TAILINGS AND PRODUCTION ROCK SITE
2013 ANNUAL REPORT

Hecla Green Creek Mining Company

April 15, 2014

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(Data Graphs see Appendix 3; Photographs see Appendix 4)

APPENDICES

1.0 Executive Summary

This annual report has been prepared by Greens Creek Mining Company in accordance with Alaska Waste Disposal Permit 0211-BA001 and the mine's General Plan of Operations Appendices 3 and 11. The following itemized list summarizes key information and indicates where in this report the information outlined in Section 6.2 of Permit 0211-BA001 is presented:

Permit Section		Report Section
6.2.1	Closure plan summary	2.8
	Precipitation	2.4, 3.4
	Mill Site 55.6" Tailings 59.4"	
	Summary of internal monitoring and fresh water monitoring plans	2.5, 3.5
	FWMP annual report separate for water year 2013 as per the ADEC request for full data presentation. Internal monitoring water compositions at both sites dominated by Ca, Mg, SO_4, neutral pH, high alkalinity, high zinc, low to moderate concentrations of other metals. Data are consistent with sulfide oxidation and carbonate mineral buffering. Sulfate reduction and/or thiosulfate reduction/-disproportionation in saturated zone of tailings pile yields low concentrations of all metals. Seasonal compositional fluctuations continue evident in most wells/drains.	
	Stability	2.3, 3.3
	Stability monitoring at the Tailings Facility and Site 23 indicate that piles meet design specifications. Foundation heads are consistently low at both sites except for short-lived spikes in one piezometer (north end of West Buttress).	
	Cover performance	3.8
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	Northwest Tailings area 351,653 total tons in 2013 (tailings 312,950 tons and other materials 28,534 tons) Site 23 118,792 total tons placed in 2013	
	Compaction	2.3, 3.3

		Target compaction densities achieved.	
	Acid Base Accounting		2.5, 3.5
		Potentially acid generating Class 2/3 production rock	
		Neutralization potential values continue to demonstrate long lag time (buffering capacity)	
		Class 1 production rock is significantly acid neutralizing (about 36% carbonate)	
	Possible water releases		2.5
		No new signs of possible releases were identified in 2013	
6.2.4	Information regarding validity, variations and trends		various
		Full FWMP data assessment in separate report	
		Internal Monitoring Plan variations are seasonal, no deleterious trends identified	

The report is separated such that all aspects of the Tailings Facility are discussed first in Section 2 followed by discussion of Site 23/D in Section 3. Information that is pertinent to both sections is generally not repeated but is discussed in the most relevant section and identified by reference in the other section.

2.0 Tailings Area

2.1 Introduction

Hecla Greens Creek Mining Company (HGCMC) has prepared this section of the Annual Report in accordance with the mine's General Plan of Operations (Appendix 3) and Alaska Waste Management Permit 0211-BA001. Permit 0211-BA001 expired in November of 2008 and is in the process of renewal. HGCMC is operating under a permit extension from ADEC (letter dated October 6, 2008) until a new permit is finalized. This report provides a summary of all operational and monitoring activities performed in 2013. Refer to GPO Appendix 3 and permit 0211-BA001 for a detailed description of the Tailings Facility and associated monitoring requirements.

HGCMC operated its Tailings Facility continuously in 2013. Primary placement of tailings was in the Northwest Expansion area (see Tailings Facility as-built in Appendix 1). HGCMC added 194,101 cubic yards of material to the Tailings Facility in 2013, bringing the total facility volume to approximately 3,881,769 cubic yards. These yardages convert to approximately 312,950 tons of tailings placed at the Tailings Facility with placement of all materials at the Tailings Facility totaling approximately 351,653 tons during this report period as calculated from HGCMC surveyed volumes and material densities.

2.2 Placement Records

Table 2.1 contains the monthly placement records for tailings, production rock and other materials at the Tailings Facility for 2013. Surveyed volumes (cubic yards) were converted to tons using a tonnage factor of 1.8 tons per cubic yard (134.2 pcf for tailings). Production rock from Site 23 used for road access and erosion control contributed approximately 13,744 tons to the facility. An additional 14,790 tons of other material were also placed at the facility in 2013. The calculated tonnage of tailings was derived by subtracting the tons of production rock and other material from the surveyed total. The full pile currently contains approximately 7 million tons of material. Based on the survey data presented in Table 2.1 there is a remaining capacity of approximately 2.6 million tons of the 9.6 million tons permitted for placement at the facility. Estimates of other miscellaneous materials disposed in the facility are shown in Table 2.2. It is difficult to determine the amount of time remaining before permitted space at the Tailings Facility is consumed, but a range of 3 – 5 years has been estimated.

In September of 2013 the FEIS and Record of Decision (ROD) was released on the tailings disposal facility expansion. Alternative D Modified was the chosen alternative in the FEIS which allows HGCMC to expand the current tailings disposal facility by approximately 10 acres for an additional capacity of 3.8 million tons. The calculations in Table 2.1 do not reflect the FEIS/ROD. HGCMC will refer to this as the Stage 3 tailings expansion.

Table 2.1 Tailings Placement Area Data

2013	All Materials Monthly Total by Survey (CY)	All Materials Cumulative by Survey (CY)	All Materials Monthly Total Tonnage (Calculated tons)	All Materials Cumulative Total Tonnage (Calculated tons)	Prod Rock from Site 23 by truck count (tons)	All Other Materials (Ditch Seds and Construction) by truck count (tons)	Tailings Tonnage (Calculated tons)
1/31/2013	15,109	3,702,777	27,373	6,708,321	865	1079	25,429
2/28/2013	10,500	3,713,277	19,023	6,727,344	498	468	18,057
3/30/2013	16,058	3,729,335	29,092	6,756,436	30	315	28,747
4/30/2013	13,500	3,742,835	24,458	6,780,894	0	156	24,302
5/30/2013	16,484	3,759,319	29,864	6,810,758	3016	2595	24,253
6/30/2013	21,399	3,780,718	38,769	6,849,527	4052	2304	32,413
7/31/2013	18,396	3,799,114	33,328	6,882,855	2238	2653	26,129
8/30/2013	19,497	3,818,611	35,323	6,918,177	873	400	26,189
9/30/2013	14,736	3,833,347	26,697	6,944,875	1580	2409	22,708
10/30/2013	13,009	3,846,356	23,568	6,968,443	468	1476	21,624
11/30/2013	16,996	3,863,352	30,792	6,999,235	0	842	29,950
12/30/2013	18,417	3,881,769	33,366	7,032,601	124	93	33,149
Totals	**194,101**	**3,881,769**	**351,653**	**7,032,601**	**13,744**	**14,790**	**312,950**
Tons calculated at 134.2 pounds per cubic foot for tailings							

Table 2.2 Miscellaneous 2013 Materials Disposal Estimates

Surface Tailings	CY	Underground	CY
Pressed Sewage Sludge	50	Tires	584 ea
Pressed Water Treatment Plant Sludge	500	Sump Sediments	4180
Incinerator Ash	16	Shop Refuse	910
Site E	0	Mill Refuse	430
		Electrical Refuse	160

2.3 Stability

Tailings placement compaction is tested to monitor the performance goal of achieving 90 percent or greater compaction relative to a standard Proctor density. HGCMC staff currently utilizes the rubber balloon method for density of soil in place. HGCMC previously used a Troxler Model 3430 nuclear moisture-density gauge to measure wet density and percent moisture content of placed tailings. Dry densities are calculated and compared to laboratory measured standard Proctors.

Compaction

Summary results for 2013 are shown in Table 2.3. Standard Proctor values were measured on samples taken from the tailings-loadout facility at the 920 and submitted to an outside materials testing lab, which performed the test within the ASTM guidelines for method #D698. The standard Proctor value was 131 pcf (pounds per cubic foot). HGCMC instituted a program at its on-site lab to determine 1-point proctors at the end of 2005. The mean dry density for 9 samples taken throughout the year in 2013 was 140 pcf, and the average percent moisture was 12.3%. Results to date confirm proctor and moisture data received from the outside materials testing lab.

Field measurement results show a high degree of achieving greater than 90% compaction (with respect to an average Standard Proctor value of 133). Twelve of 15 samples measured with the balloon method (ASTM D2167 – Density and Unit Weight of Soil in Place by the Rubber Balloon Method) in 2013 showed equal to or greater than 90%. Testing done in prior years has confirmed that density results obtained using the Troxler procedure average approximately 2 percent higher than the densities obtained via other methods.

With the co-disposal of Site E materials into the Tailings Facility beginning in 2009, field measurements were not as frequent. It is unlikely that the Troxler (or other methods) would provide useful information on the codisposed material. Unlike run-of-mill tailings, which have a relatively consistent standard Proctor value to compare field densities to, the mixture of rock and tailings will not. The Proctor density of the mixture would vary with the proportion of rock added and the density of the rock fraction. As with waste rock, measuring Proctor densities of materials containing a coarse fraction is not recommended. For co-disposal HGCMC uses the same method of compaction necessary to achieve the target density for straight tailings. This is typically at least two back and forth passes with the dozer and at least one back and forth pass with the roller. Visual observations of the codisposed material placed to date indicate that the mixed material compacts very well. HGCMC will continue to evaluate the placement procedures and continue to use the rubber balloon method or the Troxler in areas that receive just tailings.

Table 2.3 Summary Statistics for 2013 Tailings Compaction Testing Data

Compaction Variable	Mean	Max	Min	Std. Dev.	n
Std. Proctor[ASTM #D698] (pcf)	**131**	**131**	**131**	**0**	2
Opt. Moisture (%)	13.3%	13.3%	13.2%	0.1%	
1-pt Proctor (pcf)	140	150	133	7	9
As Received Moisture (%)	12.3%	14.4%	11.1%	1.0%	
Measured Dry Density (pcf)	138	155	116	10	15
Measured moisture (%)	12.8%	16.7%	9.5%	1.7%	
Rel. Compaction %	94.3%	105.0%	76.0%	7.9%	

Inspections

Several independent inspections are carried out at the tailings area throughout the year. Operators working at the site carry out daily visual work place inspections. The Surface Civil Engineer and/or Surface Operations Manager or designees carry out weekly visual inspections of the Tailings Facility area, as well as a checklist inspection of Pond 7. The environmental department carries out a monthly checklist inspection of the Tailings Facility.

ADEC representatives inspected the site once in 2013 on April 29. During 2013 the USFS conducted 10 routine inspections (Site inspections #344 - #353) to monitor for best management practices effectiveness and compliance to the General Plan of Operations. No issues of non-compliance or poor operations practices of the Tailings Facility were noted during the routine inspections. The USFS typically noted that the facility is being developed and operated to required operations and maintenance specifications of GPO Appendix 3. The BMP plan was updated in 2013 as part of the HGCMC GPO.

Well and Piezometer Water Level Data

Water level data for the Tailings Facility are presented in Figures 2.1 to 2.18. A variety of methods are used to determine water levels including:

- Measuring the depth to water by water level meter tape in PVC monitoring wells (also called standpipe piezometers). Ground water elevation equals the top of the casing elevation minus the depth to water.
- Pneumatic piezometers: When a reading is required, the operator connects a pneumatic indicator to the tubing from the transducer and sends compressed nitrogen gas from the indicator down the input tube.
  - Gas pressure increases inside the transducer. Finally, when the pressure of the gas exceeds the pressure of the water, the diaphragm is forced outward, away from the vent tube. Excess gas then escapes through the vent tube to the surface.
  - On detecting a return flow of gas at the surface, the operator turns off the flow of gas into the transducer. Gas continues to flow out through the vent tube, and pressure inside the transducer decreases until water pressure forces the diaphragm to its original position, sealing off the vent tube and preventing further escape of gas.
  - At this point, there is a balance between the pressure of gas inside the transducer and the pressure of water outside. The operator then notes the reading on the indicator’s pressure gauge.
- The VW piezometer converts water pressure to a frequency signal via a diaphragm, a tensioned steel wire, and an electromagnetic coil.
  - The piezometer is designed so that a change in pressure on the diaphragm causes a change in tension of the wire. An electro-magnetic coil is used to excite the wire, which then vibrates at its natural frequency. The vibration of the wire in the proximity of the coil generates a frequency signal that is transmitted to the readout device.

- The readout or data logger stores the reading in Hz. Calibration factors are then applied to the reading to arrive at a pressure in engineering units.

Pneumatic and vibrating wire piezometers are typically installed in locations where standpipes are impractical, such as under a liner or in active placement areas. Installation of vibrating wire piezometers allows “real time” data logging and measurement of negative pressures (matric suction). Vibrating wire piezometers can also be installed in existing PVC well casing to allow covering during liner installation and if real time data logging and water sampling is desired (e.g. MW-T-00-05A and PZ-T-00-02). A drawback of pneumatic and vibrating wire piezometers is that they do not provide a means for water sampling or aquifer testing (unless they are installed in an existing well).

The maximum saturated thickness (approximately 35 feet) occurs near the center of the main portion of the pile. However, this elevated water table level does not extend close to the down-slope toe of the pile. The foundations of the West Buttress and southern portion of the pile are well drained, as indicated by typically consistent unsaturated conditions in the blanket drains (MW-T-00-05A, Figure 2.14) and at the base of the West Buttress (piezometers 74 and PZ-T-05-08 in Figures 2.8 and 2.9). Low head elevations near the pile toe maximize the pile’s geotechnical stability. Intermittent head increases in the foundation drains are localized and of short duration and should not have an adverse effect on pile stability.

The data from standpipe and pneumatic piezometers completed above the blanket drain (Piezometer 76, PZ-T-00-01, PZ-T-00-02, PZ-T-00-03 in Figures 2.10, 2.11, 2.12, 2.13) indicate that saturated conditions can develop above the unsaturated underdrains to a thickness of approximately 12 feet. This is consistent with the low permeability of the tailings and the uncapped condition of the pile. Covering the pile will help minimize the saturated zone in the pile. This was demonstrated by the over 10 foot decrease in the water table that occurred from 1995 to 1997 when the pile was covered (see Figures 2.1 to 2.7). Water levels have rebounded to, and in some cases above, 1994 elevations in most areas. Areas where water levels exceed their 1994 values are areas where the pile is considerably thicker than it was in 1994. The increase in water levels observed in PZ-T-00-01 (and to a lesser extent in instruments nearby) from 2005 to 2007 is likely a result of new tailings placement in the area and staged decommissioning of Wet Well 2.

Periodic spikes in water levels in the wells and piezometers are due to a variety of factors including extreme weather events (e.g. Fall/Winter 2005-2006), changes to water management infrastructure (e.g. decommissioning of Wet Well 2 from 2005-2008), damage to instrumentation (Piezometer 76 in 2004), and measurement errors (e.g. MW-T-00-05A in 2002-2003 and 2007).

In February of 2013 an approximate 25 foot increase in estimated water elevation was observed for Piezometer 51 (Figure 2.7). This was likely a field error because a concurrent rise was not observed for its companion instrument (Piezometer 50, Figure 2.6). Pneumatic piezometers are susceptible to freezing and can give errant readings if ice accumulates in the tubing.

Water levels in four wells completed east and west of the pile are shown for comparison in Figures 2.15 to 2.18. The eastern wells, MW-T-00-03A (Figure 2.15) and MW-T-00-03B (Figure 2.16), are completed in the shallow sands 12 and 17 feet, respectively, below ground surface. The figures for these wells show that the water elevation in shallow completions in native materials can be readily influenced by abnormal weather conditions. Wells MW-T-01-03A and MW-T-01-

03B are installed west of the pile. Their water levels are shown in Figures 2.17 and 2.18, respectively. MW-T-01-03A is completed in bedrock to a depth of 20 feet and MW-T-01-03B is completed in clayey silt to a depth of 12 feet. These wells show similar water level fluctuations with weather conditions as the two eastern wells. However, the water level in MW-T-01-03B shows a larger differential than MW-T-01-03A because silts and clays hold more water in tension, so a small increase in water content causes a large change in head. The ground surface elevation is 134 feet in the proximity of these two wells. Both MW-T-01-03A and MW-T-01-03B were damaged by bears in 2006 and attempts to recover them were not successful until 2010. A rapid decrease followed by a gradual increase to levels above recent historical values occurred in MW-T-01-03A in 2011. In 2012, the level decreased to levels seen in the past. The cause for the change is not known at this point, however this type of behavior has been documented in the companion well (MW-T-01-03B).

2.4 Hydrology

A detailed review of the hydrology of the Tailings Facility was performed by Environmental Design Engineering (EDE) in 2001 (EDE 2002a), in 2006 (EDE 2007) and in 2011 (EDE 2011). For background and design information for Pond 7, the main water collection pond at the facility, see Klohn Crippen's 2005 report, and EDE's 2005 Pond 7 Hydrology Report. These reports describe the hydrogeology of the site and present calculations of anticipated post-closure hydrologic conditions. Water management at the facility consists of a complex network of drains under the pile, bentonite slurry walls around the perimeter of the site, and ditches to divert up-slope water and collect surface runoff. The site is underlain by a low permeability silt/clay till and other glacial/marine deposits or an engineered HDPE liner. These features minimize the potential for the downward migration of contact waters. An upward hydrologic gradient under the site further improves contact water collection. EDE updated the hydrogeologic information for the Tailings Disposal Facility in 2011, with focus on the proposed Stage 3 tailings expansion area to the south of the existing facility. The following is a summary of that most recent report:

- Updated potentiometric surfaces for the four hydrogeologic units (bedrock, undifferentiated glacial-marine unit, peat/sand unit, and tailings) indicate no major changes in the overall flow patterns compared to results of previous investigations. Groundwater in bedrock, the undifferentiated glacial-marine unit (UGM), and the peat/sand unit appears to generally flow from east to west toward Hawk Inlet, the primary discharge area. Outcrop on the steep ridge east of the TSF may be the primary bedrock recharge area, and runoff from this mountain slope is probably an important source of recharge to all three units. Flow components to the north and to the south towards Cannery Creek and Tributary Creek were interpreted on the basis of observed groundwater discharge in these areas.

- A geotechnical and environmental drilling investigation was conducted in the Stage 3 area in summer 2011. Data collected during, and subsequent to, the investigation indicate that hydrogeologic conditions in the proposed Stage 3 tailings expansion area are similar to conditions in existing tailings placement areas.

Precipitation and temperature data are presented in Table 2.4. July and August were the warmest months while December exhibited the coolest temperatures. It was a cool and wet year, with the Juneau annual climate summary stating for 2013:

> "Normal precipitation and warmer temperatures in 2013."

Flow data from Wet Wells 2 and 3 are presented with the precipitation data for 2005 – 2013 in Figure 2.19. The wet well flows respond relatively quickly to precipitation events, demonstrating a significant contribution of surface water. The use of the wet well flow meters has been discontinued since 2005 as part of the tailings expansion activities. Total precipitation for 2013 was taken from measurements near the Hawk Inlet meteorological station.

Table 2.4 Monthly Summaries of Tailings Area Climate Data

Month	Avg Temp (°C)	Precipitation (in)
January	0.12	4.79
February	2.00	5.39
March	-0.23	1.97
April	2.62	3.71
May	8.01	4.61
June	12.87	3.42
July	13.02	4.58
August	13.26	1.63
September	11.10	8.26
October	7.23	10.43
November	1.03	2.09
December	-1.18	8.52
2013	5.82	59.40

2.5 Water Quality

Compliance Monitoring

Sites around the surface tailings disposal facility have been monitored continuously since 1988. This sampling pre-dates the placement of tailings at this facility. The FWMP Annual Report for water year 2013 is being prepared separately and will be submitted to the Forest Service and ADEC upon completion.

Internal Monitoring

As described in Waste Management Permit Number 0211-BA001 Section 2.8.3.1, the internal plan addressed monitoring at both the surface Tailings Facility and the surface production rock disposal areas covered by the permit. The Internal Monitoring Plan describes monitoring within the pile areas, in contrast to the compliance monitoring (under the Fresh Water Monitoring Plan) at peripheral facility boundary sites. As such, data generated by the Internal Monitoring Plan effort are "… not for compliance purposes…" as noted in the above referenced permit Section 2.8.3.1, but provide a continuing perspective on in-pile geochemical processes.

The analytical results of HGCMC's internal site monitoring plan are summarized in Figures 2.20 to 2.31. Sites were distinguished between foundation wet wells (Wet Well 2 and Wet Well 3), wells completed in tailings (PZ-T-00-01, PZ-T-00-02, PZ-T-00-03, MW-T-02-5 and MW-T-02-6) and suction lysimeters (SL-T-02-4, SL-T-02-5, SL-T-02-6, and SL-T-02-7). These lysimeters are installed at various depths within the pile's vadose zone. These groups are separated on Figures 2.20 through 2.31 with the suffix a, b or c, respectively. For example, a figure number such as 2.20a would show the data for the wet wells group, 2.20b would show the data for the tailings completion wells, and 2.20c would show the data for the suction lysimeters.

In 2013 Wet Well 2 was capped and buried and is no longer accessible for monitoring. As a replacement, a composite sample from Wet Well A will be collected. Wet Well 3 was not sampled in 2013, but is scheduled to be sampled in 2014.

An in-depth evaluation of the hydrology and geochemistry of the Tailings Facility was performed by Environmental Design Engineering (EDE) and KGCMC in late 2001, 2007 and 2011 (EDE 2002a, EDE 2002b, EDE 2007, EDE 2011, KGCMC 2002a) and during the 2003 Tailings Expansion EIS (USFS 2003, USFS 2013). The observations made under the 2013 internal monitoring plan are consistent with the findings of the EDE, KGCMC/HGCMC and USFS reports.

All internal monitoring waters are captured and treated prior to discharge to the ocean floor under HGCMC's discharge permit (AK 004320-6). Authority over the federal permitting, compliance and enforcement NPDES program transferred to the State (ADEC - APDES) in November of 2010 for the mining industry.

Most values of pH remained between 6.0 and 8.5 for all internal monitoring site samples in 2013 (Figures 2.20a, b and c). PZ-T-00-01, PZ-T-00-2 and PZ-T-00-3, which screen the lower ten feet of the tailings pile, have the highest pH on average of the internal monitoring sites. This is likely a result of microbial sulfate reduction and equilibration with carbonate in the saturated zone of the pile. The wet wells produce water with slightly lower pH (generally between 6.5 and 7.0), reflecting minor influences from groundwater (organic acids) and oxidized surface waters (acidity from thiosalt, sulfide and iron oxidation). With the exception of SL-T-02-06, the suction lysimeters all have pH values between 6.87 and 8.03. SL-T-02-06 exhibited pH values above 8.5 between 2006 and 2009 and returned to a pH below 8.0 during the 2011 sampling event. The higher pH in SL-T-02-06 was likely a result of sulfate reduction.

Alkalinity data are presented in Figures 2.21a, b and c. Alkalinity generally ranges between 150 and 600 mg/L $CaCO_3$ within the tailings pile waters, consistent with buffering from carbonate minerals and the products of microbial sulfate reduction. The fact that these internal waters are near-neutral to alkaline and continue to show substantial alkalinity indicates that the buffering capacity of the tailings is sufficient to prevent acidification of site drainage in the near-term (at least tens of years) even though portions of this material have now been in place at this site for approximately 20 years. The alkalinity of tailings pore water is expected to decrease somewhat after an initial increase following placement of the tailing as small or readily soluble carbonate and hydroxide particles are consumed.

The conductivity results from internal monitoring site waters are presented in Figures 2.22a, b, and c. Conductivity measurements in 2012 ranged between 2,450 and 3,760 in wet wells. Conductivity measurements in 2012 and 2013 ranged between 7,650 (wells completed in tailings) and 2,670 (suction lysimeters) uS/cm. The abrupt conductivity increase observed in PZ-T-00-01 in 2013 is not consistent with other monitoring data (e.g sulfate and hardness) and may be an error. A smaller increase is expected as pore water from formerly exposed surfaces in the pile migrates downward. The higher conductivity of the site contact waters reflects a larger dissolved load caused by weathering of the tailings. Pyrite oxidation and carbonate dissolution contribute dissolved ions such as sulfate, bicarbonate, calcium and magnesium to the contact waters, increasing their conductivity. Suction lysimeter samples are drawn from the smallest pore spaces of the unsaturated zone. Water held in these pores is often isolated from flow paths and thus usually has higher dissolved constituent concentrations than water from the saturated zone and foundation drains.

Hardness and sulfate concentrations remain consistent with the conductivity results. Calcium and magnesium are the primary contributors to hardness (Figures 2.23a and b) and reflect dissolution of carbonate minerals, such as calcite and dolomite. Carbonate dissolution neutralizes acidity formed by sulfide oxidation, which is also the source of sulfate shown in Figures 2.24a, b, and c. Sulfate concentrations typically range between 150 and 5,000 mg/L in the tailings pile waters. The increase in sulfate and other constituents seen in PZ-T-00-03 and other deeper wells and lysimeters likely reflects the replacement of interstitial process water with infiltrating surface water, which carries a higher dissolved load.

Arsenic data are presented in Figures 2.25a, b and c. The variability in arsenic concentrations observed in Wet Well 2, MW-T-02-06, and some suction lysimeters is related to evolving redox conditions in the pile. As arsenic-bearing minerals such as tetrahedrite/tennantite (and to a lesser extent pyrite) weather, the arsenic that is released is typically co-precipitated with iron oxy-hydroxides. As the pile grows, reducing conditions overtake areas that were once oxidizing. This was particularly true as the water table rose following removal of the temporary PVC cover that was placed on the pile in 1995 (removal began in 1997). Dissolution of oxyhydroxides (and possibly sulfates) is expected as the waters respond to the changing redox conditions. This will contribute arsenic and iron (Figures 2.30a, b and c) to the drainage water. Arsenic concentrations in the pile drainage will therefore decrease when redox conditions in the pile stabilize (e.g. with closure and capping of the pile). Sulfate reduction may also lower arsenic concentrations. This is apparent in the composition of waters from the saturated zone and in some of the SRMP test cells (see 2012 annual report SRMP discussion).

Figures 2.26a, b and c show the concentration of zinc from the monitoring sites. Zinc levels from the saturated zone of the pile continue to remain low (Figure 2.26b), a result of sulfate reduction and/or thiosulfate disproportionation, which promote zinc sulfide precipitation. Zinc concentrations in the vadose zone are generally higher than the saturated zone and generally increase with proximity to exposed (or formerly exposed) surfaces. Zinc concentrations in wet wells are variable depending on the relative proportion of near-surface waters, drainage from the saturated zone and groundwater.

The concentrations of copper and lead are considerably lower than that of zinc. Both of these metals' concentrations are generally less than 5 ug/L in water from each site (Figures 2.27a, b and c and 2.28a, b and c). Previous observations have shown that copper and lead mobility are greatest when the tailings are first placed, then decrease with time. Isolated instances of high lead concentrations (e.g. PZ-T-00-03, June 2011 and SL-T-02-04, May 2010) may be due to laboratory error.

Cadmium data are shown in Figures 2.29a, b and c. With the exception of Wet Well 2 and 3, cadmium concentrations are low (typically less than 0.5 ug/L). Cadmium in Wet Well 3 had a maximum value of 27 ug/L in 2002 and showed seasonal fluctuation similar to that of zinc, albeit at significantly lower concentrations.

Iron and manganese data are presented in Figures 2.30 a, b and c and 2.31 a, b and c, respectively. Concentrations of iron and manganese are high in the wet wells, groundwater and most of the suction lysimeters due to oxidation/reduction and buffering reactions. Lower concentrations of iron and other metals in PZ-T-00-01, PZ-T-00-02 and PZ-T-00-03 likely indicate sulfide precipitation resulting from sulfate reduction and/or thiosulfate disproportionation in these waters.

Acid Base Accounting (ABA) Analyses

ABA analyses of monthly composite samples were taken of tailings at the Mill filter press. Figure 2.32 shows the monthly composite sample ABA results for 2001 through 2013. The average net neutralization potential (NNP) results are shown in Table 2.5. The variability from year to year is primarily due to fluctuations in acid potential (AP), which is an indication of the pyrite content of the ore. Neutralization potential (NP) values, which primarily reflect carbonate content, are generally more constant.

Table 2.5 Average Tailings NNP - Mill Filter Press

Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Average NNP ($tCaCO_3$/kt)	-281	-197	-194	-200	-134	-123	-156	-237	-289	-226	-257	-173	-206

The results of ABA analyses on grid samples taken from the Tailing Facility from 2002 to 2013 are presented in Figures 2.33 and 2.34. The grid included portions of the pile that had exposures of tailings, argillite slope armoring, road rock, and ditch sediment. Figure 2.33 shows the acid generation potential (AP) versus neutralization potential (NP) of all grid samples. The pure tailings samples plot in the upper half of this figure, indicating that they are potentially acid generating. However, the high carbonate content of the tailings (NP >100 $tCaCO_3$/kt) indicates there is substantial buffering capacity remaining in the tailings. These results remain consistent with previous studies of the mine's tailings. Samples of weathered tailings (after approximately 20 years of exposure) have been shown to still retain a considerable amount of neutralization potential, equivalent to approximately 20% calcium carbonate. A 2012 sample from the surface of a tailings weathering cell constructed in the early 1990s had a pH of 7.2, a NP of 204 $tCaCO_3$/kt, an AP of 265 $tCaCO_3$/kt and a NNP of -61 $tCaCO_3$/kt. This suggests that the potential lag time to acid generation of exposed tailings is on the order of decades. This long lag time allows time for construction and adequate closure of the site (including covering the pile with a composite soil cover designed to minimize oxygen ingress).

Figure 2.34 shows the relationship of pH to net neutralization potential for the same suite of samples shown in Figure 2.33. Rinse pH is a measure of the pH of a one-to-one mixture of "as received" fines and water. The rinse pH of all of the samples of pure tailings is above 6.0, indicating that the exposed surfaces of the tailings pile remain well buffered. Grid samples with positive NNP values are not representative of tailings and may include argillite and ditch sediments. Samples containing peat can produce a lower pH because of acids formed from the natural decomposition of organic matter.

In 2013 a new grid sampling procedure was used. In areas where the surface of the pile was covered with interim reclamation material or Class 1 argillite, effort was made to expose and sample old tailings material. The results of this sampling will indicate if the tailings near the surface has depleted its neutralization potential. None of the four near-surface samples showed signs of NP depletion (average pH 6.6, NP 251 $tCaCO_3$/kt).

2.6 General Site Management

Tailings Operation and Management

The General Plan of Operations (GPO) Appendix 3 includes the general operating and management goals to achieve site stability and satisfy regulatory requirements for the HGCMC Tailings Facility. In Appendix 3, Section 2.1.4, HGCMC operations place tailings in the impoundment using specific criteria established by Klohn Crippen Engineering in 1999 for the placement of tailings in cellular configurations with compaction standards. HGCMC continued to place tailings in this manner through 2013.

HGCMC continues the use of off-highway lidded trailered trucks to transport the tailings to the surface placement area. The material is end dumped, spread and compacted using a bulldozer, followed by a smooth-drum vibratory compactor. Compaction checks using the balloon method or a Troxler density and moisture gauge confirm the resultant performance in the placement area, as per the GPO Appendix 3. See Section 2.3 for a discussion of compaction results.

HGCMC does not expect any changes to the placement methodology in 2014 and will continue placement according to the established criteria. Continued development of placement areas for the remaining mine life are a part of the Stage 2 Expansion Project, approved in January 2004. The 2003 Stage II Tailings Expansion Environmental Impact Statement (EIS) is summarized in HGCMC Tailing and Production Rock Site 2004 Annual Report (KGCMC 2005). In 2013 the majority of tailings were placed in the northwest area. There were no major construction projects at the tailings facility area in 2013.

HGCMC submitted an updated West Tailings Facility Monitoring Action Plan on December 15, 2009 (HGCMC 2009). The plan described processes affecting water quality in the area and presented an updated monitoring plan. Key aspects of the plan and a summary of recent findings are as follows. Table 2.7 shows the data for the West Tailings area.

- A complex history of disturbance in the area poses challenges to identifying potential leakage from the facility; however, leakage would likely produce a chemical signature similar to Wet Well 3.
- Zinc in the drainage was an order of magnitude or more lower than contact water suggesting that effects from seepage, if any, from the tailings pile are minimal.
- Further Seep zinc concentrations remained relatively unchanged since 2000.
- Zinc in the upper portion of the Further Creek drainage (Site 610) increased with construction and tailings placement activity (likely dust) in the area.
- Zinc in the southern portion of the Further Creek drainage (Site 611) increased from 2004 to 2009, but the absence of manganese suggests that the source of the loading is not tailings leachate. The maximum zinc concentration at Site 611 decreased to 166 ug/L in 2010 from a high in 2009 of 214 ug/L. Sulfate also decreased to 111 mg/L in 2010 from a high of 451 mg/L in 2009.
- Site 609 is an appropriate monitoring site for tracking all facility related influences to Further Creek. Figures 2.40 and 2.41 show the concentrations of zinc and lead at Site 609. The increase in zinc and lead concentrations at Site 609 in 2011 and 2013 may be result of lower than average precipitation and deposition of dust from placement activities

in the northwest area. Despite the increase, the values for both metals were well below the Alaska Water Quality Standard in 2011 and 2013, respectively.

- The composition of waters in the Further Creek drainage is expected to improve as effects from previous disturbance, rock fill, dust and other sources decrease. Some element concentrations may temporarily increase as the drainage pH approaches its naturally acidic, dilute condition. The expected reduction in hardness would lower the Alaska Water Quality Standard (AWQS) for hardness dependent elements and may cause exceedances despite the improvement in water quality.
- Quarrying and construction of Pond 7 in 2004/2005 caused an increase in conductivity, sulfate, pH, hardness, and trace and major elements. Following installation of a pump to collect drainage from the pond foundation the Althea Creek drainage (Site 60) started to return to pre-construction conditions.
- Zinc and lead concentrations at Site 60 area shown in Figures 2.42 and 2.43. Zinc concentrations are very low (< 10 ug/L). As the hardness at Site 60 decreases toward background conditions, the AWQS for lead, which is hardness dependent, may approach the lead concentration at Site 60. This was the case in 2012 when a slight increase in lead and a continued decrease in hardness caused an exceedance of the AWQS for lead as Site 60. There were no measured exceedances for lead or zinc in 2013.
- The nearly two orders of magnitude difference in zinc concentration above and below the liner indicates that the liner is intact and functioning as designed.
- As efforts to reduce the sources of sulfate and metals loading to Althea Creek and Further Creek continue, HGCMC expects these drainages to approach pre-disturbance compositions. Background conditions typical of these muskeg drainages preclude compliance with AWQS for pH, alkalinity, aluminum and iron at sites 60 and 609. The concentrations of some metals and trace elements (e.g. lead, zinc, cadmium, mercury and manganese) are expected to exceed background levels and may not meet AWQS as the pH and hardness in the drainages decrease to background levels. The magnitude of the exceedance is expected to be small and temporary.

Table 2.7: West Tailings Monitoring Data

Site	Date	Conductivity (uhmos/cm)	Field pH	Alk (mg/l)	Hardness (mg/l)	SO4 (mg/l)	As (ug/l)	Cd (ug/l)	Fe (ug/l)	Pb (ug/l)	Mn (ug/l)	Ni (ug/l)	Zn (ug/l)	Hg (ug/l)
609	07/15/03	84.4	5.67	4.59	33.4	18.6	1.1	0.1	2010	2.82	59.1	3.27	30.8	
609	10/27/03	131	4.5	0.5	49.7	41.1	1.35	0.1	1600	1.35	104	3.25	51.9	0.1
609	12/28/04	105.7	4.49	0.5	41.7	33.9	0.968	0.045	1100	1.1	70.6	2.13	53.7	
609	09/14/06	78.3	5.14	0.5	33	26.8	1.42	0.146	714	2.01	69.3	3.07	54.8	0.1
609	05/31/07	97.4	5.05	0.5	35	27	0.964	0.193	852	1.46	74.1	2.38	55.7	
609	09/27/07	387	4.91	0.5	140	163	2.35	1	1050	1.93	102	6.41	147	0.0001
609	05/07/08	276	6.41	7.96	110	95.2	0.762	0.5	436	0.568	52.1	2.78	46.6	
609	10/14/08	199.2	6.71	11.9	95	71.4	0.22	0.31	1060	0.15	55.6	2.89	39.8	0.1
609	08/24/09	430	6.57	7.07	200	182	0.513	0.31	852	0.556	117	8.31	54.9	0.095
609	05/04/10	340	6.56	12	142	115	0.6	0.05	480	0.3	45.1	2.4	27	0
609	11/10/10	350	6.72	10	162	128	0.8	0.05		0.3	54.6	9.4	32	
609	04/14/11	329	6.63	12	146	112	0.25	0.1	250	0.4	65.7	3.4	48	0
609	07/13/11	360	7.26	10	161	138	1	0.05	430	0.7	34	3.4	41	0
609	08/22/11	329	6.96	7	154	127	1.8	0.2	870	1.3	68.3	4.5	62	
609	04/05/12	273	7.44	11	119	93	0.6	0.1	330	0.3	40	1.9	43	0
609	06/07/12	433	6.9	17	196	168	0.7	0.1	350	0.5	36.7	2.6	53	0
609	03/14/13	360	7.17	12	154	118.4	0.4	0.1	360	0.3	31.6	2.5	79	0
609	05/28/13	394	7.36	23	180	150	0.6	0.1	390	0.3	27.2	2.8	72	0
610	12/29/04	37.2	4.35	0.5	8.53	2.35	1.2	0.045	730	1.11	47.3	1.51	15.2	
610	09/14/06	44.3	5.64	2.76	26	6.25	2.22	0.131	832	1.4	26.4	2.29	49.6	0.1
610	05/10/07	125.6	6.14	2.9	41	26.9	3.99	0.5	163	1.45	117	1.07	31.7	
610	09/27/07	1019	6.51	25.6	410	424	1.87	1	111	0.5	224	11.1	60.3	0.0001
610	05/07/08	873	6.97	47.8	400	365	0.694	0.2	115	0.1	12.9	5.57	23.1	
610	10/14/08	520	7.32	78.1	250	173	0.691	0.31	152	0.15	27.2	5.55	22.3	0.1
610	09/24/09	791	7.38	1	490	318	1.05	0.23	110	0.18	16	12.6	38.1	0.025
610	05/10/10	763	6.89	77	393	259	0.25	0.1	50	0.3	16.3	4.3	35	0.015
610	11/10/10	867	7.13	5	520	399	0.7	0.1		0.5	35.1	8.6	71	
610	04/14/11	632	7.09	54	310	233	0.7	0.2	20	0.2	9.3	6.2	40	0
610	07/13/11	894	7.08	61		391	0.6	0.2	30	0.2	17.6	6.1	39	
610	08/22/11	693	7.47	61	390	305	1.5	0.4	120	1.3	25.6	12.3	110	
610	4/5/12	657	6.96	50	215	154	0.5	0.1	150	0.7	35.8	2.9	38	
610	6/7/12	904	7.49	82	463	381	0.6	0.4	30	0.3	7.7	3.2	73	
610	03/04/13	790	6.2	60	419	331.5	0.4	0.6	<20	<0.1	7.9	7.9	173	0

Table 2.7: West Tailings Monitoring Data

Site	Date	Conductivity (uhmos/cm)	Field pH	Alk (mg/l)	Hardness (mg/l)	SO4 (mg/l)	As (ug/l)	Cd (ug/l)	Fe (ug/l)	Pb (ug/l)	Mn (ug/l)	Ni (ug/l)	Zn (ug/l)	Hg (ug/l)
611	12/29/04	317	6.09	9.97	155	126	1.91	0.045	170	1.32	8.73	1.24	31.8	
611	09/14/06	436	6.42	20.5	220	177	2.19	0.1	211	0.521	16.6	3.73	42.2	0.1
611	09/27/07	440	5.66	6.89	190	201	3.41	1	203	0.5	18.3	3.53	97	0.0001
611	10/14/08	341	6.07	12.4	26	119	1.82	0.31	792	0.636	19.6	1.77	96.6	0.1
611	10/01/09	981	6.42	34	530	451	1.74	0.31	95.2	0.593	11.3	8.55	214	0.025
611	05/04/10	499	5.96	23	219	183	2	0.05	210	0.5	27.7	2.3	96	0
611	11/04/10	217	5.57	6	138	111	3	0.2	170	1.1	38.8	2.4	166	
611	04/14/11	264	6.01	15	111	77	2.5	0.1	120	64.6	12.8	2	109	0
611	07/13/11	651	7.12	27		247	2.2	0.05	340	1.3	75.6	2.9	114	
611	08/22/11	407	6.29	16	203	160	5	0.2	240	0.8	21.3	3.1	145	
611	4/5/12	309	6.58	57	135	100	2.1	0.1	180	0.5	58.4	0.5	67	
611	6/7/12	482	6.41	91	158	142	2.6	0.1	310	0.1	13.6	0.5	72	

Co-disposal Studies

HGCMC compared the relative costs of recountouring and covering the existing Site E production rock pile versus consolidating it with another surface facility, and found that relocating the material to the surface Tailings Facility is the most economical and environmentally protective solution.

Geochemical results, as well as a geotechnical summary and a site excavation plan, are presented in the Site E Removal: Waste Rock and Tailings Co-disposal Plan (HGCMC 2009). This plan was approved by the agencies on June 16, 2009. The standard operating procedure for co-disposal is to place at least 3 lifts of tailings only on top of the liner system. After those three lifts, then co-disposal can occur so that no rock will be placed near the liner system as it may have the potential to compromise the liner.

Between June and September 2009 and 2010, HGCMC removed approximately 40,000 cubic yards of waste rock and reclamation material from Site E each year. Between May and September 2011, HGCMC removed approximately 8,000 cubic yards of waste rock from Site E.
No haulage of waste rock materials from Site E to the tailings disposal facility was performed in 2012 through 2013. Delays in the progress of the permitting for the proposed tailings disposal facility expansion led to a decision to suspend co-disposal activities so that the lifetime of the remaining, permitted capacity at the tailings disposal facility could be maximized. Also, operational constraints for co-disposal were an issue in 2012 and 2013. Recently, tailings placement areas have been too close to the liner system for acceptance of co-disposal material. Even though no removal activities have occurred since 2011, contact water from the site was captured during the spring, summer and fall months and sent to the water treatment plant. Plans for Site E in 2014 include grading the south end of the site toward the north side to improve runoff collection in the storm water pond.

Dust Monitoring and Abatement

Monitoring performed under the Freshwater Monitoring Program has identified lead levels in three shallow peat wells south (Site 27) and west (Site 29 and Site 32) of the tailings pile that approach or exceed freshwater quality standards (KGCMC 2007). The formation water in these wells is generally very dilute (low conductivity and hardness) and acidic (due to organic acids), which is ideal for promoting lead mobility. Dust from the tailings pile may contribute to the lead levels observed in these wells.

Visual observations and operational experience indicate that dust loss from the tailings pile occurs when dry, windy conditions persist at the site. These conditions typically occur for short periods between mid-November and late March when high pressure systems produce cold, dry weather and strong northerly winds.

Warm, dry conditions occur periodically during the spring and summer months, but wind direction and velocity are not typically as favorable for dust entrainment during these periods. Salt formation on tailings surfaces and application of water to access roads further reduces the potential for dust formation during warmer months.

Snow samples were collected just prior to the loss of snow cover each spring in 2007, 2008, 2009, and 2011. The objective of the sampling was to quantify the amount of tailings dust that had accumulated on the snow pack when conditions for dust loss were greatest (typically December through February). The samples were analyzed for total lead concentrations, and a lead load per square meter was calculated.

The data indicated that the loading was observable up to 1600 feet from the pile. Several factors, including the number and intensity of dust-producing weather events, the length of the snow accumulation period, the location on the pile where placement was occurring and improvements to abatement measures, likely contributed variability in calculated loading values from year to year.

Lead levels in water from the three wells do not correlate directly with lead loading values. In fact, the well with the highest lead concentration (Site 32, ~ 6.5ug/l) actually has one of the lowest lead loading values determined from the snow survey. Site 32 is downwind of the Wet Well 1 building, Outfall Shack and a stand of pine trees, which may collectively act as a dust trap, preventing accumulation of dust in the immediate vicinity of the Site 32 well. Tailings dust that settles on the peat up-gradient from Site 32 may be the source of the lead observed in the well. The chemical composition of the water at Site 32 suggests that its completion zone is better suited for lead mobility than the completion zones at Site 27 and Site 29. It is the most dilute of the three waters and there is very little in the water that would cause the lead to precipitate. Complexing with organic ligands may also promote lead mobility in these peat waters.

A direct link between dust accumulation and lead concentrations in the wells has not yet been established. However the lead loading determined from snow surveys and other methods discussed below suggests that the amount of lead accumulating on the peat in the vicinity of the wells is sufficient to account for the lead values observed in the wells. This is based on the simplifying assumption that all of the lead is leached from the dust and that it is distributed evenly in a two-meter column of water (saturated peat).

HGCMC evaluated air sampling methods that may augment the lead loading analysis from snow sampling. This would allow year-round monitoring, which will help quantify the temporal distribution of loading at the site. Standard air sampler devices were determined to be an inefficient method for monitoring at this site. Maintenance issues with the air samplers and a lack of available power at most remote locations prevented the air samplers from operating effectively.

HGCMC researched additional methods for lead loading analysis and is evaluating a more passive monitoring system. This passive system involves the use of a 10 liter Atmospheric Depositional Pail (ADP) mounted approximately 1.3 meters off the ground. In January 2011 five ADP systems were deployed 50-100 meters from the base of the dry stack tailings pile. Four of the ADPs loosely correlate to the cardinal points on a compass, with the fifth system in the southwest position. On a two week cycle the ADPs were collected and filtered through a pre-weighed 47 mm glass fiber filter with a 1.5 micron pore size. Next, the filters were dried then weighed in order to measure the total loading. Following this process the filters were then analyzed for total lead and total zinc. Results from the analysis equate to the amount of material that passed through the opening of the ADP over a two week period. Therefore it is possible to calculate the average daily load per given area. HGCMC accepts that there are some limitations and possible artifacts introduced into the data using the ADP systems, however the consistency of the trends between the five ADP systems suggest that this was a very effective tool for monitoring loading. Along with the ADP systems HGCMC also monitors and records the hourly meteorological conditions near the dry stack Tailings Facility. These measurements include wind direction, wind velocity, relative humidity, rainfall, air temperature, and barometric pressure. Furthermore the surface operations department maintains a log of where in the Tailings Facility they have been placing and working. One final piece of data being collected is the temperature of the tailings pile at depth.

This data supports and verifies the statements made previously about the seasonality (winter) of this issue (Figure 2.37): it occurs under cold dry desiccating conditions with moderate wind speeds from the north or northeast. Out of the five ADP systems deployed in 2011, three received a higher rate of loading than the other two; they were ADP systems in the west, southwest, and south. Out of these three systems the southwest had the highest yearly accumulative lead load of 95,882 ug/m^2/year and the west system with accumulative lead load of 94,468 ug/m^2/year. The system to the south accumulated a lead load of 67,031 ug/m^2/year (Table 2.9). This lower load may reflect that the ADP system here is farther away from the pile than the other two. Overall, 2013 presented more lead dusting than 2012 and less lead dusting than 2011.

Table 2.9 Loading per Biweekly Sample Period Along With Seasonal Totals

	West			Southwest			South		
Period StartDate	Lead µg/m2/period			Lead µg/m2/period			Lead µg/m2/period		
1/2/2013	24310			12219			9347		
1/16/2013	1205			432			435		
1/30/2013	39172			15405			29927		
2/14/2013	1952			271			271		
2/28/2013	75			881			331		
3/20/2013	16639	84,266	µg/m2/period 1	5233	90,180	µg/m2/period 1	7413	63,441	µg/m2/period 1
4/3/2013	974	89%		245	94%		353	95%	
4/18/2013	1702			603			569		
5/2/2013	1185			371			293		
5/16/2013	334			123			125		
6/6/2013	1566			486			565		
6/27/2013	1253			718			239		
7/11/2013	638			48			48		
8/5/2013	43			48			324		
8/20/2013	1507			48			734		
9/5/2013	353			1740			54		
9/23/2013	421			856			107		
10/9/2013	101			283			97		
10/31/2013	125	10,202	µg/m2/period 2	132	5,604	µg/m2/period 2	83	3,590	µg/m2/period 2
11/18/2013	377	11%		2416	6%		1215	5%	
12/6/2013	246			41187			12819		
12/19/2013	113			10862			1296		
1/11/2014	176			1274			387		
Total 2013	94,468 µg/m2/year			95,882 µg/m2/year			67,031 µg/m2/year		

Period 1 Winter	01/02/2013 through 04/03/2013 11/18/2013 through 01/11/2014	148 days	39.3%
Period 2 Spring, Summer, Fall	04/03/2013 through 11/18/2013	229 days	60.7%

* Periods during which the collection system was not operational; during this time the previous loading rate was used for calculation purposes

Based on the predominant winds out of the north / northeast and the fact that placement occurred mostly in the northwest the expected area of loading would occur to the southwest and west of tails as supported by the data.

Approximately 93% of the load collected was deposited in 148 days out of the 377 days that were monitored. This period consisted of two sub-periods that were from 1/2/2013 – 4/3/2013 and 11/18/2013 - 1/11/2014. These results were very similar to those obtained for the previous years (2011-2012). There was an increase in the lead loading in 2013 at each monitoring location. Results were consistent with past years except for the lead loading increase in the southwest which was nearly three times the amount of 2011 and 2012 results. Another difference is the least amount of lead loading occurred in the south as shown in Table 2.9a. Lead and zinc daily loading from 2011 through 2013 is shown in Figure 2.37.

Although the majority of tailing placement occurred in the northwest area of the tailing facility there was a significant amount of tailing placed on the west-central area of the tailing facility. The placement in the west-central area of the tailings facility resulted in higher lead loading southwest of the tailings facility.

Table 2.9a. Summary of yearly lead loading at the west, southwest, and south ADPs at the tailings facility

Period 1	01/09/2011 through 04/03/2011	140 days	38.4%
Winter	11/14/2011 through 01/09/2012		
Period 2	04/03/2011 through 11/14/2011	225 days	61.6%
Spring, Summer, Fall			

	West Lead	**Southwest** Lead	**South** Lead
Total 2011	169,704 µg/m2/year	36,196 µg/m2/year	172,879 µg/m2/year

Period 1	01/09/2012 through 02/06/2012	117 days	32.6%
Winter	10/15/2012 through 01/02/2013		
Period 2	02/06/2012 through 10/15/2012	242 days	67.4%
Spring, Summer, Fall			

	West Lead	**Southwest** Lead	**South** Lead
Total 2012	72,118 µg/m2/year	32,809 µg/m2/year	38,864 µg/m2/year

Period 1	01/02/2013 through 04/03/2013	148 days	39.3%
Winter	11/18/2013 through 01/11/2014		
Period 2	04/03/2013 through 11/18/2013	229 days	60.7%
Spring, Summer, Fall			

	West Lead	**Southwest** Lead	**South** Lead
Total 2013	94,468 µg/m2/year	95,882 µg/m2/year	67,031 µg/m2/year

The difference between these three years can be attributed to the varying meteorological conditions. Based on the temperature profile from the Tailings Facility, the 2010-2011 winter season was colder than the 2011-2012 and 2012-2013 seasons as indicated by the colder temperatures at depth. Desiccation of tailings has the potential to be greater at colder temperatures, resulting in a larger ‘pool’ of material that could be liberated.

The following measures are taken to reduce dust loss from the tailings pile:

- Snow fence and concrete block wind breaks were installed on the crest of the tailings pile
- Three rows of wind fence were installed on the northern border of the tailings pile with an additional one placed on the southern end at the upper elevation of the pile
- Snow removal is limited to only active placement areas
- Interim slopes are covered with rock
- Outer slopes are hydroseeded where appropriate
- Water is applied to areas of tailings during below freezing temperatures to create an ice layer

Visual observations, snow sample assays, and ADP results suggest that these mitigation measures have helped reduce the dispersion of dust at the Tailings Facility; however, additional efforts are still warranted. HGCMC fabricated portable wind breaks that have been used up wind of the current placement area. These wind breaks measure 20' long x 9' high. The breaks provide ~90' of area leeward of the panel with wind reduction of ~70% from the windward side. Currently, two panels were installed in the summer of 2013 with plans of fabricating additional panels. Initial evaluation of the wind breaks demonstrate a potential localized dusting reduction near the tailings facility although further monitoring is required to quantify the reduced dusting. Continued water and dust monitoring will determine the effectiveness of the control measures.

2.7 Site as-built

As-built drawings for the Tailings Facility are presented in Appendix 1. The drawings depict the 2013 year-end topography, water management features, monitoring device locations and other significant features of the site. An additional tailings drawing includes cross sections that show the following information:

- existing topographic surface
- prepared ground upon which the pile was constructed
- projected locations of piezometers from Figures 2.1 – 2.18

Photographs are presented in Figures 2.38 to 2.39 (Appendix 4). Figure 2.38 is a photo of the northwest area in the fall of 2013 with recently placed tailings, and Figure 2.39 is an aerial photo of the Tailings Facility in September 2013.

2.8 Reclamation/Closure Plan

<u>Reclamation Plan</u>

HGCMC maintains and periodically updates its reclamation plan and cost estimate for closure, reclamation and long term maintenance and monitoring (GPO Appendix 14 with attachments). The reclamation plan includes all estimated costs (labor, materials, equipment, consumables, administration, monitoring, and long term maintenance) for task specific work associated with the final closure of the property under a default scenario. . The elements of the plan encompass the entire mine site, and also include reclamation performance monitoring and facility maintenance after final closure according to the Waste Disposal Permit standards.

The Stage 2 Tailings Expansion process included a National Environmental Policy Act (NEPA) review through an Environmental Impact Statement (2003 EIS) to analyze the potential environmental effects of the project. As part of the tailings expansion, a reclamation review was requested to update the reclamation plan. HGCMC submitted a revised plan and cost estimate on October 22, 2003. The estimated reclamation cost detailed in this document was approximately $26,200,000The regulatory agencies accepted this bond revision amount.

The value of the reclamation bonding fund was recalculated in 2005 and HGCMC proposed an increase to $29,000,000 as discussed in the 2006 annual presentation meeting and then presented in a 17 August 2006 letter to the regulatory agencies. The regulatory agencies provided their review response to HGCMC on 19 January 2007. HGCMC fully responded to these issues with a 25 February 2007 letter.

A fully updated reclamation plan and proposed bond amount were submitted to regulatory agencies in April 2008. The 2008 submittal fulfills a portion of the ADEC requirements for the renewal of the Waste Management Permit. SRK Consultants, in their environmental audit of the mine in 2008, reviewed the updated reclamation plan and proposed bond amount, and provided comments in their audit report.

In 2011, the agencies provided their comments on the HGCMC 2008 draft update to plan and cost estimate. The main comments received involved 1) the need to update the estimate to reflect current conditions (i.e., current day rather than 2008) and 2) the difficulty following the custom excel spreadsheets the mine used to produce the draft estimate. HGCMC retained SRK Consultants to address these concerns update the plan and cost estimate. SRK Consultants have experience producing reclamation plans and cost estimates for mining companies, including the Red Dog Mine in Alaska. SRK used the Standardized Reclamation Cost Estimator or SRCE model to update the HGCMC cost estimate. The SRCE model is required by the State of Nevada for estimating closure costs for mines in that state. The updated Reclamation Plan and proposed bond amount are currently under review by the agencies. Upon approval, HGCMC will take the necessary steps to formally update the bond amount.

Reclamation Projects

HGCMC continued using past interim reclamation measures, such as hydroseeding and various erosion controls at the Tailings Facility, to improve and maintain established site controls. A growth medium (six inches to one foot) of native soils was placed on selected slopes of the tailings pile to promote hydroseed growth. HGCMC also continued the use of other sediment control measures including silt fencing, jute mat, rock check dams, solid and flexible runoff collection pipes, coarse-rock slope armoring and slope contouring throughout the site. HGCMC is committed to the continued use of site controls as the operation has consistently demonstrated the benefits of these interim reclamation programs to reduce impacts during the operational period.

The Waste Management Permit allows time to gather cover performance information for further analysis, prior to installing the cover en mass. Continued evaluation of cover performance remains ongoing since installation of a test plot on Site 23 in 2000 to justify and improve closure cover technology. Extensive reviews in 2002 of the cover performance also took place during the HGCMC Stage 2 Tailings Expansion project work with the USFS. HGCMC recognizes that the soil covers represent a significant part of the site reclamation plan. Therefore, HGCMC has continued to commit resources to develop and monitor the performance of the closure cover. See Section 3.8 for more details on the Site 23 test cover performance.

3.0 Site 23/D

3.1 Introduction

Hecla Greens Creek Mining Company (HGCMC) has prepared this report in accordance with the mine's General Plan of Operations (Appendix 11) and Alaska Department of Environmental Conservation Waste Management Permit 0211-BA001. A summary of all operational and monitoring activities performed in 2013 is provided. Refer to GPO Appendix 11 and Permit 0211-BA001 for a detailed description of Site 23, Site D and associated monitoring requirements.

Operation of Site 23 (HGCMC's only active production rock disposal facility) continued in 2013. See the Site 23 as-built in Appendix 2 for facility layout. Approximately 70,175 cubic yards of production rock were placed at Site 23 during this report period. HGCMC estimates the projected remaining capacity at Site 23 at approximately 352,462 cubic yards, based on the current design.

3.2 Placement Records

Site 23 survey data and truck count haulage information are presented in Table 3.1. Site 23 received approximately 118,792 tons of production rock in 2013 as calculated from HGCMC surveyed volumes. HGCMC estimates 1,341,250 tons of waste rock has been placed in Site 23. A tonnage factor of 1.7 tons/yd^3 was used to convert surveyed volume to tonnage. The difference between truck count totals and calculated totals based on survey data reflects variations in tonnage factors, small differences in load capacities and double handling of materials. The surveyed volume reported in cubic yards has the least uncertainty relative to other quantities reported in Table 3.1. It is difficult to determine the amount of time remaining before permitted space at Site 23 is consumed because placement rates are highly variable and dependent on the underground mine's areas of production. Estimates based on the mine's current plans have determined that there will be sufficient area available for placement at Site 23 through the current remaining life of the mine (approximately 9years).

The acid base accounting data presented in Section 3.5 indicate that HGCMC continues to conservatively classify its production rock. Some of the phyllite that is visually classified as Class 3 is actually chemically Class 2 (i.e. laboratory testing demonstrates a NNP between 100 and –100 tons $CaCO_3$/1000t).

Table 3.1 Production Rock Placement Data

	PRODUCTION ROCK PLACED AT SITE 23						ADDITIONAL PRODUCTION ROCK HAULED					
2013	Surveyed (cy)			Surveyed (tons)			Hauled To Tails from Site 23 (tons)		From UG Truck Counts (tons)			
Date	Monthly	Cumulative	All Materials	Monthly	Cumulative	All Materials	Monthly	Cumulative	Class 1	Class 2	Class 3	Total
2/4/2013	7,395	7,395	729,551	12,518	12,518	1,234,977	865	865	1,620	240	390	2,250
2/28/2013	0	7,395	729,551	0	12,518	1,234,977	498	1,363	1,590	1,140	60	2,790
3/31/2013	9,096	16,491	738,647	15,398	27,916	1,250,374	31	1,394	4,800	390	1,170	6,360
4/30/2013	7,312	23,803	745,959	12,378	40,293	1,262,752	0	1,394	8,484	4,381	360	13,225
5/30/2013	8,647	32,450	754,606	14,638	54,931	1,277,389	3,016	4,410	5,280	3,900	0	9,180
6/30/2013	7,437	39,887	762,043	12,589	67,520	1,289,979	4,052	8,462	7,020	810	0	7,830
7/31/2013	8,648	48,535	770,691	14,639	82,160	1,304,618	2,238	10,700	9,810	930	120	10,860
8/31/2013	7,305	55,840	777,996	12,366	94,525	1,316,984	873	11,573	10,440	270	0	10,710
9/30/2013	5,551	61,391	783,547	9,397	103,922	1,326,381	1,530	13,103	9,840	450	120	10,410
10/31/2013	2,789	64,180	786,336	4,721	108,643	1,331,102	468	13,571	390	2,940	480	3,810
11/30/2013	3,871	68,051	790,207	6,553	115,196	1,337,654	0	13,571	330	6,360	240	6,930
12/31/2013	2,124	70,175	792,331	3,595	118,792	1,341,250	124	13,695	240	2,310	0	2,550
TOTAL	**70,175**		**792,331**	**118,792**		**1,341,250**	**13,695**		**59,844**	**24,121**	**2,940**	**86,905**

3.3 Stability

Klohn Crippen conducted a stability assessment of Site 23 and Site D in 2003. The stratigraphy and geology were reassessed using the results from drilling programs by HGCMC and Klohn Crippen, historical drill hole data, seismic refraction data, geological mapping and piezometer data. This assessment enabled the previous stratigraphic interpretations to be revised as follows (from top to bottom): a layer of colluvium and blocky rubble about 80 feet thick; a layer of glacial till and sediment about 120 feet thick; a comparatively thin layer of weathered bedrock about 10 to 20 feet thick; and unweathered bedrock (Klohn Crippen 2004). The blocky colluvium is interpreted to be historical (likely ancient) landslide debris.

Limit-equilibrium stability analyses and the liquefaction potential of the foundation materials were evaluated for Site 23 and Site D, using the reinterpreted geological model. Site 23 has calculated static Factors of Safety greater than 1.6 for the existing configuration, and 1.7 for the proposed final build-out geometry at 1,120 feet with 3H:1V exterior slopes. The static calculated Factor of Safety of the backslope above Site 23 ranges from 1.0 for shallow surficial slips to 1.3 for deeper surfaces.

Approximately 20 feet of saturated fill material identified at the base of drill holes DH-00-03 (north-central) and DH-02-14 (east end) at Site D was found to be potentially liquefiable under design basis earthquake (DBE) and maximum design earthquake (MDE) loading. Liquefaction of this fill material will impact the stability of Site D, but will not reduce the stability of Site 23 to unacceptable levels.

Site D is projected to fail under a significant earthquake. In its current configuration, Site D is expected to fail under the 1/475-year magnitude design earthquake. This represents an approximate probability of failure of about 0.21% annually, or about 2% during the mine's current projected remaining operational period of about 9 years.

Inspections

Several independent inspections are carried out at Site 23 throughout the year. Operators working at the site carry out daily visual work place inspections. The Surface Civil Engineer and or Surface Operations Manager carry out weekly visual inspections. The environmental department carries out a monthly checklist inspection. No visible signs of physical instability were observed at Site 23 during this report period.

ADEC representatives inspected the site once in 2013 on April 29. During 2013 the USFS conducted 10 routine inspections (Site inspections #344-#353) to monitor for best management practices effectiveness and compliance to the General Plan of Operations. No issues of non-compliance or poor operations practices of the Tailings Facility were noted during the routine inspections. The USFS typically noted that the facility is being developed and operated to required operations and maintenance specifications of GPO Appendix 11. The BMP plan was updated in 2013 as part of the HGCMC GPO.

Slope Monitoring

Slope monitoring at Site 23/D consisted of GPS monitoring of 13 survey hubs distributed across the sites. The resolution was felt sufficient to identify large potential movement and no such movements were identified. An additional three permanent surface monitoring GPS sites were installed in 2010 alongside inclinometer sites to collect full time surface movement data and were online starting in 2011. Two instruments were installed on Site 23 and one on the Mill backslope. Data from these installations show no clear trend in movement.

Inclinometers are used to measure potential subsurface displacement and aid in characterizing slope stability. A total of seven inclinometers have been installed at various locations including Site 23/D (4 units), the Tailings Facility (1unit), the Mill Backslope (1 unit), and along the 1350 access road (1 unit). One inclinometer was installed in 2005; the other six were installed in 2010. A summary of the inclinometer installations by location is shown below:

Location	Site ID	Target Geological Unit Depth	VW Piezo Target Geological Unit
Tailings Facility	IN-T-10-21	Marine clay	1 – Tailings 1 – Marine Sand
Site 23/D	IN-23-05-01	Bedrock	1 – Glacial Till 1 – Landslide Rubble
	IN-23-10-01	Glacial Till	1 – Colluvium
	IN-23-10-02	Glacial Till	1 – Landslide 1 – Landslide Rubble
	IN-23-10-08	Bedrock	1 – Glacial Till 1 - Clay
Mill Backslope	IN-920-10-05	Glacial Till	1 – Glacial Till 1 – Glacial Till
1350	IN-1350-10-01	Bedrock	1 – Bedrock 1 – Landslide

The digital inclinometer probe used prior to and for 2010 instrumentation monitoring was recalibrated in October 2010. Data taken in September (prior to instrument calibration) and November 2010 (after instrument calibration) indicate no documentable shift in data accuracy with the use of this instrument post-calibration. At the completion of 2013 September/October inclinometer monitoring, the inclinometer was again calibrated.

For the inclinometers installed in 2010, the November 2010 data is used as the baseline for following monitoring. Based on the constant rate of movement associated with the first year of quarterly inclinometer monitoring, monitoring frequency has been adjusted to semi-annual monitoring for all inclinometers. If movement activity changes (e.g., rate due to change in site conditions, placement operations, or earthquake induced), frequency of monitoring will be re-assessed. The inclinometer installations and associated intended monitoring objectives are summarized by site location in the following paragraphs.

<u>Site 23</u>

Inclinometer IN-23-05-01 was installed at Site 23 at the end of 2005 to aid with stability monitoring at Site 23/D. This inclinometer, located at the central area of the site, has been monitored since 2006, with the baseline reading taken in October 2006. The measurements are presented in two forms, absolute position and incremental displacement. The view of absolute position (Figure 3.31) shows the orientation of the inclinometer casing. A positive deviation on the A axis and a negative deviation on the B axis indicate southerly (downslope) and easterly (up valley) deviations, respectively. The deviation from vertical in this view likely represents deflection of the bore hole that occurred during drilling. The displacements measured since the initial readings are too small to show up in this view and the curves plot on top of each other. The incremental displacement chart (Figure 3.30) shows the location and magnitude of displacement since the initial 2006 reading. Displacements at the top of the hole are attributed to frost heaving, grout settling, and damage from bear activity. The incremental displacement view shows the amount of movement has been approximately 17.1 mm (from 2006 through September 2013).

There were 3 mm movement from October 2012 through September 2013, with 1.1 mm movement occurring between May and September 2013. Movement appears to be confined to a surface approximately 79.3 feet below ground surface (85 feet was previously reported in 2009; however, that value did not consider above ground casing). This depth roughly corresponds to the base of the slide/colluvium unit and the top of the dense till in the foundation.

Three additional inclinometers were installed at Site 23 during the summer of 2010 and baseline readings were taken September and November (after instrument calibration). Readings in inclinometers IN-23-10-01, IN-23-10-02, and IN-23-10-08 are consistent with the data obtained previously from IN-23-05-01. Inclinometer IN-23-10-01 was installed in the lower portion of Site D and no movement has been observed in this inclinometer. Inclinometer IN-23-10-02 was installed west of the mid-slope of Site 23 and approximately 1.8 mm of movement was observed at approximately 114.4 ft bgs from September 2012 to September 2013. This movement is along a silty sand lense between silt and the glacial till. Inclinometer IN-23-10-08 was installed at the top of Site 23 and the movement zone ranges from 125.8 to 135.8 ft bgs. This movement zone is below the landslide materials and just above the glacial till. The maximum movement in this zone was about 1.4 mm at 131.8 ft bgs from September 2012 to September 2013. The identified movement rates appear to be relatively constant.

The 2011 (KCB, 2012) Site 23/D stability update provided recommendations for trigger level monitoring for inclinometer movement rates and piezometer water levels for instrumentation installed at Site 23/D, to ensure stable static site conditions. More frequent monitoring and site reassessment for stability becomes necessary if movement is documented along the slide plane in excess of 1 inch (25.4 mm) per month, or 3 inches (76.2 mm) total. Immediate notification and response action is necessary if movement along the slide plane in excess of 4 inches (101.6 mm) per month is documented. For water levels, the general guidelines are that if water levels are trending 5-ft above the winter average for a given piezometer, that the Surface Operations Manager should notify the Design Engineer for further assessment. If the water levels are trending 10-ft above the winter average for a given piezometer, appropriate emergency response notifications and actions shall be implemented. Piezometer levels are discussed further in the next section of this report.

<u>Tailings Facility</u>
One inclinometer was installed in the west/southwest slope of the existing tailings pile in 2010 to monitor the stability of that slope area. There appears to be slight movement at a couple depths, with the primary movement zone at 79.7 ft bgs. Total movement as of October 2013 at 79.7 ft bgs is slightly less than 2 mm, with annual movement less than 1 mm. These very minor movements at depth do not show consistent downslope displacement and are likely due to consolidation of the tailings pile. It should be noted that the inclinometer is located on a bench next to a test study area, but that the tails facility continues to be built higher in elevation above this bench.

<u>Mill Backslope</u>
One inclinometer was installed in the central area of the Mill Backslope in 2010. This inclinometer was installed to monitor the slope above the main mill site. The original slope was cut between 1987 and 1989 to create the bench for the mill site area infrastructure. Shortly after excavation, slope movement was identified along the backslope and drains were installed to lower water levels and improve slope stability. Water levels are monitored and maintained to minimize the potential for slope failure. The slight movement (0.75 mm over 3 years of monitoring) at 12.7 ft bgs (approx. 970.9 ft; lithology classified as glacial till) is expected given the past and current slope conditions. These data, in correlation with the piezometer data, indicate that the dewatering

system continues to be effective at controlling subsurface water levels and mitigating potential large-scale movement of the slope.

1350 Access Road

One inclinometer was installed along the 1350 Area access road in 2010. This inclinometer was installed to evaluate whether the landslide materials observed during installation of groundwater monitoring instruments are associated with an inactive or active slide zone. Due to winter month site access road conditions, no monitoring is performed during winter months. There is continued slight movement at 83.5 ft bgs (1032 ft elevation) at a transition zone between sand and silt lithology (approx. 3.9 mm over the last year).

Well and Piezometer Water Level Data

Well and piezometer water level data are provided in Figures 3.1 to 3.12. The lack of significant pressure in piezometers installed close to the base of Site 23 (piezometers 52-55, Figures 3.1 to 3.4) demonstrates that the pile remains free draining. This is consistent with the construction of a network of finger drains under the pile and a blanket drain at the pile toe. Comparison of historic versus modeled flow from the finger drains and the curtain drain indicated they are performing as designed and as necessary (EDE 2004). The lack of pore pressure at the toe indicates that pile stability has been maximized. The inferred water table is 30 to 60 feet below the base of the production rock pile material up-slope of the Site 23 active placement area and 5 to 20 feet below the base of material placed in Site D and the toe of Site 23, respectively (see also Figures 3.5 to 3.12). Observations from wells completed in the colluvium below the sites indicate that perched water tables and braided flow paths exist beneath the site (e.g. compare Figure 3.6 and 3.7). This unit also shows large (up to 10 feet) fluctuations in head levels, which are consistent with perched, confined conditions and channel-like flow. There is a distinct seasonal pattern to the water level fluctuations beneath Site 23/D, particularly in the alluvial sands (Figures 3.9 and 3.11).

The silty/clay till that underlies the colluvial unit impedes downward flow and has an upward hydrologic gradient caused by its confining the more permeable bedrock below it. MW-23-98-01 (Figure 3.8) is completed in the till unit and indicates a water table near the top of the till, which is approximately 100 feet below the existing topographic surface. Alluvial sands occur between the colluvial unit and the silt/clay till near the toe of Site 23 and under Site D. Data from MW-23-A4 and MW-D-94-D3 (Figures 3.9 and 3.11) indicate that the sands are saturated. A curtain drain installed in between Site D and Site 23 in 1994 collects water that flows at the base of the colluvial unit and the top of the alluvial sands (see as-built and sections). This drain helps reduce pore pressures in the foundation of Site D, as well as capturing infiltration waters from Site 23.

3.4 Hydrology

Surface and groundwater are managed using a network of drains, ditches and sediment ponds at both Site D and Site 23. See the Site 23 as-built for locations of these features. Water that is collected in the finger drains beneath Site 23 is routed to Pond 23 along with Site 23 runoff via a lined ditch. Pond 23 also periodically receives stormwater via pipeline from the 920 area. A curtain drain below the toe of Site 23 captures groundwater from the colluvial unit beneath the site and reports to the Pond D wet well via pipelines. Pond D also captures surface water and drainage from seeps near the toe of Site D. Pond D water is returned to the Pond 23 pump station where it is either sent to the Mill or down to the Pond 7 water treatment facility. An 18” HDPE pipeline was installed in 2008 to carry stormwater from Pond 23 (which receives water from Pond D) to the Pond 7 water treatment facility. This pipeline, along with the installation of new pumps, increased the stormwater handling capacity of Site 23/D to a 25-year 24-hour storm.

Flow data for Pond D are shown in Figure 3.13. The data used for the figure is calculated from a flow meter that records instantaneous flow every 5 minutes. The data logging will be programmed and edited to record more frequently and improve accuracy in 2014.

Monthly temperature and precipitation data are provided in Table 3.2. August was the driest month with less than an inch of precipitation. June and August were the warmest months while March exhibited the coolest temperatures. Temperature recordings were unavailable at the Mill from September through December.

The production rock and colluvium units respond rapidly to hydrologic events such as snowmelt and rainfall, indicating very local recharge and discharge (EDE 2004).

Table 3.2 Monthly Summaries of Mill Site Climate Data

Month	**Avg Temp (°C)**	**Precipitation (in)**
January	-1.16	5.06
February	0.29	5.86
March	-2.09	1.32
April	1.01	3.96
May	7.55	4.87
June	13.10	3.47
July	12.48	5.87
August	12.95	0.92
September	no data	7.06
October	no data	9.06
November	no data	1.24
December	no data	6.89
2013	5.52	55.6

3.5 Water Quality

An in-depth re-evaluation of the geochemistry and hydrology of Site 23 and Site D was performed in 2003 by Environmental Design Engineering (EDE) and HGCMC in accordance with the ADEC Waste Management Permit Section 4.1.1. In general, metal concentrations in the production rock are above crustal averages and are higher than those of the underlying till, colluvium, and alluvium units. Site contact water, therefore, has a generally higher dissolved load than background surface water and groundwater. Bruin Creek and Greens Creek have specific conductivities that range seasonally from 50 to 225 μS/cm. The lack of significant differences between upgradient and downgradient sites on these two creeks demonstrates that effects from Site 23/D are negligible.

Groundwater upgradient and downgradient of Site 23/D also varies between sites and seasonally, with specific conductivity ranging from 200 to 800 μS/cm. Compositional differences between upgradient and downgradient wells demonstrate that the slide unit hosts a series of disconnected, perched water tables of varying water qualities.

Monitoring data from surface water and groundwater sites indicate that the combination of finger drains, curtain drain, ditches and ponds is effectively collecting contact waters and that downgradient effects from Site 23/D are negligible.

Data collected from basal drains, the curtain drain and Pond D show a progressive, down-slope increase in the groundwater component of the flow. This is consistent with the hydrologic interpretation that water infiltrates through the slide material and daylights as springs near the toe of this unit. As Site 23 expands, the proportion of contact water in the flow increases, as demonstrated by the increase in the curtain drain dissolved load since 1995. While the volume of contact water has increased, the dissolved load of the contact water has not increased over time. This is a positive result because it demonstrates that acid generation is not imminent.

A dissolved load analysis based on calculated TDS was performed to determine the relative proportions of various source waters in downgradient waters. Based on this analysis, Pond D contains 12% contact water, and approximately 80% of the Pond D flow is contributed by the curtain drain.

Representative water quality analyses for the major water types are consistent with the conductivity and TDS results and help to further define the geochemical processes occurring at the site. Alkalinity and pH values from all site waters support the conclusion that carbonate minerals are effectively neutralizing acids formed by oxidation of pyrite in the production rock. Zinc, cadmium, manganese, nickel and arsenic are more mobile than other metals of interest in the drainage. Precipitation of iron oxy-hydroxides and manganese oxides controls the concentrations of iron, manganese, and arsenic. Zinc, cadmium and nickel are controlled by mixing and sorption mechanisms. Gypsum is controlling the concentration of calcium in the drainage.

Compliance Monitoring

Water sampling sites around the Site 23/D production rock disposal area have been monitored for various periods. Sites have been added and deleted over time as rock disposal area development is required. The full FWMP Annual Report for water year 2013 is being prepared separately and will be submitted to the Forest Service and ADEC upon completion.

Internal Monitoring

In May 2001 Greens Creek submitted an Internal Monitoring Plan to the Alaska Department of Environmental Conservation – Solid Waste Management Program. This submittal satisfied Section 2.8.3.1 of the HGCMC Waste Disposal Permit Number 0111-BA001.

As described in Section 2.8.3.1 of the permit, the internal plan addressed monitoring at both the surface Tailings Facility and the surface production rock disposal areas covered by the permit. The Internal Monitoring Plan describes monitoring of the pile areas, in contrast to the compliance monitoring (under the Fresh Water Monitoring Plan) at peripheral facility boundary sites. As such, data generated by the Internal Monitoring Plan effort are "… not for compliance purposes…" as noted in the above referenced permit Section 2.8.3.1.

Waters represented by the internal monitoring sites are captured, routed to the Mill or Tailings Facility and treated prior to discharge to the ocean floor under HGCMC's discharge permit (AK 004320-6). Authority over the federal permitting, compliance and enforcement NPDES program transferred to the State (ADEC - APDES) in November of 2010 for the mining industry.

Production rock Site 23 and the adjacent production rock Site D are treated as a single entity, primarily due to their conterminous positions making isolation from one another impractical. Consequently, they are referred to as Site 23/D in this report.

The results of HGCMC's Site 23/D internal site monitoring plan are summarized in Figures 3.14 to 3.26. Personnel issues and EIS field activities contributed to a reduction in monitoring of these internal sites in 2012 and 2013. Review of the prior years' data suggests that changes in chemical composition were not imminent, and HGCMC will increase the frequency of monitoring of these sites or replacements in 2014. Sites were distinguished between finger drains and groundwater. These groups are separated on the Figures 3.14 through 3.26 with the suffix a or b, respectively. For example, a figure number such as 3.14a would show the pH data for the finger drains, and 3.14b would show the pH data for the groundwater sites. Sample collection from the Site 23 finger drains is dependent upon their flow. Flow from several of these finger drains is very irregular, responding directly to precipitation-induced infiltration and groundwater fluctuations (Figure 3.27). Monthly sampling of the flowing drains has identified the typical range of concentrations of constituents in the drain waters. HGCMC reduced the frequency of sampling to quarterly for all internal monitoring sites starting in 2003.

Figure 3.14a shows the pH of waters collected from Site 23 Finger Drains 2 through 8, and Figure 3.14b shows the pH of monitoring wells MW-23-A2D, MW-23-A4, MW-D3 and Pond D (see as-built in Appendix 2 for locations). Monitoring of pH at these sites was not conducted in 2013. The lower pH values (generally pH 6.0 to 7.0) were recorded in MW-23-A4 and MW-D3, both of which are completed in alluvial sands beneath Site 23 and Site D, respectively. MW-23-A2D, which screens colluvium upgradient of Site 23, typically has the highest pH (generally pH 7.0 to 8.5). The Site 23 finger drains fluctuate at values between those of the monitoring wells. Figures 3.14a and b suggest that waters from different foundation units have different pH values and that Site 23 and Site D contact waters and the materials with which they are in contact exhibit sufficient buffering capacity to prevent acidification of site drainage in the near term. Seasonal fluctuations are apparent in the finger drains with highest pH values occurring in winter months and lower pH in mid to late summer.

As with pH, high alkalinity values (Figures 3.15a and b) indicate that the waters are well buffered. Fluctuations in alkalinity correlate with those of other parameters, such as hardness (Figures 3.16a and b) and conductivity (Figures 3.17a and b), and also appear to be seasonal. Carbonate minerals in the production rock contribute to the high alkalinity of the drainage from the finger drains. Alkalinity is lowest in samples with the highest groundwater component (e.g. the monitoring wells, Pond D, 23FD-5 and 23FD-7). Calcium and magnesium are the primary contributors to hardness (Figure 3.16a) and reflect dissolution of carbonate minerals, such as calcite and dolomite. Carbonate dissolution neutralizes acidity formed by sulfide oxidation, which is also the source of sulfate shown in Figure 3.18a.

Conductivity results from internal monitoring site waters are presented in Figures 3.17a and b. The 2013 conductivity measurements range up to 5,700 uS/cm. MW-23-A2D and MW-D3 have not been sampled since 2011. MW-D3 is completed in alluvial sands below the fill placed at Site D. The finger drains with the highest flow (e.g. 23FD-5, which directly drains an excavated spring) generally have lower conductivities than the drains with lower flow. This reflects a larger contribution from groundwater to the high-flow drains relative to a higher proportion of site contact water in the other finger drains. The significant decrease in conductivity in 23FD-7 (Figure 3.17a) that occurred in 2000 is probably the result of incorporation of groundwater collected in the upper portion of the drain above the active placement area. The presence of contact water in the alluvial sand below Site 23 (as seen in MW-23-A4) is not surprising given the permeable nature of the colluvium that lies immediately beneath the site. A clay till layer underlies the colluvium and alluvial sands beneath the site. The clay till serves as a barrier to downward flow; however, as discussed earlier, it occurs well below the base of both piles. The fact that MW-D3 does not show signs of a contribution from contact water suggests that an upward hydrologic gradient may exist beneath Site D.

Finger Drain 23FD-2 has the highest conductivity but consistently low flow, suggesting no significant influence from groundwater. In fact, lack of flow from this drain typically precludes sampling. In 2009 it was dropped from the routine sampling list. The higher conductivity of the site contact waters reflects a larger dissolved load caused by weathering of the production rock. As with tailings, pyrite oxidation and carbonate dissolution contribute dissolved ions such as sulfate, bicarbonate, calcium and magnesium to the contact waters, increasing their conductivity. Sulfate concentrations for the finger drains and groundwater wells are plotted in Figures 3.18a and 3.18b and match closely the relative value patterns of conductivity. The drier than average spring and summer in 2009 and 2010 likely contributed to a greater buildup of oxidation products and reduced groundwater contribution to the water balance. This may result in higher conductivity and sulfate values for some sample sites.

Arsenic data are presented in Figures 3.19a and b and are generally quite low. All finger drains and MW-23-A4 experienced increases in their arsenic concentrations in September 2003, with subsequent decreases back down to historical levels in October. The flows in the finger drains positively correlate with these changes. Fluctuations in arsenic values in 23FD-2 can be attributed to changes in redox conditions. Low arsenic and iron (Figures 3.25 a and b) concentrations indicate that these metals are precipitating as oxyhydroxides on rock surfaces in the pile.

Figures 3.20a and b show the concentration of zinc in the internal monitoring locations at Site 23/D. Zinc levels appear to be controlled by seasonal conditions. Zinc concentrations in the range of 20 to 70 mg/L are consistent with laboratory kinetic weathering tests performed on samples of argillite and serpentinite (Vos 1993). The zinc concentrations recorded for Pond D are generally below 0.9 mg/L and reflect contributions from several source waters. Pond D receives water from Site D surface runoff, seeps on the slope and at the toe of the site and the effluent from the curtain drain that HGCMC installed between Site D and Site 23.

Cadmium concentrations (Figures 3.21a and b) correlate well with those of zinc for the internal monitoring sites although at much lower values (0 to 35 ug/L).

The concentrations of copper and lead (Figures 3.22a and b and 3.23a and b) are considerably lower than that of zinc in the Site 23/D internal monitoring sites. Both of these metals show the same general trends as zinc although 23FD-7 lead levels have increased recently but still remain below zinc levels and Alaska water quality criteria. The nickel concentrations presented in Figures 3.24a and b support the observation that the drainage from 23FD-2 is different than that of other drainages. It is possible that the material that supplies water to this drain has a greater proportion of serpentinite, which was shown to produce higher zinc and nickel concentrations than other rock types such as argillite and phyllite (Vos 1993). What appeared to be a linear increase in nickel concentrations in 23FD-2 prior to 2002 now appears to be decreasing or at least cyclical. The December 2005 sample from MW-23-A2D was an order of magnitude higher than historical values and was likely an analytical error as it did not correspond with the conductivity and TDS of that sample. Also, the more recent metal concentrations for this site have returned within historical data values. Monitoring will continue to determine trends.

An overall increase in arsenic, cadmium, copper and zinc concentrations was apparent in the majority of finger drain samples between 2005 and 2006, though the elevated levels remained within historical limits. This may be the result of capturing the flow from a spring along the site's backslope.

Manganese concentrations (Figures 3.26a and b) are generally less than 50 ug/L for MW23-A2D, MW23-A4, and three of the finger drains (23FD-3, 23FD-5 and 23FD-8). The other three finger drains (23FD-2, 23FD-6 and 23FD-7) and MW-D3 and Pond D have elevated manganese concentrations, indicative of the different redox conditions. Precipitation/dissolution of iron oxyhydroxides and manganese oxides controls the concentrations of iron and manganese in these waters.

Acid Base Accounting Data

Acid base accounting (ABA) results from 49 underground rib composites collected in 2013 are presented in Table 3.3 and Figure 3.28. Class 1 rib samples had an average neutralization potential (NP) of 260 tons $CaCO_3$/1000t, which is equivalent to about 30% carbonate. The Class 1 samples had an average acid potential (AP) of 73 tons $CaCO_3$/1000t, which produced an average net neutralization potential (NNP) of 186 tons $CaCO_3$/1000t. Class 1 production rock does not have the potential to generate acid rock drainage; however, HGCMC recognizes the potential for metal mobility (primarily zinc) from this argillite rock. HGCMC has long-recognized this characteristic of Class 1 production rock and handles the material accordingly by placing it in controlled facilities, such as Site 23 and the tailings area.

Class 2 production rock rib samples had an average NP value of 188 tons $CaCO_3$/1000t and an average AP of 178 tons $CaCO_3$/1000t. The resulting average NNP for the Class 2 rib samples was 11 tons $CaCO_3$/1000t. Class 3 rib samples had an average NP, AP and NNP of 133, 209 and, -76 tons$CaCO_3$/1000t, respectively. Negative values for NNP indicate that the materials are potentially acid generating, thus requiring appropriate ARD control measures. Carbonate in the Class 2 and Class 3 production rock prevents ARD formation in the short term, allowing time for co-disposal at the tailings facility and placement of a composite soil cover to be constructed during reclamation. The soil cover is designed to inhibit ARD formation by minimizing oxygen and water infiltration into the underlying sulfide-bearing material. Class 4 rib samples produced an average NNP of -431 tons $CaCO_3$/1000t. Class 4 material is retained underground.

Figure 3.28 compares actual class designation based on ABA analyses to the results of visual designation use underground to classify the production rock. Of the 49 composites, visual classification assigned 7 samples (14%) to a lower, less conservative class. Twenty eight (57%) of the composites were assigned to the appropriate class and 14 (29%) to a higher, more conservative class. These data represent an 86% success rate for the visual classification program.

Table 3.3 ABA Data Summary for Underground Rib Samples and Site 23

2013	Class 1		Class 2		Class 3		Class 4
	Site 23 #1	Rib Sample #1	Site 23 #2	Rib Sample #2	Site 23 #3	Rib Sample #3	Rib Sample
NP	NA	260	NA	188	NA	133	43
AP	NA	73	NA	178	NA	209	474
NNP	NA	186	NA	11	NA	-76	-431

Notes: Values are averages from 49 rib samples
ABA units are tons $CaCO_3$/1000t
NP determined by modified Sobek method
AP determined from total sulfur assay (converted to pyrite equivalent)

No ABA Site 23 active placement composite samples were collected from the pile in 2013. 2010 ABA composite results from the Site 23 active placement areas are shown in Figure 3.29a. Active placement area ABA results from previous years as well as the 2006-2013 grid data are also shown on Figure 3.29a. Paste pH sample results are shown in Figure 3.29b. The AP to NP distribution in the Site 23 samples differs from that of the underground rib samples. The Class 2 and Class 3 stockpile areas are frequently empty except for a safety berm, which is constructed of Class 1 rock in the absence of other material. It is probable that several of the samples included this berm material. The grid sampling is also skewed toward higher NNP values because most of the outer surface of the pile is covered with Class 1 rock.

In 2013 a new grid sampling procedure was used. In areas where the surface of the pile was covered with interim reclamation material or Class 1 argillite, effort was made to expose and sample Class 2/3 material. The results of this sampling will indicate if the potentially acid generating material near the surface has depleted its neutralization potential. There are few places on Site 23 that have Class 2/3 material within two feet of the final outer surface. The one sample location that encountered Class 2 material on the outer Slope of Site 23 showed no sign of NP depletion (pH 7.7, NP 188 tons $CaCO_3$/1000t).

3.6 General Site Management

The construction method used at Site 23 (bottom-up construction) limits the site's complexity. Designated placement zones are marked on the active lift of the site and production rock is placed according to class. A lined pad was constructed in 2013 in order to place reclamation material from the 1350. This pad was built to contain a maximum capacity of 8,000 cubic yards. No other activities other than routine placement and monitoring occurred at Site 23 in 2013.

In 2005 HGCMC modified placement methods to minimize the formation of permeable areas, or chimneys, between placement zones. The homogenous, planar placement surface that resulted from the new method created surface drainage challenges. HGCMC experimented with a ridge and swale pattern that appeared to improve drainage during the rainy season but was susceptible to drifting snow in the winter months. Fine tuning of methods to improve drainage and accessibility has continued.

In 2008, HGCMC received approval from ADEC to construct an interim disposal area for waste rock to be backfilled underground (see photo Figure 3.35). A 25,000 cubic yard capacity area was constructed to aid in concurrent reclamation efforts and can potentially be utilized on a continual 12-month schedule. This was a large increase over the previous 920 remuck bay which had a limited 700 cubic yard capacity. The area is layered with 6” of sand; a 36 mil reinforced polypropylene liner, another 6” layer of sand, 3’ of class 3 production rock, and finally a geofabric layer. An HDPE pipe collects water from the area which is sloped to a central collection point. The water collected in this area drains to Pond 23. Material placed in this area is treated with up to 1 wt% lime. Waste rock from the 1350 is placed at the Site 23 temporary disposal area. These materials are backfilled underground as space and resources become available. In 2012, work began to decommission approximately half of the 25,000 cubic yard capacity area resulting in approximately 12,500 cubic yards of capacity for placement.

Approximately 5,000 cubic yards of material was excavated from the backslope of Site 23 during the 2005 construction season. The material was used as fill in the 960 road base and the Mill Backslope road. Additional material that was removed is stored at 4.9 on the B Road for future site reclamation activities. In 2007, approximately 8,000 cubic yards were removed from this area for site development and other various projects. In 2008, 360 cubic yards were excavated for the B Pond berm project. In 2009, improvements in the D pond area included installation of a larger pump system to increase pumping capacity. Also, approximately 4,500 cubic yards of waste rock and pyritic berm material were removed, and replaced with clean fill. The majority of the fill was sourced from the backslope of Site 23, with minor amounts of sand and gravel used for drains. In 2010, approximately 9 cy of Pond D berm material was removed and replaced with clean fill. Also, the construction of the 860 pad was completed adjacent to Site 23. In 2013, approximately 6,000 cubic yards of material were removed from the 1350 and placed on the temporary disposal pad.

3.7 Site as-built

As-built drawings for Site 23/D are presented in Appendix 2. Three drawings from the Site 23/D Hydrogeology and Geochemistry Analysis Report (EDE 2004) (Site 23/D conceptual model, Site 23/D colluvium potentiometric surface and Site 23/D cross section) are also included in Appendix 2. The drawings show the year-end topography, water management features, monitoring device locations, and other significant features of the site. The as-built also includes cross sections that show the following information:

- existing topographic surface
- prepared ground upon which the pile was constructed
- original unprepared ground
- fill design level

Figure 3.34 shows a photo of Site 23 in October 2013 with a pile of 1350 reclamation material placed on the eastern- pad. An aerial photo of Site 23 in September 2013 is shown in Figure 3.35.

3.8 Reclamation

HGCMC has monitored the performance of a one-acre composite soil cover plot on Site 23 since September 2000 (see Site 23 as-built in Appendix 2 for plot location). Key performance aspects of the cover system for 2001 - 2011 years include:

- Calculated potential evaporation (PE) long term average is 15.9 inches.
- The degree of saturation in the barrier layer was greater than 85%. This is a positive cover performance aspect and implies that the oxygen diffusion coefficient of the barrier

material was minimized, thus minimizing the ingress of atmospheric oxygen with respect to diffusion through the pore-air space.

- The recorded temperatures within the growth medium layer and the compacted barrier layers have been similar for the 11 years of monitoring. The data show that freezing conditions have not been encountered in the compacted barrier layer, suggesting that freeze/thaw cycling is not impacting the barrier layer structure.
- Vegetative cover continues to be dominated by the hydroseeded grass and clover plant species. However natural invasion, primarily by spruce seedlings, is evident, particularly on the western-most portion of the cover area.

In December 2006 HGCMC began collaborating with Oregon State University (OSU) and M.A. O'Kane Consultants Inc. to further characterize the hydrology of the cover plot and evaluate how evolution of native forest vegetation (spruce-hemlock forest) may affect cover system performance. Key findings from OSU's 2010 final report (Hopp et al. 2010) and associated paper (Hopp et al. 2011) are included in the 2011 Annual Report.

HGCMC is working with O'Kane Consultants to update cover design models based on information provided by performance monitoring to date. Goals of the investigation include:

- Numerical modeling of potential design modifications and improvements
- Incorporating 3D topographic elements of the tailings pile into the design
- Developing a design for a new cover test plot and monitoring system at the tailings facility

Reclamation Plan

The HGCMC Reclamation Plan, as well as its implementation is discussed above in Section 2.8 of this report. Please refer to that discussion for aspects relevant to Site 23/D area reclamation.

4.0 References

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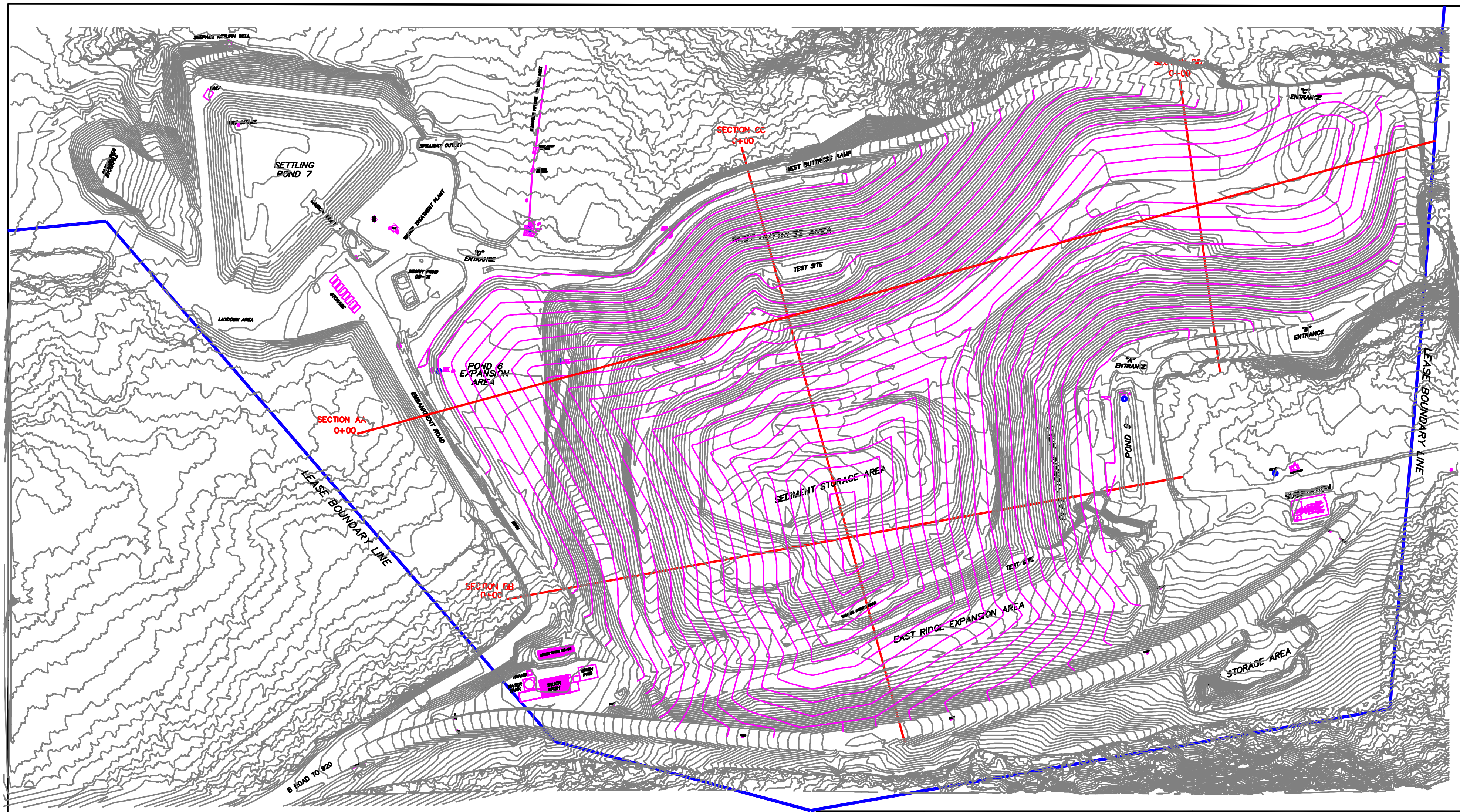
APPENDIX 1

Tailings Facility 2013 As-built and Cross Sections



Tailings Stage 2 volumes remaining as of 12/31/13

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
comp stage 2 design vs n123113	**1.000**	**1.000**	1964792.72 Sq. Ft.	23268.24 Cu. Yd.	1693859.55 Cu. Yd.	1670591.31 Cu. Yd.<Fill>
Totals			1964792.72 Sq. Ft.	23268.24 Cu. Yd.	1693859.55 Cu. Yd.	1670591.31 Cu. Yd.<Fill>

LEDGEND:
DESIGN PLAN
ORIGINAL GROUND
EXISTING GROUND
CROSS SECTIONS
LEASE BOUNDARY

SYMBOLS:
FIRE HYDRANT
MONITORING POINT
BOLLARDS
POWER POLES
WATER VALVE
CATCH BASIN

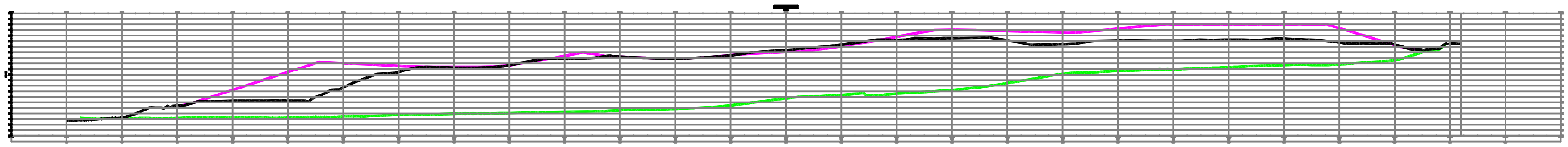
DATE: 12-31-13
DRAWING BY: Shelby Edwards
DESIGN BY: ----
REVIEWED BY: ----
PROJ OR REF. ----

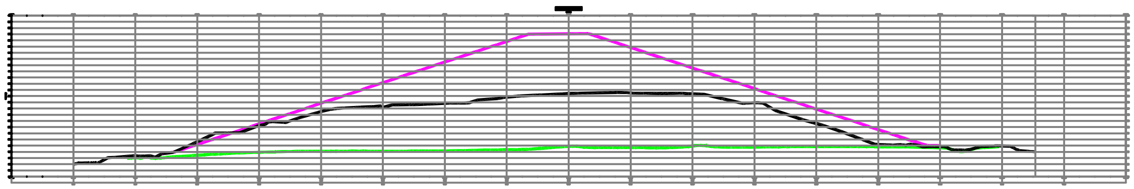
HECLA GREENS CREEK MINING CO.
P.O. BOX 32199 JUNEAU, ALASKA 99803
PHONE: (907)790-8441 FAX: (907)790-8448

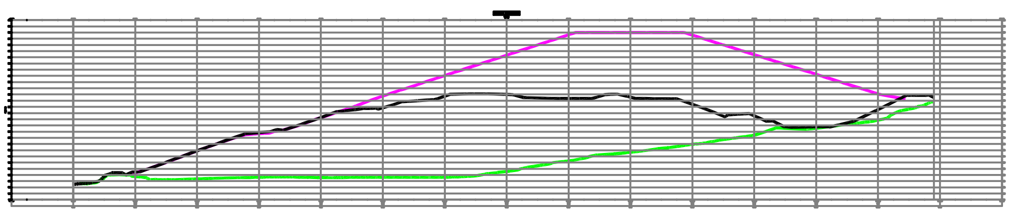
TITLE: 2013 STAGE 2 TAILINGS EXISTING DESIGN & VOLUMES

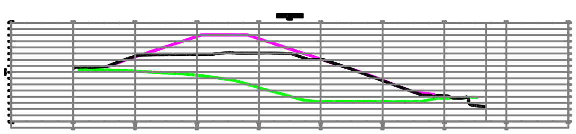
0 20 50 100

SHEET: 1 OF 1









LEDGEND:

- ORIGINAL GROUND (green)
- EXISTING GROUND (black)
- STAGE 2 DESIGN (magenta)

SYMBOLS:

FIRE HYDRANT · MONITORING POINT · BOLLARDS · POWER POLES · WATER VALVE · CATCH BASIN

HECLA GREENS CREEK MINING CO.
P.O. BOX 32199 JUNEAU, ALASKA 99803
PHONE: (907)790-8441 FAX: (907)790-8448

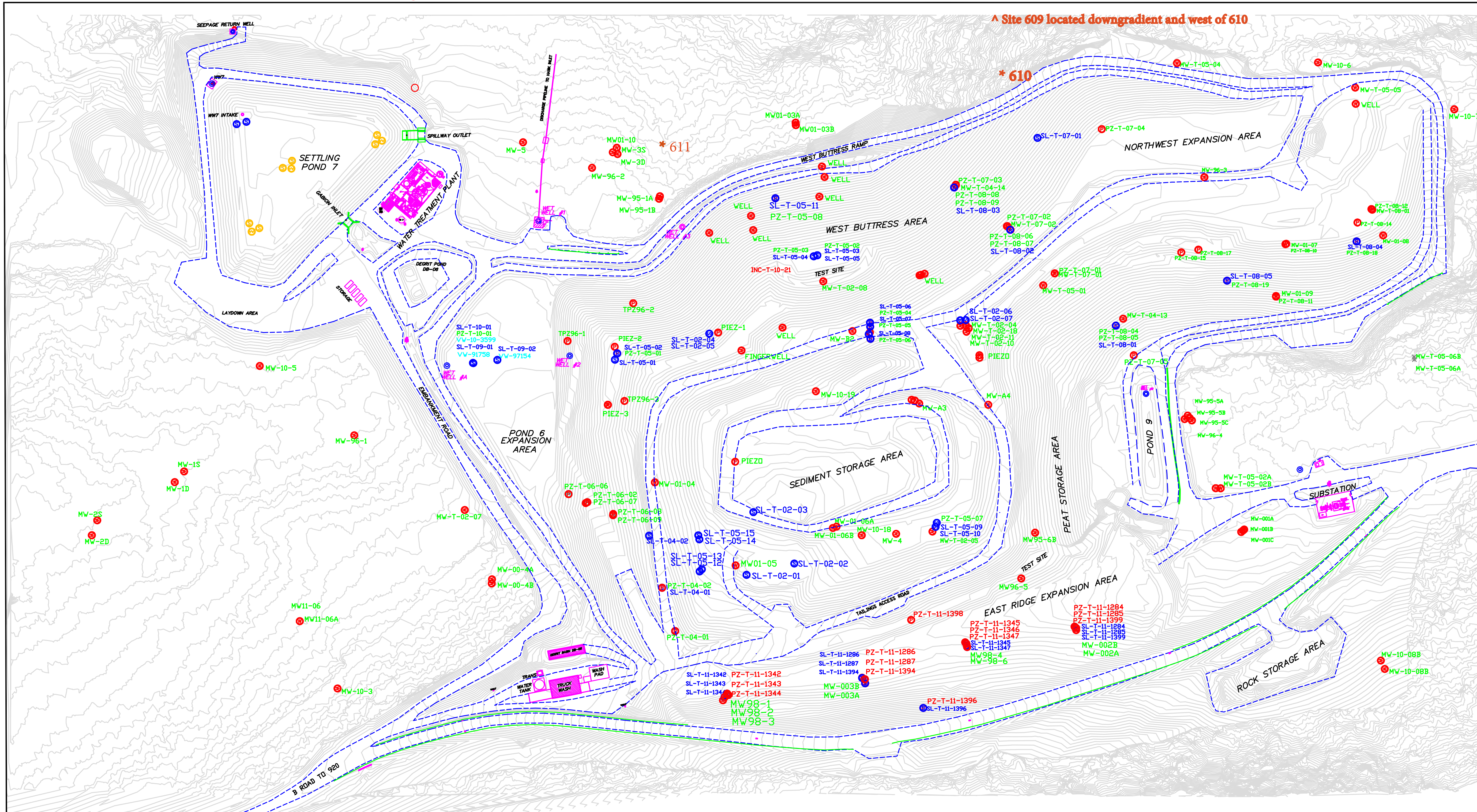
DATE: 12-31-13
DRAWING BY: Shelby Edwards
DESIGN BY: ----
REVIEWED BY: ----
PROJ OR REF. ----

TITLE:

2013 STAGE 2 TAILINGS PROFILE VIEWS

0 20 50 100

SHEET: 1 OF 1



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P.O. BOX 32199 JUNEAU, ALASKA 99803

PHONE: (907)790-8441 FAX: (907)790-8448

LEGEND:

- WATER
- SEWER
- ROADS
- ELECT UTILS
- FUEL UTILS
- CONCRETE CURBS

SYMBOLS:

- FIRE HYDRANT
- MONITORING POINT
- BOLLARDS
- POWER POLES
- WATER VALVE
- CATCH BASIN

GRAPHIC SCALE:

TRUE

DRAWING BY:	Shelby Edwards
DESIGN BY:	----
REVIEWED BY:	----
PROJ OR REF.	----

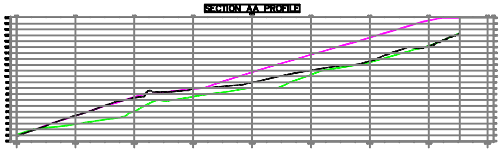
TITLE: Tailings Asbuilt with Environmental monitoring sites

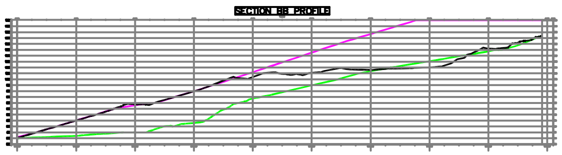
SHEET: 2/28/14

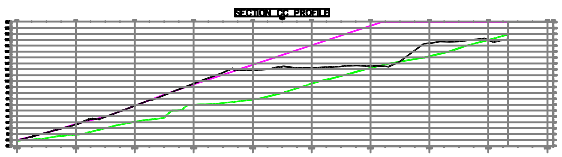
SHEET: 1 OF 1

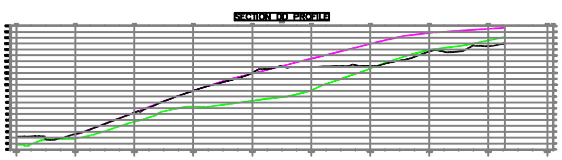
APPENDIX 2

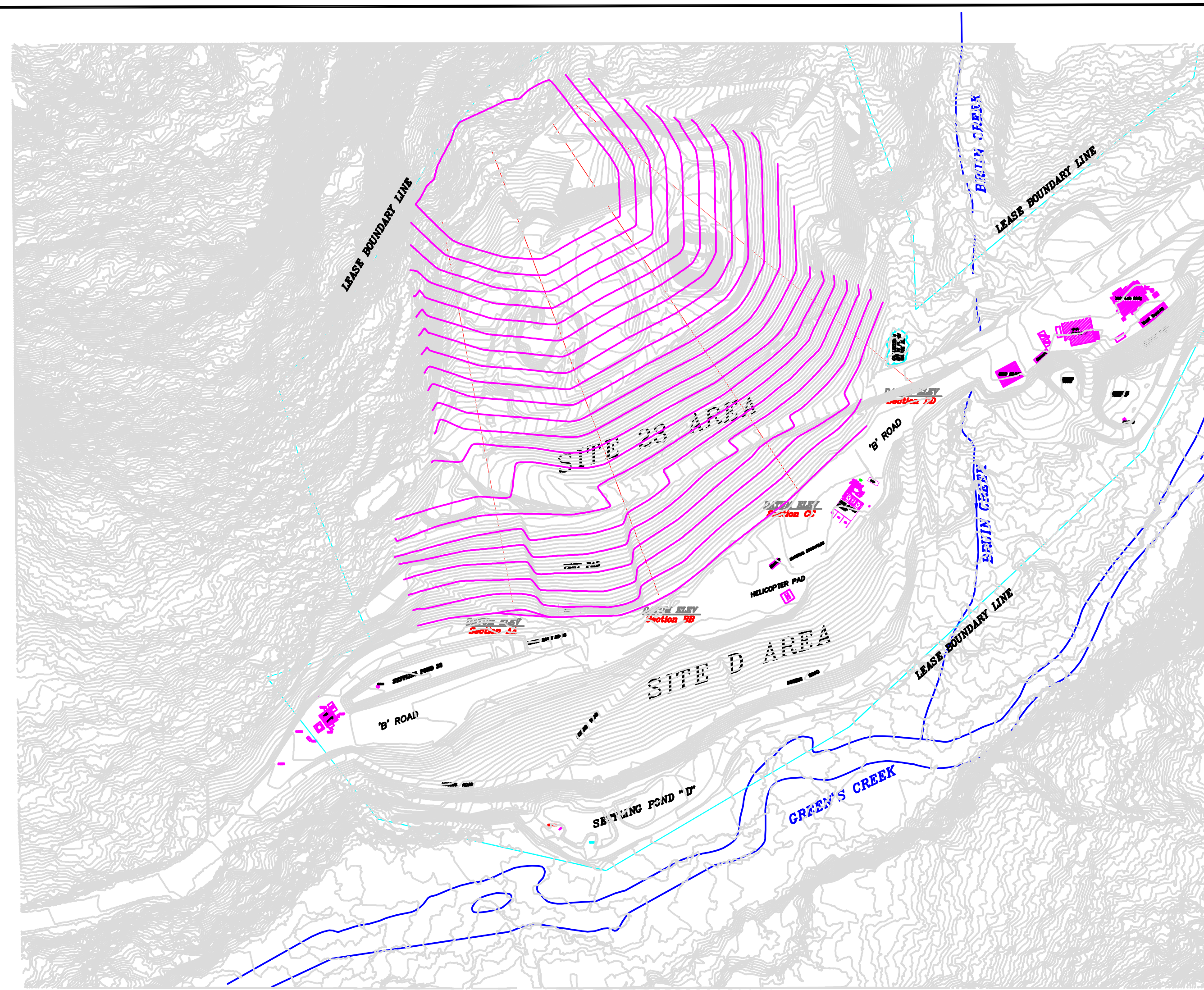
Site 23/D 2013 As-built and Cross Section











SITE 23 REMAINING VOLUME AS OF 12-31-13

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
COMP 123113	**1.000**	**1.000**	686749.11 Sq. Ft.	11281.45 Cu. Yd.	355048.11 Cu. Yd.	343766.66 Cu. Yd.<Fill>
Totals			686749.11 Sq. Ft.	11281.45 Cu. Yd.	355048.11 Cu. Yd.	343766.66 Cu. Yd.<Fill>

LEDGEND:

ORIGINAL GROUND TOPO

EXISTING GROUND

FINAL FILL DESIGN

CROSS SECTIONS

LEASE BOUNDARY

HECLA GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

2013 SITE 23
YEAR END ASBUILT
W/ PROFILE & VOLUMES

DATE: 12-31-13
DRAWING BY: Shelby Edwards
DESIGN BY:
REVIEWED BY:
PROJ OR REF. #

PREPARED BY:
Greens Creek Mining Co.
JUNEAU, ALASKA
PHONE: [illegible] FAX: [illegible]

GCMC DWG

SCALE: NOT TO SCALE

SHEET: 1 OF 1

KENNECOTT MINERALS

KENNECOTT GREENS CREEK MINING CO.

DATE: 4-30-03
DRAWING BY: TZ
DESIGN BY: PC
REVIEWED BY: ----
PROJ OR REF. EDE-Site 23/D Hydrology

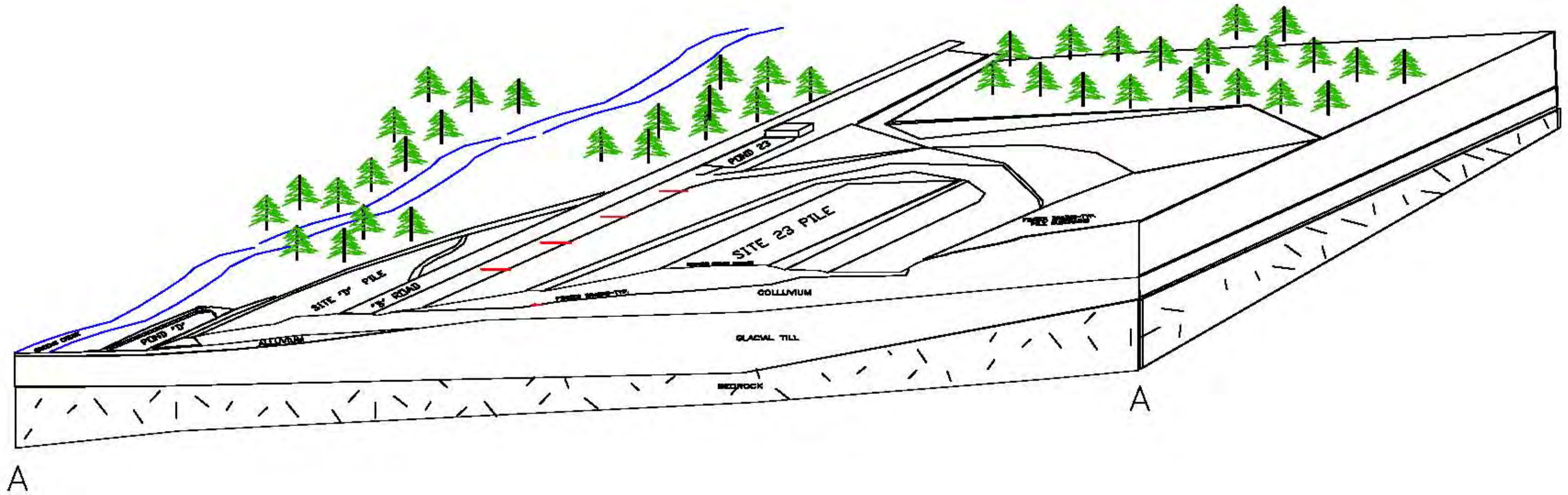
TITLE:

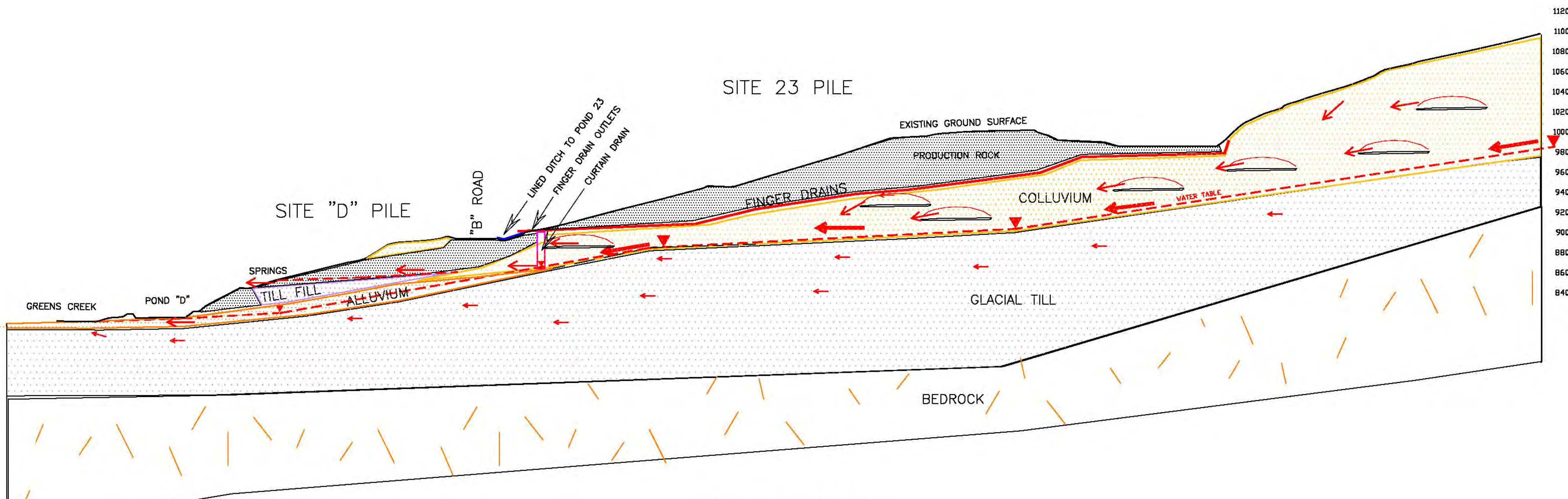
SITE 23/D CONCEPTUAL GROUNDWATER FLOW

LEGEND:

- CLAY LENSES WITH PERCHED WATER
- WATER TABLE
- WATER FLOW VECTORS – FLOW RATE PROPORTIONAL
- EXISTING GROUND
- PRODUCTION ROCK FILL
- FINGER DRAINS TYPICAL
- COLLUVIUM
- ALLUVIUM
- GLACIAL TILL LAYER
- BEDROCK

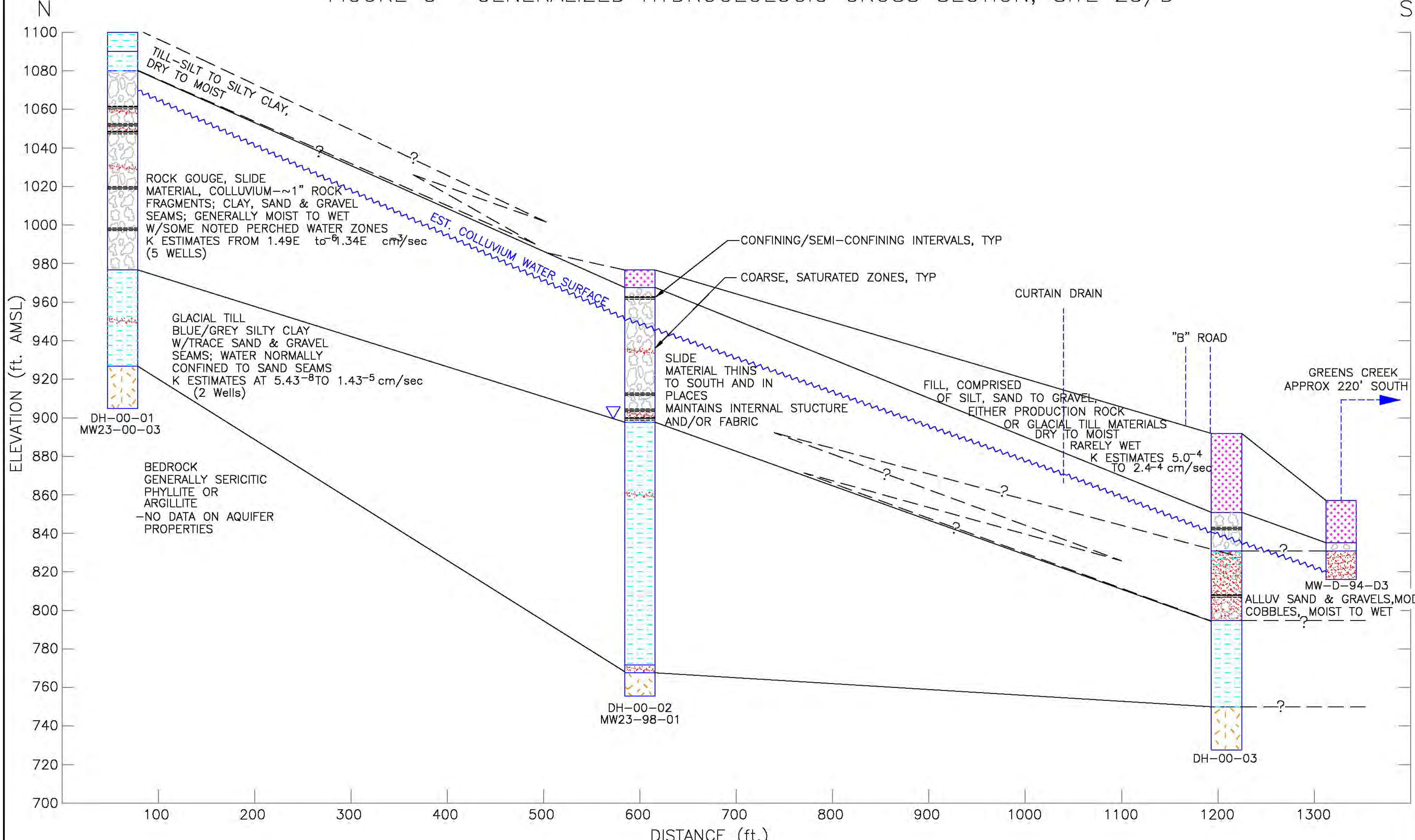
FIGURE 2

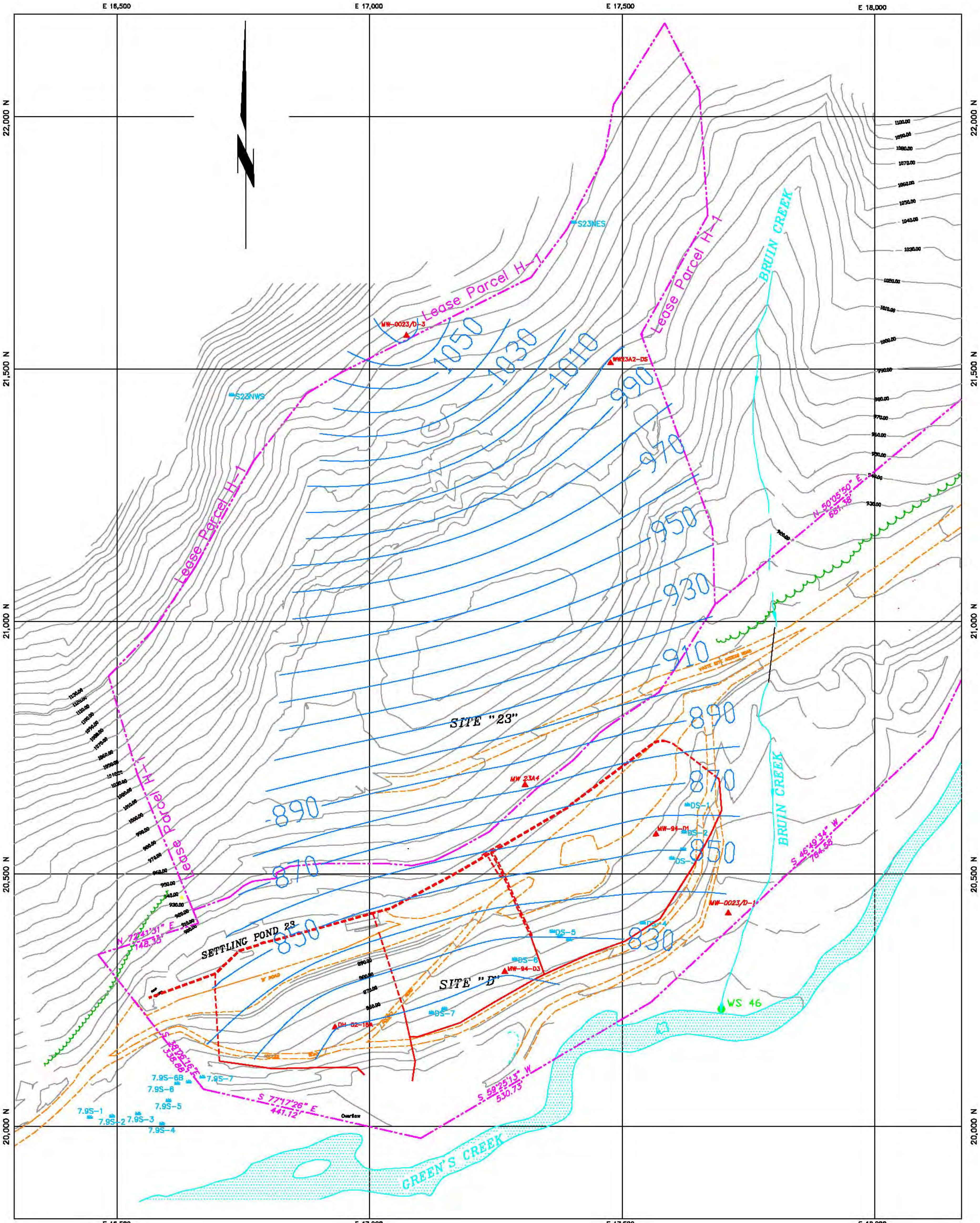




CROSS SECTION A–A

FIGURE 3--GENERALIZED HYDROGEOLOGIC CROSS SECTION, SITE 23/D





LEGEND:

- ▲ PIEZOMETER/WELL
- LEASE BOUNDARY
- 10' CONTOUR LINE
- STREAM CHANNEL
- ROAD
- CURTAIN DRAIN
- CURTAIN DRAIN OUTFALL
- 7.9S-4 SEEPS/SPRINGS
- COLLUVIUM POTENTIOMETRIC ISOPLETHS C.I. = 10'

FIGURE 4

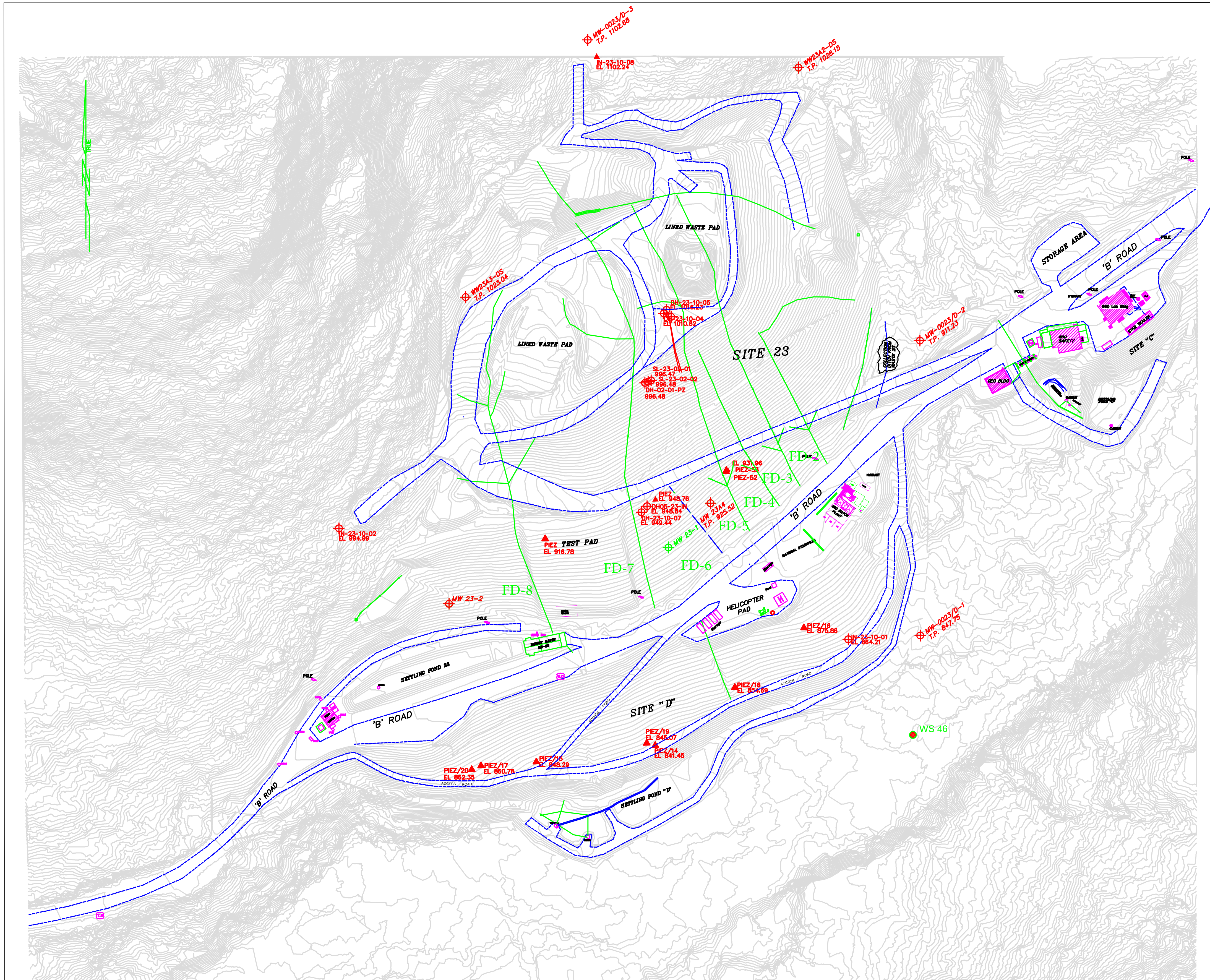
KENNECOTT MINERALS

KENNECOTT GREENS CREEK MINE

ADMIRALTY ISLAND, ALASKA

SITE 23/D
COLLUVIUM POTENTIOMETRIC
SURFACE 2003

DATE: 03/04/04 DRAWING BY: RWH DESIGN BY: RWH REVIEWED BY: RWH PROJ OR REF. ____	EDE Consultants Environmental Engineering * Hydrology * Water Resources Engineering 23 North Scott St., #23 Sheridan, WY 82801 PHONE: (307) 672-3763 EDE DWG site 23 base map.dwg
SCALE: 1" = 200'	SHEET: 1 OF 1



HECLA GREENS CREEK MINING CO.

P.O. BOX 32199 JUNEAU, ALASKA 99803

LEGEND

Ⓐ CHEMICAL TANK
㉔ PETROLEUM TANK
TO- TRANSFORMER
ⓈⒸ SPILL RESPONSE

LEGEND:
ROADS/DITCHES
SEWER
WATER UTILS
ELECT UTILS
FUEL UTILS
Drains

SYMBOLS:
FIRE HYDRANT
BOLLARDS
WATER VALVE
MONITORING POINT
POWER POLES
CATCH BASIN

DRAWING BY: Shelby Edwards
DESIGN BY: ----
REVIEWED BY: ----
PROJ OR REF.

TITLE: SITE 23 Asbuilt with Environmental monitoring sites

2-28-14

SHEET: 1 OF 1

APPENDIX 3

Data Figures

Figure 2.1 Water Level Data for Piezometer 41

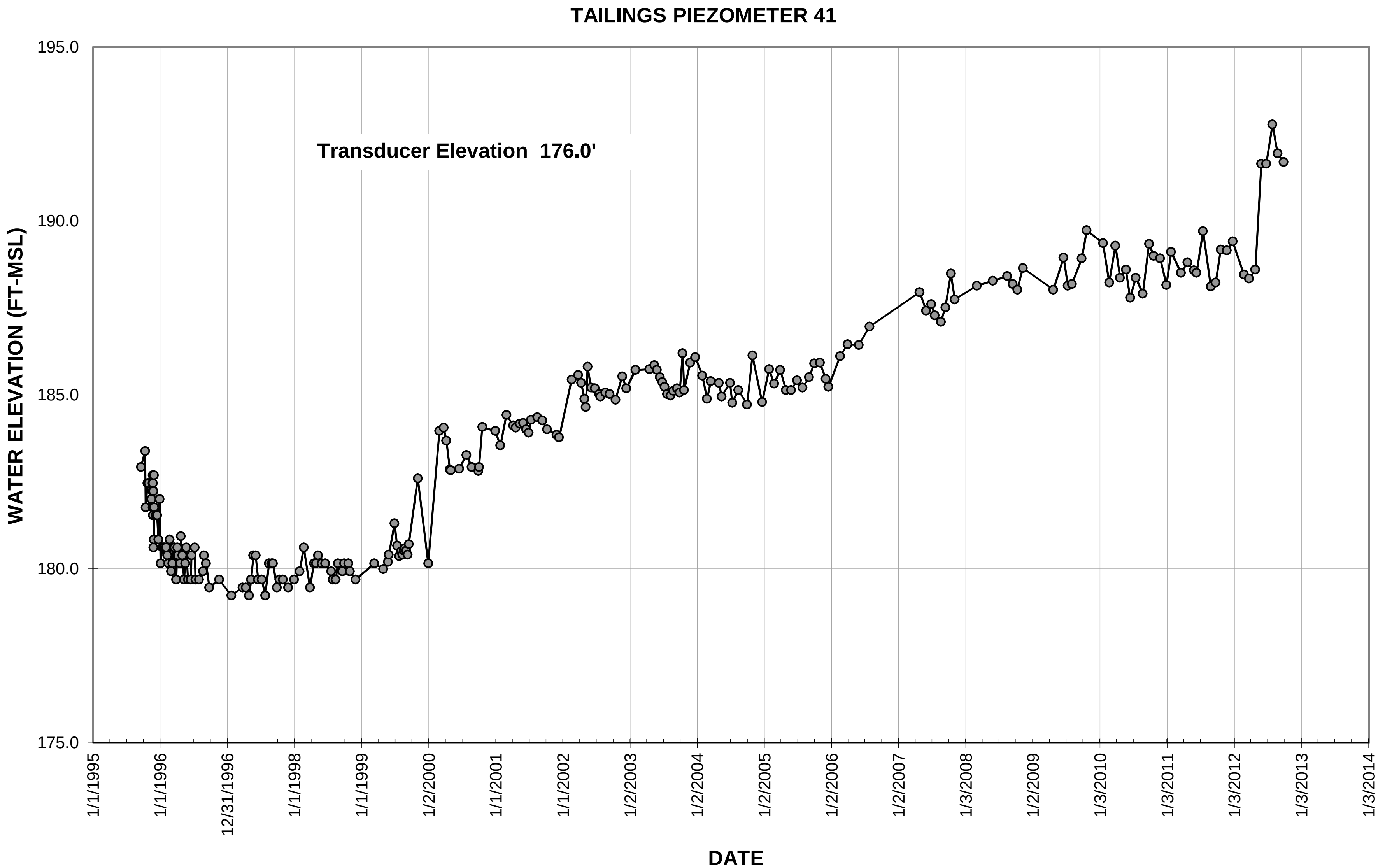


Figure 2.2 Water Level Data for Piezometer 42

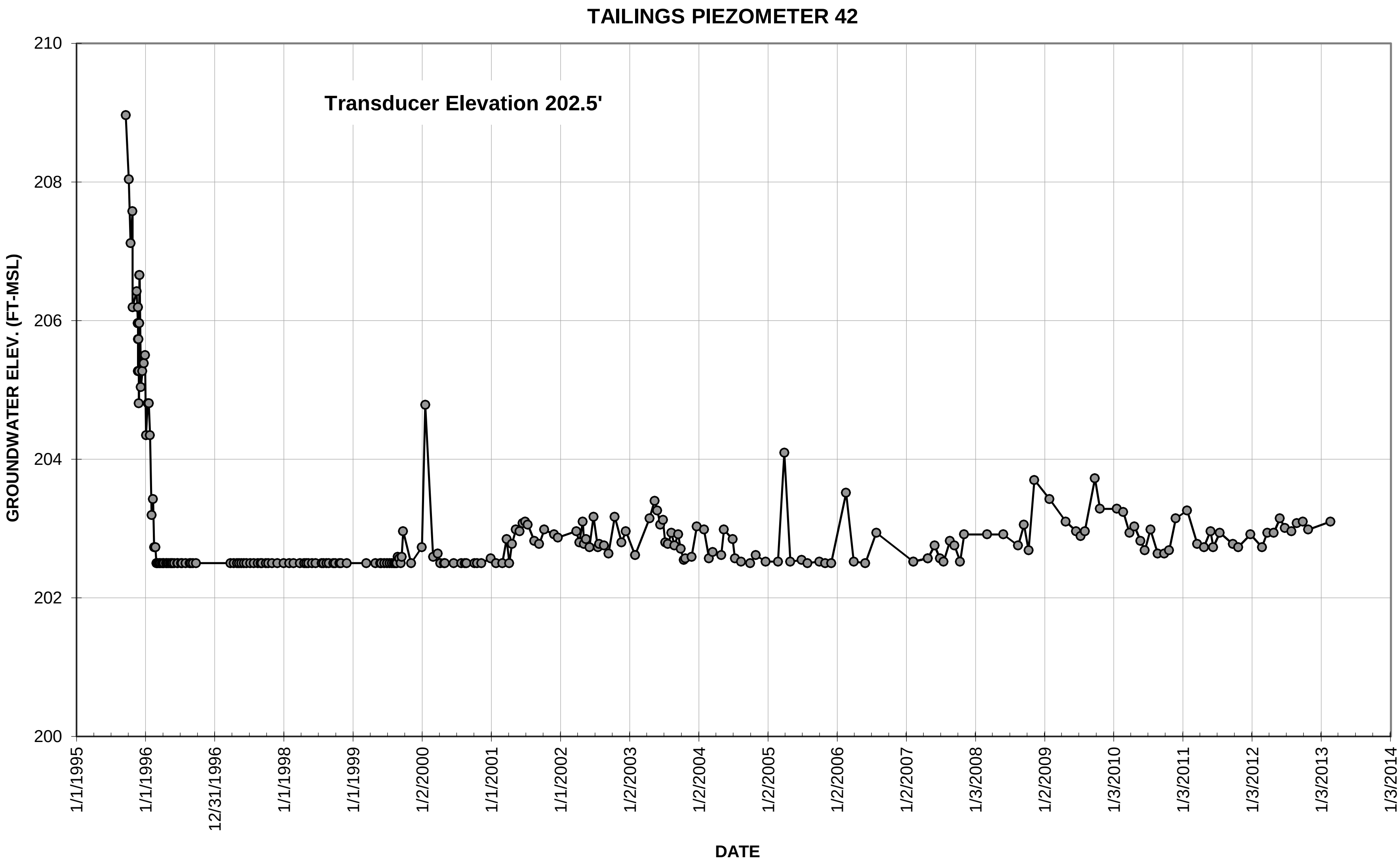


Figure 2.3 Water Level Data for Piezometer 44

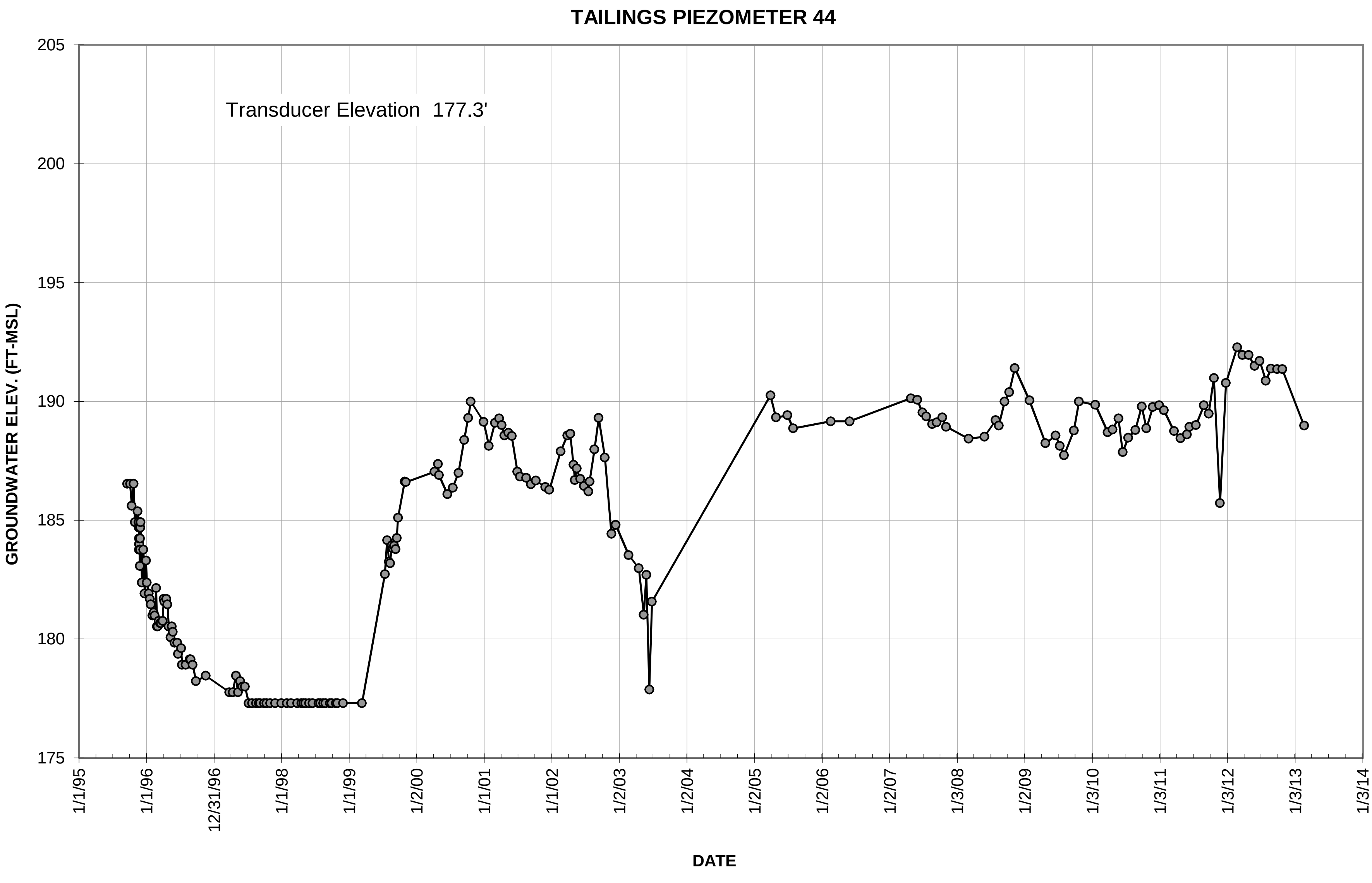


Figure 2.4 Water Level Data for Piezometer 46

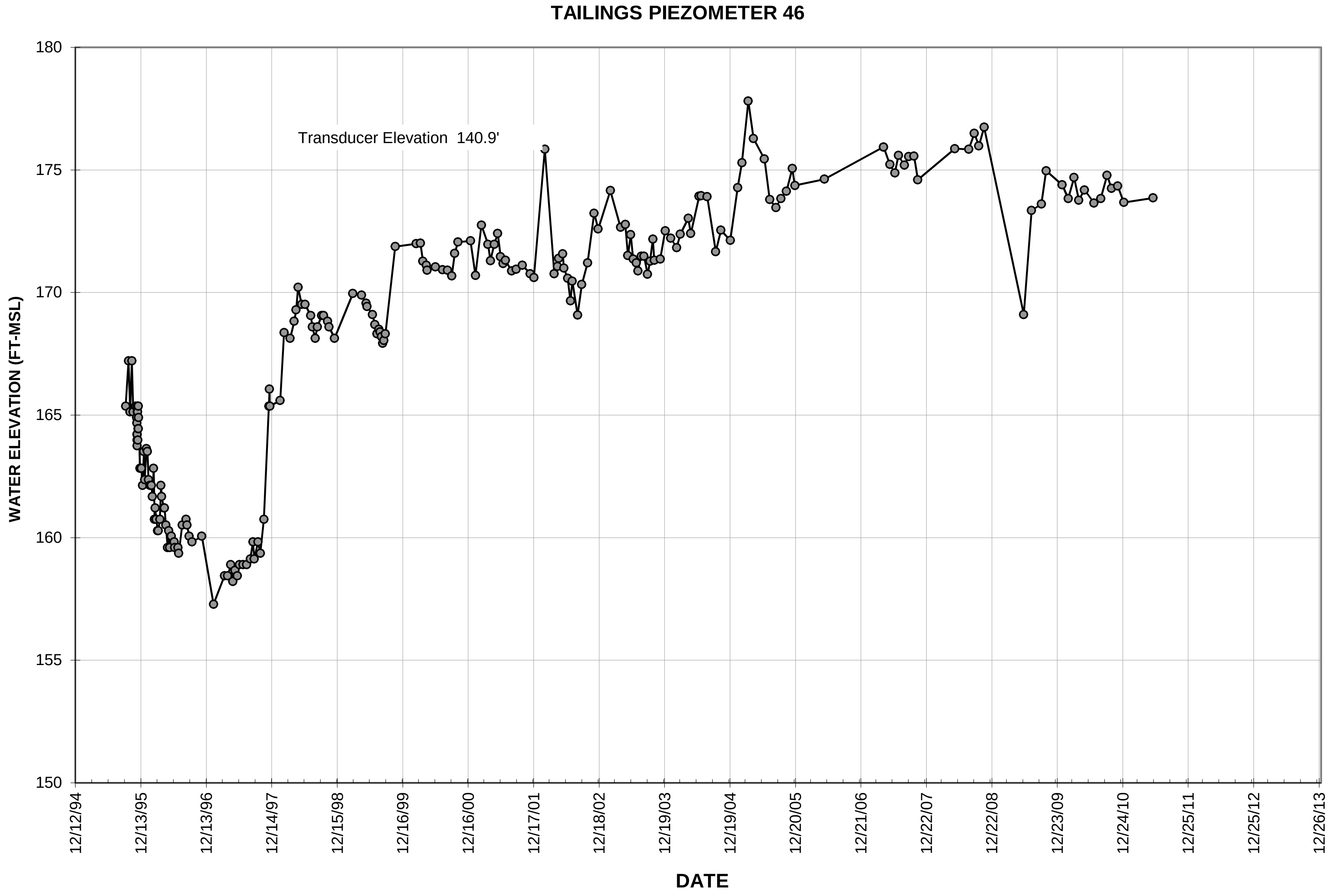


Figure 2.5 Water Level Data for Piezometer 47

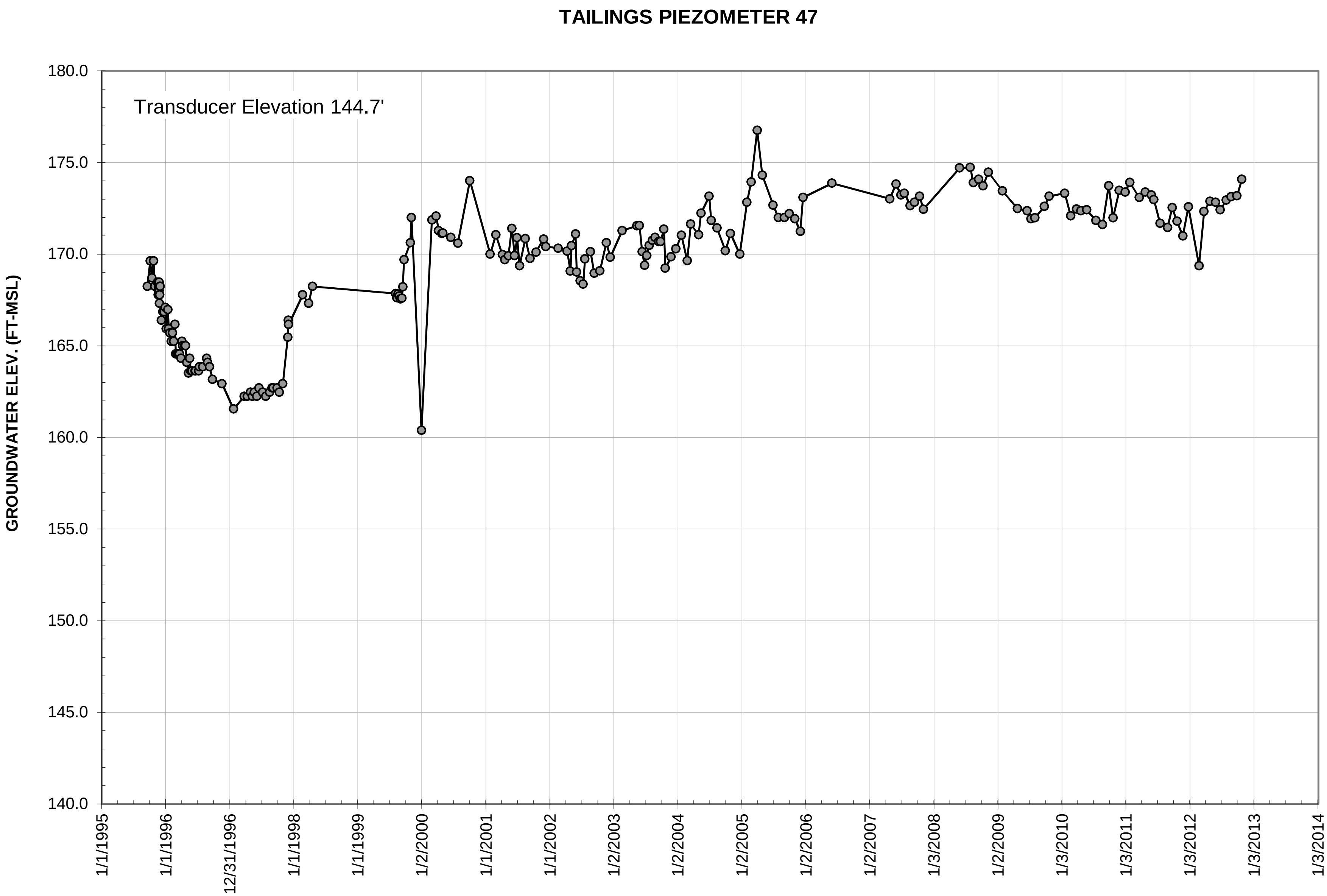


Figure 2.6 Water Level Data for Piezometer 50

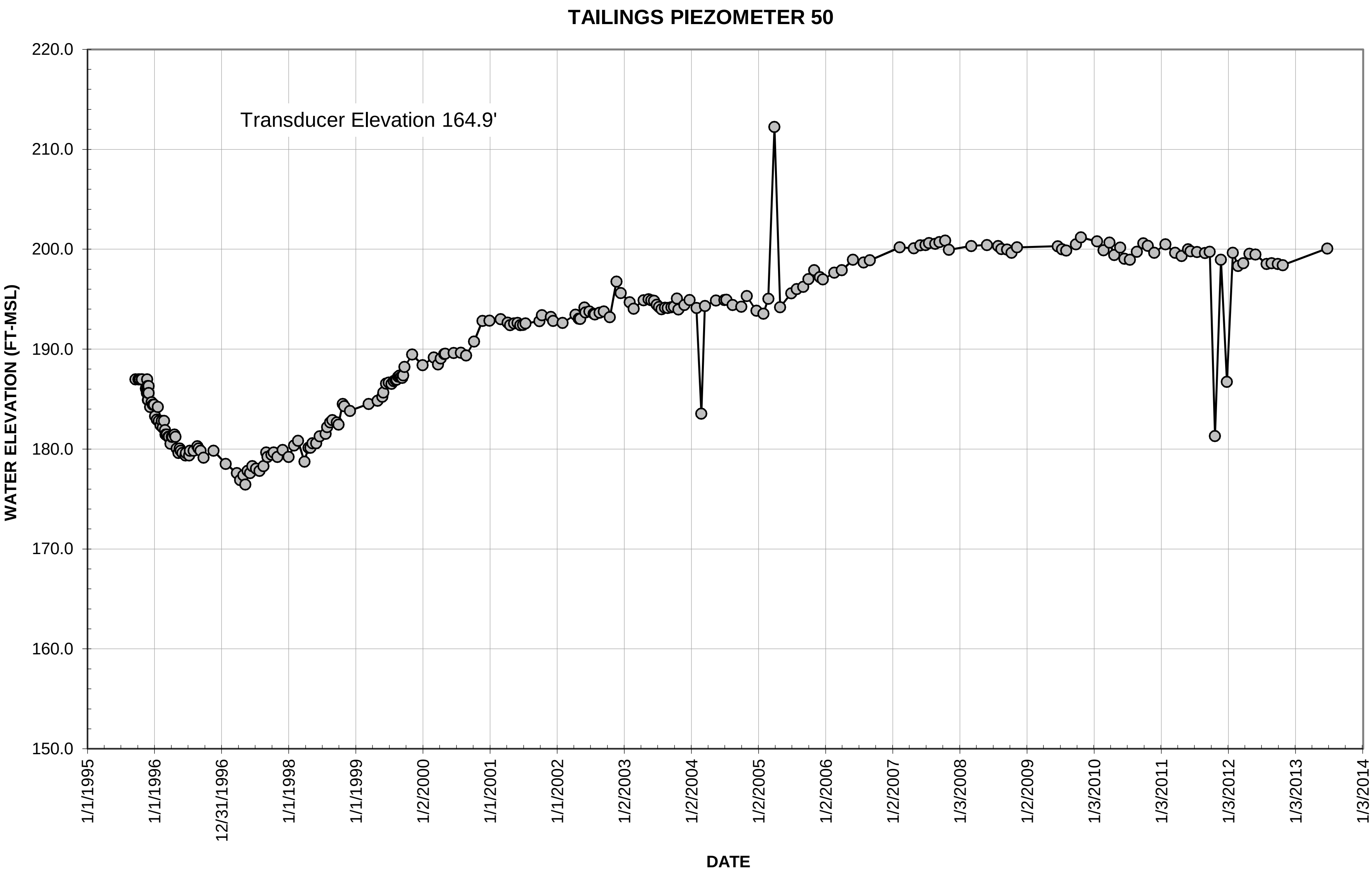


Figure 2.7 Water Level Data for Piezometer 51

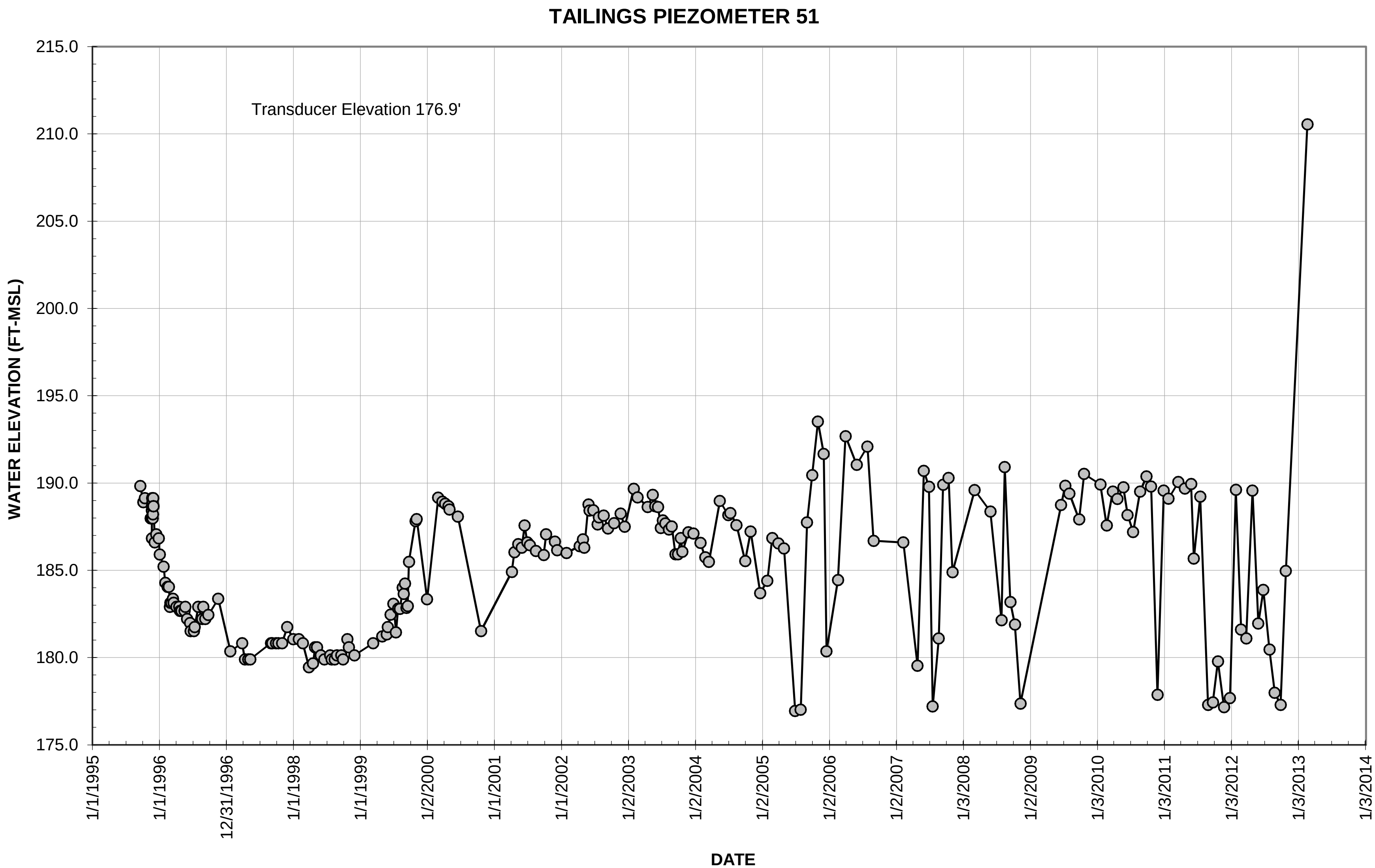


Figure 2.8 Water Level Data for Piezometer 74

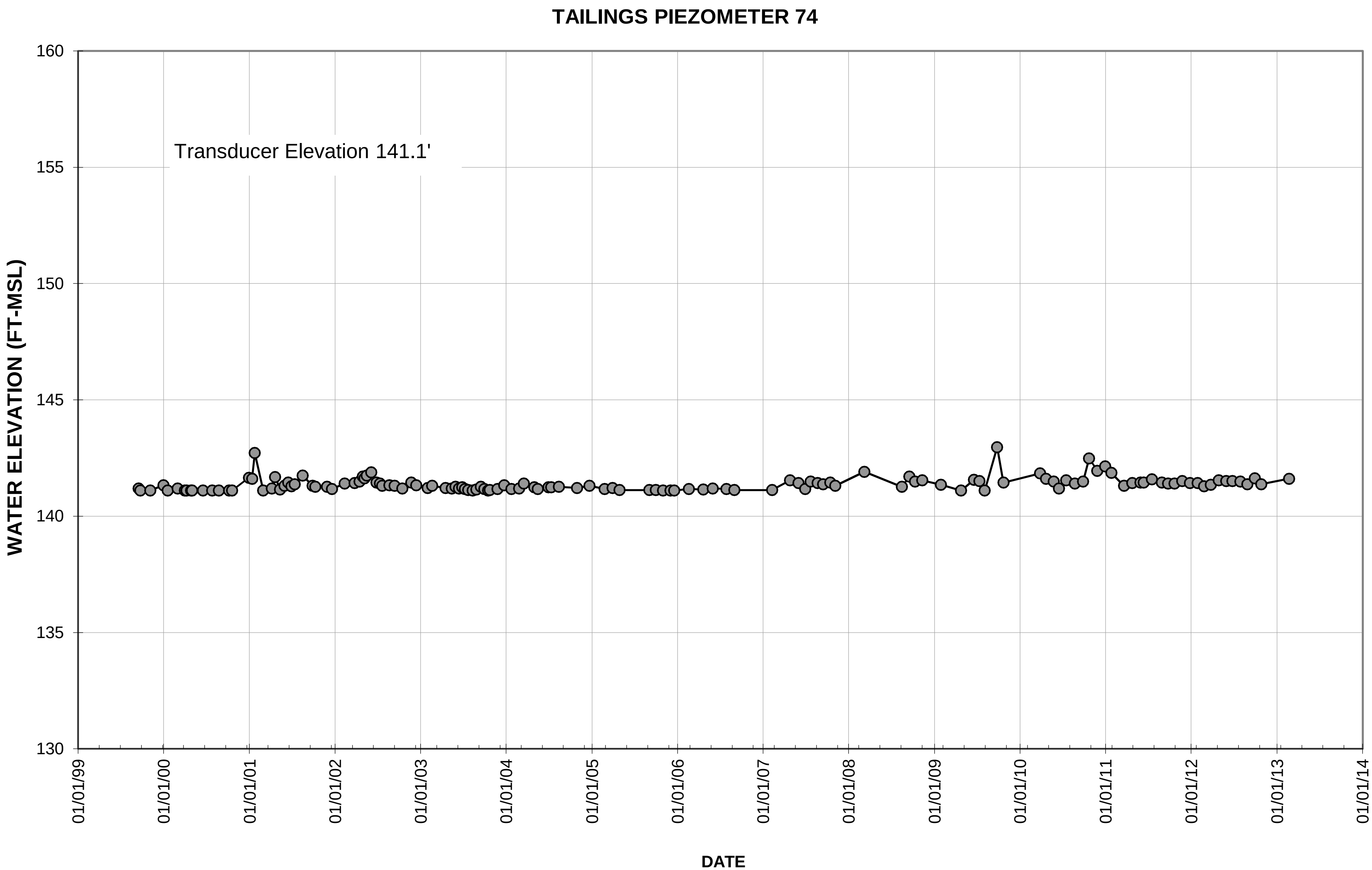


Figure 2.9 Water Level Data for Piezometer PZ-T-05-08 VW

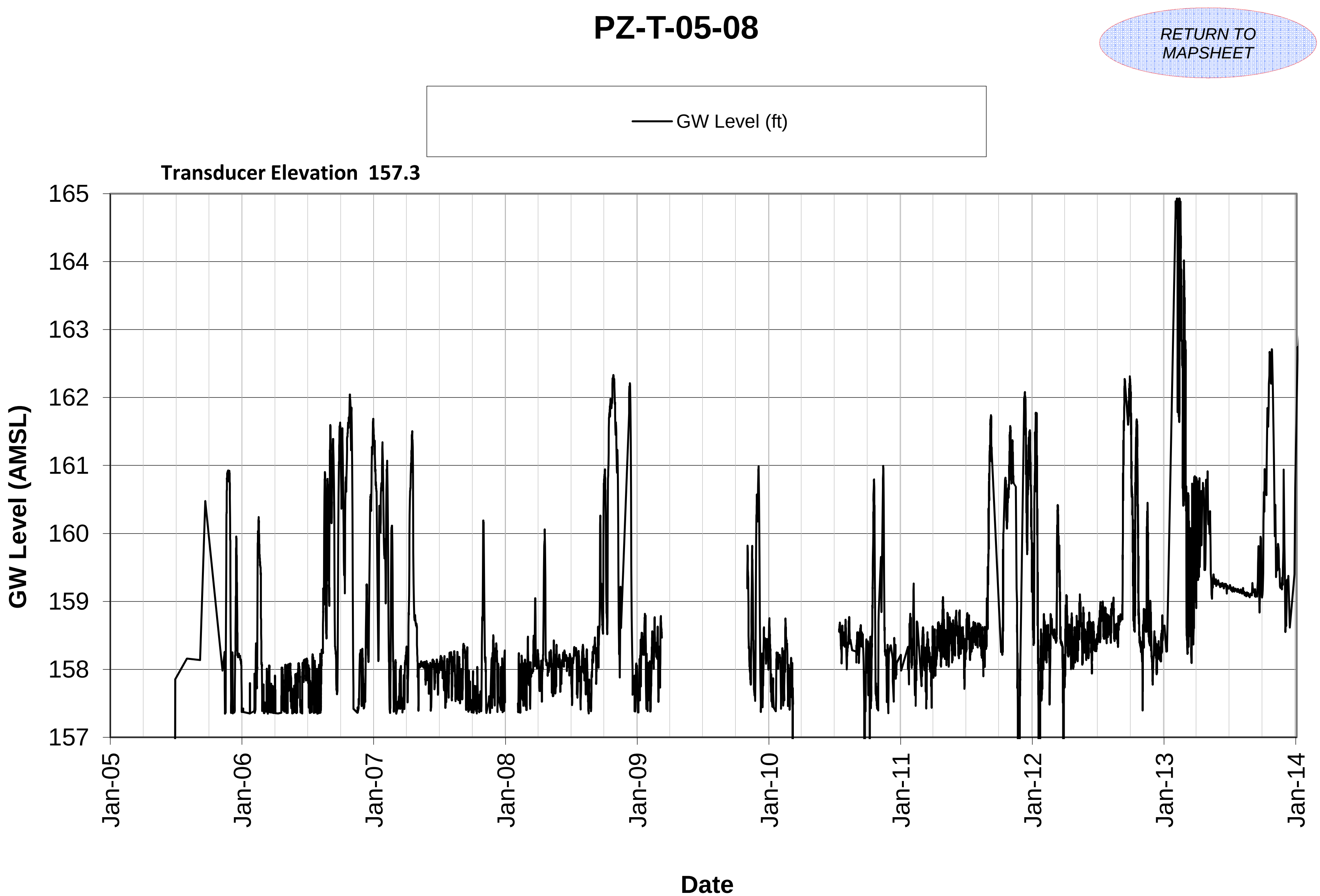


Figure 2.10 Water Level Data for Piezometer 76

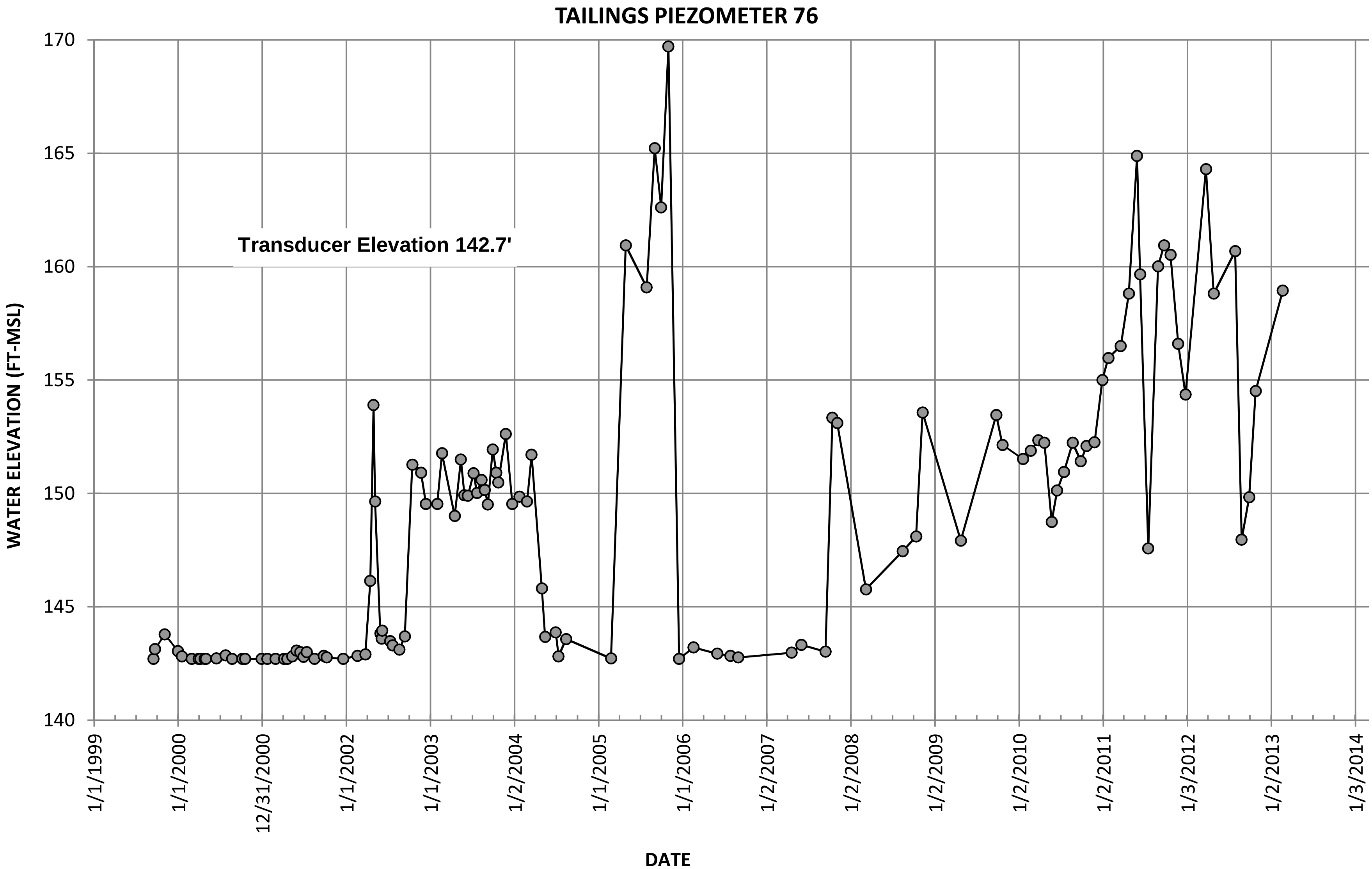


Figure 2.11 Water Level Data for Standpipe Piezometer PZ-T-00-01

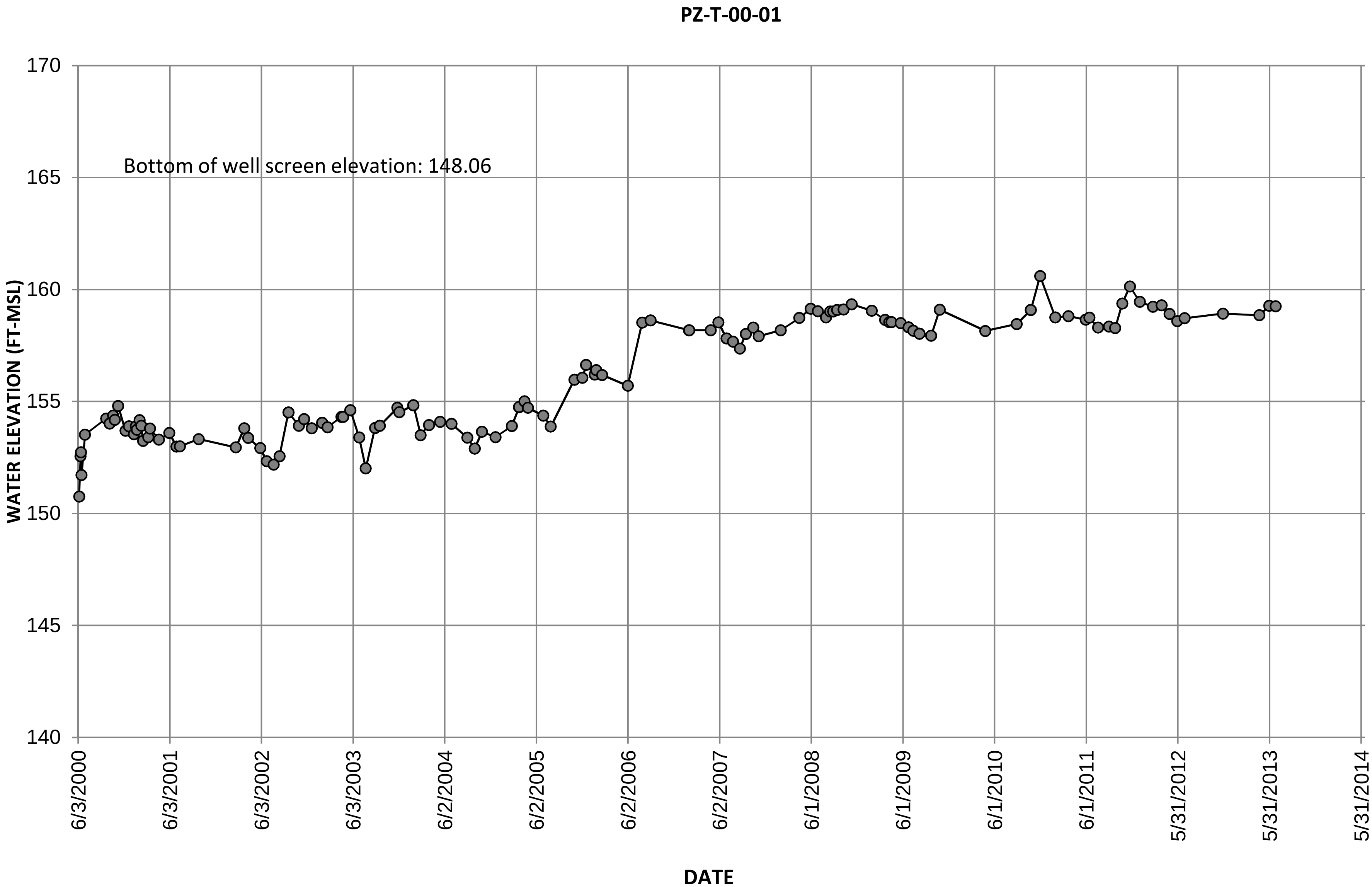


Figure 2.12 Water Level Data for Standpipe Piezometer PZ-T-00-02

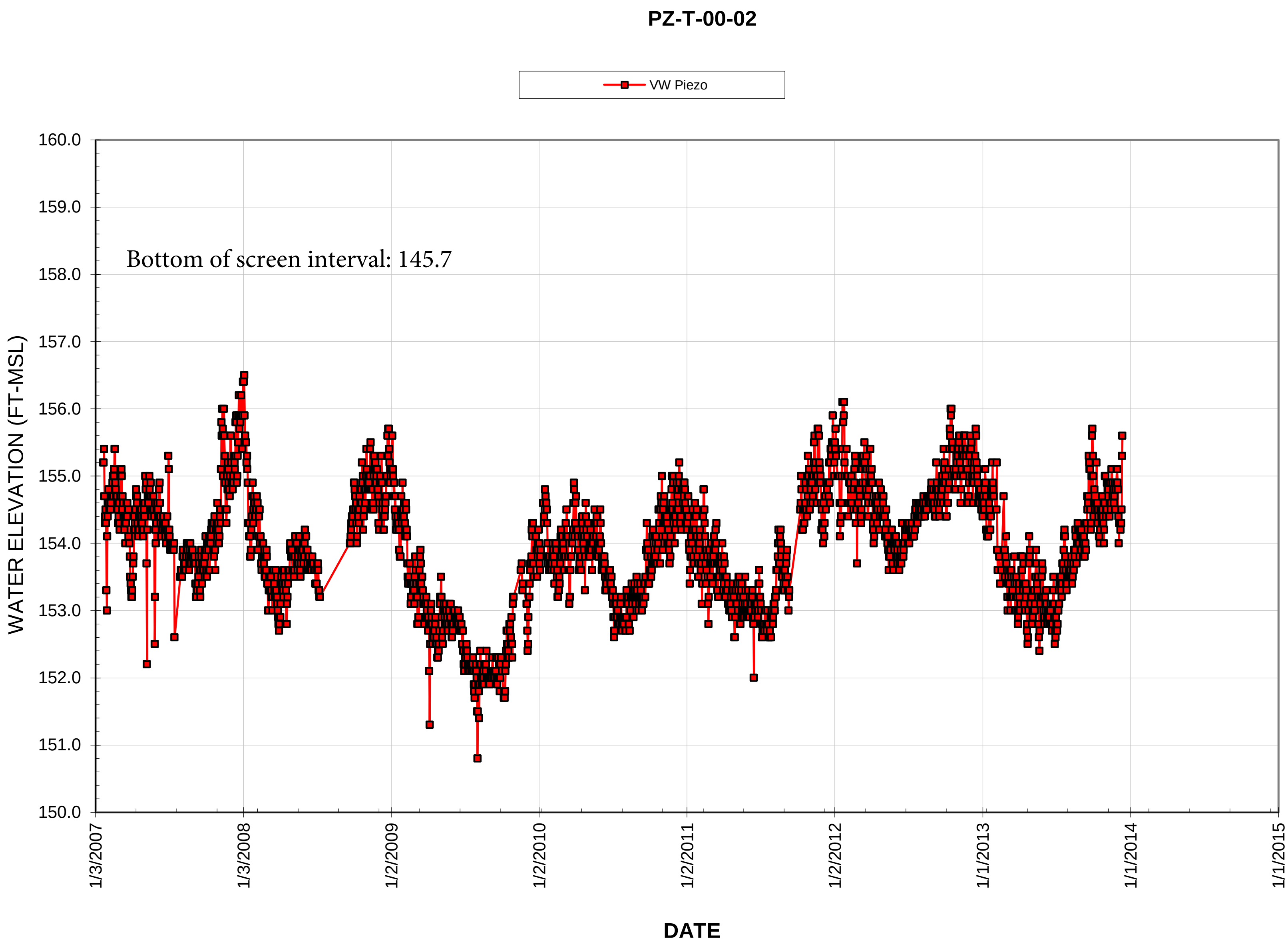


Figure 2.13 Water Level Data for Standpipe Piezometer PZ-T-00-03

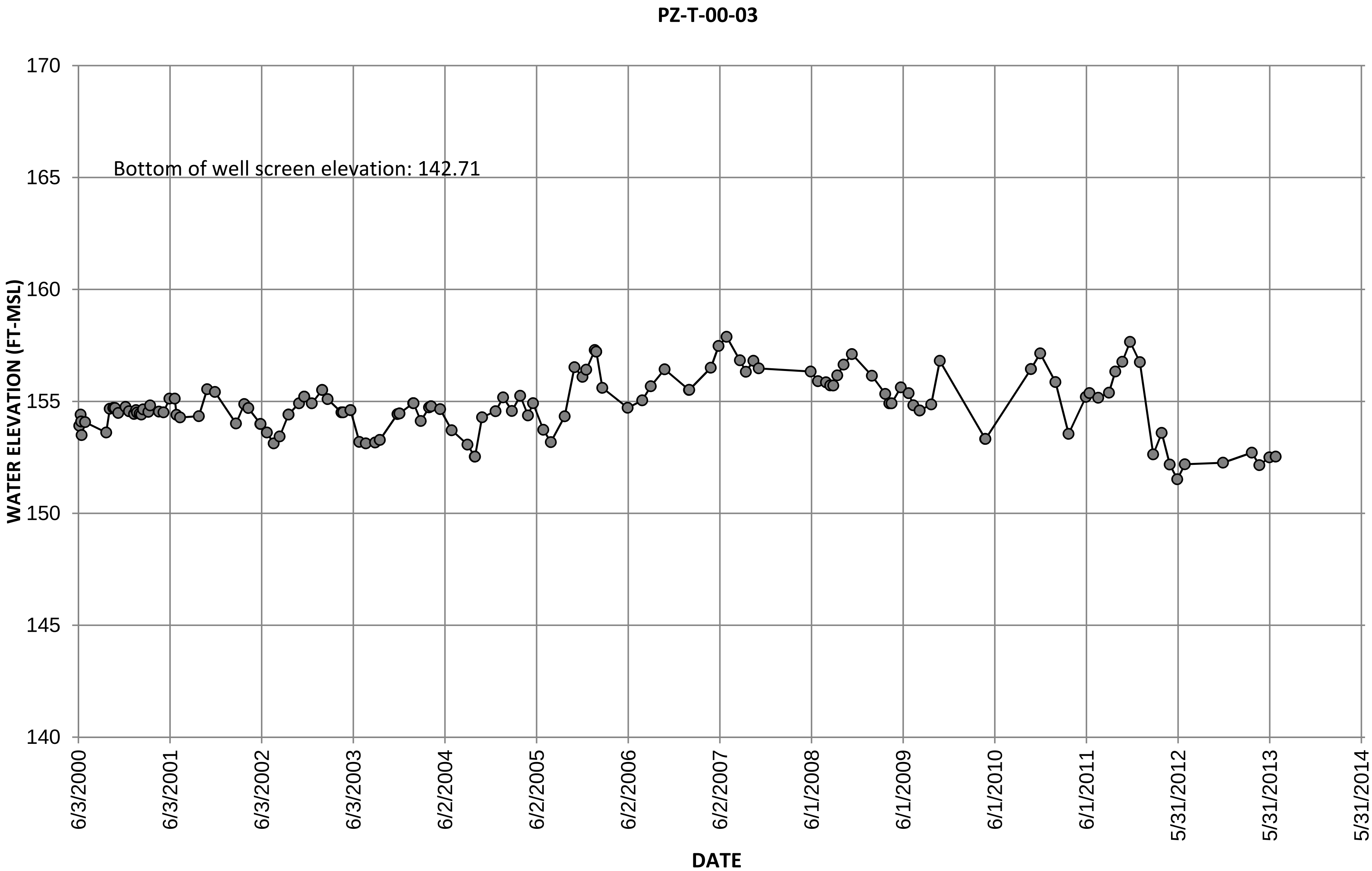


Figure 2.14 Water Level Data for Standpipe Piezometer MW-T-00-05A

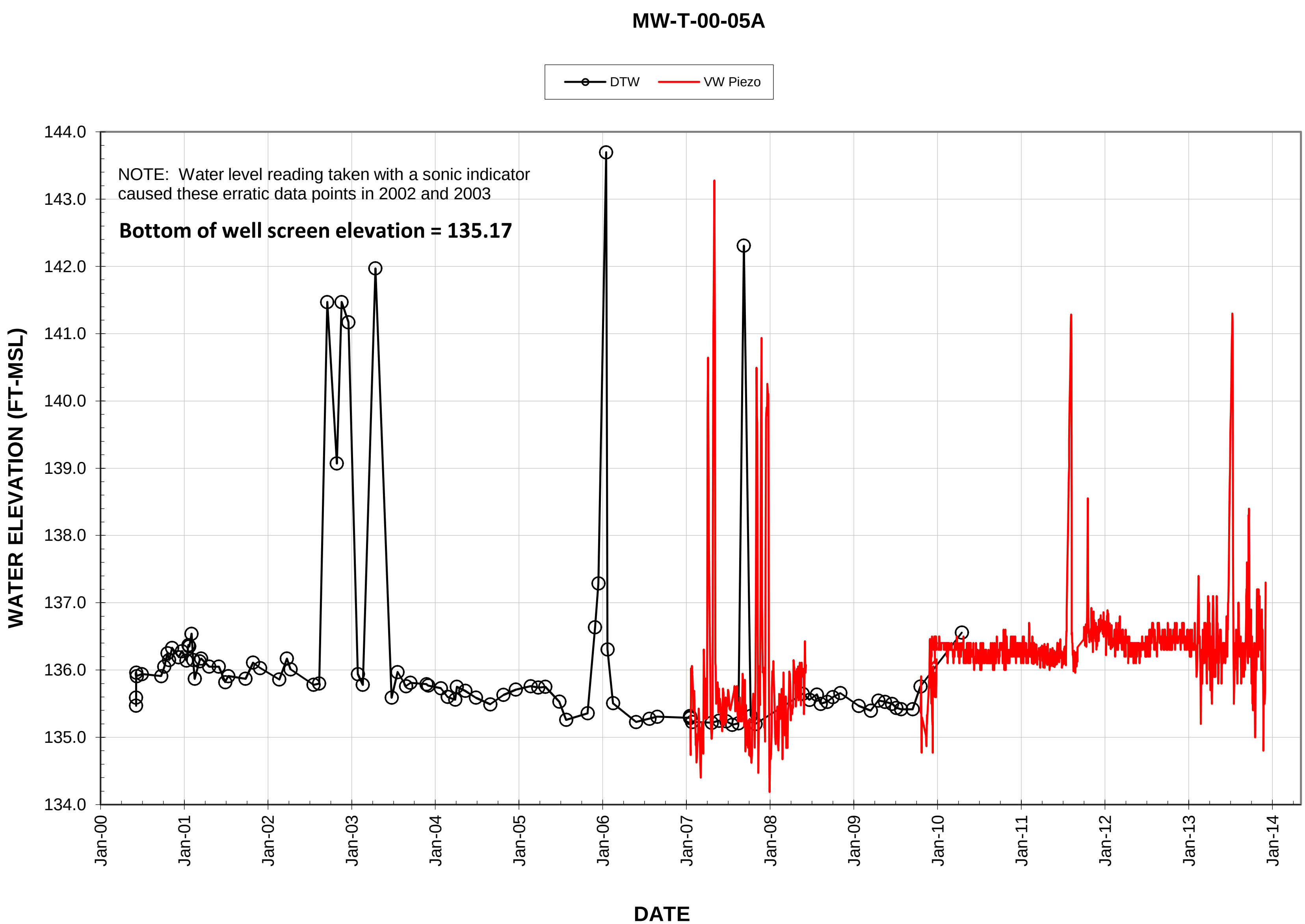


Figure 2.15 Water Level Data for Well MW-T-00-003A

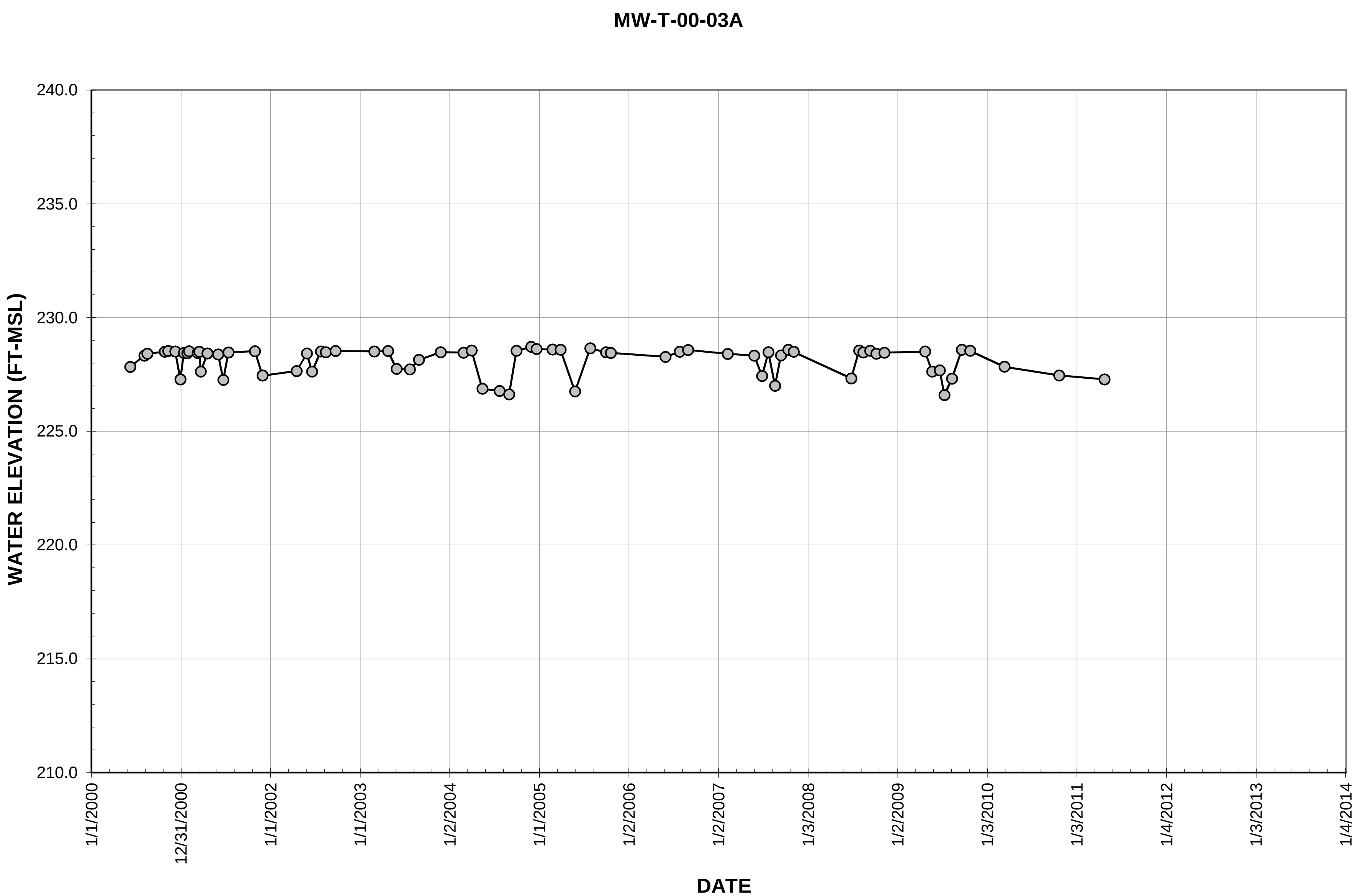


Figure 2.16 Water Level Data for Well MW-T-00-03B

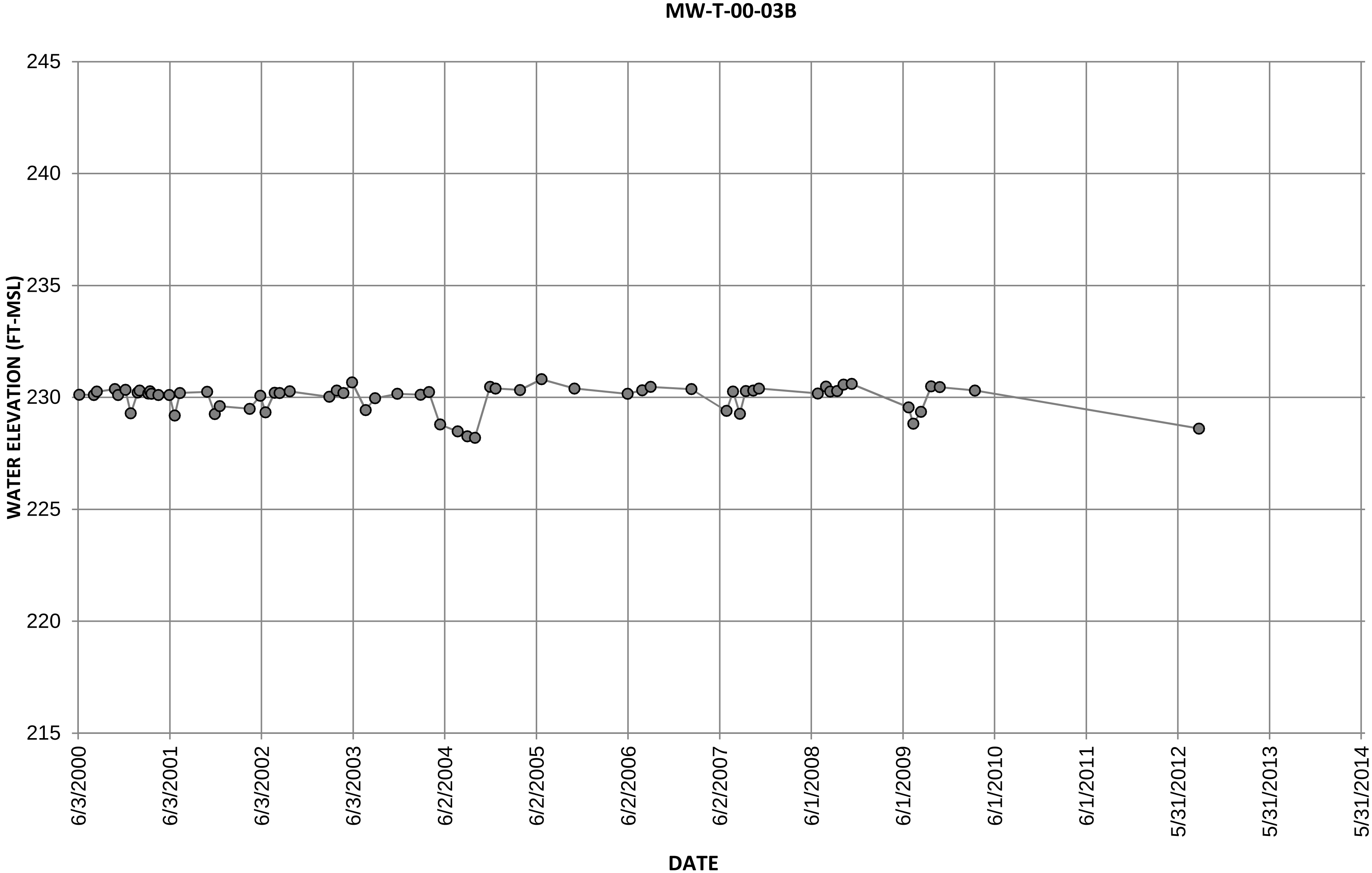


Figure 2.17 Water Level Data for Well MW-T-01-03A

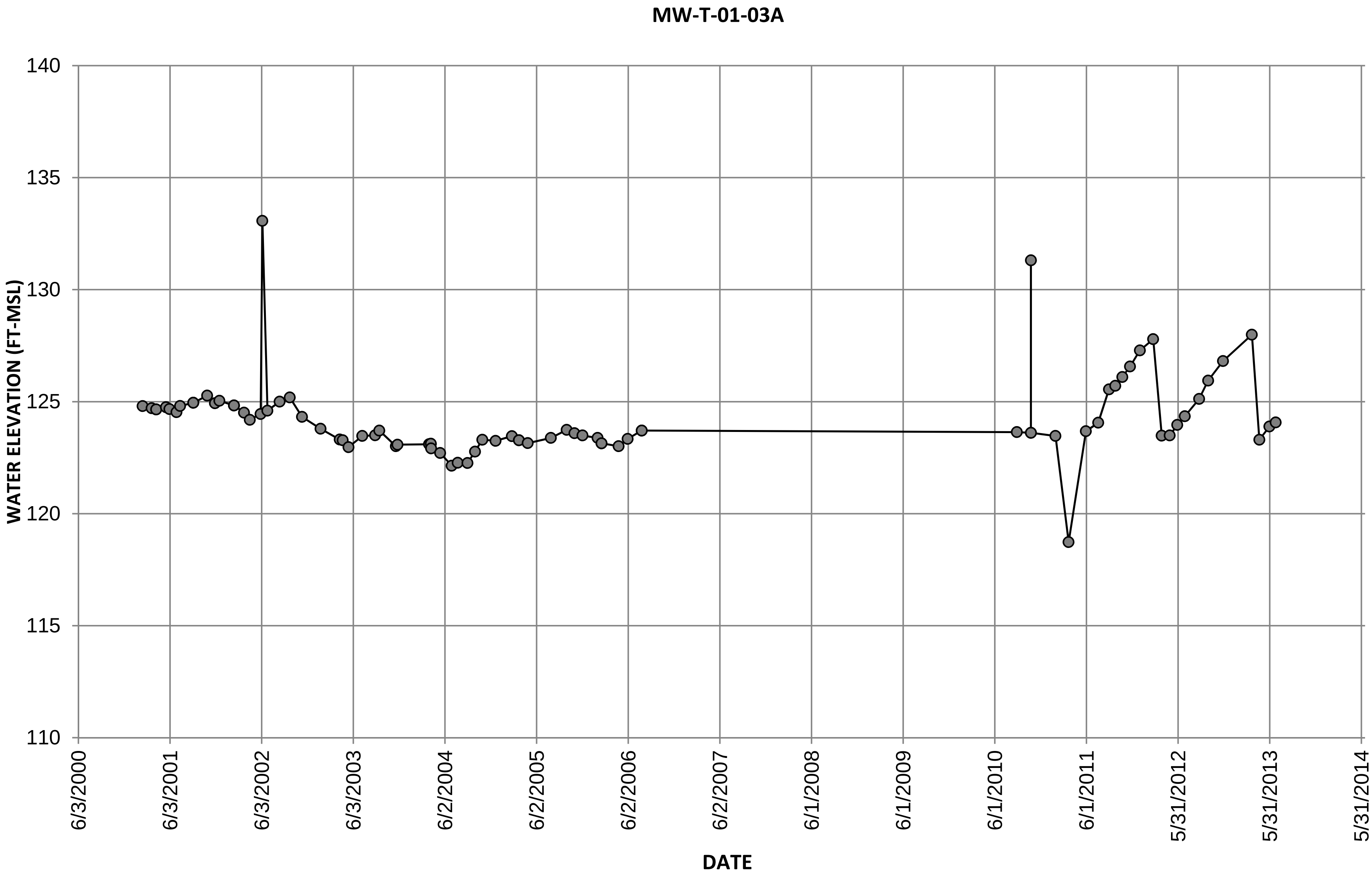


Figure 2.18 Water Level Data for Well MW-T-01-03B

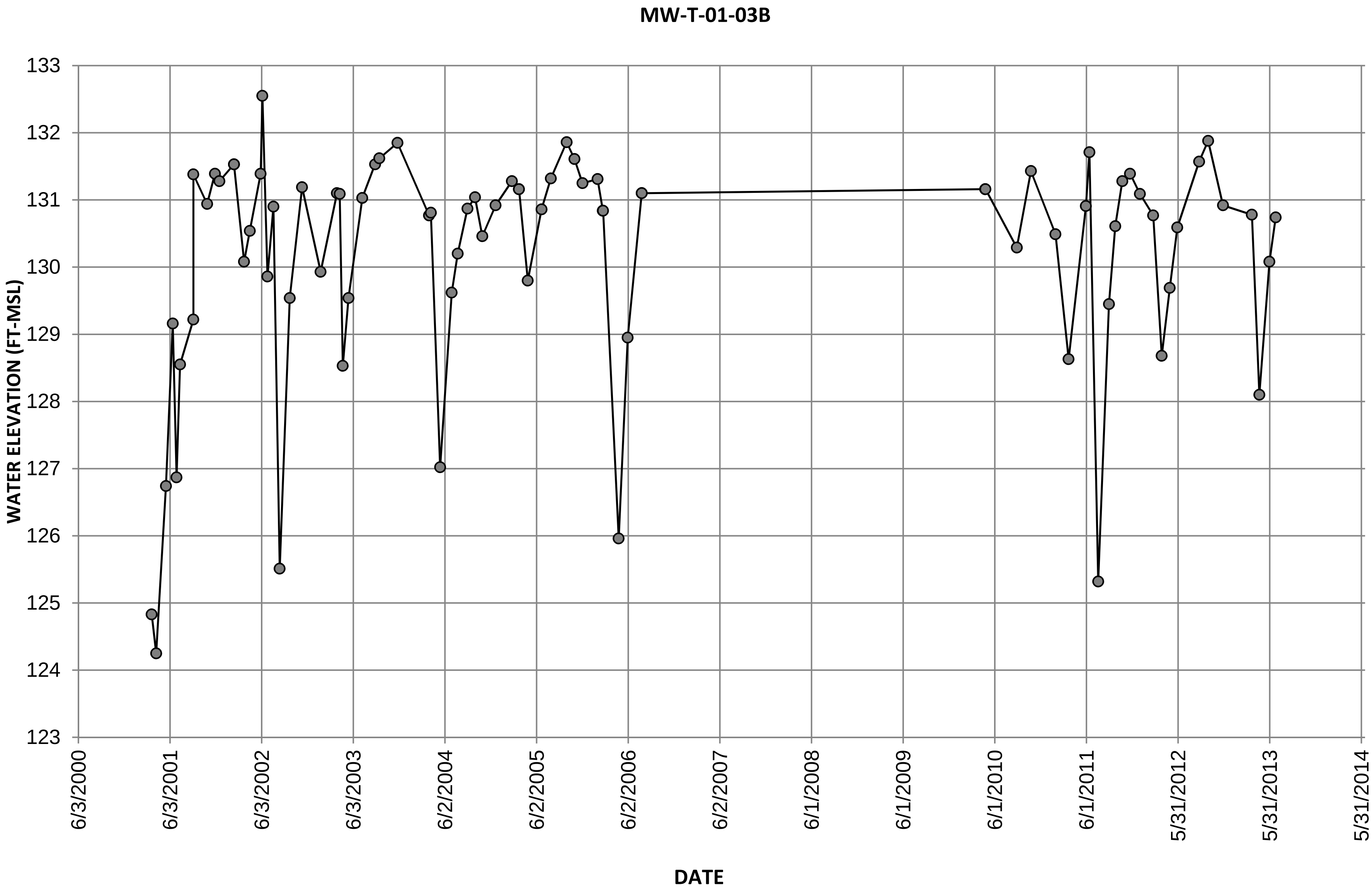


Figure 2.19 Tailings Area Wet Well Flow Data

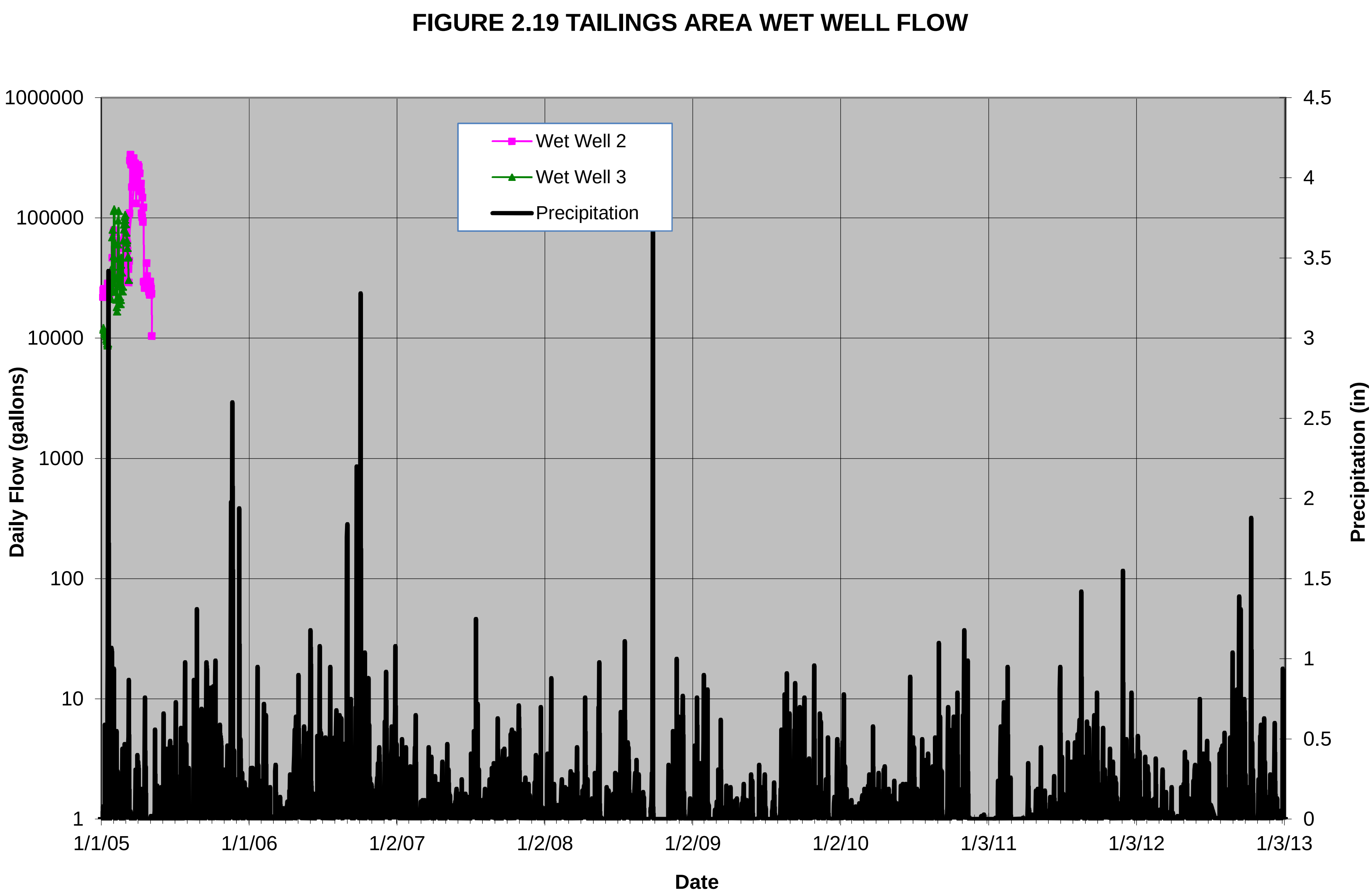


Figure 2.20a GREENS CREEK TAILINGS AREA INTERNAL MONITORING SITES: WET WELLS - pH DATA

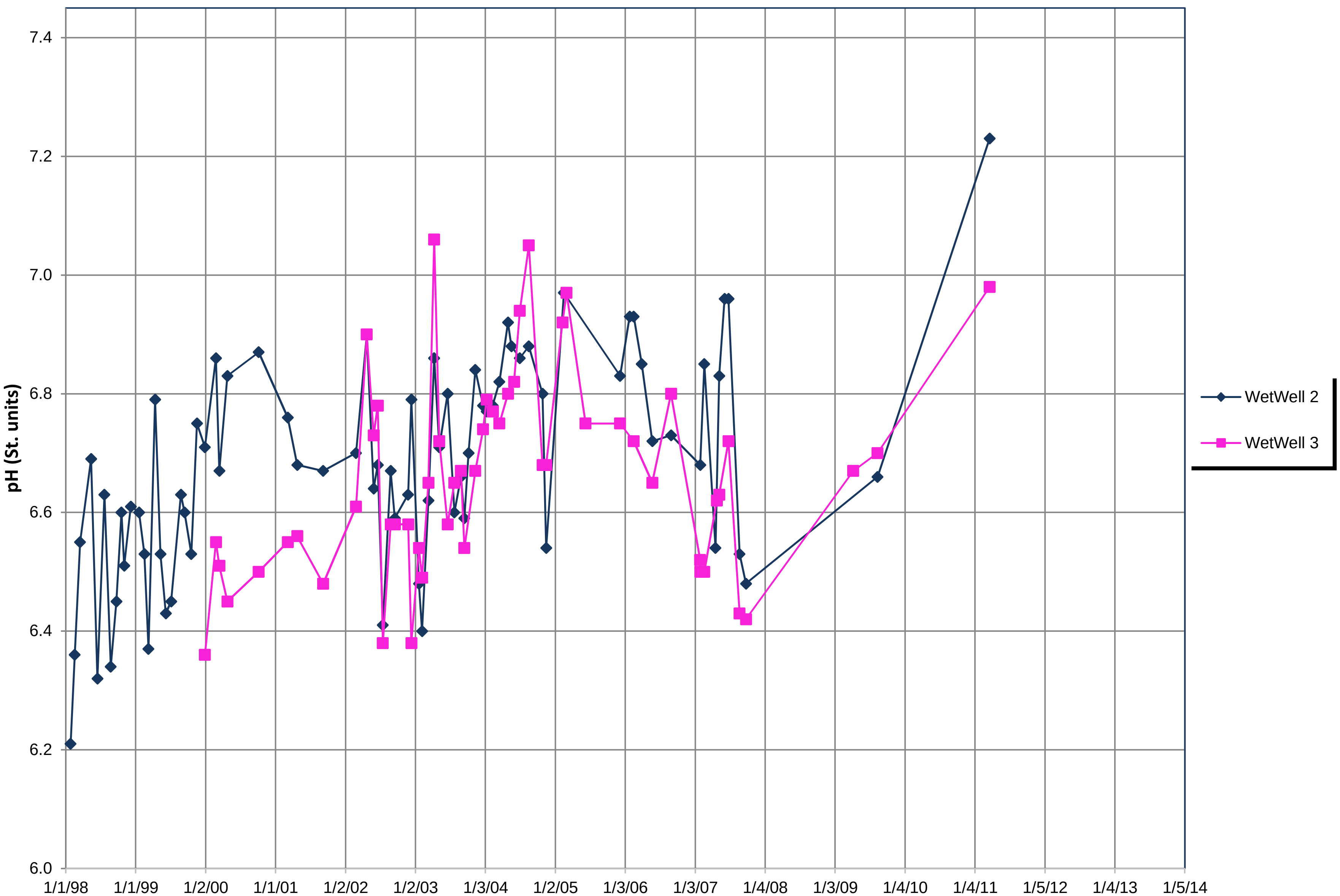


Figure 2.20b GREENS CREEK TAILINGS INTERNAL MONITORING SITES:

TAILINGS COMPLETIONS - pH DATA

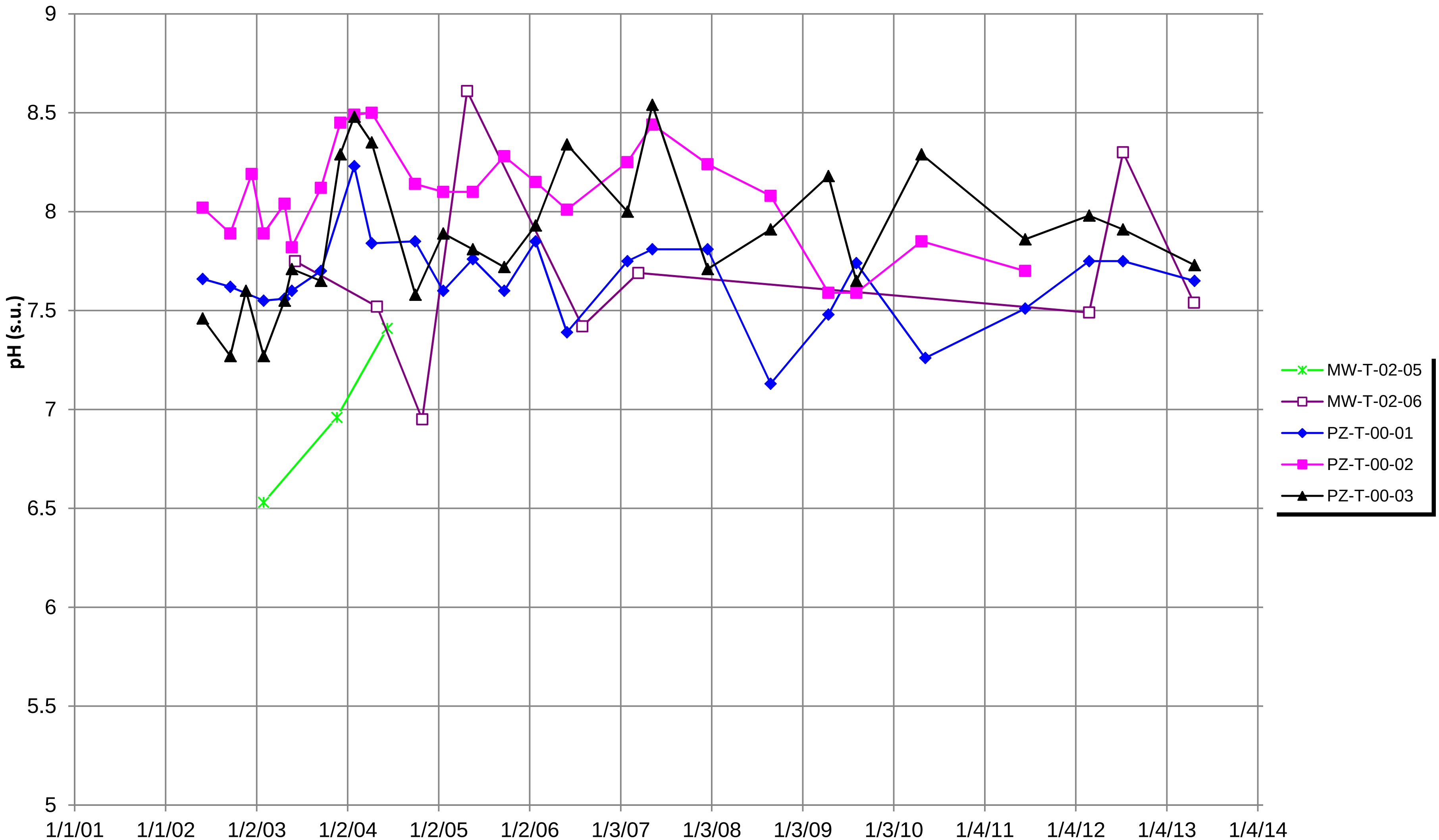


Figure 2.20c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - pH

Figure 2.21a GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
WET WELLS - ALKALINITY
(Non-detectable analysis plotted as zero)

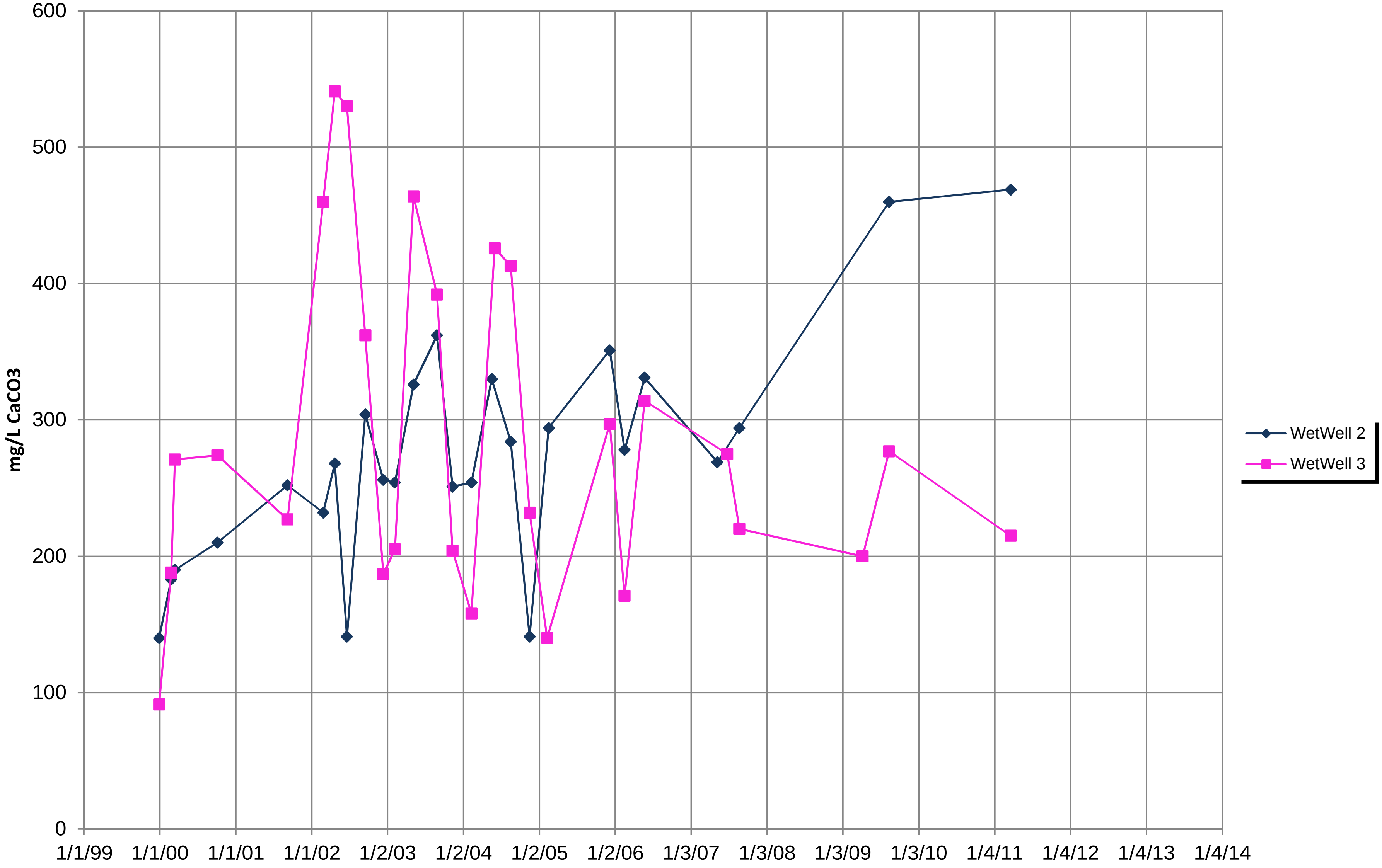


Figure 2.21b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - ALKALINITY DATA

(Non-detectable analyses plotted as zero)

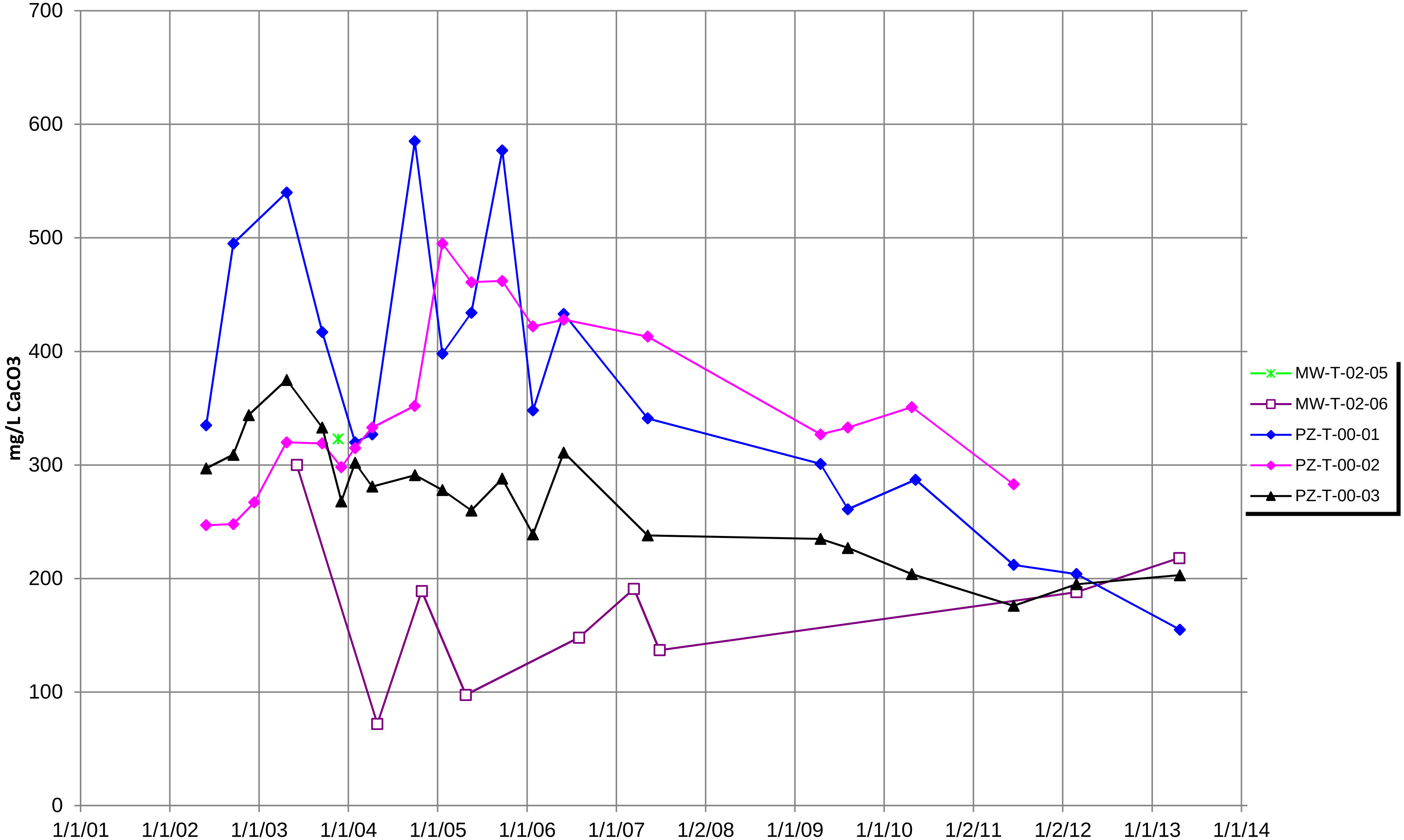


Figure 2.21c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - FIELD ALKALINITY

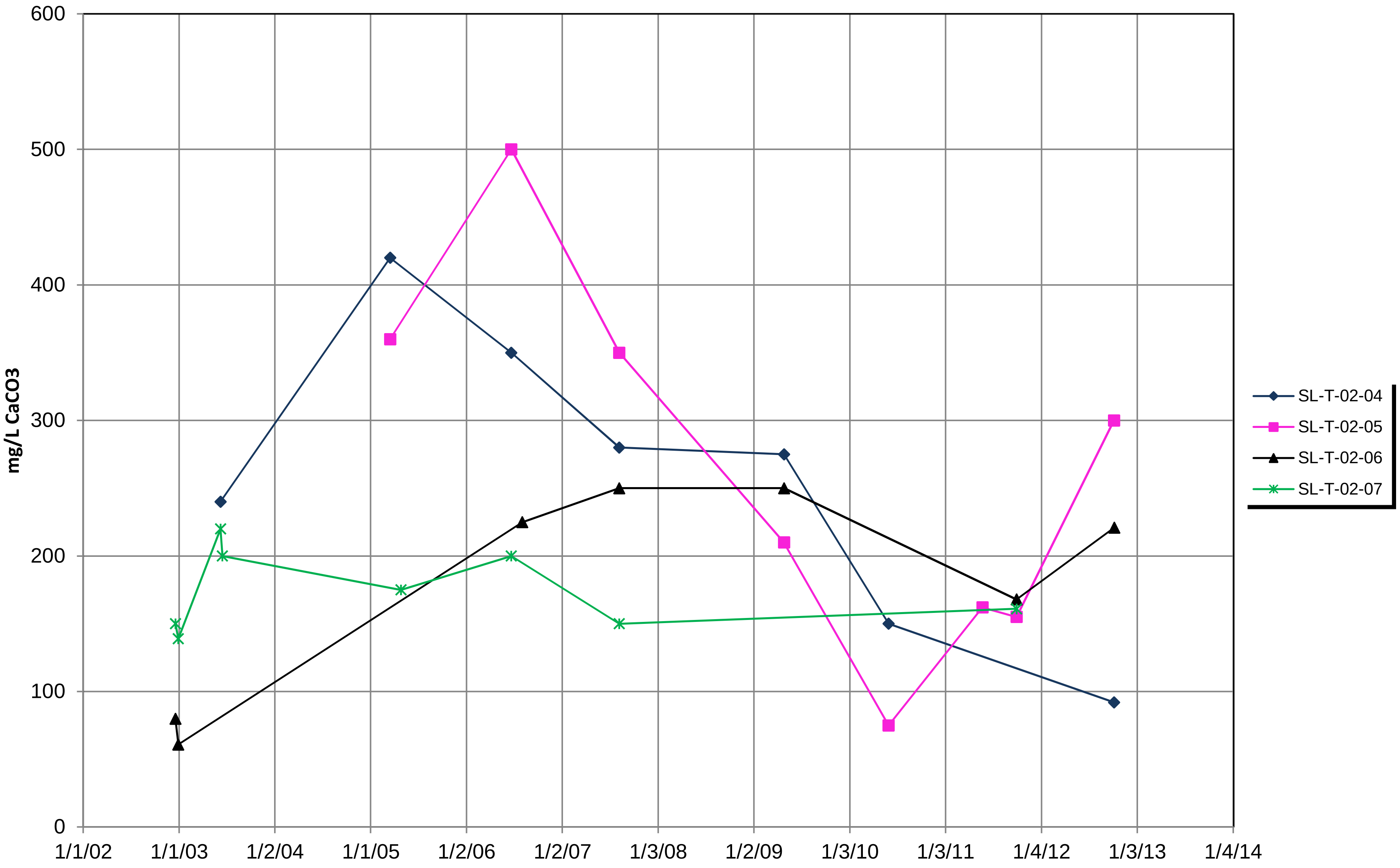


**Figure 2.22a GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
WET WELLS - CONDUCTIVITY DATA**

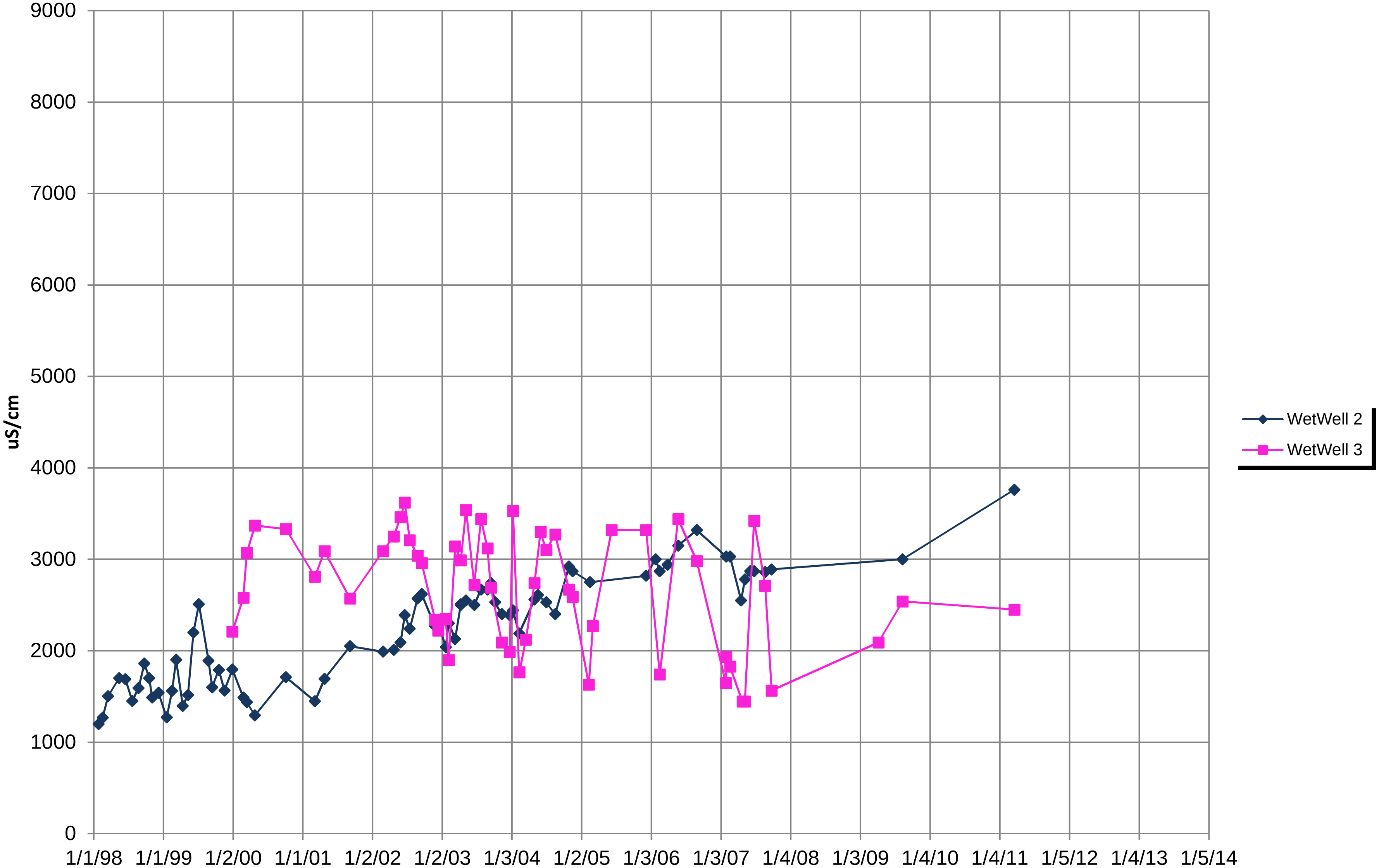


Figure 2.22b GREENS CREEK TAILINGS INTERNAL MONITORING SITES:

TAILINGS COMPLETIONS - CONDUCTIVITY DATA

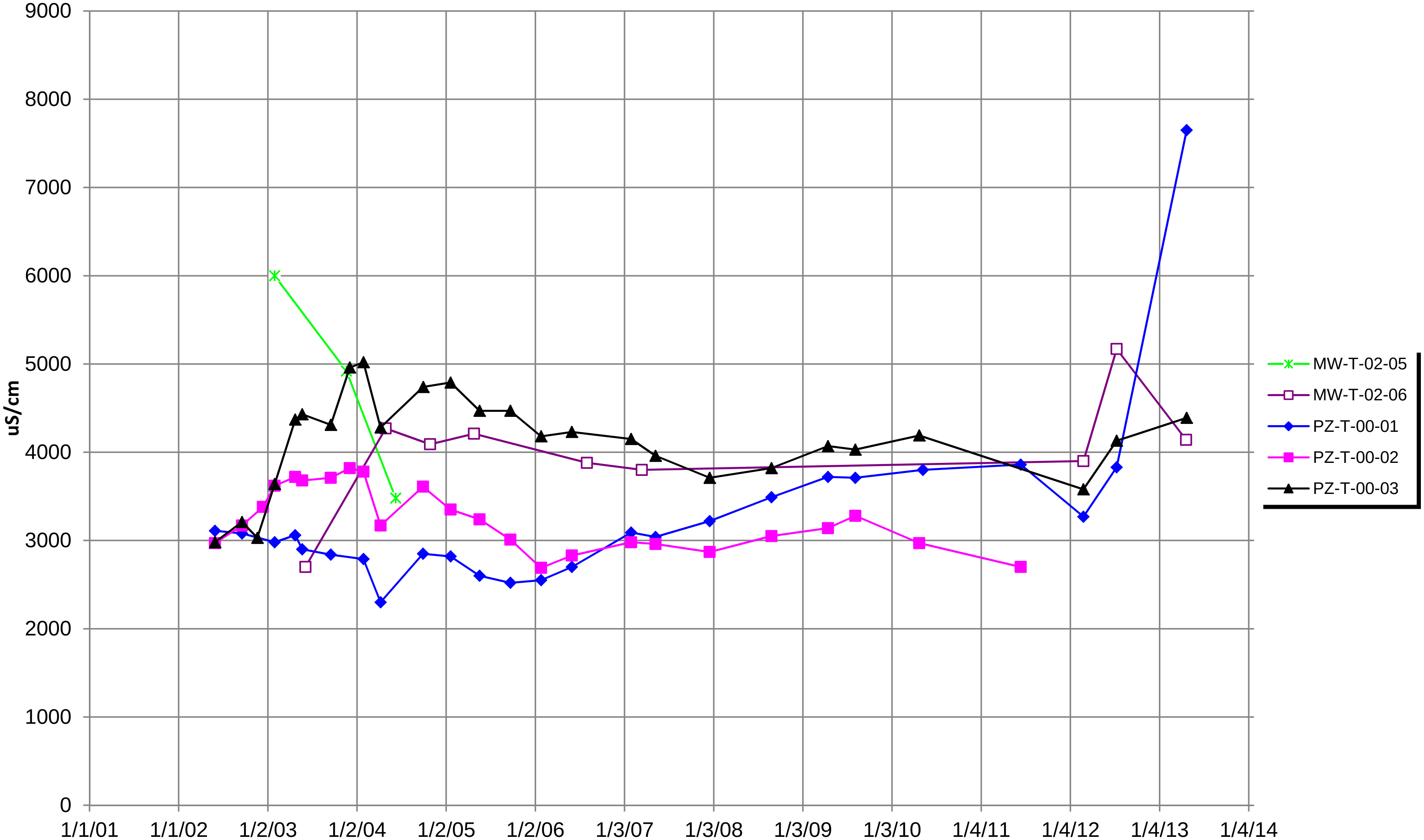


Figure 2.22c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - CONDUCTIVITY

Figure 2.23a GREENS CREEK TAILINGS INTERNAL MONITORING SITES: WET WELLS - HARDNESS DATA (Non-detectable analysis plotted as zero)

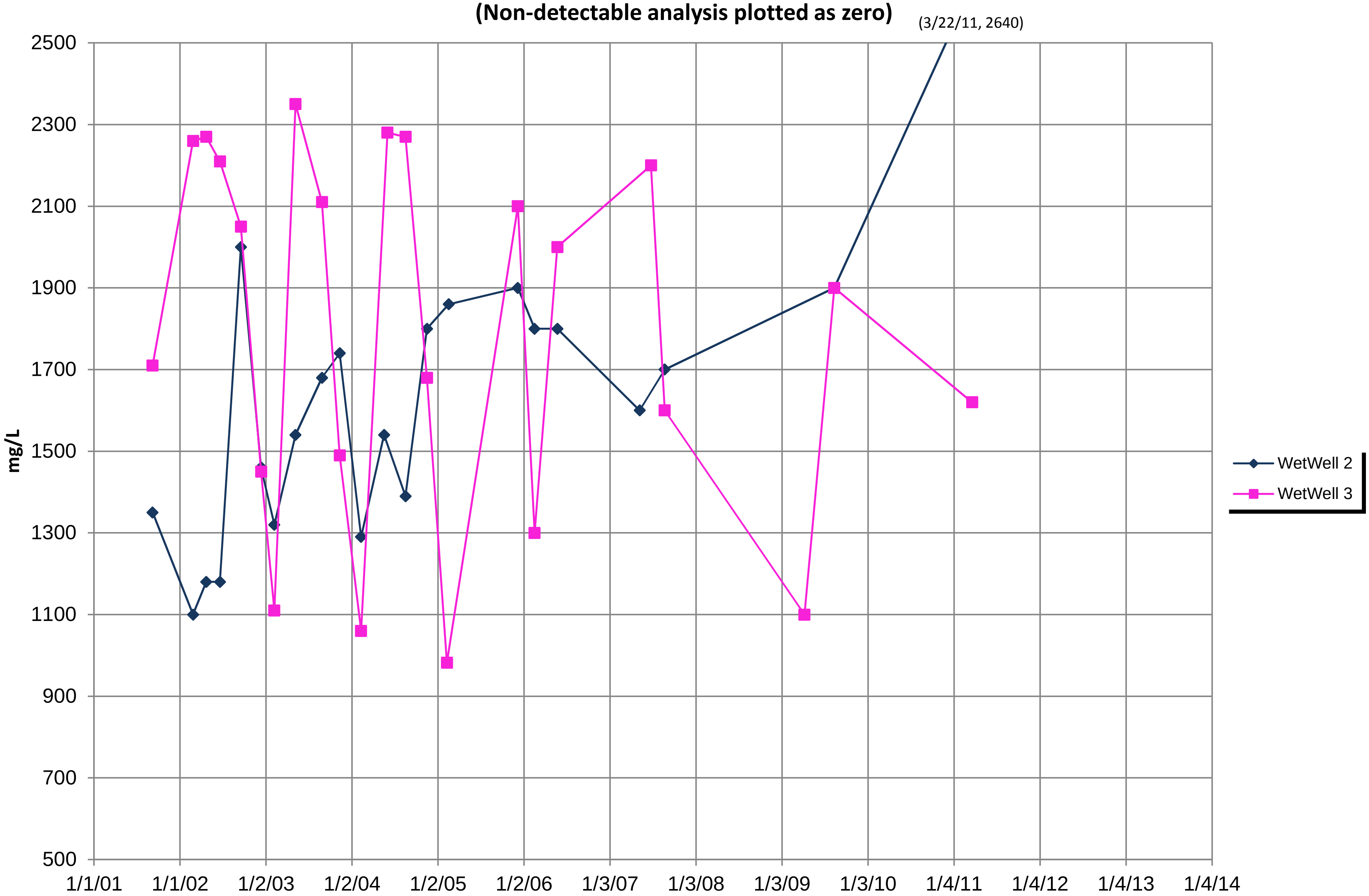


Figure 2.23b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - HARDNESS DATA
(Non-detectable analyses plotted as zero)

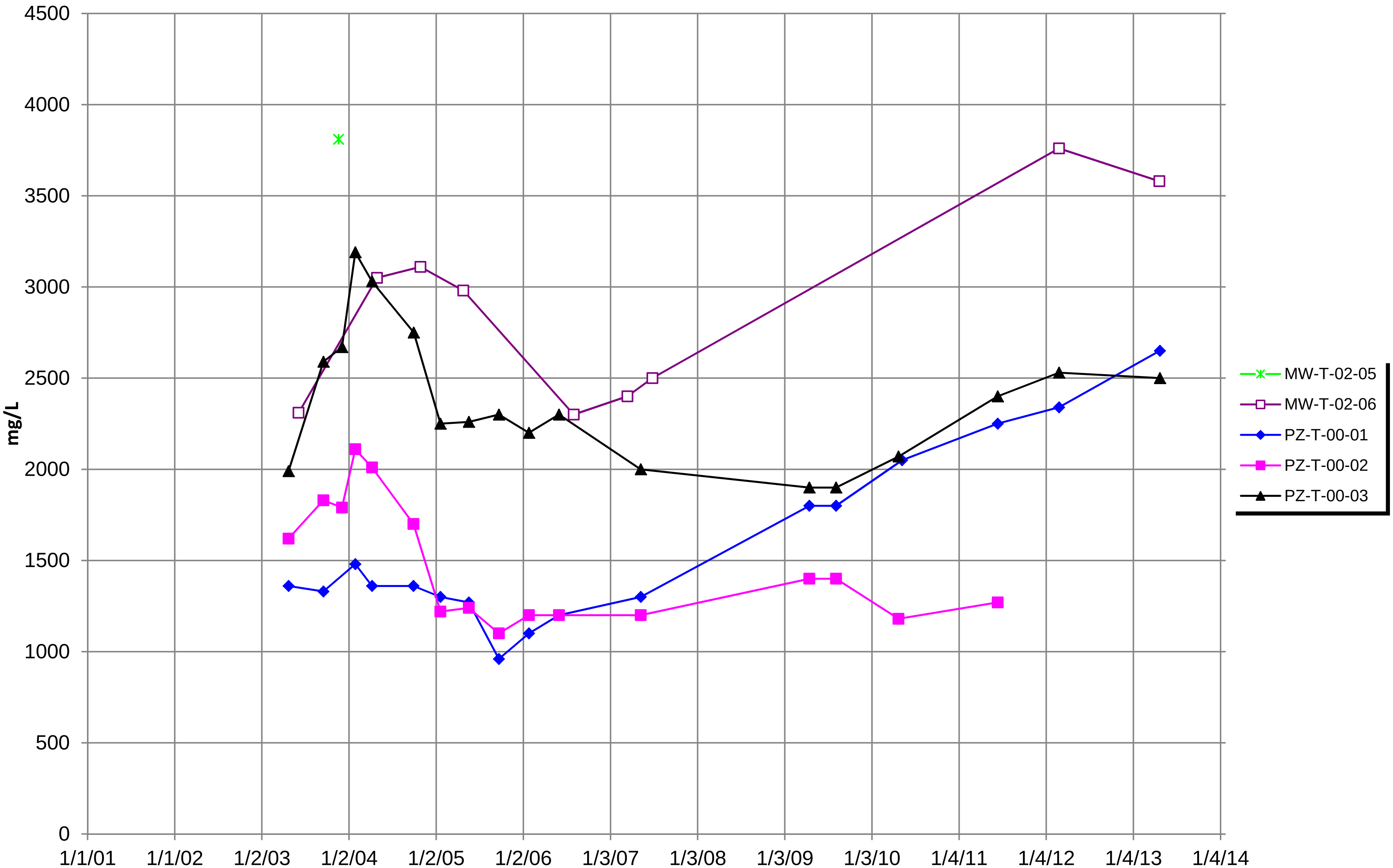


Figure 2.24a GREENS CREEK TAILINGS INTERNAL MONITORING SITES: WET WELLS - SULFATE DATA (Non-detectable analysis plotted as zero)

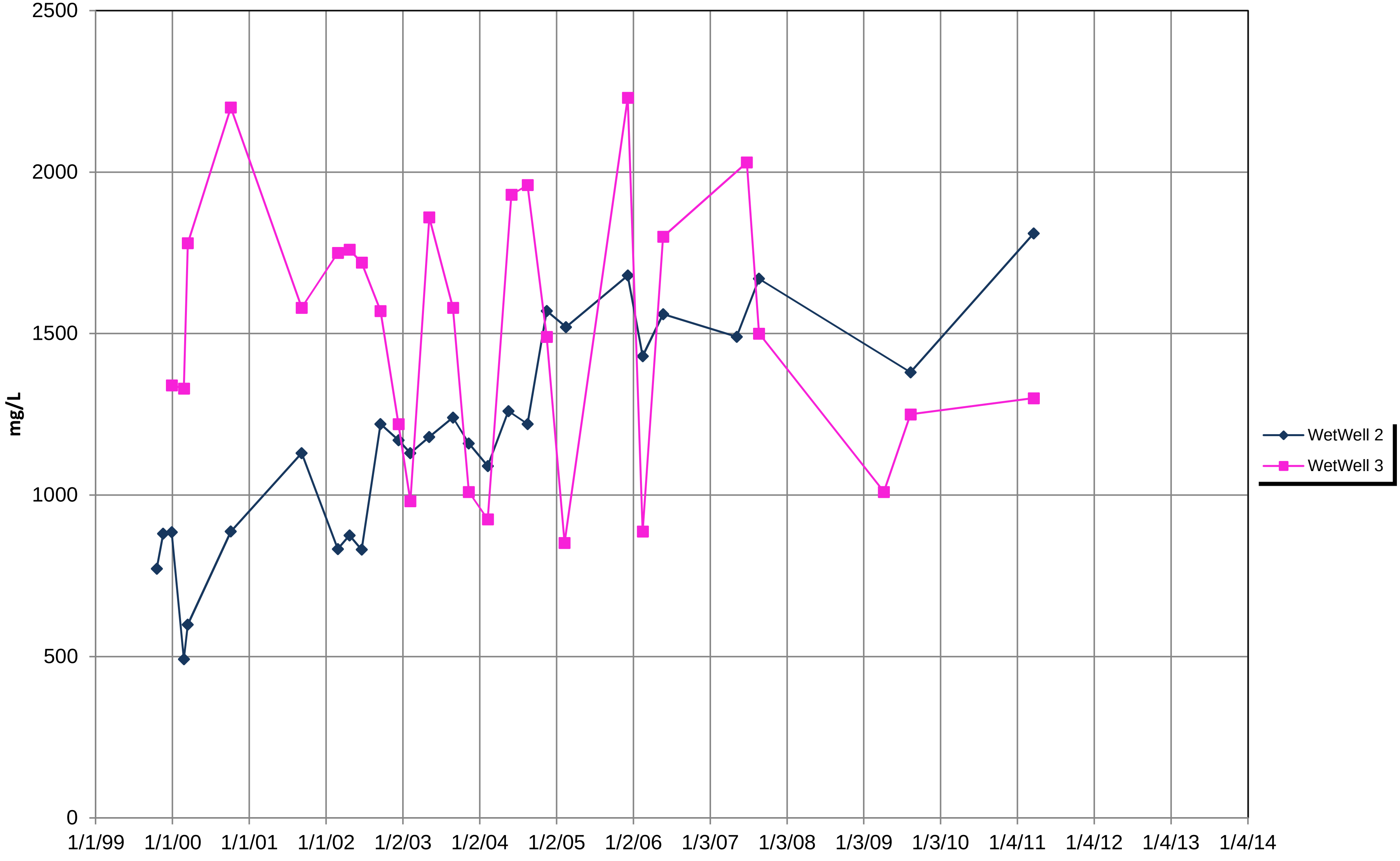


Figure 2.24b GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
TAILINGS COMPLETIONS - SULFATE DATA
(Non-detectable analyses plotted as zero)

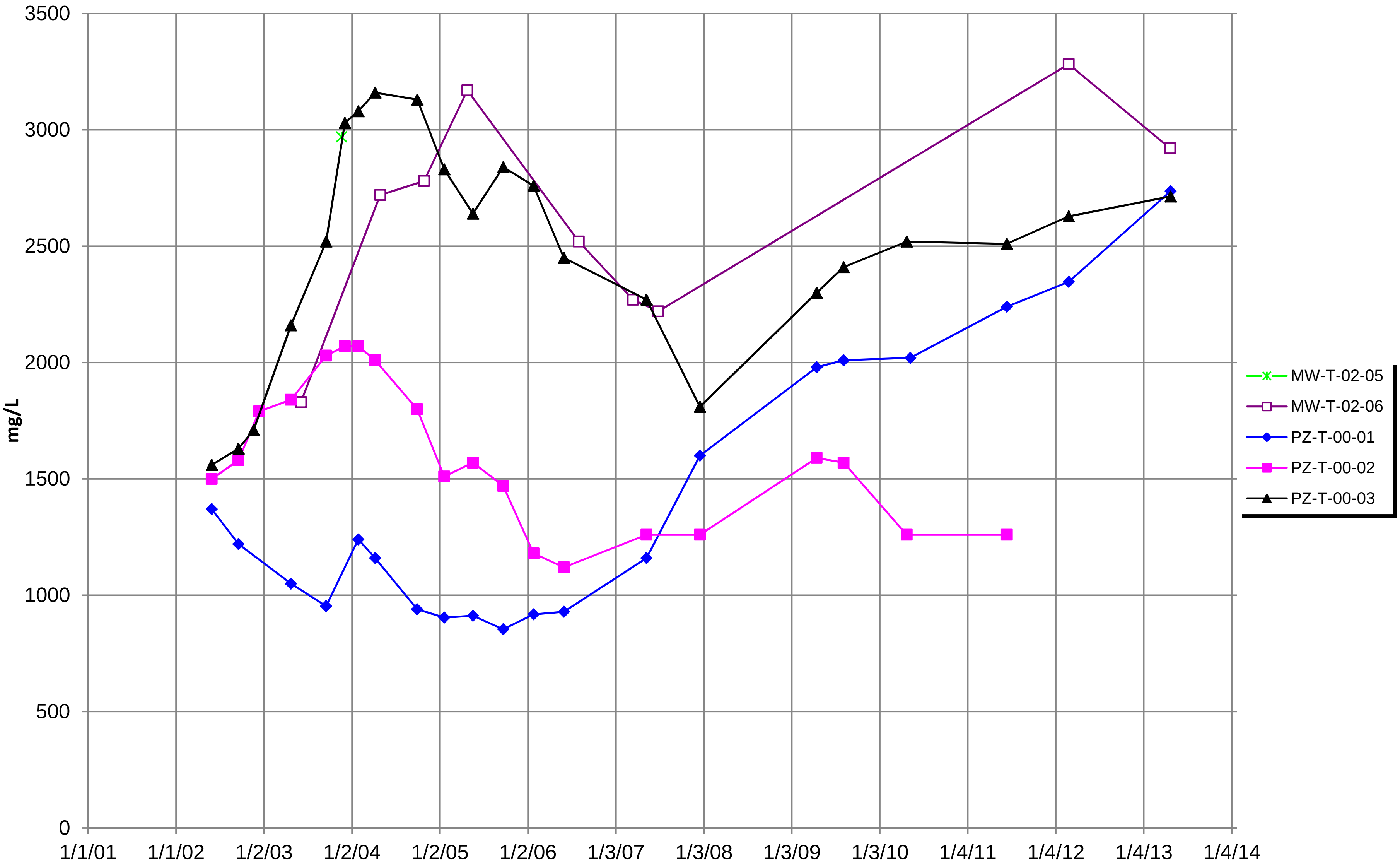


Figure 2.24c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - SULFATE DATA (Non-detectable analysis plotted as zero)

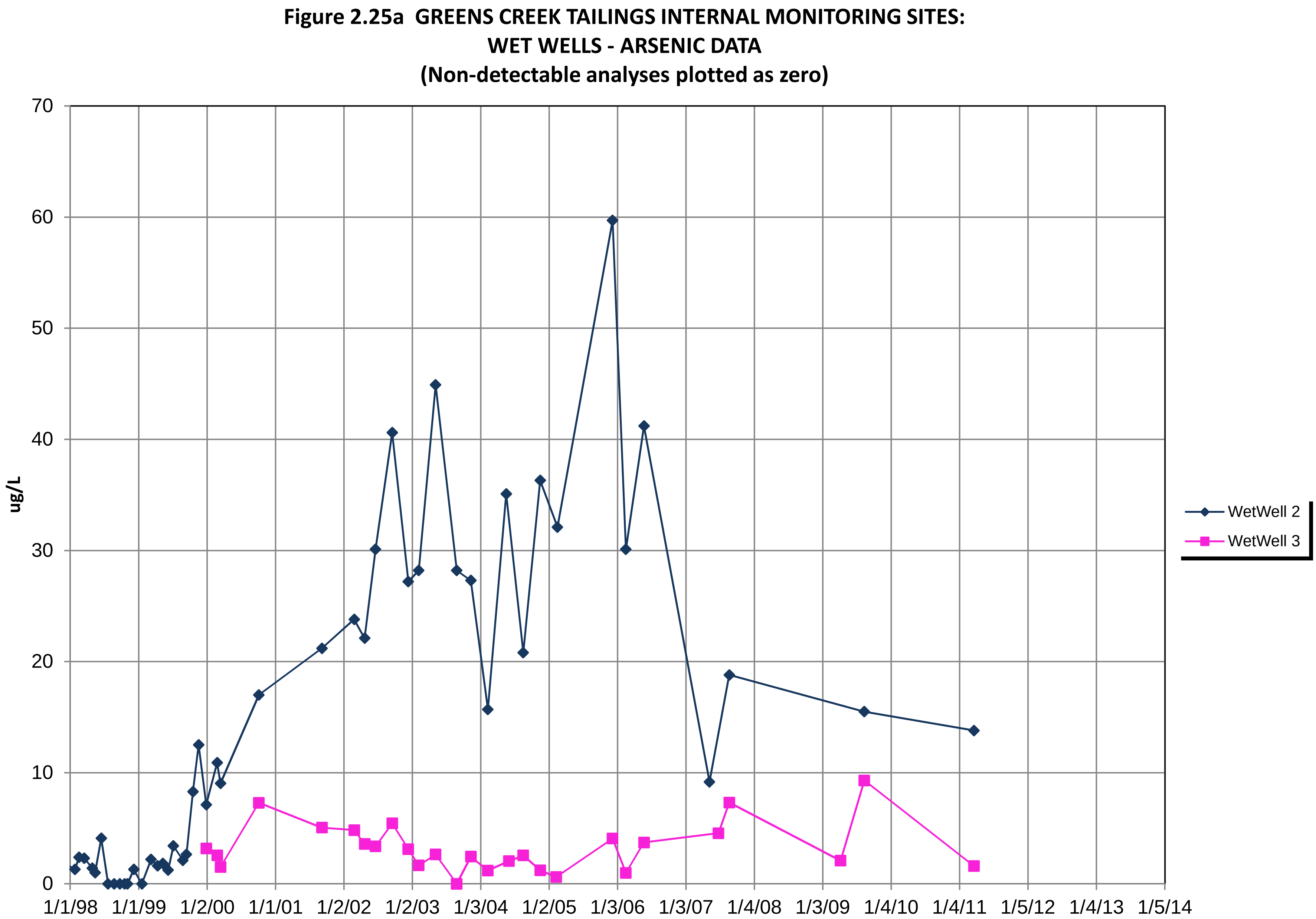


Figure 2.25a GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
WET WELLS - ARSENIC DATA
(Non-detectable analyses plotted as zero)
ug/L
70
60
50
40
30
20
10
0
1/1/98
1/1/99
1/2/00
1/1/01
1/2/02
1/2/03
1/3/04
1/2/05
1/3/06
1/3/07
1/4/08
1/3/09
1/4/10
1/4/11
1/5/12
1/4/13
1/5/14
WetWell 2
WetWell 3

Figure 2.25b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - ARSENIC DATA

(Non-detectable analyses plotted as zero)

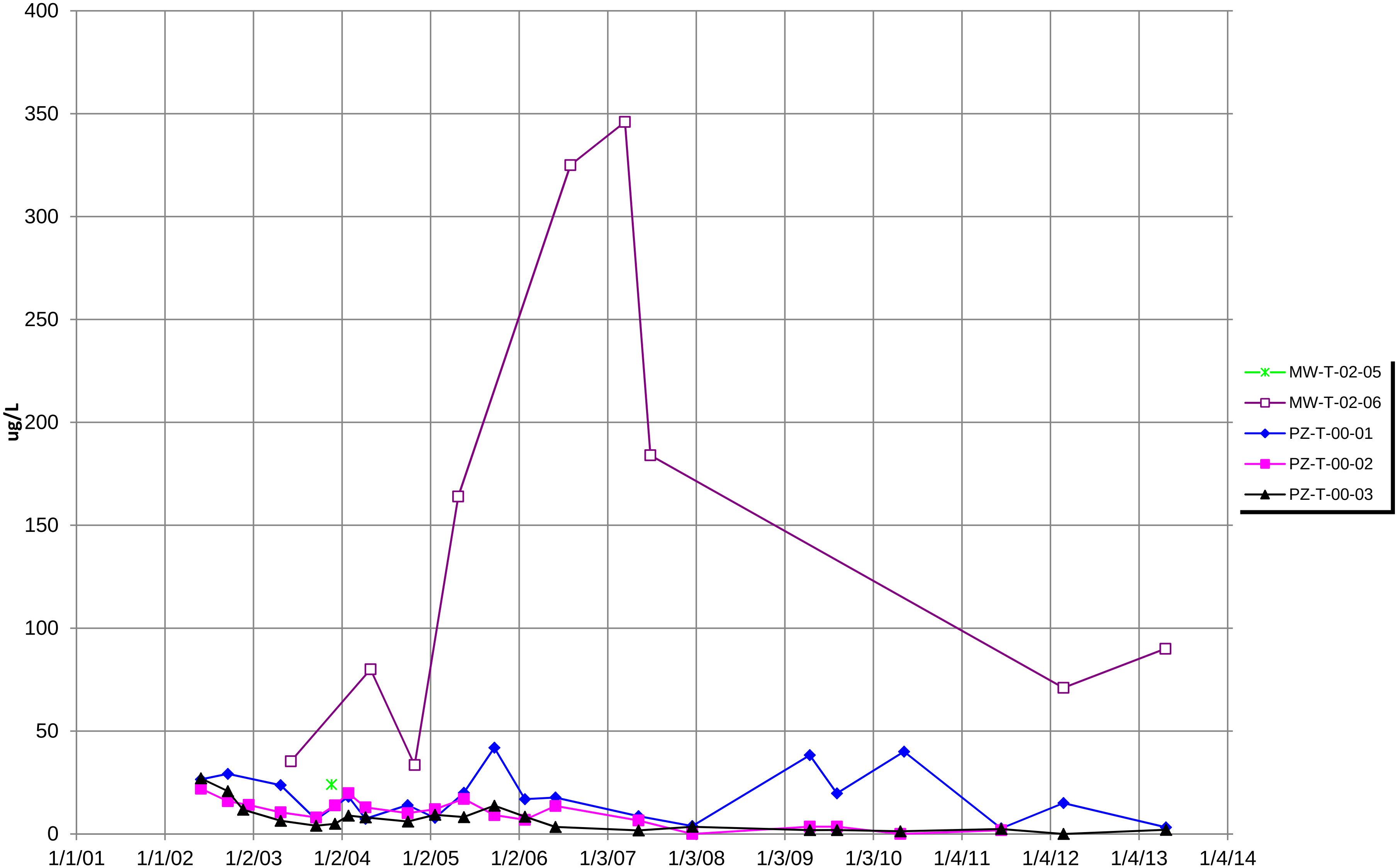


Figure 2.25c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - ARSENIC DATA (Non-detectable analyses plotted as zero)

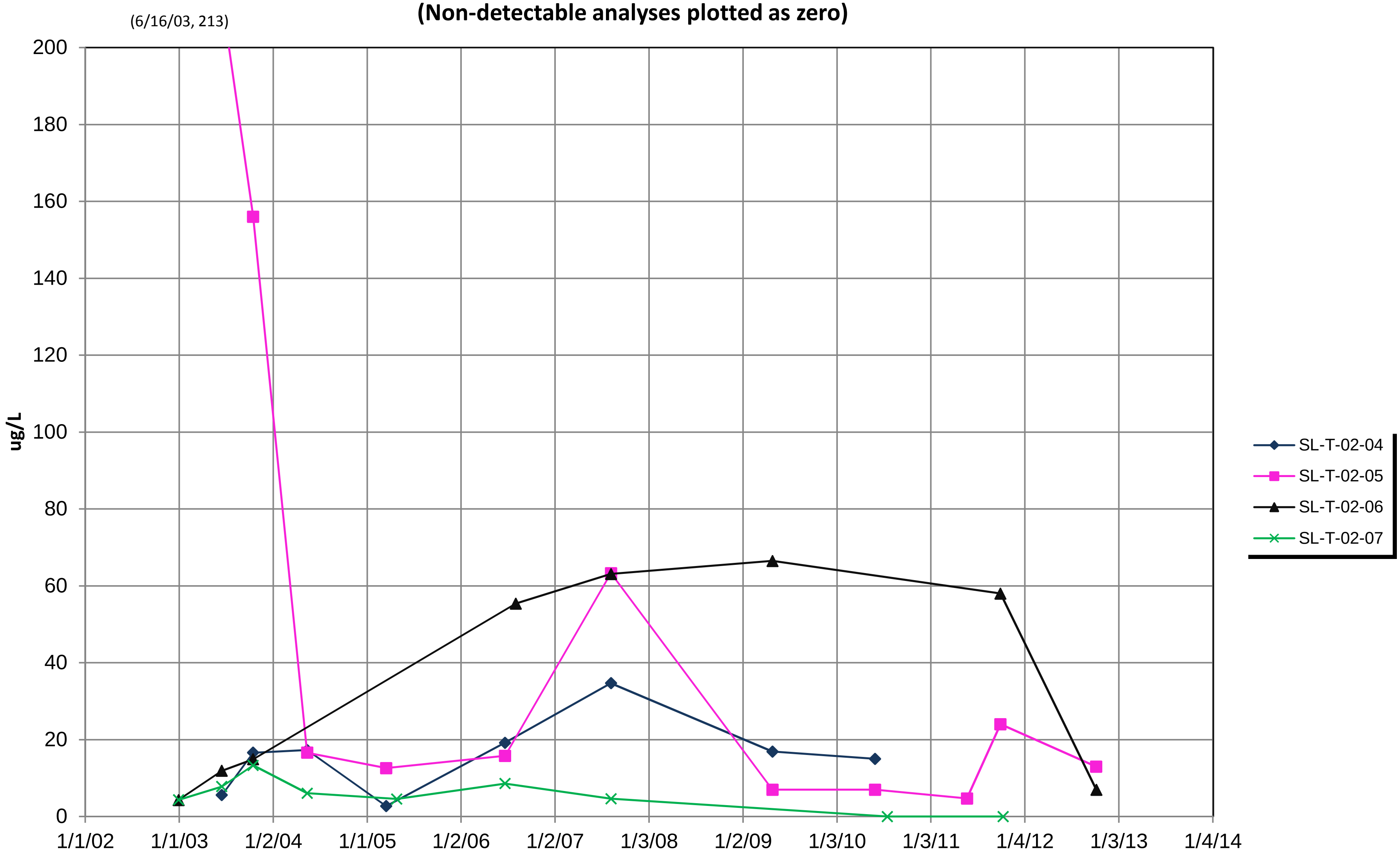


Figure 2.26a GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
WET WELLS - ZINC DATA
(Non-detectable analyses plotted as zero)

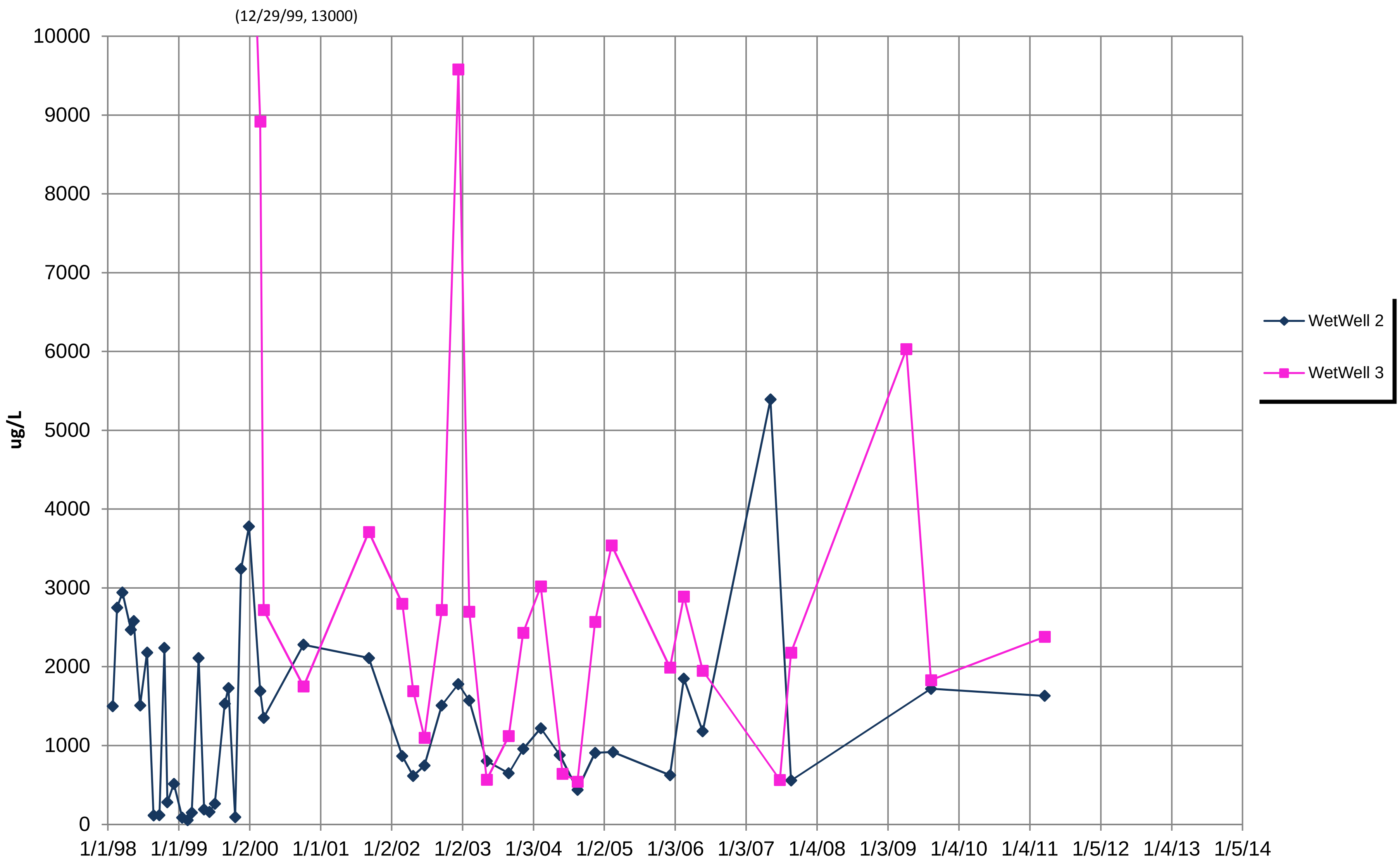


Figure 2.26b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - ZINC DATA

(Non-detectable analyses plotted as zero)

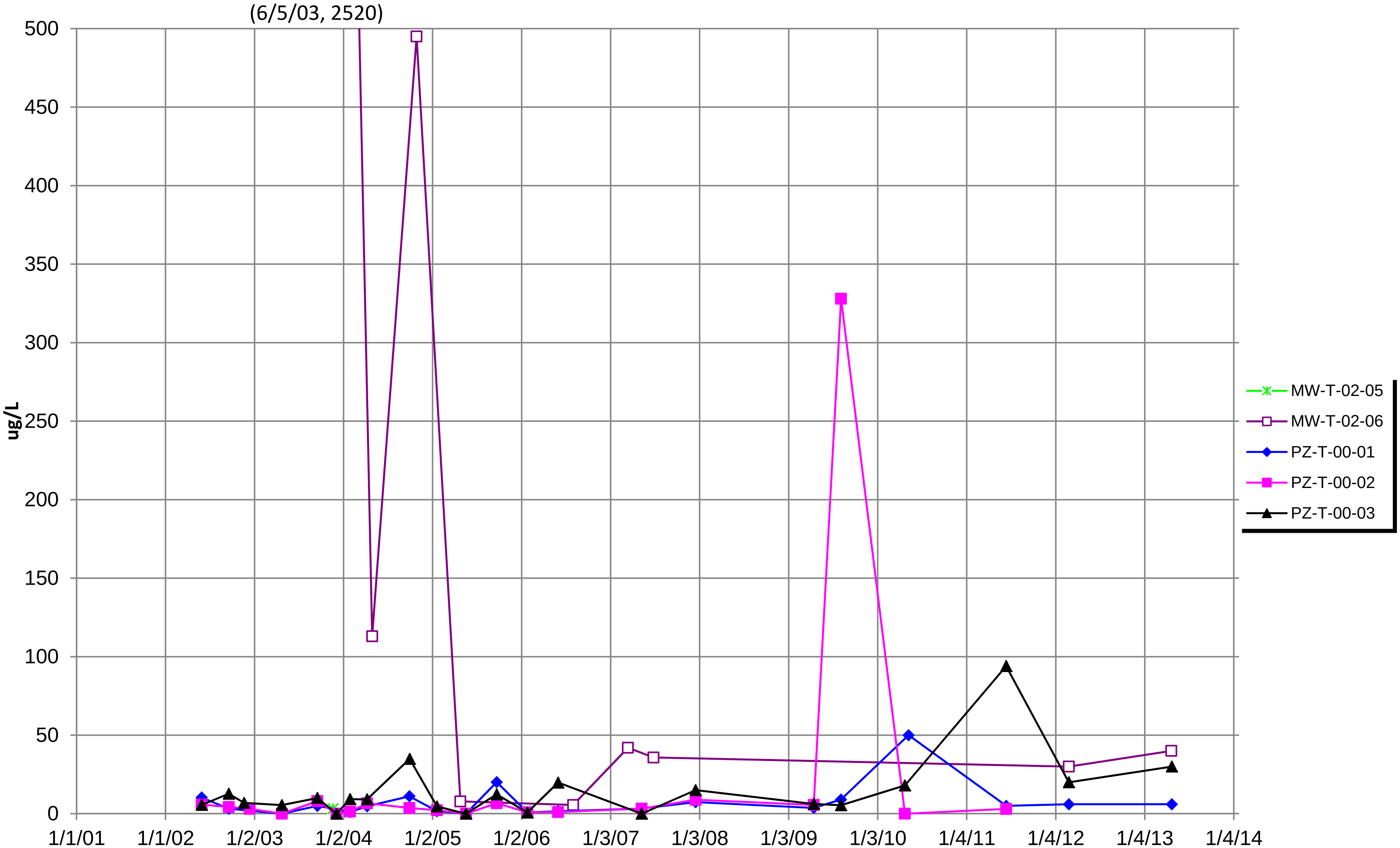


Figure 2.26c GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
SUCTION LYSIMETERS - ZINC DATA
(Primary and secondary y axis: Non-detectable analysis plotted as zero)

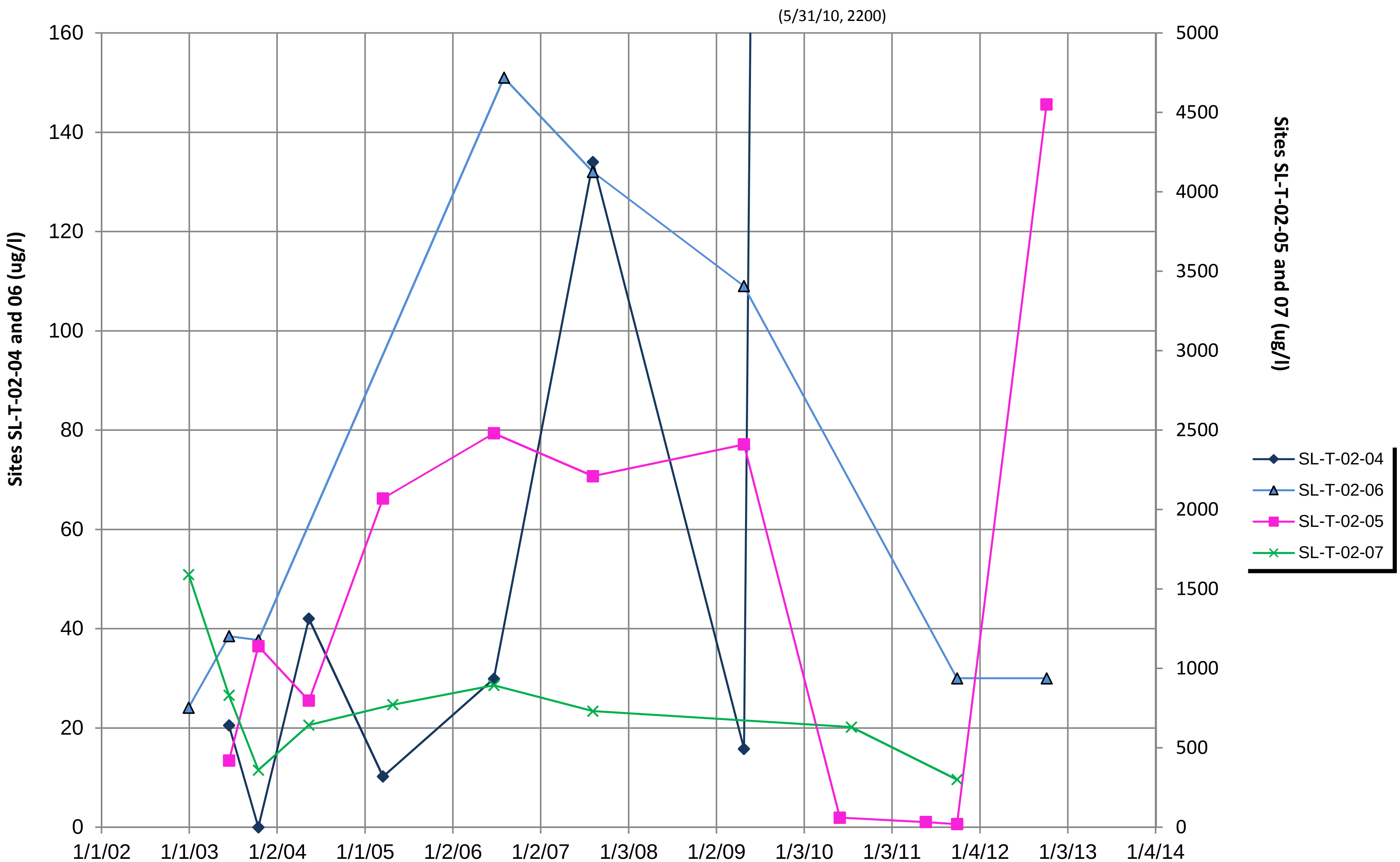


Figure 2.27a GREENS CREEK TAILINGS INTERNAL MONITORING SITES: WET WELLS - COPPER DATA (Non-detectable analyses plotted as zero)

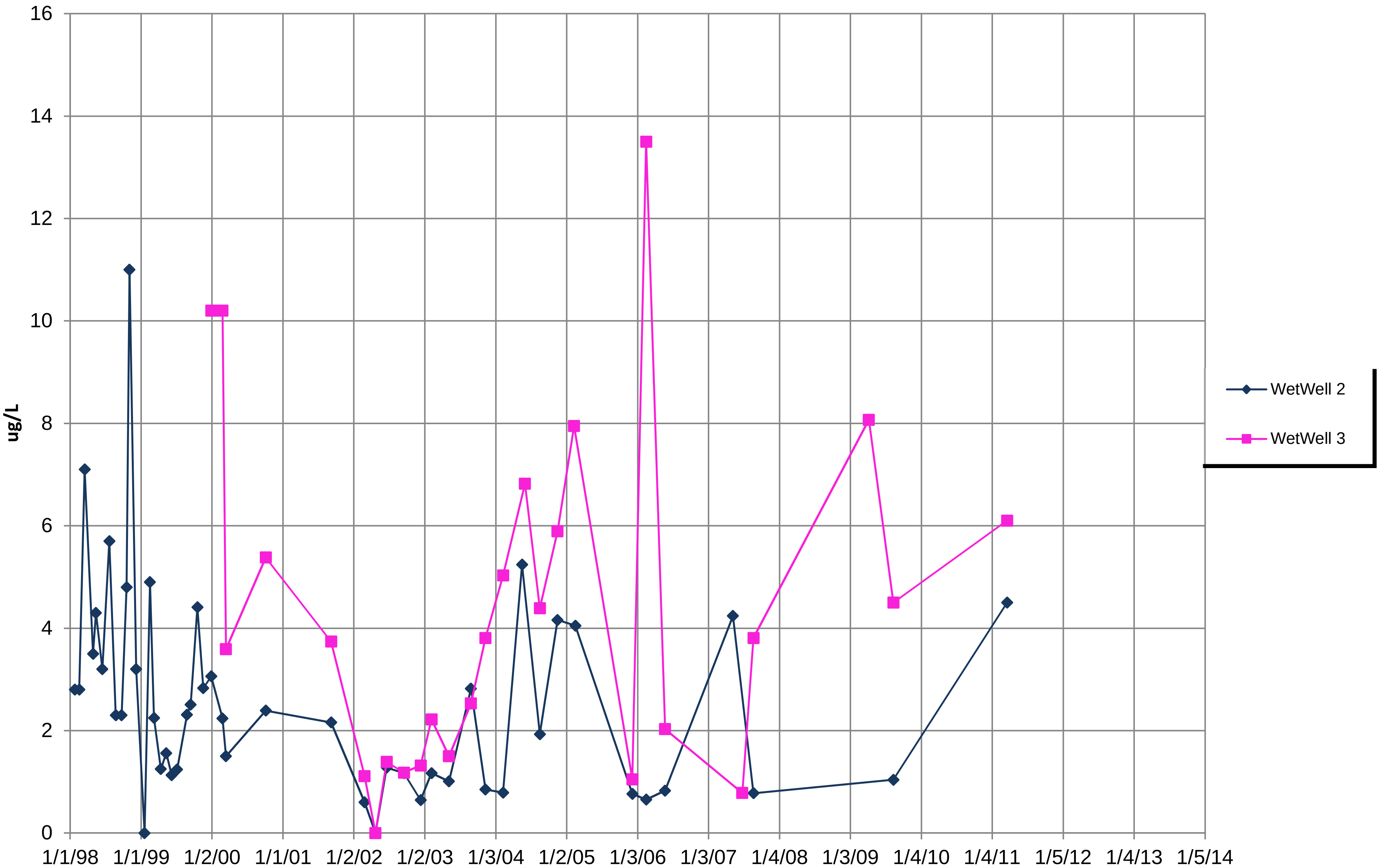


Figure 2.27b GRRENS CREEK TAILINGS INTERNAL MONITORING SITES:
TAILINGS COMPLETIONS - COPPER DATA

(Non-detectable analyses plotted as zero)

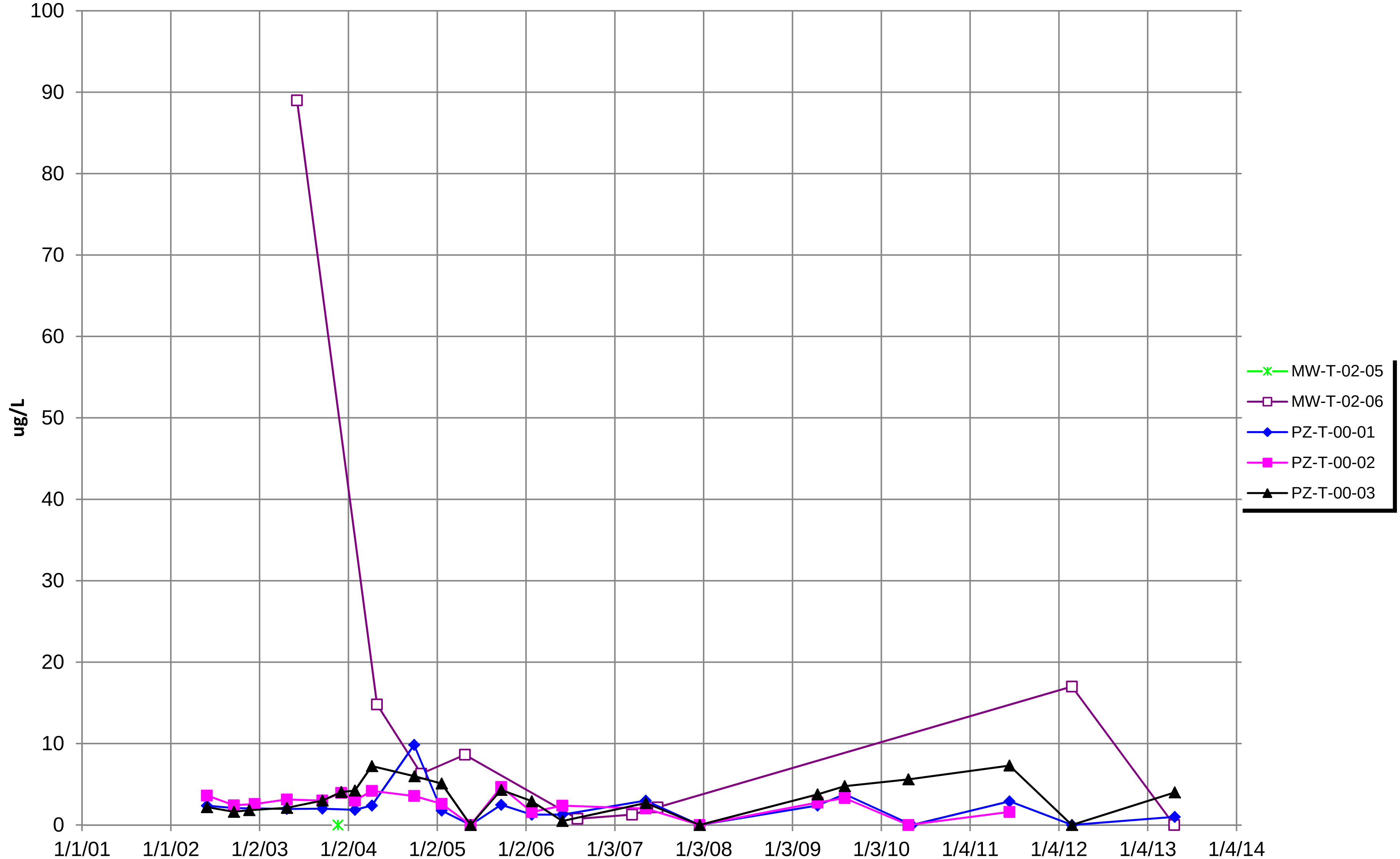
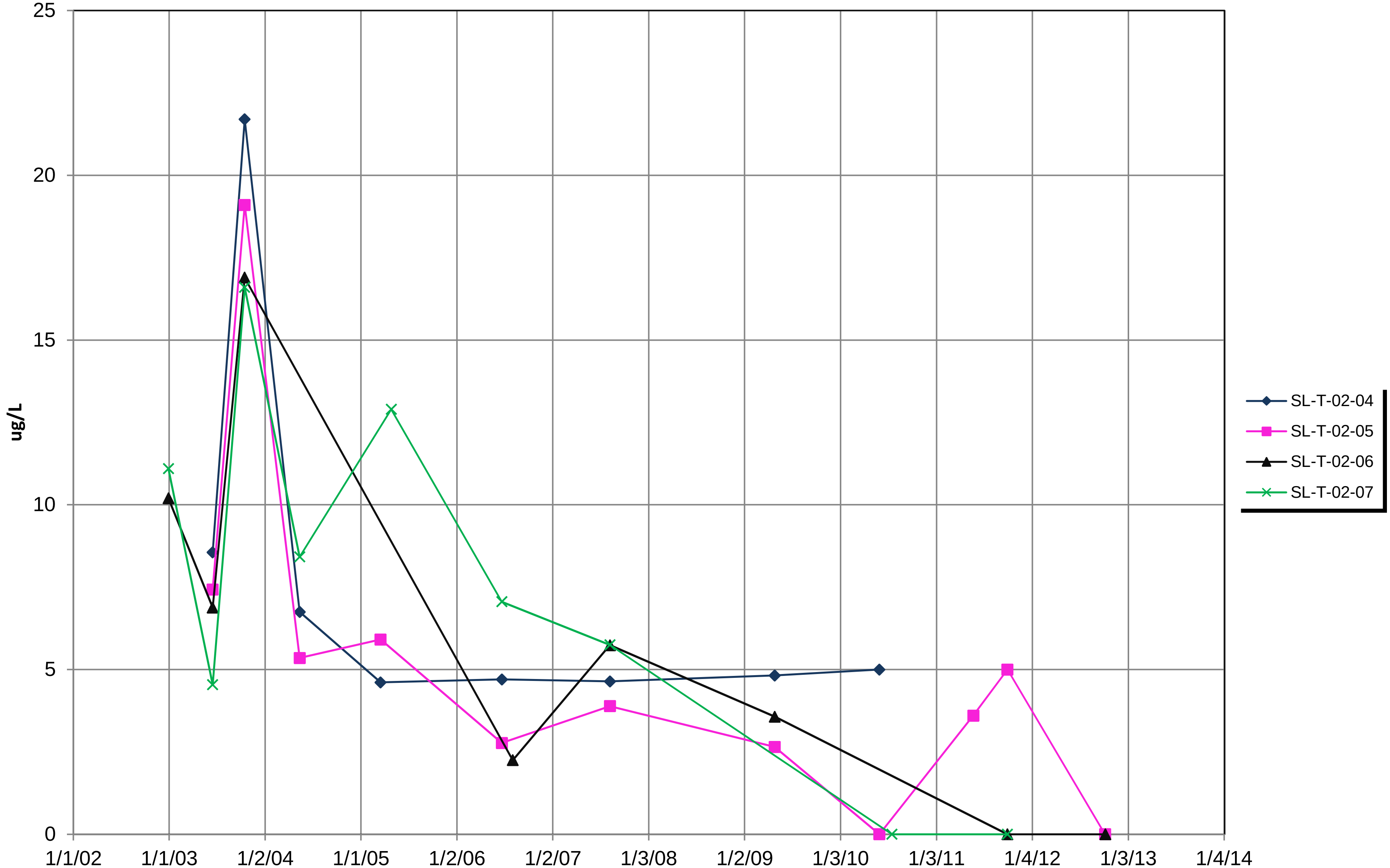


Figure 2.27c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - COPPER DATA (Non-detectable analyses plotted as zero)



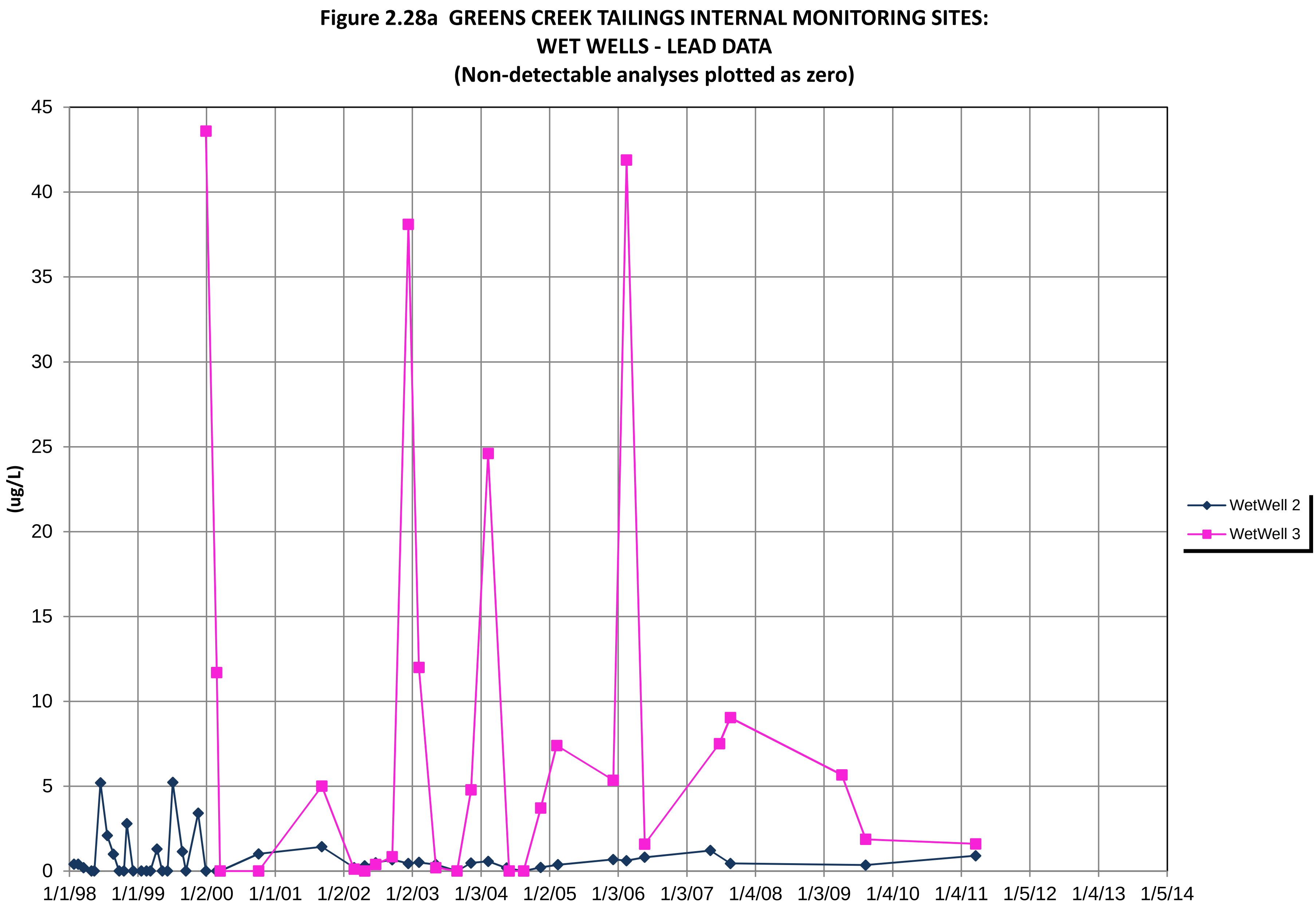


Figure 2.28a GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
WET WELLS - LEAD DATA
(Non-detectable analyses plotted as zero)
45
40
35
30
25
20
15
10
5
0
(ug/L)
1/1/98
1/1/99
1/2/00
1/1/01
1/2/02
1/2/03
1/3/04
1/2/05
1/3/06
1/3/07
1/4/08
1/3/09
1/4/10
1/4/11
1/5/12
1/4/13
1/5/14
WetWell 2
WetWell 3

Figure 2.28b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - LEAD DATA

(Non-detectable analyses plotted as zero)

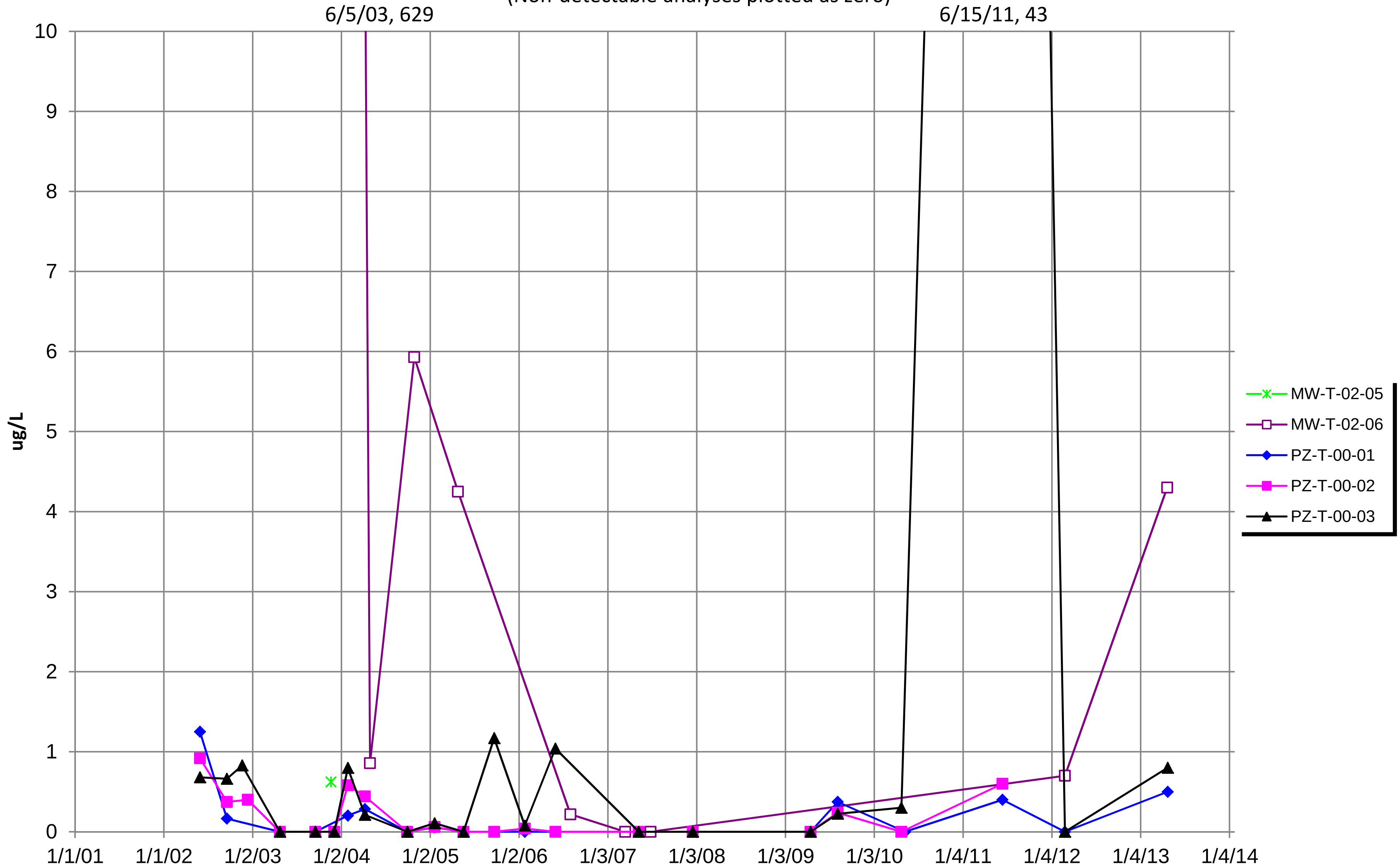


Figure 2.28c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - LEAD DATA (Non-detectable analyses plotted as zero)

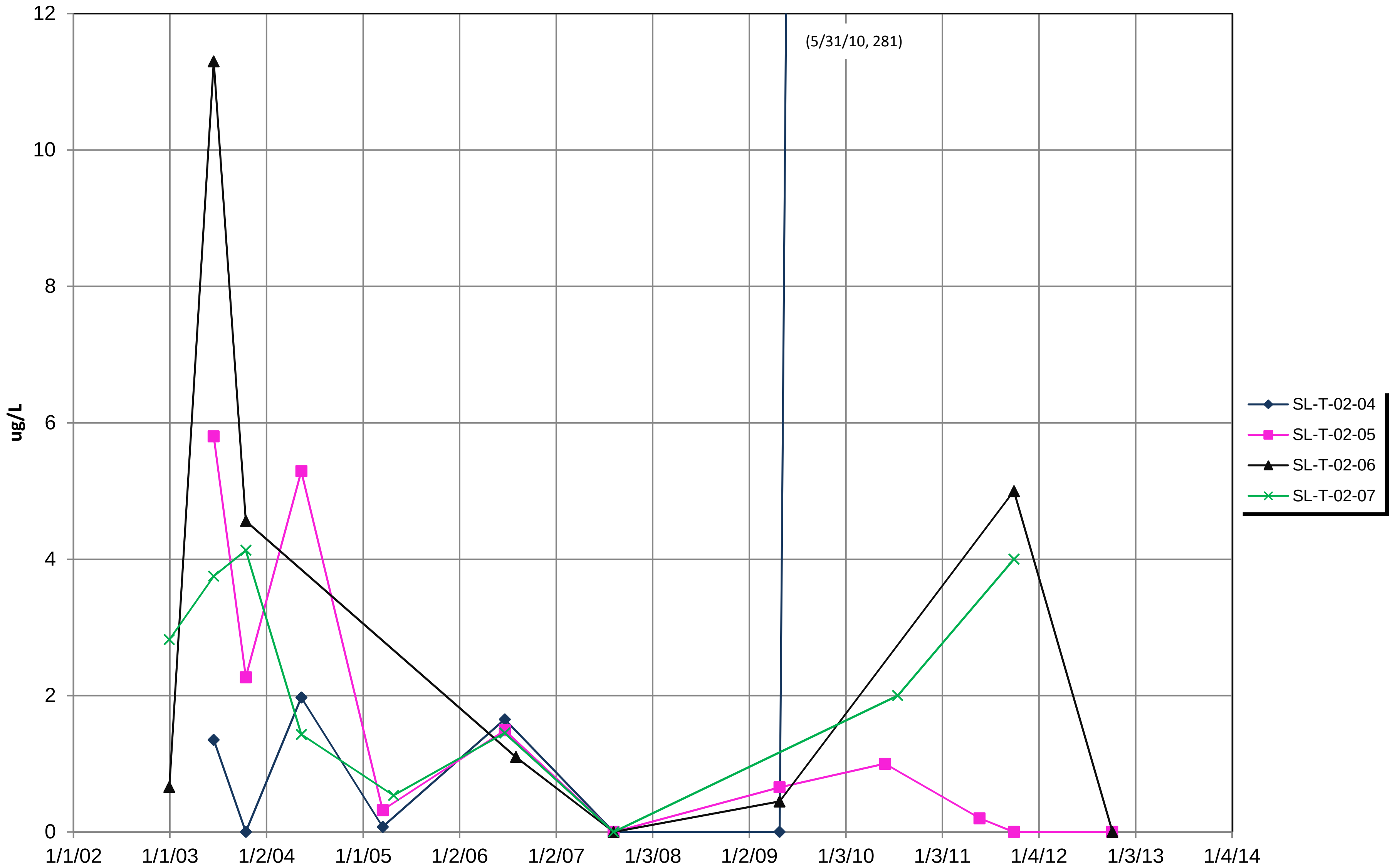


Figure 2.29a GREENS CREEK TAILINGS INTERNAL MONITORING SITES: WET WELLS - CADMIUM DATA (Non-detectable analyses plotted as zero)

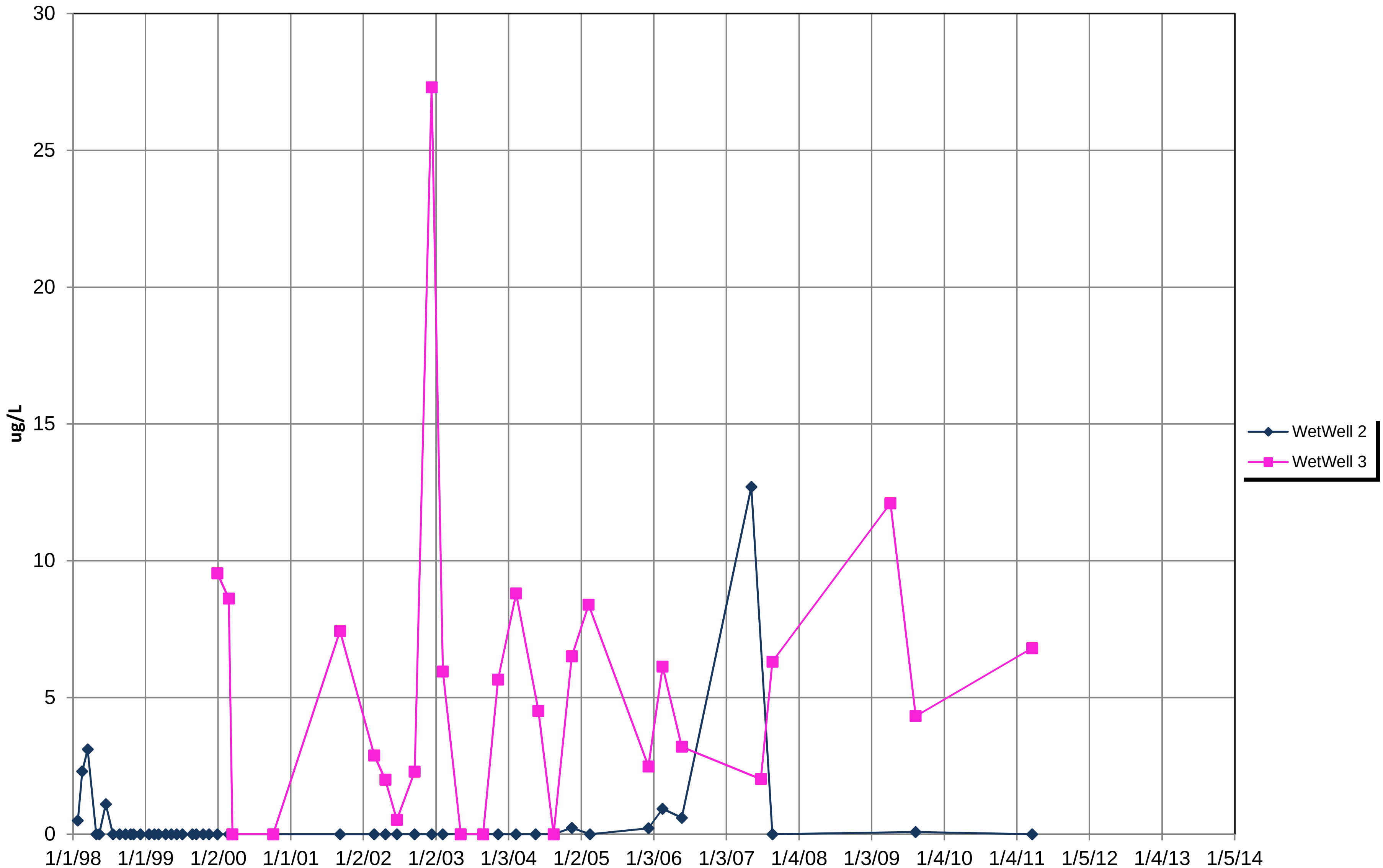


Figure 2.29b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - CADMIUM DATA

(Non-detectable analyses plotted as zero)

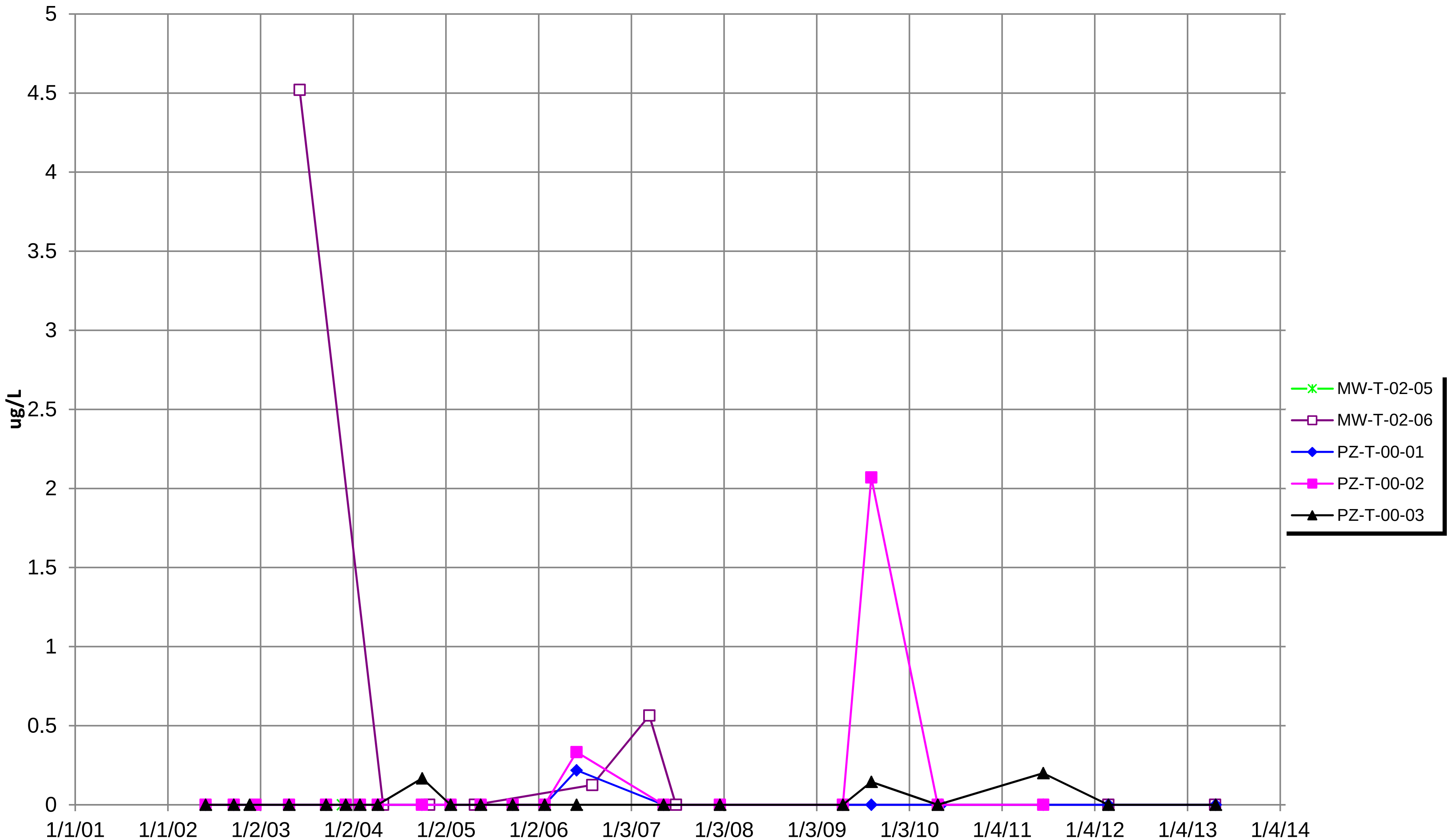


Figure 2.29c GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
SUCTION LYSIMETERS - CADMIUM DATA
(Non-detectable analyses plotted as zero)

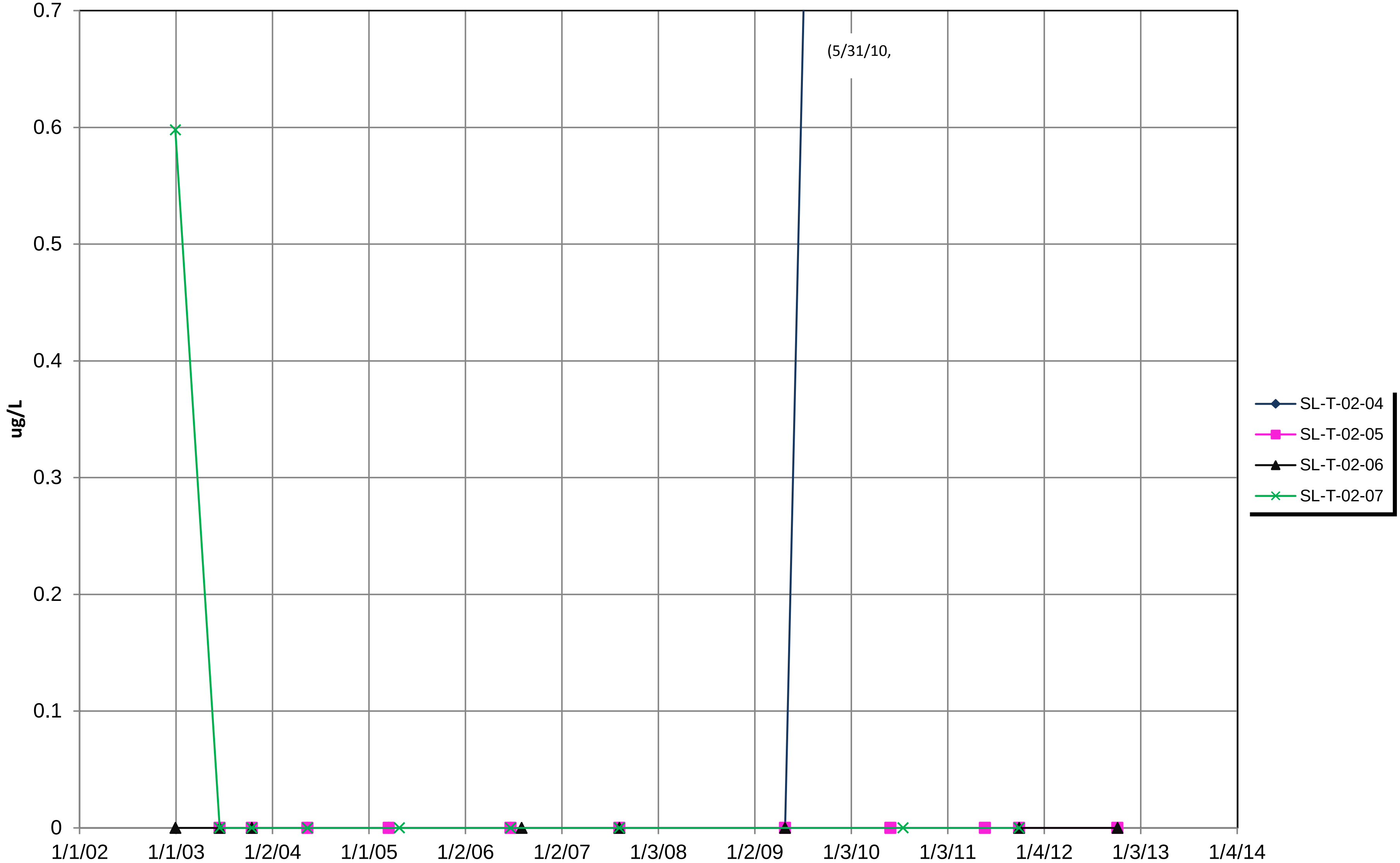


Figure 2.30a GREENS CREEK TAILINGS INTERNAL MONITORING SITES: WET WELLS - IRON DATA (Non-detectable analyses plotted as zero)

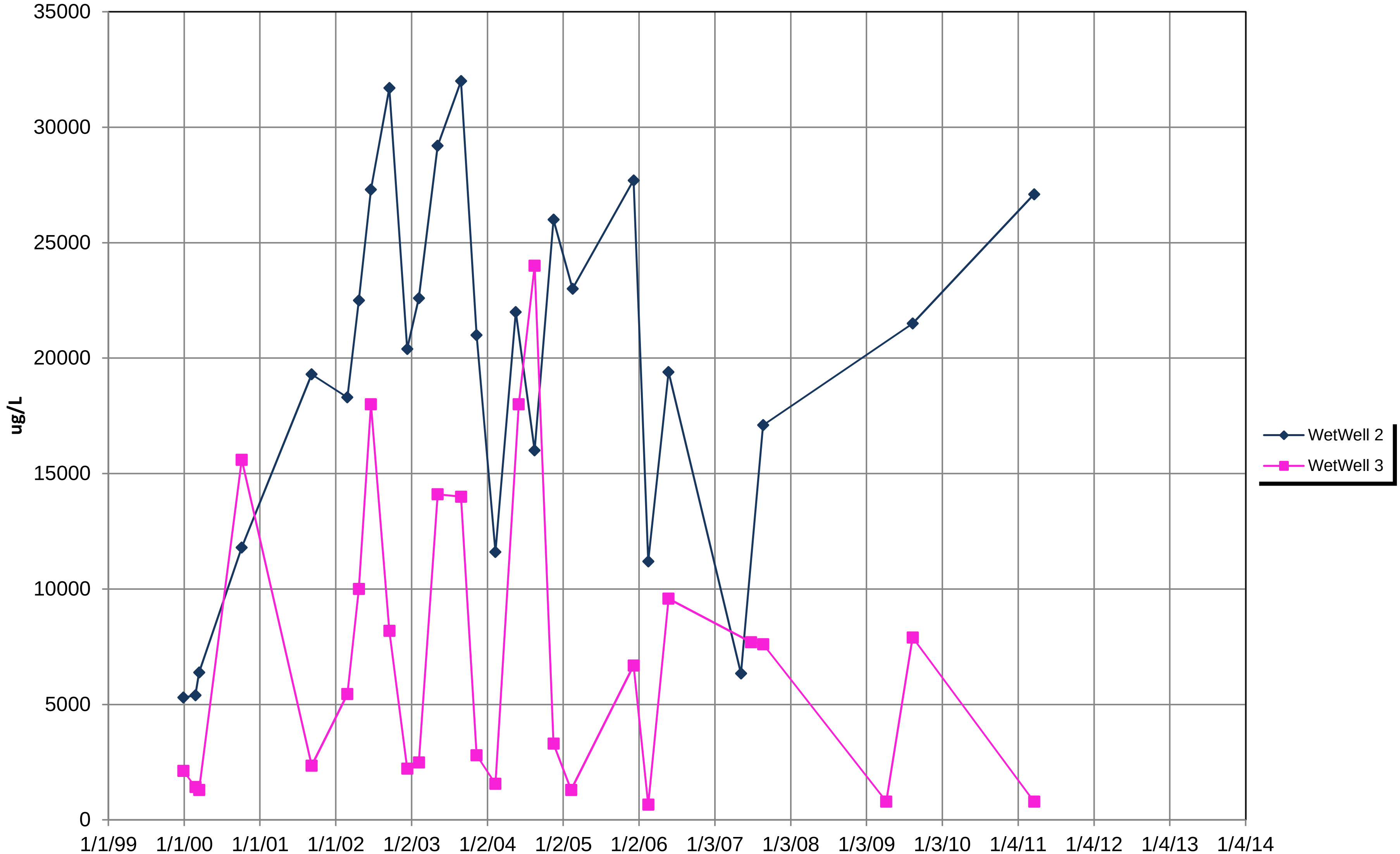


Figure 2.30b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - IRON DATA
(Non-detectable analyses plotted as zero)

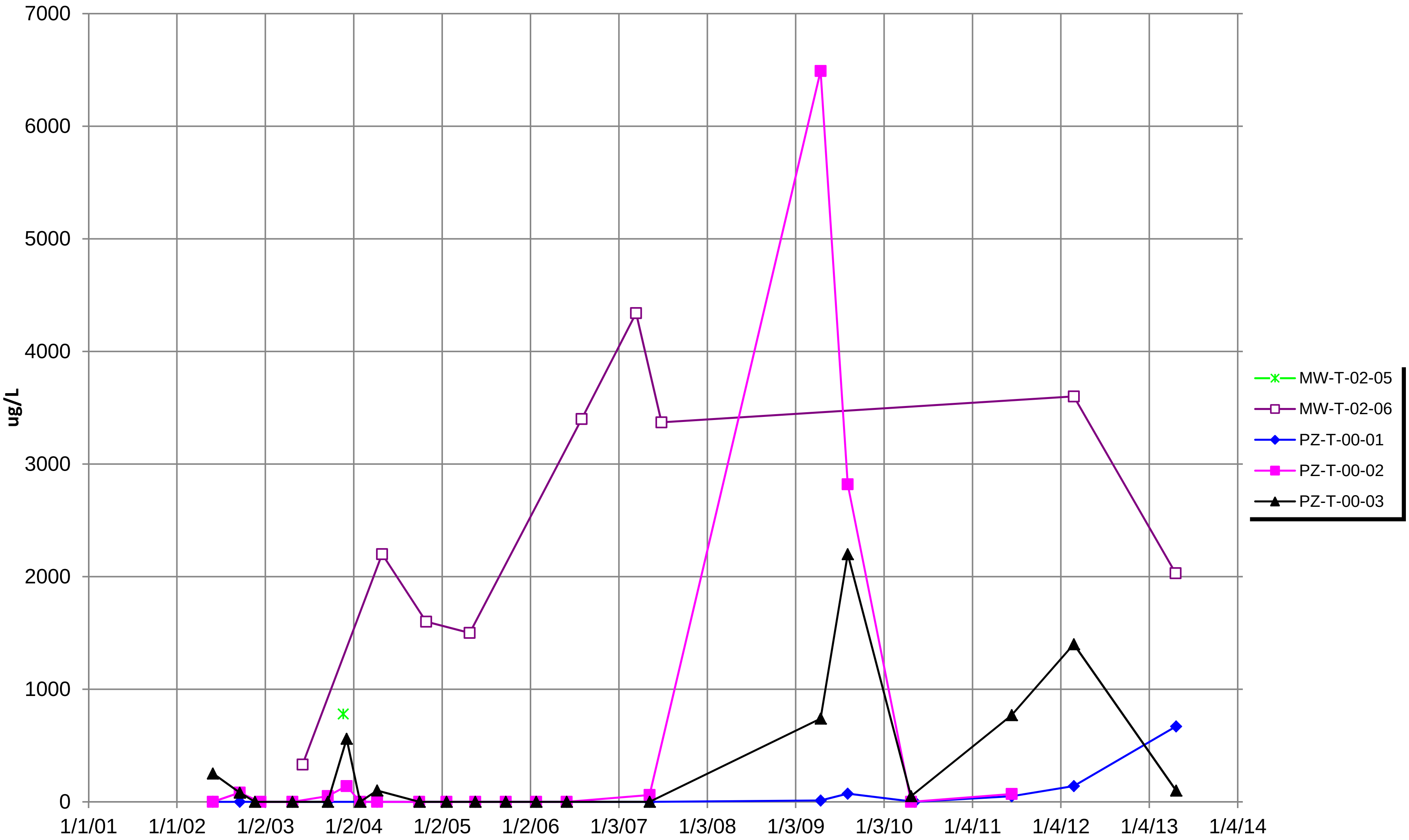


Figure 2.30c GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
SUCTION LYSIMETERS - IRON DATA
(Non-detectable analyses plotted as zero)

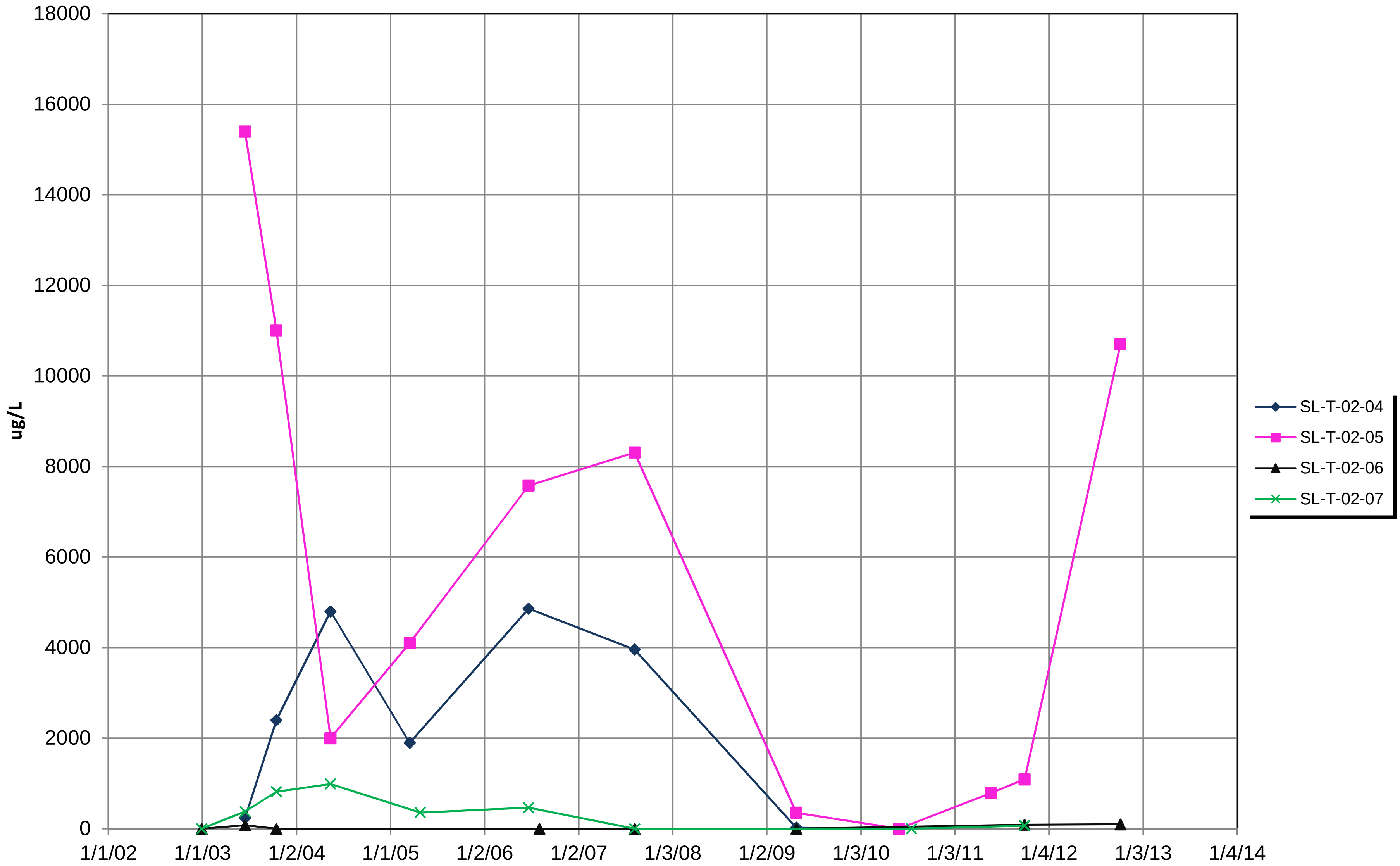


Figure 2.31a GREENS CREEK TAILINGS INTERNAL MONITORING SITES: WET WELLS - MANGANESE DATA (Non-detectable analyses plotted as zero)

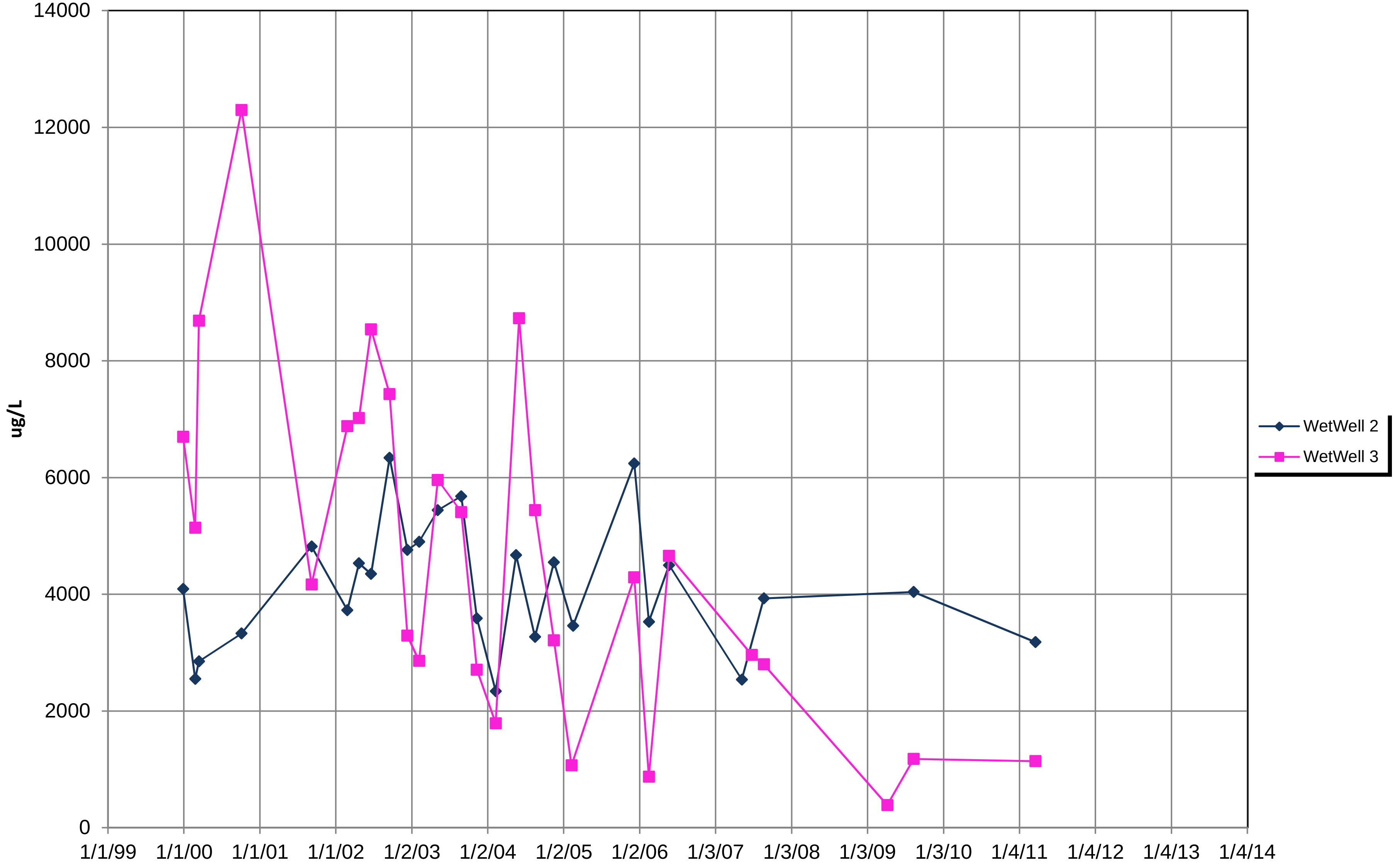


Figure 2.31b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - MANGANESE DATA (Non-detectable analyses plotted as zero)

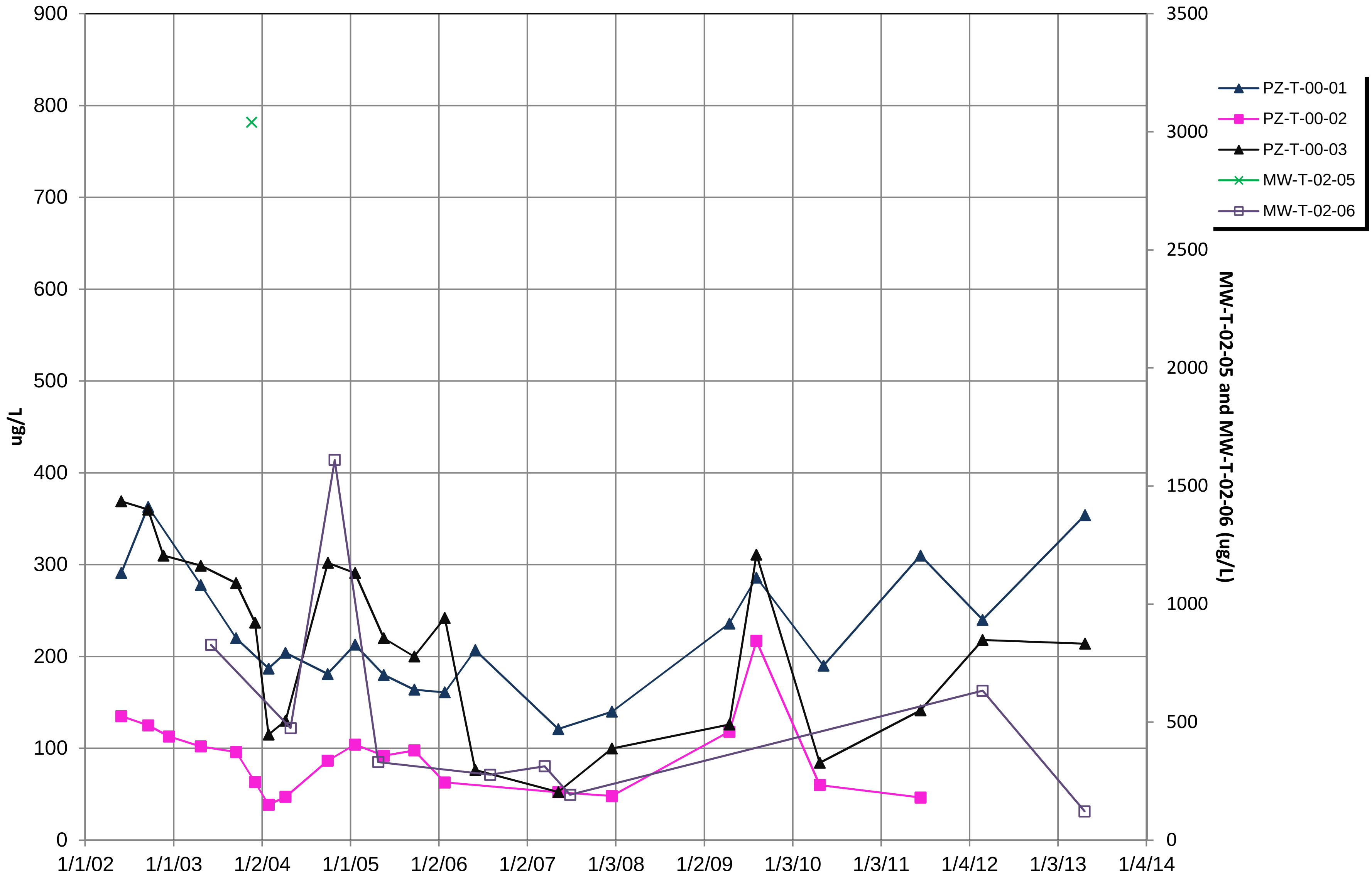


Figure 2.31c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - MANGANESE DATA (Non-detectable analyses plotted as zero)

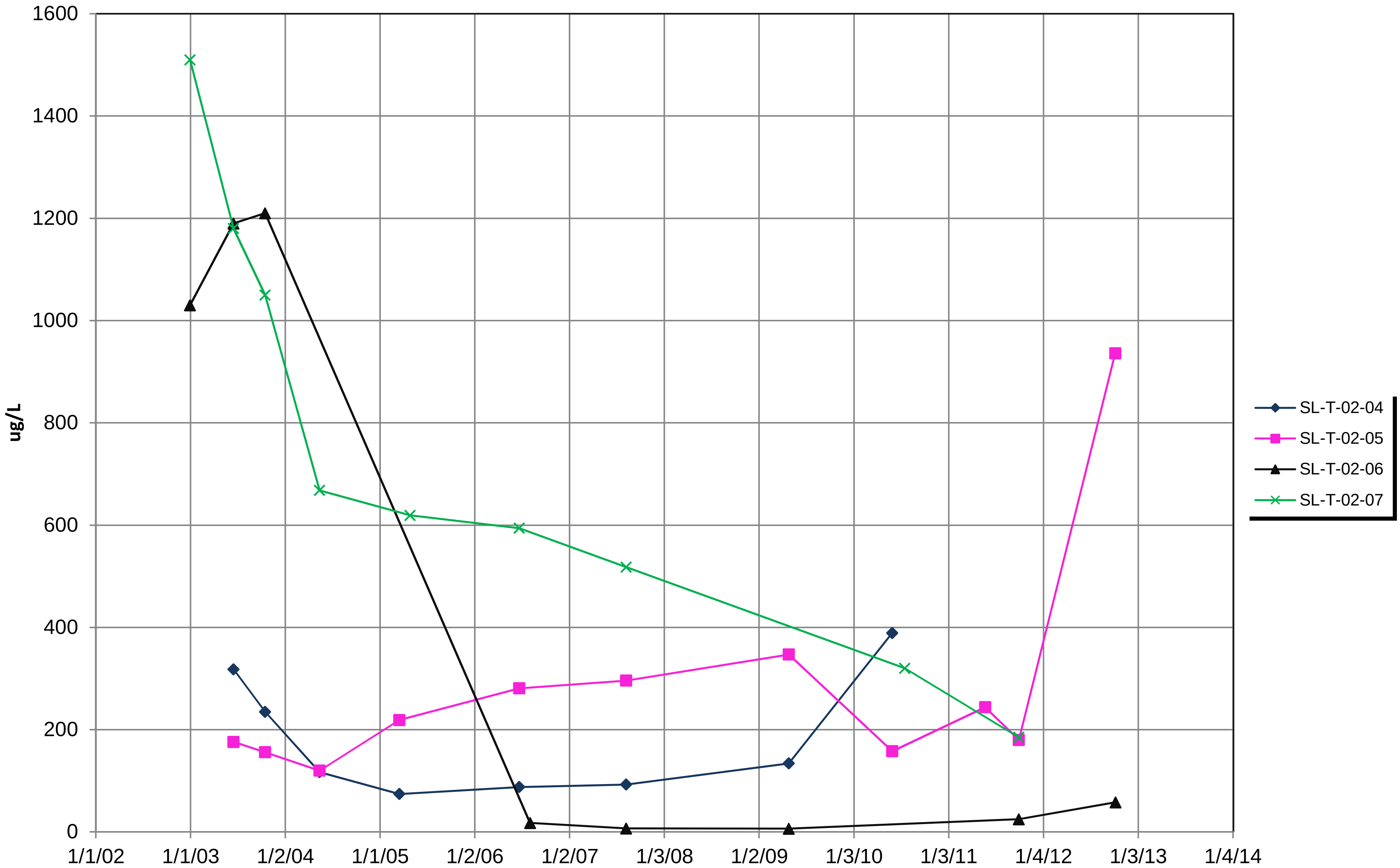
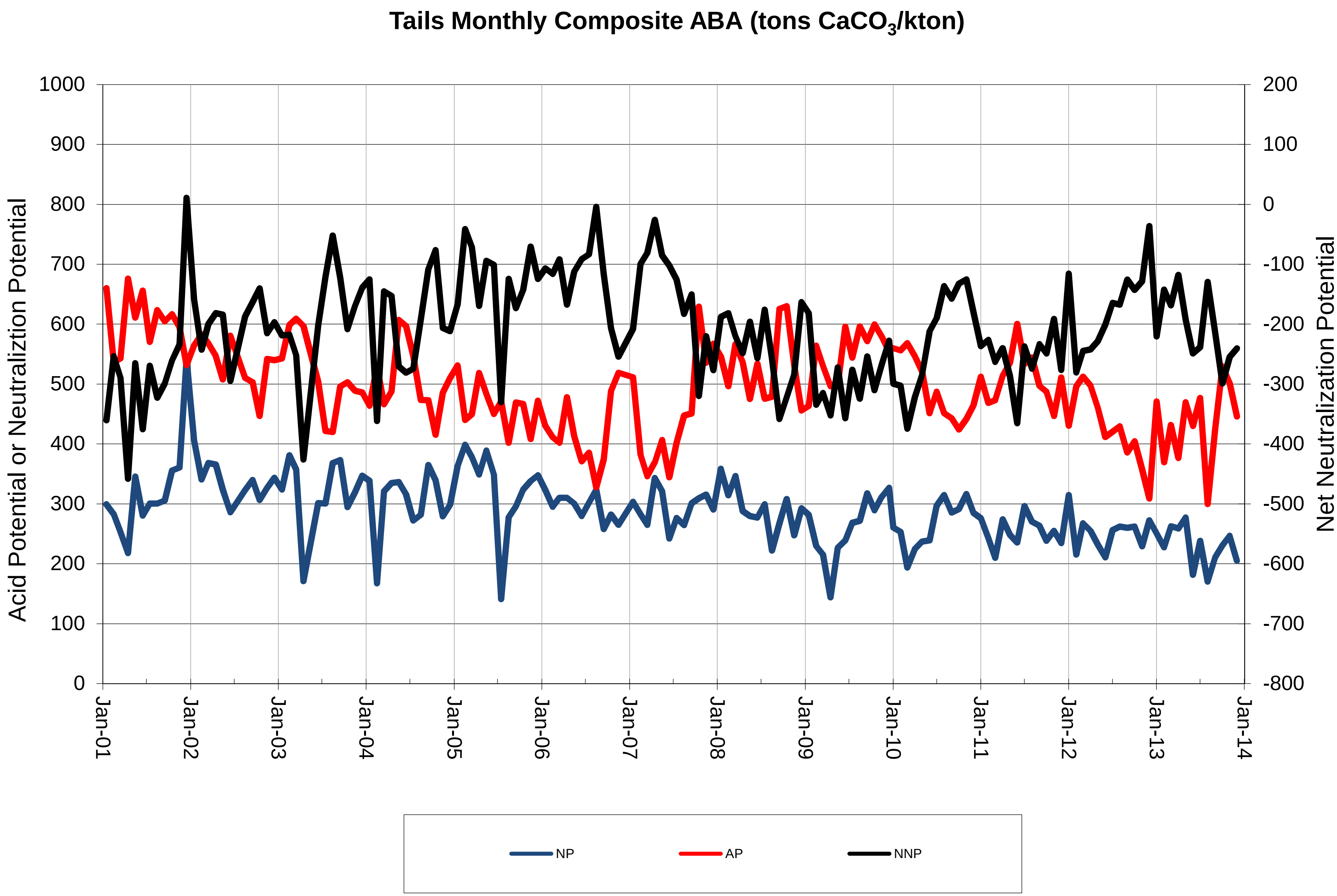


Figure 2.32



Tails Monthly Composite ABA (tons $CaCO_3$/kton)
Acid Potential or Neutraliztion Potential
Net Neutralization Potential
1000
900
800
700
600
500
400
300
200
100
0
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
NP
AP
NNP

Figure 2.33 Tailings ABA Data

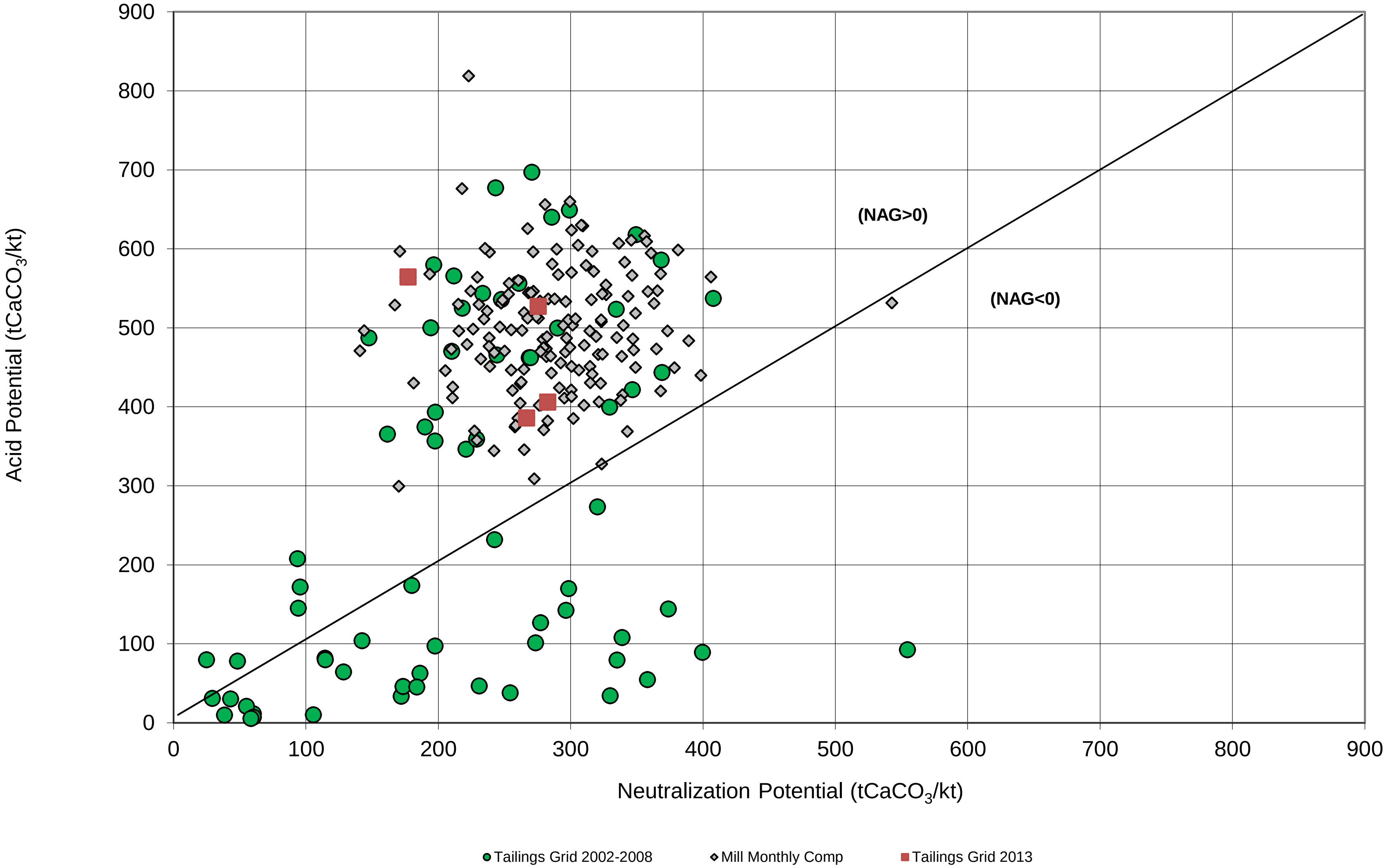


Figure 2.34 Tailings Grid ABA Data

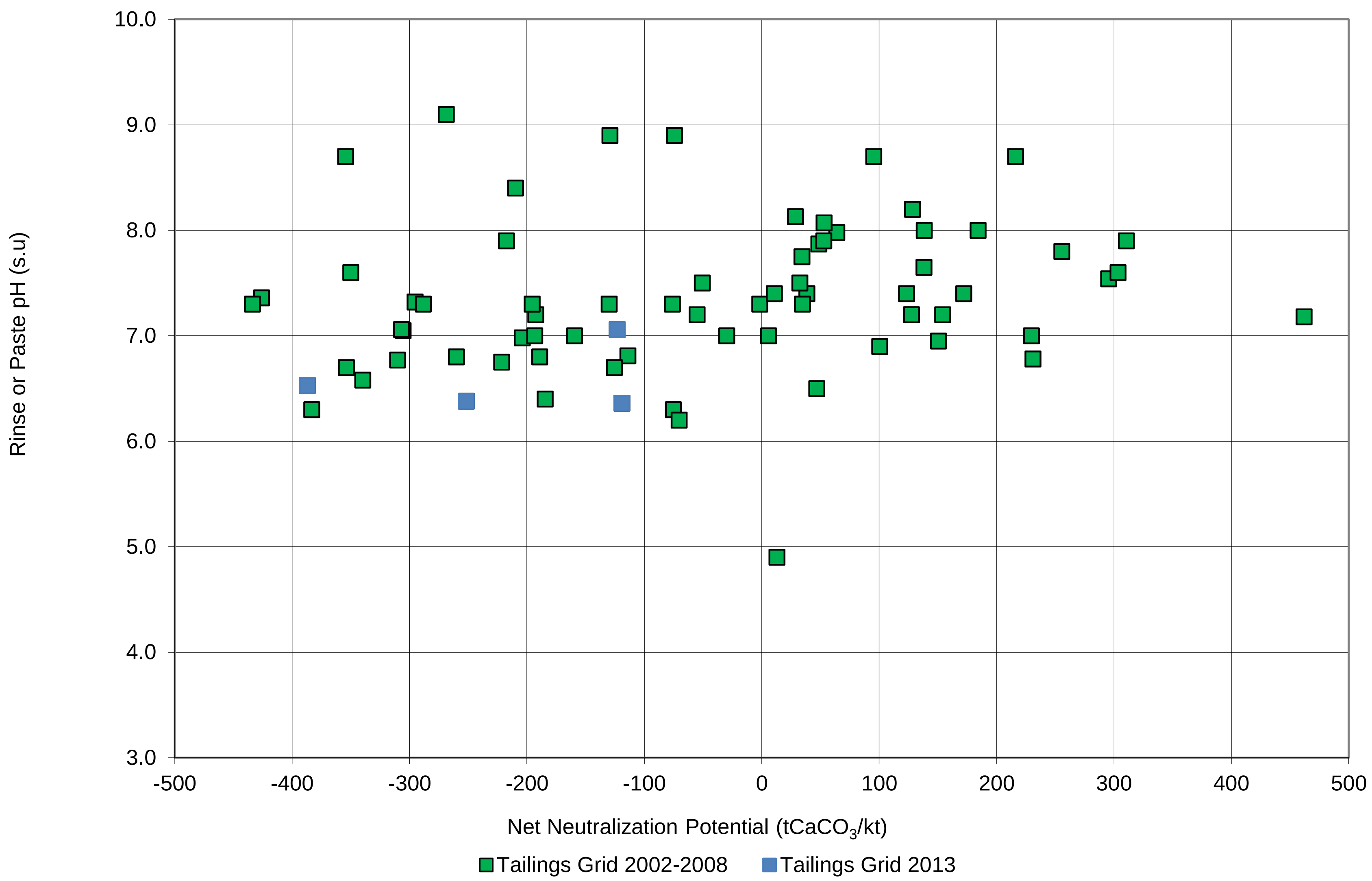
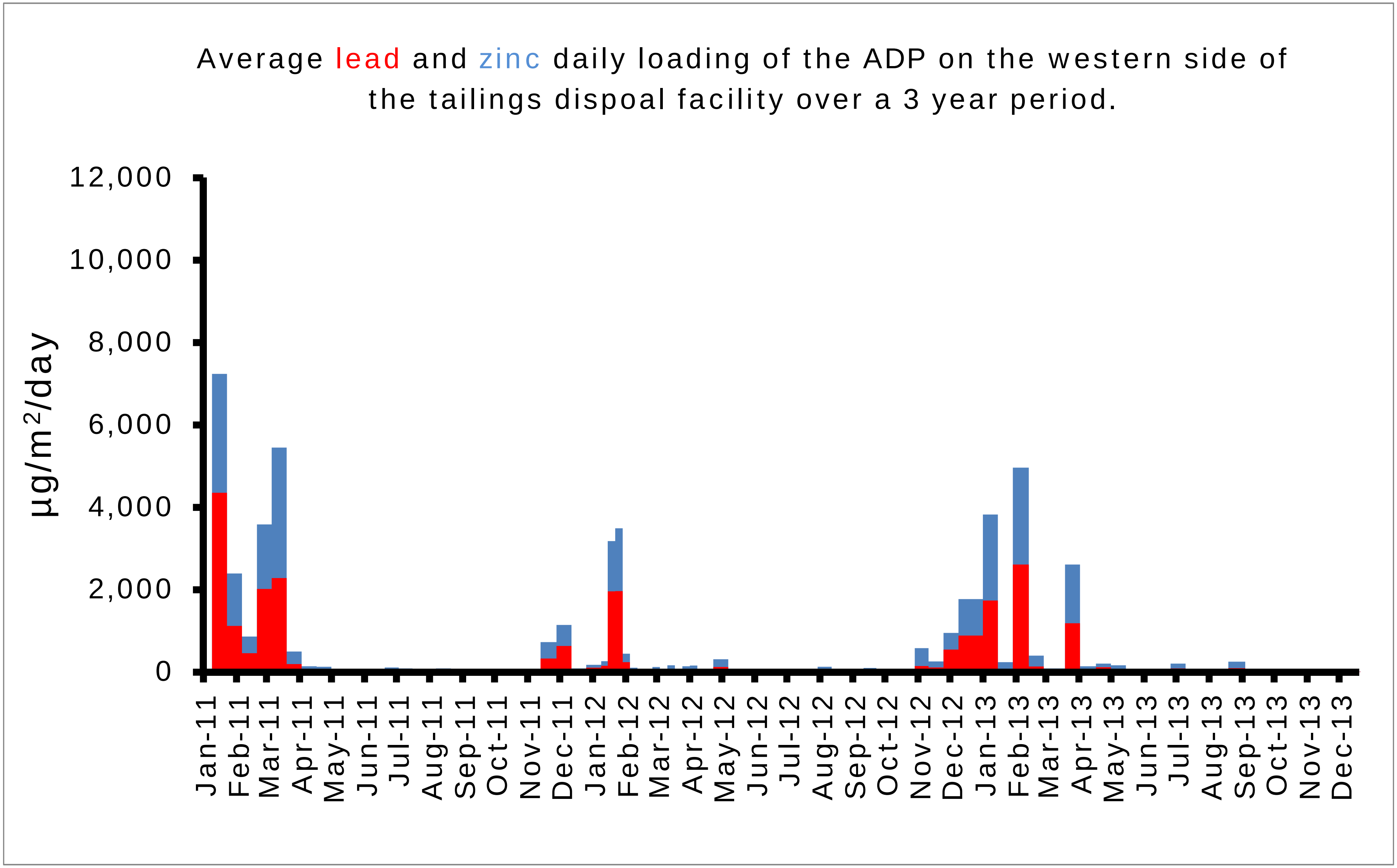


FIGURE 2.37



Average lead and zinc daily loading of the ADP on the western side of the tailings dispoal facility over a 3 year period.
µg/m2/day
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan-11
Feb-11
Mar-11
Apr-11
May-11
Jun-11
Jul-11
Aug-11
Sep-11
Oct-11
Nov-11
Dec-11
Jan-12
Feb-12
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12
Dec-12
Jan-13
Feb-13
Mar-13
Apr-13
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13

Figure 2.40 Site 609 Zinc Concentrations

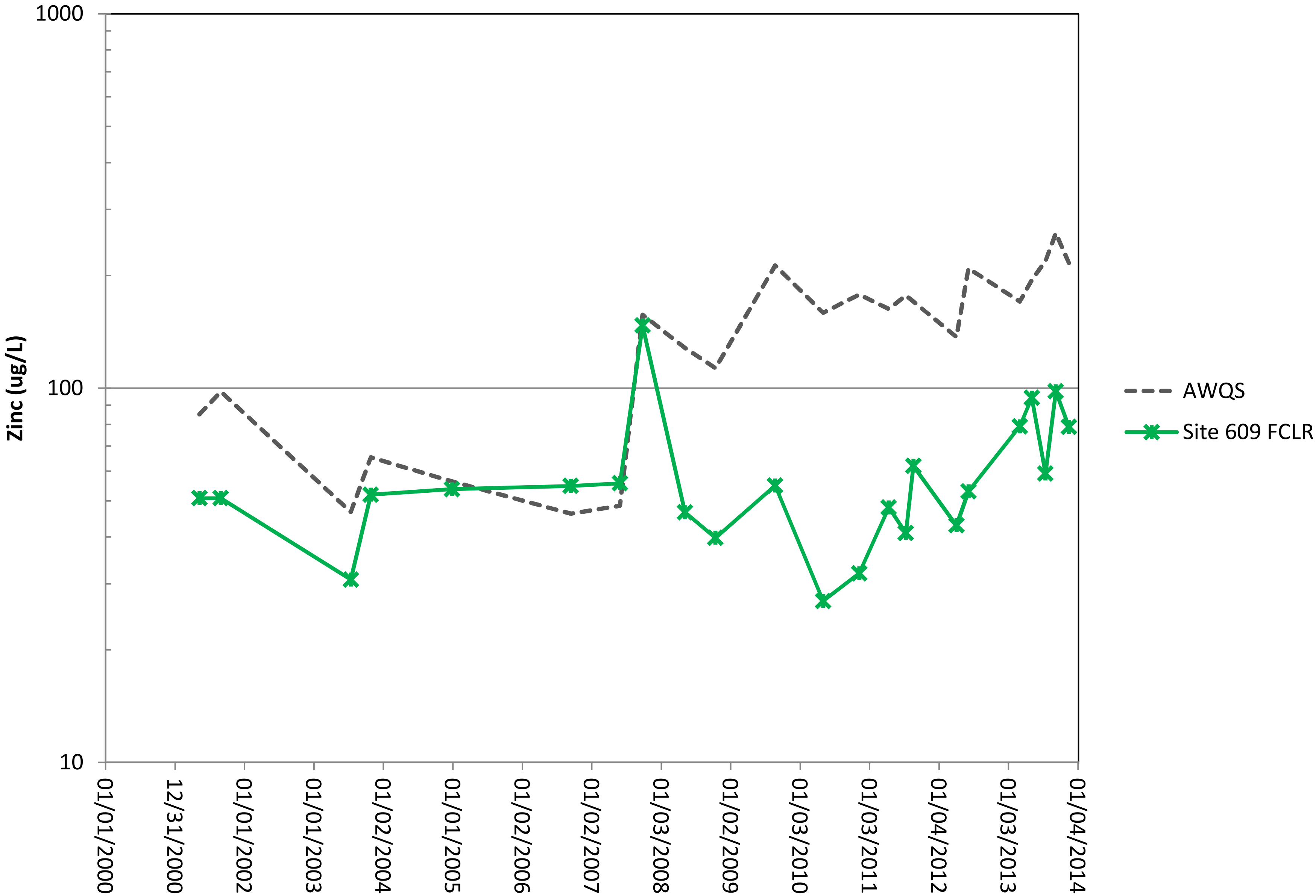


Figure 2.41 Site 609 Lead Concentrations

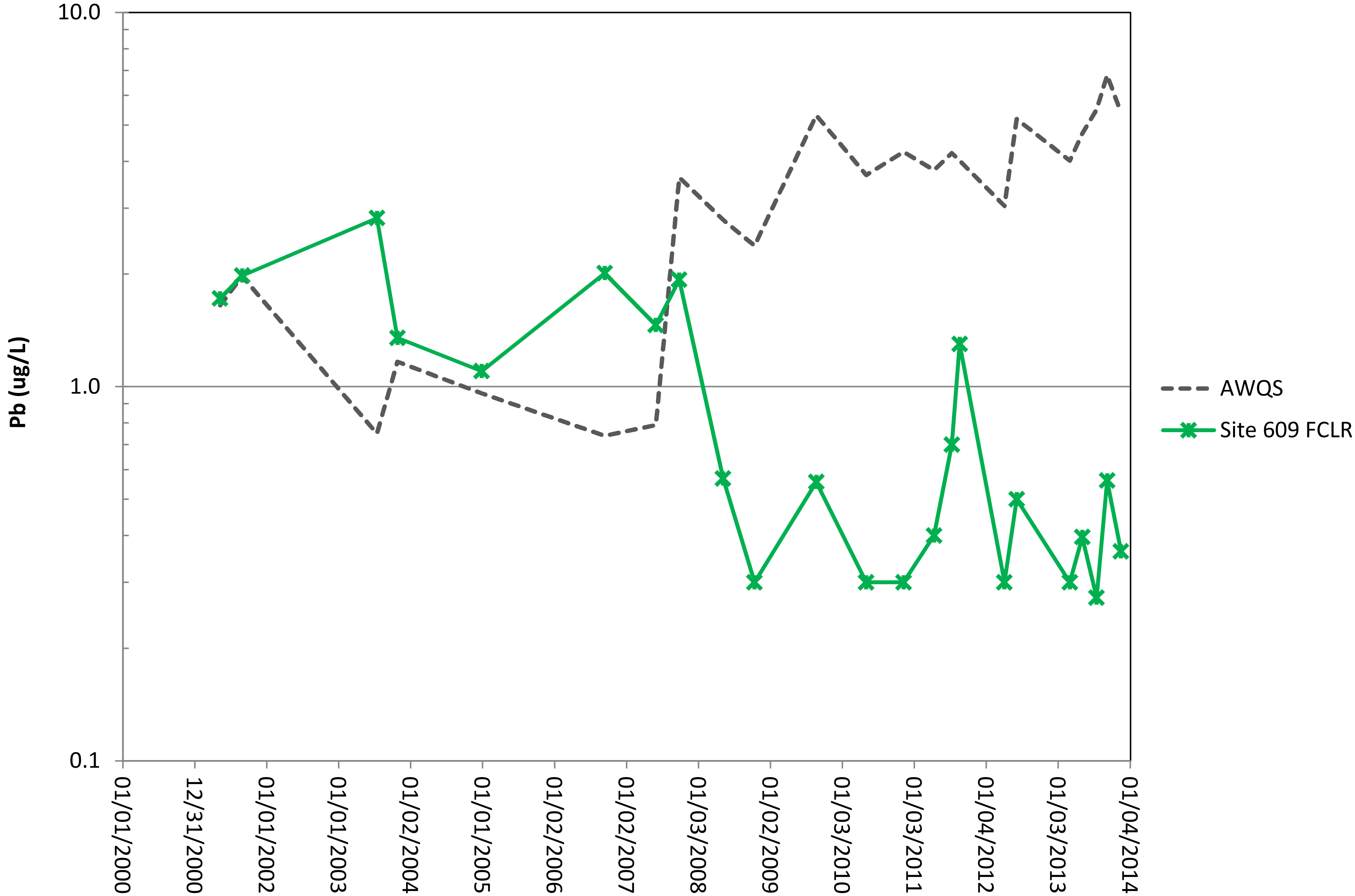


Figure 2.42 Site 60 Zinc Concentration

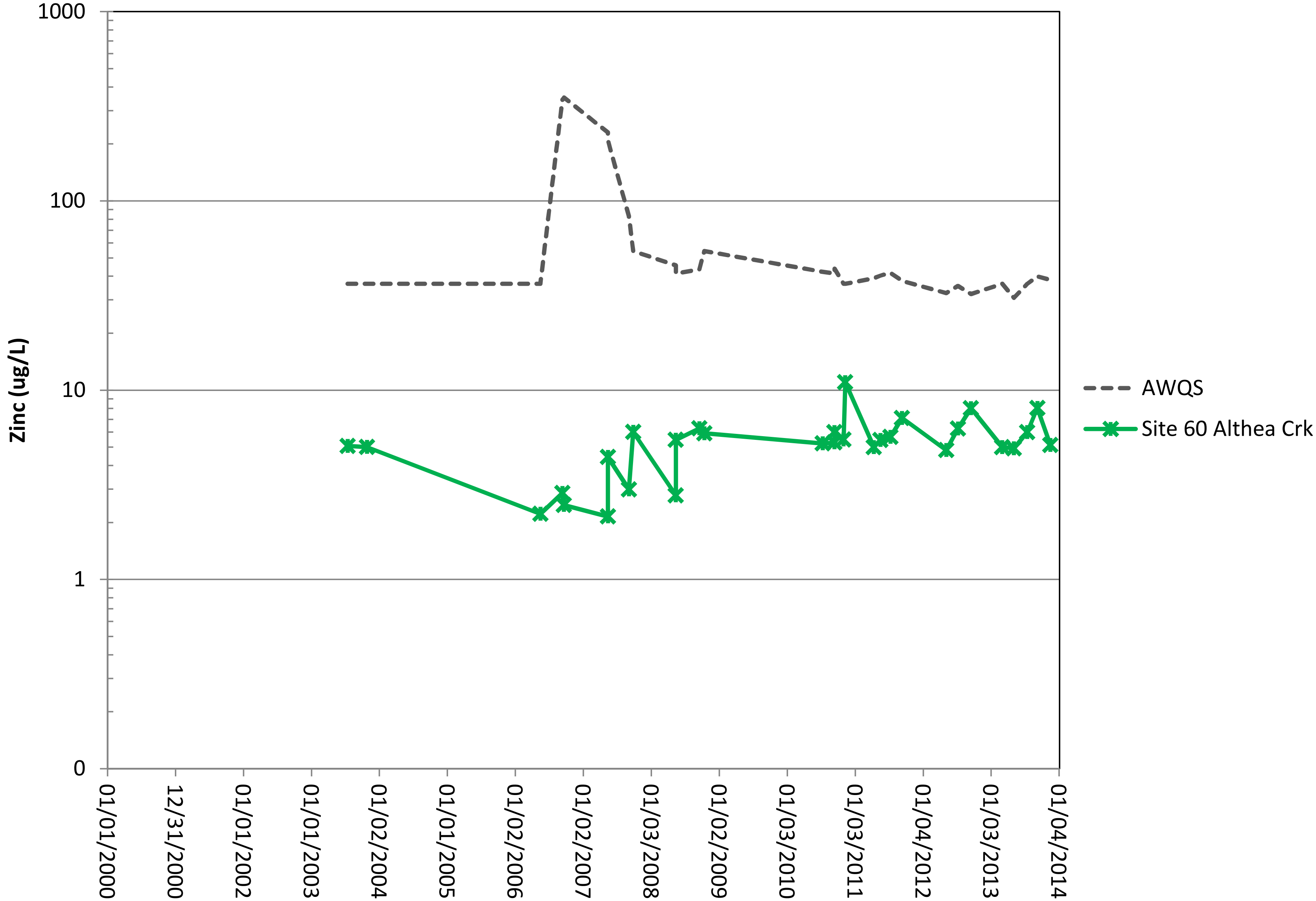


Figure 2.43 Site 60 Lead Concentration

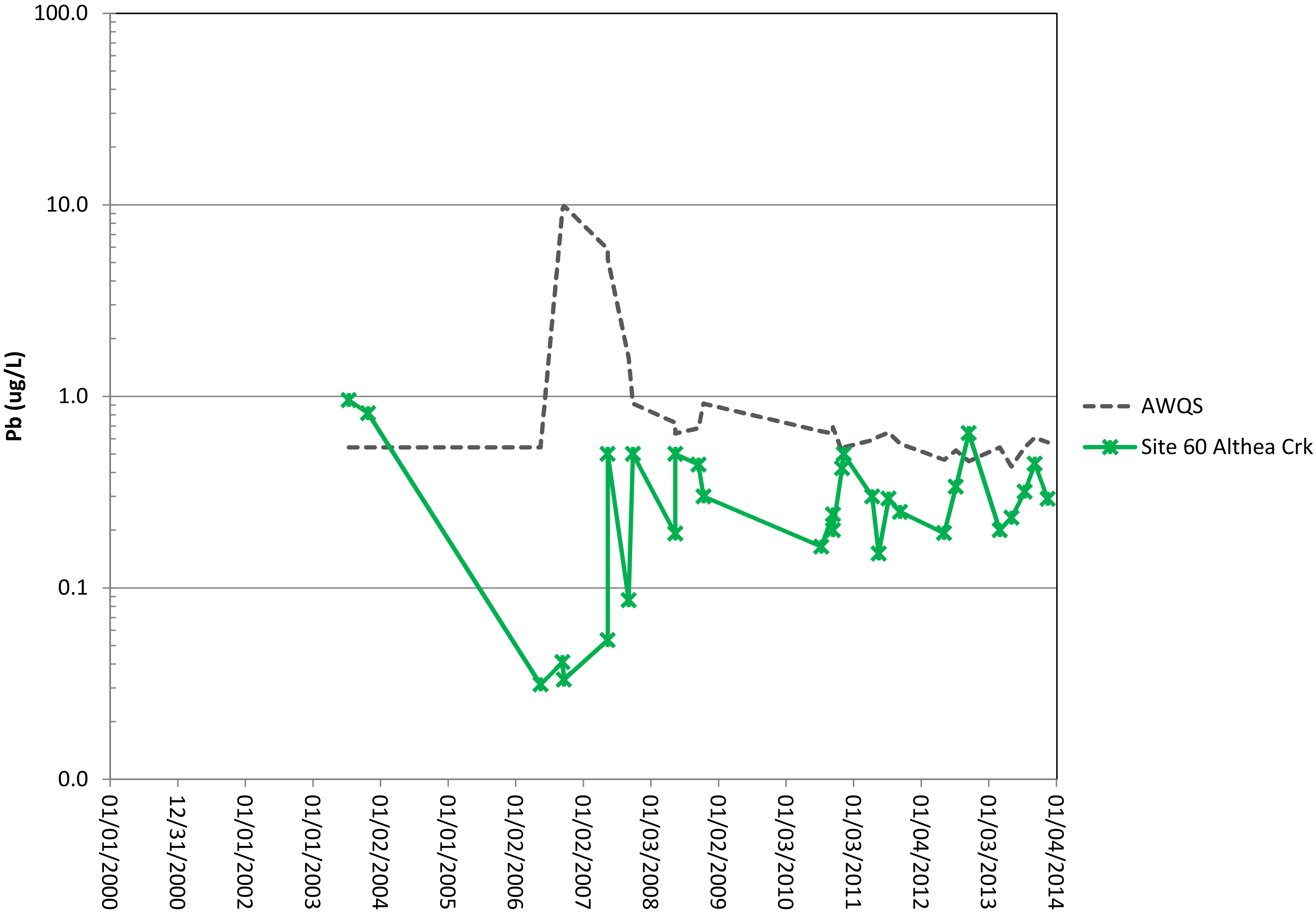


Figure 3.1 Pressure Data for Piezometer 52

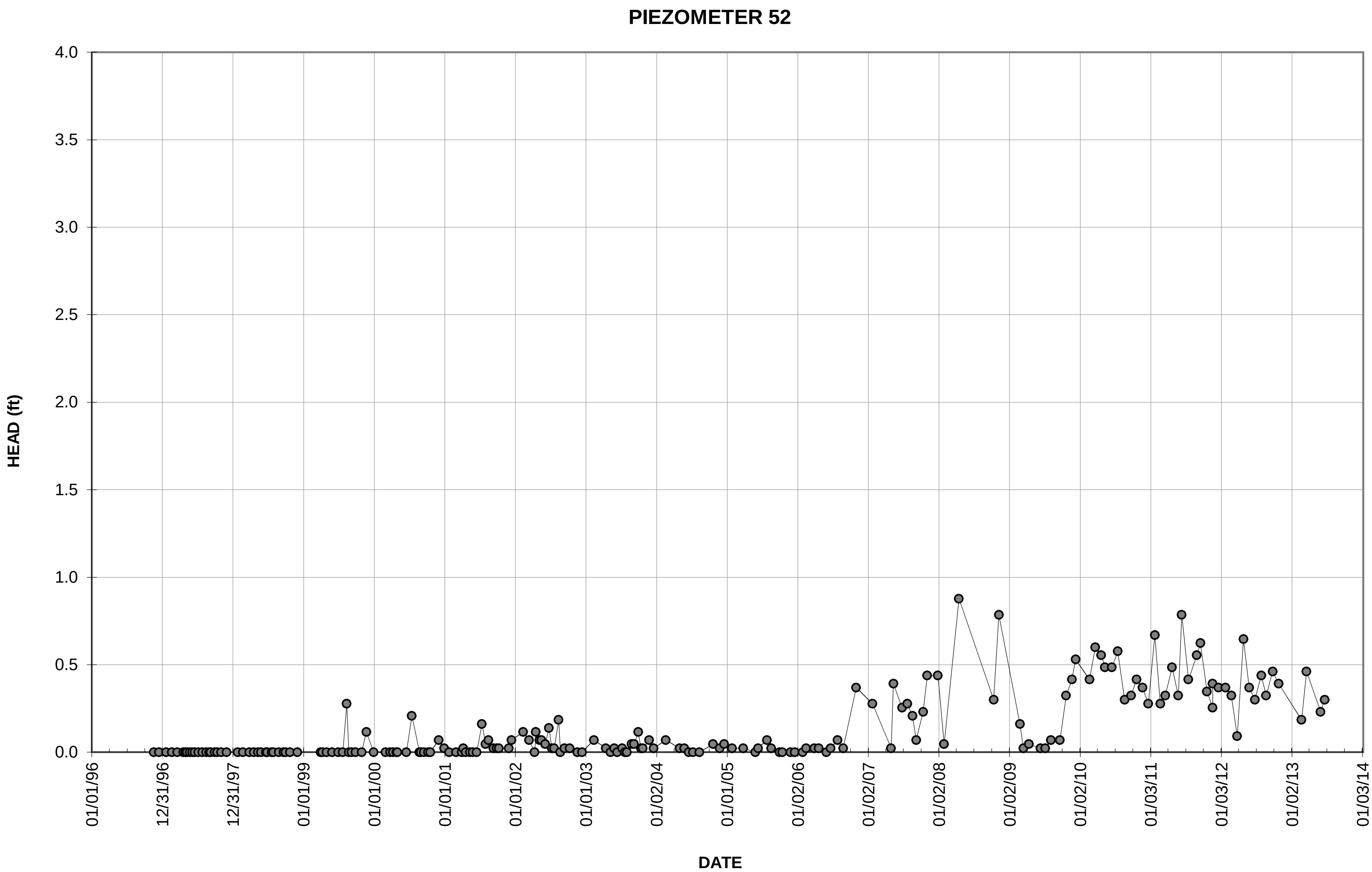


Figure 3.2 Pressure Data for Piezometer 53

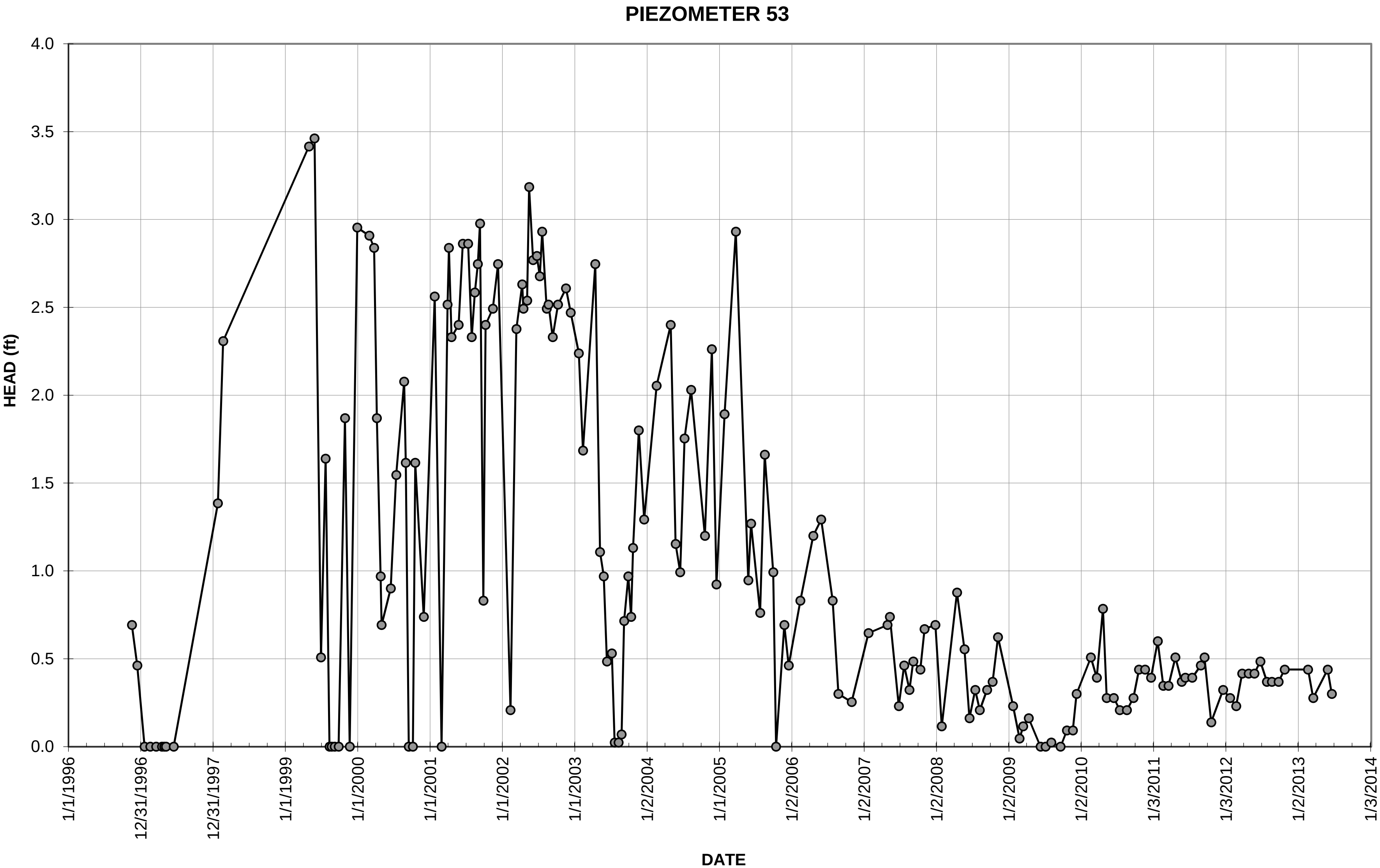


Figure 3.3 Pressure Data for Piezometer 54

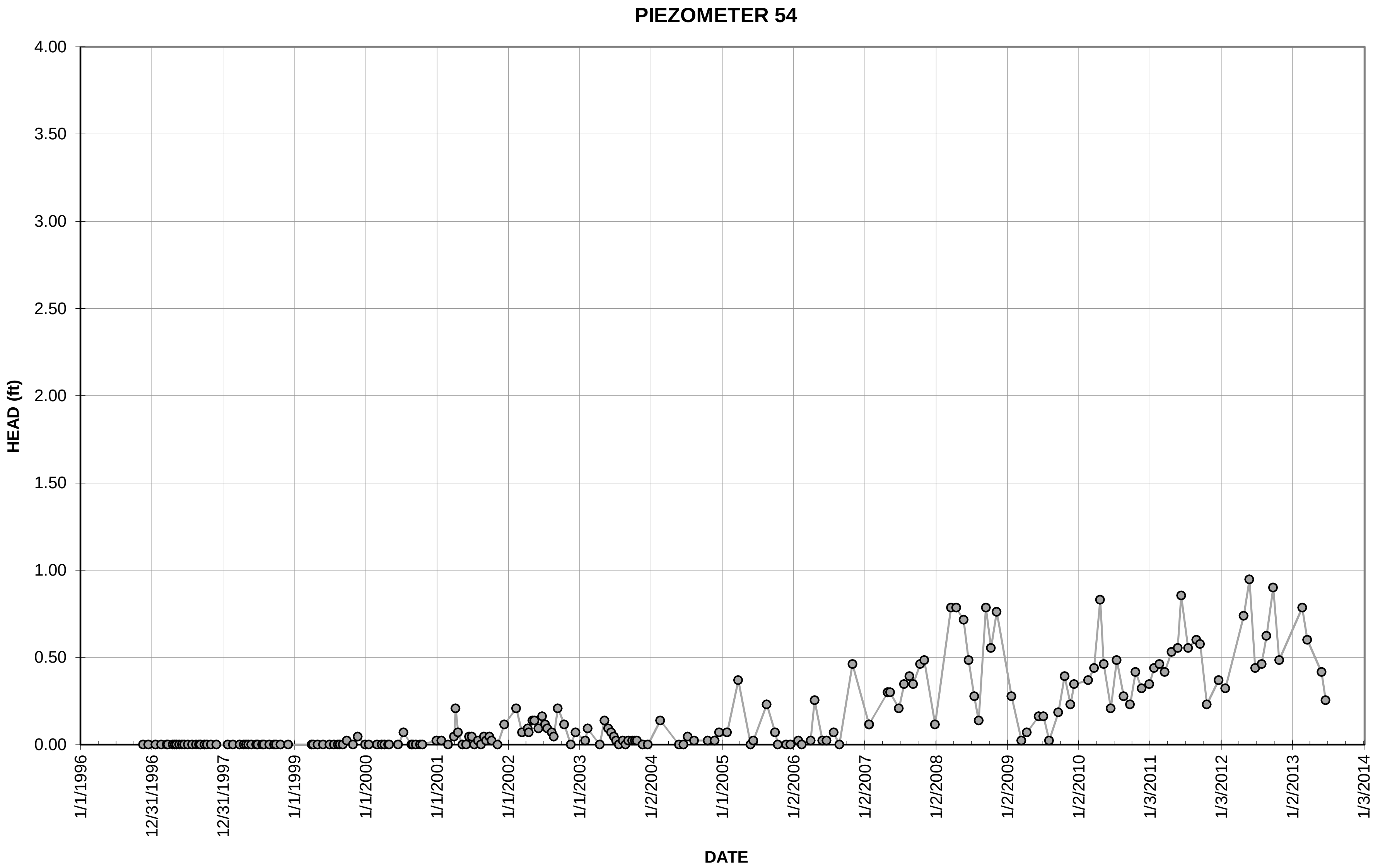


Figure 3.4 Pressure Data for Piezometer 55

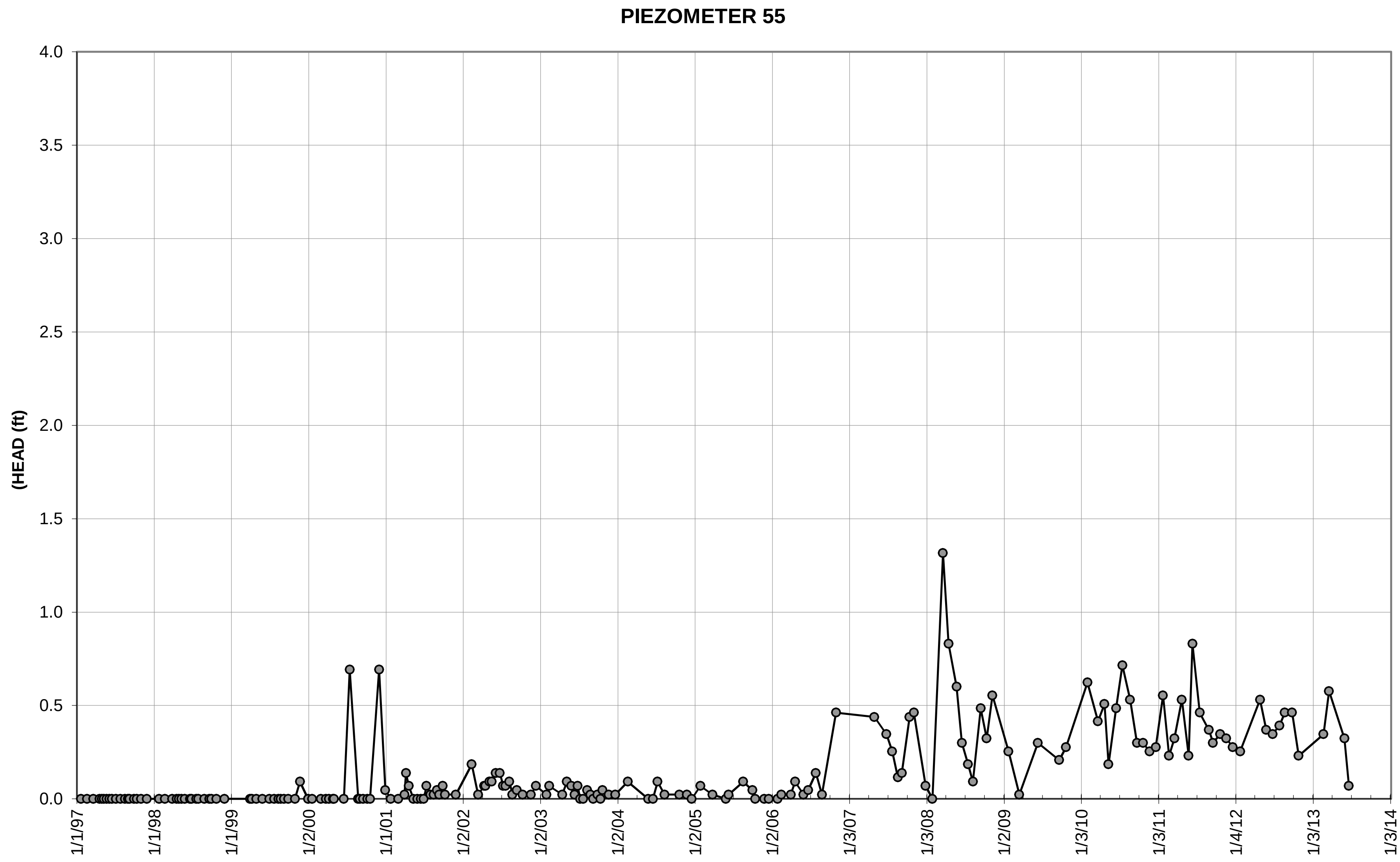


Figure 3.5 Water Level Data for Well MW-23/D-00-03

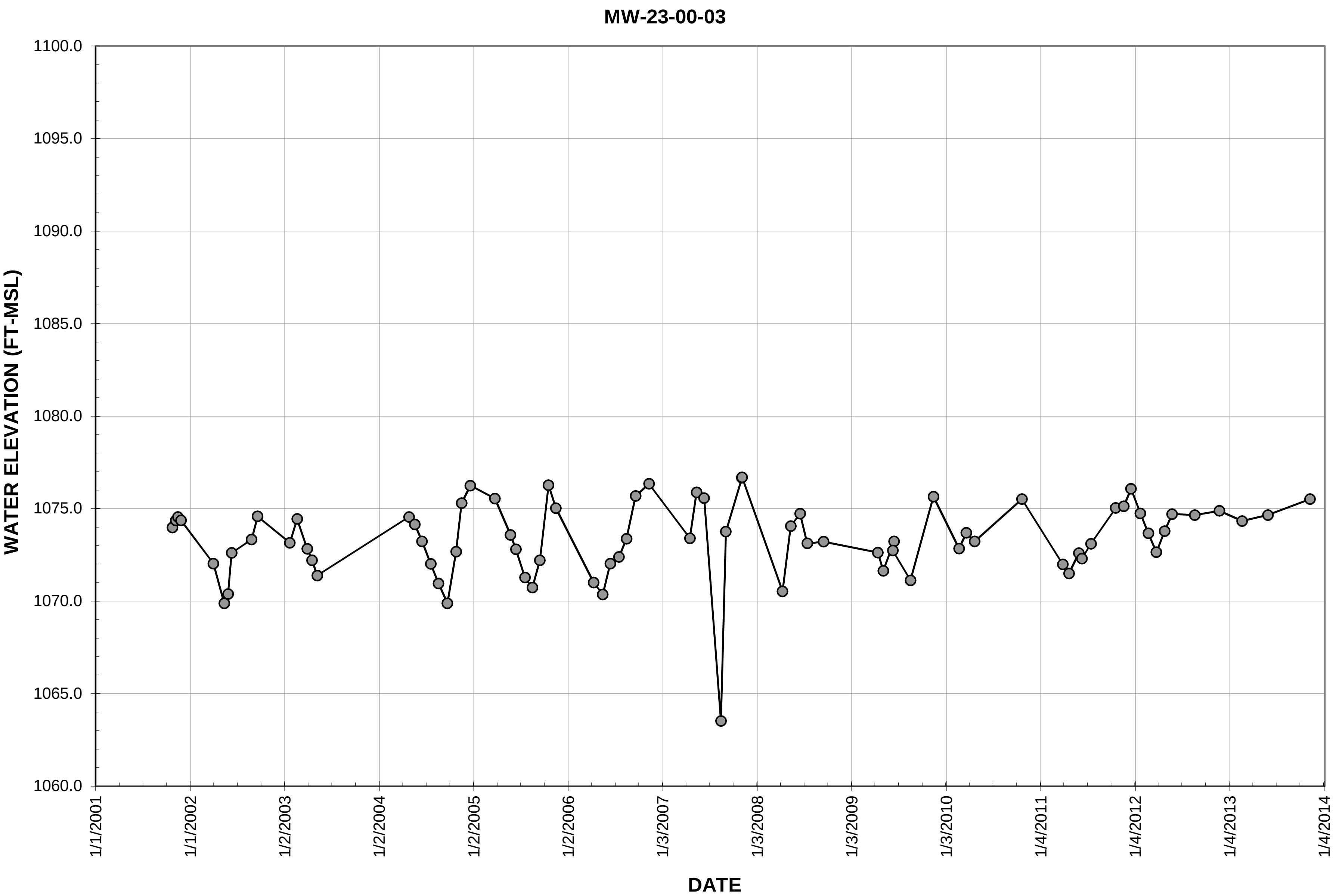


Figure 3.6 Water Level Data for Well MW-23-A2D

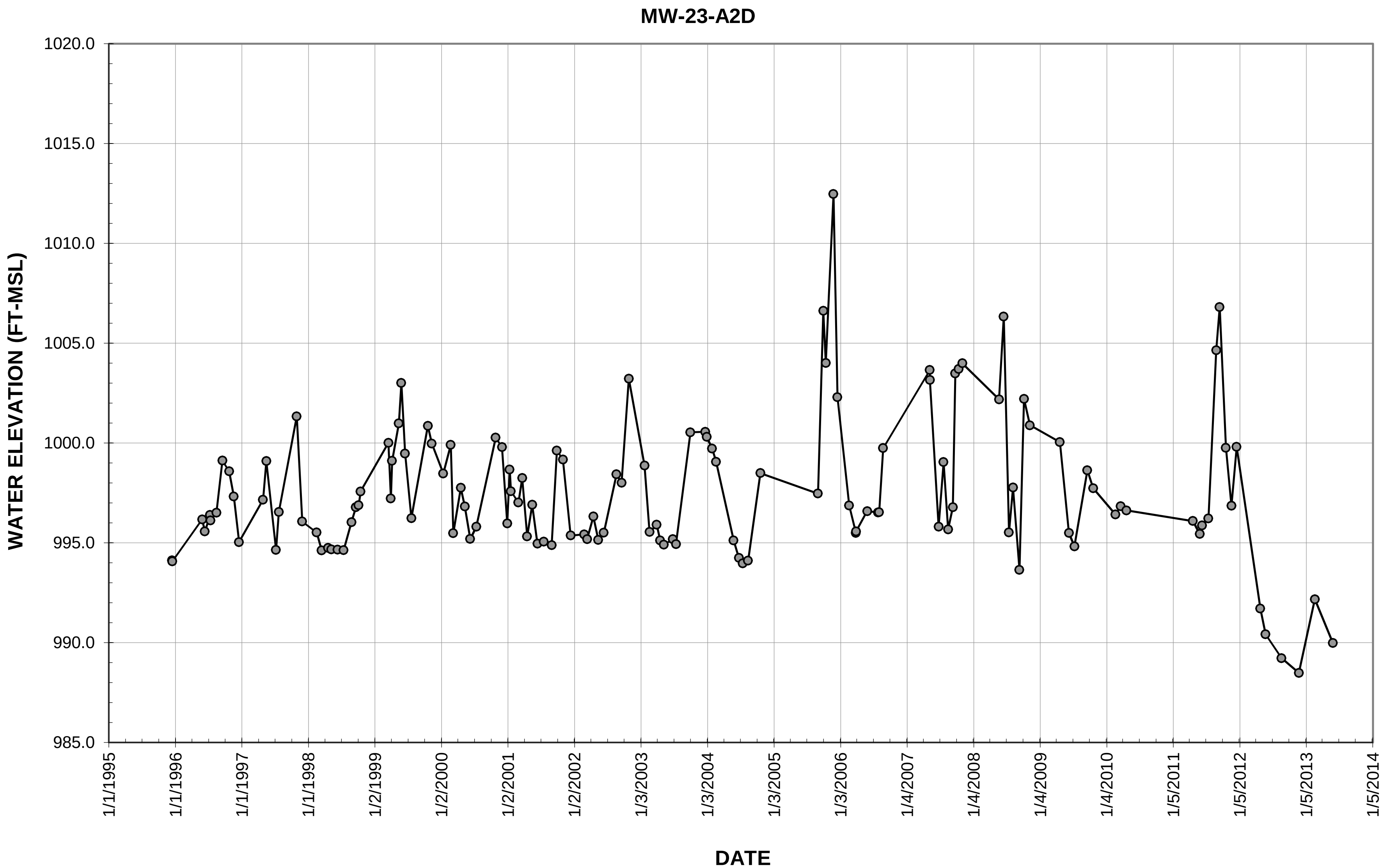


Figure 3.7 Water Level Data for Well MW-23-A2S

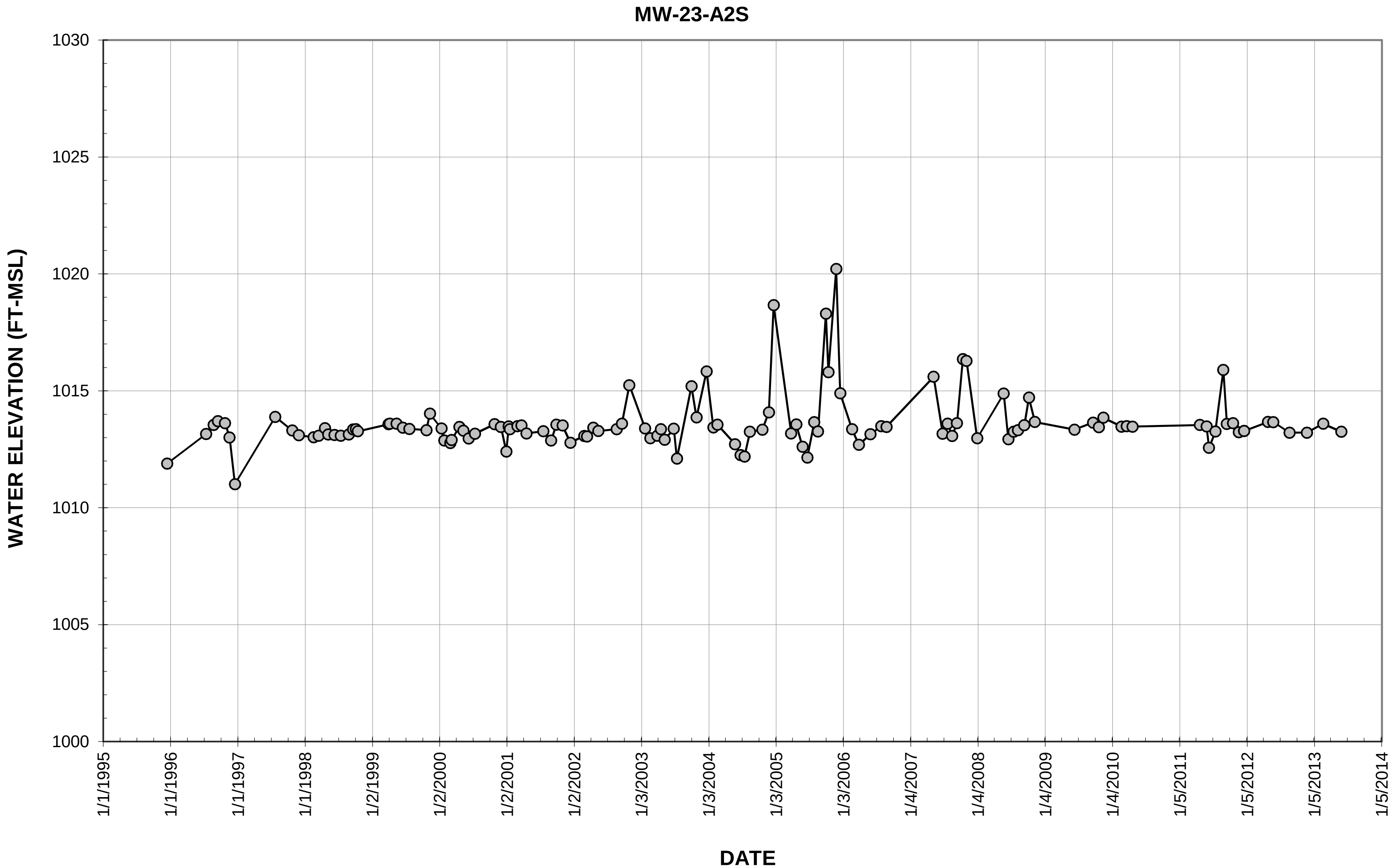


Figure 3.8 Water Level Data for Well MW-23-98-01

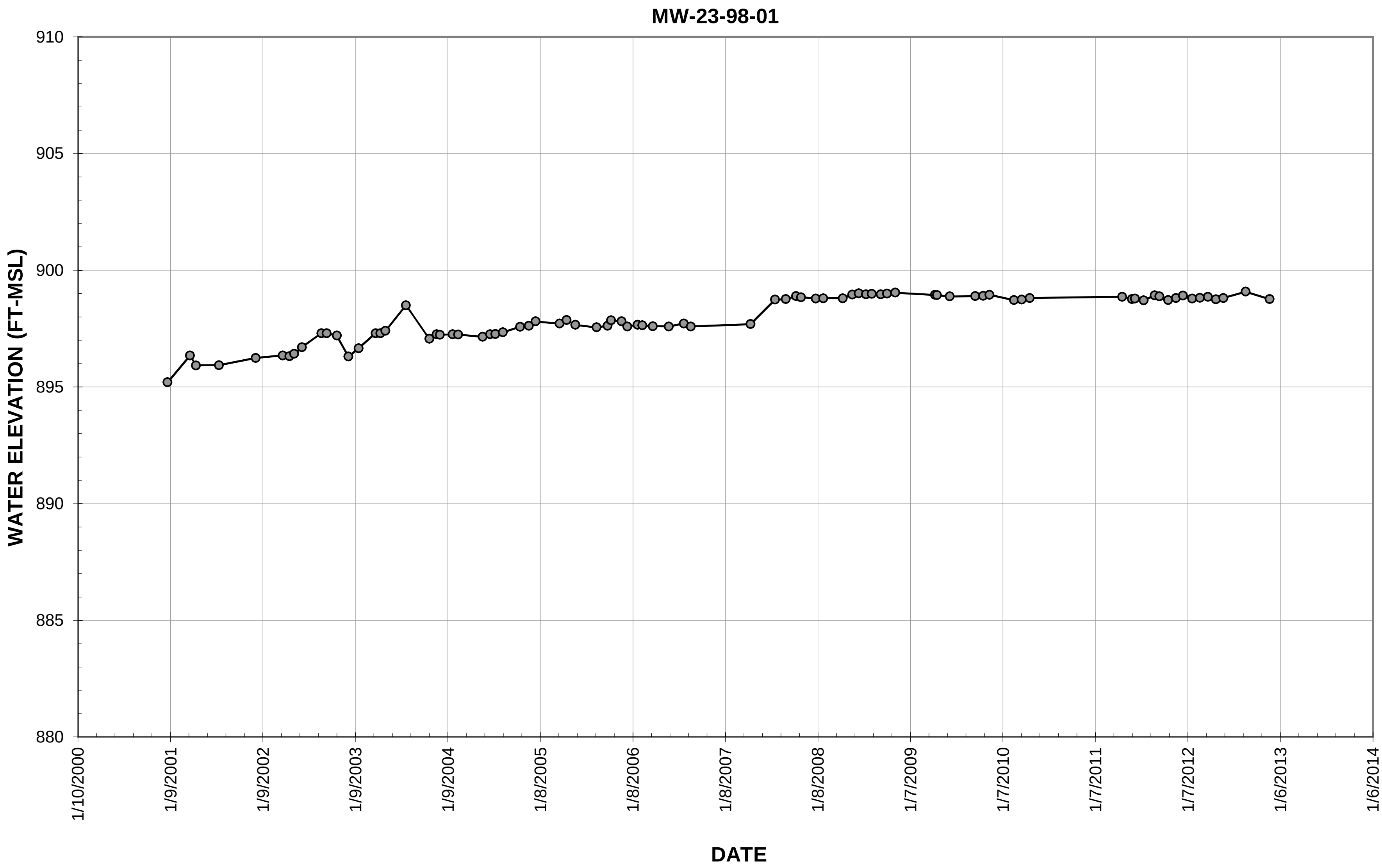


Figure 3.9 Water Level Data for Well MW-23-A4

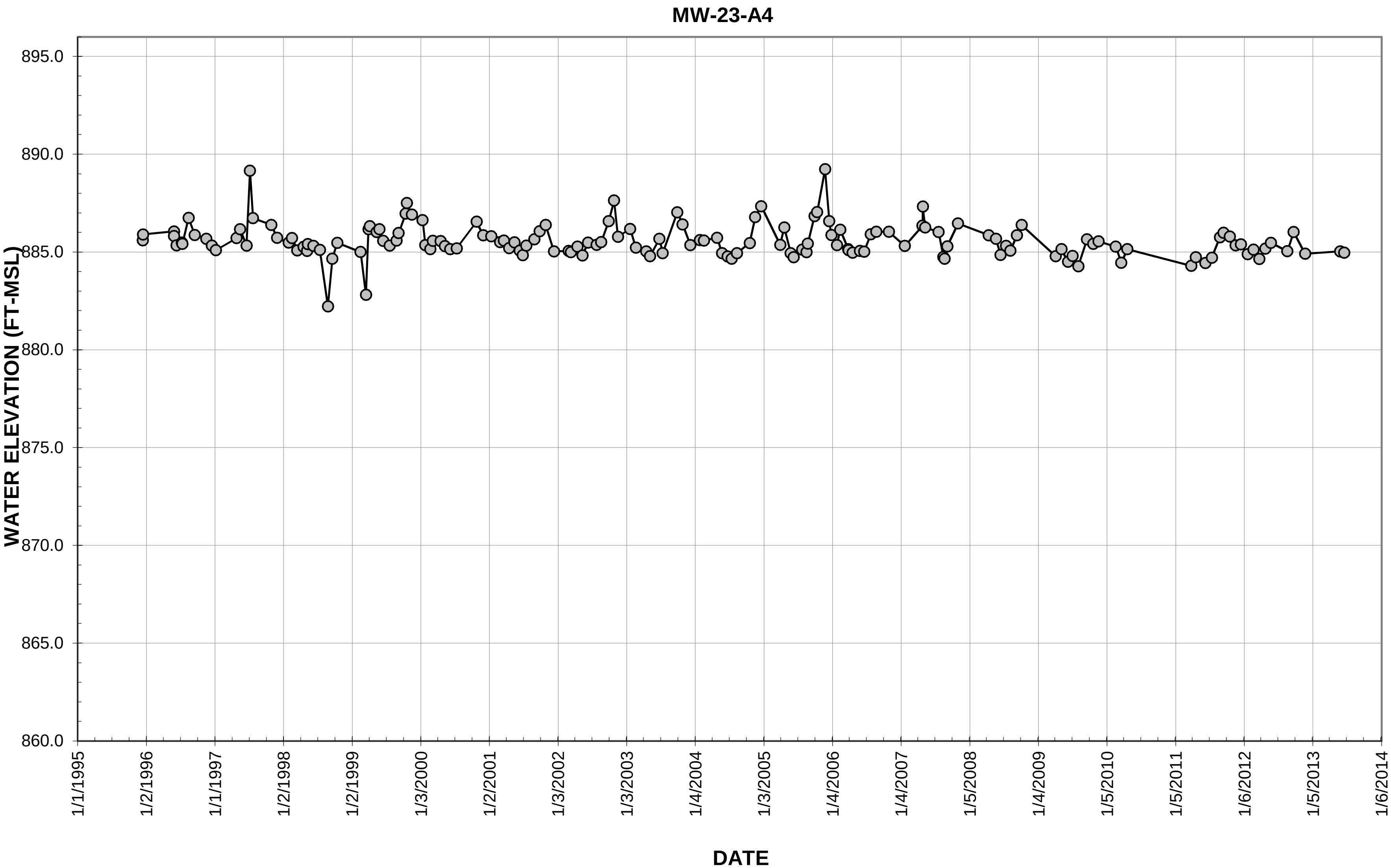


Figure 3.10 Water Level Data for MW-23/D-00-01

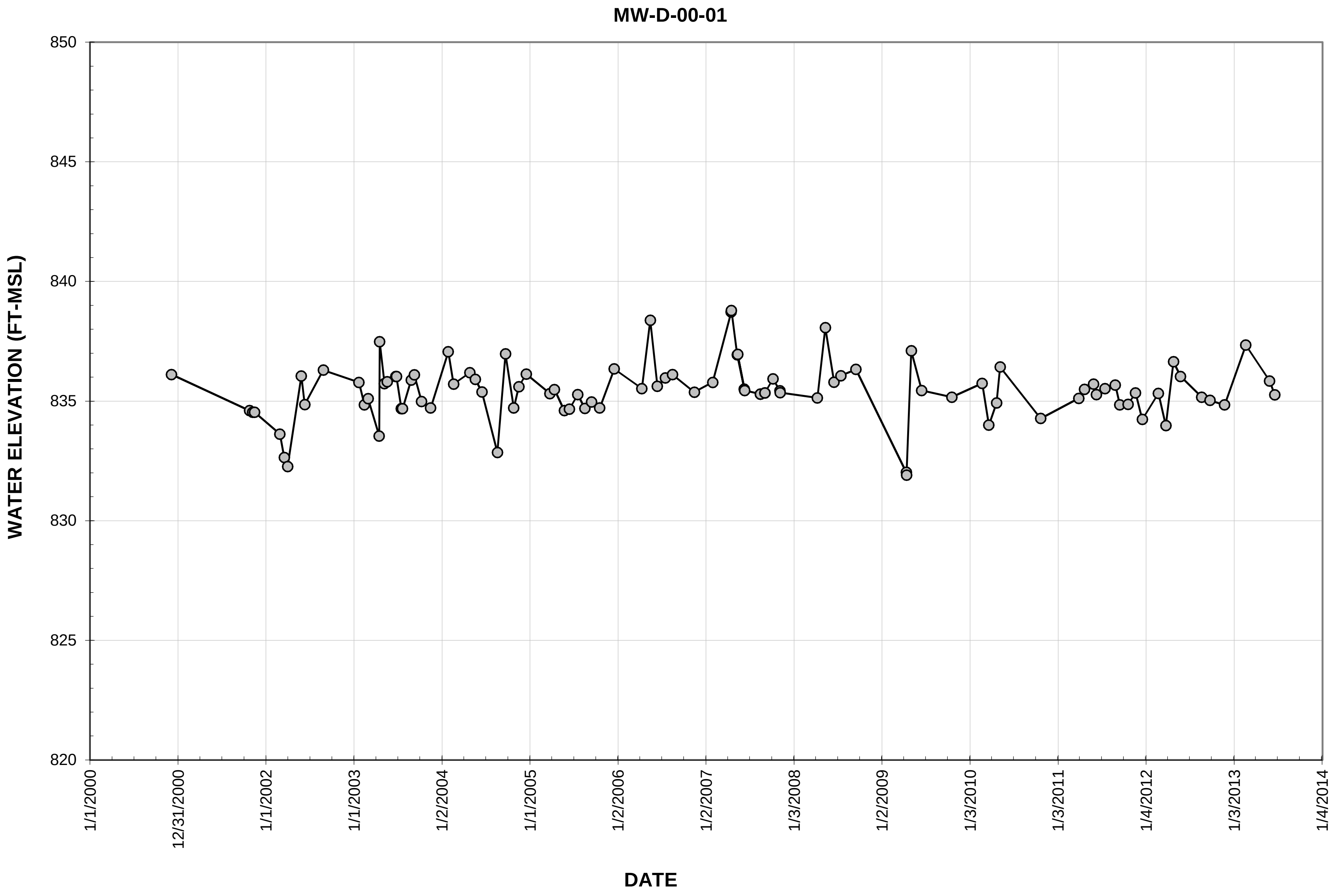


Figure 3.11 Water Level Data for Well MW-D-94-D3

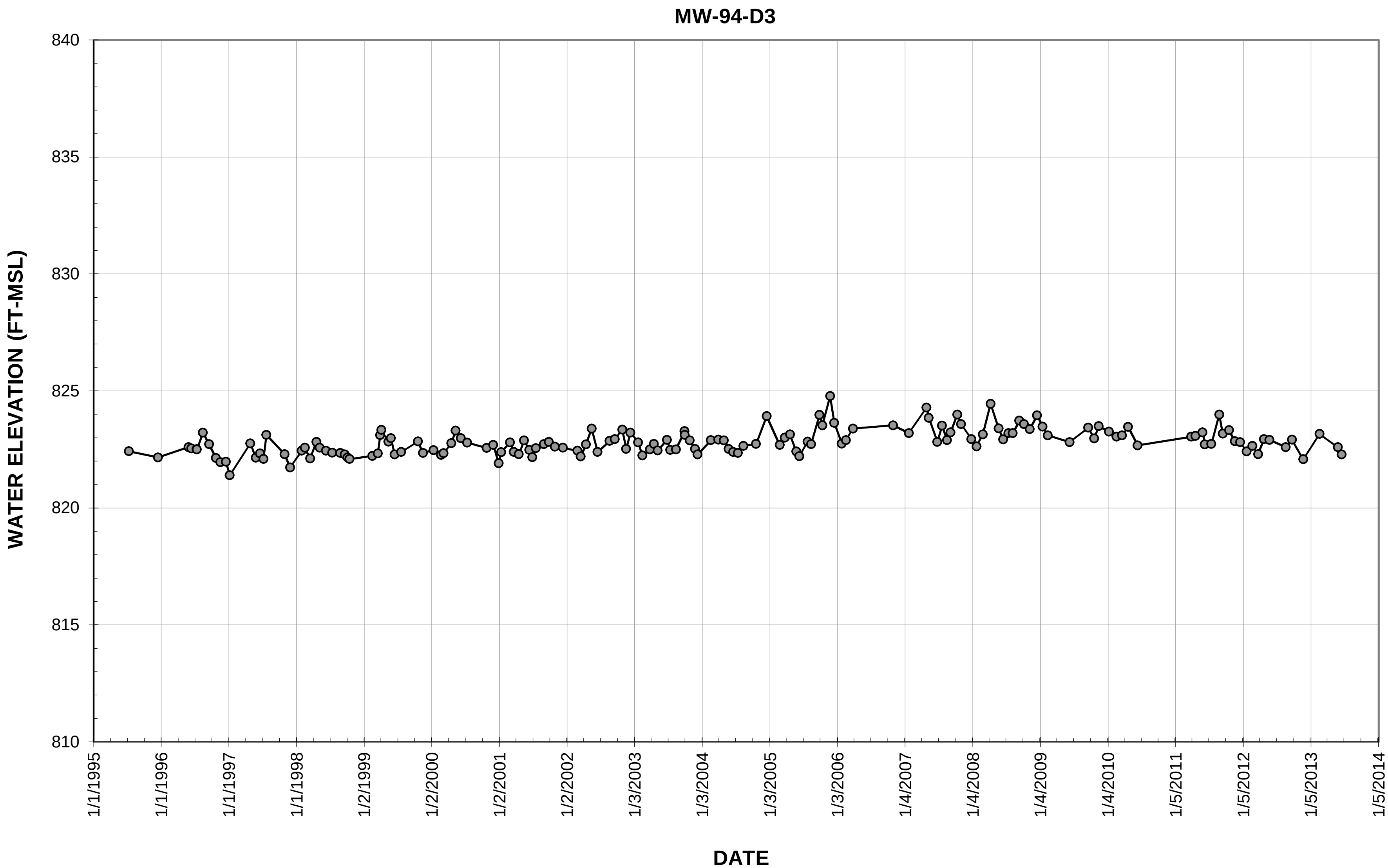


Figure 3.12 Water Level Data for Well MW-D-94-D4

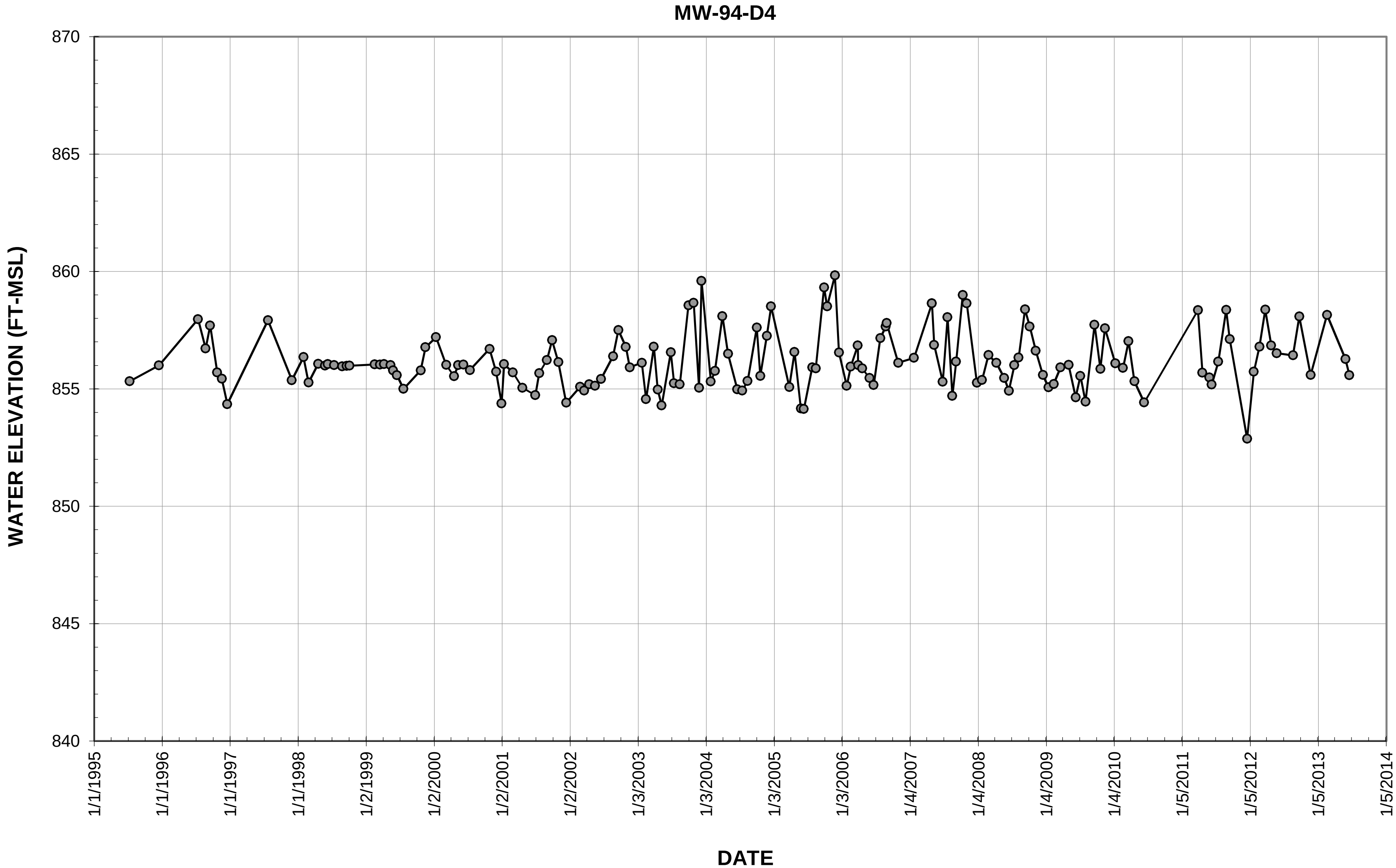


FIGURE 3.13 Pond D Flow Data

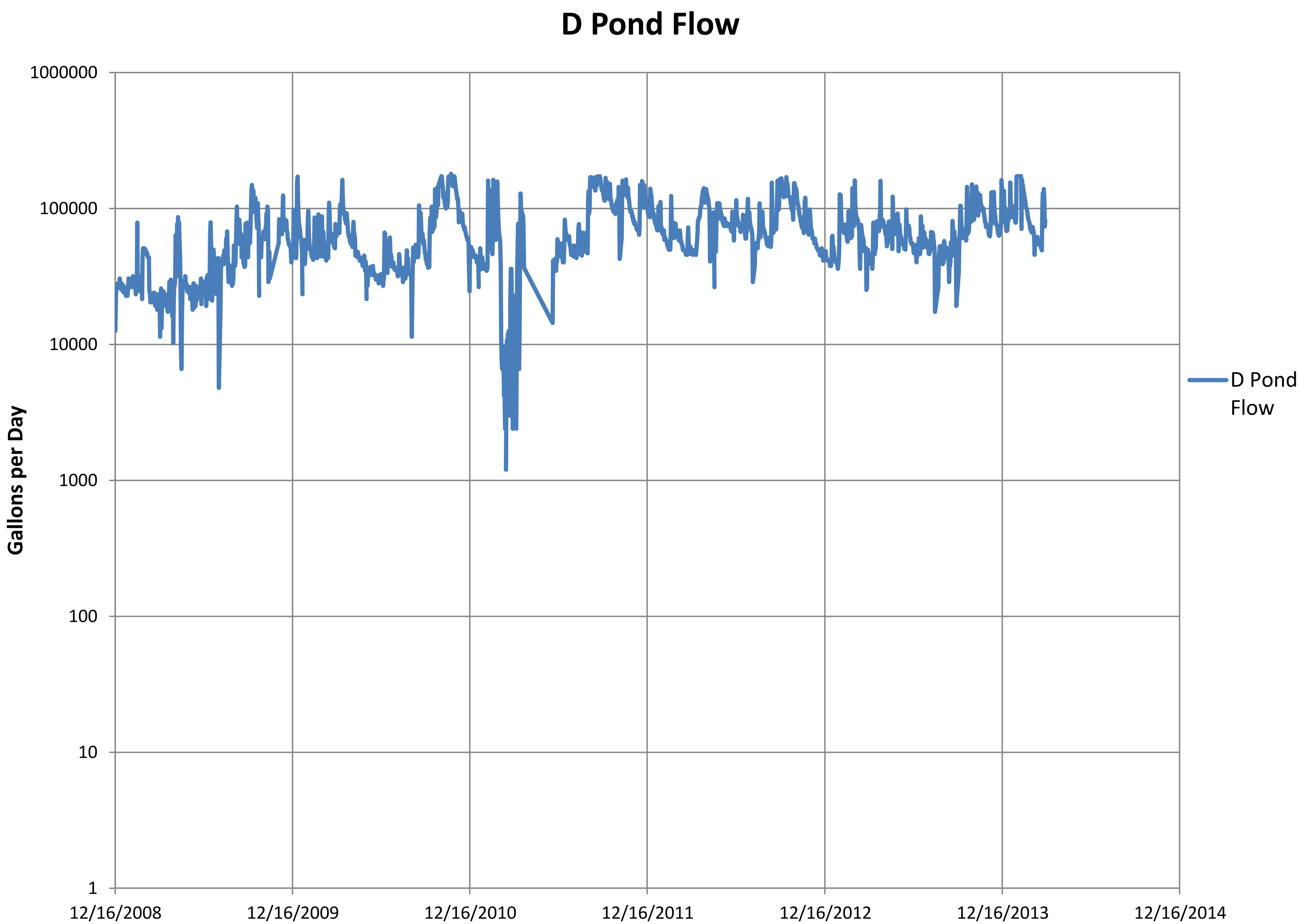


Figure 3.14a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES:

FINGER DRAINS - pH DATA

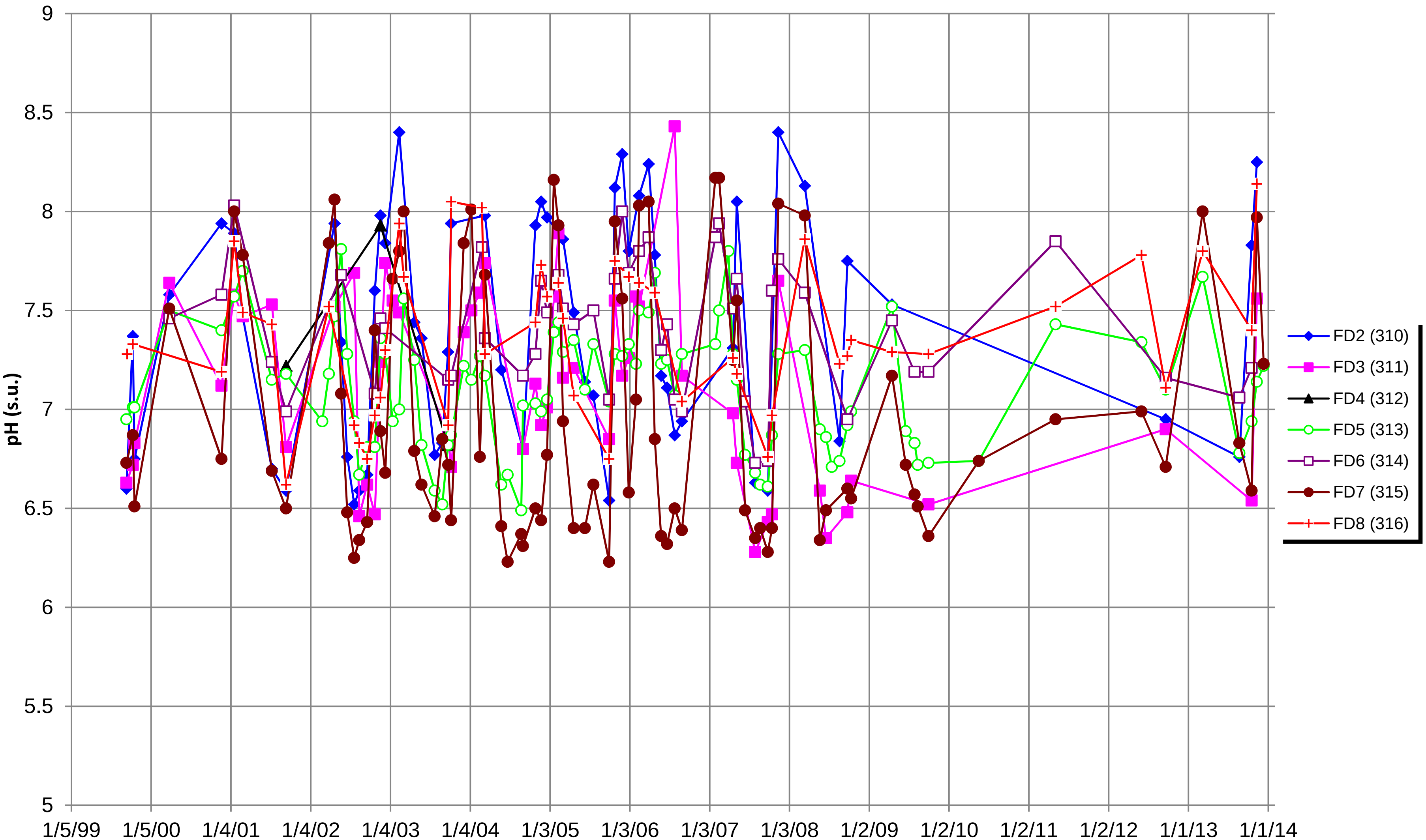


Figure 3.14b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - pH DATA

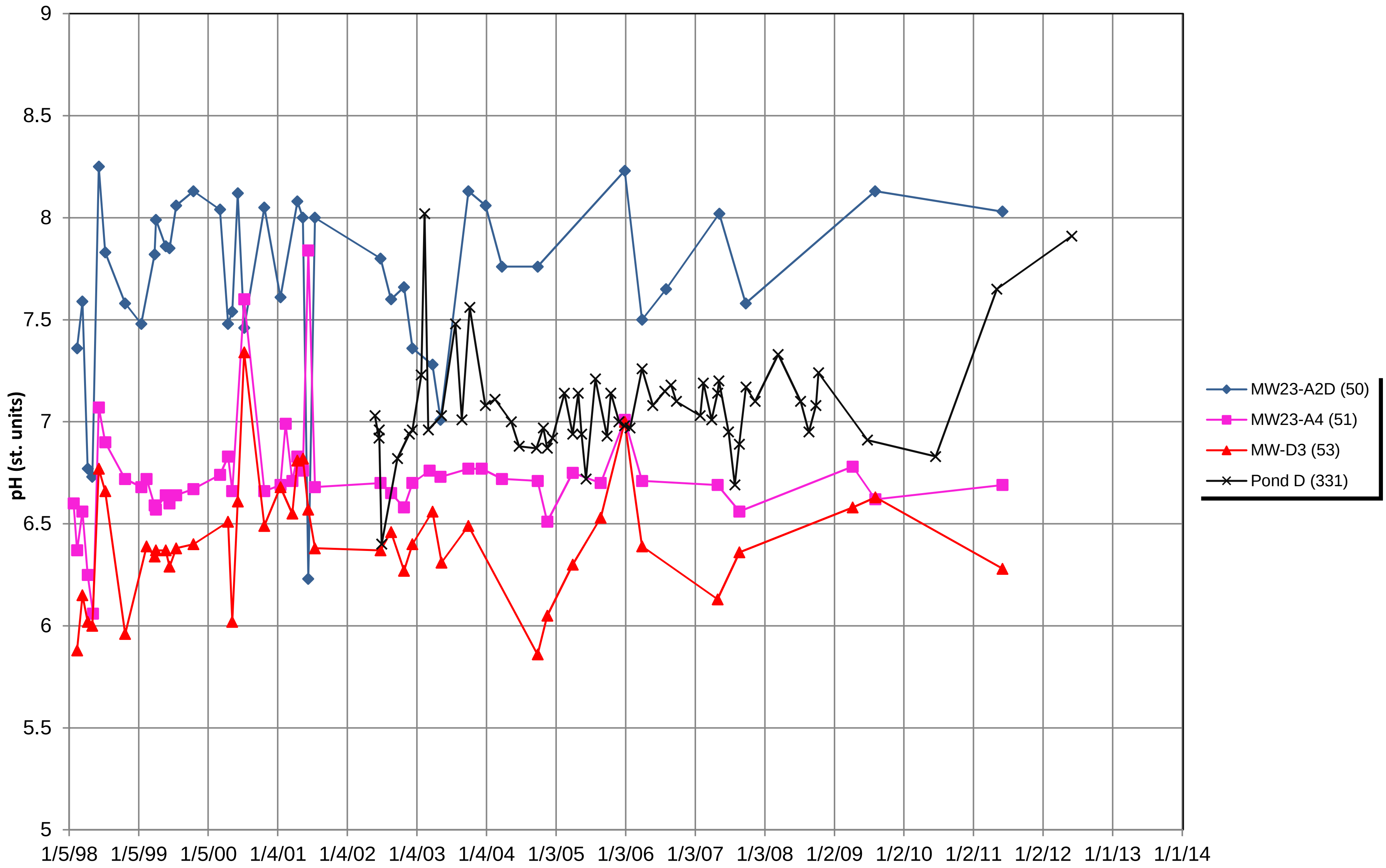


Figure 3.15a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - ALKALINITY DATA

(Non-detectable analyses plotted as zero)

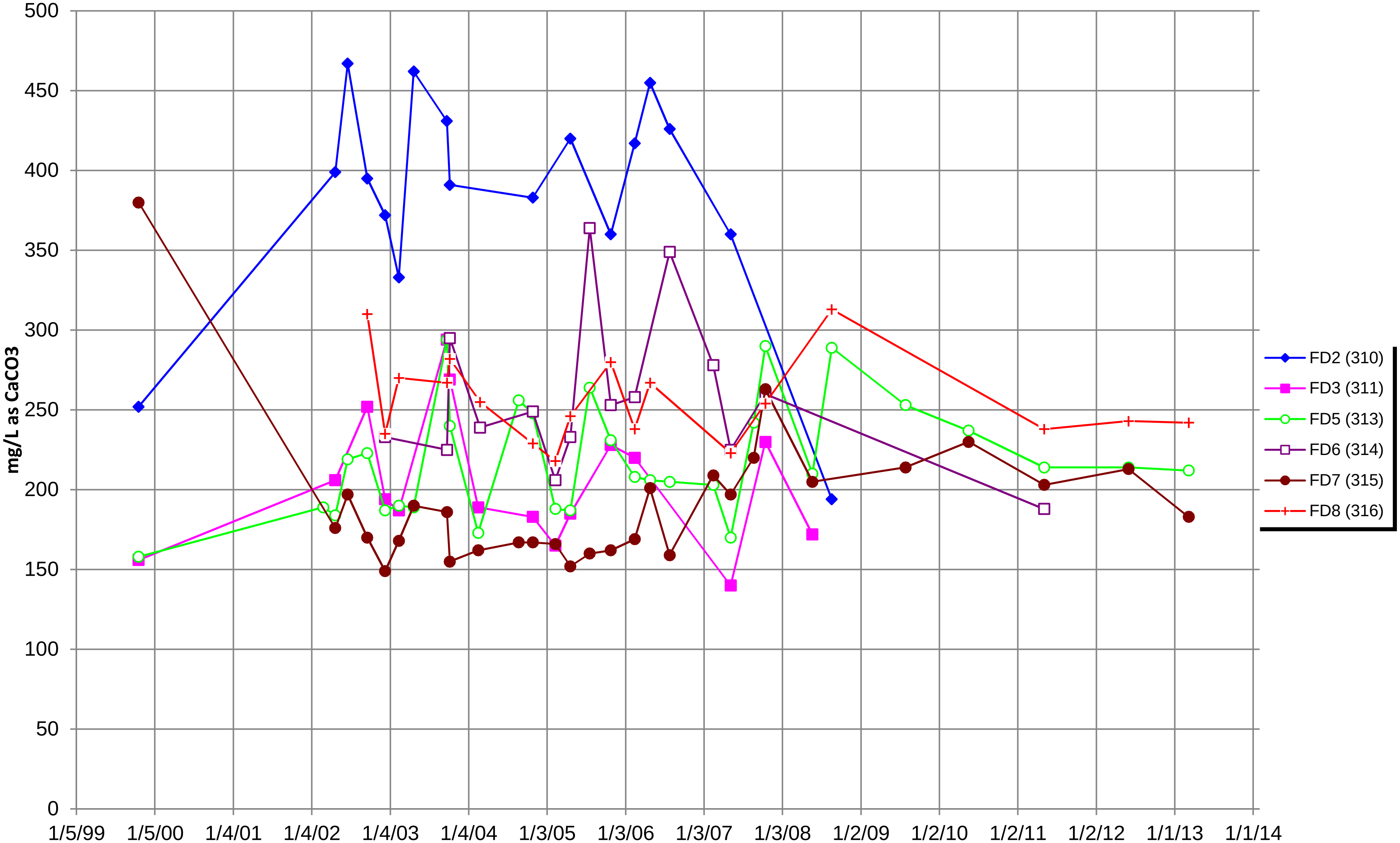


Figure 3.15b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES:
GROUND WATER - ALKALINITY DATA
(Non-detectable analyses plotted as zero)

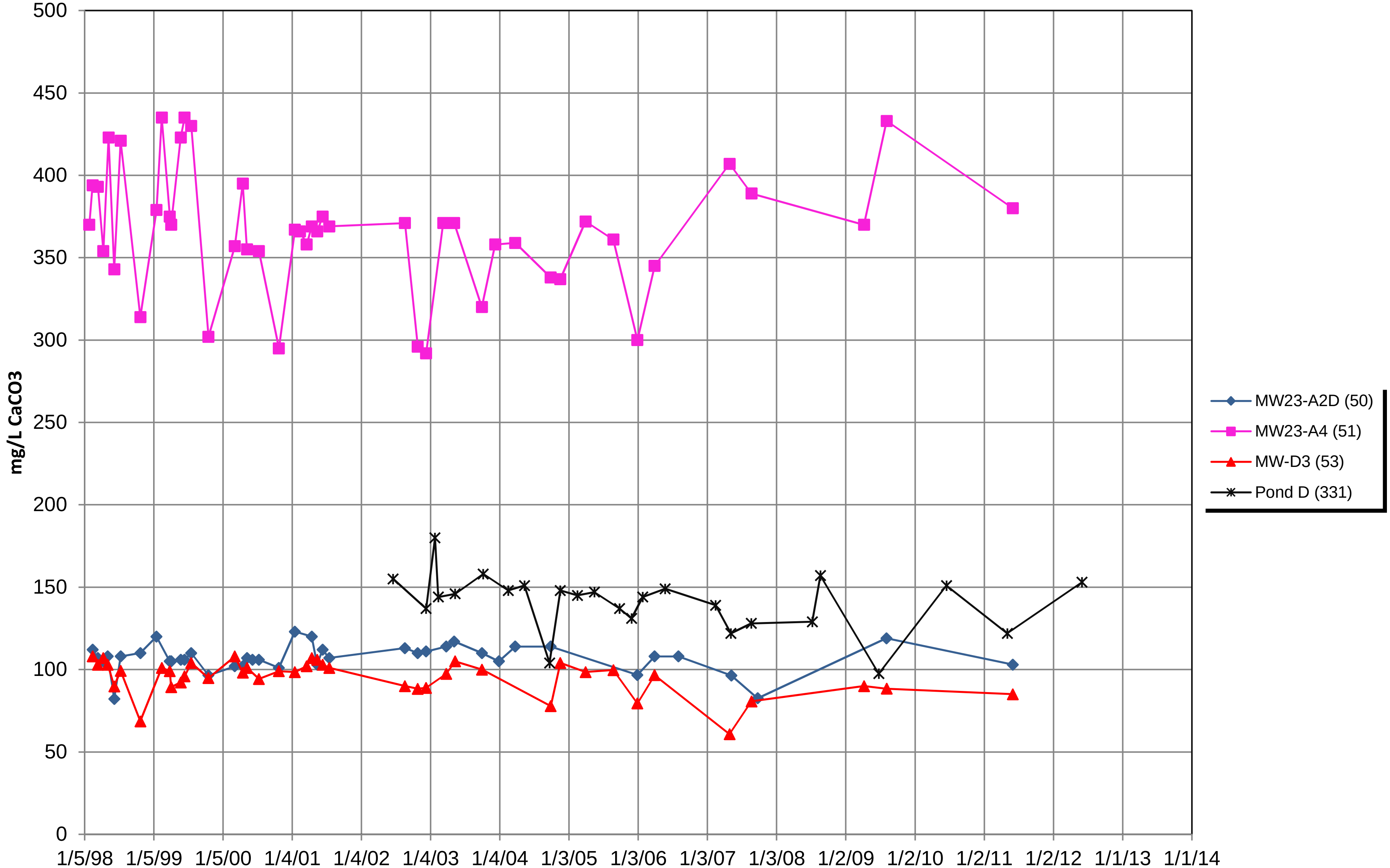


Figure 3.16a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES:
FINGER DRAINS - HARDNESS DATA
(Non-detectable analyses plotted as zero)

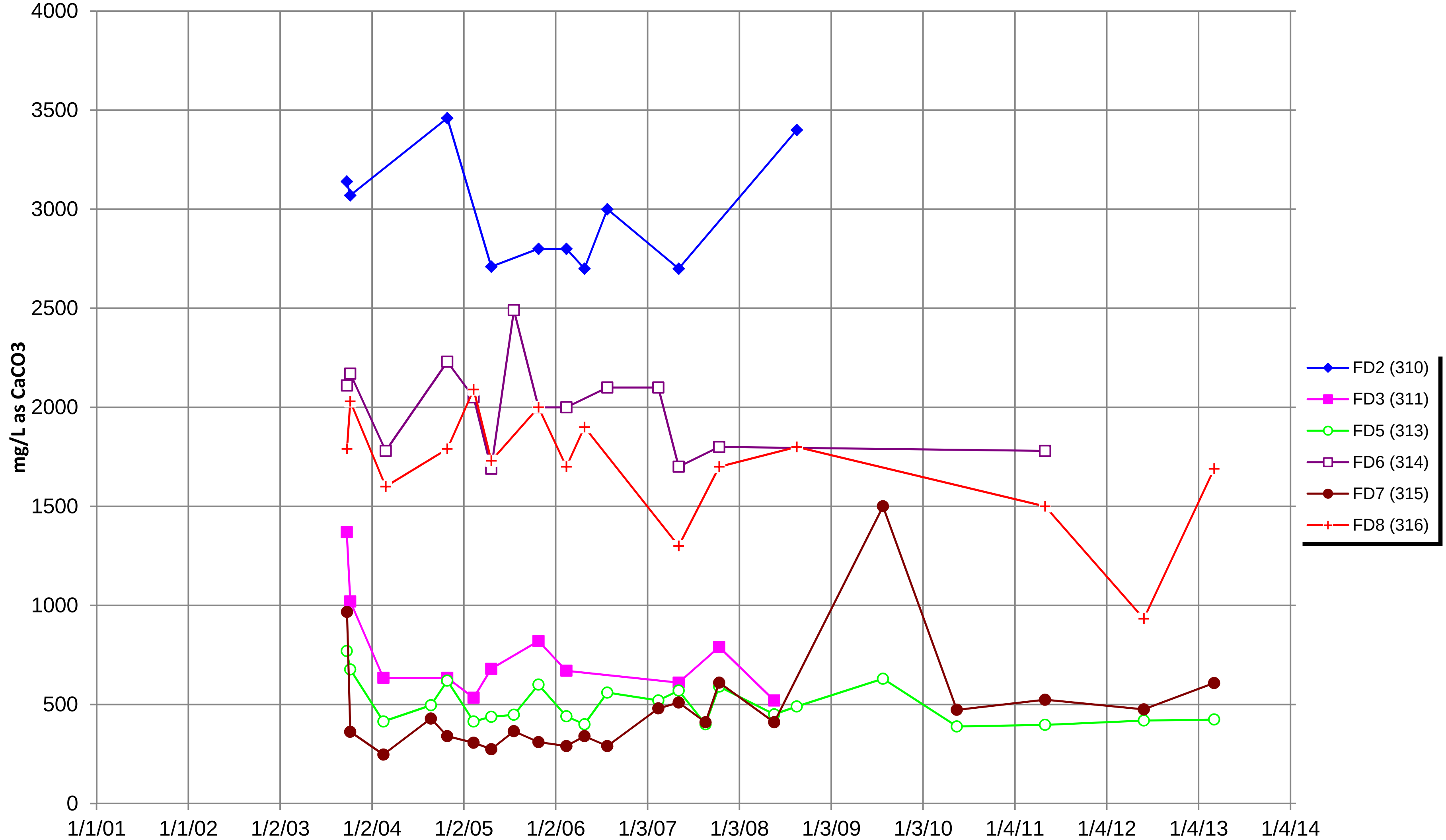


Figure 3.16b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - HARDNESS DATA (Non-detecable analyses plotted as zero)

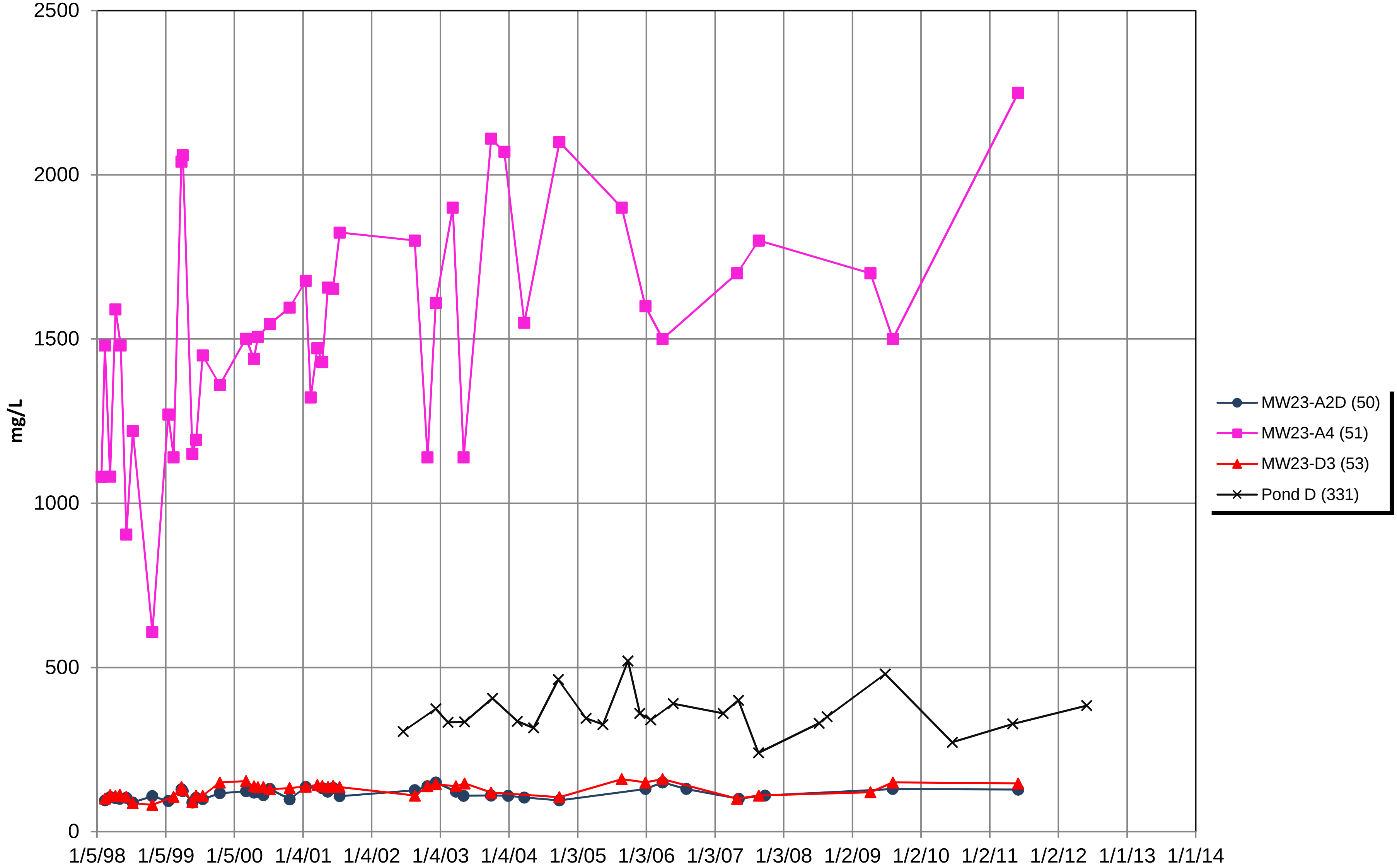


Figure 3.17a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES:

FINGER DRAINS - CONDUCTIVITY

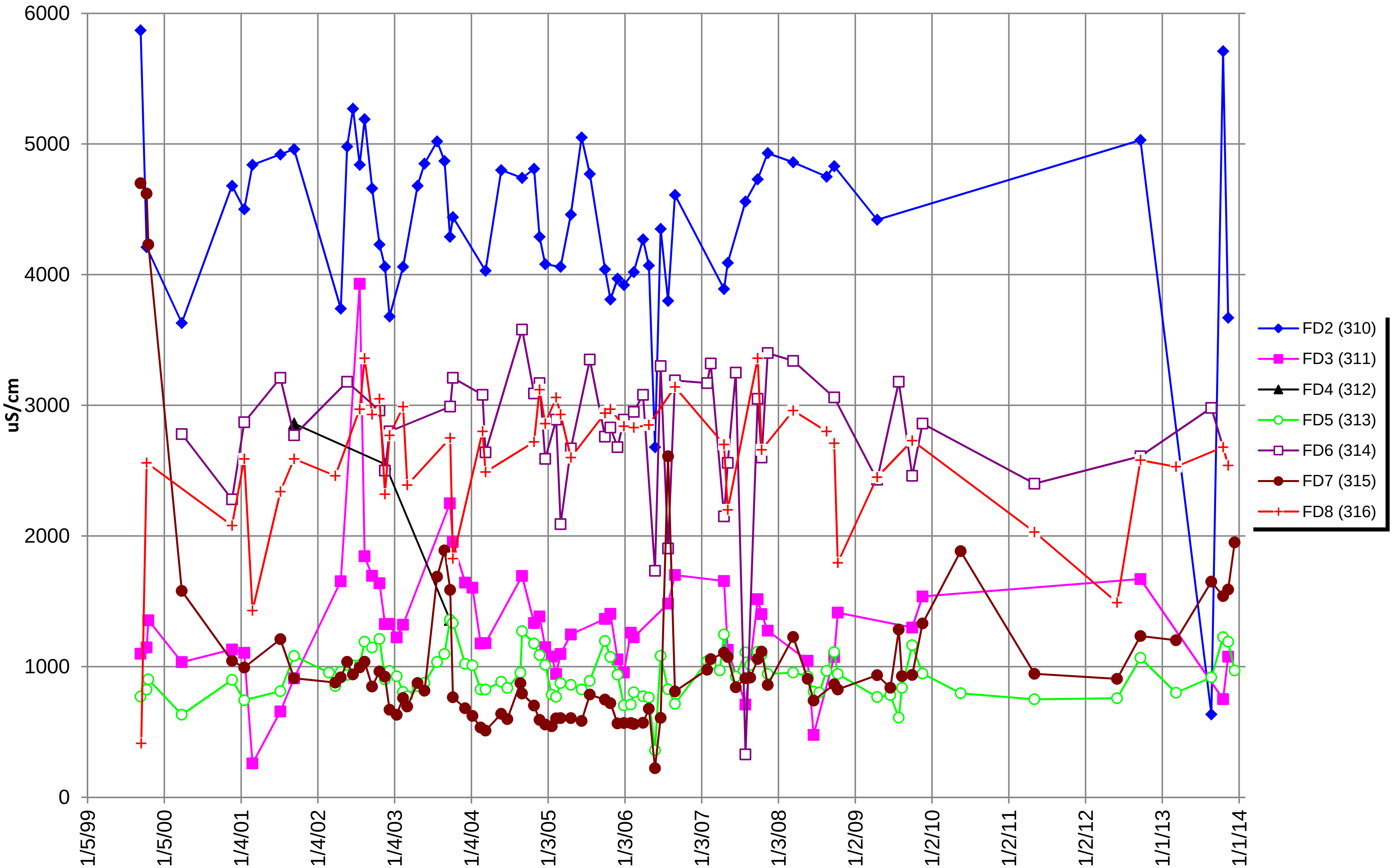


Figure 3.17b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - CONDUCTIVITY

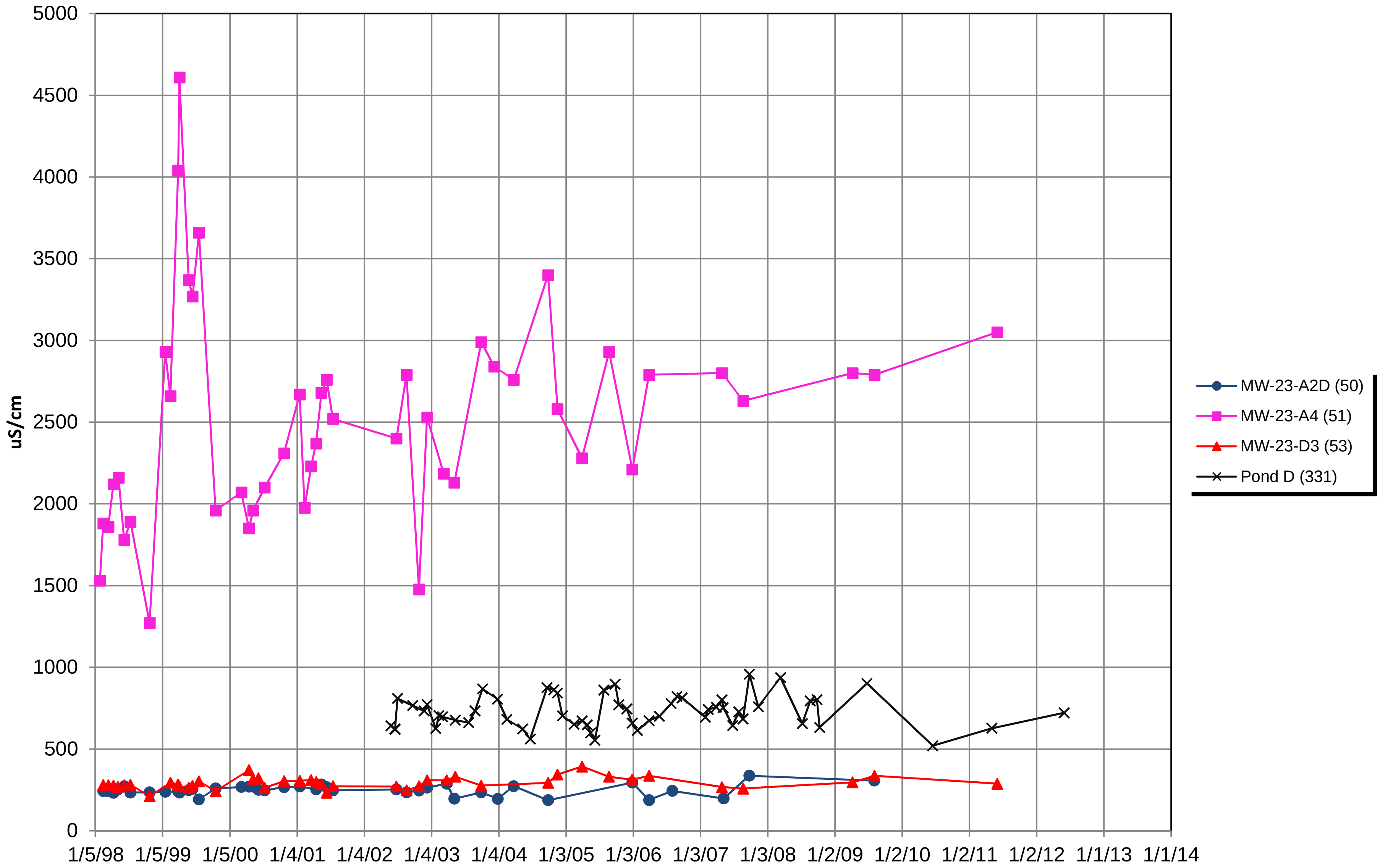


Figure 3.18a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - SULFATE

(Non-detectable analyses plotted as zero)

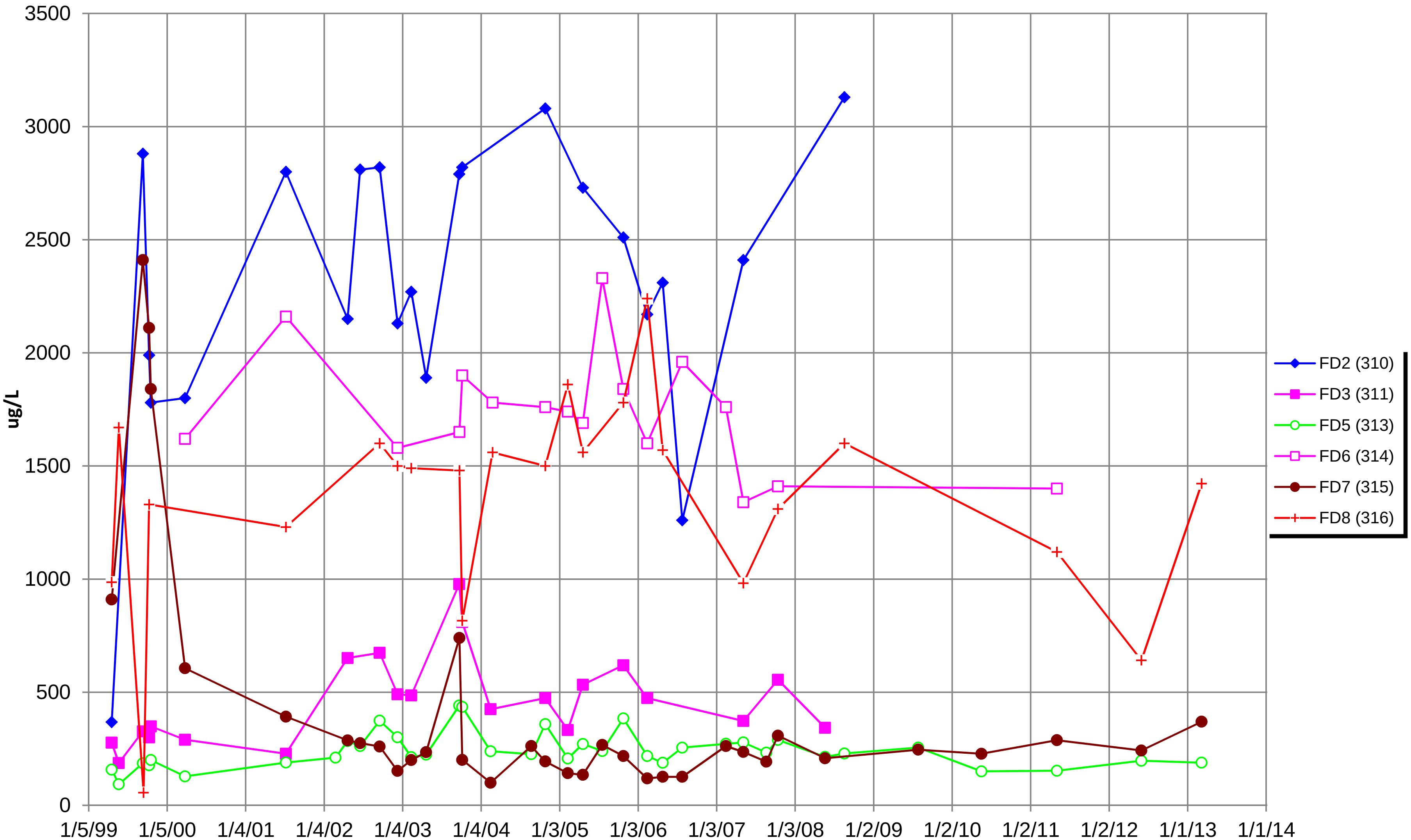


Figure 3.18b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - SULFATE (Non-detectable analyses plotted as zero)

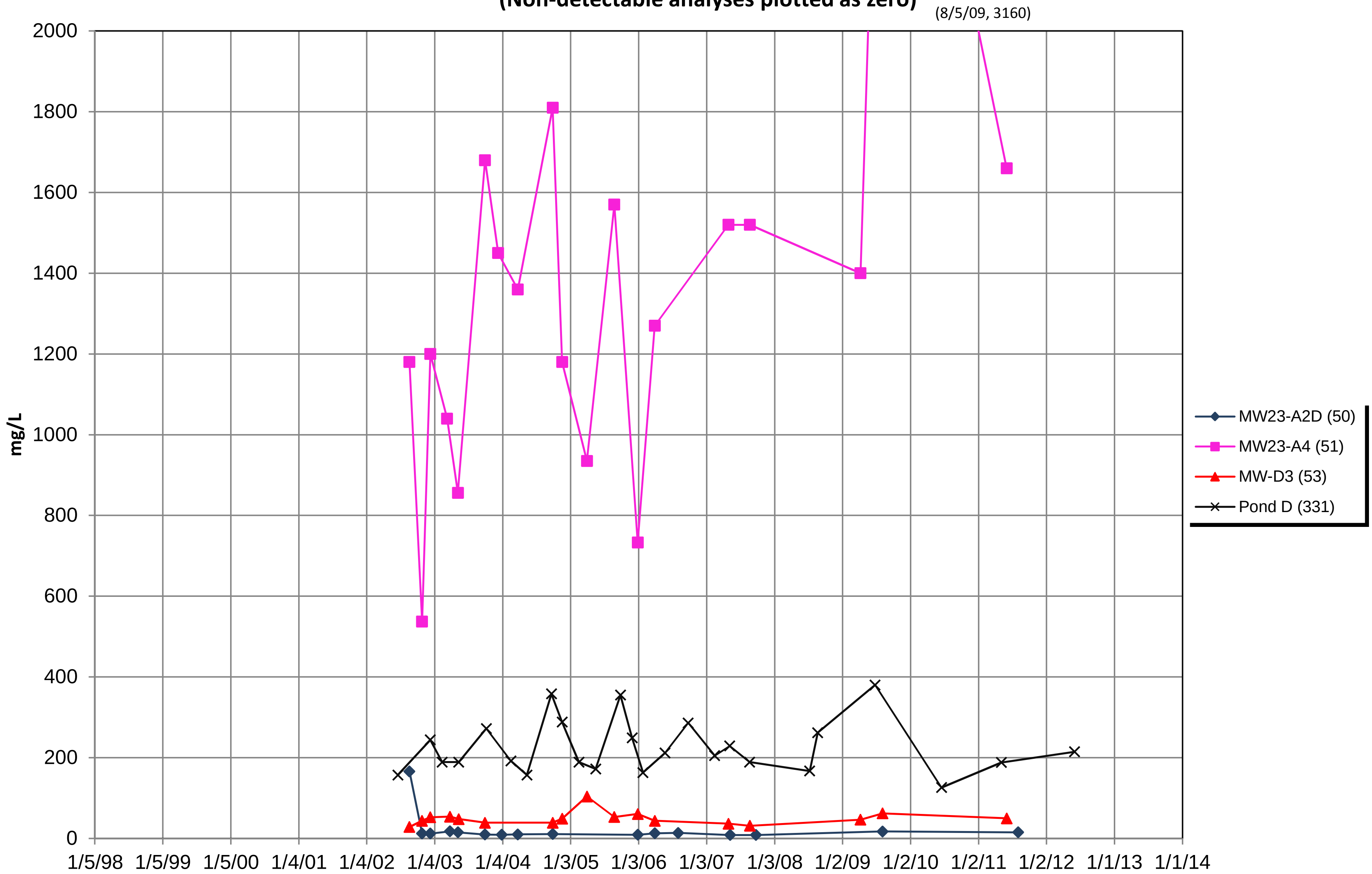


Figure 3.19a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS ARSENIC DATA

(Non-detectable analyses plotted as zero)

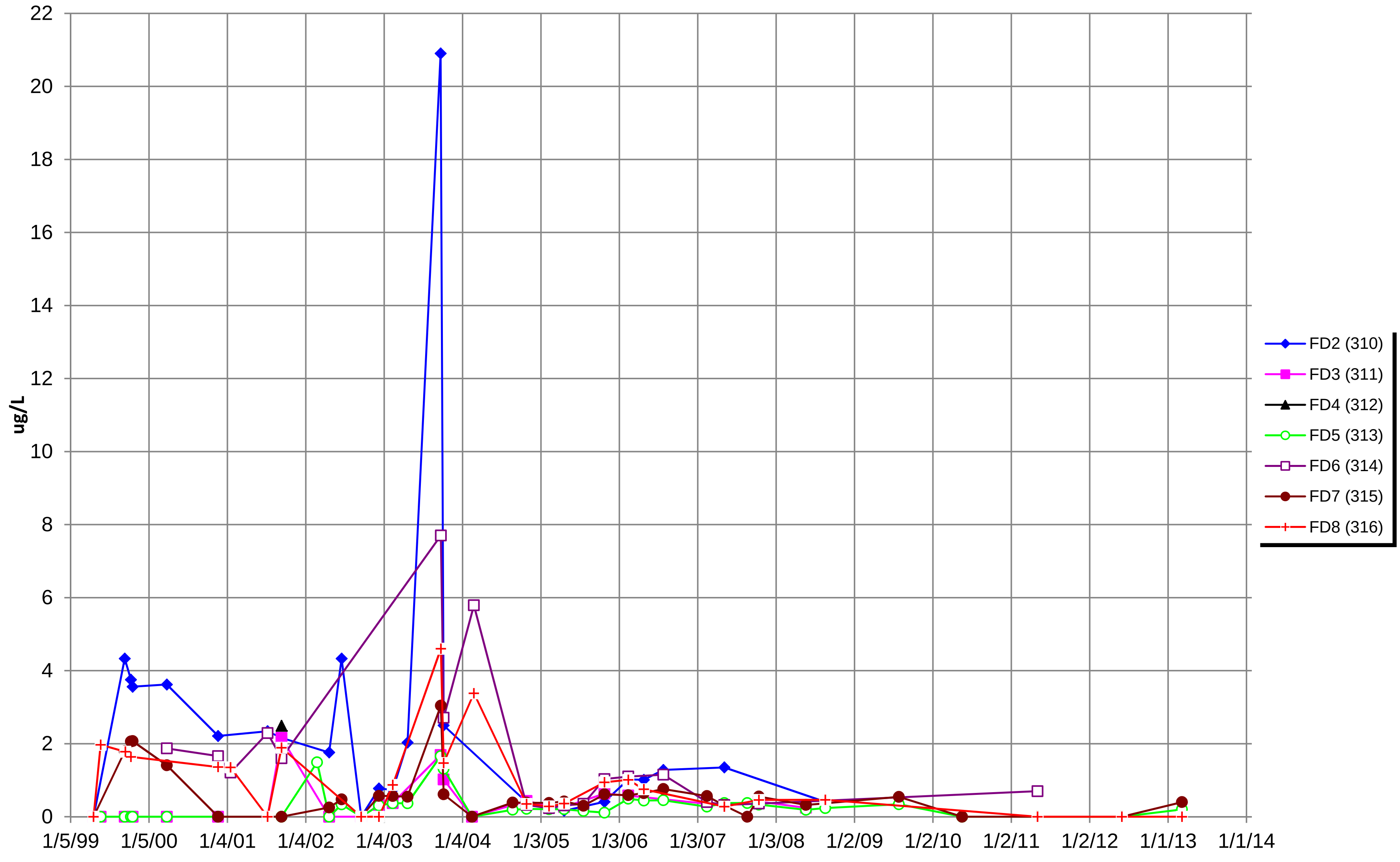


Figure 3.19b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - ARSENIC DATA (Non-detectable analyses plotted as zero)

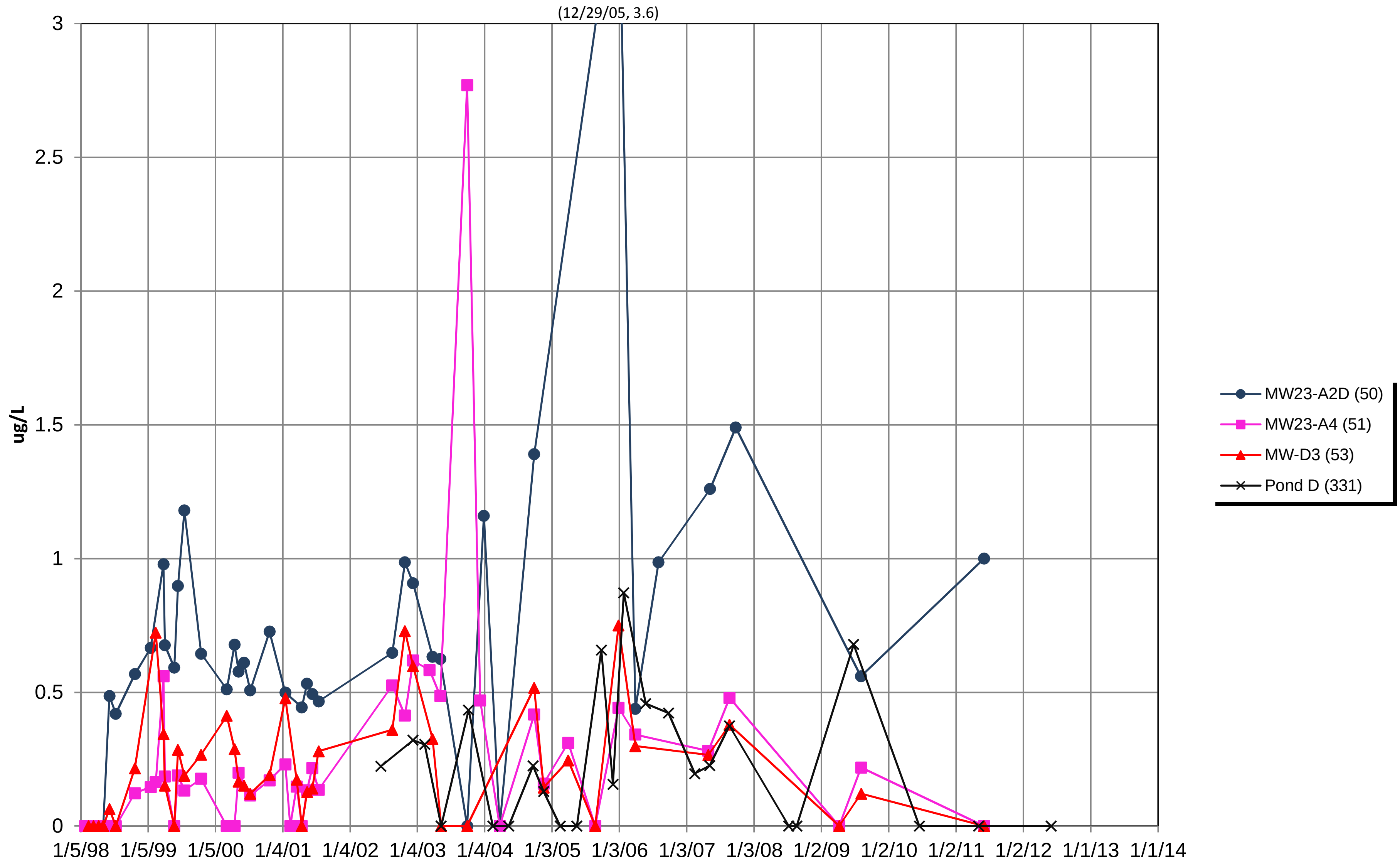


Figure 3.20a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - ZINC DATA (Non-detectable analyses plotted as zero)

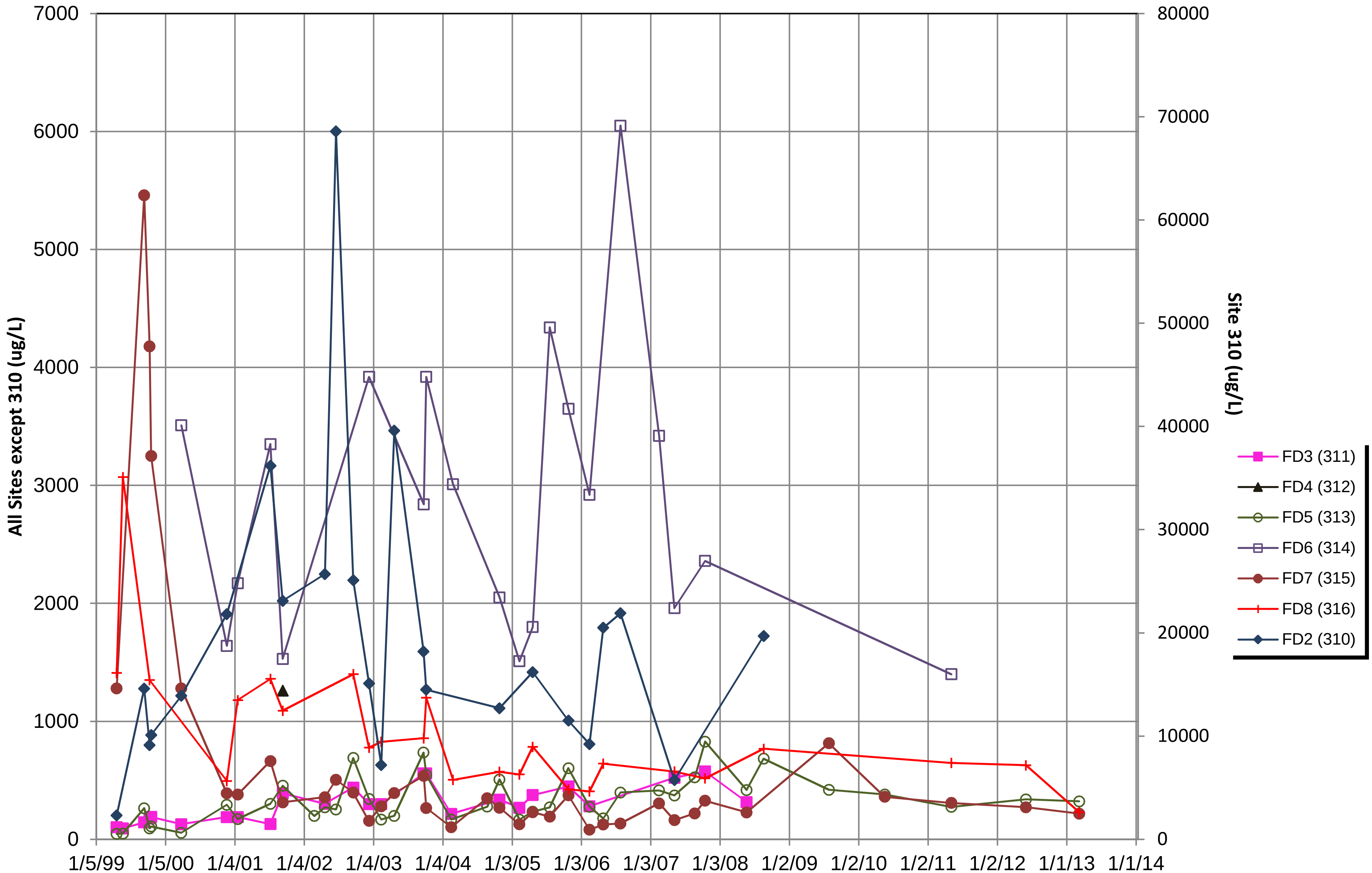


Figure 3.20b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - ZINC DATA (Non-detectable analyses plotted as zero)

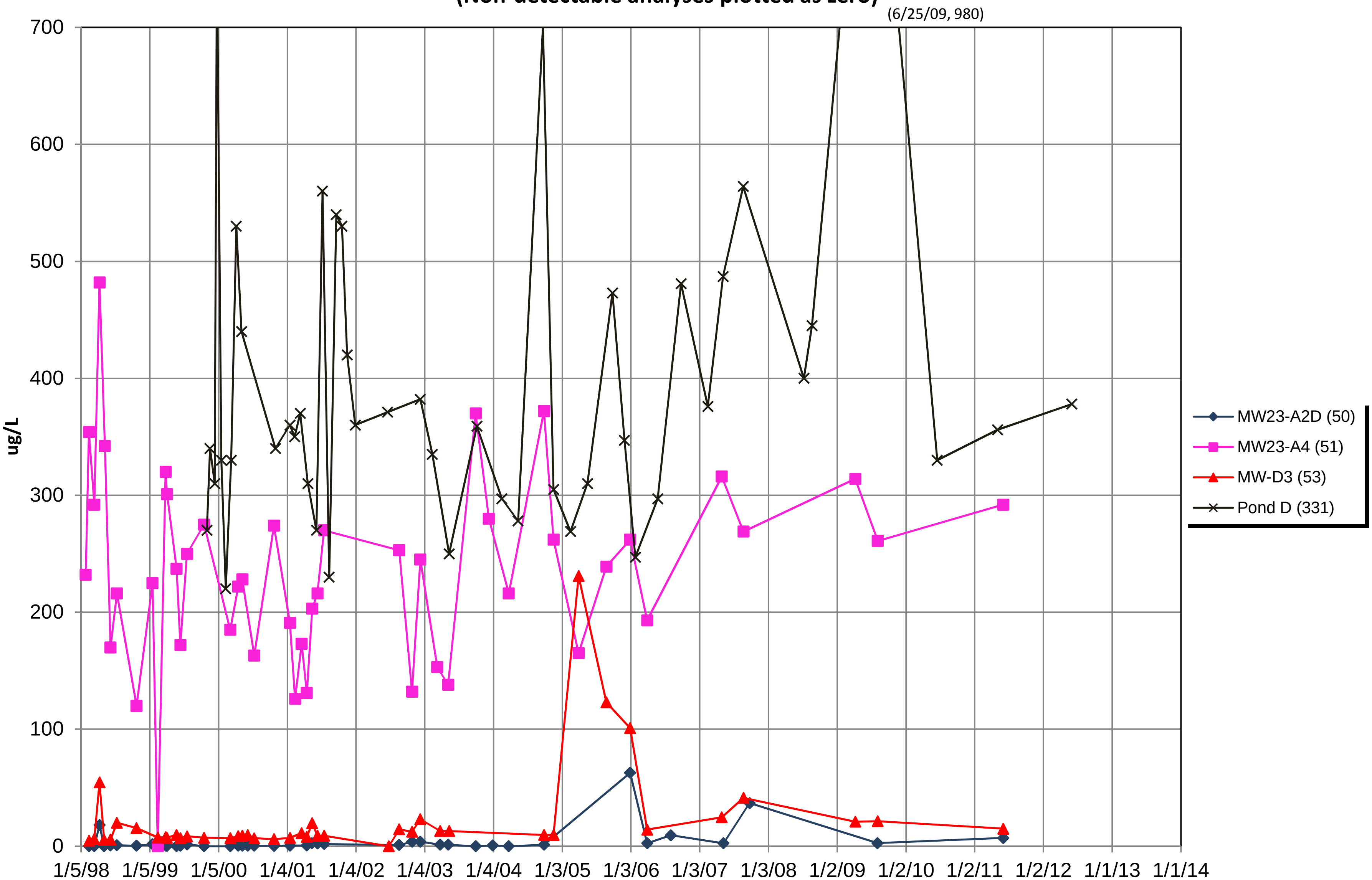
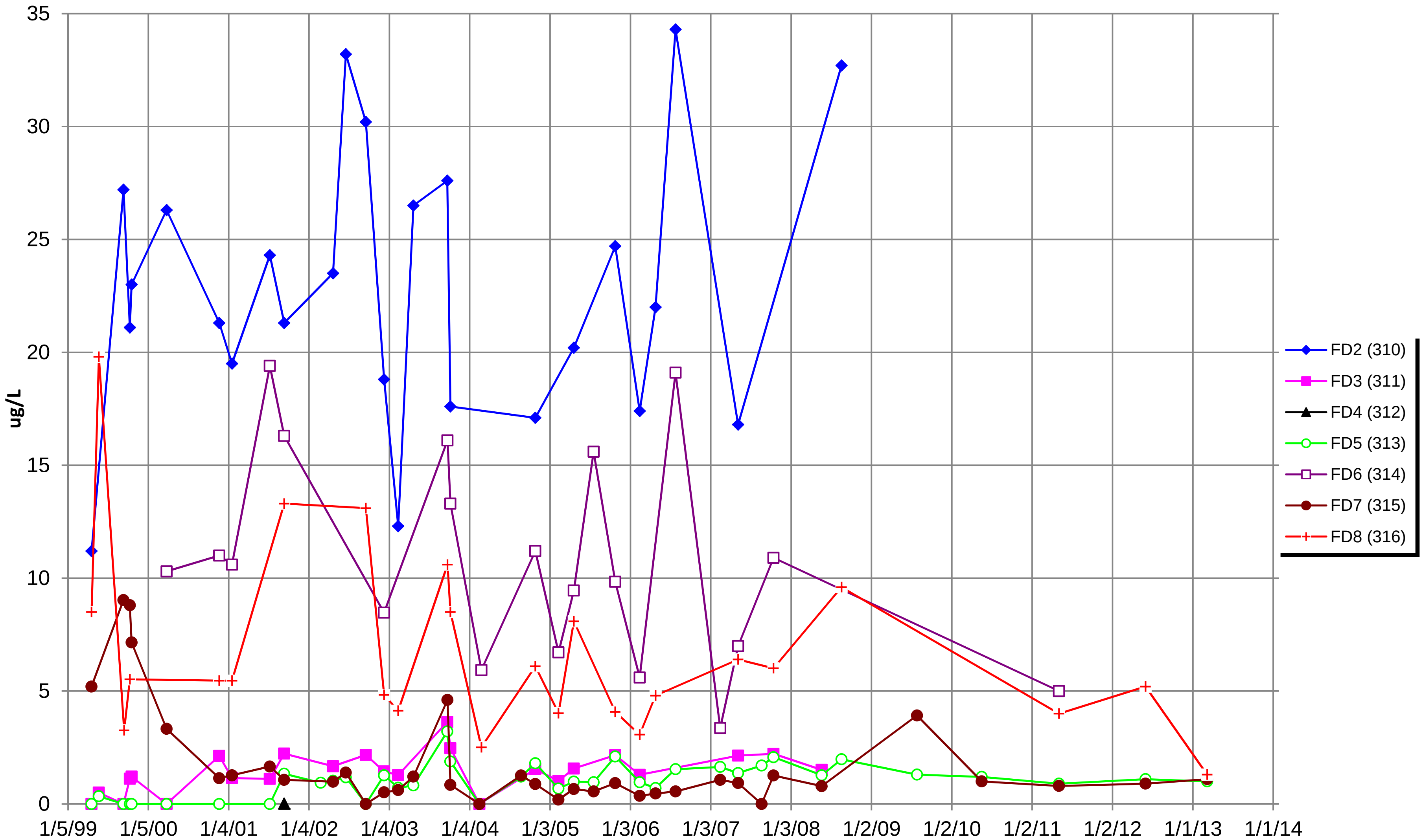


Figure 3.21a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES:
FINGER DRAINS - CADMIUM DATA
(Non-detectable analyses plotted as zero)



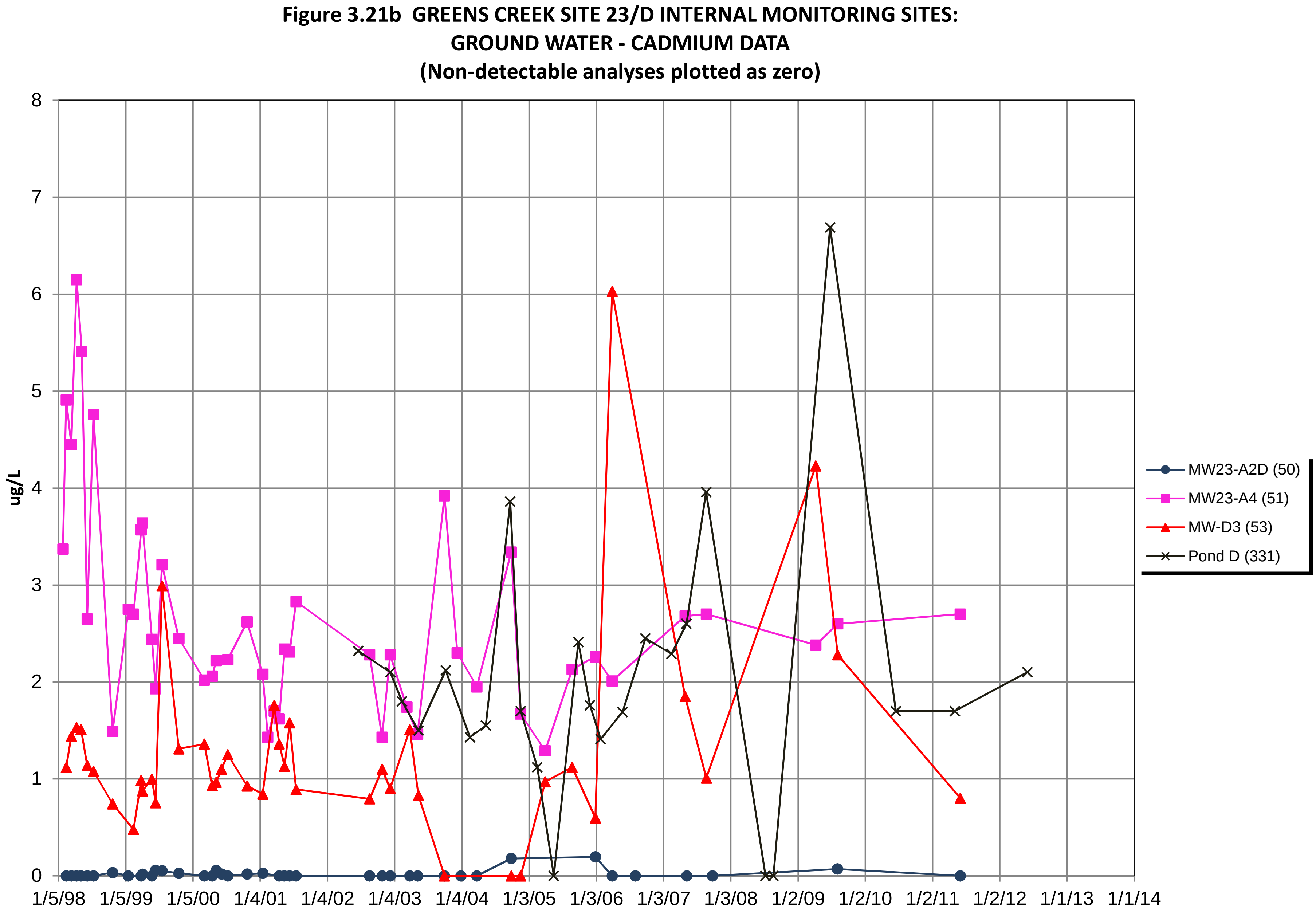


Figure 3.21b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES:
GROUND WATER - CADMIUM DATA
(Non-detectable analyses plotted as zero)
ug/L
0
1
2
3
4
5
6
7
8
1/5/98
1/5/99
1/5/00
1/4/01
1/4/02
1/4/03
1/4/04
1/3/05
1/3/06
1/3/07
1/3/08
1/2/09
1/2/10
1/2/11
1/2/12
1/1/13
1/1/14
MW23-A2D (50)
MW23-A4 (51)
MW-D3 (53)
Pond D (331)

Figure 3.22a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - COPPER DATA

(Non-detectable analyses plotted as zero)

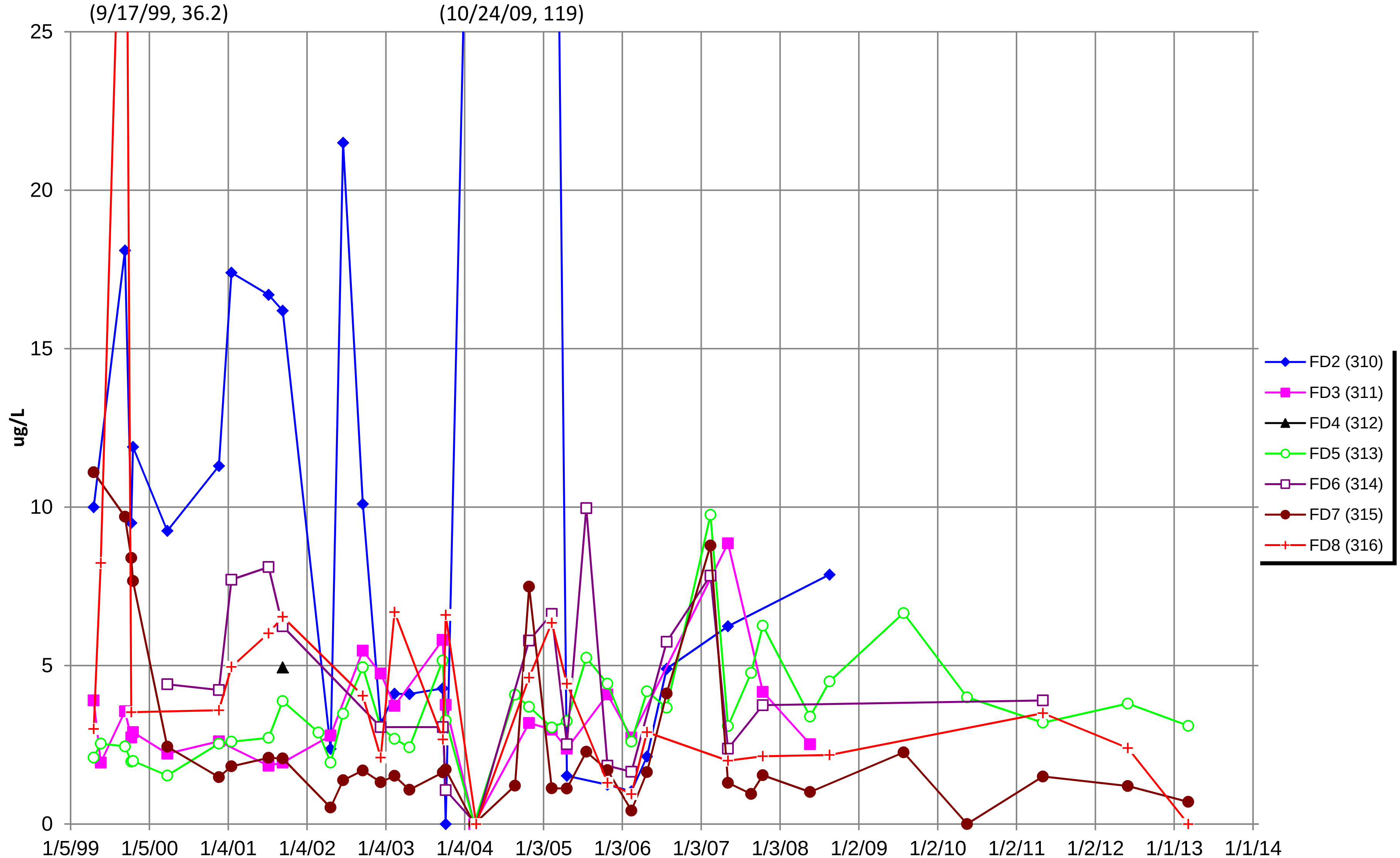


Figure 3.22b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - COPPER DATA (Non-detectable analyses plotted as zero)

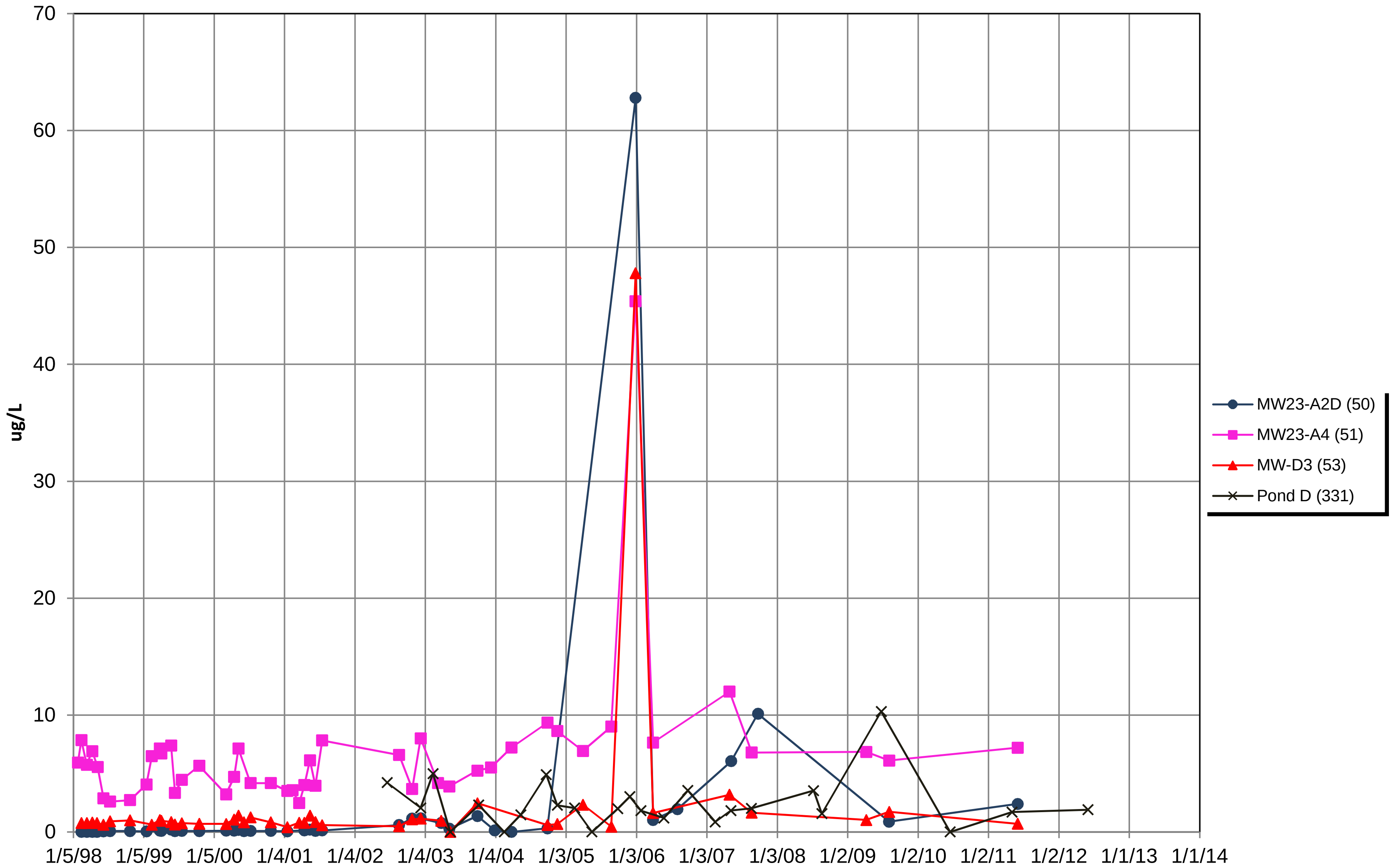


Figure 3.23a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - LEAD DATA

(Non-detectable analyses plotted as zero)

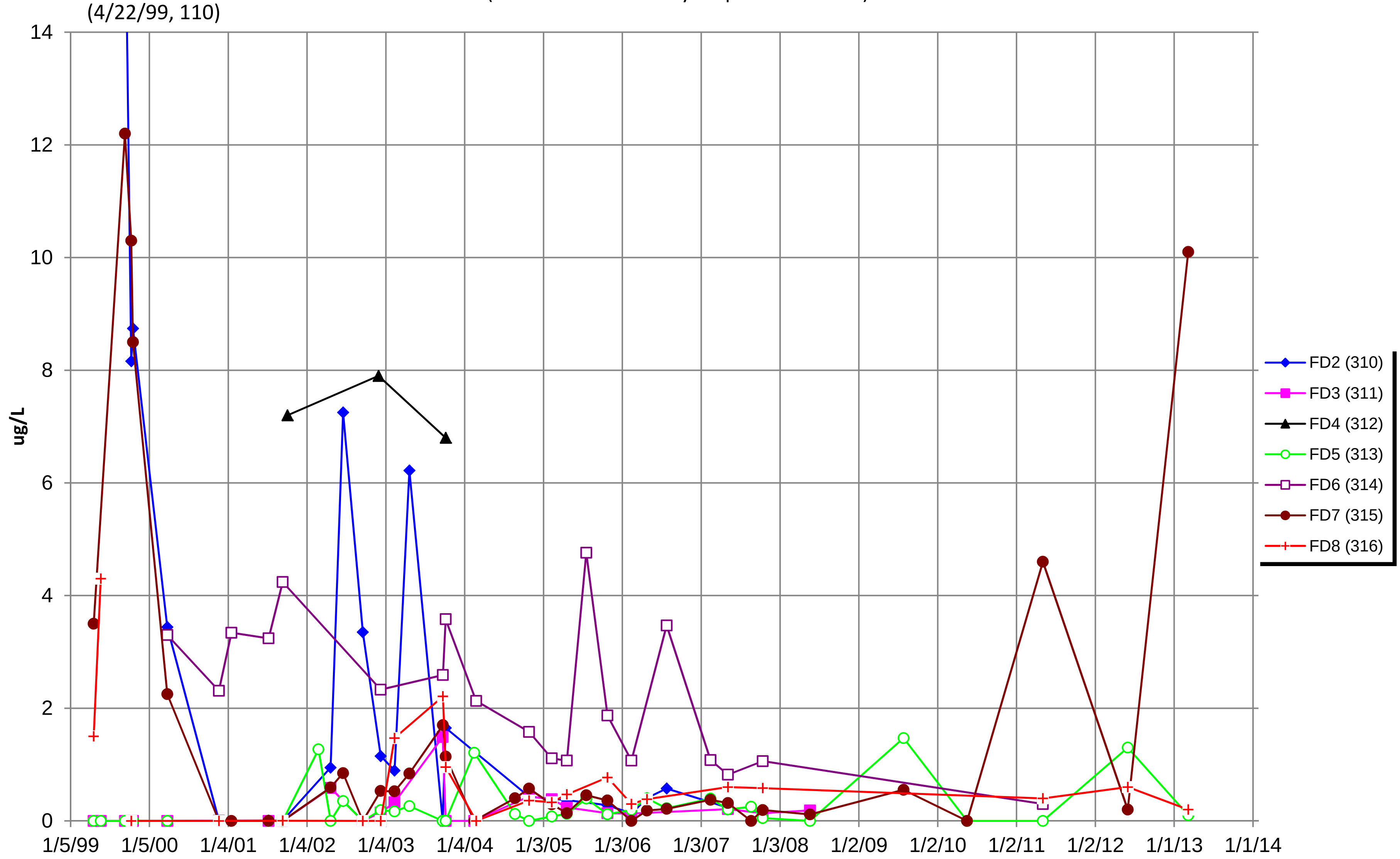


Figure 3.23b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - LEAD DATA (Non-detectable analyses plotted as zero)

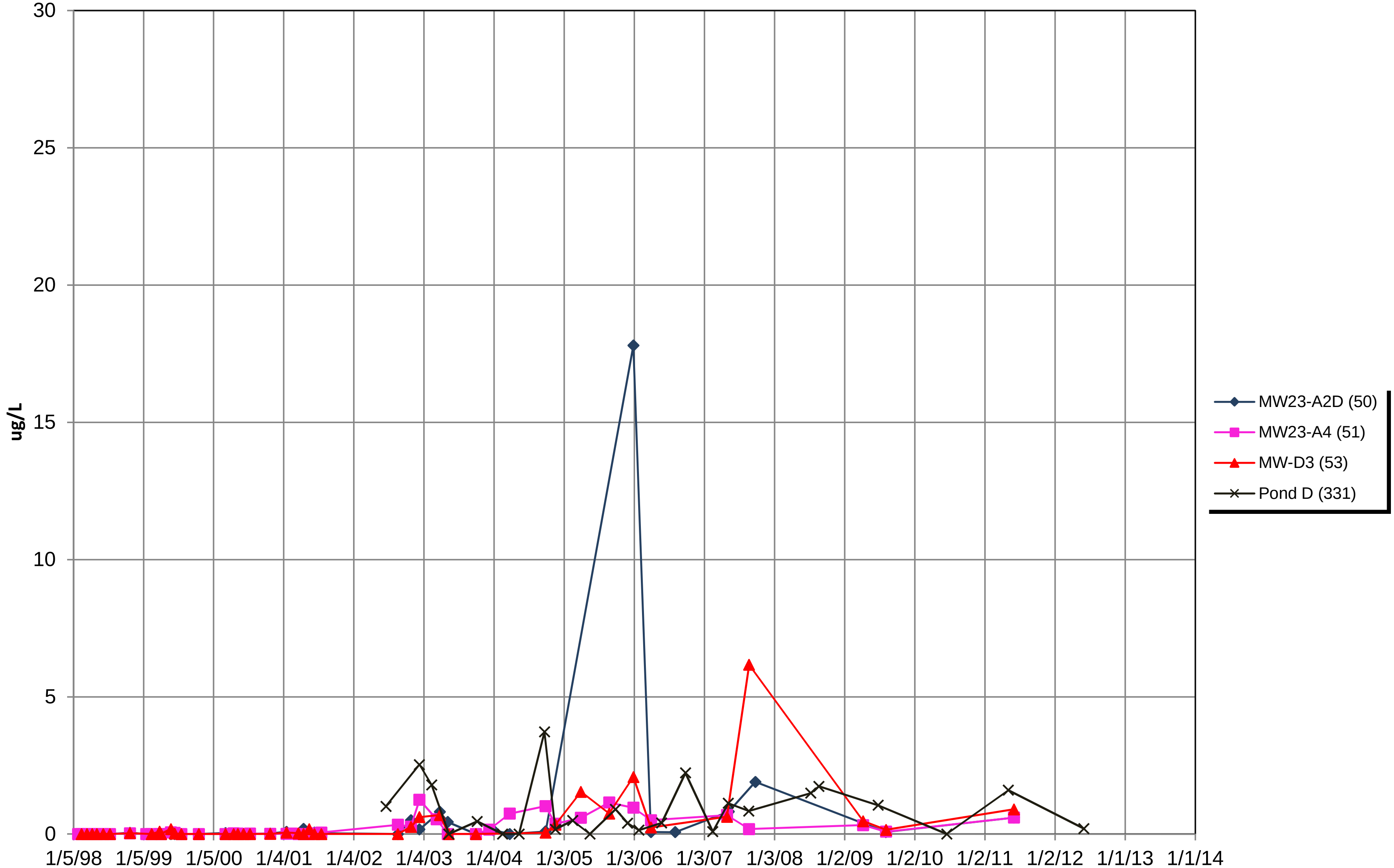


Figure 3.24a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - NICKEL DATA (Non-detectable analyses plotted as zero)

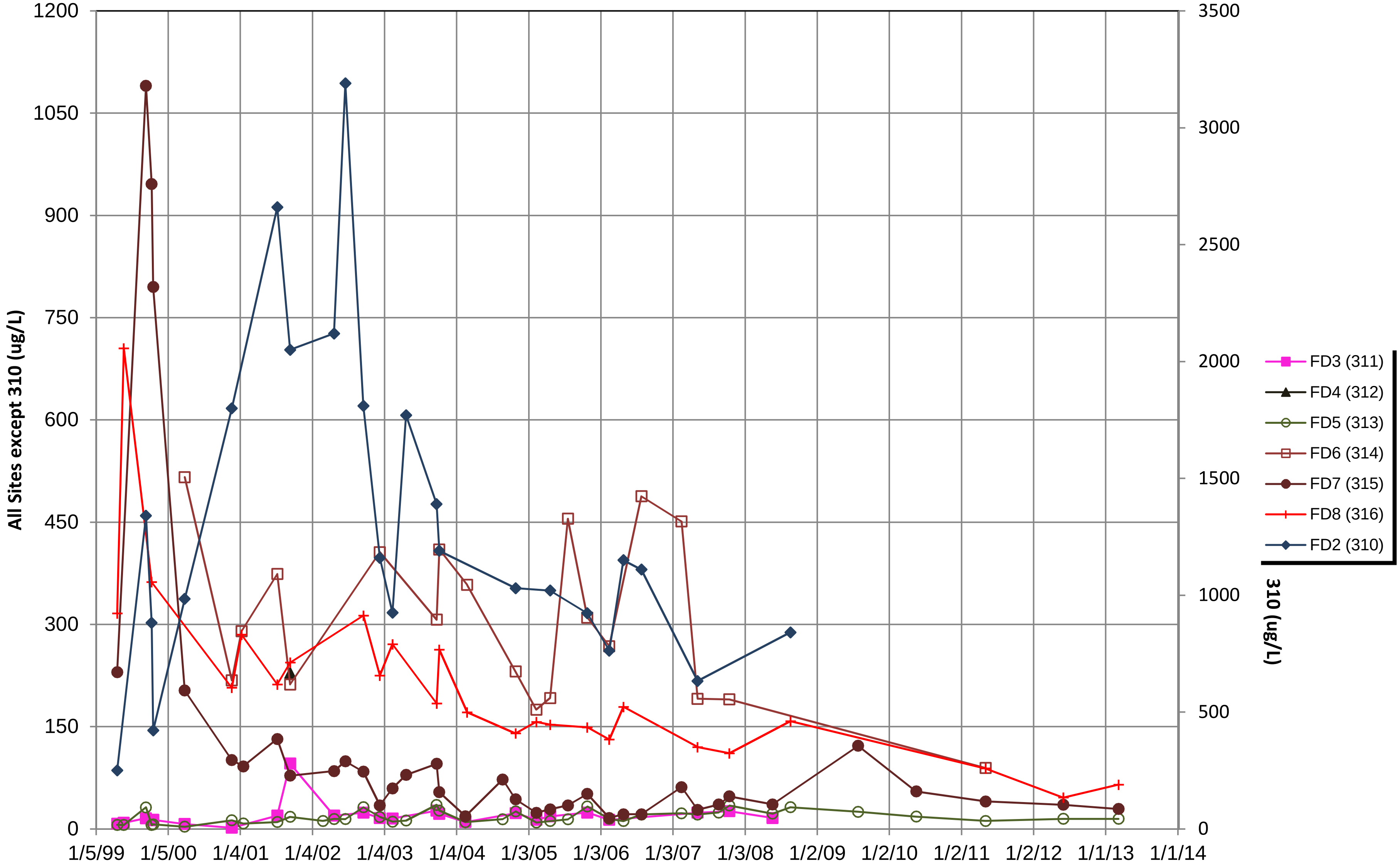


Figure 3.24b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - NICKEL DATA (Non-detectable analyses plotted as zero)

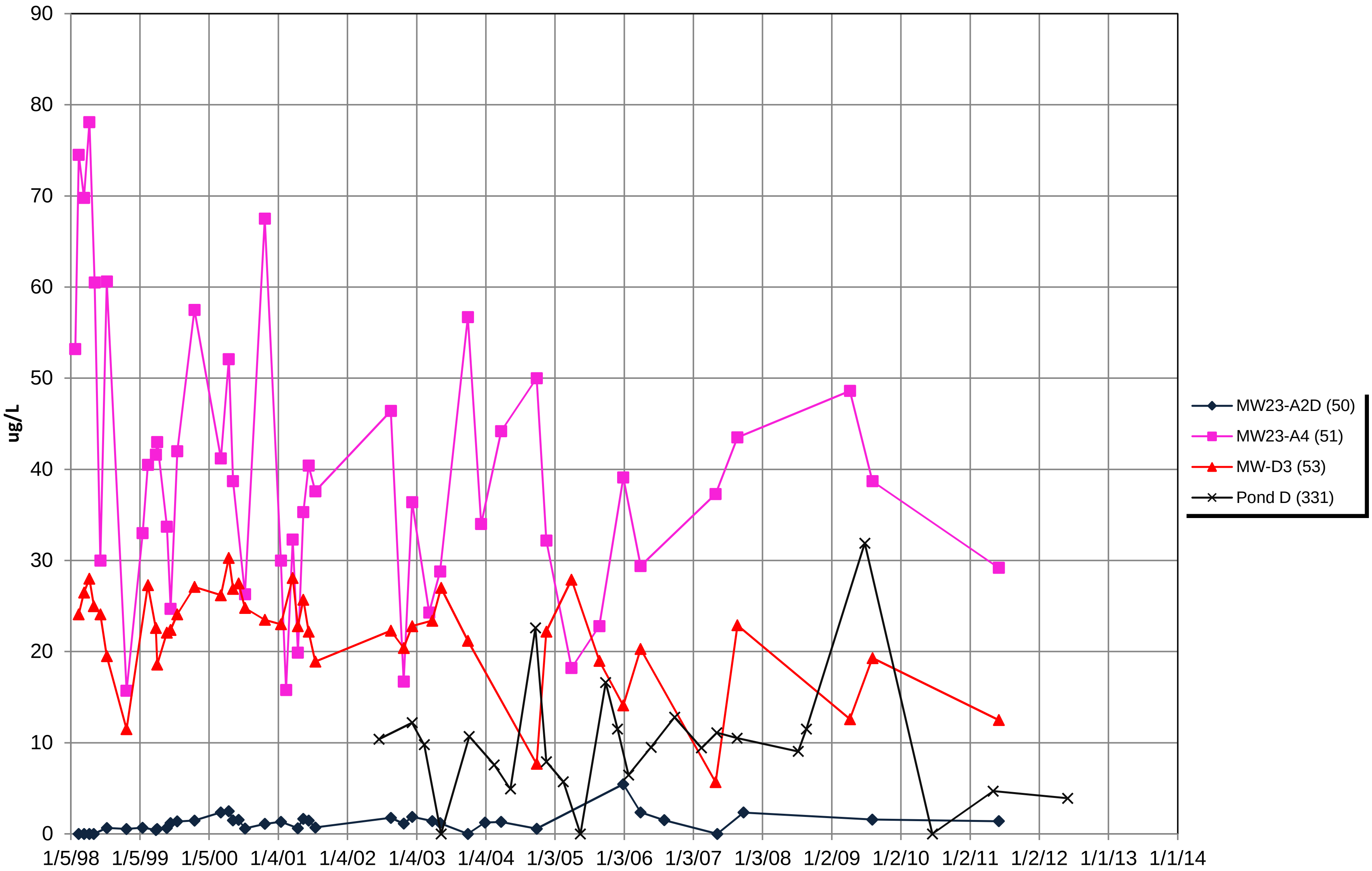


Figure 3.25a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - IRON DATA
(Non-detectable analyses plotted as zero)

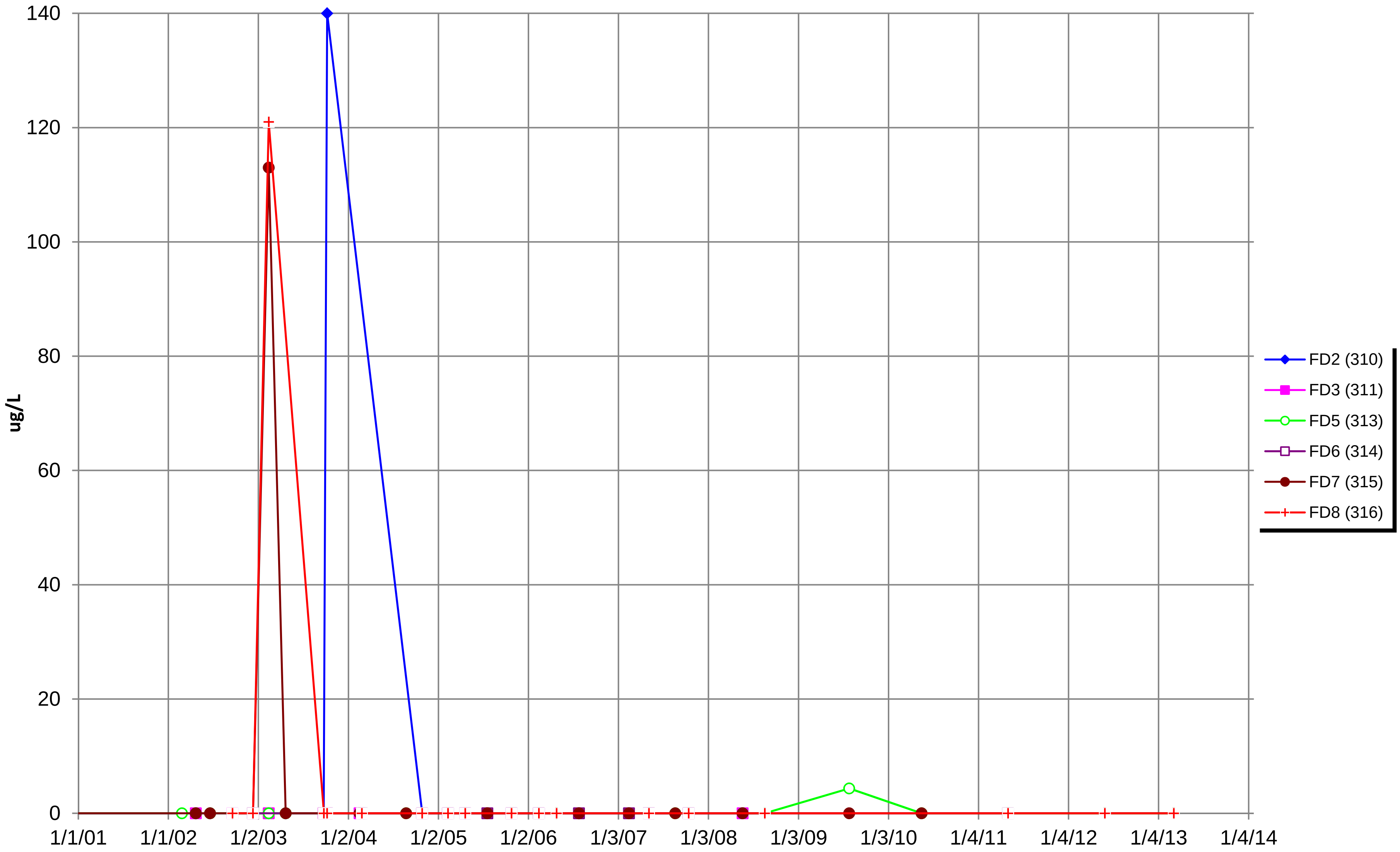


Figure 3.25b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - IRON DATA (Non-detectable analyses plotted as zero)

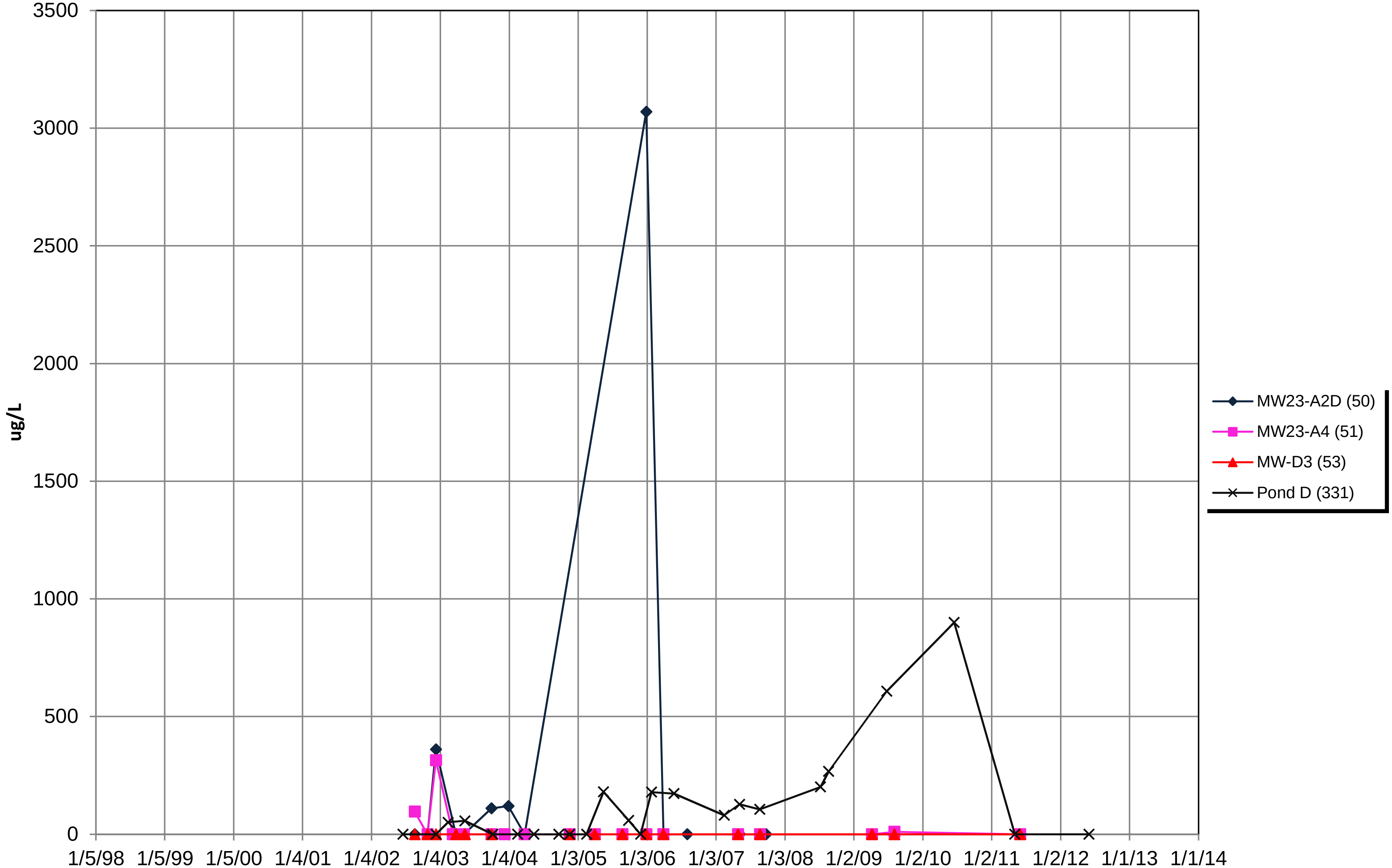


Figure 3.26a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - MANGANESE DATA
(Non-detectable analyses plotted as zero)

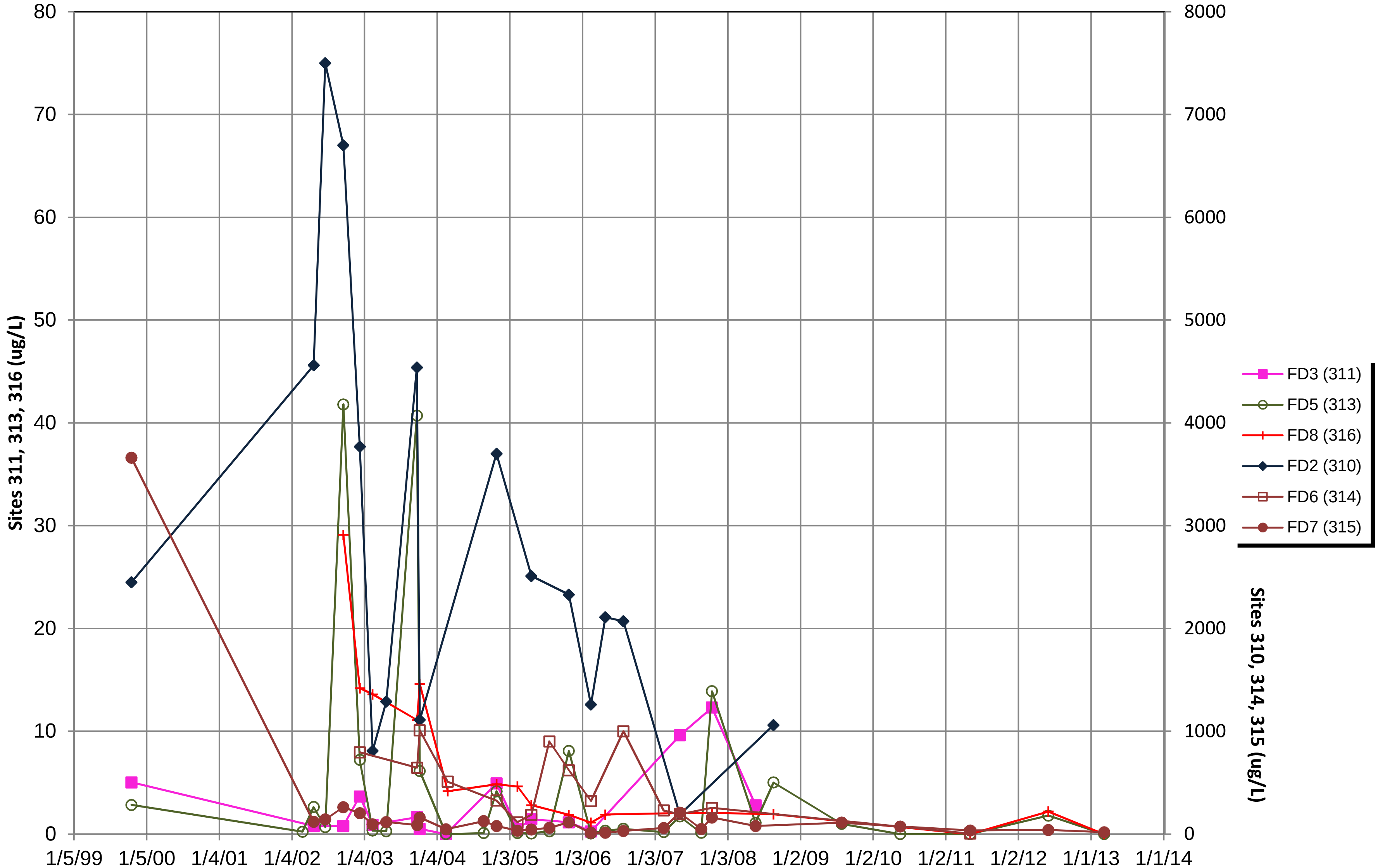


Figure 3.26b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES:
GROUND WATER - MANGANESE DATA
(Non-detectable analyses plotted as zero)

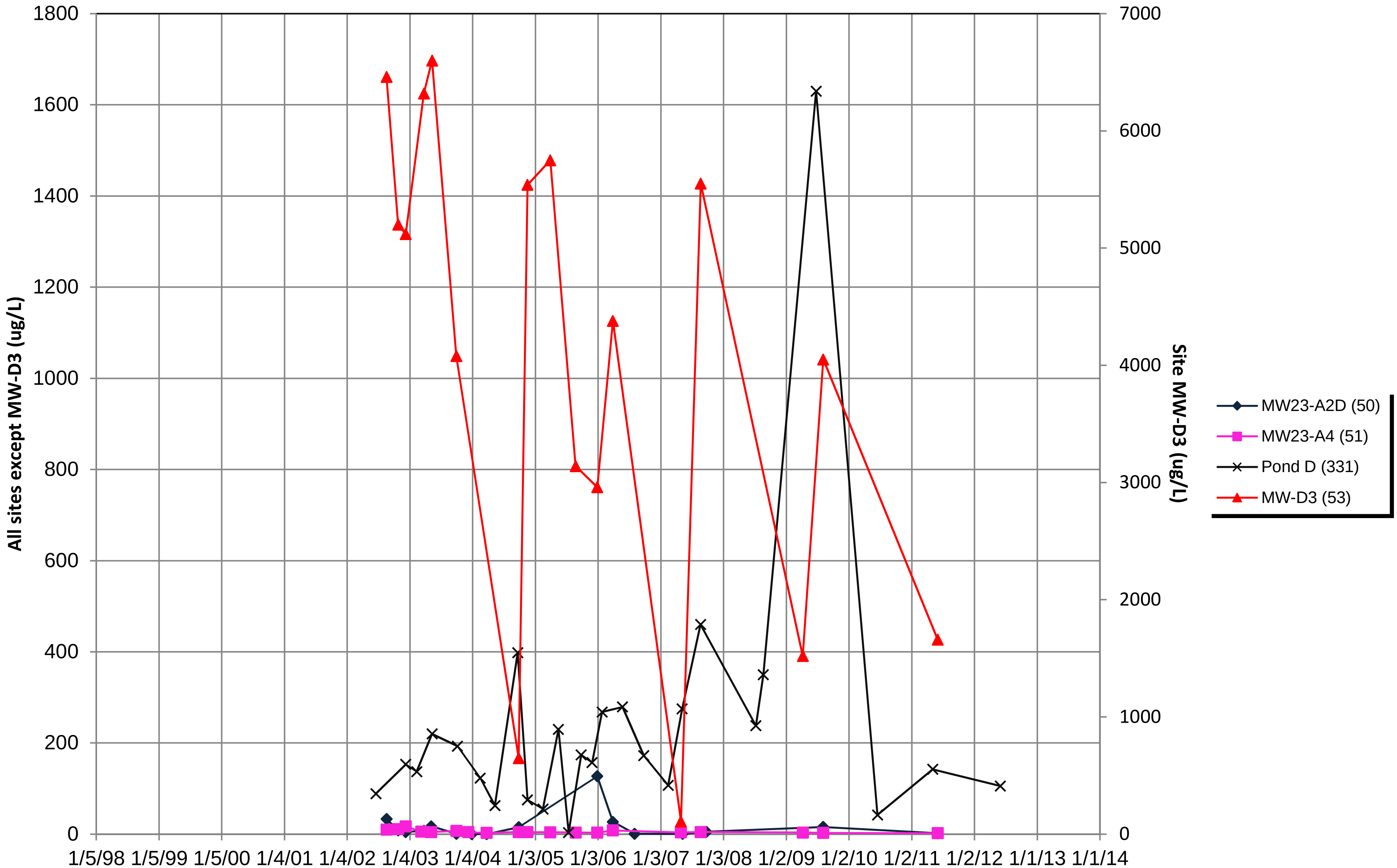


Figure 3.27 GREENS CREEK SITE 23/D INTERNAL MONITORING SITES:

FINGER DRAINS - FLOW DATA

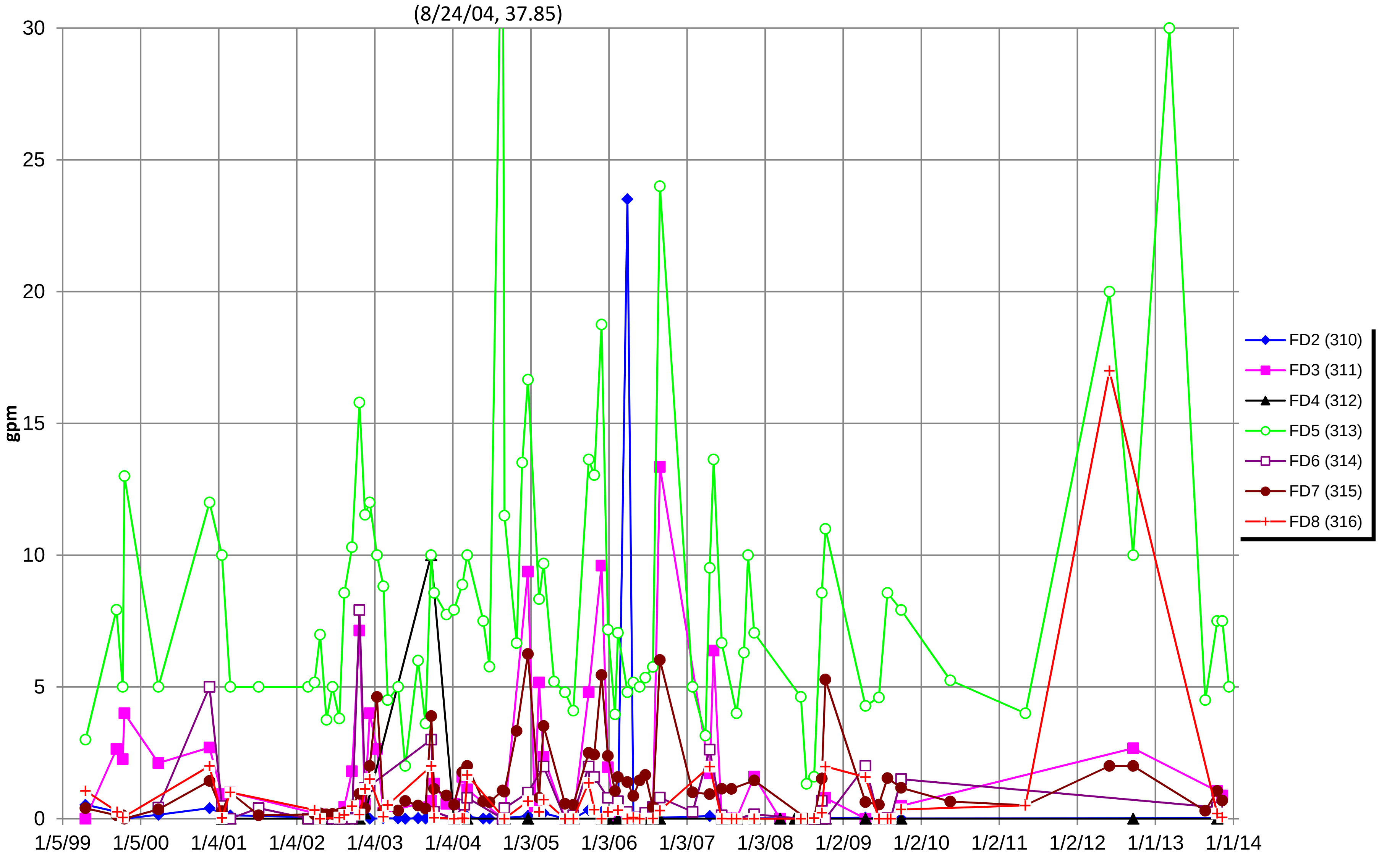


FIGURE 3.28 2013 ABA DATA FROM UNDERGROUND RIB SAMPLES

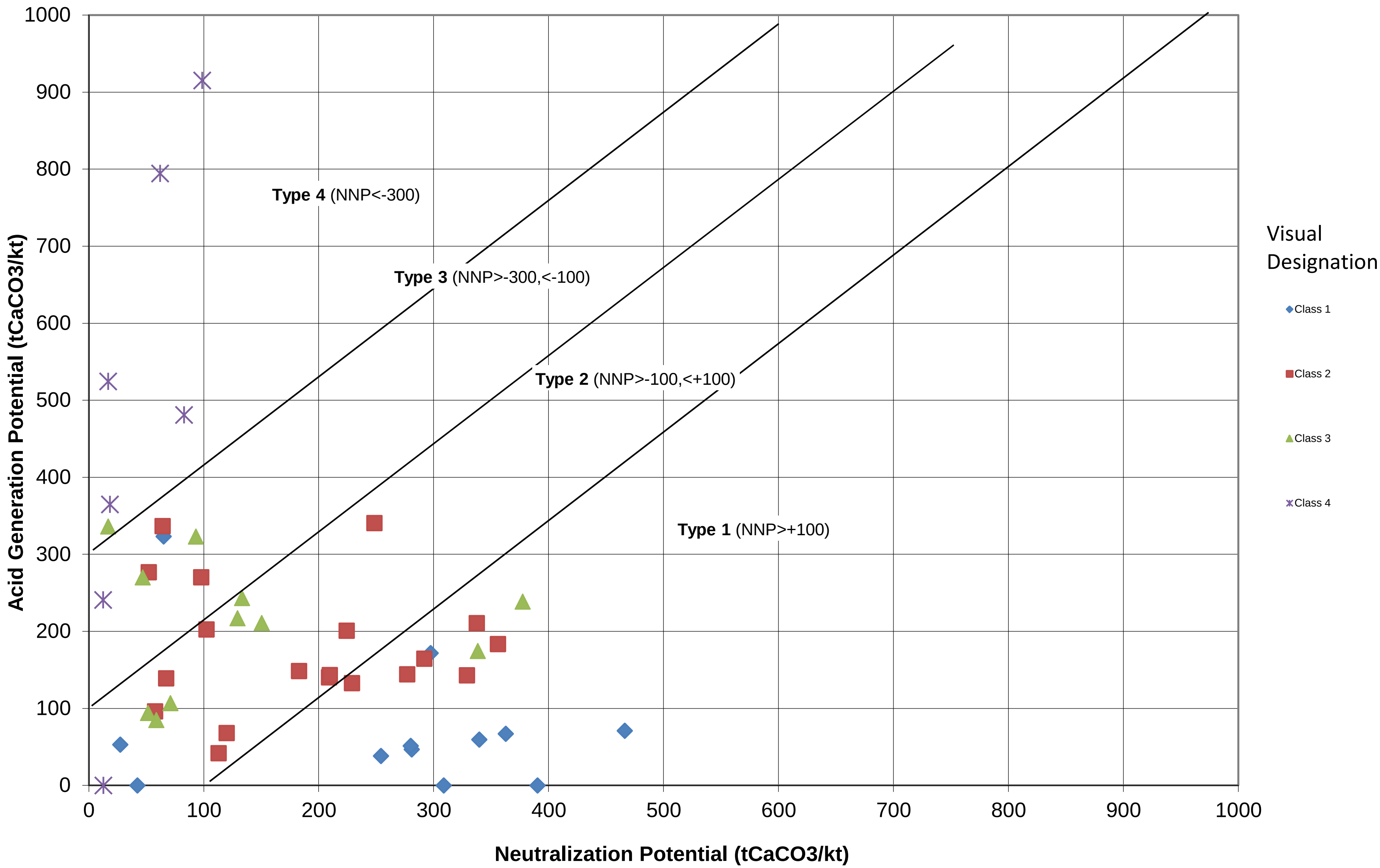


FIGURE 3.29b SITE 23 GRID ABA DATA

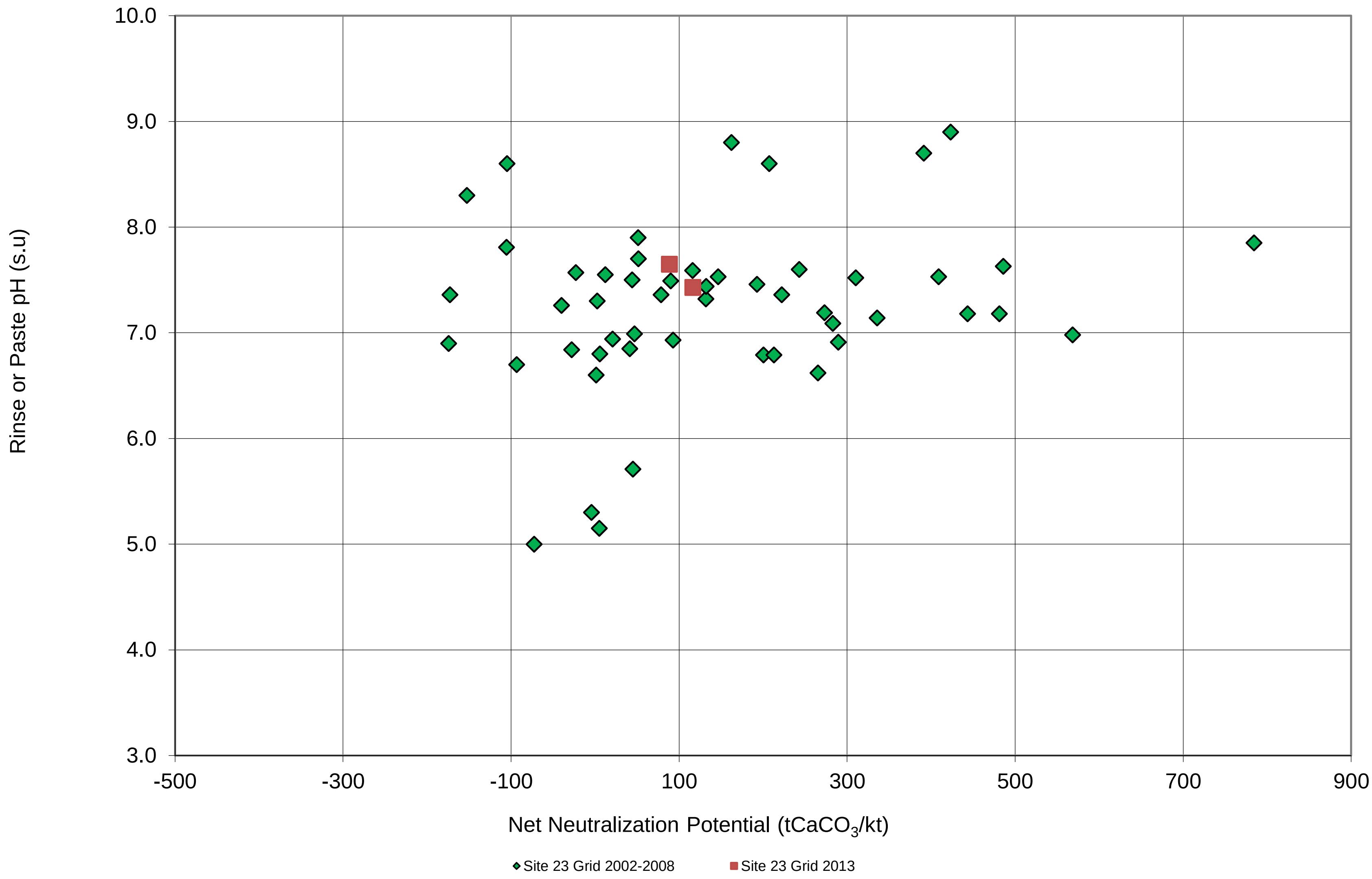
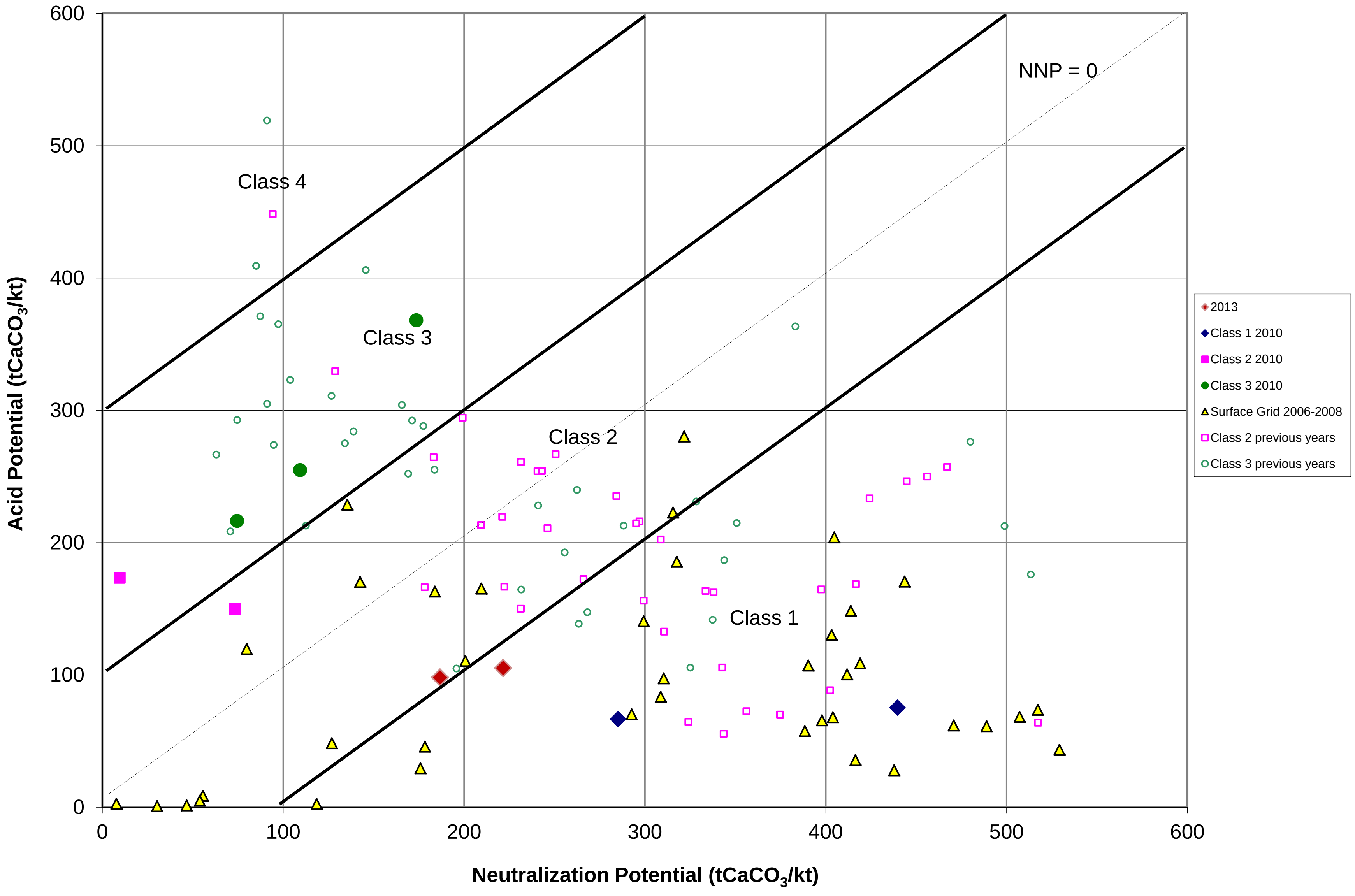


FIGURE 3.29a SITE 23 ABA DATA



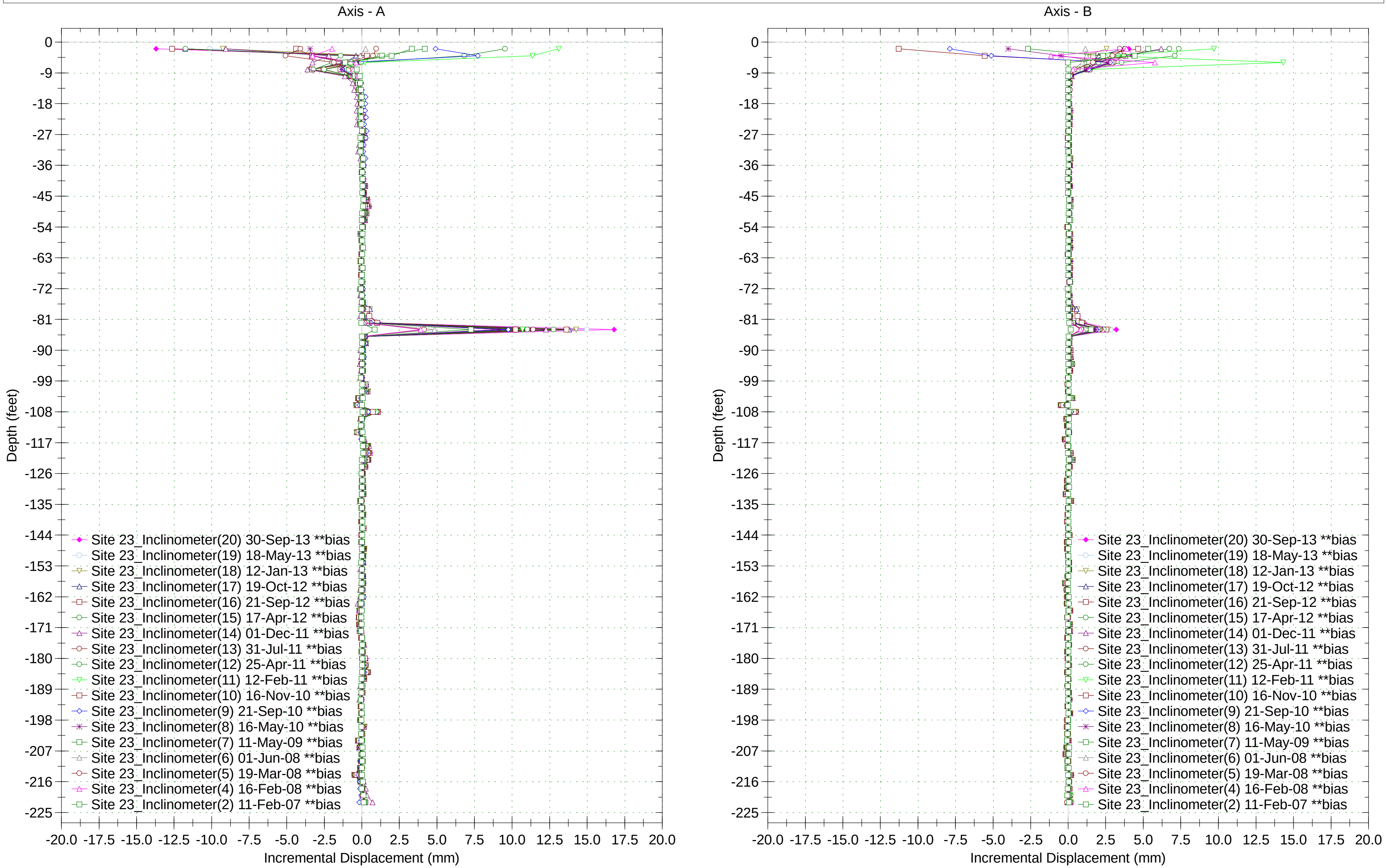
RST Instruments Ltd.

Borehole : Inclinometer
Project : Site 23
Location : IN-23-05-01
Northing : 20671.4520 ft
Easting : 17186.4160 ft

Figure 3.30 Site 23 Inclinometer Incremental Displacement

Inclinalysis

Spiral Correction : N/A
Collar Elevation : 948.840 ft
Borehole Total Depth : 222.0 feet
North Groove Azimuth :
Base Reading : 2006 Oct 07 10:28



Note:
Zero reference is top of casing, at ~4.7 ft above ground surface.
Top section of casing replaced at joint in July 2011 due to damage.
Bias-shift correction by pinning data sets at 150-ft depth (A-B axes).

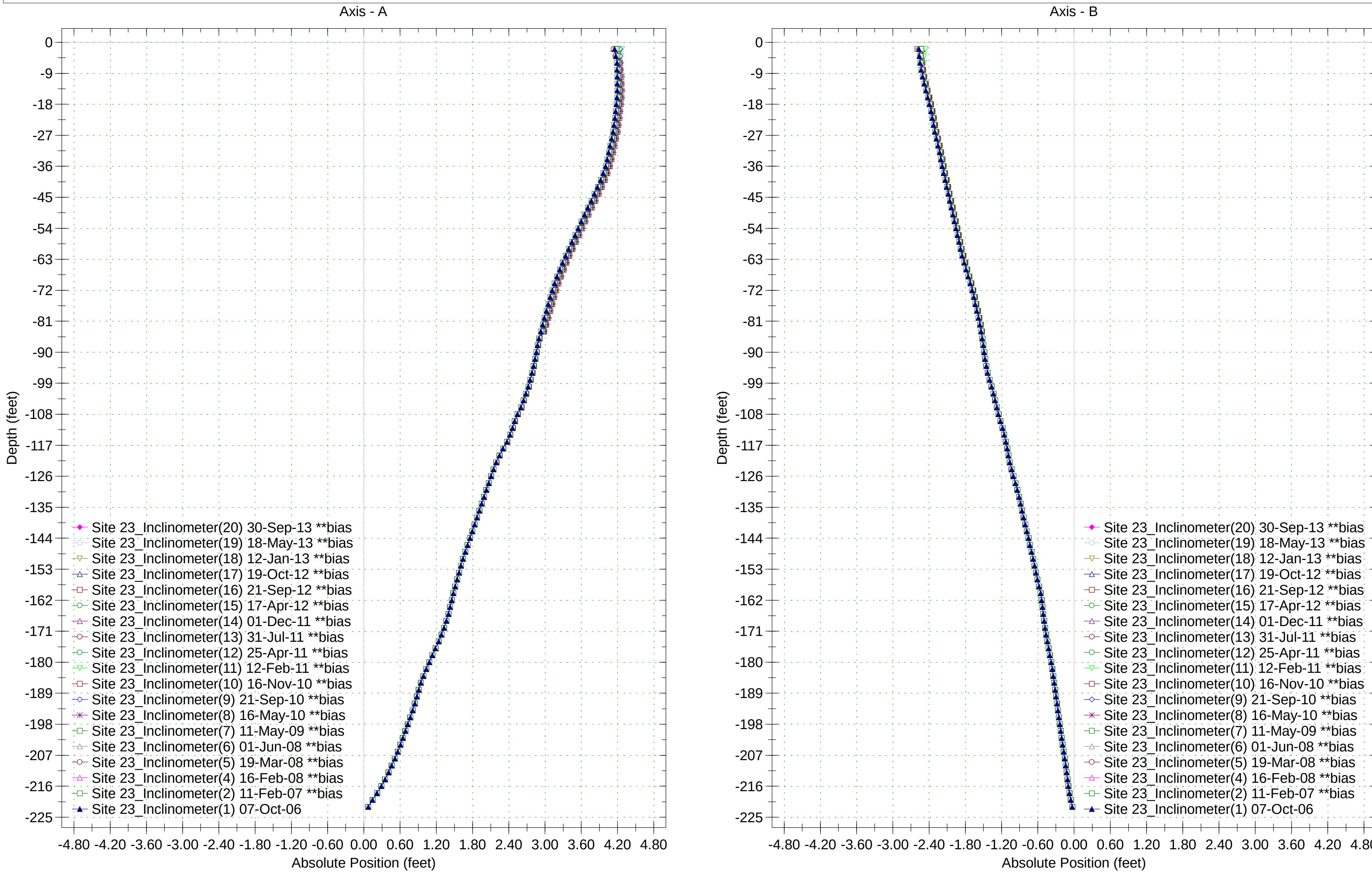
RST Instruments Ltd.

Borehole : Inclinometer
Project : Site 23
Location : IN-23-05-01
Northing : 20671.4520 ft
Easting : 17186.4160 ft

Figure 3.31 Site 23 Inclinometer Absolute Displacement

Inclinalysis

Spiral Correction : N/A
Collar Elevation : 948.840 ft
Borehole Total Depth : 222.0 feet
North Groove Azimuth :
Base Reading : 2006 Oct 07 10:28



Note:
Zero reference is top of casing, at ~4.7 ft above ground surface.
Top section of casing replaced at joint in July 2011 due to damage.
Bias-shift correction by pinning data sets at 150-ft depth (A-B axes).

APPENDIX 4

Site Photographs

Figure 2.38 TDF northwest area in the fall of 2013 during tailing placement

Figure 2.39 Tailings Aerial Photo September 2013

Figure 3.34 Site 23 - October 2013 Reclamation material pile from the 1350 on the far (east) end

Figure 3.35 Site 23 Aerial Photo (oblique north view) Temporary Disposal Area- September 2013