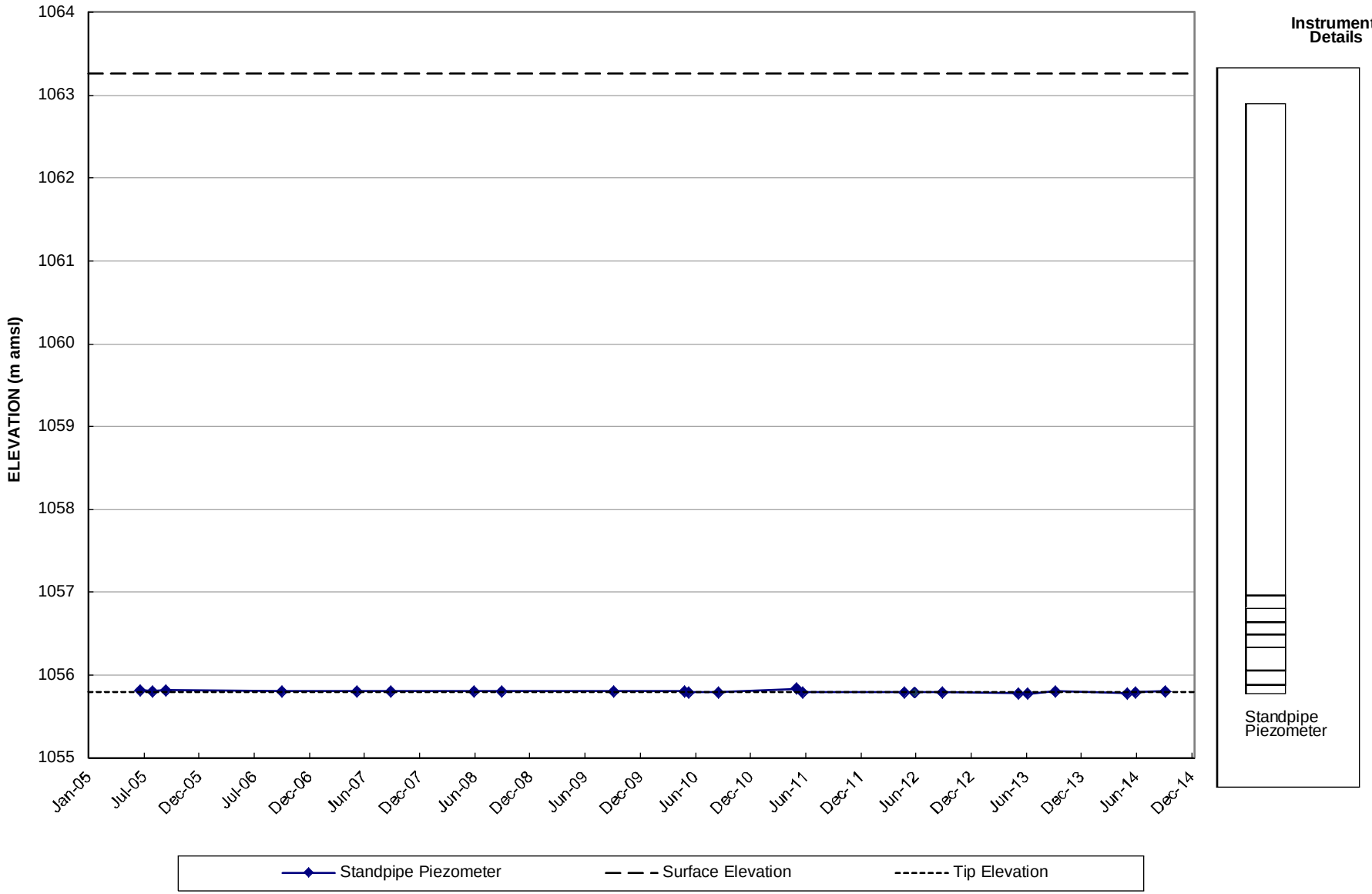
Secondary Tailings Dam
Piezometer P81-06



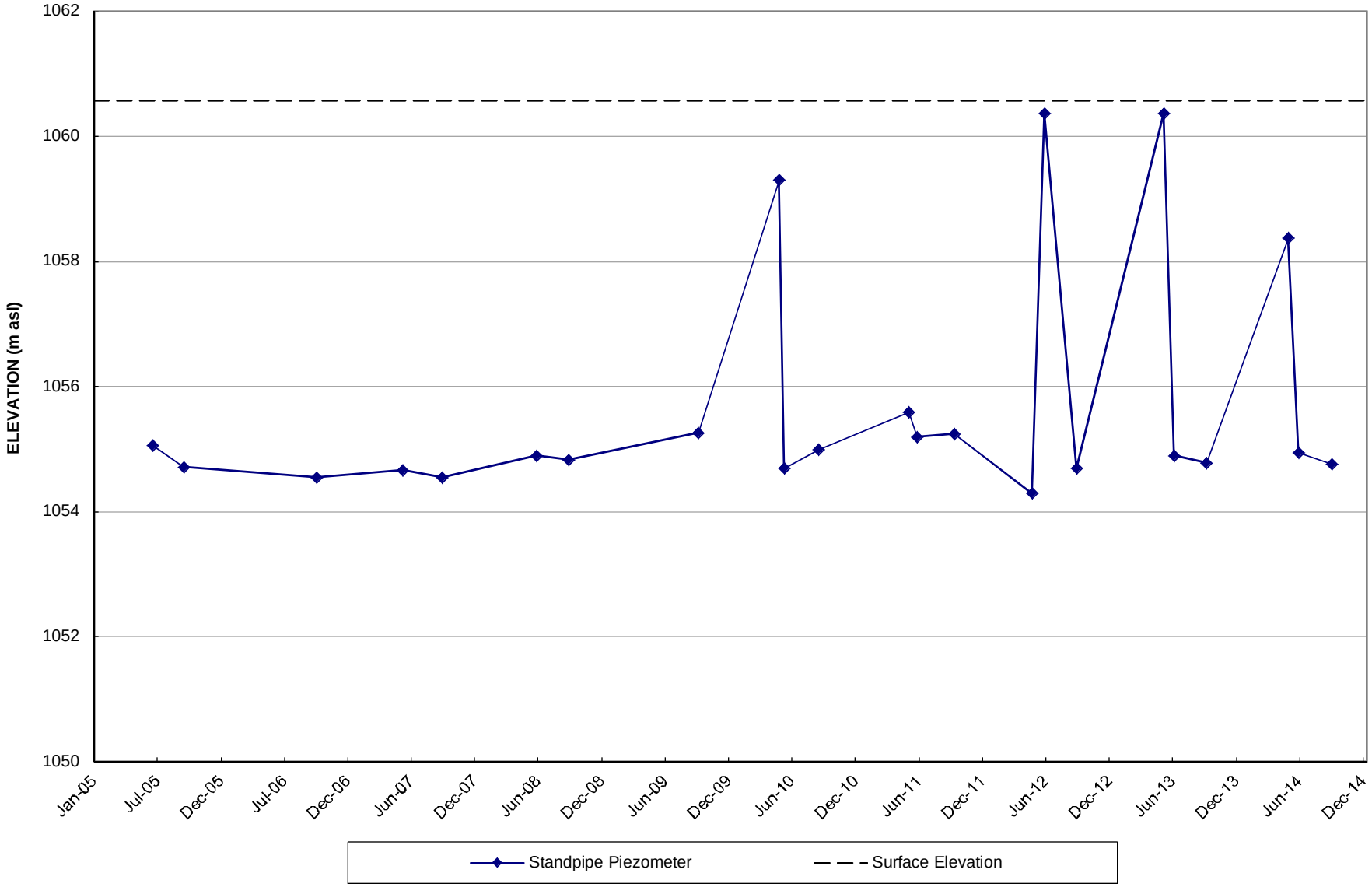
Secondary Tailings Dam
Piezometer P81-07



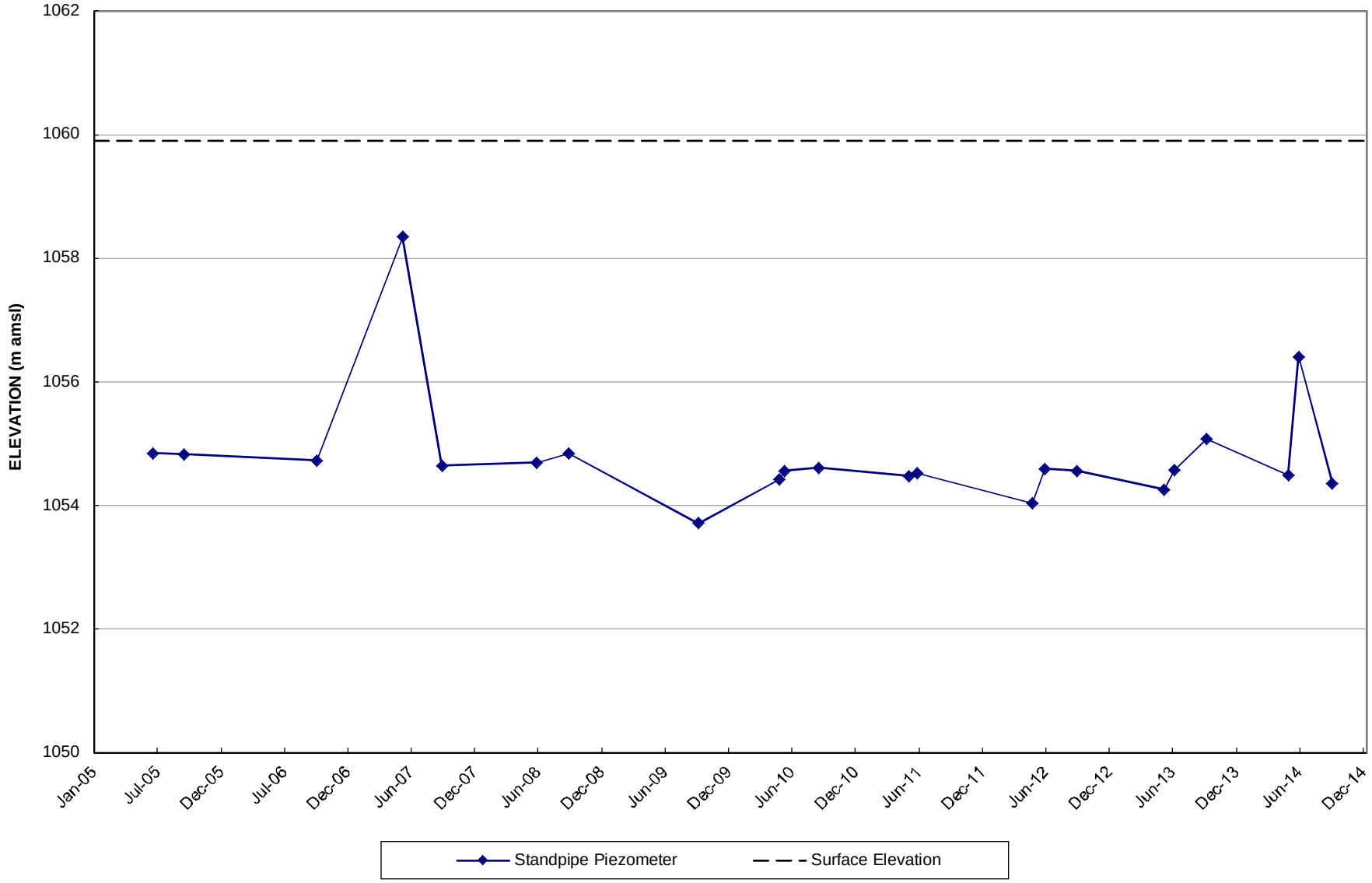
Secondary Tailings Dam
Piezometer P81-08



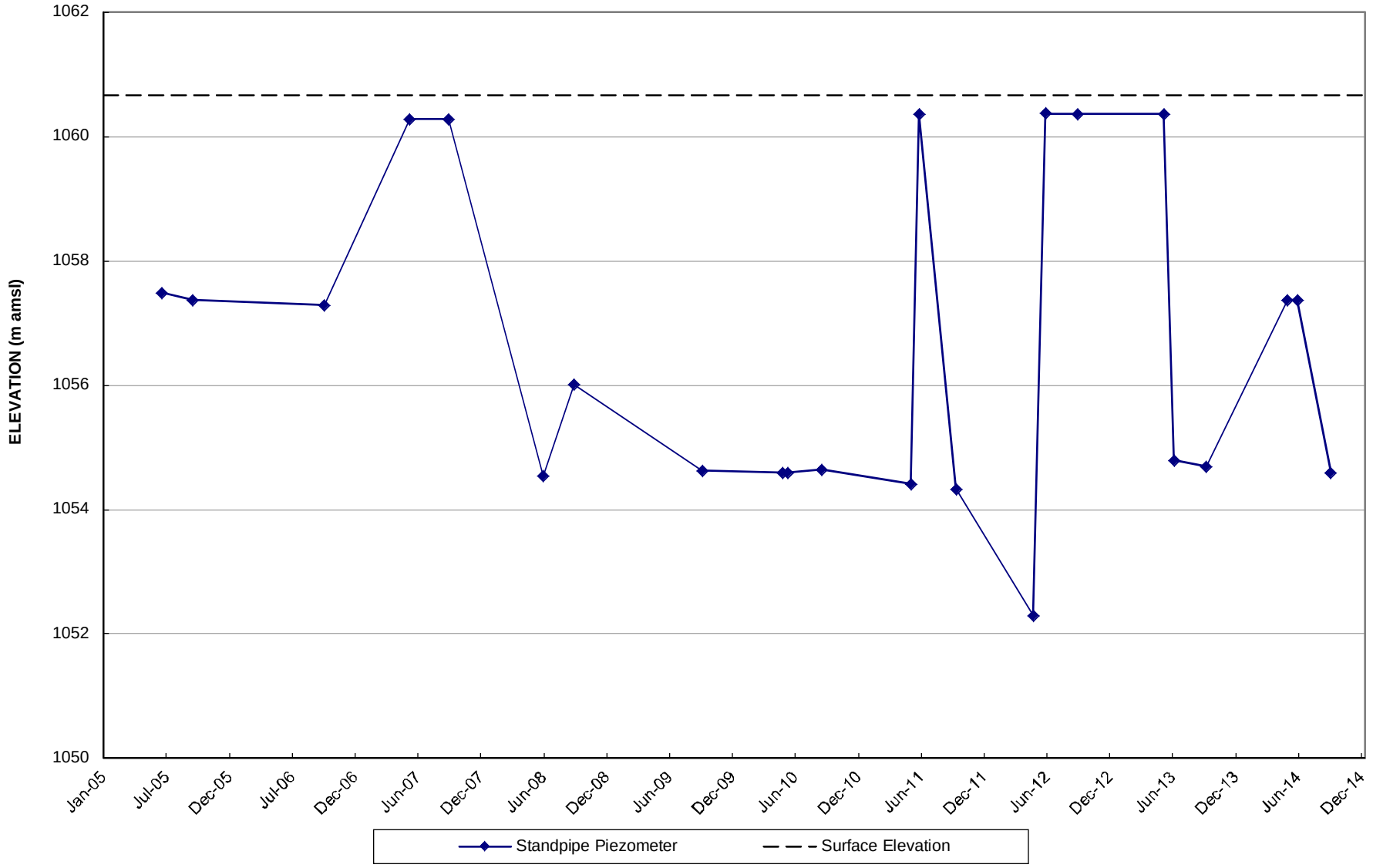
Secondary Tailings Dam
Piezometer P03-01



Secondary Tailings Dam
Piezometer P03-02



Secondary Tailings Dam
Piezometer P03-03



APPENDIX II-H

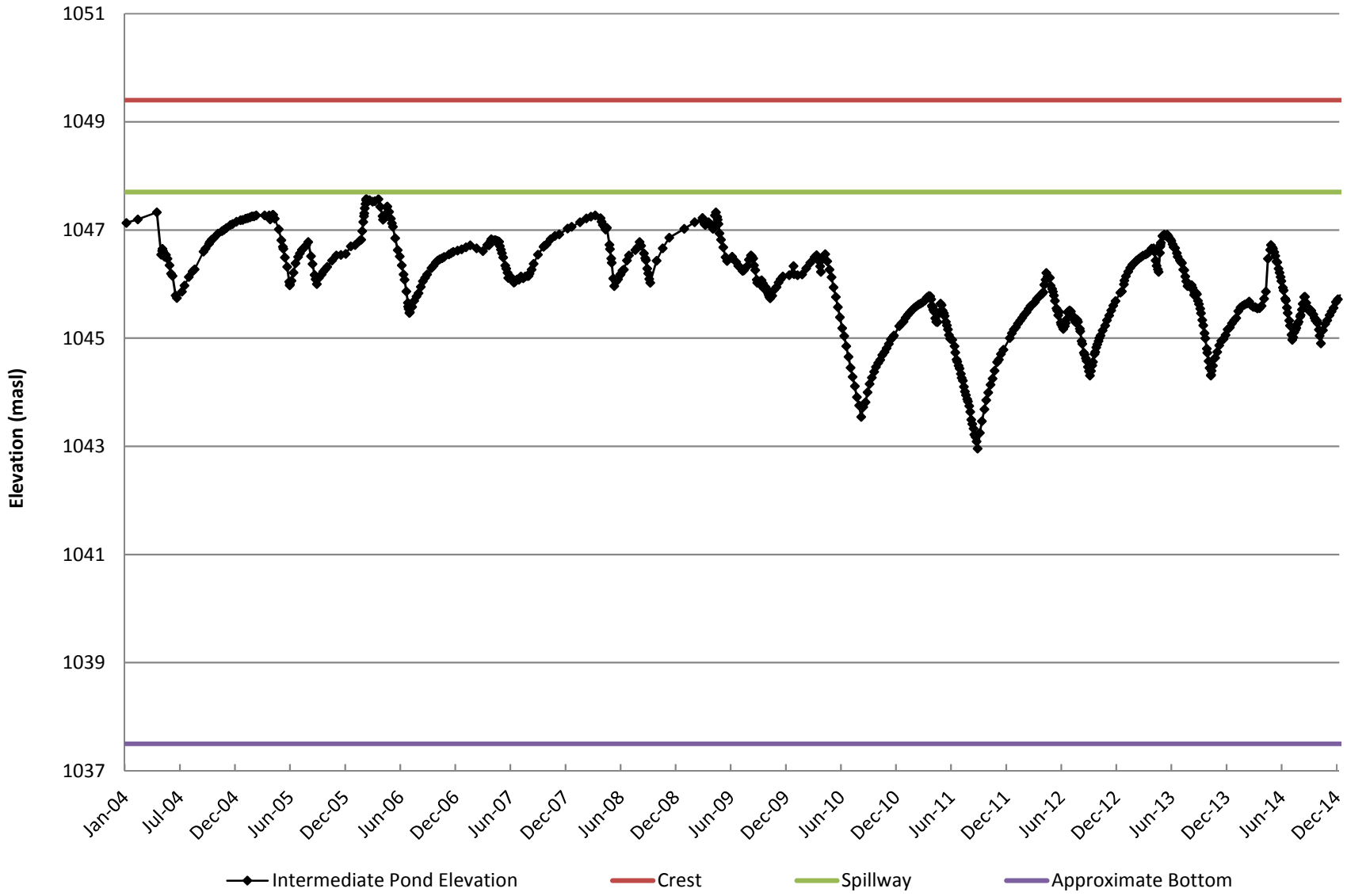
Intermediate Dam

H1 – Pond Level (Intermediate Pond)

H2 – Piezometers

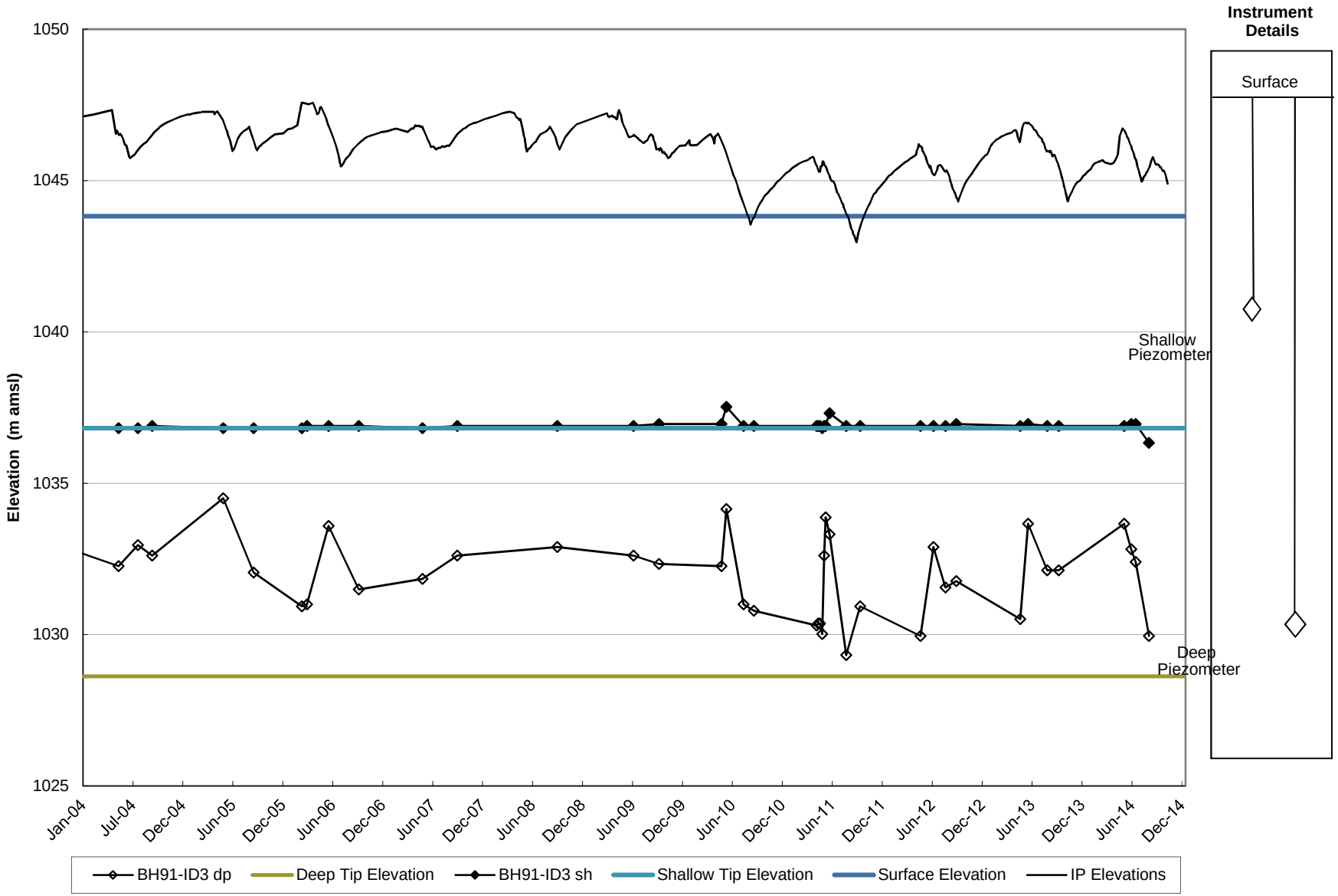
H1 – Pond Level (Intermediate Pond)

Intermediate Pond Water Level

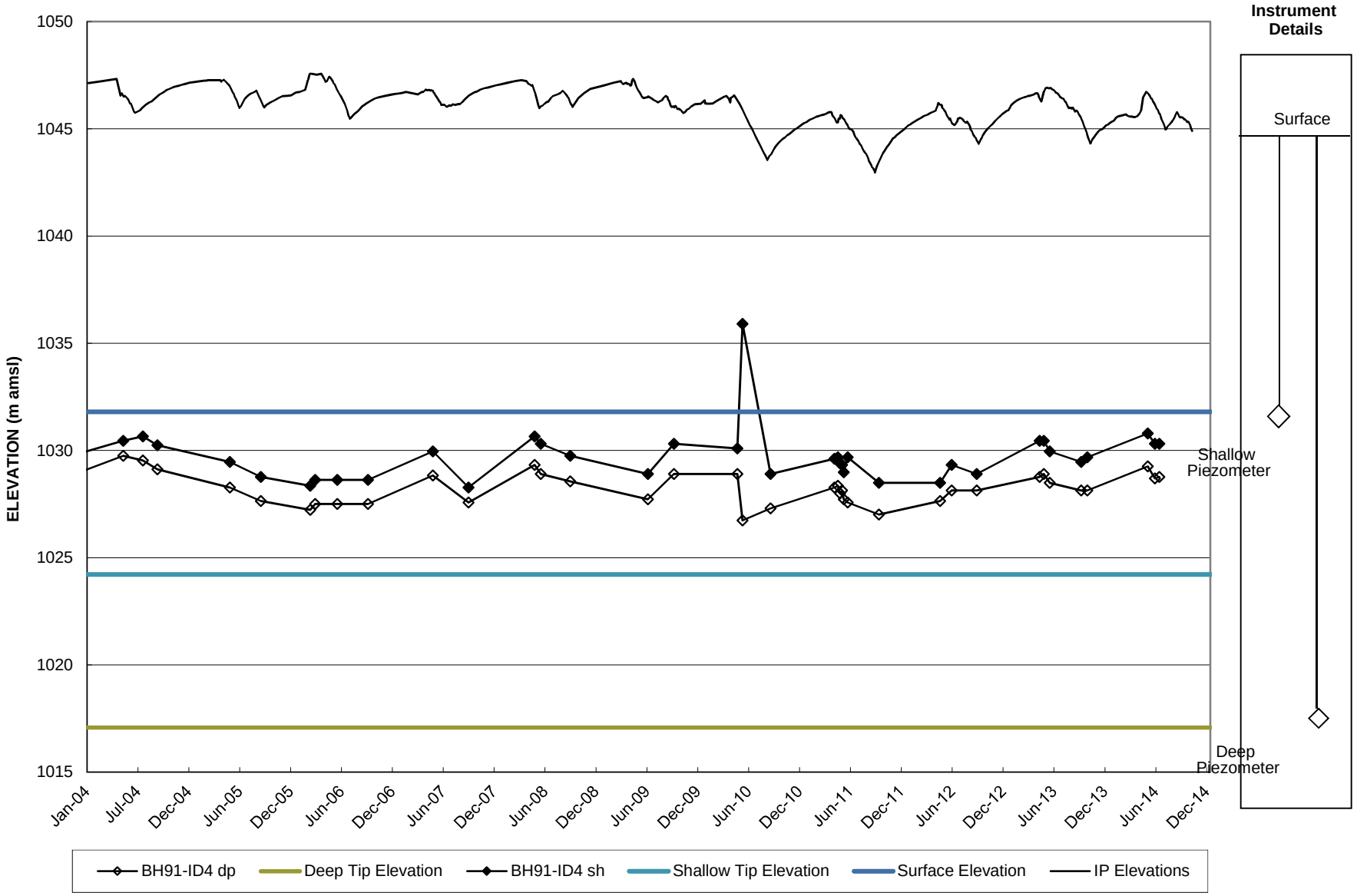


H2 – Piezometers

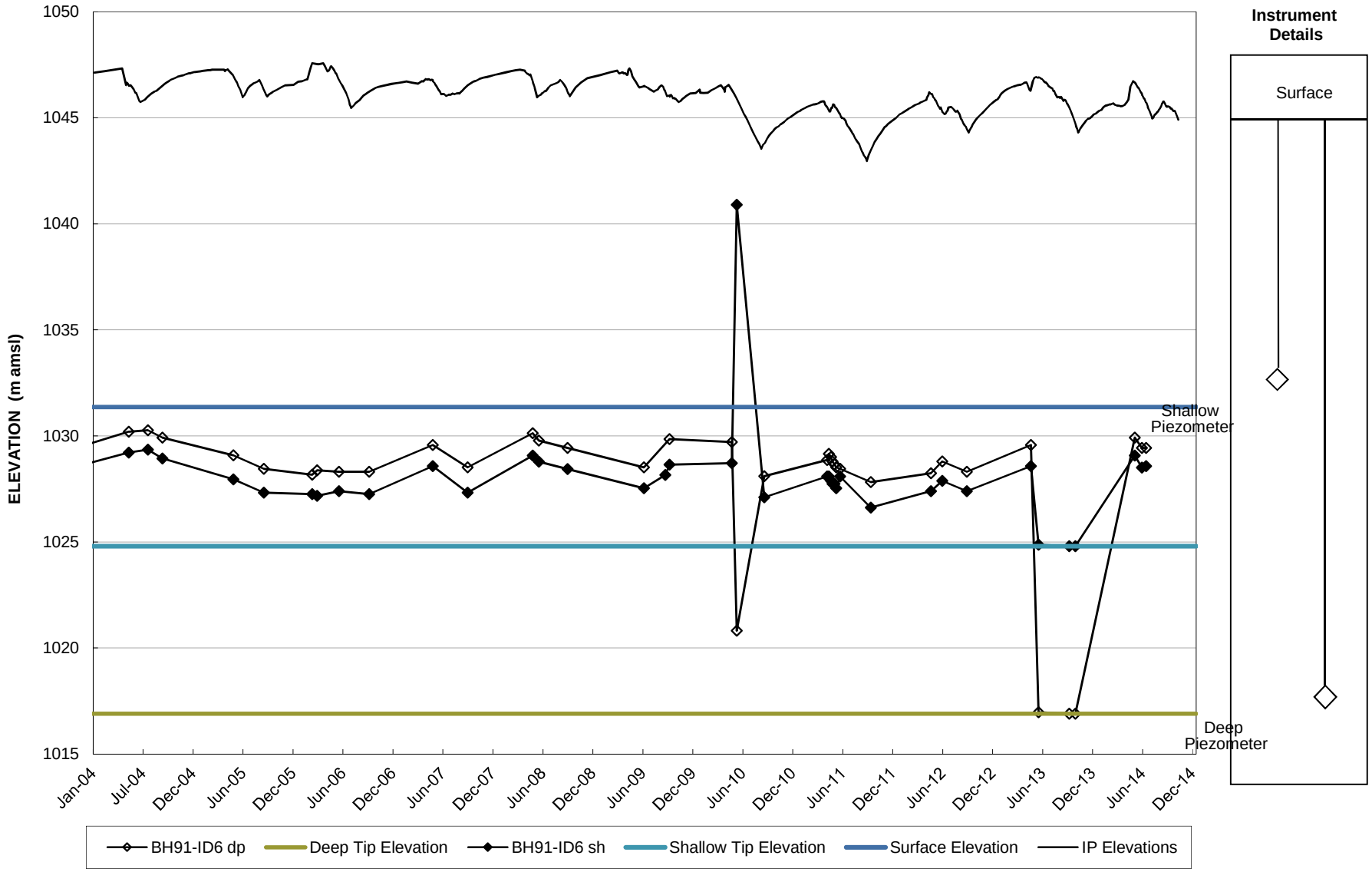
Intermediate Dam
Piezometer BH91-ID3



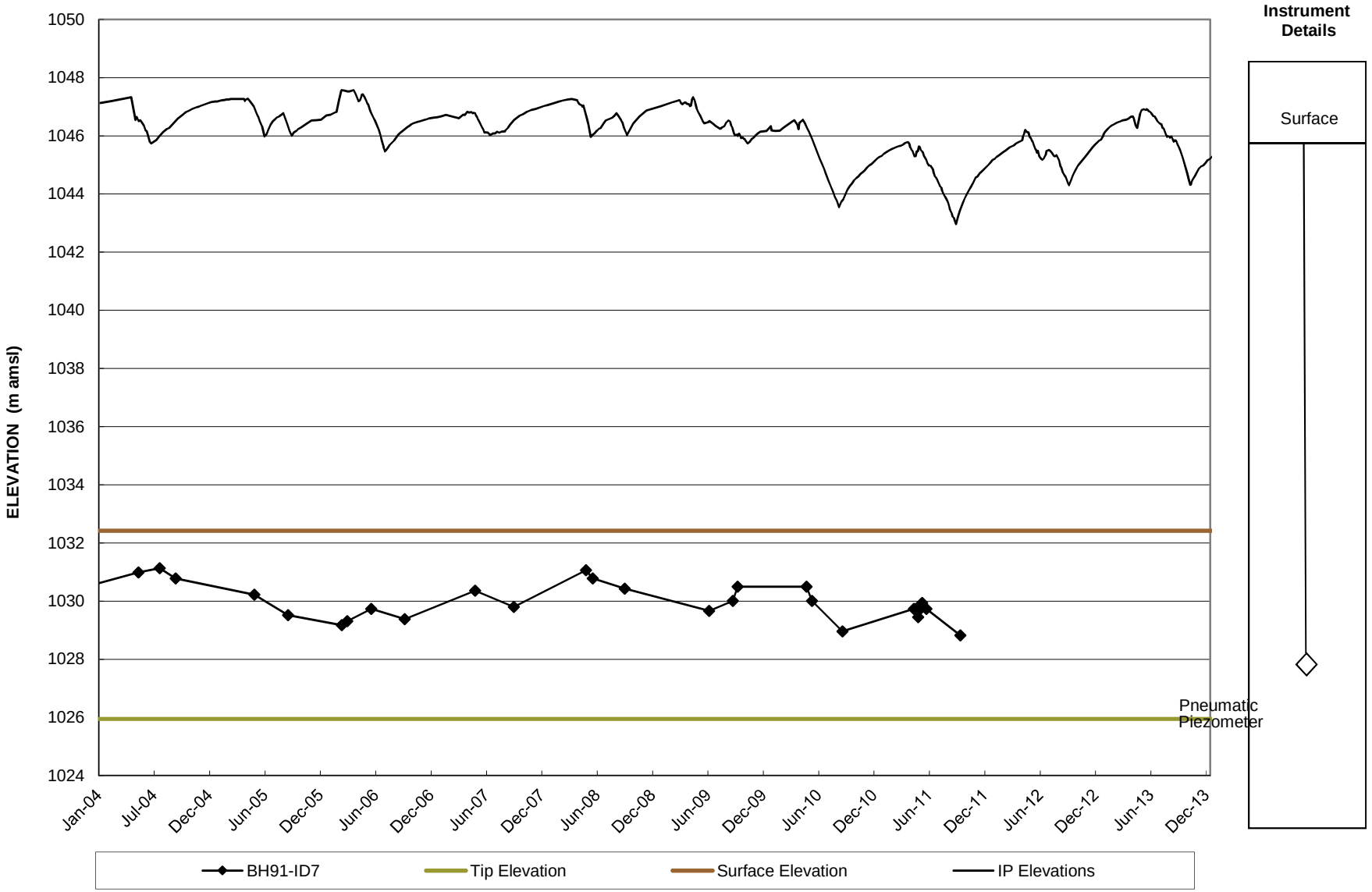
Intermediate Dam
Piezometer BH91-ID4



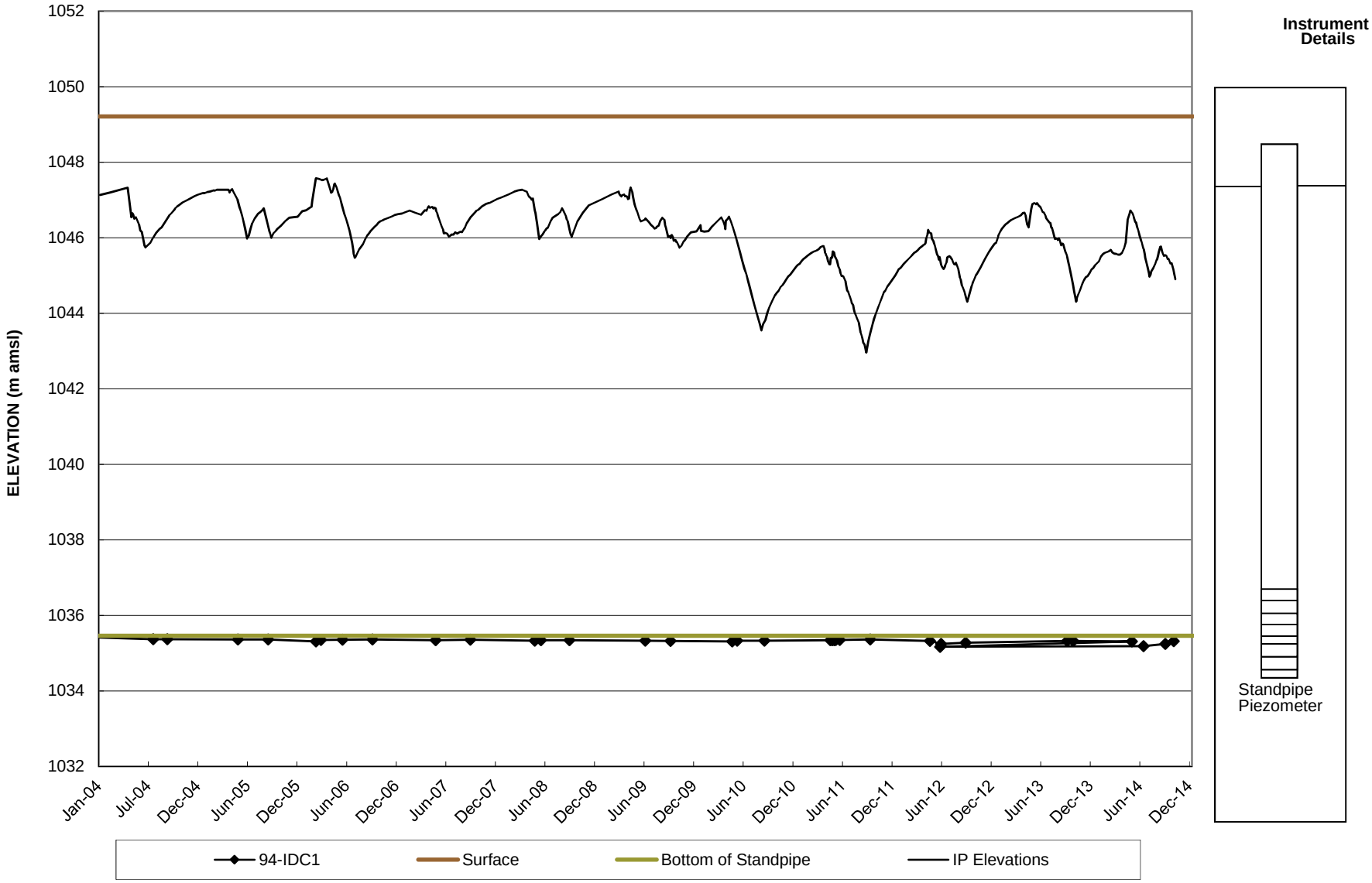
Intermediate Dam
Piezometer BH91-ID6



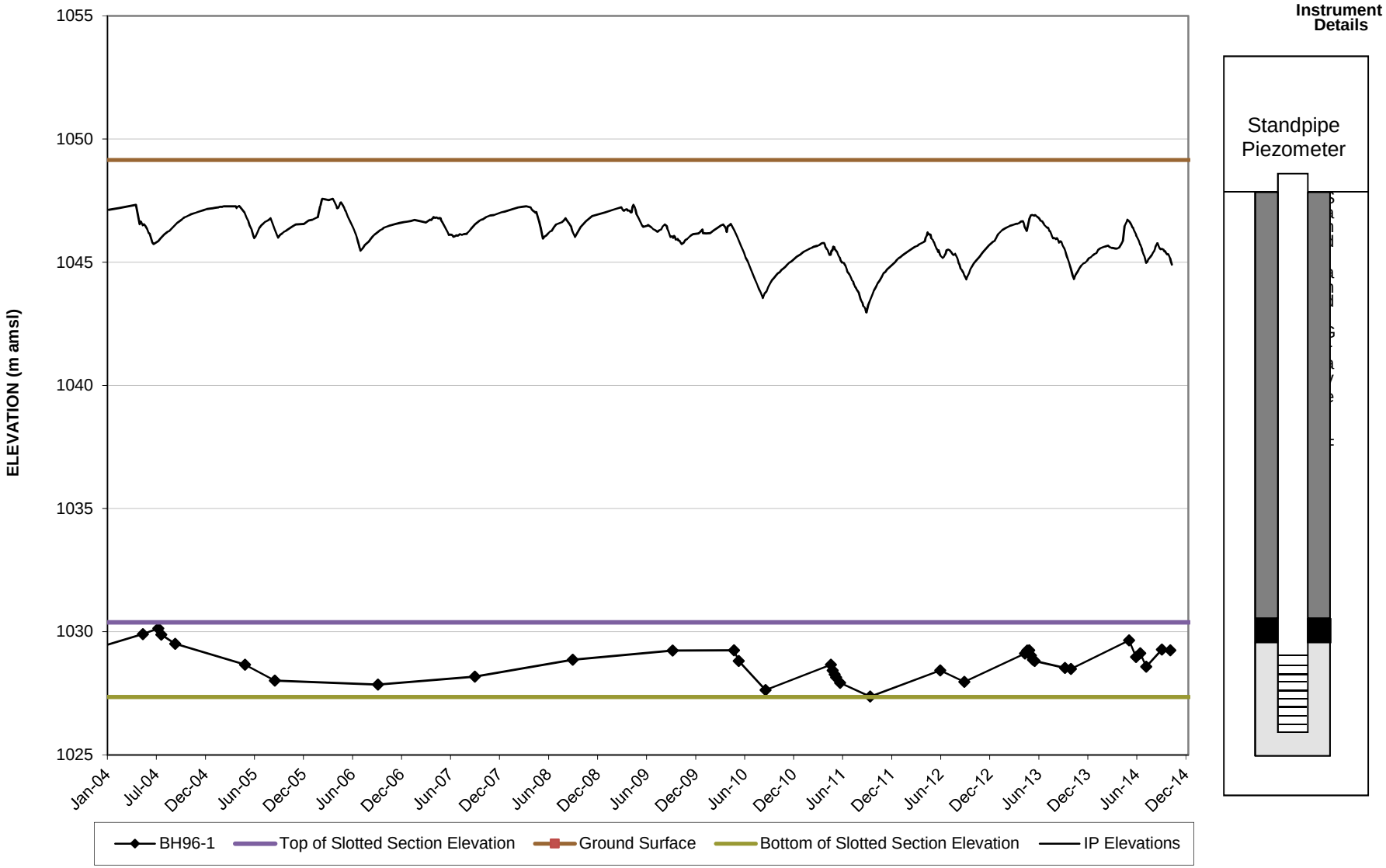
Intermediate Dam
Piezometer BH91-ID7



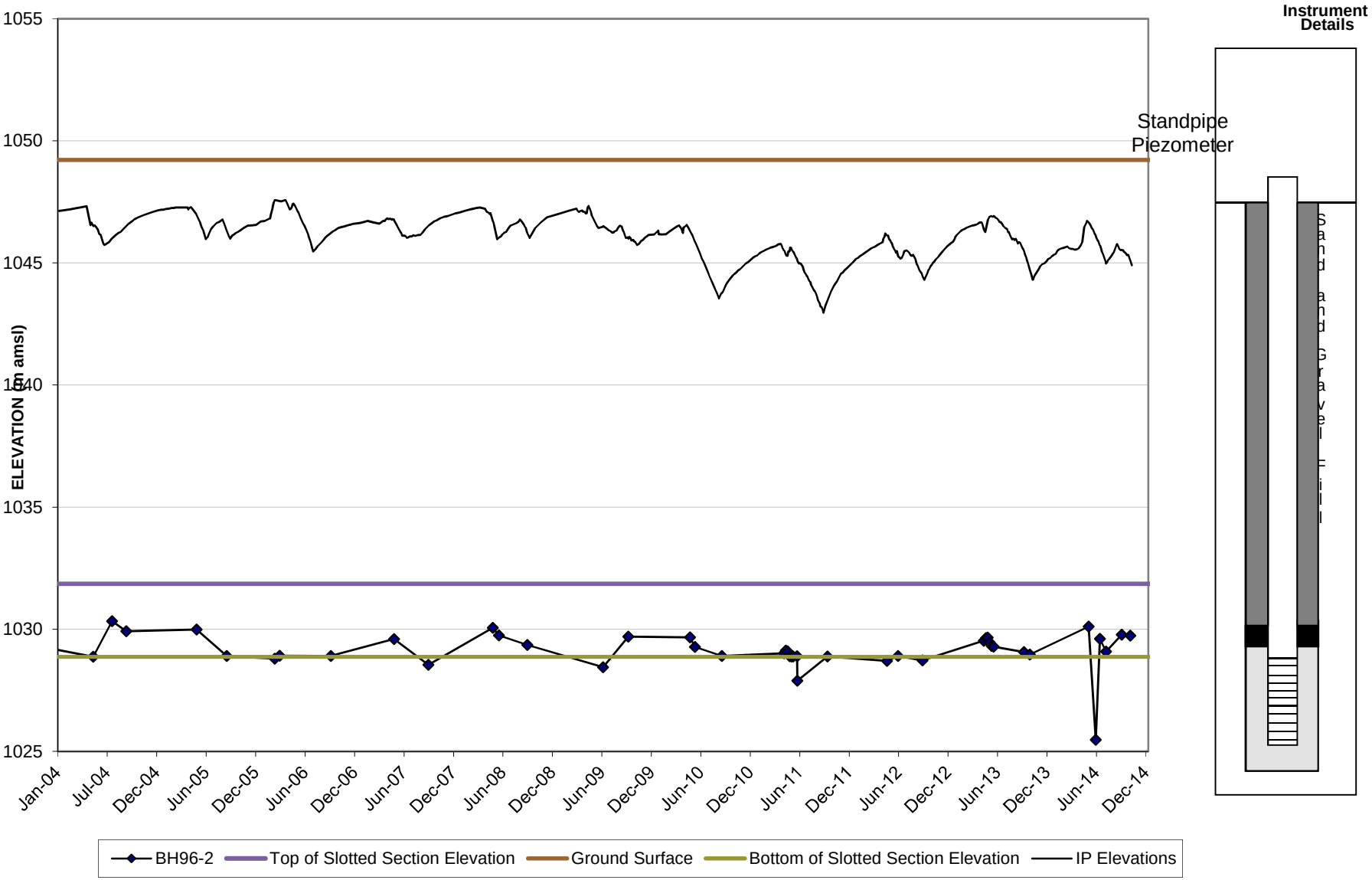
Intermediate Dam
Piezometer BH94-IDC-1



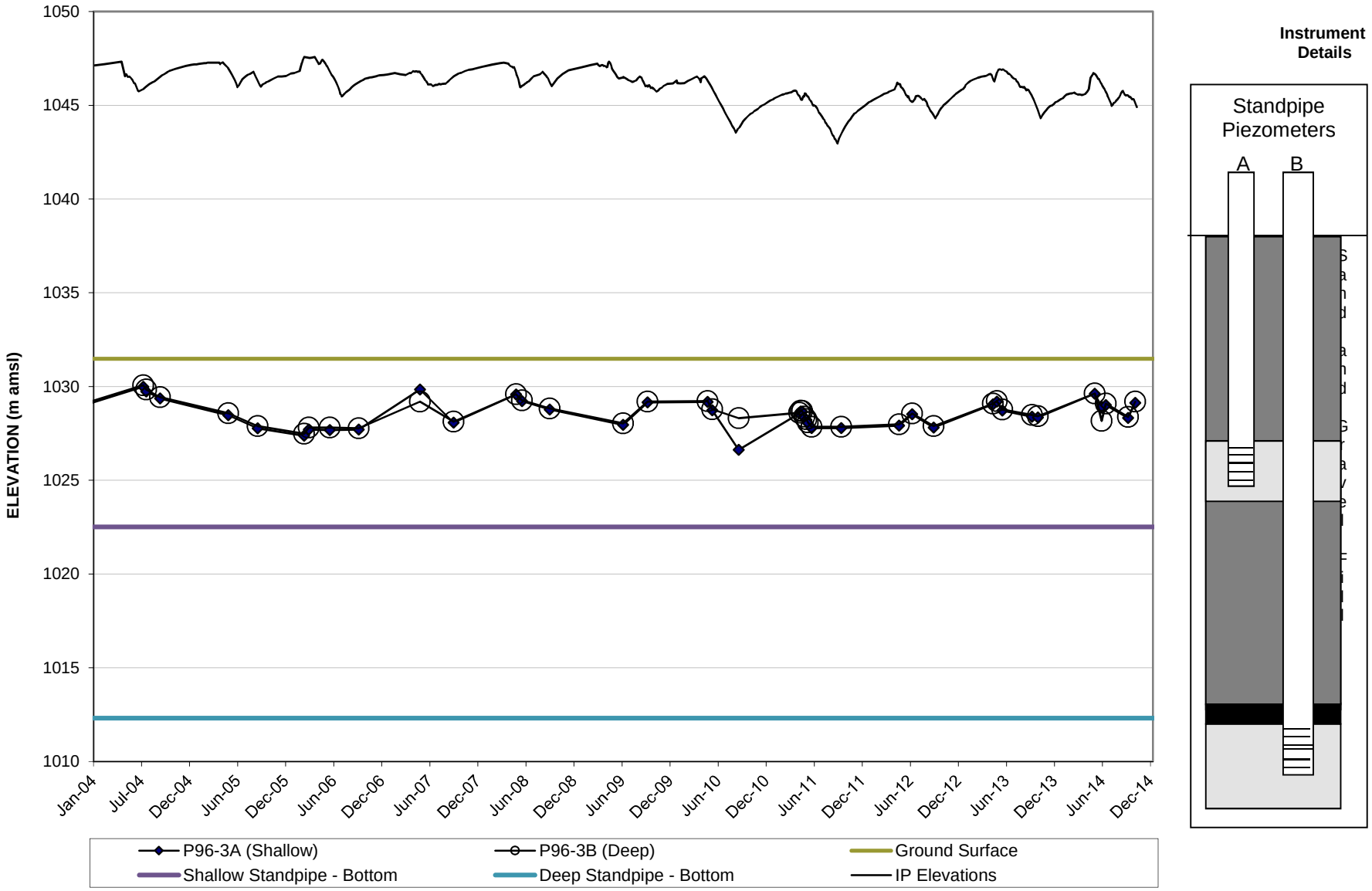
Intermediate Dam
Piezometer BH96-1



Intermediate Dam
Piezometer BH96-2

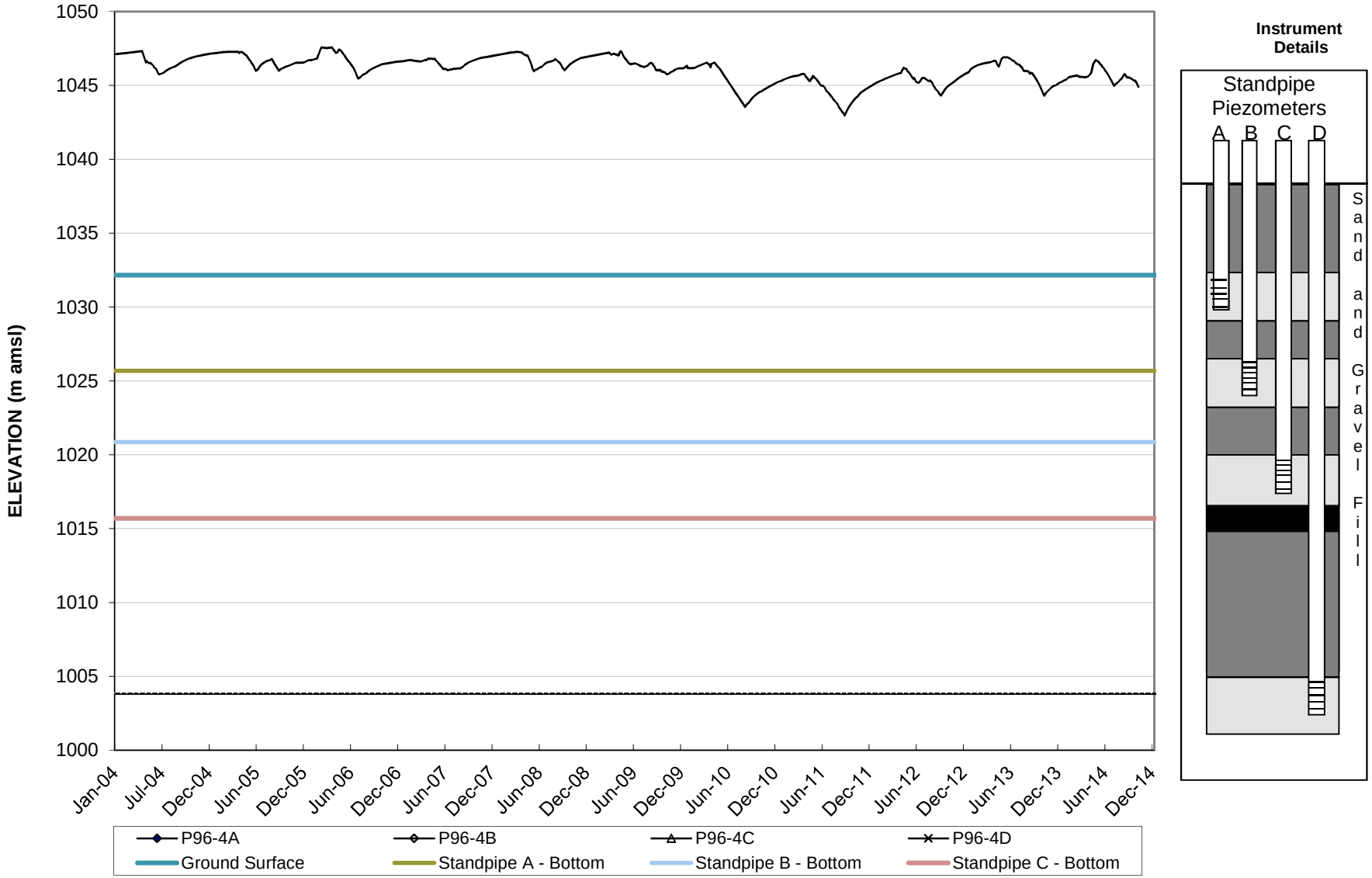


Intermediate Dam
Piezometer BH96-3

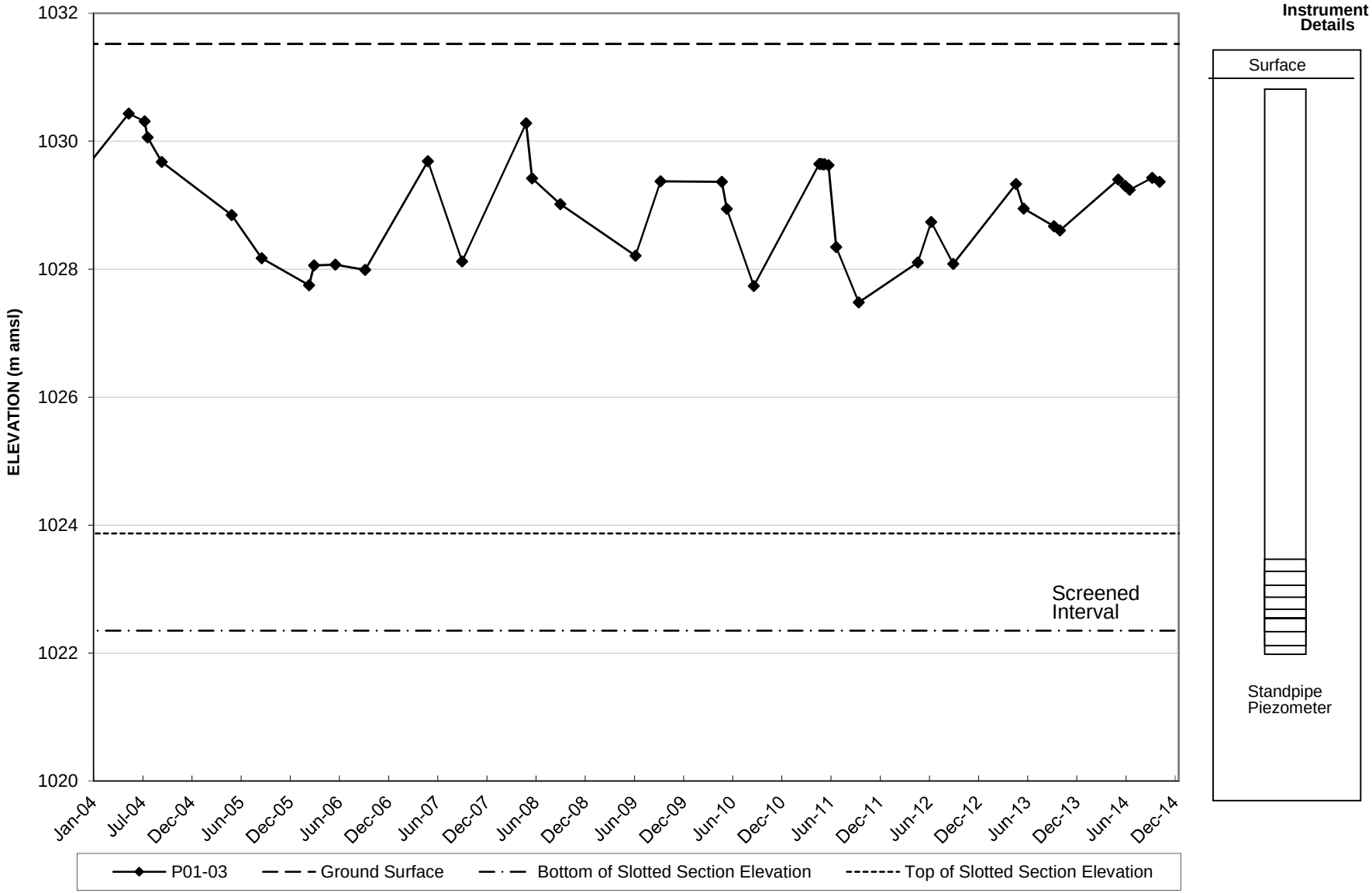


Instrument Details

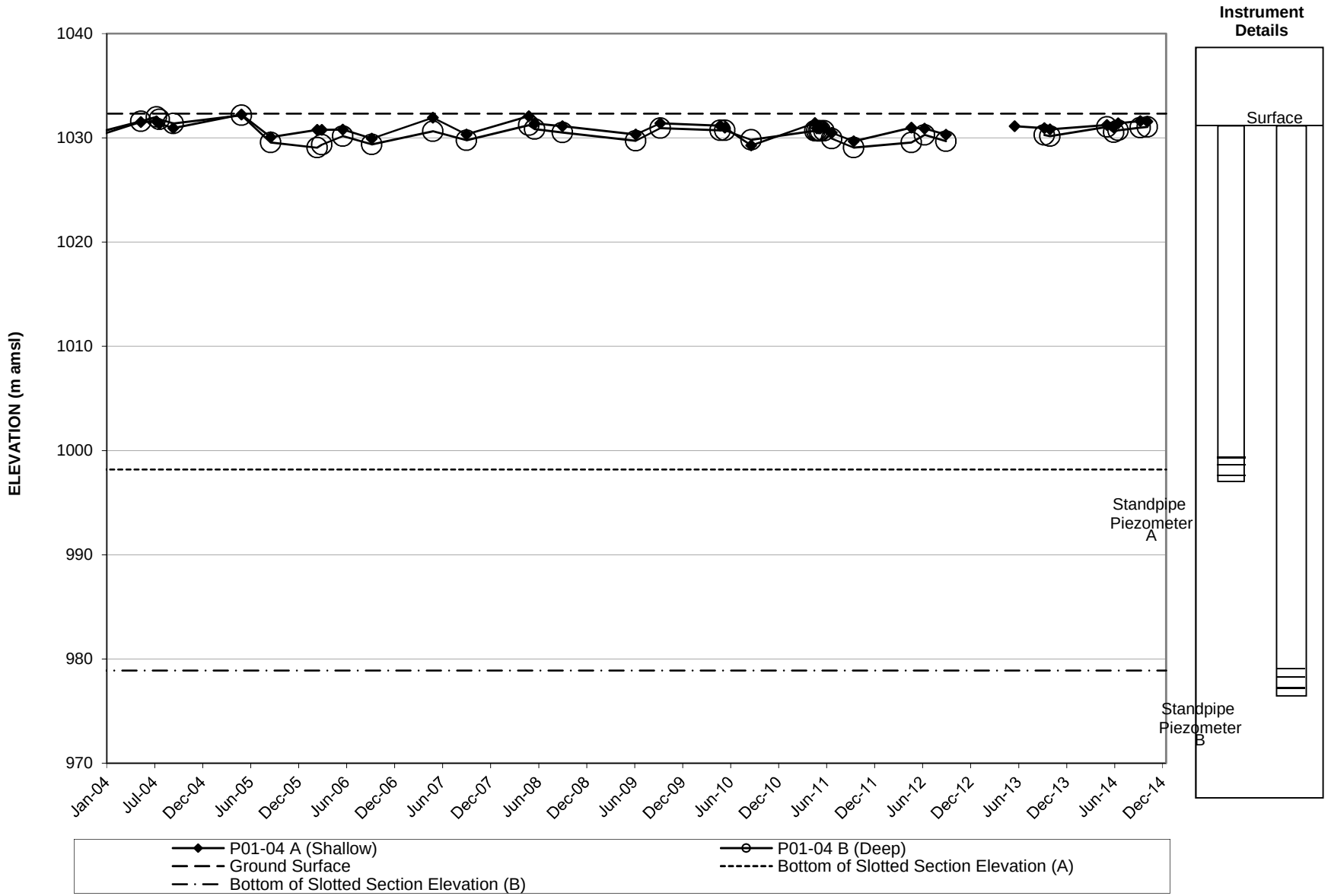
Intermediate Dam
Piezometer BH96-4



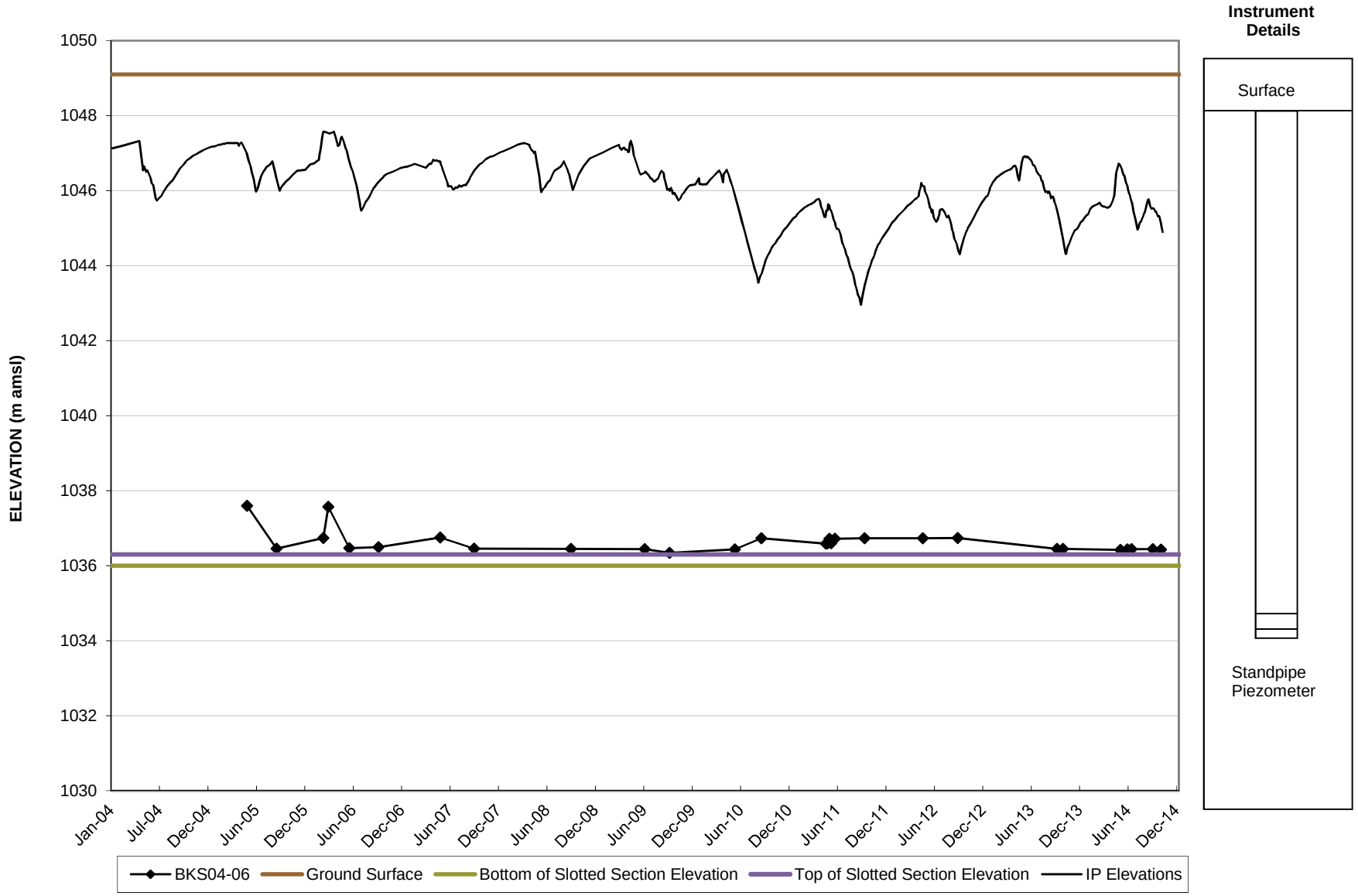
Intermediate Dam
Piezometer P01-03



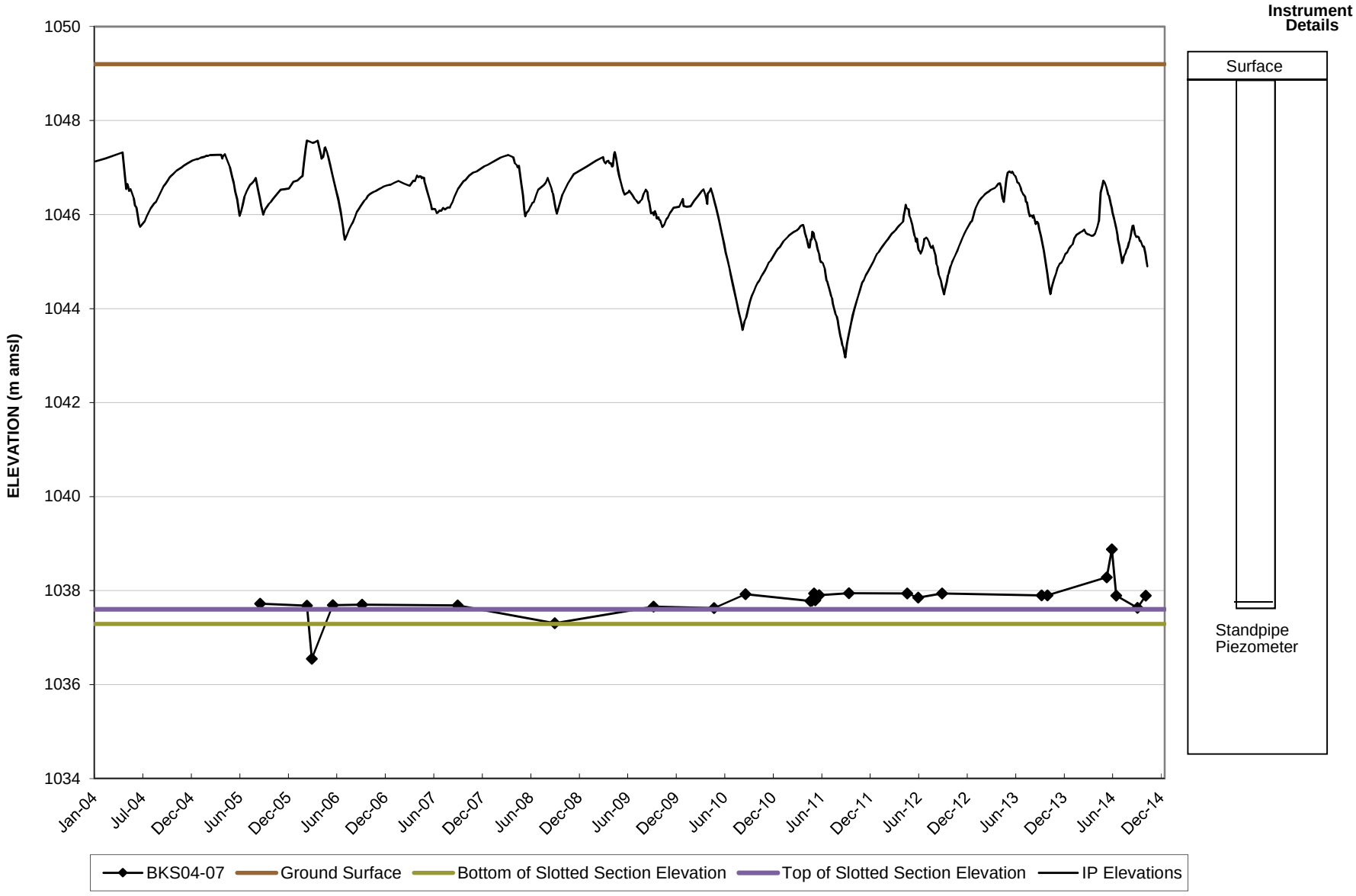
Intermediate Dam
Piezometer P01-04



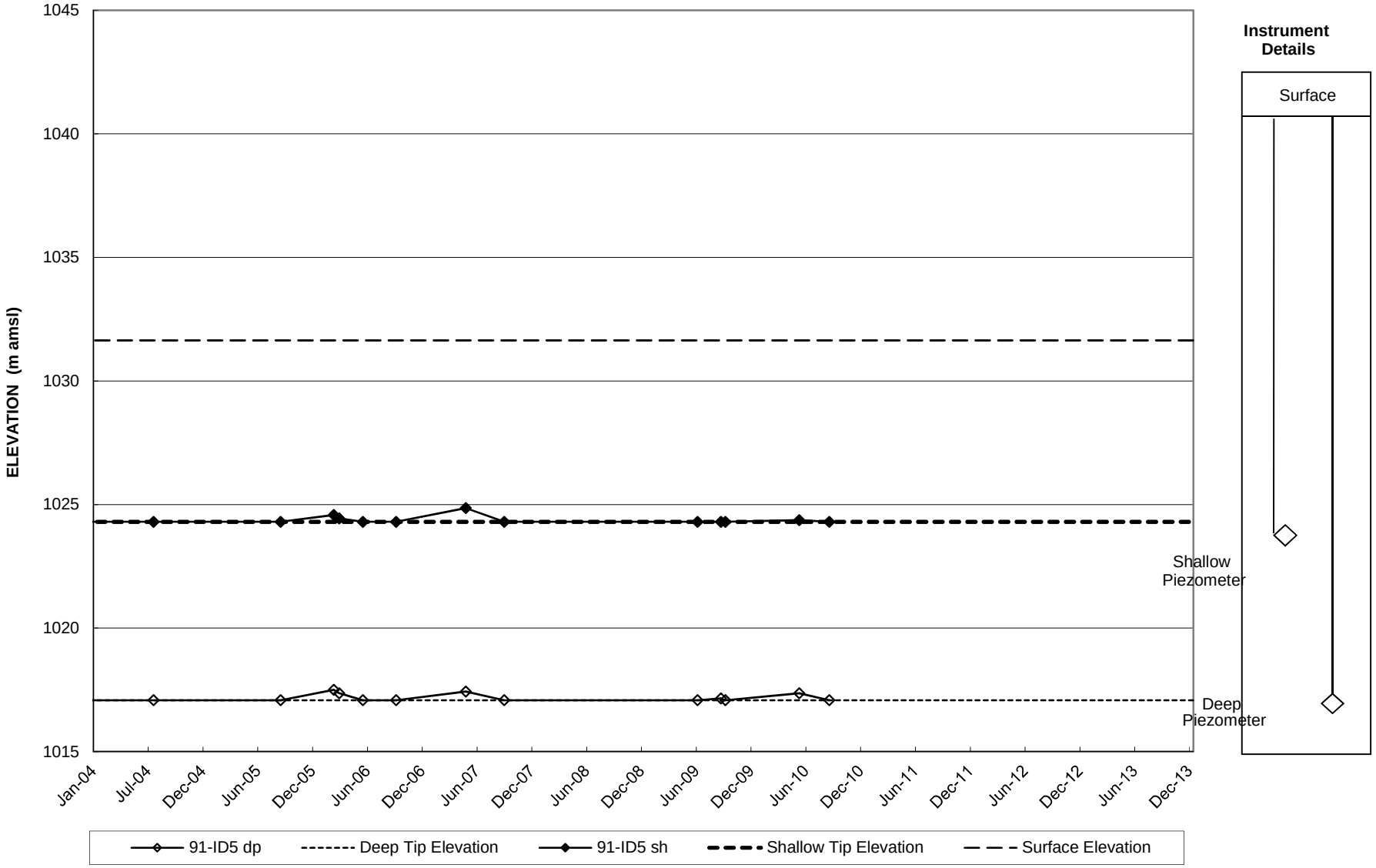
Intermediate Dam
Piezometer BKS04-06



Intermediate Dam
Piezometer BKS04-07



Piezometric Monitoring
BH91-ID5 Pneumatic Piezometer (Both Tips)



APPENDIX II-I

Cross Valley Dam

I1 – Pond Level (Polishing Pond)

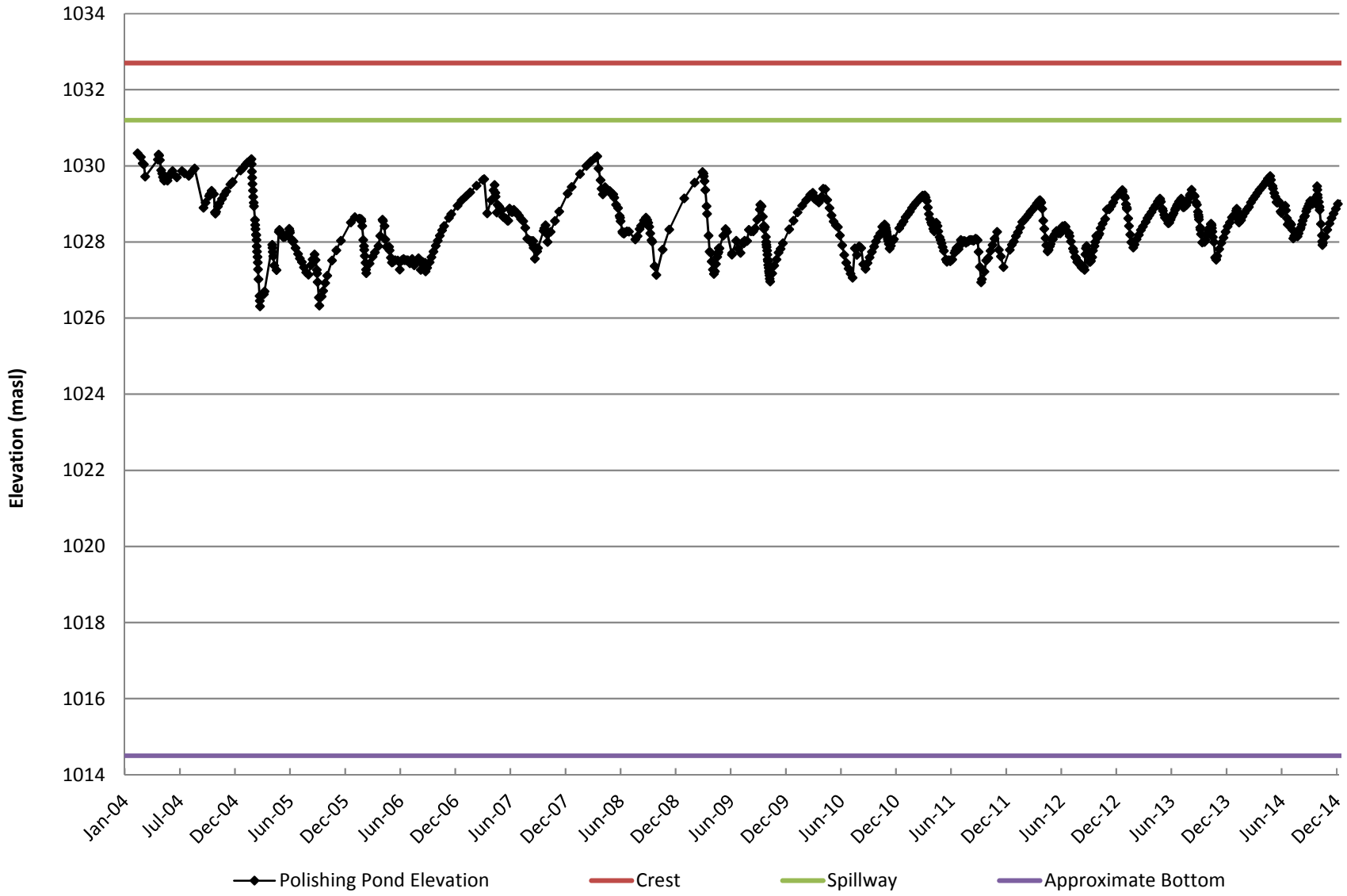
I2 – Piezometers

I3 – Thermistors (Not included)

I4 – DS Weirs Flow

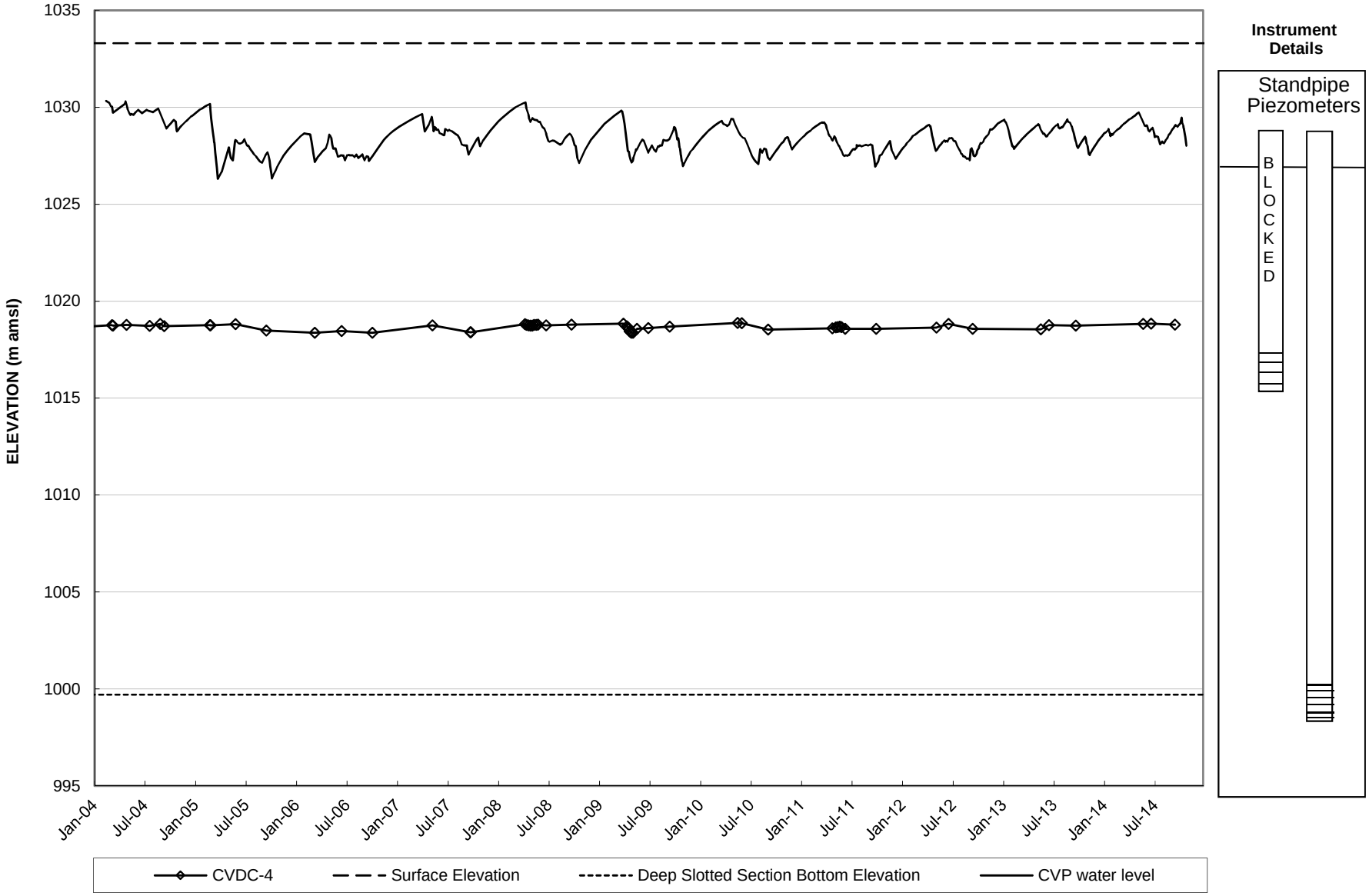
I1 – Pond Level (Polishing Pond)

Polishing Pond Water Level

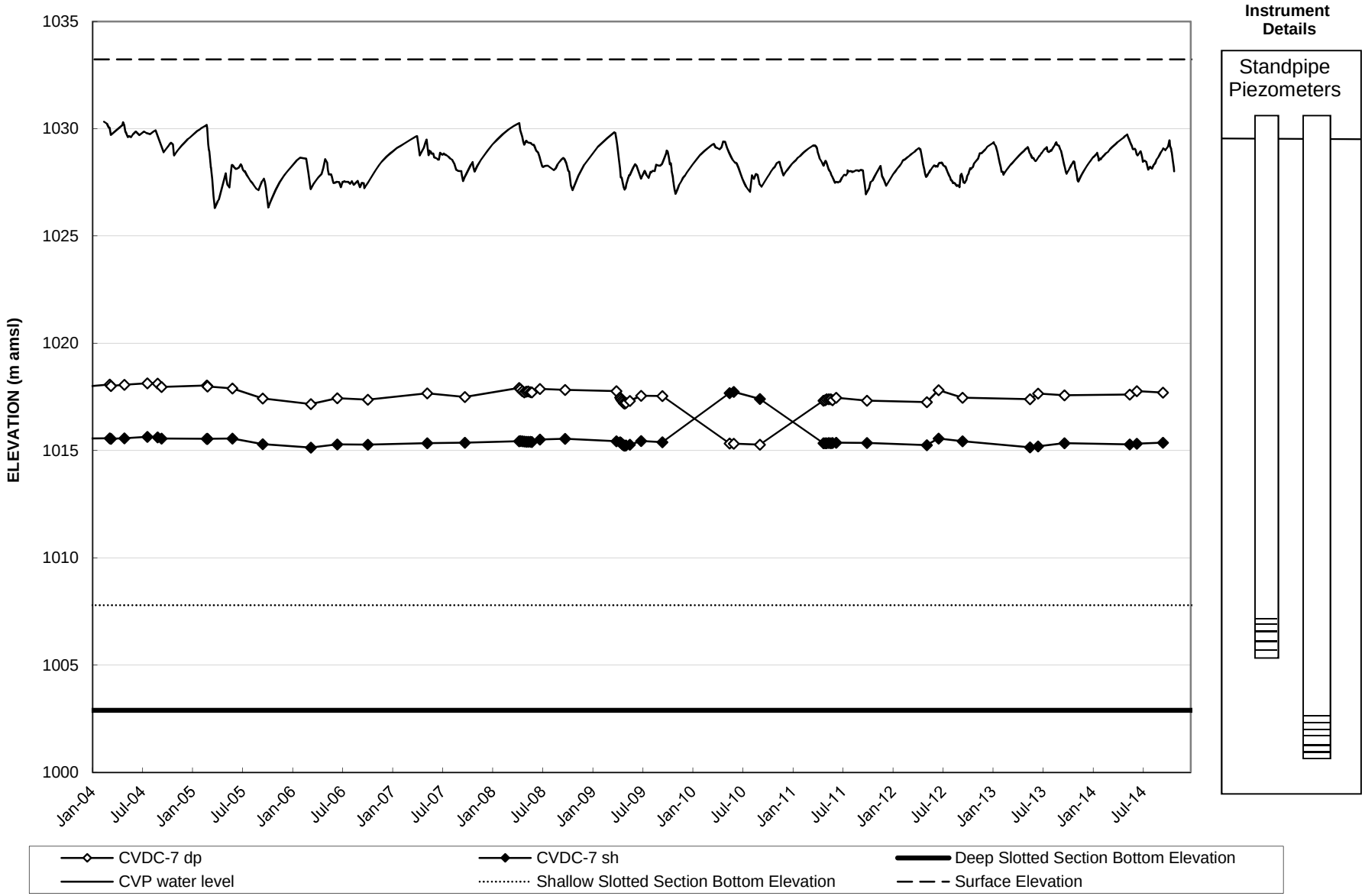


I2 – Piezometers

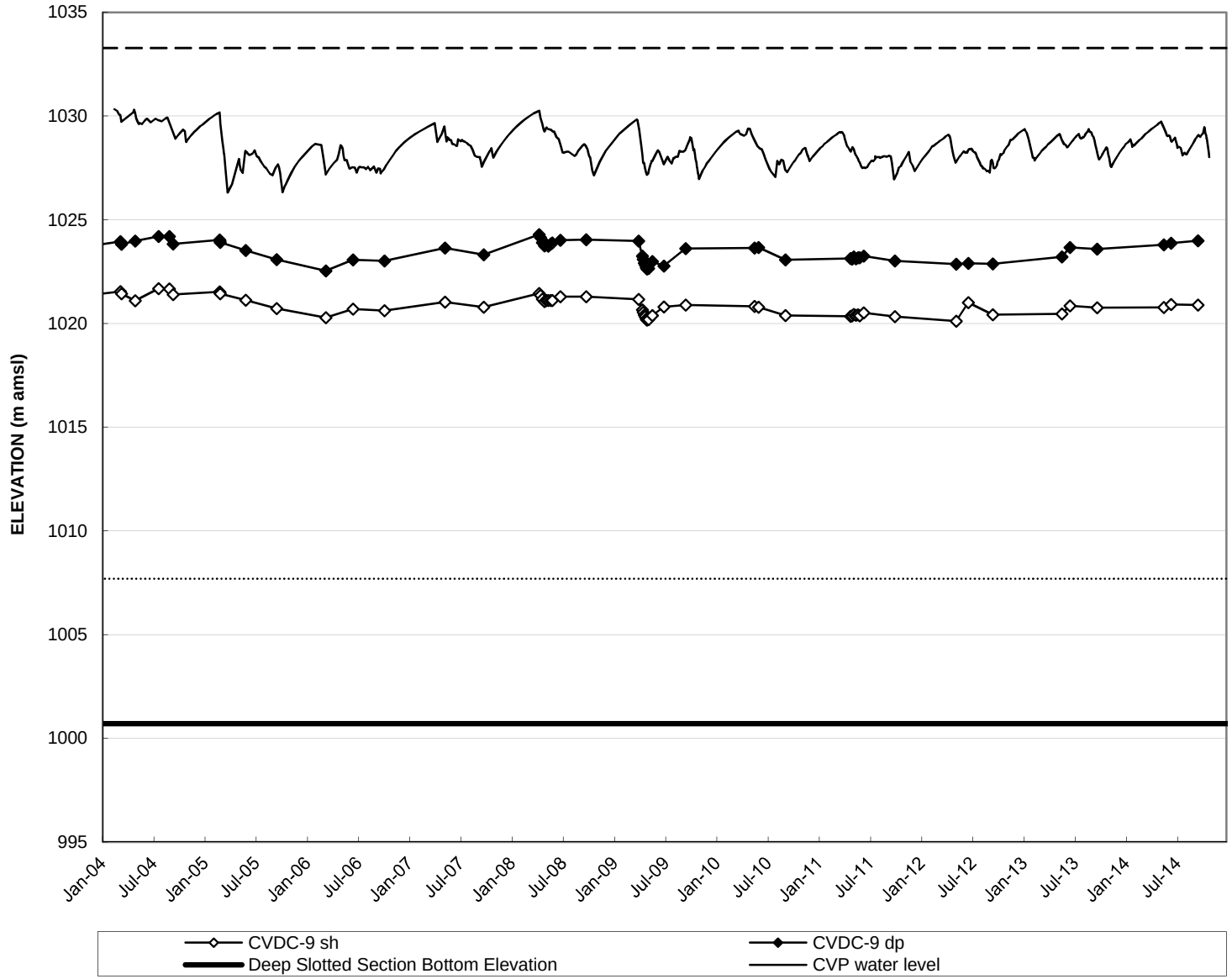
Cross Valley Dam
Piezometer CVDC-4

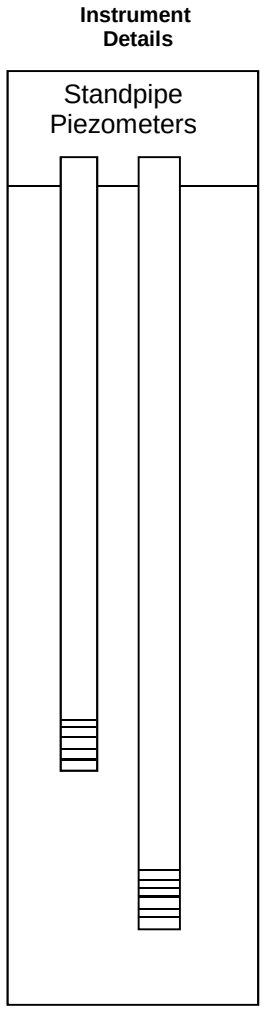


Cross Valley Dam
Piezometer CVDC-7

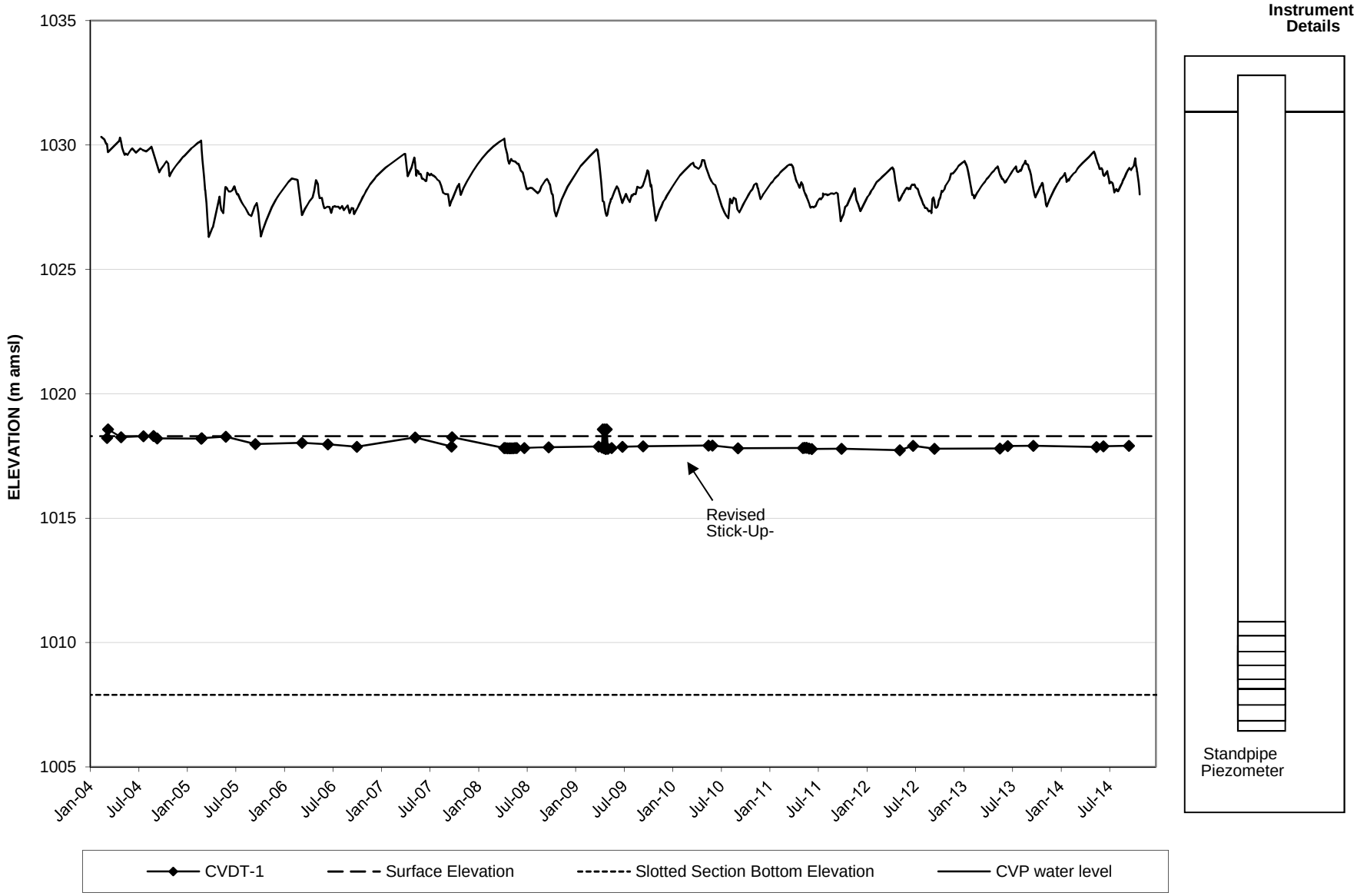


Cross Valley Dam
Piezometer CVDC-9

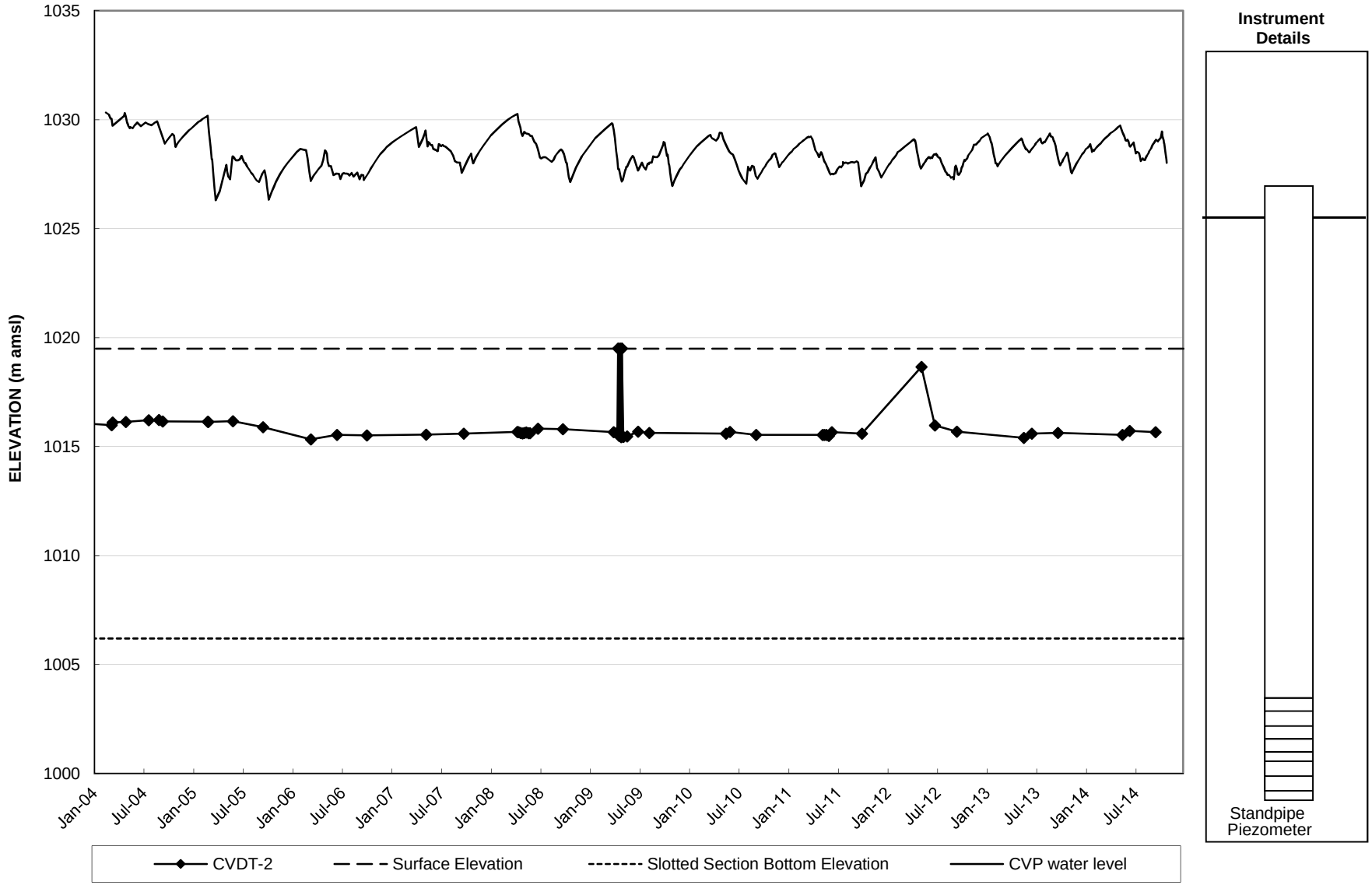




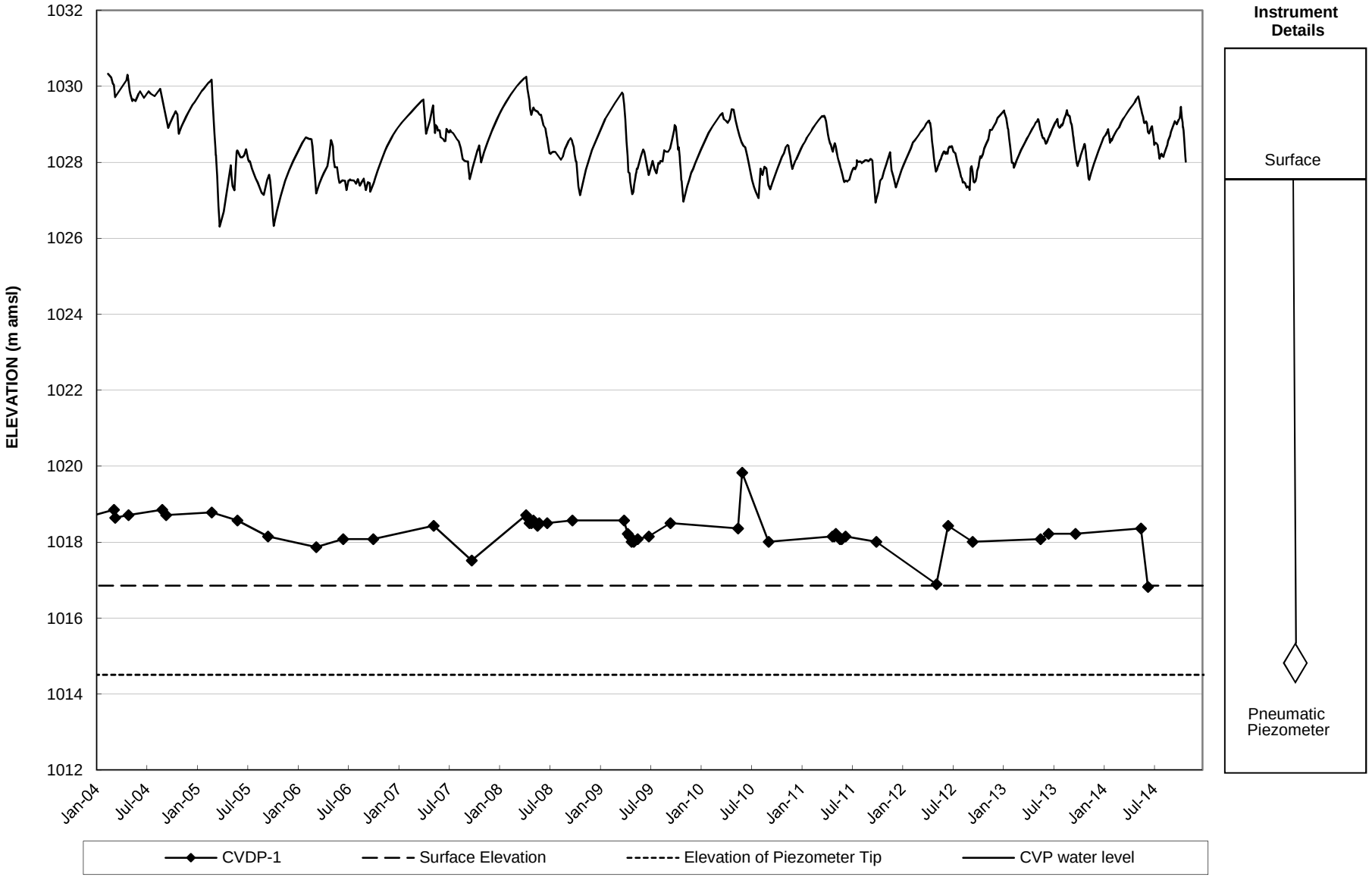
Cross Valley Dam
Piezometer CVDT-1



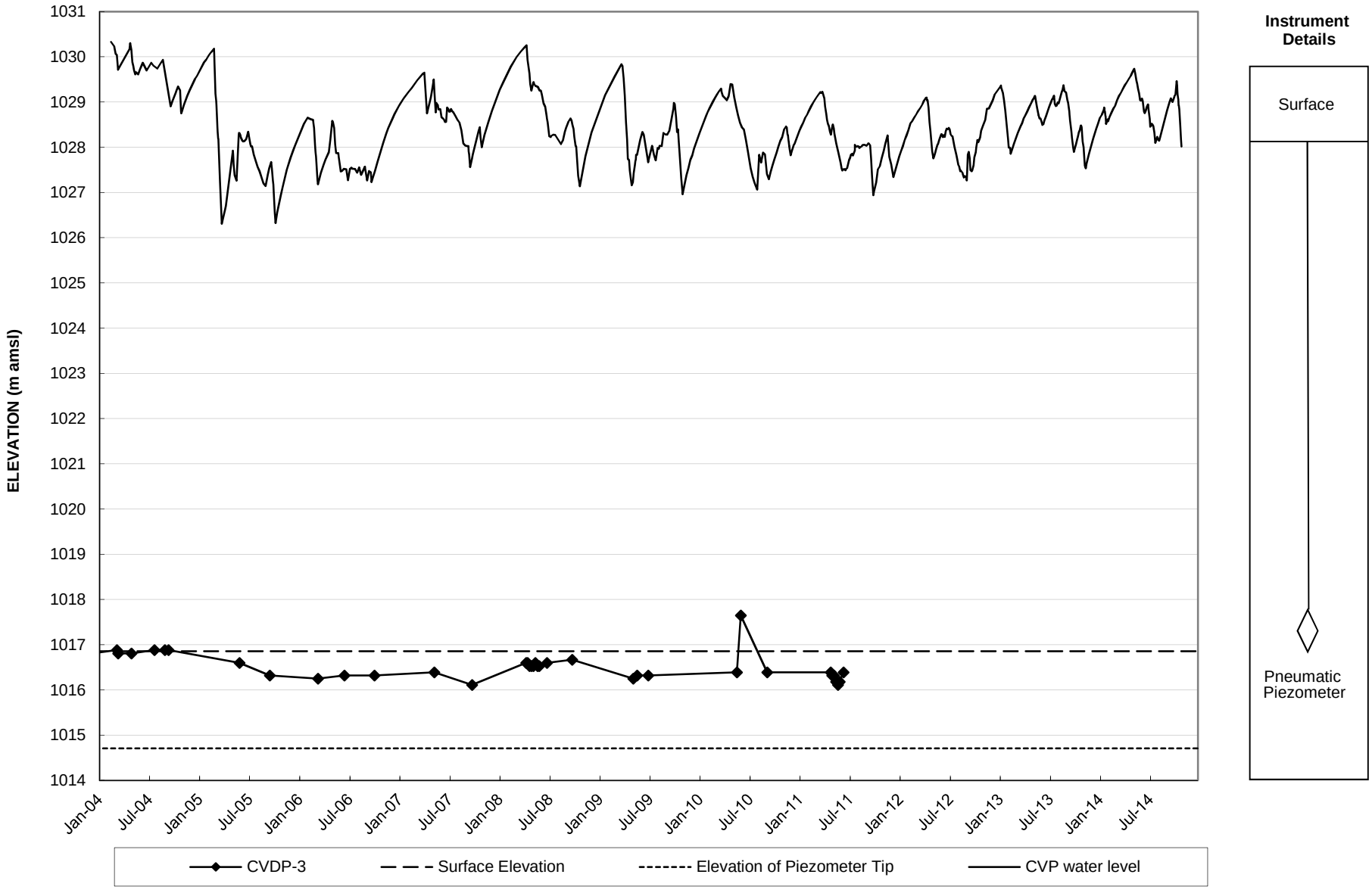
Cross Valley Dam
Piezometer CVDT-2



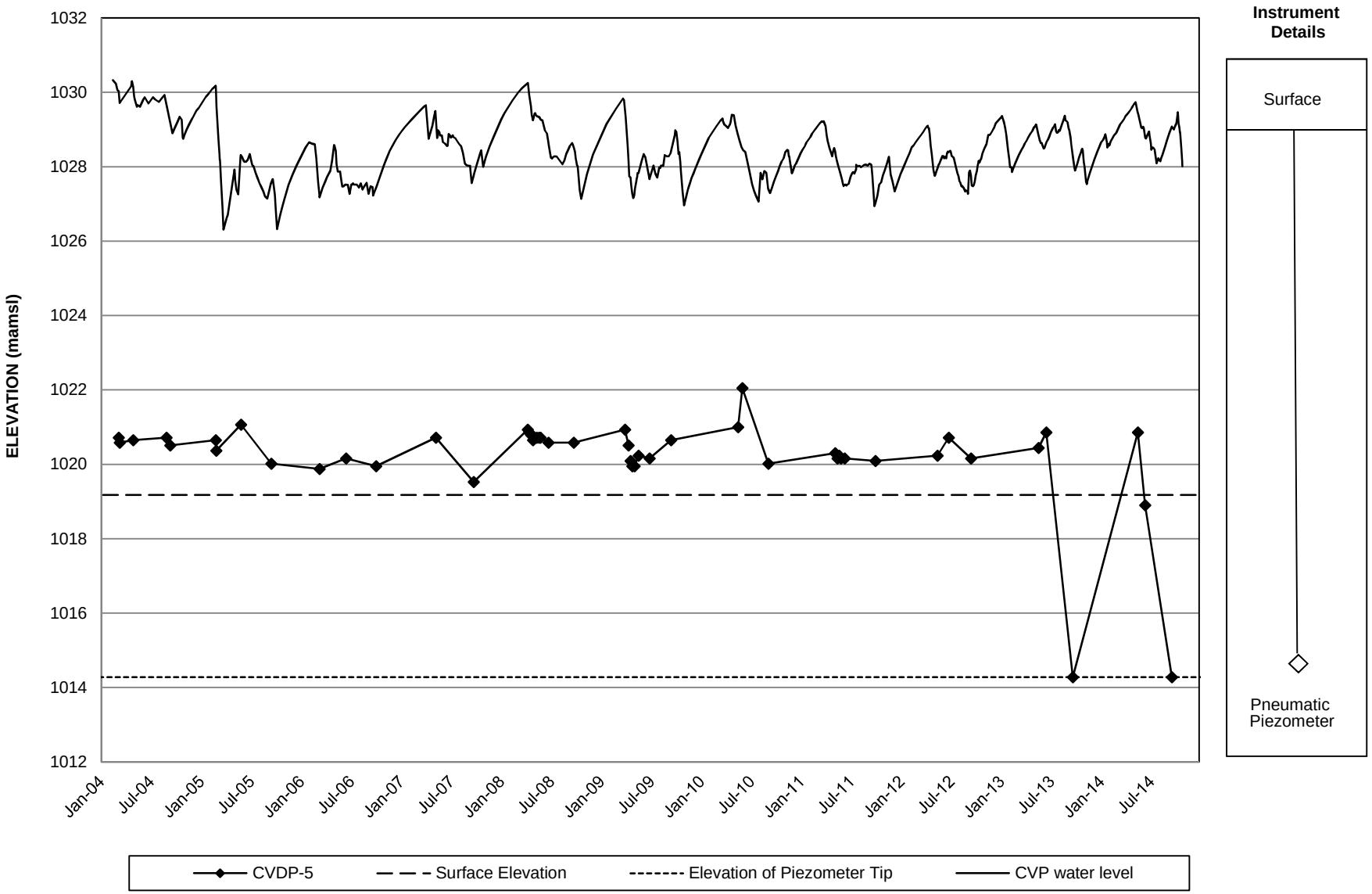
Cross Valley Dam
Piezometer CVDP-1



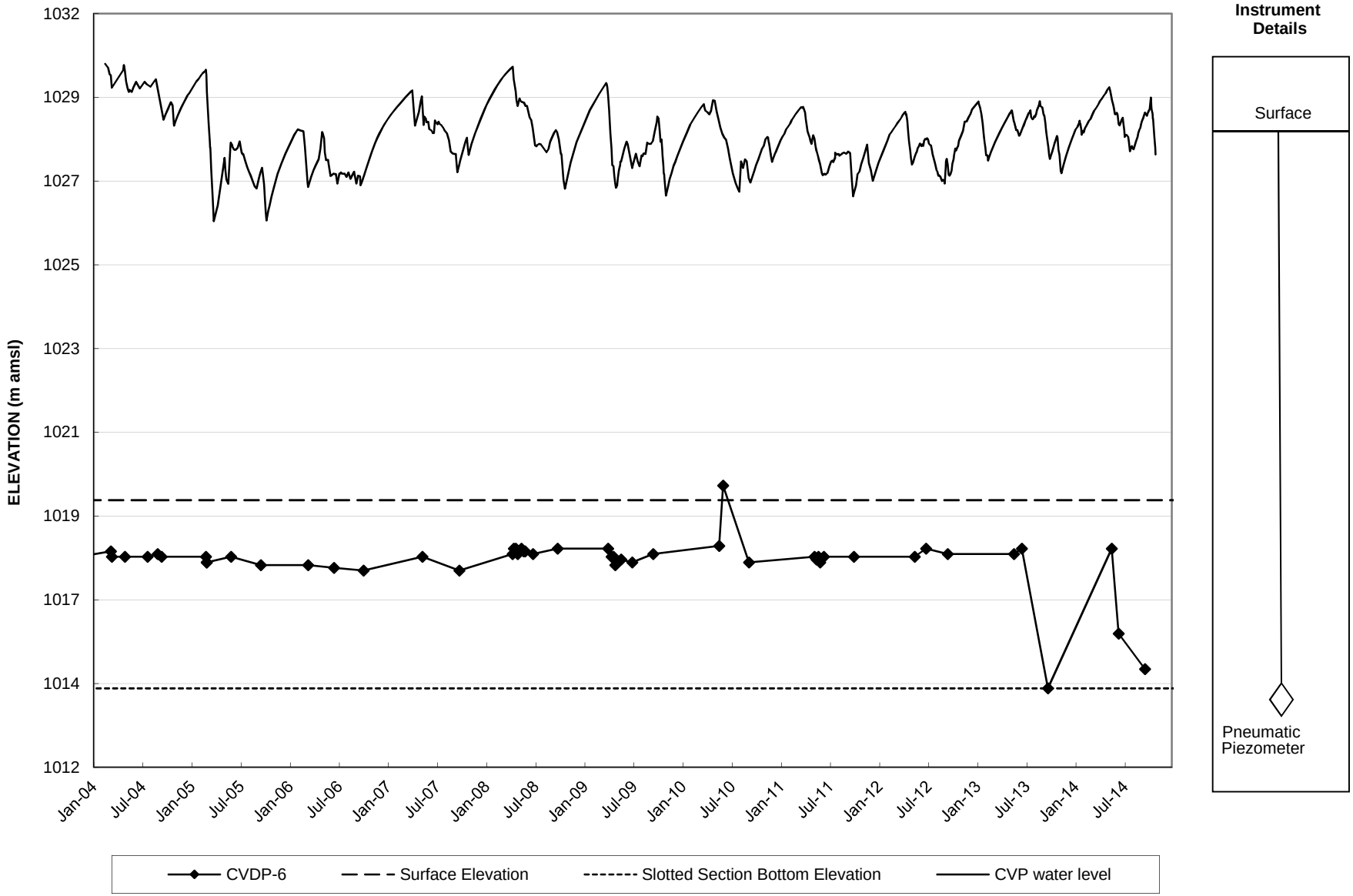
Cross Valley Dam
Piezometer CVDP-3



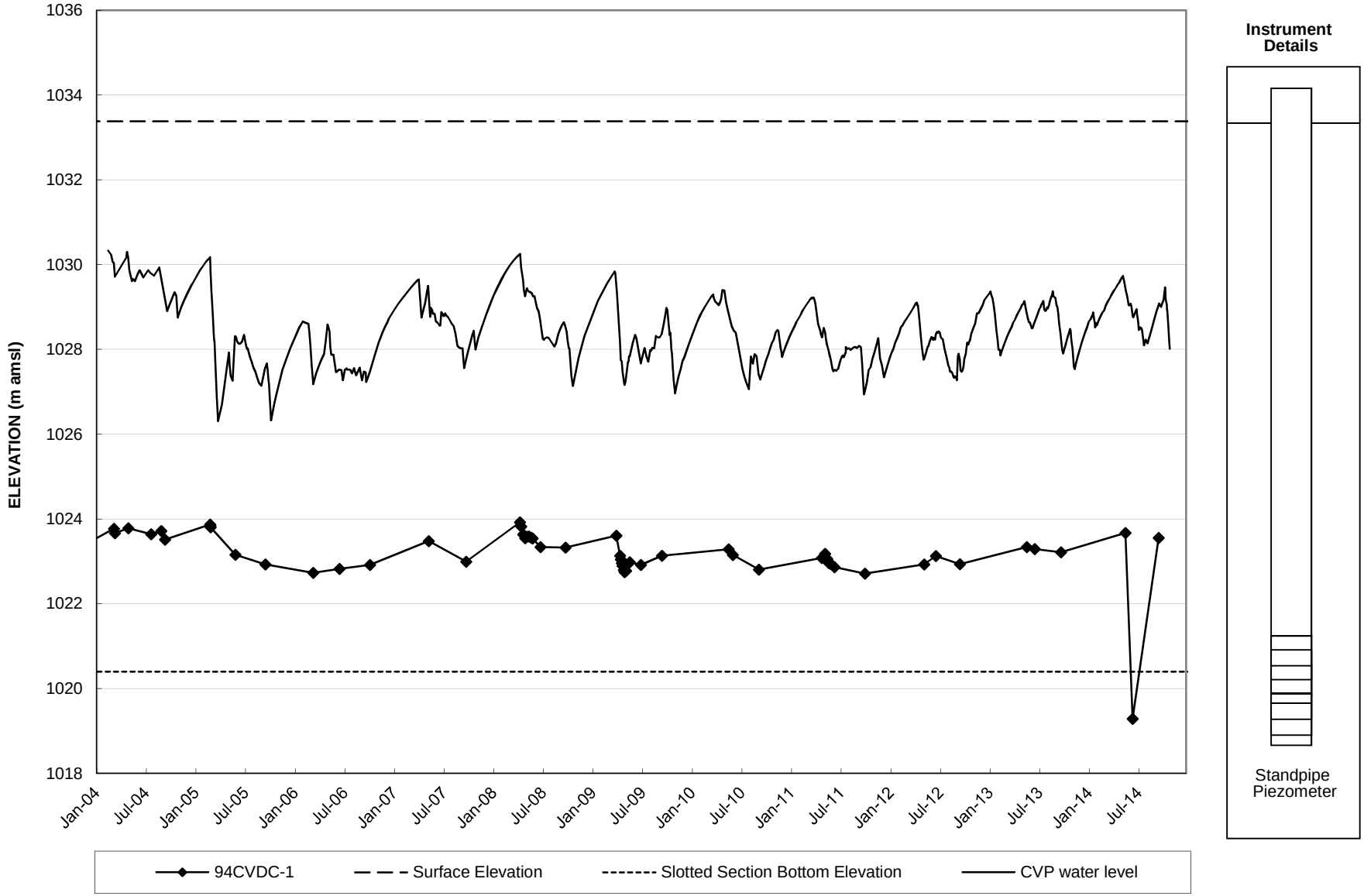
Cross Valley Dam
Piezometer CVDP-5



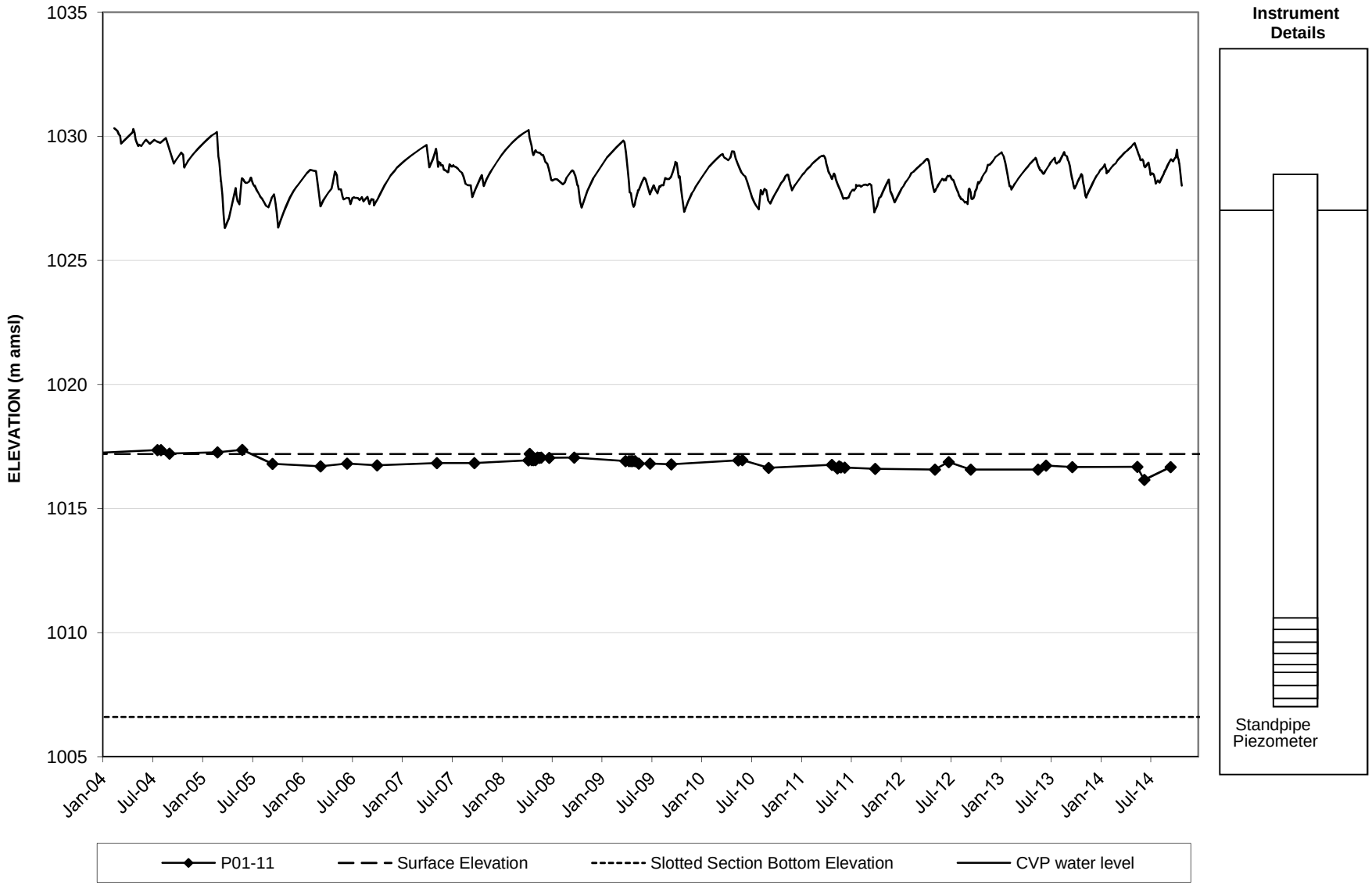
Cross Valley Dam
Piezometer CVDP-6



Cross Valley Dam
Piezometer 94CVDC-1



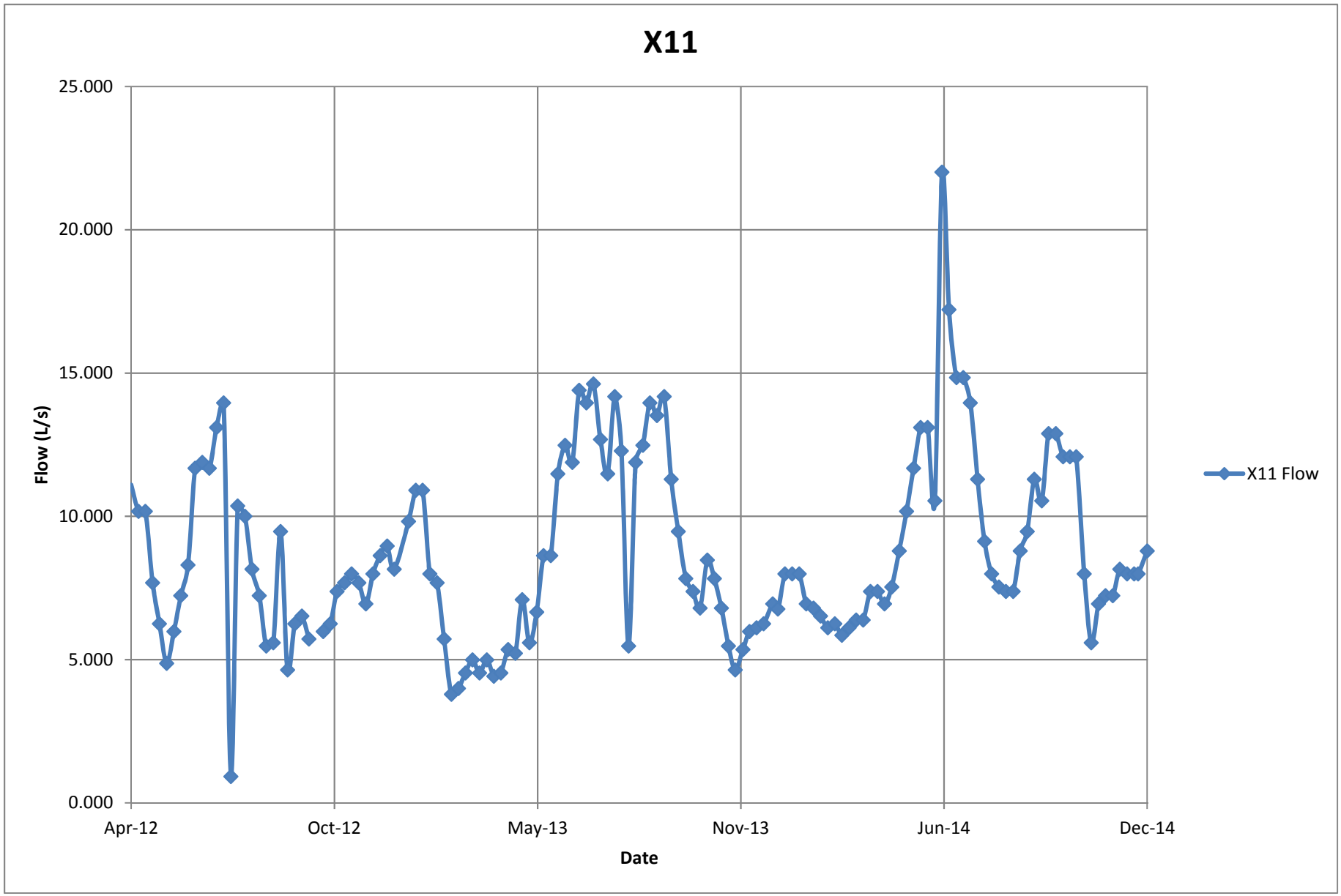
Cross Valley Dam
Piezometer P01-11

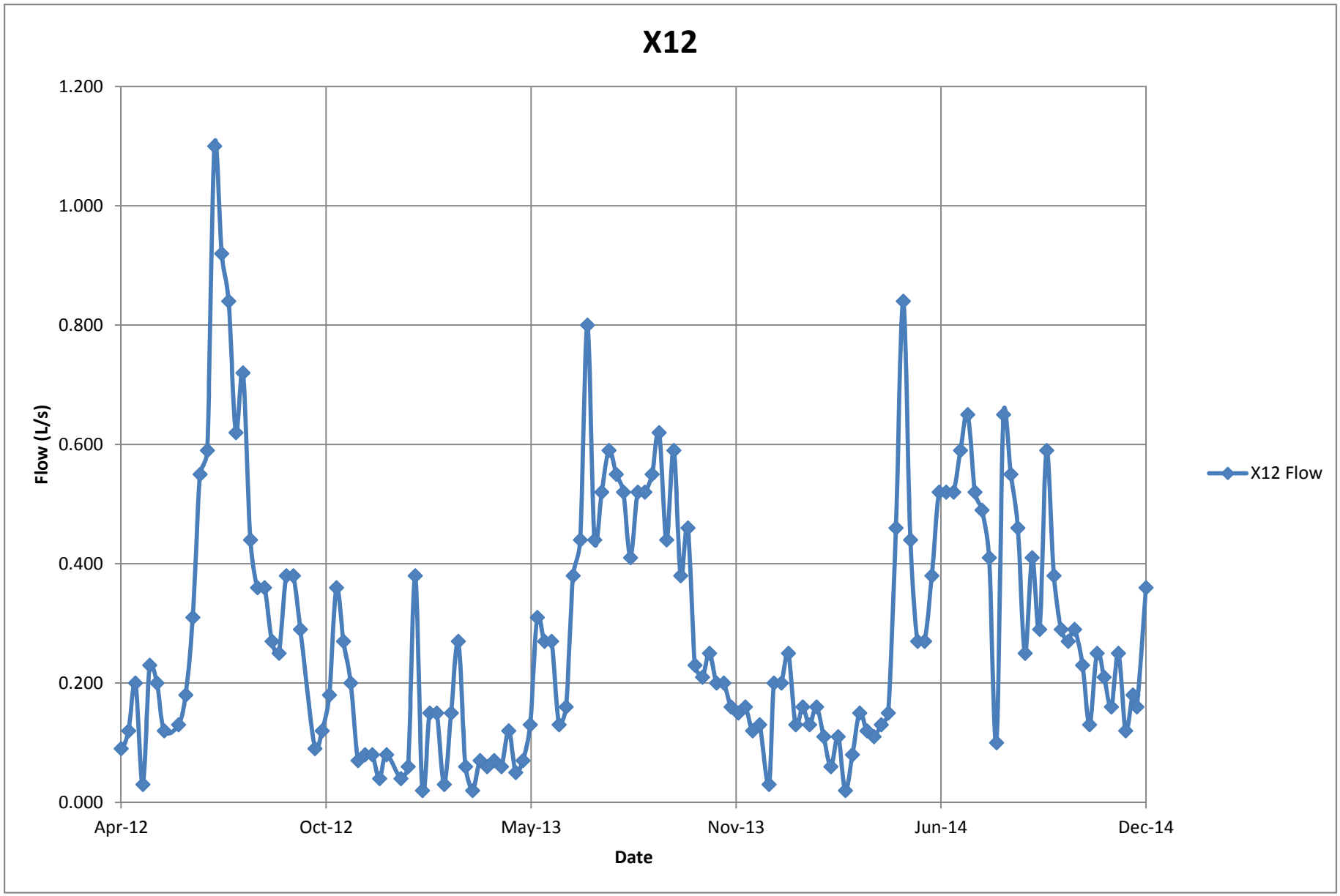


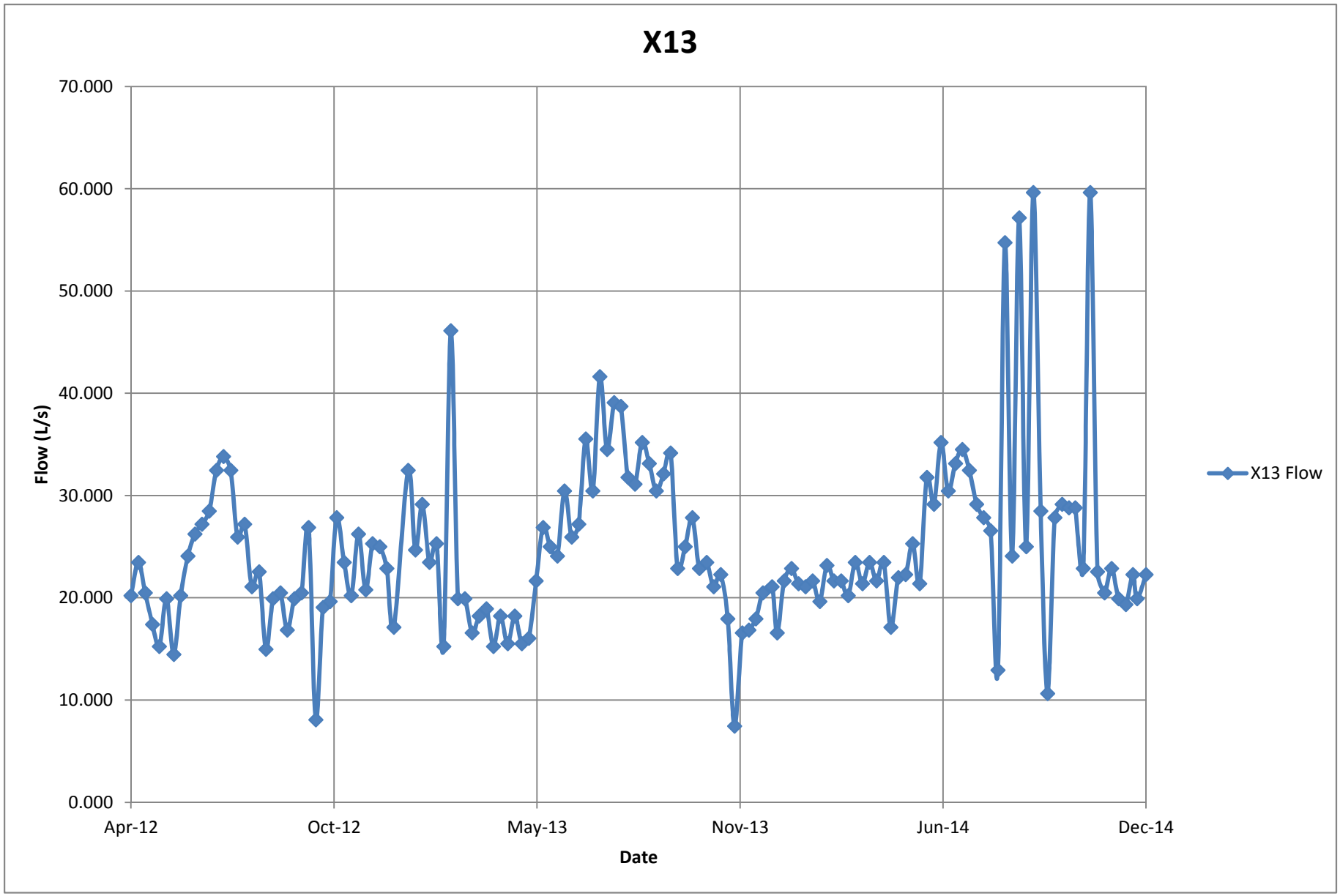
I3 – Thermistors

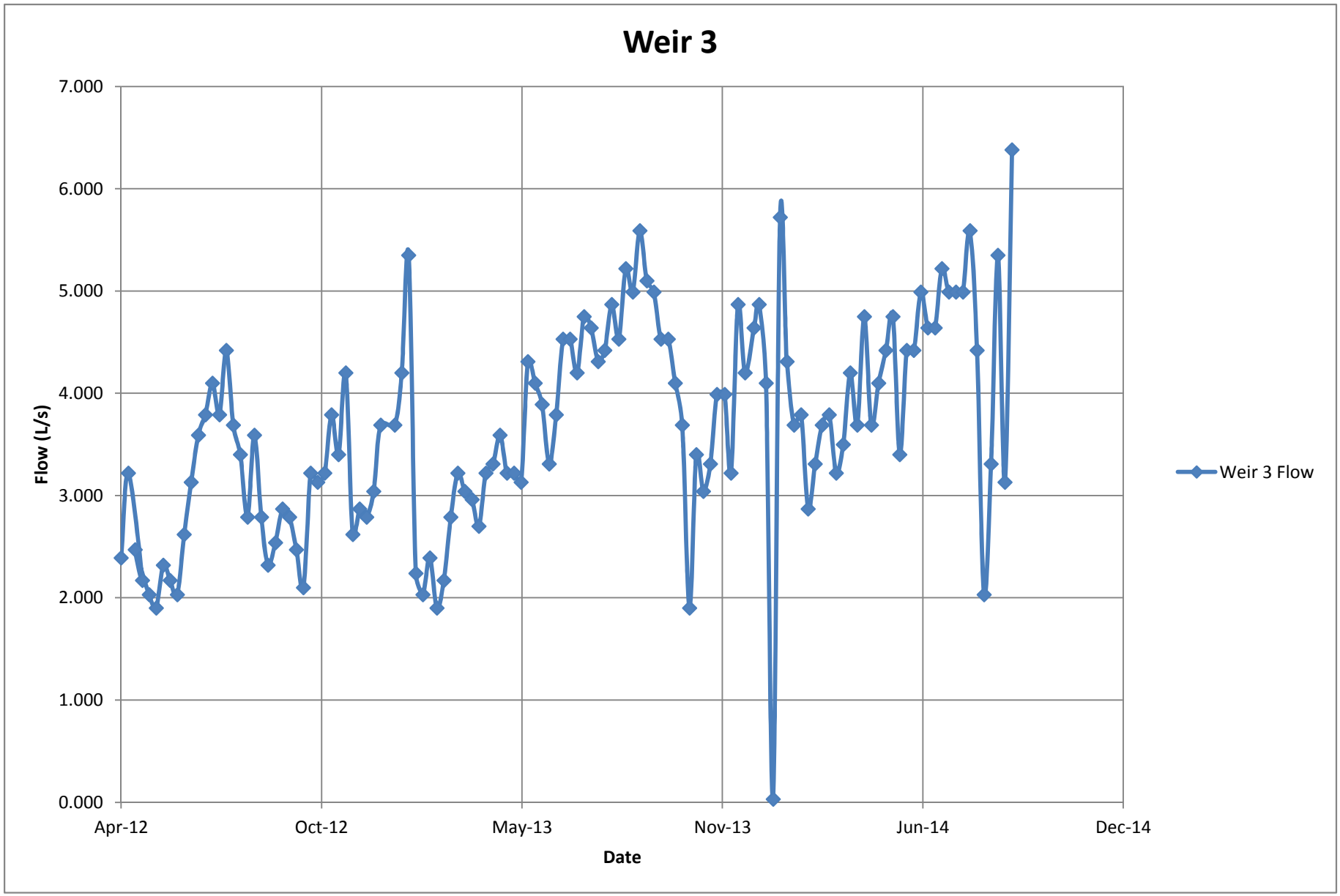
Not included

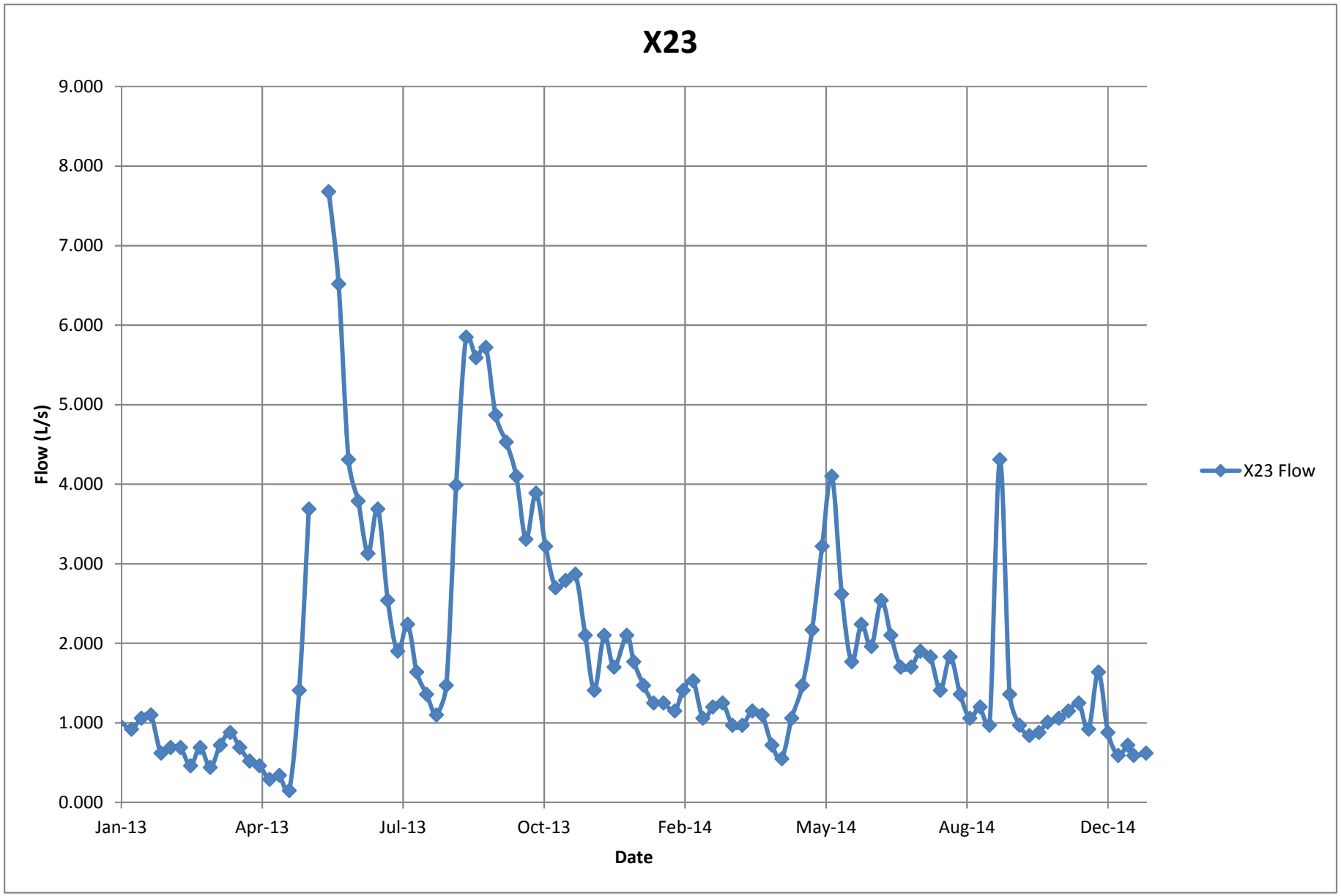
I4 – DS Weirs Flow


X11
25.000
20.000
15.000
10.000
5.000
0.000
Flow (L/s)
Apr-12
Oct-12
May-13
Nov-13
Jun-14
Dec-14
Date
X11 Flow


X12
1.200
1.000
0.800
0.600
0.400
0.200
0.000
Flow (L/s)
Apr-12
Oct-12
May-13
Nov-13
Jun-14
Dec-14
Date
X12 Flow


X13
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0.000
Flow (L/s)
Apr-12
Oct-12
May-13
Nov-13
Jun-14
Dec-14
Date
X13 Flow


Weir 3
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
Flow (L/s)
Apr-12
Oct-12
May-13
Nov-13
Jun-14
Dec-14
Date
Weir 3 Flow


X23
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
Flow (L/s)
Jan-13
Apr-13
Jul-13
Oct-13
Feb-14
May-14
Aug-14
Dec-14
Date
X23 Flow

APPENDIX II-J

Grum Pit

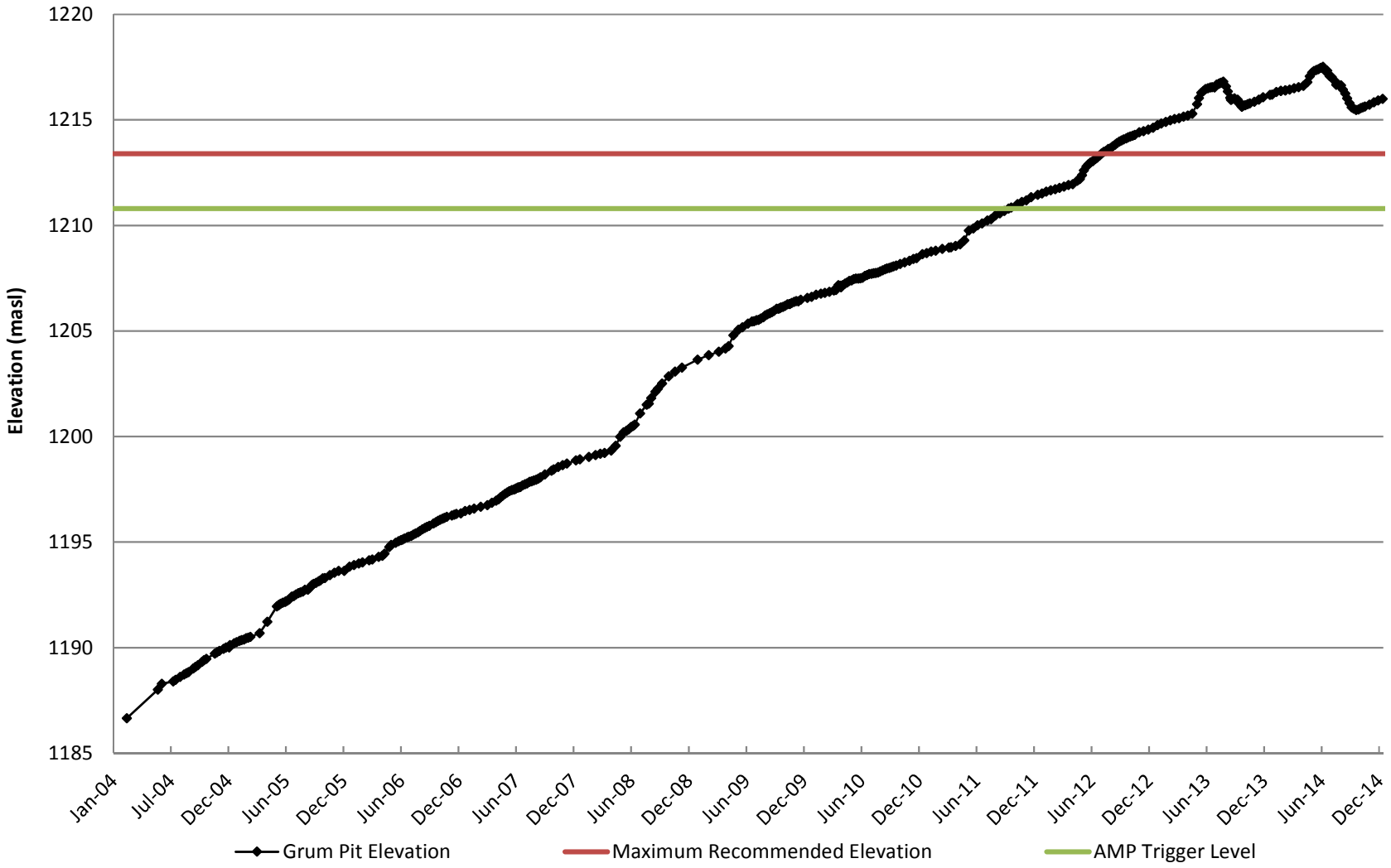
J1 – Pond Level

J2 – Pit Rim Reference Rods

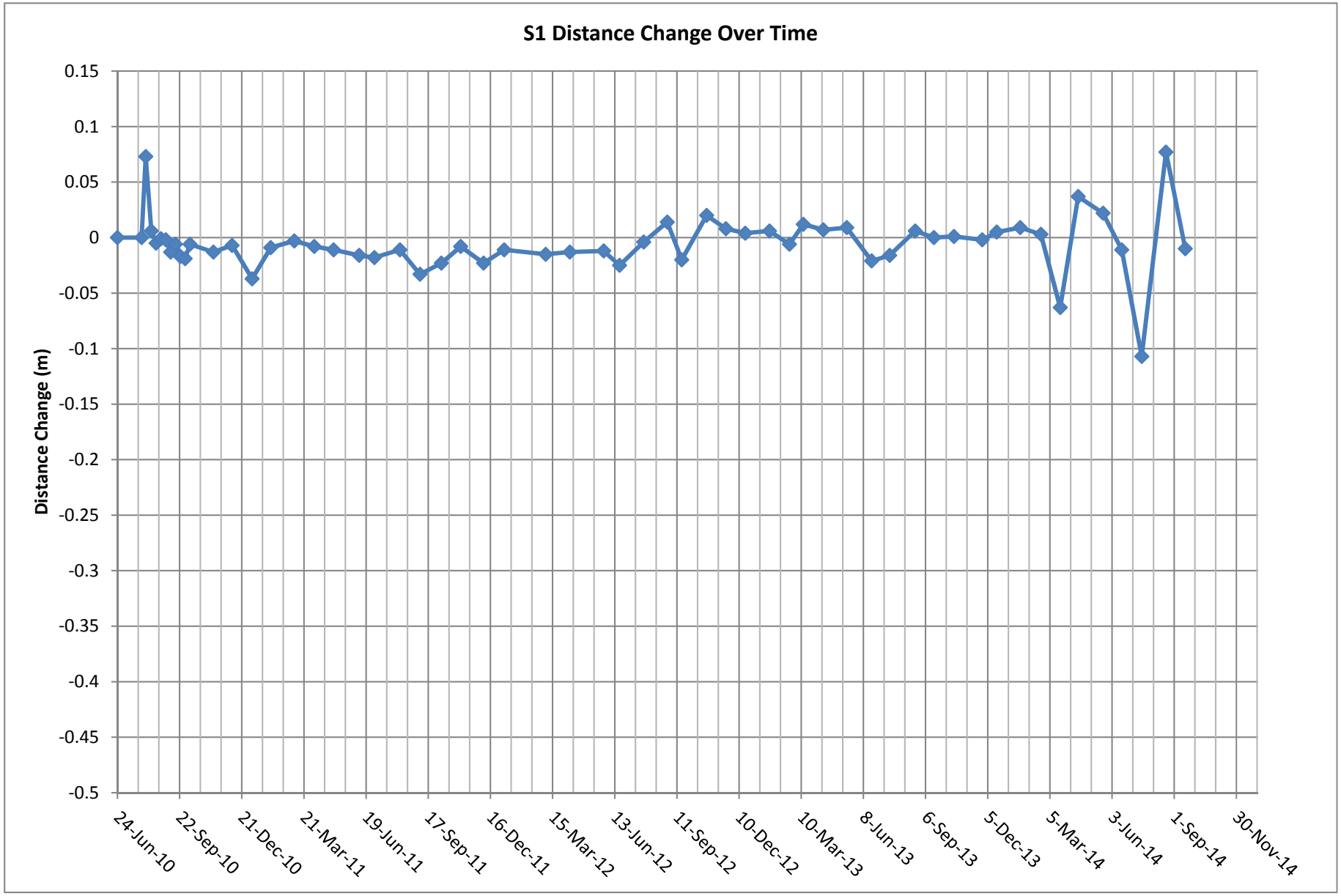
J3 – Pit Slot Cut Piezometers

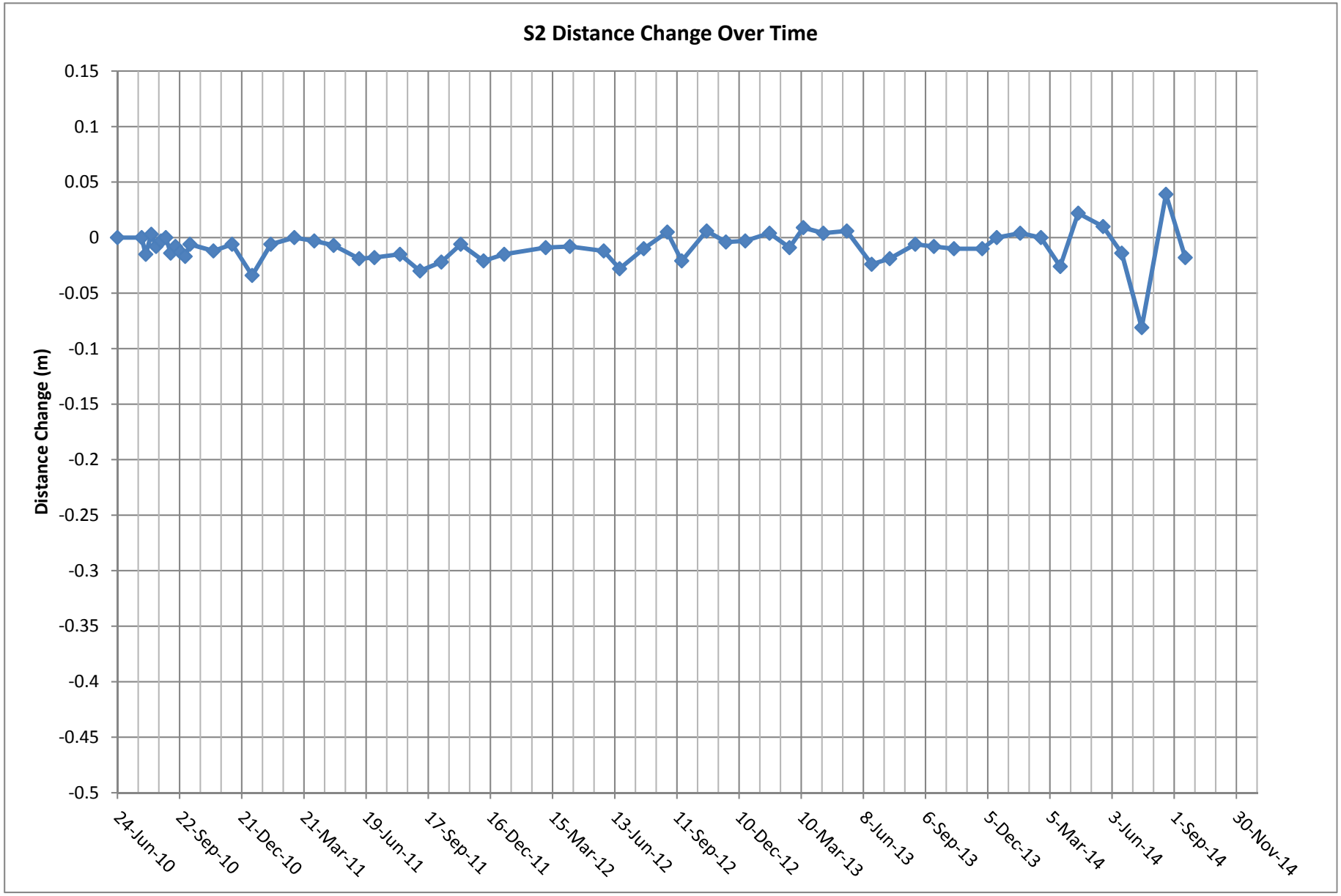
J1 – Pond Level

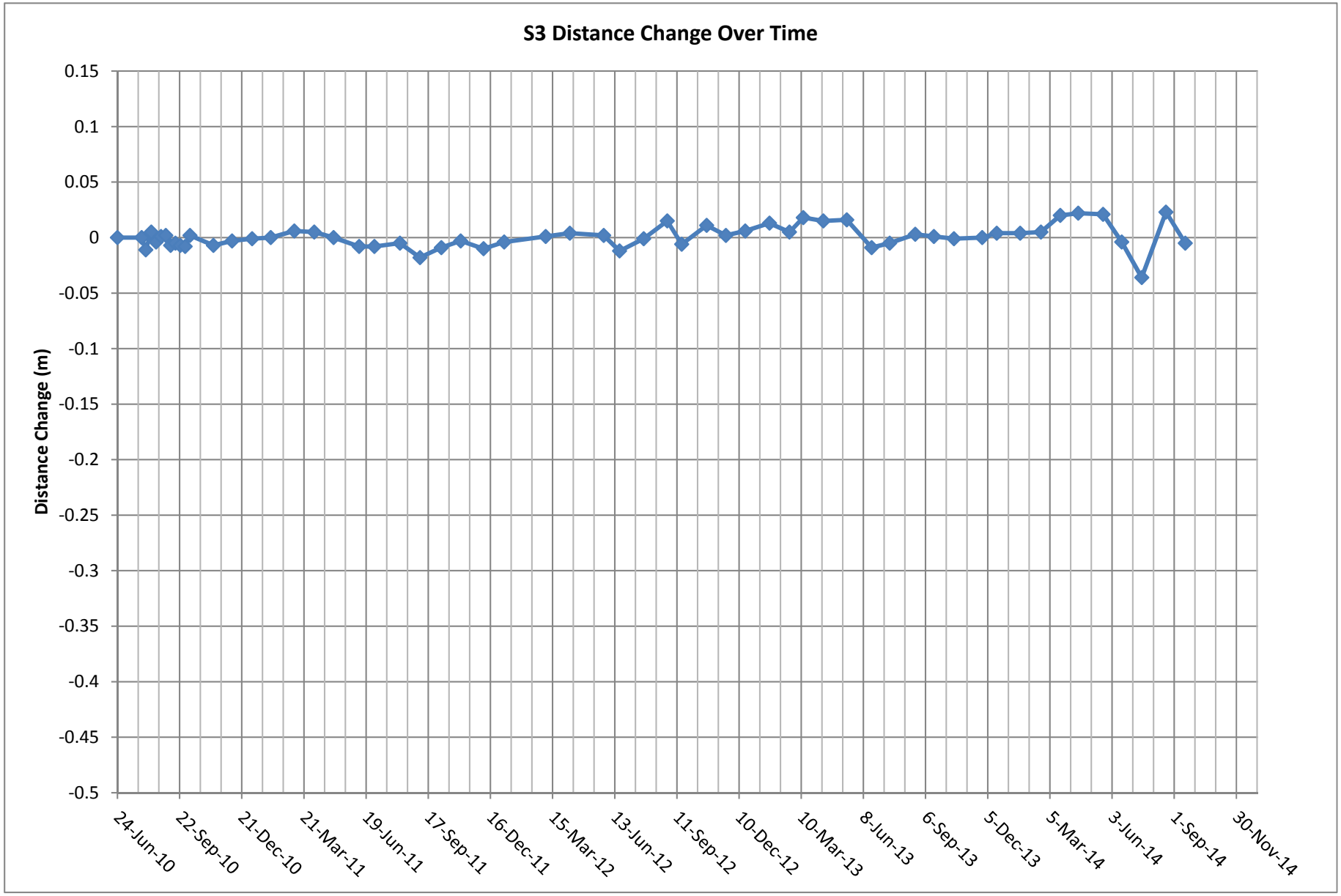
Grum Pit Water Level

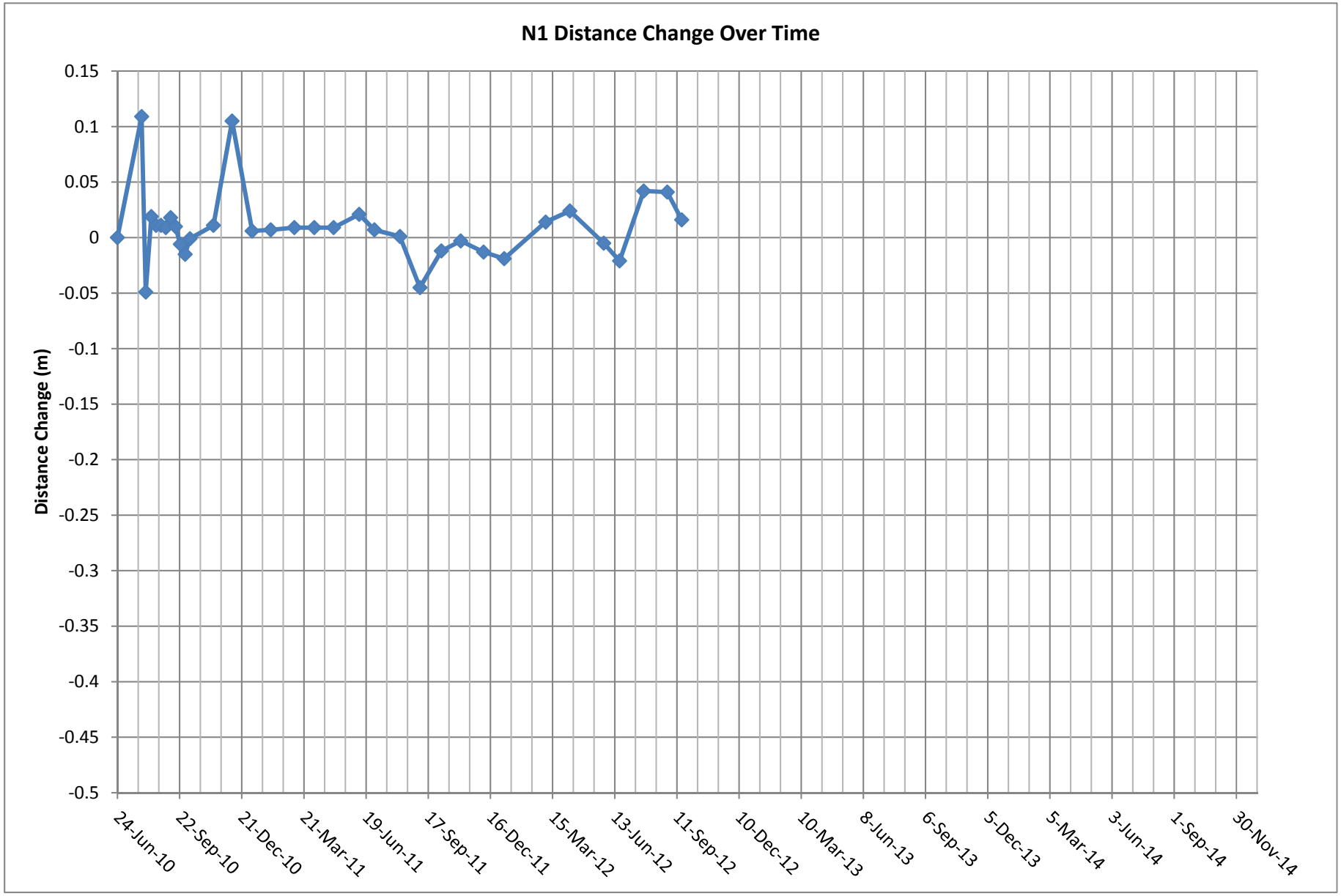


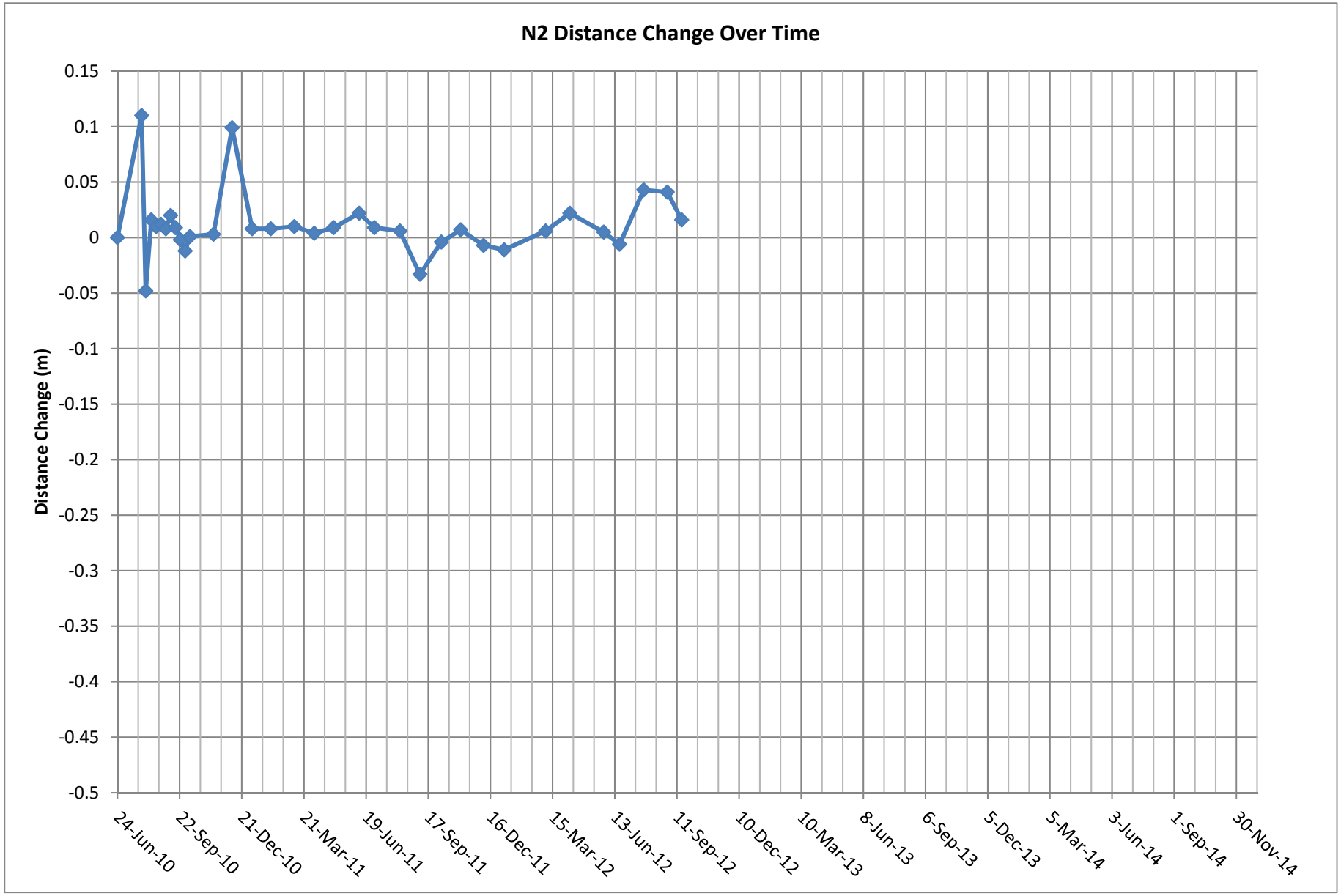
J2 – Pit Rim Reference Rods

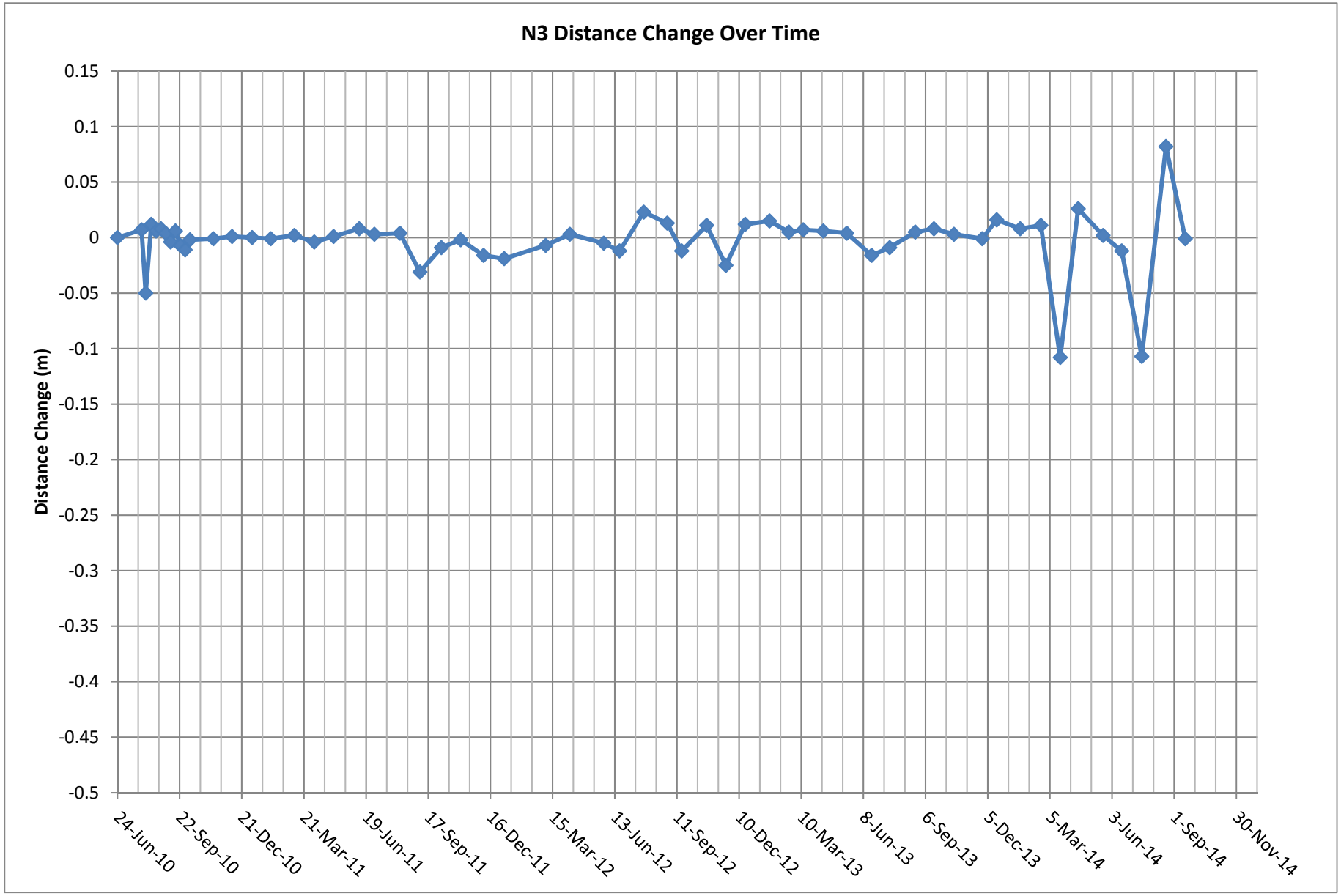

S1 Distance Change Over Time
Distance Change (m)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
-0.5
24-Jun-10
22-Sep-10
21-Dec-10
21-Mar-11
19-Jun-11
17-Sep-11
16-Dec-11
15-Mar-12
13-Jun-12
11-Sep-12
10-Dec-12
10-Mar-13
8-Jun-13
6-Sep-13
5-Dec-13
5-Mar-14
3-Jun-14
1-Sep-14
30-Nov-14

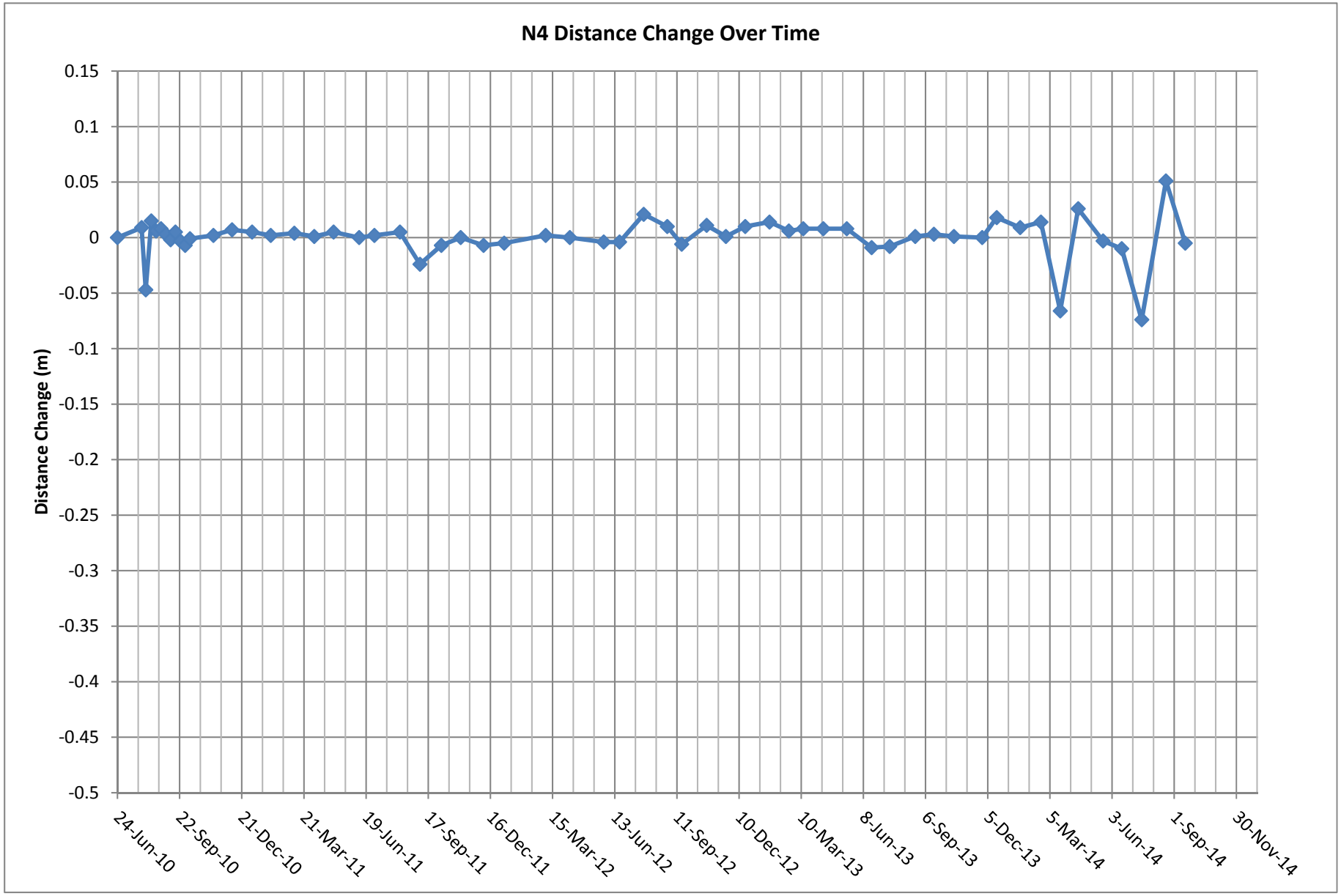

S2 Distance Change Over Time
Distance Change (m)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
-0.5
24-Jun-10
22-Sep-10
21-Dec-10
21-Mar-11
19-Jun-11
17-Sep-11
16-Dec-11
15-Mar-12
13-Jun-12
11-Sep-12
10-Dec-12
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3-Jun-14
1-Sep-14
30-Nov-14

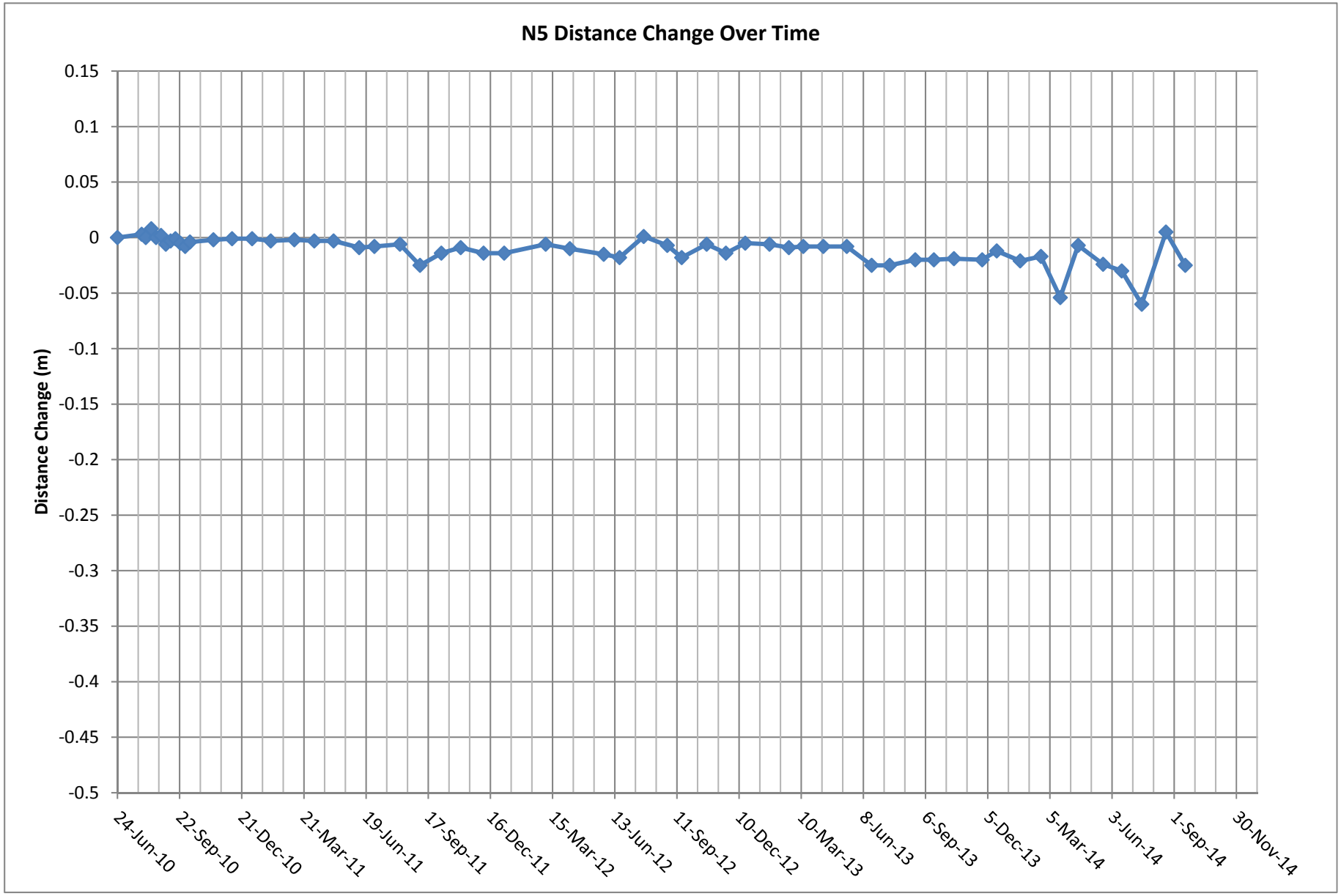

S3 Distance Change Over Time
Distance Change (m)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
-0.5
24-Jun-10
22-Sep-10
21-Dec-10
21-Mar-11
19-Jun-11
17-Sep-11
16-Dec-11
15-Mar-12
13-Jun-12
11-Sep-12
10-Dec-12
10-Mar-13
8-Jun-13
6-Sep-13
5-Dec-13
5-Mar-14
3-Jun-14
1-Sep-14
30-Nov-14


N1 Distance Change Over Time
Distance Change (m)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
-0.5
24-Jun-10
22-Sep-10
21-Dec-10
21-Mar-11
19-Jun-11
17-Sep-11
16-Dec-11
15-Mar-12
13-Jun-12
11-Sep-12
10-Dec-12
10-Mar-13
8-Jun-13
6-Sep-13
5-Dec-13
5-Mar-14
3-Jun-14
1-Sep-14
30-Nov-14


N2 Distance Change Over Time
Distance Change (m)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
-0.5
24-Jun-10
22-Sep-10
21-Dec-10
21-Mar-11
19-Jun-11
17-Sep-11
16-Dec-11
15-Mar-12
13-Jun-12
11-Sep-12
10-Dec-12
10-Mar-13
8-Jun-13
6-Sep-13
5-Dec-13
5-Mar-14
3-Jun-14
1-Sep-14
30-Nov-14

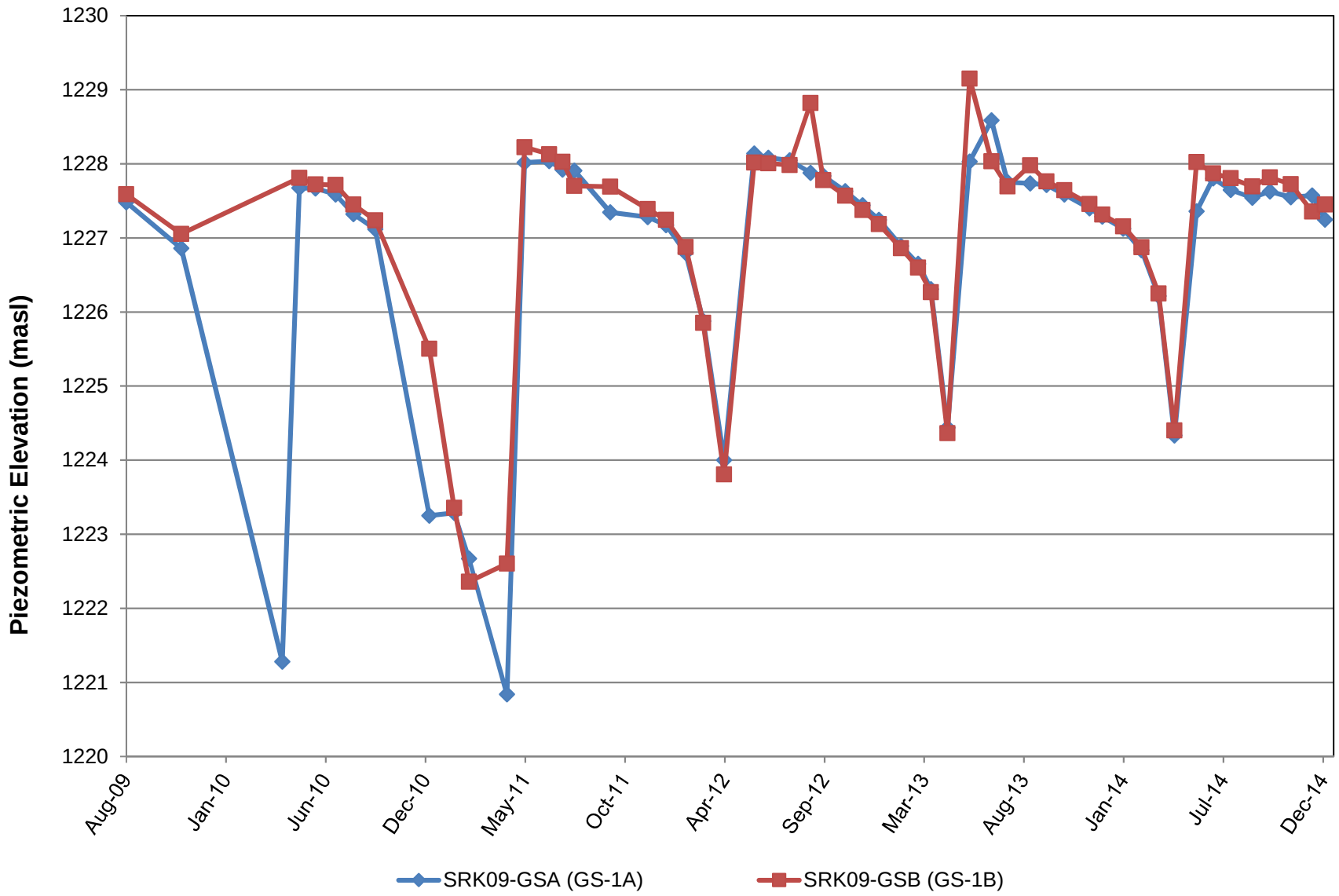

N3 Distance Change Over Time
Distance Change (m)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
-0.5
24-Jun-10
22-Sep-10
21-Dec-10
21-Mar-11
19-Jun-11
17-Sep-11
16-Dec-11
15-Mar-12
13-Jun-12
11-Sep-12
10-Dec-12
10-Mar-13
8-Jun-13
6-Sep-13
5-Dec-13
5-Mar-14
3-Jun-14
1-Sep-14
30-Nov-14


N4 Distance Change Over Time
Distance Change (m)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
-0.5
24-Jun-10
22-Sep-10
21-Dec-10
21-Mar-11
19-Jun-11
17-Sep-11
16-Dec-11
15-Mar-12
13-Jun-12
11-Sep-12
10-Dec-12
10-Mar-13
8-Jun-13
6-Sep-13
5-Dec-13
5-Mar-14
3-Jun-14
1-Sep-14
30-Nov-14


N5 Distance Change Over Time
Distance Change (m)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
-0.5
24-Jun-10
22-Sep-10
21-Dec-10
21-Mar-11
19-Jun-11
17-Sep-11
16-Dec-11
15-Mar-12
13-Jun-12
11-Sep-12
10-Dec-12
10-Mar-13
8-Jun-13
6-Sep-13
5-Dec-13
5-Mar-14
3-Jun-14
1-Sep-14
30-Nov-14

J3 – Pit Slot Cut Piezometers

Water Elevations - Grum Slot Cut Piezometers



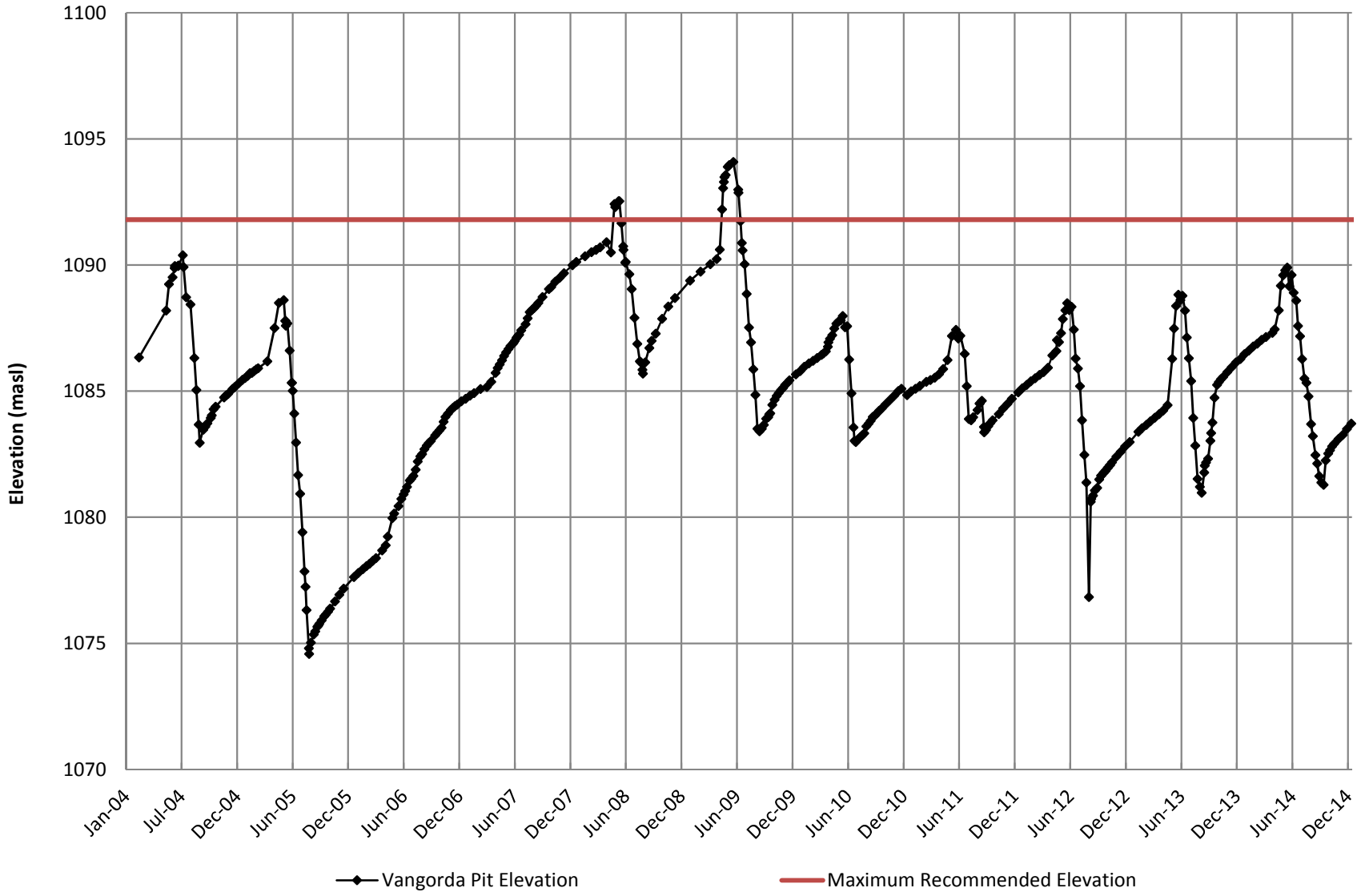
APPENDIX II-K

Vangorda Pit

K1 – Pond Level

K1 – Pond Level

Vangorda Pit Water Level



APPENDIX II-L

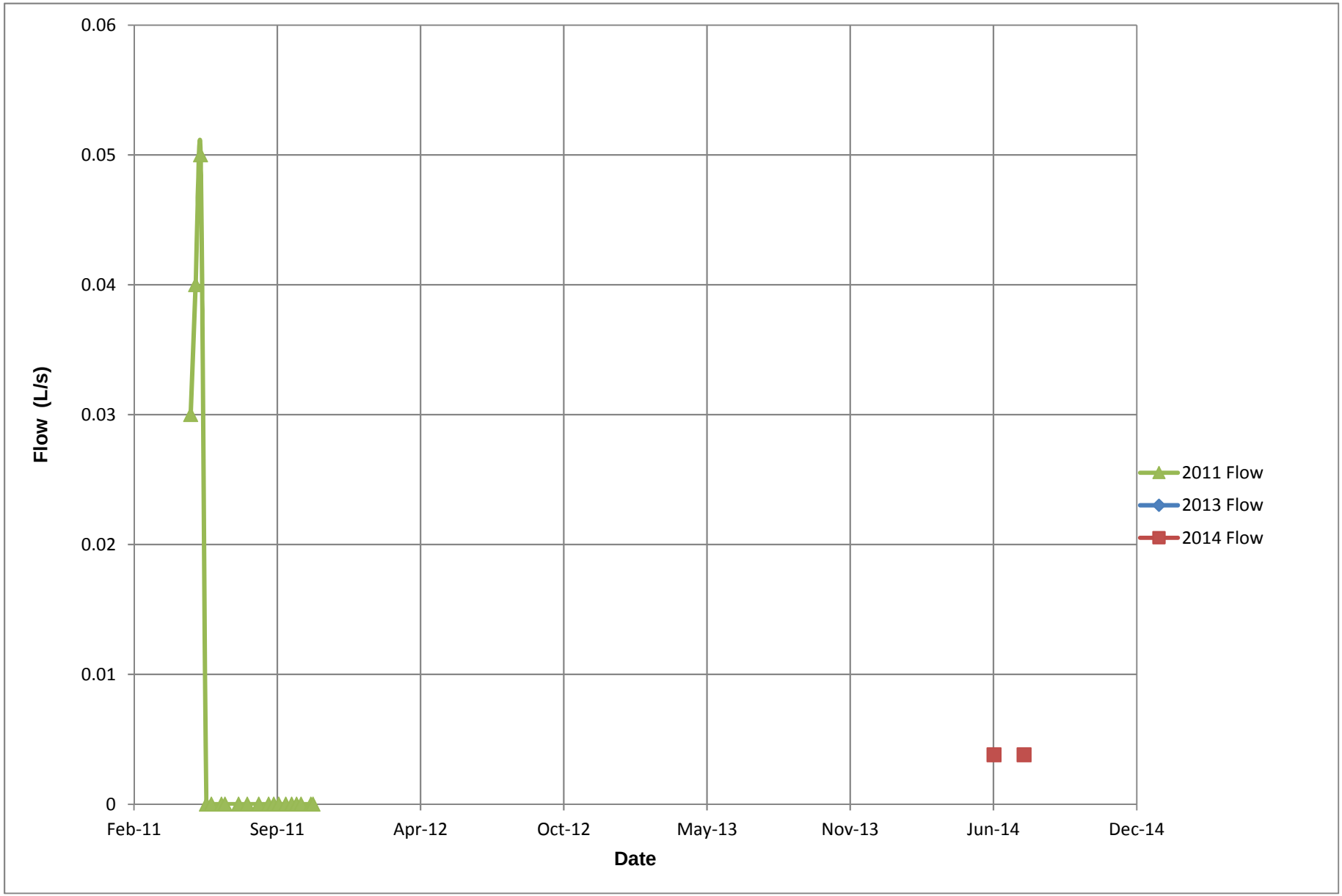
Vangorda Waste Rock Dump

L1 – Weirs Flow

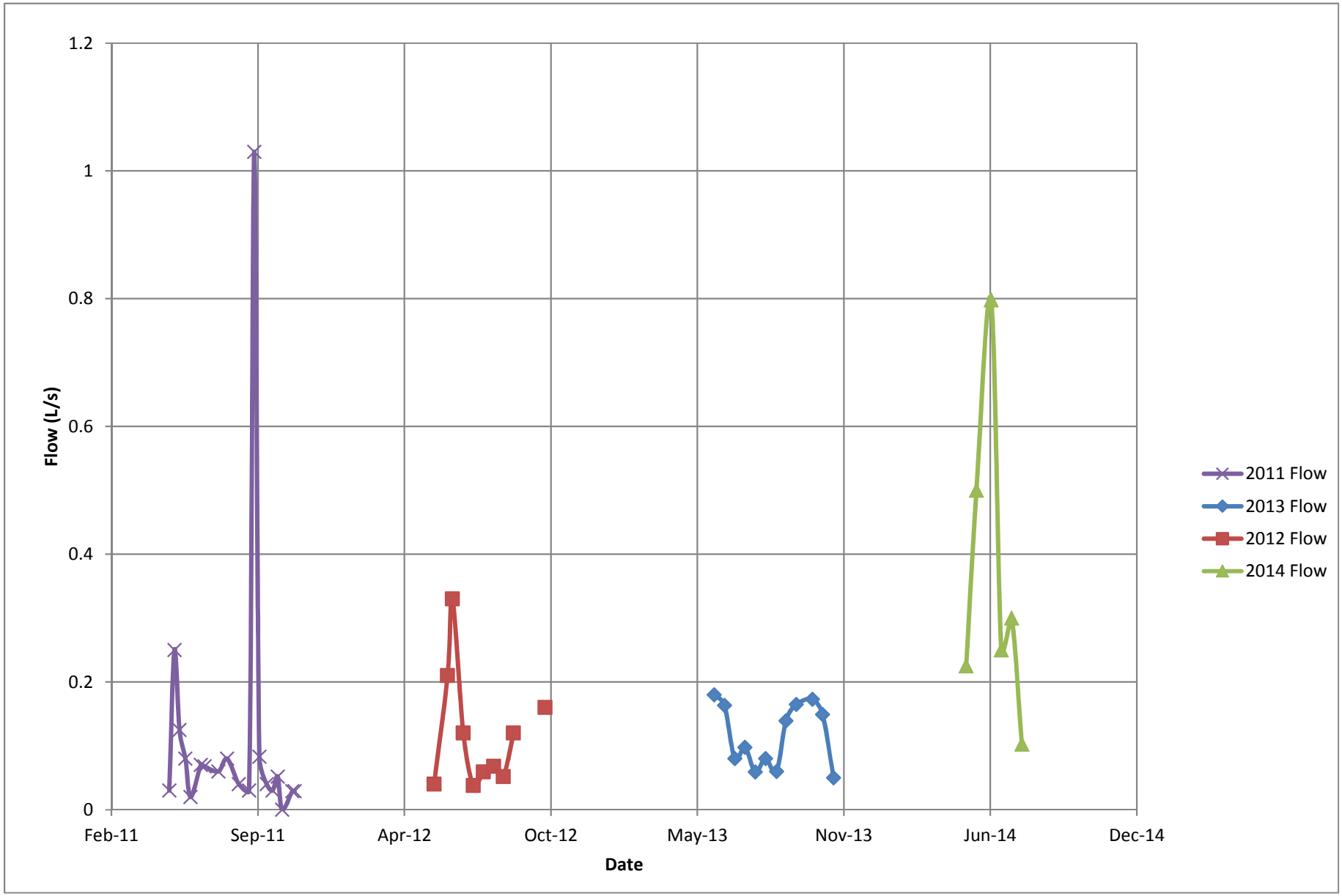
L2 – Piezometers

L1 – Weirs Flow

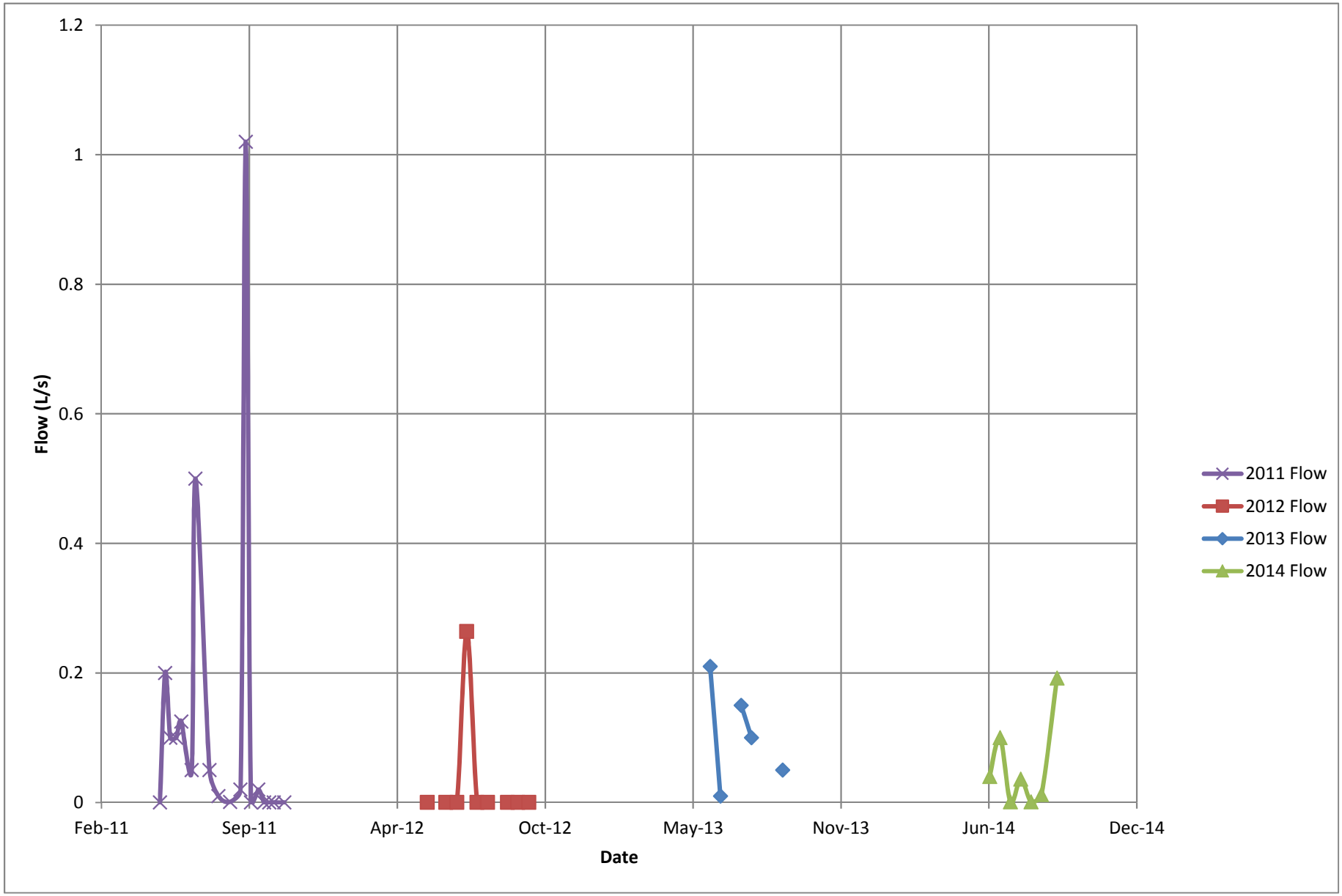
V29 (Drain 2)


0.06
0.05
0.04
0.03
0.02
0.01
0
Flow (L/s)
Feb-11
Sep-11
Apr-12
Oct-12
May-13
Nov-13
Jun-14
Dec-14
Date
2011 Flow
2013 Flow
2014 Flow

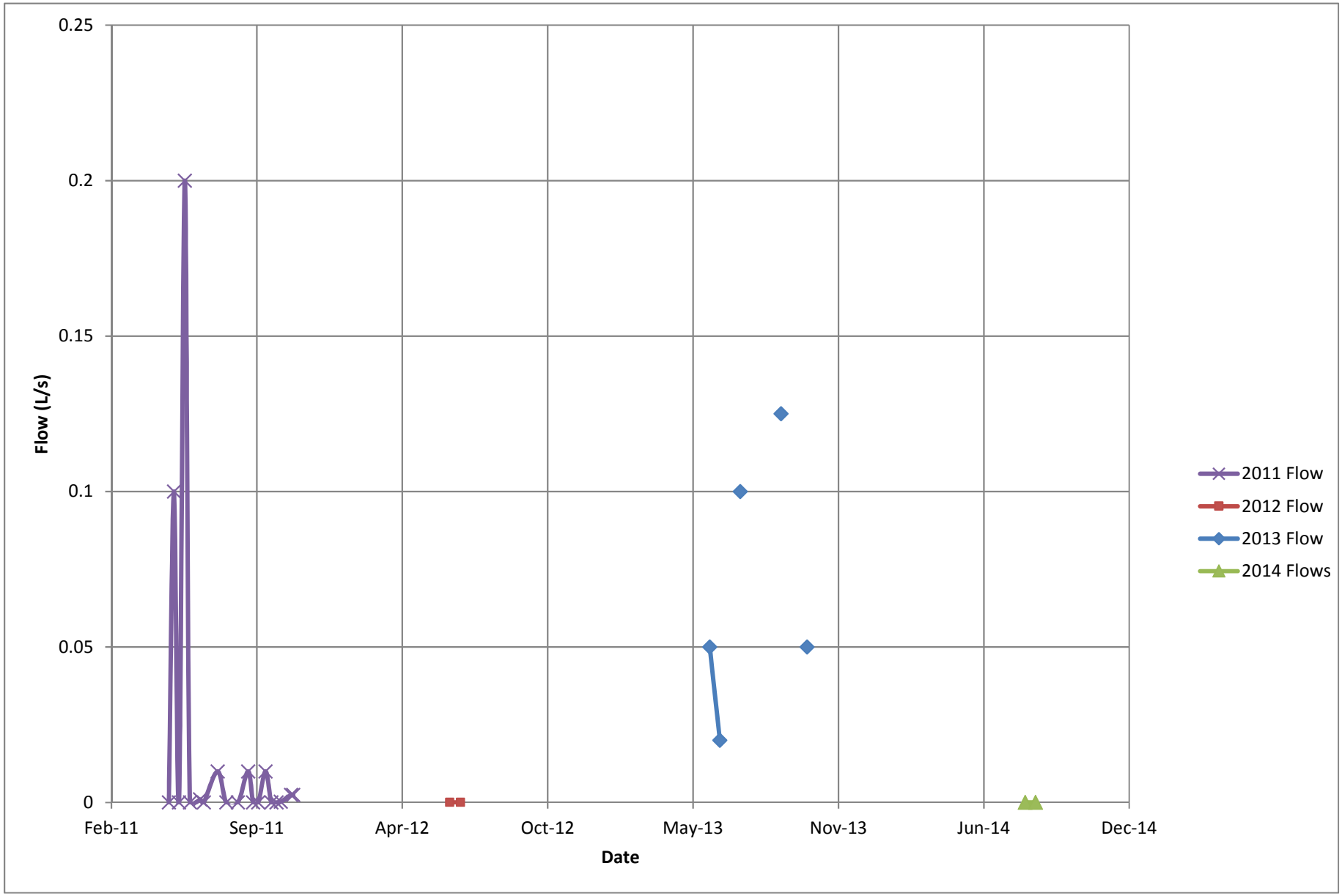
V30 (Drain 3)


1.2
1
0.8
0.6
0.4
0.2
0
Flow (L/s)
Feb-11
Sep-11
Apr-12
Oct-12
May-13
Nov-13
Jun-14
Dec-14
Date
2011 Flow
2013 Flow
2012 Flow
2014 Flow

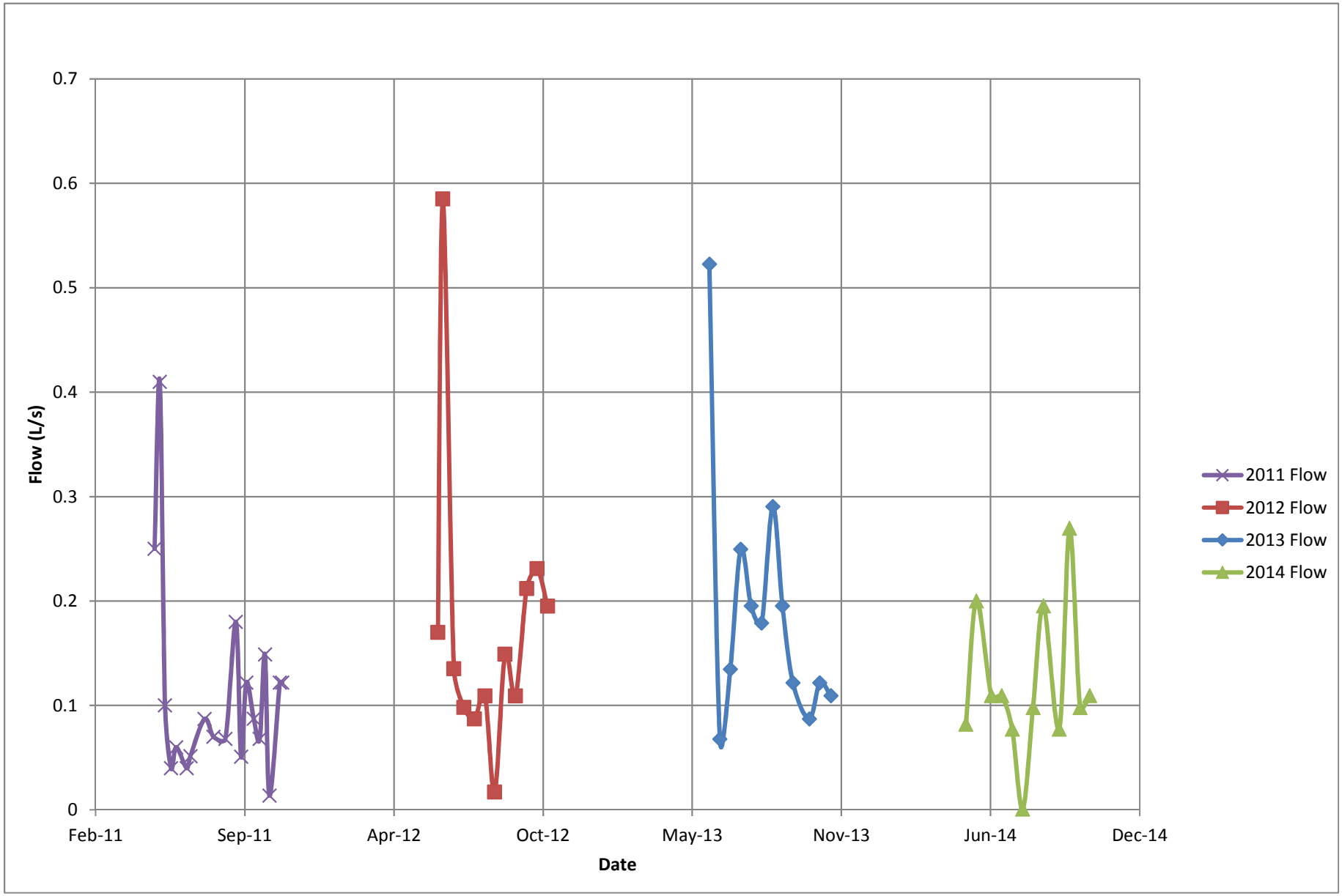
V31 (Drain 4)


1.2
1
0.8
0.6
0.4
0.2
0
Flow (L/s)
Feb-11
Sep-11
Apr-12
Oct-12
May-13
Nov-13
Jun-14
Dec-14
Date
2011 Flow
2012 Flow
2013 Flow
2014 Flow

V32 (Drain 5)

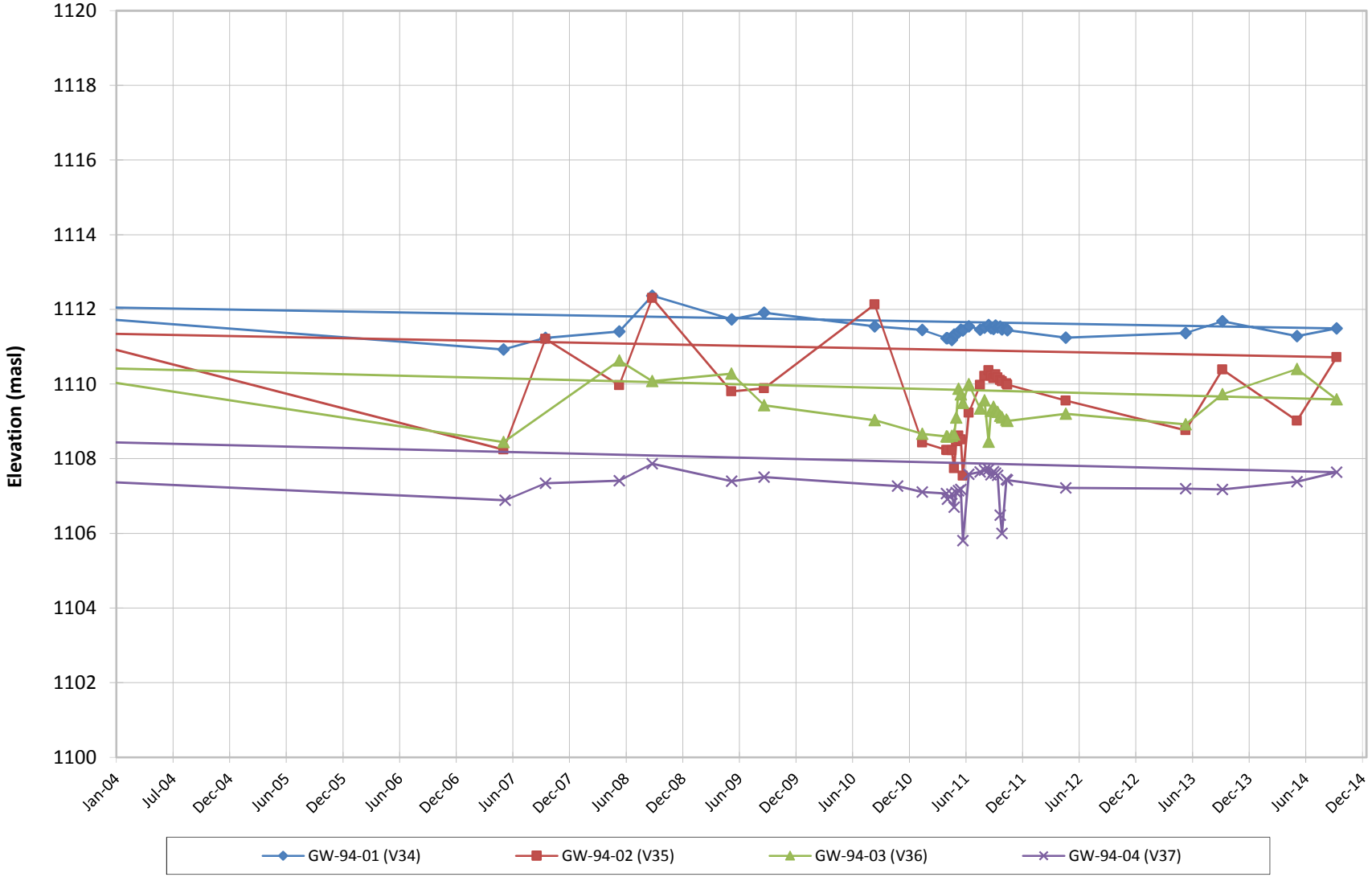

0.25
0.2
0.15
0.1
0.05
0
Flow (L/s)
Feb-11
Sep-11
Apr-12
Oct-12
May-13
Nov-13
Jun-14
Dec-14
Date
2011 Flow
2012 Flow
2013 Flow
2014 Flows

V33 (Drain 6)

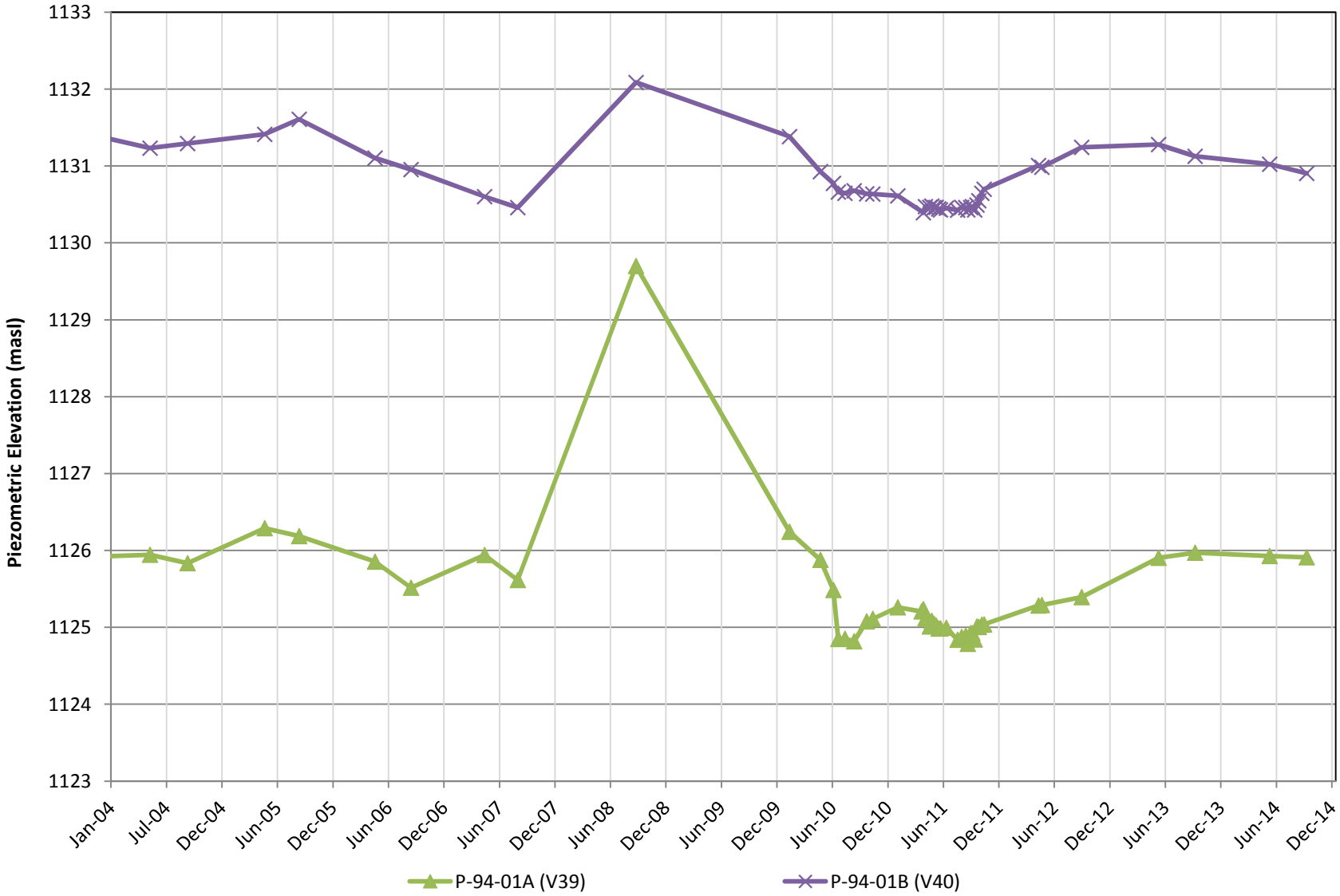

0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Flow (L/s)
Feb-11
Sep-11
Apr-12
Oct-12
May-13
Nov-13
Jun-14
Dec-14
Date
2011 Flow
2012 Flow
2013 Flow
2014 Flow

L2 – Piezometers

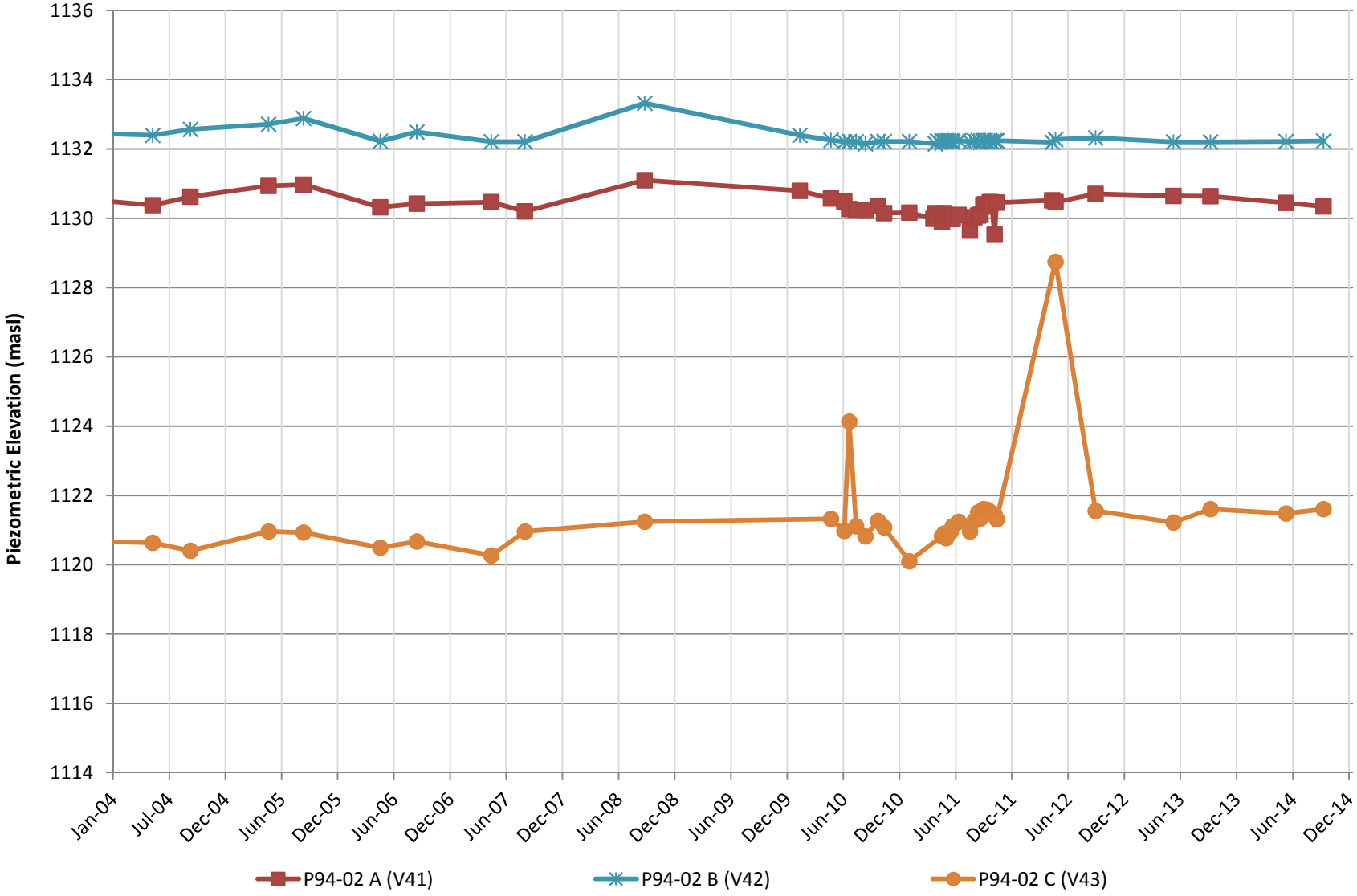
Vangorda Dump Toe Groundwater Elevations
V34, V35, V36, V37



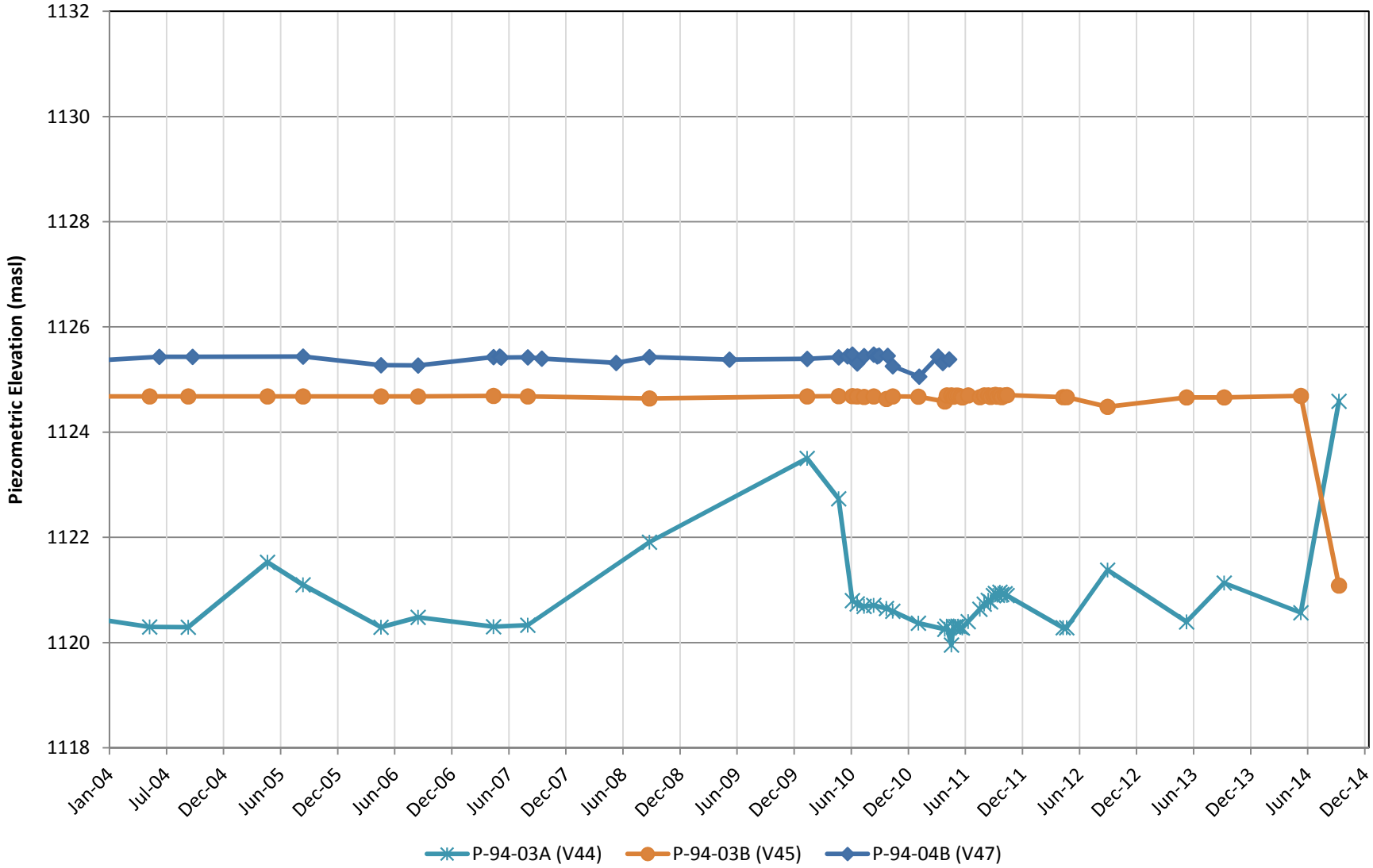
Vangorda Waste Rock Dump
Piezometric Elevations
P94-01A (V39)
P94-01B (V40)



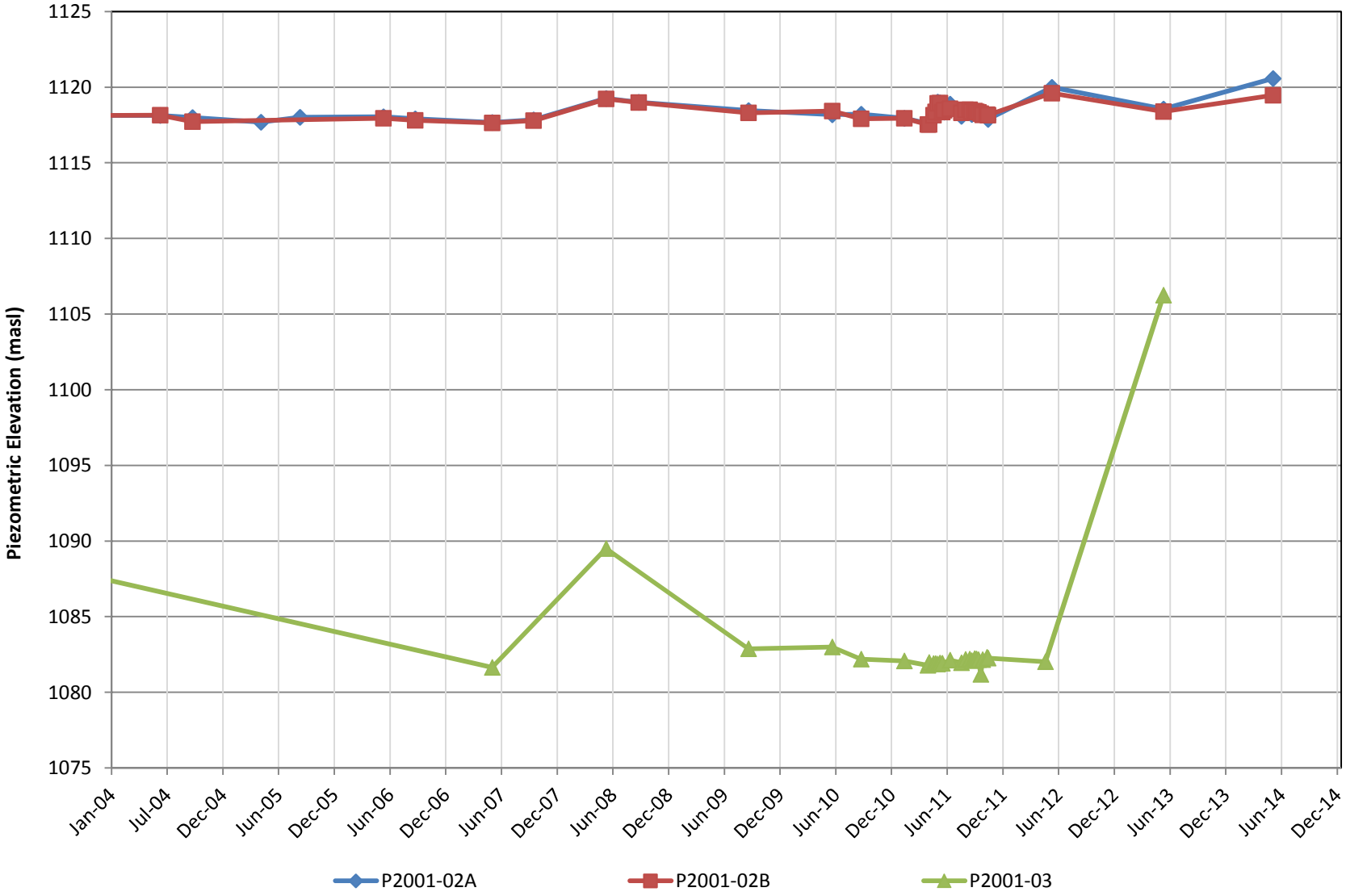
Vangorda Waste Rock Dump
Piezometric Elevations
V41, V42, V43

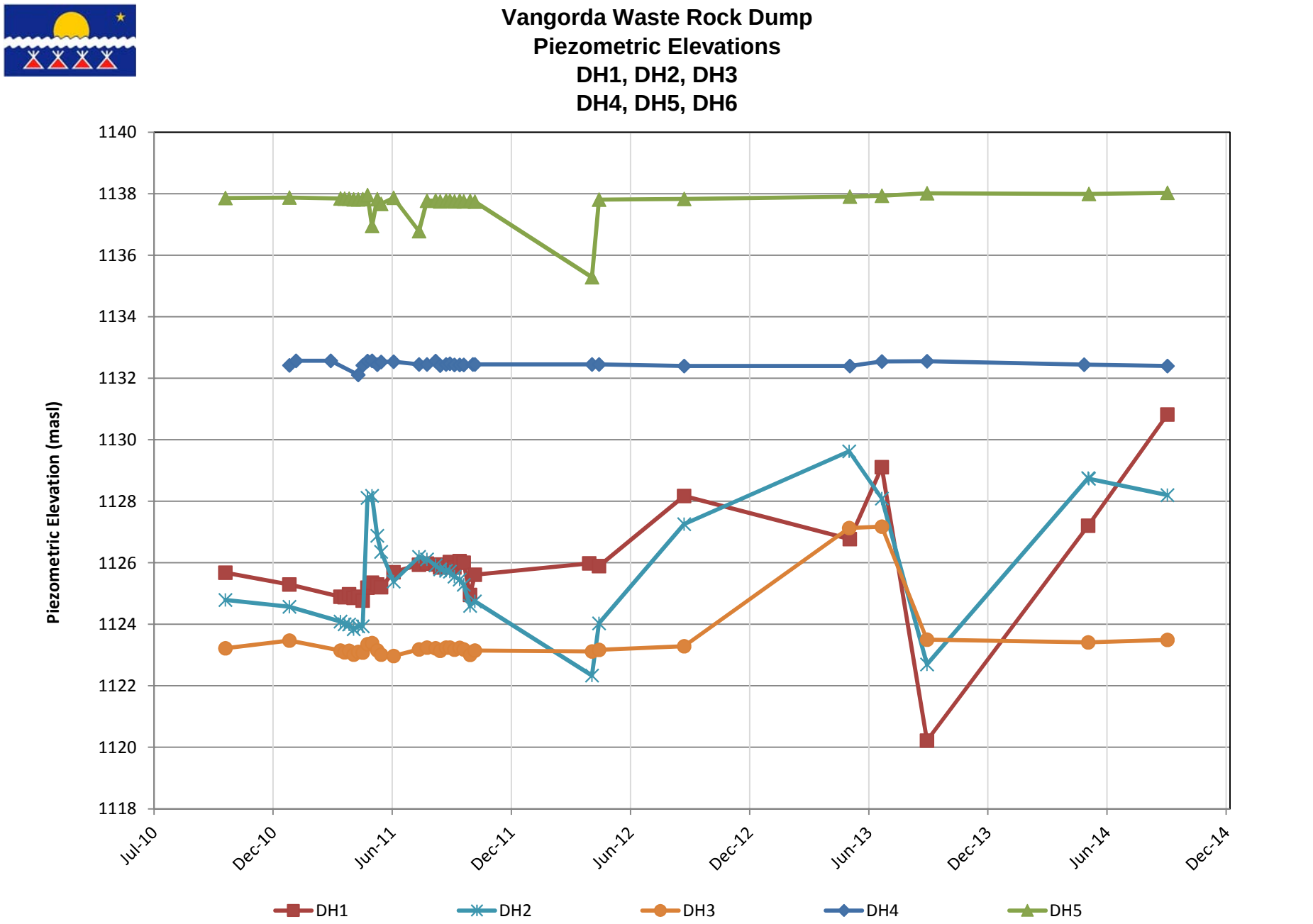


Vangorda Waste Rock Dump
Piezometric Elevations
P94-03A (V44)
P94-03B (V45)
P94-04B (V47)



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




Vangorda Waste Rock Dump
Piezometric Elevations
DH1, DH2, DH3
DH4, DH5, DH6
Piezometric Elevation (masl)
1140
1138
1136
1134
1132
1130
1128
1126
1124
1122
1120
1118
Jul-10
Dec-10
Jun-11
Dec-11
Jun-12
Dec-12
Jun-13
Dec-13
Jun-14
Dec-14
DH1
DH2
DH3
DH4
DH5

APPENDIX II-M

Little Creek Dam

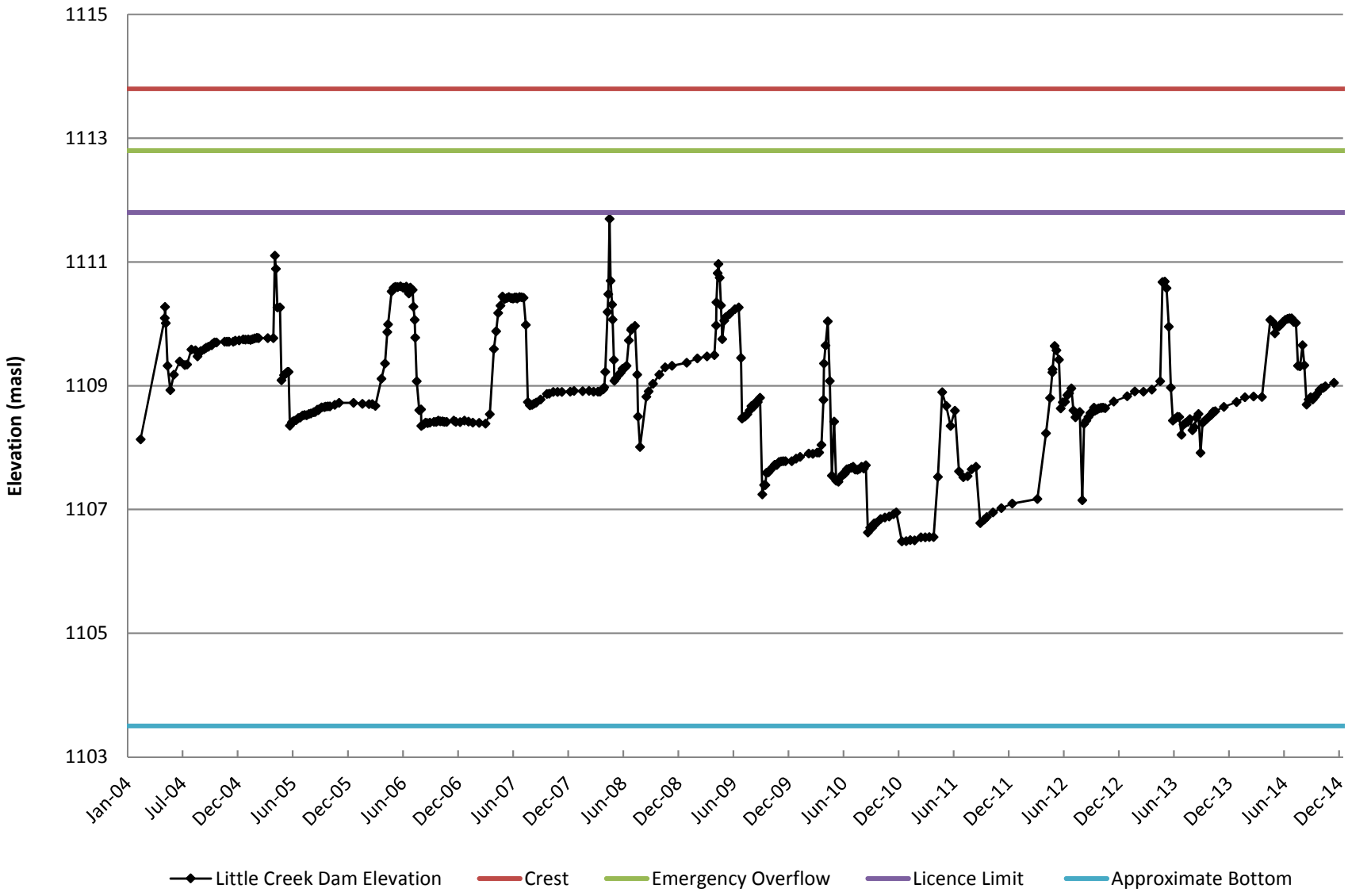
M1 – Pond Level (Little Creek Pond)

M2 – Piezometers

M3 – Thermistors (Not included)

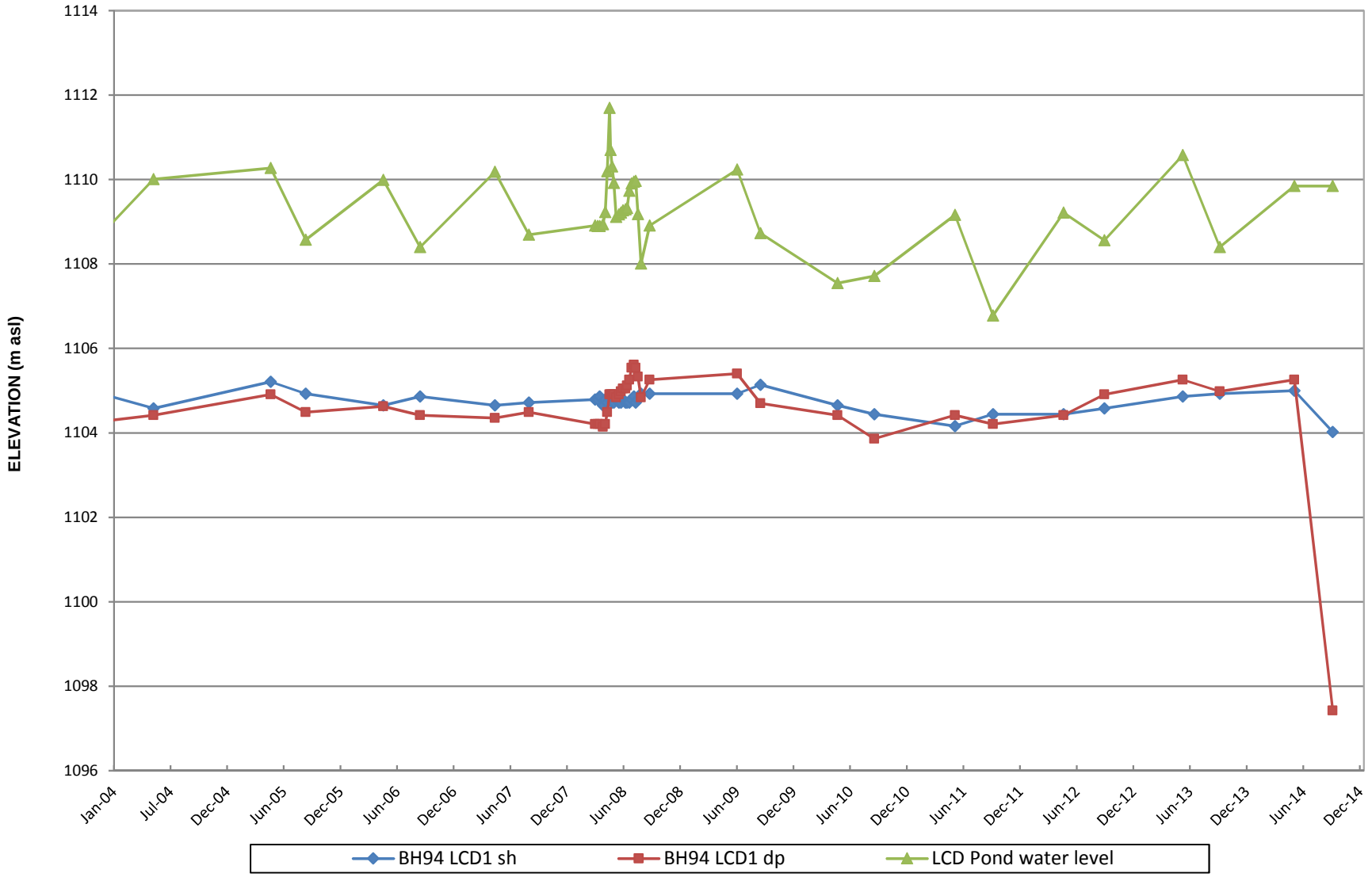
M1 – Pond Level (Little Creek Pond)

Little Creek Dam Pond Water Level

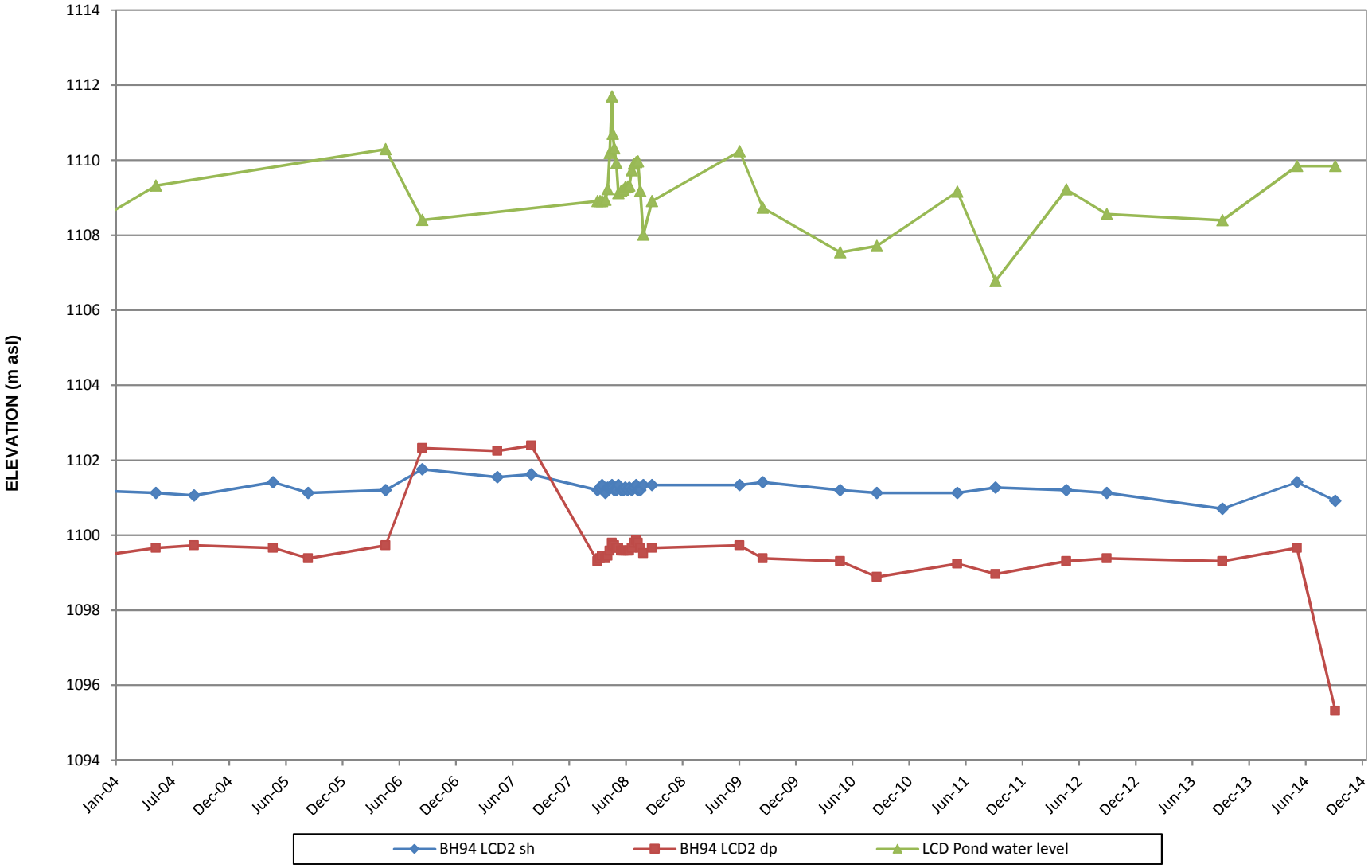


M2 – Piezometers

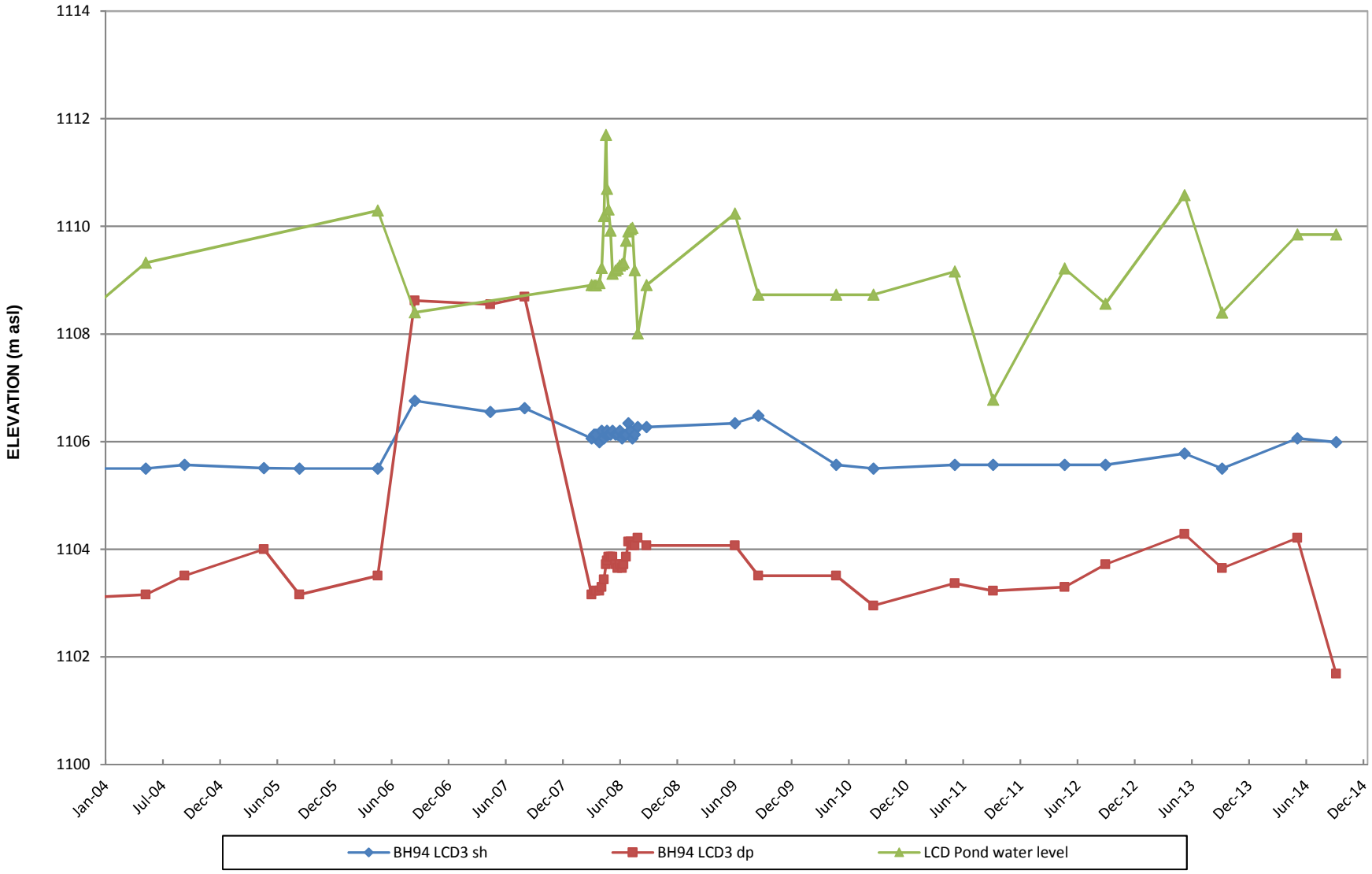
Little Creek Dam
Piezometer BH94 LCD1



Little Creek Dam
Piezometer BH94 LCD2



Little Creek Dam
Piezometer BH94 LCD3



M3 – Thermistors

Not included

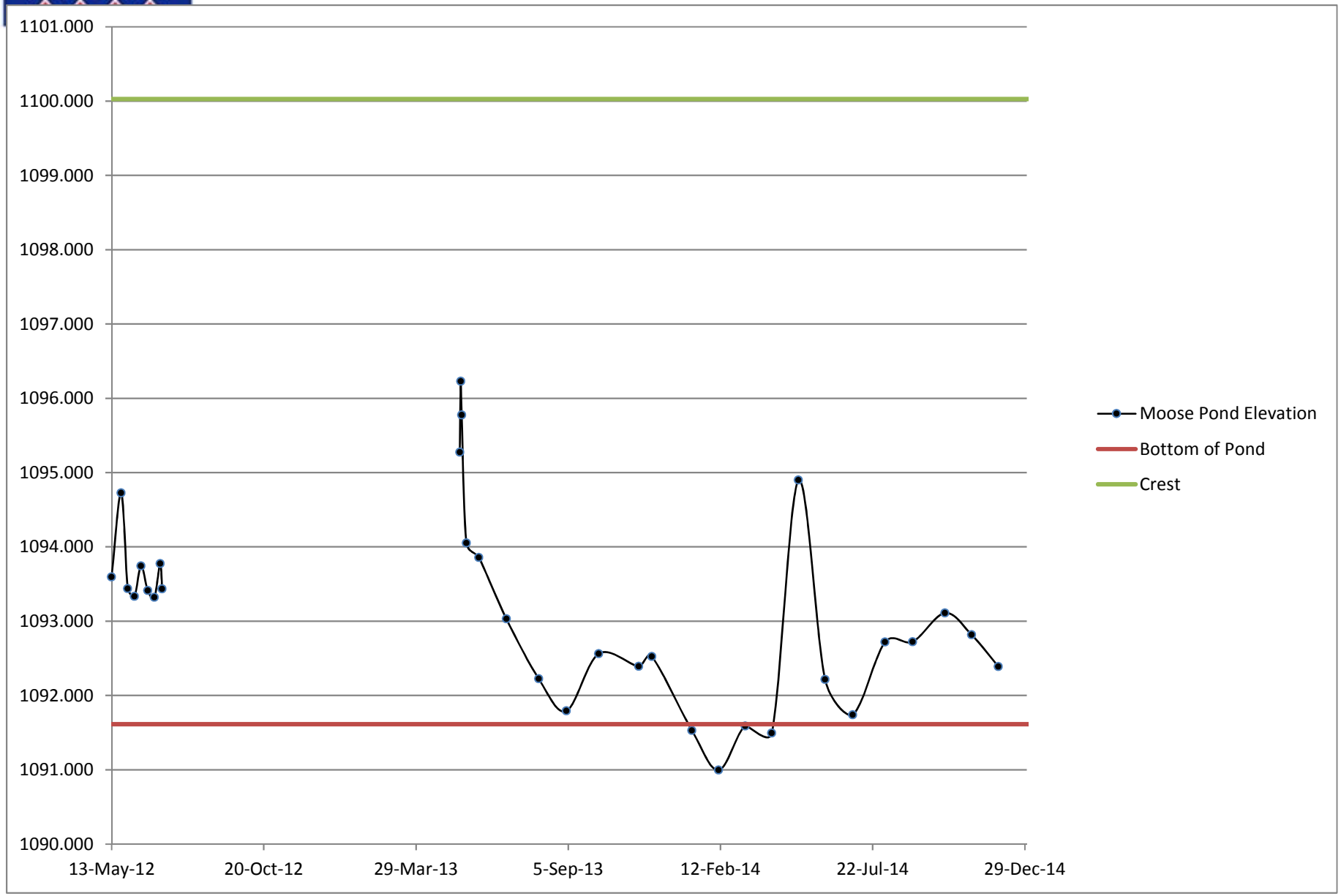
APPENDIX II-N

Moose Pond

N1 – Pond Level

N1 – Pond Level

Moose Pond Elevations

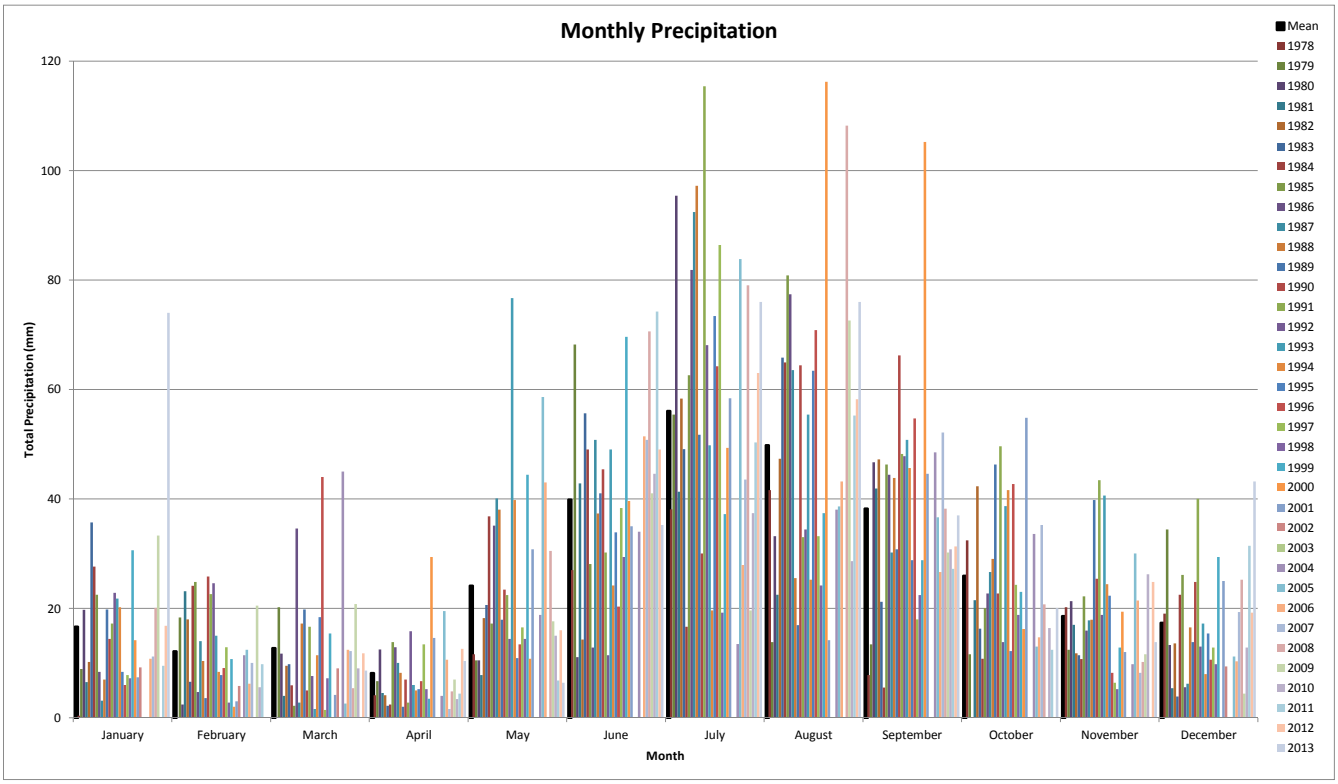


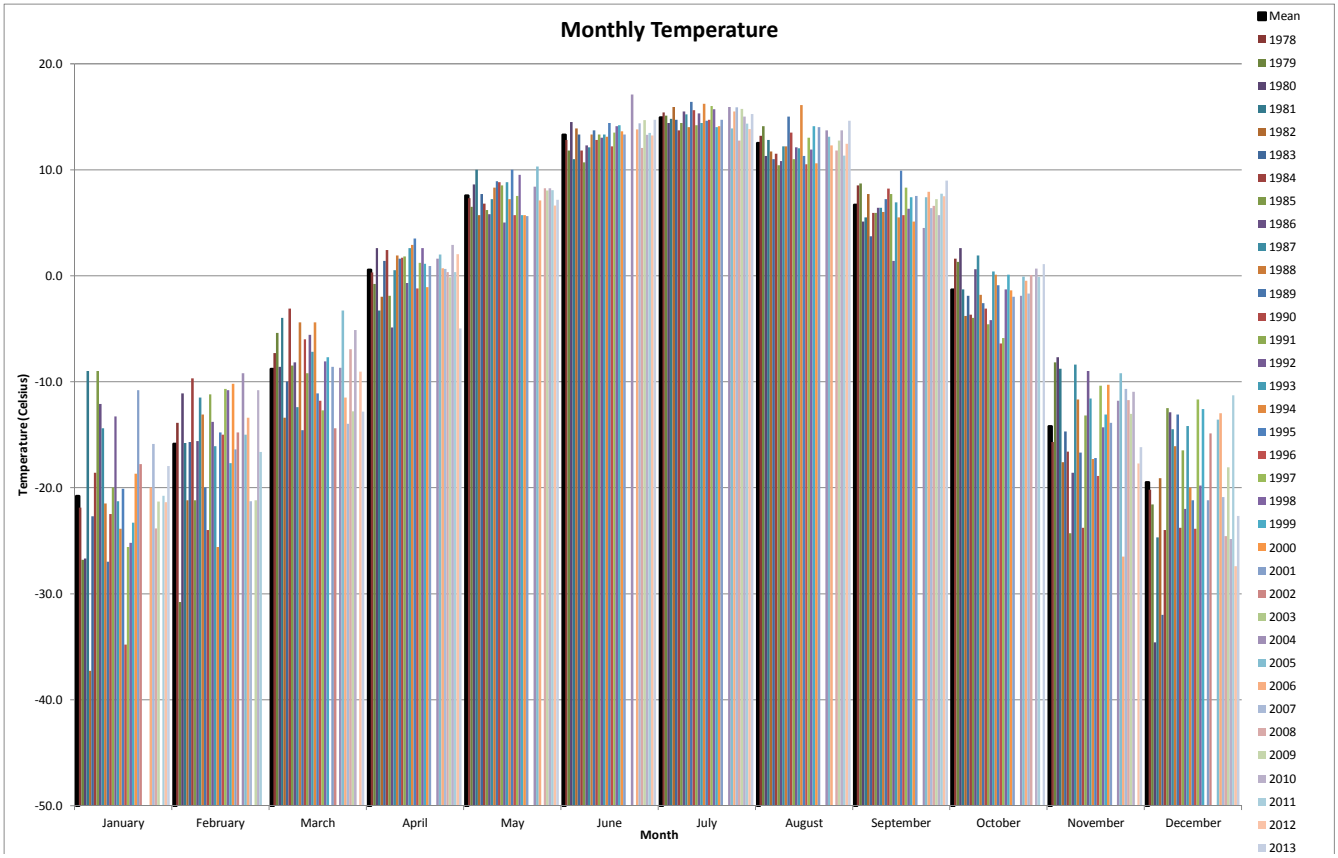
APPENDIX II-O

Faro Airport Climate

O1 – Monthly Precipitation/Temperature

O1 – Monthly Precipitation/Temperature


Monthly Precipitation
Total Precipitation (mm)
120
100
80
60
40
20
0
January
February
March
April
May
June
July
August
September
October
November
December
Month
Mean
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013


Monthly Temperature
Temperature (Celsius)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
January
February
March
April
May
June
July
August
September
October
November
December
Month
Mean
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

APPENDIX III

Instrumentation Status and Monitoring Schedule

Appendix IIII
Instrumentation Status and Monitoring Schedule

III-1 SUMMARY

Appendix III summarizes the current status of instrumentation monitored by TEES for the annual geotechnical review program. Table III.1 presents a summary of instrumentation monitored in 2014 at various structures and corresponding reference tables given in the main text and recorded data presented in Sections of Appendix II. Table III.2 shows the 2014 monitoring schedule presented in our 2013 annual review report. Table III.3 shows the monitoring schedule proposed for 2015 with minor adjustment.

III-2 RATIONALE FOR PROPOSED CHANGE IN MONITORING SCHEDULE

Our proposed minor changes apply only to the thermistors and inclinometers located on the Back Slope of the Rose Creek Diversion Channel. The current slumping activities on the Back Slope appear to be recurrent events that were active in the past at various locations and at different time. Two mechanisms could contribute to these activities: surficial saturation effect due to precipitation and runoff, and weakening effect of the newly thawed subsoil at depth.

The 2014 monitoring of Thermistors: BS-5, BS-9, BS-10 and BS-12 located on the Back Slope indicated that most of these thermistors are not functioning, with the exception of two at 4.5 m and 6.5 m depth in BS-9. We recommend that these thermistors be rehabilitated or replaced to provide correct in situ ground temperature in 2015. In addition, all other thermistors located on the Back Slope should also be checked to see whether they can be rehabilitated or replaced for ongoing ground temperature monitoring at depth in other reaches of the Back Slope.

The subsoil horizontal-movement profiles obtained from 2014 monitoring of Inclinometers: BS-5, BS-9 and BS-10 are presented in Section II-E3, pages 4 to 6 of Appendix II. No excessive horizontal movement is indicated in these profiles. Thus, we recommend only one set of reading in 2015 for these inclinometers. However, It should be noted that all existing Back Slope inclinometers were installed on the hillside of the installed earthfill thermal liner with a set back from the channel side slope. Thus, the favourable subsoil horizontal deformation profiles at these inclinometers do not reflect the condition underneath the deformed hillside channel side slope.

Due to Health and Safety concerns, programs of distance monitoring by TEES at the pit rim of the Faro Pit east wall and Grum Pit east wall were discontinued in September 2014.

Table III.1 Status of Instrumentation Monitoring

Structure	Type of Instrument	Instrument Status - Table in Main Text	2014 Data - Section in Appendix II	Comments Regarding 2015 Monitoring Schedule
Faro Pit[1]	Lake Level	Table 2.1	Section II-A1	As required by YG[2]
	Rim Reference Bars and Prisms	-	Sections II-A2 and II-A3	Reference Bars - May, September; Prisms - Yearly
Grum Pit[1]	Lake Level	-	Section II-J1	As required by YG[2]
	Rim Reference Rods	Table 3.1	Section II-J2	Reference Rods - Monthly
	Piezometers	-	Section II-J3	As required by YG[2]
Vangorda Pit[1]	Lake Level	-	Section II-K1	As required by YG[2]
Faro Creek Diversion	Staff Gauges	Table 2.1	Section II-B1 and II-B2	Twice monthly - April to October
Rose Creek Diversion / Canal Dyke	Staff Gauges	Table 2.3	Section II-D1 and II-D2	Daily - April to September
	Piezometers	Table 2.4	Section II-E1	Three times yearly - May, June, September
	Inclinometers	Table 2.4	Section II-E3	Once yearly - all inclinometers (repeat until correct readings taken, critical in Back Slope)
	Thermistors	Table 2.4	Section II-E2	Once yearly - all thermistors in Back Slope and the following thermistors for Canal Dyke: CD-10, CD-15, CD-21, SP-2, SP-3 and SP-5. Preserve remaining thermistors for potential use in future.
North Valley Interceptor	Ditch Flow	Table 2.2	Section II-C1	As required by YG[2]
North Fork Rock Drain	Water Level	Table 2.5	Section II-F1	As required by YG[2]
Secondary Tailings Dam	Piezometers	Table 2.6	Section II-G1	Three times yearly - May, June, September
Intermediate Dam	Pond Level	Table 2.7	Section II-H1	As required by YG[2]
	Piezometers	Table 2.7	Section II-H2	Three times yearly - May, June, September
Cross Valley Dam / Polishing Pond	Pond Level	Table 2.8	Section II-I1	As required by YG[2]
	Piezometers	Table 2.8	Section II-I2	Three times yearly - May, June, September
	Thermistors	-	-	Preserve thermistors for potential use in future
	Weirs Flow	Table 2.9	Section II-I3	As required by YG[2]
Little Creek Dam	Pond Level	Table 3.4	Section II-M1	As required by YG[2]
	Piezometers	Table 3.4	Section II-M2	Twice yearly - May, September
	Thermistors	-	-	Preserve thermistors for potential use in future
Moose Pond	Pond Level	-	Section II-N1	As required by YG[2]
Vangorda Waste Dump	Piezometers	Table 3.2	Section II-L2	Twice yearly - May, September
	Weirs Flow	Table 3.3	Section II-L1	Twice monthly - April to October

Notes: 1. Photos of Instability Zones in Faro Pit East Wall and Grum Pit East Wall and Vangorda Northwest Wall to be taken at same vantage points, see Appendix I and Golder (2014).
2. No proposed schedule adjustment is made in Table III.3 for those instrumentations commented with "As Required by Yukon Government (YG)".

Table III.2 2014 Faro Mine Complex Geotechnical - Hydrotechnical Monitoring Program

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rose Creek Diversion Canal													
Thermistors	Canal Dyke: CD-10[2], CD-15[2], CD-21[2], BGC05-04, BGC05-07, CD-26						M						
	Spoil Pile[2]: SP-2, SP-3, SP-5						M						
	Backslope[2]: BS-5, BS-9, BS-10, BS-12						M			M			
Slope Indicators	Canal Dyke: CD-10, -15, -19, -21. BH94CD-1. BH91-CD1. BGC05-05, -08.					One successful reading for all inclinometers							
	Spoil Pile: SP-2, SP-5					One successful reading for all inclinometers							
	Backslope: BS-5, BS-9, BS-10					Two successful readings for all inclinometers:							
						one set in spring/summer, the other in fall							
Piezometers	Canal Dyke: CD-13, -15,-21. BGC05-02, -03, -06. CD-26.					M	M			M			
	Backslope: BS-5, BS-9					M	M			M			
Staff Gauges	RCDC-4				Daily	Daily	Daily	Daily	Daily	Daily			
Cross Valley Dam													
Thermistors	CVDC-6, BH88-4												
Piezometers	CVDC-4, -7, -9. CVDT-1, -2. CVDP-1, -3, -5, -6. 94 CVDC-1.					M	M			M			
Weir Flows	X11, X12, Weir 3	M	M	M	M	M	M	M	M	M	M	M	M
	X13	W	W	W	W	W	W	W	W	W	W	W	W
Elevations	Polishing Pond	W	W	W	W	W	W	W	W	W	W	W	W
Intermediate Dam													
Piezometers	91ID-4, -6, -7. 94-IDC-1, 96-1, -2, -3, -4. P01-03, -04. BKS04-06, -07.					M	M			M			
	91-ID3					M	M		M	M			
Observe	Seepage observations near south abutment					M	M		M	M			
Elevations	Intermediate Pond	W	W	W	W	W	W	W	W	W	W	W	W
Secondary Tailings Dam													
Piezometers	P81-6, P81-7, P81-8, P03-01, P03-02, P03-03					M	M			M			
North Fork Rock Drain													
Data loggers	NFRD23				M	M	M	M	M	M	M		
Staff Gauges	NFRD23, X2				Daily	Daily	Daily	W	W	W	W		
Elevations	NF1, NF2					W	W	W	TAM	TAM			
Observe	NF1, NF2	M	M	M	M	M	M	M	M	M	M	M	M
K8 Rock Drain													
Observe						M	M	M					
Faro Creek Diversion Channel													
Staff Gauges	FCD-1, FCD-2, FCD-3, FCD-4				TAM	TAM	TAM	TAM	TAM	TAM	TAM		
Flows	FCD-1, FCD-2, FCD-3, FCD-4				TAM	TAM	TAM	TAM	TAM	TAM	TAM		
Faro Pit													
Measure	15356, 15717, 15355, 15737, 15354, 15742, 13908, 15352, 15351					M				M			
Observe	Faro Pit	M	M	M	M	M	M	M	M	M	M	M	M
Haul Road													
Observe	K8 Rock Drain					M	M	M					
Grum Pit													
Measure	GP-S1, -S2,-S3, -S4. GP-N1, -N2, -N3, -N4, -N5, -N6.	M	M	M	M	M	M	M	M	M	M	M	M
Observe	Grum Pit Wall	M	M	M	M	M	M	M	M	M	M	M	M
Piezometers	SRK09-GSA, SRK09-GSB	M	M	M	M	M	M	M	M	M	M	M	M
Vangorda Pit													
Observe	Vangorda Pit Wall	M	M	M	M	M	M	M	M	M	M	M	M
Vangorda Waste Rock Dump													
Observe	V28, V29, V30, V31, V32, V33					M	M	M	M	M	M		
Observe	Drainage Ditch						M						
Observe	Northeast Dump Crest						M						
Flows	V29, V30, V31, V32, V33					TAM	TAM	TAM	TAM	TAM	TAM		
Piezometers	V39, 40, 41, 42, 43, 44, 45, 46, 47. PW-10-01, -02, -03, -04, -05.					M				M			
Data loggers	PW-10-01, PW-10-02, PW-10-03, PW-10-5					M				M			
Little Creek Dam													
Piezometers	BH94 LCD-1, BH94 LCD-2, BH94 LCD-3					M				M			
Thermistors	BH94 LCD-4, BH94 LCD-5, BH94 LCD-6												
Observe	Dam Crest						M						
Observe	Inlet of Culvert Spillway						M						
Vangorda Creek Diversion													
Observe	Trash Rack at Headworks					M	M	M					
Observe	Seepage Collection Pond						M						
Observe	Sideslopes Above Flume					M	M	M					
Sludge Pond Embankment													
Observe	Downstream slopes and Embankments						M						
Grum Settling Pond													
Observe	Spillway from Grum Settling Pond to Grum Inteceptor Ditch						M						
Grum Interceptor Ditch and Sheep Pad Pond													
Observe	Outlets / Inlets to Ditch						M						
	Sheep Pad Pond Dyke						M						

Notes: 1. M means monthly, W means weekly and TAM means twice a month

2. It is critical to take readings of thermistors located in Back Slope and Spoil Pile as well as Thermistors CD-10, CD-15 and CD-21 in 2014.

Faro Mine Complex
Table III.3 Geotechnical Monitoring Program

Faro Mine Complex Geotechnical Program 2015	January	February	March	April	May	June	July	August	September	October	November	December
Rose Creek												
Thermistors												
Canal Dyke: CD-15, CD-21, BGC05-04, BGC05-07, CD-26					Monthly	Monthly			Monthly			
Spoil Pile: SP-3, SP-5						Monthly						
Backslope: BS-5, BS-9, BS-10, BS-12						Monthly			Monthly			
Slope Indicators	If blocked in May attempt in June											
Canal Dyke: CD-10, CD-15, CD-19, CD-21, BH94CD-1, BH91-CD1, BGC05-05, BGC05-08					Monthly				Monthly			
Spoil Pile: SP-2, SP-5						Monthly						
Backslope: BS-5, BS-9, BS-10						Monthly			Monthly			
Piezometers												
Canal Dyke: CD-13, CD-15, CD-21, BGC05-02, BGC05-03, BGC05-06, CD-26					Monthly	Monthly			Monthly			
Backslope: BS-5, BS-9						Monthly			Monthly			
Staff Gauges												
RCDC-4				Daily	Daily	Daily	Daily	Daily	Daily			
NFRD23, X2				Daily	Daily	Daily	Weekly	Weekly	Weekly	Weekly		
Data loggers												
NFRD23				Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly		
Elevations												
NF1, NF2					Weekly	Weekly	Weekly	TAM	TAM			
Observations												
NF1, NF2	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Cross Valley Dam												
Thermistors												
CVDC-6, BH88-4						Monthly						
Piezometers												
CVDC-4, CVDC-7, CVDC-9, CVDT-1, CVDT-2, CVDP-1, CVDP-3, CVDP-5, CVDP-6, 94 CVDC-1					Monthly	Monthly			Monthly			
Weir Flows												
X11, X12, Weir 3	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
X13	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Elevations												
Polishing Pond	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Intermediate Dam												
Piezometers												
91ID-4, 91-ID-6, 91-ID-7, 94-IDC-1, 96-1, 96-2, 96-3, 96-4, P01-03, P01-04, BKS04-06, BKS04-07					Monthly	Monthly			Monthly			
914-ID3					Monthly	Monthly		Monthly	Monthly			
Observations												
Seepage observations near south abutment					Monthly	Monthly		Monthly	Monthly			
Elevations												
Intermediate Pond	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Secondary Tailings Dam												
Piezometers												
P81-6, P81-7, P81-8, P03-01, P03-02, P03-03					Monthly	Monthly			Monthly			
North Wall Interceptor Ditch												
Flows												
NWID	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Faro Creek Diversion Channel												
Staff Gauges												
FCD-1, FCD-2, FCD-3, FCD-4				TAM	TAM	TAM	TAM	TAM	TAM	TAM		
Flows												
FCD-1, FCD-2, FCD-3, FCD-4				TAM	TAM	TAM	TAM	TAM	TAM	TAM		
Faro Pit												
Observations												
Faro Pit	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Haul Road												
Observations												
K8 Rock Drain	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Grum Pit												
Observations												
Grum Pit Wall	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Piezometers												
SRK09-GSA, SRK09-GSB	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Vangorda Pit												
Observations												
Vangorda Pit Wall	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Vangorda Waste Rock Dump												
Observations												
V28, V29, V30, V31, V32, V33					Monthly	Monthly	Monthly	Monthly	Monthly	Monthly		
Drainage Ditch						Monthly						
Northeast Dump Crest						Monthly						
Flows												
V29, V30, V31, V32, V33					TAM	TAM	TAM	TAM	TAM	TAM		
Piezometers												
V29, V30, V31, V32, V33					TAM	TAM	TAM	TAM	TAM	TAM		
Piezometers												
V39, V40, V41, V42, V43, V44, V45, V46, V47, PW-10-01, PW-10-02, PW-10-03, PW-10-04, PW-10-05					Monthly				Monthly			
Data loggers												
PW-10-01, PW-10-02, PW-10-03, PW-10-5					Monthly				Monthly			
Little Creek Dam												
Piezometers												
BH94 LCD-1, BH94 LCD-2, BH94 LCD-3					Monthly				Monthly			
Thermistors												
BH94 LCD-4, BH94 LCD-5, BH94 LCD-6					Monthly							
Observations												
Dam Crest						Monthly						
Inlet of Culvert Spillway						Monthly						
Vangorda Creek Diversion												
Observations												
Trash Rack at Headworks						Monthly						
Seepage Collection Pond						Monthly						
Sideslopes Above Plume						Monthly						
Sludge Pond Embankment												
Observations												
Downstream slopes and Embankments						Monthly						
Grum Settling Pond												
Observations												
Spillway from Grum Settling Pond to Grum Inteceptor Ditch						Monthly						
Grum Interceptor Ditch and Sheep Pad Pond												
Observations												
Outlets / Inlets to Ditch						Monthly						
Sheep Pad Pond Dyke						Monthly						
Moose Pond												
Observations												
Kaori's Seep	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
						Monthly						
Elevations												
Moose Pond	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly

APPENDIX IV

Training PowerPoint Slides for TEES Monitoring Staff - June 12, 2014

FARO MINE COMPLEX – STAFF TRAINING

Robert C. Lo, P.Eng. June, 2014

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)

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Faro Mine Complex
Key Structures

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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 Flume

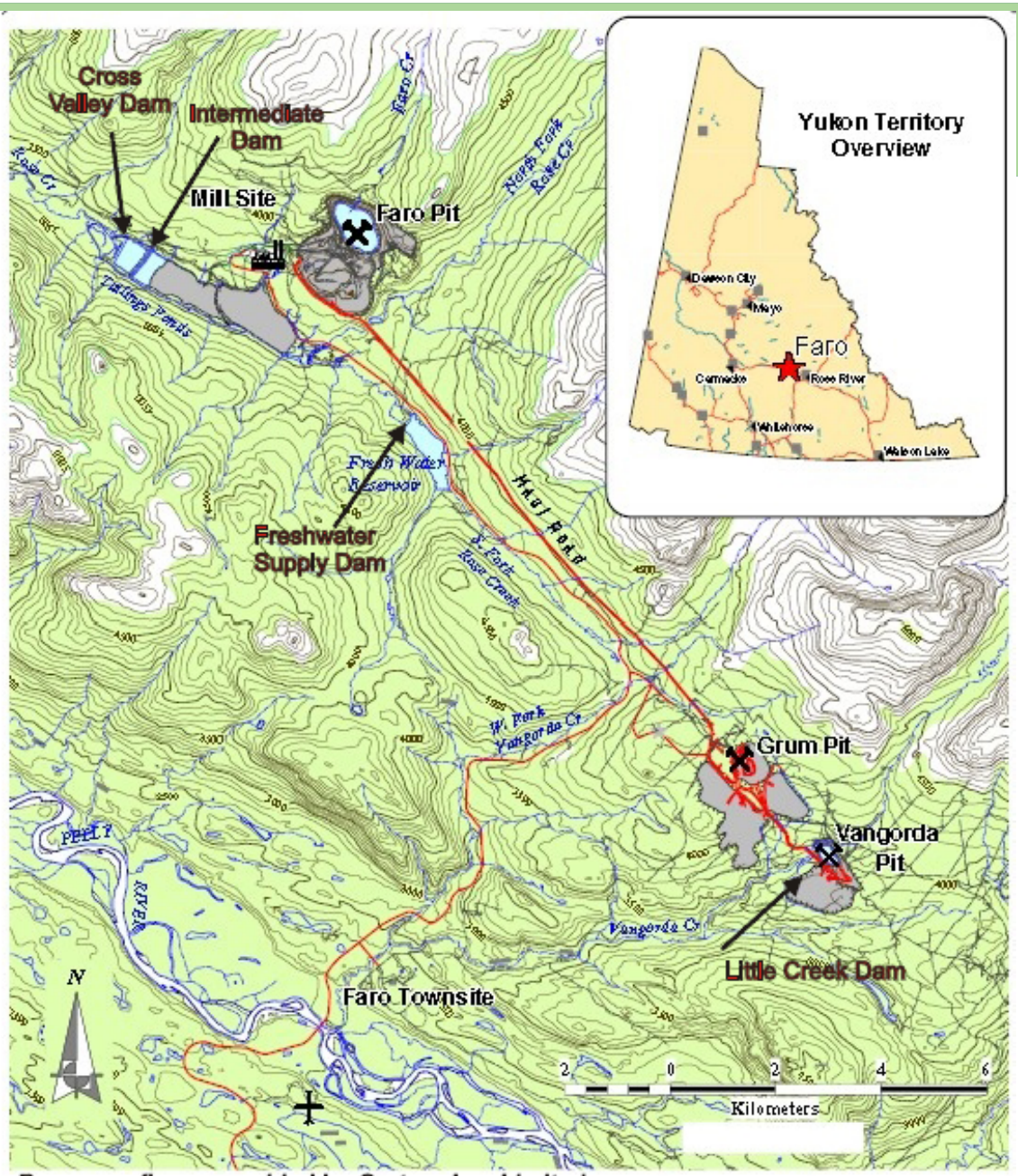
Grum Interceptor Ditch

Moose Pond

Vangorda Waste Rock Pile

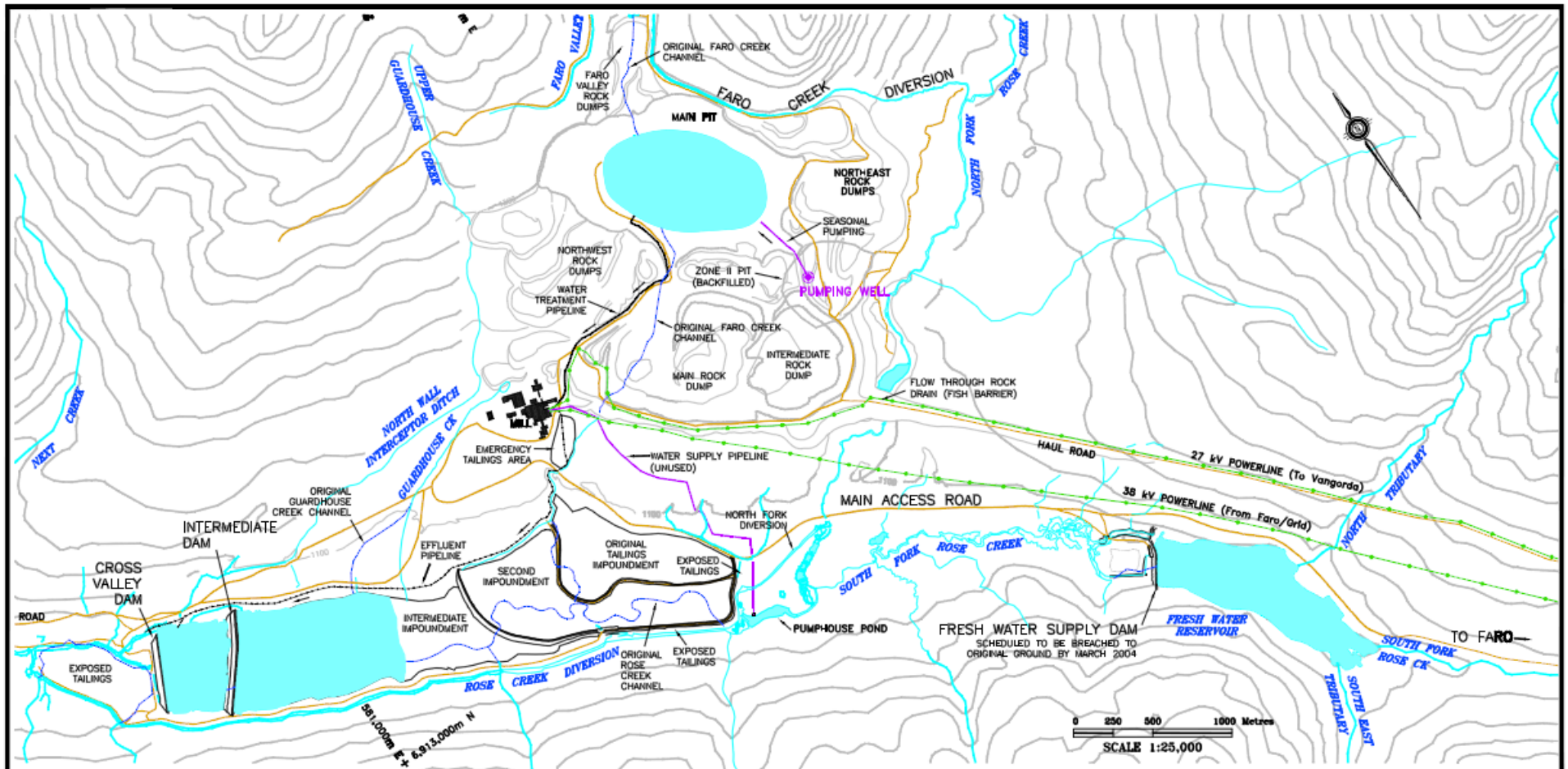
Faro Pit, Grum Pit and Vangorda Pit

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Note: Base map figure provided by Gartner Lee Limited.

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CLIENT:
Deloitte & Touche

NOTE: BASE MAP FIGURE PROVIDED BY GARTNER LEE LTD.

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

REV.	DATE	REVISION NOTES	DRAWN	CHECKED	APPROVED

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

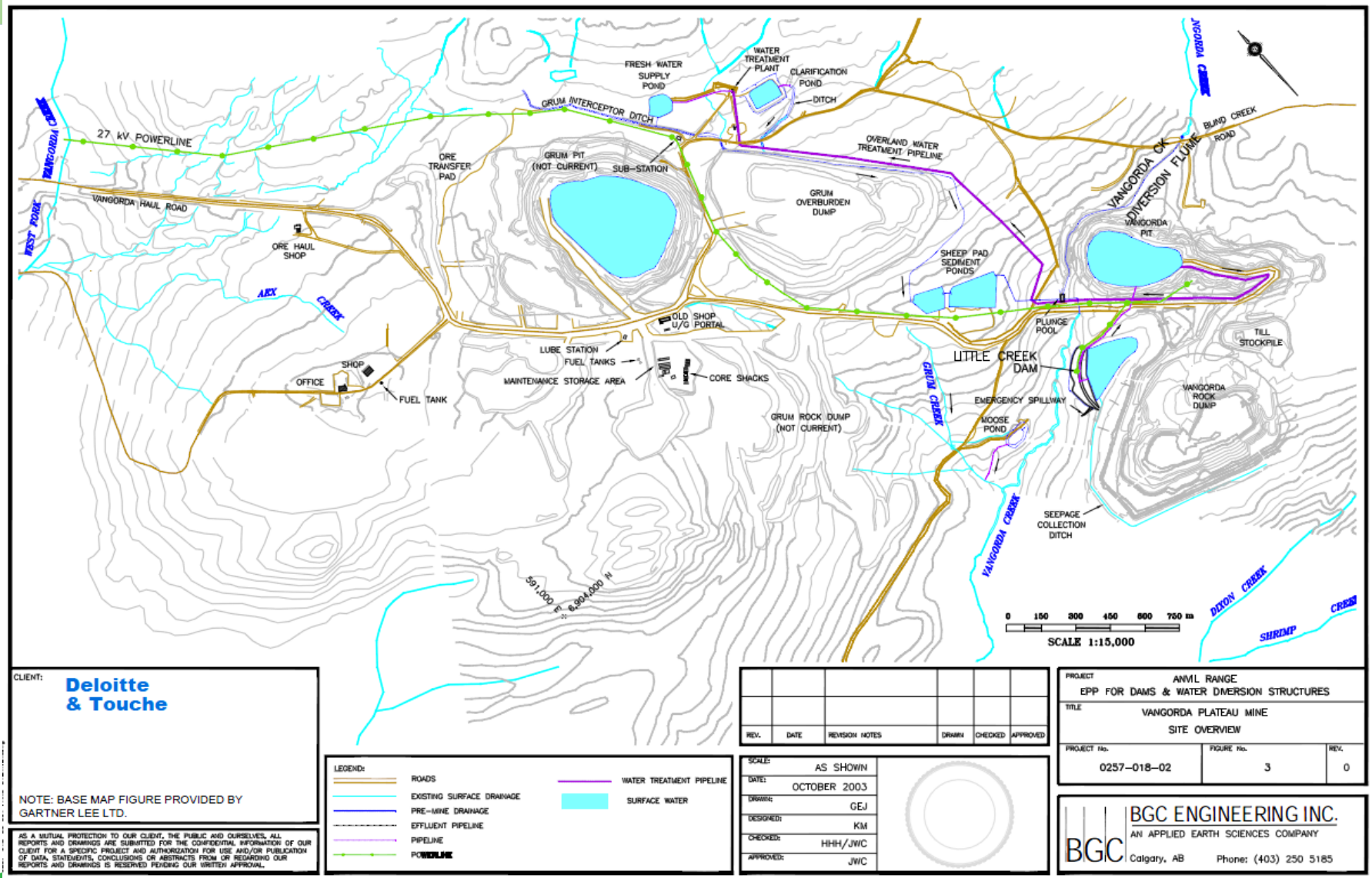
PROJECT: ANVIL RANGE
EPP FOR DAMS & WATER DIVERSION STRUCTURES

TITLE: FARO MINE SITE
OVERVIEW

PROJECT No.	FIGURE No.	REV.
0257-018-02	2	0

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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

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

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Dam Safety Related Reports

- Operations, Maintenance and Surveillance Manual
  March 2014
- Emergency Response Plan
  March 2014
- Dam Breach and Inundation Study
  February 2014
- 2013 Annual Geotechnical Review
  June 2014

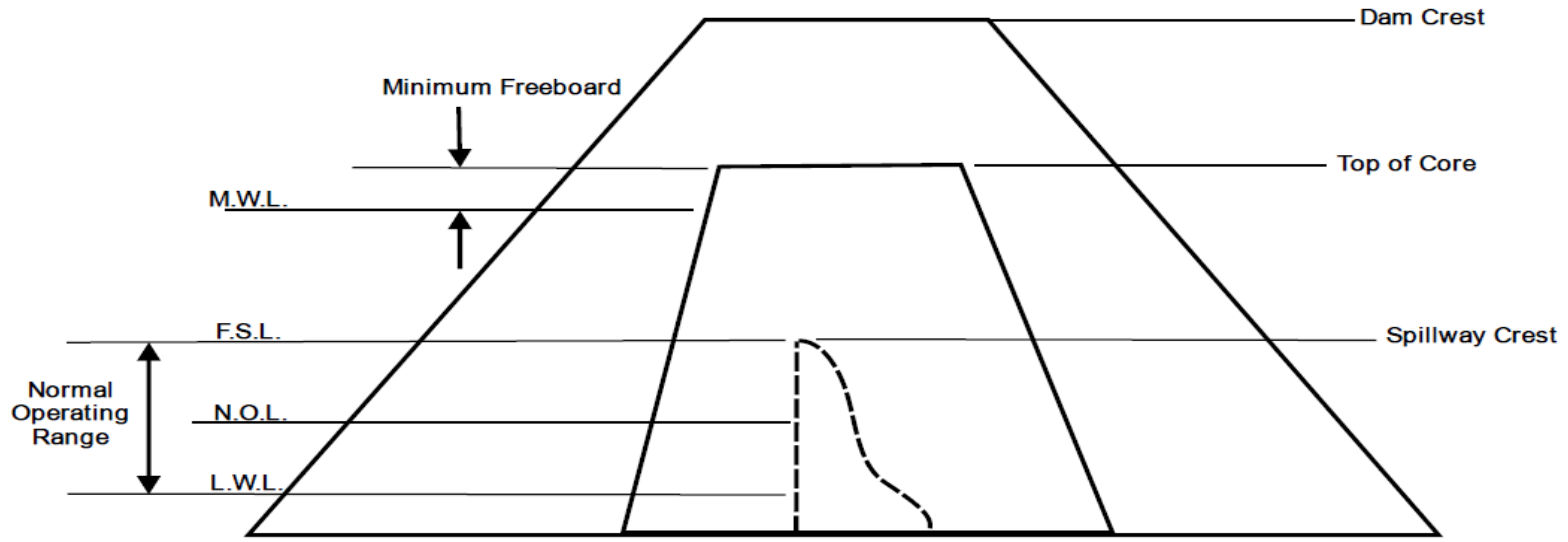
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Instrumentation Used on Site

- 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	
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Failure Mechanisms Inspection for Problems

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Failure Mechanisms

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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.

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.

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Diversion Channels and Exfiltration Pond

North Valley Wall Interceptor Ditch

Rose Creek Diversion Channel

Faro Creek Diversion

Vangorda Creek Diversion Flume

Grum Interceptor Ditch

Moose Pond

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Waste Dumps

Vangorda Rock Waste Dump
- **Toe Seepage Collection Ditch**

Other Waste Dumps
- **Faro Waste Dumps**
- **Grum 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

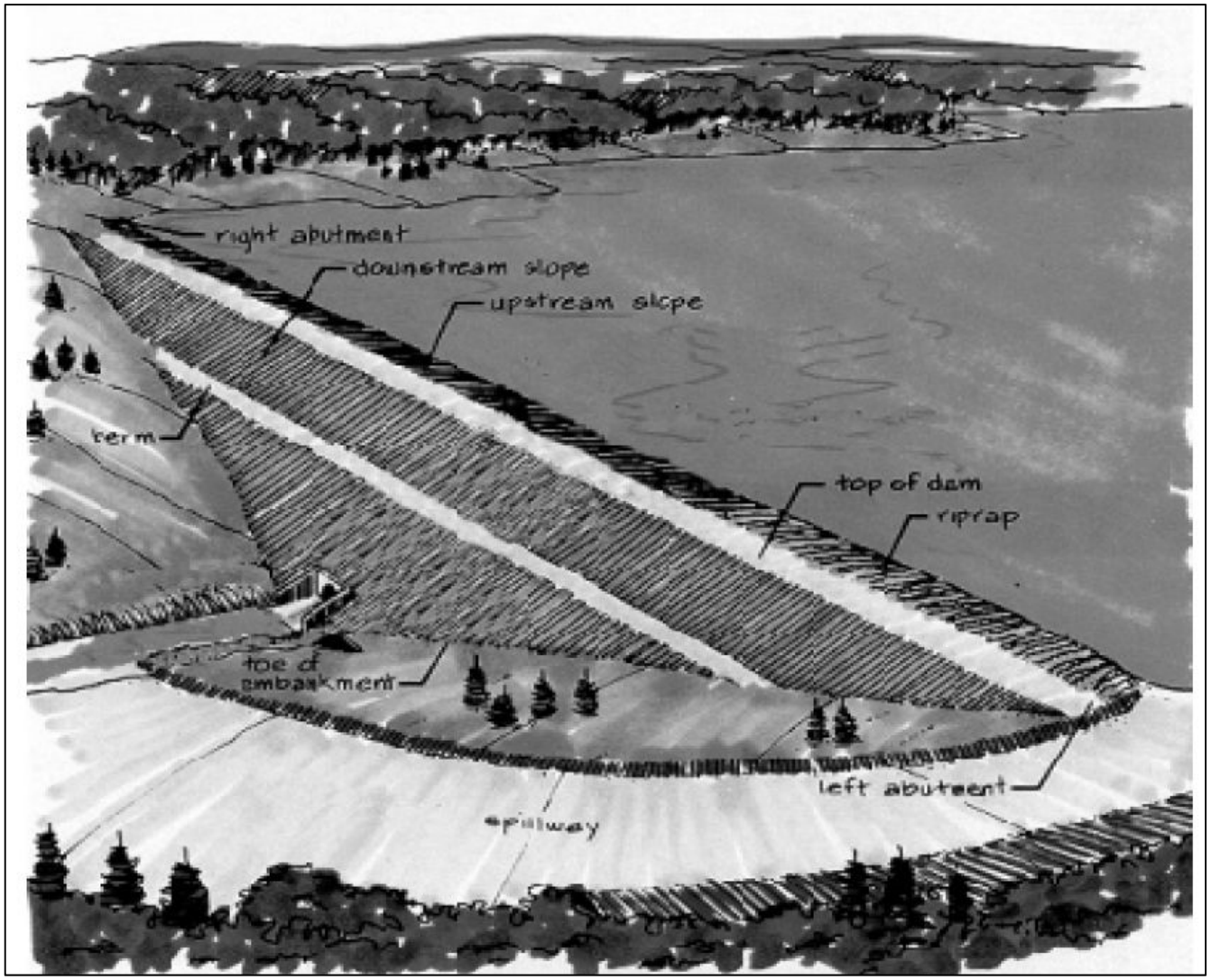


Inspection & Maintenance of Dams

(B.C. Ministry of Environment 2011)

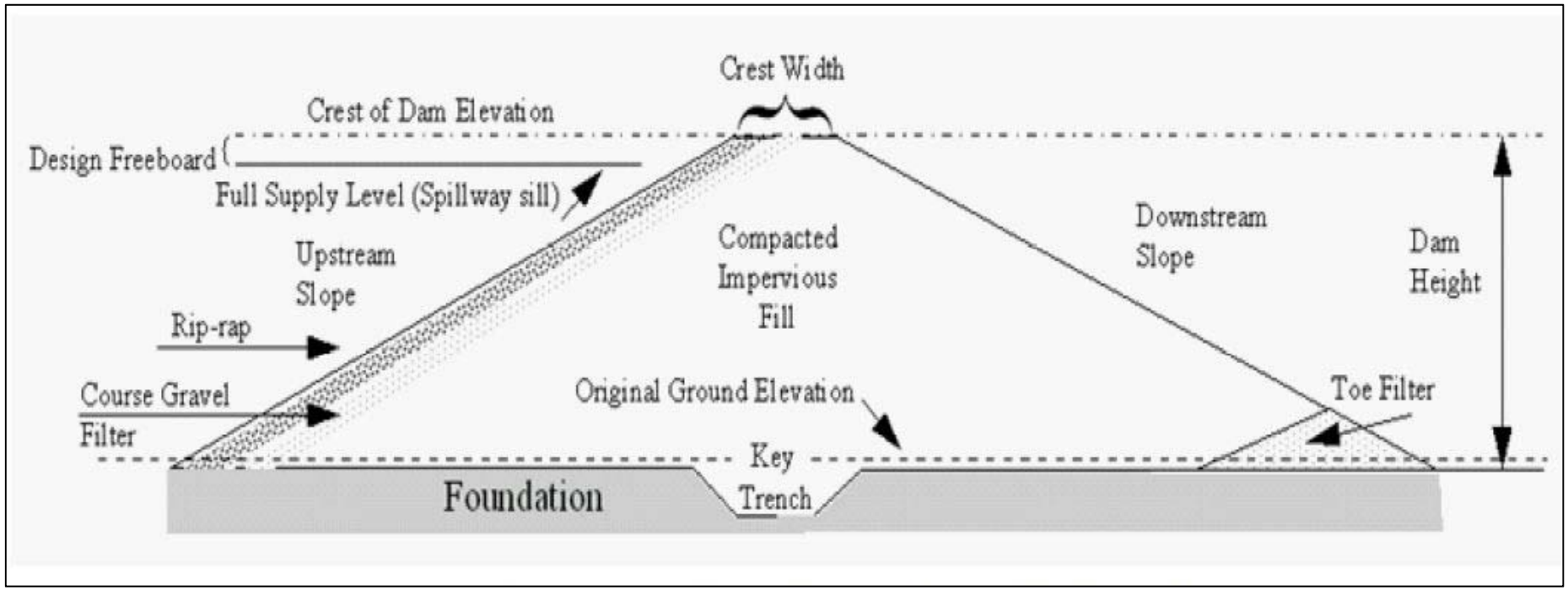
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Figure 1 – Principal Parts of an Embankment Dam



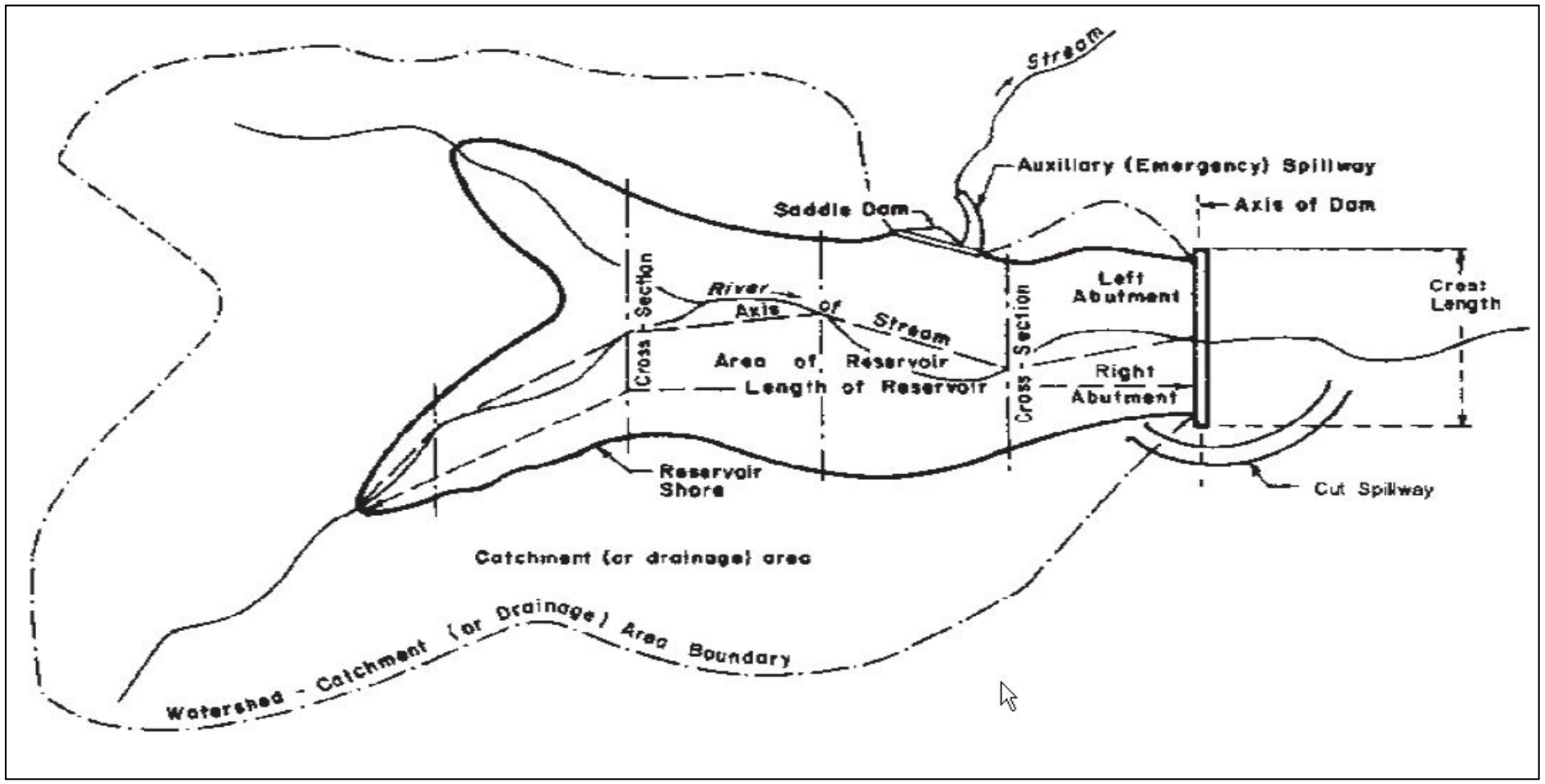
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Figure 2 – Typical Cross Section of an Embankment Dam



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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



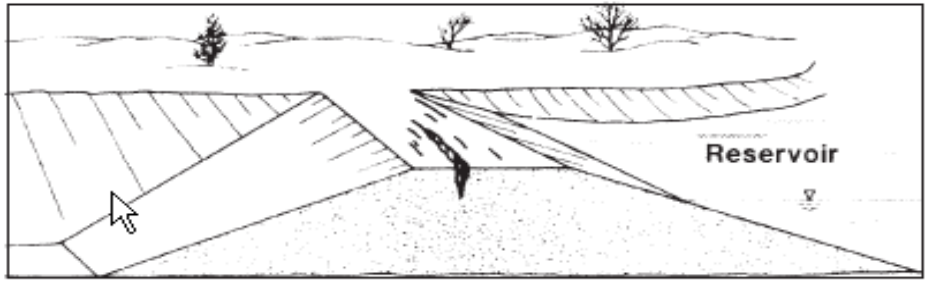
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Figure 6 – Ellis Creek Dam Failure (near Penticton) 1941

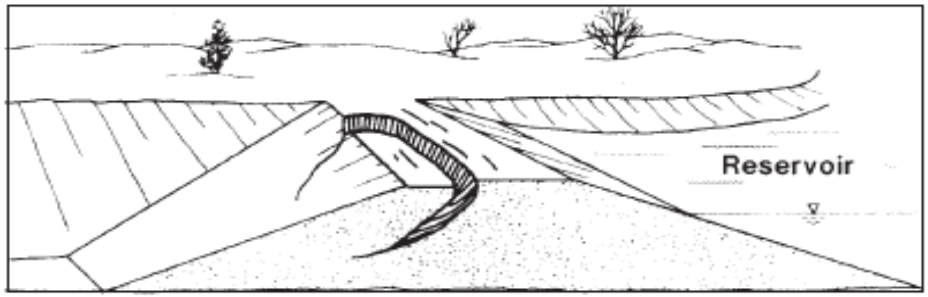


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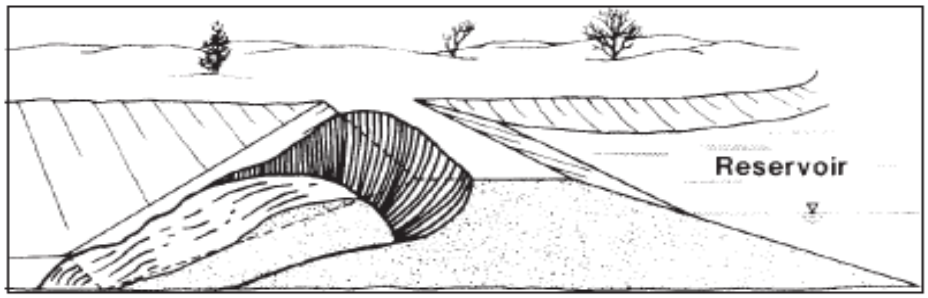
Figure 7 – Development of a Slope Failure from Longitudinal Cracking



A - Longitudinal cracks form and runoff water enters



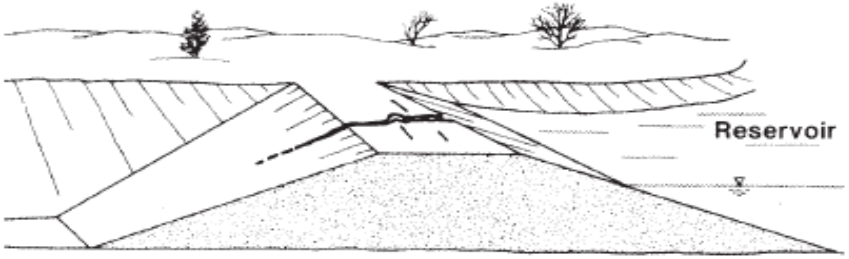
B - Cracks widen and the ground settles on one side of the crack



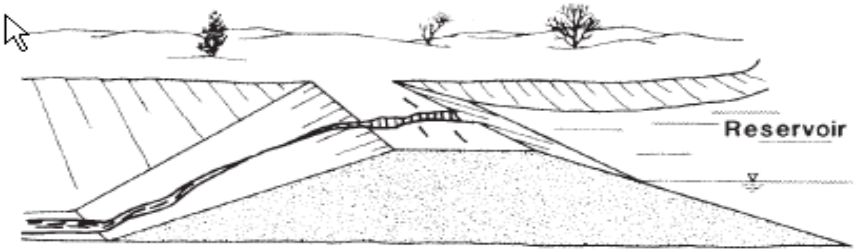
C - The slope fails

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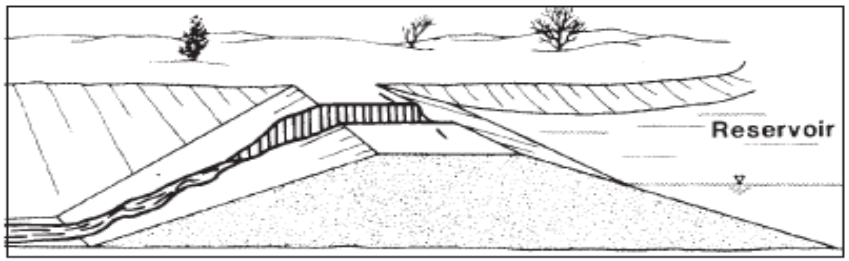
Figure 8 – Development of a Failure from Transverse Cracking



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



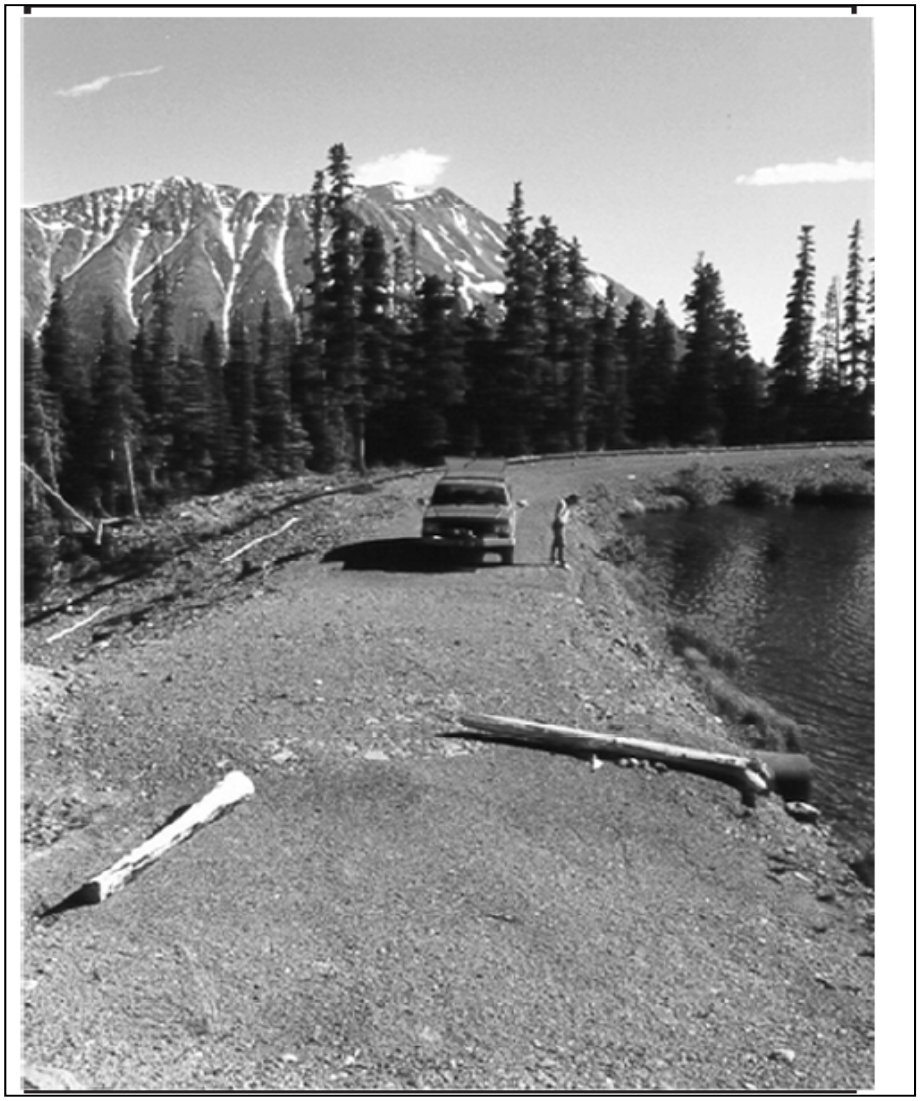
B - Progression of Transverse Cracking to a point below the waterline
Water from the reservoir begins to flow through the crack.



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

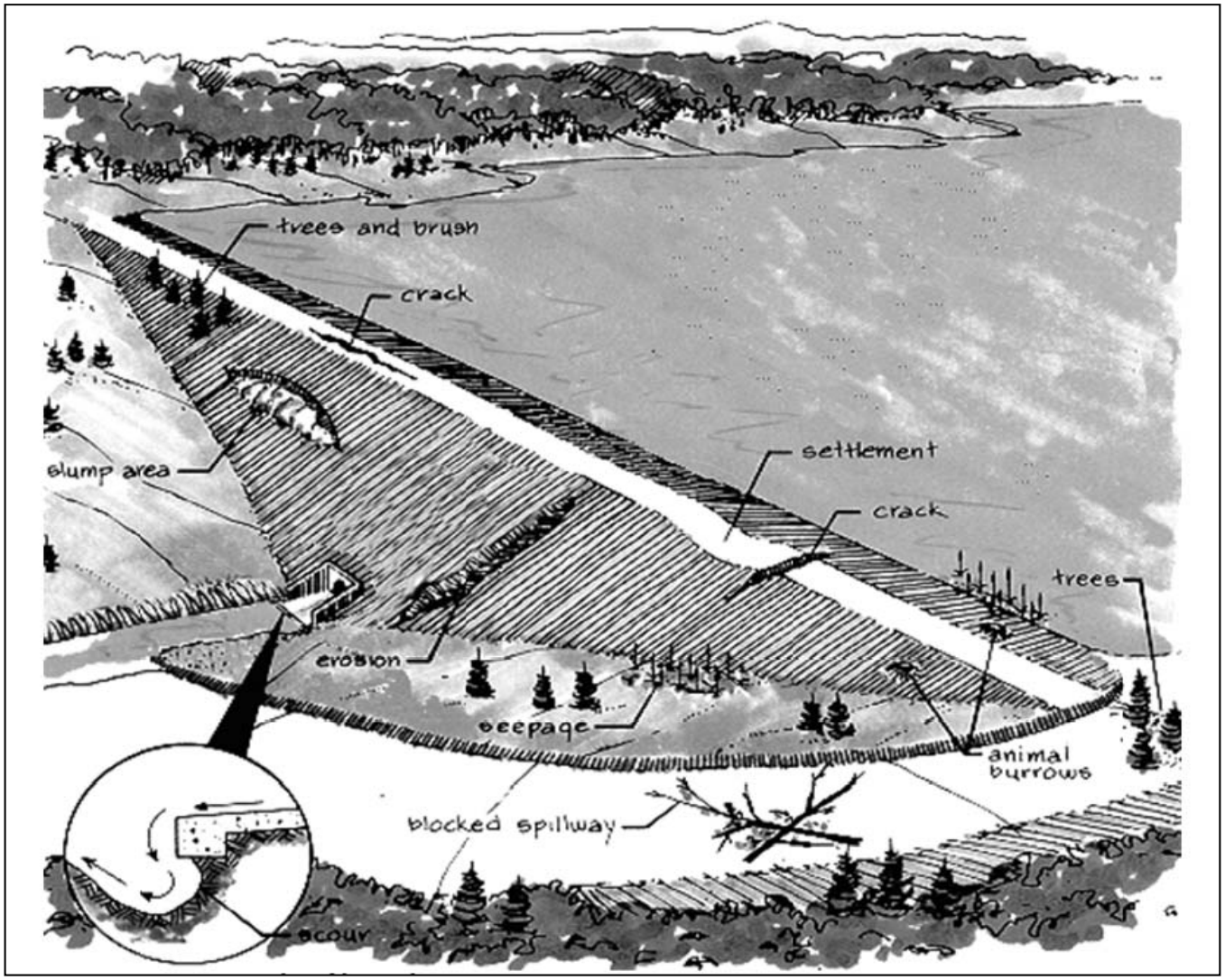
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Figure 9 – Dam Inspection in Northern B.C.



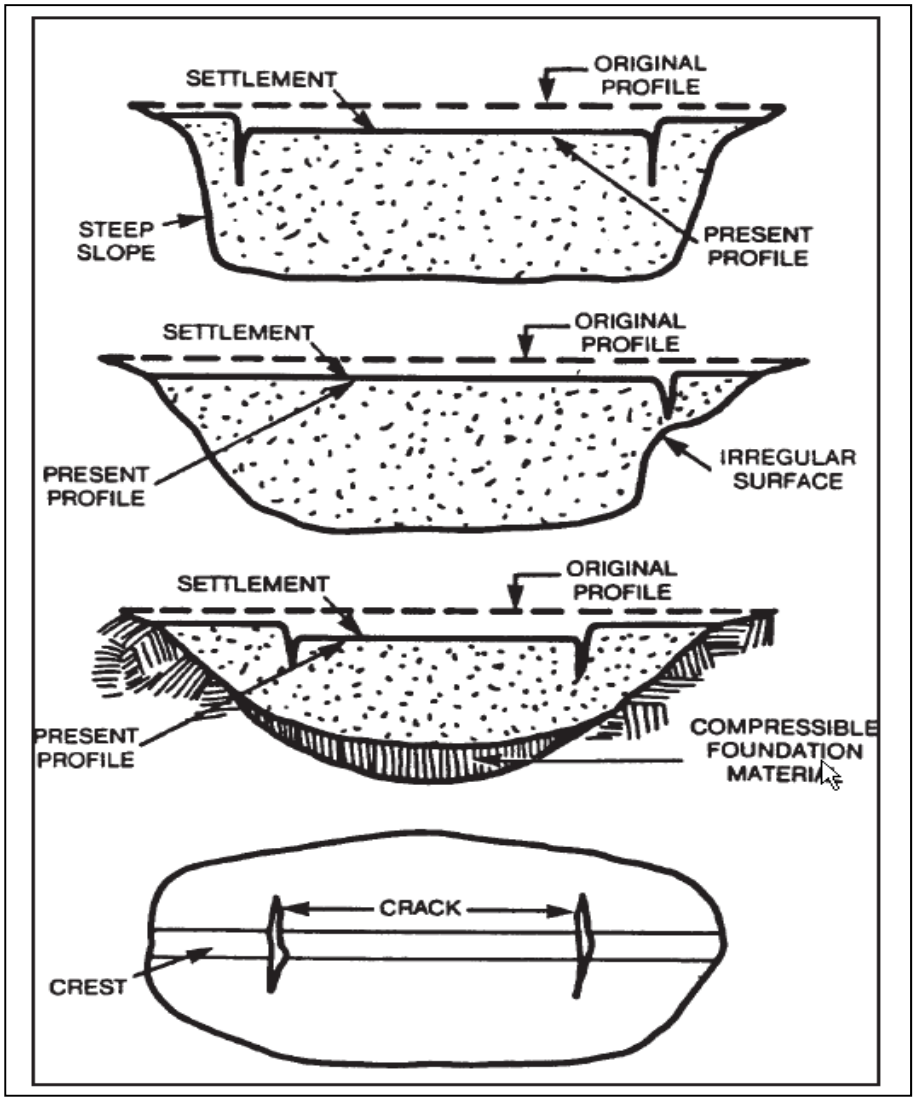
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Figure 10 – Potential Problem Indicators



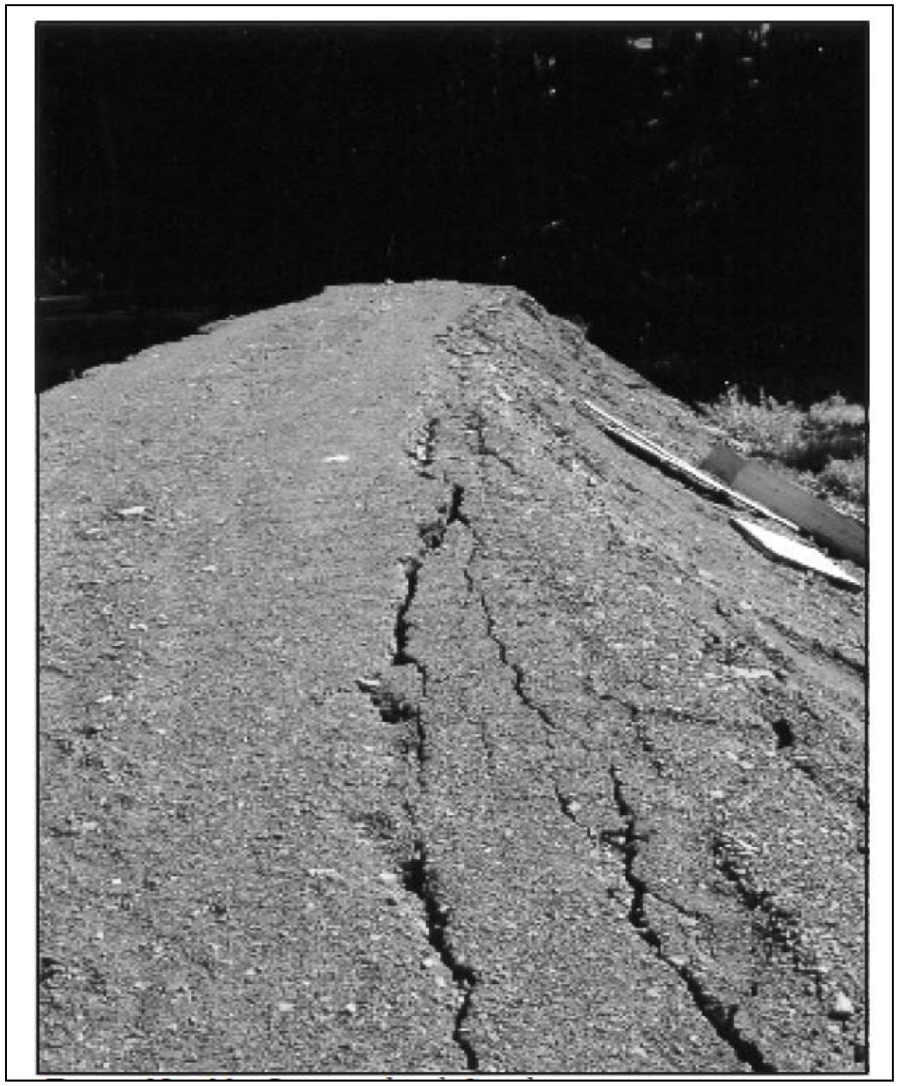
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Figure 11 – Transverse Cracking



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Figure 12 – Longitudinal Cracking



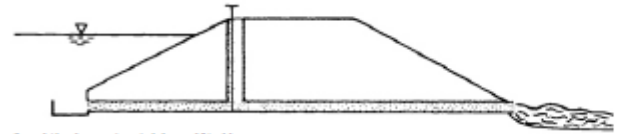
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Figure 13 – Obstructed spillway channel



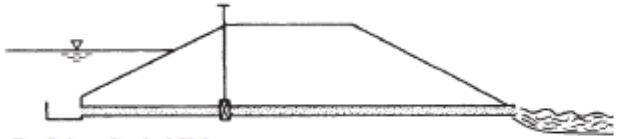
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Figure 14 – Most Common Types of Low Level Outlet Controls



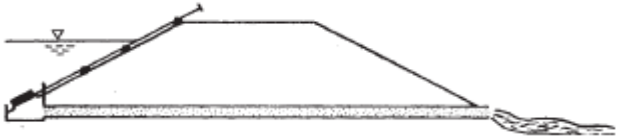
A - Slidegate / Dry Well

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.



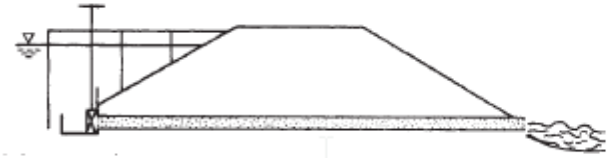
B - Inline Sealed Valve

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.

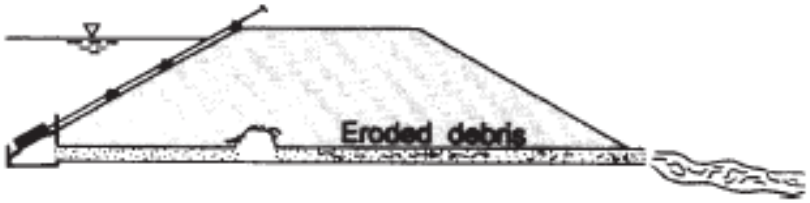


E - Downstream Valve

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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