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Memorandum

To: Mohsen Kourehdar, Washington State Department of Ecology

Copies: Dan Silver, B&L Woodwaste Site Custodial Trust

From: Brett Beaulieu, Kristin Anderson, and Teri Floyd, Floyd|Snider; Charles Hand, AMEC

Date: November 14, 2014

Re: **Operations Recommendation for 2015**

INTRODUCTION

The goal of this memorandum is to provide Washington State Department of Ecology (Ecology) with a recommended approach to resolve the discrepancy between the hydraulic performance standard and the containment of leachate in the southwest corner of the landfill where a gap is present in the underlying aquitard. The southwest aquitard gap has been perceived as a central technical challenge throughout the implementation of the 2008 Cleanup Action Plan (CAP). Hydrogeologic modeling of the effects of the southwest gap affected the design of both the barrier wall and groundwater recovery and treatment plant systems. Now that these systems have entered a phase of regular operations, sufficient data are available to adjust operations to better accommodate actual conditions. Adaptive management steps will be necessary throughout the remediation of groundwater at the site in order to use actual performance data to adjust system operations to gain the maximum groundwater remediation benefit at the lowest reasonable cost.

As described in the 2008 CAP, the primary remedial objective at the site is attaining compliance in groundwater outside the landfill perimeter. Monitoring of arsenic concentrations in groundwater downgradient of the barrier wall is being used to assess this goal. The containment of landfill groundwater is a secondary goal intended to support the primary goal by preventing recontamination of off-site groundwater. As an indicator of this secondary goal, a cross-wall head difference (horizontal “gradient”) of 0.5 feet, and an upward vertical gradient in aquitard gap areas, were selected as performance standards for hydraulic control in 2010. The performance standard of 0.5 feet is an arbitrary number that was thought to be conservatively protective of groundwater outside the landfill based on modeling and the information known prior to design and initial operations.

Hydraulic control (inward and upward gradients) at a standard of 0.01 feet is now considered by the project team to be essentially as protective of downgradient groundwater as the 0.5 foot standard, because the system control logic is based on continuous monitoring. Based on its first 2 years of operation, however, the groundwater recovery system is not currently capable of attaining either the 0.5-foot or 0.01-foot standard in the southwest corner. Substantial increases in pumping rates from existing recovery wells in the southwest corner were implemented in 2014, however, and hydraulic control at one piezometer cluster (PZ-4a/b/c) is still not being achieved. Currently, over 50 percent of all recovered groundwater (approximately 17 gallons per minute [gpm]) is pumped from the southwest corner, and the gradients at this location have been slightly outward across the barrier wall throughout the past year and downward vertically within the barrier for most of the year. Further increases in pumping rates involving additional recovery wells would be needed to attain hydraulic control in the southwest corner at a standard of 0.01 feet. It is not known whether the groundwater treatment plant would have the capacity to sustain these higher pumping rates without offsetting them by lowering pumping rates elsewhere. The arsenic concentrations in the groundwater that is being pumped from this corner of the landfill are quite low, typically ranging from around 50 to 300 micrograms per liter (µg/L) in the two primary recovery wells. This results in over 50 percent of the capacity of the plant being used to treat relatively clean groundwater—a non-optimal expenditure of capacity and treatment chemicals.

Meanwhile, monitoring results from the current groundwater monitoring network used to assess groundwater downgradient of the southwest corner have raised questions about whether leachate-impacted water is migrating beyond the landfill perimeter in this area. Increases in arsenic concentrations in these monitoring wells since barrier wall construction have raised the level of importance of understanding the relationships between hydraulic control and groundwater quality, so that appropriate action can be taken.

To address this situation, the B&L Custodial Trust (Trust) developed a conceptual site model based on a review of available and newly-collected hydrogeologic and water quality data from the southwest corner, and prepared a recommendation for changes in 2015 operations. A summary of this evaluation is provided in this memorandum.

DATA SUMMARY

The affected piezometers and monitoring wells described in this section are shown on the attached site map (Figure 1) and cross-section (Figure 2).

Hydraulic Performance and Arsenic Concentrations at PZ-4

As reported with monthly treatment plant metrics, water level measurements from piezometer pairs throughout the landfill indicate that the groundwater recovery system is generally attaining inward cross-wall and upward vertical gradients, and, in most cases, meeting the 0.5-foot performance standard. Neither inward nor upward gradients are being attained at PZ-4, however, despite a substantial increase in pumping from recovery wells R-7, R-8, and R-9 in May of 2014. The PZ-4 cluster is located in the aquitard gap on the southwestern edge of the landfill.

Head differences for the PZ-4 and PZ-5 clusters from October 2013 through September 2014 are presented in Attachment 1. Cross-wall gradients are measured between shallow (approximately 15 to 25 feet deep) piezometers inside the barrier wall ('b' piezometers) and shallow piezometers outside the barrier wall ('a' piezometers). An inward cross-wall gradient is generally able to be maintained in seven out of eight piezometer clusters. For all cross-wall barrier pairs except PZ-4a/b, an inward cross-wall gradient is typically maintained, with six pairs generally meeting the 0.5-foot standard and PZ-5a/b attaining an approximately 0.2- to 0.3-foot inward gradient. During this period, PZ-4a/b typically had an outward cross-wall gradient of approximately -0.1 feet, which was unaffected by the increased pumping rate beginning in May.

A vertical gradient is measured in areas of aquitard gaps between the shallow 'b' piezometers and piezometers inside the barrier wall with screened intervals several feet deeper ('c' piezometers), below the depth of the aquitard. Throughout the year, an inward vertical gradient of approximately 0.2 feet was maintained at the PZ-5b/c cluster. At PZ-4b/c, slightly downward (approximately -0.1 feet) gradients were typical during this period.

Gradient data, therefore, indicate that groundwater is entering the landfill by flowing under the barrier wall at PZ-5, and exiting the landfill by flowing under the barrier wall at PZ-4. However, arsenic concentrations measured in October 2014 in PZ-4a, -4b, and -4c were 5.1 µg/L, 0.7 µg/L, and 2.3 µg/L, respectively, indicating that leachate-impacted groundwater is not exiting the landfill in this location. The arsenic concentration measured at nearby recovery well R-7 in October was of 42.9 µg/L. In contrast, at recovery well R-8, further inside the landfill and located in an area of thicker waste, the arsenic concentration measured in October was 8,030 µg/L.

Groundwater Quality and Hydrogeologic Conditions at D-8A/B

The monitoring wells D-8A and D-8B are located in the southwest corner aquitard gap, which extends beyond the landfill perimeter, and are used to monitor groundwater compliance on the western edge of the landfill. As shown on Figure 1, the well pair is located adjacent to an area of arsenic-contaminated shallow soil that is planned for excavation in 2015. D-8A is screened in the depth corresponding to the upper sand aquifer (approximately 6.5 to 16.5 feet below ground surface [bgs]), and D-8B is screened from a depth corresponding to the Lower Sand Aquifer, approximately 30 to 35 feet bgs.

Monitoring results for D-8A, D-8B, and recovery wells (R-7, R-8, R-9) and piezometers (PD-214, PZ-4a/b/c) sampled in October 2014 are included in Attachment 2. Historical time-concentration trend plots for D-8A and D-8B are included in Attachment 3. Since the time of the barrier wall construction in 2009, the arsenic concentration at D-8A increased from <50 µg/L to >400 µg/L, before a recent decrease to approximately 100 µg/L in October 2014. The concentration increase and variability observed are consistent with the historical trends for D-8A, which vary widely within this range. The fluctuation in arsenic concentrations at this location does not appear correlated with the onset of groundwater recovery activities in the fall of 2012. Arsenic was measured at 15.6 µg/L in nearby shallow piezometer PD-214 in October 2014.

During the same period, the arsenic concentration at D-8B also experienced a substantial increase, from a typical concentration of <15 µg/L prior to barrier wall construction to 370 µg/L in April 2013. The arsenic concentration in D-8B was initially elevated (800 µg/L) following its installation, though this was associated with the temporary disturbance of the consolidation and capping of the landfill in 1993 and 1994. Arsenic concentrations at D-8B were ≤30 µg/L between 1998 and the sudden increase in concentration in April 2013. Following the onset of pumping in the landfill recovery wells in the fall of 2012, the concentrations in this well were restored to <15 µg/L, which is supported by the most recent (October 2014) result of 10.7 µg/L.

The upward trend in arsenic concentration at D-8A between 2009 and 2013 has been attributed to the alteration of flow paths following the installation of the barrier wall. The hypothesis that this alteration resulted in leachate-impacted groundwater reaching D-8A was examined through collection of water level data from area wells. The results indicate that D-8A and nearby piezometer PD-214 are located in an area of the shallow aquifer with relatively flat gradients, in which the local flow direction periodically changes. Water levels are typically higher in monitoring well MW-34 in the agricultural field west of D-8A/B. In addition, D-8A and D-8B have virtually no difference in head, indicating that there is a neutral vertical gradient in this area.

CONCEPTUAL MODEL OF SOUTHWEST CORNER HYDROGEOLOGY AND ARSENIC TRANSPORT

Based on a review of available data, we conclude the following:

- Arsenic concentrations measured at D-8A do not result from leachate-impacted groundwater escaping the landfill beneath the barrier wall through the aquitard gap. The depth of the D-8A well screen is far shallower than the bottom of the barrier wall, and there is no upward gradient evident that would suggest a flow path from beneath the barrier wall.
- Monitoring well D-8A is located in a zone of stagnation, in which area groundwater flow is re-directed by the barrier wall to flow around this location. Groundwater quality measured at D-8A appears to be influenced by local conditions within the stagnation zone, rather than groundwater transported from the landfill. Ditch bank soils that are known to exceed cleanup levels are close to D-8A, and other isolated zones of arsenic-containing soils may be present. The concentration increase and fluctuations since 2009 are consistent with wide concentration swings in historical data and suggest a local source of arsenic concentration rather than landfill leachate.
- Monitoring well D-8B measures groundwater that flows westerly, from beneath the aquitard and barrier wall. Groundwater measured at this location appears to be representative of mixed water in both the upper and lower aquifers that may exit the landfill beneath the barrier. The depth of this monitoring well appears to be appropriate for monitoring the quality of groundwater that may exit the landfill beneath the barrier wall in the southwest corner.

- Comparisons of groundwater elevations in the PZ-4 cluster indicate that there is a flowpath from PZ-4b to PZ-4c to PZ-4a, by which groundwater beneath the landfill flows out beneath the barrier wall. The water balance for groundwater apparently exiting the landfill beneath the barrier wall near PZ-4 appears to be accounted for by groundwater entering the landfill beneath the barrier wall from the south and from the Lower Sand Aquifer near PZ-5, based on the flow path indicated by the water level measurements from PZ-5a to PZ-5c to PZ-5b.
- North of PZ-4a/b/c, where groundwater beneath the landfill is more heavily impacted with arsenic exceeding the cleanup level, the aquitard is present and hydraulic control is able to be maintained, based on measurements at PZ-3a/b.
- The groundwater apparently leaving the landfill near PZ-4 is unimpacted by leachate and is in compliance with the groundwater CUL of 5 µg/L. The groundwater quality data are consistent with the low mass of waste present in the corner, where the mound pinches out to a thin strip. The groundwater quality data are also consistent with the source of the recovered water in this area being unimpacted deeper groundwater.
- Lack of complete gradient control in the southwest corner as measured at PZ-4a/b/c does not mean that arsenic-contaminated groundwater is migrating beyond the landfill perimeter. Not all the groundwater within the barrier wall is impacted by leachate.

RECOMMENDED CHANGES FOR 2015

Based on the data and interpretations presented above, the Trust recommends the following changes be implemented for the 2015 operations year:

- The cross-wall and vertical hydraulic performance standards at PZ-4 should be replaced with monitoring of groundwater for arsenic, as described below:
    - One new monitoring well (MW-40B) should be installed at the depth of the Lower Sand Aquifer, as shown on Figure 1.
    - D-8B and MW-40B should be monitored monthly for arsenic concentration. Samples can be collected by the operator. The arsenic analysis can be performed on-site by the operator as part of regular analysis using existing equipment, and the well can be submitted for laboratory analysis semiannually as part of compliance monitoring.
- The cross-wall hydraulic performance standard at PZ-5 should be adjusted to 0.01 feet. The vertical gradient standard should remain “upward.”
- For now, the existing cross-wall hydraulic performance standard of 0.5 feet would be maintained in the remainder of landfill. Based on available information, the Trust views this standard to be conservatively high and understands that maintaining a lower head difference would also be protective of downgradient groundwater.

- The full design capacity of recovery wells outside the barrier wall should be utilized. Currently, two outside area recovery wells (R-13 and R-17) have been shut down because arsenic concentrations have been measured at concentrations less than 50 µg/L and treatment plant capacity has been in demand to control gradient in the southwest corner. These wells should be utilized fully to prioritize remediation of the outside area.

The current average pumping rate is 32 gpm. By reducing the average pumping rates in the southwest corner recovery wells (R-7, R-8, and R-9) by a total of 8 gpm, and increasing the average pumping rates in unutilized outside area wells (R-13 and R-17) by a total of 2 gpm, these changes are expected to result in a reduced average flow rate of approximately 26 gpm. Under this program, pumping from the southwest corner would still account for approximately 30 percent of the total flow to the treatment plant.

Estimated Costs

The estimated costs for operations in 2015, following these changes, is broken down into the up-front cost to install the monitoring well; additional cost to collect and analyze two groundwater samples; operations and maintenance costs for labor, chemicals, and consumables, which are affected by operating at a reduced average flow rate of 26 gpm; and other operations and monitoring costs assumed to be unaffected by the lower flow rate. Estimated costs for operating at the current average flow rate of 32 gpm are provided below for comparison.

	Estimated 2105 Cost for Operations with Recommended Changes	**Estimated 2015 Cost for Continued Operation**
Well Installation and Development	$8,000	NA
Monthly Monitoring and Analysis	$2,000	NA
Groundwater Treatment Plant Operations: Labor, Chemicals, and Consumables	$203,000	$259,000
Groundwater Treatment Plant Operations: Other	$260,000[1]	$260,000[1]
TOTAL ESTIMATED 2015 COST	**$473,000**	**$519,000**

Note:
1 This estimated cost is approximate. The budget for 2015 operations has not been finalized.

The total cost to implement the changes and operate the plant in 2015 is estimated to be approximately $46,000 less than the cost to operate the plant under the current program. The potential savings in future years may be as much as $56,000 per year.

CONCLUSION AND FUTURE CONSIDERATIONS

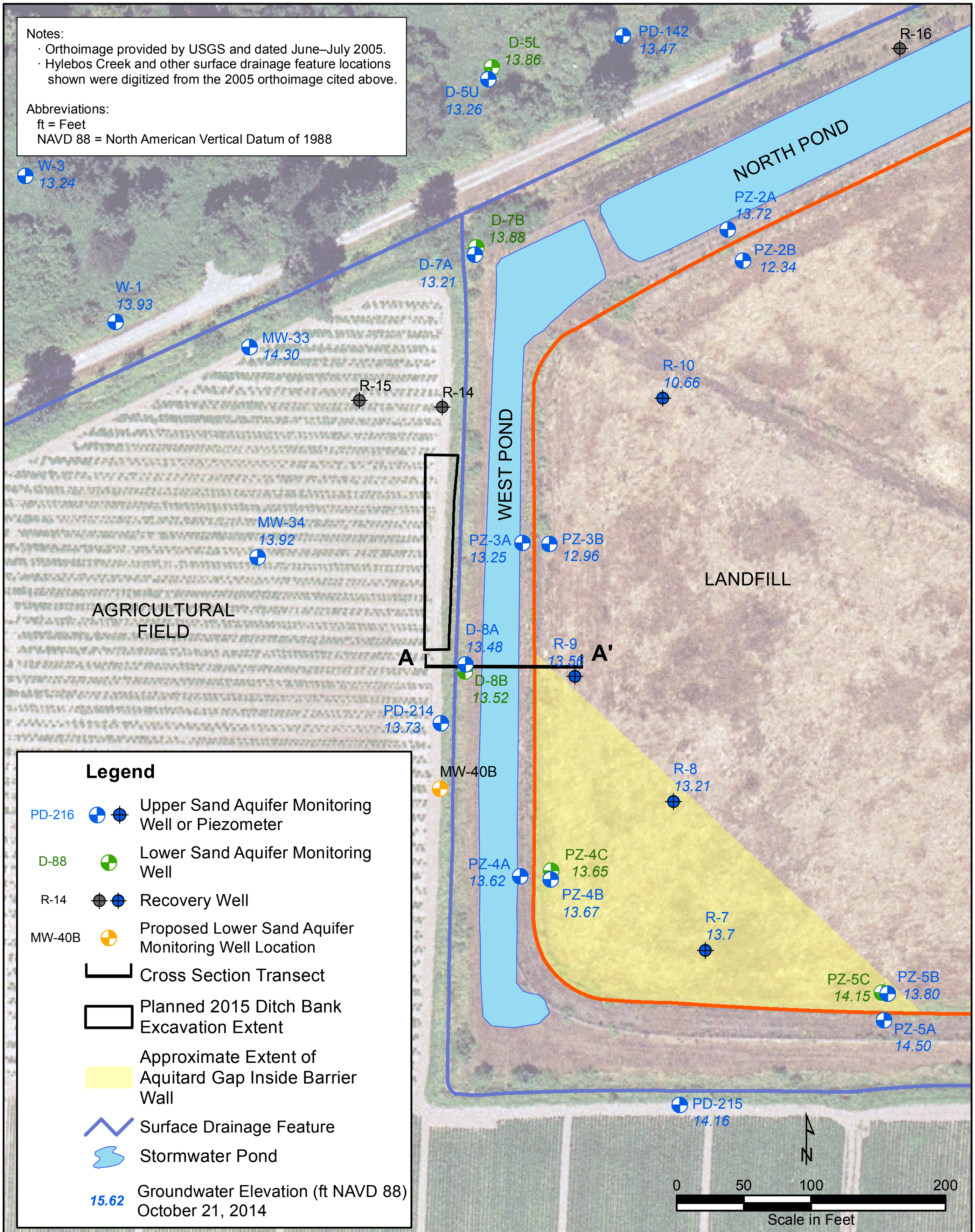
The Trust believes the changes recommended in this memorandum are reasonable and cost-effective steps to make an informed correction in the way that landfill leachate containment is monitored and evaluated, and then evaluate the effectiveness of the change. The changes would shift the focus from using gradient measurements in an area of an aquitard gap, to monitoring for direct evidence of landfill leachate outside the landfill barrier, prevention of which is the primary goal of the cleanup. Use of gradients to assess containment is not appropriate for the southwest corner because meeting this standard is not necessary to prevent impacts to groundwater outside the landfill, is not feasible under current conditions in an aquitard gap area, and attempts to meet the standard needlessly generate large volumes of relatively clean water that must be treated at considerable added cost. This change would also allow for more aggressive remediation of impacted groundwater outside the barrier wall, which is important given the limited duration of the Trust. To this end, the Trust would welcome an opportunity to meet with Ecology to discuss further changes to the hydraulic performance standard throughout the landfill.

As operations continue in 2015, the Trust plans to remove a substantial volume of arsenic-contaminated soil from the ditch bank area near D-8A/B, and will monitor for improvements in groundwater quality in this area. In the event that groundwater monitoring under the new approach indicates that leachate is impacting groundwater, several potential options are available for consideration. These options include restoring the higher pumping rates in the southwest, and changing the treatment plant discharge point to the West Pond to raise water levels outside the barrier.

ATTACHMENTS

Figure 1	Site Map
Figure 2	Southwest Landfill Corner Potentiometric Surface Conceptual Cross Section, September–October, 2014
Attachment 1	PZ-4 and PZ-5 Head Difference Plots
Attachment 2	Groundwater Sampling Results
Attachment 3	Historical Concentration Trends for D-8A and D-8B

Figures



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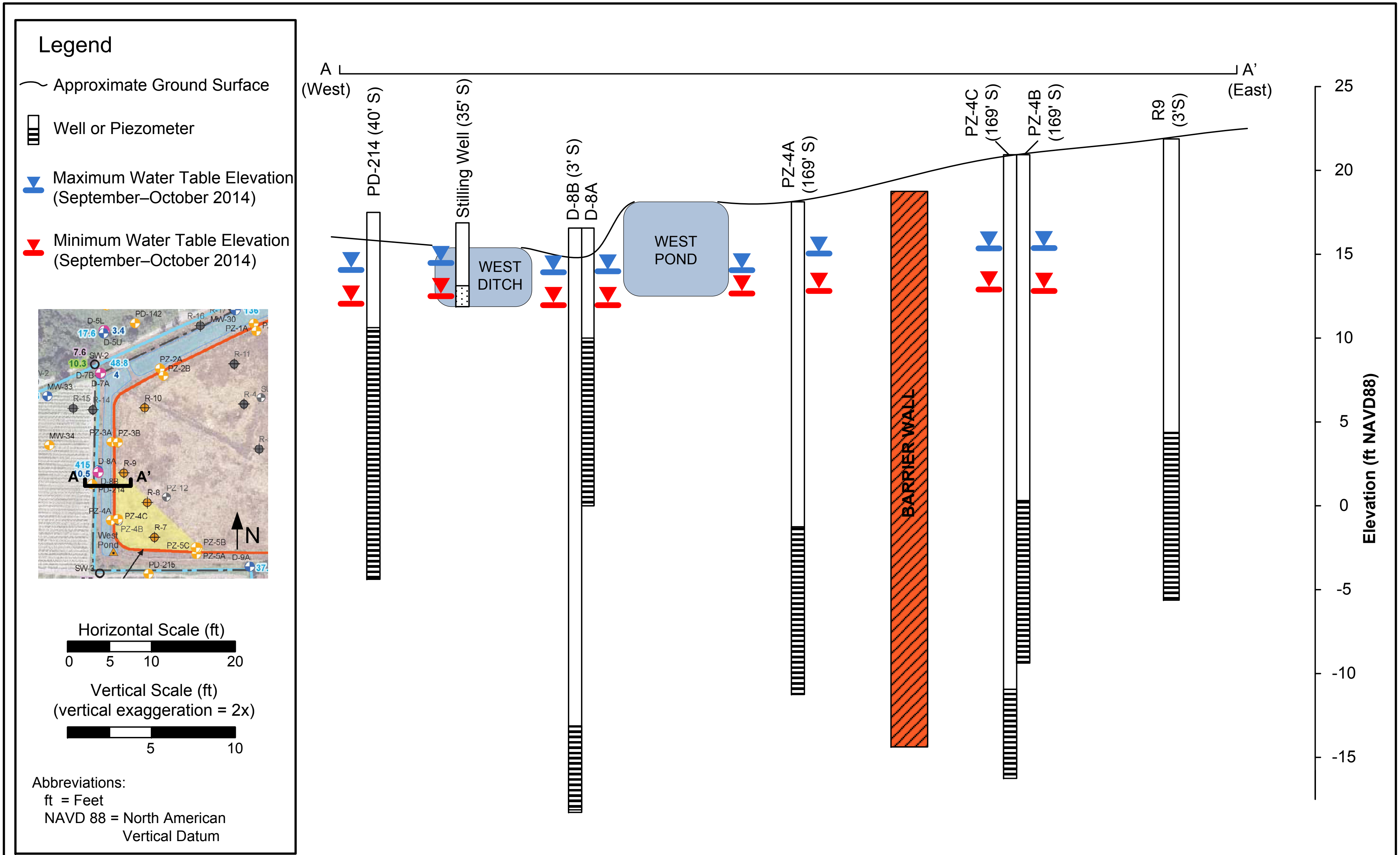
B&L Woodwaste Site
Pierce County, Washington

Figure 1
Site Map

I:\GIS\Projects\B&L-O&M\MXD\Figure 1 Site Map.mxd
11/11/2014



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Operations Recommendation for 2015
B&L Woodwaste Site
Pierce County, Washington

Figure 2
Southwest Landfill Corner Potentiometric Surface Conceptual Cross Section, September–October 2014

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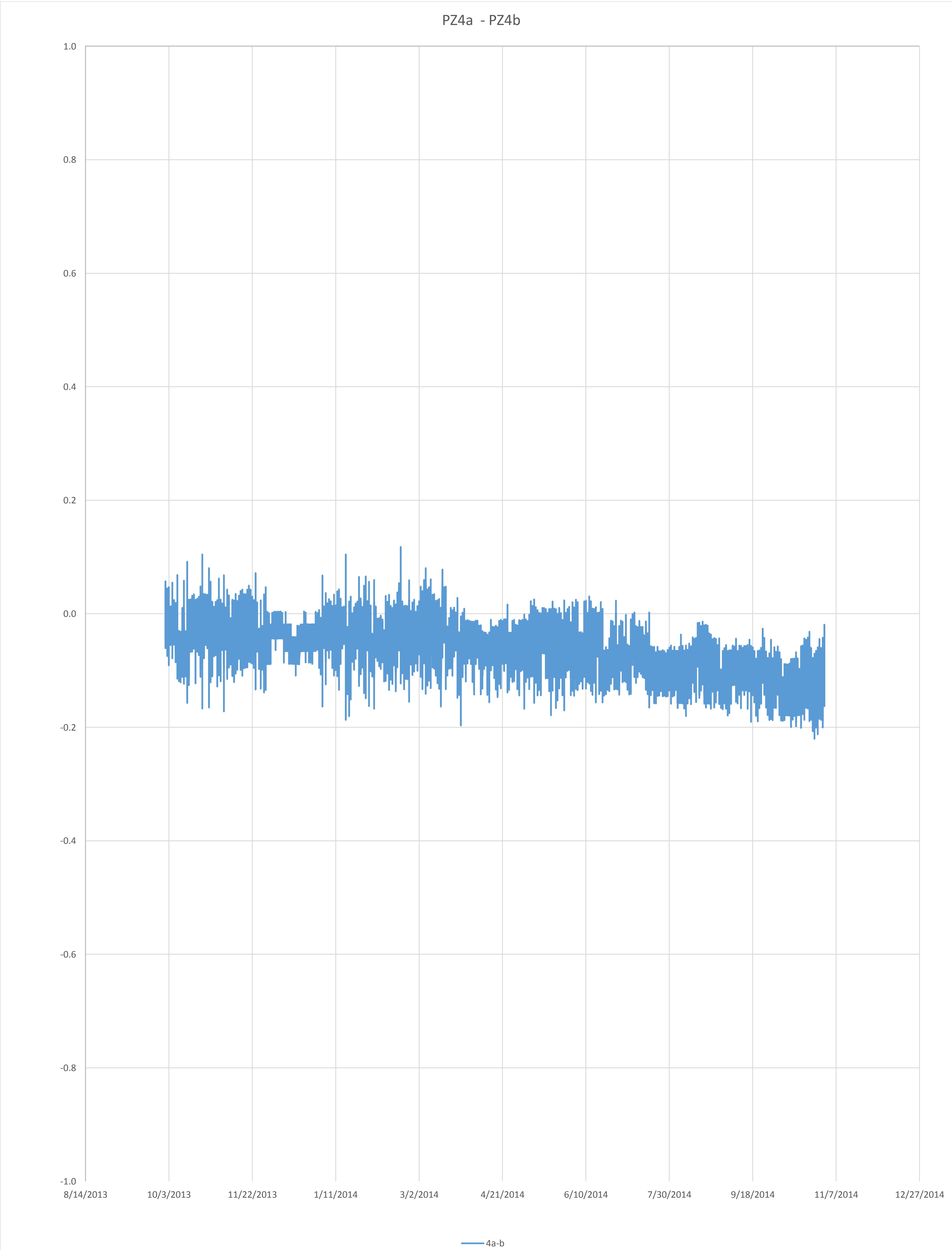
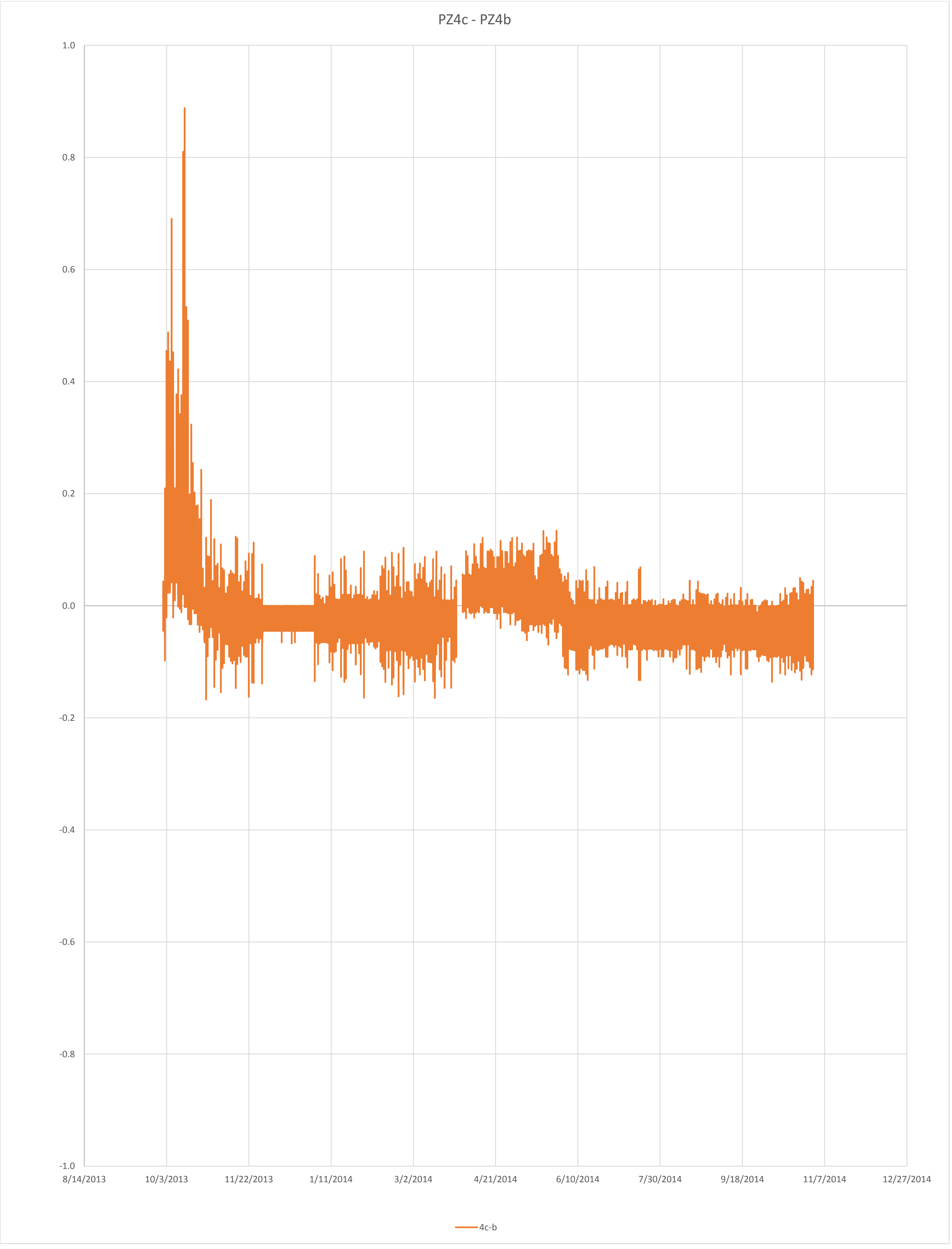
11/12/2014

Attachment 1
PZ-4 and PZ-5 Head Difference Plots


PZ4a - PZ4b
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
8/14/2013
10/3/2013
11/22/2013
1/11/2014
3/2/2014
4/21/2014
6/10/2014
7/30/2014
9/18/2014
11/7/2014
12/27/2014
4a-b


PZ4c - PZ4b
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
8/14/2013
10/3/2013
11/22/2013
1/11/2014
3/2/2014
4/21/2014
6/10/2014
7/30/2014
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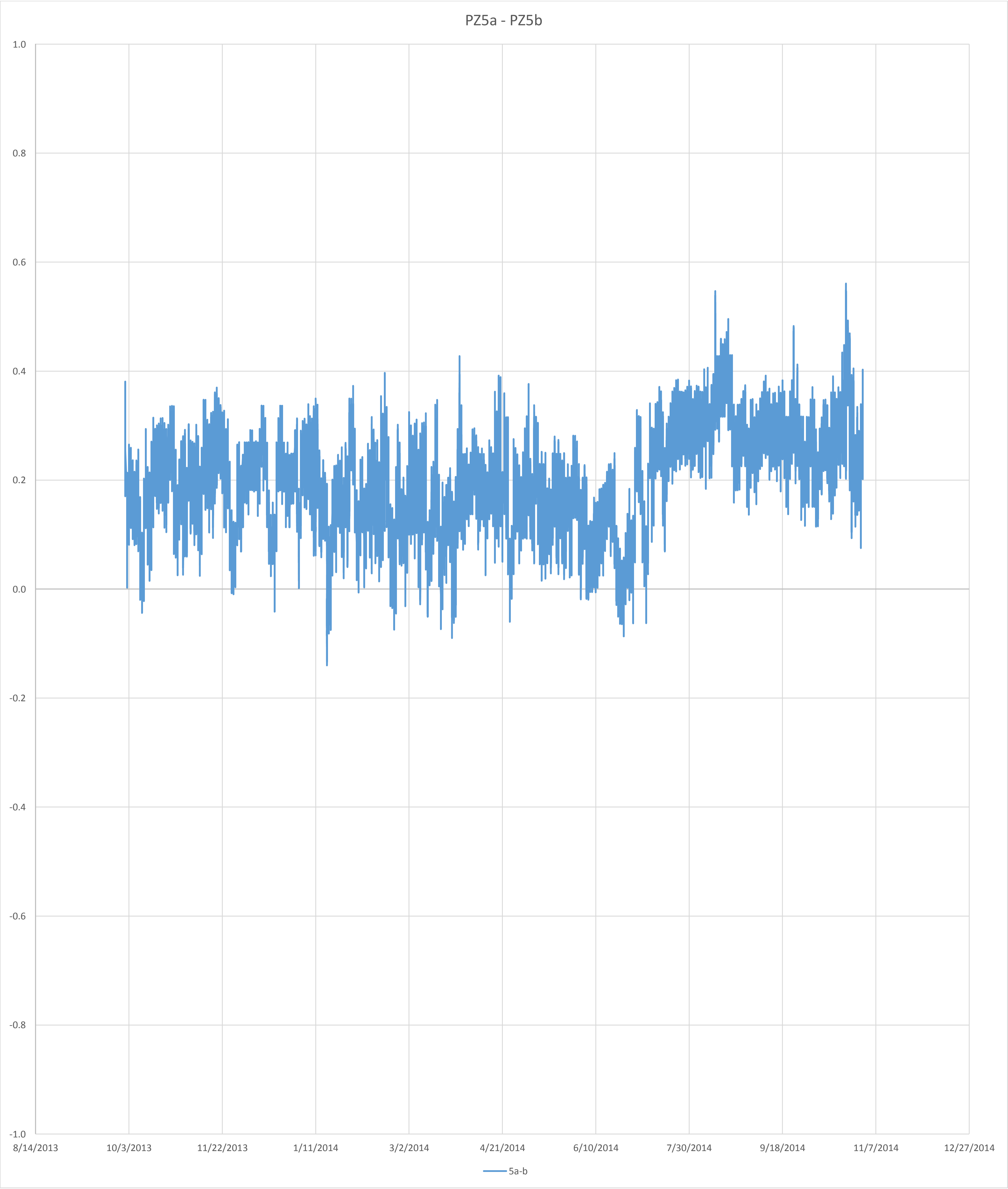
12/27/2014
4c-b


PZ5a - PZ5b
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
8/14/2013
10/3/2013
11/22/2013
1/11/2014
3/2/2014
4/21/2014
6/10/2014
7/30/2014
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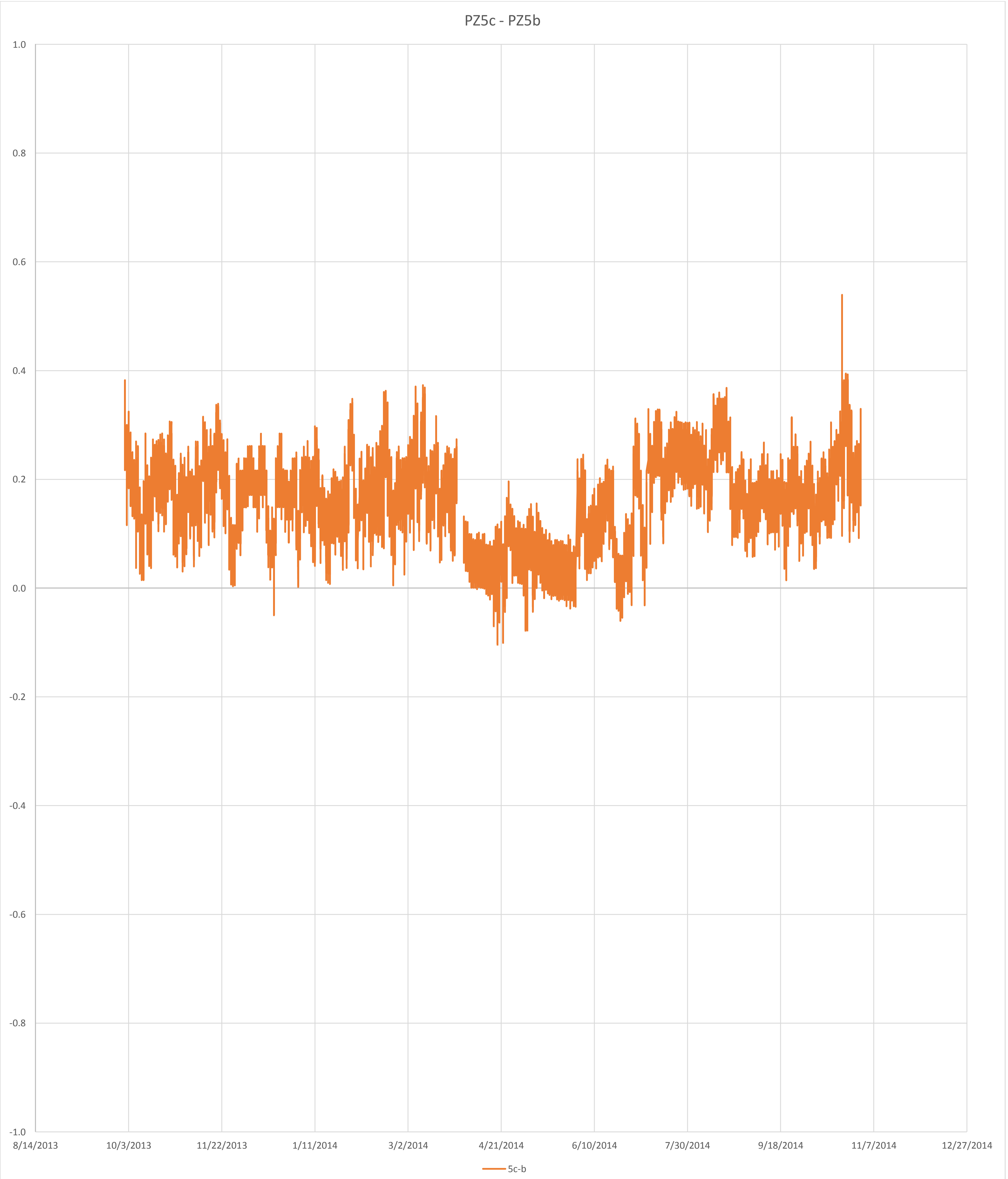
12/27/2014
5a-b


PZ5c - PZ5b
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
8/14/2013
10/3/2013
11/22/2013
1/11/2014
3/2/2014
4/21/2014
6/10/2014
7/30/2014
9/18/2014
11/7/2014
12/27/2014
5c-b

Attachment 2
Groundwater Sampling Results

Groundwater Arsenic Results[1]

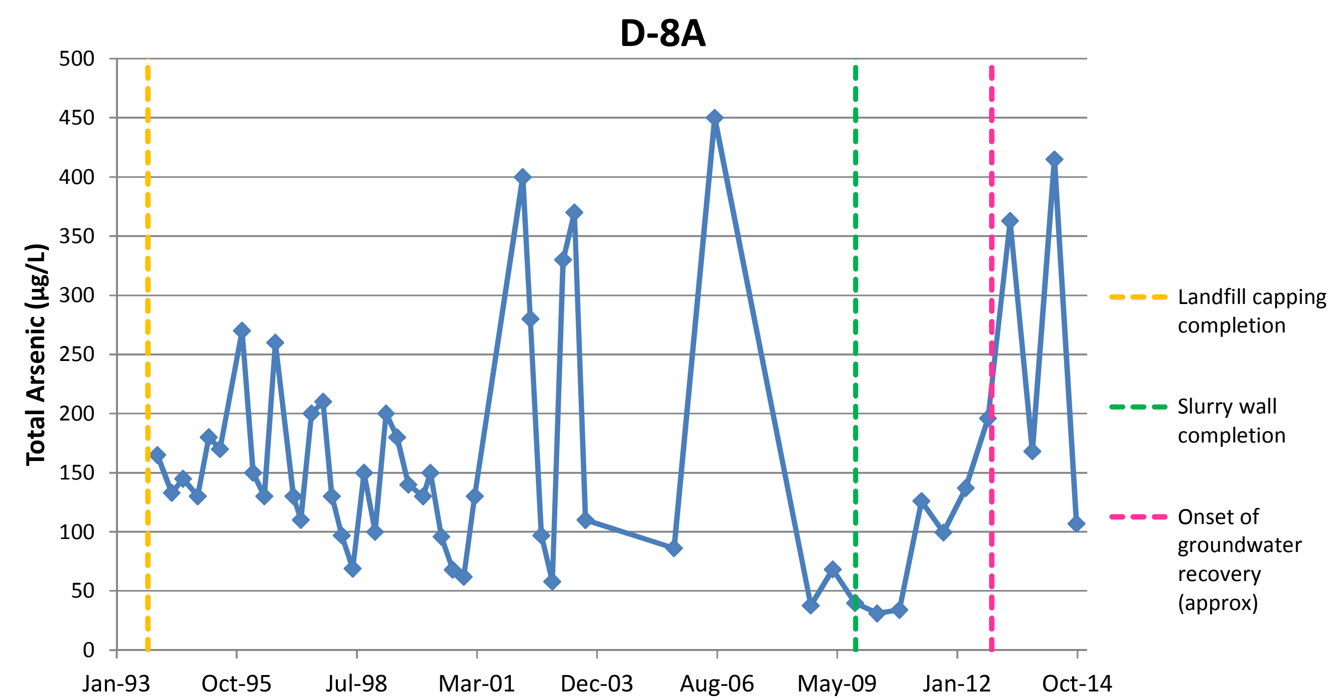
	Arsenic Concentration (µg/L)								
	D-8A	D-8B	PD-214	R-7	R-8	R-9	PZ-4A	PZ-4B	PZ-4C
Monitoring Events									
October 2014	107	10.7	15.6	42.9	8,030	312	5.1	0.7	2.7
May 2014	NS	NS	NS	54.0	NS	357	NS	NS	NS
April 2014	415	10.5	NS	NS	NS	NS	NS	NS	NS
October 2013	168	13.9	NS	NS	NS	NS	NS	NS	NS
April 2013	363	16.6	NS	NS	NS	NS	NS	NS	NS
October 2012	196	155	NS	NS	NS	NS	NS	NS	NS
April 2012	137	370	NS	NS	NS	NS	NS	NS	NS
September 2011	99.6	28.2	NS	NS	NS	NS	NS	NS	NS
April 2011	126	21.2	NS	NS	NS	NS	NS	NS	NS
October 2010	34	6.1	NS	NS	NS	NS	NS	NS	NS
April 2010	31.1	12.8	NS	NS	NS	NS	NS	NS	NS
October 2009	39.8	11	NS	NS	NS	NS	NS	NS	NS
April 2009	68.2	11.1	NS	NS	NS	NS	NS	NS	NS
October 2008	37.7	12.2	NS	NS	NS	NS	NS	NS	NS
Historical Events									
March 2007	NS	18	NS	NS	NS	NS	NS	NS	NS
August 2006	450	NS	NS	NS	NS	NS	NS	NS	NS
September 2005	86.1	NS	NS	NS	NS	NS	NS	NS	NS
March 2005	NS	21.2	NS	NS	NS	NS	NS	NS	NS
December 2003	NS	21	NS	NS	NS	NS	NS	NS	NS
September 2003	110	20	NS	NS	NS	NS	NS	NS	NS
June 2003	370	30	NS	NS	NS	NS	NS	NS	NS
March 2003	330	30	NS	NS	NS	NS	NS	NS	NS
December 2002	58	20	NS	NS	NS	NS	NS	NS	NS
September 2002	97	20	NS	NS	NS	NS	NS	NS	NS
June 2002	280	30	NS	NS	NS	NS	NS	NS	NS
April 2002	400	30	NS	NS	NS	NS	NS	NS	NS
December 2001	NS	30	NS	NS	NS	NS	NS	NS	NS
June 2001	NS	30	NS	NS	NS	NS	NS	NS	NS
March 2001	130	30	NS	NS	NS	NS	NS	NS	NS
December 2000	62	20	NS	NS	NS	NS	NS	NS	NS
September 2000	68	20	NS	NS	NS	NS	NS	NS	NS
June 2000	96	20	NS	NS	NS	NS	NS	NS	NS
March 2000	150	20	NS	NS	NS	NS	NS	NS	NS
January 2000	130	30	NS	NS	NS	NS	NS	NS	NS
September 1999	140	20	NS	NS	NS	NS	NS	NS	NS
June 1999	180	20	NS	NS	NS	NS	NS	NS	NS
March 1999	200	30	NS	NS	NS	NS	NS	NS	NS
December 1998	100	30	NS	NS	NS	NS	NS	NS	NS
September 1998	150	20	NS	NS	NS	NS	NS	NS	NS
June 1998	69	20	NS	NS	NS	NS	NS	NS	NS
March 1998	97	40	NS	NS	NS	NS	NS	NS	NS
December 1997	130	60	NS	NS	NS	NS	NS	NS	NS
September 1997	210	60	NS	NS	NS	NS	NS	NS	NS
June 1997	200	60	NS	NS	NS	NS	NS	NS	NS
March 1997	110	60	NS	NS	NS	NS	NS	NS	NS
January 1997	130	90	NS	NS	NS	NS	NS	NS	NS
September 1996	260	100	NS	NS	NS	NS	NS	NS	NS
June 1996	130	100	NS	NS	NS	NS	NS	NS	NS
March 1996	150	100	NS	NS	NS	NS	NS	NS	NS
December 1995	270	100	NS	NS	NS	NS	NS	NS	NS
June 1995	170	200	NS	NS	NS	NS	NS	NS	NS
March 1995	180	200	NS	NS	NS	NS	NS	NS	NS
December 1994	130	300	NS	NS	NS	NS	NS	NS	NS
August 1994	145	400	NS	NS	NS	NS	NS	NS	NS
May 1994	133	700	NS	NS	NS	NS	NS	NS	NS
January 1994	165	800	NS	NS	NS	NS	NS	NS	NS

Note:
1 Reported value is the maximum concentration per location, per sampling date.

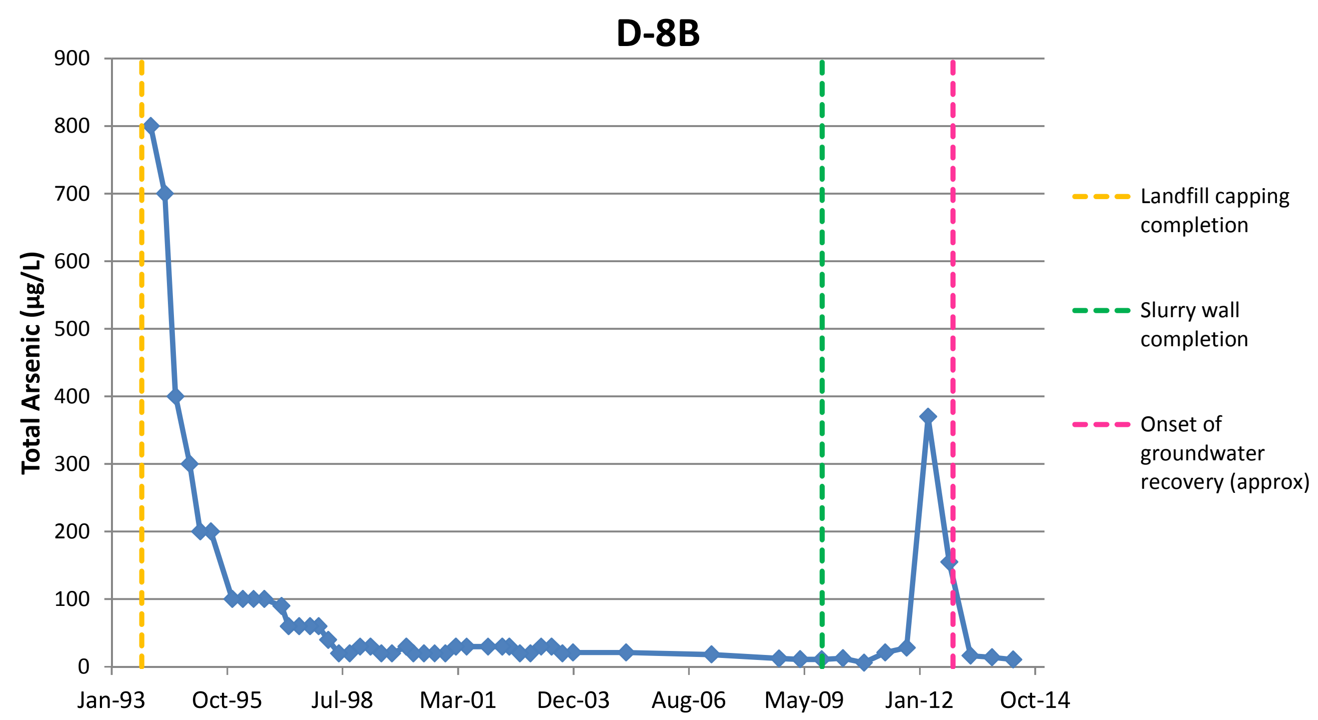
Abbreviations:
µg/L Micrograms per liter
NS Not sampled

Qualifier:
U Analyte is undetected at given reporting limit

Attachment 3
Historical Concentration Trends
for D-8A and D-8B



Notes: Detection limits vary. Non-detect results with detection limits of 5 µg/L or less are plotted at the detection limit. Non-detect results with detection limits greater than 5 µg/L have been omitted. Refer to Table 2.3.



Notes: Detection limits vary. Non-detect results with detection limits of 5 µg/L or less are plotted at the detection limit. Non-detect results with detection limits greater than 5 µg/L have been omitted. Refer to Table 2.3.