7316

Department of Energy
Washington, DC 20585

May 24, 2012

Mr. Timothy Fischer
U.S. Environmental Protection Agency
Region V-SRF-6J
77 W. Jackson Blvd.
Chicago, IL 60604-3590

Mr. Thomas A. Schneider
Ohio Environmental Protection Agency
401 East 5th Street
Dayton, Ohio 45402

Dear Mr. Fischer and Mr. Schneider:

SUBJECT: **Transmittal of the 2011 Site Environmental Report**

This letter transmits the Fernald Preserve Site Environmental Report for calendar year 2011 to the United States Environmental Protection Agency (EPA) and Ohio EPA. The enclosed report is submitted in order to meet the June 1, 2012 commitment date, which fulfills the annual reporting commitment identified in Attachment D of the Comprehensive Legacy Management and Institutional Controls Plan, Revision 4.

The 2011 Site Environmental Report documents the results of the environmental monitoring activities over the calendar year. This report consists of the following two components:

- Summary Report – Similar to previous annual site environmental reports, it includes background information about the Fernald Preserve and associated remediation activities. It also provides a summary-level presentation of environmental data for groundwater, surface water and treated effluent. This summary report also includes an exposure pathway dose assessment for 2011 and a natural resources update.

- Appendices A through D – The appendices present the detailed compilation of environmental data for 2011, and primarily consist of graphs and tables. This detailed information supports the findings and data interpretations presented in the summary report.

The summary report is intended to serve the same audience as past annual reports and will be distributed to Fernald Preserve stakeholders. The appendices are intended to serve a more technical audience such as the regulatory agencies; therefore, distribution will be more limited.

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Attachment 1 lists the proposed changes to environmental monitoring at the Fernald Preserve. These changes are a result of the data evaluation process followed during the preparation of the 2011 Site Environmental Report. Attachment 1 contains summary information. Please see the affected appendices and attachments for detailed information.

The summary report and appendices will be available to all stakeholders through the Visitors Center, which is located at 7400 Willey Rd., Hamilton, OH 45013; (513) 648-7500 (open Wednesday through Saturday, 9:00 a.m. to 5:00 p.m., or by appointment). The summary report will also be made available on the Department of Energy Office of Legacy Management's internet site (http://www.lm.doe.gov) under the Legacy Management Sites icon.

As in the past, comments on this report will be addressed through a comment response document and incorporated in future annual reports, as appropriate, rather than through a revision of this document. Please call me at (720) 880-4349 if you have any questions. Please send any correspondence to:

U.S. Department of Energy
Office of Legacy Management
10995 Hamilton-Cleves Hwy.
Harrison, OH 45030

Sincerely,

Gwen N Hooten
2012.05.24
09:48:06 -06'00'

Gwen Hooten
Acting Fernald Preserve Manager
DOE-LM-20.2

Enclosures

cc w/enclosure:
S. Helmer, ODH
T. Schneider, Ohio EPA (3 copies of enclosure)
T. Tucker, Ohio EPA-Columbus
Project Record File FER030.1(A) (thru W. Sumner)

cc w/o enclosure:
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J. Homer, Stoller
G. Lupton, Stoller
T. Pauling, DOE
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K. Reed, DOE
K. Voisard, Stoller
C. White, Stoller

Attachment 1

Proposed Changes to Environmental Monitoring at the Fernald Preserve

Appendix A, Attachment A.2

Heavy rain events in 2011 damaged Flume 2 in the Storm Sewer Outfall Ditch. Stoller proposes to remove the flume and only calculate infiltration rates when flow down this channel is not occurring. Infiltration assessments would be made over shorter time periods when flow measurements in the remaining flumes indicate that infiltration could be occurring. The calculation would rely mostly on flow measurements in Flumes 1, 4, and 6 with minor contributions from Flumes 3 and 5.

Appendix A, Attachment A.5

- If the first quarter 2012 tritium data is similar to the three quarter's of data collected in 2011, all tritium monitoring will be discontinued for all of the on-site disposal facility (OSDF) cells.

- Ammonia was detected for the first and second time in the OSDF Cell 3 leak detection system (LDS) in 2009 and 2010. Because the Cell 3 LDS was dry for all of 2011, ammonia will be monitored in the Cell 3 LDS the next time a sample can be collected.

- Chromium was detected in the leachate collection system (LCS) of Cell 6 for a second time in 2011. It was first detected in 2010. Because chromium has been detected two consecutive times in the LCS, chromium will be monitored in the LDS of Cell 6 during the next subsequent scheduled sampling event.

- Because 1,1-dichloroethene continues to be detected in the Cell 7 LCS, it will continue to be monitored in the Cell 7 LDS.

- Chromium has been sampled at least eight times in the LCS of Cell 7 and detected at least 25 percent of the time. Because it failed the null hypothesis of the Tarone-Ware test, it will be added to the quarterly sampling list for the LCS, LDS, and Great Miami Aquifer wells of each cell beginning in January 2013.

- Sulfate had previously been removed from the horizontal till well (HTW) monitoring at all cells. It is being added back into the Cell 8 HTW monitoring list in order to provide data needed to construct a uranium-sulfate bivariate plot for Cell 8.

Appendix D

- The *Wetland Mitigation Monitoring Report* is the primary driver for future monitoring activities. The report specifies that intensive annual monitoring of mitigation wetlands is no longer required. However, as stated in the report, wetlands will continue to be evaluated on a three-year rotation, as part of a continued functional monitoring program. Hydrologic monitoring will continue as well.

- Pursuant to the *Natural Resource Restoration Plan*, implementation monitoring will continue as well, with a second year of herbaceous cover in the Resolution No. 3 project areas. Several restoration projects are planned for 2012, and these will be evaluated for herbaceous cover and woody vegetation survival. Project-specific species inventory activities will also continue.

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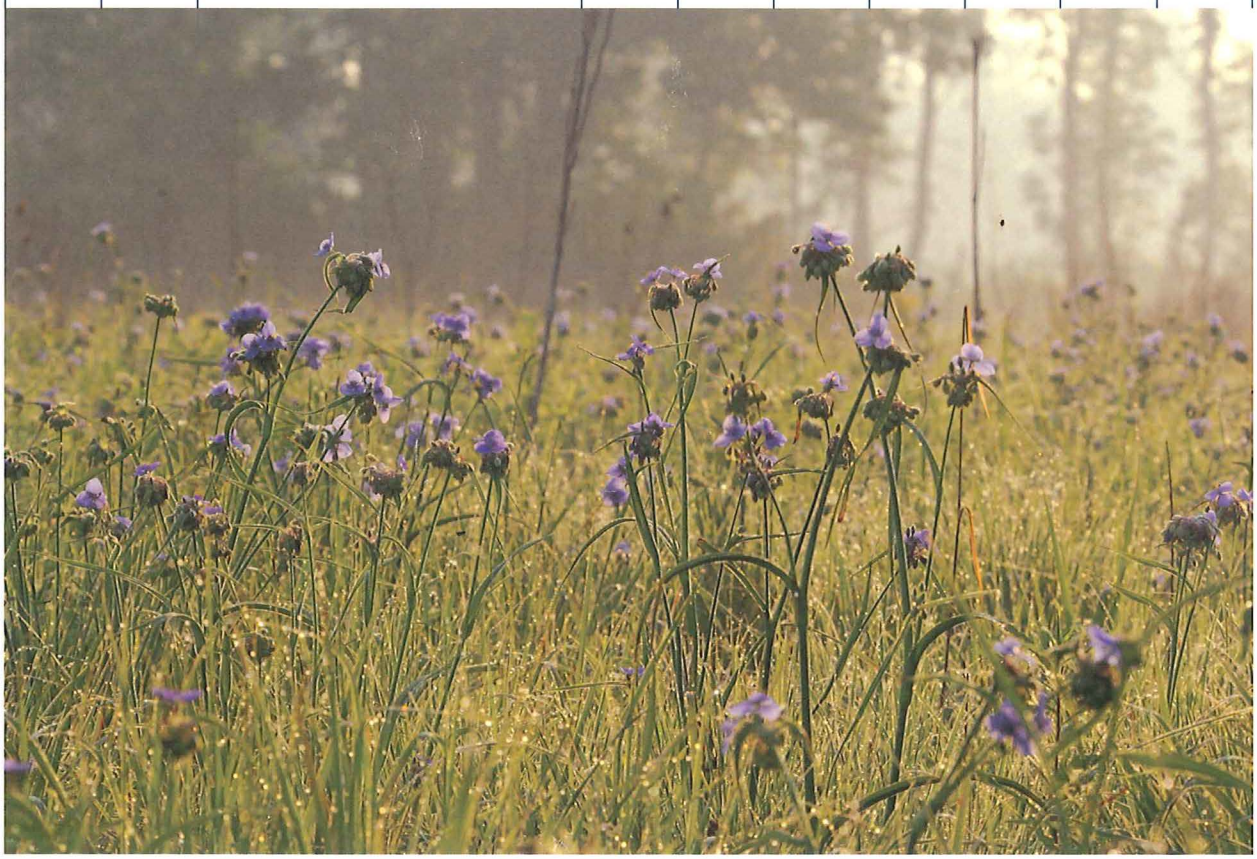
FERNALD PRESERVE

2011 Site Environmental Report



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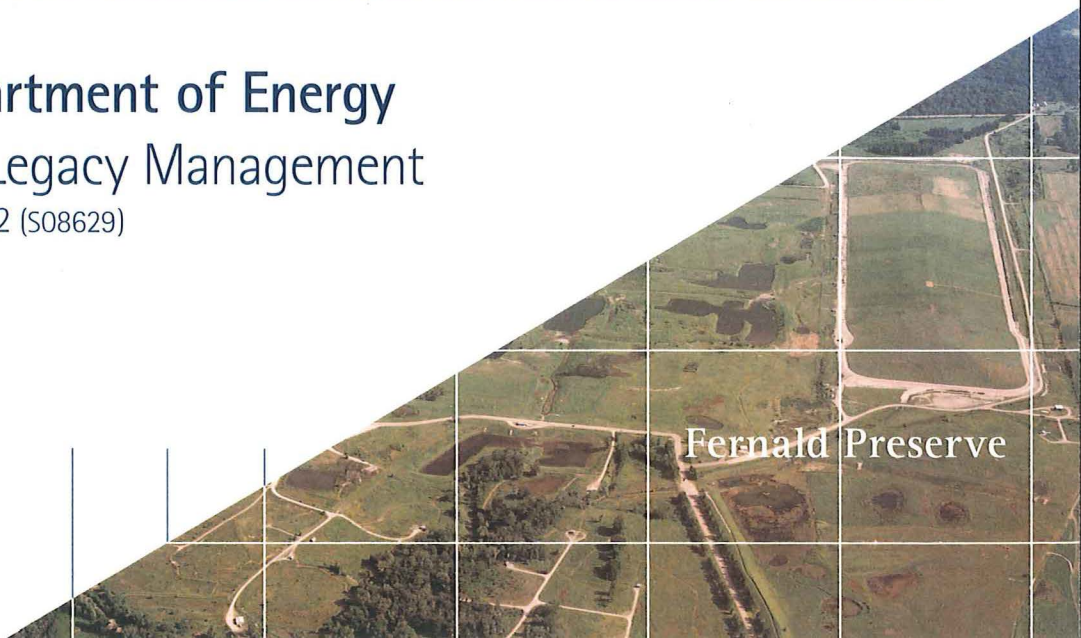

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Fernald Preserve

2011 Site Environmental Report

May 2012

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Contents

Abbreviations iv
Measurement Abbreviations v
Units (Abbreviations) and Conversion Table vi
Executive Summary vii
1.0 Site Background 1
1.1 The Path to Site Closure 3
1.2 Environmental Monitoring Program 6
1.3 Characteristics of the Site and Surrounding Area 6
1.3.1 Land Use and Demography 6
1.3.2 Geography 7
1.3.3 Geology 7
1.3.4 Surface Hydrology 8
1.3.5 Natural Resources 8
2.0 Remediation Status and Compliance Summary 19
2.1 CERCLA Remediation Status 19
2.2 Summary of Compliance with Other Requirements 24
2.2.1 RCRA 24
2.2.1.1 RCRA Property Boundary Groundwater Monitoring 24
2.2.1.2 Waste Management 24
2.2.2 Clean Water Act 24
2.2.3 Clean Air Act 25
2.2.4 Superfund Amendments and Reauthorization Act of 1986 25
2.2.5 Other Environmental Regulations 25
2.2.6 Other Permits 29
2.2.7 Pollution Prevention and Source Reduction 29
2.2.8 Federal Facilities Compliance Agreement 29
2.2.9 Environmental Management Systems Requirement 30
2.3 Split Sampling Program 30
3.0 Groundwater Pathway 33
3.1 Summary of the Nature and Extent of Groundwater Contamination 33
3.2 Selection and Design of the Groundwater Remedy 34
3.3 Groundwater Monitoring Highlights for 2011 38
3.3.1 Restoration Monitoring 44
3.3.1.1 Operational Summary 44
3.3.1.2 South Plume/South Plume Optimization Module Operational Summary 47
3.3.1.3 South Field Module Operational Summary 47
3.3.1.4 Waste Storage Area Module Operational Summary 49
3.3.1.5 Monitoring Results for Total Uranium 50
3.3.1.6 Monitoring Results for Non-Uranium Constituents 51
3.3.2 Other Monitoring Commitments 54
3.4 Groundwater Remediation Assessment 54
3.5 OSDF Monitoring 55
4.0 Surface Water and Treated Effluent Pathway 59
4.1 Summary of Surface Water and Treated Effluent Pathway 59
4.2 Remediation Activities Affecting the Surface Water Pathway 61
4.3 Surface Water, Treated Effluent, and Sediment Monitoring Program 61

4.3.1 Surveillance Monitoring 62
4.3.2 Compliance Monitoring 66
4.3.2.1 FFCA and OU5 ROD Compliance 66
4.3.2.2 NPDES Permit Compliance 70
4.3.3 Uranium Discharges in Surface Water and Treated Effluent 70
5.0 Direct Radiation Pathway and Radiation Dose 73
5.1 Monitoring for Direct Radiation 73
5.2 Direct Radiation Dose 75
5.3 Total of Doses to the Maximally Exposed Individual 77
5.4 Significance of Estimated Radiation Doses for 2011 77
5.5 Estimated Dose to Biota 79
6.0 Natural Resources 81
6.1 Ecological Restoration Activities 83
6.1.1 Ecological Restoration Repair, Maintenance, and Enhancement 83
6.1.2 Ecological Restoration Monitoring 84
6.1.2.1 Wetland Mitigation Monitoring 85
6.1.2.2 Functional Monitoring 89
6.1.2.3 Implementation Monitoring 92
6.2 Fernald Preserve Site and OSDF Inspections 93
6.3 Affected Habitat Findings 93
6.4 Threatened and Endangered Species and Species Inventories 94
6.5 Cultural Resources 95
7.0 References 99
8.0 Glossary 103

Figures

Figure 1. Fernald Preserve and Vicinity 9
Figure 2. Major Communities in Southwestern Ohio 10
Figure 3. Fernald Preserve Perspective 11
Figure 4. Cross Section of the New Haven Trough, Looking North 13
Figure 5. Regional Groundwater Flow in the Great Miami Aquifer 14
Figure 6. Great Miami River Drainage Basin 15
Figure 7. Annual Precipitation, 1994–2011 16
Figure 8. Monthly Precipitation for 2011 Compared to Average Monthly Precipitation for 1951–2011 17
Figure 9. Uncertified Areas and Subgrade Utility Corridors 21
Figure 10. DOE and Ohio EPA Groundwater Split Sample Locations 32
Figure 11. Extraction Wells Active in 2011 35
Figure 12. Diagram of a Typical Groundwater Monitoring Well 39
Figure 13. Monitoring Well Relative Depths and Screen Locations 40
Figure 14. Locations for Semiannual Total Uranium Monitoring 41
Figure 15. Locations for Semiannual Non-Uranium Monitoring 42
Figure 16. Groundwater Elevation Monitoring Wells 43
Figure 17. Net Mass of Uranium Removed from the Great Miami Aquifer, 1993–2011 46
Figure 18. Total Uranium Plume in the Aquifer with Concentrations Greater Than 30 µg/L at the End of 2011 48
Figure 19. Non-Uranium Constituents with 2011 Results Above FRLs 53

Figure 20. OSDF Footprint and Monitoring Well Locations 56
Figure 21. Controlled Surface Water Areas and Uncontrolled Runoff Flow Directions 60
Figure 22. IEMP/NPDES Surface Water and Treated Effluent Sample Locations 63
Figure 23. IEMP Background Surface Water Sample Locations 65
Figure 24. Annual Average Total Uranium Concentrations in Paddys Run at Willey Road (SWP-03) Sample Location, 1985–2011 67
Figure 25. Mass of Uranium Discharged to the Great Miami River through the Parshall Flume (PF 4001) in 2011 68
Figure 26. 2011 Monthly Average Total Uranium Concentration in Water Discharged Through the Parshall Flume (PF 4001) to the Great Miami River 69
Figure 27. Uranium Discharged via the Surface Water Pathway, 1993–2011 71
Figure 28. Direct Radiation (OSL) Monitoring Locations 74
Figure 29. 2011 Quarterly Results for OSL Monitoring Locations 76
Figure 30. Comparison of 2011 All-Pathway Doses and Allowable Limits 78
Figure 31. Restoration Project Areas 82
Figure 32. Ecological Monitoring Activities 88
Figure 33. Threatened and Endangered Species Habitat Areas 96
Figure 34. Cultural Resource Survey Area 97

Tables

Table 1. Operable Unit Remedies 4
Table 2. Compliance with Other Environmental Regulations 26
Table 3. 2011 DOE/Ohio EPA Groundwater Split Sampling Comparison 31
Table 4. Groundwater Restoration Module Status for 2011 45
Table 5. Non-Uranium Constituents with Results Above FRLs During 2011 52
Table 6. OSDF Groundwater, Leachate, and LDS Monitoring Summary 57
Table 7. Direct Radiation (OSL) Measurement Summary 75
Table 8. Dose to MEI 77
Table 9. Wetland Mitigation Monitoring Results 87
Table 10. Wetland Mitigation Amphibian Monitoring Summary 89
Table 11. Forest Functional Monitoring Herbaceous Vegetation Summary 90
Table 12. Forest Functional Monitoring Woody Vegetation Summary 91
Table 13. Forest Functional Monitoring Comparison 91
Table 14. Implementation Monitoring Summary 92

Appendixes

Appendix A Supplemental Groundwater Information
Appendix B Supplemental Surface Water, Treated Effluent, and Sediment Information
Appendix C Supplemental Air Information
Appendix D Ecological Restoration Monitoring

Abbreviations

AR	Administrative Record
ARARs	applicable or relevant and appropriate requirements
BCG	Biota Concentration Guide
CAWWT	Converted Advanced Wastewater Treatment facility
CC	coefficient of conservatism
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FFCA	Federal Facility Compliance Agreement
FQAI	Floristic Quality Assessment Index
FRL	final remediation level
IEMP	Integrated Environmental Monitoring Plan
LCS	leachate collection system
LDS	leak detection system
LM	DOE Office of Legacy Management
LMICP	*Comprehensive Legacy Management and Institutional Controls Plan*
MEI	maximally exposed individual
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRRP	Natural Resource Restoration Plan
Ohio EPA	Ohio Environmental Protection Agency
OSDF	onsite disposal facility
OSL	optically stimulated luminescence
OU5 ROD	Operable Unit 5 Record of Decision
PCB	polychlorinated biphenyl
PF	Parshall Flume
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act of 1986
SSOD	storm sewer outfall ditch
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VIBI	Vegetation Index of Biotic Integrity
WM1	Wetland Mitigation, Phase I
WM2	Wetland Mitigation, Phase II

Measurement Abbreviations

cm	centimeter
ft	feet
gpm	gallons per minute
kg	kilogram
km	kilometer
lb	pound
Lpm	liters per minute
m	meter
M gal	million gallons
M liters	million liters
mg/L	milligrams per liter
mGy/day	milligray per day
mrem/yr	millirem per year
mSv/yr	millisieverts per year
pCi/L	picocuries per liter
rem	roentgen equivalent man
µg/L	micrograms per liter

Units (Abbreviations) and Conversion Table

Multiply	By	To Obtain	Multiply	By	To Obtain
inches	2.54	centimeters (cm)	cm	0.3937	inches
feet (ft)	0.3048	meters (m)	m	3.281	ft
miles (mi)	1.609	kilometers (km)	km	0.6214	mi
pounds (lb)	0.454	kilograms (kg)	kg	2.205	lb
gallons	3.785	liters (L)	L	0.2642	gallons
square feet (ft^2)	0.0929	square meters (m^2)	m^2	10.76	ft^2
acres	0.4047	hectares	hectares	2.471	acre
cubic yards (yd^3)	0.7646	cubic meters (m^3)	m^3	1.308	yd^3
cubic feet (ft^3)	0.02832	cubic meters (m^3)	m^3	35.31	ft^3
picocuries (pCi)	10^{-12}	curies (Ci)	Ci	10^{12}	pCi
pCi/L	10^{-6}	microcuries per liter (µCi/L)	µCi/L	10^6	pCi/L
millirem (mrem)	0.001	rem	rem	1000	mrem
mrem	0.01	millisievert (mSv)	mSv	100	mrem
rem	0.01	sievert (Sv)	Sv	100	rem
mSv	0.001	Sv	Sv	1000	mSv
person-rem	0.01	person-Sv	person-Sv	100	person-rem
rad	0.01	gray (Gy)	Gy	100	rad
milligray (mGy)	0.001	Gy	Gy	1000	mGy
milligrams per liter (mg/L)	1000	micrograms per liter (µg/L)	µg/L	0.001	mg/L
Fahrenheit (˚F)	(˚F–32) × 5/9	Celsius (˚C)	˚C	(˚C × 9/5) + 32	˚F
For Natural Uranium in Water					
pCi/L	0.0015	mg/L	mg/L	675.7	pCi/L
pCi/L	1.48	µg/L	µg/L	0.6757	pCi/L
µg/L	0.6757	pCi/L	pCi/L	1.48	µg/L
For Natural Uranium in Soil					
pCi/g	1.48	µg/g	µg/g	0.6757	pCi/g
mg/kg	1	µg/g	µg/g	1	mg/kg

Executive Summary

The *2011 Fernald Preserve Site Environmental Report* provides stakeholders with the results from the Fernald, Ohio, Site's environmental monitoring programs for 2011; a summary of the U.S. Department of Energy's (DOE's) activities conducted on site; and a summary of the Fernald Preserve's compliance with the various environmental regulations, compliance agreements, and DOE policies that govern site activities. This report has been prepared in accordance with DOE Order 436.1, *Departmental Sustainability*, and the "Integrated Environmental Monitoring Plan," which is Attachment D of the *Comprehensive Legacy Management and Institutional Controls Plan* (LMICP) (DOE 2010).

The Fernald Preserve has been successfully remediated with the exception of the groundwater remedy, and the care and maintenance of the onsite disposal facility (OSDF), which are the only ongoing components of remediation.

During 2011, activities at the Fernald Preserve included:

- Environmental monitoring activities related to direct radiation, groundwater, and surface water.
- Prescribed burns.
- Ecological restoration activities as well as inspections, care, and monitoring of the site and the OSDF to ensure that provisions of the LMICP are fully implemented.
- Collection, monitoring, and treatment of leachate from the OSDF.
- Extraction, monitoring, and treatment of contaminated groundwater from the Great Miami Aquifer (Operable Unit 5).
- Ongoing operation of the Fernald Preserve Visitors Center, associated outreach, and educational activities.
- National Pollution Discharge Elimination System permit monitoring.
- Completion of the third Comprehensive Environmental Response, Compensation, and Liability Act 5-year review report.

Environmental monitoring programs were developed to ensure continued protection of the remediation. The requirements of these programs are described in detail in the LMICP and reported via this site environmental report as outlined below.

Liquid Pathway Highlights

Groundwater Pathway

The groundwater pathway at the Fernald Preserve is routinely monitored to:

- Verify that hydraulic capture is maintained, track the restoration of the total uranium plume, including non-uranium constituents, and evaluate water quality conditions in the aquifer that may indicate a need to modify the design or the operation of restoration modules.
- Meet compliance-based groundwater monitoring obligations.

During 2011, active restoration of the Great Miami Aquifer continued. A total of 140 monitoring wells were sampled semiannually to determine water quality. Aquifer water elevations were measured quarterly in 178 monitoring wells. The following highlights describe the key findings from the 2011 groundwater data:

- Two billion, four hundred and thirty-one million gallons (9,201 million liters) of groundwater were extracted from the Great Miami Aquifer, and 544 pounds (lb) (247 kilograms [kg]) of uranium were removed from the aquifer.
- The results of the groundwater capture analysis and monitoring for total uranium and non-uranium constituents indicate that the design of the groundwater remedy for the aquifer restoration system is appropriate for capture of the plume.
- Pumping of the South Plume/South Plume Optimization Module continued to meet the objective of preventing further southward migration of the southern total uranium plume beyond the extraction wells.
- Since 2005, the percentage of treatment needed to achieve discharge limits has decreased significantly. The aquifer remedy can now achieve uranium discharge limits without groundwater treatment.

On-site Disposal Facility Monitoring

Engineered features within the OSDF continue to perform as designed, indicating that a leak from the facility is not occurring. Leachate flow continues to diminish as expected, and LDS flow volumes indicate that the cell liners are performing well within design specifications.

Surface Water and Treated Effluent Pathway

Surface water and treated effluent are monitored to determine the effects of Fernald Preserve activities on Paddys Run (an intermittent stream), the Great Miami River, and the underlying Great Miami Aquifer and to meet compliance-based surface water and treated effluent monitoring obligations. In addition, the results from sediment sampling are discussed as a component of this primary exposure pathway.

In 2011, 21 surface water and treated effluent locations were sampled at various frequencies. The following highlights describe the key findings from the 2011 surface water and treated effluent monitoring programs:

- Five hundred and sixty-two pounds (255 kg) of uranium were discharged in treated effluent to the Great Miami River, which was below the limit of 600 lb (272 kg) per year. Approximately 126 lb (57.5 kg) of uranium were released to the environment through uncontrolled storm water runoff. Therefore, the total amount of uranium released through the treated effluent and uncontrolled surface water pathways during 2011 was estimated to be 688 lb (313 kg).
- Analytical results of 27 surface water samples exceeded the final remediation level (FRL) for total uranium, the site's primary contaminant. The 27 exceedances were from SWD-09, which was established to monitor the maintenance action completed west of the former Waste Pit Area. The surface water at location SWD-09 does not flow off property. There were no FRL exceedances for any other constituent.

- Compliance sampling, consisting of sampling for nonradiological pollutants from uncontrolled runoff and treated effluent discharges from the Fernald Preserve, is regulated under the state-administrated National Pollutant Discharge Elimination System (NPDES) program. Discharges were in compliance with effluent limits identified in the NPDES permit 100 percent of the time.

Direct Radiation Pathway Highlights

The direct radiation pathway is routinely monitored to assess the impact of direct radiation on the surrounding public and environment. In addition, the data are used to demonstrate compliance with various regulations and DOE orders. Eleven dosimeters (four trail locations, five boundary locations, one location at the Visitors Center, and one background location) were used in 2011 to determine compliance with the applicable limits.

The direct radiation levels measured in 2011 indicate that the individual measurements obtained in the northeast quadrant of the site are slightly higher than background, but annual averages for onsite and background locations are not significantly different. The highest value for an onsite dosimeter produces a dose of 12 millirem per year (mrem/yr) (0.12 millisievert per year [mSv/yr]) above background to an individual who spends the entire year (24 hours a day) at the location.

Estimated Dose

In 2011, the maximally exposed individual, standing at the northeastern boundary monitor with the highest above-background reading, could receive a dose of 12 mrem (0.12 mSv). This estimate represents the maximum incremental dose above background attributed to direct radiation. This dose is 12 percent of the adopted DOE limit, which is 100 mrem/yr (1 mSv/yr) above background, as established by the International Commission on Radiological Protection.

Natural Resources

Natural resources include the diversity of plant and animal life and their supporting habitats in and around the Fernald Preserve. A number of ecological activities were conducted in 2011. Maintenance in ecologically restored areas included prescribed burning of prairies, minor erosion repair, mowing, spot herbicide application, and hazing for control of nuisance geese. Monitoring focused on continued wetland mitigation monitoring and forest functional monitoring. For the wetland monitoring program, a jurisdictional wetland delineation was conducted, as well as hydrologic monitoring, vegetation surveys, amphibian surveys, and soil and water sampling. Follow-up implementation monitoring of several restoration projects was also conducted.

Quarterly site and OSDF inspections continued in 2011. No major issues were identified. There were no unexpected discoveries of cultural resources. An archaeological survey was conducted on a portion of the western edge of the site in preparation for a 2012 ecological restoration project. No prehistoric or historic properties were identified.

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1.0 Site Background

Abbreviated Timeline

1951	Construction of the Feed Materials Production Center began.
1952	Uranium production started.
1986	EPA and DOE signed the Federal Facilities Compliance Agreement, thus initiating the remedial investigation/feasibility study process under the National Contingency Plan.
1989	Uranium production was suspended. The Fernald site was placed on the National Priorities List, which is the list of CERCLA sites most in need of cleanup.
1990	As part of the Amended Consent Agreement, the site was divided into operable units for characterization and remedy determination.
1991	Uranium production formally ended. The site mission changed from uranium production to environmental remediation and site restoration.
1994	Decontamination and dismantling of the first building was completed under the Operable Unit 3 Interim Record of Decision.
1996	The last operable unit's Record of Decision was signed, signifying the end of the 10-year remedial investigation/feasibility study process. (The Operable Unit 4 Record of Decision was later re-opened.) Construction began in support of the Operable Unit 1 selected remedy. Soil remedial excavation began as part of the Operable Unit 5 selected remedy.
1997	Construction of Cell 1 of the onsite disposal facility took place, and the first waste placement began in December. Environmental monitoring and reporting were consolidated under the Integrated Environmental Monitoring Plan (IEMP) to align with remediation efforts.
1998	Operable Unit 2 remedial excavations began.
1999	Excavation of the waste pits was initiated under the Operable Unit 1 Record of Decision, and the first rail shipment of waste material was transported to Envirocare of Utah, Inc.
2000	The Record of Decision Amendment for Operable Unit 4 Silos 1 and 2 Remedial Actions was signed by EPA, thus establishing a new selected remedy for Operable Unit 4.
2001	Cell 1 of the onsite disposal facility was capped. Remediation of the Southern Waste Units was completed.
2002	The Silos 1 and 2 Radon Control System began operation and successfully reduced radon levels within the silos. The offsite transfer of nuclear product material was completed. Wastes were placed into Cells 2 through 5 of the onsite disposal facility.
2003	All major Operable Unit 2 remedial actions were completed. In addition, approximately 412,000 cubic yards (315,015 cubic meters) of waste were placed in Cells 3 through 6 of the onsite disposal facility.
2004	Removal of Silos 1 and 2 wastes from the silos to the holding tank facility began. Plans to reduce the size of the site's wastewater treatment infrastructure were approved and implemented. The last of Fernald's 10 uranium production complexes, plus an additional 35 structures and 73 trailers, were demolished. Also, all eight cells of the onsite disposal facility were capped or received waste, and approximately 513,000 cubic yards (392,240 cubic meters) were placed in Cells 4 through 8.
2005	Removal of Silo 3 waste began, and the first shipment of waste arrived at Envirocare of Utah. Remedial actions for Operable Unit 1 were completed in June. The first shipment of Silos 1 and 2 wastes arrived at Waste Control Specialists in Texas.
2006	Remediation of the Fernald site was completed on October 29, 2006, and the site was officially transferred into DOE's Office of Legacy Management on November 17, 2006.
2008	The old Silos Warehouse was remodeled into the new Fernald Preserve Visitors Center and opened to the public in August 2008. In addition, the community was allowed unescorted access at the Fernald Preserve.

In 1951, the U.S. Atomic Energy Commission, a predecessor agency of the U.S. Department of Energy (DOE), began building the Feed Materials Production Center on a 1,050-acre (425-hectare) tract of land outside the small farming community of Fernald, Ohio. The facility's mission was to produce "feed materials" in the form of purified uranium compounds and metal for use by other government facilities involved in the production of nuclear weapons for the nation's defense.

Uranium metal was produced at the Feed Materials Production Center from 1952 through 1989. During that time, more than 500 million pounds (lb) (227 million kilograms [kg]) of uranium metal products were delivered to other sites. These production operations caused releases to the surrounding environment, which resulted in contamination of soil, surface water, sediment, and groundwater on and around the site.

In 1991, the mission of the site officially changed from uranium production to environmental cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as Superfund), as amended. The site was renamed the Fernald Environmental Management Project in 1991. In 2003, the site name changed to the Fernald Closure Project to reflect the mission of the site as on a path to closure. In 2007, the site name changed to the Fernald Preserve to reflect the completion of the cleanup (with the exception of groundwater) ushered by the successful transition to the DOE Office of Legacy Management (LM) in

late 2006, and the new mission to be an asset to the community as an undeveloped park with an emphasis on wildlife.

S.M. Stoller Corporation, the LM Support contractor, continues to be responsible for site activities, including the ongoing groundwater remedy. The U.S. Environmental Protection Agency (EPA) Region 5 and the Southwest District Office of the Ohio EPA provide regulatory oversight.

In the 1980s, the goals of environmental monitoring activities were to assess the impact of production operations and monitor the environmental pathways through which residents of the local community might be exposed to contaminants from the site (exposure pathways). The environmental monitoring program provided comprehensive on- and off-property surveillance of contaminant levels in surface water, groundwater, air, and biota (produce). The goal was to measure the levels of contaminants associated with uranium production operations and report this information to the regulatory agencies and stakeholders.

Exposure Pathways

An **exposure pathway** is a route that materials can travel between the point of release (a source) and the point of delivering a radiation or chemical dose (a receptor). At the Fernald Preserve, two primary exposure pathways (water and air) have been identified. A primary pathway is one that may allow pollutants to directly reach the public or the environment. Therefore, the water and air pathways provide a basis for environmental sampling and information useful for evaluating potential dose to the public or the environment.

Secondary exposure pathways have been thoroughly evaluated under previous environmental monitoring programs. Secondary exposure pathways represent indirect routes by which pollutants may reach receptors. An example of a secondary pathway is produce. Through the food chain, one organism may accumulate a contaminant and then be consumed by humans or other animals. The contaminant travels through the air to the soil, where it is absorbed into produce through the roots and is consumed by humans or animals. An evaluation of past monitoring data has shown that secondary exposure pathways at the Fernald Preserve are insignificant routes of exposure to offsite receptors. Therefore, the main focus of the site monitoring program (described in the IEMP) is on the primary exposure pathways.

Refer to Section 5 of this report for information pertaining to 2011 dose calculations from all pathways.

After the conclusion of the site's uranium production and the completion of the CERCLA remedy selection process, the focus was on the safe and efficient implementation of environmental remediation activities and facility decontamination and dismantling operations. In recognition of this shift in emphasis toward remedy implementation, the environmental monitoring program was revised in 1997 to align with the remediation activities planned for the Fernald site. The site's environmental monitoring program is described in the "Integrated Environmental Monitoring Plan" (IEMP), which is Attachment D of the *Comprehensive Legacy Management and Institutional Controls Plan* (LMICP) (DOE 2010). The environmental monitoring program is designed to ensure the continued protectiveness of the completed remedial actions as well as implementation of the ongoing groundwater remedy and performance of the onsite disposal facility (OSDF).

This *Fernald Preserve 2011 Site Environmental Report* summarizes the findings from the IEMP monitoring program and provides a status on the progress toward final site restoration. This report consists of the following:

Summary Report. The summary report (Sections 1 through 6) documents the results of environmental monitoring activities at the Fernald Preserve in 2011. It includes a discussion of ongoing groundwater remediation activities and summaries of environmental data from groundwater, surface water and treated effluent, direct radiation, and natural resources monitoring programs. It also summarizes the information contained in the appendixes.

Appendixes. The detailed appendixes provide the 2011 environmental monitoring data for the various media, primarily in the form of graphs and tables. The appendixes are generally distributed only to the regulatory agencies. However, a complete copy of the appendixes is available on the LM website at http://www.lm.doe.gov/fernald/Sites.aspx and by contacting LM at (513) 648-7500 or S.M. Stoller Public Affairs at (513) 648-4026.

CERCLA Remedial Process

The process of cleaning up sites under CERCLA consists of the following general phases:

Site Characterization—During this phase, contaminants are identified and quantified, and the potential impacts of those contaminants on human health are determined. This phase includes the remedial investigation and the baseline risk assessment.

Remedy Selection—During this phase, cleanup alternatives are developed and evaluated. Activities include the feasibility study and proposed remedial action plan. After public comments are received, a remedy is selected and documented in a Record of Decision.

Remedial Design and Remedial Action—This phase of the CERCLA process includes the detailed design and implementation of the remedy. The CERCLA process ends with certification and site closure.

A CERCLA 5-year review process is triggered by the onset of construction for the first operable unit remedial action that will result in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure. Of all the operable units, the site preparation construction to support the Waste Pits Project under the *Operable Unit 1 Record of Decision* (DOE 1995a) was the first such action. This construction began on April 1, 1996. Three CERCLA 5-year reviews have been conducted and approved by the regulatory agencies to date (April 2001 [DOE 2001a], April 2006 [DOE 2006a], and September 2011 [DOE 2011]). These reviews ensure that the remedy remains effective and continues to be protective of human health and the environment. The next scheduled 5-year review is in early 2016.

Site closure, relative to the completion of remediation, was defined in the contract between Fluor Fernald, Inc. and DOE as the physical completion of the scope of work required by the five Records of Decision with the exception of the groundwater remedy.

LM assumed the long-term surveillance monitoring and maintenance of the Fernald site on November 17, 2006, to ensure continued protection of human health and the environment and continued operation of the groundwater remedy. The *Comprehensive Legacy Management and Institutional Controls Plan* (DOE 2010) defines the activities to be conducted with respect to long-term stewardship at the Fernald Preserve. The CERCLA 5-year review process will continue to provide stakeholders with information on the remedy performance and with long-term stewardship information.

The rest of this introductory section provides:

- An overview of the environmental remediation completed as well as ongoing remedy implementation.
- A description of environmental monitoring activities at the Fernald Preserve.
- A description of the physical and ecological characteristics of the area.

1.1 The Path to Site Closure

In 1986, the Fernald site began working through the CERCLA process to characterize the nature and extent of contamination at the site, establish risk-based cleanup standards, and select the appropriate remediation technologies to achieve those standards. To facilitate this process, the site was organized into five operable units in 1991. The purpose of the operable unit concept under CERCLA was to organize site components by geographical function and by the potential for similar technologies to be used for environmental remediation. The remedy selection process culminated in 1996 with the approval of the final Records of Decision for all five operable units. However, several of the Records of Decision (including those for Operable Units 1, 4, and 5) have subsequently been modified through issuance of Explanation of Significant Differences or Amendment documents. These documents were prepared, submitted for EPA and public review, and issued in accordance with CERCLA regulations. Following approval of the initial Records of Decision, work began on the design and implementation of the operable unit remedies. Table 1 describes each operable unit and an overview of its associated remedy.

Table 1. Operable Unit Remedies

Operable Unit	Description	Remedy Overview
1	• Waste Pits 1-6 • Clearwell • Burn pit • Berms, liners, caps, and soil within the boundary	Record of Decision approved: March 1995 Explanation of Significant Differences approved: September 2002 Record of Decision Amendment approved: November 2003 Excavation of materials with constituents of concern above final remediation levels (FRLs), waste processing and treatment by thermal drying (as necessary), offsite disposal at a permitted facility, and soil remediation/certification. **Remedial actions completed: June 2005** **Final Remedial Action Report approved: August 2006**
2	• Solid waste landfill • Inactive fly ash pile • Active fly ash pile (now inactive) • North and South Lime Sludge Ponds • Other South Field areas • Berms, liners, and soil within the operable unit boundary	Record of Decision approved: May 1995 Post-Record of Decision Fact Sheet approved: April 1999 Excavation of all materials with constituents of concern above FRLs, treatment for size reduction and moisture control as required, onsite disposal in the OSDF, and offsite disposal of excavated material that exceeded the waste acceptance criteria for the OSDF. **Remedial actions completed: June 2006** **Final Remedial Action Report approved: September 2006**
3	Former Production Area, associated facilities, and equipment (includes all above- and below-grade improvements), including but not limited to: • All structures, equipment, utilities, effluent lines, and K-65 transfer line • Wastewater treatment facilities • Fire training facilities • Coal pile • Scrap metals piles • Drums, tanks, solid waste, waste product, feedstocks, and thorium	Record of Decision for Interim Remedial Action approved: June 1994 Record of Decision for Final Remedial Action approved: August 1996 Adoption of Operable Unit 3 Interim Record of Decision; alternatives to disposal through the unrestricted or restricted release of materials as economically feasible for recycling, reuse, or disposal; treatment of material for on- or offsite disposal; required offsite disposal for process residues, product materials, process-related metals, acid brick, concrete from specific locations, and any other material exceeding the OSDF waste acceptance criteria; and onsite disposal for material that meets the OSDF waste acceptance criteria. **Remedial actions completed: October 2006** **Final Remedial Action Report approved: February 2007**

Table 1 (continued). Operable Unit Remedies

Operable Unit	Description	Remedy Overview
4	• Silos 1 and 2 (containing K-65 residues; demolished in 2005) • Silo 3 (containing cold metal oxides; demolished in 2006) • Silo 4 (empty and never used; demolished in 2003) • Decant tank system • Berms and soil within the operable unit boundary	Record of Decision approved: December 1994 Explanation of Significant Differences for Silo 3 approved: March 1998 Record of Decision Amendment for Silos 1 and 2 approved: July 2000 Record of Decision Amendment for Silo 3 approved: September 2003 Explanation of Significant Differences for Silos 1 and 2 approved: November 2003 Explanation of Significant Differences for Operable Unit 4 approved: January 2005. Removal of Silo 3 materials for treatment and Silos 1 and 2 residues and decant sump tank sludges with onsite stabilization of materials, residues, and sludges followed by offsite disposal. Excavation of silos area soils contaminated above the FRLs with onsite disposal for contaminated soils and debris that meet the OSDF waste acceptance criteria; and site restoration. Concrete from Silos 1 and 2, and contaminated soil and debris that exceeded the OSDF waste acceptance criteria were disposed of offsite. **Remedial actions for Silo 3 completed: April 2006** **Remedial actions involving the completion of the shipment of stabilized Silos 1 and 2 material to a temporary storage facility in Texas was completed in May 2006.** **Final Remedial Action Report approved: September 2006** **Permanent disposal of the 3,776 containers of Silos 1 and 2 material began on October 7, 2009, and the last container was placed November 2, 2009.**
5	• Groundwater • Surface water and sediments • Soil not included in the definitions of Operable Units 1 through 4 • Flora and fauna	Record of Decision approved: January 1996 Explanation of Significant Differences was approved in November 2001, formally adopting EPA's Safe Drinking Water Act maximum contaminant level for uranium of 30 micrograms per liter (µg/L) as both the FRL for groundwater remediation and the monthly average uranium effluent discharge limit to the Great Miami River. Extraction of contaminated groundwater from the Great Miami Aquifer to meet FRLs at all affected areas of the aquifer. Treatment of contaminated groundwater, storm water, and wastewater to attain concentration and mass-based discharge limits and FRLs in the Great Miami River. Excavation of contaminated soil and sediment to meet FRLs. Excavation of contaminated soil containing perched water that presents an unacceptable threat through contaminant migration to the underlying aquifer. Onsite disposal of contaminated soil and sediment that meet the OSDF waste acceptance criteria. Soil and sediment that exceeded the waste acceptance criteria for the OSDF was treated, when possible, to meet the OSDF waste acceptance criteria or was disposed of at an offsite facility. Also includes site restoration, institutional controls, and post-remediation maintenance. **Interim Remedial Action Report approved: August 2008**

1.2 Environmental Monitoring Program

In the 1980s, an environmental monitoring program was initiated to assess the impact of past operations on the environment and monitor potential exposure pathways to the local community. Additionally, characterization activities were conducted at the Fernald site for nearly 10 years through the remedial investigation phase of the CERCLA process. The initial environmental evaluations performed during the remedial investigation/feasibility study process were used to select the final remedy for Operable Unit 5, which addressed contamination in soil, groundwater, surface water, sediment, air, and biota—in short, all environmental media and contaminant exposure pathways affected by past uranium production operations at the site. The selected remedy for Operable Unit 5 defined the site's final contaminant cleanup levels and established the extent of on- and off-property remedial actions necessary to provide permanent solutions to environmental concerns posed by the site.

The Operable Unit 5 remedy included plans for removing the contamination that might be released through these exposure pathways and for monitoring these pathways to measure the site's continuing impact on the environment as remediation progresses. The characterization data used to develop the final remedy were also used to focus on and develop the environmental monitoring program documented in the IEMP. The following describes the IEMP's key elements:

- The IEMP defines monitoring activities for environmental media, such as groundwater, surface water and treated effluent, sediment, direct radiation, and natural resources. In general, the primary exposure pathway (water) is monitored, and the program focuses on assessing the effect on the surrounding environment.
- The IEMP establishes a data evaluation and decision-making process for each environmental medium. Through this process, environmental conditions at the site are continually evaluated. These evaluations sometimes affect decisions made about the implementation of remediation activities. For example, environmental data are routinely evaluated to identify any significant trends that may indicate the potential for an unacceptable future impact to the environment if action is not taken.
- The IEMP is reviewed annually and revised as necessary to ensure that the monitoring program adequately addresses changing activities.
- The IEMP consolidates routine reporting of environmental data into this comprehensive annual report.

1.3 Characteristics of the Site and Surrounding Area

The natural settings of the Fernald Preserve and nearby communities were important factors in selecting the final remedy and remain important in the continual evaluation of the environmental monitoring program. Land use and demography, local geography, geology, surface hydrology, meteorology, and natural resources all impact monitoring activities and the implementation of the site remedy.

1.3.1 Land Use and Demography

Economic activities in the area rely heavily on the physical environment. Land in the area is used primarily for livestock, crop farming, and gravel pit excavation operations. There also is a

private water utility approximately 2 miles (3.2 kilometers [km]) east of the Fernald Preserve that pumps groundwater primarily for industrial use.

Downtown Cincinnati is approximately 18 miles (29 km) southeast of the Fernald Preserve (Figure 1). The cities of Fairfield and Hamilton are 6 and 8 miles (10 and 13 km) to the east and northeast, respectively (Figure 2). Scattered residences and several villages, including Fernald, New Baltimore, New Haven, Ross, and Shandon, are located near the site.

1.3.2 Geography

Figure 3 depicts the location of the major physical features of the site, such as the buildings and supporting infrastructure. The Former Production Area and the OSDF dominate this view. The Former Production Area occupies approximately 136 acres (55 hectares) in the center of the site, and the OSDF occupies approximately 120 acres (48.6 hectares). The Great Miami River cuts a terraced valley to the east of the site, and Paddys Run (an intermittent stream) flows from north to south along the site's western boundary. In general, the site lies on a terrace that slopes gently among vegetated bedrock outcrops to the north, southeast, and southwest.

1.3.3 Geology

Bedrock in the area indicates that approximately 450 million years ago a shallow sea covered the Cincinnati area. Sediments that later became flat-lying shale with interbedded limestone were deposited in the shallow sea, as evidenced by the abundance of marine fossils in the bedrock. In the more recent geologic past, the advance and retreat of three separate glaciers shaped the southwestern Ohio landscape. A large river drainage system south of the glaciers created river valleys up to 200 feet (ft) (61 meters [m]) deep, which were then filled with sand and gravel when the glaciers melted. These filled river valleys are called buried valleys.

The last glacier to reach the area left a glacial overburden—a low-permeability mixture of clay and silt with minor amounts of sand and gravel—deposited across the land surface. The site is situated on a layer of glacial overburden that overlies portions of a 2- to 3-mile-wide (3- to 5-km-wide) buried valley. This valley, known as the New Haven Trough, makes up part of the Great Miami Aquifer. The impermeable shale and limestone bedrock that defines the edges and bottom of the New Haven Trough restricts the groundwater to the sand and gravel within the buried valley. Where present, the glacial overburden limits the downward movement of precipitation and surface water runoff into the underlying sand and gravel of the Great Miami Aquifer.

The Great Miami River and its tributaries have eroded considerable portions of the glacial overburden and exposed the underlying sand and gravel of the Great Miami Aquifer. Thus, in some areas, precipitation and surface water runoff can easily migrate into the underlying Great Miami Aquifer and transport contaminants to the aquifer as well. Natural and man-made breaches of the glacial overburden were key pathways where contaminated water entered the aquifer, causing the groundwater plumes that are being addressed by aquifer restoration activities. Figure 4 provides a view of the structure of subsurface deposits in the region along an east-west cross section through the site, and Figure 5 presents the regional groundwater flow patterns in the Great Miami Aquifer.

1.3.4 Surface Hydrology

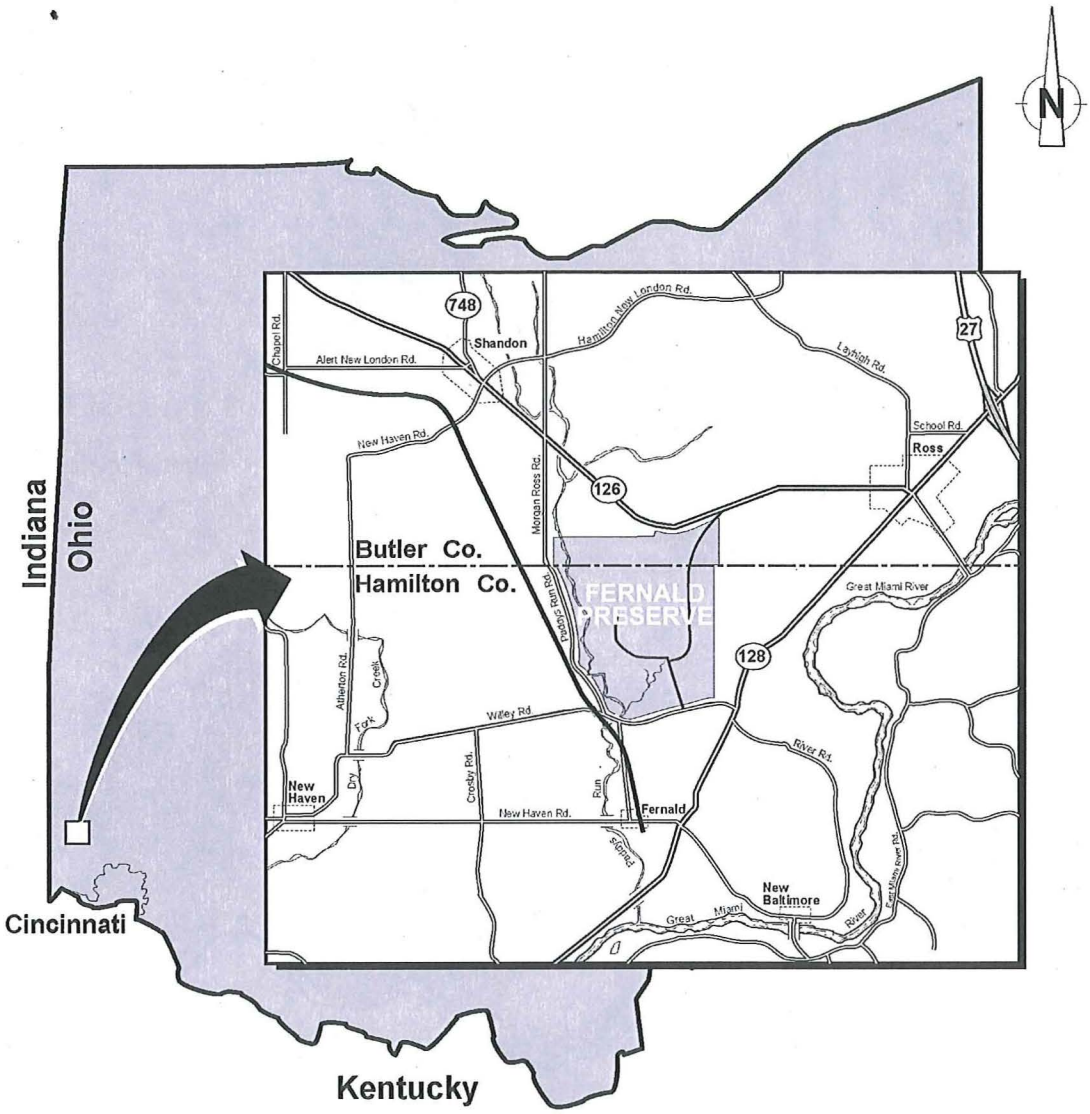
The Fernald Preserve is located in the Great Miami River drainage basin (Figure 6). Natural drainage from the site to the Great Miami River occurs primarily via Paddys Run. This intermittent stream begins losing flow to the underlying sand and gravel aquifer south of the former Waste Pit Area. Paddys Run empties into the Great Miami River 1.5 miles (2.4 km) south of the site. The Great Miami River, 0.6 mile (1 km) east of the Fernald Preserve, runs in a southerly direction and flows into the Ohio River about 24 miles (39 km) downstream of the site. The segment of the river between the Fernald Preserve and the Ohio River is not used as a source of public drinking water.

The average flow volume for the Great Miami River in 2011 was 7,977 cubic feet per second (225.9 cubic meters per second). This average is based on daily measurements collected at the U.S. Geological Survey (USGS) Hamilton stream gauge (USGS 3274000) approximately 10 river miles (16 river km) upstream of the site's effluent discharge.

In 2011, 60.20 inches (152.9 centimeters [cm]) of precipitation were measured at the Butler County Regional Airport. This is higher than the average annual precipitation of 41.28 inches (104.9 cm) for 1951 through 2011. Figure 7 shows the average precipitation recorded at the Fernald Preserve for each year from 2001 through 2011 and the annual average precipitation for the Cincinnati area from 1951 through 2011. Figure 8 shows monthly precipitation at the site for 2011 compared to the Cincinnati area average monthly precipitation from 1951 through 2011.

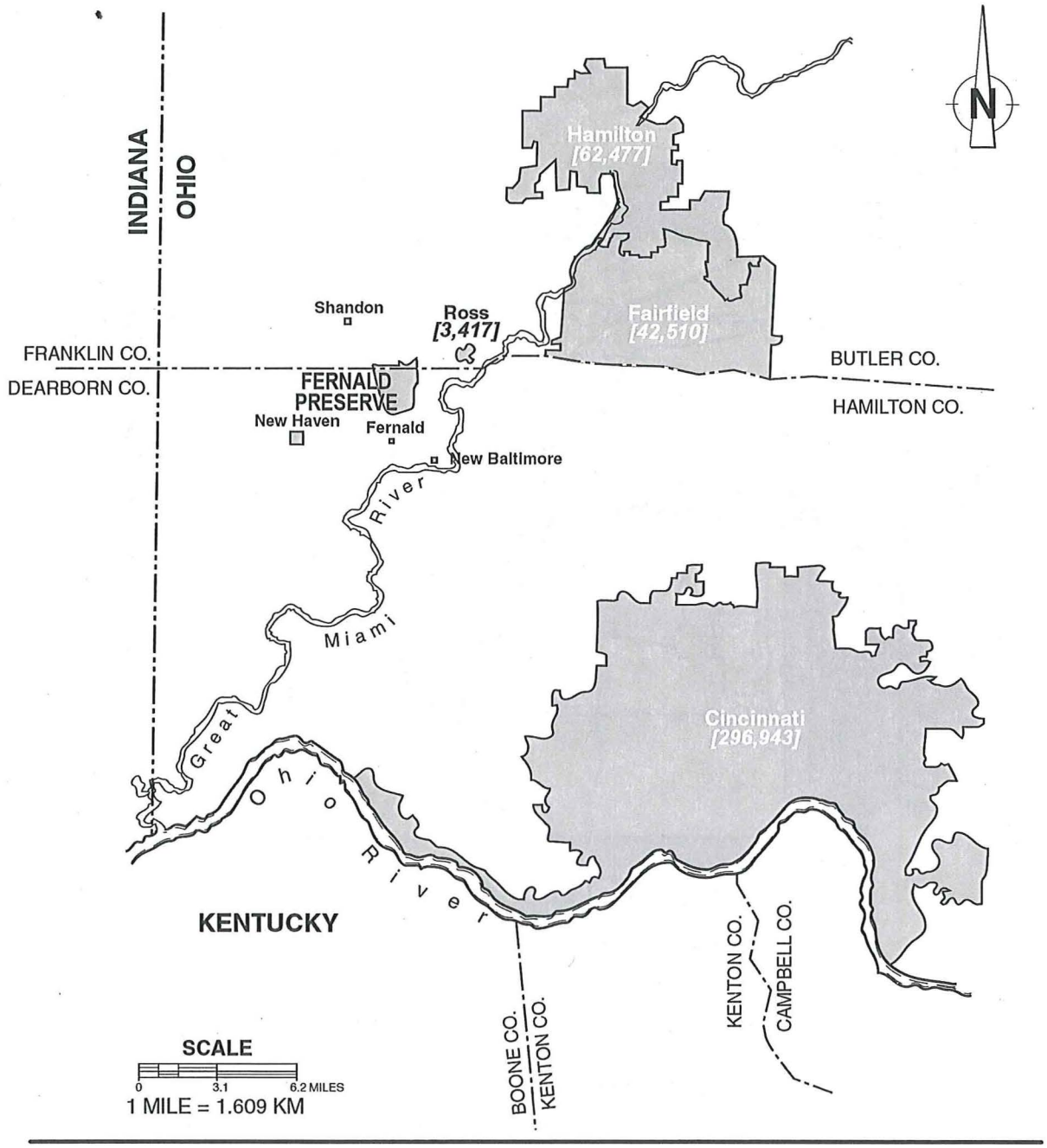
1.3.5 Natural Resources

Natural resources have important aesthetic, ecological, economic, educational, historical, recreational, and scientific value to the United States. Their establishment and protection is an ongoing process at the Fernald Preserve. Section 6.0 discusses the site's diverse natural and cultural resources, and it summarizes 2011 inspection, monitoring, and maintenance activities.



The Fernald Preserve covers about 1,050 acres (425 hectares).

Figure 1. Fernald Preserve and Vicinity



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Populations (shown in brackets) are estimated from 2010 U.S. Census Bureau figures.

Figure 2. Major Communities in Southwestern Ohio

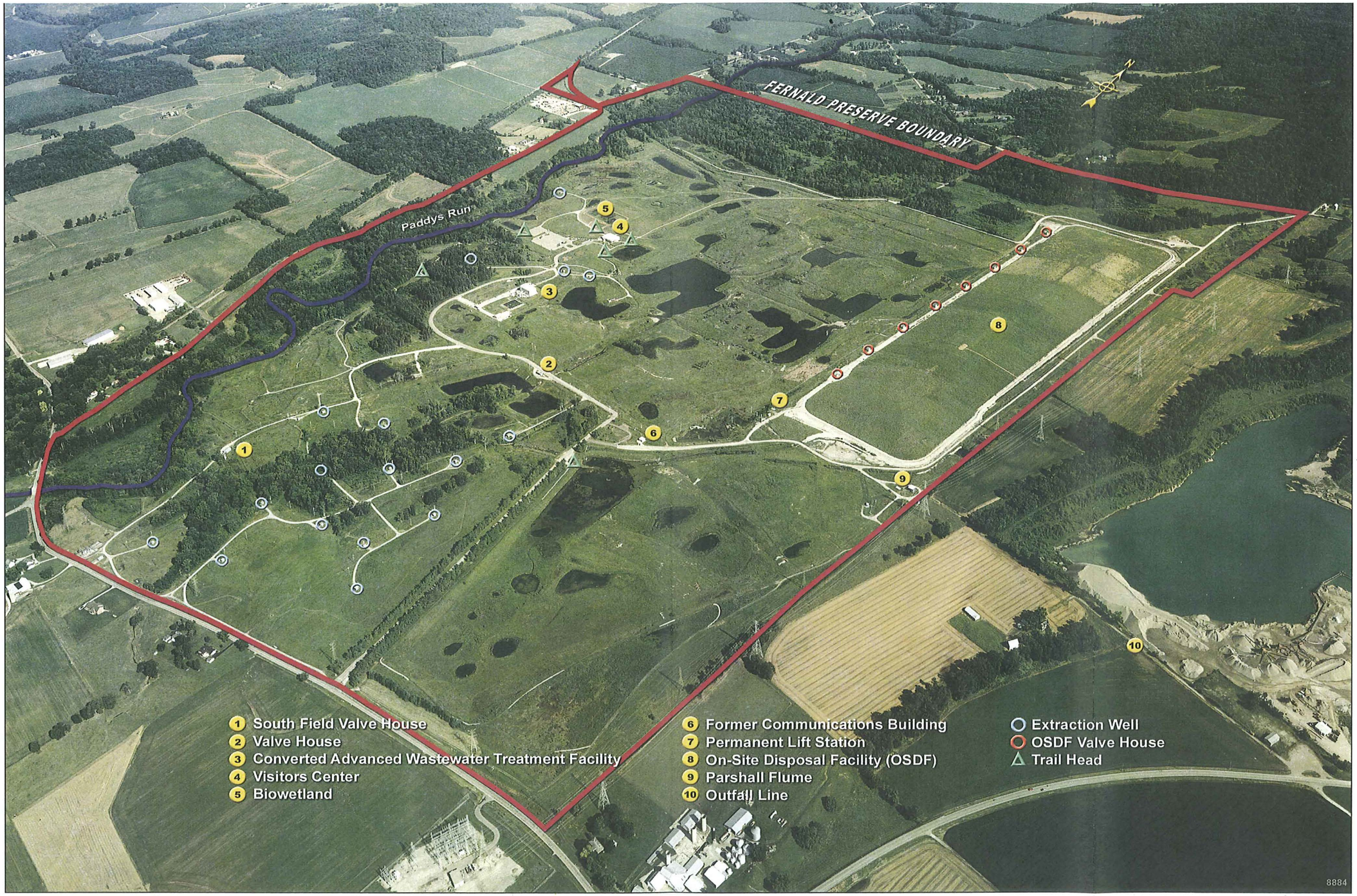

Figure 3. Fernald Preserve Perspective

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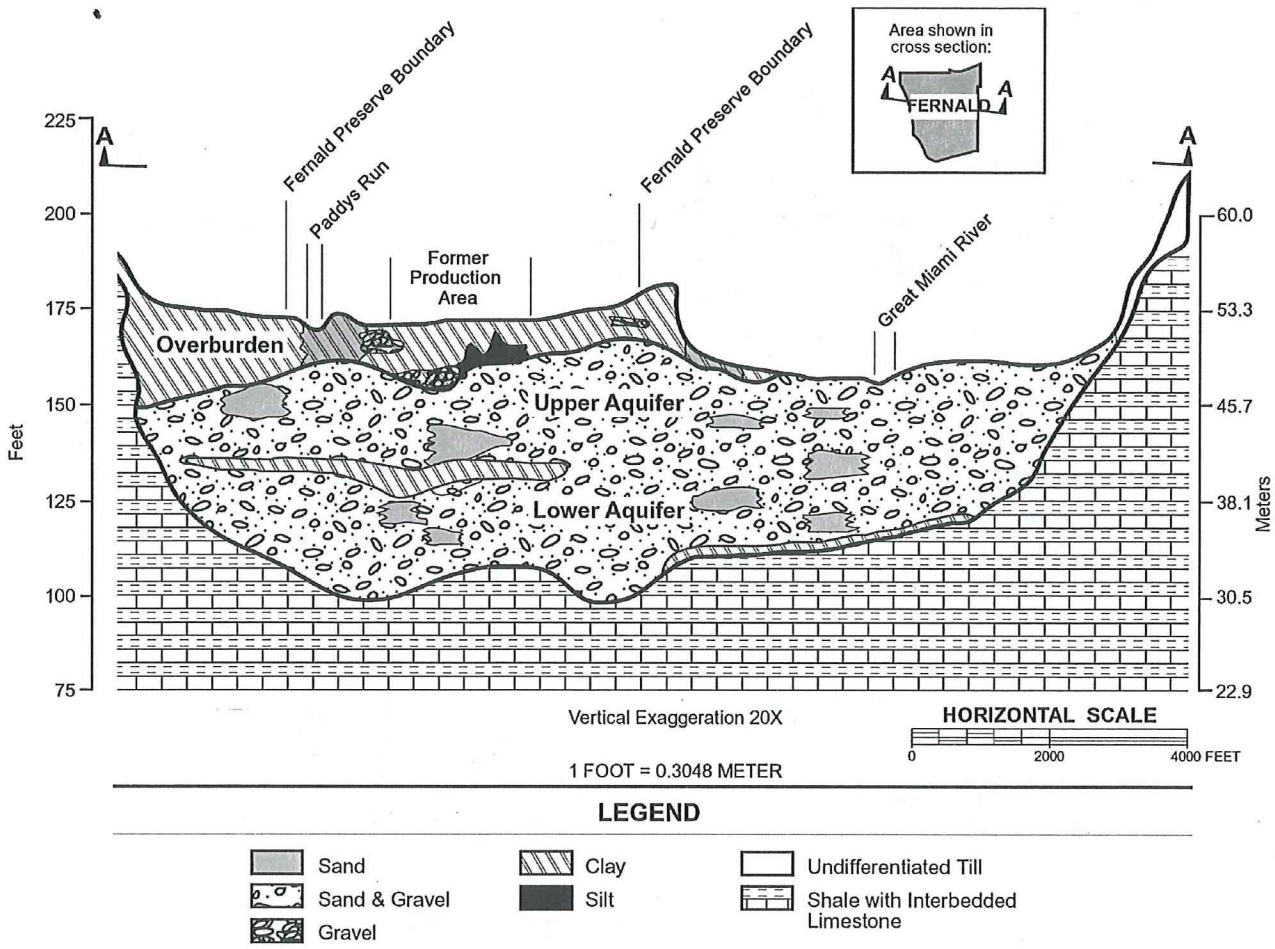
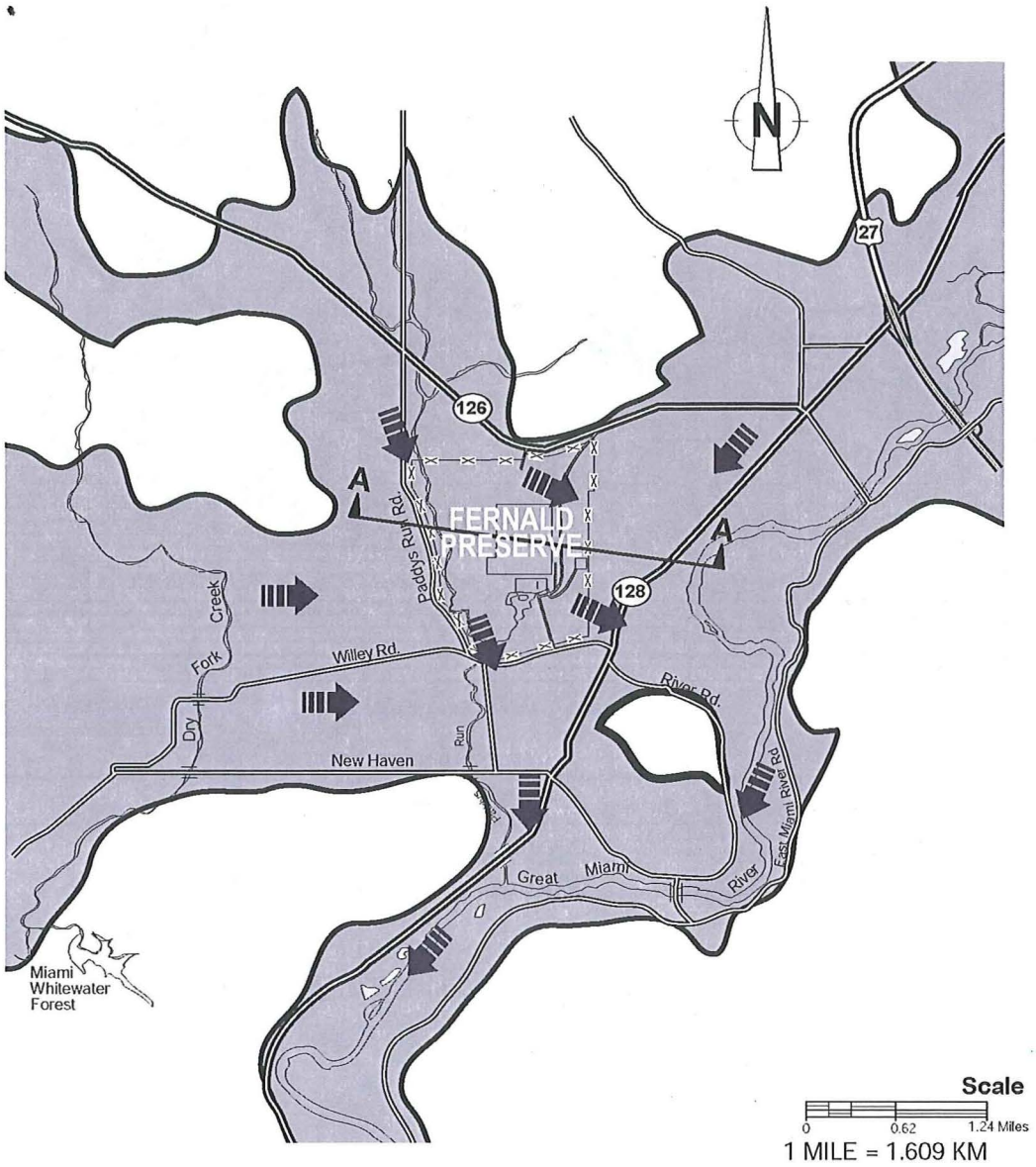


Figure 4. Cross Section of the New Haven Trough, Looking North



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- Buried Valley Aquifer
- General Direction of Groundwater Flow
- Fernald Preserve Boundary
- A A Location of Cross Section Shown in Figure 4

Figure 5. Regional Groundwater Flow in the Great Miami Aquifer

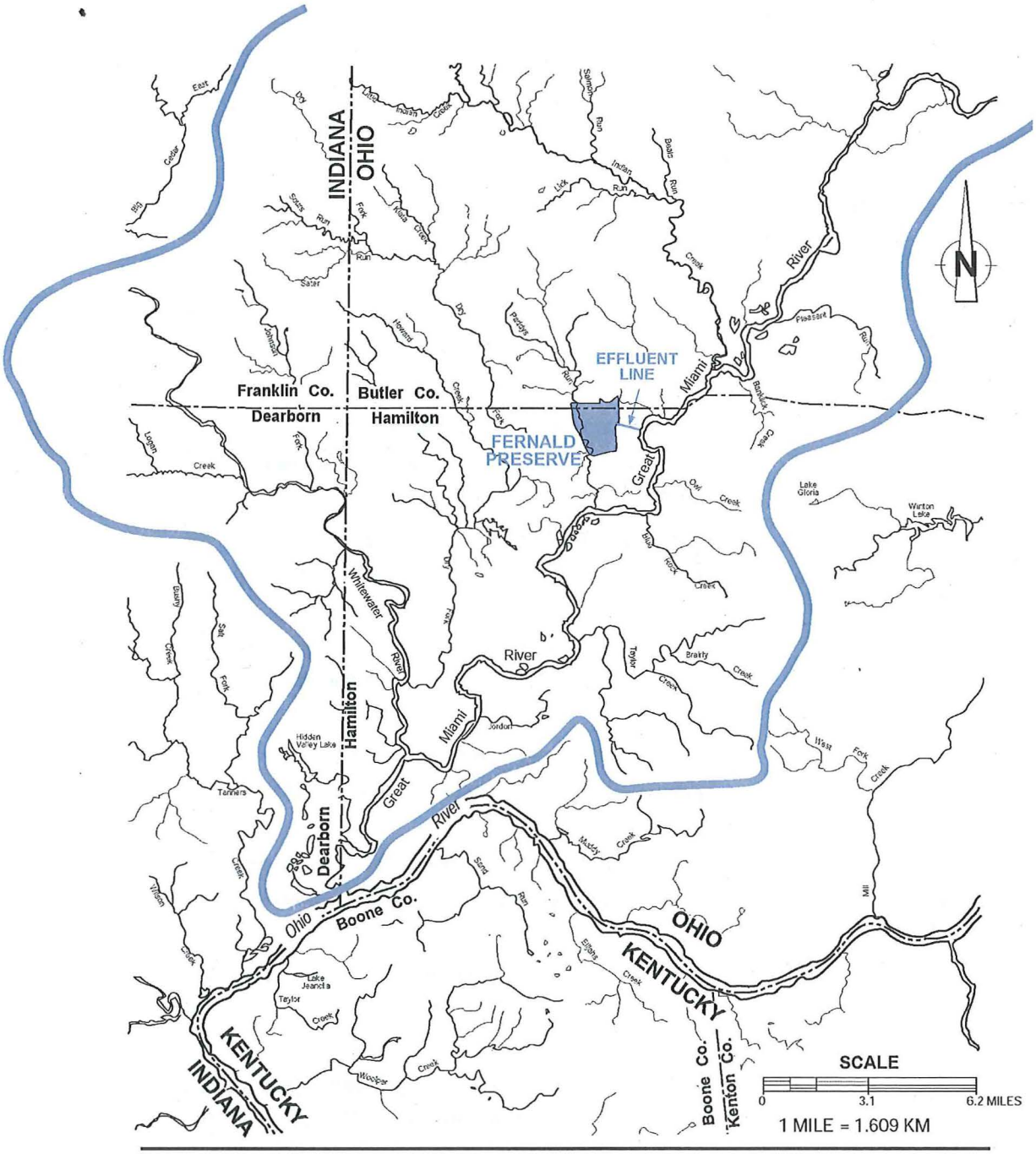

Figure 6. Great Miami River Drainage Basin

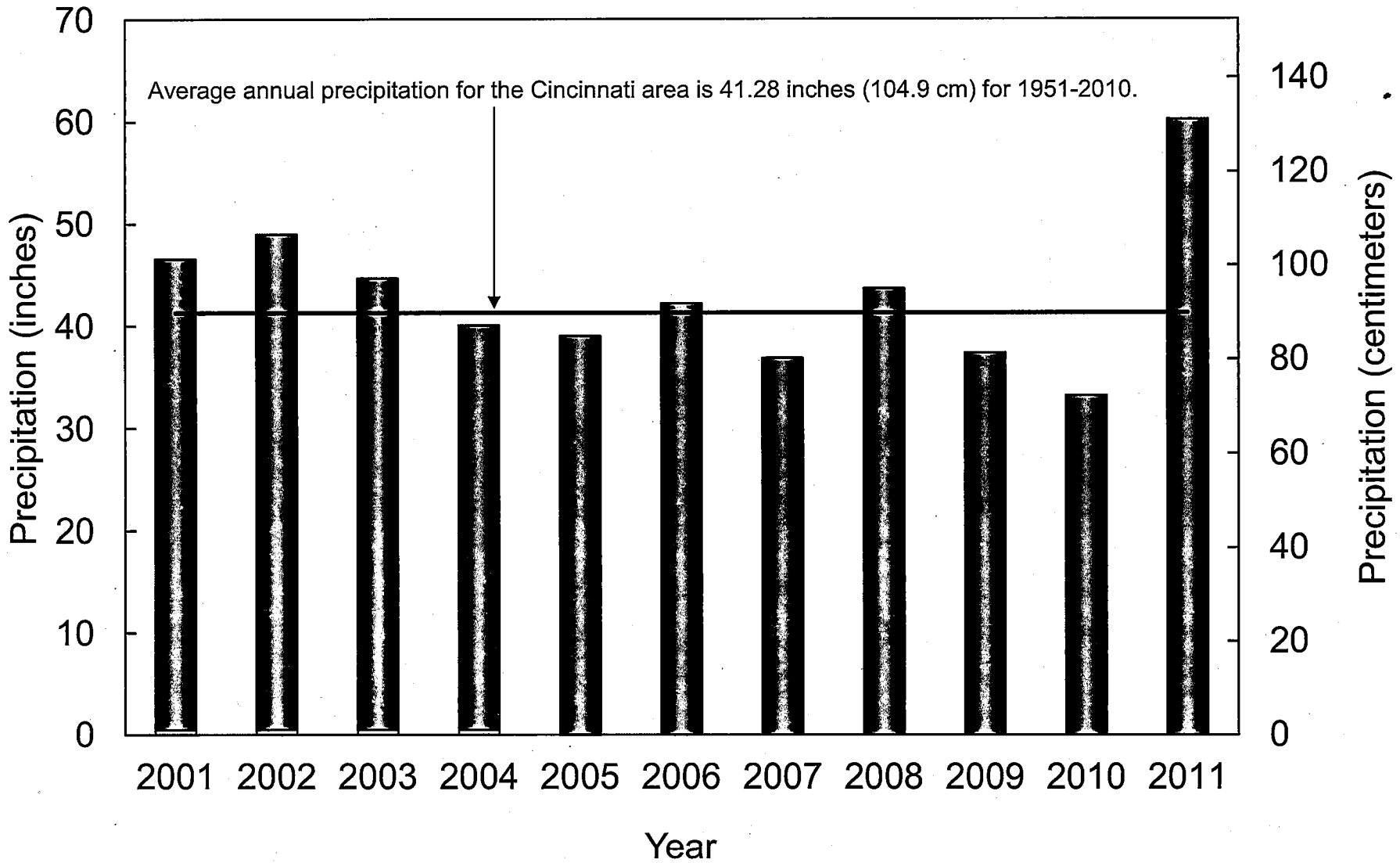

Figure 7. Annual Precipitation, 1994–2011

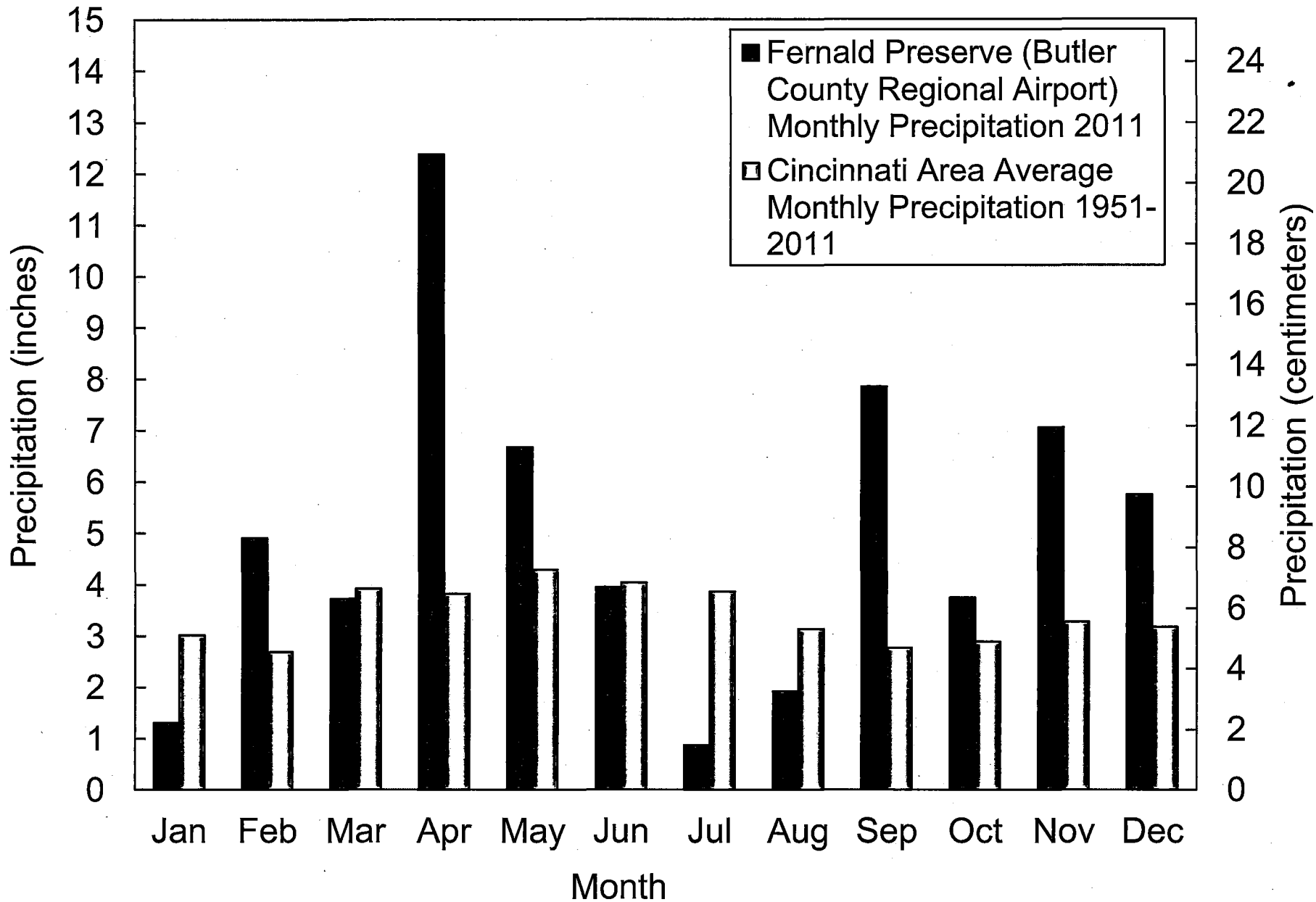

Figure 8. Monthly Precipitation for 2011 Compared to Average Monthly Precipitation for 1951–2011

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2.0 Remediation Status and Compliance Summary

This section provides a summary of CERCLA remediation activities in 2011 and summarizes compliance activities with other applicable environmental laws, regulations, and legal agreements. Compliance under CERCLA dictates the environmental remediation of the Fernald Preserve.

EPA and Ohio EPA enforce the environmental laws, regulations, and legal agreements governing work at the Fernald Preserve. EPA develops, promulgates, and enforces environmental protection regulations and technology-based standards. EPA regional offices and state agencies enforce these regulations and standards by review of data collected at the Fernald Preserve. EPA Region 5 has regulatory oversight of the CERCLA process at the Fernald Preserve, with active participation from Ohio EPA.

For some programs, such as those under the Resource Conservation and Recovery Act (RCRA), as amended, the Clean Air Act, as amended (excluding National Emissions Standards for Hazardous Air Pollutants compliance), and the Clean Water Act, as amended, EPA has authorized or delegated the State of Ohio to act as the primary enforcement authority. For these programs, Ohio promulgates state regulations that must be at least as stringent as federal requirements. Several legal agreements among DOE, EPA Region 5, and Ohio EPA identify site-specific requirements for compliance with the regulations. To comply with these regulations, DOE-Headquarters issues directives to its field and area offices and conducts audits to ensure compliance with all regulations.

2.1 CERCLA Remediation Status

In October 2006, remedial actions were completed for four of the five operable units. As of October 29, 2006, the only active remedy implementation efforts remaining involved the continuation of the groundwater remedy under Operable Unit 5. Other activities under CERCLA during 2011 involved monitoring the performance of the completed remedies, implementing the requirements of the LMICP, and completion of the third CERCLA 5-year review.

All cleanup-related CERCLA documentation, including a copy of the Administrative Record (AR), is available online at http://www.lm.doe.gov/CERCLA_Home.aspx. The original and a copy of the AR are located in the records warehouse at the LM Business Center in Morgantown, West Virginia. A copy of the AR is also located at EPA's Region 5 office in Chicago, Illinois. The Fernald Preserve records staff can be contacted by phone at (513) 648-4449 for assistance in searching for a document in the CERCLA AR. The CERCLA AR will be updated as new documents are created.

The completion and closure of a National Priorities List (NPL) site encompasses several milestones and specific documentation requirements for each milestone completed (EPA 2000). These milestones begin with remedial action completion and end with deletion from the NPL and include:

- Remedial action completion (Final or Interim Remedial Action Reports).
- Construction completions (Preliminary Closeout Report)—all construction activities are complete, immediate threats are addressed, and long-term threats are under control.

- Site completion (Final Closeout Report)—all site cleanup goals are met, all Records of Decision are complete, institutional controls are in place, and site conditions are protective of human health and the environment.
- Site deletion from the NPL (Notice of Intent to Delete).

Final Remedial Action Reports have been prepared and approved by both EPA and Ohio EPA for Operable Units 1, 2, 3 and 4. The *Interim Remedial Action Report for Operable Unit 5* (DOE 2008) was approved by EPA in August 2008. That report details the ongoing aquifer restoration activities and provides information indicating that all required groundwater infrastructure has been installed and is functioning as designed. Further, the report provides information that all soils have been remediated (except those associated with the groundwater infrastructure) and that the OSDF is functioning as designed. Operable Unit 5 will remain open until a future final Remedial Action Report for Operable Unit 5 has been prepared. This report will be developed once groundwater actions are complete, and all soils and infrastructure associated with the groundwater remedy have been adequately addressed (estimated completion date in 2026, based on modeling projections). EPA issued the *Preliminary Closeout Report U.S. DOE Feed Materials Production Center, Fernald, Ohio* (EPA 2006) in December 2006.

CERCLA also requires a 5-year review process of remedial actions implemented under the signed Record of Decision for each operable unit. The purpose of a 5-year review is to determine, through evaluation of performance of the selected remedy, whether the remedy at a site remains protective of human health and the environment. The first 5-year review report for the Fernald Preserve (DOE 2001a) was approved by EPA in September 2001. The second 5-year review report was submitted in April 2006 (DOE 2006a) and approved by EPA in September 2006. The third 5-year review report was submitted to EPA in March 2011 (DOE 2011) and approved by EPA in August 2011.

CERCLA remediation highlights during 2011 included the following:

- The performance of the OSDF was satisfactory during 2011. The cap underwent four formal inspections. Leachate generation has continued to decline, and liner performance is meeting design requirements. Leachate/leak detection performance is discussed in Section 3. Cap performance is discussed further in Section 6.
- Figure 9 indicates soil areas that remain uncertified pending the end of the groundwater remedy and the decontamination and decommissioning of the related facilities and the associated utilities. Elevated uranium concentrations persist in surface water in an area adjacent to former Waste Pit 3. No specific actions other than continued monitoring were conducted in 2011. This issue is further explained in Section 4.
- Monitoring and maintenance of ecologically restored areas continued during 2011, and required site inspections were performed. Other than occasional instances of hikers straying off trail, there were no instances of breaches in or violations of the institutional controls established in the LMICP. Further discussion of the site inspection process is included in Section 6.

For 2011, the ongoing groundwater remedy resulted in a total of 2,431 million gallons (M gal) (9,201 million liters [M liters]) of groundwater being extracted from the Great Miami Aquifer, and 544 lb (247 kg) of uranium were removed from the aquifer. Section 3 discusses groundwater monitoring and remediation performance.

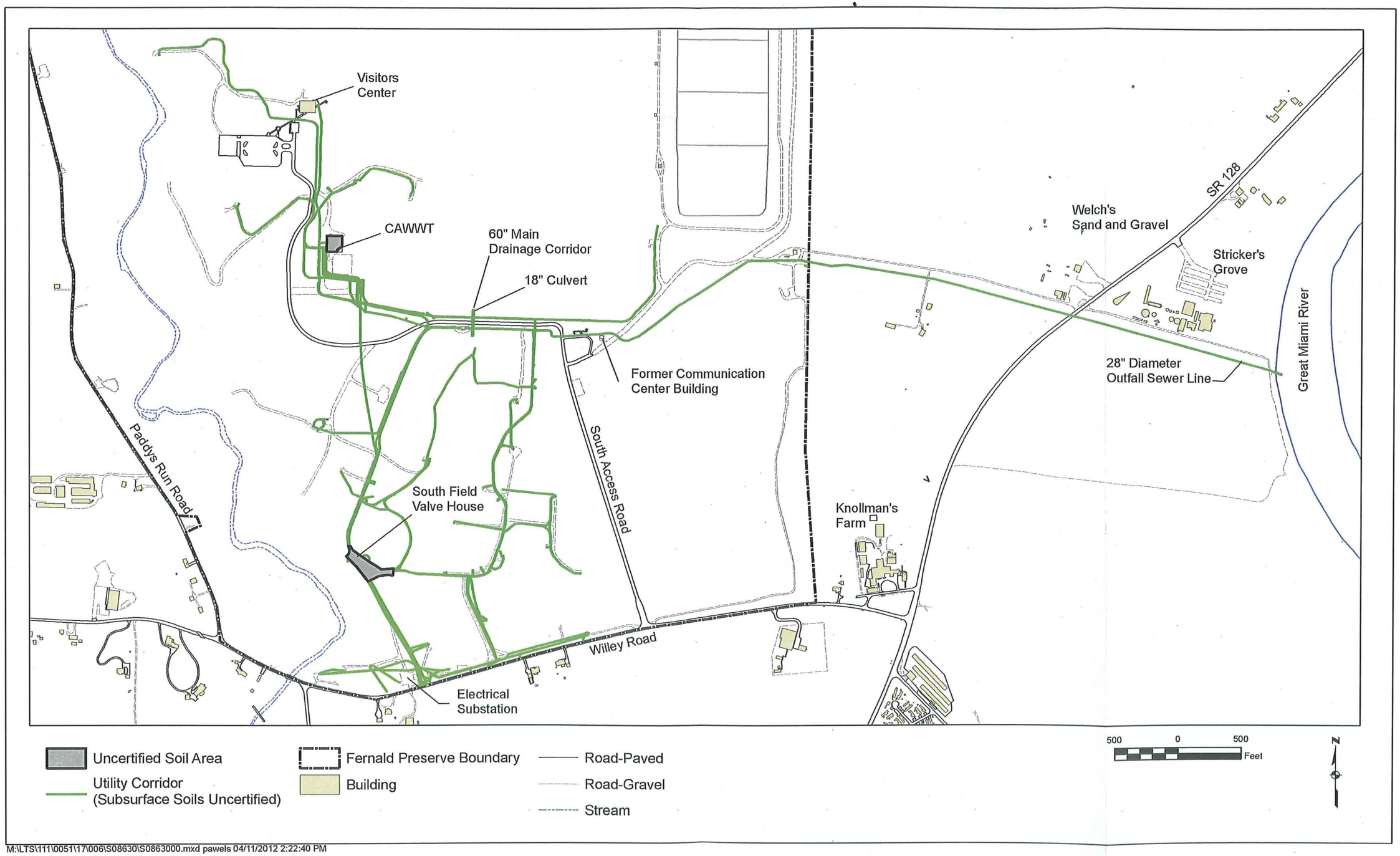

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Figure 9. Uncertified Areas and Subgrade Utility Corridors

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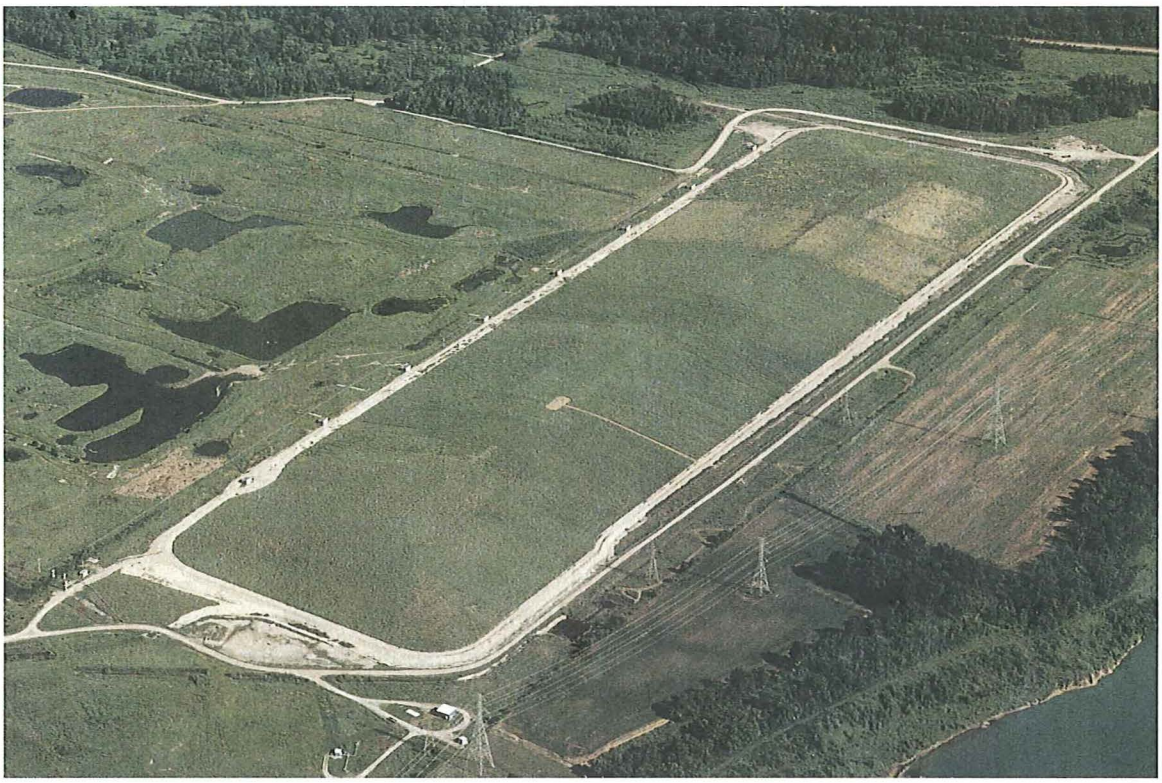


OSDF after Completion of all Caps (June 2011)

The Converted Advanced Wastewater Treatment Facility

2.2 Summary of Compliance with Other Requirements

CERCLA requires compliance with other laws and regulations as part of remediation of the Fernald Preserve. These requirements are referred to as applicable or relevant and appropriate requirements (ARARs). ARARs that are pertinent to remediation of the Fernald Preserve are specified in the Record of Decision for each operable unit. This section of the report highlights some of the major requirements related to environmental monitoring and waste management and describes how the Fernald Preserve complied with these requirements in 2011.

The regulations discussed in this section have been identified as ARARs within the Records of Decision. The Fernald Preserve must comply with these regulations while site remediation under CERCLA is underway; compliance is enforced by EPA and Ohio EPA. Some of these requirements include permits for controlled releases, which are also discussed in this section.

2.2.1 RCRA

RCRA regulates the treatment, storage, and disposal of hazardous waste and mixed waste that contains radioactive and hazardous waste components. These wastes are regulated under RCRA and Ohio hazardous waste management regulations; therefore, the Fernald Preserve must comply with legal requirements for managing hazardous and mixed wastes. Ohio EPA has been delegated or authorized by EPA to enforce its hazardous waste management regulations in lieu of the federal RCRA program. In addition, hazardous waste management is subject to the 1988 Consent Decree, the 1993 Stipulated Amendment between the State of Ohio and DOE, and a series of Director's Final Findings and Orders issued by Ohio EPA.

2.2.1.1 RCRA Property Boundary Groundwater Monitoring

The Director's Findings and Orders for Groundwater, which were signed September 10, 1993, described an alternate monitoring system for RCRA groundwater monitoring. A revision of this document was approved on September 7, 2000, to align with the groundwater monitoring strategy identified in the IEMP. The Property Boundary Groundwater Monitoring program is discussed in Section 3.

2.2.1.2 Waste Management

Although the RCRA regulations remain applicable, the Fernald Preserve had no hazardous waste treatment, storage, or disposal activities during 2011. Wastes managed during 2011 were limited to universal waste, uncontaminated solid wastes, and small quantities of low-level radioactive wastes.

2.2.2 Clean Water Act

Under the Clean Water Act, as amended, the Fernald Preserve is governed by the National Pollutant Discharge Elimination System (NPDES) regulations that require the control of discharges of nonradiological pollutants to waters of the state of Ohio. The NPDES permit, issued by the State of Ohio, specifies discharge and sample locations, sampling and reporting schedules, and discharge limitations. The Fernald Preserve submits monthly reports on NPDES activities to Ohio EPA demonstrating compliance with stipulated discharge limits. There were no

instances of noncompliance during 2011. Section 4 discusses the surface water and treated effluent information in detail.

2.2.3 Clean Air Act

Ohio EPA is authorized to enforce the state of Ohio's air standards for particulate matter at the Fernald Preserve. Compliance is accomplished by implementing the Fugitive Dust Control Policy negotiated between DOE and Ohio EPA in 1997. The policy allows for visual observation of fugitive dust and implementation of dust control measures.

2.2.4 Superfund Amendments and Reauthorization Act of 1986

The Superfund Amendments and Reauthorization Act of 1986 (SARA) amended CERCLA and was enacted, in part, to clarify and expand CERCLA requirements. SARA Title III is also known as the Emergency Planning and Community Right to Know Act.

A letter was submitted to Ohio EPA, to the local emergency planning committees of Hamilton and Butler Counties, and to the Crosby Township Fire Department on February 28, 2011, stating that the Fernald Preserve was not required to submit the SARA Title III, Section 312, Emergency and Hazardous Chemical Inventory Report for 2011. During 2011 there were no chemicals stored on the Fernald Preserve above threshold planning quantities.

Another SARA Title III report, the Section 313 Toxic Chemical Release Inventory Report (Form R), is required if quantities of chemicals released at the Fernald Preserve exceed an applicable threshold for any SARA 313 chemical. If required, the Toxic Chemical Release Inventory Report lists routine and accidental releases and information about the activities, uses, and waste for each reported toxic chemical. No chemical releases have exceeded the threshold for several years. On June 21, 2011, a negative survey report was submitted to Ohio EPA documenting that no such chemicals above thresholds were on site at any time during 2011. No chemical exceeded a reporting threshold during 2011.

Also under SARA Title III, any offsite release meeting or exceeding a reportable quantity as defined by SARA Title III, Section 304, requires that immediate notifications be made to local emergency planning committees and the state emergency response commission. Notifications are also made to the National Response Center and other appropriate federal, state, and local regulatory entities. All releases that might occur at the Fernald Preserve are evaluated and documented to ensure that proper notifications are made in accordance with SARA, and under CERCLA Section 103, RCRA, the Toxic Substances Control Act, the Clean Air Act, the Clean Water Act, and Ohio environmental laws and regulations. There were no releases at the Fernald Preserve that met the reporting criteria under CERCLA during 2011.

2.2.5 Other Environmental Regulations

The Fernald Preserve is also required to comply with other environmental laws and regulations in addition to those described above. Table 2 summarizes compliance with each of these requirements for 2011.

Table 2. Compliance with Other Environmental Regulations

Regulation and Purpose	Background Compliance Issues	2011 Compliance Activities
Toxic Substances Control Act		
Regulates the manufacturing, use, storage, and disposal of toxic materials, including polychlorinated biphenyl (PCB) and PCB items.	The last routine Toxic Substances Control Act inspection of the Fernald Preserve's program was conducted by EPA Region 5 on September 21, 1994. No violations of PCB regulations were identified during the inspection.	No PCB liquids were shipped in 2011.
Ohio Solid Waste Act		
Regulates infectious waste.	The Fernald Preserve was registered with Ohio EPA as a generator of infectious waste (generating more than 50 lb [23 kg] per month) until December 6, 1999, when Ohio EPA concurred with the Fernald Preserve's qualification as a small quantity generator.	No infectious waste activities were required in 2011.
Federal Insecticide, Fungicide, and Rodenticide Act		
Regulates the registration, storage, labeling, and use of pesticides (such as insecticides, herbicides, and rodenticides).	The last inspection of the Federal Insecticide, Fungicide, and Rodenticide Act program conducted by EPA Region 5 on September 21, 1994, found the Fernald Preserve to be in full compliance with the requirements mandated by the Federal Insecticide, Fungicide, and Rodenticide Act.	Pesticide applications at the Fernald Preserve were conducted according to federal and state regulatory requirements.
National Environmental Policy Act		
Requires the evaluation of environmental, socioeconomic, and cultural impacts before any action, such as a construction or cleanup project, is initiated by a federal agency.	An Environmental Assessment for proposed final land use was issued for public review in 1998. It was prepared under DOE's guidelines for implementation of National Environmental Policy Act, 10 CFR 1021. The assessment requires consulting the public before any decisions on land use are made; it includes previous DOE commitments.	No National Environmental Policy Act activities were required in 2011.
Endangered Species Act		
Requires the protection of any threatened or endangered species found at the site as well as any critical habitat that is essential for the species' existence.	Ecological surveys conducted by Miami University and DOE, in consultation with the Ohio Department of Natural Resources and the U.S. Fish and Wildlife Service, have established the following list of threatened and endangered species and their habitats existing on site: Cave salamander, state-listed endangered—marginal habitat, none found; Sloan's crayfish, state-listed threatened—found on northern sections of Paddys Run; Indiana brown bat, federally listed endangered—found in riparian areas along Paddys Run.	No surveys were conducted specifically for endangered species in 2011.

Table 2 (continued). Compliance with Other Environmental Regulations

Regulation and Purpose	Background Compliance Issues	2011 Compliance Activities
Floodplains/Wetlands Review Requirements		
DOE regulations require a floodplain/wetlands assessment for DOE construction and improvement projects.	A wetlands delineation of the Fernald Preserve, completed in 1992 and approved by the U.S. Army Corps of Engineers in August 1993, identified 36 acres (15 hectares) of freshwater wetlands on the Fernald Preserve property.	No assessments were performed in 2011.
National Historic Preservation Act		
Establishes a program for the protection, maintenance, and stewardship of federal prehistoric and historic properties.	The Fernald Preserve is located in an area of sensitive historic and prehistoric cultural resources that are eligible for or on the National Register of Historic Places. These cultural resources include historic structures, buildings, and bridges, plus Native American villages and campsites.	An archeological survey was conducted on approximately 4 acres along Paddys Run Road. This survey was conducted in advance of planned restoration activities in 2012. No cultural resources were identified. Monitoring for unexpected discoveries was conducted during sitewide field activities.
Native American Graves Protection and Repatriation Act		
Establishes a means for Native Americans to request the return or "repatriation" of human remains and other cultural items. Federal agencies must return human remains, associated funerary objects, sacred objects, and objects of cultural patrimony to the Native American nations or tribes with cultural affiliation to the remains or material.	Native American remains have been discovered during remediation activities at the Fernald Preserve. Native American remains and artifacts have been removed or left in place, with consultation from Native American nations, tribes, and groups.	No Native American remains were discovered or repatriated to Native American nations, tribes, or groups in 2011. As stated within the "Background Compliance Issues" column, monitoring for unexpected discoveries was conducted during sitewide field activities.

Table 2 (continued). Compliance with Other Environmental Regulations

Regulation and Purpose	Background Compliance Issues	2011 Compliance Activities
Natural Resource Requirements Under CERCLA and Executive Order 12580		
Requires DOE to act as a trustee (i.e., guardian) for natural resources at its federal facilities.	DOE and the other trustees, which include Ohio EPA and the U.S. Department of the Interior (administered by the U.S. Fish and Wildlife Service), meet regularly to discuss potential impact to natural resources and to coordinate trustee activities. The trustees also interact with the Fernald Community Alliance.	In November 2008, the State of Ohio and DOE reached a settlement of the 1986 Natural Resource injury claim at Fernald. While the components of restoration had been established through a 2001 Memorandum of Understanding (DOE 2001d) and restoration of the site continues, the State of Ohio and DOE settled outstanding issues such as the payment of monetary penalties, establishment of environmental covenants, and a mutually agreed upon Natural Resource Restoration Plan (NRRP), which is Appendix B of the *Partial Consent Decree Resolving Ohio's Natural Resource Damage Claim against DOE* (State of Ohio 2008). In 2009, activities commenced as required in the final NRRP. Activities in 2011 included the third year of wetland mitigation monitoring. A jurisdictional wetland delineation was conducted along with monitoring for hydrology, vegetation, and soil chemistry. The 3-year mitigation monitoring effort was reported in the *Fernald Preserve Wetland Mitigation Monitoring Report* (DOE 2012), which was submitted to the trustees. Additional monitoring activities included forest functional monitoring across the site and an evaluation of areas that were seeded in 2010. Section 6 provides a summary of trustee activities and monitoring data.

2.2.6 Other Permits

Certain environmental laws are implemented through permits. However, there are no other permits currently in effect other than the Fernald Preserve's permit for discharging water under NPDES regulations discussed in Section 2.2.2.

2.2.7 Pollution Prevention and Source Reduction

The Fernald Preserve is actively involved in an effort to reduce solid, hazardous, radioactive, and mixed waste generation and to eliminate or minimize pollutants released to all environmental media. Various waste streams were recycled during 2011, including:

- 7,187 lb (3,260 kg) of paper
- 106 lb (48.1 kg) of aluminum
- 228 lb (103 kg) of batteries
- 2,879 lb (1,306 kg) of electronic equipment (universal waste)
- 163 lb (73.9 kg) of toner cartridges
- 164,244 lb (74,500 kg) of concrete
- 17,480 lb (7,929 kg) of iron/steel
- 1,677 lb (760.7 kg) of copper
- 5,983 lb (2,714 kg) of commingled cardboard, glass, plastic, and paper
- 77,000 lb (32,930 kg) of baled hay (reused as soil amendment)

The Fernald Preserve's affirmative procurement program involves source reduction and the use of EPA-designated materials to increase the market for recovered materials. In accordance with Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance,* and Executive Order 13423, *Strengthening Federal Environmental, Energy and Transportation Management*, the Fernald Preserve uses 30 percent post-recycled-content copier paper. The Fernald Preserve generated and submitted an annual report demonstrating compliance with these orders in December 2011.

As part of the Annual Site Sustainability Plan required under DOE Order 436.1, the Fernald Preserve generated and submitted a summary report of waste generated and pollution prevention progress in December 2011.

2.2.8 Federal Facilities Compliance Agreement

In July 1986, DOE entered into a Federal Facility Compliance Agreement (FFCA) with EPA, which requires the Fernald Preserve to:

- Maintain a sampling program for the South Plume extraction wells and report the results to EPA, Ohio EPA, and the Ohio Department of Health. The sampling program conducted to address this requirement has also been modified over the years and is currently governed by an agreement reached with EPA and Ohio EPA on May 1, 1996. These data are reported in Appendix A.

- Maintain a continuous sample collection program for radiological constituents at the treated effluent discharge points and report the results to EPA, Ohio EPA, and the Ohio Department of Health. The sampling program to address this requirement has been modified over the years and is currently governed by an agreement reached with EPA and Ohio EPA that became effective May 1, 1996. These data are reported in Appendix B.

2.2.9 Environmental Management Systems Requirement

DOE requires that sites develop and implement an Environmental Management System as a means of systematically planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals. This requirement is specified in DOE Order 436.1, *Departmental Sustainability*.

The implementation of an Environmental Management System ensures that sound stewardship practices protective of the air, water, land, and other natural and cultural resources potentially affected by operations are employed throughout the project. An Environmental Management System is a systematic process for reducing the environmental impacts resulting from DOE and contractor work activities, products, and services and directs work to proceed in a manner that protects workers, the public, and the environment. The process adheres to "Plan-Do-Check-Act" principles, mandates environmental compliance, and integrates green initiatives into all phases of work, including scoping, planning, construction, subcontracts, and operations. Proposed site maintenance activities will be assessed for opportunities to improve environmental performance and sustainable environmental practices. Some areas for consideration include reusing and recycling products or wastes, using environmentally preferable products (i.e., products with recycled content, products with reduced toxicity; and energy efficient products), using alternative fuels and renewable energy, and making environmental habitat improvements.

2.3 Split Sampling Program

Since 1987, DOE has participated in the split sampling program with Ohio EPA. Split samples are obtained when technicians alternately add portions of a sample to two individual sample containers. This collection method helps ensure that both samples are as close as possible to being identical. The split samples are then submitted to two analytical laboratories; this allows for an independent comparison of data to ascertain quality assurance for laboratory analysis and field sampling methods. Ohio EPA performs independent sampling in addition to split sampling.

In 2011, DOE and Ohio EPA cooperated in the split sampling program. Table 3 provides the analytical results of split groundwater samples, and Figure 10 shows the split sample locations.

Table 3. 2011 DOE/Ohio EPA Groundwater Split Sampling Comparison

Sample Location[a]	2011 Sample Date	Constituent	DOE Result (µg/L)[b]	Ohio EPA Result (µg/L)	FRL[c] (µg/L)
2060	April	Total Uranium	38.7	44.3	30
2060	November	Total Uranium	53.1	52.3	30
13	April	Total Uranium	15.4	16.7	30
13	November	Total Uranium	10.3	9.46	30
14	April	Total Uranium	4.09	4.31	30
14	November	Total Uranium	3.94	3.25	30

[a] Refer to Figure 10 for groundwater split sample locations.
[b] µg/L = micrograms per liter
[c] The groundwater pathway and final remediation levels (FRL) are discussed in Section 3.

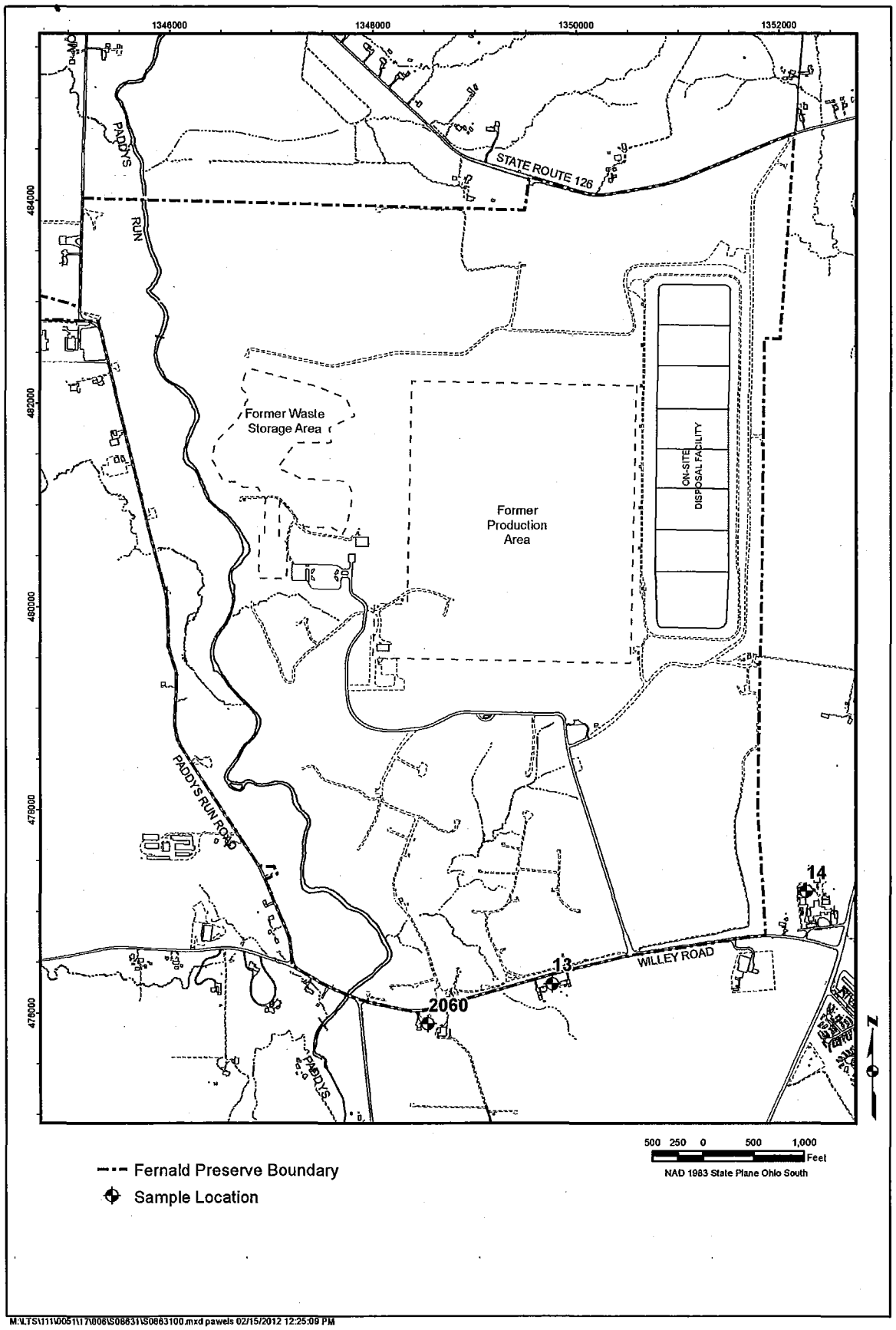


Figure 10. DOE and Ohio EPA Groundwater Split Sample Locations

Section 3

3.0 Groundwater Pathway

Results in Brief: 2011 Groundwater Pathway

Groundwater Remedy

Since 1993

- 32,183 M gallons (121,813 M liters) of water have been pumped from the Great Miami Aquifer.
- 10,805 net lb (4,905 kg) of uranium have been removed from the Great Miami Aquifer.

During 2011

- 2,431 M gallons (9,201 M liters) of water were pumped from the Great Miami Aquifer.
- 544 lb (247 kg) of uranium were removed from the Great Miami Aquifer.

Groundwater Monitoring Results—Historically high precipitation levels in 2011 resulted in high water levels in the Great Miami Aquifer. High water levels in the aquifer provide ideal conditions to update the dimensions of the maximum uranium plume because more of the vertical component of the plume can be sampled. DOE took full advantage of high water levels in 2011 to update maximum uranium plume dimensions. The data collected in 2011 indicate that uranium concentrations within the footprint of the maximum uranium plume continue to decrease in response to pumping. The footprint of the maximum uranium plume in 2011 was approximately 144 acres (a decrease of approximately 21.7 percent from what was mapped in 2010 [184 acres]).

Groundwater elevation data continue to show that the uranium plume is being captured by the pumping wells.

As predicted, the percentage of treatment needed to achieve uranium discharge limits has been decreasing. This is a normal operational progression seen in pump-and-treat remediations. The aquifer remedy can continue without groundwater treatment and achieve uranium discharge limits. In 2011, DOE, EPA, and Ohio EPA agreed to proceed with reducing the treatment capacity of Converted Advanced Wastewater Treatment facility from approximately 1,800 gpm to 500 to 600 gpm. The reduced capacity will be maintained to handle other site water treatment needs and to provide for a contingency for the limited treatment of groundwater if deemed necessary.

OSDF Monitoring—In 2011, every sampling horizon of each cell was sampled quarterly for up to 23 parameters. The leachate collection system was sampled annually for *Ohio Administrative Code* 3745-27-10 Appendix I constituents and PCBs. Flow data from the engineered facility, coupled with the water quality monitoring results and the results of quarterly disposal facility physical inspections, indicate that the facility performed as designed in 2011.

This section provides background information on the nature and extent of groundwater contamination in the Great Miami Aquifer due to past operations at the Fernald Preserve and summarizes aquifer restoration progress and groundwater monitoring activities and results for 2011.

Restoration of the affected portions of the Great Miami Aquifer and continued protection of the groundwater pathway are primary considerations in the groundwater remediation strategy for the Fernald Preserve. The groundwater pathway will continue to be monitored following remediation to ensure the protection of this primary exposure pathway.

3.1 Summary of the Nature and Extent of Groundwater Contamination

Groundwater Modeling at the Fernald Preserve

The Fernald Preserve uses a computer model to make predictions about how the concentration/location of contaminants in the aquifer will change over time. Because the model contains simplifying assumptions about the aquifer and the contaminants, the predictions about future behavior must be verified with laboratory analyses of groundwater samples collected during monitoring activities.

If groundwater monitoring data indicate the need for operational changes to the groundwater remedy, the groundwater model is run to predict the effect those changes might have on the aquifer and the contaminants. If the predictions indicate the proposed changes would increase cleanup efficiency and reduce the cleanup time and cost, the operational changes are made, and monitoring data are collected after the changes to verify whether model predictions were correct. If model predictions prove to be incorrect, modifications are made to the model to improve its predictive capabilities.

The nature and extent of groundwater contamination from operations at the Fernald site were investigated, and the risk to human health and the environment from those contaminants was evaluated in the Operable Unit 5 Remedial Investigation Report (DOE 1995b). As documented in that report, the primary groundwater contaminant at the site is uranium.

Groundwater contamination resulted from infiltration of contaminated surface water through the bed of Paddys Run, the storm sewer outfall ditch (SSOD), the Pilot Plant drainage ditch, and the Old Drainage Ditch from the Plant 1

Pad (see Figure 18). In these areas, the glacial overburden is absent (eroded), creating a direct pathway between surface water and the sand and gravel of the aquifer. To a lesser degree, groundwater contamination also resulted where past excavations (such as the waste pits) removed some of the protective clay contained in the glacial overburden and exposed the aquifer to contamination.

3.2 Selection and Design of the Groundwater Remedy

While a remedial investigation and feasibility study was in progress and a groundwater remedy was being selected, off-property contaminated groundwater was being pumped from the South Plume area by the South Plume Removal Action System (referred to as the South Plume Module). In 1993, this system was installed south of Willey Road and east of Paddys Run Road to stop the uranium plume in this area from migrating any farther to the south. Figure 11 shows South Plume Module extraction wells 3924, 3925, 3926, and 3927. These extraction wells have successfully stopped further southern migration of the uranium plume beyond the wells and have contributed to significantly reducing total uranium concentrations in the off-property portion of the plume.

After the nature and extent of groundwater contamination was defined in the *Remedial Investigation Report for Operable Unit 5* (DOE 1995b), various remediation technologies were evaluated in the *Feasibility Study Report for Operable Unit 5* (DOE 1995c). Remediation cost, and various land-use scenarios were considered during the development of the preferred remedy for restoring the quality of groundwater in the aquifer. The *Feasibility Study Report for Operable Unit 5* recommended a concentration-based, pump-and-treat remedy for the groundwater contaminated with uranium, consisting of 28 groundwater extraction wells located on and off property. Computer modeling suggested that the 28 extraction wells pumping at a combined rate of 4,000 gallons per minute (gpm) (15,140 liters per minute [Lpm]) would remediate the aquifer within 27 years.

The recommended groundwater remedy, that included state and community acceptance, was presented in the *Proposed Plan for Operable Unit 5* (DOE 1995d) as the preferred groundwater remedy. Once the proposed plan was approved, the *Record of Decision for Remedial Actions at Operable Unit 5* (OU5 ROD) (DOE 1996) was issued.. The OU5 ROD formally defines the selected groundwater remedy and establishes final remediation levels (FRLs) for all constituents of concern.

Re-injection at the Fernald Site

From 1998 to 2004, re-injection was an enhancement to the groundwater remedy at the Fernald site, supplementing pump-and-treat operations. The term "well-based" refers to the injection of treated groundwater through specially designed re-injection wells. Groundwater pumped from the aquifer was treated via ion exchange to remove contaminants and then re-injected into the aquifer at strategic well locations. Because the treatment process was not 100 percent efficient, a small amount of uranium was re-injected into the aquifer with the treated water. The re-injected groundwater increased the speed at which dissolved contaminants moved through the aquifer and were pulled by extraction wells, thereby decreasing the overall remediation time. Based on updated groundwater modeling and the unfavorable results of a cost/benefit analysis, well-based re-injection was discontinued in 2004.

The OU5 ROD commits to an ongoing evaluation of innovative remediation technologies so that remedy performance can be improved as such technologies become available. As a result of this commitment, an enhanced groundwater remedy was presented in the Operable Unit 5 *Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1)* (DOE 1997).

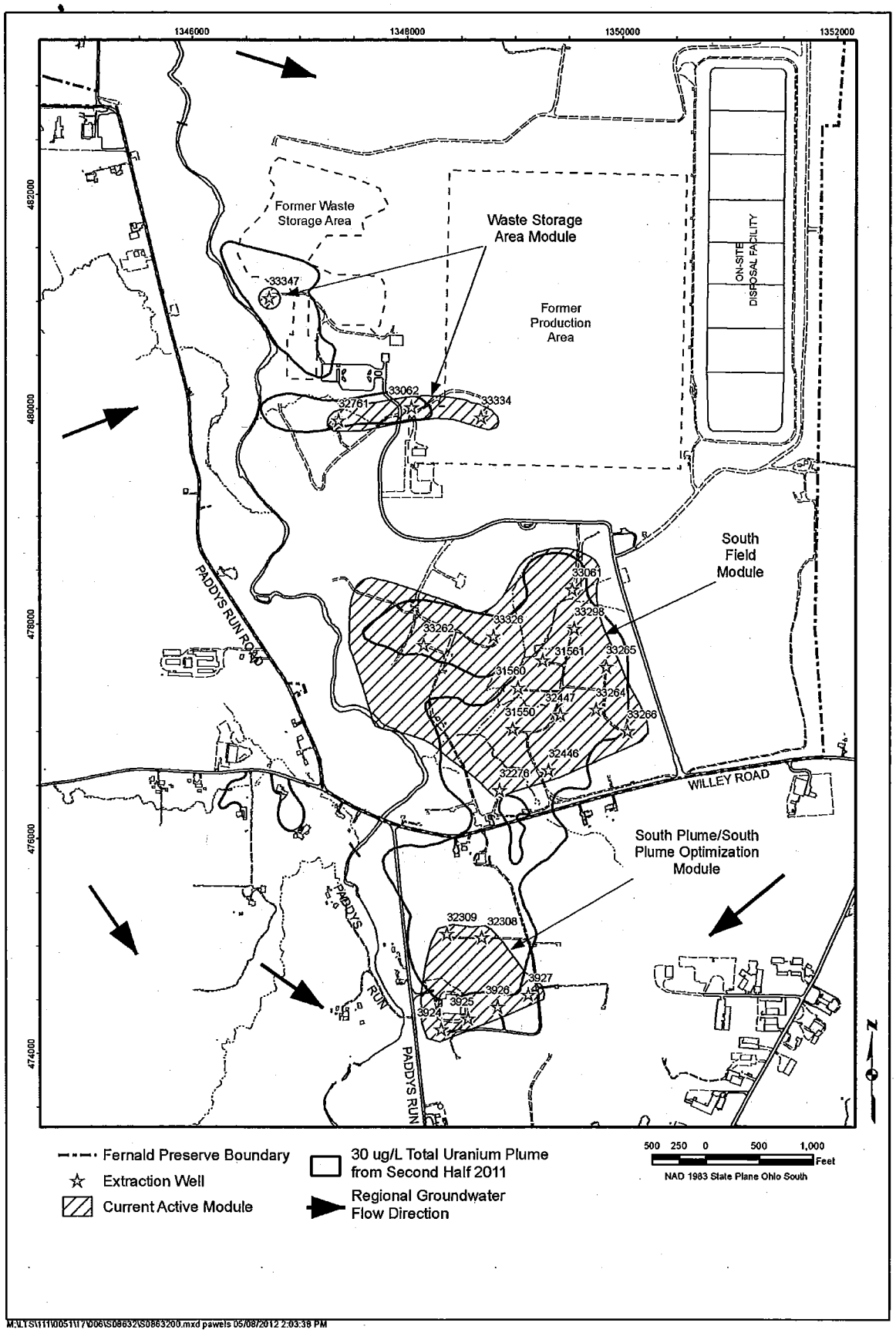


Figure 11. Extraction Wells Active in 2011

Groundwater modeling studies conducted to design the enhanced groundwater remedy suggested that, with the early installation of additional extraction wells and the use of re-injection technology, the remedy could potentially be reduced to 10 years. EPA and Ohio EPA approved the enhanced groundwater remedy that relied on pump-and-treat and re-injection technology. The groundwater remedy included the use of well-based re-injection until September 2004.

Evolution of the enhanced groundwater remedy has been documented through a series of approved designs. These designs are: The Operable Unit 5 *Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1)* (DOE 1997), *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas* (DOE 2001b), *Design for Remediation of the Great Miami Aquifer South Field (Phase II) Module* (DOE 2002a), *Comprehensive Groundwater Strategy Report* (DOE 2003), the *Groundwater Remedy Evaluation and Field Verification Plan* (DOE 2004), and the *Waste Storage Area Phase II Design Report* and Addendum (DOE 2005a).

The enhanced groundwater remedy commenced in 1998 with the startup of the South Field (Phase I), the South Plume Optimization, and the Re-injection Demonstration Modules. It focused primarily on the removal of uranium but was also designed to limit further expansion of the plume, achieve removal of all targeted contaminants to concentrations below designated FRLs, and prevent undesirable groundwater drawdown impacts beyond the site boundary. Startup of the enhanced groundwater remedy included a year-long re-injection demonstration that began in September 1998. Through the years, extraction and re-injection wells have been added to and removed from these initial restoration modules.

In 2001, EPA and Ohio EPA approved the *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas* (DOE 2001b). Approval of this design initiated the installation of the next planned aquifer restoration module. The design specified three extraction wells in the Waste Storage Area to address contamination in the Pilot Plant drainage ditch plume (Phase I) and two extraction wells to address the remaining contamination after the waste pits excavation was completed (Phase II). One of the three Phase I Waste Storage Area wells (Well 32761) was installed in 2000 to support an aquifer pumping test to help determine the restoration well field design. The remaining two Phase I wells (Well 33062 and Well 33063) were installed in summer 2001 after EPA and Ohio EPA approved the design. All three wells became operational on May 8, 2002. Well 33063 was abandoned in 2004 to facilitate site remediation work. A replacement well (Well 33334) was installed and began operating in 2006. Well locations are shown in Figure 11.

The *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas* (DOE 2001b) also provided data indicating that the uranium plume in the former Plant 6 Area was no longer present. It was believed that the uranium concentrations in the plume had decreased to levels below the FRL as a result of plant operations shutting down in the late 1980s and the pumping of highly contaminated perched water as part of the Perched Water Removal Action No. 1 in the early 1990s. Because a uranium plume with concentrations above the groundwater FRL was no longer present in the former Plant 6 Area at the time of the design, a restoration module for the area was determined to be unnecessary. Groundwater monitoring continues in the former Plant 6 Area with one well (Well 2389) in the area having sporadic total uranium FRL exceedances. The location of monitoring well 2389 is shown in Figure 14.

In 2002, EPA and Ohio EPA approved the next planned groundwater restoration design document, the *Design for Remediation of the Great Miami Aquifer South Field (Phase II) Module* (DOE 2002a). The Phase II design presents an updated interpretation of the uranium plume in the South Field area along with recommendations on how to proceed with remediation in the area, based on the updated plume interpretation. Installation of Phase II components was initiated in 2002. The overall system (Phases I and II) is referred to as the South Field Module.

In 2003, groundwater remediation approaches were evaluated to determine the most cost-effective groundwater remedy infrastructure, including the wastewater treatment facility, to remain after site closure. An evaluation of alternatives was presented in the *Comprehensive Groundwater Strategy Report* (DOE 2003). In October 2003, initial discussions were held with the regulators and the public concerning the various alternatives identified in the report. These discussions culminated in an identified path forward to work collaboratively with the Fernald Citizens Advisory Board, EPA, and Ohio EPA to determine the most appropriate course of action for the ongoing aquifer restoration and water treatment activities at the Fernald site.

In 2004, a decision regarding the future aquifer restoration and wastewater treatment approach was made following regulatory and public input. In May, EPA and Ohio EPA approved the decision to reduce the size of the advanced wastewater treatment facility; in June, they approved the decision to discontinue the use of well-based re-injection. Reducing the size of the advanced wastewater treatment facility provided the opportunity to dismantle and dispose of approximately 90 percent of the existing facility in the OSDF in time to meet the 2006 closure schedule. This resulted in a protective, more cost-effective, long-term water treatment facility to complete aquifer restoration. Well-based re-injection was discontinued in 2004 on the basis of groundwater modeling cleanup predictions presented in the *Comprehensive Groundwater Strategy Report* (DOE 2003) and the *Groundwater Remedy Evaluation and Field Verification Plan* (DOE 2004). The updated modeling indicated that the aquifer restoration time frame would likely be extended beyond dates previously predicted as a result of refined modeling input. The updated modeling also indicated that continued use of the groundwater re-injection wells would shorten the aquifer remedy by approximately 3 years. Therefore, the benefit of continuing re-injection did not justify the cost. Well-based re-injection was discontinued in September 2004 to support construction of the Converted Advanced Wastewater Treatment facility (CAWWT). All re-injection wells remain in place as potential groundwater remedy performance monitoring locations.

In 2005, the *Waste Storage Area Phase II Design Report* (DOE 2005a) was issued. Comments received from EPA and Ohio EPA resulted in the issuance of an addendum to the report in December 2005. The design consisted of the installation of one more extraction well (Well 33347) in the former Waste Storage Area, near the former silos area. Well 33347 is shown in Figure 11.

In 2005, an infiltration test was conducted in the SSOD. The test consisted of gauging the flow into and out of the SSOD with six Parshall flumes to obtain the overall infiltration rate along the SSOD. Findings from the test were included in the *Storm Sewer Outfall Ditch Infiltration Test Report* (DOE 2005b). The decision was made that natural storm water flow into the SSOD will be supplemented with pumped clean groundwater.

The *Fernald Groundwater Certification Plan* was issued and approved by EPA in 2005 (DOE 2006b). Ohio EPA approved Revision 2 of the plan in 2006. Revision 2 addressed

comments that the Ohio EPA had on the 2005 submittal. The certification plan defines a programmatic strategy for certifying completion of the aquifer remedy. It was developed through a series of four technical information exchange meetings held in 2005 among DOE, EPA, and Ohio EPA. The *Fernald Groundwater Certification Plan* (DOE 2006b) identifies that the IEMP will continue to be the plan that includes remedy performance monitoring requirements.

In 2006, the Waste Storage Area Phase II Module components became operational, marking completion of the groundwater remediation system design. Completion of the Waste Storage Area Phase II Module brought the total number of extraction wells in the former Waste Storage Area to four (Wells 32761, 33062, 33334, and 33347). These four well locations are shown in Figure 11.

On December 14, 2006, the site began pumping clean groundwater from three existing construction wells located on the east side of the Fernald Preserve to the former SSOD. This water is being pumped as needed to maintain a flow of approximately 500 gpm (1,890 Lpm) into the former SSOD. Pumping will continue until the existing wells, pumps, or motors are no longer serviceable. At that time the operation will be suspended, pending a determination by DOE regarding the benefits to the aquifer remedy. Also, with the completion of site soil remediation, surface water runoff from portions of the Former Production Area is being directed to the former SSOD.

Figure 11 shows the extraction well locations that were active in 2011. The operational information associated with these modules is presented in the following subsections.

3.3 Groundwater Monitoring Highlights for 2011

For this annual site report, groundwater monitoring results are discussed in terms of restoration and compliance monitoring.

The key elements of the Fernald Preserve groundwater monitoring program design are described below.

Sampling—Sample locations, frequency, and constituents address operational assessment, restoration assessment, and compliance requirements. Monitoring is conducted to ascertain groundwater quality and groundwater flow direction.

As part of the comprehensive groundwater monitoring program specified in the current IEMP, 140 wells were monitored for water quality in 2011. Figure 12 is a diagram of a typical groundwater monitoring well. Figure 13 illustrates monitoring well depths and screen locations. Figure 14 and Figure 15 identify the locations of the current water quality monitoring wells. In addition to water quality monitoring, 178 wells were monitored quarterly for groundwater elevations to determine groundwater flow direction. Figure 16 depicts the routine water level (groundwater elevation) monitoring wells.

Additionally, 28 locations were sampled using a direct-push sampling tool in 2011. Results are provided in Appendix A, Attachment A.2.

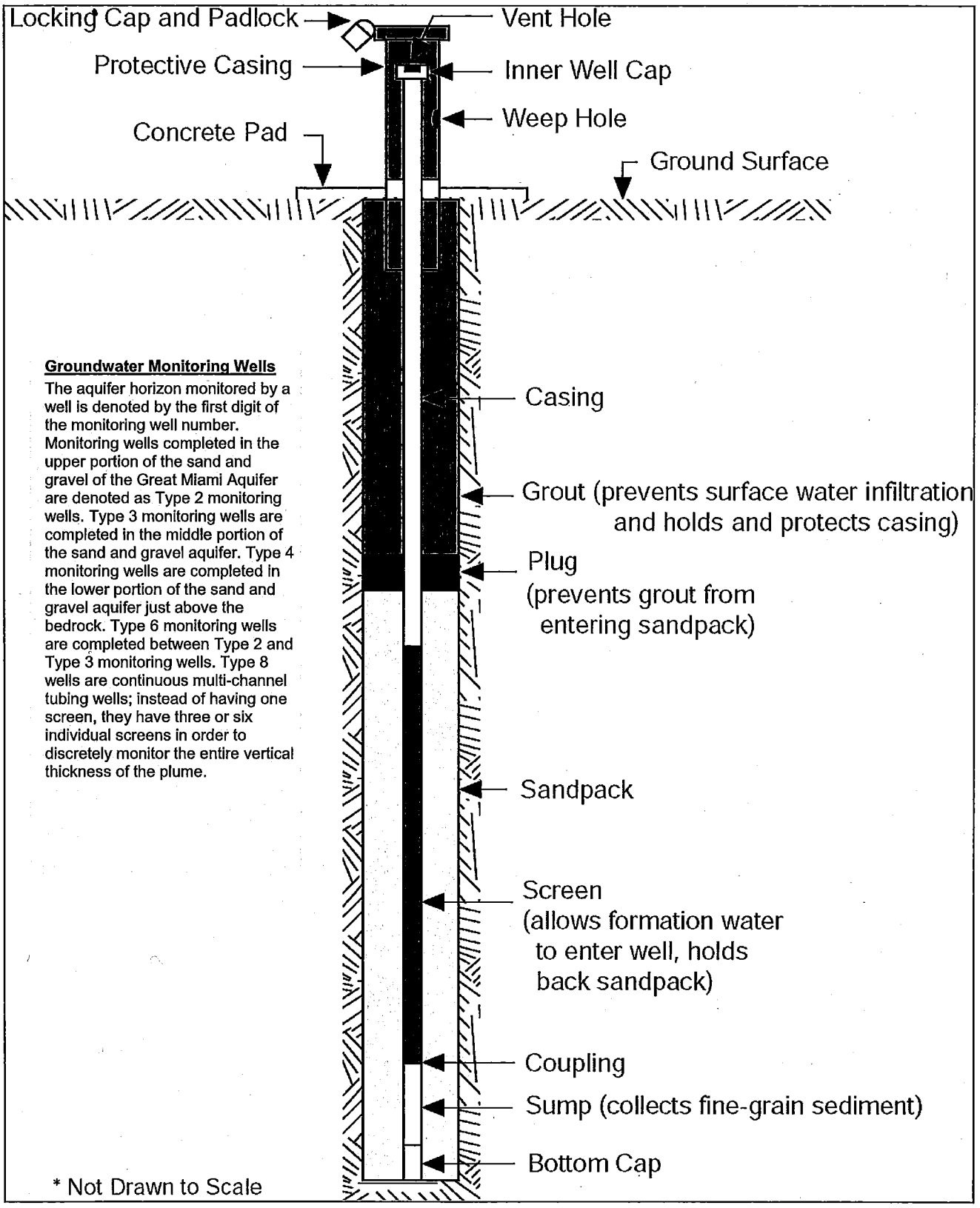


Figure 12. Diagram of a Typical Groundwater Monitoring Well

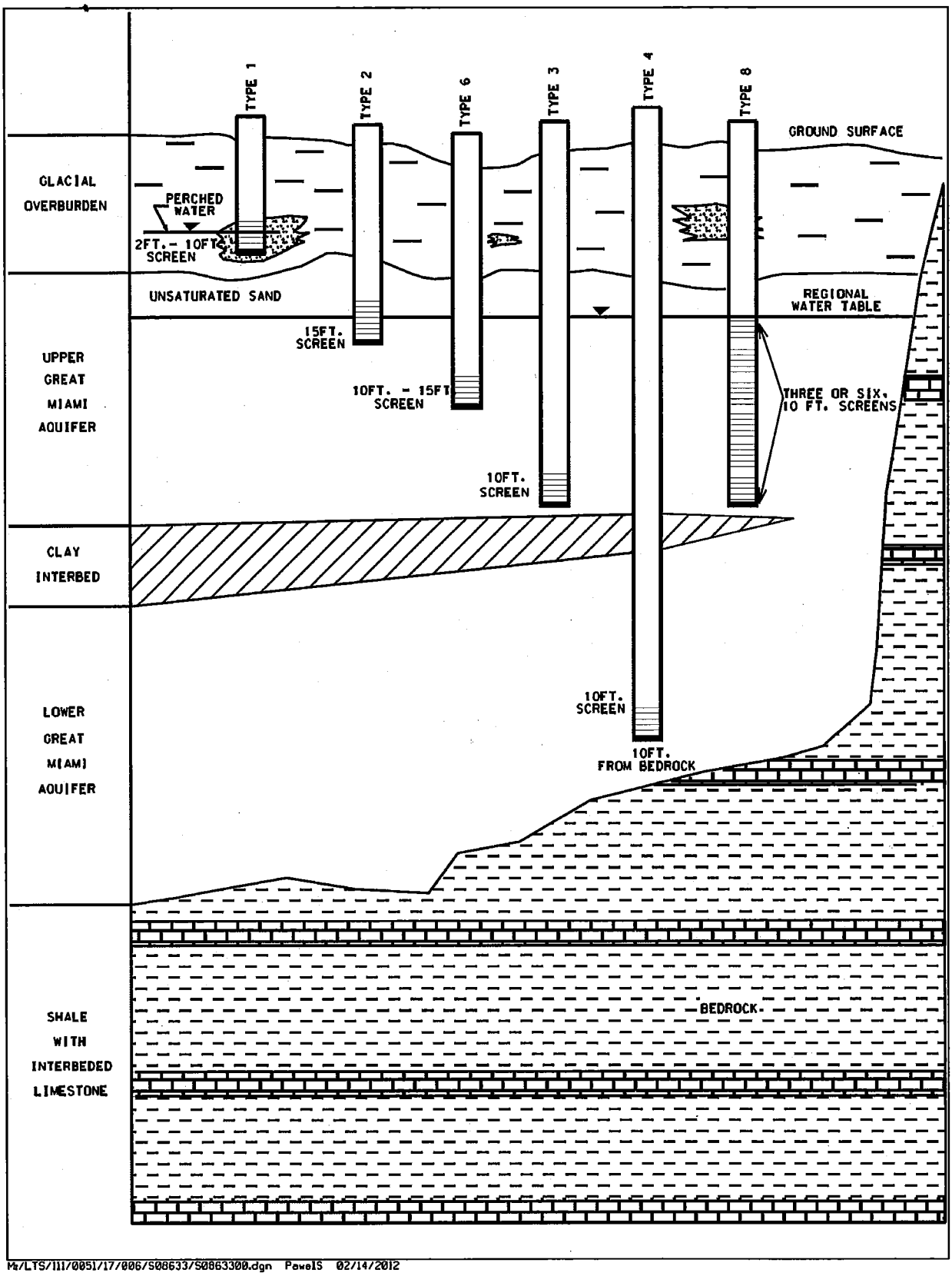


Figure 13. Monitoring Well Relative Depths and Screen Locations

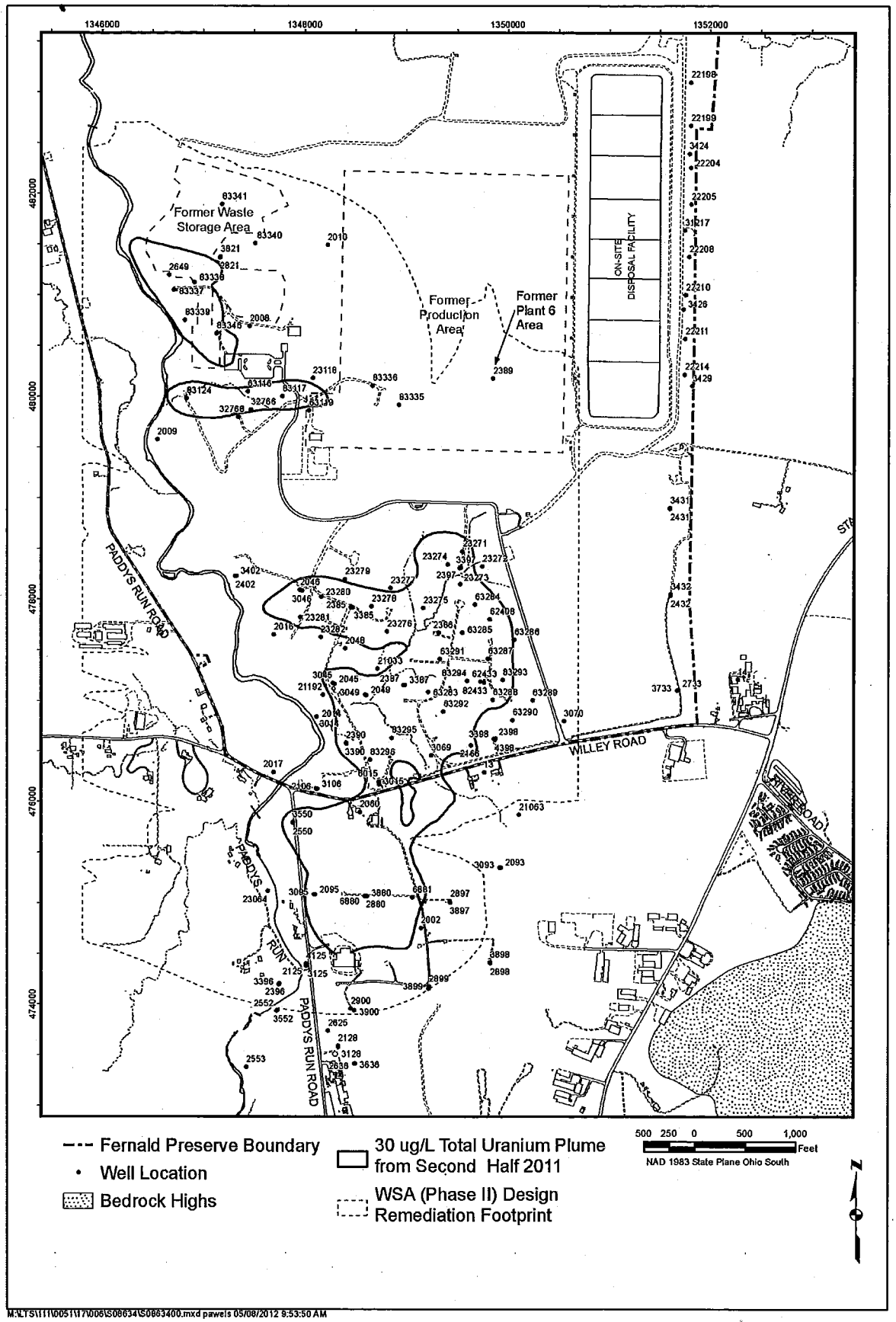


Figure 14. Locations for Semiannual Total Uranium Monitoring

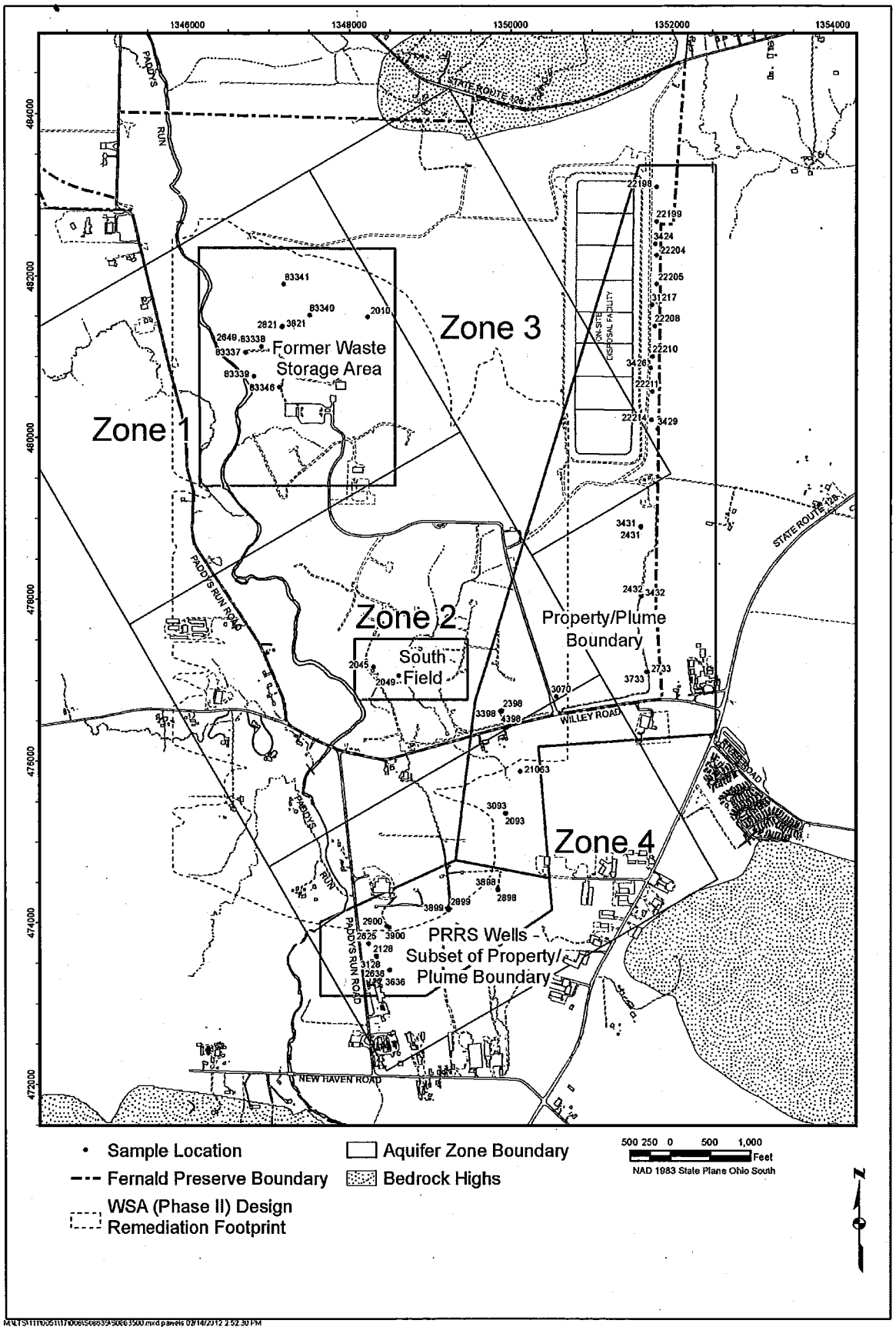


Figure 15. Locations for Semiannual Non-Uranium Monitoring

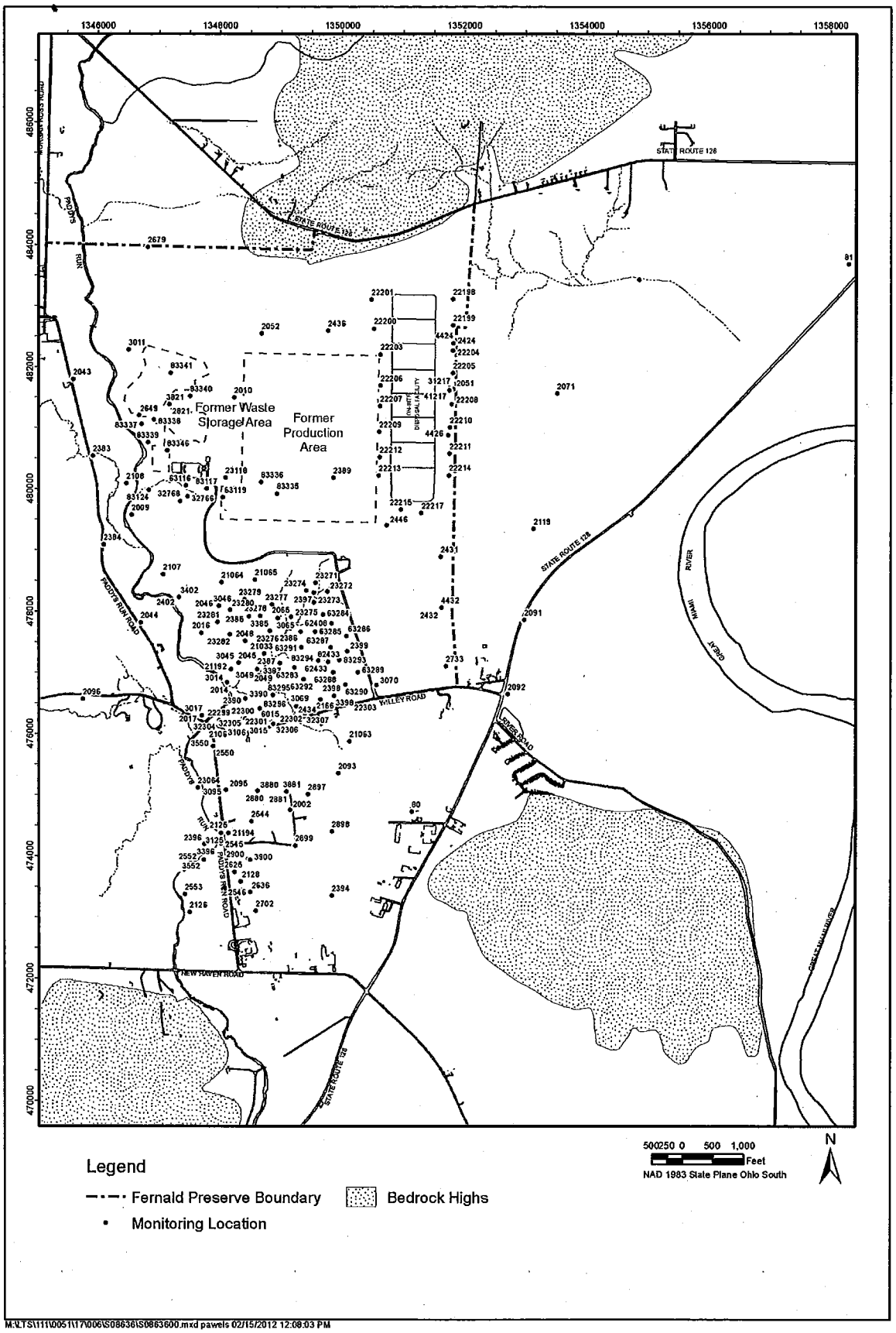


Figure 16. Groundwater Elevation Monitoring Wells

Data Evaluation—The integrated data evaluation process involves review and analysis of the data collected from wells and direct-push sampling locations to determine capture and restoration of the uranium plume, capture and restoration of non-uranium FRL constituents, water quality conditions in the aquifer that indicate a need to modify the design and installation of restoration modules, and the impact of ongoing groundwater restoration on the Paddys Run Road Site plume (a separate contaminant plume unrelated to the Fernald Preserve, resulting from industrial activities in the area located south of the Fernald Preserve along Paddys Run Road).

Reporting—All data are reported in the annual Site Environmental Reports.

3.3.1 Restoration Monitoring

In general, restoration monitoring tracks the progress of the pump-and-treat stage of the groundwater remedy and water quality conditions. All operational modules are evaluated during the year to determine the progress of aquifer remediation. Uranium concentration maps are developed from analytical data and compared with groundwater elevation maps to verify capture of the uranium plume.

Appendix A provides more-detailed information. Sections that follow identify the specific attachment of Appendix A where the detailed information can be found.

3.3.1.1 Operational Summary

The amount of groundwater that needs to be treated to maintain compliance with the monthly average uranium discharge concentration limit has decreased dramatically over the last 6 years. The aquifer remedy can now achieve the uranium discharge limits (i.e., average monthly concentration of less than 30 micrograms per liter [µg/L] and 600 lb [272 kg] annually) established in the OU5 ROD without groundwater treatment. In 2011, DOE, EPA, and Ohio EPA agreed to proceed with reducing the treatment capacity of CAWWT from approximately 1,800 gpm (6,814 Lpm) to 500 to 600 gpm (1,893 to 2,271 Lpm).

Figure 11 shows the extraction well locations associated with the restoration modules operating in 2011. Table 4 summarizes the mass of uranium removed and the volume of groundwater pumped during 2011. Unplanned operational disruptions in 2011 were minimal. Additional details are provided in the module operational summaries in Sections 3.3.1.2 through 3.3.1.4. Figure 17 identifies the yearly and cumulative mass of uranium removed from the Great Miami Aquifer from 1993 through 2011.

Since 1993:

- 32,183 M gallons (121,813 M liters) of water have been pumped from the Great Miami Aquifer.
- 1,936 M gallons (7,328 M liters) of treated water have been re-injected into the Great Miami Aquifer.
- 10,805 net lb (4,906 kg) of total uranium have been removed from the Great Miami Aquifer.

Appendix A, Attachment A.1, provides detailed operational information on each extraction well. The following sections provide an overview of the individual modules.

Table 4. Groundwater Restoration Module Status for 2011

Modules and Restoration Wells	Target Pumping		Volume Pumped (Millions)		Uranium Removed	
	gpm	Lpm	gallons	liters	lb	kg
South Plume/ South Plume Optimization Module: 3924, 3925, 3926, 3927, 32308, 32309	1,200	4,542	621	2,350	108	49
South Field Module: 31550, 31560, 31561, 32276, 32446, 32447, 33061, 33262, 33264, 33265, 33266, 33298, 33326	2,575	9,746	1,291	4,886	338	153
Waste Storage Area Module: 32761, 33062, 33334, 33347	1,000	3,785	520	1,968	98	44
Aquifer Restoration System Total Pumped	4,775	18,073	2,431	9,204	544	247

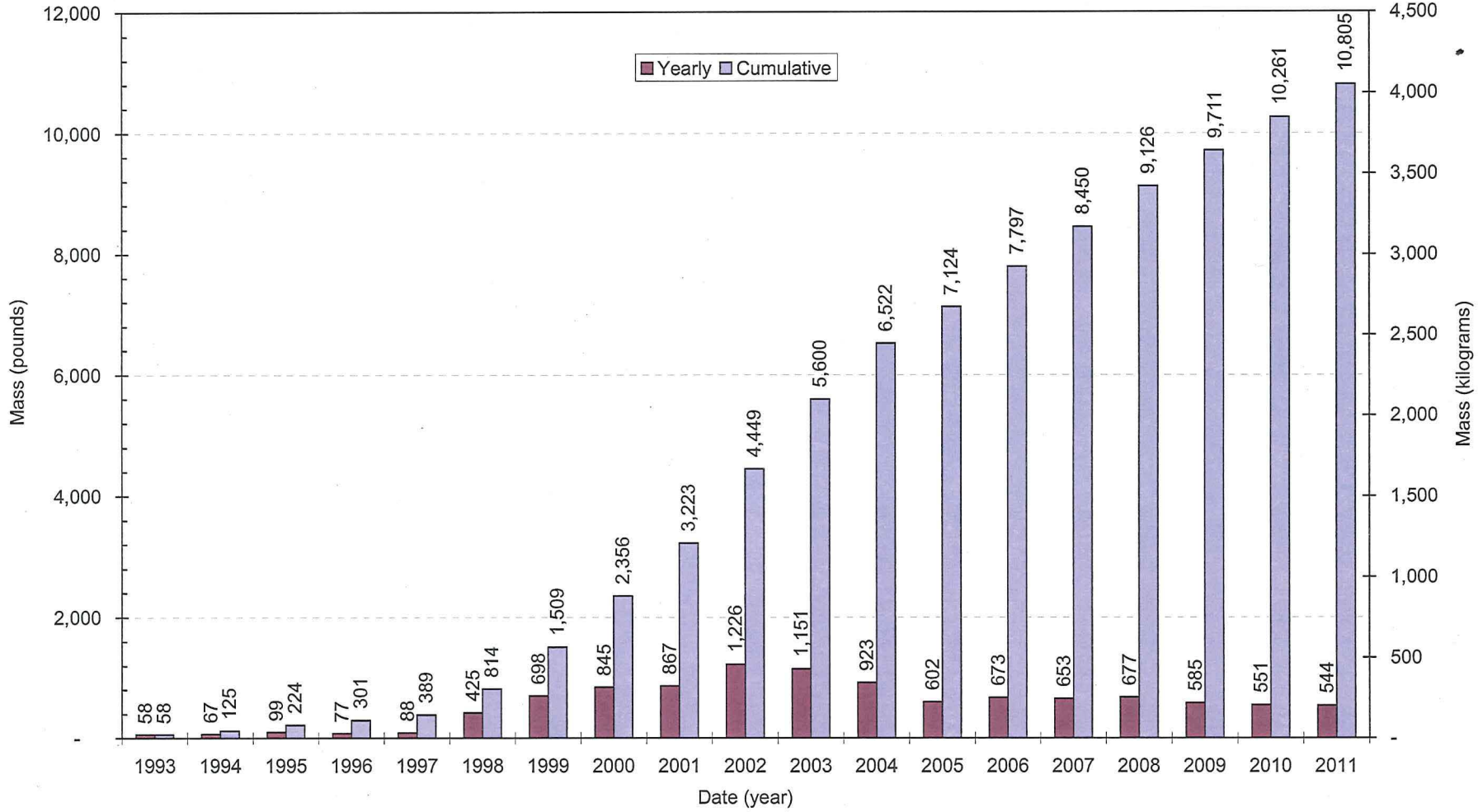


Figure 17. Net Mass of Uranium Removed from the Great Miami Aquifer, 1993–2011

3.3.1.2 South Plume/South Plume Optimization Module Operational Summary

The four extraction wells (3924, 3925, 3926, and 3927) of the South Plume Module began operating in August 1993. The two extraction wells (32308 and 32309) of the South Plume Optimization Module began operating in August 1998. Figure 18 illustrates the southern extent of capture observed for the South Plume/South Plume Optimization Module in the fourth quarter of 2011.

During 2011, 621 M gallons (2,350 M liters) of groundwater and 108 lb (49 kg) of uranium were removed from the Great Miami Aquifer by the South Plume/South Plume Optimization Module. Based on analysis of the data collected in 2011, the module continues to meet its primary objectives as demonstrated by the following:

- Southward movement of the uranium plume beyond the southernmost extraction wells has not been detected.
- Active remediation of the central portion of the off-property uranium plume continues to reduce plume concentration. Nearly the entire off-property uranium plume concentration is now below 100 µg/L. When pumping began in 1993, areas in the off-property uranium plume had concentrations over 300 µg/L.
- Paddys Run Road Site plume, located south of the extraction wells, is not being pulled toward the South Plume Extraction Wells.

3.3.1.3 South Field Module Operational Summary

The South Field Module was constructed in two phases. Phase I began operating in July 1998, and Phase II began operating in July 2003. During 2011, 13 extraction wells were operational.

The 10 original extraction wells installed under Phase I were 31550, 31560, 31561, 31562, 31563, 31564, 31565, 31566, 31567, and 32276. Six of the original 10 wells have been shut down (31564, 31565, 31566, 31563, 31562, and 31567).

- Extraction wells 31564 and 31565 were shut down in December 2001 and May 2001, respectively, because these wells were located near the upgradient edge of the plume, uranium concentrations in that region of the aquifer were low, and soil remediation was underway in the area around the wells.
- Extraction well 31566 was shut down in August 1998 and was replaced by extraction well 33262, which was installed as part of South Field (Phase II) Module.
- Extraction well 31563 was shut down in December 2002 and converted to a re-injection well that operated in 2003 and 2004.
- Extraction well 31562 was shut down in March 2003 and replaced by extraction well 33298.
- Extraction well 31567 was shut down in September 2005 and replaced by extraction well 33326.

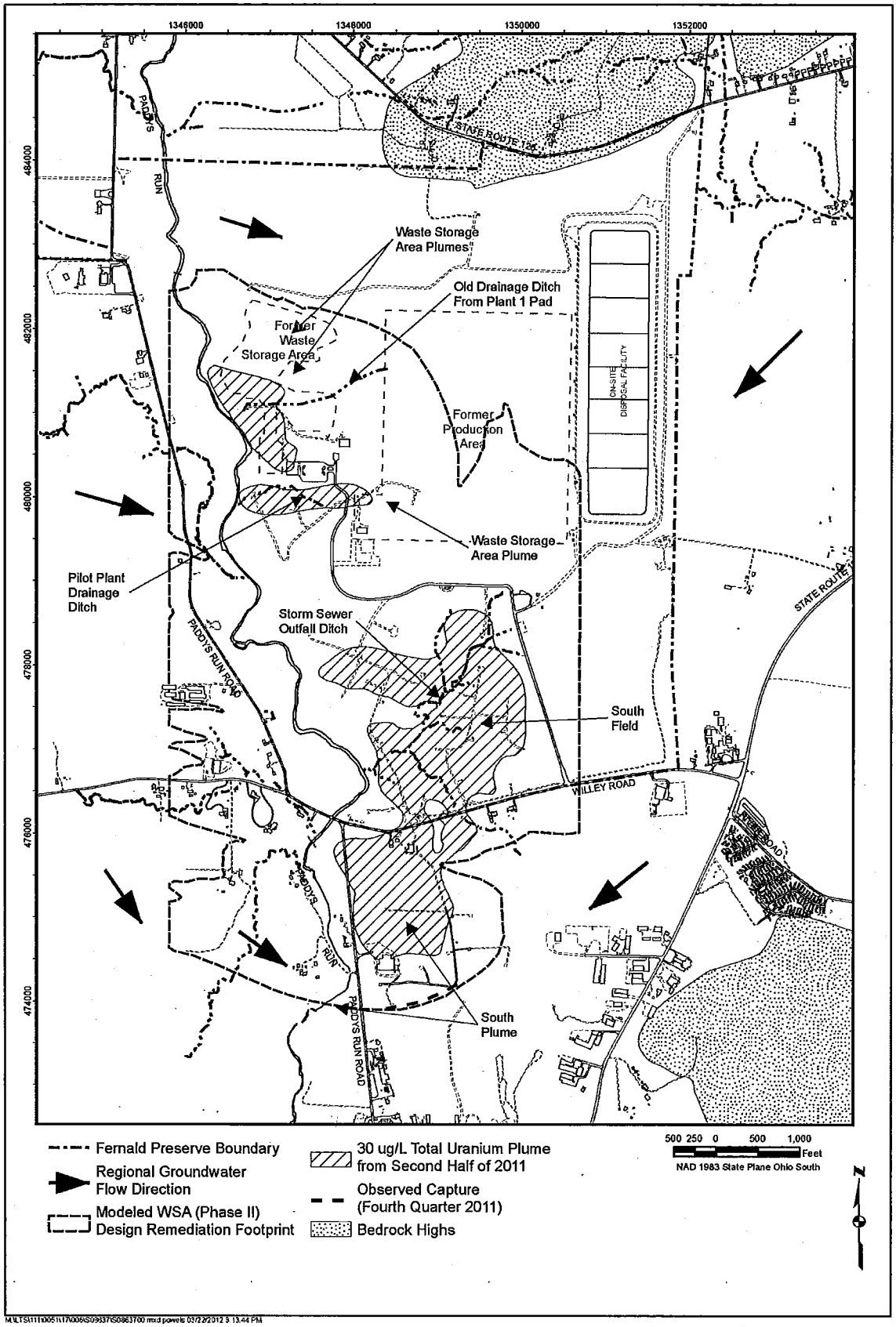


Figure 18. Total Uranium Plume in the Aquifer with Concentrations Greater Than 30 µg/L at the End of 2011

Three new extraction wells (32446, 32447, and 33061) were added to the South Field Module between 1998 and 2002. These new wells were installed in the eastern, downgradient portion of the South Field plume, at locations where total uranium concentrations were considerably above the FRL. Two of these three wells (32446 and 32447) were installed in late 1999 and began pumping in February 2000. The third extraction well (33061) was installed in 2001 and became operational in 2002.

Phase II components of the South Field Module are described in the *Design for Remediation of the Great Miami Aquifer, South Field (Phase II) Module* (DOE 2002a), which was issued in May 2002. The design provides an updated characterization of the uranium plume in the Great Miami Aquifer beneath the southern portion of the site and a modeled design for the South Field Module located in that area. All Phase II design components became operational in 2003. The components include:

- Four additional extraction wells, one in the former Southern Waste Units area (extraction well 33262) and three along the eastern edge of the on-property portion of the southern uranium plume (extraction wells 33264, 33265, and 33266).
- One additional re-injection well in the former Southern Waste Units area (re-injection well 33263).
- An extraction well (31563) that was converted into a re-injection well.
- An injection pond that was located in the western portion of the former Southern Waste Units excavations.

South Field Module re-injection components were shut down in September 2004.

During 2011, the South Field Module removed 1,291 M gallons (4,886 M liters) of groundwater and 338 lb (153 kg) of uranium from the Great Miami Aquifer.

3.3.1.4 Waste Storage Area Module Operational Summary

The Waste Storage Area Module was constructed in two phases. Phase I became operational on May 8, 2002, nearly 17 months ahead of the October 1, 2003, start date established in the Operable Unit 5 Remedial Action Work Plan. Phase I consisted of three extraction wells (32761, 33062, and 33063). These three wells were installed to remediate a uranium plume in the Pilot Plant drainage ditch area, according to the *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas* (DOE 2001b). In July 2004, extraction well 33063 was plugged and abandoned to make way for surface excavation activities required for site remediation. A replacement well for extraction well 33063 was installed in 2005 (extraction well 33334) and became operational June 29, 2006. Phase II consisted of one additional extraction well (extraction well 33347), which became operational on October 5, 2006.

During 2011, 520 M gallons (1,968 M liters) and 98 lb (44 kg) of uranium were removed from the Great Miami Aquifer through the Waste Storage Area Module.

3.3.1.5 Monitoring Results for Total Uranium

The Waste Storage Area (Phase II) Design remediation footprint illustrates how far a particle of water will travel in response to pumping over the 16-year time period modeled for the Waste Storage Area (Phase II) Design.

Total uranium is the primary FRL constituent because it is the most prevalent site contaminant, and it has affected the largest area of the aquifer. Figure 18 shows general groundwater flow directions observed during the fourth quarter of 2011 and the interpretation of the uranium plume in the aquifer updated through the end of 2011. The shaded areas represent the interpreted size of the maximum uranium plume that is above the 30 µg/L groundwater FRL for total uranium.

Historically high precipitation levels in 2011 resulted in high water levels in the Great Miami Aquifer. High water levels in the aquifer provide ideal conditions to update the dimensions of the maximum uranium plume because more of the vertical component of the plume can be sampled. DOE took full advantage of high water levels in 2011 to update maximum uranium plume dimensions. The data collected in 2011 indicate that uranium concentrations within the footprint of the maximum uranium plume continue to decrease. At the end of 2011, the footprint of the maximum total uranium plume was approximately 144 acres (58 hectares), a decrease of approximately 21.7 percent from 2010 (184 acres [74 hectares]). Capture observed during the fourth quarter of 2011 for the active restoration modules is also identified in Figure 18. The map indicates that the existing extraction system is capturing the South Plume and preventing further movement of uranium to the south of the extraction wells. Figure 18 also depicts the time-of-travel remediation footprint that was predicted by modeling the Waste Storage Area (Phase II) Remediation Design.

Appendix A, Attachment A.2, provides detailed uranium plume maps for 2011. Appendix A, Attachment A.3, provides quarterly groundwater elevation maps and capture interpretations, along with graphical displays of groundwater elevation data. Highlights for 2011 for the former Waste Storage Area, former Plant 6 Area, and South Field/South Plume area are provided below.

Geoprobe (Direct-Push Sampling)
The Geoprobe, a hydraulically powered, direct-push sampling tool, is used at the Fernald Preserve to obtain groundwater samples at specific intervals without installing a permanent monitoring well. Direct-push means that the tool employs the weight of the vehicle it is mounted on and percussive force (hammering) to push into the ground without drilling (or cutting) to displace soil in the tool's path. The Fernald Preserve uses this technique to collect data on the progress of aquifer restoration and to determine the optimal location and depth of additional monitoring and extraction wells that may be installed in the future.

Former Waste Storage Area—This area includes the Pilot Plant Drainage Ditch Plume. The mapped footprint of the maximum uranium plume in the Former Waste Storage Area at the end of 2011 was 26.3 acres (10.6 hectares). This is a decrease of 45.7 percent from the 2010 estimate of 48.4 acres (19.6 hectares).
In 2011 direct-push samples were collected from seven locations in the former Waste Storage Area to supplement routine sampling of monitoring wells.

Data are presented in Appendix A, Attachment A.2. Figure 18 shows the outline of the maximum uranium plumes in the former Waste Storage Area, as measured during the second half of 2011.

Former Plant 6 Area—Plans for a restoration module in the former Plant 6 Area were abandoned in 2001 based on the outcome of the *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas* (DOE 2001b). The design data indicated that the total uranium

plume in the former Plant 6 Area was no longer present. EPA and Ohio EPA concurred with this decision. Monitoring in the area continues.

Monitoring well 2389 is the only well remaining in the area. Sporadic uranium FRL exceedances were detected at this well between 2002 and 2007, and again in 2011. As discussed in past reports, sporadic FRL exceedances occur in this area when the water table in the aquifer is high. The high amount of precipitation in 2011 resulted in high water table conditions. The two samples collected in 2011 at monitoring well 2389 had uranium concentrations of 78.2 µg/L and 43.2 µg/L. A direct-push sample was also collected in the Former Plant 6 area in 2011. The water table was high enough to detect a uranium FRL exceedance of 37.7 µg/L. The Former Plant 6 area will continue to be targeted for additional direct push sampling when the water table is high to determine if the uranium groundwater FRL exceedance is dissipating over time.

South Field and South Plume Areas—The mapped footprint of the South Field/South Plume Maximum Uranium Plume was 118 acres (47.8 hectares), a reduction of approximately 13.2 percent over 2010 estimates (136 acres [54.8 hectares]). Direct-push samples were collected at 18 locations. Direct-push data for 2011 are presented in Appendix A, Attachment A.2.

An off-property portion of the uranium plume (just south of Willey Road) was better delineated in 2011 by the collection of direct-push data. The plume area appears to be impacted by a stagnation zone within the aquifer. Stagnation zones are created by the competition of extraction wells for water within the aquifer. The water in a stagnation zone is essentially pulled from different directions, resulting in its being held in place rather than moving toward an extraction well. This has the potential to extend remediation completion times. Potential ways to improve the aquifer remedy in this area are being explored to see if remediation of the lobe can be improved.

3.3.1.6 Monitoring Results for Non-Uranium Constituents

Although the groundwater remedy is primarily targeting remediation of the uranium plume, other FRL constituents within the uranium plume are also being monitored. Figure 19 identifies the locations of the wells that had non-uranium FRL exceedances. Table 5 shows the number of wells with constituents exceeding FRLs in 2011, the number of wells with constituents exceeding FRLs outside the Waste Storage Area (Phase II) remediation footprint, the groundwater FRLs, and the range of 2011 data inside and outside the Waste Storage Area (Phase II) remediation footprint.

During 2011, eight non-uranium FRL constituents had FRL exceedances. Exceedance locations are shown in Figure 19. Several of the locations are outside the Waste Storage Area (Phase II) remediation footprint. No plumes for the non-uranium constituents above FRLs at the locations outside the Waste Storage Area (Phase II) remediation footprint were identified in the extensive groundwater characterization efforts evaluated as part of the *Remedial Investigation Report for Operable Unit 5* (DOE 1995b).

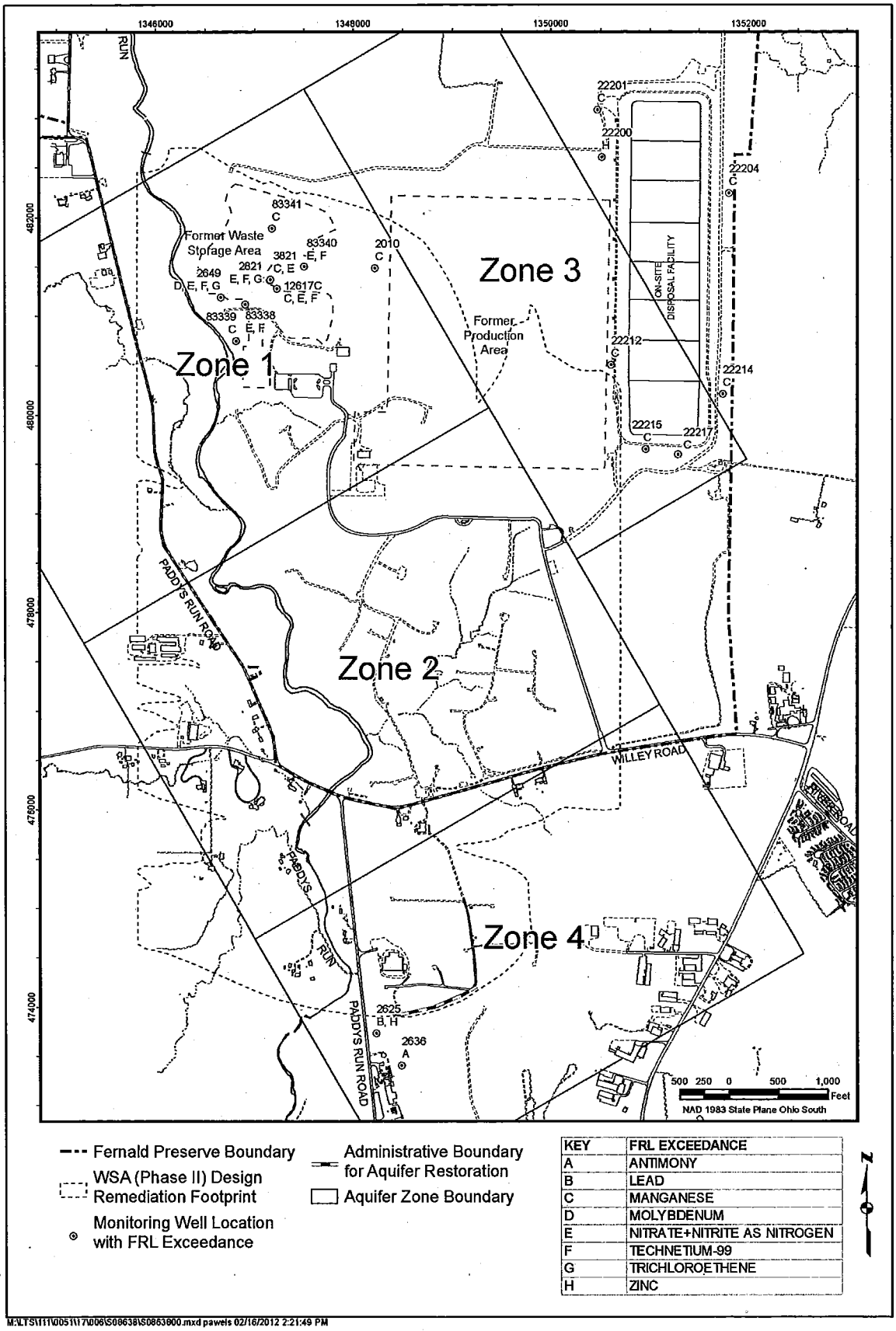
Table 5. Non-Uranium Constituents with Results Above FRLs During 2011

Constituent	Number of Wells Exceeding the FRL	Number of Wells Exceeding the FRL Outside the Waste Storage Area (Phase II) Remediation Footprint	Groundwater FRL	Range of 2011 Data Inside the Waste Storage Area (Phase II) Remediation Footprint[a]	Range of 2011 Data Outside the Waste Storage Area (Phase II) Remediation Footprint[a]
General Chemistry			(mg/L)[b]	(mg/L)	(mg/L)
Nitrate/Nitrite as N	9	0	11[c]	11.3 to 85.5	NA
Inorganics					
Antimony	1	1	0.0060	NA	0.00669
Lead	1	1	0.015	NA	0.0154
Manganese	10	6	0.90	1.29 to 3.15	0.994 to 2.31
Molybdenum	1	0	0.10	0.587 to 0.794	NA
Zinc	2	2	0.021	NA	0.0323 to 0.0751
Volatile Organics			(µg/L)	(µg/L)	(µg/L)
Trichloroethene	2	0	5.0	7.53 to 14.7	NA
Radionuclides			(pCi/L)	(pCi/L)	(pCi/L)
Technetium-99	7	0	94	103 to 1660	NA

[a] NA = not applicable
[b] mg/L = milligrams per liter
[c] FRL based on nitrate, from OU5 ROD, Table 9-4; however, the sampling results are for nitrate/nitrite as nitrogen.

Non-uranium constituents with FRL exceedances at the well locations outside the Waste Storage Area (Phase II) remediation footprint were further evaluated to determine if they were random events or if they were persistent according to criteria discussed in Appendix A, Attachment A.4. One of the exceedances in 2011 was classified as persistent (manganese at monitoring well 22204). Manganese concentrations have exceeded the FRL at location 22204 since 2004. In past years, many of the exceedances identified as persistent became non-persistent in later years. A change in the design of the aquifer remedy to address the persistent exceedance at monitoring well 22204 is not planned. Additional sampling for manganese near the OSDF was conducted in 2008 (and reported in the Site Environmental Report [DOE 2009]) to determine if a localized manganese plume was present. Results did not support the presence of a localized manganese plume.

The manganese FRL is 0.90 mg/L and is based on background values in the aquifer. Unconsolidated glaciofluvial aquifers in Ohio have relatively high manganese concentrations naturally. Manganese is an impurity in shale, which is a major component of bedrock in the area. The background value upon which the groundwater FRL is based may not be representative of the aquifer.



KEY	FRL EXCEEDANCE
A	ANTIMONY
B	LEAD
C	MANGANESE
D	MOLYBDENUM
E	NITRATE+NITRITE AS NITROGEN
F	TECHNETIUM-99
G	TRICHLOROETHENE
H	ZINC

Figure 19. Non-Uranium Constituents with 2011 Results Above FRLs

3.3.2 Other Monitoring Commitments

Two other groundwater monitoring activities are included in the IEMP: private well monitoring and property boundary monitoring. As stated earlier, the groundwater data from these activities, along with the data from all other IEMP groundwater monitoring activities, are collectively evaluated for total uranium and, where necessary, non-uranium constituents of concern. The discussion that follows provides additional details on the two compliance monitoring activities.

The three private wells (monitoring wells 2060, 13, and 14, see Figure 10) located along Willey Road are monitored under the IEMP to assist in the evaluation of the uranium plume migration. Off-property groundwater contamination was initially detected at one of these wells (well 2060) in 1981. In 1997 a DOE-sponsored public water supply became available to Fernald site neighbors who were affected by off-property groundwater contamination. The availability of the public water supply resulted in the discontinuation of monitoring at many private wells in off-property areas. Data from the three private wells sampled under the IEMP were incorporated into the uranium plume map shown in Figure 18.

During 2011, Property/Plume Boundary monitoring consisted of 36 monitoring wells located downgradient of the Fernald Preserve, along the eastern and southern portions of the property boundary. Twenty-five of these wells were monitored along the eastern Fernald Preserve boundary and slightly downgradient of the South Plume to determine if contaminants were migrating offsite. Eleven of these wells were sampled in the Paddys Run Road area to document the influence, or lack thereof, that pumping in the South Plume was having on the Paddys Run Road Site plume. Data from the Property/Plume Boundary wells were integrated with other groundwater data for 2011 and were incorporated into the uranium plume maps shown in Figure 18 and in Appendix A, Attachment A.2. Non-uranium data from these wells are included in Section 3.3.1.6.

As indicated in Section 2, Ohio EPA issued the Director's Findings and Orders on September 7, 2000. These orders specify that the site's groundwater monitoring activities will be implemented in accordance with the IEMP. The revised language allows modification of the groundwater monitoring program as necessary, via the IEMP revision process (subject to Ohio EPA approval), without issuance of a new Director's Order. As determined by Ohio EPA, the IEMP will remain in effect following remediation.

3.4 Groundwater Remediation Assessment

Historically high precipitation levels in 2011 resulted in high water levels in the Great Miami Aquifer. High water levels in the aquifer provide ideal conditions to update the dimensions of the maximum uranium plume because more of the vertical component of the plume can be sampled. DOE took full advantage of high water levels in 2011 to update maximum uranium plume dimensions. The data collected in 2011 indicate that uranium concentrations within the footprint of the maximum uranium plume continue to decrease in response to pumping. The footprint of the maximum uranium plume in 2011 was approximately 144 acres (a decrease of approximately 21.7 percent from what was mapped in 2010 [184 acres]). Additional information concerning the dimensions of the maximum uranium plume is provided in Appendix A, Attachment A.2.

Groundwater elevations collected in 2011 continue to show that capture of the uranium plume is being maintained by the pumping wells. Natural groundwater flow directions within the aquifer are being enhanced and modified through pumping to achieve capture of the uranium plume.

Appendix A, Attachment A.3 provides additional information concerning capture of the uranium plume.

Data collected in 2011 continue to show that the mass of uranium being removed from the aquifer is in close agreement to groundwater model predictions, indicating that the pumping system remains effective in removing uranium from the aquifer. Appendix A, Attachment A.1 provides additional information concerning the mass of uranium removed from the aquifer.

Computer modeling was used in 2005 to support the final groundwater remediation design and to predict how uranium concentrations would decrease during the remedy. An assessment using 2010 uranium data indicates that the groundwater model predictions made in 2005 are remaining reasonable over time. The next assessment is scheduled for 2015.

Direct-push sampling south of Willey Road in 2011 was used to better define an area of the plume that is not responding to remediation as quickly as predicted. This area has been identified as having the potential to extend the remediation completion time beyond that predicted by the groundwater model (DOE 2011). Potential ways to improve the aquifer remedy design in this area are being explored to see if remediation times can be improved (e.g., change the pumping rates of existing extraction wells, convert an out-of-service injection well into an extraction well, install a new extraction well). DOE will discuss improvements options with EPA and Ohio EPA before taking any action to proceed with an option.

3.5 OSDF Monitoring

Monitoring of the OSDF is conducted in the Leachate Collection System (LCS), leak detection system (LDS), glacial till (perched water), and the Great Miami Aquifer. Figure 20 identifies the OSDF footprint and monitoring well locations for Cells 1 through 8. Flow is being monitored within the LCS and LDS to determine if the facility is operating as designed. Water quality is being monitored in the LCS, LDS, perched groundwater in the glacial till, and in groundwater in the Great Miami Aquifer to determine if a leak from the facility might be occurring.

LCS and LDS flow data collected in 2011 indicate that engineered features within the OSDF continue to perform as designed, indicating that a leak from the facility is not occurring. Leachate flow continues to diminish as expected, and LDS flow volumes indicate that the cell liners are performing well within design specifications.

A comparison of water quality data collected in 2011 from within the facility (LCS and LDS) to water quality data collected beneath the facility (perched groundwater in the glacial till and groundwater in the Great Miami Aquifer) indicates that a leak from the OSDF is not occurring. Table 6 summarizes the groundwater, LCS, and LDS monitoring information for Cells 1 through 8 of the OSDF, by providing the range of total uranium concentrations measured in 2011. The majority of uranium concentrations measured in 2011 fell within the historical range of concentrations previously measured for that monitoring horizon. New low and high concentrations measured in 2011 are identified with bold font on Table 6. Concentrations of two non-uranium constituents (manganese and zinc) exceeded groundwater FRLs in OSDF aquifer monitoring wells in 2011. Appendix A, Attachments A.4 and A.5 provide additional information on non-uranium groundwater FRL exceedances and on the groundwater, LDS, and LCS sampling results for the OSDF.

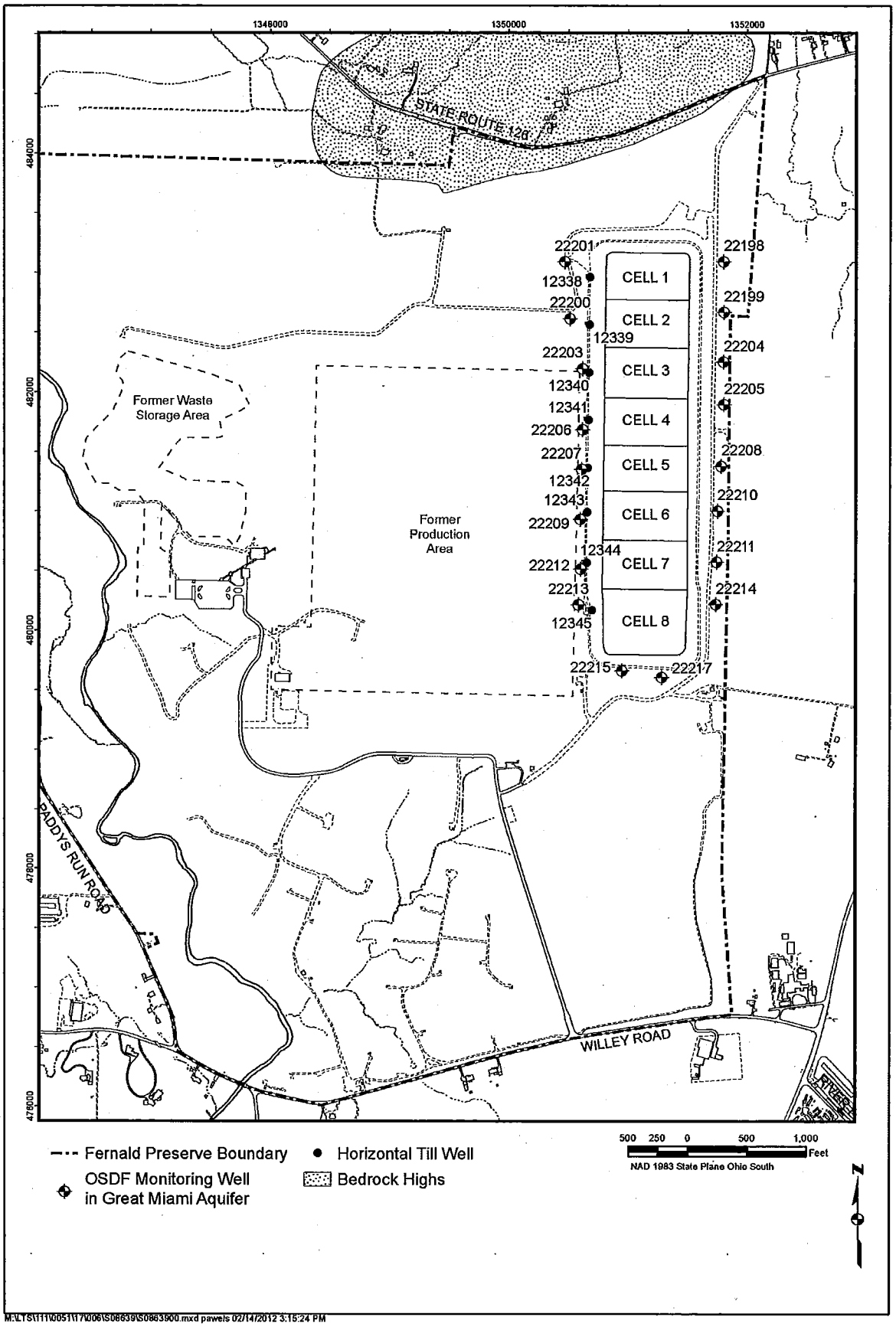


Figure 20. OSDF Footprint and Monitoring Well Locations

Table 6. OSDF Groundwater, Leachate, and LDS Monitoring Summary

Cell (Waste Placement Start Date)	Monitoring Location	Monitoring Zone	Date Sampling Started	Total # Samples	Range of Total Uranium Concentrations[a] (µg/L)
Cell 1 (Dec. 1997)	12338C	LCS	Feb. 17, 1998	55	ND–206
	12338D	LDS	Feb. 18, 1998	38	1.5–**37.0**
	12338	Glacial Till	Oct. 30, 1997	75	ND–19
	22201	Great Miami Aquifer	Mar. 31, 1997	70	ND–**11.2**
	22198	Great Miami Aquifer	Mar. 31, 1997	103	0.577–15.2
Cell 2 (Nov. 1998)	12339C	LCS	Nov. 23, 1998	51	4.51–404
	12339D	LDS	Dec. 14, 1998	21	4.08–22.3[b]
	12339	Glacial Till	Jun. 29, 1998	74	ND–36.9
	22200	Great Miami Aquifer	Jun. 30, 1997	65	ND–1.11
	22199	Great Miami Aquifer	Jun. 25, 1997	78	ND–12.1
Cell 3 (Oct. 1999)	12340C	LCS	Oct. 13, 1999	48	9.27–113
	12340D	LDS	Aug. 26, 2002	20	8.9–27.7[b]
	12340	Glacial Till	Jul. 28, 1998	67	ND–58.5
	22203	Great Miami Aquifer	Aug. 24, 1998	63	ND–7.92
	22204	Great Miami Aquifer	Aug. 24, 1998	77	ND–**22.9**
Cell 4 (Nov. 2002)	12341C	LCS	Nov. 04, 2002	34	4.41–171
	12341D	LDS	Nov. 04, 2002	34	5.74–21.3
	12341	Glacial Till	Feb. 26, 2002	47	**4.82**–7.91
	22206	Great Miami Aquifer	Nov. 06, 2001	51	ND–5.78
	22205	Great Miami Aquifer	Nov. 05, 2001	64	0.446–19.7
Cell 5 (Nov. 2002)	12342C	LCS	Nov. 04, 2002	36	3.39–285
	12342D	LDS	Nov. 04, 2002	33	2.93–27.1
	12342	Glacial Till	Feb. 26, 2002	48	7.45–21.1
	22207	Great Miami Aquifer	Nov. 06, 2001	51	ND–4.48
	22208	Great Miami Aquifer	Nov. 05, 2001	66	ND–2.1
Cell 6 (Nov. 2003)	12343C	LCS	Oct. 27, 2003	33	8.03–197
	12343D	LDS	Oct. 27, 2003	32	3.1–**43.7**
	12343	Glacial Till	Mar. 14, 2003	40	ND–24.2
	22209	Great Miami Aquifer	Dec. 16, 2002	46	ND–2.43
	22210	Great Miami Aquifer	Dec. 16, 2002	58	ND–1.02
Cell 7 (Sep. 2004)	12344C	LCS	Sep. 02, 2004	29	4.72–355
	12344D	LDS	Sep. 02, 2004	27	12.2–33.7
	12344	Glacial Till	Feb. 24, 2004	37	0.674–8.61
	22212	Great Miami Aquifer	Jan. 21, 2004	39	ND–**5.53**
	22211	Great Miami Aquifer	Jan. 21, 2004	48	ND–3.21
Cell 8 (Dec. 2004)	12345C	LCS	Oct. 18, 2004	28	1.51–**335**
	12345D	LDS	Oct. 18, 2004	26	9.38–**64.4**
	12345	Glacial Till	May 19, 2004	20	3.48–7.3
	22213	Great Miami Aquifer	Mar. 31, 2004	38	ND–0.627
	22214	Great Miami Aquifer	Mar. 31, 2004	48	ND–**2.95**
	22215	Great Miami Aquifer	Aug. 22, 2005	29	ND–**16.4**
	22217[c]	Great Miami Aquifer	Aug. 22, 2005	28	ND–**18.3**

[a] ND = not detected. **Bold text indicates a new high or low detected in 2011.**
[b] Some data are not considered representative of true LDS uranium concentrations in Cell 2 (December 14, 1998, through May 23, 2000, data set) due to malfunction in the Cell 2 leachate pipeline and the resulting mixing of individual flows. Additionally, it is suspected that some November 2004 samples (i.e., 12339C with 12339D and 12340C with 12340D) were switched. If data from these events were included above, the maximum total uranium concentrations would be 71 µg/L for 12339D and 72.4 µg/L for 12340D.
[c] Monitoring location 22216 was plugged and abandoned in April 2006. Monitoring location 22217 is its replacement. The results listed for location 22217 also include the results for location 22216.

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Section 4

4.0 Surface Water and Treated Effluent Pathway

Results in Brief: 2011 Surface Water and Treated Effluent Pathway

Surveillance Monitoring—No treated effluent analytical results from samples collected in 2011 exceeded the surface water FRL for total uranium, the primary site contaminant. Twenty-five surface water analytical results exceeded the surface water FRL for total uranium. Sample results from three surface water cross-media locations exceeded the groundwater FRL for total uranium.

Uranium Discharges—In 2011, 562 lb (255 kg) of uranium were discharged in treated effluent to the Great Miami River. Approximately 126 lb (57.5 kg) of uranium were released to the environment through uncontrolled storm water runoff. The estimated total pounds of uranium released through the surface water and treated effluent pathway was approximately 688 lb (313 kg).

This section presents the 2011 monitoring activities and results for surface water, treated effluent, and sediment to determine the effects of site activities on the surface water pathway.

In general, low levels of contaminants enter the surface water pathway at the Fernald Preserve by two primary mechanisms: treated effluent that is monitored as it is discharged to the Great Miami River, and uncontrolled runoff entering the site's drainages from remediated areas that are now certified and restored. Because these discharges have continued through remediation and legacy management, the surface water and sediment pathways will continue to be monitored. Effective use of the site's wastewater treatment capabilities and implementation of runoff and sediment controls minimize the site's impact on the surface water pathway.

4.1 Summary of Surface Water and Treated Effluent Pathway

To assist in the understanding of this section, the following key definitions are provided:

- **Controlled runoff** is contaminated storm water that is collected and, under normal circumstances, treated and discharged to the Great Miami River as treated effluent. However, currently the only storm water that is controlled is associated with the footprint of the outdoor processing activities at the wastewater treatment facility.
- **Uncontrolled runoff** is storm water that is not collected for treatment, but enters the site's natural drainages.
- **Treated effluent** is water that is treated through the site's wastewater treatment facility and then discharged to the Great Miami River.
- **Surface water** is water that flows within natural drainage features.

The treated effluent pathway consists of flows discharged to the Great Miami River via the Parshall Flume (PF 4001). Discharges through this point are considered under the control of wastewater operations. Treated effluent is currently composed of treated and untreated groundwater, leachate from the OSDF, and storm water associated with the footprint of the outdoor processing activities at the wastewater treatment facility.

The volume and flow rate of uncontrolled runoff depends on the amount of precipitation within any given period of time. Figure 8 in Section 1 shows monthly precipitation totals for 2011. Figure 21 shows the site's natural drainage features. The site's natural surface water drainages include several tributaries to Paddys Run (e.g., SSOD) as well as the northeast drainage that flows to the Great Miami River. The arrows on Figure 21 indicate the general flow direction of uncontrolled runoff that is determined from the topography. Uncontrolled runoff from the Fernald Preserve leaves the property via two drainage pathways: Paddys Run and the northeast drainage ditch.

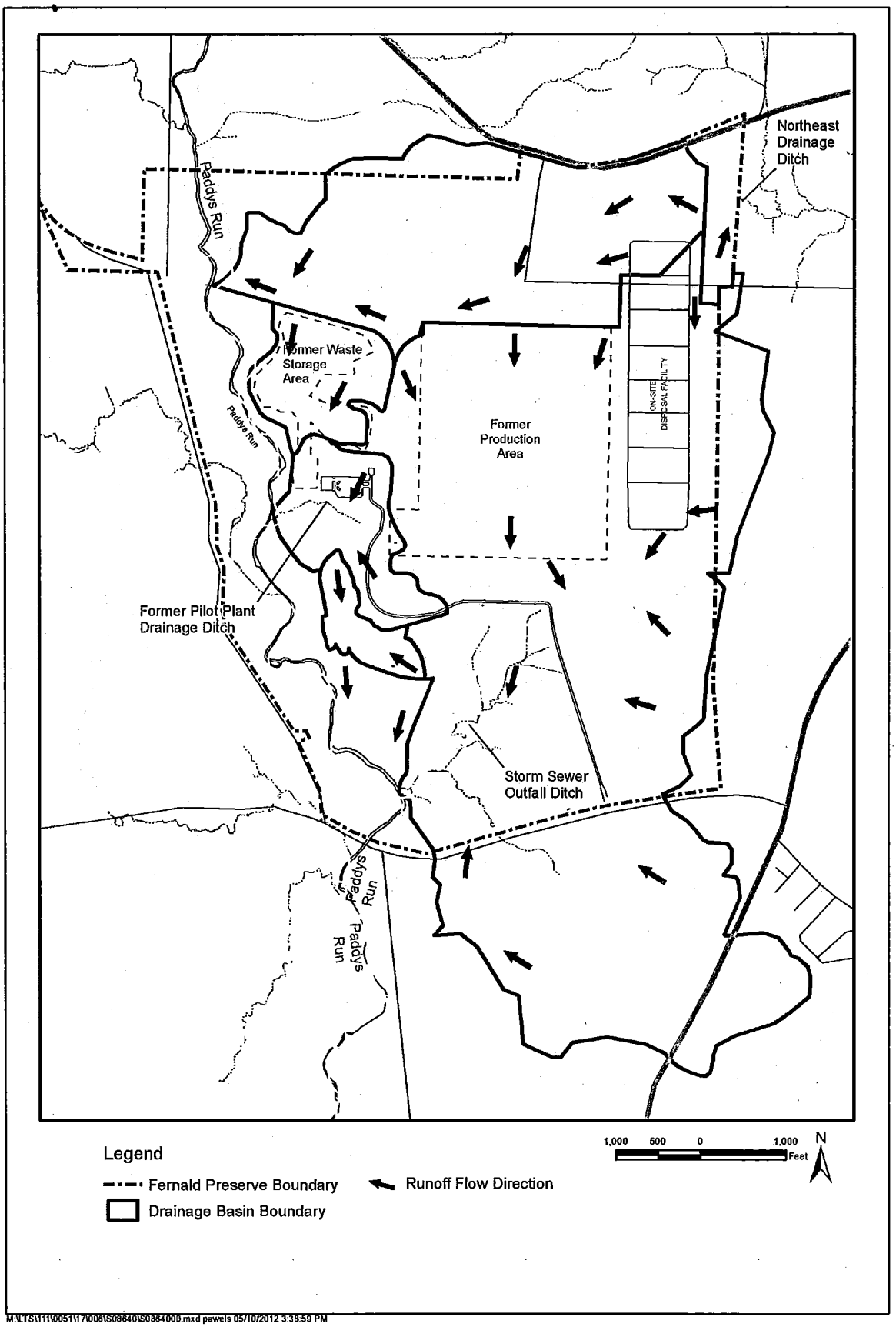


Figure 21. Controlled Surface Water Areas and Uncontrolled Runoff Flow Directions

4.2 Remediation Activities Affecting the Surface Water Pathway

Activities that had the potential to affect the surface water pathway included routine operation and maintenance activities of the OSDF and the CAWWT, and ecological restoration activities conducted throughout the property, including repairing areas of erosion.

Now that remediation has been completed and the infrastructure to continue the groundwater remedy has been installed, the restored areas of the Fernald Preserve will be the primary focus relative to uncontrolled runoff. Controls to mitigate sediment leaving the site will be primarily based on the vegetation and stabilization practices within the restored areas.

Surface water monitoring conducted in a small area west of the former waste pits continued to show elevated uranium concentrations. The location in question is a series of small puddles and drainage ditches due west of the center of former waste pit 3, which drain generally south to a depression near the former cement pond. This area does not drain directly to Paddys Run.

After a limited maintenance activity was completed in the fall of 2007, DOE committed to continued monitoring of the area. Two monitoring points (SWD-05 and SWD-09) were added to the surface water program to fulfill this monitoring commitment (Figure 22). These two locations are sampled weekly, when water is present. In 2011, there was a sufficient amount of surface water necessary to collect 25 samples at SWD-05 and 38 samples at SWD-09.

4.3 Surface Water, Treated Effluent, and Sediment Monitoring Program

Surface water, treated effluent, and sediment are sampled to determine the effect of the Fernald Preserve's activities on the environment. Surface water is sampled at several locations in the site's drainages and analyzed for various radiological and nonradiological constituents. Treated effluent is sampled prior to discharge into the Great Miami River. Sediment is sampled for total uranium in the Great Miami River.

The key elements of the surface water and treated effluent program design are:

- **Sampling**—Sample locations, frequency, and constituents were selected to address requirements of the NPDES Permit, the FFCA, and the OU5 ROD and to provide a comprehensive assessment of surface water quality at key locations, including two background locations (refer to Figure 22 and Figure 23). Surface water is monitored for 16 FRL constituents.
- **Data Evaluation**—The integrated data evaluation process focuses on tracking and evaluating data compared with background and historical ranges, FRLs, and NPDES limits. This information is used to assess impacts on surface water due to site remediation activities affecting uncontrolled runoff or treated effluent. The assessment also includes identifying the potential for impacts from surface water to the groundwater in the underlying Great Miami Aquifer. The ongoing data evaluation is designed to support remedial action decision making.
- **Reporting**—Surface water and treated effluent data are reported through the annual Site Environmental Report. Monthly discharge monitoring reports required by the NPDES permit are submitted to the Ohio EPA.

In 2009, the IEMP sediment monitoring sampling frequency was changed from annual to once every 5 years at the suggestion of Ohio EPA according to DOE/EH-0173T (1991), *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*. The data are reported through the annual Site Environmental Report. The next sediment sampling event will occur in 2014.

Data from samples collected under the IEMP are used to fulfill surveillance and compliance monitoring functions. Surveillance monitoring results of the IEMP surface water and treated effluent program are used to assess the collective effectiveness of site storm water controls and wastewater treatment processes in preventing unacceptable impacts to the surface water and groundwater pathways. Compliance monitoring includes sampling at storm water and treated effluent discharge points and is conducted to comply with provisions in the NPDES permit, the FFCA, and the OU5 ROD. The data are routinely evaluated to identify any unacceptable trends and to trigger corrective actions when needed to ensure protection of these critical environmental pathways. Figure 22 depicts IEMP/NPDES surface water and treated effluent sample locations; Figure 23 shows IEMP background sample locations.

4.3.1 Surveillance Monitoring

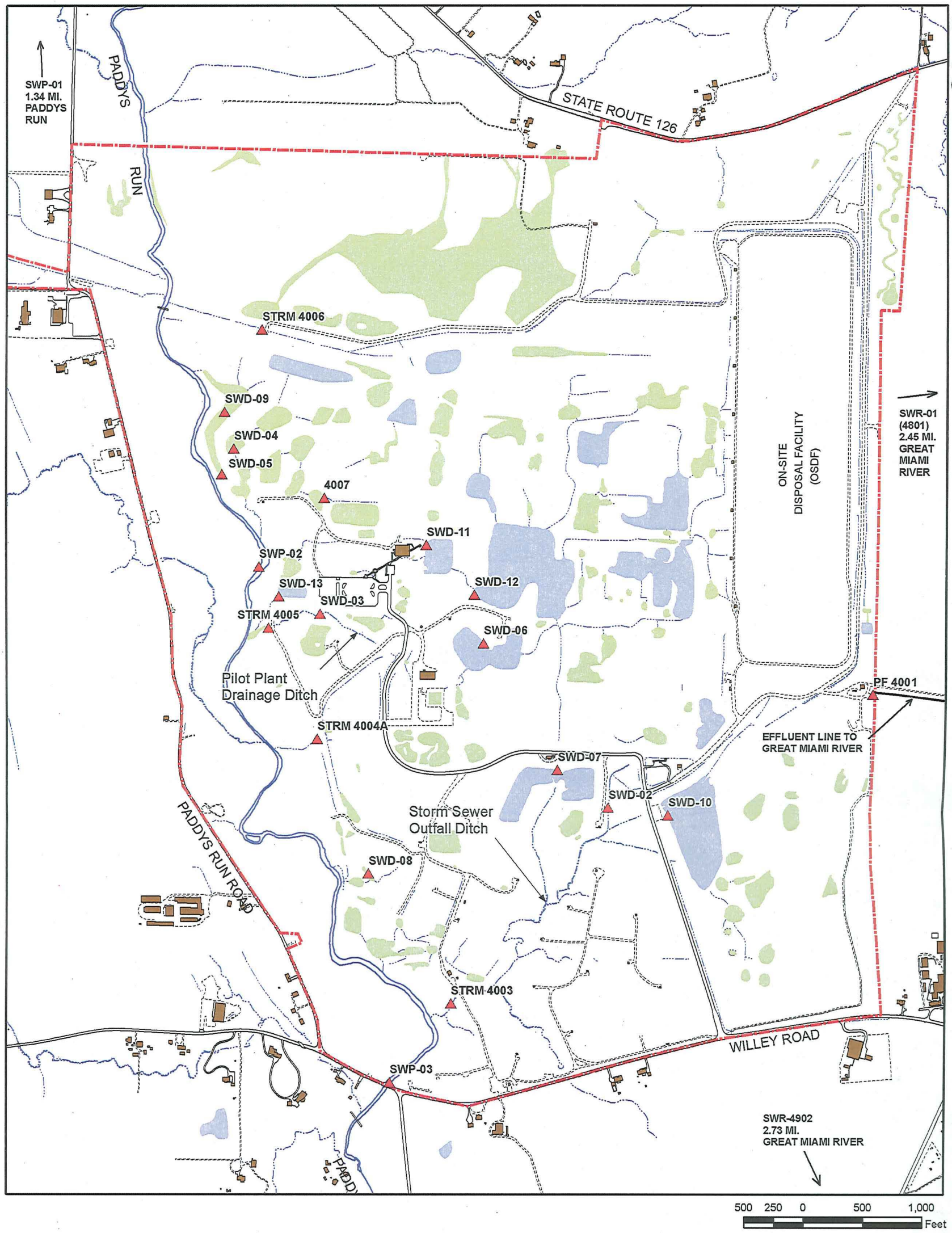
Treated effluent is discharged to the Great Miami River through the effluent line identified on Figure 22. Samples of the treated effluent are collected at the Parshall Flume (PF 4001). The resulting data are used to calculate the concentration of each FRL constituent after the effluent water mixes with the water in the Great Miami River.

Data resulting from 2011 semiannual sampling events were evaluated to provide surveillance monitoring of site activities. This evaluation indicated that during 2011, 27 surface water analytical results from sampling location SWD-09 exceeded the surface water FRL for total uranium. SWD-09 is a surface water monitoring point established to monitor the area west of the former Waste Pits Area where elevated surface water uranium concentrations have been detected in the past. There were no exceedances of total uranium in any of the treated effluent samples, and there were no non-uranium FRL exceedances.

The following two key sample locations represent points where surface water or treated effluent leaves the site:

- Paddys Run at the Willey Road property boundary (surface water sample location SWP-03).
- PF 4001 is located at the entry point of the treated effluent line leading to the Great Miami River.

There were no exceedances of the surface water FRLs during 2011 at these two locations.



Legend

- Sample Location
- Fernald Preserve Boundary
- Building
- Road-paved
- Road-gravel
- Open Water
- Wetland
- Creek
- Intermittent Stream

NOTE 1: STRM 4003, SWR-4902, SWR-01, AND PF 4001 ARE REGULATED UNDER THE NPDES PERMIT.

NOTE 2: DISTANCES TO OFFSITE SAMPLE LOCATIONS ARE MEASURED FROM THE CENTER OF THE FORMER PRODUCTION AREA

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Figure 22. IEMP/NPDES Surface Water and Treated Effluent Sample Locations

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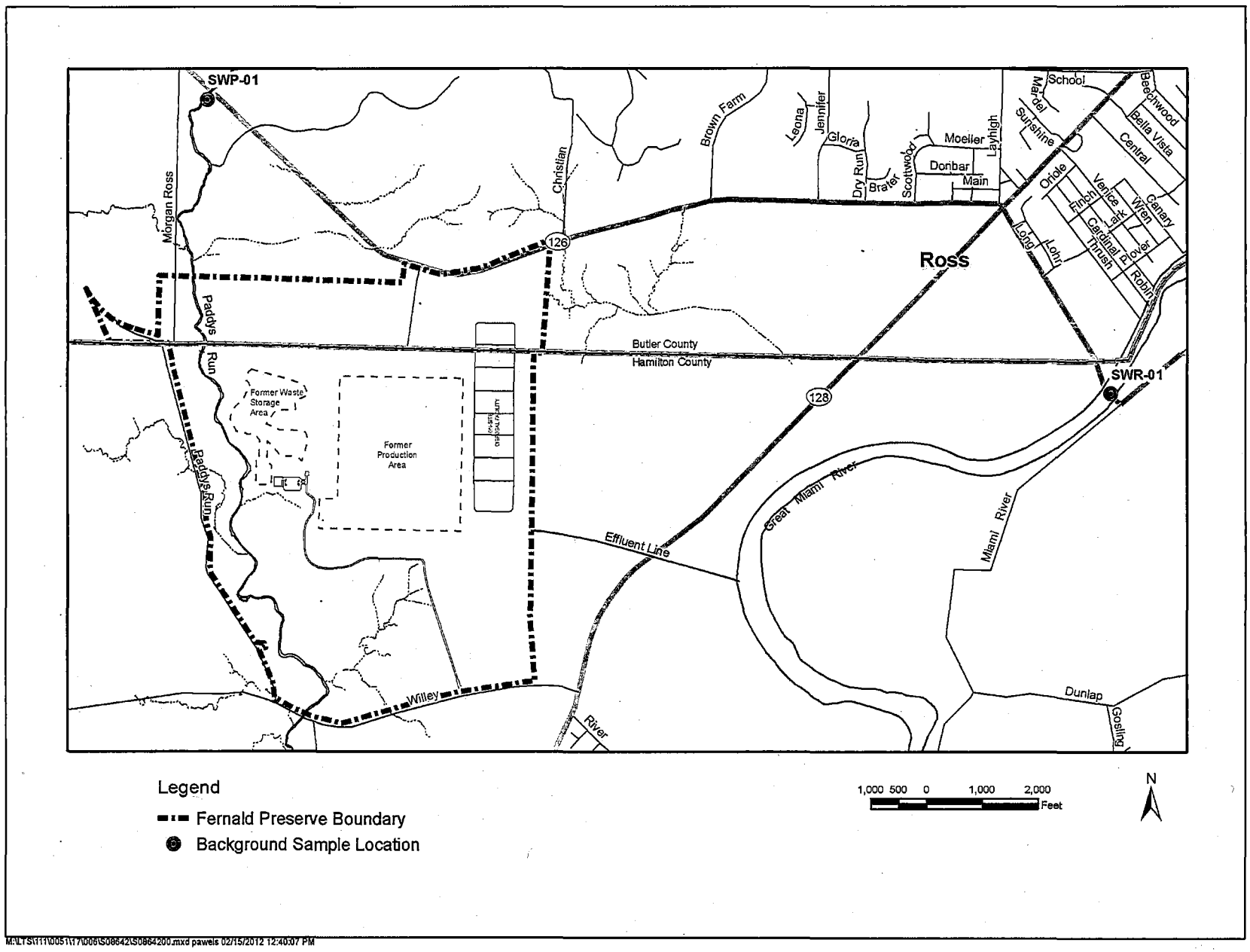

Figure 23. IEMP Background Surface Water Sample Locations

The maximum total uranium concentration at SWP-03 during 2011 was 3.53 µg/L, well below the surface water total uranium FRL of 530 µg/L. Figure 24 shows the annual average total uranium concentration in Paddys Run at Willey Road for the period 1985 through 2011. This figure illustrates the decrease of the total uranium concentration in Paddys Run from 1986.

Samples collected at PF 4001 are used in the surveillance evaluation because this is the last point where treated effluent is sampled prior to discharge to the Great Miami River. The maximum daily total uranium concentration at PF 4001 in 2011 was 31.8 µg/L, well below the surface water total uranium FRL of 530 µg/L. Data collected from this location cannot directly be compared to the surface water FRL without considering the effect of the effluent waters mixing with the Great Miami River. This comparison is done through the use of a mixing equation when constituents exceed the FRL. The mixing equation is discussed further in Appendix B. After the actual flow rate in the Great Miami River and the discharge flow rate in which this maximum uranium concentration was observed were accounted for, the resulting concentration in the river was estimated to be 2.61 µg/L.

Evaluation of surface water data is also performed to provide an ongoing assessment of the potential for cross-media impacts from surface water to the underlying Great Miami Aquifer. In areas where there is no glacial overburden, a direct pathway exists for contaminants to reach the aquifer. This contaminant pathway to the aquifer was considered in the design of the groundwater remedy. The groundwater remedy includes placing groundwater extraction wells downgradient of these areas where direct infiltration occurs in order to mitigate any potential cross-media impacts during surface remediation. To provide this assessment, sample locations were selected to evaluate contaminant concentrations in surface water just upstream of, or within, those areas where site drainages have eroded through the protective glacial overburden. The locations are SWP-02, SWD-02, SWD-03, SWD-04, SWD-05, SWD-07, SWD-08, and STRM 4005.

In 2011, surface water cross-media impact locations STRM 4005, SWD-04, and SWD-05 had sample results that exceeded the total uranium groundwater FRL of 30 µg/L. Additional details of the FRL exceedances are presented in Appendix B.

4.3.2 Compliance Monitoring

4.3.2.1 FFCA and OU5 ROD Compliance

The Fernald Preserve is required to monitor treated effluent discharges at PF 4001 for total uranium mass discharges and total uranium concentrations. This requirement is identified in the July 1986 FFCA and the OU5 ROD. The OU5 ROD requires treatment of effluent so that the mass of total uranium discharged to the Great Miami River through PF 4001 does not exceed 600 lb (272 kg) per year. The OU5 ROD (DOE 1996) and the subsequent *Explanation of Significant Differences for Operable Unit 5* (DOE 2001c) also require that the monthly average total uranium concentration in the effluent must be at or below 30 µg/L.

Figure 25 shows that the cumulative mass of total uranium discharged to the Great Miami River during 2011 was 562 lb (255 kg), which is below the annual discharge limit of 600 lb (272 kg). Figure 26 shows that the monthly average total uranium concentration was below the 30 µg/L limit every month during 2011.

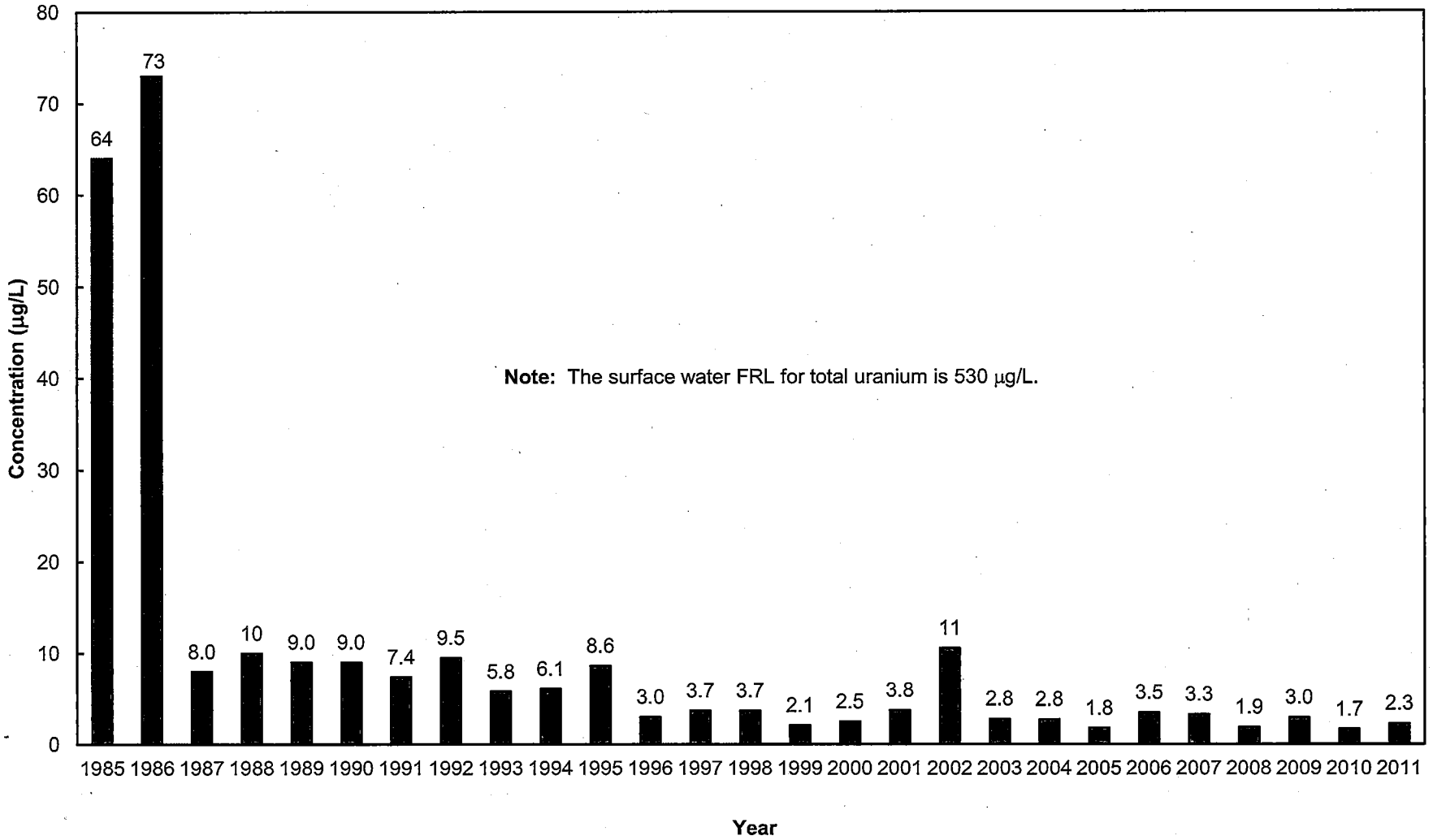

Figure 24. Annual Average Total Uranium Concentrations in Paddys Run at Willey Road (SWP-03) Sample Location, 1985–2011

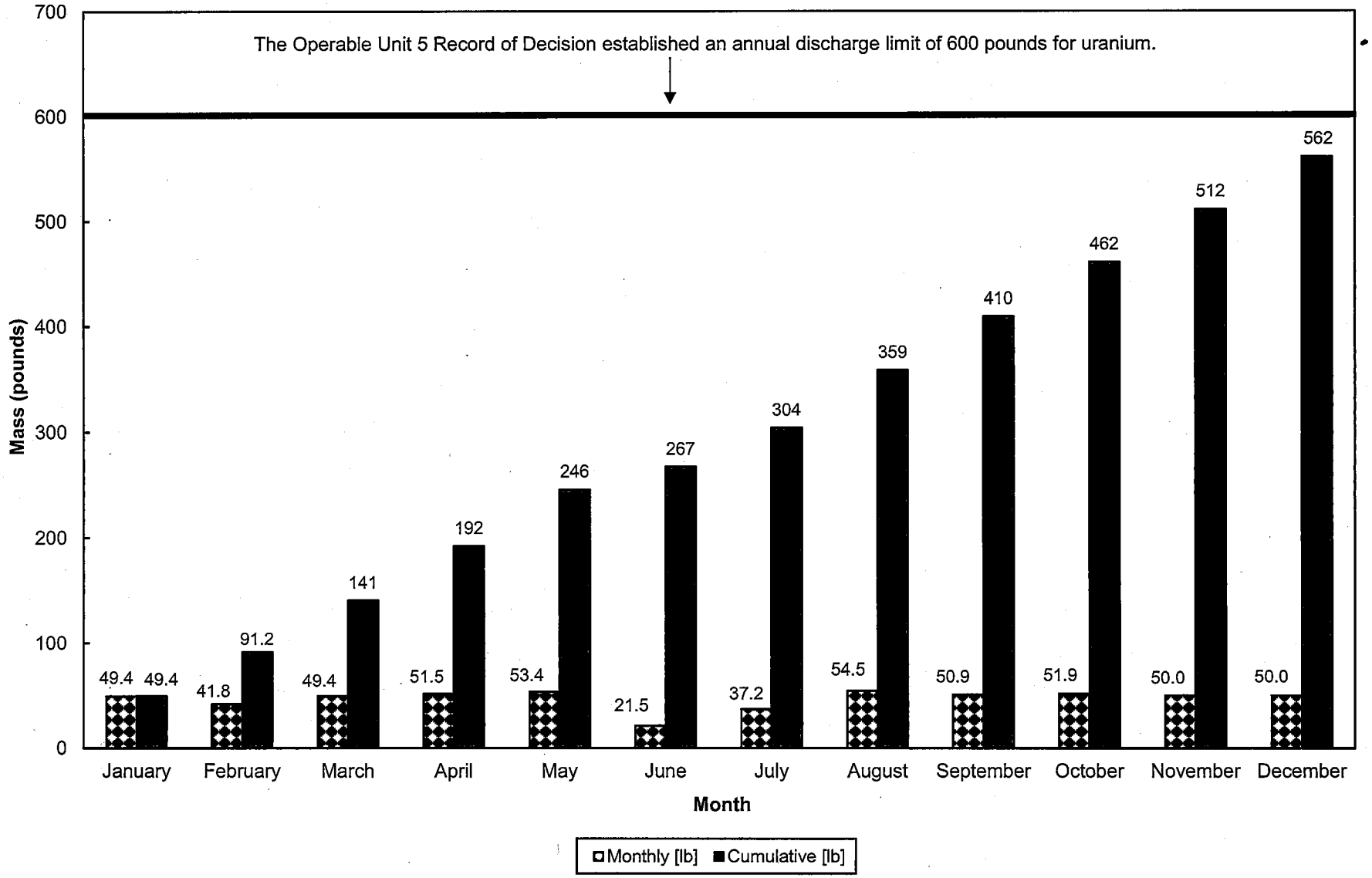

Figure 25. Mass of Uranium Discharged to the Great Miami River through the Parshall Flume (PF 4001) in 2011

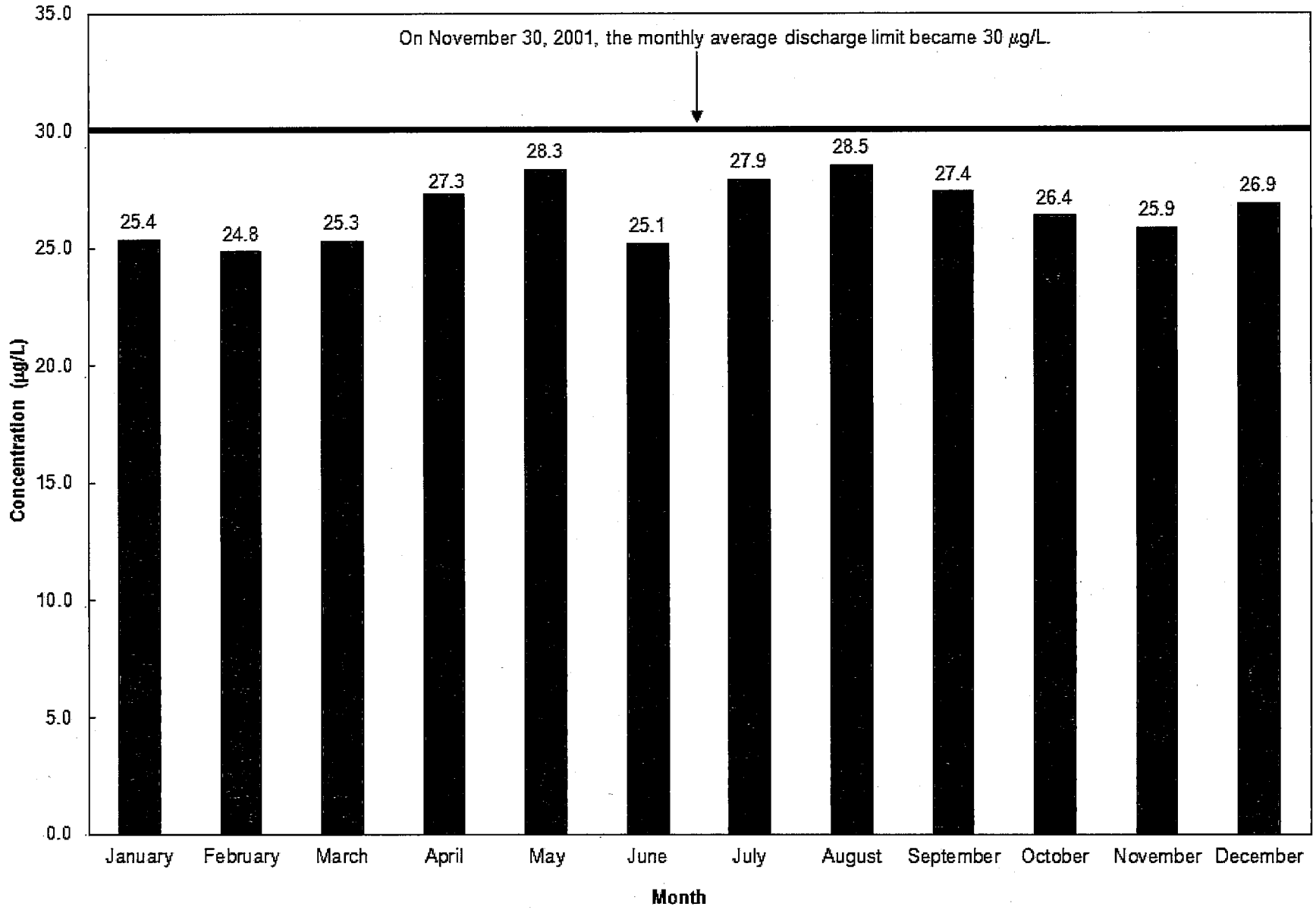

Figure 26. 2011 Monthly Average Total Uranium Concentration in Water Discharged Through the Parshall Flume (PF 4001) to the Great Miami River

4.3.2.2 NPDES Permit Compliance

Compliance sampling, consisting of sampling for nonradiological pollutants from uncontrolled runoff and treated effluent discharges from the Fernald Preserve, is regulated under the state-administrated NPDES program. A new permit was received from Ohio EPA on April 1, 2009, and is effective until March 31, 2014. There were no incidents of NPDES noncompliance in 2011.

4.3.3 Uranium Discharges in Surface Water and Treated Effluent

As identified in Figure 25, 562 lb (255 kg) of uranium in treated effluent were discharged to the Great Miami River through PF 4001 in 2011. In addition to the treated effluent, uncontrolled runoff is also contributing to the amount of uranium entering surface water. Figure 27 presents the mass of uranium from the uncontrolled runoff and controlled discharges from 1993 through 2011.

A loading term is used to estimate the pounds of uranium discharged to Paddys Run via uncontrolled runoff. This loading term was revised and approved in August 2004 based on total uranium data, which reflect the decreasing total uranium concentrations measured at points discharging to Paddys Run. Total uranium concentrations measured in Paddys Run were decreasing through remediation as a result of significant improvements in the capture of contaminated storm water and should remain low now that soil remediation has been completed. The loading term is 2.1 lb (0.95 kg) of uranium per inch (2.54 cm) of rainfall.

During 2011, 60.20 inches (152.9 cm) of precipitation fell at the Fernald Preserve; therefore, an estimated 126 lb (57.5 kg) of uranium entered the environment through uncontrolled runoff.

The estimated total amount of uranium discharged to the surface water pathway for the year, including controlled treated effluent discharges and uncontrolled runoff, was approximately 688 lb (313 kg).

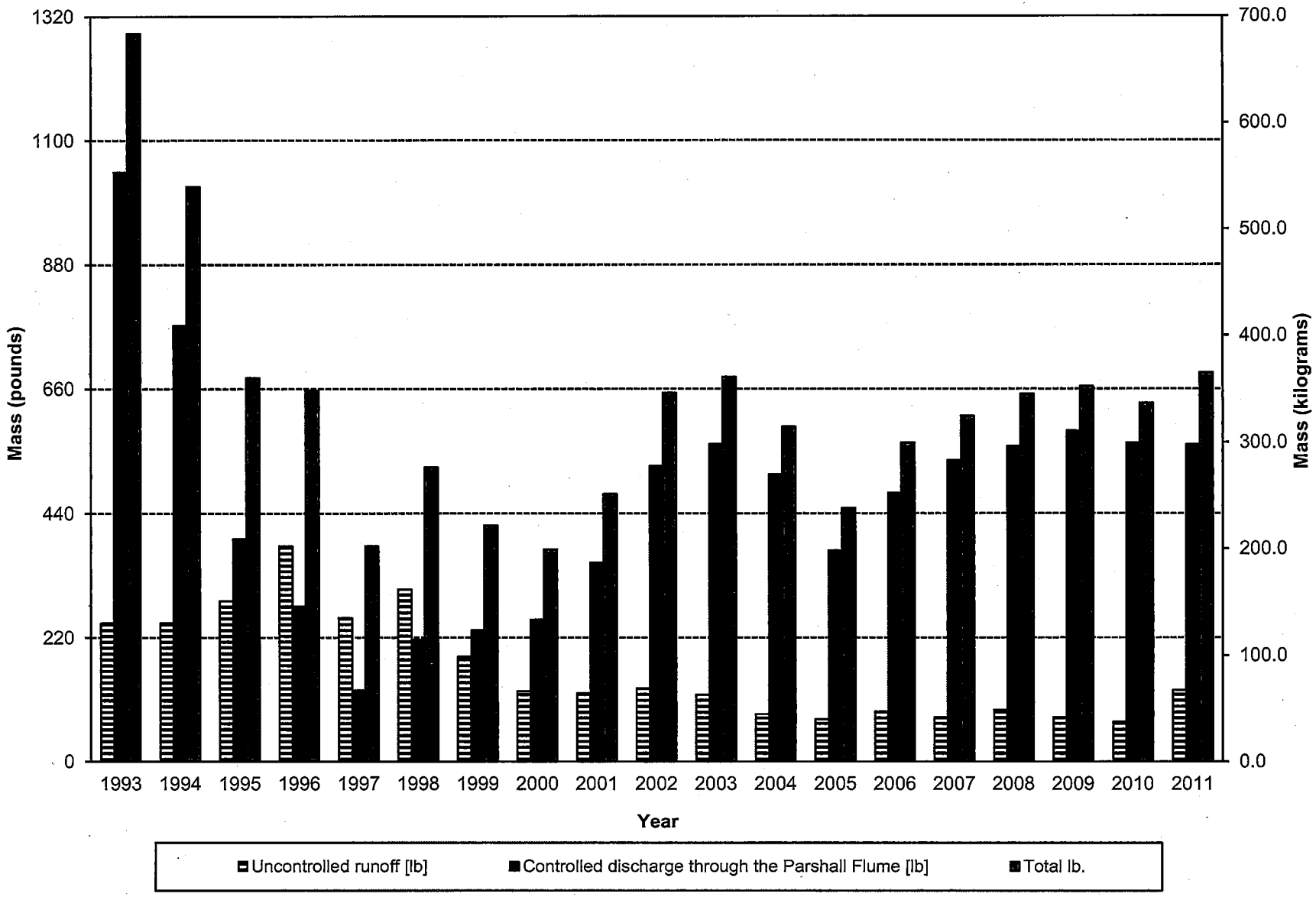

Figure 27. Uranium Discharged via the Surface Water Pathway, 1993–2011

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Section 5

5.0 Direct Radiation Pathway and Radiation Dose

Results in Brief: 2011 Estimated Doses

Direct Radiation—The estimated 2011 effective dose equivalent at the northeastern boundary of the site was 12 mrem/yr (0.12 mSv/yr). This is 12 percent of the 100-mrem/yr (1-mSv/yr) DOE limit.

Dose to the maximally exposed individual (MEI)—The dose to the MEI for 2011 was estimated to be 12 mrem/yr (0.12 mSv/yr) at the northeastern boundary of the site. This is 12 percent of the 100-mrem/yr (1-mSv/yr) DOE limit.

This section provides the 2011 results for direct radiation monitoring and the estimated dose to the public from the direct radiation pathway. It also addresses biotic dose to aquatic organisms from remedial actions associated with the groundwater restoration program.

In the past, the Fernald Preserve demonstrated compliance with the DOE effective dose limit of 100 millirem per year (mrem/yr) (1 millisievert per year [mSv/yr]) from exposure pathways (excluding radon) using direct radiation measurements and data collected from samples of airborne emissions to estimate the total dose to the maximally exposed individual (MEI). In consultation with EPA, DOE ended air monitoring for particulate emissions on January 4, 2010, because 3 years of post-remediation data indicated emissions are at or near background. Therefore, the 2011 dose estimate reflects the incremental dose above background that is attributed to direct radiation.

This section also provides an assessment of dose to aquatic organisms that may be affected by the site's effluent to nearby streams and rivers. An assessment of dose to biota (i.e., aquatic and terrestrial organisms) is one of the requirements of DOE Order 5400.5. By limiting the dose to aquatic organisms, DOE Order 5400.5 seeks to limit the severity and likelihood of offsite environmental impacts attributable to the aquifer restoration effort at the Fernald Preserve. The dose assessment to biota is performed through the use of a computer model that estimates dose from measured radionuclide concentrations in Paddys Run and effluent discharged to the Great Miami River.

5.1 Monitoring for Direct Radiation

Direct radiation originates from sources such as cosmic radiation, naturally occurring radionuclides in soil and food, and anthropogenic radioactive materials. Gamma rays and X-rays are the dominant types of radiation that create a public exposure concern because they penetrate into the deep tissues of the body. The largest historical source of direct radiation at the Fernald Preserve was waste material associated with the Silos Project. The last waste material associated with the Silos Project was removed from the site in 2006. Presently, there are no significant sources for direct radiation at the Fernald Preserve. During 2011, direct radiation levels at the Fernald Preserve were continuously measured at four trail locations, the Visitors Center, five boundary locations, and one background location with optically stimulated luminescence (OSL) dosimeters. The background location is 3.2 miles from the center of the Fernald Preserve (Figure 28).

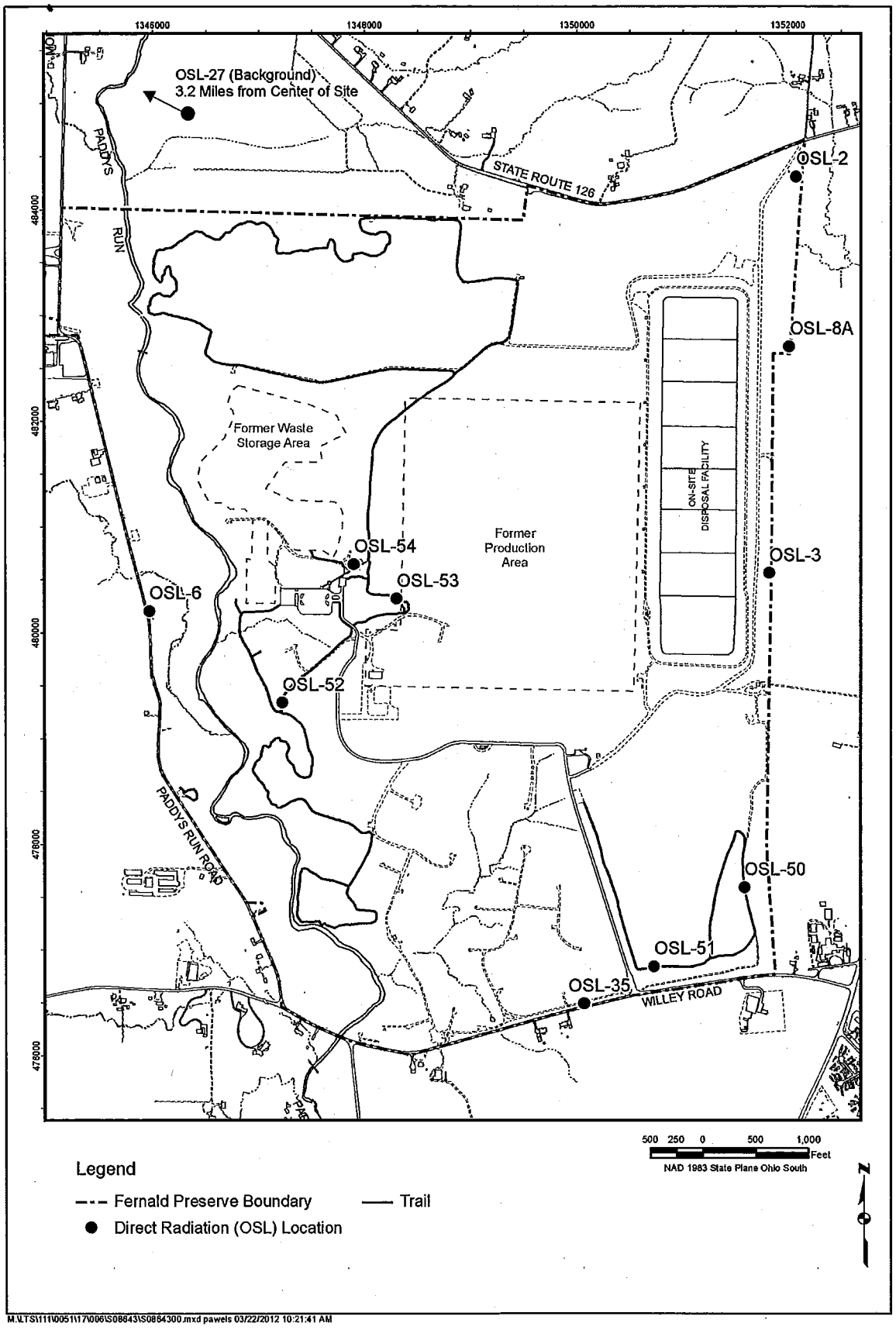

Figure 28. Direct Radiation (OSL) Monitoring Locations

Table 7 provides the annual range of direct radiation measurements for 2010 and 2011, and Figure 29 illustrates the quarterly results for 2011. Each quarterly result is the average of three measurements obtained from three separate dosimeters placed at each location. In general, the first-quarter results are less than other quarters because the first quarter had fewer exposure days, and the winter months may hold more moisture in the ground, which can attenuate radiation emitted from soil particles. Compared to background results, many of the onsite results are slightly higher, and the Visitors Center results are lower due to the shielding provided by the building materials. However, as noted in Appendix C, Attachment C.1, the mean of the quarterly boundary measurements is similar to background when statistical variability is evaluated, which is in agreement with removal of the last direct radiation waste sources in 2006.

Table 7. Direct Radiation (OSL) Measurement Summary

	Direct Radiation (mrem)	
Location	**Sum of 2011 Quarterly Results**	**Sum of 2010 Quarterly Results**
Onsite		
Minimum	16	18
Maximum	33	28
Background[a]		
Minimum	21	18
Maximum	21	18

[a] The minimum and maximum results are identical because there is only one background dosimeter.

5.2 Direct Radiation Dose

Direct radiation dose to deep tissue is primarily the result of gamma and X-ray emissions from radionuclides. The largest historical source of direct radiation at the site was the waste materials stored in the silos. This and all other significant surface radiation sources were removed from the site in 2006. Remaining surface sources for radiation are soil, which contains radium, thorium, and uranium isotopes at activities that are below the FRLs established in the OU5 ROD (DOE 1996), and small pieces of debris that are exposed by soil erosion.

From the data in Table 7, the maximum measurement is 33 mrem/yr (0.33 mSv/yr) at OSL-2 and OSL-8A (Figure 28), and the background dose is 21 mrem/yr (0.21 mSv/yr). The difference in the OSL dose between OSL-2 or OSL-8A dosimeters and the background dosimeter is 12 mrem/yr (0.12 mSv/yr), which is assumed to be the direct radiation dose for a hypothetical individual who stands at the OSL-2 or OSL-8A location for 1 year. This is a very conservative estimate of the dose, as an individual would not spend an entire year at OSL-2 or OSL-8A. Additionally, Appendix C, Attachment C.1 shows that the present quarterly measurements at the boundary are indistinguishable from background results when statistical variability is considered.

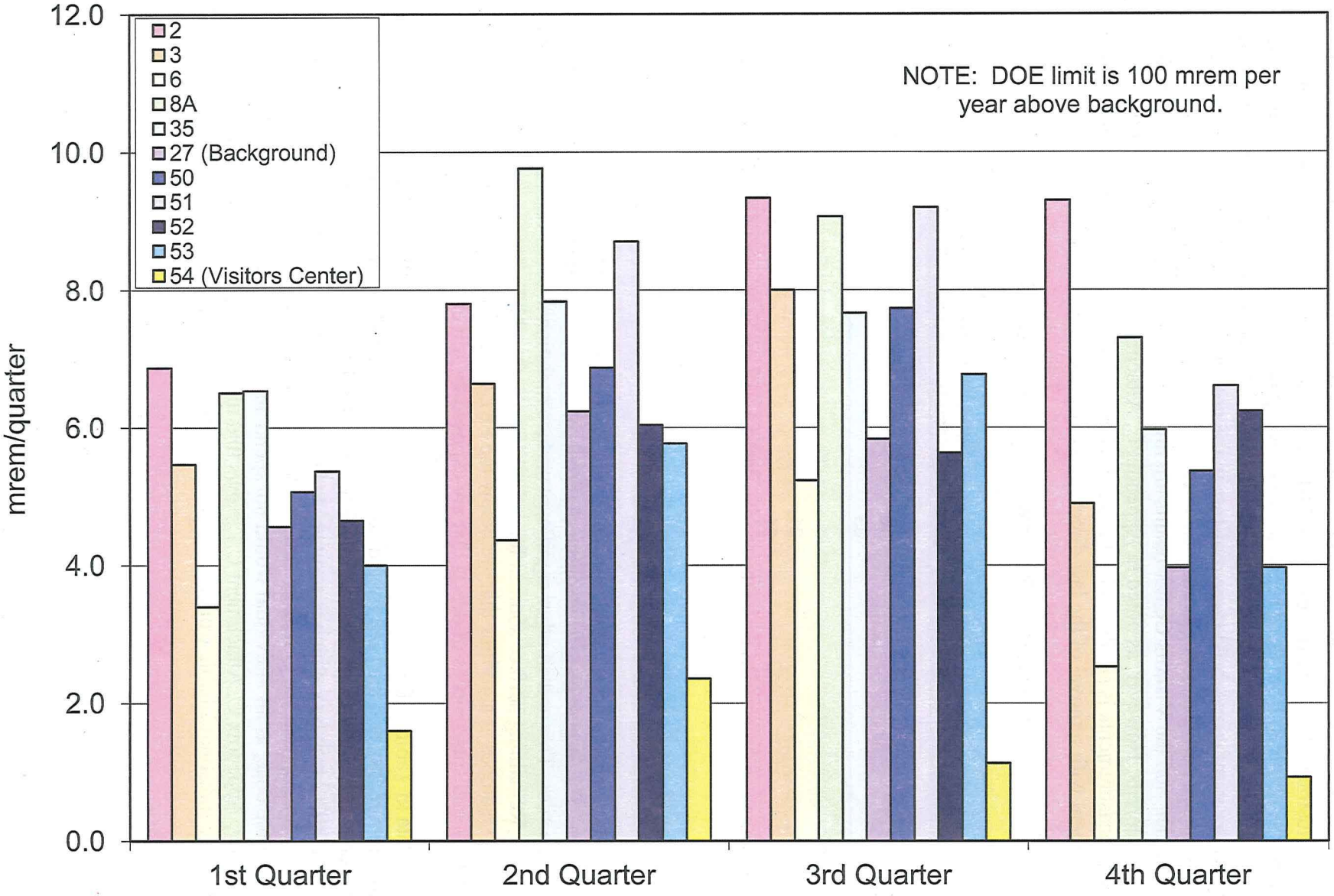

Figure 29. 2011 Quarterly Results for OSL Monitoring Locations

5.3 Total of Doses to the Maximally Exposed Individual

The MEI is the member of the public who receives the highest estimated effective dose based on the sum of the individual pathway doses (as noted above, direct radiation is the only pathway considered in 2011). It is the maximum dose because the MEI is assumed to spend 24 hours a day, 365 days a year at the location where the maximum direct radiation is measured. As shown in Table 8, the 2011 dose to the MEI is 12 mrem/yr (0.12 mSv/yr) and represents the sum of the estimated dose from direct radiation at OSL-2 or OSL-8A. The conservative exposure assumptions used to estimate the dose ensures that the dose to the MEI is the maximum possible dose any member of the public could receive.

Table 8. Dose to MEI

Pathway	Dose Attributable to the Fernald Preserve	Applicable Limit
Direct radiation[a]	12 mrem/yr (0.12 mSv/yr)	100 mrem/yr (1 mSv/yr) (total for all pathways)
MEI	12 mrem/yr (0.12 mSv/yr)	100 mrem/yr (1 mSv/yr) (total for all pathways)

[a] Represents the sum of the estimated dose from direct radiation at OSL-2 or OSL-8A.

The estimate represents the incremental dose above background attributable to the Fernald Preserve. Figure 30 provides a comparison between the average background radiation dose at the background location (21 mrem/yr [0.21 mSv/yr]) and the dose to the MEI (12 mrem/yr [0.12 mSv/yr]), relative to the annual DOE limit (100 mrem/yr [1 mSv/yr]).

5.4 Significance of Estimated Radiation Doses for 2011

One method of evaluating the significance of the estimated doses is to compare them with doses received from background radiation. Background radiation delivers an annual dose of approximately 100 mrem/yr (1 mSv/yr) from natural sources, excluding radon. For example, the dose received each year from cosmic and terrestrial background radiation contributes approximately 26 mrem/yr (0.26 mSv/yr) and 28 mrem/yr (0.28 mSv/yr), respectively. This sum (54 mrem/yr) is about 2.5 times greater than the direct radiation dose of 21 mrem/yr at the background location, and it is about four times greater than the dose of 12 mrem/yr above background estimated for the individual at OSL-2 or OSL-8A. The 100 mrem/yr per person background also includes dose from the ingestion of food and from medical X-rays (about 46 mrem/yr), which is not recorded by the direct radiation OSLs at the boundary and background locations. In addition, the background radiation dose will vary in different parts of the country. Living in the Cincinnati, Ohio, area contributes an annual dose of approximately 110 mrem/yr (1.1 mSv/yr), whereas living in Denver, Colorado, increases the background to approximately 125 mrem/yr (1.25 mSv/yr) (National Academy of Science 1980, National Council on Radiation Protection and Measurements 1984).

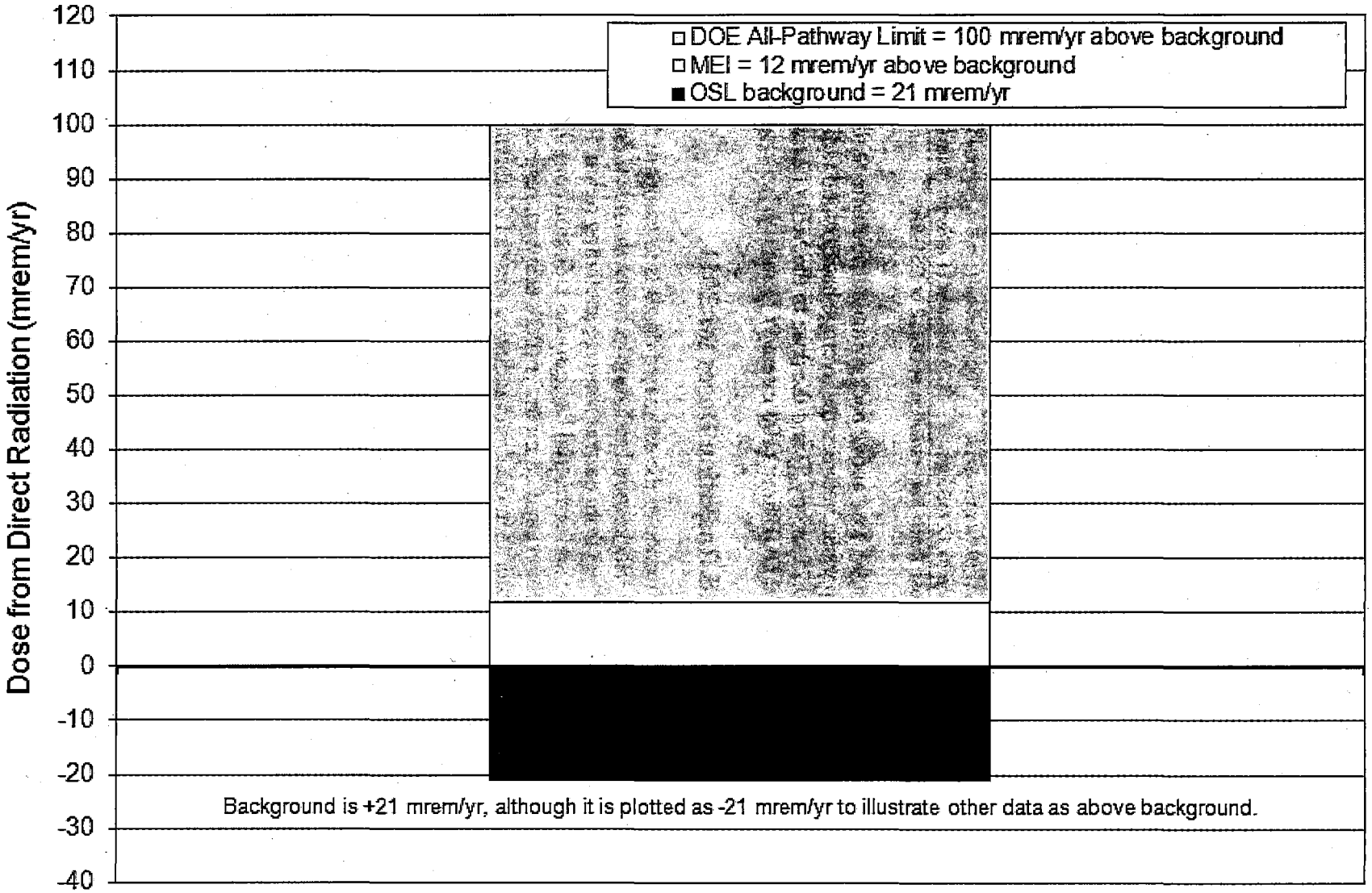

Figure 30. Comparison of 2011 All-Pathway Doses and Allowable Limits

Another method of determining the significance of the estimated dose is to compare it with dose limits developed to protect the public. The International Commission on Radiological Protection has recommended that members of the public receive less than 100 mrem/yr (1 mSv/yr) above background. As a result of this recommendation, DOE has incorporated 100 mrem/yr (1 mSv/yr) above background as the limit in DOE Order 5400.5. The sum of all estimated doses from 2011 site operations (12 mrem/yr [0.12 mSv/yr]) is considerably below this limit (Figure 30).

5.5 Estimated Dose to Biota

DOE Order 5400.5 requires that populations of aquatic biota be protected at a dose limit of 1 rad/day (10 milligray per day [mGy/day]). DOE has issued a technical standard entitled *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002b) and supporting software (RAD-BCG) for use in the evaluation and reporting of biota dose limits.

In general, the dose and compliance assessment process involves comparing radionuclide concentrations measured in surface water or sediment samples to biota concentration guides (BCGs) established by researchers. The BCGs are set so that biota exposed at the BCG level would not be expected to exceed the biota dose limit of 1 rad/day (10 mGy/day) during a calendar year. The measured radionuclide concentration in water or sediment is divided by the appropriate BCG value, and if the resulting fraction is less than 1.0, compliance with the biota dose limit is demonstrated for that radionuclide. BCGs have been established for radionuclides that are relatively common constituents in past releases to the environment from DOE facilities. At facilities such as the Fernald Preserve, where multiple contaminants (e.g., radium, thorium, and uranium) can be released, a "sum-of-the-fractions" rule applies. The sum-of-the-fractions rule means each radionuclide fraction (i.e., the measured concentration divided by the BCG for that nuclide) must be summed, and the sum of all radionuclide fractions must be less than 1.0.

For 2011, compliance with the dose limit to aquatic biota was determined by using the maximum concentration of each radionuclide found in Paddys Run at Willey Road (SWP-03) and effluent discharged from PF 4001 to the Great Miami River (refer to Section 4). The maximum concentration in water delivered from the Parshall Flume and Paddys Run is multiplied by the annual volume of water discharged from the Parshall Flume and Paddys Run to obtain a net mass for each nuclide delivered to the Great Miami River. The net mass is divided by the sum of the discharge volumes and low-flow volume from the Great Miami River to derive input concentrations to the RAD-BCG computer model. The results of this assessment indicate that the sum of the fractions for radium-226 (Parshall Flume only) and uranium isotopes is 0.006, which is well below the compliance threshold value of 1.0. Appendix C, Attachment C.2 provides additional information on the biota dose assessment.

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6.0 Natural Resources

This section provides background information on the natural resources associated with the Fernald Preserve and summarizes the activities in 2011 relating to these resources. Included in this section is a discussion of the following:

- Ecological restoration activities.
- Fernald Preserve site and OSDF inspections.
- Affected habitat areas.
- Threatened and endangered species.
- Cultural resources.

Results in Brief: Ecological Monitoring Activities

Wetland Mitigation Monitoring

- Jurisdictional wetland delineation acreage was surveyed to determine which onsite wetlands meet the Army Corp of Engineer's standards for wetland vegetation, hydrology, and soils. A total of 31.3 acres (12.7 hectares) of wetlands were delineated, well above the 17.9 acres (7.24 hectares) that DOE is required to restore pursuant to the *NRRP*.
- Comparisons of other measurements to wetland performance standards were mixed. Most site wetlands have sufficient water levels (i.e., hydrology). Native wetland vegetation is well established, but not all wetlands met the vegetation standards. Soil biogeochemistry standards were mostly not met. Long periods of time are required for development of the organic soils found in natural wetlands.

Forest Functional Monitoring

- Forest areas showed general improvement, but some concern remains with respect to impacts from invasive species.

Site and OSDF Inspections

- No major issues were observed with respect to institutional controls or the integrity of the OSDF cap. Findings focused mainly on invasive plants and woody vegetation in the vicinity of the OSDF, and debris in portions of the Former Production and Former Waste Pits areas.

Much of the 1,050 acres (425 hectares) of the Fernald Preserve property is undeveloped land that provides habitat for a variety of animals and plants. Wetlands, deciduous and riparian (streamside) woodlands, old fields, grasslands, and aquatic habitats are among the site's natural resources. Over 900 acres (364 hectares) of the site have undergone ecological restoration. Figure 31 shows the restoration project areas that have been completed. Some of these areas provide habitat for state and federal endangered species. These endangered species are identified in Section 6.4. Cultural resources, such as prehistoric archaeological sites have also been surveyed.

Monitoring of these natural and cultural resources is addressed in the *Natural Resource Monitoring Plan*, which is included in the IEMP. The *Natural Resource Monitoring Plan* presents an approach for monitoring and reporting the status of several priority natural resources to remain in compliance with pertinent regulations and agreements. The approach for monitoring and maintenance of ecologically restored areas was expanded in 2009. DOE and Ohio EPA signed a Consent Decree in November 2008 that settled a long-standing natural resource damage claim under Section 107 of CERCLA. As a result, the Fernald Natural Resource Trustees (DOE, Ohio EPA, and the U.S. Department of Interior) have finalized the Natural Resource Restoration Plan (NRRP), which is Appendix B of the *Consent Decree Resolving Ohio's Natural Resource Damage Claim against DOE* (State of Ohio 2008). The NRRP specifies an enhanced monitoring program for ecologically restored areas at the site. This includes an enhanced wetland mitigation monitoring program and a functional monitoring program that evaluates restored communities.

These monitoring activities continued in 2011, with a third year of wetland monitoring that included vegetation surveys, amphibian sampling, hydrologic monitoring, and soil and water sampling. A jurisdictional wetland delineation was also conducted. For functional monitoring, 2011 activities included vegetation surveys of forest communities. The site and OSDF inspection process, which is defined in the LMICP, was also continued in 2011 to evaluate the condition of natural resources at the Fernald Preserve.

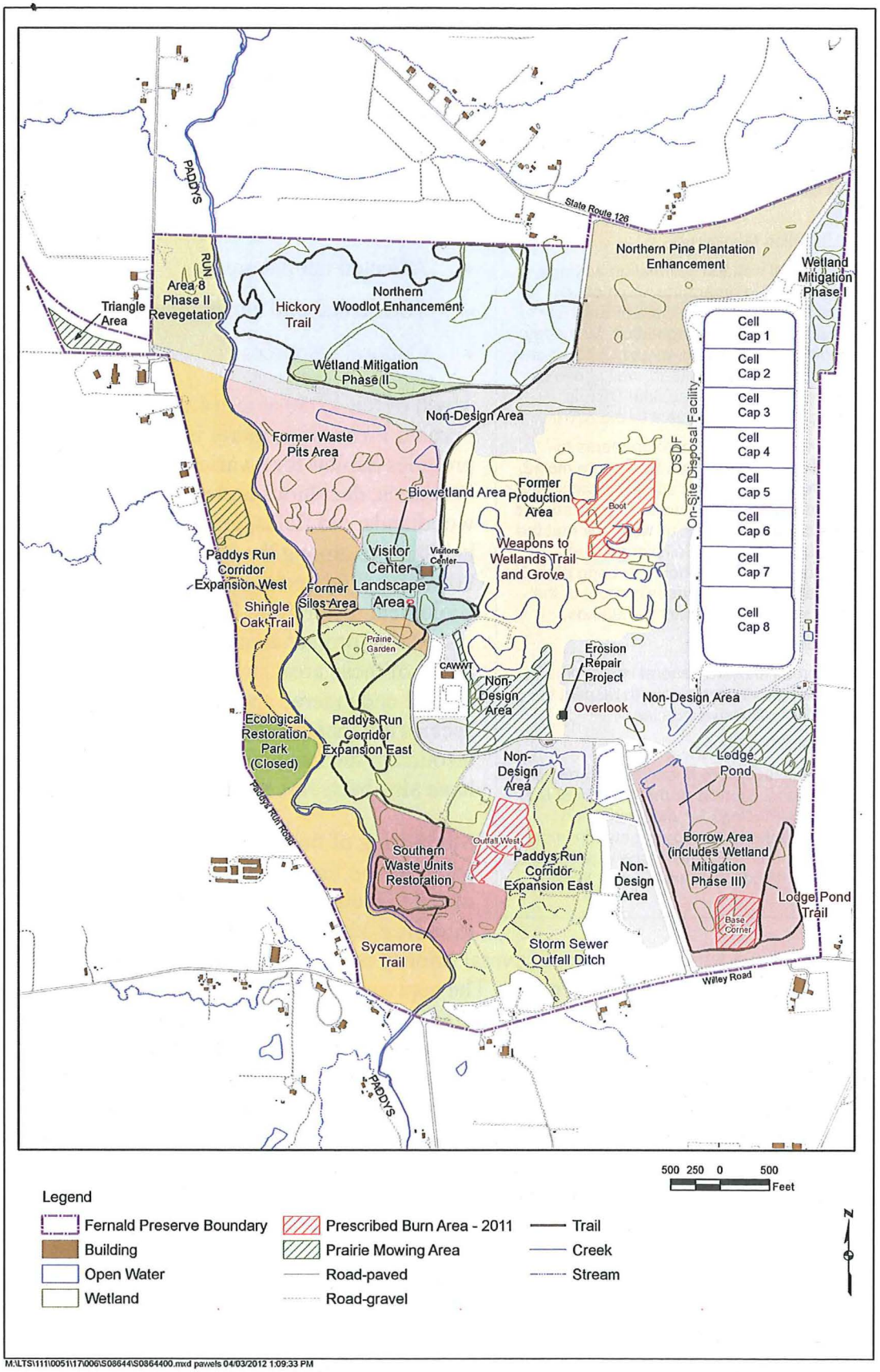

Figure 31. Restoration Project Areas

6.1 Ecological Restoration Activities

The Fernald Preserve's mission of long-term stewardship under LM includes the establishment, management, and monitoring of ecologically restored areas across the site. In 2011, repair and enhancement of ecologically restored areas was limited to minor erosion repair in several locations within the Former Production Area. Maintenance in ecologically restored areas included continued control of noxious weeds and invasive plants, and limiting impacts due to nuisance animals (e.g., deer and geese). In addition, the use of prescribed burns continued at the Fernald Preserve.

6.1.1 Ecological Restoration Repair, Maintenance, and Enhancement

An erosion repair effort was conducted within the Former Production Area (Figure 31). This project involved regrading and seeding to repair a gully that formed following heavy rains. Coir matting has been installed over the repaired area, which can be seen from the access road to the Visitors Center. Dormant willow cuttings were used to revegetate several other minor erosion areas.

Spot spraying with a broad-leaf herbicide, in conjunction with mowing and manual cutting, was continued in 2011 to control Canada thistle and other noxious weeds across the site. Manual cutting, followed by herbicide application to the stumps, was also used to remove bush honeysuckle and Callery pear from several areas along the eastern side of the site and within the Wetland Mitigation Phase I project. Callery pear is an emerging nuisance at the site. Callery pear is the common name for any of a variety of common commercial landscape trees, such as Bradford pear. These trees have been observed in the northeastern portion of the site, as well as within the OSDF. These non-native plants crowd out more desirable native species.

The use of prescribed burns continued at the Fernald Preserve in 2011. Prescribed burning has several benefits. The tallgrass prairie species that have been seeded at the Fernald Preserve are well adapted to periodic fires. Most prairie species are deep-rooted. They have an extensive root system that is developed before the stem and leaf clump form above the surface. The root system allows them to be burned, eliminating the above-surface plant clump, without killing the plant. After a burn, when prairie plants grow back from the roots, they are vibrant. The burns convert the plant material to ash, reducing the accumulation of thatch. The ash is in contact with the soil and breaks down quickly, and the nutrients in the ash become available in the soil. Also, the blackened, ash-covered ground absorbs more heat from sunlight and warms the soil. As a result, the soil reaches a temperature conducive to germination and native plant growth earlier in the spring. The growing season for the grasses and wildflowers is increased, and the sunlight on the soil surface promotes the growth of new plants and increases the productivity of existing plants.

Three areas were burned in 2011, totaling approximately 17 acres (6.9 hectares). Figure 31 shows the location of the burn areas. The Base Corner burn, located in the Lodge Pond area, was conducted in November. The other two burns were conducted in March. Each burn was conducted safely with no incidents.

Several areas were mowed, raked, and baled in order to discourage cool season grasses and weedy vegetation following seeding. These areas included Non-Design Areas east of the CAWWT and south of the OSDF. The area east of the CAWWT, known as the Prairie Area, was

seeded in 2010 as part of the Natural Resource Trustee Resolution No. 3 projects. A portion of the restored prairie was mowed on the east side of Paddys Run Road in anticipation of restoration activities that will take place in 2012. The Triangle Area west of Paddys Run Road was mowed as well. Figure 31 shows the location of mowed areas.

The primary nuisance animals on site are white-tailed deer and Canada geese, which are an ongoing concern. Existing deer exclosure fencing was maintained sitewide to prevent deer from browsing and rubbing the planted trees. The goose-hazing program, which began in 2007, uses trained border collies to harass the geese. This program continued in 2011. The dogs, brought onto the Fernald Preserve by their handlers, try to herd the geese. The geese believe the dogs are predators and fly off. This hazing is effective at keeping geese from both land and water. The goal is to keep the geese from areas that have been seeded so that the vegetation has time to become established. Once the grasses become tall, the geese are no longer attracted to those areas. A second goal is to make the geese too uncomfortable to nest at the Fernald Preserve. Habitat conditions change across the site due to maintenance activities. Geese congregate in mowed and burned areas, so while portions of the site become less hospitable to geese, other areas open up; therefore, goose hazing will continue in 2012.

6.1.2 Ecological Restoration Monitoring

Vegetation Monitoring Parameters
There are a number of ways to evaluate the type and quality of vegetation within an area. At the Fernald Preserve, vegetation monitoring focuses on determining the extent of native species composition and calculating a Floristic Quality Assessment Index (FQAI). The FQAI process is described in the *Floristic Quality Assessment Index for Vascular Plants and Mosses for the State of Ohio* (Andreas 2004). The specific parameters used at the Fernald Preserve include the following:

- **Total Species**: The total number of species sampled within a given area.
- **Native Species**: The total number of species native to Ohio. The Ohio Vascular Plant Database is used to determine whether a species is native (Andreas 2004).
- **Percent Native Species**: The number of native species divided into the total number of species. Relative frequency of native species has also been used in the past. This is calculated by dividing the frequency (or number of times a species is observed) into the total number of observations for a given area.
- **Average Coefficient of Conservatism (CC)**: The CC is a number between 0 and 10 that has been assigned to virtually every species that may be found in Ohio. The CC value is related to how "tolerant" a species is and what its habitat requirements are. Non-native plants have a CC of 0. Common species that can grow in a wide variety of habitats are considered "tolerant," and are scored a CC between 0 and 3. Native plants with very specific habitat requirements are scored high CC values, in the 7 to 10 range. The Ohio Vascular Plant Database lists the CC for each plant found in Ohio (Andreas 2004).
- **Floristic Quality Assessment Index (FQAI)**: The CC values described above are used to calculate the FQAI. The FQAI is the sum of CC values divided by the square root of the total number of species for a given area.

Ecological restoration monitoring in 2011 centered on completion of the expanded wetland mitigation monitoring program. DOE has the responsibility to create 17.9 acres (7.22 hectares) of jurisdictional wetlands at the Fernald Preserve. While over 80 acres (32 hectares) of wetland habitat have been created as part of ecological restoration activities, DOE is required to demonstrate that a minimum of 17.9 acres (7.22 hectares) of these meet the definition of a jurisdictional wetland. A wetland is considered jurisdictional if it meets specific criteria regarding vegetation, hydrology (water), and soils. To accomplish this, the *Fernald Preserve Wetland Mitigation Monitoring Plan* (DOE 2009) was developed to establish performance standards and monitoring requirements for wetland mitigation projects at the Fernald Preserve. The plan adopts existing Ohio EPA performance standards and monitoring protocols for emergent wetlands. A series of parameters was evaluated between 2009 and 2011, including the shape and size of wetlands, water elevations, soil and water chemistry, vegetation, amphibians, and other wildlife. Evaluation of these parameters ensures that the functions and services that wetlands provide are addressed.

Additional monitoring of restored areas has been divided into two phases: the implementation phase and the functional phase. Implementation phase monitoring is conducted to ensure that restoration projects are completed as intended in their designs. This effort involves the mortality counts and herbaceous cover estimates that are conducted after a project is completed. Herbaceous surveys of the Natural Resource Trustee Resolution No. 3 projects were conducted in 2011.

Functional phase monitoring is more general and considers projects in terms of their contribution to the ecological community as a whole. This is accomplished by comparing projects to pre-remediation baseline conditions and to ideal reference sites. The NRRP, which was finalized in November 2008 with settlement of the Natural Resource Damage Claim (State of Ohio 2008), reinstituted the use of functional-phase monitoring as a means of evaluating restored communities. In 2011, functional monitoring centered on forest communities.

6.1.2.1 Wetland Mitigation Monitoring

Hydrophytic Vegetation: Vegetation that is adapted to grow in soil that is periodically deficient in oxygen as a result of excessive water content.

Hydric Soil: Wetland soil that is saturated, ponded, or flooded long enough during the growing season that oxygen-deficient conditions form.

Wetland Hydrology: A measurement of how much water is present within a wetland area.

Morphometry: A measurement of the shape of a wetland area, as in the steepness of side slopes.

Vegetation Index of Biotic Integrity: A scoring system using vascular plants as a means of assessing the quality of a given community.

Amphibian Index of Biotic Integrity: A scoring system using amphibians as a means of assessing the quality of wetland communities.

For 2011, monitoring activities included a jurisdictional wetland delineation. Additional efforts focused on an evaluation of the design of the created wetlands, hydrologic monitoring, vegetation surveys, characterizing amphibian communities, and soil biogeochemical sampling. A summary of these efforts is provided below.

Mitigation wetland acreage was estimated via jurisdictional wetland delineation. The 1987 U.S. Army Corps of Engineers (USACE) *Wetland Delineation Manual* (USACE 1987) and associated *Interim Regional Supplement to the Corps of Engineers Wetlands Delineation Manual: Midwest Region* (USACE 2008) were used to delineate wetland boundaries within all wetland basins evaluated. Delineation involved sampling selected points within major landscape or vegetation units throughout the wetland. Each point was evaluated for hydrophytic vegetation, hydric soils, and wetland hydrology. Any point that showed presence of all three indicators was considered to be within the wetland boundary. All sampling points and boundaries were mapped with Global Positioning System. Figure 32 shows the delineation boundaries that were identified for each of the mitigation wetlands. A total of 31.3 acres (12.7 hectares) were delineated. Table 9 provides the delineated acreage for each basin.

Additional evaluation of the wetland design was conducted using Geographic Information System technology. Basin morphometry, which is a way of measuring the form of a wetland, was calculated based on site topography. Mitigation wetlands should have less than a 15 to 1 (horizontal to vertical) side slope. The performance standard is met when over 50 percent of the area meets this level. Percentages for each basin are presented in Table 9. All of the basins except Basin FPAW7 met the performance standard.

Hydrologic monitoring is a way of measuring how much water is present within a wetland. Daily water level readings from shallow wells (piezometers) are collected from each of the wetland areas. Figure 32 shows the locations of piezometers within site wetlands. Parameters and associated performance standards include average depth to groundwater (less than 11.6 inches [29.4 cm]), the percent of time water is present in the root zone (greater than 53 percent of the year), and flashiness index (less than 2.0). The flashiness index is a measurement of how fast wetlands fill and release water following a storm event. Table 9 summarizes the 2011 findings. Most areas met the standards for hydrologic monitoring.

The method for vegetation survey involved the use of fixed plot quadrats pursuant to Ohio EPA monitoring protocols. Figure 32 shows the location of fixed plot grids within each of the wetland basins evaluated. Data collected from these grids are used to calculate several performance standards, including Vegetation Index of Biotic Integrity (VIBI). Table 9 summarizes the findings. The *Fernald Preserve Wetland Mitigation Monitoring plan* (DOE 2009) sets a VIBI goal of 48 to 63 for restored wetlands. Comparison to performance standards showed mixed results. Nearly half of the basins met the VIBI standards, including all basins within the Wetland Mitigation Phase II project and the North Pines Plantation project. The other two performance standards include greater than 75 percent native perennial hydrophytes (native wetland plants that are perennial, meaning they survive for multiple years) and less than 10 percent unvegetated open water. The results show that diverse wetland communities have been established, but additional long-term vegetation monitoring is needed.

Soil samples were also collected throughout the wetlands. Samples were analyzed for total nitrogen, total organic carbon, and percent solids. These parameters provide an indication of wetland soil development. Long periods of inundation cause a number of chemical changes to natural wetland soils. These unique properties help wetlands provide some of their important ecological functions, such as filtering and storing capacity. Table 9 lists the performance standards for soil biogeochemistry and summarizes the results. Nearly all basins failed to meet the standards for soil chemistry parameters. These findings are expected for the relatively young age of the wetlands evaluated.

Amphibian monitoring involved surveying wetlands using funnel traps. Ten traps were placed in a wetland basin and left for 24 hours. Amphibians and other wildlife easily crawl or swim into the traps but have a difficult time escaping. Field personnel return the following day and record and release whatever is found. Wildlife are usually returned to their environment unharmed. Fifteen wetland basins were included in the amphibian monitoring program. Figure 32 shows the location of basins surveyed. This amphibian information is used to calculate an Amphibian Index of Biotic Integrity (AIBI) score. Table 10 provides a summary of species findings and calculated AIBI score for each basin monitored. Although there is no numerical performance standard for AIBI, there are several noteworthy findings, including a total of four different species of mole salamander (ambystomatid salamanders). As in the past, the Northern Pine Plantation and Wetland Mitigation Phase II (WM2) wetlands score relatively high because of the abundance of salamander findings. In 2011, a salamander was trapped in the Wetland Mitigation Phase I (WM1) wetlands.

Table 9. Wetland Mitigation Monitoring Results

		Design Parameters		Hydrologic Regime Paramaters			Vegetation Parameters			Soil Chemistry Parameters		
		Delineation	Morphometry	Water in Root Zone	Mean Depth of Water	Flashiness Index	Unvegetated Open Water	Native Perennial Hydrophytes	Vegetation Index of Biotic Integrity	Percent Solids	Percent Total Organic Carbon	Percent Total Nitrogen
	Performance Standard	17.85 Acres	>50% is less than 15:1 side slope	>53%	<29.4 cm	<2.0	<10%	>75%	48-63	<46.6 %	>3.9%	>0.5%
Restoration Project Area	**Basin**											
Borrow Area (BAP)	BAPW2	NA[a]	NA[a]	70%	17	0.6	1.3%	84.3%	46	75.4%	1.2%	0.2%
	BAPW3	2.8	84%	81%	5	0.7	2.0%	67.2%	42	74.3%	0.5%	0.1%
	BAPW4	3.0	86%	81%	13	0.7	1.3%	61.8%	23	74.6%	0.9%	0.1%
	BAPW7	NA[a]	NA*	79%	22	0.4	1.8%	55.5%	50	67.3%	1.6%	0.2%
	BAPW9	7.3	76%	77%	10	0.9	3.0%	70.2%	29	85.7%	1.5%	0.4%
Former Production Area (FPA)	FPAW2	2.0	84%	78%	22	0.4	40.0%	96.1%	40	75.0%	6.0%	0.2%
	FPAW4	1.4	76%	85%	13	0.3	26.0%	42.0%	18	60.0%	4.5%	0.1%
	FPAW5	1.2	85%	81%	18	0.4	11.5%	56.0%	54	55.3%	3.3%	0.2%
	FPAW7	1.4	48%	80%	19	0.8	1.0%	29.1%	13	79.6%	5.7%	0.2%
	FPAW9	0.5	68%	76%	30	0.3	2.8%	58.3%	56	85.9%	4.3%	0.1%
	PREW6	2.8	75%	83%	4	0.5	17.3%	46.2%	25	74.9%	0.4%	0.1%
Northern Pine Plantation Enhancement (NPP)	NPPW4	0.7	73%	76%	14	0.1	5.3%	72.1%	58	78.0%	0.8%	0.1%
	NPPW5	0.2	98%	73%	18	0.7	3.8%	79.6%	61	71.2%	0.6%	0.1%
Wetland Mitigation Phase I (WM1)	WM1W1	0.9	68%	55%	39	0.7	1.3%	47.2%	39	78.2%	1.7%	0.1%
	WM1W2	1.1	91%	74%	27	0.3	2.1%	60.6%	61	77.8%	1.1%	0.3%
	WM1M3	0.8	80%	69%	33	0.7	3.8%	75.6%	46	83.8%	1.3%	0.2%
	WM1W4	0.8	88%	79%	20	0.4	8.0%	60.2%	54	76.3%	0.6%	0.1%
	WM1W5	0.2	71%	67%	26	1.3	0.0%	71.0%	32	79.5%	1.5%	0.1%
	WM1W6	1.5	83%	46%	53	0.5	1.3%	42.8%	48	85.5%	1.1%	0.1%
	WM1W7	0.5	76%	66%	21	0.5	2.9%	64.0%	42	84.3%	1.9%	0.1%
Wetland Mitigation Phase II (WM2)	WM2W1	1.2	55%	97%	3	0.9	1.0%	63.8%	53	73.9%	0.5%	0.0%
	WM2W2	0.6	89%	60%	19	0.1	13.8%	81.0%	49	85.0%	0.1%	0.1%
	WM2W3	0.5	53%	96%	3	0.5	20.5%	55.6%	51	78.6%	0.3%	0.0%
All Basins		31.3										

[a]NA = Not Applicable. BAPW2 and BAPW7 were combined during the delineation. The acreage for these three areas is included in the delineation acreage and morphometry calculation for BAPW9.

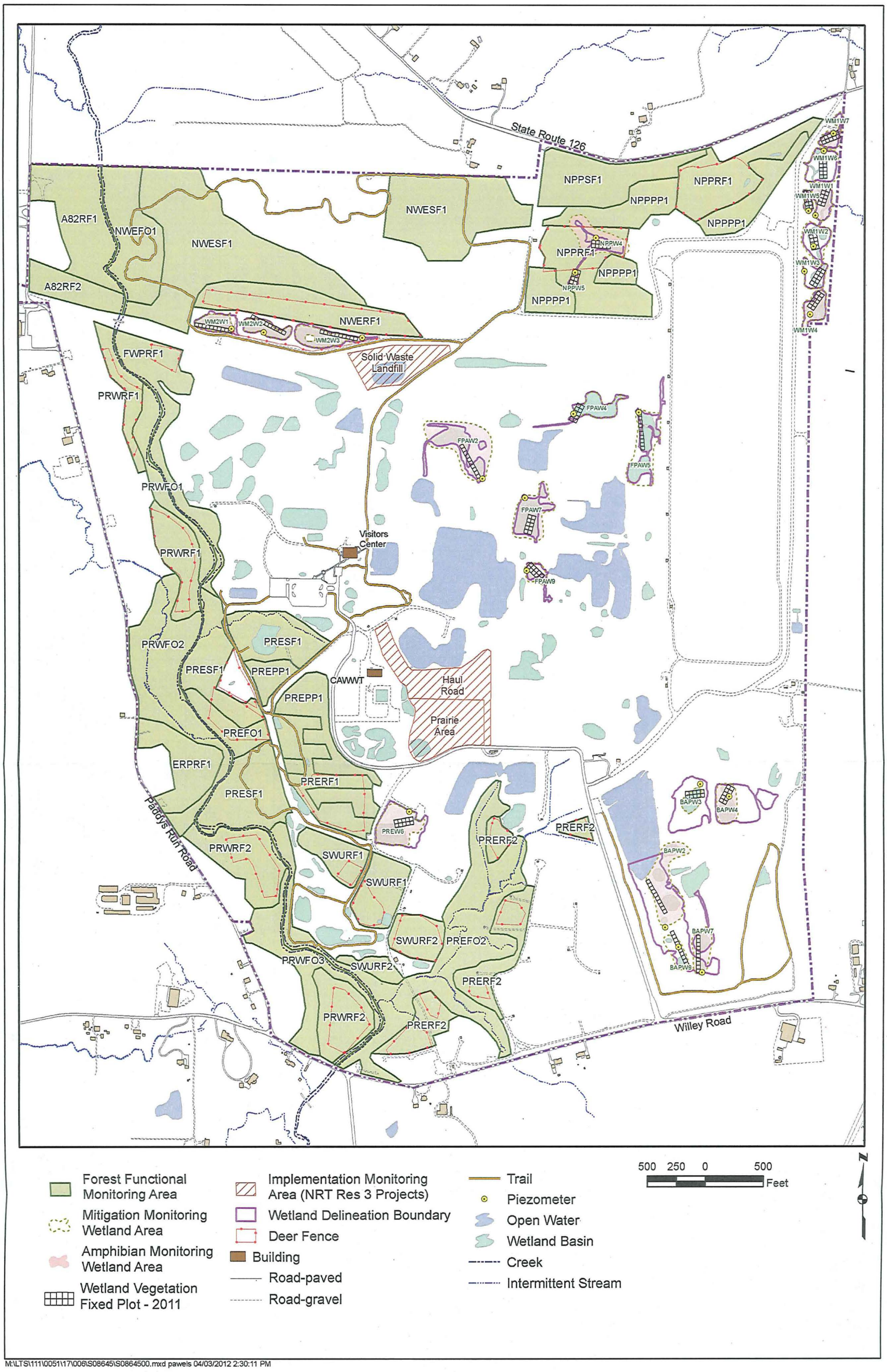

Figure 32. Ecological Monitoring Activities

All of the data collection discussed above was summarized and reported in the *Wetland Mitigation Monitoring Report* (DOE 2012), which was submitted to the Fernald Natural Resource Trustees in December 2011. Although the monitoring results show mixed compliance with performance standards, the field data collected, along with wildlife observations and progress photographs, indicate that quality wetlands are forming. The approximately 31 acres (13 hectares) of mitigation wetlands are likely of higher quality than the cattail marsh impoundments that were replaced. Appendix D provides additional detail regarding basin-specific data collection, calculation of monitoring parameters, and comparison to performance standards. The *Wetland Mitigation Monitoring Report* was approved in April 2012.

Table 10. Wetland Mitigation Amphibian Monitoring Summary

			Species and Number of Individuals												
Restoration Project Area	**Wetland Area**	**AIBI[a]**	**Cricket Frog (*Acris crepitans*)**	**Streamside Salamander (*Ambystoma barbouri*)**	**Marbled Salamander (*Ambystoma opacum*)**	**Salamander Species (*Ambystomid sp*)**	**Tiger Salamander (*Ambystoma tigrinum*)**	**American Toad (*Anaxyrus americanus*)**	**Fowlers Toad (*Anaxyrus fowleri*)**	**Toad Species (*Anaxyrus sp*)**	**American Bull Frog (*Lithobates catesbeiana*)**	**Green Frog (*Lithobates clamitans*)**	**Northern Leopard Frog (*Lithobates pipiens*)**	**Frog Species (*Lithobates sp*)**	**Spring Peeper (*Pseudacris crucifer*)**
Borrow Area (BAP)	BAPW2	0	0	0	0	0	0	0	0	0	3	0	0	2	0
	BAPW4	0	0	0	0	0	0	0	0	0	0	1	0	19	0
	BAPW7	13	1	0	0	0	0	0	0	0	0	1	1	1	1
Former Production Area (FPA)	FPAW2	13	1	0	0	0	0	0	0	0	2	0	0	0	1
	FPAW7	0	0	0	0	0	0	0	0	0	1	0	0	10	0
	FPAW9	10	12	0	0	0	0	0	0	1	0	0	0	28	0
	PREW6	13	10	0	0	0	0	0	0	0	10	2	0	0	0
Northern Pine Plantation Enhancement (NPP)	NPPW4	33	40	0	0	1	1	0	0	0	4	2	1	0	0
	NPPW5	0	0	0	0	0	0	0	0	0	3	0	0	0	14
Wetland Mitigation Phase I (WM1)	WM1W1	3	0	0	0	1	0	0	0	0	1	3	0	0	0
	WM1W4	3	1	0	0	0	0	0	0	0	15	7	0	19	0
	WM1W7	0	0	0	0	0	0	0	0	0	0	0	0	0	40
Wetland Mitigation Phase II (WM2)	WM2W1	6	0	2	0	7	0	0	0	10	98	2	2	0	0
	WM2W2	6	0	1	1	0	0	0	0	213	2	0	1	134	2
	WM2W3	12	1	0	0	16	0	0	0	0	2	0	0	2	28

[a]AIBI = Amphibian Index of Biotic Integrity Score

6.1.2.2 Functional Monitoring

In addition to the enhanced wetland mitigation monitoring program, functional monitoring of restored areas resumed in 2009 as well. This process compares restored communities to pre-restoration "baseline" conditions and high-quality reference sites. Baseline and reference sites were characterized in 2001 and 2002. From 2003 to 2005, restored areas were evaluated. Instead of a project-specific data set, broader community types (i.e., wetlands, prairie, and forest) were evaluated. Wetlands were evaluated in 2003, prairie communities in 2004, and forest habitats in 2005. This 3-year rotation was reproduced in 2009 (wetlands), 2010 (prairie communities), and 2011 (forest habitats). Presented below are the results of the 2011 functional monitoring of restored forested communities.

Forest communities are evaluated using separate vegetation surveys for herbaceous vegetation (grasses and flowers) and woody vegetation (trees and shrubs). Forest communities were divided into four different types: mature forest, young forest, pine plantation, and restored forest. The

percentage and frequency of native species is calculated, along with the average Coefficient of Conservatism and FQAI. Presented below are the results of this effort.

Figure 32 shows forest functional monitoring locations, and Table 11 and Table 12 present summary data for each of the areas monitored. Table 13 provides a comparison with baseline and reference sites, along with areas that were initially evaluated in 2005.

Results are mostly as expected across the site, with older forests containing quality herbaceous vegetation and larger trees. A number of restored forest communities have diverse native trees and shrubs due to revegetation efforts during restoration. For the baseline and reference site comparison, results show improvement over baseline conditions in Area 8, Phase II, but relatively similar conditions in the Northern Woodlot Enhancement and the Southern Waste Units. The Northern Woodlot Enhancement area benefits from restoration plantings, but this was offset by several new woody invasives that were not present in 2005, such as Callery pear, multiflora rose, and amur honeysuckle. Continued control of invasive species is needed to reverse this trend. This information will continue to be collected on a 3-year rotation, so that long term trends can be established.

Table 11. Forest Functional Monitoring Herbaceous Vegetation Summary

Community Type	Functional Monitoring Area	Total Species	Native Species	Percent Native	Relative Frequency of Native Species	Average CC[a]	FQAI[b]
Mature Forest	NWEFO1	44	35	80%	72%	2.18	14.43
	PREFO1	36	27	75%	67%	1.67	10.00
	PREFO2	53	39	74%	65%	2.35	17.14
	PRWFO1	22	12	55%	33%	1.54	6.57
	PRWFO2	50	41	82%	67%	2.32	16.40
	PRWFO3	38	25	66%	85%	3.32	20.44
Pine Plantation	NPPPP1	35	22	63%	55%	1.33	7.89
	PREPP1	49	37	76%	72%	2.04	14.30
Restored Forest	A82RF1	45	31	69%	68%	1.86	12.48
	A82RF2	47	30	64%	55%	1.59	10.91
	ERPRF1	42	25	60%	53%	1.83	11.83
	FWPRF1	46	27	59%	56%	1.17	7.91
	NPPRF1	43	30	70%	68%	1.76	11.52
	NWERF1	54	38	70%	63%	1.47	10.81
	PRERF1	49	33	67%	64%	1.50	10.50
	PRERF2	36	23	64%	54%	1.41	8.47
	PRWRF1	41	28	68%	58%	1.85	11.82
	PRWRF2	50	34	68%	57%	1.53	10.84
	SWURF1	42	23	55%	52%	1.55	10.05
	SWURF2	38	26	68%	68%	2.09	12.86
Young Forest	NPPSF1	32	23	72%	58%	1.30	7.35
	NWESF1	32	15	47%	68%	1.74	9.83
	PRESF1	60	42	70%	69%	1.56	12.11

[a] CC = Coefficient of Conservatism

[b] FQAI = Floristic Quality Assessment Index

Table 12. Forest Functional Monitoring Woody Vegetation Summary

Community Type	Functional Monitoring Area	Total Species	Native Species	Percent Native	Relative Density of Native Species	Average CC[a]	FQAI[b]	Average Size (DBH, in cm)[c]
Mature Forest	NWEFO1	9	9	100%	100%	4.78	14.33	32.4
	PREFO1	17	15	88%	35%	4.00	16.49	17.8
	PREFO2	18	16	59%	35%	4.17	17.68	19.3
	PRWFO1	17	16	94%	20%	4.88	20.10	24.2
	PRWFO2	17	14	82%	46%	3.00	12.37	19.6
	PRWFO3	16	14	88%	13%	3.71	14.82	19.2
Pine Plantation	NPPPP1	12	9	75%	54%	3.25	11.26	8.3
	PREPP1	17	13	76%	81%	3.24	13.34	11.9
Restored Forest	A82RF1	33	29	88%	92%	3.39	19.46	6.9
	A82RF2	14	12	86%	77%	3.31	12.38	13.3
	ERPRF1	19	15	79%	80%	3.65	15.91	1.8
	FWPRF1	35	33	94%	89%	3.60	21.30	1.4
	NPPRF1	38	34	89%	95%	3.71	22.87	2.3
	NWERF1	26	21	81%	77%	2.80	14.28	5.6
	PRERF1	29	24	83%	98%	3.24	17.46	2.1
	PRERF2	40	36	90%	94%	4.00	25.30	1.4
	PRWRF1	32	27	84%	96%	3.45	19.53	2.1
	PRWRF2	24	20	83%	81%	3.33	16.33	1.7
	SWURF1	13	11	85%	87%	4.00	14.42	1.1
	SWURF2	19	16	84%	40%	4.58	19.96	2.1
Young Forest	NPPSF1	15	14	93%	25%	4.07	15.75	16.6
	NWESF1	13	11	85%	32%	3.38	12.20	22.6
	PRESF1	23	21	91%	50%	4.18	20.06	11.8

[a] CC = Coefficient of Conservatism

[b] FQAI = Floristic Quality Assessment Index

[c] DBH = Diameter at Breast Height

Table 13. Forest Functional Monitoring Comparison

	Southern Waste Units				Area 8 Phase II				Northern Woodlot Enhancement			
Parameter	2005	2011	Reference (Upland Forest Complex)	Baseline (Developed)[a]	2005	2011	Reference (Riparian)	Baseline (Grazed Pasture)	2005	2011	Reference (Upland Forest Complex)	Baseline (Woodlot)
Total Species	82	82	62	NA	66	74	95	38	82	68	62	56
Total Native Species	61	55	58	NA	44	55	85	15	58	50	58	42
Percent Native Species	74%	67%	94%	NA	67%	74%	91%	39%	71%	74%	94%	75%
Average CC[b]	3.0	2.6	3.9	NA	2.2	2.5	3.3	0.4	1.8	2.0	3.9	2.4
FQAI[c]	26.70	23.13	30.50	NA	17.50	21.38	31.80	2.60	16.70	16.89	30.50	18.00

[a]NA = Not Applicable (Developed areas were not characterized. Baseline conditions are assumed to be zero for all parameters.)

[b]CC = Coeffient of Conservatism

[c]FQAI = Floristic Quality Assessment Index

6.1.2.3 Implementation Monitoring

Implementation monitoring in 2011 consisted of herbaceous surveys of the Natural Resource Trustee Resolution No. 3 project areas (Figure 32). Seeding took place in late summer 2010, so these areas were surveyed in 2011 to determine the extent of native species establishment and total cover. Results are presented in Table 14. The Solid Waste Landfill and Haul Road areas met the 50 percent native species goal and almost attained the 90 percent total cover goal. Native vegetation was not well established in the Prairie Area, which is located just south of the Haul Road area. This area was interseeded in 2011 with a tallgrass prairie mix, following herbicide application of existing cool season vegetation. As discussed in Section 6.1.1, the area was mowed, raked, and baled in an effort to aid prairie establishment. These areas will be re-evaluated in 2012.

Table 14. Implementation Monitoring Summary

Area	Total Species	Total Native Species	Percent Native Species	Relative Frequency of Native Species	Percent Cover
FPA - Solid Waste Landfill	24	14	58%	51%	85%
FPA-Haul Road	19	11	58%	49%	85%
FPA-Prairie Area	15	5	33%	40%	73%

Ohio spiderwort blooms following a spring prescribed burn

6.2 Fernald Preserve Site and OSDF Inspections

The LMICP sets out a routine inspection process for both the site and the OSDF. Inspections are conducted quarterly with joint participation from DOE and the regulators. Inspections document evidence of unauthorized uses of the site, the effectiveness of institutional controls, and the need for repairs. Ecologically restored areas are evaluated for the presence of noxious weeds, erosion, the condition of vegetation, and signs of damage from nuisance animals. As with 2010, findings in 2011 consisted mostly of the presence of weeds and deer fencing that was damaged by falling trees and limbs. The erosion repair areas described in Section 6.1.1 were identified during the site inspection process. Construction debris also continues to be found, primarily in the Former Production Area and Former Waste Pits area.

For the OSDF inspections, the vegetated cap is walked down and evaluated to ensure that its integrity is maintained. Erosion rills, holes from burrowing animals, noxious weeds, settlement cracks, and other indications that there may be an issue with the proper functioning of the cap are flagged and repaired. In 2011, there were no signs that the integrity of the cap had been compromised in any way. Findings consisted mainly of woody vegetation, noxious weeds, and animal burrows. A stand of woody vegetation (honeysuckle, willows, and multiflora rose) was removed from an area near the southwest corner of the OSDF to proactively remove a seed source from becoming a problem on the OSDF cap.

Quarterly inspection reports are posted on the Legacy Management website at http://www.lm.doe.gov/fernald/Sites.aspx. The quarterly inspection reports can also be viewed online at the Fernald Preserve Visitors Center or by contacting S.M. Stoller Public Affairs at (513) 648-4026.

6.3 Affected Habitat Findings

With large-scale remediation complete, the potential for unanticipated habitat impacts is limited. Nevertheless, impacts may occur during construction or maintenance activities. In 2011, no large areas of restored habitat were affected.

6.4 Threatened and Endangered Species and Species Inventories

Sloan's Crayfish—The state-listed threatened Sloan's crayfish (*Orconectes sloanii*) is found in southwest Ohio and southeast Indiana. It prefers streams with constant (though not necessarily fast) current flowing over rocky bottoms. A large, well-established population of Sloan's crayfish is found at the Fernald Preserve in the northern reaches of Paddys Run.

Indiana Brown Bat—The federally listed endangered Indiana brown bat (*Myotis sodalis*) forms colonies in hollow trees and under loose tree bark along riparian (streamside) areas during the summer. Excellent habitat for the Indiana brown bat has been identified at the Fernald Preserve along the wooded banks of the northern reaches of Paddys Run. The habitat provides an extensive mature canopy of older trees and water throughout the year. One Indiana brown bat was captured and released on the property in August 1999.

Running Buffalo Clover—The federally listed endangered running buffalo clover (*Trifolium stoloniferum*) is a member of the clover family whose flower resembles that of the common white clover. Its leaves, however, differ from those of white clover in that they are heart-shaped and a lighter shade of green. Running buffalo clover has not been identified at the Fernald Preserve; however, because running buffalo clover is found nearby in the Miami Whitewater Forest, the potential exists for this species to become established at the site. The running buffalo clover prefers habitat with well-drained soil, filtered sunlight, limited competition from other plants, and periodic disturbances. Suitable habitat areas include partially shaded former grazed areas along Paddys Run and the storm sewer outfall ditch.

Spring Coral Root—The state-listed threatened spring coral root (*Corallorhiza wisteriana*) is a white and red orchid that blooms in April and May and grows in partially shaded areas of forested wetlands and wooded ravines. This plant has not been identified at the Fernald Preserve; however, suitable habitat exists in portions of the northern woodlot.

Cave Salamander—The state-listed endangered cave salamander (*Eurycea lucifuga*) is slender, red to orange with irregular black dots. It is found in caves, springs, small limestone streams, outcrops, and old springhouses where groundwater is present. It has only been documented in Ohio in Hamilton, Butler, and Adams counties. Suitable habitat within the Fernald Preserve is limited, but populations have been observed just north of the site.

Cobblestone Tiger Beetle—The state-listed threatened cobblestone tiger beetle (*Cicindela marginipennis*) is recognized by its olive-gray back, white sides, and red abdomen. It's found on large gravel bars on medium-sized rivers. Populations have been recorded east of the Fernald Preserve along the Great Miami River.

The Endangered Species Act requires the protection of any federally listed threatened or endangered species and any habitat critical for the species' existence. Several Ohio laws mandate the protection of state-listed endangered species as well. Since 1993, a number of surveys have been conducted to determine the presence of any threatened or endangered species at the site. As a result of these surveys, the federally listed endangered Indiana brown bat and the state-listed threatened Sloan's crayfish have been found at the Fernald Preserve. In addition, suitable habitat exists for the federally listed endangered running buffalo clover, the state-listed threatened spring coral root, the state-listed endangered cave salamander, and the state-listed threatened cobblestone tiger beetle. None of these species have been found on the site, but their habitat ranges encompass the Fernald Preserve. Figure 33 shows the potential habitats for these species. According to provisions in the IEMP, threatened or endangered species habitat will be surveyed as needed prior to any construction activities. If threatened or endangered species are identified, appropriate avoidance or mitigation efforts will be taken.

Although no specific threatened or endangered species surveys were conducted in 2011, several other species inventories took place. Reptile and small-mammal surveys continued around a number of site wetlands using coverboards, which are 2 ft by 4 ft (61 cm by 122 cm) pieces of corrugated sheet metal. Animals are attracted to the cover and warmth the coverboards provide. Three species of snakes and five species of small mammals were observed as part of this effort.

The species surveys in 2011 included the final year of data collection for the Ohio Breeding Bird Atlas, a project that documents the distribution of breeding birds throughout Ohio. As a result of Fernald Preserve's 4-year participation in the Ohio Breeding Bird Atlas, 92 species have been confirmed as nesting on the Fernald Preserve property, and another 15 species have been identified as probable nesters. A total of 212 species have been seen at the Fernald Preserve since its opening in 2008, making it one of the prime birding destinations in southwestern Ohio. The

diverse habitat, which encompasses open water, wetlands, prairies, and forest, supports 6 of the 10 species that the National Audubon Society has deemed a common species in decline, including nesting field sparrows and grasshopper sparrows, northern bobwhite, eastern meadowlark, migrating greater scaup, and northern pintails. During the National Audubon Society's annual Christmas Bird Count, 56 species were seen at the Fernald Preserve, making the site one of the most productive in greater Cincinnati. From a birdwatcher's perspective, the highlight of 2011 was the sighting of a rare garganey at the Fernald Preserve. The garganey is a Eurasian teal that rarely visits North America. Birdwatchers from 24 states and Canada visited Fernald during a 2-week period in late April and early May to view the garganey. The bird's presence also prompted media coverage from a number of local outlets, as well as a mention in national bird-watching publications.

In June 2011, the Fernald Preserve hosted a 24-hour species inventory called a BioBlitz. Many countries hold BioBlitz events, which are a blend of science, celebration, education, and community. Scientists and subject matter experts from a variety of fields took members of the public on searches for amphibians, birds, fish, insects, mammals, mushrooms, plants, reptiles, and spiders. The BioBlitz is an excellent way to learn about the biodiversity at the Fernald Preserve and the surrounding area and to better understand how to protect the many different species that live there. Despite rain during the first evening, a total of 498 species were cataloged at the site.

6.5 Cultural Resources

The Fernald Preserve and surrounding area are located in a region of rich soil and many sources of water, such as the Great Miami River. Because of its advantageous location, the area was settled repeatedly throughout prehistoric and historical time, resulting in richly diverse cultural resources. In summary, 148 prehistoric and 40 historic sites have been identified within 1.24 miles (2 km) of the Fernald Preserve.

Several laws have been established to protect cultural resources. The National Historic Preservation Act requires DOE to consider the effects of its actions on sites that are listed or eligible for listing on the National Register of Historic Places. The Native American Graves Protection and Repatriation Act (43 CFR 10) requires that prehistoric human remains and associated artifacts be identified and returned to the appropriate Native American tribe.

To comply with these laws, DOE conducted archaeological surveys prior to remediation activities in undeveloped areas of the Fernald Preserve. Figure 34 shows the areas of the Fernald Preserve that have been surveyed. These surveys have resulted in the identification of five sites that may be eligible for listing on the National Register of Historic Places. None of these sites were affected by construction activities. An archaeological survey was conducted on approximately 4 acres (1.6 hectares) on the western edge of the site, along Paddys Run Road. This survey was conducted in advance of planned restoration activities in 2012. No prehistoric or historic properties were identified.

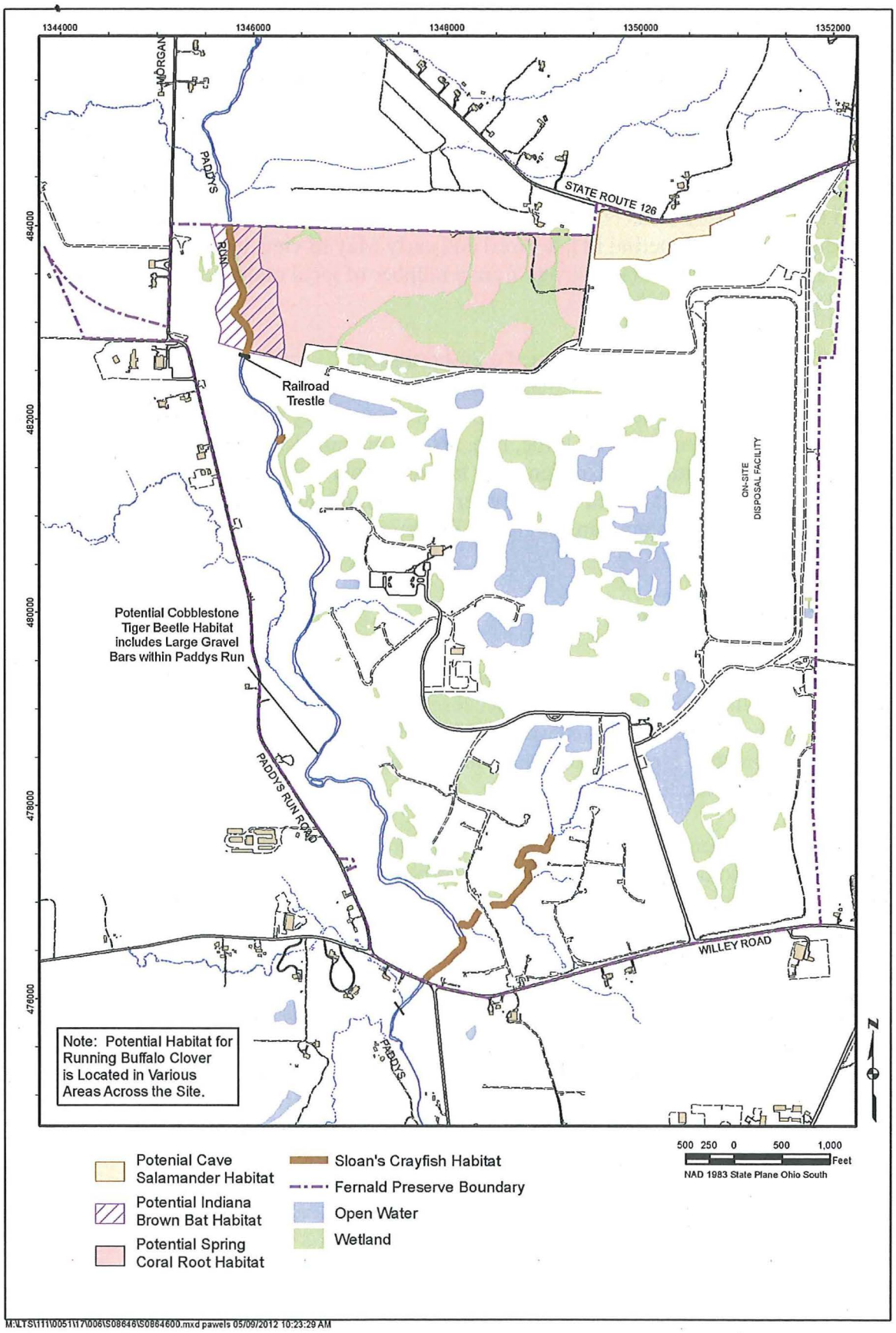

Figure 33. Threatened and Endangered Species Habitat Areas

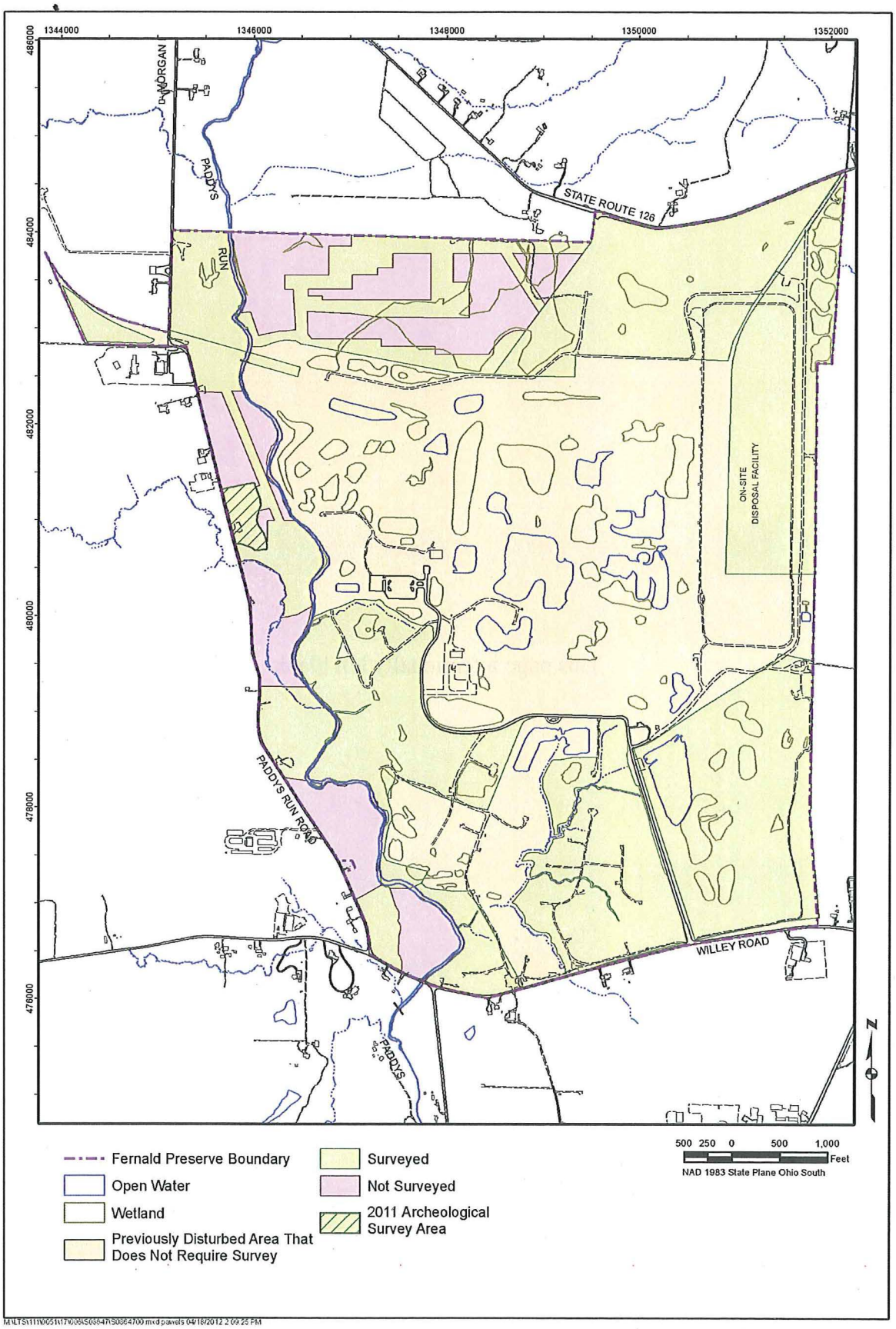

Figure 34. Cultural Resource Survey Area

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Section 8

8.0 Glossary

Amphibian Index of Biotic Integrity—A scoring system that uses amphibians as a means of assessing the quality of wetland communities.

Aquifer—A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs.

ARARs—An acronym for "applicable or relevant and appropriate requirements." Requirements set forth in regulations that implement environmental and public health laws and must be attained or exceeded by a selected remedy unless a waiver is invoked. ARARs are divided into three categories: chemical-specific, location-specific, and action-specific, according to whether the requirement is triggered by the presence or emission of a chemical, by a vulnerable or protected location, or by a particular action.

Background Radiation—Particle or wave energy spontaneously released from atomic nuclei in the natural environment, including cosmic rays and such releases from naturally radioactive elements outside and inside the bodies of humans and animals, and fallout from nuclear weapons tests.

Capture Zone—Estimated area that is being "captured" by the pumping of groundwater extraction wells. The definition of the capture zone is important in ensuring that the uranium plumes targeted for cleanup are being remediated.

Certification—The process by which a soil remediation area is certified as clean. Samples from the area are collected and analyzed, and then the contaminant levels are compared to the final remedial levels established in the OU5 ROD. Not all soil remediation areas at the Fernald site require excavation before certification is done.

Contaminant—A substance that when present in air, surface water, sediment, soil, or groundwater above naturally occurring (background) levels causes degradation of the media.

Controlled Runoff—Contaminated storm water requiring treatment; it is collected, treated, and eventually discharged to the Great Miami River as treated effluent.

Curie (Ci)—Unit of radioactivity that describes the rate of spontaneous, energy-emitting transformations in the nuclei of atoms; 1 curie is equal to 37 billion (3.7×10^{10}) nuclear transformations per second.

Dose—Amount of radiation absorbed in tissue.

Ecological Receptor—A biological organism selected by ecological risk assessors to represent a target species most likely to be affected by site-related chemicals, especially through bioaccumulation. Such organisms may include terrestrial and aquatic species.

Effective Dose Equivalent—The sum of the products of the dose equivalent received by specified tissues of the body and tissue-specific weighting factor. This sum is a risk-equivalent value and can be used to estimate the risk of health effects to the exposed individual. The tissue-specific weighting factor represents the fraction of the total health risk resulting from uniform whole-body irradiation that would be contributed by that particular tissue. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent due to penetrating radiation from sources external to the body. Effective dose equivalent is expressed in units of rem or sievert.

Exposure Pathway—A route materials can travel between the point of release and the point of delivery of a radiation or chemical dose to a receptor organism.

Fly Ash—The ash remaining after burning coal in a boiler plant.

Gamma Ray—Type of electromagnetic radiation of discrete energy emitted during radioactive decay of many radioactive elements.

Glacial Overburden/Glacial Till—Silt, sand, gravel, and clay deposited by glacial action on top of the Great Miami Aquifer and surrounding bedrock highs.

Great Miami Aquifer—Sand and gravel deposited by the meltwaters of Pleistocene glaciers within the entrenched ancestral Ohio and Miami rivers. This is also called a buried channel or a sand and gravel aquifer.

Groundwater—Water in a saturated zone or stratum beneath the surface of land.

Hydric—Wetland soil; soil that is saturated, ponded, or flooded long enough during the growing season that oxygen-deficient conditions form.

Hydrophytic—Wetland vegetation; vegetation that is adapted to grow in soil that is periodically deficient in oxygen as a result of excessive water content.

Mixed Waste—Hazardous waste that has been contaminated with low-level radioactive materials.

Morphometry—Measurement of the shape or form of an area.

Point Source—The single defined point (origin) of a release such as a stack, vent, or other discernible conveyance.

Radiation—The energy released as particles or waves when an atom's nucleus spontaneously loses or gains neutrons or protons. The three main types are alpha particles, beta particles, and gamma rays.

Radioactive Material—Refers to any material or combination of materials that spontaneously emits ionizing radiation.

Radionuclide—Refers to a radioactive nuclide. There are several hundred known radionuclides that are artificially produced and naturally occurring. Radionuclides are characterized by the number of neutrons and protons in an atom's nucleus and their characteristic decay processes.

Receptors—Individuals or organisms that are or can be impacted by contamination.

Remedial Action—The actual construction and implementation phase of a Superfund site cleanup that follows the remedy selection process and remedial design.

Remedial Investigation/Feasibility Study—The first major event in the remedial action process that serves to assess site conditions and evaluate alternatives to the extent necessary to select a remedy.

Removal Action—A short-term cleanup or removal of released hazardous substances from the environment. A removal action is performed in response to a release or the imminent threat of release of hazardous substances into the environment.

Roentgen Equivalent Man (rem)—A special unit of dose equivalent that expresses the effective dose calculated for all radiation on a common scale; the absorbed dose in rads multiplied by certain modifying factors (e.g., quality factor); 100 rem = 1 sievert.

Sediment—The unconsolidated inorganic and organic material that is suspended in surface water and is either transported by the water or has settled out and become deposited in beds.

Source—A controlled source of radioactive material used to calibrate radiation detection equipment. Can also be used to refer to any source of contamination (e.g., a point source such as the stack on the waste pits stack, a source of radon such as the silo's headspace).

Surface Water—Water that is flowing within natural drainage features.

Treated Effluent—Water from numerous areas at the site that is treated through one of the site's wastewater treatment facilities and discharged to the Great Miami River.

Uncontrolled Runoff—Storm water that is not collected by the site for treatment, but enters the site's natural drainages.

Vegetation Index of Biotic Integrity—A scoring system that uses vascular plants as a means of assessing the quality of a given plant community.

Volatile Organic Compound—A hydrocarbon compound, except methane and ethane, with a vapor pressure equal to or greater than 0.1 millimeter of mercury.

Waste Acceptance Criteria—Disposal facilities specify the types and sizes of materials, acceptable levels of constituents, and other criteria for all material that will be disposed in that facility. These are known as waste acceptance criteria. Offsite disposal facilities such as the Nevada National Security Site (formerly called the Nevada Test Site) that dispose of Fernald waste have specific waste acceptance criteria. In addition, the OSDF had waste acceptance criteria that were approved by the regulatory agencies.

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7316

LMS/FER/S08629

Fernald Preserve
2011 Site Environmental Report

2011 Environmental Summary (Appendixes A Through D)

May 2012

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Fernald Preserve
2011 Site Environmental Report

2011 Environmental Summary (Appendixes A Through D)

May 2012

U.S. Department of Energy
Office of Legacy Management

7316

Appendix A

Appendix A

Supplemental Groundwater Information

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Contents

Attachment A.1 Operational Assessment
Attachment A.2 Assessment of Total Uranium Results
Attachment A.3 Groundwater Elevations and Capture Assessment
Attachment A.4 Non-uranium FRL Results
Attachment A.5 On-Site Disposal Facility Monitoring Results
Sub-attachment A.5.1 Cell 1
Sub-attachment A.5.2 Cell 2
Sub-attachment A.5.3 Cell 3
Sub-attachment A.5.4 Cell 4
Sub-attachment A.5.5 Cell 5
Sub-attachment A.5.6 Cell 6
Sub-attachment A.5.7 Cell 7
Sub-attachment A.5.8 Cell 8

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Acronyms

amsl	above mean sea level
bgs	below ground surface
CAWWT	Converted Advanced Wastewater Treatment Facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CUSUM	Shewhart-cumulative sum
EPA	U.S. Environmental Protection Agency
EW	extraction well
FRL	final remediation level
GMA	Great Miami Aquifer
GMA-D	Great Miami Aquifer-downgradient
GMA-SE	Great Miami Aquifer-southeast
GMA-SW	Great Miami Aquifer-southwest
GMA-U	Great Miami Aquifer-upgradient
GWLMP	Groundwater/Leak Detection and Leachate Monitoring Plan
HTW	horizontal till well
IEMP	Integrated Environmental Monitoring Plan
LCS	leachate collection system
LDS	leak detection system
LM	DOE Office of Legacy Management
LMICP	*Comprehensive Legacy Management and Institutional Controls Plan*
NA	not applicable
ND	not detected
NTU	Nephelometric Turbidity Units
ODH	Ohio Department of Health
OMMP	Operations and Maintenance Master Plan
OSDF	on-site disposal facility
OU	Operable Unit
PCB	polychlorinated biphenyls
P/PB	Property/Plume Boundary
PRRS	Paddys Run Road Site
PQL	practical quantitation limit
RCRA	Resource Conservation and Recovery Act
RDL	required detection limit
ROD	Record of Decision
RW	recovery well
SCL	Shewhart control limit

SD	standard deviation
SSOD	Storm Sewer Outfall Ditch
SU	standard unit
TDS	total dissolved solids
TOC	total organic carbon
TOX	total organic halogens
UCL	upper confidence level
VAM 3D	Variable Saturated Analysis Model in 3 Dimensions
WSA	Waste Storage Area

Measurement Abbreviations

ft	feet
gpad	gallons per acre per day
gpm	gallons per minute
lb	pound
m	meter
M gal	million gallons
mg/L	milligrams per liter
pCi/L	picocuries per liter
µg/L	micrograms per liter
yd^3	cubic yards

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Appendix A presents groundwater data and analysis in support of Chapter 3. This appendix consists of the following five attachments:

- Attachment A.1 provides operational data for the South Field Module, the South Plume Module, and the Waste Storage Area Module.
- Attachment A.2 provides total uranium data (including summary statistics) and plume maps for the first and second halves.
- Attachment A.3 provides groundwater elevation data and quarterly water level maps.
- Attachment A.4 provides an analysis of the non-uranium final remediation level (FRL) exceedances both inside and outside the Waste Storage Area (Phase II) design remediation footprint.
- Attachment A.5 presents leak detection and leachate monitoring results associated with the On-Site Disposal Facility (OSDF) monitoring program.

Groundwater analytical data are available through the Department of Energy Office of Legacy Management's Geospatial Environmental Mapping System (http://www.lm.doe.gov/Fernald/Sites.aspx).

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Attachment A.1

Attachment A.1

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A.1.0 Operational Assessment

This attachment presents operational data for each extraction well pumping in 2011, and estimates on when uranium concentrations at each extraction well will reach the aquifer cleanup standard for uranium of 30 micrograms per liter (µg/L). During 2011, 23 extraction wells were operational. Figure A.1–1 depicts the locations of extraction and former re-injection wells and identifies surrounding monitoring wells. Table A.1–1 provides summaries of gallons pumped, total uranium removed, and uranium removal indices for 2011 and for August 1993 through December 2011.

Information in this attachment is organized into the following subsections:

- South Field Module (Section A.1.1)
- South Plume Module (Section A.1.2)
- Waste Storage Area Module (Section A.1.3)
- Total Uranium Data (Section A.1.4)
- Pumping Rates (Section A.1.5).

A.1.1 South Field Module

Thirteen extraction wells were operational in the South Field Module in 2011. The 13 active extraction wells (EW) are 31550 (EW-18), 31560 (EW-19), 31561 (EW-20), 33326 (EW-17a), 32276 (EW-22), 32446 (EW-24), 32447 (EW-23), 33061 (EW-25), 33262 (EW-15a), 33264 (EW-30), 33265 (EW-31), 33266 (EW-32), and 33298 (EW-21a).

The target combined pumping rate for the South Field Module wells in 2011 was 2,575 gallons per minute (gpm). The combined performance data for the South Field Module are presented in Table A.1–1. This target rate is consistent with pumping rates defined for the Waste Storage Area (Phase II) Model Design. Tables A.1–2 through A.1–14 provide individual extraction well performance data for 2011. The footnotes explain individual extraction well outages of greater than 24 hours.

During 2011, 1,290.96 million gallons (M gal) of groundwater were pumped by the active extraction wells in the South Field Module, resulting in the removal of 337.71 pounds (lbs) of uranium from the Great Miami Aquifer (GMA). Since startup of the South Field Module in July 1998, the module has removed 14.87 billion gallons of water and 6,504.87 lbs of uranium from the GMA.

A.1.2 South Plume Module

Six extraction wells were operational in the South Plume Module in 2011. The six active recovery wells (RW) are 3924 (RW-1), 3925 (RW-2), 3926 (RW-3), 3927 (RW-4), 32308 (RW-6), and 32309 (RW-7). These wells are located south of Willey Road and north of New Haven Road.

The target combined pumping rate for the South Plume Module in 2011 was 1,200 gpm. Tables A.1–15 through A.1–20 provide individual extraction well performance data for the

South Plume Module extraction wells in 2011. The footnotes explain individual extraction well outages of greater than 24 hours. The combined performance data for the South Plume Module are presented in Table A.1–1.

During 2011, 620.53 M gal of groundwater were pumped by the six wells in the South Plume Module, resulting in the removal of 107.94 lbs of uranium from the GMA. Since startup of the South Plume Module in August 1993, the module has removed 13.05 billion gallons of groundwater and 2,685.66 lbs of uranium from the GMA.

During 2011, the South Plume Module continued to meet the primary objectives of:

- Preventing further southward movement of the total uranium plume while capturing the main lobe of the South Plume without adversely affecting the Paddys Run Road Site (PRRS) plume (3924 [RW-1], 3925 [RW-2], 3926 [RW-3], and 3927 [RW-4]).
- Actively remediating the higher concentration region of the off-property plume (32308 [RW-6] and 32309 [RW-7]).

Attachment A.3 presents additional details concerning capture, along with supporting data.

In 2011, as in previous years, PRRS constituents of concern (arsenic, phosphorus, potassium, sodium, and volatile organic compounds) were monitored at 11 monitoring well locations immediately south of the South Plume Module to ensure that the operation of the system does not adversely impact the PRRS plume. The 11 wells monitored were 2128, 2625, 2636, 2898, 2899, 2900, 3128, 3636, 3898, 3899, and 3900 (refer to Figure A.1–1).

The Mann-Kendall test for trend was run on PRRS data collected from these wells. As indicated in Table A.1–21, three parameters at five different wells monitored for PRRS constituents of concern had "up, significant" trends:

- Arsenic in monitoring wells 2898, 2899, 3636, 3898, and 3899
- Potassium in monitoring wells 2898, 2899, 3898, and 3899
- Sodium in monitoring wells 3898 and 3899

Concentration versus time plots for these constituents and wells are provided in Figures A.1–2 through A.1–12. As reported in Attachment A.3, with the exception of well 3636, the groundwater flow direction at these wells was from the northeast to southwest. This indicates that the increasing concentrations at these locations were moving toward the PRRS plume, not away from it. Well 3636 is south of the south plume extraction wells. Water table maps provided in Attachment A.3 indicate that the flow direction at Well 3636 is to the south, away from the south plume wells.

The monitoring activity for PRRS constituents of concern also included sampling for volatile organic compounds. These compounds are monitored because they were present in the PRRS plume, which is not of Fernald origin (ERM Midwest, Inc. 1994).

In 2011, toluene was detected in five different monitoring wells (well 2900, well 3636, well 3898, well 3899, and well 3900). All results were assigned a qualifier of "J", which indicates the results are estimated values. The "J" qualifier was assigned, because the results were above the method detection limit but below contract required detection limit of 10 μg/L.

Toluene was detected last year in wells 3636 and 3900, again qualified as "J" for the same reason. Toluene is a common lab contaminant. Given the low estimated values of these detections, continued monitoring is the recommended action at this time.

A.1.3 Waste Storage Area Module

Four extraction wells were operational in the former Waste Storage Area in 2011. The four extraction wells are 32761 (EW-26), 33062 (EW-27), 33334 (EW-28a), and 33347 (EW-33a).

The target combined pumping rate for the Waste Storage Area Module wells in 2011 was 1,000 gpm. This target pumping rate is consistent with the Waste Storage Area (Phase II) Model Design. Tables A.1–22 through A.1–25 provide individual extraction well performance data for the Waste Storage Area Module wells. The combined performance data for the Waste Storage Area Module are presented in Table A.1–1.

During 2011, 519.93 M gal of groundwater were pumped from extraction wells in the Waste Storage Area Module, resulting in the removal of 98.07 lbs of uranium from the GMA. Since startup of the Waste Storage Area Module in May 2002, 4.264 billion gallons of water and 1,690.642 lbs of uranium have been removed from the GMA.

A.1.4 Total Uranium Data

Water samples were collected monthly in 2011 from the extraction wells and analyzed for total uranium. The total uranium concentrations are used to calculate the mass of uranium removed by the well, support the statistical trend analysis presented in Attachment A.2, and determine if a well is routed to treatment or to bypass treatment. Figure A.1–13 provides a graph of the monthly gallons of groundwater extracted versus the monthly gallons of groundwater treated for 2011. Since 2005, the percentage of treatment needed to achieve uranium discharge limits has been decreasing. Data collected since 2010 indicates that the aquifer remedy can now achieve the uranium discharge limits (i.e., average monthly concentration of less than 30 µg/L, and 600 lbs annually) established in the Operable Unit 5 (OU5) Record of Decision (ROD) without groundwater treatment.

Uranium concentration data collected from the extraction wells are also being tracked graphically to predict when the extraction-well-specific uranium concentrations will reach the groundwater remediation goal of 30 µg/L and to help determine how long groundwater treatment will be necessary. The data are tracked by plotting uranium concentrations over time and then fitting a regression line to the data set.

Figures A.1–14 through A.1–36 are uranium concentration versus time plots for each extraction well. Each graph displays three different data sets (operational data, 95 percent upper confidence level [UCL] of the operational data, and model predictions). Trend lines for the operational data set and the 95 percent UCL of the operational data set were fitted using the regression analysis function in Microsoft Excel software.

As pumping continues, the uranium concentration of the pumped groundwater will decrease. The slope of a fitted regression curve through the uranium concentration data set collected at each extraction well provides a prediction of when pumping concentrations will decrease below 30 µg/L at each well. However, the slope of a fitted regression curve through the pumped uranium concentration data set is an insufficient statistical measure by itself because future

measured concentrations could vary about the trend curve. U.S. Environmental Protection Agency (EPA) guidelines in *General Methods for Remedial Operation Performance Evaluations* (EPA 1992a) suggest that a 95 percent UCL of the measured uranium concentration data set can be used to help evaluate the uncertainty of the predicted data trend. From this perspective, the concentration trend of the measured data set presents a less conservative prediction of when pumping concentrations will decrease below 30 µg/L, and the 95 percent UCL data trend presents a more conservative trend prediction (i.e., longer predicted cleanup times).

The graphs in Figures A.1–14 through A.1–36 predict for each extraction well when the actual measured concentrations and the 95 percent UCL calculated concentrations will reach the 30 µg/L FRL for total uranium. For example, the concentration trend of pumped water from extraction well 31550 (refer to Figure A.1–18) reaches 30 µg/L in approximately 2010 (trend for the measured data set) or beyond 2025 (trend for the 95 percent UCL data).

Figures A.1–14 through A.1–36 also show how modeled uranium concentration predictions relate to the measured and 95 percent UCL data trends. The Variable Saturated Model in 3 Dimensions (VAM 3D) groundwater model uranium concentration predictions are taken from modeling results for the Waste Storage Area (Phase II) Design (DOE 2005a). Groundwater model predictions are based on the assumption that an equilibrium linear isotherm adequately describes the partitioning of total uranium between the sorbed and dissolved phases.

The Fernald groundwater model predicts the future average pounds of uranium that will be removed from the aquifer for each year of the modeled remedy. The average annual pounds of uranium actually removed from the aquifer are compared to the model predictions to assess remedy progress. Concentration regression equations based on measured concentration data collected at the extraction wells are also used to provide a prediction of the number of pounds of uranium that will be removed from the aquifer in future years. Regression equations based on uranium concentration data collected at extraction wells through December 31, 2011, are summarized in Table A.1–26.

At the end of December 2011, approximately 10,805 net lbs of uranium had been removed from the GMA by the pump-and-treat remedy. Model predictions indicate that through 2024 an additional 3,219 lbs of uranium will be removed from the GMA by operating the system according to the Waste Storage Area (Phase II) Design. The concentration data set indicates that an additional 3,313 lbs of uranium will be removed from the GMA based on regression analyses of the individual well data. The 95 percent UCL measured concentration data set indicates that an additional 13,250 lbs of uranium will be removed from the GMA based on regression analyses of the individual well data. A summary of the predictions are provided below.

	Data	Model	95% UCL[a]
Net pounds of uranium extracted through December 2011	10,805		
Predicted pounds of uranium to be extracted between 2012 and the end of the pump and treat stage of the aquifer remedy	3,313	3,219	13,250
Total predicted pounds of uranium to be removed	**14,118**	**13,930**	**24,055**
Estimated Percent Complete (based on pounds of uranium to be removed)	**76%**	**77%**	**45%**

[a] UCL = Upper Confidence Limit

Table A.1–27 provides a yearly breakdown for the three predictions. Figure A.1–37 illustrates the relationship between the three estimates.

Results indicate that as of January 1, 2011, the extraction well concentration trend-based estimated percent complete for the pump and treat stage of the aquifer remedy is approximately 76 percent (based on the uranium concentration data set) or 77 percent (based on the model predictions). The pump and treat stage of the aquifer remedy is approximately 45 percent complete based on the 95 percent UCL data set. The regression trend predictions based on the measured concentration data are very close to the modeled predictions.

As shown in Table A.1-27, 2011 marks the first year that the percent complete based on concentration data is smaller than the percent complete based on model predictions (76 percent compared to 77 percent respectively). This switch indicates that the modeled cleanup predictions are becoming more optimistic than the actual measured concentration data indicates. The uranium decreases plotted at each extraction well illustrate that the concentration curves are trending asymptotic. Actual uranium decreases measured in the field are decreasing each year. This trend is a characteristic of pump-and-treat remediations in general. DOE will continue to track this trend and may recommend operational changes in efforts to improve uranium removal efficiencies as the remedy continues.

A.1.5 Pumping Rates

Daily pumping rate data for each extraction well are presented on the U.S. Department of Energy Office of Legacy Management's (LM) website under the Fernald Preserve (http://www.lm.doe.gov/fernald/Sites.aspx); therefore, those data are not repeated here. The footnotes in the well-specific operational tables explain individual well outages of greater than 24 hours.

Target extraction well pumping rates for 2011 are provided in Table A.1–28. The total target pumping rate of 4,775 gpm is consistent with the rate defined by the Waste Storage Area (Phase II) Model Design. As additional operational experience is gained, pumping rates may change as efforts are made to maximize the effectiveness of each module.

Table A.1–1. Aquifer Restoration System Operational Summary Sheet

	Reporting Period					
	January 2011 through December 2011			August 1993 through December 2011		
	Gallons Pumped/ Re-injected (M gal)[a]	Total Uranium Removed/ Re-injected (lbs)	Uranium Removal Index[b] (lbs/M gal)	Gallons Pumped/ Re-injected (M gal)	Total Uranium Removed/ Re-injected (lbs)	Uranium Removal Index[b] (lbs/M gal)
South Field Module	1,290.96	337.71	0.26	14,867.885	6,504.874	0.44
Waste Storage Area Module	519.93	98.07	0.19	4,264.753	1,690.642	0.40
South Plume Module	620.53	107.94	0.17	13,050.465	2,685.655	0.21
Re-injection Module[c]	0	0	NA	1,936.478	76.27	NA
Aquifer Restoration Systems Totals						
Extraction Wells	2,431.42	543.72	0.22	32,183.103	10,881.171	0.34
(Re-injection Wells[c])	0	0	NA	(1,936.478)	(76.27)	NA
Net	2431.42	543.72	NA	30,246.625	10,804.901	NA

[a] million gallons
[b] NA = not applicable
[c] Re-injection module was shut down in September 2004

Table A.1–2. Extraction Well 31550 (EW-18) Operational Summary Sheet For 2011

Reference Elevation (feet [ft] amsl) – 572.11 (top of well)
Northing Coordinate ('83) – 477,018.5
Easting Coordinate ('83) – 1,348,979.8

Hours in reporting period – 8,760
Hours not pumped – 682

Hours pumped – 8,078
Operational percent – 92.21
Adjusted operational percent[a] – 99.90

Target pumping rate – 100 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11		105.3		4.698		35.4		0.30
2/11		105.5		4.255		35.4		0.30
3/11		105.0		4.688		36.4		0.30
4/11		102.1		4.412		40.9		0.34
5/11		103.3		4.612		45.0		0.38
6/11		42.8		1.849		43.4		0.36
7/11		82.2		3.669		45.0		0.38
8/11		104.7		4.675		43.0		0.36
9/11		100.6		4.347		41.4		0.35
10/11		104.5		4.666		38.3		0.32
11/11		108.5		4.687		37.7		0.31
12/11		105.9		4.727		38.3		0.32
	Average	97.5	Total	51.286	Average	40.0	Average	0.33

[a] Adjusted for planned annual well field shutdown.
[b] Well 18 was down from Jun 13 to Jul 11 for annual well field shutdown.
Well 18 was down from Jul 24 to Jul 26 for a blown fuse.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–3. Extraction Well 31560 (EW-19) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 574.93 (top of well)
Northing Coordinate ('83) – 477,403.1
Easting Coordinate ('83) – 1,349,028.9

Hours in reporting period – 8,760
Hours not pumped – 682

Hours pumped – 8,078
Operational percent – 92.21
Adjusted operational percent[a] – 99.89

Target pumping rate – 100 gpm

Monthly Measurements at Well Field							
Month	**Monthly Average Pumping Rate[b] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11	108.3		4.833		16.1		0.65
2/11	106.2		4.280		15.1		0.54
3/11	106.2		4.739		16.9		0.67
4/11	107.2		4.630		21.1		0.82
5/11	108.8		4.857		24.5		0.99
6/11	44.9		1.940		23.2		0.38
7/11	72.8		3.248		30.3		0.82
8/11	106.3		4.744		29.0		1.15
9/11	103.4		4.466		24.7		0.92
10/11	106.0		4.733		22.9		0.90
11/11	108.9		4.706		20.4		0.80
12/11	112.4		5.017		22.4		0.94
Average	99.3	Total	52.193	Average	22.2	Average	0.19

[a] Adjusted for planned annual well field shutdown.
[b] Well 19 was down from Jun 13 to Jul 11 for annual well field shutdown.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–4. Extraction Well 31561 (EW-20) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 578.77 (top of well)
Northing Coordinate ('83) – 477,660.8
Easting Coordinate ('83) – 1,349,254.5

Hours in reporting period – 8,760
Hours not pumped – 774.5

Hours pumped – 7,986
Operational percent – 91.16
Adjusted operational percent[a] – 98.75

Target pumping rate – 100 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**M Gal Pumped**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11	111.2	4.966	30.3	0.25
2/11	108.3	4.368	30.6	0.26
3/11	112.9	5.038	27.0	0.23
4/11	108.9	4.705	29.2	0.24
5/11	106.4	4.751	27.7	0.23
6/11	43.7	1.886	29.2	0.24
7/11	73.7	3.289	29.3	0.24
8/11	108.7	4.854	32.2	0.27
9/11	110.5	4.774	33.2	0.28
10/11	110.3	4.923	34.5	0.29
11/11	113.8	4.915	33.9	0.28
12/11	115.2	5.140	32.9	0.27
Average	102.0	Total 53.609	Average 30.8	Average 0.26

[a] Adjusted for planned annual well field shutdown.
[b] Well 20 was down from Feb 16 to Feb 17 for chemical treatment.
Well 20 was down from Jun 13 to Jul 11 for annual well field shutdown.
Well 20 was down from Nov 22 to Nov 23 for chemical treatment.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–5. Extraction Well 33326 (EW-17a) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 574.84 (top of well)
Northing Coordinate ('83) – 477,905.5
Easting Coordinate ('83) – 1,348,854.1

Hours in reporting period – 8,760
Hours not pumped – 1,091

Hours pumped – 7,669
Operational percent – 87.55
Adjusted operational percent[a] – 94.8

Target pumping rate – 175 gpm

Monthly Measurements at Well Field							
Month	**Monthly Average Pumping Rate[b] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11	160.3		7.155		16.2		0.14
2/11	164.6		6.638		16.5		0.14
3/11	174.2		7.778		17.0		0.14
4/11	177.0		7.648		20.1		0.17
5/11	187.6		8.375		20.3		0.17
6/11	65.8		2.843		18.8		0.16
7/11	115.9		5.176		22.4		0.19
8/11	160.2		7.151		22.9		0.19
9/11	134.6		5.815		22.0		0.18
10/11	197.0		8.795		19.3		0.16
11/11	191.5		8.273		19.8		0.17
12/11	189.7		8.469		20.2		0.17
Average	159.9	Total	84.116	Average	19.6	Average	0.16

[a] Adjusted for planned annual well field shutdown.
[b] Well 17a was down from Feb 16 to Feb 17 for chemical treatment.
Well 17a was down from Jun 9 to Jun 10 for chemical treatment.
Well 17a was down from Jun 13 to Jul 11 for annual well field shutdown.
Well 17a was down from Aug 23 to Aug 24 for chemical treatment.
Well 17a was down from Aug 28 to Sep 8 due to a ground fault.
Well 17a was down from Sep 7 to Sep 8 to replace variable frequency drive.
Well 17a was down from Sep 19 to Sep 20 for chemical treatment.
Well 17a was down from Dec 19 to Dec 20 for chemical treatment.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–6. Extraction Well 32276 (EW-22) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 567.14 (top of well)
Northing Coordinate ('83) – 476,447.3
Easting Coordinate ('83) – 1,348,857.3

Hours in reporting period – 8,760
Hours not pumped – 738

Hours pumped – 8,023
Operational percent – 91.58
Adjusted operational percent[a] – 99.21

Target pumping rate – 300 gpm

Monthly Measurements at Well Field								
Month	**Monthly Average Pumping Rate[b] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**	
1/11		300.0		13.392		32.9		0.27
2/11		276.0		11.128		31.9		0.27
3/11		316.9		14.146		30.2		0.25
4/11		316.9		13.688		33.6		0.28
5/11		328.8		14.678		34.0		0.28
6/11		132.4		5.720		37.8		0.32
7/11		224.1		10.005		40.5		0.34
8/11		421.0		18.792		35.3		0.29
9/11		327.5		14.146		33.5		0.28
10/11		326.9		14.594		32.2		0.27
11/11		330.7		14.288		30.6		0.26
12/11		298.1		13.308		29.6		0.25
	Average	298.1	Total	157.877	Average	33.5	Average	0.28

[a] Adjusted for planned annual well field shutdown.
[b] Well 22 was down from Feb 21 to Feb 22 for chemical treatment.
Well 22 was down from Jun 13 to Jul 11 for annual well field shutdown.
Well 22 was down from Dec 21 to Dec 22 for chemical treatment.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–7. Extraction Well 32446 (EW-24) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 578.367 (top of well)
Northing Coordinate ('83) – 476,634.53
Easting Coordinate ('83) – 1,349,312.38

Hours in reporting period – 8,760
Hours not pumped – 981

Hours pumped – 7,779
Operational percent – 88.8
Adjusted operational percent[a] – 96.19

Target pumping rate – 300 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11		279.1		12.460		42.6		0.36
2/11		291.1		11.738		31.9		0.25
3/11		321.4		14.348		40.2		0.34
4/11		317.4		13.710		43.5		0.36
5/11		293.5		13.104		42.9		0.36
6/11		36.8		1.589		39.8		0.33
7/11		213.2		9.515		40.9		0.34
8/11		303.9		13.567		41.2		0.34
9/11		315.6		13.633		42.5		0.35
10/11		323.8		14.453		41.6		0.35
11/11		312.0		13.477		40.6		0.34
12/11		330.6		14.757		40.0		0.33
	Average	278.2	Total	146.352	Average	40.6	Average	0.34

[a] Adjusted for planned annual well field shutdown.
[b] Well 24 was down from Jan 10 to Jan 13 due to a problem with the variable frequency drive.
Well 24 was down from Feb 17 to Feb 18 for chemical treatment.
Well 24 was down from Jun 6 to Jun 9 for chemical treatment and motor repair.
Well 24 was down from Jun 13 to Jul 11 for annual well field shutdown.
Well 24 was down from Aug 22 to Aug 23 for chemical treatment.
Well 24 was down from Aug 30 to Aug 31 for chemical treatment.
Well 24 was down from Nov 21 to Nov 22 for chemical treatment.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–8. Extraction Well 32447 (EW-23) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 574.528 (top of well)
Northing Coordinate ('83) – 477,150.24
Easting Coordinate ('83) – 1,349,421.19

Hours in reporting period – 8,760
Hours not pumped – 918

Hours pumped – 7,842
Operational percent – 89.5
Adjusted operational percent[a] – 96.97

Target pumping rate – 300 gpm

Monthly Measurements at Well Field							
Month	**Monthly Average Pumping Rate[b] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11	259.7		11.593		23.7		0.20
2/11	261.2		10.531		51.5		0.43
3/11	313.1		13.976		47.6		0.40
4/11	296.4		12.804		52.4		0.44
5/11	247.6		11.052		50.4		0.42
6/11	87.3		3.769		40.58		0.34
7/11	215.7		9.629		44.98		0.38
8/11	276.1		12.324		52.3		0.44
9/11	313.7		13.554		53.4		0.45
10/11	304.4		13.591		53.4		0.45
11/11	278.7		12.038		51.3		0.43
12/11	326.2		14.561		53		0.44
Average	265.0	Total	139.422	Average	47.9	Average	0.40

[a] Adjusted for planned annual well field shutdown.
[b] Well 23 was down from Feb 17 to Feb 18 for chemical treatment.
Well 23 was down from June 6 to June 7 for chemical treatment.
Well 23 was down from Jun 8 to Jun 9 for chemical treatment.
Well 23 was down from Jun 13 to Jul 11 for annual well field shutdown.
Well 23 was down from Aug 22 to Aug 23 for chemical treatment.
Well 23 was down from Aug 30 to Aug 31 for chemical treatment.
Well 23 was down from Nov 21 to Nov 22 for chemical treatment.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–9. Extraction Well 33061 (EW-25) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 575.56 (top of well)
Northing Coordinate ('83) – 478,318.82
Easting Coordinate ('83) – 1,349,531.03

Hours in reporting period – 8,760
Hours not pumped – 823

Hours pumped – 7937
Operational percent – 90.6
Adjusted operational percent[a] – 98.15

Target pumping rate – 100 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**	**M Gal Pumped**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**	
1/11		145.9		6.512		25.20		0.21
2/11		129.4		5.219		21.20		off
3/11		107.8		4.812		22.20		off
4/11		103.6		4.476		37.30		0.31
5/11		109.2		4.873		53.50		0.45
6/11		28.5		1.233		52.55		0.44
7/11		71.4		3.187		46.22		0.39
8/11		104.6		4.669		45.90		0.38
9/11		99.4		4.293		36.10		0.30
10/9		105.1		4.691		32.20		0.27
11/11		106.7		4.609		30.70		0.26
12/11		104.1		4.649		41.50		0.35
	Average	101.3	Total	53.222	Average	37.0	Average	0.33

[a] Adjusted for planned annual well field shutdown.
[b] Well 25 was down from Feb 15 to Feb 16 for chemical treatment.
Well 25 was down from Jun 9 to Jul 11 for rehab and annual well field shutdown.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–10. Extraction Well 33262 (EW-15a) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 568.368 (top of well)
Northing Coordinate ('83) – 477,799.912
Easting Coordinate ('83) – 1,348,149.97

Hours in reporting period – 8,760
Hours not pumped – 898

Hours pumped – 7,863
Operational percent – 89.8
Adjusted operational percent[a] – 97.23

Target pumping rate – 200 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11		216.8		9.679		25.0		0.21
2/11		217.4		8.767		24.9		0.21
3/11		216.0		9.640		23.5		0.20
4/11		210.4		9.091		32.8		0.27
5/11		155.6		6.947		33.8		0.28
6/11		88.0		3.802		35.5		0.30
7/11		151.1		6.744		38.4		0.32
8/11		217.5		9.708		35.1		0.29
9/11		213.8		9.234		32.7		0.27
10/11		213.3		9.521		37.5		0.31
11/11		218.6		9.443		32.5		0.27
12/11		216.1		9.645		36.0		0.30
	Average	194.5	Total	102.221	Average	32.3	Average	0.27

[a] Adjusted for planned annual well field shutdown.
[b] Well 15a was down from May 14 to May 23 due to lightning strike.
Well 15a was down from Jun 13 to Jul 11 for annual well field shutdown.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–11. Extraction Well 33264 (EW-30) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 573.818 (top of well)
Northing Coordinate ('83) – 477,200.945
Easting Coordinate ('83) – 1,349,751.49

Hours in reporting period – 8,760
Hours not pumped – 850

Hours pumped – 7,910
Operational percent – 90.3
Adjusted operational percent[a] – 97.8

Target pumping rate – 200 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11		210.0		9.374		39.0		0.33
2/11		201.9		8.141		39.1		0.33
3/11		210.1		9.377		42.4		0.35
4/11		207.8		8.976		46.0		0.38
5/11		204.1		9.113		43.2		0.36
6/11		53.7		2.318		37.3		0.31
7/11		145.0		6.474		25.8		0.22
8/11		213.0		9.510		41.4		0.35
9/11		203.7		8.798		40.7		0.34
10/11		213.5		9.532		42.3		0.35
11/11		211.4		9.132		40.5		0.34
12/11		210.0		9.375		40.1		0.33
	Average	190.3	Total	100.12	Average	39.8	Average	0.33

[a] Adjusted for planned annual well field shutdown.
[b] Well 30 was down from Jun 9 to Jul 11 for rehab and annual well field shutdown.
Well 30 was down from Dec 30 to Dec 31 for unknown reasons.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–12. Extraction Well 33265 (EW-31) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 577.474 (top of well)
Northing Coordinate ('83) – 477,598.909
Easting Coordinate ('83) – 1,349,849.01

Hours in reporting period – 8,760
Hours not pumped – 1,049

Hours pumped – 7,711
Operational percent – 88.03
Adjusted operational percent[a] – 95.35

Target pumping rate – 300 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11		326.7		14.583		12.4		0.10
2/11		318.3		12.833		11.8		0.10
3/11		322.3		14.388		13.4		0.11
4/11		313.2		13.531		14.0		0.12
5/11		244.2		10.899		16.0		0.13
6/11		130.2		5.623		15.5		0.13
7/11		214.0		9.555		21.3		0.18
8/11		311.2		13.891		18.4		0.15
9/11		313.7		13.551		14.2		0.12
10/11		280.3		12.514		12.5		0.10
11/11		319.9		13.819		14.4		0.12
12/11		306.2		13.669		13.8		0.12
	Average	283.3	Total	148.858	Average	14.8	Average	0.12

[a] Adjusted for planned annual well field shutdown.
[b] Well 31 was down from May 5 to May 12 due to hole in pipe in valve house.
Well 31 was down from Jun 13 to Jul 11 for annual well field shutdown.
Well 31 was down from Aug 25 to Aug 26 for chemical treatment.
Well 31 was down from Oct 14 to Oct 18 for chemical treatment.
Well 31 was down from Dec 30 to Dec 31 for unknown reasons.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–13. Extraction Well 33266 (EW-32) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 579.625 (top of well)
Northing Coordinate ('83) – 476,997.576
Easting Coordinate ('83) – 1,350,046.97

Hours in reporting period – 8,760
Hours not pumped – 752

Hours pumped – 8,008
Operational percent – 91.42
Adjusted operational percent[a] – 99.02

Target pumping rate – 200 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**M Gal Pumped**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11	213.9	9.547	5.6	0.05
2/11	211.6	8.532	5.7	0.05
3/11	214.8	9.590	5.4	0.05
4/11	210.4	9.089	5.8	0.05
5/11	216.4	9.662	5.1	0.04
6/11	86.0	3.715	5.8	0.05
7/11	144.0	6.428	6.9	0.06
8/11	281.0	12.546	5.6	0.05
9/11	215.9	9.325	5.2	0.04
10/11	223.9	9.997	5.3	0.04
11/11	222.9	9.629	4.5	0.04
12/11	218.6	9.758	4.9	0.04
Average	205.0	Total 107.818	Average 5.5	Average 0.05

[a] Adjusted for planned annual well field shutdown.
[b] Well 32 was down from Jun 13 to Jul 11 for annual well field shutdown.
Well 32 was down from Dec 19 to Dec 20 for chemical treatment.
Well 32 was down from Dec 30 to Dec 31 for unknown reasons.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–14. Extraction Well 33298 (EW-21a) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 576.21 (top of well)
Northing Coordinate ('83) – 477,953.1
Easting Coordinate ('83) – 1,349,499.9

Hours in reporting period – 8,760
Hours not pumped – 1,456

Hours pumped – 7,304
Operational percent – 83.4
Adjusted operational percent[a] – 90.32

Target pumping rate – 200 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**M Gal Pumped**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11	217.1	9.689	37.1	0.31
2/11	214.7	8.657	35.7	0.30
3/11	215.2	9.607	35.5	0.30
4/11	212.8	9.191	41.5	0.35
5/11	207.6	9.266	48.8	0.41
6/11	86.5	3.738	45.7	0.38
7/11	144.8	6.462	54.9	0.46
8/11	212.6	9.491	47.2	0.39
9/11	207.1	8.948	42.0	0.35
10/11	214.3	9.567	41.3	0.34
11/11	213.8	9.236	38.4	0.32
12/11	0.0	0.000	0.0	0.00
	Average 178.9	Total 93.854	Average 32.9	Average 0.33

[a] Adjusted for planned annual well field shutdown.
[b] Well 21a was down from Jun 13 to Jul 11 for rehab annual well field shutdown.
Well 21a was down from Dec 1 to Dec 31 for pump and motor and to investigate possible hole in screen.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–15. Extraction Well 3924 (RW-1) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 533.51 (top of well)
Northing Coordinate ('83) – 474,219.7
Easting Coordinate ('83) – 1,348,314.3

Hours in reporting period – 8,760 Hours pumped – 8608.5 Target pumping rate – 200 gpm
Hours not pumped – 151.5 Operational percent – 98.27

Monthly Measurements at Well Field								
Month	**Monthly Average Pumping Rate[a] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[b] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**	
1/11		218.6		9.756		20.8		0.17
2/11		213.5		8.608		19.7		0.16
3/11		216.6		9.670		19.7		0.16
4/11		293.6		12.684		19.2		0.16
5/11		297.5		13.279		16.5		0.14
6/11		238.1		10.285		14.8		0.12
7/11		208.5		9.306		14.1		0.12
8/11		212.2		9.473		15.0		0.13
9/11		258.2		11.153		14.6		0.12
10/11		243.8		10.884		14.7		0.12
11/11		219.2		9.469		14.5		0.12
12/11		218.5		9.756		15.2		0.13
	Average	236.5	Total	124.324	Average	16.6	Average	0.14

[a] Well 1 was down from Mar 1 to Mar 2 for chemical treatment.
Well 1 was down from Jun 28 to Jun 29 for annual Cla-Val maintenance.
Well 1 was down from Aug 18 to Aug 19 for chemical treatment.
[b] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–16. Extraction Well 3925 (RW-2) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 542.01 (top of well)
Northing Coordinate ('83) – 474,319.7
Easting Coordinate ('83) – 1,348,565.4

Hours in reporting period – 8,760
Hours not pumped – 150.5
Hours pumped – 8,609.5
Operational percent – 98.3
Target pumping rate – 200 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[a] (gpm)**	**M Gal Pumped**	**Monthly Total Uranium Concentration[b] (µg/L)**	**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11	219.2	9.784	16.6	0.14
2/11	206.8	8.339	16.5	0.14
3/11	216.7	9.674	15.9	0.13
4/11	293.1	12.663	16.9	0.14
5/11	298.2	13.310	15.8	0.13
6/11	237.3	10.252	17.6	0.15
7/11	212.2	9.472	18.2	0.15
8/11	210.5	9.395	18.9	0.16
9/11	247.5	10.692	16.9	0.14
10/11	230.8	10.303	16.7	0.14
11/11	200.3	8.654	15.8	0.13
12/11	160.4	7.160	16.3	0.14
Average	227.8	Total 119.7	Average 16.8	Average 0.14

[a] Well 2 was down from Mar 1 to Mar 2 for chemical treatment.
Well 2 was down from Jun 28 to Jun 29 for annual Cla-Val maintenance.
Well 2 was down from Aug 18 to Aug 19 for chemical treatment.
[b] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–17. Extraction Well 3926 (RW-3) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 586.73 (top of well)
Northing Coordinate ('83) – 474,428.6
Easting Coordinate ('83) – 1,348,837.5

Hours in reporting period – 8,760
Hours not pumped – 201
Hours pumped – 8,559
Operational percent – 97.71
Target pumping rate – 200 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[a] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[b] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11		185.0		8.261		22.2		0.19
2/11		162.6		6.556		22.0		0.18
3/11		208.0		9.286		21.5		0.18
4/11		207.5		8.965		27.9		0.23
5/11		205.7		9.183		21.4		0.18
6/11		196.5		8.490		22.2		0.19
7/11		197.2		8.805		23.9		0.20
8/11		190.9		8.520		24.4		0.20
9/11		206.0		8.900		24.0		0.20
10/11		215.6		9.623		24.2		0.20
11/11		193.6		8.365		25.9		0.22
12/11		175.7		7.843		25.9		0.22
	Average	195.4	Total	102.797	Average	23.8	Average	0.20

[a] Well 3 was down from Mar 3 to Mar 4 for chemical treatment.
Well 3 was down from Jun 8 to Jun 9 for chemical treatment.
Well 3 was down from Jun 28 to Jun 29 for annual Cla-Val maintenance.
Well 3 was down from Aug 17 to Aug 18 for chemical treatment.
Well 3 was down from Sep13 to Sep 14 for chemical treatment.
[b] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–18. Extraction Well 3927 (RW-4) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 591.84 (top of well)
Northing Coordinate ('83) – 474,541.8
Easting Coordinate ('83) – 1,349,127.3

Hours in reporting period – 8,760 Hours pumped – 6,583.75 Target pumping rate – 200 gpm
Hours not pumped – 2,176.3 Operational percent – 75.16

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[a] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[b] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11		218.1		9.738		2.4		0.02
2/11		211.8		8.540		5.0		0.04
3/11		167.8		7.492		3.0		0.03
4/11		0.0		0.000		3.0		0.00
5/11		152.2		6.795		3.5		0.03
6/11		145.5		6.287		3.8		0.03
7/11		211.4		9.435		3.4		0.03
8/11		223.7		9.986		3.1		0.03
9/11		114.0		4.925		2.6		0.02
10/11		146.7		6.550		2.4		0.02
11/11		215.8		9.323		2.6		0.02
12/11		213.3		9.520		3.0		0.03
	Average	168.4	Total	88.591	Average	3.2	Average	0.03

[a] Well 4 was down from Mar 24 to May 16 due to suspected hole in screen.
Well 4 was down from Jun 13 to Jun 21 due to an electrical problem.
Well 4 was down from Jun 28 to Jun 29 for annual Cla-Val maintenance.
Well 4 was down from Aug 17 to Aug 18 for chemical treatment.
Well 4 was down from Sep 16 Oct 10 for VFD installation.
[b] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–19. Extraction Well 32308 (RW-6) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 582.05 (top of casing)
Northing Coordinate ('83) – 475,078.83
Easting Coordinate ('83) – 1,348,693.9

Hours in reporting period – 8,760
Hours not pumped – 884.3

Hours pumped – 7,875
Operational percent – 89.91
Adjusted operational percent[a] – 97.38

Target pumping rate – 200 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11		123.4		5.511		33.4		0.28
2/11		103.6		4.175		32.4		0.27
3/11		100.8		4.497		33.6		0.28
4/11		216.0		9.331		34.0		0.28
5/11		218.5		9.754		34.3		0.29
6/11		88.4		3.817		31.4		0.26
7/11		97.0		4.331		31.8		0.27
8/11		211.8		9.455		32.9		0.27
9/11		215.6		9.315		34.5		0.29
10/11		208.2		9.293		35.1		0.29
11/11		219.5		9.484		37.7		0.31
12/11		218.0		9.730		37.0		0.31
	Average	168.4	Total	88.693	Average	34.0	Average	0.28

[a] Adjusted for planned annual well field shutdown.
[b] Well 6 was down from Mar 30 to Mar 31 for pump replacement.
Well 6 was down from Jun 11 to Jul 18 for rehab annual well field shutdown.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–20. Extraction Well 32309 (RW-7) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 582.05 (top of casing)
Northing Coordinate ('83) – 475,109.60
Easting Coordinate ('83) – 1,348,366.34

Hours in reporting period – 8,760
Hours not pumped – 780.5

Hours re-injected – 7,980
Operational percent – 91.09
Adjusted operational percent[a] – 98.68

Target pumping rate – 200 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11		177.0		7.903		30.3		0.25
2/11		152.4		6.144		31.3		0.26
3/11		152.9		6.825		31.5		0.26
4/11		203.3		8.783		34.5		0.29
5/11		218.9		9.770		38.1		0.32
6/11		88.3		3.814		32.5		0.27
7/11		147.3		6.574		34.5		0.29
8/11		211.3		9.434		33.2		0.28
9/11		207.8		8.975		32.4		0.27
10/11		201.3		8.987		31.1		0.26
11/11		218.8		9.451		28.4		0.24
12/11		218.7		9.764		26.4		0.22
	Average	183.2	Total	96.426	Average	32.0	Average	0.27

[a] Adjusted for planned annual well field shutdown.
[b] Well 7 was down from Jun 13 to Jul 11 for annual well field shutdown.
Well 7 was down from Sep 13 to Sep 14 for chemical treatment.
Well 7 was down from Oct 29 to Oct 31 due to an electrical problem.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–21. PRRS Groundwater Summary Statistics and Trend Analysis

Analyte	Monitoring Well	Number of Samples[a,b,c]	Min.[a,b,c,d] (mg/L)	Max.[a,b,c,d] (mg/L)	Avg.[a,b,c,d] (mg/L)	SD[a,b,c,d,e]	Trend[a,b,c,d,e,f]
Arsenic	2128	238	0.000195	0.188	0.0114	0.0206	Down, Significant
	2625	211	0.00110	0.0706	0.0118	0.0095	Down, Significant
	2636	181	0.01	0.0939	0.0443	0.0185	Down, Significant
	2898	55	0.000147	0.0820	0.0043	0.0117	**Up, Significant**
	2899	48	0.00032	0.0283	0.0023	0.0043	**Up, Significant**
	2900	237	0.00032	0.0609	0.0050	0.0054	Down, Significant
	3128	58	0.0004	0.234	0.0075	0.0307	No Significant Trend
	3636	57	0.0005	0.0233	0.0028	0.0039	**Up, Significant**
	3898	55	0.0005	0.0434	0.0043	0.0068	**Up, Significant**
	3899	56	0.000147	0.0307	0.0026	0.0048	**Up, Significant**
	3900	56	0.000375	0.0208	0.0029	0.0034	No Significant Trend
Phosphorus	2128	64	0.025	16.2	1.47	2.44	Down, Significant
	2625	35	0.307	12.3	3.09	2.75	No Significant Trend
	2636	33	9.6	170	87.1	44.3	No Significant Trend
	2898	56	0.005	9.95	0.274	1.34	No Significant Trend
	2899	47	0.005	0.831	0.0600	0.122	No Significant Trend
	2900	54	0.05	4.74	0.492	0.682	Down, Significant
	3128	65	0.005	13.0	0.252	1.61	No Significant Trend
	3636	56	0.00955	1.10	0.073	0.148	No Significant Trend
	3898	54	0.0075	1.24	0.107	0.178	No Significant Trend
	3899	55	0.005	0.830	0.0940	0.152	Down, Significant
	3900	56	0.005	1.38	0.0930	0.244	Down, Significant
Potassium	2128	56	0.83	18.0	3.47	3.42	No Significant Trend
	2625	36	0.64	9.49	3.22	1.92	No Significant Trend
	2636	33	4.6	218	67.1	52.8	Down, Significant
	2898	56	1.11	9.64	4.36	1.27	**Up, Significant**
	2899	48	1.36	8.85	4.04	1.02	**Up, Significant**
	2900	55	0.0095	6.00	2.01	1.08	No Significant Trend
	3128	58	1.09	3.70	1.97	0.65	Down, Significant
	3636	56	1.09	4.24	2.22	0.55	Down, Significant
	3898	55	0.61	3.93	2.47	0.61	**Up, Significant**
	3899	56	0.875	4.24	2.51	0.45	**Up, Significant**
	3900	56	0.975	3.19	1.73	0.40	Down, Significant
Sodium	2128	56	12.3	75.2	34.8	11.6	Down, Significant
	2625	36	13.1	50.7	31.4	8.15	Down, Significant
	2636	33	23.0	148	54.6	26.9	No Significant Trend
	2898	56	4.95	29.2	18.7	4.3	No Significant Trend
	2899	48	11.2	24.5	17.0	2.8	No Significant Trend
	2900	55	0.0136	43.3	27.2	7.3	No Significant Trend
	3128	58	3.52	13.4	5.63	2.64	Down, Significant
	3636	56	3.14	13.0	5.93	2.83	Down, Significant
	3898	55	7.29	24.9	10.8	3.8	**Up, Significant**
	3899	56	6.24	29.5	9.45	3.37	**Up, Significant**
	3900	56	3.13	10.8	4.90	1.84	Down, Significant

Table A.1–21 (continued). PRRS Groundwater Summary Statistics and Trend Analysis

[a] The data are based on unfiltered samples from the Operable Unit 5 Remedial Investigation/Feasibility Study data set (1988 through 1993) and 1994 through 2011 groundwater data (unfiltered and filtered for 2001 through 2011).
[b] If more than one sample is collected per well per day (e.g., duplicate), then only one sample is counted for the total number of samples, and the sample with the maximum concentration is used to determine the summary statistics (minimum, maximum, average, standard deviation, and Mann-Kendall test for trend).
[c] Rejected data qualified with an R were not included in this count or the summary statistics.
[d] Where concentrations are below the detection limit each result used in the summary statistics is set at half the detection limit.
[e] SD = standard deviation.
[f] Trend starts on August 27, 1993, and is based on the start-up of the South Plume extraction wells (DOE 1993).

Table A.1–22. Extraction Well 32761 (EW-26) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 570.88 (top of casing)
Northing Coordinate ('83) – 479,892.36
Easting Coordinate ('83) – 1,347,364.02

Hours in reporting period – 8,760
Hours not pumped – 720

Hours pumped – 8,040
Operational percent – 91.78
Adjusted operational percent[a] – 99.42

Target pumping rate – 300 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**M Gal Pumped**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11	312.0	13.926	25.2	0.21
2/11	325.6	13.128	26.0	0.22
3/11	328.9	14.684	27.1	0.23
4/11	314.8	13.600	30.3	0.25
5/11	325.6	14.534	32.8	0.27
6/11	129.0	5.573	27.1	0.23
7/11	215.6	9.623	30.6	0.26
8/11	323.8	14.454	30.7	0.26
9/11	318.6	13.762	27.3	0.23
10/11	325.5	14.532	26.7	0.22
11/11	327.0	14.128	25.9	0.22
12/11	327.1	14.600	26.8	0.22
Average	297.8	Total 156.544	Average 28.0	Average 0.23

[a] Adjusted for planned annual well field shutdown.
[b] Well 26 was down from Jun 13 to Jul 11 for annual well field shutdown.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–23. Extraction Well 33062 (EW-27) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 575.1 (top of casing)
Northing Coordinate ('83) – 480,013.01
Easting Coordinate ('83) – 1,348,037.2

Hours in reporting period – 8,760
Hours not pumped – 932

Hours pumped – 7,828
Operational percent – 89.36
Adjusted operational percent[a] – 96.80

Target pumping rate – 200 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**M Gal Pumped**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11	219.8	9.814	28.3	0.24
2/11	217.6	8.775	28.8	0.24
3/11	221.4	9.885	27.7	0.23
4/11	216.3	9.346	31.4	0.26
5/11	220.6	9.846	33.5	0.28
6/11	84.5	3.649	30.2	0.25
7/11	95.1	4.245	32.2	0.27
8/11	205.5	9.173	34.2	0.29
9/11	216.5	9.353	31.3	0.26
10/11	219.5	9.798	33.7	0.28
11/11	217.0	9.375	31.9	0.27
12/11	221.4	9.883	30.9	0.26
Average	196.3	Total 103.141	Average 31.2	Average 0.26

[a] Adjusted for planned annual well field shutdown.
[b] Well 27 was down from Jun 13 to Jul 11 for annual well field shutdown.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–24. Extraction Well 33334 (EW-28a) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 570.441 (top of casing)
Northing Coordinate ('83) – 479,918.959
Easting Coordinate ('83) – 1,348,686.378

Hours in reporting period – 8,760
Hours not pumped – 745.5

Hours pumped – 8,015
Operational percent – 91.49
Adjusted operational percent[a] – 99.11

Target pumping rate – 200 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**M Gal Pumped**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11	208.7	9.316	20.10	0.17
2/11	216.0	8.709	9.90	0.08
3/11	217.6	9.712	9.80	0.08
4/11	213.6	9.226	10.80	0.09
5/11	216.4	9.660	9.90	0.08
6/11	85.0	3.672	10.05	0.08
7/11	140.4	6.266	8.75	0.07
8/11	219.9	9.817	9.80	0.08
9/11	208.1	8.989	10.10	0.08
10/11	217.3	9.702	10.50	0.09
11/11	216.6	9.358	9.80	0.08
12/11	214.9	9.593	10.20	0.09
Average	197.9	Total 104.019	Average 10.8	Average 0.09

[a] Adjusted for planned annual well field shutdown.
[b] Well 28a was down from Jun 13 to Jul 12 for rehab annual well field shutdown.
Well 28a was down from Aug 23 to Aug 24 for chemical treatment.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–25. Extraction Well 33347 (EW-33a) Operational Summary Sheet For 2011

Reference Elevation (ft amsl) – 574.86 (top of casing)
Northing Coordinate ('83) – 481,031.762
Easting Coordinate ('83) – 1,346,715.817

Hours in reporting period – 8,760
Hours not pumped – 726

Hours pumped – 8034
Operational percent – 91.7
Adjusted operational percent[a] – 99.34

Target pumping rate – 300 gpm

Monthly Measurements at Well Field									
Month		**Monthly Average Pumping Rate[b] (gpm)**		**M Gal Pumped**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lbs of total uranium removed/M gal pumped)**
1/11		319.4		14.258		9.1		0.08
2/11		328.3		13.237		15.60		0.13
3/11		328.1		14.647		15.40		0.13
4/11		308.7		13.336		19.1		0.16
5/11		326.1		14.557		20.4		0.17
6/11		130.8		5.650		17.2		0.14
7/11		202.3		9.029		22.1		0.18
8/11		327.1		14.604		26.9		0.22
9/11		326.2		14.094		23.6		0.20
10/11		328.3		14.656		20.7		0.17
11/11		329.0		14.211		19.2		0.16
12/11		312.5		13.952		21.9		0.18
	Average	297.2	Total	156.231	Average	19.3	Average	0.16

[a] Adjusted for planned annual well field shutdown.
[b] Well 33a was down from Apr 18 to Apr 19 for sampling.
Well 33a was down from Jun 13 to Jul 11 for annual well field shutdown.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1–26. Regression Equations for Uranium Concentration Data Collected at Extraction Wells—Data Collected Through December 31, 2011

Well ID	Location ID	Data Trend	R^2	95% UCL	R^2	Function Type
RW-1	3924	$y=1.10E+05e^{-2.19E-04x}$	0.78	$y = 4.39E+03e^{-1.14E-04x}$	0.72	Exponential Function
RW-2	3925	$y = 1.090E-06x^2 - 8.772E-02x + 1.782E+03$	0.69	$y = 1.09E-06x^2 - 8.77E-02x + 1.80E+03$	0.69	Polynomial
RW-3	3926	$y = -2.03E-06x^2 + 1.56E-01x - 2.96E+03$	0.76	$y = -2.03E-06x^2 + 1.56E-01x - 2.94E+03$	0.76	Polynomial
RW-4	3927	$y = 7.39E-03e^{1.53E-04x}$	0.31	$y = 3.43E-01e^{6.95E-05x}$	0.25	Exponential Function
RW-6	32308	$y = 7.82E+04e^{-1.931E-04x}$	0.83	$y = 8.71E+03e^{-1.23E-04x}$	0.83	Exponential Function
RW-7	32309	$y = 2.73E+05e^{-2.26E-04x}$	0.87	$y = 1.42E+04e^{-1.34E-04x}$	0.85	Exponential Function
EW-15a	33262	$y = 2.27E+54x^{-1.15E+01}$	0.74	$y = 1.29E+35x^{-7.24E+00}$	0.74	Power Function
EW-17a	33326	$y = 6.70E+03e^{-1.431E-04x}$	0.51	$y = 1.54E+03e^{-9.20E-05x}$	0.50	Exponential Function
EW-18	31550	$y = 3.06E+04e^{-1.70E-04x}$	0.48	$y = 4.05E+03e^{-1.01E-04x}$	0.46	Exponential Function
EW-19	31560	$y = 2.71E+08e^{-4.09E-04x}$	0.87	$y = 9.77E+04e^{-1.75E-04x}$	0.78	Exponential Function
EW-20	31561	$y = 3.99E+03e^{-1.21E-04x}$	0.46	$y = 1.32E+03e^{-8.16E-05x}$	0.48	Exponential Function
EW-21a	33298	$y = 1.97E+06e^{-2.70E-04x}$	0.77	$y = 3.35E+04e^{-1.45E-04x}$	0.75	Exponential Function
EW-22	32276	$y = 2.52E+09e^{-4.54E-04x}$	0.94	$y = 3.18E+05e^{-1.92E-04x}$	0.89	Exponential Function
EW-23	32447	$y = 2.88E+08e^{-3.88E-04x}$	0.89	$y = 3.50E+05e^{-1.94E-04x}$	0.85	Exponential Function
EW-24	32446	$y = 1.97E+05e^{-2.12E-04x}$	0.73	$y = 1.41E+04e^{-1.29E-04x}$	0.69	Exponential Function
EW-25	33061	$y = 3.09E+04e^{-1.70E-04x}$	0.36	$y = 3.78E+03e^{-1.05E-04x}$	0.33	Exponential Function
EW-30	33264	$y = 5.06E+09e^{-4.60E-04x}$	0.88	$y = 1.76E+06e^{-2.40E-04x}$	0.85	Exponential Function
EW-31	33265	$y = 5.45+06e^{-3.19E-04x}$	0.71	$y = 4.01E+04e^{-1.793E-04x}$	0.66	Exponential Function
EW-32	33266	$y = 3.95E+11e^{-6.16E-04x}$	0.91	$y = 1.20E+06e^{-2.69E-04x}$	0.81	Exponential Function
EW-26	32761	$y = 4.76E+09e^{-4.71E-04x}$	0.88	$y=6.38E+05e^{-2.20E-04x}$	0.81	Exponential Function
EW-27	33062	$y = 2.23E+10e^{-5.08E-04x}$	0.83	$y=7.69E+05e^{-2.18E-04x}$	0.71	Exponential Function
EW-28a	33334	$y = 8.28E+13e^{-7.36E-04x}$	0.88	$y=4.78E+05e^{-2.10E-04x}$	0.67	Exponential Function
EW-33a	33347	$y = 2.63E+13e^{-6.97E-04x}$	0.45	$y=5.13E+06e^{-2.78E-04x}$	0.42	Exponential Function

Table A.1–27. Estimated Percent Complete Based on Pounds of Uranium Removed from the Aquifer

Year	Annual Uranium To Be Extracted From GMA (pounds) Based on Conc. Data	Annual Uranium To Be Extracted From GMA (pounds) Based on Model	Annual Uranium To Be Extracted From GMA (pounds) Based on 95% UCL
2012	456	404	1,448
2013	404	366	1,355
2014	360	335	1,267
2015	320	307	1,186
2016	291	276	1,137
2017	260	247	1,064
2018	233	225	997
2019	209	208	934
2020	189	193	875
2021	170	180	820
2022	154	169	769
2023	140	159	722
2024	127	150	677
Total To Be Extracted	3,313	3,219	13,250
Pounds Already Extracted Through 12-31-2010	10,805	10,805	10,805
Total	14,118	13,930	24,055
% Complete Based on Pounds (2011)	**76**	**77**	45
% Complete Based on Pounds (2010)	75	74	43
% Complete Based on Pounds (2009)	72	70	41
% Complete Based on Pounds (2008)	69	66	39
% Complete Based on Pounds (2007)	66	61	37
% Complete Based on Pounds (2006)	59	55	33

Table A.1–28. Extraction Well Target Pumping Rates

Module	Extraction Well	January 1 to December 31 (gpm)
South Plume	3924 (RW-1)	200
	3925 (RW-2)	200
	3926 (RW-3)	200
	3927 (RW-4)	200
	32308 (RW-6)	200
	32309 (RW-7)	200
Subtotal		1,200
Waste Storage Area	32761 (EW-26)	300
	33062 (EW-27)	200
	33334 (EW-28a)	200
	33347 (EW-33a)	300
Subtotal		1,000
South Field Extraction	31550 (EW-18)	100
	31560 (EW-19)	100
	31561 (EW-20)	100
	33298 (EW-21a)	200
	33326 (EW-17a)	175
	32276 (EW-22)	300
	32446 (EW-24)	300
	32447 (EW-23)	300
	33061 (EW-25)	100
	33264 (EW-30)	200
	33265 (EW-31)	300
	33266 (EW-32)	200
	33262 (EW-15a)	200
Subtotal		2,575
Total Pumping		4,775

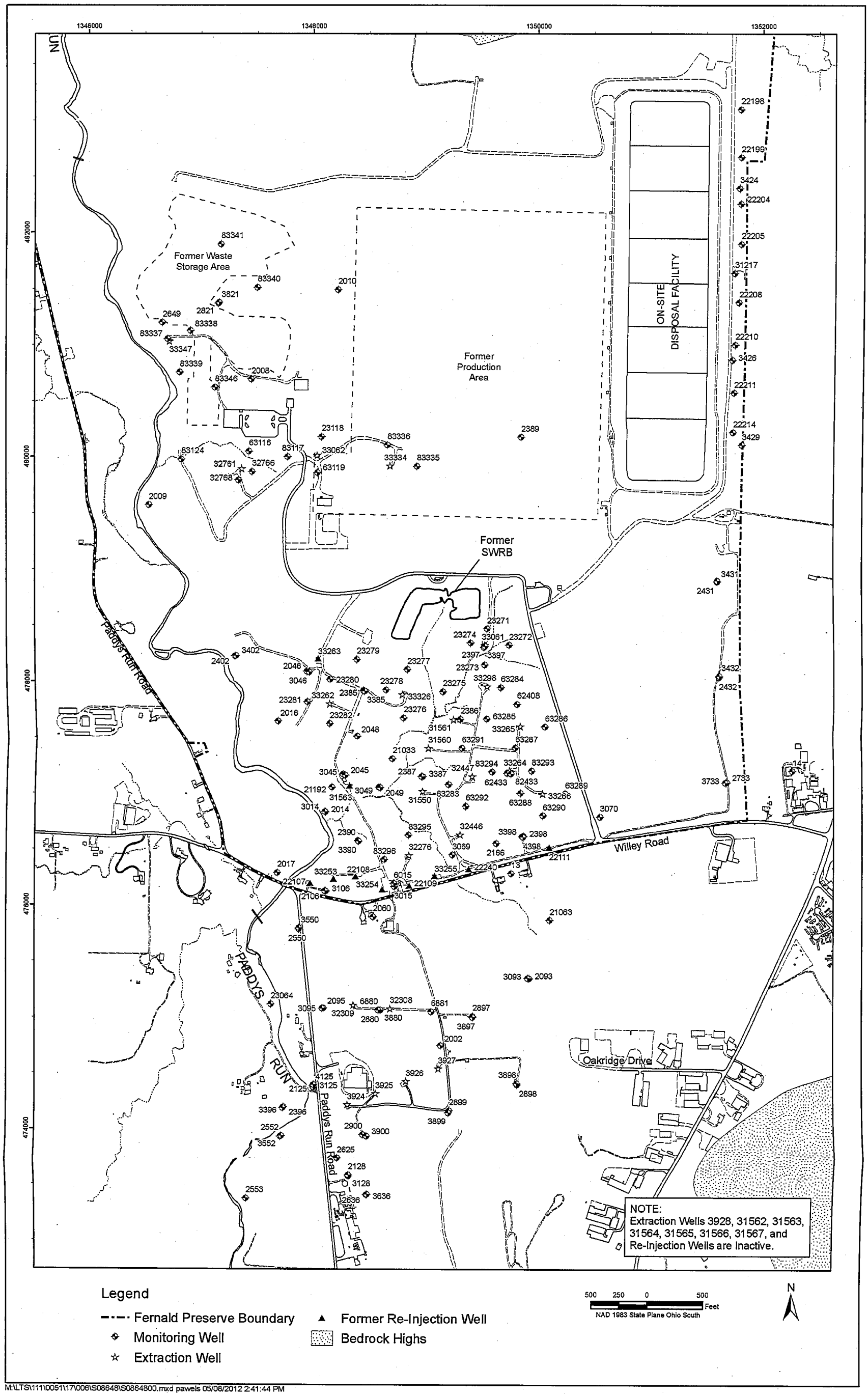

Figure A.1–1. Well Locations for South Plume, South Field, Waste Storage Area, and PRRS Monitoring Activities

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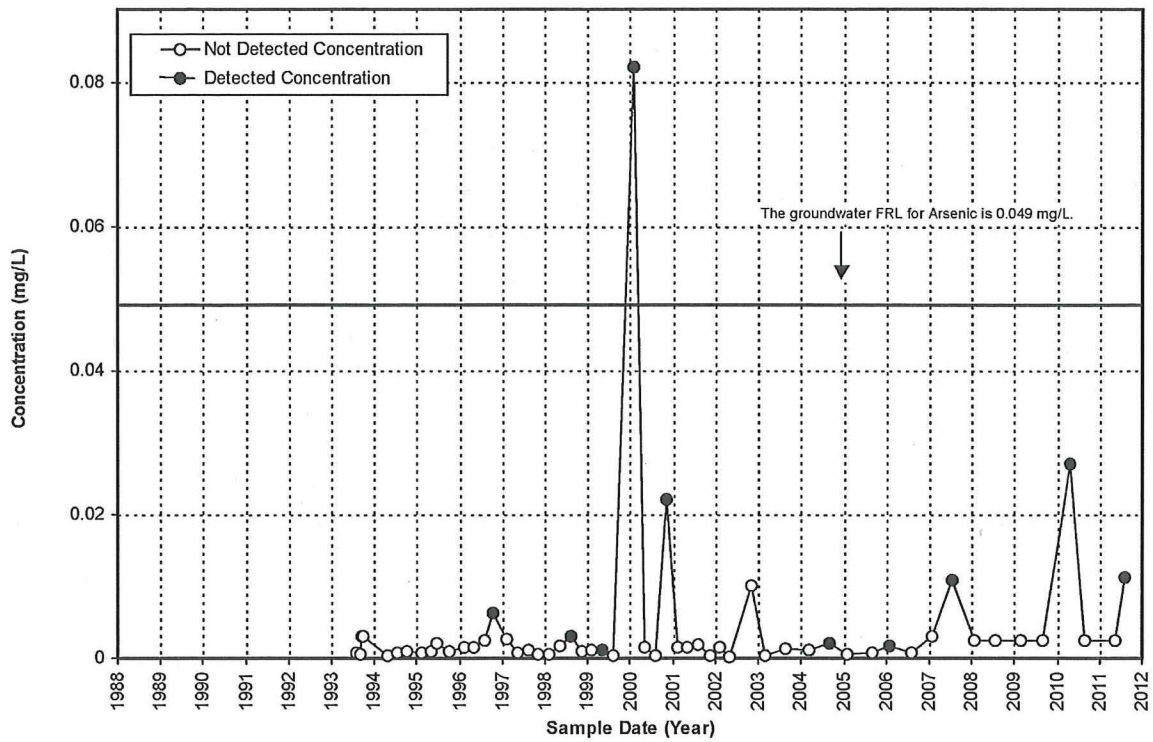

Figure A.1-2. Arsenic Concentration VS. Time Plot for Monitoring Well 2898

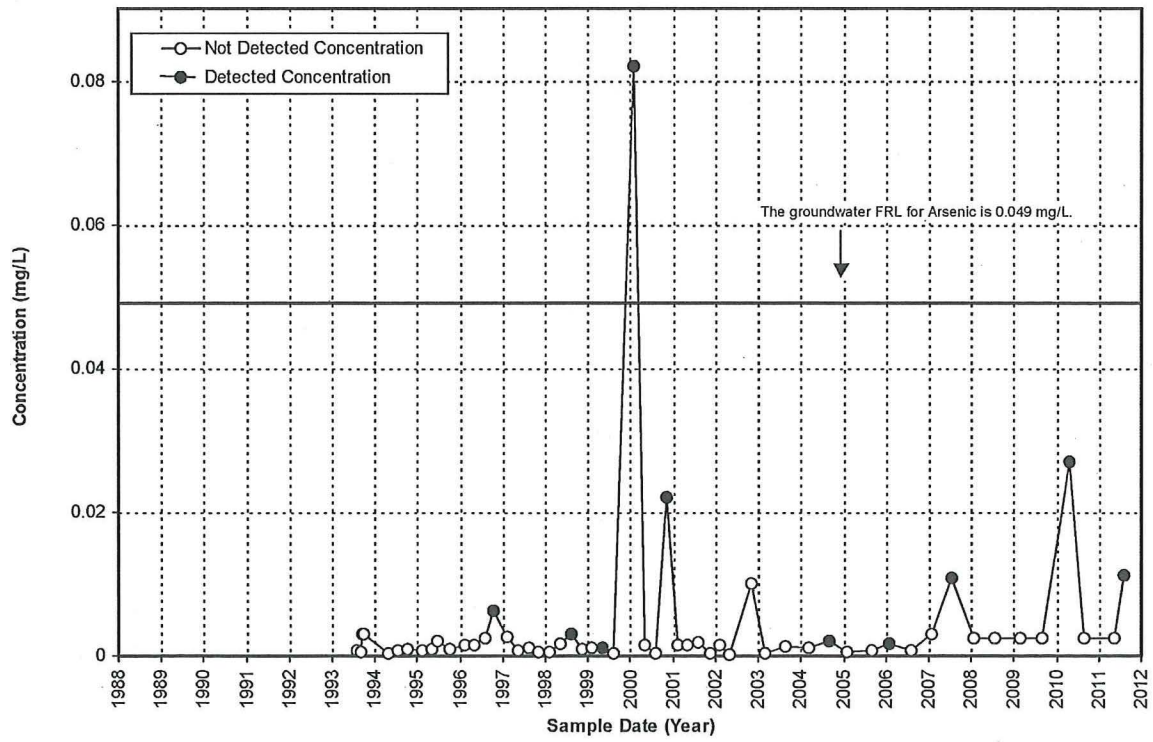

Figure A.1-3. Arsenic Concentration VS. Time Plot for Monitoring Well 2899

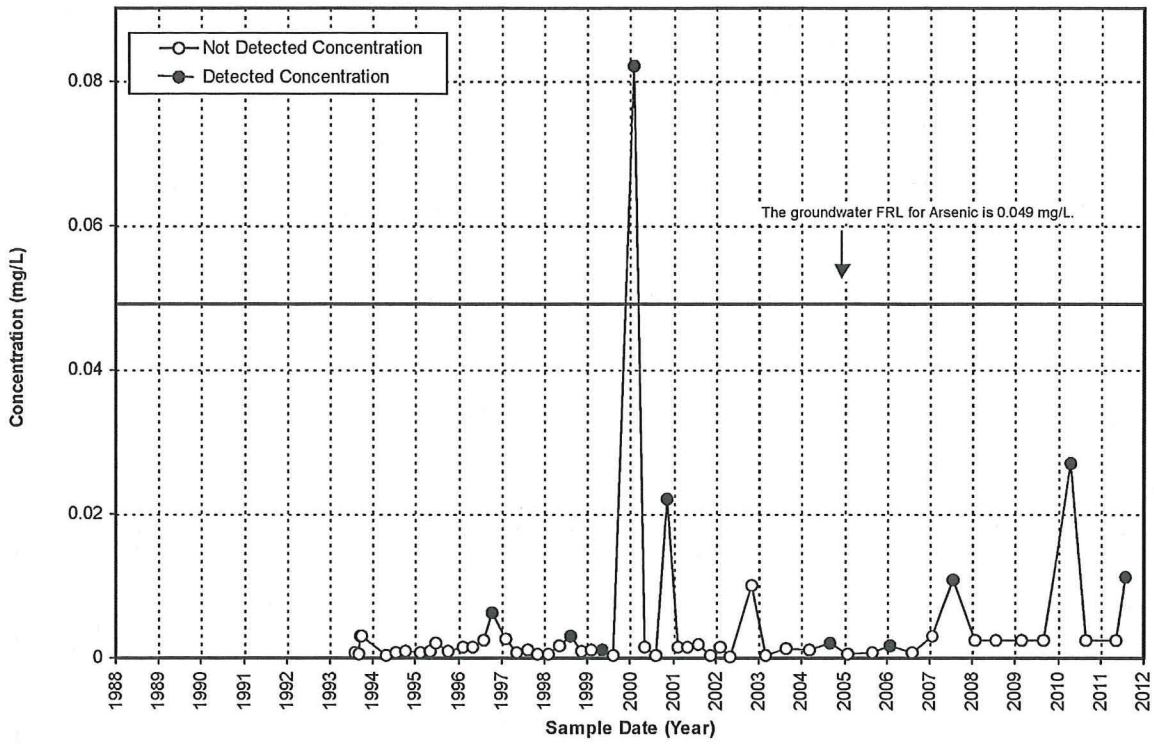

Figure A.1-4. Arsenic Concentration VS. Time Plot for Monitoring Well 3636

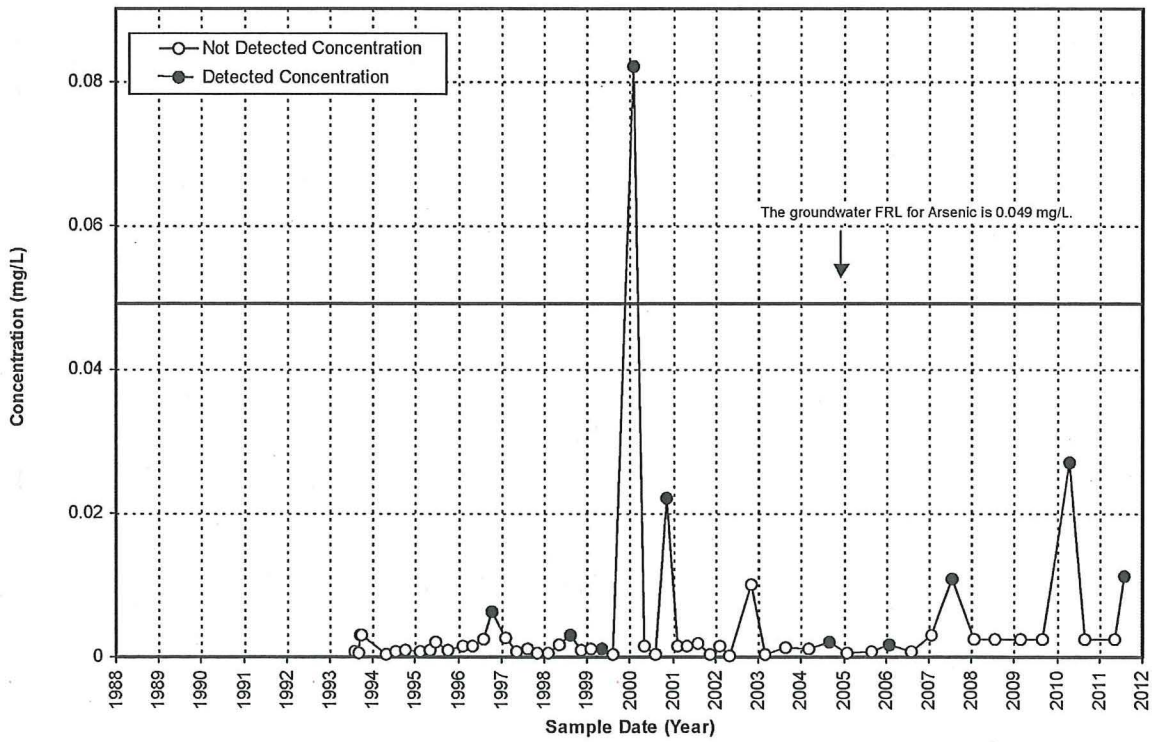

Figure A.1-5. Arsenic Concentration VS. Time Plot for Monitoring Well 3898

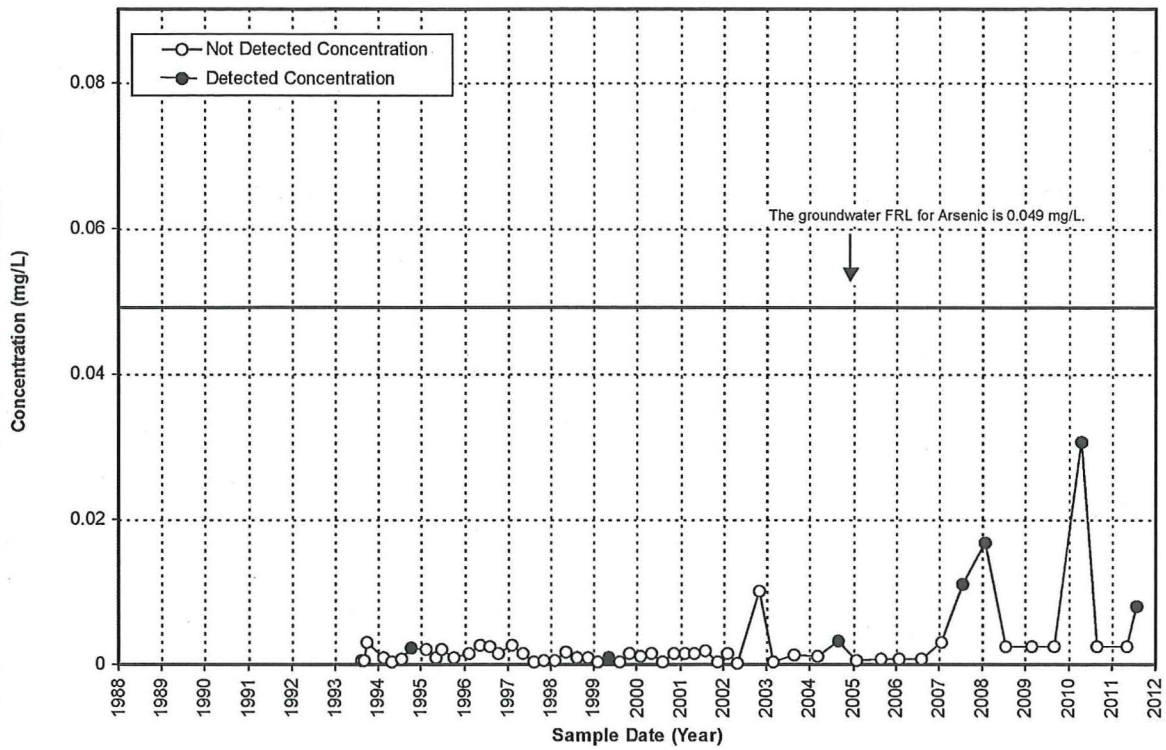

Figure A.1-6. Arsenic Concentration VS. Time Plot for Monitoring Well 3899

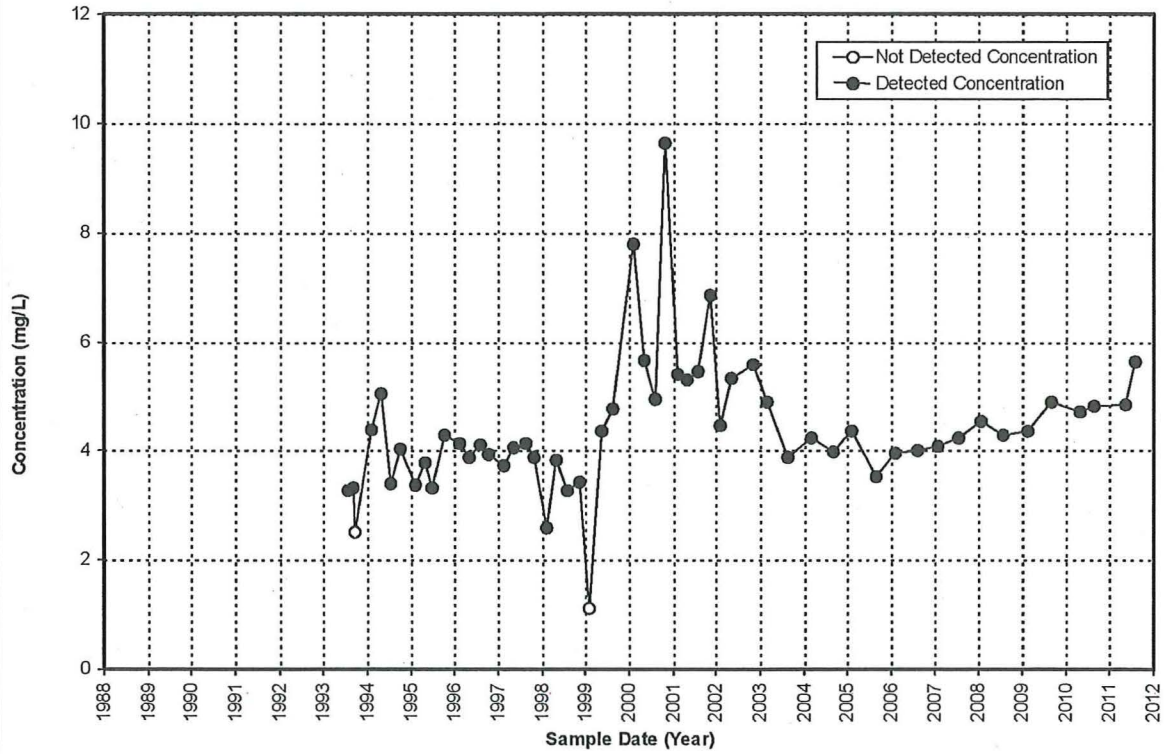

Figure A.1-7. Potassium Concentration VS. Time Plot for Monitoring Well 2898

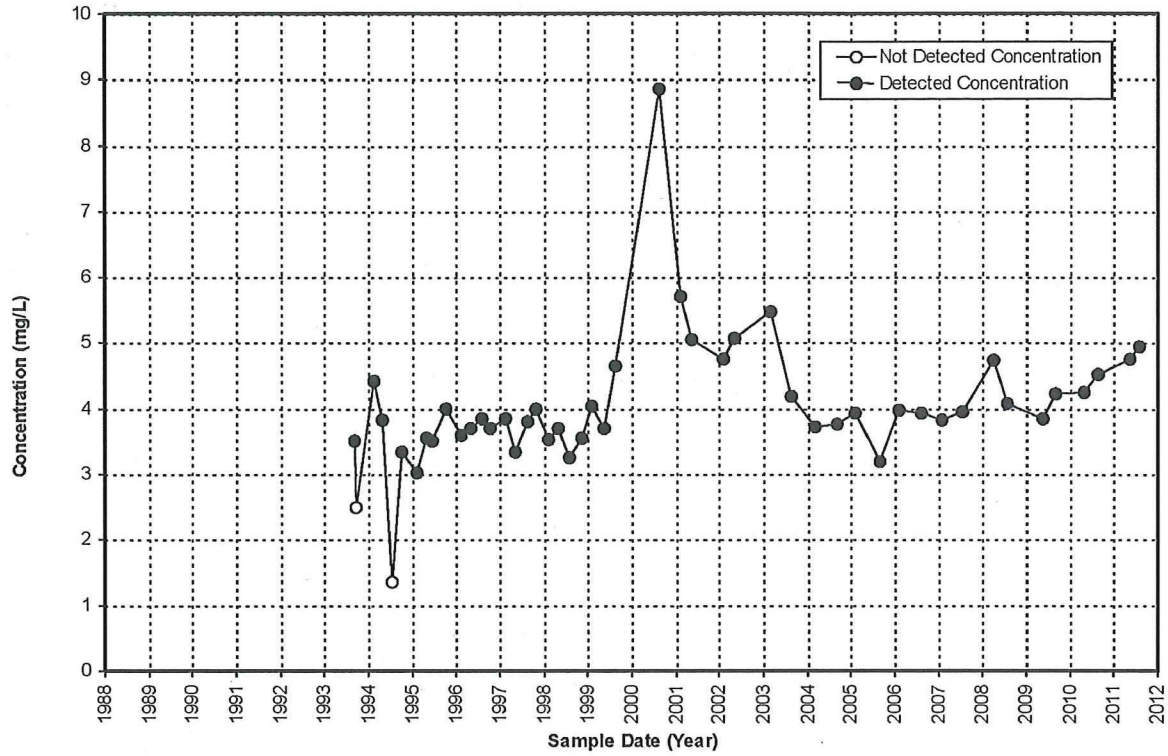

Figure A.1-8. Potassium Concentration VS. Time Plot for Monitoring Well 2899

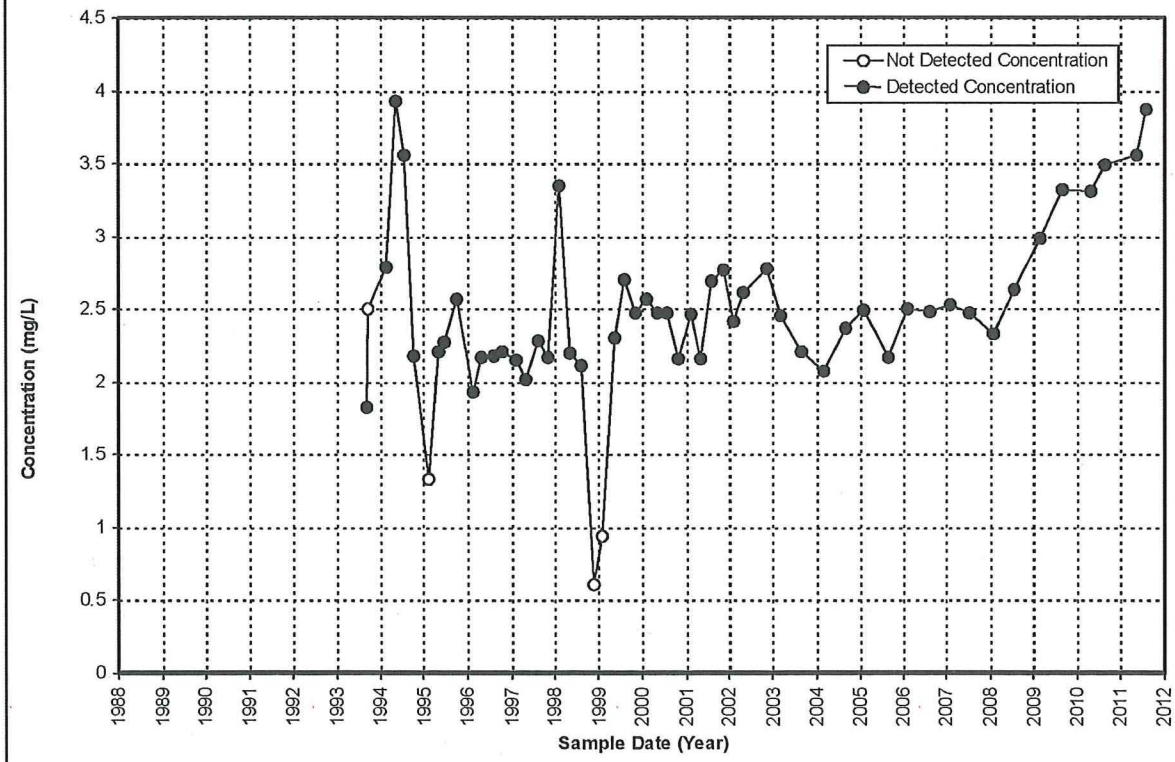

Figure A.1-9. Potassium Concentration VS. Time Plot for Monitoring Well 3898

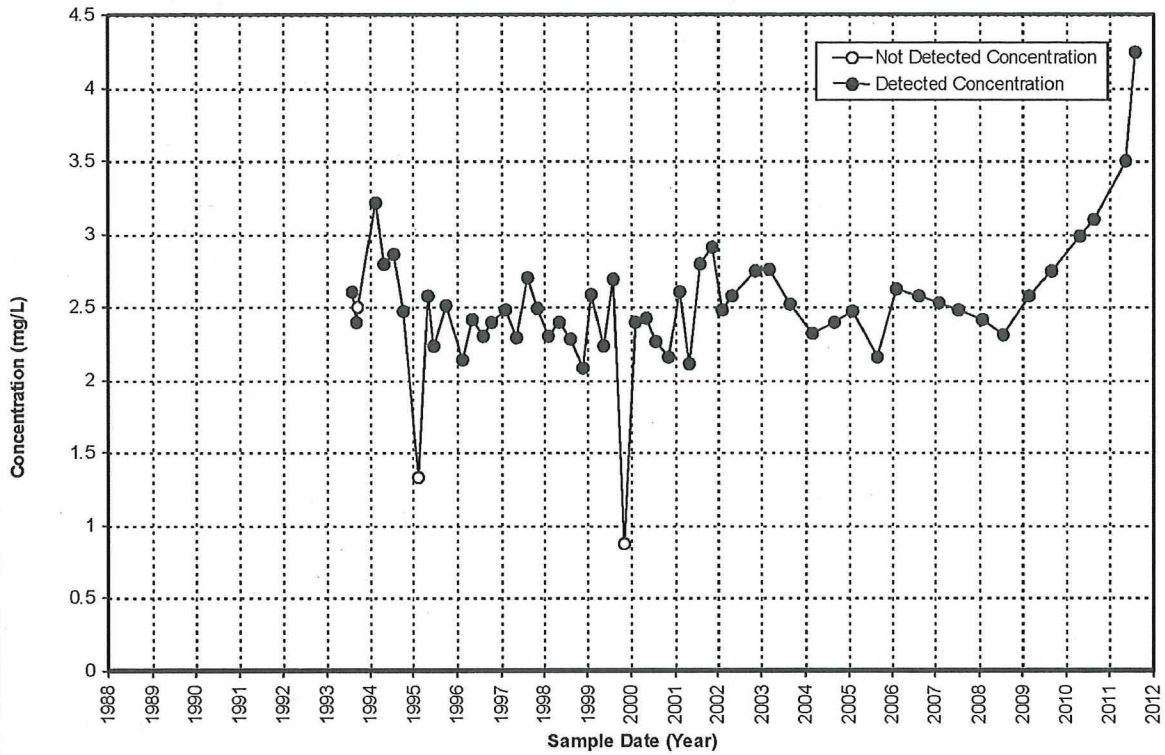

Figure A.1-10. Potassium Concentration VS. Time Plot for Monitoring Well 3899

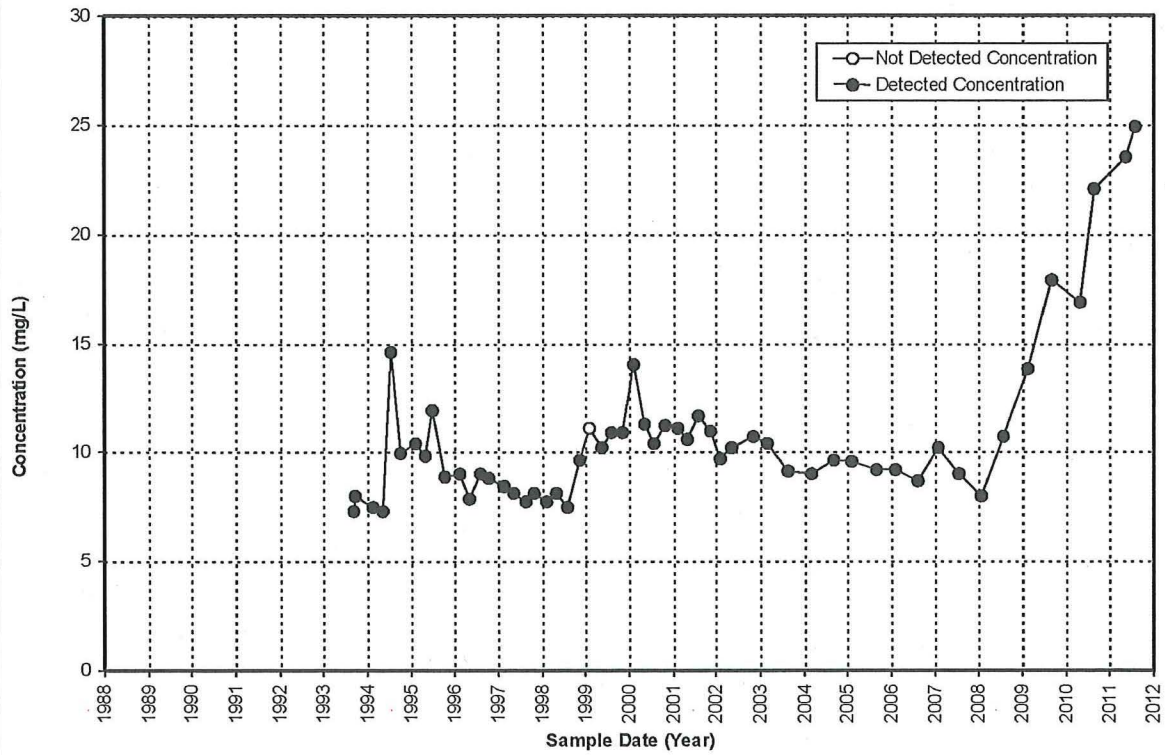

Figure A.1-11. Sodium Concentration VS. Time Plot for Monitoring Well 3898

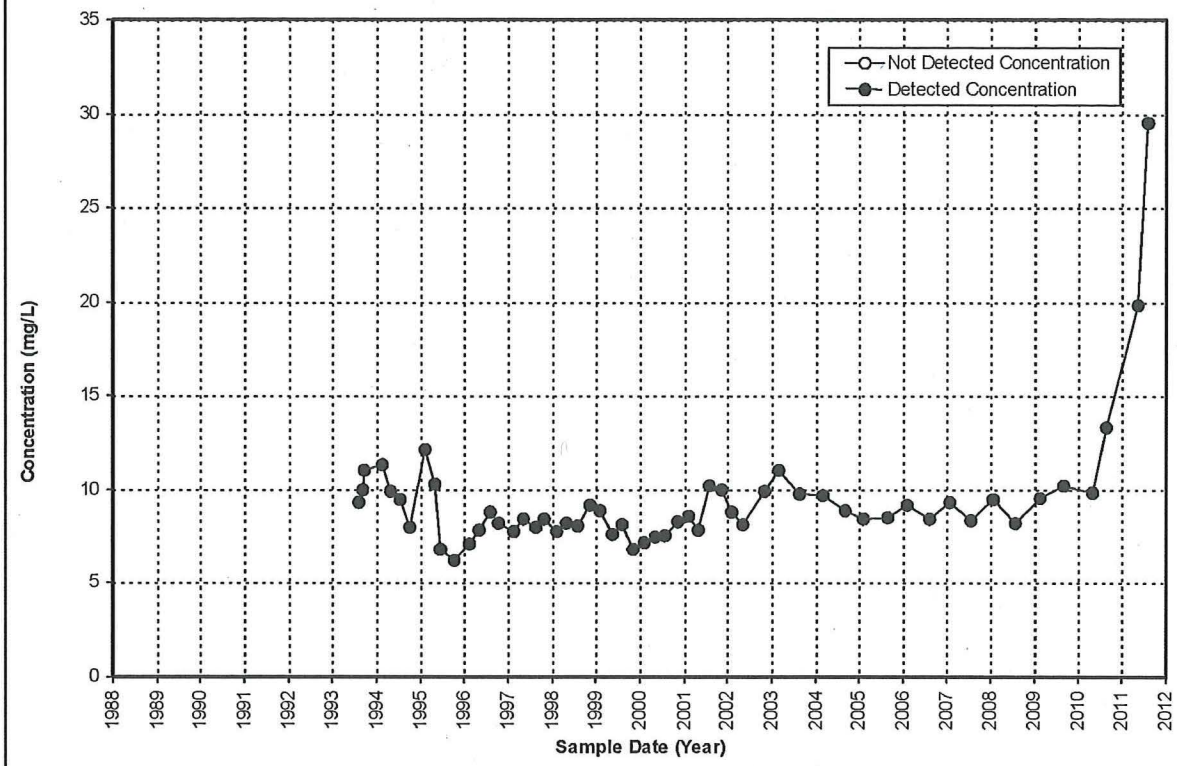

Figure A.1-12. Sodium Concentration VS. Time Plot for Monitoring Well 3899

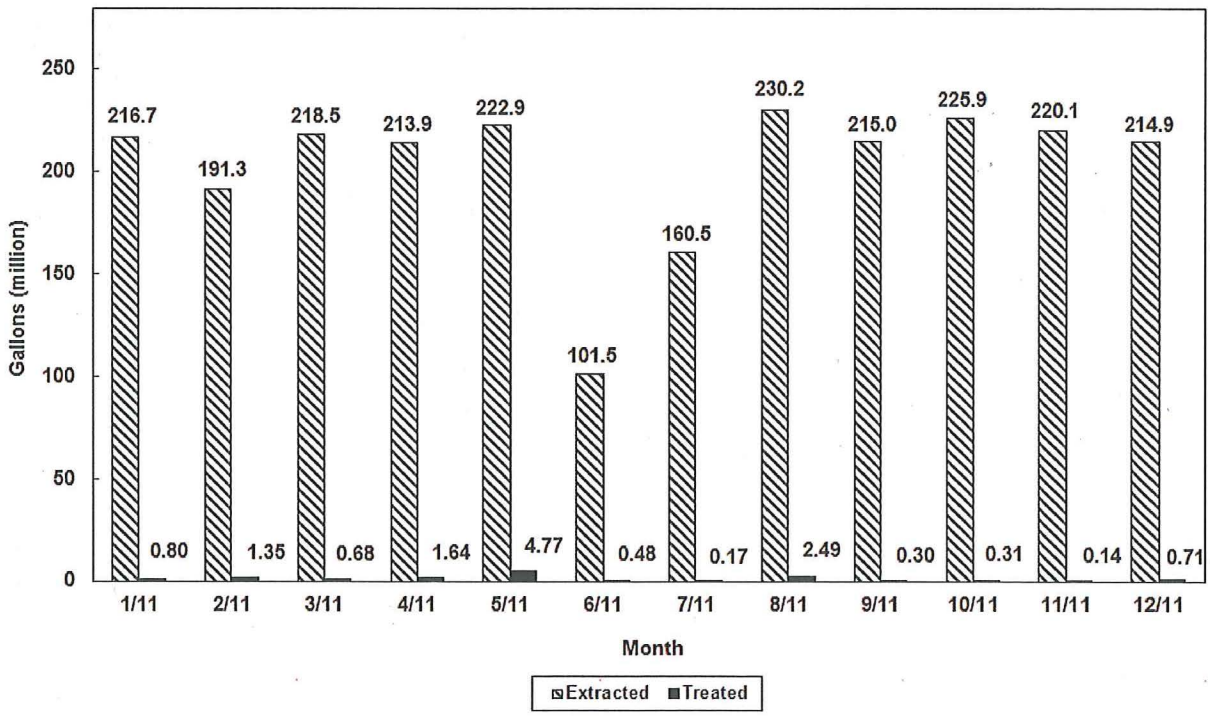

Figure A.1-13. Total Groundwater Extracted vs. Groundwater Treated for 2011

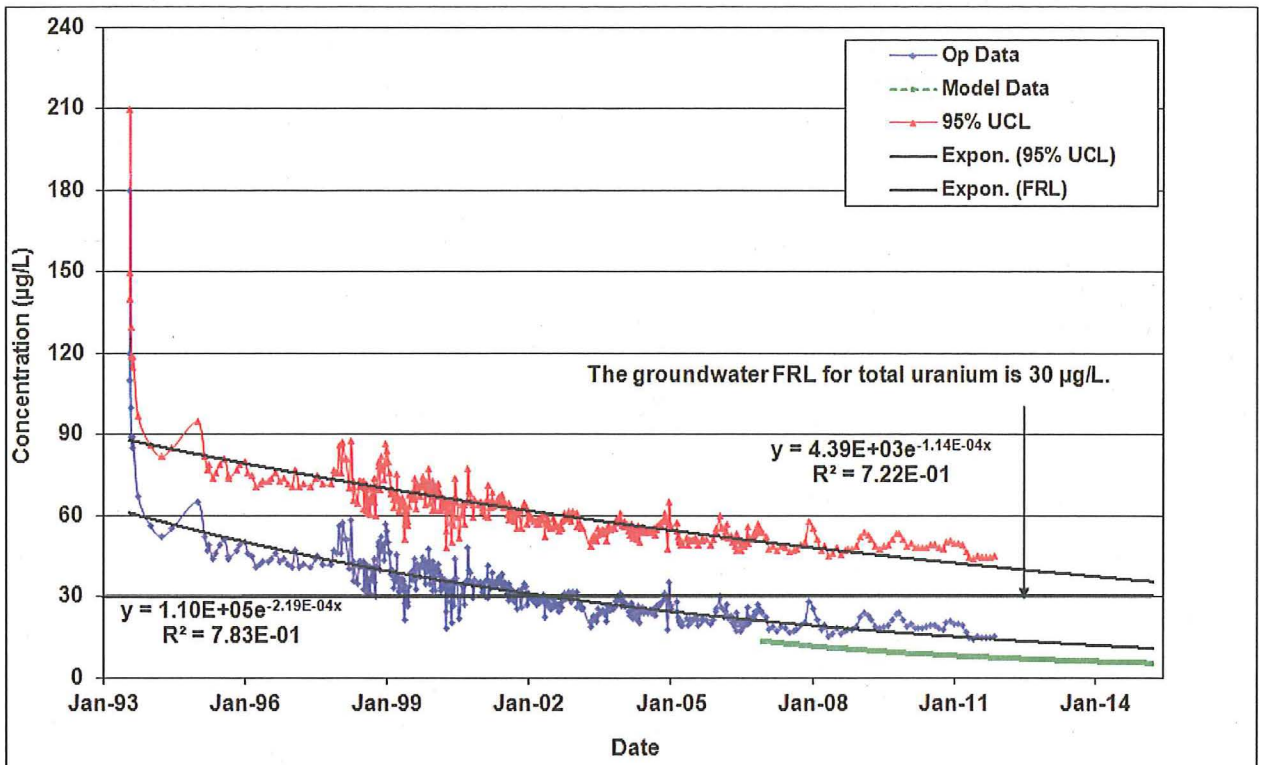

Figure A.1-14. Total Uranium Concentration vs. Time Plot for Extraction Well 3924 (RW-1) with Regression Analysis

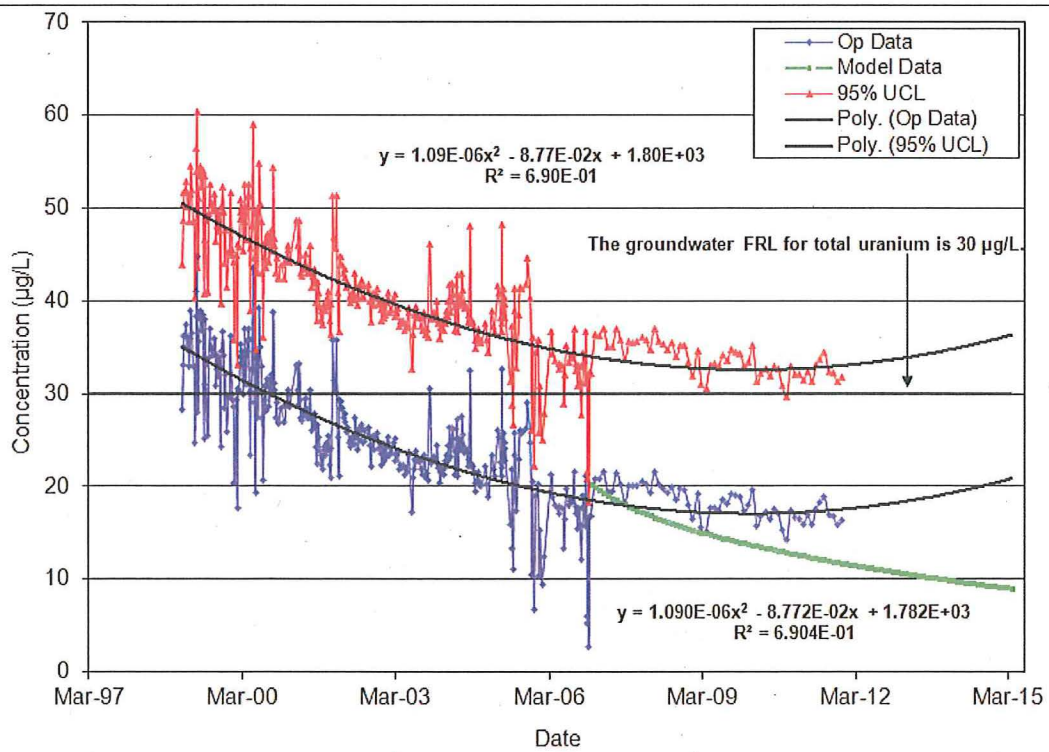

FIGURE A.1-15. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 3925 (RW-2) WITH REGRESSION ANALYSIS

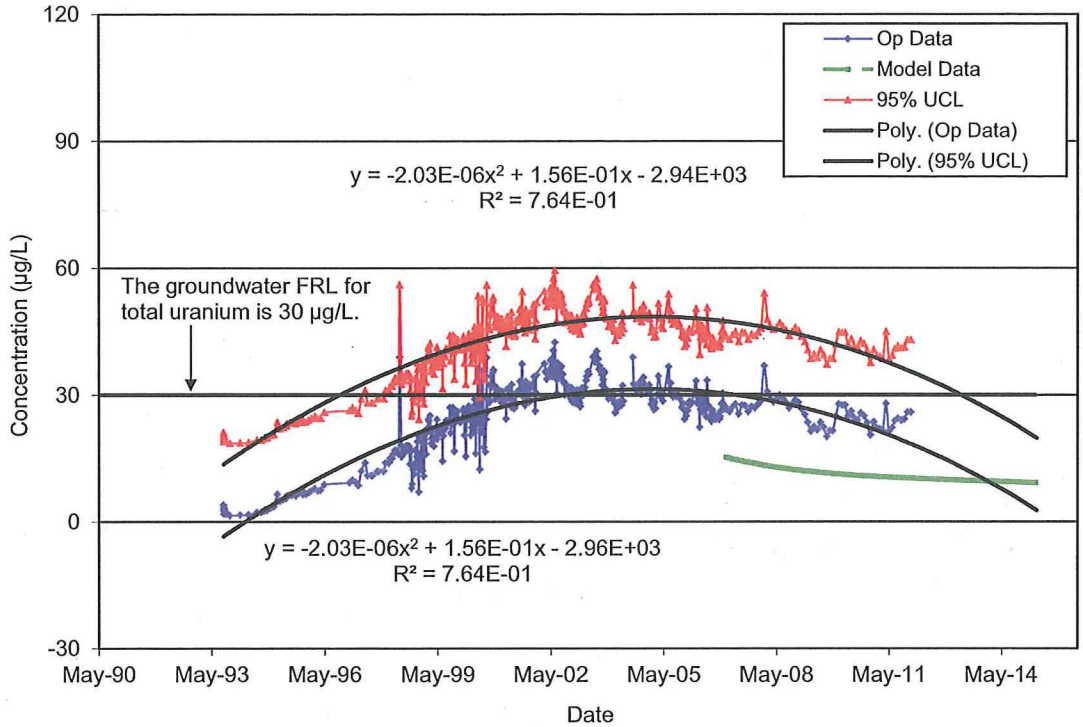

Figure A.1-16. Total Uranium Concentration vs. Time Plot for Extraction Well 3926 (RW-3) with Regression Analysis

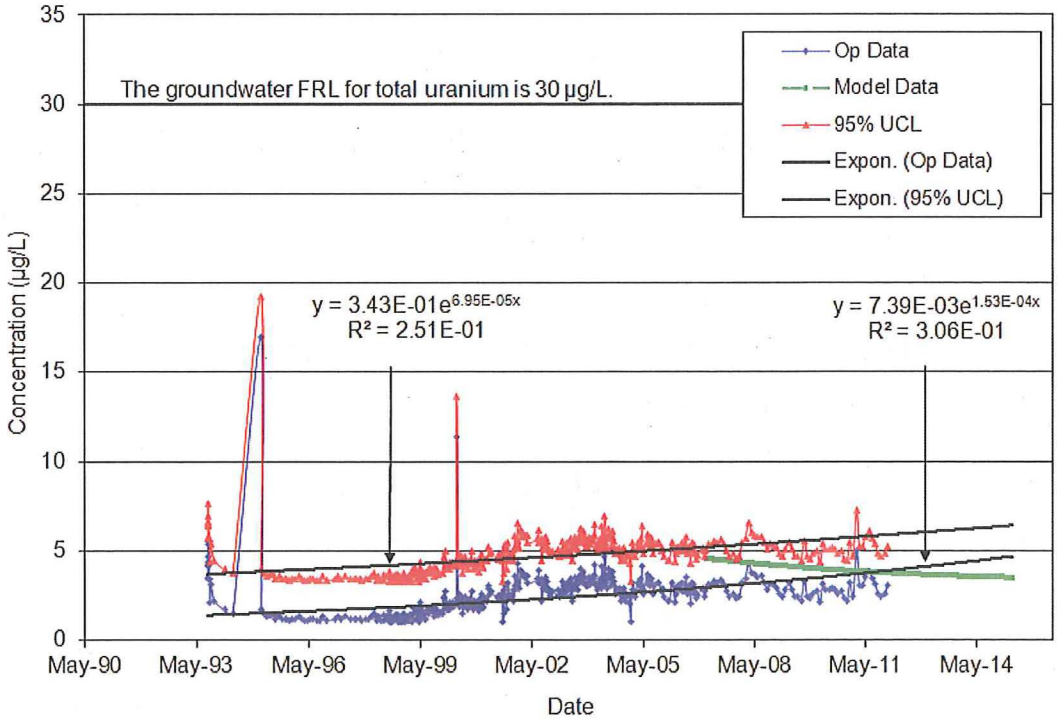

Figure A.1-17. Total Uranium Concentration vs. Time Plot for Extraction Well 3927 (RW-4) with Regression Analysis

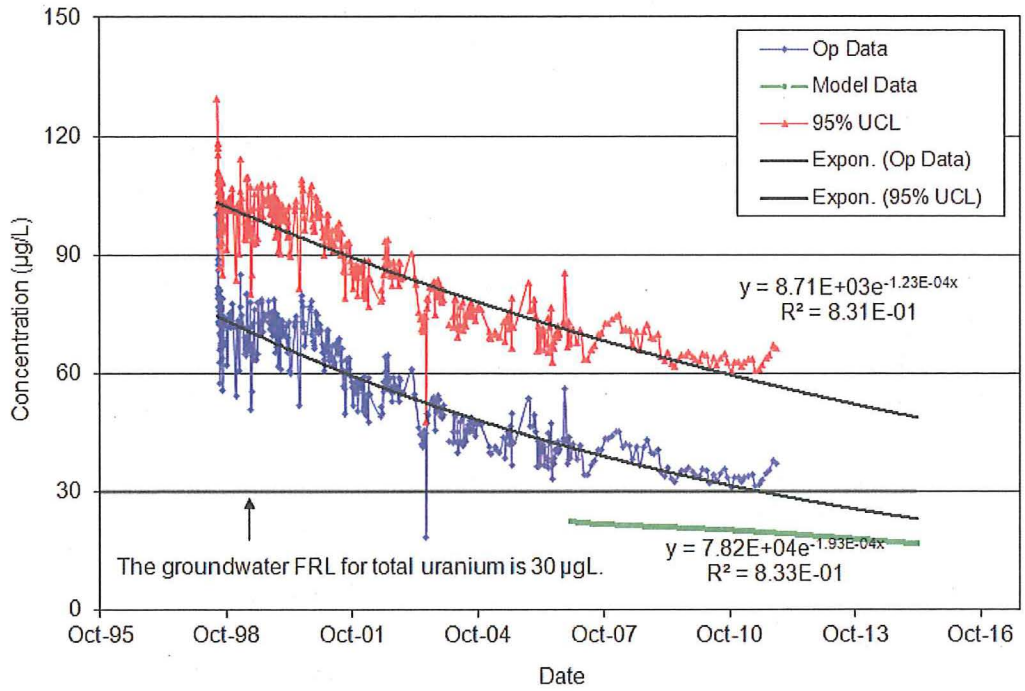

Figure A.1-18. Total Uranium Concentration vs. Time Plot for Extraction Well 32308 (RW-6) with Regression Analysis

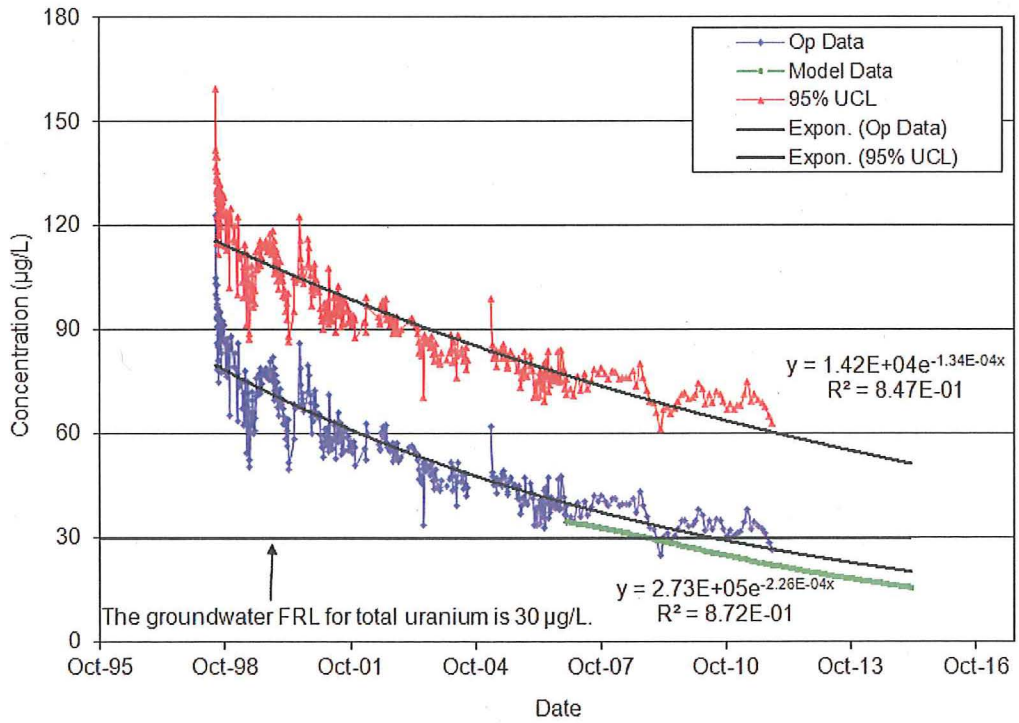

FIGURE A.1-19. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 32309 (RW-7) WITH REGRESSION ANALYSIS

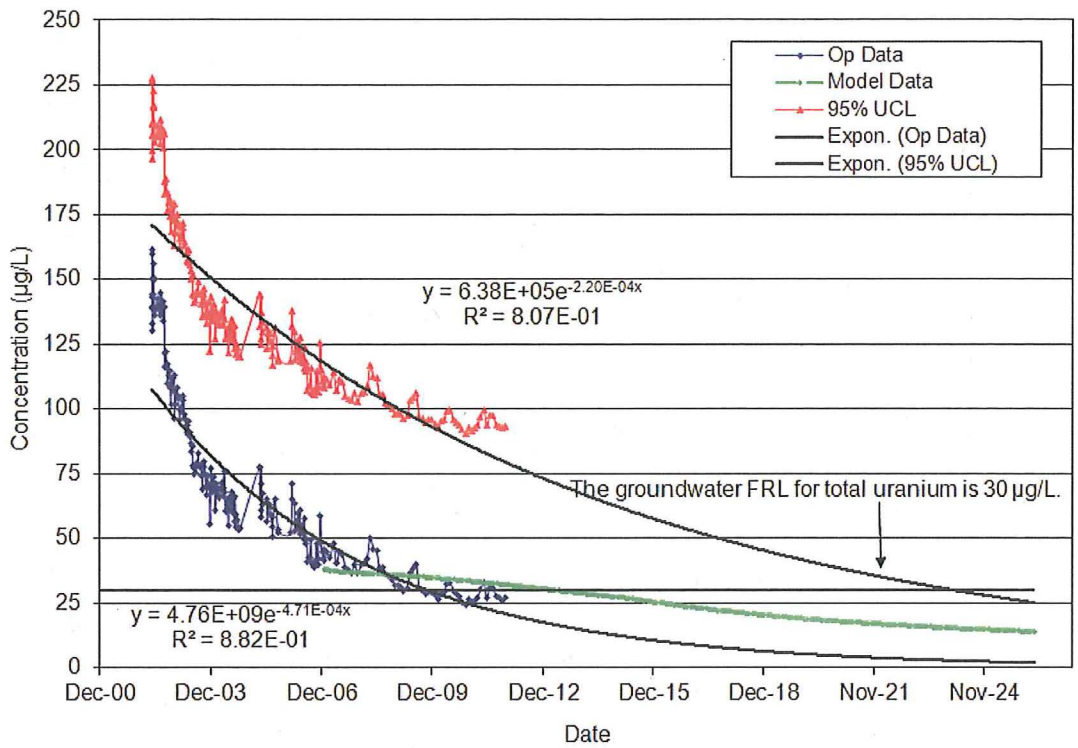

Figure A.1-20. Total Uranium Concentration vs. Time Plot for Extraction Well 32761 (EW-26) with Regression Analysis

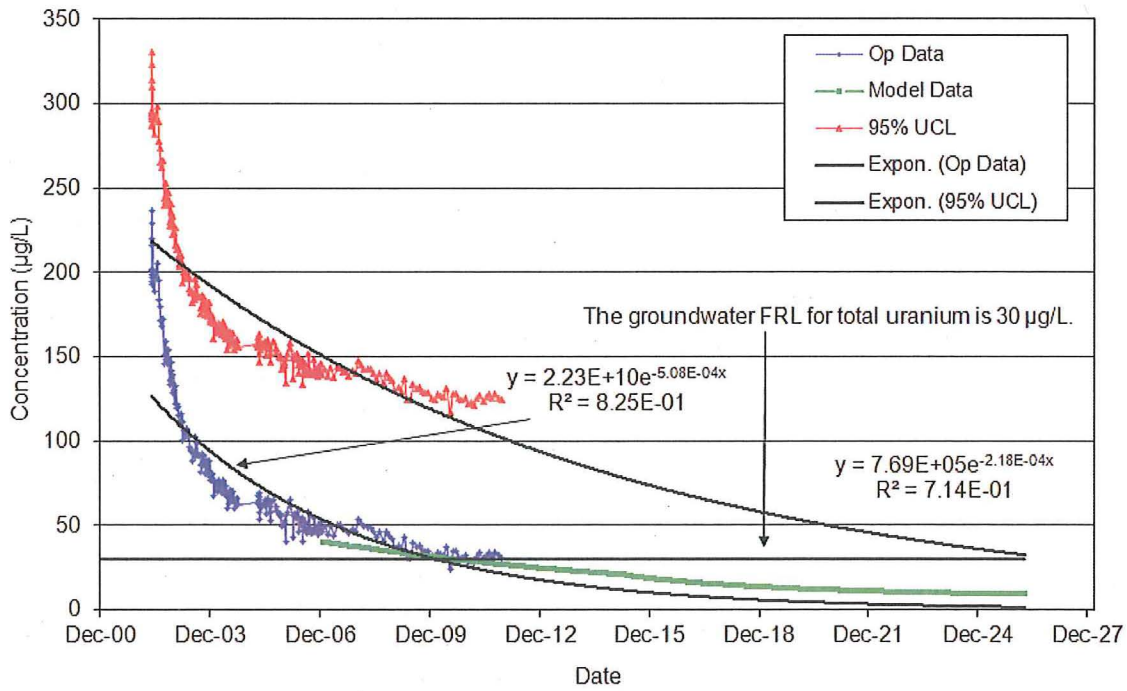

Figure A.1-21. Total Uranium Concentration vs. Time Plot for Extraction Well 33062 (EW-27) with Regression Analysis

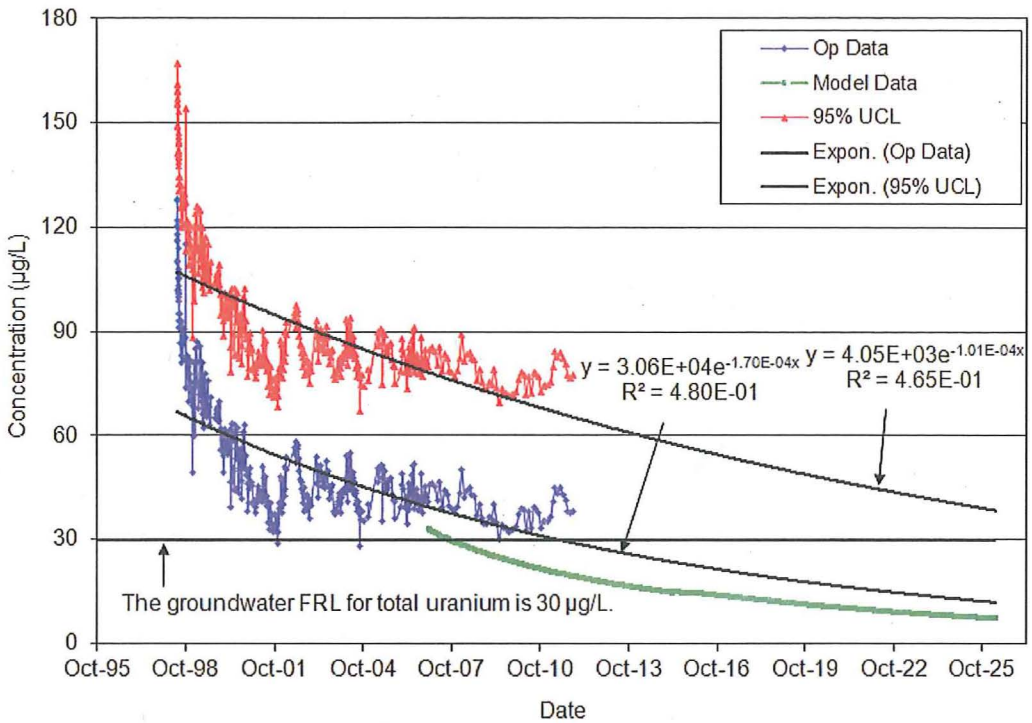

Figure A.1-22. Total Uranium Concentration vs. Time Plot for Extraction Well 31550 (EW-18) with Regression Analysis

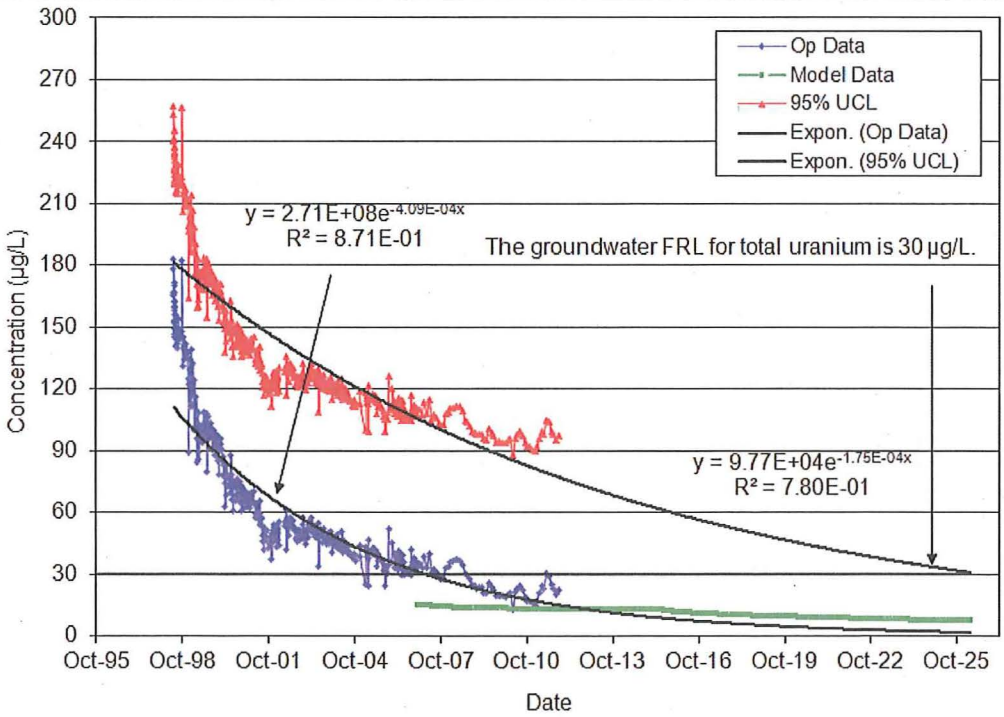

Figure A.1-23. Total Uranium Concentration vs. Time Plot for Extraction Well 31560 (EW-19) with Regression Analysis

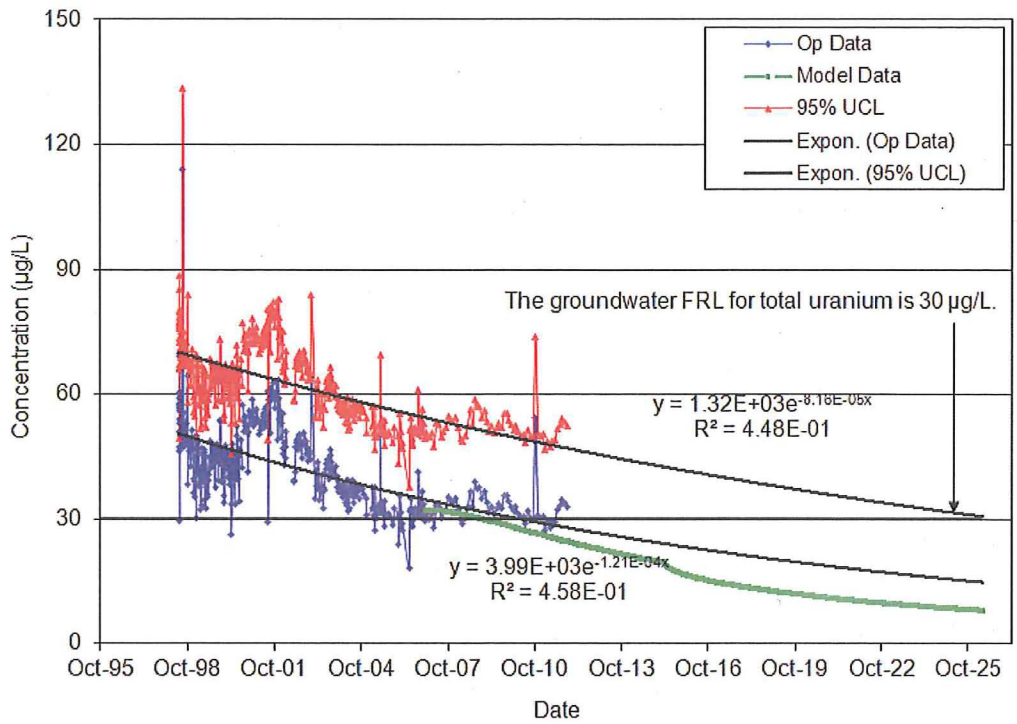

Figure A.1-24. Total Uranium Concentration vs. Time Plot for Extraction Well 31561 (EW-20) with Regression Analysis

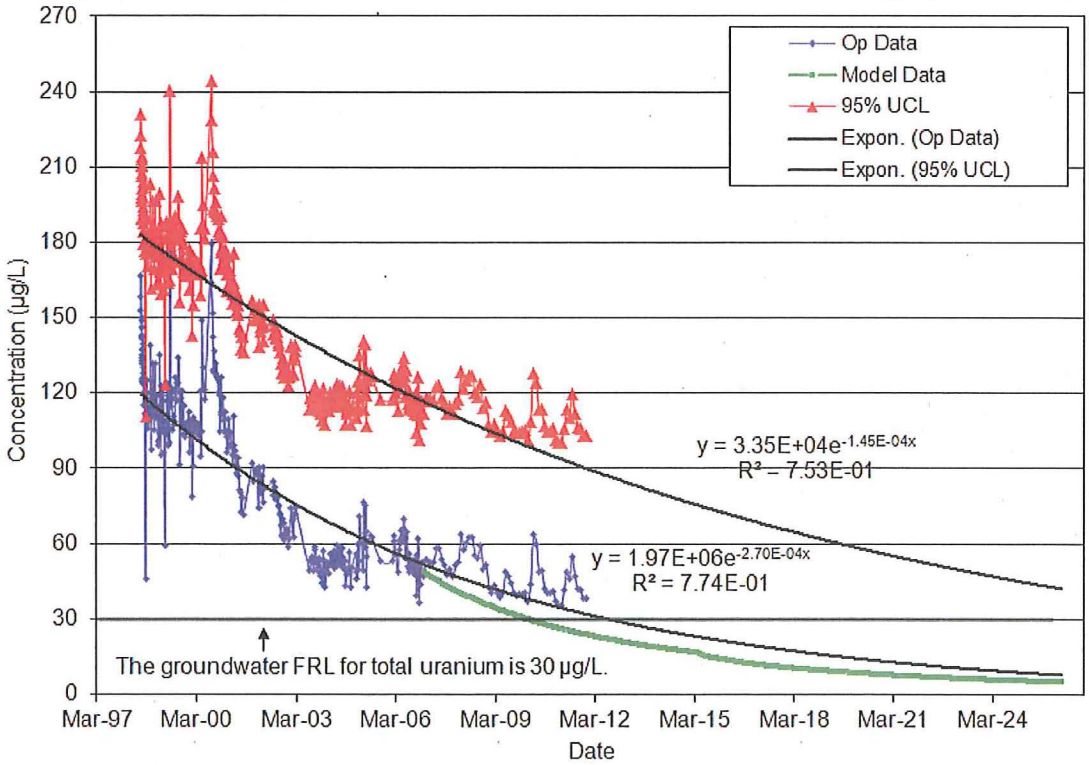

Figure A.1-25. Total Uranium Concentration vs. Time Plot for Extraction Well 31562 (EW-21) / 33298 (EW-21a) with Regression Analysis

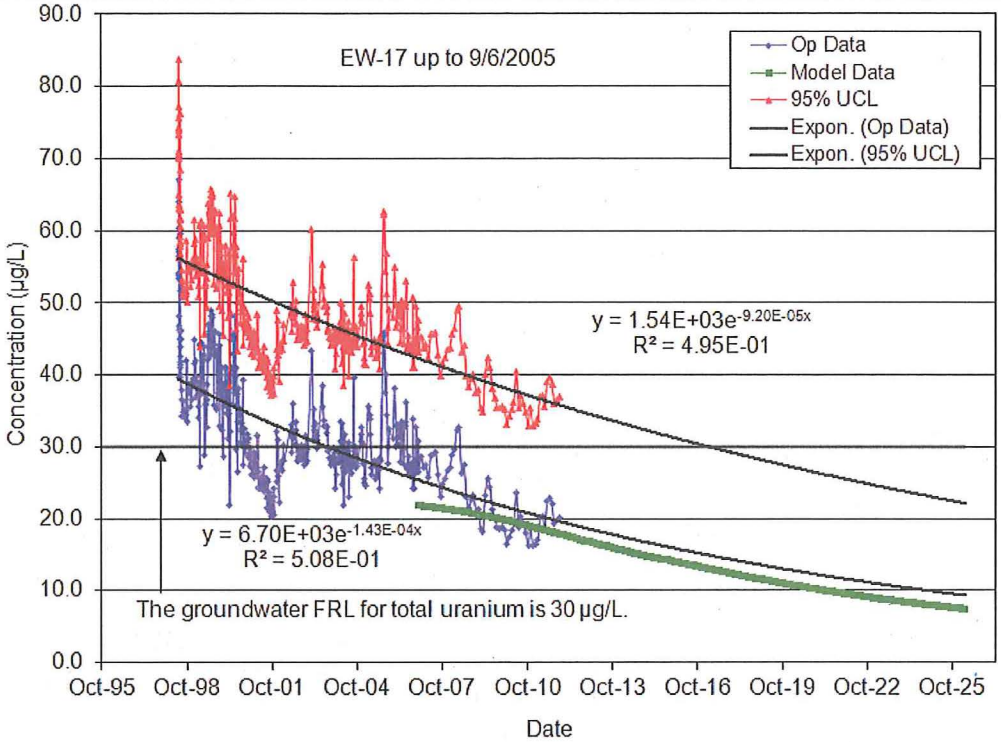

Figure A.1-26. Total Uranium Concentration vs. Time Plot for Extraction Well 31567 (EW-17)/ 33326 (EW-17a) with Regression Analysis

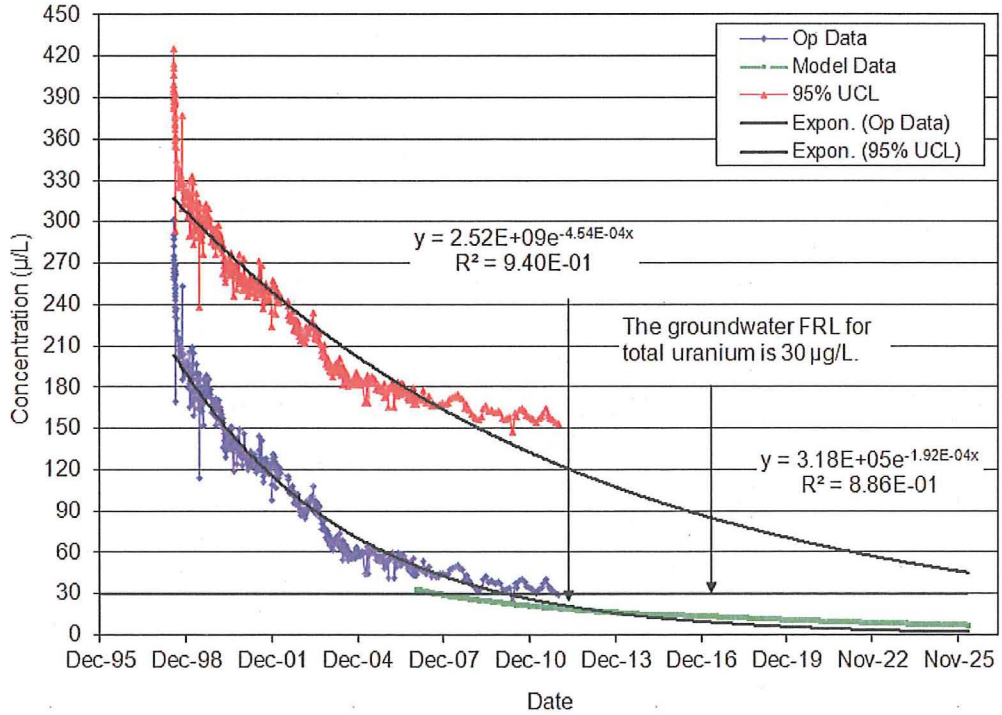

Figure A.1-27. Total Uranium Concentration vs. Time Plot for Extraction Well 32276 (EW-22) with Regression Analysis

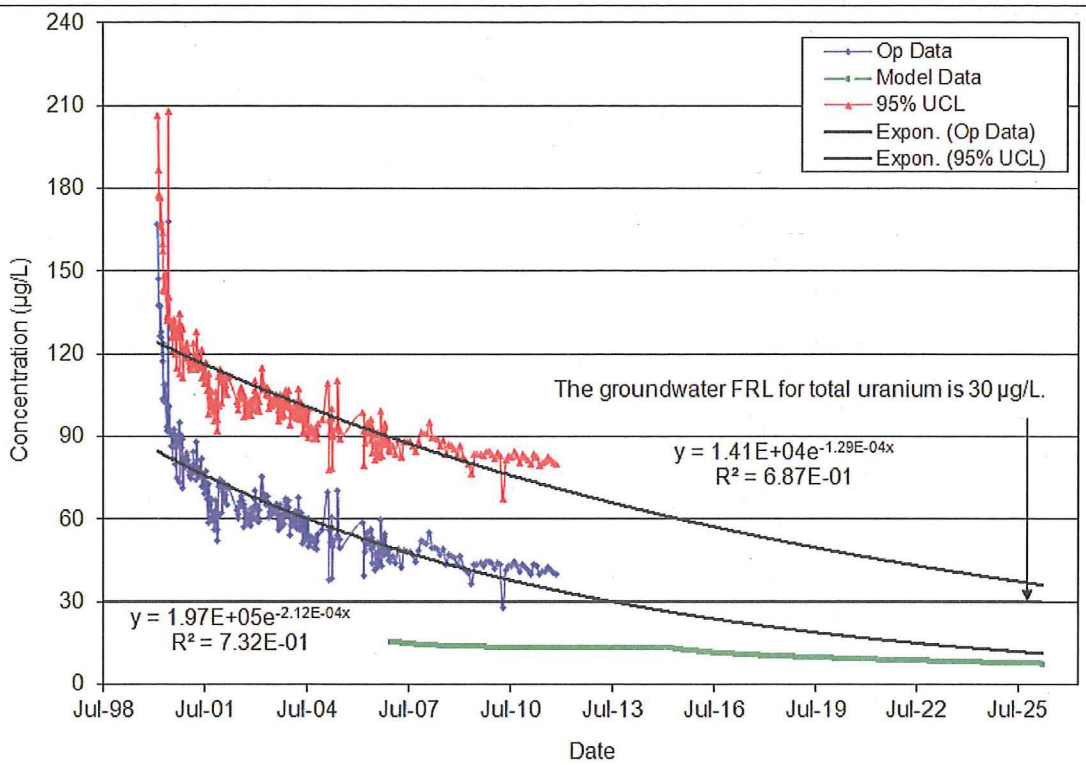

Figure A.1-28. Total Uranium Concentration vs. Time Plot for Extraction Well 32446 (EW-24) with Regression Analysis

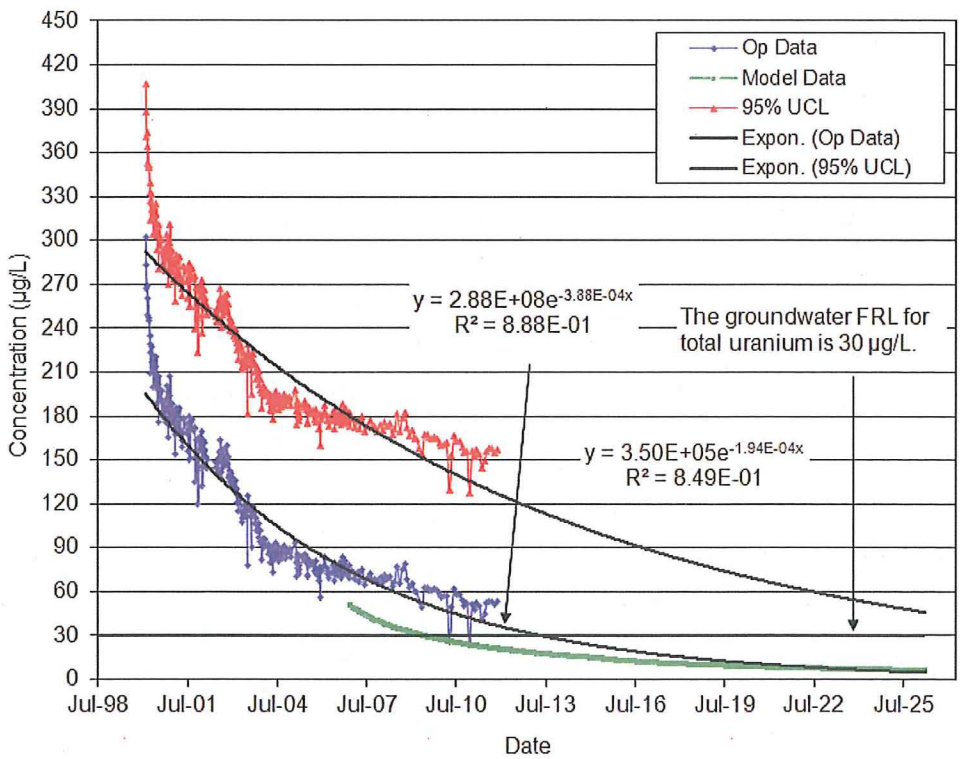

Figure A.1-29. Total Uranium Concentration vs. Time Plot for Extraction Well 32447 (EW-23) with Regression Analysis

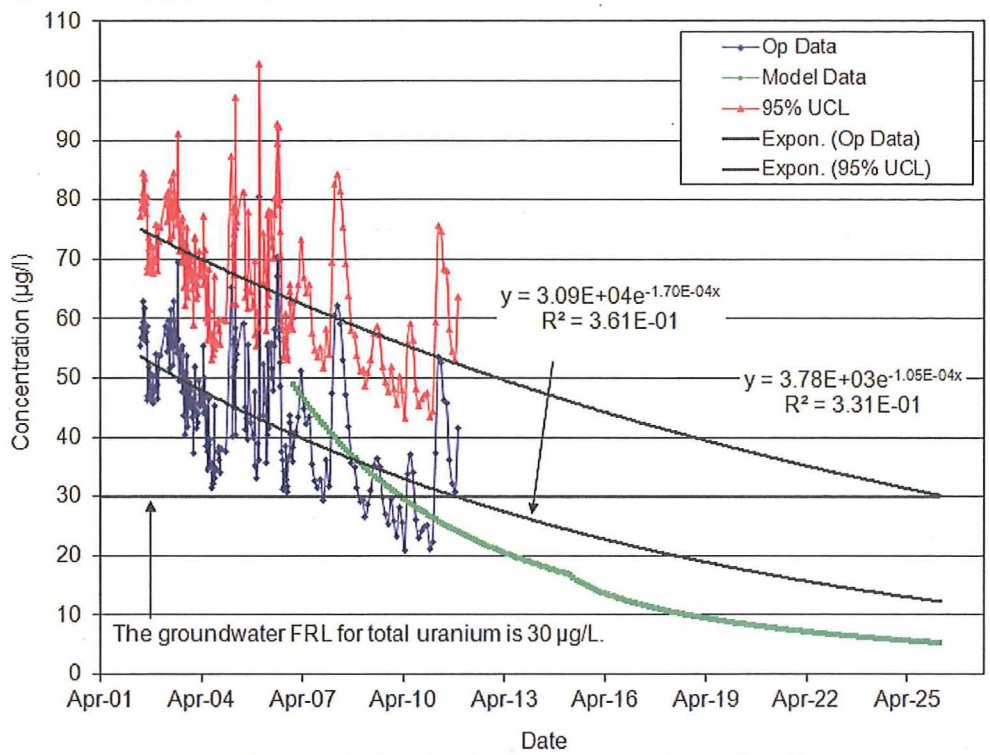

Figure A.1-30. Total Uranium Concentration vs. Time Plot for Extraction Well 33061 (EW-25) with Regression Analysis

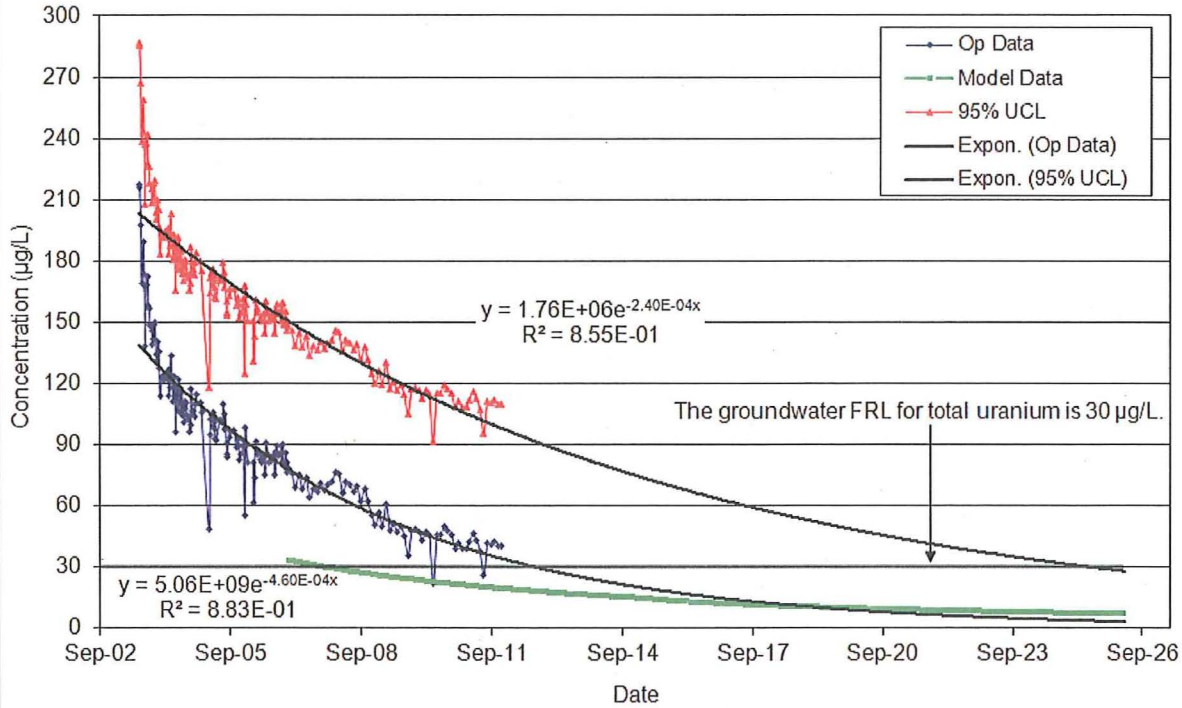

Figure A.1.31. Total Uranium Concentration vs. Time Plot for Extraction Well 33264 (EW-30) with Regression Analysis

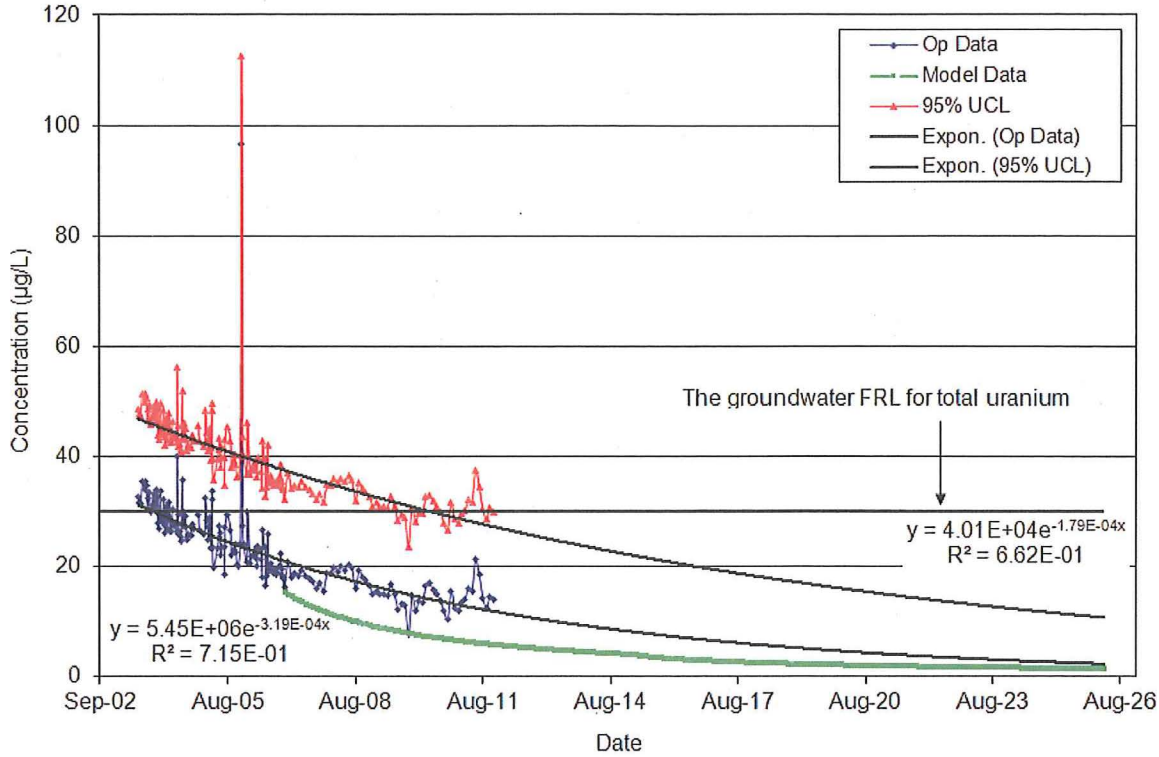

Figure A.1-32. Total Uranium Concentration vs. Time Plot for Extraction Well 33265 (EW-31) with Regression Analysis

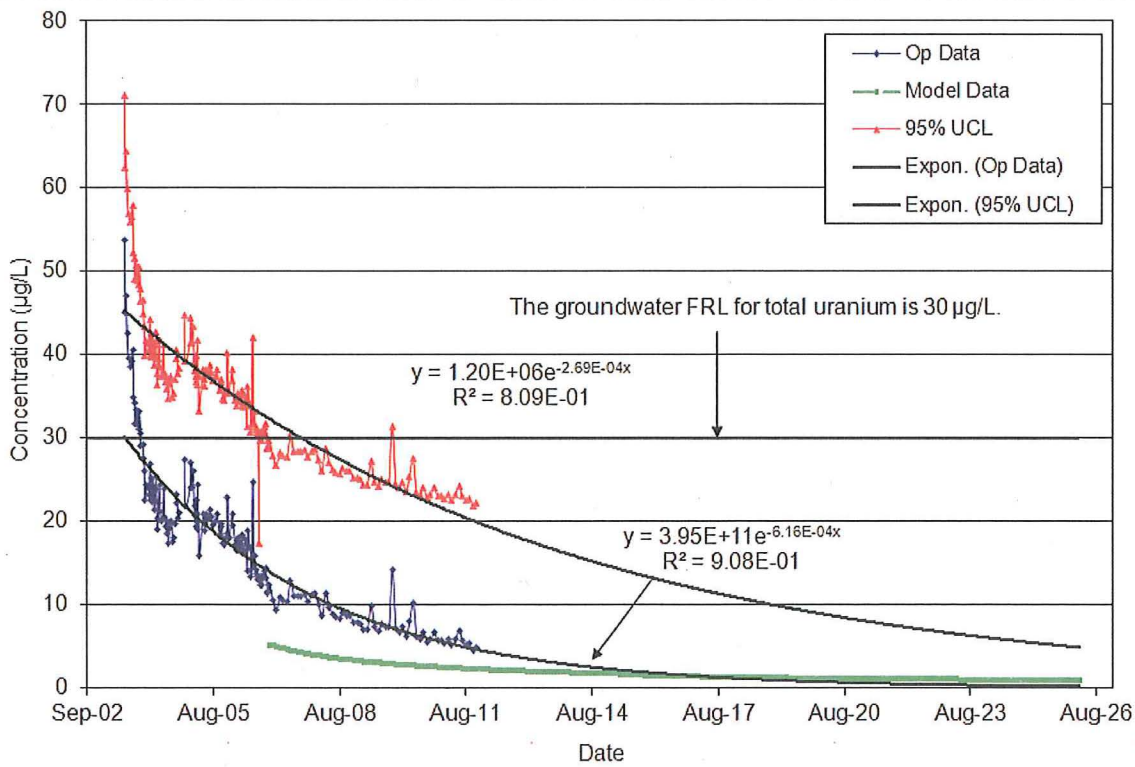

Figure A.1-33. Total Uranium Concentration vs. Time Plot for Extraction Well 33266 (EW-32) with Regression Analysis

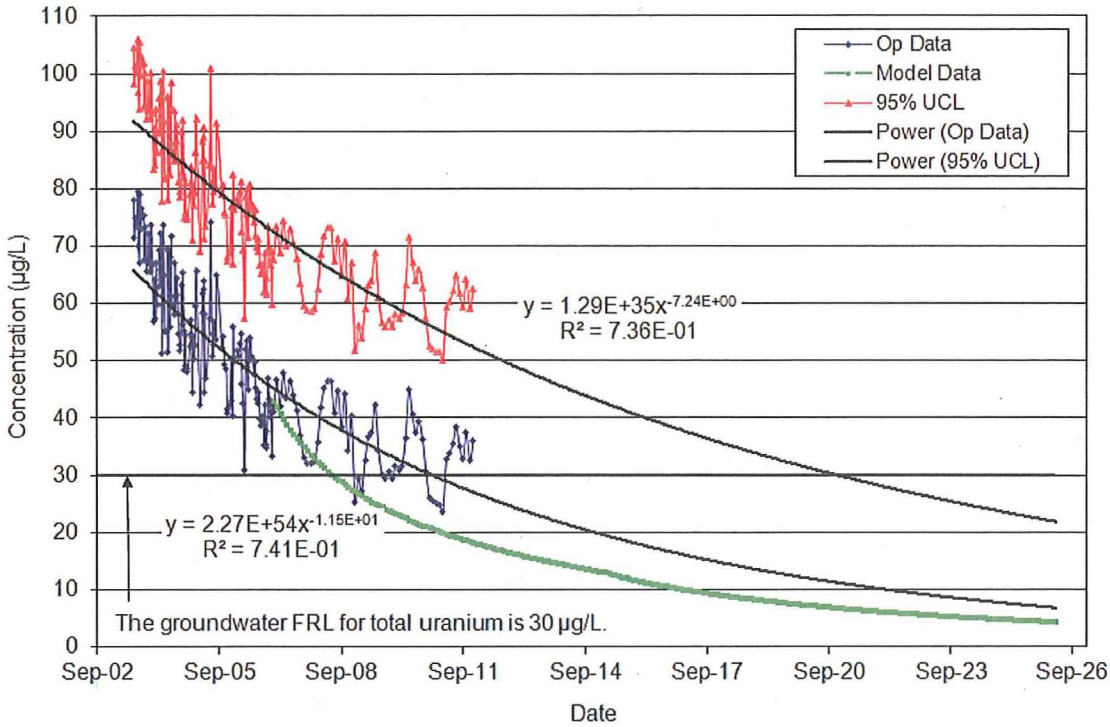

Figure A.1-34. Total Uranium Concentration vs. Time Plot
for Extraction Well 33262 (EW-15a) with Regression Analysis

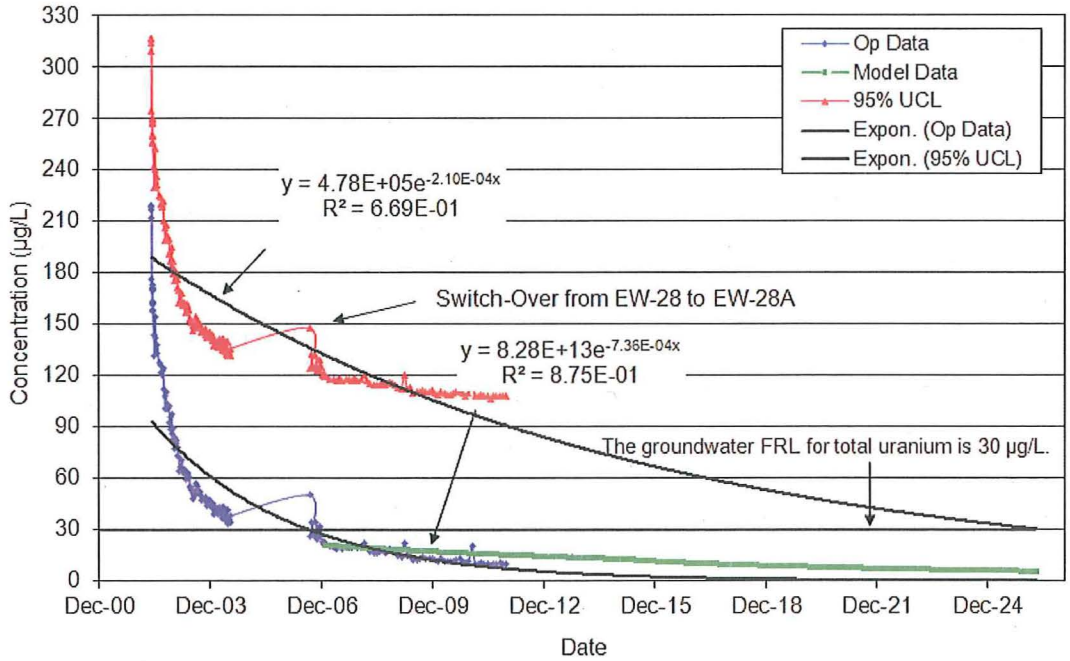

Figure A.1-35. Total Uranium Concentration vs. Time Plot
for Extraction Well 33063 (EW-28) / 33334 (EW-28a) with Regression Analysis

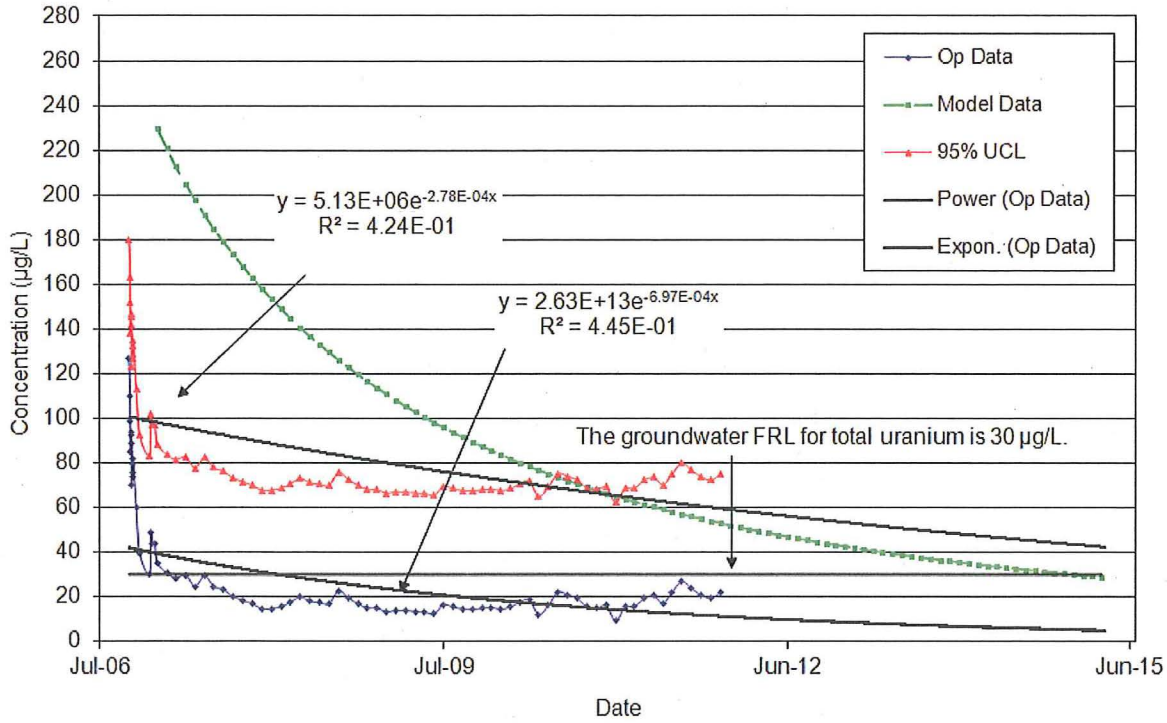

Figure A.1-36. Total Uranium Concentration vs. Time Plot for Extraction Well 33347 (EW-33a) with Regression Analysis

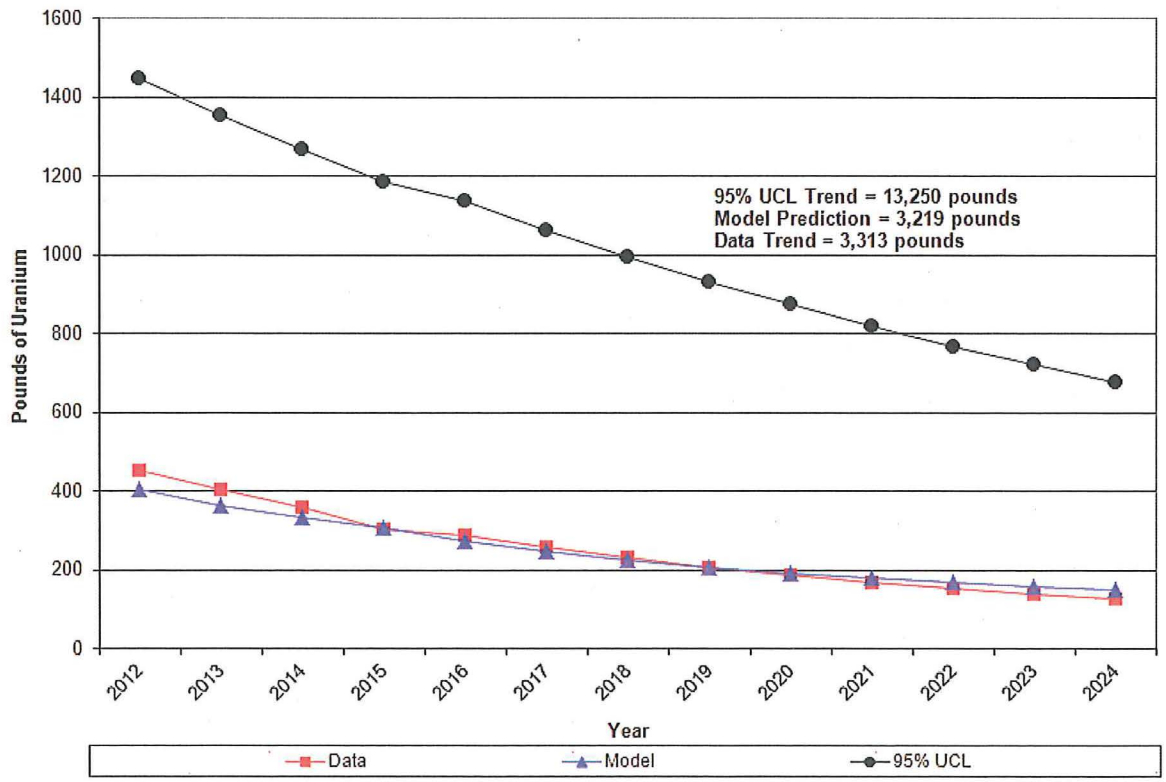

Figure A.1–37. Estimate of Yearly Pounds of Uranium to be Pumped from Aquifer (Model Predictions vs. Measured Concentration Trends) Data Collected Through 2011

Attachment A.2

Attachment A.2

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A.2.0 Assessment of Total Uranium Results

This attachment discusses groundwater monitoring total uranium results through 2011. The groundwater total uranium sampling requirements are presented in the Integrated Environmental Monitoring Plan (IEMP), which is Attachment D of the *Comprehensive Legacy Management and Institutional Controls Plan* (LMICP) (DOE 2011a). IEMP groundwater monitoring and extraction well locations are shown in Figure A.2–1. For integration purposes, the OSDF monitoring well locations are also shown on Figure A.2–1. In addition to the routine well monitoring specified in the IEMP, 28 locations were sampled using a direct-push sampling tool (Geoprobe®) in 2011. Direct-push sampling results are presented in Tables A.2–1 through A.2–28.

As reported in Attachment A.3, record high precipitation occurred in 2011. The average annual precipitation for the site is approximately 41 inches a year (OU5 Remedial Investigation [DOE 1995]). Precipitation data collected at the Butler County Regional Airport is reported in the SER. For calendar year 2011, the Butler County Regional Airport recorded 60.20 inches of precipitation. A portion of the large amount of precipitation served to recharge the aquifer and raise the water table. High water levels in the aquifer provide ideal conditions to update the dimensions of the maximum uranium plume because more of the vertical component of the plume can be sampled. DOE took full advantage of the high water levels in 2011 and collected 28 direct push samples to support updating the dimensions of the total uranium plume. As reported below, data obtained from these 28 samples, along with data collected from fixed monitoring well locations, were used to decrease the footprint of the mapped maximum uranium plume in 2011 by approximately 40 acres or 21.6 percent from what was mapped at the end of 2010.

A minor mapping change was initiated in 2011 that also contributed a small decrease (less than 1 acre) to the size of the maximum uranium plume map for 2011. In past years, small circles were arbitrarily drawn around locations that had intermittent uranium FRL exceedances. The arbitrary sizes of the small circles were then counted as part of the overall maximum uranium plume acreage. In 2010, the maximum uranium plume map had four of these small circles adding approximately 0.957 acres to the size of the maximum plume. In 2011, these small circles were eliminated and replaced with symbols indicating intermittent exceedances. This technique provides better estimates of the actual size of the maximum uranium plume. It also serves to keep track of the locations with intermittent uranium groundwater FRL exceedances so that their presence can be carried forward into the certification stage of the remediation project.

Figures A.2–2A, A.2–2B, A.2–3A, and A.2–3B show maximum total uranium plume maps for the first and second halves of 2011, respectively. Figures A.2–2A and A.2–3A show direct-push data. Figures A.2–2B and A.2–3B show monitoring well and extraction well data. Data collected from the aquifer are used to progressively update the maximum total uranium plume maps in the following conservative manner:

- Total uranium concentration data are posted on a map with the contours from the previous map. The highest representative total uranium value at a monitoring well location is posted. The highest concentration associated with each direct-push location is also posted.
- If a recently measured concentration from a well is greater than the previous concentration contour value at that location, then the plume is re-contoured using the higher value.

- If the most recent concentration measurement from a well is less than the previous contour for that location, then the new data are posted, but the plume contours are not adjusted using the new data until confirmatory direct-push sampling can be conducted.
- If direct-push data or multi-level monitoring well data are available and a complete vertical profile of an area indicates that concentrations have changed, then the map is re-contoured using the new direct-push data or multilevel well data. Note, under this strategy, a reduction in the size of the mapped plume is based on vertical profile data.

Table A.2–29 lists the monitoring wells where total uranium concentrations exceeded the 30 µg/L Final Remediation Level (FRL) during 2011. Included in the table are total uranium statistical summaries for each well, which include Mann-Kendall trend analyses. Table A.2–30 provides total uranium statistical summaries for the extraction wells, including Mann-Kendall trend analyses. Figure A.2–4 illustrates the statistics presented in Table A.2–29 (e.g., where total uranium concentrations have, if any, an "up, significant," "down, significant," or a "no significant" trend).

Attachment A.2 is subdivided into the following sections:

- A.2.1 Former Waste Storage Area
- A.2.2 Former Plant 6 Area
- A.2.3 South Field and Off-Property South Plume Uranium Plumes
- A.2.4 Flow Monitoring in the Storm Sewer Outfall Ditch

A.2.1 Former Waste Storage Area

A.2.1.1 Former Waste Storage Area Maximum Uranium Plume

The mapped footprint of the 30 µg/L maximum uranium plume in the former Waste Storage Area decreased in 2011. In 2010, the mapped footprint was estimated to be 22.429 acres. In 2011, the mapped footprint is estimated to be 15.656 acres, a decrease of 30.2 percent.

Direct push sampling was conducted at three location in the former waste storage area in 2011 (12617C, 13422, and 12618C). Results (provided in Tables A.2–1 through A.2–3) helped define the decrease in plume size noted above. As reported last year, the area around monitoring wells 2821 and 3821 was targeted for direct push sampling in 2011 (Location 12617C). Sampling was conducted in 2011 and results for location 12617C are provided in Table A.2-1. The results indicate that uranium concentrations are below the 30 µg/L uranium FRL, but that groundwater FRL exceedances for technetium-99, nitrate/nitrite, and manganese remain.

Monitoring well 2649 had its highest recorded uranium FRL exceedance in 2011 (954 µg/L) (Figure A.2-5). The high uranium concentration is attributed to sorbed uranium in the vadose zone in this former source area. High water levels within the aquifer in 2011 allowed some of the sorbed uranium to dissolve into the water and raise the uranium concentration.

The northwest corner of the maximum uranium plume in the former Waste Storage Area is bounded by Paddys Run to the west and the former waste pits to the east. Intermittent puddles of surface water collect in this area west of the former Waste Pit 3. Surface water samples are collected and analyzed from these small intermittent puddles. As presented in Appendix B, the

uranium concentration of some of the collected samples exceeds the groundwater FRL. Surface water runoff in the former Waste Storage Area is directed to where the Clear Well and Pit 3 were once located. The surface water is allowed to infiltrate into the ground and serve as a source of recharge to the aquifer. The area of infiltration is within capture of the former Waste Storage Area pumping wells.

A.2.1.2 Pilot Plant Drainage Ditch Maximum Uranium Plume

The mapped footprint of the 30 µg/L maximum uranium plume in the Pilot Plant Drainage Ditch Area decreased in 2011. In 2010, the mapped footprint was estimated to be 25.733 acres. In 2011, the mapped footprint is estimated to be 9.653 acres, a decrease of 60.48 percent.

Direct push sampling was conducted at four locations in the Pilot Plant Drainage Ditch Area in 2011 (13418A, 13412A, 13428, and 12717B). Results (provided in Tables A.2–4 through A.2–7) helped define the plume decrease noted above. Up until 2011, monitoring well 83335_C2 defined the eastern edge of the Pilot Plant Drainage Ditch Plume even though a uranium FRL exceedance had not been detected in the well for the last 2.5 years (Figure A.2-6). High water level conditions in the aquifer during the second half of 2011 resulted in a uranium FRL exceedance (38.7 µg/L). This monitoring well location is identified on the 2011 maximum uranium plume map as a location with intermittent uranium FRL exceedances. If future monitoring in well 83335 indicates that the intermittent uranium FRL exceedances are continuing or increasing, additional direct-push sampling may be conducted in the area when water levels are high to verify the extent of the intermittent exceedances and revisions to the maximum total uranium plume map will be made if warranted.

A.2.2 Former Plant 6 Area

Plans for a groundwater restoration module in the former Plant 6 Area were abandoned in 2001 based on the outcome of the *Design for Remediation of the Great Miami Aquifer in the former Waste Storage and Plant 6 Areas* (DOE 2001a). This design provided data that indicated that the total uranium plume in the former Plant 6 area was no longer present. The EPA and Ohio EPA (OEPA) concurred with this decision.

Monitoring well 2389 is the only groundwater monitoring well remaining in the area where Plant 6 was located in the former production area (Figure A.2–1). Figure A.2–7, shows that sporadic uranium FRL exceedances were detected between 2002 and 2007 at monitoring well 2389. As discussed below, the FRL exceedances at this monitoring well are associated with high water table conditions. High water level conditions in 2011 resulted in two uranium FRL exceedances being measured in 2011; 78.2 ug/L in the first half of the year, and 43.2 ug/L in the second half of the year. The 78.2 ug/L concentration is the highest concentration measured in monitoring well 2389 since 1990.

Direct-push sampling in this area indicates that the intermittent uranium FRL exceedances are associated with a thin amount of contamination that is detected under high water table conditions. The former Plant 6 area is targeted for direct-push sampling when the water-table elevation is at an elevation of 514.8 ft amsl or higher. As shown below, unless the water table is at an elevation of 514.8 feet amsl or higher uranium FRL exceedances are not detected. A direct push sample was collected in this area in 2011 (location 13360C). As shown below, the regional

water table was high enough for the sample to detect an exceedance. The concentration of the exceedance (37.7 ug/L) is similar to the exceedance detected back in 2008 (37.2 ug/L).

Year	Location	Uranium Concentration (µg/L)	Midpoint Screen Elevation (ft amsl)
2007	13360	< 1.0	512.3
2008	13360A	37.2	514.8
2010	13360B	4.4	510.3
2011	13360C	37.7	515.1

Up until this year, a small uranium plume was arbitrarily drawn circling monitoring well 2389 on the maximum total uranium plume map to represent the intermittent uranium FRL exceedances. This year the monitoring well is identified as an intermittent exceedance location with a symbol rather than a circle. The well will continue to be identified on maximum uranium plume map as being a location where intermittent uranium FRL exceedances have been measured so that its presence will be carried forward into the certification stage of the aquifer remediation.

A.2.3 South Field and Off-Property South Plume Uranium Plumes

The mapped footprint of the 30 µg/L maximum uranium plume in the South Field and off property South Plume decreased in 2011. In 2010, the mapped footprint was estimated to be 135.513 acres. In 2011, the mapped footprint is estimated to be 117.998 acres, a decrease of 12.9 percent.

Direct push sampling was conducted at twenty locations in the South Field and South Plume in 2011 (12369P, 12372Q, 13241A, 13297A, 13356A, 13357A, 13412A, 13413A, 13419A, 13419B, 13420, 13421, 13423, 13424, 13425, 13426, 13427, 13430, 13431, and 13432). Locations are shown in Figure A.2–3A. Results from these twenty locations were used to help define the plume decrease noted above. The four main areas change to the mapped plume are discussed below.

Area 1: The northern edge of the South Field plume was moved south based on results from direct push sampling locations 13419A, 13419B, 13430, and 13431. This area is located just south of the site access road, and southeast of the stormwater retention basins. Direct-push sampling results are provided in Tables A.2-13 through A.2-16. Location 13419 was sampled twice in 2011. The first sampling event (13419A) stopped at a depth of 67 feet below the ground surface (bgs) because the material encountered was too fine to yield a sample. The second sampling event (13419B) was successful in reaching a deeper depth of 127 feet bgs. The highest uranium concentration measured was from the first sampling event (23.8 ug/L), and was used in the maximum uranium plume map to be conservative.

Area 2: The southeastern edge of the South Field plume was moved west in two areas based on results from direct push sampling locations 13241A, 13356A, and 13432 and monitoring wells in the area. Direct push sampling results from these locations are provided in Tables A.2-9, A.2-20, and A.2-28, respectively. Uranium plume contours just west of direct push location 13241A incorporate direct push sampling results that are over 7 years old. This area is being targeted for direct push sampling in 2012 in order to update the plume profile and provide a more up-to-data maximum plume interpretation.

Area 3: The southern edge of the South Plume was moved north to honor direct push sampling location 13427 and monitoring well sampling results in the area.

Area 4: An off property lobe of the uranium plume was better delineated in 2011 by the collection of direct push data. As discussed in the Fernald Preserve Site Environmental Report, 2010 (DOE 2011a) and the *Third Five-Year Review Report for the Fernald Preserve* (DOE 2011b) stagnation zones within the uranium plume are identified as having the potential to extend remediation completion times for the aquifer beyond that predicted by the groundwater model. Stagnation zones are created by the competition of extraction wells for water within the aquifer. A stagnation zone exists just south of Willy Road, located between the South Plume extraction wells and the South Field extraction wells. Figure A.2–3A is a maximum uranium plume map for the second half of 2011. The subject off-property lobe of the uranium plume can be located on Figure A.2-3A by the dense concentration of direct push sampling data obtained in 2011 just south of Willy Road. The data indicates that the lobe is actually connected to the main off-property plume to the southwest.

With the southern extent of the lobe defined by 2011 direct-push data, potential ways to improve the aquifer remedy design in this area are being explored to see if remediation times can be improved (e.g., change the pumping rates of existing extraction wells; convert an out-of-service injection well just north of the lobe into an additional extraction well; and/or possibly install a new extraction well). DOE will discuss improvement options with EPA and Ohio EPA before taking any action in the area.

Update of Cross Sections along Willey Road

Since 1998 several locations along Willey Road have been sampled using a direct-push sampling tool: 12367, 12368, 12369, 12370, 12371, 12372, and 12373. These locations were originally sampled to track re-injection progress along Willey Road. Re-injection was discontinued in September 2004; however, annual sampling continued at five of the seven locations (12368, 12369, 12370, 12371, and 12372) to provide updates on remediation progress. Up until 2010, the results were used to prepare two cross sections of the area.

Sampling of the locations annually was creating a problem in the field, in that it was becoming hard to find a location free of grout from the multiple previous sample collection efforts. Over the years, the plume has decreased so that only two locations remain within the plume (locations 12372 and 12369). DOE is installing multi-level monitoring wells at these locations. Soggy field conditions in 2011 pushed the installations into 2012. The remaining locations, that are no longer in the plume (locations 12373, 12368, and 12370), will not be sampled again until the south plume certification stage of the groundwater remedy, unless it is deemed necessary to do so.

Figure A.2-8 is a cross section of 2011 monitoring results at locations 12372Q and 12369P. The data indicates that the plume continues to decrease in this area. Historical data for location 12373P is provided in the figure for reference purposes to show that a high concentration of uranium was measured at an elevation of approximately 516 feet amsl in 2005. If and when water levels get this high again, additional sampling direct push sampling will be conducted at location 12373 to provide an update.

A.2.4 Flow Monitoring in the Storm Sewer Outfall Ditch

As reported in the *Groundwater Remedy Evaluation and Field Verification Plan* (DOE 2004a), a modeled infiltration rate of 500 gpm through the SSOD decreased the model-predicted cleanup time estimate by one year. A field study was conducted in 2005 to gauge seasonal flow of water in the Storm Sewer Outfall Ditch (SSOD) and to determine if recharge to the GMA through the SSOD at a rate of 500 gpm was feasible (DOE 2005b). Although the study concluded that the operation would not be cost effective, subsequent discussions in 2006 with EPA and OEPA led to an agreement to continue the infiltration operation.

As shown in Figure A.2–9, six Parshall flumes are installed in the SSOD. These flumes are used to measure flow into and out-of the SSOD. The natural flow into the SSOD is being supplemented (since 2006) with water supplied from a group of three water wells located on the east side of the site (42202, 42471, and 43309). Well 42471 became inoperable in June of 2010 due to an electrical issue. As stated in the Operations and Maintenance Master Plan (OMMP), this is Attachment A of the LMICP (DOE 2010a): Supplemental pumping into the SSOD will continue until the wells, pumps, or motors are no longer serviceable. At that time, operations will be suspended, pending a determination that the remedy is benefiting from the operation (DOE 2011a). The wells are pumped as necessary to supplement natural flow and maintain a flow of approximately 500 gpm into the SSOD. Water pumped from the wells is discharged into a ditch that empties into the Lodge Pond. Water from the Lodge Pond is allowed to overflow into the mouth of the SSOD. Flume 6 is the first flume located downstream of the Lodge Pond. Flumes 2, 3, 4, 5, and 6 all measure flows into the SSOD. Flume 1 is the most southernmost flume. It measures flow emptying out of the SSOD and into Paddys Run.

Pumping Operations

In 2011, 138,680,400 gallons of clean groundwater at an average rate of 359 gpm were pumped into the SSOD. Pumping of clean groundwater into the SSOD began on December 14, 2006. Since pumping began, flow metering indicates 717,739,050 gallons of clean groundwater water have been pumped from the aquifer and used to supplement flow in the SSOD.

Year	Total Gallons of Water Pumped	Average Pumping Rate (gpm)
2006 (Dec. 14–Dec. 31)	8,154,900	334
2007	138,900,400	264
2008	119,256,249	227
2009	132,584,001	252
2010	180,163,100	343
2011	138,680,400	359
Total	**717,739,050**	

Throughout 2011, pumping was intermittently halted due to high pond levels as a result of record high seasonal and annual rainfall, and despite excessive drainage of the Lodge Pond through or near the engineered outlet for the pond. From May 14 to May 23, pumping of water into the

SSOD was temporarily increased by pumping both wells to maintain the water level of the Lodge Pond due to this excessive drainage through or near the engineered outlet for the pond. From November 27 to December 12, pumping was halted so that repairs to the engineered outlet could be made to stem this excessive drainage. Preliminary data after repairs at the end of 2011 indicate that this excessive drainage was largely reduced.

Infiltration Assessment

Figure A.2–10 plots the flow rate into the SSOD (Flumes 2, 3, 4, 5, and 6) and the flow rate out of the SSOD (Flume 1) from March 17, 2011 through December 7, 2011. Until March 17, 2011, nighttime temperatures were still periodically falling low enough to freeze the water in the stilling wells of the flumes causing the water level instrumentation to give incorrect readings. Monitoring in 2011 was interrupted due to a malfunctioning water level instrument in Flume 1 that failed on August 31st, but was not discovered until October 17th. An additional interruption was caused by flooding water knocking out the freeze plug in the Flume 1 standpipe, preventing representative readings. These interruptions are noted in the figure.

As illustrated in Figure A.2–10 from May through August, it appears that infiltration was occurring in the section of the SSOD being monitored. The amount of water entering the SSOD exceeded the amount of water leaving the SSOD indicating that infiltration was occurring. The average amount of infiltration (for those days when infiltration was recorded) is approximately 129 gpm. How much of the water actually reached the aquifer is unknown as evaporation and transpiration are not accounted for.

In 2011, operations were successful in achieving the target flow rate of 500 gpm in the SSOD, aided largely by record high annual precipitation. The average annual flow rate into the SSOD in 2011 was 1,159 gpm. This flow rate consisted of natural flow and supplemented pumping from the clean production wells located on the east side of the site.

Figure A.2–11 shows a monthly comparison of the flow rate into the SSOD from 2006 to 2011. Flow entering the SSOD in 2006 was natural until December of 2006, when supplemental pumping into the SSOD began. As shown in Figure A.2–11 supplemental pumping has helped to keep flow rates higher in the summer months when natural flow is lower. In 2011 the average flow rate was greatly aided by record high seasonal and annual rainfall. In fact, the monthly average flow rate only dipped below the target of 500 gpm in the month of August (495 gpm). The average flow rate for 2011 overall was 1,253 gpm.

Proposed Change

Heavy rain events in 2011 damaged Flume 2. Water flowing down the channel eroded the stream bank back from the wing-walls of the flume, silted up the upgradient side of the flume, and dispersed sandbags that once supported the wing-walls down the channel. This damage indicates that the flume was undersized to handle the large periodic storm events that occurred in 2011.

Rather than continue with potential repairs to this flume, DOE proposes to remove the flume and only calculate infiltration rates when flow down this channel is not occurring. No changes would be made to the other flumes. Infiltration assessments would be made over shorter time periods when flow measurements in the remaining flumes indicate that infiltration could be occurring. The calculation would rely mostly on flow measurements in Flumes 6, 4, and 1 with minor contributions from Flumes 5 and 3.

Table A.2–1. Geoprobe Location 12617C

Easting '83: 1347225.04 feet
Northing '83: 481284.9 feet
Ground Elevation: 581.39 feet above mean sea level (AMSL)
Depth to Water Table: 62 feet below ground surface (BGS)
Water Table Elevation: 519.39 feet AMSL

Work Completed: 5/16/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium (ug/L) (FRL=30)	Tc-99 (pCi/L) (FRL=94)	Nitrate/Nitrite (mg/L) (FRL=11)	Manganese (mg/L) (FRL=0.9)	Molybdenum (mg/L) (FRL=0.1)	Nickel (mg/L) (FRL=0.1)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	514	67.0	0 - 10	14.9	5.85	58.5	3.15	0.0403	0.0539	13.8	6.85	1.74	>1000	10.0	8.90
2	504	77.0	10 - 20	6.02	5.36	57.5	1.97	0.0334	0.0314	15.0	7.33	1.47	>1000	3.06	9.23
3	504	77.0	10 - 20	6.03	2.99	53.8	2.21	0.0358	0.0369	15.0	7.33	1.47	>1000	3.06	9.23
4	494	87.0	20 - 30	3.64	6.78	45.0	0.833	0.0119	0.0153	14.6	7.27	1.33	>1000	19.7	5.20
5	484	97.0	30 - 40	5.09	121	68.3	0.733	0.0053	0.0166	14.7	7.08	1.83	>1000	19.7	6.90

[a]Samples are filtered through a 5 micron filter.

Table A.2–2. Geoprobe Location 12618C

Easting '83: 1347181.43 feet
Northing '83: 480411.73 feet
Ground Elevation: 579.31 feet above mean sea level (AMSL)
Depth to Water Table: 60 feet below ground surface (BGS)
Water Table Elevation: 519.31 feet AMSL

Work Completed: 5/5/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium (ug/L) (FRL=30)	Tc-99 (pCi/L) (FRL=94)	Nitrate/Nitrite (mg/L) (FRL=11)	Manganese (mg/L) (FRL=0.9)	Molybdenum (mg/L) (FRL=0.1)	Nickel (mg/L) (FRL=0.1)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	514	65.0	0 - 10	117	5.80	2.17	0.598	0.0180	0.0126	11.1	6.81	0.803	>1000	21.0	9.00
2	504	75.0	10 - 20	6.79	5.85	2.89	0.644	0.0178	0.00922	13.2	6.80	0.830	>1000	34.8	8.64
3	504	75.0	10 - 20	6.87	5.75	1.57	0.596	0.0160	0.00812	13.2	6.80	0.830	>1000	34.8	8.64
4	494	85.0	20 - 30	4.79	5.75	1.96	0.501	0.0241	0.0113	17.1	7.61	0.805	>1000	26.0	6.17
5	484	95.0	30 - 40	7.05	5.75	1.65	0.401	0.0129	0.00925	14.8	7.41	0.663	>1000	34.0	5.61

[a]Samples are filtered through a 5 micron filter.

Table A.2–3. Geoprobe Location 13422

Easting '83: 1347388.25 feet
Northing '83: 480697.16 feet
Ground Elevation: 577.18 feet above mean sea level (AMSL)
Depth to Water Table: 58 feet below ground surface (BGS)
Water Table Elevation: 519.18 feet AMSL

Work Completed: 5/18/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium (ug/L) (FRL=30)	Tc-99 (pCi/L) (FRL=94)	Nitrate/Nitrite (mg/L) (FRL=11)	Manganese (mg/L) (FRL=0.9)	Molybdenum (mg/L) (FRL=0.1)	Nickel (mgL) (FRL=0.1)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	**514**	**63.0**	0 - 10	11.7	5.80	1.84	0.604	0.0293	0.0132	13.1	7.06	0.750	>1000	6.75	8.53
2	**504**	**73.0**	10 - 20	8.18	5.65	1.62	0.839	0.0331	0.0142	13.5	7.38	0.794	>1000	6.10	10.8
3	**504**	**73.0**	10 - 20	8.18	5.70	2.12	0.810	0.0309	0.0137	13.5	7.38	0.794	>1000	6.10	10.8
4	**494**	**83.0**	20 - 30	8.01	5.90	1.96	0.398	0.0173	0.00696	13.4	7.38	0.724	>1000	5.45	8.77

[a]Samples are filtered through a 5 micron filter.

Table A.2–4. Geoprobe Location 12717B

Easting '83: 1348134.99 feet
Northing '83: 480201.41 feet
Ground Elevation: 575.01 feet above mean sea level (AMSL)
Depth to Water Table: 55.5 feet below ground surface (BGS)
Water Table Elevation: 519.51 feet AMSL
Work Completed: 6/15/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	515	60.5	0 - 10	3.90	15.2	6.75	1.23	> 1000	49.4	5.35
2	505	70.5	10 - 20	1.10	15.0	7.03	1.27	> 1000	35.7	4.60
3	505	70.5	10 - 20	1.40	15.0	7.03	1.27	> 1000	35.7	4.60
4	495	80.5	20 - 30	1.30	14.8	7.28	1.14	> 1000	20.9	4.25
5	485	90.5	30 - 40	3.70	15.2	7.22	0.898	> 1000	27.7	3.64
6	475	100.5	40 - 50	1.00	14.9	7.24	0.687	> 1000	10.9	4.19

[a]Samples are filtered through a 5 micron filter.

Table A.2–5. Geoprobe Location 13412A

Easting '83: 1346721.47 feet
Northing '83: 479727.87 feet
Ground Elevation: 551.92 feet above mean sea level (AMSL)
Depth to Water Table: 31 feet below ground surface (BGS)
Water Table Elevation: 520.92 feet AMSL
Work Completed: 6/7/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	516	36.0	0 - 10	6.70	14.9	7.21	0.596	> 1000	21.2	7.86
2	506	46.0	10 - 20	5.00	16.9	7.32	0.846	> 1000	23.7	8.45
3	506	46.0	10 - 20	4.70	16.9	7.32	0.846	> 1000	23.7	8.45
4	496	56.0	20 - 30	3.60	14.8	7.76	0.625	> 1000	47.6	8.25
5	486	66.0	30 - 40	8.20	16.3	7.58	0.716	> 1000	128	6.46

[a]Samples are filtered through a 5 micron filter.

Table A.2-6. Geoprobe Location 13418A

Easting '83: 1346540.23 feet
Northing '83: 480130.6 feet
Ground Elevation: 551.35 feet above mean sea level (AMSL)
Depth to Water Table: 30 feet below ground surface (BGS)
Water Table Elevation: 521.35 feet AMSL
Work Completed: 6/6/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	516.35	35.0	0 - 10	1.30	16.3	7.37	0.619	> 1000	891	9.37
2	506.35	45.0	10 - 20	3.90	14.5	7.58	0.562	> 1000	> 1000	9.58
3	506.35	45.0	10 - 20	3.90	14.5	7.58	0.562	> 1000	> 1000	9.58
4	496.35	55.0	20 - 30	5.40	17.8	7.88	0.477	> 1000	141	8.76
5	486.35	65.0	30 - 40	11.4	17.0	7.75	0.597	> 1000	390	7.97
6	476.35	75.0	40 - 50	10.1	15.4	7.91	0.582	> 1000	28.9	6.62

[a]Samples are filtered through a 5 micron filter.

Table A.2-7. Geoprobe Location 13428

Easting '83: 1347354.36 feet
Northing '83: 479994.53 feet
Ground Elevation: 566.06 feet above mean sea level (AMSL)
Depth to Water Table: 45.5 feet below ground surface (BGS)
Water Table Elevation: 520.56 feet AMSL
Work Completed: 7/6/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	515.56	50.5	0 - 10	71.0	20.3	7.04	0.806	> 1000	737	5.46
2	505.56	60.5	10 - 20	11.9	18.9	7.58	0.754	> 1000	315	6.45
3	505.56	60.5	10 - 20	13.5	18.9	7.58	0.754	> 1000	315	6.45
4	495.56	70.5	20 - 30	6.10	16.7	7.62	0.661	> 1000	65.3	6.19
5	485.56	80.5	30 - 40	7.10	15.8	7.54	0.618	> 1000	31.9	6.50
6	475.56	90.5	40 - 50	0.50	17.7	7.61	0.652	> 1000	39.8	5.41
7	465.56	100.5	50 - 60	0.50	15.7	7.60	0.612	> 1000	45.3	4.48

[a]Samples are filtered through a 5 micron filter.

Table A.2–8. Geoprobe Location 13360C

Easting '83: 1349832.67 feet
Northing '83: 480171.24 feet
Ground Elevation: 574.41 feet above mean sea level (AMSL)
Depth to Water Table: 54 feet below ground surface (BGS)
Water Table Elevation: 520.41 feet AMSL
Work Completed: 5/31/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	515.41	59	0 - 10	37.7	17.6	6.76	1.61	> 1000	>1000	7.50
2	505.41	69	10 - 20	4.90	18.8	6.93	1.25	> 1000	>1000	7.26
3	505.41	69	10 - 20	2.20	18.8	6.93	1.25	> 1000	>1000	7.26
4	495.41	79	20 - 30	2.60	18.4	6.97	1.09	> 1000	493	5.20

[a]Samples are filtered through a 5 micron filter.

Table A.2–9. Geoprobe Location 13241A

Easting '83: 1350068.84 feet
Northing '83: 477048.29 feet
Ground Elevation: 579.38 feet above mean sea level (AMSL)
Depth to Water Table: 60.5 feet below ground surface (BGS)
Water Table Elevation: 518.88 feet AMSL
Work Completed: 6/1/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	513.88	65.5	0 - 10	6.90	18.5	6.73	1.00	> 1000	1000	6.43
2	503.88	75.5	10 - 20	1.30	20.5	7.03	1.04	> 1000	89.0	6.13
3	503.88	75.5	10 - 20	1.90	20.5	7.03	1.04	> 1000	89.0	6.13
4	493.88	85.5	20 - 30	2.00	17.1	7.08	1.02	> 1000	195	7.29
5	483.88	95.5	30 - 40	3.30	16.9	7.06	0.934	> 1000	139	4.64
6	473.88	105.5	40 - 50	2.60	18.2	7.07	0.907	> 1000	193	4.91
7	463.88	115.5	50 - 60	2.60	17.9	7.37	0.837	> 1000	157	7.81

[a]Samples are filtered through a 5 micron filter.

Table A.2–10. Geoprobe Location 13413A

Easting '83: 1349041.94 feet
Northing '83: 477749.1 feet
Ground Elevation: 554.63 feet above mean sea level (AMSL)
Depth to Water Table: 37 feet below ground surface (BGS)
Water Table Elevation: 517.63 feet AMSL
Work Completed: 5/10/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	512.63	42.0	0 - 10	15.8	15.3	7.03	0.846	> 1000	>1000	8.55
2	502.63	52.0	10 - 20	19.8	15.3	7.14	0.837	> 1000	314	6.80
3	502.63	52.0	10 - 20	19.0	15.3	7.14	0.837	> 1000	314	6.80
4	492.63	62.0	20 - 30	3.25	15.1	7.22	0.654	> 1000	41.0	2.39
5	482.63	72.0	30 - 40	1.40	15.0	7.25	0.609	> 1000	95.0	3.40
6	472.63	82.0	40 - 50	0.858	13.9	7.17	0.594	> 1000	111	2.88
7	462.63	92.0	50 - 60	4.31	14.8	7.17	0.600	> 1000	66.3	4.51

[a]Samples are filtered through a 5 micron filter.

Table A.2–11. Geoprobe Location 13421

Easting '83: 1349309.74 feet
Northing '83: 476024.38 feet
Ground Elevation: 570.68 feet above mean sea level (AMSL)
Depth to Water Table: 60 feet below ground surface (BGS)
Water Table Elevation: 510.68 feet AMSL
Work Completed: 2/11/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	505.68	65.0	0 - 10	43.9	10.1	7.01	0.806	> 1000	292	6.35
2	495.68	75.0	10 - 20	181	9.89	7.53	0.784	> 1000	716	9.09
3	495.68	75.0	10 - 20	185	9.89	7.53	0.784	> 1000	716	9.09
4	485.68	85.0	20 - 30	97.8	10.8	7.68	0.721	> 1000	673	6.87
5	475.68	95.0	30 - 40	5.11	9.48	7.09	0.712	> 1000	954	6.13
6	465.68	105.0	40 - 50	3.45	7.37	7.24	0.744	> 1000	> 1000	8.01
7	455.68	115.0	50 - 60	61.8	8.95	7.35	0.722	> 1000	> 1000	6.86

[a]Samples are filtered through a 5 micron filter.

Table A.2–12. Geoprobe Location 13421A

Easting '83: 1349311.17 feet
Northing '83: 476025.03 feet
Ground Elevation: 570.76 feet above mean sea level (AMSL)
Depth to Water Table: 52 feet below ground surface (BGS)
Water Table Elevation: 518.76 feet AMSL
Work Completed: 7/13/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	513.76	57.0	0 - 10	3.70	18.5	7.20	0.830	> 1000	208	7.79
2	503.76	67.0	10 - 20	116	16.3	8.23	0.828	> 1000	>1000	7.50
3	503.76	67.0	10 - 20	112	16.3	8.23	0.828	> 1000	>1000	7.50
4	493.76	77.0	20 - 30	216	16.9	7.47	0.768	> 1000	602	6.00
5	483.76	87.0	30 - 40	82.3	17.1	7.53	0.722	> 1000	17.4	3.90
6	473.76	97.0	40 - 50	5.10	16.6	7.55	0.716	> 1000	10.6	3.61
7	463.76	107.0	50 - 60	3.50	17.1	7.52	0.731	> 1000	475	4.50
6	453.76	117.0	60 - 70	7.20	18.4	7.45	0.759	> 1000	522	3.49
7	443.76	127.0	70 - 80	6.40	20.5	7.64	0.794	> 1000	>1000	6.80

[a]Samples are filtered through a 5 micron filter.

Table A.2–13. Geoprobe Location 13419A

Easting '83: 1349215.19 feet
Northing '83: 478810.95 feet
Ground Elevation: 560.72 feet above mean sea level (AMSL)
Depth to Water Table: 42 feet below ground surface (BGS)
Water Table Elevation: 518.72 feet AMSL
Work Completed: 6/2/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	513.72	47	0 - 10	18.0	19.0	6.74	1.27	> 1000	294	6.48
2	503.72	57	10 - 20	23.6	16.5	6.75	1.39	> 1000	25.2	6.03
3	503.72	57	10 - 20	23.8	16.5	6.75	1.39	> 1000	25.2	6.03
4	493.72	67	20 - 30	2.14	15.4	6.73	1.60	> 1000	31.7	3.69

[a]Samples are filtered through a 5 micron filter.

Table A.2–14. Geoprobe Location 13419B

Easting '83: 1349215.19 feet
Northing '83: 478810.95 feet
Ground Elevation: 560.72 feet above mean sea level (AMSL)
Depth to Water Table: 41 feet below ground surface (BGS)
Water Table Elevation: 519.72 feet AMSL
Work Completed: 7/5/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	514.72	46.0	0 - 10	7.40	25.1	6.85	1.39	> 1000	>1000	5.75
2	504.72	56.0	10 - 20	16.8	18.0	6.60	1.43	> 1000	31.0	2.54
3	504.72	56.0	10 - 20	17.7	18.0	6.60	1.43	> 1000	31.0	2.54
4	494.72	66.0	20 - 30	2.90	16.4	6.94	1.18	> 1000	671	5.16
5	484.72	76.0	30 - 40	0.50	18.5	7.12	0.971	> 1000	49.0	0.38
6	474.72	86.0	40 - 50	0.50	18.7	7.27	0.587	> 1000	42.0	3.00
7	464.72	96.0	50 - 60	0.50	18.2	7.25	0.584	> 1000	365	4.13

[a]Samples are filtered through a 5 micron filter.

Table A.2–15. Geoprobe Location 13430

Easting '83: 1349215.91 feet
Northing '83: 478472.08 feet
Ground Elevation: 575.04 feet above mean sea level (AMSL)
Depth to Water Table: 55 feet below ground surface (BGS)
Water Table Elevation: 520.04 feet AMSL
Work Completed: 6/29/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	515	60.0	0 - 10	134	15.1	6.97	1.50	> 1000	592	5.86
2	505.04	70.0	10 - 20	19.9	15.5	7.09	1.04	> 1000	53.1	4.81
3	505.04	70.0	10 - 20	22.5	15.5	7.09	1.04	> 1000	53.1	4.81
4	495	80.0	20 - 30	7.60	16.8	7.36	0.827	> 1000	68.9	5.35
5	485.04	90.0	30 - 40	10.0	16.3	7.34	0.699	> 1000	116	4.95
6	475.04	100.0	40 - 50	2.10	16.9	7.54	0.580	> 1000	99.2	3.43
7	465.04	110.0	50 - 60	3.20	17.9	7.51	0.568	> 1000	115	3.27

[a]Samples are filtered through a 5 micron filter.

Table A.2–16. Geoprobe Location 13431

Easting '83: 1349534.36 feet
Northing '83: 478506.57 feet
Ground Elevation: 575.58 feet above mean sea level (AMSL)
Depth to Water Table: 55 feet below ground surface (BGS)
Water Table Elevation: 520.58 feet AMSL
Work Completed: 6/30/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (μg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	515.58	60.0	0 - 10	124	15.1	6.67	1.69	> 1000	>1000	6.75
2	505.58	70.0	10 - 20	21.0	15.2	6.95	1.10	> 1000	17.3	2.82
3	505.58	70.0	10 - 20	30.3	15.2	6.95	1.10	> 1000	17.3	2.82
4	495.58	80.0	20 - 30	24.1	15.4	7.09	0.914	> 1000	490	4.95
5	485.58	90.0	30 - 40	12.2	15.6	7.19	0.931	> 1000	>1000	3.35
6	475.58	100.0	40 - 50	1.90	16.4	7.22	0.868	> 1000	51.1	4.36
7	465.58	110.0	50 - 60	0.50	16.9	7.26	0.868	> 1000	47.0	4.26

[a]Samples are filtered through a 5 micron filter.

Table A.2–17. Geoprobe Location 12369P

Easting '83: 1348853.58 feet
Northing '83: 476056.79 feet
Ground Elevation: 574.76 feet above mean sea level (AMSL)
Depth to Water Table: 57.5 feet below ground surface (BGS)
Water Table Elevation: 517.26 feet AMSL
Work Completed: 7/25/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (μg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	512	62.5	0 - 10	67.8	20.3	7.08	0.953	>1000	400	7.67
2	502.26	72.5	10 - 20	11.5	18.7	7.08	0.746	>1000	518	5.50
3	502.26	72.5	10 - 20	11.4	18.7	7.08	0.746	>1000	518	5.50
4	492.26	82.5	20 - 30	6.2	19.3	7.15	0.698	>1000	40.3	6.50

[a]Samples are filtered through a 5 micron filter.

Table A.2–18. Geoprobe Location 12372Q

Easting '83: 1348558.39 feet
Northing '83: 476215.36 feet
Ground Elevation: 576.43 feet above mean sea level (AMSL)
Depth to Water Table: 58 feet below ground surface (BGS)
Water Table Elevation: 518.43 feet AMSL
Work Completed: 7/19/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	513	63.0	0 - 10	23.8	20.1	7.20	0.874	>1000	84.4	4.78
2	503.43	73.0	10 - 20	12.1	18.5	7.59	0.826	>1000	1000	6.95
3	503.43	73.0	10 - 20	14.7	18.5	7.59	0.826	>1000	1000	6.95
4	493.43	83.0	20 - 30	7.8	18.3	7.75	0.773	>1000	781	4.93

[a]Samples are filtered through a 5 micron filter.

Table A.2–19. Geoprobe Location 13297A

Easting '83: 1349400.49 feet
Northing '83: 475889.75 feet
Ground Elevation: 573.74 feet above mean sea level (AMSL)
Depth to Water Table: 62 feet below ground surface (BGS)
Water Table Elevation: 511.74 feet AMSL
Work Completed: 2/8/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	506.74	67.0	0 - 10	0.984	11.5	6.69	0.773	> 1000	1000	5.26
2	496.74	77.0	10 - 20	0.360	8.83	7.57	0.750	> 1000	464	7.00
3	496.74	77.0	10 - 20	0.465	8.83	7.57	0.750	> 1000	464	7.00
4	486.74	87.0	20 - 30	0.452	9.59	7.58	0.713	> 1000	385	6.95
5	476.74	97.0	30 - 40	2.25	9.17	7.62	0.744	> 1000	753	6.99
6	466.74	107.0	40 - 50	0.641	11.6	7.60	0.768	> 1000	485	5.40
7	456.74	117.0	50 - 60	0.779	10.6	7.42	0.781	> 1000	214	4.61

[a]Samples are filtered through a 5 micron filter.

Table A.2–20. Geoprobe Location 13356A

Easting '83: 1349682.93 feet
Northing '83: 476451.82 feet
Ground Elevation: 580.86 feet above mean sea level (AMSL)
Depth to Water Table: 32.5 feet below ground surface (BGS)
Water Table Elevation: 548.36 feet AMSL
Work Completed: 6/8/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	543.36	37.5	0 - 10	16.1	17.1	7.35	1.00	> 1000	>1000	9.14
2	533.36	47.5	10 - 20	17.8	19.8	7.24	1.03	> 1000	32.1	3.11
3	533.36	47.5	10 - 20	18.1	19.8	7.24	1.03	> 1000	32.1	3.11
4	523.36	57.5	20 - 30	27.6	10.6	7.34	0.951	> 1000	16.9	2.82
5	513.36	67.5	30 - 40	5.20	19.9	7.37	0.931	> 1000	54.7	3.65
6	503.36	77.5	40 - 50	2.60	18.1	7.28	0.904	> 1000	22.0	5.26
7	493.36	87.5	50 - 60	0.50	17.7	7.25	0.921	> 1000	12.1	4.45

[a]Samples are filtered through a 5 micron filter.

Table A.2–21. Geoprobe Location 13357A

Easting '83: 1349119.38 feet
Northing '83: 475740.11 feet
Ground Elevation: 580.89 feet above mean sea level (AMSL)
Depth to Water Table: 68 feet below ground surface (BGS)
Water Table Elevation: 512.89 feet AMSL
Work Completed: 2/14/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	508	73.0	0 - 10	44.4	11.3	6.82	0.890	> 1000	127	6.73
2	497.89	83.0	10 - 20	49.3	11.6	7.50	0.788	> 1000	231	6.54
3	497.89	83.0	10 - 20	47.1	11.6	7.50	0.788	> 1000	231	6.54
4	488	93.0	20 - 30	3.43	12.1	7.51	0.733	> 1000	157	3.00
5	477.89	103.0	30 - 40	1.76	11.8	7.42	0.720	> 1000	440	5.28
6	467.89	113.0	40 - 50	0.831	11.9	7.35	0.708	> 1000	189	2.30
7	457.89	123.0	50 - 60	0.762	11.4	7.39	0.683	> 1000	281	3.58

[a]Samples are filtered through a 5 micron filter.

Table A.2–22. Geoprobe Location 13420

Easting '83: 1349173.35 feet
Northing '83: 475858.71 feet
Ground Elevation: 581.66 feet above mean sea level (AMSL)
Depth to Water Table: 68 feet below ground surface (BGS)
Water Table Elevation: 513.66 feet AMSL
Work Completed: 2/3/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	508.66	73.0	0 - 10	65.7	9.16	7.22	0.905	> 1000	139	8.78
2	498.66	83.0	10 - 20	44.5	10.33	7.45	0.865	> 1000	2.63	3.19
3	498.66	83.0	10 - 20	41.7	10.33	7.45	0.865	> 1000	2.63	3.19
4	488.66	93.0	20 - 30	85.0	9.59	7.55	0.754	> 1000	14.3	4.67
5	478.66	103.0	30 - 40	2.26	8.83	6.78	0.697	> 1000	5.39	4.38
6	468.66	113.0	40 - 50	5.93	9.48	7.37	0.712	> 1000	733	7.69
7	458.66	123.0	50 - 60	4.85	9.27	7.42	0.710	> 1000	282	9.01

[a]Samples are filtered through a 5 micron filter.

Table A.2–23. Geoprobe Location 13423

Easting '83: 1349407.32 feet
Northing '83: 476023.97 feet
Ground Elevation: 570.18 feet above mean sea level (AMSL)
Depth to Water Table: 51 feet below ground surface (BGS)
Water Table Elevation: 519.18 feet AMSL
Work Completed: 7/12/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	514.18	56.0	0 - 10	1.20	21.0	7.26	0.865	> 1000	23.1	7.18
2	504.18	66.0	10 - 20	3.70	18.5	7.33	0.816	> 1000	56.7	3.46
3	504.18	66.0	10 - 20	3.20	18.5	7.33	0.816	> 1000	56.7	3.46
4	494.18	76.0	20 - 30	73.7	19.7	7.40	0.755	> 1000	33.4	2.95
5	484.18	86.0	30 - 40	16.0	21.7	7.56	0.759	> 1000	>1000	5.34
6	474.18	96.0	40 - 50	3.90	20.0	8.52	0.749	> 1000	69.6	5.23
7	464.18	106.0	50 - 60	3.10	19.4	7.02	0.770	> 1000	>1000	6.26
6	454.18	116.0	60 - 70	0.50	17.2	7.26	0.781	> 1000	55.4	2.82
7	444.18	126.0	70 - 80	2.70	18.7	7.25	0.783	> 1000	27.9	6.20

[a]Samples are filtered through a 5 micron filter.

Table A.2–24. Geoprobe Location 13424

Easting '83: 1349244.7 feet
Northing '83: 475743.2 feet
Ground Elevation: 579.55 feet above mean sea level (AMSL)
Depth to Water Table: 61 feet below ground surface (BGS)
Water Table Elevation: 518.55 feet AMSL
Work Completed: 5/12/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (μg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	513.55	66.0	0 - 10	2.91	19.6	7.18	0.935	> 1000	24.5	8.36
2	503.55	76.0	10 - 20	20.9	17.4	7.43	0.816	> 1000	80.7	4.50
3	503.55	76.0	10 - 20	22.7	17.4	7.43	0.816	> 1000	80.7	4.50
4	493.55	86.0	20 - 30	8.50	17.5	7.59	0.736	> 1000	729	8.10
5	483.55	96.0	30 - 40	1.82	17.8	7.49	0.735	> 1000	196	5.38
6	473.55	106.0	40 - 50	9.69	18.1	7.35	0.720	> 1000	320	5.01
7	463.55	116.0	50 - 60	5.30	17.4	7.29	0.759	> 1000	792	5.73
6	453.55	126.0	60 - 70	5.66	16.2	6.94	0.702	> 1000	>1000	9.52
7	443.55	136.0	70 - 80	4.35	15.0	7.13	0.702	> 1000	>1000	9.72

[a]Samples are filtered through a 5 micron filter.

Table A.2–25. Geoprobe Location 13425

Easting '83: 1349040.38 feet
Northing '83: 475678.36 feet
Ground Elevation: 579.39 feet above mean sea level (AMSL)
Depth to Water Table: 61 feet below ground surface (BGS)
Water Table Elevation: 518.39 feet AMSL
Work Completed: 5/11/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (μg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	513.39	66.0	0 - 10	2.60	16.5	7.05	0.956	> 1000	527	8.23
2	503.39	76.0	10 - 20	17.0	18.6	7.50	0.796	> 1000	>1000	7.65
3	503.39	76.0	10 - 20	20.7	18.6	7.50	0.796	> 1000	>1000	7.65
4	493.39	86.0	20 - 30	49.0	16.5	7.60	0.697	> 1000	>1000	7.69
5	483.39	96.0	30 - 40	17.3	16.4	7.55	0.693	> 1000	803	7.75
6	473.39	106.0	40 - 50	1.10	16.9	7.52	0.739	> 1000	28.0	3.88
7	463.39	116.0	50 - 60	0.50	16.3	7.37	0.715	> 1000	152	3.23
6	453.39	126.0	60 - 70	1.30	16.7	7.42	0.722	> 1000	>1000	6.78
7	443.39	136.0	70 - 80	1.60	16.4	7.29	0.732	> 1000	357	5.48

[a]Samples are filtered through a 5 micron filter.

Table A.2–26. Geoprobe Location 13426

Easting '83: 1349554.51 feet
Northing '83: 476014.02 feet
Ground Elevation: 568.85 feet above mean sea level (AMSL)
Depth to Water Table: 51 feet below ground surface (BGS)
Water Table Elevation: 517.85 feet AMSL
Work Completed: 7/20/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	512.85	56.0	0 - 10	2.70	23.4	7.49	0.877	> 1000	34.1	7.16
2	502.85	66.0	10 - 20	0.50	19.8	7.58	0.883	> 1000	19.0	3.92
3	502.85	66.0	10 - 20	0.50	19.8	7.58	0.883	> 1000	19.0	3.92
4	492.85	76.0	20 - 30	3.80	18.5	7.45	0.766	> 1000	253	3.46
5	482.85	86.0	30 - 40	1.20	18.0	7.73	0.767	> 1000	448	5.13
6	472.85	96.0	40 - 50	0.50	21.5	10.7	0.795	> 1000	325	6.35
7	462.85	106.0	50 - 60	2.00	18.2	10.7	0.804	> 1000	923	6.97

[a]Samples are filtered through a 5 micron filter.

Table A.2–27. Geoprobe Location 13427

Easting '83: 1348271.87 feet
Northing '83: 474448.65 feet
Ground Elevation: 533.5 feet above mean sea level (AMSL)
Depth to Water Table: 19 feet below ground surface (BGS)
Water Table Elevation: 514.5 feet AMSL
Work Completed: 8/2/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	509.5	24.0	0 - 10	21.0	21.0	6.82	0.928	> 1000	108	6.36
2	499.5	34.0	10 - 20	6.90	24.0	7.57	0.779	> 1000	22.7	5.88
3	499.5	34.0	10 - 20	6.70	24.0	7.57	0.779	> 1000	22.7	5.88
4	489.5	44.0	20 - 30	3.30	19.1	7.59	0.677	> 1000	18.4	0.65
5	479.5	54.0	30 - 40	18.4	17.9	7.42	0.616	> 1000	16.0	5.12
6	469.5	64.0	40 - 50	1.80	16.6	7.41	0.807	> 1000	25.3	4.02
7	459.5	74.0	50 - 60	8.40	16.8	7.20	0.749	> 1000	20.0	4.31

[a]Samples are filtered through a 5 micron filter.

Table A.2–28. Geoprobe Location 13432

Easting '83: 1349488.62 feet
Northing '83: 476401.27 feet
Ground Elevation: 579.69 feet above mean sea level (AMSL)
Depth to Water Table: 62.5 feet below ground surface (BGS)
Water Table Elevation: 517.19 feet AMSL
Work Completed: 7/26/2011

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	512	67.5	0 - 10	1.90	18.1	7.07	0.874	> 1000	15.5	9.00
2	502.19	77.5	10 - 20	1.80	19.0	7.00	0.889	> 1000	534	6.90
3	502.19	77.5	10 - 20	1.80	19.0	7.00	0.889	> 1000	534	6.90
4	492	87.5	20 - 30	1.40	18.1	7.05	0.758	> 1000	232	5.10
5	482.19	97.5	30 - 40	4.70	20.1	7.01	0.769	> 1000	233	4.55
6	472.19	107.5	40 - 50	2.70	20.7	7.02	0.771	> 1000	149	3.90
7	462.19	117.5	50 - 60	3.30	17.6	7.12	0.777	> 1000	>1000	4.30

[a]Samples are filtered through a 5 micron filter.

Table A.2–29. Summary Statistics and Trend Analysis of Monitoring Wells for Total Uranium with 2011 Results Above FRLs

Well	No. of Sample	Minimum (µg/L)[a,b,c,d]	Maximum (µg/L)[a,b,c,d]	Average (µg/L)[a,b,c,d,e]	Standard Deviation (µg/L)[a,b,c,d,e]	Trend[a,b,c,d,e,f]
2045	62	12.0	462	127	110	**Up, Significant**
2046	61	20.0	907	164	214	No Significant Trend
2049	49	3.0	178	80.1	43.1	Down, Significant
2060	77	8.4	332	80.0	61.2	No Significant Trend
2095	62	27.0	208	105	46	Down, Significant
23271	20	34.6	144	76.9	32.3	Down, Significant
23273	20	114	421	261	80	No Significant Trend
23274	31	120	384	188	67	Down, Significant
23275	19	119	349	173	60	**Up, Significant**
23276	20	60.4	115	85.9	14.5	**Up, Significant**
23278	20	44.9	201	102	44	Down, Significant
23280	20	57.2	700	173	154	Down, Significant
23281	20	41.5	367	150	81	Down, Significant
2385	43	76.6	592	244	107	Down, Significant
2387	43	18.1	492	147	85	**Up, Significant**
2389	32	0.90	120	27.2	25.3	**Up, Significant**
2390	42	31.6	163	76.3	30.0	Down, Significant
2397	30	212	737	396	125	No Significant Trend
2550	53	3.3	120	60.9	19.9	Down, Significant
2649	38	6.01	954	137	243	**Up, Significant**
2880	43	0.40	62.9	15.1	20.5	**Up, Significant**
3069	69	0.50	398	129	96	Down, Significant
3095	63	2.0	94	25.4	17.6	No Significant Trend
32766	21	24.4	79.9	44.3	15.3	Down, Significant
62408	31	29.5	157	82.4	43.9	Down, Significant
62433	32	82.6	845	361	190	Down, Significant
63285	20	74.9	277	207	50	**Up, Significant**
63287	20	82.3	316	171	62	Down, Significant
63288	20	34.3	267	94.2	65.8	Down, Significant
6880	30	62.8	145	90.3	22.2	Down, Significant
82433_C2	13	20.0	214	95.2	68.9	Down, Significant
82433_C3	22	70.7	506	233	133	Down, Significant
83117_C1	22	440	1620	902	277	No Significant Trend
83117_C2	11	44.8	330	156	117	Down, Significant
83117_C3	11	40.6	128	85.1	31.6	Down, Significant
83117_C4	11	71.3	111	88.2	12.4	**Up, Significant**
83124_C1	33	185	1070	481	204	No Significant Trend
83124_C2	16	27.8	103	55.1	20.1	Down, Significant
83124_C4	11	25.4	62.2	38.9	10.5	**Up, Significant**
83124_C5	11	24.4	61.4	50.8	9.8	No Significant Trend
83294_C1	17	98.5	198	170	29	**Up, Significant**
83294_C2	24	188	575	387	90	No Significant Trend
83294_C3	13	161	539	346	137	Down, Significant
83295_C2	16	92.3	178	148	23	No Significant Trend

Table A.2–29 (continued). Summary Statistics and Trend Analysis of Monitoring Wells for Total Uranium with 2011 Results Above FRLs

Well	No. of Sample	Minimum (µg/L)[a,b,c,d]	Maximum (µg/L)[a,b,c,d]	Average (µg/L)[a,b,c,d,e]	Standard Deviation (µg/L)[a,b,c,d,e]	Trend[a,b,c,d,e,f]
83295_C3	14	99.2	175	141	25	Down, Significant
83295_C4	12	47.8	199	113	57	Down, Significant
83295_C5	11	57.2	155	86.0	30.3	Down, Significant
83295_C6	11	3.4	64.4	30.0	23.0	**Up, Significant**
83296_C1	8	56.7	135	87.4	26.4	No Significant Trend
83296_C2	17	32.0	117	60.4	23.5	Down, Significant
83335_C2	11	4.5	49.5	26.6	14.7	No Significant Trend
83337_C1	14	871	2430	1490	510	No Significant Trend
83337_C2	21	2.7	835	161	220	Down, Significant
83338_C1	9	454	710	556	81	No Significant Trend
83338_C2	12	22.7	648	194	186	Down, Significant
83340_C1	8	13.2	44.8	24.5	9.8	No Significant Trend
83341_C1	5	28.8	39.4	36.0	4.1	No Significant Trend
83346_C1	8	39.7	70.7	46.8	10.1	No Significant Trend

[a] Summary statistics and Mann-Kendall test for trend are primarily based on unfiltered samples with some filtered samples from the Operable Unit 5 remedial investigation/feasibility study data set (1988 through 1993) and 1994 through 2011 groundwater data.
[b] If more than one sample is collected per well per day (e.g., duplicate), then only one sample is counted for the number of samples, and the sample with the maximum representative concentration is used for determining the summary statistics (minimum, maximum, average, and standard deviation) and Mann-Kendall test for trend.
[c] Rejected data qualified with an R were not included in this count, the summary statistics, or Mann-Kendall test for trend.
[d] If the number of samples is greater than or equal to four, then all of the summary statistics and the Mann-Kendall test for trend are reported. If the total number of samples is equal to three, then the minimum, maximum, and average are reported. If the total number of samples is equal to two, then the minimum and maximum are reported. If the total number of samples is equal to one, then the data point is reported as the minimum.
[e] For results where the concentrations are below the detection limit, the results used in the summary statistics and Mann-Kendall test for trend are each set at half the detection limit.
[f] Mann-Kendall test for trend is performed using data from third quarter 1998 through 2011.

Table A.2–30. Summary Statistics and Trend Analysis of Extraction Wells for Total Uranium

Well	Number of Samples[a,b]	Minimum (µg/L)[a,b,c]	Maximum (µg/L)[a,b,c]	Average (µg/L)[a,b,c]	Standard Deviation (µg/L)[a,b,c]	Trend[a,b,c]
South Plume Module (August 27, 1993, through December 31, 2011)						
3924	573	1.8	180	31	15	Down, Significant
3925	574	0.5	84.0	24.6	7.7	Down, Significant
3926	563	1.5	42.4	25.4	8.3	**Up, Significant**
3927	571	1.0	17.0	2.6	1.1	**Up, Significant**
South Plume Optimization Module (August 9, 1998, through December 31, 2011)						
32308	499	18.4	100	55	15	Down, Significant
32309	507	24.8	123	56	19	Down, Significant
South Field Module (July 13, 1998, through December 31, 2011)						
31550	524	16.2	128	52	19	Down, Significant
31560	547	12.1	183	61	37	Down, Significant
31561	521	18.1	114[d]	41	10	Down, Significant
32276	564	20.2	290	103	62.	Down, Significant
32446	420	24.5	168	61	20	Down, Significant
32447	440	21.9	302	110	53	Down, Significant
33061	320	18.3	98.5	47.1	13.8	Down, Significant
33262	277	23.5	110	48	13	Down, Significant
33264	273	15.8	364	86	40	Down, Significant
33265	272	7.5	96.5	22.0	7.5	Down, Significant
33266	270	4.5	105	16	10	Down, Significant
33298	228	19.5	76.2	52.8	8.7	Down, Significant
33326	178	16.2	62.2	26.9	6.3	Down, Significant
Waste Storage Area Module (May 8, 2002, through December 31, 2011)						
32761	312	24.1	161	63	32	Down, Significant
33062	326	21.2	236	71	45	Down, Significant
33334	141	8.7	50.0	17.7	6.8	Down, Significant
33347	136	7.0	126	27	22	Down, Significant

[a] If more than one sample is collected per well per day (e.g., duplicate), then only one sample is counted for the number of samples, and the sample with the maximum representative concentration is used for determining the summary statistics (minimum, maximum, average, and standard deviation) and Mann-Kendall test for trend.
[b] Rejected data qualified with an R were not included in this count, the summary statistics, or Mann-Kendall test for trend.
[c] For results where the concentrations are below the detection limit, the results used in the summary statistics and Mann-Kendall test for trend are each set at half the detection limit.
[d] This result (sampled August 31, 1998) appears to be an outlier. It is suspected that the sample for this well was switched with the sample from extraction well 31562.

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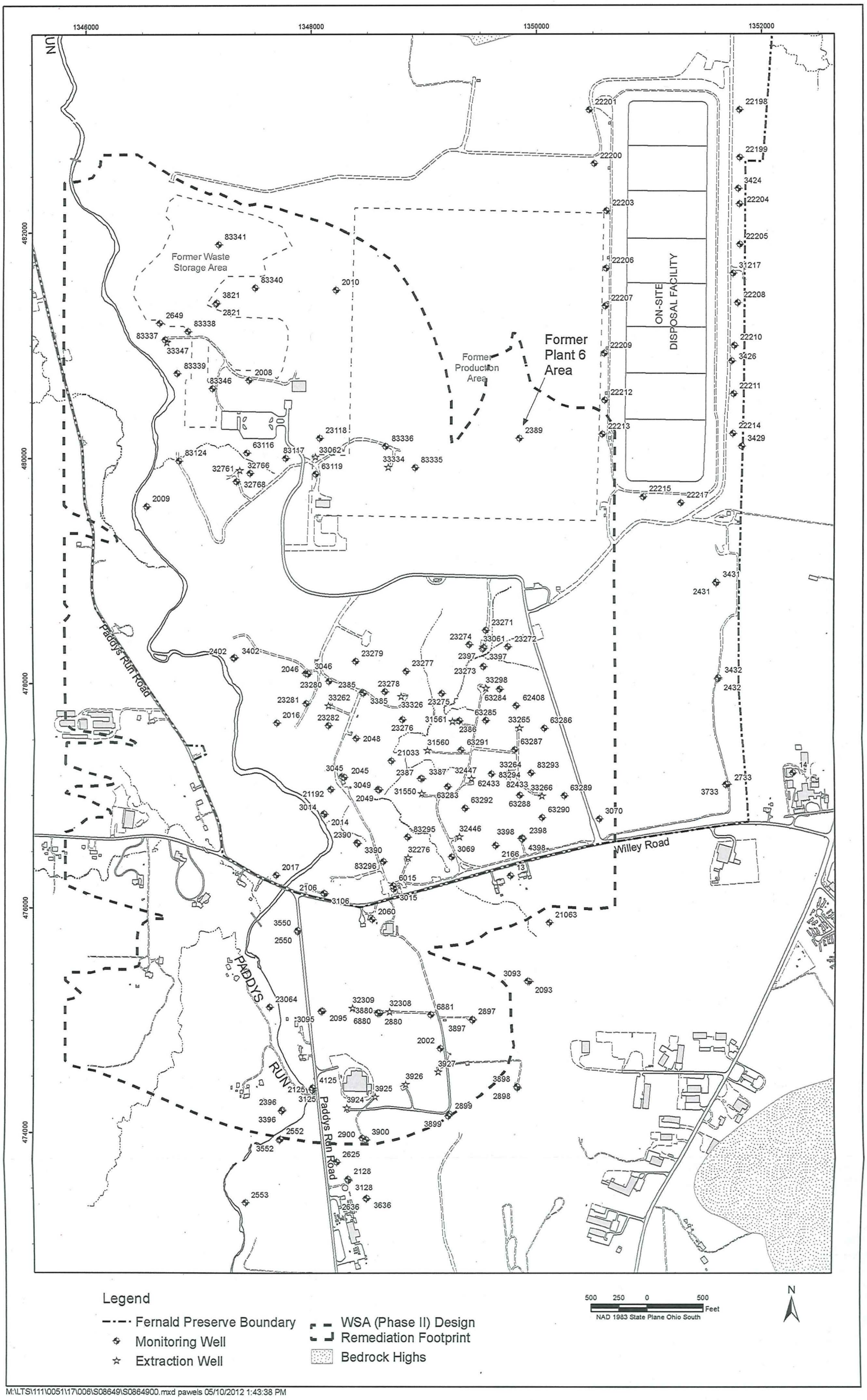

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Figure A.2-1. IEMP Water Quality Monitoring Wells and Extraction Wells

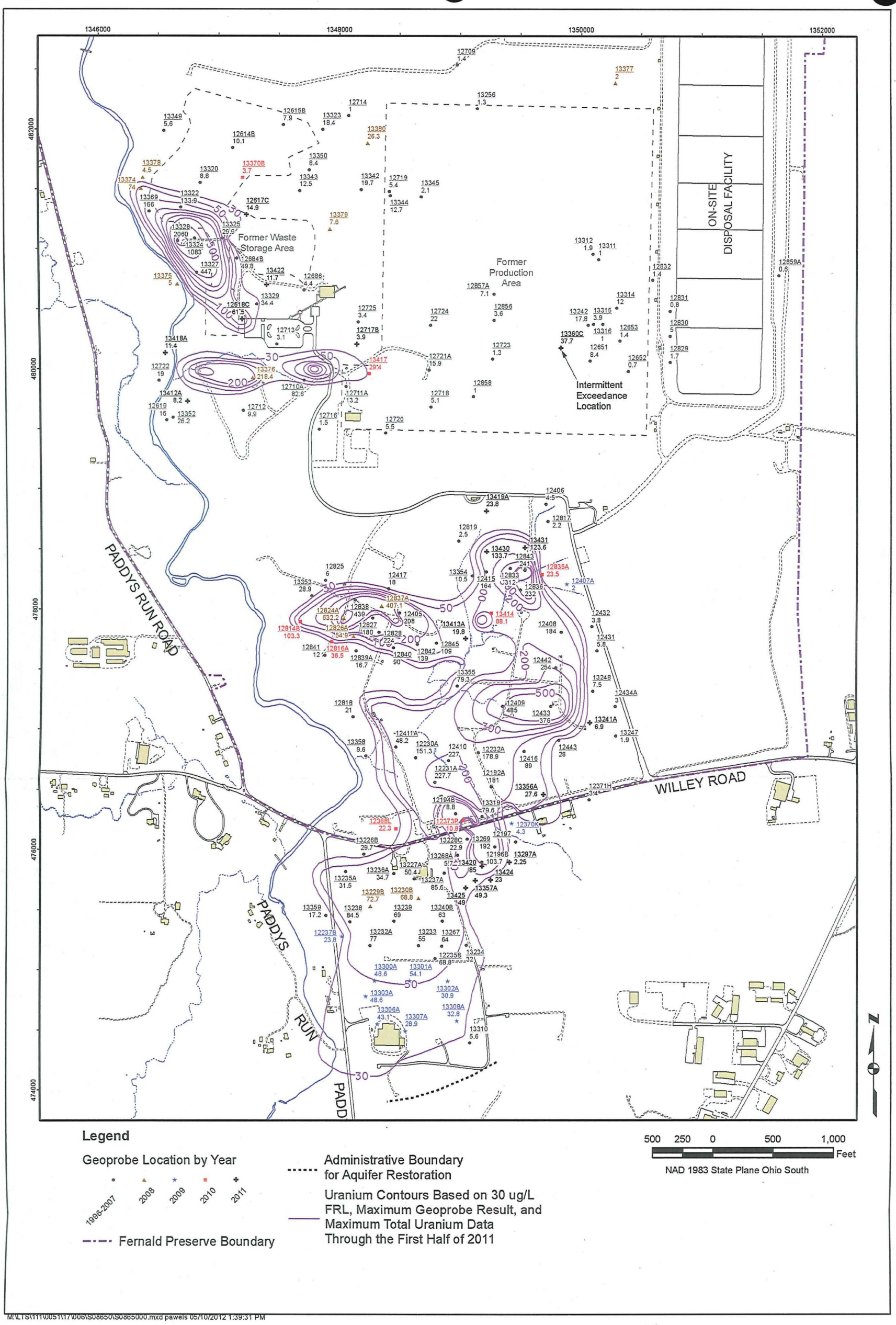

Figure A.2–2A. Direct-Push Data and Maximum Total Uranium Plume through the First Half of 2011

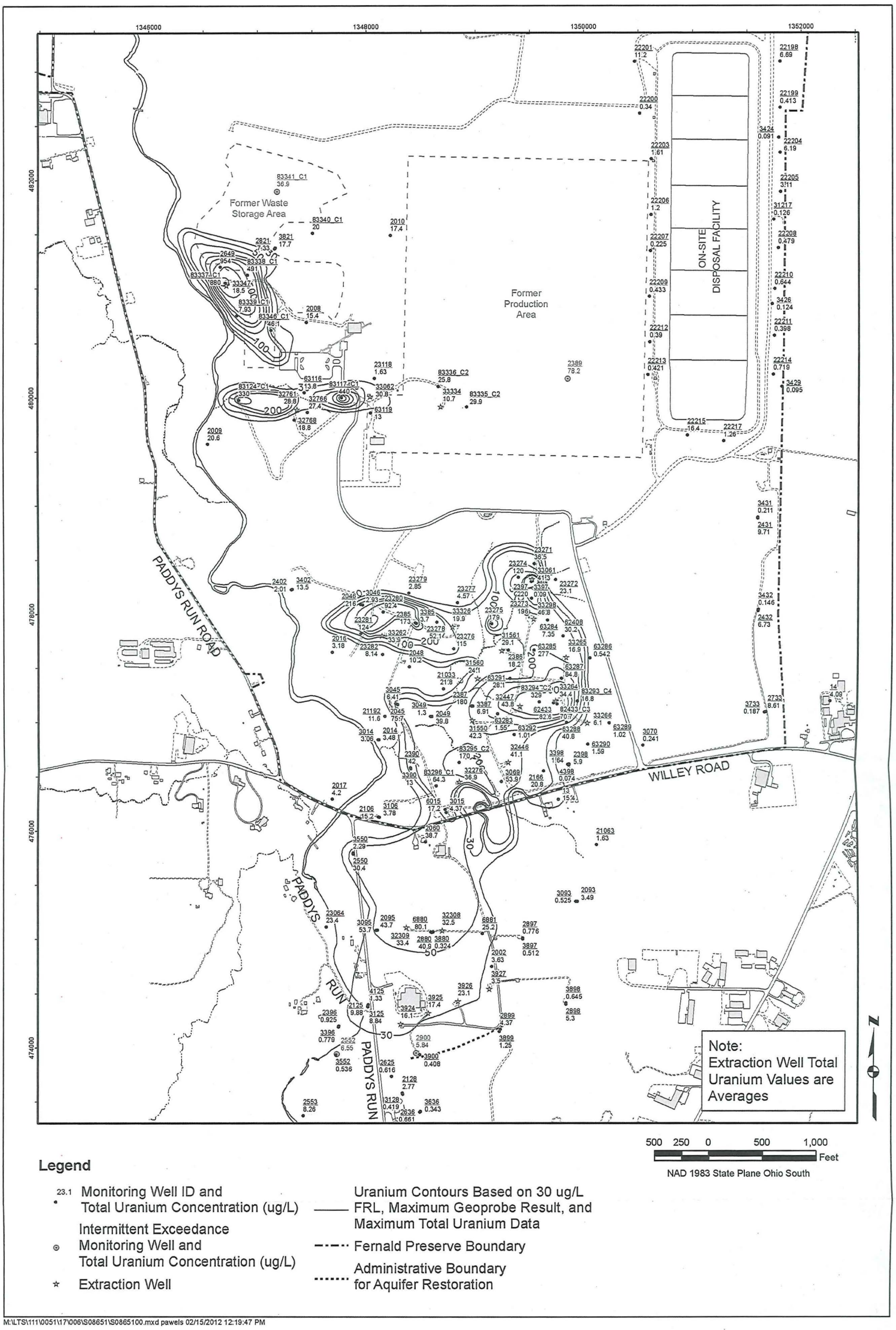

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Figure A.2-2B. Monitoring Well Data and Maximum Total Uranium Plume through the First Half of 2011

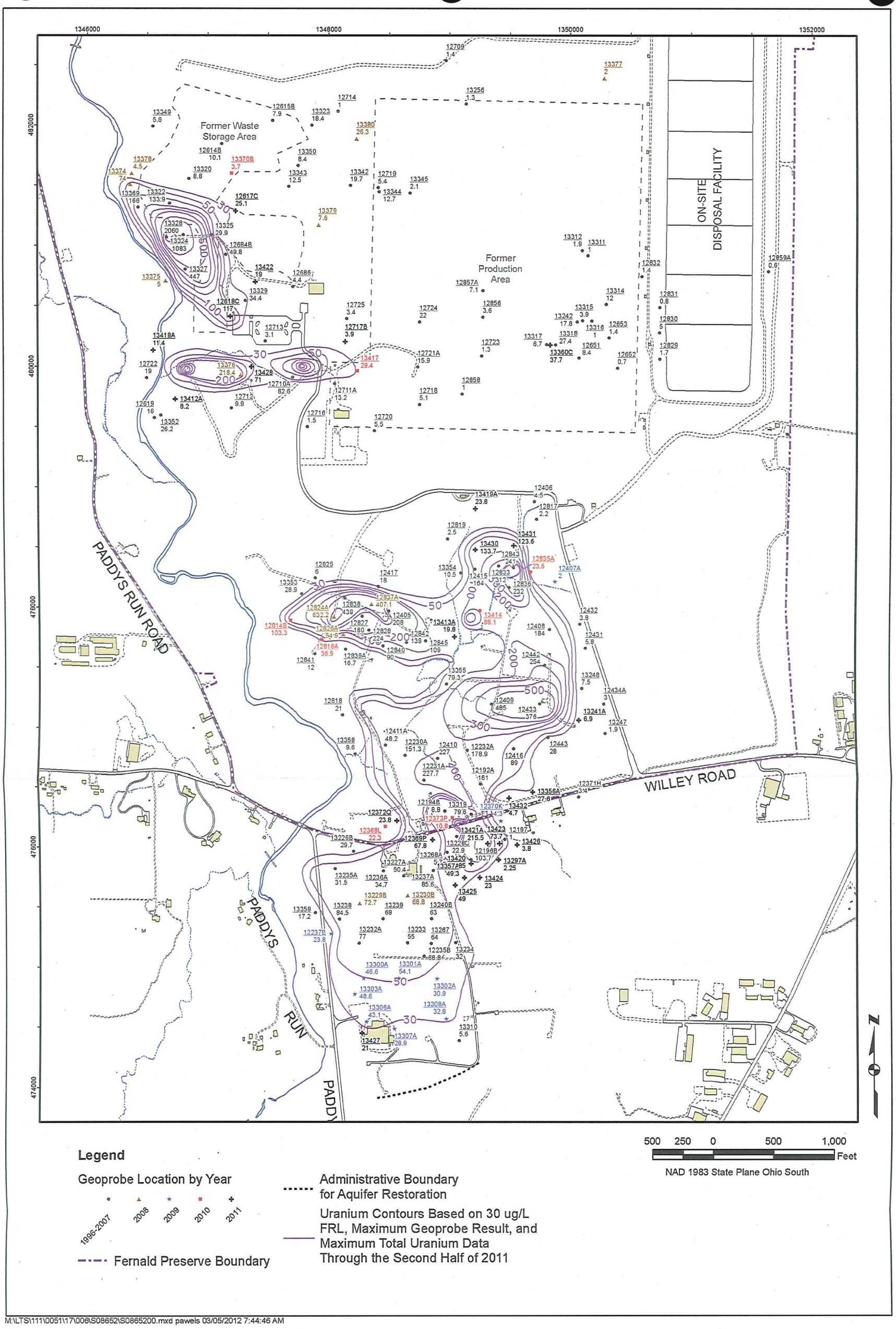

Figure A.2−3A. Direct-Push Data and Maximum Total Uranium Plume through the Second Half of 2011

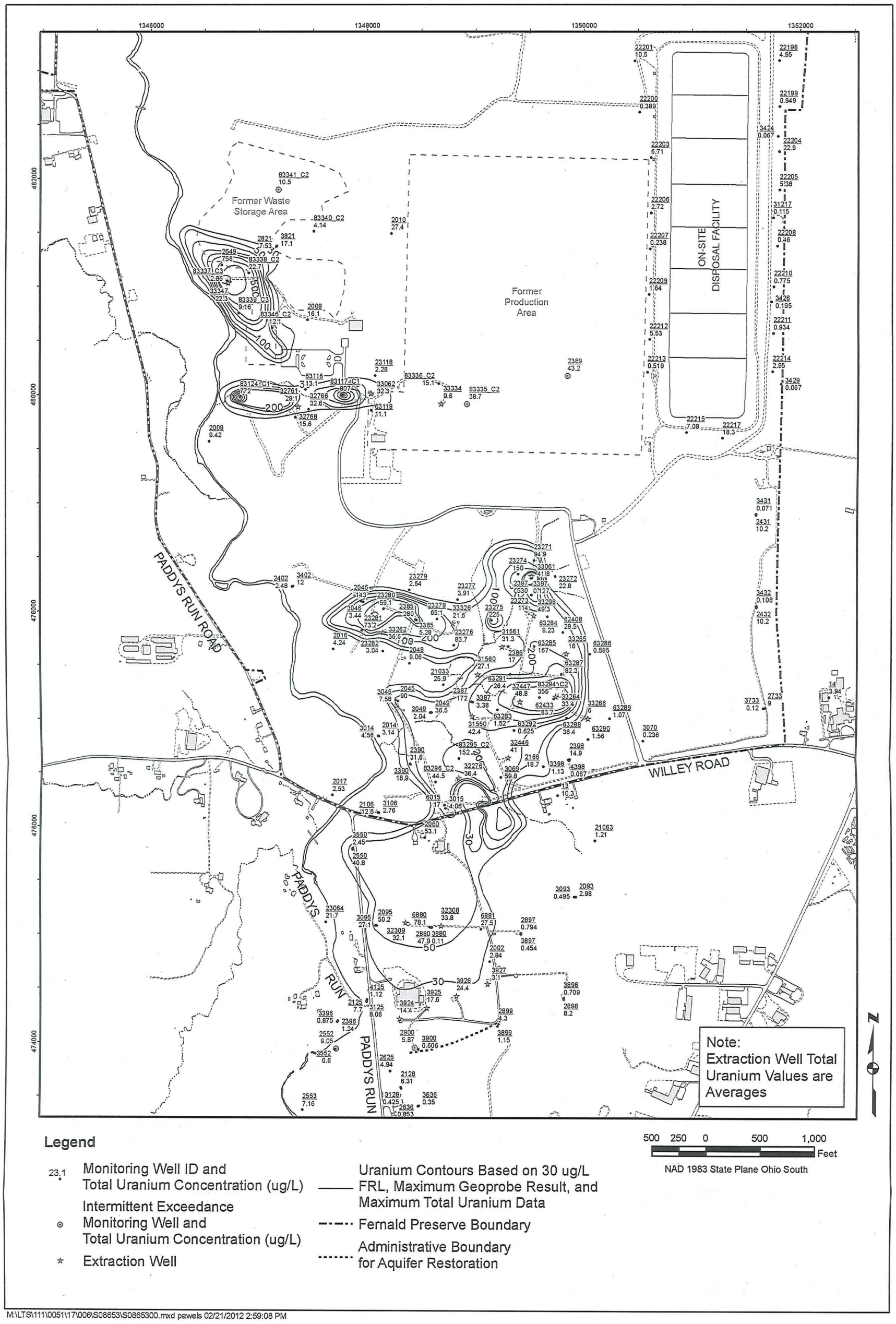

Figure A.2–3B. Monitoring Well Data and Maximum Total Uranium Plume through the Second Half of 2011

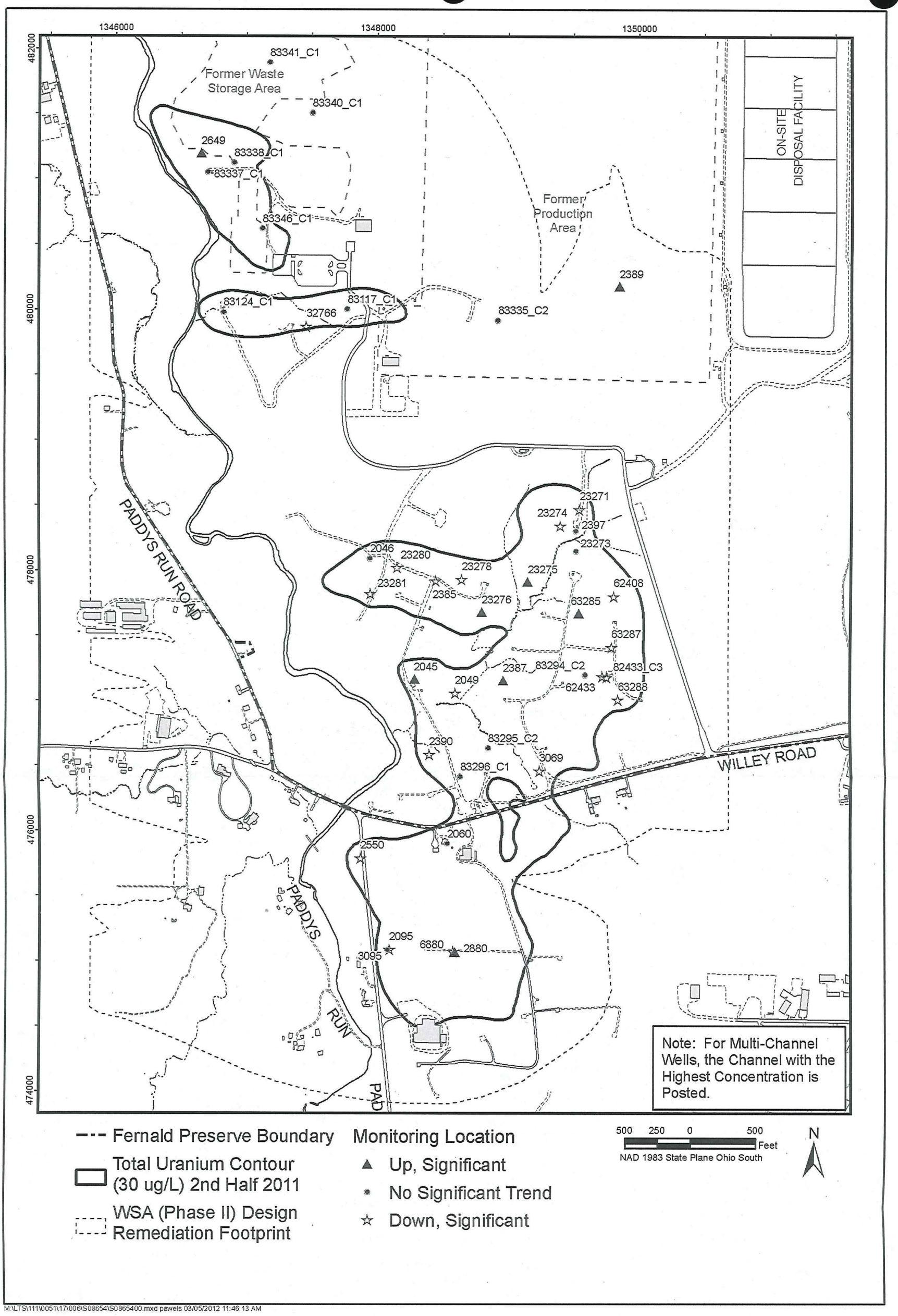

Figure A.2–4. Monitoring Wells with 2011 Exceedances for Total Uranium with Up, Down, or No Significant Trends

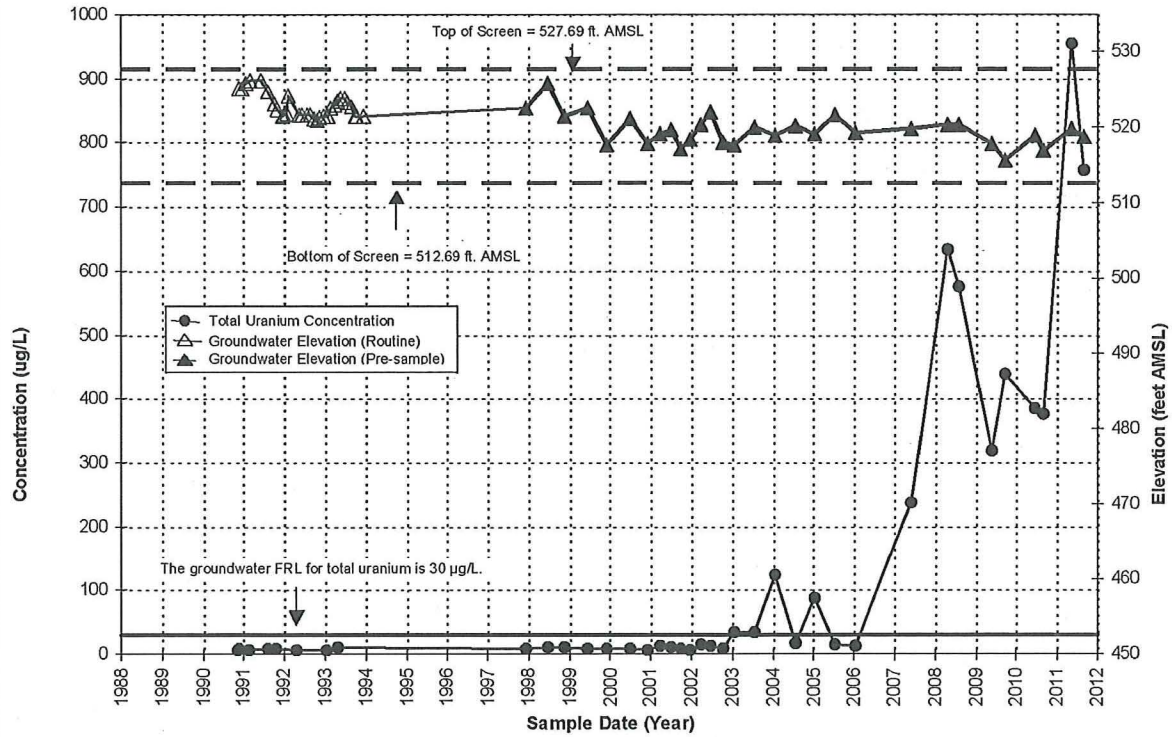

FIGURE A.2-5. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2649

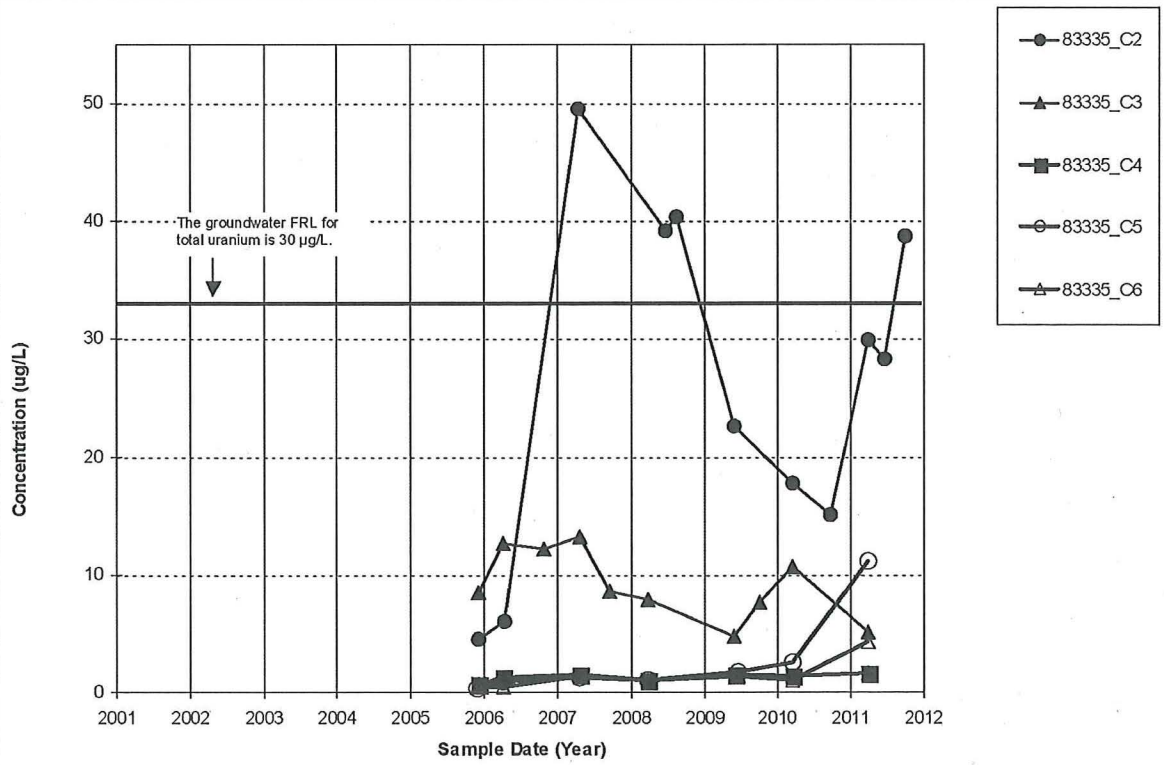

FIGURE A.2-6. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 83335

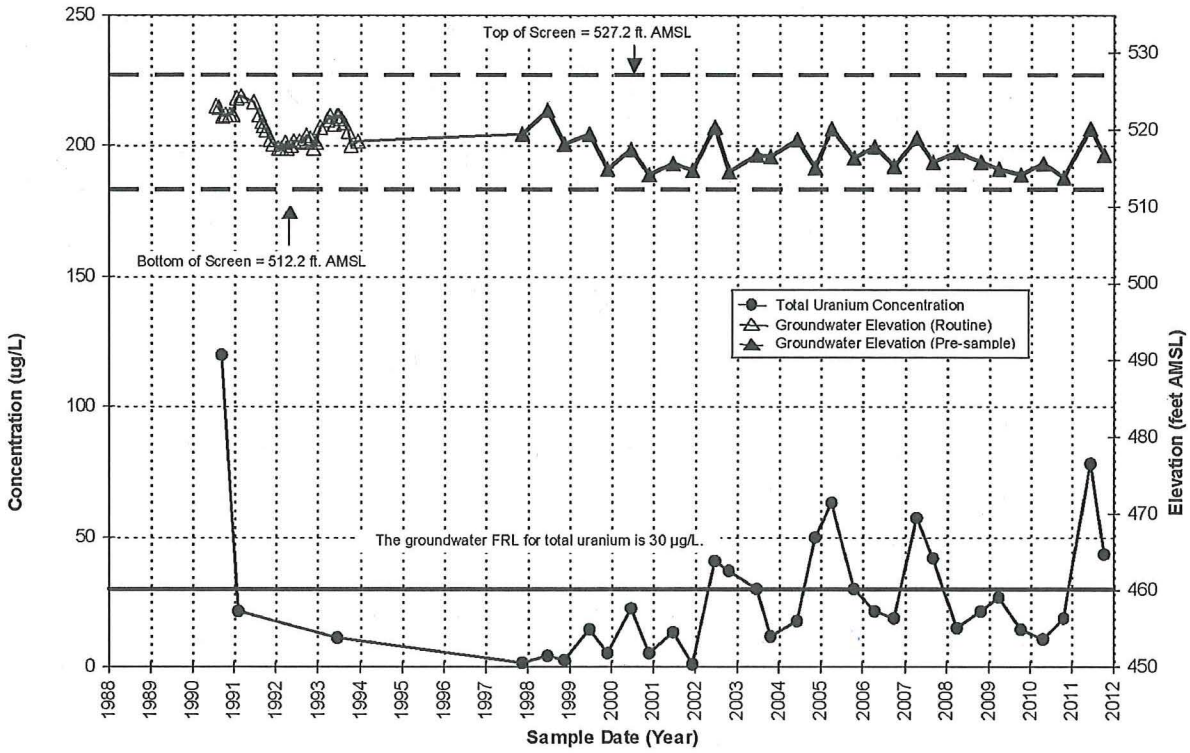

FIGURE A.2-7. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2389

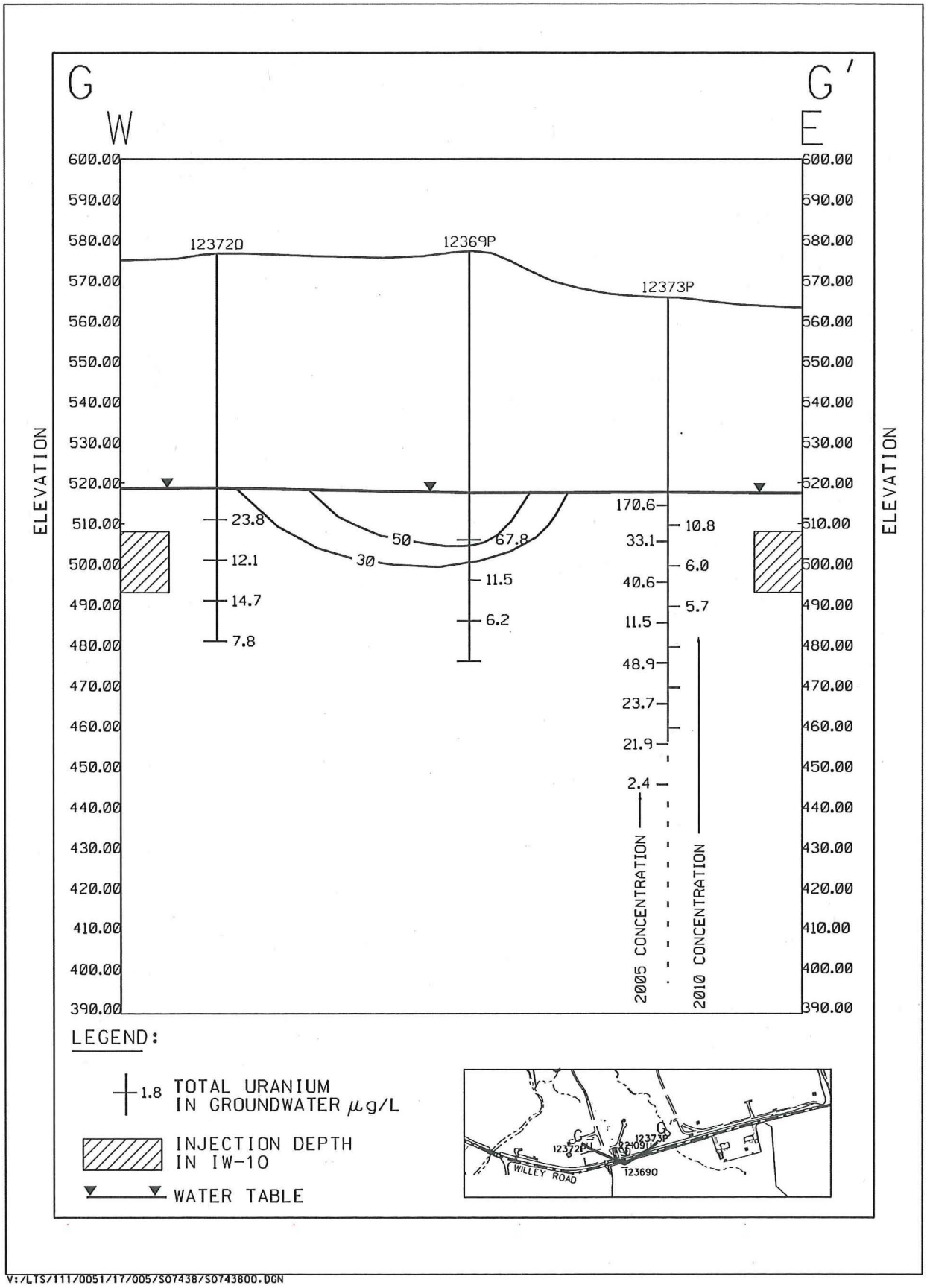

Figure A.2–8. Total Uranium in Groundwater (2011) Next to and South of IW-10

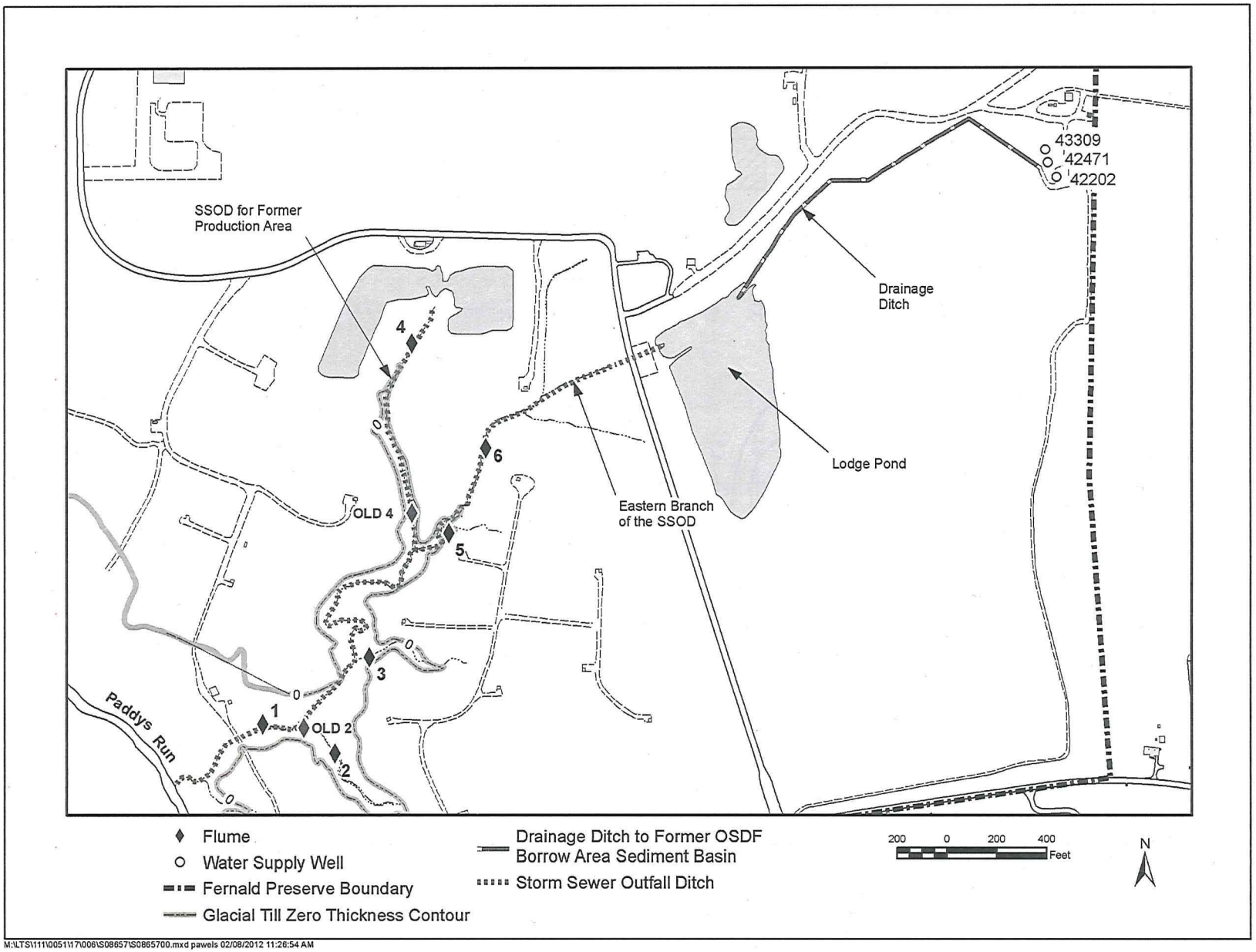

Figure A.2–9. SSOD Flumes and Water Supply Wells

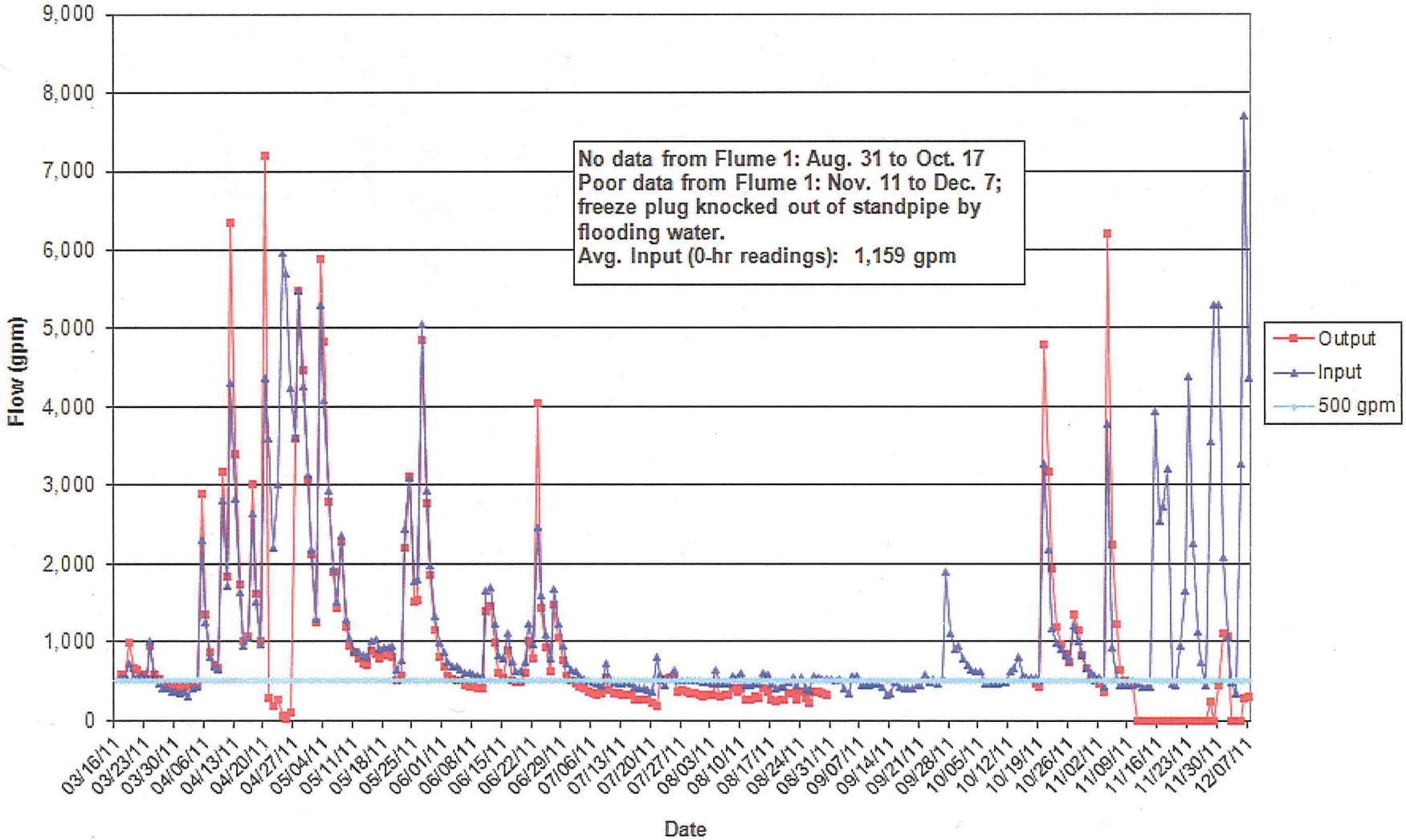

Figure A.2−10. Flow In and Out of the SSOD in 2011

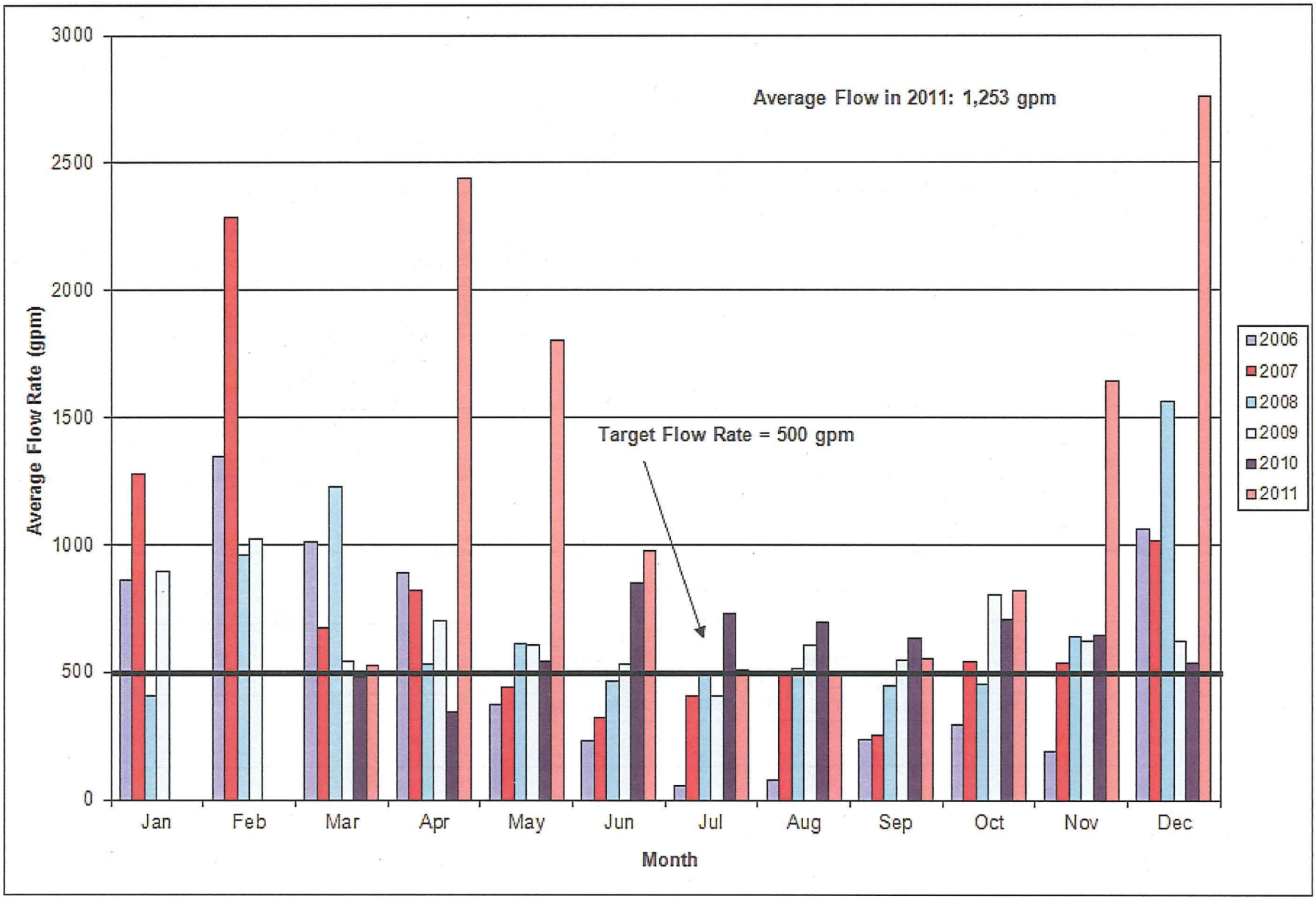

Figure A.2–11. Average Flow Rate into SSOD: 2006–2011 Flumes 2, 3, 4, 5 and 6

Attachment A.3

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A.3.0 Groundwater Elevations and Capture Assessment

A.3.1 Groundwater Elevations and Capture Assessment

Quarterly groundwater elevation maps for 2011 are provided in Figures A.3–1 through A.3–4. Each groundwater elevation map contains the following quarter-specific information:

- Groundwater elevation data.
- Interpreted water table contours, capture zones, and flow divides.
- Bedrock highs.
- Waste Storage Area (Phase II) Design particle track defined remediation footprint.
- Extent of the maximum 30 µg/L total uranium plume.
- Module-specific pumping rates during the time period in which the groundwater elevation measurements were collected and the number of wells in each module.

Water levels in 2011 were measured at 178 locations, as specified in the IEMP (DOE 2011a).

Quarter	Measurement Dates	Number of Days	Average Water Level (ft amsl)
1	1/17/11 to 1/20/11	4	511.98
2	4/11/11 to 4/12/11	2	515.96
3	7/18/11 to 7/21/11	4	519.48
4	10/10/11 to 10/12/11	3	515.71

Twenty-one monitoring wells were not measured at various times in 2011 because the wells were dry. A summary is provided below.

Well	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
2014	DRY	DRY		DRY
21192	DRY	DRY		DRY
22303	DRY			
2384	DRY			
2544	DRY			
2636	DRY			DRY
82433_C1	DRY	DRY		DRY
83117_C1	DRY			
83293_C1	DRY	DRY		DRY
83294_C1	DRY	DRY		DRY
83295_C1	DRY	DRY		DRY
83296_C1	DRY			
83335_C1	DRY	DRY	DRY	DRY
83335_C2	DRY	DRY		
83336_C1	DRY	DRY	DRY	DRY
83337_C1	DRY	DRY		DRY
83338_C1	DRY			
83339_C1	DRY			
83340_C1	DRY	DRY		
83341_C1	DRY	DRY		
83346_C1	DRY			

The 2011 quarterly groundwater elevation maps shown in Figures A.3–1 through A.3–4 illustrate capture of the maximum total uranium plume by means of groundwater elevation contours derived from quarterly water level measurements and predicted capture based on Waste Storage Area (Phase II) design particle track modeling. The pumping rates reported on Figures A.3–1 through A.3–4 are averages of the actual pumping rates during the measurement period.

The Waste Storage Area (Phase II) design remediation footprint used in this report was constructed using reverse, non-retarded, particle path interpretations from the VAM 3D, Zoom Groundwater Model. Figure A.3–5 shows the resulting particle tracks that were used to define the Waste Storage Area (Phase II) design remediation footprint. Model particles were seeded at each extraction well. The resulting particle tracks represent the individual path that each particle traveled over the time period modeled for the Waste Storage Area (Phase II) design (2007 to 2023). The limits of most of the particle tracks are truncated because the particles reached the edge of the VAM 3D Zoom Groundwater Model domain.

A groundwater flow divide between Paddys Run Outlet and the New Baltimore Outlet is not readily distinguishable. Groundwater flow diverges around the bedrock high that separates the Paddys Run Outlet from the New Baltimore Outlet, but without additional measurement locations in the New Baltimore Outlet, the location where flow is dividing is not apparent. Additional measurement locations in the New Baltimore Outlet though are not needed for capture assessment purposes.

During 2011, the flow direction in the vicinity of the OSDF was generally northeast to south/southwest. This flow direction is influenced by active pumping taking place for the groundwater remediation which is predicted to last until 2023. Prior to the start of pumping for the groundwater remediation, flow in the vicinity of the OSDF was generally west to east. It is anticipated that when pumping stops, flow direction in the vicinity of the OSDF will return to a generally west to east direction.

Average annual water table fluctuations and yearly ranges for 2006 through 2011 are as follows:

Year	Average Fluctuation (ft)	Fluctuation Range (ft)
2011	7.50	7.4 to 14.5
2010	3.78	0.06 to 12.1
2009	2.46	0.1 to 5.5
2008	5.7	1.0 to 10.46
2007	4.45	1.7 to 7.7
2006	3.4	2.0 to 7.1

Quarterly capture zone interpretations coupled with the Waste Storage Area (Phase II) particle track interpretations and contoured water table gradients indicate that the 30-µg/L total uranium plume was being captured in 2011.

A.3.2 Annual Planned Well Field Shutdown

Unplanned well field pumping disruptions were minimal in 2011. The entire well field (excluding the South Plume recovery wells) was shut down once in 2011 for a total of 28 days from June 13 to July 11 as planned to allow water levels to recover to non-pumping elevations. Routine quarterly water level measurements were not collected in 2011 during the planned shutdowns.

Uranium contamination is bound to aquifer sediments in the unsaturated portion of the GMA beneath former contamination source areas. This contamination will remain bound unless water levels in the aquifer rise, saturate the contaminated sediments, and allow the bound contamination to dissolve into the groundwater.

Planned annual well field shutdowns have been conducted since 2007 to allow water levels in the aquifer to rise as high as possible to saturate aquifer material that is not normally saturated. To achieve the highest water level rise possible, the well field shutdowns are planned to coincide with seasonal high-water levels in the aquifer.

Regional water levels in 2011 were high due to the large amount of precipitation received during the year. The high regional water levels provided ideal conditions for the shut down exercise. Figure A.3–6 shows cumulative annual precipitation levels for 2004 through 2011, as recorded at the Butler County Regional Airport. Cumulative precipitation in 2011 was approximately 60.20 inches. This is the highest amount of annual precipitation recorded in the last seven years.

Water Level Results

Pressure transducers were installed in 11 groundwater monitoring wells (2045, 2046, 2649, 23274, 62433, 32763, 23118, 22301, 22302, 22303, and 63119) for the shutdown (Figure A.3–7). Water level measurements were recorded at the top of each hour.

The zero hour transducer readings (midnight) were used to track water level changes in the transducer wells during the shutdown period. The maximum water level rise measured during the shutdown in 2011 at each transducer are presented below:

Location	Just Prior to Shutdown 6/13/2011	Just Prior to Restart 7/11/2011	Water Level Rise (ft)
2045	519.94	521.62	1.68
2046	519.77	521.41	1.64
2649	520.07	522.34	2.27
23274	519.23	520.97	1.74
63119	518.89	521.20	2.31
22302	520.74	524.15	3.41
23118	519.26	521.48	2.22
22301	518.74	520.45	1.71
22303	520.76	522.47	1.71
32763	518.77	521.99	3.22
62433	518.44	520.66	2.22

The water level rise calculations indicate that during the shutdown the water level rise at the transducer wells ranged from 1.64 ft to 3.41 ft.

Figure A.3–8 shows water levels verses precipitation from May 25, 2007, through February 2, 2012. Three wells are shown on the figure, well 2649 (former Waste Storage Area), well 2046 (west side of South Field Area), and well 62433 (east side of South Field Area). The combination of the shutdown and seasonal water level rise in 2011 resulted in a water level rise of approximately:

- 8.23 feet in the former Waste Storage Area (monitoring well 2649);
- 9.38 feet in the west side of the South Field (monitoring well 2046); and
- 11.06 feet in the east side of the South Field (monitoring well 62433).

Uranium Concentration Results

Uranium concentrations were measured in six groundwater monitoring wells (2045, 2046, 23274, 83124, 83294, and 83337 [Figure A.3–9]) before, during, and after the 2011 shutdown. The results of the 2011 IEMP first-half uranium sampling are used to represent uranium concentrations in the well before the shutdown. Groundwater samples collected on either July 6 or July 7 represent concentrations during the shutdown, and the results of the 2011 IEMP second-half uranium sampling are used to represent uranium concentrations in the well after the shutdown exercise was completed. The two shallowest channels (Channels 1 and 2) of the Type-8 monitoring wells were sampled. Uranium concentration measurements at the six monitoring wells before, during, and after the 2011 shutdown are provided in Table A.3–1.

A comparison of pre-shutdown uranium concentrations to pre-startup uranium concentrations in the monitoring wells yields mixed results. In some wells uranium concentrations during the shutdown increased (i.e., 2045, 23274, 83124_C1, 83294_C1 and 83337_C1); in other monitoring wells the uranium concentrations during the shutdown decreased (i.e., 2046, 83124_C2, 83294_C2, and 83337_C1). During the second half of the year, the channel with the highest uranium concentration (as measured during the first half of the year) is sampled. Therefore, no sample was collected from 83124_C2 during the second half of 2011.

Uranium concentrations were also measured at the extraction wells before and daily for 4 days after the wells were restarted. The first water sample was collected after the well had been pumping for approximately 5 minutes. Results are provided in Table A.3–2. The last column of the table provides the difference between the maximum uranium concentration measured after the wells were restarted, and the average uranium concentration measured in June at the extraction well. As the data indicate, the uranium concentration increased at most of the wells. As reported in Table A.3–2, during the shutdown, wells RW-6 and EW-28A underwent rehabilitation. During rehabilitation the well is shut down, liquid acid descalar (LAD) and hydrochloric acid (HCL) are placed in the well and the well is surged to clean the screen and loosen up the formation around the well screen. The objective is to restore pumping efficiency.

A.3.3 Continued Transducer Monitoring

Although not required by the IEMP, pressure transducers installed in 2007 to support the first annual well field shutdown remain in the wells and continue to operate so that daily changes in water levels can be recorded on a continuous, routine basis at key points in the aquifer. The transducers are programmed to record a water level measurement at the top of each hour. Data from three of the six locations (former Waste Storage Area [2649], east side of the South Field Area [2046], and west side of the South Field Area [62433]) (locations shown in Figure A.3–7) are plotted in Figure A.3–8 along with precipitation data collected through February 2, 2012. The intent is to leave these transducers operating. The data will provide a more complete record of seasonal and short-term water table fluctuations and should prove helpful for planning the timing of future well field shutdowns.

Table A.3–1. Uranium Concentrations at Monitoring Wells Before, During, and After the 2011 Well Field Shutdown

Well	Easting	Northing	First Half 2010 Pre-Shutdown Concentrations		Pre-Start-Up Concentrations		Second Half 2011 Post-Shutdown Concentrations	
			Date	Uranium (µg/L)	Date	Uranium (µg/L)	Date	Uranium (µg/L)
2045	1348291	477158.9	4/18/2011	75.7	7/6/2011	90	9/7/2011	72.5
2046	1347950	478087.8	6/9/2011	216	7/6/2011	143	10/5/2011	67.5
23274	1349406	478337	4/7/2011	120	7/6/2011	127	9/29/2011	150
83124_C1	1346826	479977.2	3/16/2011	330	7/6/2011	579	9/27/2011	772
83124_C2	1346826	479977.2	3/16/2011	54.6	7/6/2011	46.9	NA[a]	NA[a]
83294_C1	1349599	477189.5	6/7/2011	171	7/6/2011	173	10/11/2011	DRY
83294_C2	1349599	477189.5	4/6/2011	329	7/6/2011	308	10/3/2011	356
83337_C1	1346704	481051.9	4/18/2011	880	7/7/2011	871	9/6/2011	DRY
83337_C2	1346704	481051.9	4/18/2011	15.3	7/7/2011	306	9/6/2011	2.93

[a]NA = not applicable

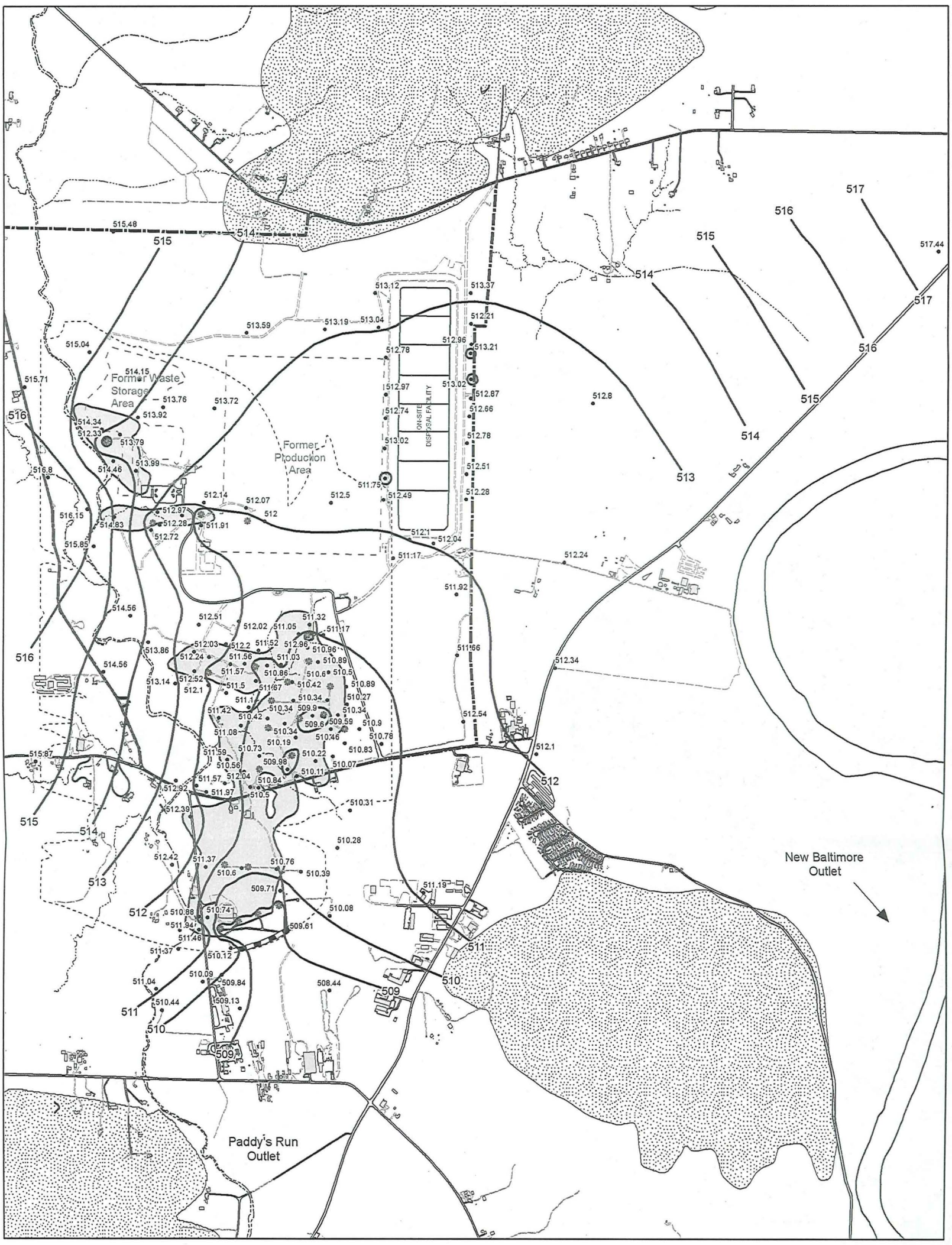
Only the highest elevation channel was sampled during the second half of 2011.

Table A.3–2. Uranium Concentrations at Extraction Wells Before and After the Well Field Shutdown

Extraction Well	June Avg. Uranium Conc. (ug/L)	Uranium Concentration (ug/L) After Well Field Re-Start							Max. after Re-Start Minus June Avg.[a] (ug/L)
		7/11/2011	7/12/2011	7/13/2011	7/14/2011	Min[a]	Max[a]	Range[a]	
RW-1	14.5	14.2	13.9	14.0	14.4	13.9	14.4	0.5	-0.1
RW-2	16.7	18.8	18.2	17.9	18.2	17.9	18.8	0.9	2.1
RW-3	20.6	24.2	23.9	23.6	24.5	23.6	24.5	0.9	3.9
RW-4	3.7	3.6	3.4	3.3	3.4	3.3	3.6	0.3	-0.1
RW-6	31.6	**REHAB**	**REHAB**	**REHAB**	**REHAB**	NA	NA	NA	NA
RW-7	33.3	35.4	34.7	33.8	33.9	33.8	35.4	1.6	2.1
EW-15A	34.9	37.8	36.9	36.7	40.8	36.7	40.8	4.1	5.9
EW-17A	19.9	23.7	23.4	21.6	23.7	21.6	23.7	2.1	3.8
EW-18	45.2	42.7	46.0	46.7	45.8	42.7	46.7	4.0	1.5
EW-19	27.9	30.7	31.2	30.3	32.4	30.3	32.4	2.1	4.5
EW-20	28.8	29.6	29.4	28.1	30.1	28.1	30.1	2.0	1.3
EW-21A	49.9	63.5	51.8	50.6	53.9	50.6	63.5	12.9	13.6
EW-22	33.7	44.8	40.7	38.4	39.1	38.4	44.8	6.4	11.1
EW-23	49.5	45.6	47.7	48.5	50.0	45.6	50.0	4.4	0.5
EW-24	41.0	43.8	42.3	42.4	42.3	42.3	43.8	1.5	2.8
EW-25	63.4	46.6	46.5	46.3	47.6	46.3	47.6	1.3	-15.8
EW-26	29.1	33.4	31.8	29.6	31.1	29.6	33.4	3.8	4.3
EW-27	29.7	33.3	31.5	31.2	32.8	31.2	33.3	2.1	3.6
EW-28A	9.8	**REHAB**	8.7	8.7	8.8	8.7	8.8	0.1	-1
EW-30	43.2	15.8	19.8	21.7	26.7	15.8	26.7	10.9	-16.5
EW-31	16.6	23.6	23.4	23.2	23.3	23.2	23.6	0.4	7
EW-32	5.0	7.4	7.0	6.6	6.4	6.4	7.4	1.0	2.4
EW-33	23.8	24.7	23.9	23.2	25.8	23.2	25.8	2.6	2

Shading indicates Uranium concentration after well field re-start is greater than June average uranium concentration.
[a]NA = not applicable

Shutdown began on 6-13-2011 @ 8:30 AM
Shutdown ended on 7-11-2011 @ 9:30 AM



Extraction Well
Groundwater Elevation Contour
Bedrock Highs
Capture Zone
WSA (Phase II) Design Remediation Footprint (Defined in Attachment A.3)
516.22 Groundwater Elevation (Feet AMSL)
Extent of the Maximum Total Uranium 30 ug/L Contour through First Half 2011

January 17 - January 20, 2011 Operational Status
Average Pumping Rates (gpm)

South Plume (6 wells): 1230 gpm
South Field Extraction (13 Wells): 2690 gpm
Waste Storage Area (4 Wells): 745 gpm

1000 0 1000 Feet

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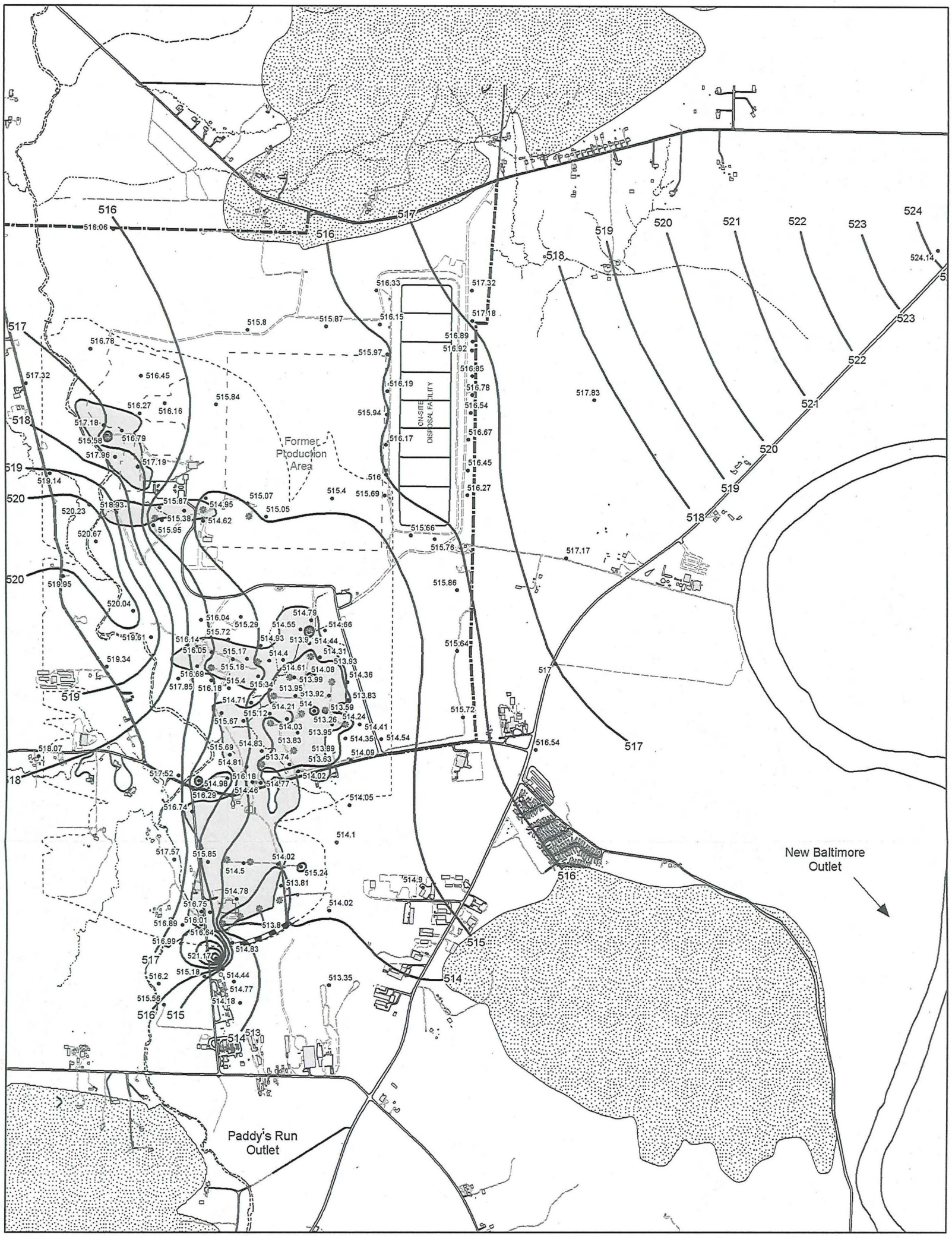
Figure A.3-1. Routine Groundwater Elevation Map, First Quarter 2011 (January 17 through January 20, 2011)



Extraction Well
Groundwater Elevation Contour
Bedrock Highs
Capture Zone
WSA (Phase II) Design Remediation Footprint (Defined in Attachment A.3)
516.22 Groundwater Elevation (Feet ASML)
Extent of the Maximum Total Uranium 30 ug/L Contour through First Half 2011

April 11 - April 14, 2011 Operational Status
Average Pumping Rates (gpm)

South Plume (5 wells): 1251 gpm
South Field Extraction (13 Wells): 2739 gpm
Waste Storage Area (4 Wells): 795 gpm

N

1000 0 1000
Feet

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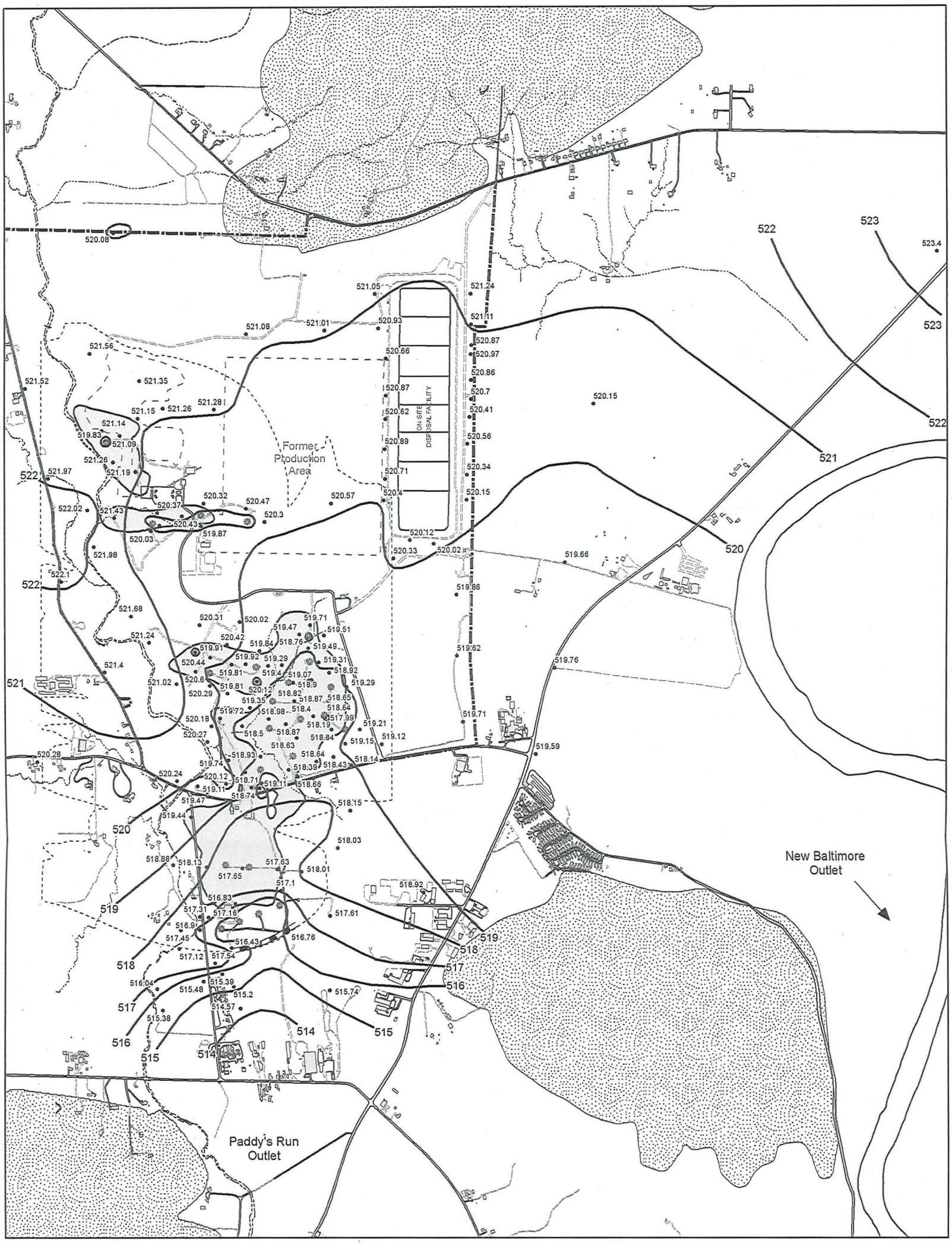
Figure A.3-2. Routine Groundwater Elevation Map, Second Quarter 2011 (April 11 through April 14, 2011)



Extraction Well

Groundwater Elevation Contour

Bedrock Highs

Capture Zone

WSA (Phase II) Design Remediation Footprint (Defined in Attachment A.3)

516.22 Groundwater Elevation (Feet ASML)

Extent of the Maximum Total Uranium 30 ug/L Contour through Second Half of 2011

July 18 - July 21, 2011 Operational Status
Average Pumping Rates (gpm)

South Plume (6 wells): 1292 gpm
South Field Extraction (13 Wells): 2819 gpm
Waste Storage Area (4 Wells): 659 gpm

N

1000 0 1000 Feet

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Figure A.3-3. Routine Groundwater Elevation Map, Third Quarter 2011 (July 18 through July 121, 2011)

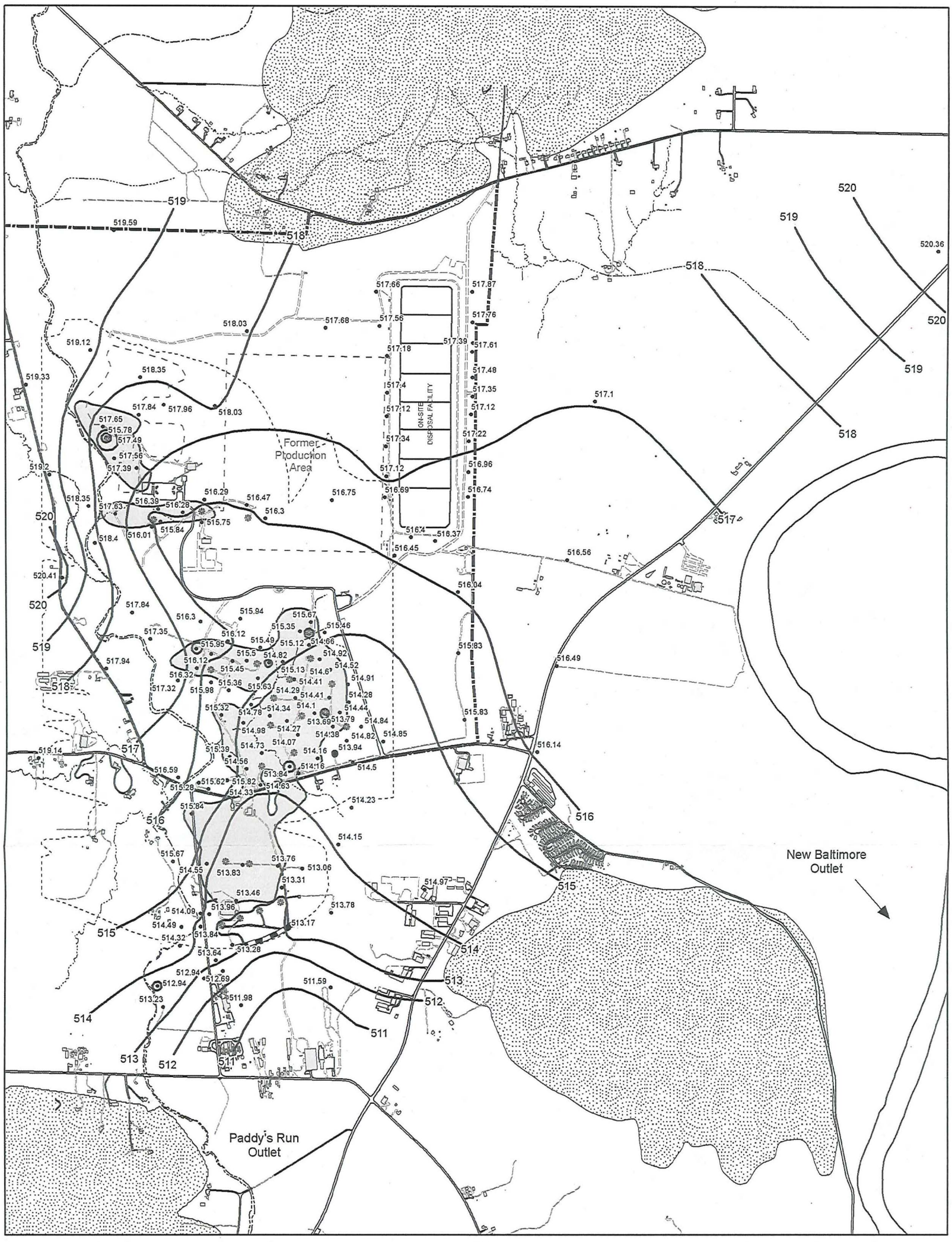

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Figure A.3-4. Routine Groundwater Elevation Map, Fourth Quarter 2011 (October 10 through October 12, 2011)

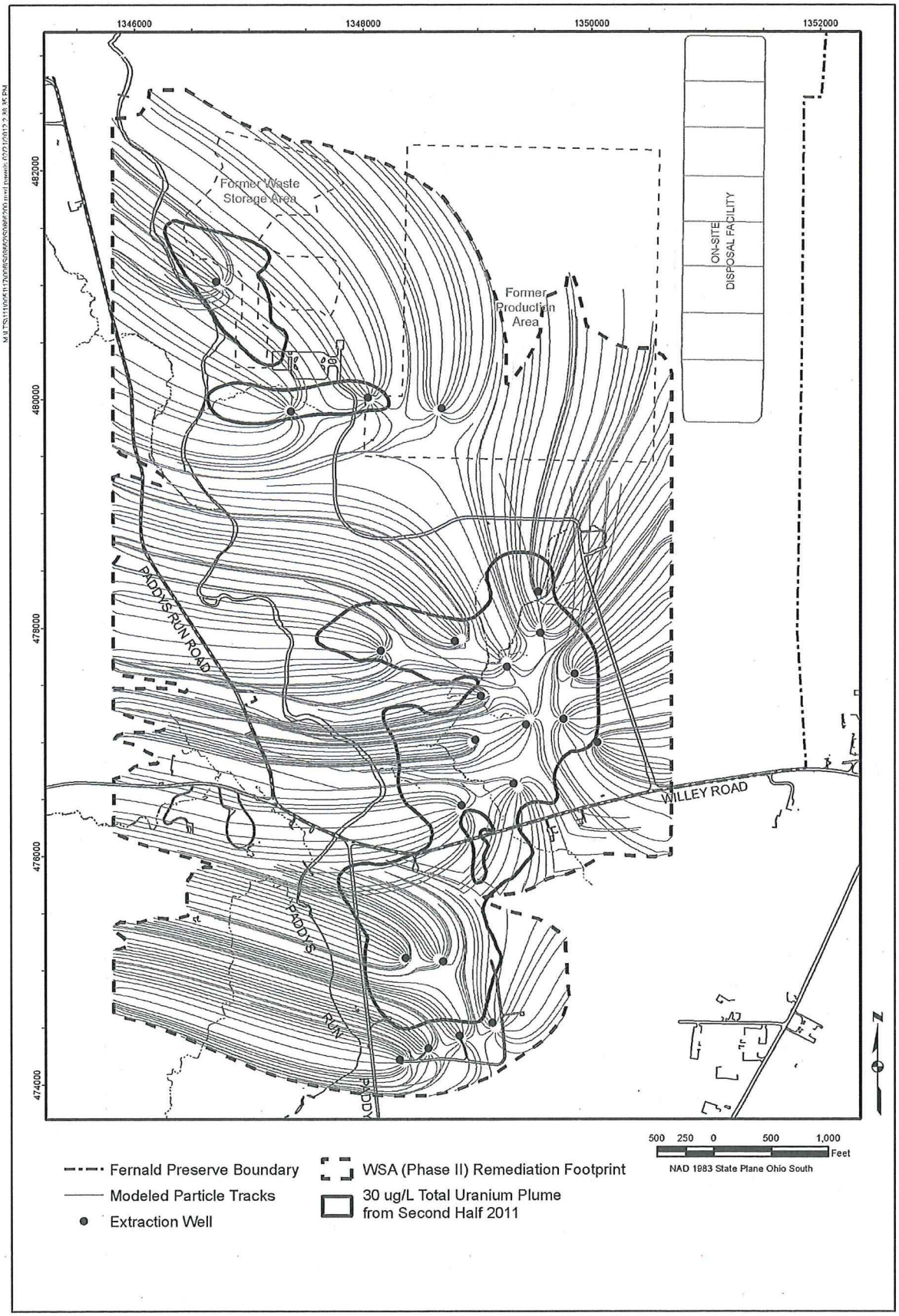

Figure A.3-5. WSA (Phase II) Design Remediation Footprint

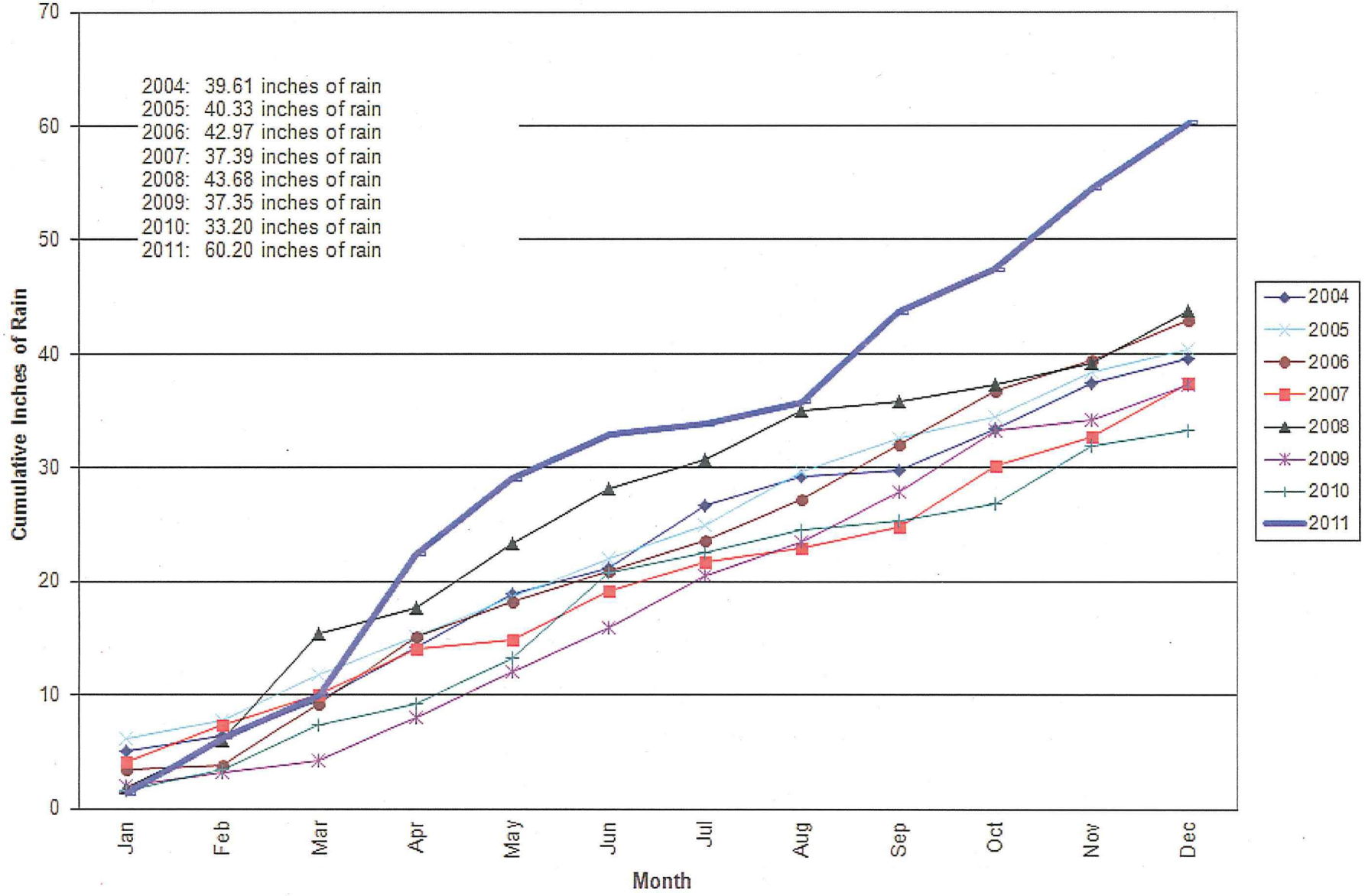

Figure A.3–6. Cumulative Annual Precipitation: 2004 through 2011 as Recorded at the Butler County Regional Airport

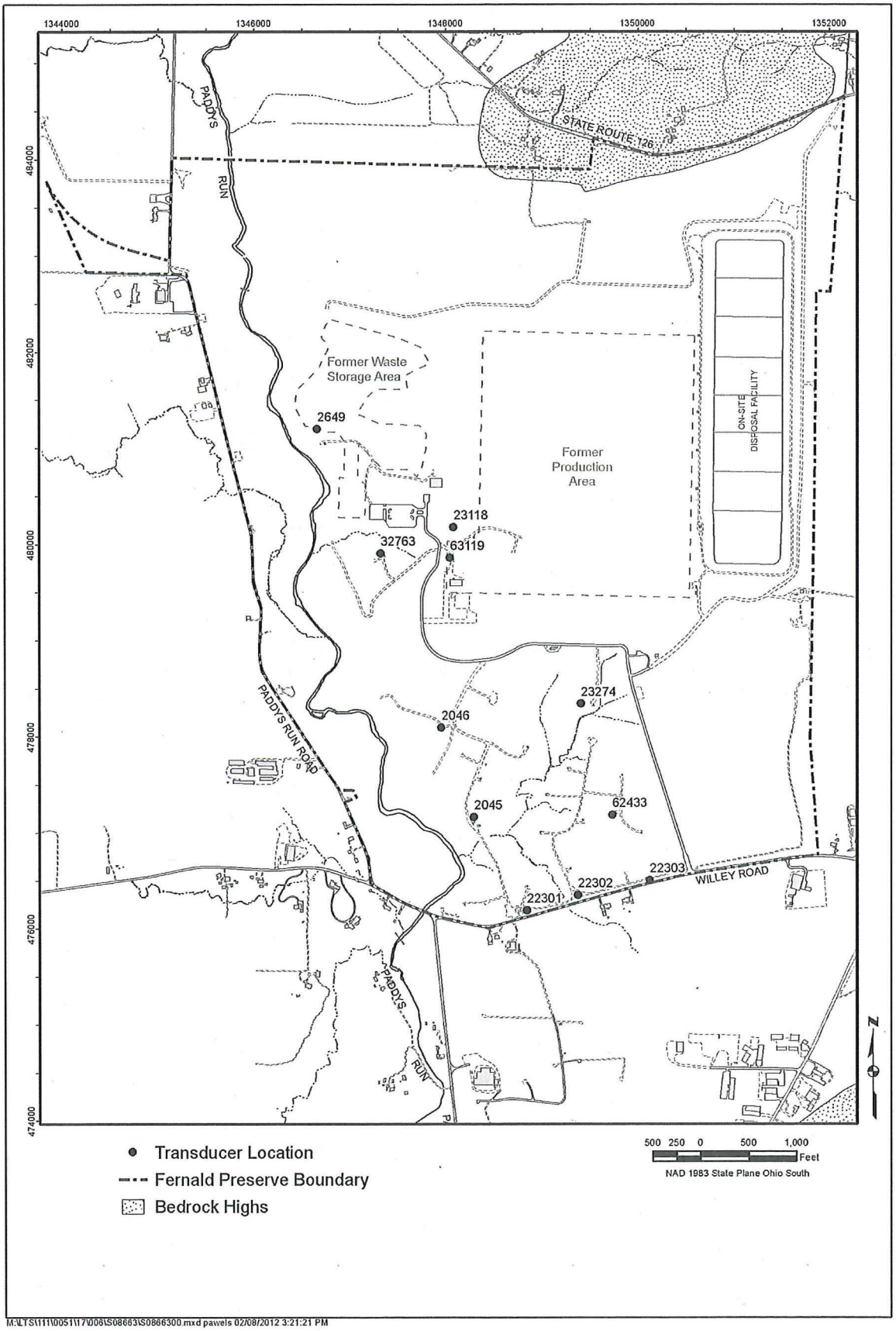

Figure A.3-7. Transducer Locations for the 2011 Operational Shutdown

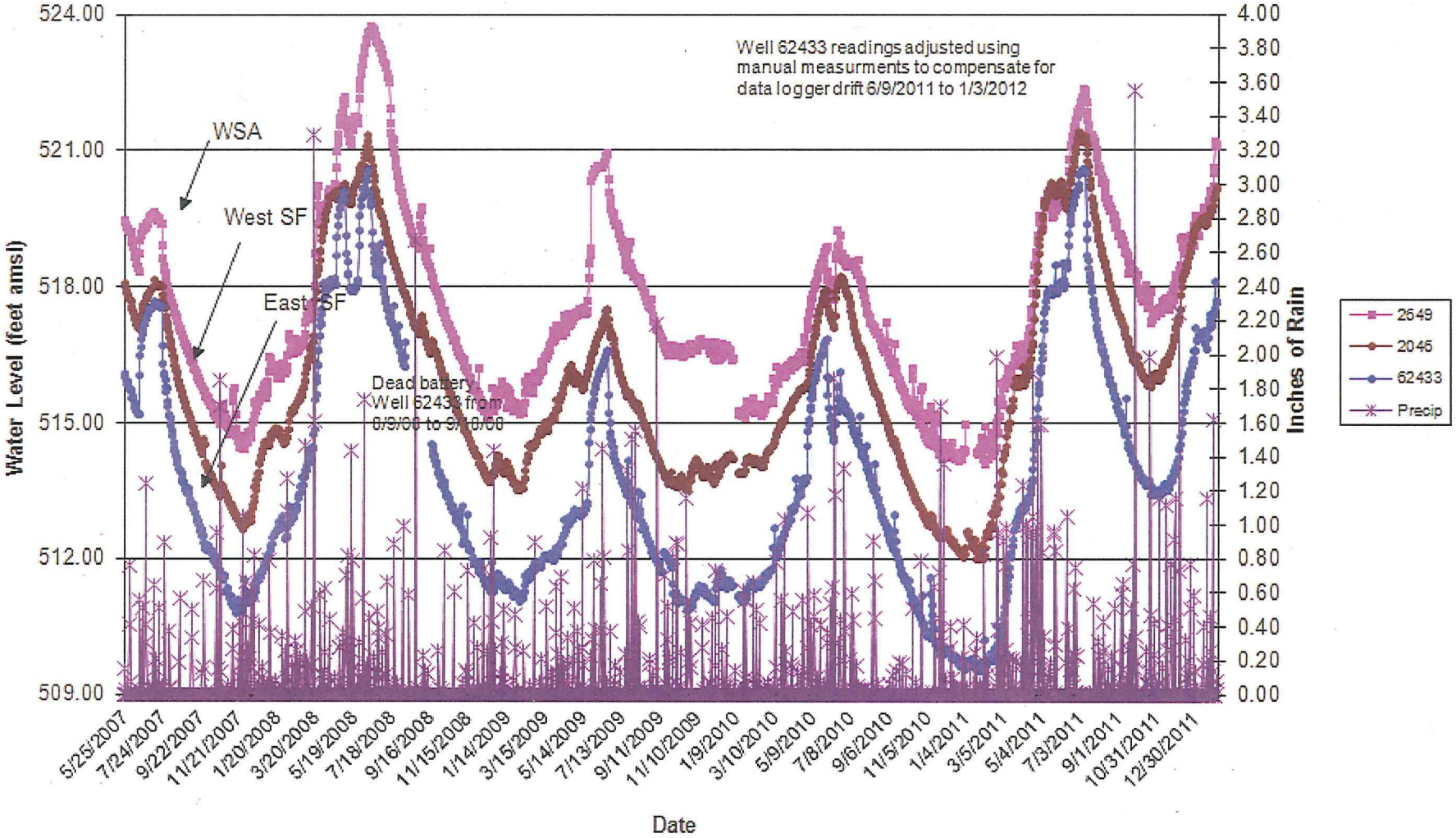

Figure A.3–8. Water Levels versus Precipitation May 25, 2007, through February 2, 2012

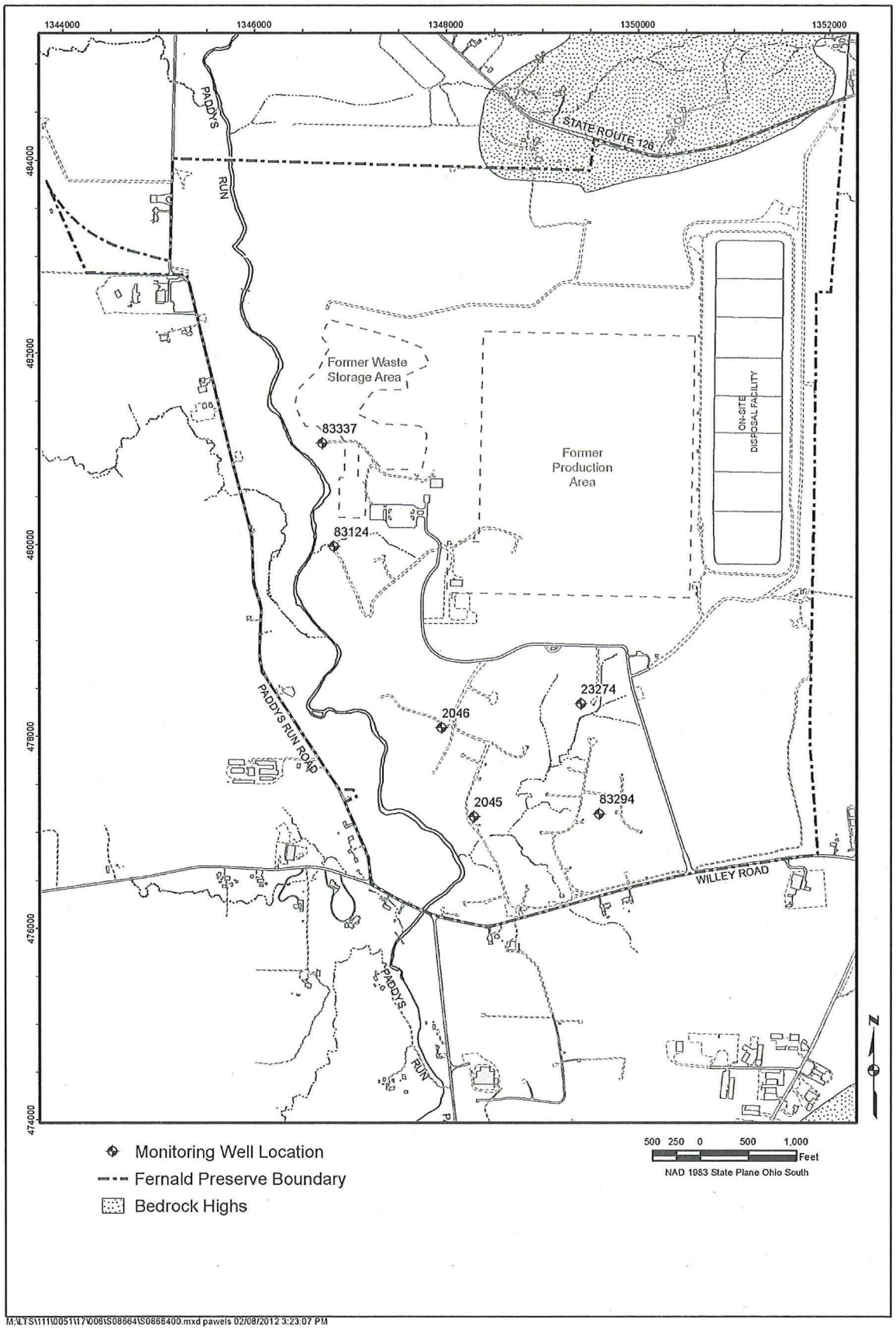

Figure A.3-9. Monitoring Well Locations for the 2011 Operational Shutdowns

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Attachment A.4

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A.4.0 Non-Uranium FRL Results

This attachment evaluates non-uranium FRL results for 2011. The purpose of the evaluation is to:

- Identify 2011 non-uranium FRL exceedances (Section A.4.1).
- Determine the persistence of non-uranium FRL exceedances outside the Waste Storage Area (Phase II) design remediation footprint (Section A.4.2).
- Present conclusions (Section A.4.3).

A.4.1 Non-Uranium FRL Exceedances for 2011

Table A.4–1 shows the summary statistics and trend analysis for the 2011 non-uranium FRL exceedances from monitoring wells both inside and outside the Waste Storage Area (Phase II) design footprint. As indicated in Table A.4–1, eight non-uranium FRL constituents had one or more FRL exceedances during 2011. Figure A.4–1 identifies the location of these FRL exceedances.

Figure A.4–1 shows that the non-uranium FRL exceedances in 2011 for monitoring wells were located in the former Waste Storage Area, along the eastern edge of the site, and in the PRRS area. Those in the former Waste Storage Area were within the Waste Storage Area (Phase II) design remediation footprint. Those along the eastern property boundary and in the PRRS area were located outside the Waste Storage Area (Phase II) design remediation footprint. Specific discussion regarding exceedances and persistence outside the footprint is provided in Section A.4.2.

Table A.4–2 identifies all the locations and constituents that had non-uranium FRL exceedances between 1997 and 2011. The first column in Table A.4–2 lists the groundwater FRL constituents monitored in 2011. The second column identifies the wells monitored that have had an exceedance since 1997 for each constituent. The third column identifies the associated aquifer zone monitored. The fourth column identifies the associated monitoring program for each well/constituent. The remaining columns show monitoring years that reflect a semiannual sampling frequency, although the monitoring was performed quarterly prior to 2003. For the sampling that occurred prior to 2003, a "1" denotes an exceedance for one of the two quarters and a "2" denotes an exceedance for both quarters. Table A.4–2 also indicates whether exceedances occurred inside or outside of the remediation footprint (shading indicates the well is located outside the footprint).

There were 13 non-uranium constituents monitored in 2011; 8 had exceedances. The following table summarizes the 2011 non-uranium monitoring information:

Constituent	Monitoring Program	2011 Monitoring Summary
Antimony	Property/Plume Boundary for PRRS Constituents	Exceedance in the PRRS area
Arsenic	Property/Plume Boundary for PRRS Constituents	No exceedances
Boron	South Field	No exceedances
Carbon Disulfide	Waste Storage Area	No exceedances
Fluoride	Property/Plume Boundary	No exceedances
Lead	Property/Plume Boundary	Exceedance in the PRRS area
Manganese	Property/Plume Boundary, Waste Storage Area	Exceedances in former Waste Storage Area wells and along the eastern site boundary
Molybdenum	Waste Storage Area	Exceedances in former Waste Storage Area wells
Nickel	Waste Storage Area	No exceedances
Nitrate/Nitrite	Waste Storage Area	Exceedances in former Waste Storage Area wells
Technetium-99	Waste Storage Area	Exceedances in former Waste Storage Area wells
Trichloroethene	Waste Storage Area	Exceedance in former Waste Storage Area wells
Zinc	Property/Plume Boundary	Exceedances along the eastern site boundary and in the PRRS area

A.4.2 Evaluation of 2011 Non-Uranium FRL Exceedances Outside the Waste Storage Area (Phase II) Design Remediation Footprint

This section presents an evaluation of the persistence of non-uranium FRL exceedances outside the Waste Storage Area (Phase II) design remediation footprint.

A.4.2.1 Background

The *Restoration Area Verification Sampling Program Summary Report* (DOE 1998) states that any FRL exceedance detected at the property boundary during routine monitoring outside the 10-year uranium-based restoration footprint (DOE 1997a) would also be evaluated for persistence. The evaluation would be performed using the same conservative data evaluation method approved in the *Restoration Area Verification Sampling Program Project-Specific Plan* (DOE 1997b) to determine if a change in the aquifer restoration remedy is required. This evaluation was expanded beginning with the *2000 Site Environmental Report* (DOE 2001b) to include all non-uranium FRL exceedances detected outside of the 10-year uranium-based restoration footprint, not just those detected at the property boundary. In the *2003 Site Environmental Report* (DOE 2004b), the 10-year uranium-based restoration footprint was replaced with a 10-year time-of-travel remediation footprint based on 2003 target pumping rates and using the VAM 3D Zoom Groundwater Model. The footprint was updated in 2005 to reflect capture during the time period modeled for the Waste Storage Area (Phase II) remediation design. The footprint is shown in Figure A.4–1.

Analytical data from samples collected immediately following an FRL exceedance are evaluated to determine if the exceedance is persistent. In accordance with the approved Restoration Area

Verification Sampling method, if two or more consecutive sampling events following an FRL exceedance indicate that the concentration has decreased below the groundwater FRL, then the exceedance is not considered persistent. If an FRL exceedance outside the Waste Storage Area (Phase II) design remediation footprint is determined to not be persistent, then no additional action is required beyond the routine groundwater monitoring specified in the current IEMP. If an FRL exceedance is determined to be persistent, then the cause of the persistent exceedance will be identified and its effect on the aquifer remedy design assessed. Ultimately, the cause needs to be addressed either through a modification of the aquifer remedy or by other means.

A.4.2.2 Evaluation and Discussion

Ten possible persistent FRL exceedances were identified in 2010 requiring additional data to be collected through routine monitoring in 2011. The exceedances were for antimony in wells 22198 and 2636, arsenic in well 2636, lead in well 22198, manganese in wells 22201, and 22205, and zinc in monitoring wells 2625, 2636, 22198, and 22204. The non-uranium FRL exceedances for 2011 along with the possible persistent exceedances identified in 2010 are addressed below.

Figure A.4–1 and the shaded portion of Table A.4–1 identify the 2011 non-uranium FRL exceedances outside the Waste Storage Area (Phase II) design remediation footprint. In 2011, four constituents had one or more FRL exceedance at 9 wells located outside the Waste Storage Area (Phase II) design remediation footprint:

- Antimony at monitoring well 2636.
- Lead at monitoring well 2625.
- Manganese at monitoring wells 22201, 22204, 22212, 22214, 22215, and 22217.
- Zinc at monitoring wells 2625 and 22200.

Table A.4–3 addresses possible persistent FRL exceedances that occur outside the Waste Storage Area (Phase II) design remediation footprint. It includes the exceedances for 2011 listed in the bullets above, as well as those still being evaluated or deemed persistent from 2010. If the results of two or more sampling events immediately following an FRL exceedance indicate that the concentration decreased below the FRL, then the exceedance is identified as not persistent in Table A.4–3. As shown in Table A.4–3, an FRL exceedance for manganese was identified as being persistent in 2011 at monitoring well 22204. The manganese exceedance at monitoring well 22204 has been identified since 2004. The persistent exceedance identified in 2010 at monitoring well 22217 did not have an exceedance in the first half of 2011.

The following is a summary of results presented in Table A.4–3:

- The FRL exceedance recorded for antimony at monitoring well 22198 in 2010 is not persistent. Additional data, to be collected through routine monitoring in 2012, are necessary to determine the persistence of the antimony exceedance at monitoring well 2636.
- The FRL exceedance recorded for arsenic at monitoring well 2636 in 2010 is not persistent.
- The FRL exceedance recorded for lead at monitoring well 22198 in 2010 is not persistent. Additional data, to be collected through routine monitoring in 2012, are necessary to determine the persistence of the lead exceedance at monitoring well 2625.

- The FRL exceedance recorded for manganese at monitoring well 22204 in 2011 is persistent (Figure A.4–7).
- The FRL exceedance recorded for manganese at monitoring well 22205 in 2010 is not persistent. Additional data, to be collected through routine monitoring in 2012, are necessary to determine the persistence of the manganese exceedances at monitoring wells 22201, 22212, 22214, 22215, and 22217.
- The FRL exceedances recorded for zinc in monitoring wells 2636, 22198, and 22204 in 2010 are not persistent. Additional data, to be collected through routine monitoring in 2012, are necessary to determine the persistence of the zinc exceedances at monitoring well 2625 and 22200.

Figures A.4–2 through A.4–11 present individual graphs of time versus concentration for the wells listed on Table A.4–3 that are identified persistent or requiring additional data. Quarterly sampling results from OSDF monitoring activities are included in the evaluation of property boundary wells. Therefore, some wells were sampled more than semi-annually as reflected in Table A.4–3 and Figures A.4–2 through A.4–11.

The evaluation for persistence of non-uranium FRL exceedances in wells located outside the Waste Storage Area (Phase II) design remediation footprint in 2011 marks 15 years that an evaluation has been conducted as part of the IEMP. In the past, many exceedances identified as persistent became nonpersistent in later years. To date, the only persistent exceedance outside the remediation footprint appears to be isolated to monitoring well 22204 (manganese).

Manganese was a process chemical used in the former production area. The manganese groundwater FRL is 0.900 milligram per liter (mg/L) and is based on background values in the aquifer. Additional manganese data were collected from the GMA near the OSDF in 2008. Results were reported in the Fernald Preserve Site Environmental Report for 2008 (DOE 2009b). The purpose for collecting the additional data was to determine if manganese exceedances in the GMA near the OSDF indicate the presence of a localized plume. The additional data collected in 2008 indicated that the manganese exceedances were likely a background issue. Unconsolidated glacial fluvial aquifers in Ohio have relatively high manganese concentrations. Manganese is an impurity in shale, which is a major component of bedrock in the area. The background value upon which the groundwater FRL is based may not be representative of actual natural aquifer conditions. In past reports, biofouling has also been discussed as a possibility for the persistent manganese exceedance that was only seen at one monitoring well.

At this time, no change to the aquifer remedy is planned to address the persistent manganese exceedance at monitoring well 22204.

A.4.3 Conclusions

From the information provided in this attachment, the following conclusions can be made:

- Non-uranium FRL exceedances occurring in the former Waste Storage Area were taken into consideration for the Waste Storage Area (Phase II) Remediation Module Design.
- One persistent non-uranium FRL exceedance outside the Waste Storage Area (Phase II) design footprint was identified in 2011: manganese at monitoring well 22204. The exceedance is most likely a background definition issue. A change in the design of the aquifer remedy to address the exceedance is not being considered at this time.
- Additional data are needed to verify whether the antimony, arsenic, lead, manganese, and zinc exceedances detected in 2011 outside the Waste Storage Area (Phase II) design footprint (identified in Table A.4–3) are persistent.

Table A.4–1. Summary Statistics and Trend Analysis for Non-Uranium Constituents with 2011 Results Above FRLs

Constituent (FRL)[a]	Monitoring Well	No. of Samples[b,c,d]	No. of Samples Above FRL[b,c,d]	No. of Samples Above FRL for 2010[c,d]	Minimum[b,c,d,e,f]	Maximum[b,c,d,e,f]	Average[b,c,d,e,f]	Standard Deviation[b,c,d,e,f]	Trend[b,c,d,e,f,g]
					(mg/L)	(mg/L)	(mg/L)	(mg/L)	
Antimony (0.006 mg/L)	2636	8	5	1	0.0015	0.00741	0.00488	0.00269	No Significant Trend
Lead (0.015 mg/L)	2625	9	1	1	0.00015	0.0154	0.00361	0.00474	Up
Manganese (0.90 mg/L)	2010	20	16	2	0.525	6.14	2.24	1.77	No Significant Trend
	22201	13	6	2	0.0322	2.06	0.93	0.74	No Significant Trend
	22204	29	24	4	0.418	3.01	1.32	0.51	No Significant Trend
	22212	11	1	1	0.219	1.23	0.43	0.30	No Significant Trend
	22214	25	1	1	0.244	0.972	0.42	0.17	No Significant Trend
	22215	11	2	2	0.240	1.94	0.56	0.59	Up
	22217	11	5	1	0.537	1.57	0.98	0.35	No Significant Trend
	3821	24	19	2	0.145	11.4	2.66	2.49	No Significant Trend
	83339_C3	10	2	1	0.00289	1.29	0.41	0.48	No Significant Trend
	83341_C2	10	3	1	0.127	2.16	0.65	0.71	Down
Molybdenum (0.10 mg/L)	2649	22	22	2	0.178	0.794	0.47	0.16	No Significant Trend
Nitrate + Nitrite as N (11 mg/L)[h]	2649	30	24	1	0.805	102	43.4	28.2	No Significant Trend
	2821	32	15	2	1.38	120	26.7	32.6	Up
	3821	32	9	2	0.010	171	20.1	39.8	Up
	83338_C1	8	3	2	0.404	73.8	22.7	29.0	Up
	83338_C2	11	5	1	1.98	109	28.1	33.0	Up
	83338_C3	11	7	2	2.42	105	34.8	34.3	No Significant Trend
	83340_C1	7	7	2	11.3	58.2	36.3	17.1	Down
	83340_C2	10	10	2	12.5	86.7	51.8	29.2	No Significant Trend
	83340_C3	10	10	2	11.6	133	61.7	42.9	Down

Table A.4–1 (continued). Summary Statistics and Trend Analysis for Non-Uranium Constituents with 2011 Results Above FRLs

Constituent (FRL)[a]	Monitoring Well	No. of Samples[b,c,d]	No. of Samples Above FRL[b,c,d]	No. of Samples Above FRL for 2010[c,d]	Minimum[b,c,d,e,f]	Maximum[b,c,d,e,f]	Average[b,c,d,e,f]	Standard Deviation[b,c,d,e,f]	Trend[b,c,d,e,f,g]
Zinc (0.021 mg/L)					(mg/L)	(mg/L)	(mg/L)	(mg/L)	
	22200	11	2	1	0.00165	0.0377	0.016	0.011	No Significant Trend
	2625	8	4	2	0.00325	0.0751	0.024	0.025	Up
Technetium-99					(pCi/L)	(pCi/L)	(pCi/L)	(pCi/L)	
(94 pCi/L)	2649	30	30	2	101	1660	654	463	No Significant Trend
	2821	32	19	1	0.253	651	163	166	Up
	83338_C1	8	3	2	10.1	181	69	73	Up
	83338_C2	11	6	2	7.12	587	168	173	No Significant Trend
	83338_C3	11	6	1	0.059	313	130	115	Up
	83340_C1	7	7	2	186	817	349	223	No Significant Trend
	83340_C3	10	7	1	66.1	428	187	121	Down
					(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Trichloroethene	2649	22	17	2	0.125	120	42.9	34.7	Down
(5.0 µg/L)	2821	24	9	2	0.125	11.5	3.97	4.21	Up

Note: Shading indicates well is outside the Waste Storage Area (Phase-II) design remediation footprint.

[a]From *Record of Decision for Remedial Actions at Operable Unit 5* (DOE 1996), Table 9-4.
[b]Based on samples from August 1997 through 2011.
[c]If more than one sample is collected per well per day (e.g., duplicate), then only one sample is counted for the total number of samples, and the sample with the maximum representative concentration is used for determining the summary statistics (minimum, maximum, average, and standard deviation) and Mann-Kendall test for trend.
[d]Rejected data qualified with either an R were not included in the count, the summary statistics, or Mann-Kendall test for trend.
[e]If the number of samples is greater than or equal to four, then the Mann-Kendall test for trend and all of the summary statistics are reported. If the total number of samples is equal to three, then the minimum, maximum, and average are reported. If the total number of samples is equal to two, then the minimum and maximum are reported. If the total number of samples is equal to one, then the data point is reported as the minimum.
[f]For results where the concentrations are below the detection limit, the results used in the summary statistics and Mann-Kendall test for trend are each set at half the detection limit.
[g]Mann-Kendall test for trend is performed using data from third quarter 1998 through 2011.
[h]FRL based upon nitrate from *Record of Decision for Remedial Actions at Operable Unit 5* (DOE 1996), Table 9–4.

Table A.4-2. Groundwater FRL Exceedances From 1997 Through 2011 Quarterly/Semiannually

Constituent	Well[a]	Aquifer Zone	Project[b]	1997	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011	
				2[c]	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Antimony																																
	22198	0	OSDF																									1	1			
	22199	0	OSDF																									1				
	22204	0	OSDF																									1				
	22205	0	OSDF																									1				
	22208	0	OSDF													1												1				
	2398	2	P/PB																				1									
	2431	0	P/PB													1												1				
	2432	0	P/PB																				1					1				
	2636	4	PRRS														1		1				1						1			1
	2733	0	P/PB																				1									
	3070	2	P/PB																				1					1				
	31217	0	P/PB																									1				
	3398	2	P/PB																				1									
	3424	0	P/PB																				1					1				
	3426	0	P/PB																				1									
	3431	0	P/PB																									1				
	3432	0	P/PB																				1					1				
	4398	2	P/PB																				1					1				
Arsenic																																
	2625	4	PRRS						1																							
	2636	4	PRRS	1	1		2						1				1												1			
	2898	4	PRRS						1																							
	2900	4	PRRS						1																							
Boron																																
	2045	2	SF				1	1	1																							
	2049	2	SF	2		2	2	2	2	1				1																		
Carbon disulfide																																
	2649	1	WSA			1																										
	3821	1	WSA					1										1														
Fluoride																																
	2431	0	P/PB			1																										

Table A.4-2 (continued). Groundwater FRL Exceedances From 1997 Through 2011 Quarterly/Semiannually

Constituent	Well[a]	Aquifer Zone	Project[b]	1997	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011	
				2[c]	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Lead																																
	22198	0	P/PB																										1			
	2431	0	PRRS						1																							
	3733	0	P/PB	1						1																						1
Manganese																																
	2010	1	WSA							1		1			1	1	1	1		1	1	1	1	1	1	1		1				
	22198	0	OSDF											1																	1	1
	22201	0	OSDF																										1	1		
	22204	0	OSDF												1			1	1	1	1	1	1	1	1	1	1	1	2	2	2	
	22205	0	OSDF																	1										1	2	2
	22217	3	OSDF																								1		1	2		
	2431	0	P/PB		2																											1
	2432	0	P/PB							1		2	1		1																	1
	2648	1	WSA	1		1		1	1		1		1					1	1		1										1	1
	2898	4	PRRS										1				1															1
	2899	4	PRRS							1																						
	2900	4	PRRS							1																						
	3093	4	P/PB																													
	3821	1	WSA					1	1		1		1		1	1	1			1	1		1	1	1	1	1	1	1	1		
	83337_C1	1	WSA																						1	1						
	83337_C2	1	WSA																							1						
	83337_C3	1	WSA																							1		1				
	83338_C2	1	WSA																				1		1		1				1	1
	83339_C1	1	WSA																				1		1	1						
	83339_C2	1	WSA																								1					
	83339_C3	1	WSA																						1							
	83341_C1	1	WSA																				1		1	1						
	83341_C2	1	WSA																				1	1								
	83346_C1	1	WSA																				1		1	1	1					
	83346_C2	1	WSA																				1	1		1	1					
Molybdenum																																
	2649	1	WSA	1		1		1	1		1		1		1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1

Table A.4–2 (continued). Groundwater FRL Exceedances From 1997 Through 2011 Quarterly/Semiannually

Constituent	Well[a]	Aquifer Zone	Project[b]	1997	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011	
				2[c]	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Nickel																																
	22198	0	OSDF					1																								
	2398	2	P/PB	1	2	2		2																								
	4398	2	P/PB				1		1																							
	83346_C1	1	WSA																						1							
	83346_C2	1	WSA																						1		1					
Nitrate/Nitrite																																
	2648	1	WSA		1			1	1		1					1	1	1			1											
	2649	1	WSA	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1		1	1		1		1	1					1	
	2821	1	WSA					1							1				1		1	1	1	1	1	1	1	1	1	1	1	1
	3821	1	WSA							1		1								1				1			1	1	1	1	1	1
	83338_C1	1	WSA																										1		1	1
	83338_C2	1	WSA																					1				1	1	1	1	
	83338_C3	1	WSA																					1			1	1	1	1	1	1
	83340_C1	1	WSA																				1		1	1	1		1		1	1
	83340_C2	1	WSA																				1	1	1	1	1	1	1	1	1	1
	83340_C3	1	WSA																				1	1	1	1	1	1	1	1	1	1
	83341_C1	1	WSA																				1									
	83341_C2	1	WSA																						1							
	83341_C3	1	WSA																				1		1							
Technetium-99																																
	2648	1	WSA					1			2				1																	
	2649	1	WSA	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1
	2821	1	WSA					1						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	83338_C1	1	WSA																										1		1	1
	83338_C2	1	WSA																					1				1	1	1	1	1
	83338_C3	1	WSA																					1			1	1	1	1	1	
	83340_C1	1	WSA																				1		1	1	1		1		1	1
	83340_C2	1	WSA																				1	1	1	1	1	1				
	83340_C3	1	WSA																				1	1	1	1	1	1				1
Trichloroethene																																
	2649	1	WSA			1		1	1		1		1		1	1	1	1	1	1	1		1			1	1				1	1
	2821	1	WSA																				1	1		1	1	1	1	1	1	1

Table A.4-2 (continued). Groundwater FRL Exceedances From 1997 Through 2011 Quarterly/Semiannually

Constituent	Well[a]	Aquifer Zone	Project[b]	1997	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011	
				2[c]	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Zinc																																
	22198	0	OSDF																										1			
	22199	0	OSDF												1																	
	22200	0	OSDF																										1		1	
	22204	0	OSDF												1										1				1			
	22210	0	OSDF																1		1						1					
	22213	3	OSDF																											1		
	2398	2	P/PB		1																											
	2431	0	P/PB			2			1																							
	2432	0	P/PB				1		1	1																						
	2625	0	PRRS																						1	1					1	1
	2636	0	PRRS																						1	1						
	2733	0	P/PB				1																									
	2900	4	PRRS							1							1							1								
	3128	4	PRRS																1													
	3426	0	P/PB				1	1																								
	3429	0	P/PB				2																									
	3431	0	P/PB										1																			
	3733	0	P/PB												1																	
	3899	4	PRRS								1																					

Note: Shading indicates well is outside the Waste Storage Area (Phase-II) design remediation footprint.

[a] From 1997 through 2002, all monitoring was quarterly. Where a "2" is indicated there was a FRL exceedance in each quarter of the semiannual time period. As of 2003, all monitoring is semiannual except as of 2009 OSDF monitoring is quarterly.

[b] WSA = Waste Storage Area

SF = South Field

P/PB = Property/Plume Boundary for FRL exceedances

PRRS = Property/Plume Boundary for Paddys Run Road Site

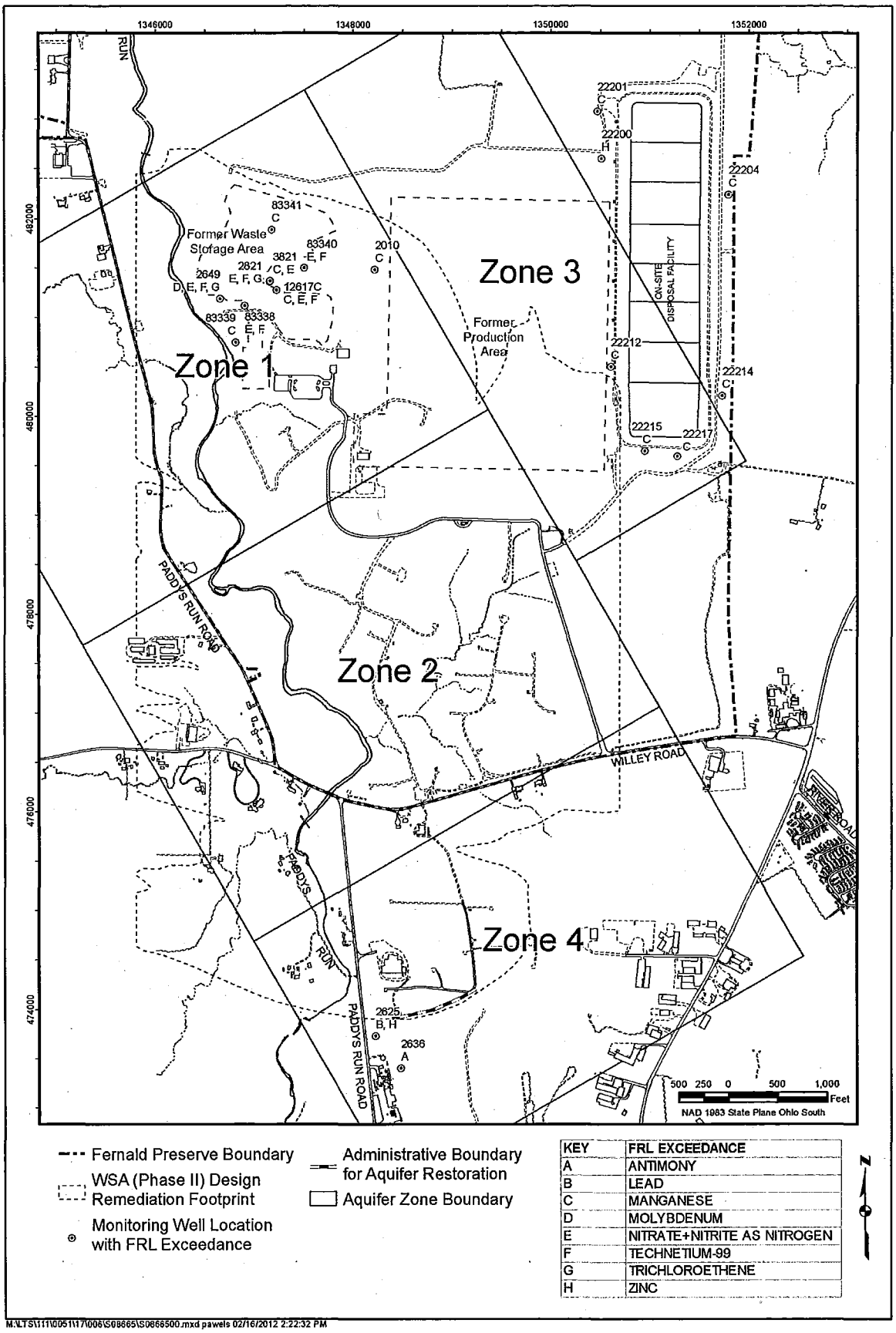
OSDF = Property/Plume Boundary for on-site disposal facility

[c] Sampling for the IEMP was initiated in August 1997.

Table A.4–3. Summary of Persistence Evaluation of Non-Uranium FRL Exceedances Outside the Waste Storage Area (Phase-II) Design Remediation Footprint

Constituent	Monitoring Well	Pertinent 2010 Results[a]	2011 FRL Exceedance		Evaluation Results for 2011	Figure Number[a]
			1st Half of 2011	2nd Half of 2011		
Antimony	22198	Additional Routine Data Required	No	No	Not Persistent	NA
	2636	Additional Routine Data Required	No	Yes	Additional Routine Data Required	A.4–2
Arsenic	2636	Additional Routine Data Required	No	No	Not Persistent	NA
Lead	22198	Additional Routine Data Required	No	No	Not Persistent	NA
	2625	NA	No	Yes	Additional Routine Data Required	A.4-3
Manganese	22201	Additional Routine Data Required	Yes	No	Additional Routine Data Required	A.4–4
	22204	**Persistent**	Yes	Yes	**Persistent**	A.4–5
	22205	Additional Routine Data Required	No	No	Not Persistent	NA
	22217	**Persistent**	No	Yes	Additional Routine Data Required	A.4–6
	22212	NA	No	Yes	Additional Routine Data Required	A.4–7
	22214	NA	No	Yes	Additional Routine Data Required	A.4–8
	22215	NA	Yes	Yes	Additional Routine Data Required	A.4–9
Zinc	2625	Additional Routine Data Required	Yes	Yes	Additional Routine Data Required	A.4–10
	2636	Additional Routine Data Required	No	No	Not Persistent	NA
	22198	Additional Routine Data Required	No	No	Not Persistent	NA
	22200	Not Persistent	Yes	No	Additional Routine Data Required	A.4–11
	22204	Additional Routine Data Required	No	No	Not Persistent	NA

[a] NA = not applicable



KEY	FRL EXCEEDANCE
A	ANTIMONY
B	LEAD
C	MANGANESE
D	MOLYBDENUM
E	NITRATE+NITRITE AS NITROGEN
F	TECHNETIUM-99
G	TRICHLOROETHENE
H	ZINC

Figure A.4-1. Non-Uranium Constituents with 2011 Results Above FRLs

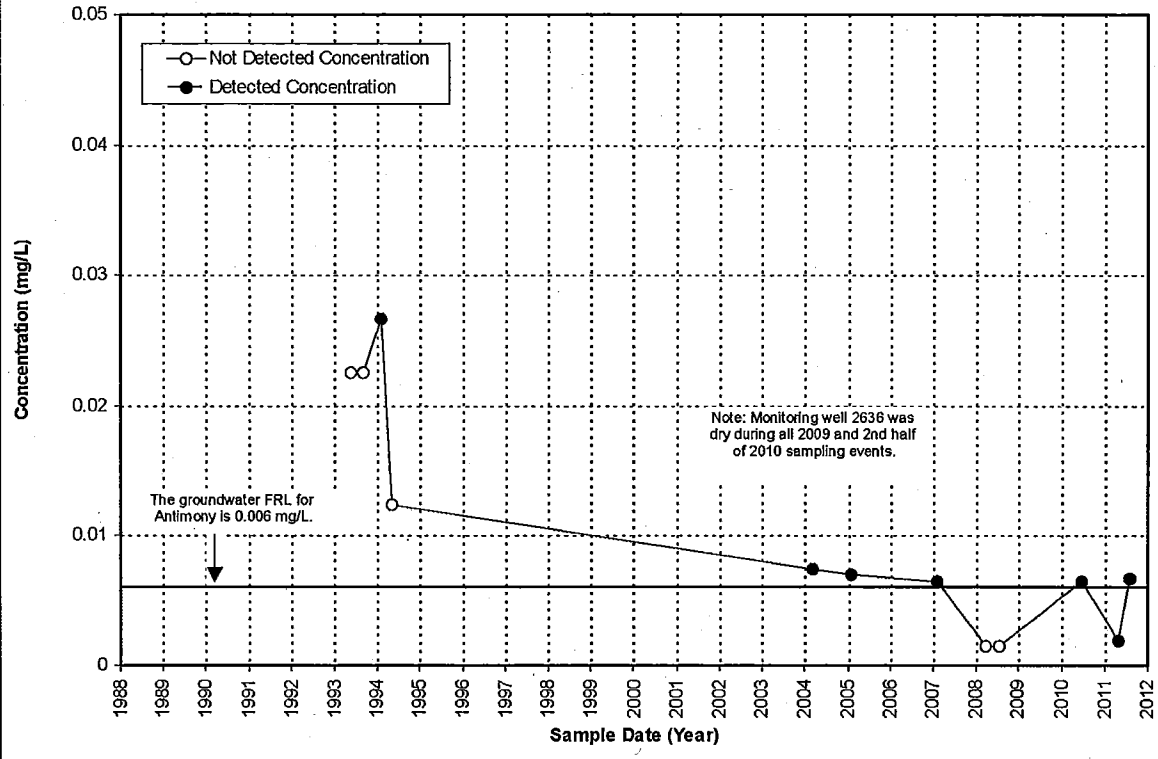


Figure A.4-2. Antimony Concentration vs. Time Plot for Monitoring Well 2636

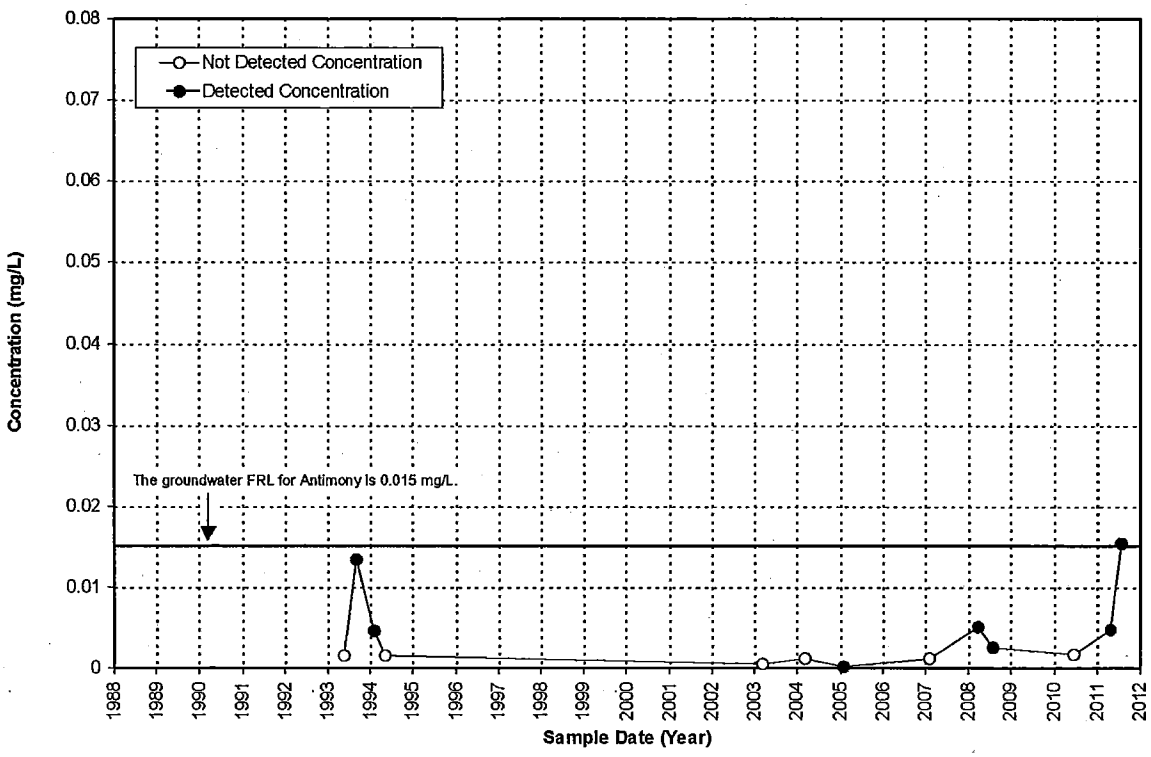


Figure A.4-3. Lead Concentration vs. Time Plot for Monitoring Well 2625

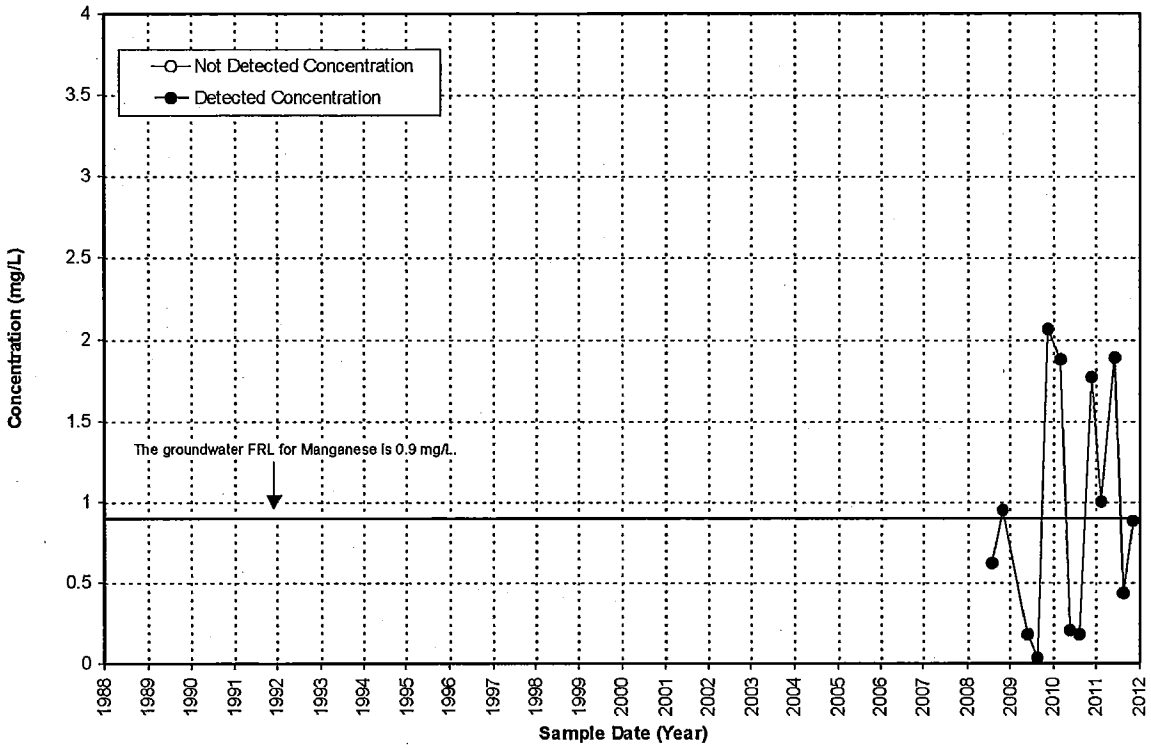


Figure A.4-4. Manganese Concentration vs. Time Plot for Monitoring Well 22201

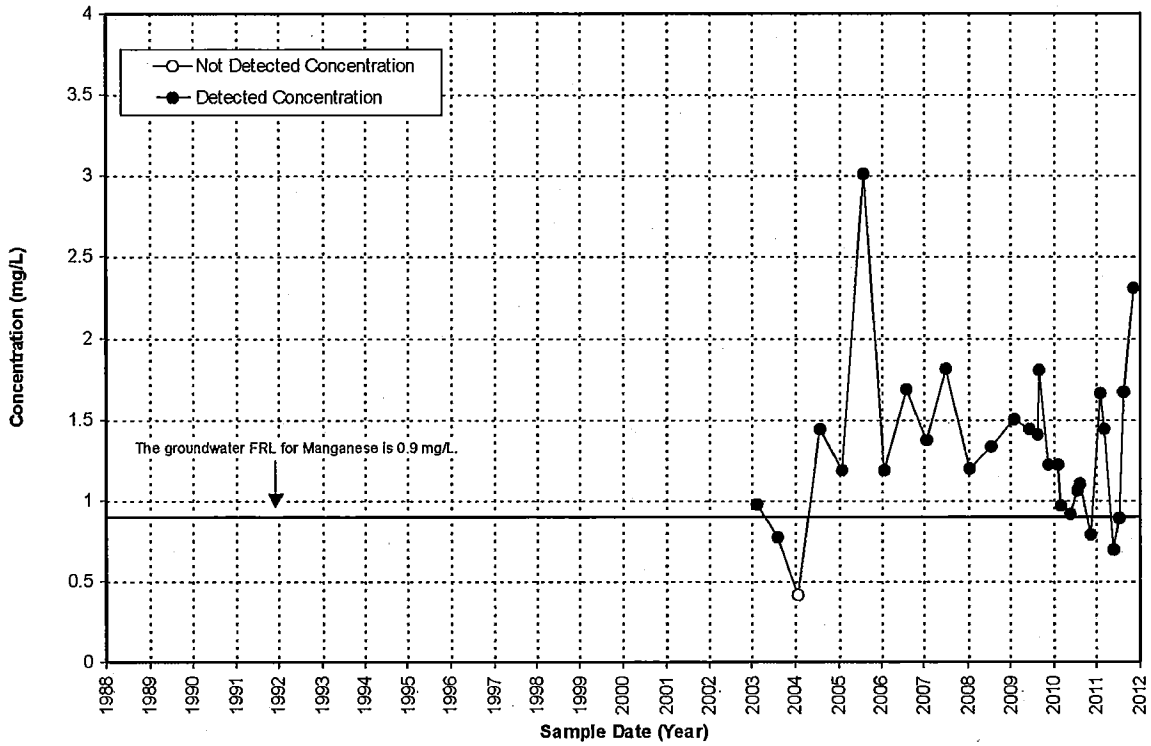


Figure A.4-5. Manganese Concentration vs. Time Plot for Monitoring Well 22204

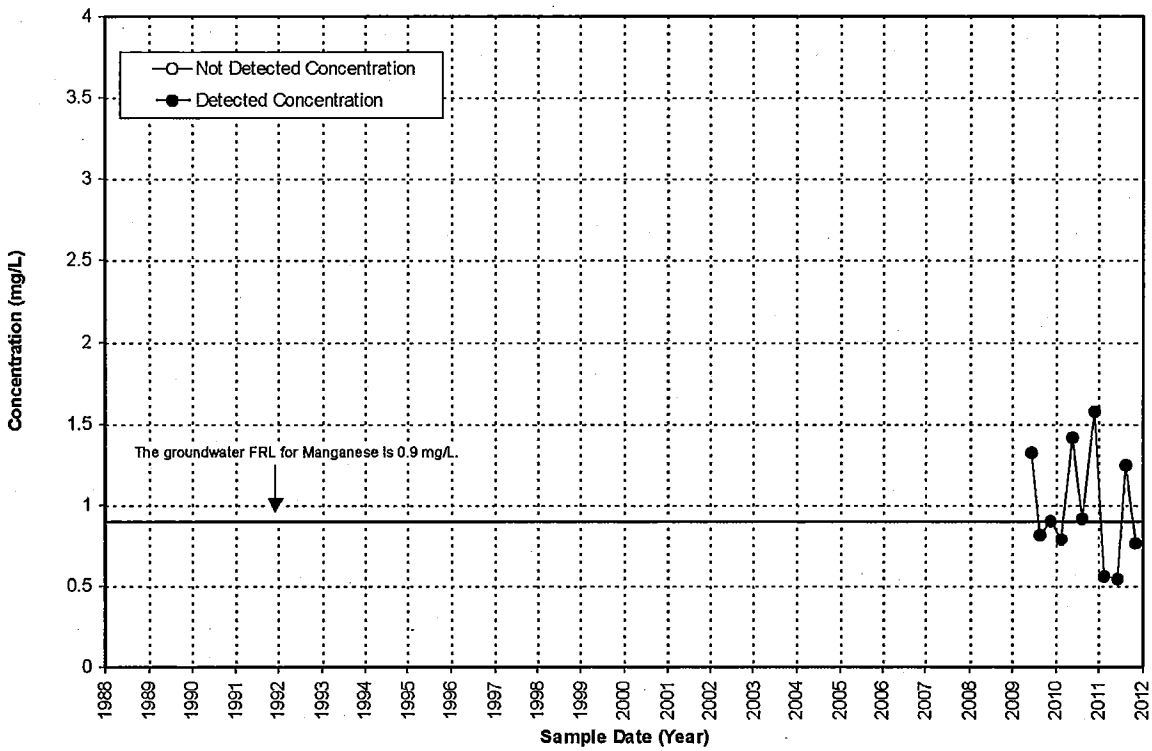


Figure A.4-6. Manganese Concentration vs. Time Plot for Monitoring Well 22217

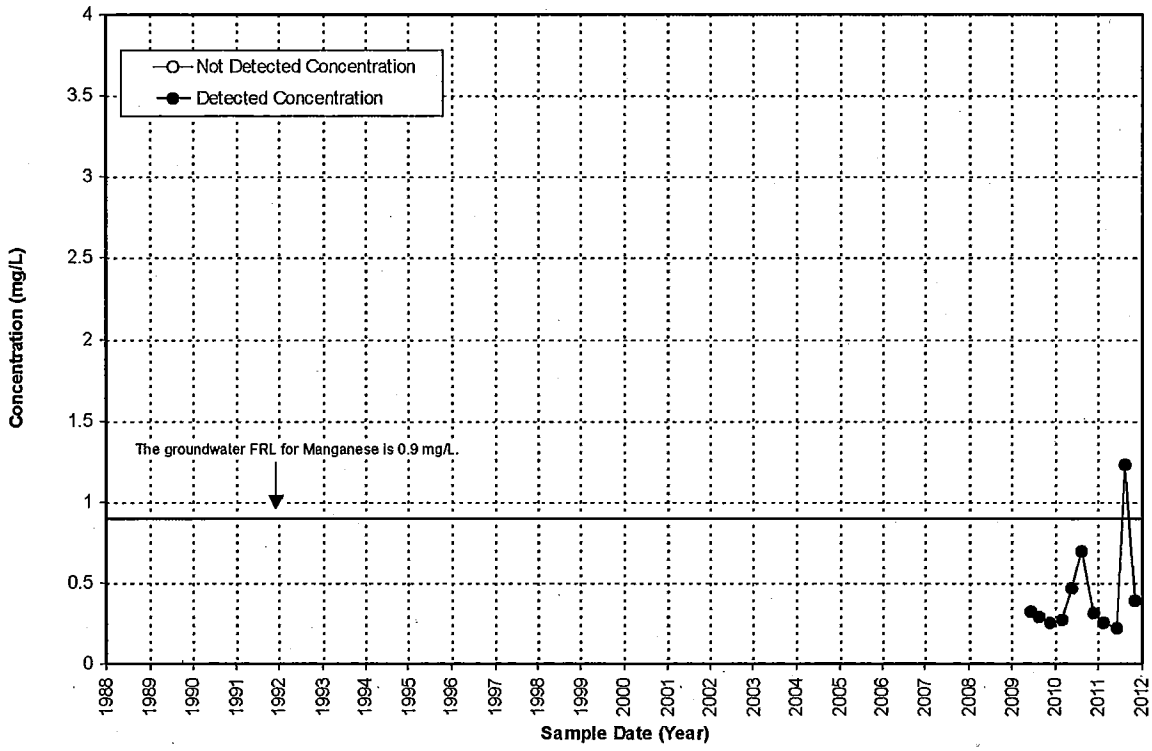


Figure A.4-7. Manganese Concentration vs. Time Plot for Monitoring Well 22212

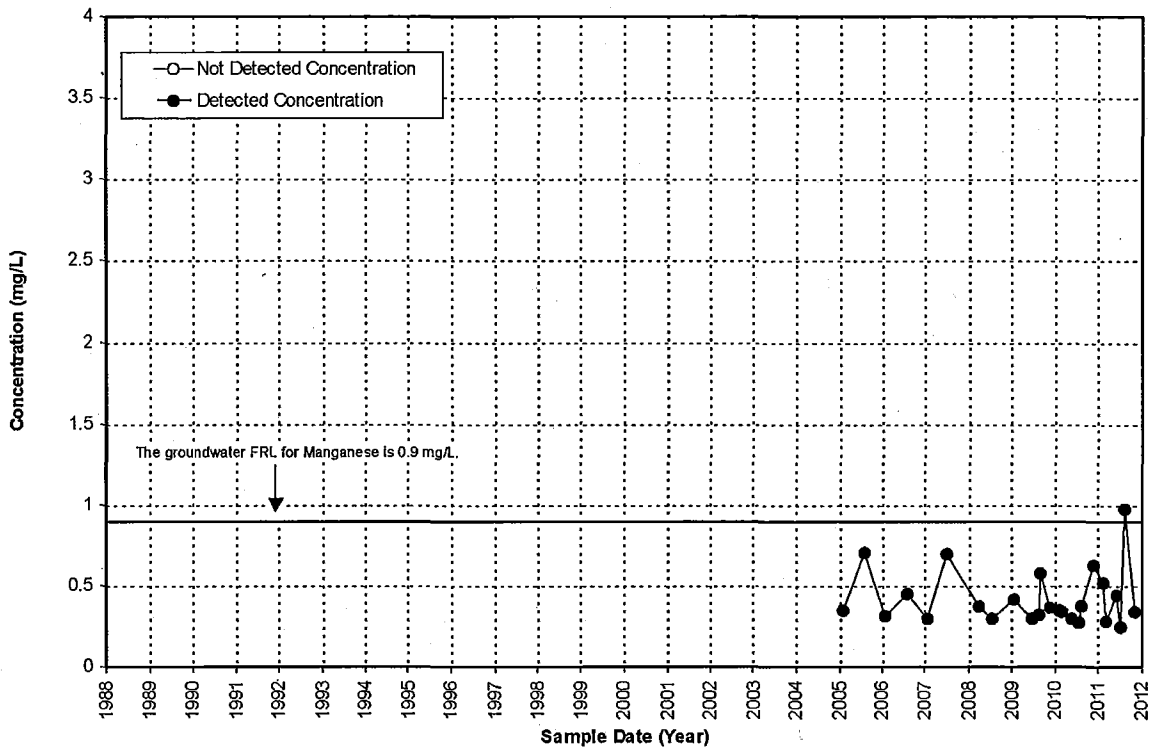


Figure A.4-8. Manganese Concentration vs. Time Plot for Monitoring Well 22214

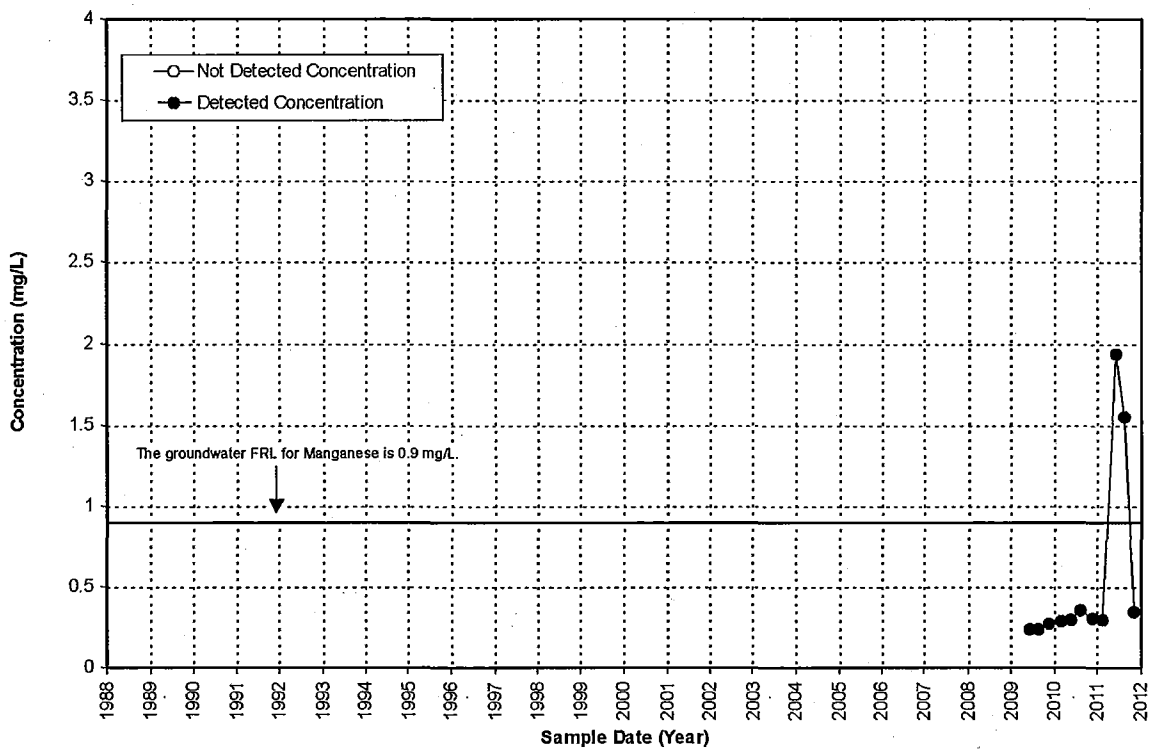


Figure A.4-9. Manganese Concentration vs. Time Plot for Monitoring Well 22215

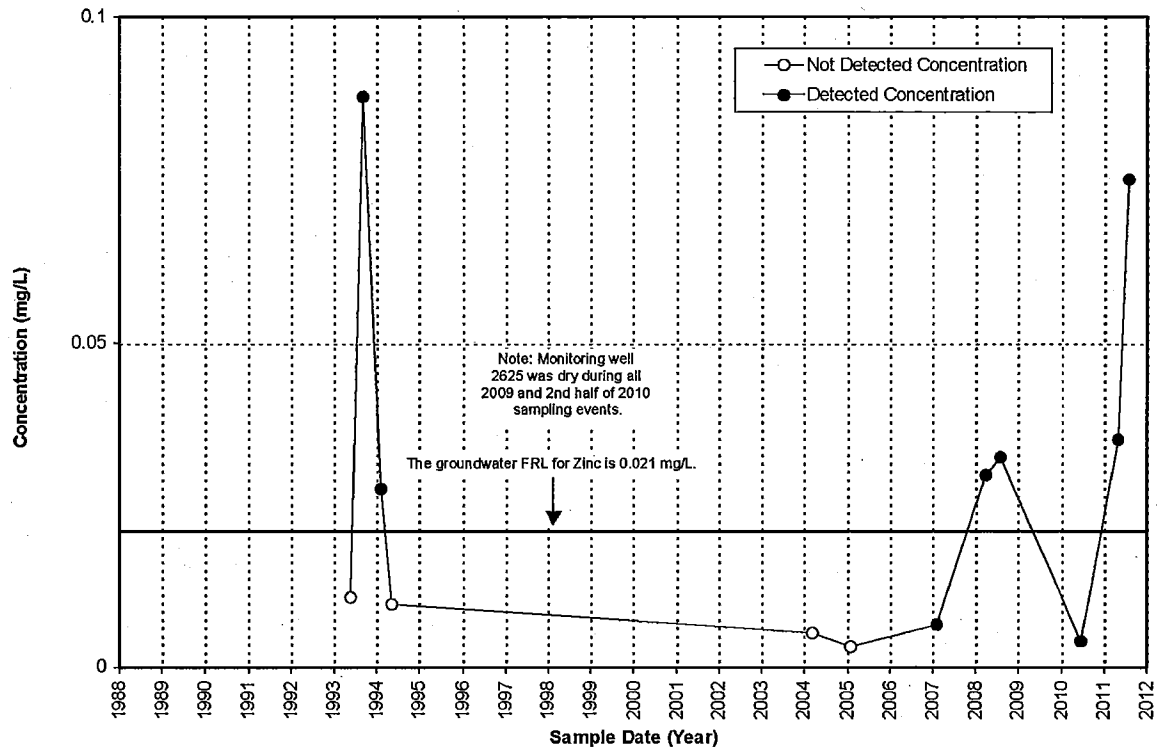


Figure A.4-10. Zinc Concentration vs. Time Plot for Monitoring Well 2625

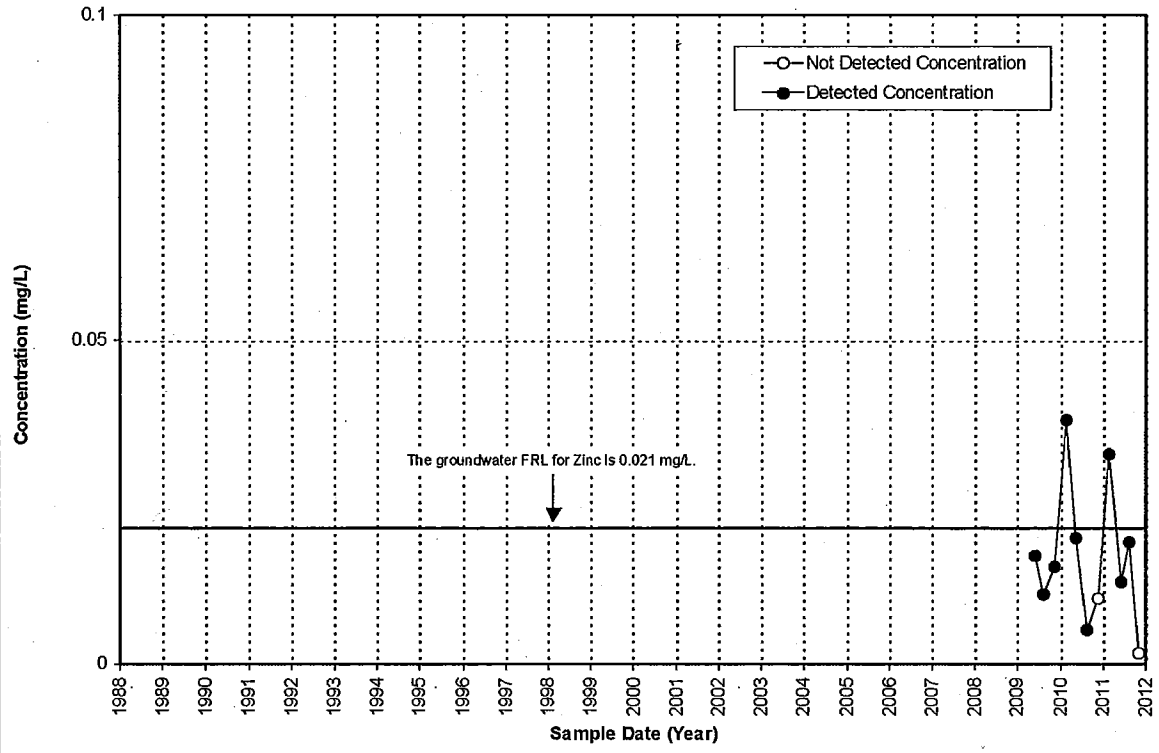


Figure A.4-11. Zinc Concentration vs. Time Plot for Monitoring Well 22200

Attachment A.5

Attachment A.5

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A.5.0 On-Site Disposal Facility Monitoring Results

This attachment provides results for the on-site disposal facility (OSDF) leak detection and leachate monitoring program for 2011. Monitoring and sampling were conducted in accordance with the *Comprehensive Legacy Management and Institutional Controls Plan* (LMICP), Attachment C "Groundwater/Leak Detection and Leachate Monitoring Plan" (GWLMP) (DOE 2010a). The objective of the GWLMP is to meet regulatory requirements for groundwater detection monitoring in the Great Miami Aquifer (GMA) and perched groundwater system and to provide leachate monitoring information.

Facility Description

The OSDF is situated in the northeast area of the Fernald Preserve. It has a capacity of 2.96 million cubic yards (yd^3) (2.26 million cubic meters [m^3]), a maximum height of approximately 65 feet (ft) (20 meters [m]), and covers an area of approximately 75 acres (30 hectares). The facility consists of eight individual cells. All eight cells were 100 percent full and capped by October 2006.

Protection of the GMA and the overlying perched groundwater system includes the following measures for each of the eight cells (refer to Figure A.5–1 for a cross section of the liner system):

- Leachate collection system (LCS),
- Leak detection system (LDS),
- Multilayer composite liner system, and
- Multilayer composite cap system.

The LCS consists of a gravel layer installed beneath the waste to collect rainwater that came in contact with the waste during cell construction and additional moisture that is draining from the waste following capping. The LDS is located beneath both the LCS and the primary geosynthetic liner system and provides a mechanism for collecting and monitoring leakage through the primary liner layer of the OSDF prior to any releases to the environment. Both systems drain to the west and extend beyond the synthetic liner systems into valve houses, where leachate becomes accessible for monitoring.

The base of each cell liner also slopes toward the centerline of the cell, and the centerline of the base is sloped toward the west. Leachate moving along the top of a liner would first travel toward the centerline and then west along the centerline to be drained from the cell via piping at the penetration box, which is the lowest elevation point of the cell.

Each cell is monitored below the penetration box with a horizontal till well (HTW), which represents the first monitoring point for a release from a cell. HTWs provide monitoring of the perched groundwater quality beneath the point where the LCS and LDS pipes exit the liner system. The GMA is monitored via both an upgradient and a downgradient monitoring well for each cell. Figure A.5–2 identifies the well locations associated with the OSDF. Table A.5–1 identifies specific dates for the following cell activities:

- Sample initiation for each monitoring horizon,
- Waste placement initiation,
- LDS volume measurement initiation,
- Cap geomembrane layer completion, and
- Cap completion (through seeding).

A construction quality assurance/quality control program was executed for each cell of the OSDF. The synthetic liners and caps of each cell were inspected and tested for defects at the time of installation. Given the attention to quality assurance/quality control during the installation of the OSDF liner system, it is doubtful that a breach in the liner would have gone unnoticed, but it is possible that a breach could develop. Such a breach would provide a potential pathway for leachate migration, but adequate hydraulic head is needed to drive leachate through the breach and clay liner into the underlying horizon.

The GWLMP provides the facility performance assessment strategy for the OSDF and covers the following topics:

- Understanding how a cell can leak,
- Monitoring hydraulic head in the LDS and the action leakage rate,
- Water quality monitoring in the LCS, LDS, HTW, and GMA wells, and
- Residual soil contamination beneath the facility and its possible impact to HTW water quality results.

Information Organization

The 2011 OSDF leak detection and leachate monitoring information is organized in the following sections:

- Flow and Hydraulic Performance (Section A.5.1),
- Water Quality: Data Presentations and Evaluations (Section A.5.2),
- Cell Cap Inspections (Section A.5.3),
- Monitoring Changes (Section A.5.4), and
- Summary of Overall Performance/Findings and Recommendations (Section A.5.5).

Sub-attachments A.5.1 through A.5.8 provide cell-specific information for disposal cells 1 through 8.

A.5.1 Flow and Hydraulic Performance

A.5.1.1 Overall LCS Volumes

In 2011, leachate volumes pumped from the LCS tanks were measured by recording readings from capacitance probes installed in each primary containment vessel. The probes are attached through a remote control unit to the Converted Advanced Wastewater Treatment Facility (CAWWT) control room, where water levels are converted automatically to volumes based on the tank manufacturer's design specifications for the tanks.

Leachate volumes have been measured since waste placement began. Figure A.5–3 is a graph showing monthly leachate volumes from October 2006 through December 2011. The data collected in 2011 indicate that 161,682 gallons of leachate were collected and pumped to the CAWWT Backwash Basin for subsequent treatment at the CAWWT. The total volume measured in 2011 represents an 8 percent decrease from the total volume measured in 2010 (176,087 gallons). The volume of precipitation that fell on the OSDF in 2011 was approximately 88.5 million gallons (60.2 inches of rain over 54.1 acres). The facility cap inhibits rainwater from permeating the OSDF. Collected leachate in 2011 represents approximately 0.2 percent of the precipitation that fell on the OSDF in 2011, indicating that the cap is performing as designed to reduce infiltration.

The GWLMP identifies that trend analysis of the LCS flow-monitoring measurements will be conducted for capped cells to provide an indication of changes in system performance. Monthly accumulation volumes for Cells 1 through 8 are plotted and provided in Sub-attachments A.5.1 through A.5.8. The semi-log plots indicate that leachate volumes from the capped cells continue to decline over time, but the rate of decline is decreasing. In 2011 the overall monthly facility leachate flow declined by 821 gallons or approximately 5.5 percent (14,938 gallons for January 2011 versus 14,117 gallons for December 2011).

A.5.1.2 LDS Accumulation Rates and Volumes

Quantitative measurement of the volumes accumulating in and pumped from the LDS tanks was initiated according to the various dates in Table A.5–1. These measurements were taken using the same methodology as described above for the LCS. These data are used to determine both accumulation rates (in gallons per acre per day [gpad]) and accumulation volumes (in gallons) for each cell's LDS.

The GWLMP states that trend analysis of the LDS flow monitoring measurements will be conducted for capped cells to provide an indication of changes in system performance. Monthly accumulation volumes for Cells 1 through 8 are provided and graphically displayed in Sub-attachments A.5.1 through A.5.8. The graphs indicate that overall LDS flows are declining.

The *On-site Disposal Facility Final Design Calculation Package* (DOE 1997c) defines an initial response leakage rate for individual cells of 20 gpad. The 2011 maximum LDS accumulation rates and the percent of the initial response leakage rate for each cell are as follows:

Cell	LDS Maximum Accumulation Rate (gpad)	Initial Response Leakage Rate (percent)
1	0.01	0.0
2	0.14	0.7
3	0.00	0.0
4	0.11	0.5
5	0.11	0.5
6	0.28	1.4
7	0.04	0.2
8	0.38	1.9

These LDS accumulation rates indicate that the liner systems for the cells are performing well within the specifications outlined in the approved OSDF design. The initial response leakage rate of 20 gpad is a design criterion for commencing an investigation into the possibility that the cell is not performing as designed. Because all of the cells are closed and capped, it is expected that LDS accumulation rates will continue to diminish over time. Rates will continue to be closely tracked to document if the primary liner systems continue to perform as designed.

A.5.1.3 Liner Efficiencies

Cell-specific apparent liner hydraulic efficiencies are calculated using the following equation:

$$\text{Hydraulic efficiency} = [1-(\text{Volume}_{LDS}/\text{Volume}_{LCS})] \times 100$$

Apparent liner hydraulic efficiency is a measure of how a cell's liner is performing. The above equation considers *all* the LDS volume to be leakage through the primary liner, which is a conservative measure. In the *Report on the 1995 Workshop on Geosynthetic Clay Liners* (EPA 1996), several sources of flow from leak detection layers are identified. These sources include:

- Top liner leakage,
- Construction water and compression water,
- Consolidation water, and
- Water from groundwater infiltration.

Quarterly apparent liner efficiencies were consistently greater than 97 percent for Cells 1 through 8 throughout 2011. Quarterly apparent liner efficiencies (in percentages) are provided for Cells 1 through 8 below.

Apparent Liner Efficiency (percent), Quarterly for 2011

Quarter	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
First	99.96	100	100	99.81	99.20	99.40	99.78	99.58
Second	99.96	99.98	99.98	99.81	99.88	99.67	99.97	97.61
Third	99.98	97.48	100	99.39	99.77	98.23	99.85	99.91
Fourth	100	99.89	100	100	100	99.32	100	100

A.5.1.4 HTW Water Yields

HTW water yields are monitored at each cell to document trends in perched-water purge volumes. In 2011 the HTWs were purged four times (February, May, August, and November). Average purge water yields from the HTWs ranged from 0 gallons beneath Cell 8 to 1,056 gallons beneath Cell 5. The Cell 3 HTW water yield, which had been trending upward from 2001 through 2005, showed a sixth-year decline in average yield. The HTW water yields will continue to be tracked and factored into the OSDF leak detection evaluation, where appropriate. The water-yield graphs are provided in each cell's sub-attachment and are updated with purge volume data collected prior to each sampling event.

A.5.2 Water Quality: Data Presentations/Evaluations

The water quality and data presentations/evaluations presented in this report consist of the following:

- Quarterly monitoring summary statistics (Section A.5.2.1)
- Concentration plots (Section A.5.2.2)
  - — LCS, LDS, and HTW, of each cell
  - — HTW and GMA wells of each cell
- Control charts (Section A.5.2.3)
- Annual LCS monitoring results (Section A.5.2.4)
- Parameter selection process statistics/results for Cells 7 and 8 based on annual LCS samples (Section A.5.2.5)
- Bivariate plots for each cell (Section A.5.2.6)
- Summary of Increasing Concentration Trends in the HTW and GMA Downgradient Wells (Section A.5.2.7).

A.5.2.1 Quarterly Monitoring Summary Statistics

Summary statistics for the 23 parameters monitored quarterly in the LCS, LDS, HTW, and GMA wells of each cell in 2011 are provided in Sub-attachments A.5.1 to A.5.8 (Tables A.5.1–1 through A.5.8–1). The information provided in each summary table is based on a standardized quarterly sampling frequency.

The process used for conducting the summary statistics is illustrated in Figure A.5–4. Table A.5–2 lists the rules that are used to report the data provided on Tables A.5.1–1 to A.5.8–1. For results where the concentrations are below the detection limit, the results used in the average, standard deviation, distribution, trend, serial correlation, and outliers are each set at half the detection limit. One objective of conducting the summary statistics is to identify the parameters that meet the requirements for control charts (i.e., normal or lognormal distribution, no trend, and no serial correlation).

Data used in the summary statistics were "quarterized" (i.e., normalized to quarterly data). The rationale behind this is that during different time periods, data were collected at varying time

intervals. For example, from October 30, 1997 through December 8, 1997 there were 15 uranium measurements taken at HTW 12338. In all of 1998 only 4 were taken, in 1999 there were 7, in 2000 there were 6, and 4 each were taken in 2001 through 2003. So, in a 5 to 6 week period in 1997, nearly as much data were collected as were collected from 1998 to 2000.Without normalizing the data, the time periods with more sampling activity would carry more weight, and, therefore, with respect to the calculations, be considered more important. Additionally, sampling the same well at too short of an interval (often just one day apart in 1997) also violated the statistical assumption of independence. Well data that are collected too closely in time are serially correlated and can distort the statistics underlying the control charts. Even with quarterly sampling, there is often an issue with serial correlation.

ChemStat®, Version 6.3, (a Starpoint Software Program) was used to conduct the statistics. ChemStat® is software used to perform the statistical analysis of groundwater monitoring data at Resource Conservation Recovery Act (RCRA) facilities. The website for the software is www.pointstar.com.

Data set distributions were checked using the Shapiro Wilks Test (95 percent confidence interval) for data sets with less than 50 samples, and the Shapiro-Francia Test (95 percent confidence interval) for data sets with 50 samples or more. The Mann-Kendall test for trend (95 percent confidence interval) was used to determine the presence of either an upward or downward concentration trend over time. The rank Von Neumann test (confidence interval of 99 percent) was used to check for serial correlation.

A.5.2.2 Concentration Plots

Concentration plots for the 23 parameters monitored quarterly in the LCS, LDS, and HTW of each cell in 2011 are presented in Sub-attachments A.5.1 to A.5.8. The plots are presented with a common *y*-scale based on the parameter.

Concentration plots are also presented in Sub-attachments A.5.1 to A.5.8 for the 23 parameters monitored quarterly in the HTW and GMA wells of each cell in 2011. The plots are also constructed with a common *y*-scale based on the parameter.

A.5.2.3 Control Charts

Intrawell control charts employ historical measurements from a compliance point as background. The *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance* (EPA 2009) defines the process of creating a Shewart-cumulative sum (CUSUM) control chart works as follows. Appropriate background data are used to define a baseline for the well. The baseline parameters for the chart, estimates of the mean, and standard deviation are obtained from the background data. These baseline measurements characterize the expected background concentrations at the monitoring point. As future concentrations are collected the baseline parameters are used to standardize the newly gathered data. After these measurements are standardized and plotted, a control chart is declared "out of control" if future concentrations exceed the baseline control limit. This is indicated on the control chart when either the Shewart or CUSUM plot traces begin to exceed a control limit. The limit is based on the rationale that if the monitoring point remains unchanged from the baseline condition, new standardized observations should not deviate substantially from the baseline mean. If a change occurs, the

standardized values will deviate significantly from the baseline and tend to exceed the control limit.

A minimum of eight samples are recommended for use in ChemStat® software to define the baseline for a control chart. Therefore, only sample sets with greater than 8 samples were selected for control charts. By default, the ChemStat® software plots both a CUSUM control limit (h) and a Shewart control limit (SCL) on the control chart. The software recommends a value of 5 for the CUSUM control limit (h) and a value of 4.5 for the SCL control limit (SCL).

EPA Unified Guidance suggests that to simplify the interpretation of the control chart that an out of control condition be based on the CUSUM (h) limit alone. Plotting the SCL limit is not needed. The ChemStat® software though, by default, plots both the SCL and CUSUM control limits on the charts. As a "work-a-round", the SCL limit was defined as 5 to match the recommended CUSUM limit. On the charts the combined limit is identified as hCL. For interpretation purposes, regard hCL as the CUSUM limit (h).

One hundred and forty Shewart-CUSUM control charts are presented in Sub-attachments A.5.1 through A.5.8 for parameters monitored quarterly in the HTW and GMA wells in 2011 and had data sets that achieved control chart criteria (i.e., more than eight samples, normal or lognormal distribution, no trend, and no serial correlation). Last year, only 59 data sets met the control chart criteria listed above.

Of the 140 control charts presented, 129 (92 percent) exhibit "in control" conditions, and 11 (8 percent) exhibit "out of control" conditions.

A.5.2.4 Annual LCS Monitoring Results

Once a year, the LCS of each cell is sampled for Appendix I parameters and polychlorinated biphenols (PCBs) listed in Ohio Administrative Code (OAC) 3745-27-10. A summary of the results for each cell is provided in Sub-attachments A.5.1 thru A.5.8 (Tables A.5.1–2 thru A.5.8–2). As stated in Appendix B of the GWLMP (DOE 2010a) "two consecutive detects in a cell's LCS will trigger sampling in the cell's LDS during the next scheduled sampling round." Highlights of sampling results from 2011 are provided below.

- No new parameters were detected in the LCS of Cells 1 thru 7.
- Cadmium was detected for the first time in the LCS of Cell 8. If cadmium is detected again in the LCS of Cell 8 in 2012, sampling in the LDS for cadmium will begin with the next subsequent scheduled sampling event.
- Lead was not detected in the LCS of Cell 4. In 2010, lead was detected for the first time in Cell 4.
- Chromium was detected for the second consecutive time in the LCS of Cell 6. Chromium will be added to the analyte list for the Cell 6 LDS in the next subsequent sampling round. Chromium was detected in the LCS of Cell 6 for the first time in 2010.
- The LDS of Cell 3 was dry in 2011 so ammonia was not sampled. Ammonia will be sampled in the LDS of Cell 3 the next time a sample can be collected. Ammonia was detected in the LCS of Cell 3 for the first time in 2009, and for the second consecutive time in 2010.

- 1,1-dichloroethene was not detected in the LDS of Cell 7. 1,1-dichloroethene was detected for the first time in the LCS of Cell 7 in 2009 and for the second consecutive time in 2010.
- 1,1-dichloroethene was not detected in the LDS of Cell 8. 1,1-dichloroethene was detected for the first time in the LCS of Cell 8 in 2009 and for the second consecutive time in 2010.

A.5.2.5 Parameter Selection for Cells 7 and 8 based on Annual LCS Samples

Parameter selection results reported herein, marks the completion of a parameter selection process that was established in consultation with the Ohio EPA in 2005 and 2006. The objective of the process was to identify the Appendix I and PCB parameters detected in the LCS that would provide the most promise for detecting a leak from the facility and therefore warrant more frequent and robust monitoring (i.e., quarterly monitoring). The process is presented in Figures A.5–5A and A.5–5B.

As shown in Figure A.5–5A, the parameter selection process involves data sets with a minimum of eight samples and 25 percent or more detects. As shown in Figure A.5–5B, statistical procedures were used to determine if the mean concentration of a cells LCS data set was statistically different from the mean concentration of either the pre-design or background data set. Specifically, the null hypothesis that was created for each test states that the mean concentration of the LCS data set was less than or equal to the mean of the pre-design or background data set. Therefore, failure of the null hypothesis for a specific test parameter indicates that the mean of the LCS data set is greater than the mean of the pre-design or background data set.

Selection of a statistical method is based on the percentage of detects within the data sets. More specifically:

- If there are greater than or equal to 85 percent detects, and both data sets have either a normal or lognormal distribution (based on a Shapiro-Wilks or Shapiro-Francia test): a parametric test method is used (i.e., *t*-test, with a 95 percent confidence interval).
- If there are greater than 85 percent detects, but both data sets do not have a normal or lognormal distribution (based on a Shapiro-Wilks or Shapiro-Francia test) a nonparametric test method is used (i.e., Wilcoxon Rank Sum Test and Quantile Test, 95 percent confidence interval).
- If there are less than 85 percent detects, a nonparametric test method is used (i.e., Tarone-Ware test, 95 percent confidence interval).

In regard to the first bullet, the Shapiro-Wilks procedure (95 percent confidence interval) was used to check the distribution of data sets. EPA recommends this as the preferred test for normality in data sets less than or equal to 50 measurements (EPA 1992b). The Shapiro-Francia method (95 percent confidence interval) was used to check data sets with more than 50 measurements. If the test failed using the original data set, data were transformed into the natural log and checked for a lognormal distribution.

In regard to the second bullet, the Wilcoxon Rank Sum Test is a nonparametric group comparison method for comparing compliance measurements to background. It follows U.S. Navy guidance (U.S. Navy 1999). Because the test is nonparametric, normality is not required.

The Quantile Test, a nonparametric method is used to determine if observations as a group are statistically elevated when compared to background point measurements as a group. It follows the U.S. Navy guidelines (U.S. Navy 1999). Because the test is nonparametric, normality is not required.

If either the Wilcoxon Rank Sum Test or Quantile Test fails the null hypothesis, it is concluded that the mean of the LCS data set is greater than the mean of the pre-design or background data set. These two tests are used in conjunction, because the Wilcoxon Rank Sum Test is effective at detecting differences in central tendency (means and medians) but not in detecting differences in the tails of distributions. On the other hand, the Quantile Test is not effective at detecting differences in central tendency, but is effective at detecting differences in the tails of distributions. Used in conjunction, the two tests are effective at detecting differences in both the central tendency and tails of distributions.

In regard to the third bullet, the Tarone-Ware Two Sample Test for censored data is recommended in the *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance* (EPA 2009). The Tarone-Ware procedure is designed to provide a valid statistical test, even with a large fraction of censored (e.g., non-detected) data. The parameter selection process was revised in 2010 by replacing the use of a Poisson Test with the Tarone Ware Two Sample Test for Censored Data. The Poisson Test needed to be replaced because it exhibited scale dependency issues. The Tarone-Ware test is recommended in the *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance* (EPA 2009) for use with data sets that contain a large fraction of non-detects (left censored data).

Results from the parameter selection process for LCS data from Cells 1, 2, and 3 were reported in the *Fernald Preserve 2007 Site Environmental Report* (DOE 2008). Six additional parameters were identified for more frequent and robust monitoring (arsenic, cobalt, nickel, selenium, total dissolved solids [TDS], and zinc). Quarterly sampling for these additional six new parameters in the LCS, LDS, HTW, and GMA wells of each cell began in 2009.

Results from the parameter selection process for LCS data from Cells 4 and 5 were presented in the *Fernald Preserve 2009 Site Environmental Report* (DOE 2010b). Eight additional parameters were identified for more frequent and robust monitoring (alkalinity, chloride, nitrate/nitrite, barium, calcium, copper, magnesium, and potassium). Quarterly sampling for these additional eight parameters in the LCS, LDS, HTW, and GMA wells of each cell began in 2011. Vanadium was also identified for quarterly sampling in the LCS, LDS, HTW, and GMA wells of Cell 5.

Results from the parameter selection process for LCS data from Cell 6 were presented in the *Fernald Preserve 2010 Site Environmental Report* (DOE 2011b). No new parameters were identified for quarterly monitoring.

The data sets for Cell 7 and Cell 8 reached a minimum size of eight samples in 2011. Specific details concerning the assessment for Cell 7 and Cell 8 are provided in Table A.5.7–4 (contained in Sub-attachment A.5.7) and Table A.5.8–4 (contained in Sub-attachment A.5.8) respectively. Results are summarized below.

Cell 7

Four Appendix I parameters (not on the quarterly sampling list) reached the 25 percent detection criterion in 2011; ammonia, beryllium, chromium, and technetium-99. Pre-design and/or background data does not exist for beryllium so parameter selection statistics could not be conducted. The low beryllium concentrations detected (maximum of 0.00025 mg/L) imply that adding it to the quarterly sampling list would not significantly enhance early detection capability of the monitoring program. Therefore, beryllium will not be added to the quarterly sampling list for Cell 7. As reported in the *Fernald Preserve 2009 Site Environmental Report*, technetium-99 was already evaluated for Cell 7 and passed the null hypothesis therefore it was not evaluated again this year. Parameter selection statistics were conducted on ammonia and chromium. Ammonia passed the null hypothesis and chromium failed the null hypothesis. Chromium will be added to the quarterly monitoring list for the LCS, LDS, and GMA wells of each cell beginning in January 2013.

Cell 8

Three Appendix I parameters (not on the quarterly sampling list) reached the 25 percent detection criterion in 2011: ammonia, chromium, and tetrachloroethene. Parameter selection statistics were conducted on ammonia and chromium. Both passed the null hypothesis of the Tarone-Ware test so do not need to be added to the quarterly sampling list. (Note: Chromium failed the null hypothesis in Cell 7 so is on the quarterly sampling list beginning in January 2013).

Pre-design and/or background data does not exist for tetrachloroethene so parameter selection statistics could not be conducted. Since 2004, tetrachloroethene has been sampled 19 times and detected 6 times. Four of the six detects were at concentrations that were greater than the MDL but less than either the practical quantitation limit (PQL) or required detection limit (RDL). The two other detects were also very low (1.1 ug/L and 1.24 ug/L). Given the low concentrations, adding tetrachloroethene to the quarterly sampling list would not significantly enhance the early detection capability of the monitoring program.

After the earlier parameter selection process was performed for Cells 1 through 5, a decision was made to include those parameters selected for quarterly monitoring in Cells 1 through 5 for all eight cells. Therefore, chromium that was selected for Cell 7 this year will be added to the quarterly monitoring list for the LCS, LDS, and GMA wells of each cell beginning in January 2013.

Table A.5–3 provides an overview of the parameters that have been selected for quarterly sampling in the LCS, LDS, and GMA wells of each cell based on the evaluation for Cells 1 through 8. Also identified in the table are those parameters that were detected in 2011, but are not being sampled quarterly, and those parameters that were not detected in 2011, but have been detected at least 25 percent of the time based on previous years' results.

The table illustrates that the list of parameters chosen for quarterly sampling is very comprehensive when compared to the list of parameters detected in the LCS in 2011 or have

been detected at least 25 percent of the time based on previous years. This robust list of parameters should be adequate to detect a leak from the facility. These are the parameters that are most detected in the LCS at concentrations large enough to be measured beneath the facility should a leak in the facility occur, have been detected at least 25 percent of the time in the LCS, and have been shown statistically to have a mean concentration in the LCS that is larger than the mean concentration of the pre-design or background data sets.

The parameter selection process has now been completed for all eight cells, DOE plans to conduct a final comprehensive look to determine if the list of parameters can be further optimized. Results of the final evaluation will be made available to the Ohio EPA as soon as they are available.

A.5.2.6 Bivariate Plots for Each Cell

Bivariate plots for (uranium-sodium) are presented for each cell in Sub-attachments A.5.1 through A.5.8. The bivariate plots illustrate the concentration signatures for uranium-sodium in each monitoring horizon. Distinct clustering of horizon concentrations indicates that the fluids in the different horizons are not mixing. In response to an Ohio EPA comment on the *Fernald Preserve 2009 Site Environmental Report* (DOE 2010b) (OEPA Comment Number 35) the closest points between monitoring horizons are dated.

An additional bivariate plot for (uranium–sulfate) is presented for Cell 8 in Sub-attachment A.5.8. The additional uranium-sulfate bivariate plot provides supporting information concerning the water chemistry signatures that are present in the LDS and HTW of Cell 8; specifically that they are separate and distinct.

A.5.2.7 Increasing Concentration Trends in the HTW and GMA Wells

As presented in subsections A.5.1 through A.5.8, several parameter concentrations are increasing in the GMA beneath the OSDF. Bivariate plots (uranium-sodium and uranium-sulfate) indicate separate and distinct chemical signatures for the LCS, LDS, and HTW of all 8 cells. This indicates that water is not mixing from inside the facility to outside the facility, leading to the conclusion that the facility is not leaking. Therefore, concentration increases observed in the GMA wells are attributed to fluctuating ambient concentrations beneath the cells, and not to cell performance. Additional information is provided in Sub-attachments A.5.1 through A.5.8.

A.5.3 Cell Cap Inspections

OSDF cell cap inspections are conducted quarterly. The inspection team typically includes representatives from Ohio EPA, Ohio Department of Health (ODH), and S.M. Stoller Corporation. Issues identified during inspections typically include small erosion rills, rocks that surface as top soil settles, animal burrows and digging, small areas that require reseeding, and the presence of woody vegetation, thistle, or other noxious species.

The issues are addressed as follows:

- Erosion rills are repaired if they exceed 3 inches wide by 6 inches deep.
- Rocks that surface are removed, especially if they will interfere with mowing activities or may be a source location for erosion.
- Animal burrows and holes are filled in and reseeded, if necessary.
- Areas that require reseeding are seeded and covered with jute matting to help prevent erosion of the seed.
- Woody vegetation is removed and herbicide is applied to the noxious weeds.

Following each inspection, a report is submitted to the agencies documenting the inspection, issues and stating how issues will be addressed. These reports are available to the public on the Fernald Preserve website http://www.lm.doe.gov/fernald/Sites.aspx. In 2011, inspections were conducted in March, June, September, and December. In 2011, there were no visual signs that the integrity of the cap had been compromised in any way.

A.5.4 Monitoring Changes

Beginning in the second quarter of 2011, DOE implemented the following monitoring changes:

- For one year, tritium was added to the quarterly sampling list for all four horizons of all eight cells.
- The quarterly sampling list for the HTW of each cell was reduced to tritium, uranium, arsenic, and sodium. Sodium was retained to support the preparation of bi-variate plots.

These changes stem from an informal proposal made to DOE by Ohio EPA in February 2011 via e-mail.

Three quarters of tritium data were collected in 2011. The last quarter will be collected during the first quarter of 2012. Preliminary results show that tritium was only detected in one sample. The August 4, 2011 sample from the Cell 8 LCS (12345C) had a concentration of 296 picocuries per liter (pCi/L), with a "J" validation qualifier indicating that the concentration was estimated.

The fourth quarter of tritium data will be collected in 2012. If the fourth quarter results are consistent with the first three quarters, DOE plans to discontinue sampling for tritium altogether. Quarterly sampling in the HTW will continue for uranium, arsenic, sodium, and sulfate. Arsenic is included at the request of Ohio EPA, and uranium, sodium and sulfate are included to provide data for bivariate plots.

A.5.5 Summary of Overall Performance/Findings and Recommendations

Based on LCS and LDS flow data, engineered drainage features within the OSDF continue to perform as designed. Separate and distinct chemical signatures for uranium and sodium in the LCS, LDS, and HTW of each cell (and uranium and sulfate in Cell 8) indicate that waters from the different horizons are not mixing, and therefore it can be inferred that the primary and secondary liners are not leaking. Water quality constituent concentration increases noted in the

HTW and GMA wells are attributed to fluctuating ambient concentrations beneath the OSDF, and not to OSDF performance.

Specific findings are listed below:

- LCS volumes continue to diminish with time, but the decline is decreasing. Total facility leachate volume in 2011 was 8 percent less than in 2010 (approximately 161,682 gallons compared to 176,087 gallons).
- The largest LDS maximum accumulation rate recorded in 2011 was 0.38 gpad in Cell 8; approximately 2 percent of the initial response leakage rate of 20 gpad.
- LDS accumulation rates indicate that the liner systems are performing well within the specification outlined in the approved cell design.
- Quarterly apparent liner efficiencies were consistently greater than 97 percent for Cells 1 through 8 throughout 2011.
- Bivariate plots continue to illustrate that the water chemistries in the LCS, LDs, and HTW of each cell are distinct and separate indicating that waters from the different horizons are not mixing.
- In 2011, 140 data sets met the criteria for control Shewart-CUSUM control charts. In 2010 only 59 data sets met the criteria for control charts. Of the 140 control charts presented for 2011, 127 (92 percent) exhibited "in control" conditions, and 11 (8 percent) exhibited "out of control" conditions.
- Annual LCS sampling for Appendix I and PCB parameters led to the following results.
  - No new Appendix I or PCB parameters were detected in the LCS of Cells 1 through 7.
  - One Appendix I parameter (cadmium) was detected for the first time in 2011 in the LCS of Cell 8. If cadmium is detected in the LCS of Cell 8 in 2012, the LDS of Cell 8 will be sampled for cadmium in the next subsequent scheduled sampling round.
  - Chromium was detected for the second time in the LCS of Cell 6. Chromium will be added to the analyte list for the Cell 6 LDS in the next subsequent scheduled sampling round.
  - 1,1-dichloroethene was not detected in the LDS of either Cell 7 or Cell 8 even though it has been detected two consecutive times in the LCS of each cell.
- Parameter selection results reported herein marks the completion of a parameter selection process that was established in consultation with the Ohio EPA in 2005 and 2006. The parameter selection process was applied to the LCS data sets from Cell 7 and Cell 8. The result was the addition of chromium to the quarterly sampling list for the LCS, LDS, and GMA wells of each cell beginning in January 2013. DOE plans to conduct a final comprehensive look at the list of twenty-four parameters that have been selected for quarterly monitoring to determine if the list of parameters can be further optimized. Results of the evaluation will be made available to the Ohio EPA as soon as they are available.

- Three of four quarters of tritium data were collected in 2011 in the LCS, LDS, HTW, and GMA wells of each cell. All of the samples were non-detects, except one. The August 4, 2011 sample from the Cell 8 LCS (12345C) had a concentration of 296 pCi/L, with a validation qualifier of "J" indicating that the concentration was estimated. The fourth quarter of tritium data will be collected in 2012. If the fourth quarter results are consistent with the first three quarters, DOE plans on discontinuing sampling for tritium altogether. Quarterly sampling in the HTW will continue for uranium, arsenic, sodium, and sulfate. Arsenic is included at the request of Ohio EPA, and uranium, sodium and sulfate are included to provide data for bivariate plots.
- In 2011, quarterly physical inspections of the OSDF revealed no visual signs that the integrity of the OSDF cap had been compromised.

Table A.5–1. OSDF Initiation and Completion Dates

Cell	Sample Initiation per Horizon[a]	Waste Placement Initiation	LDS Volume Measurement Initiation[b]	Cap Geomembrane Layer Completion[c]	Cap Completion[d]
1	LCS: February 17, 1998 LDS: February 18, 1998 HTW: October 30, 1997 GMA-U: March 31, 1997 GMA-D: March 31, 1997	December 23, 1997	May 1999	August 17, 2001	December 20, 2001
2	LCS: November 23, 1998 LDS: December 14, 1998 HTW: June 29, 1998 GMA-U: June 30, 1997 GMA-D: June 25, 1997	November 12, 1998	May 1999	July 17, 2003	November 12, 2003
3	LCS: October 13, 1999 LDS: August 26, 2002 HTW: July 28, 1998 GMA-U: August 24, 1998 GMA-D: August 24 1998	October 26, 1999	October 1999	July 16, 2004	September 20, 2004
4	LCS: November 4, 2002 LDS: November 4, 2002 HTW: February 26, 2002 GMA-U: November 6, 2001 GMA-D: November 5, 2001	November 08, 2002	November 2002	December 18, 2004	April 29, 2005
5	LCS: November 4, 2002 LDS: November 4, 2002 HTW: February 26, 2002 GMA-U: November 6, 2001 GMA-D: November 5, 2001	November 19, 2002	November 2002	June 22, 2005	August 29, 2005
6	LCS: October 27, 2003 LDS: October 27, 2003 HTW: March 14, 2003 GMA-U: December 16, 2002 GMA-D: December 16, 2002	November 18, 2003	January 2004	October 28, 2005	January 12, 2006

Table A.5-1 (continued). OSDF Initiation and Completion Dates

Cell	Sample Initiation per Horizon[a]	Waste Placement Initiation	LDS Volume Measurement Initiation[b]	Cap Geomembrane Layer Completion[c]	Cap Completion[d]
7	LCS: September 2, 2004 LDS: September 2, 2004 HTW: February 24, 2004 GMA-U: January 21, 2004 GMA-D: January 21, 2004	September 9, 2004	September 2004	July 2006	October 25, 2006
8	LCS: October 18, 2004 LDS: October 18, 2004 HTW: May 19, 2004 GMA-U: March 31, 2004 GMA-D: March 31, 2004 GMA-SW: August 22, 2005 GMA-SE: August 22, 2005	December 2, 2004	December 2004	September 24, 2006	October 25, 2006

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer; GMA-SW = southwest Great Miami Aquifer; and GMA-SE = southeast Great Miami Aquifer
[b]Prior to 1999, overall LDS volumes were measured. From 1999 on, LDS volumes were measured by cell.
[c]The cap geomembrane layer is made of high density polyethylene.
[d]Cap completion includes seeding.

Table A.5-2. Rules for Summary Statistics for Cells 1 through 8

Rules	No. of Detected Samples	Total No. of Samples	Percent of Detects	Min[a,b]	Max[a,b]	Average	Std. Dev.	Distribution Type	Trend	Serial Correlation	Outliers
Include outliers	Yes	Yes	Yes	No	No	No	No	No	No	No	
Only one result	Yes	Yes	Yes	report "NA"	report value	report "Insuff"	report "Insuff"	report "Insuff"	report "Insuff"	report "Insuff"	
Only two results	Yes	Yes	Yes	report value	report value	report "Insuff"	report "Insuff"	report "Insuff"	report "Insuff"	report "Insuff"	
All non-detects	Yes	Yes	Yes	report "ND"	report "NA"	report "Insuff"	report "Insuff"	report "Insuff"	report "Insuff"	report "Insuff"	
Other rules						Need 3 detections otherwise report "Insuff"	Need 4 detections otherwise report "Insuff"	Need at least 3 samples to report distribution	Need at least 4 samples to report trend	Need at least 6 samples to report serial correlation	Need at least 4 samples to report outliers
Other rules						If distribution is "Lognormal," substitute "LogMean"					
Other rules						If distribution is "Undefined," substitute "Median"					

[a]NA=not applicable; ND=not detected
[b]If reported value is a nondetected result, report ND.

Table A.5-3. Overview of Constituents Selected for Quarterly Monitoring from LCS Annual Monitoring

Parameters Selected for Quarterly Sampling in All Cells								
Constiuent	**Cell 1**	**Cell 2**	**Cell 3**	**Cell 4**	**Cell 5**	**Cell 6**	**Cell 7**	**Cell 8**
Alkalinity	X	X	X	X	X	X	X	X
Chloride	X	X	X	X	X	X	X	X
Nitrate/nitrite	X	X	X	X	X	X	X	X
TDS	X	X	X	X	X	X	X	X
TOC	X	X	X	X	X	X	X	X
TOX	X	X	X	X	X	X	X	X
Sulfate	X	X	X	X	X	X	X	X
Arsenic	25%	X			X		25%	
Barium	X	X	X	X	X	X	X	X
Boron	X	X	X	X	X	X	X	X
Calcium	X	X	X	X	X	X	X	X
Cobalt	X	X	X	X	X	X	X	X
Copper	X	X	X	X	X	X	X	X
Iron	X	X	X	X	X	X	X	X
Lithium	X	X	X	X	X	X	X	X
Magnesium	X	X	X	X	X	X	X	X
Manganese	25%	X	X	X	X	25%	X	X
Nickel	X	X	X	X	X	X	X	X
Potassium	X	X	X	X	X	X	X	X
Selenium	X	X	X	X	X	X	X	X
Sodium	X	X	X	X	X	X	X	X
Zinc	X	X	X	X	X	X	X	X
Uranium	X	X	X	X	X	X	X	X
Chromium	X	X	X	X	X	X	X	X

Parameters Selected for Quarterly Sampling in Some Cells								
Constiuent	**Cell 1**	**Cell 2**	**Cell 3**	**Cell 4**	**Cell 5**	**Cell 6**	**Cell 7**	**Cell 8**
Technetium-99 (Cell 8)				25%	25%	25%	25%	25%
Vanadium (Cell 5)		X						

Not Sampled Quarterly								
Constiuent	**Cell 1**	**Cell 2**	**Cell 3**	**Cell 4**	**Cell 5**	**Cell 6**	**Cell 7**	**Cell 8**
Ammonia	X	X	X	X	X	X	X	X
Antimony		X						
Beryllium							25%	
Cadmium	X	X						1
Lead		X						
Acetone								
Thallium		X						
1,1-dichloroethene			25%				X	X
Toluene								
Tetrachloroethene								X

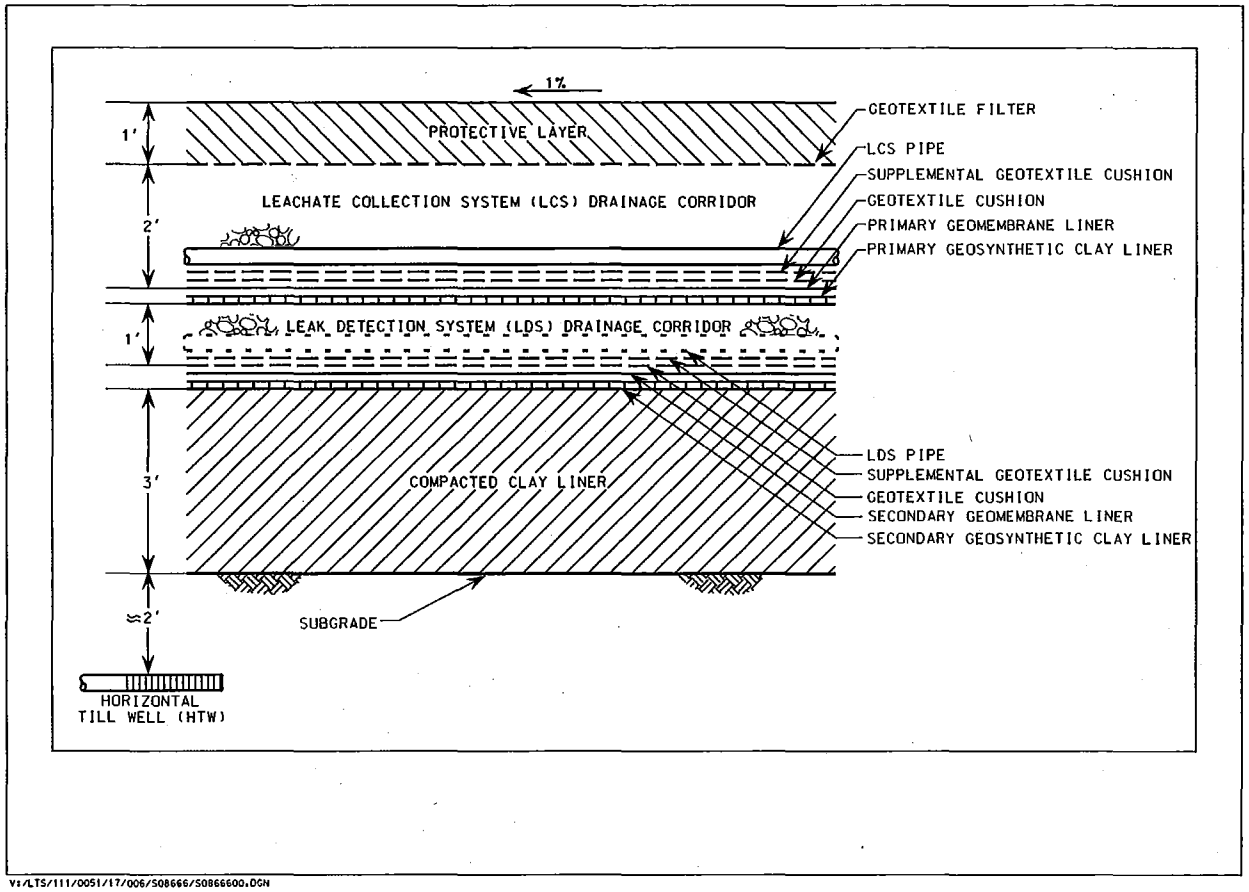
A blank indicates that it was not detected in 2011, and has not been detected 25% of the time overall

X Detected in 2011.

X Detected in 2011 and at least 25% of time overall.

25% Not detected in 2011, but has been detected at least 25% of time overall

1 First time detect in 2011.



V:/LTS/111/0051/17/006/S08666/S0866600.DGN

Figure A.5–1. On-Site Disposal Facility Liner System with HTW at the Drainage Corridor

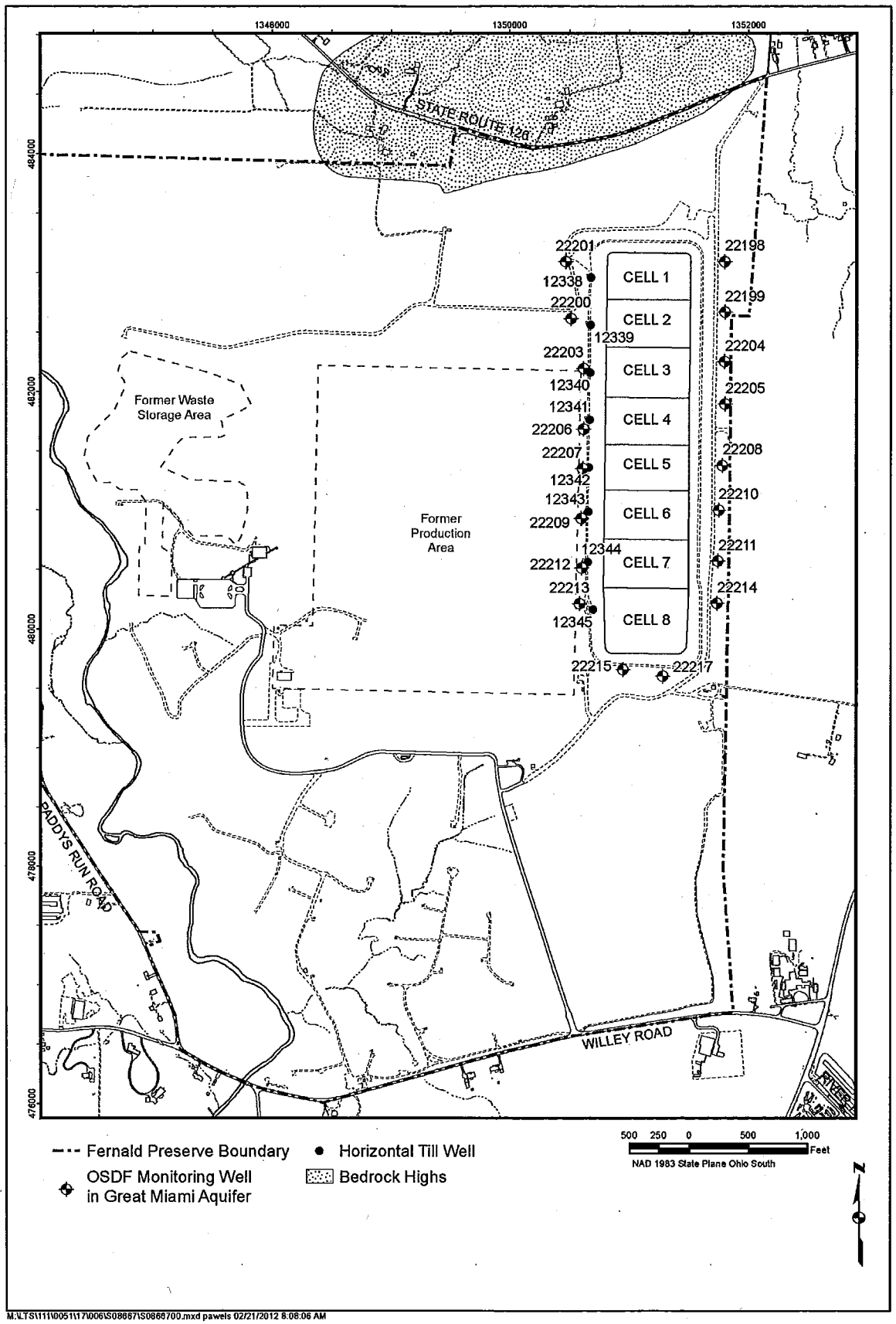


Figure A.5–2. On-Site Disposal Facility Footprint and Monitoring Well Locations

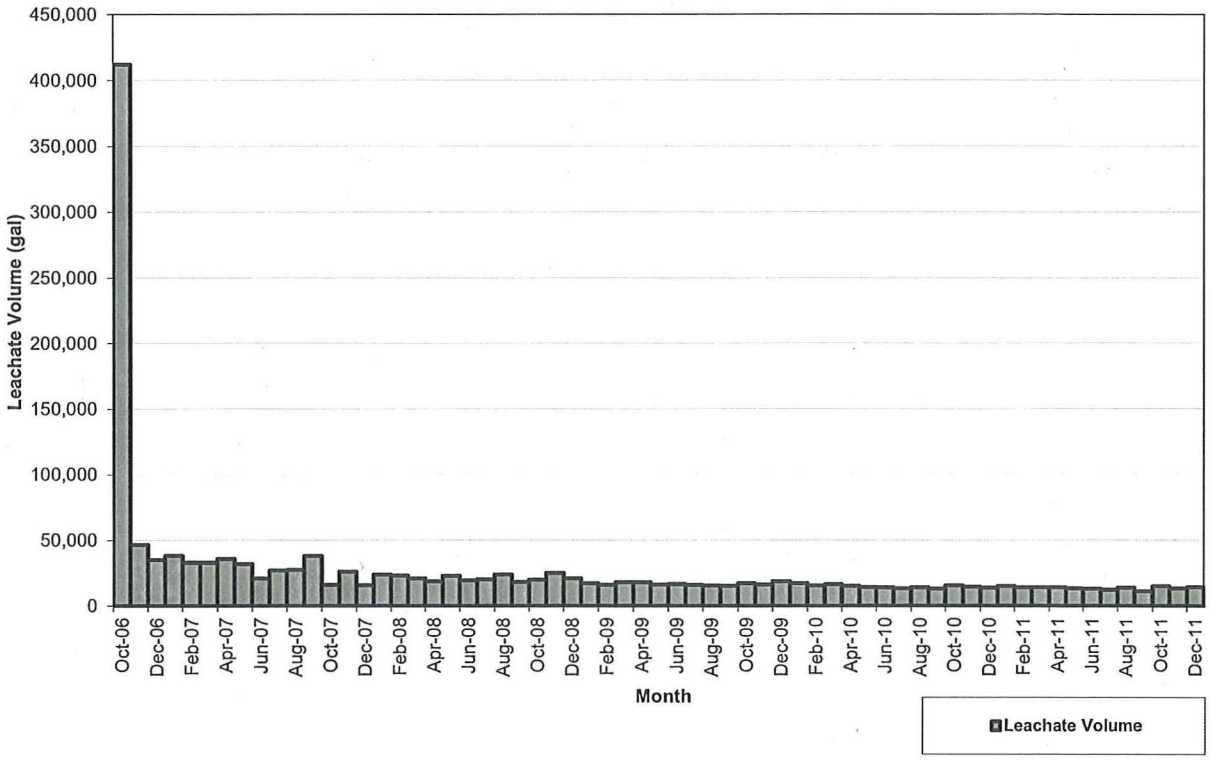


Figure A.5–3. OSDF Monthly LCS Flow (October 2006 through December 2011)

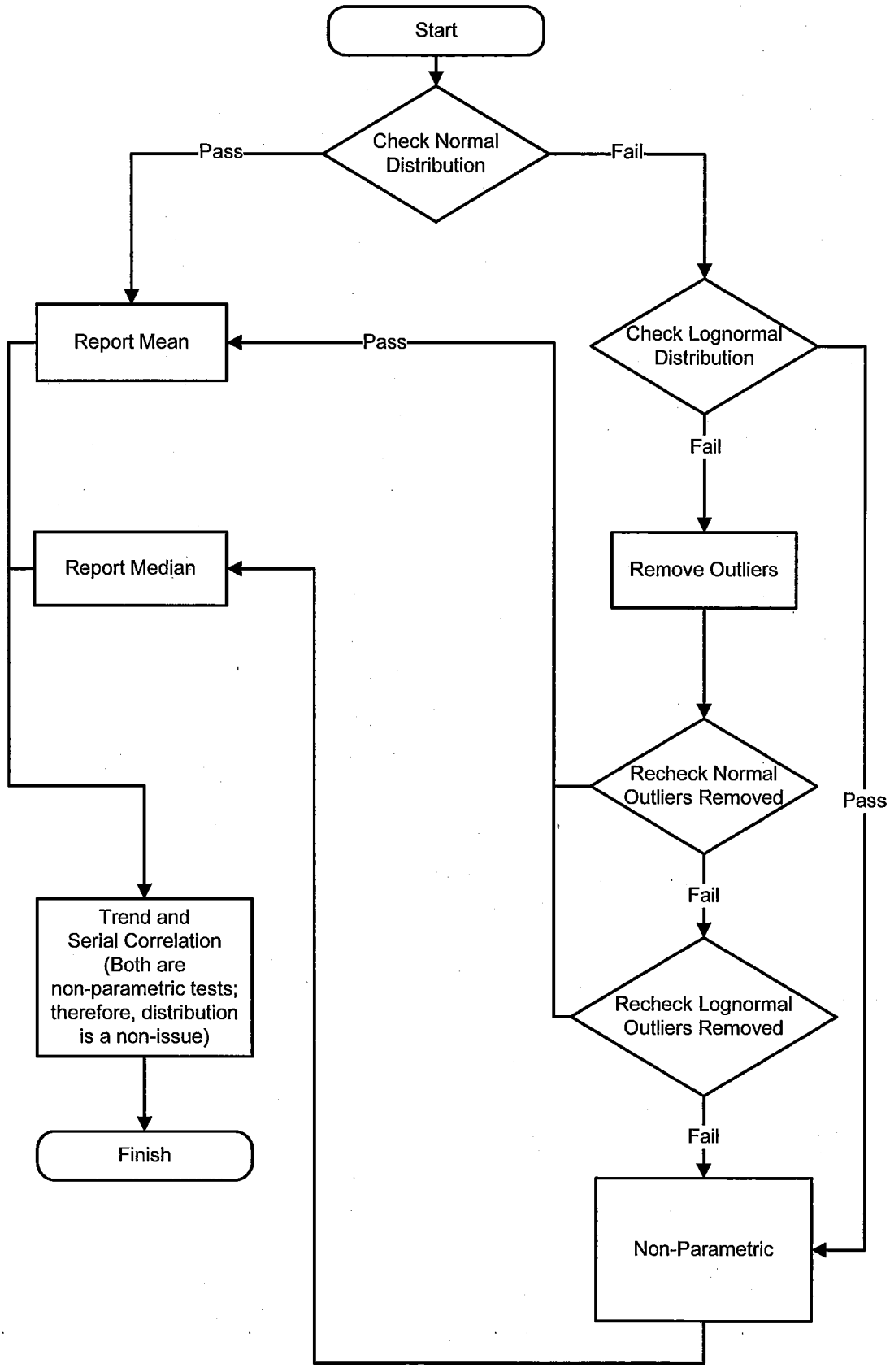


Figure A.5–4. OSDF Statistical Evaluation Process

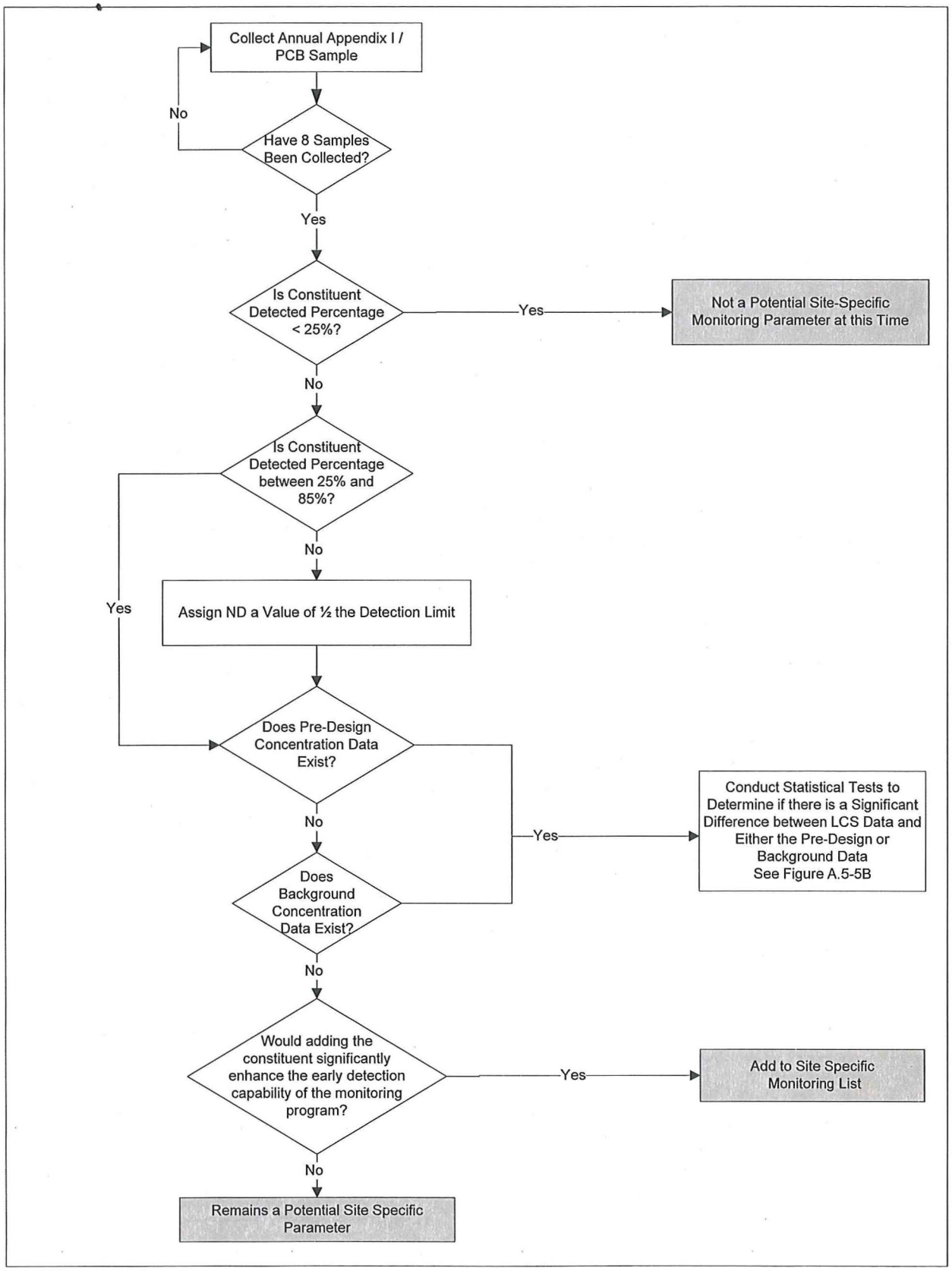


Figure A.5–5A. OSDF Site-Specific Leachate Monitoring Parameter Selection Approach

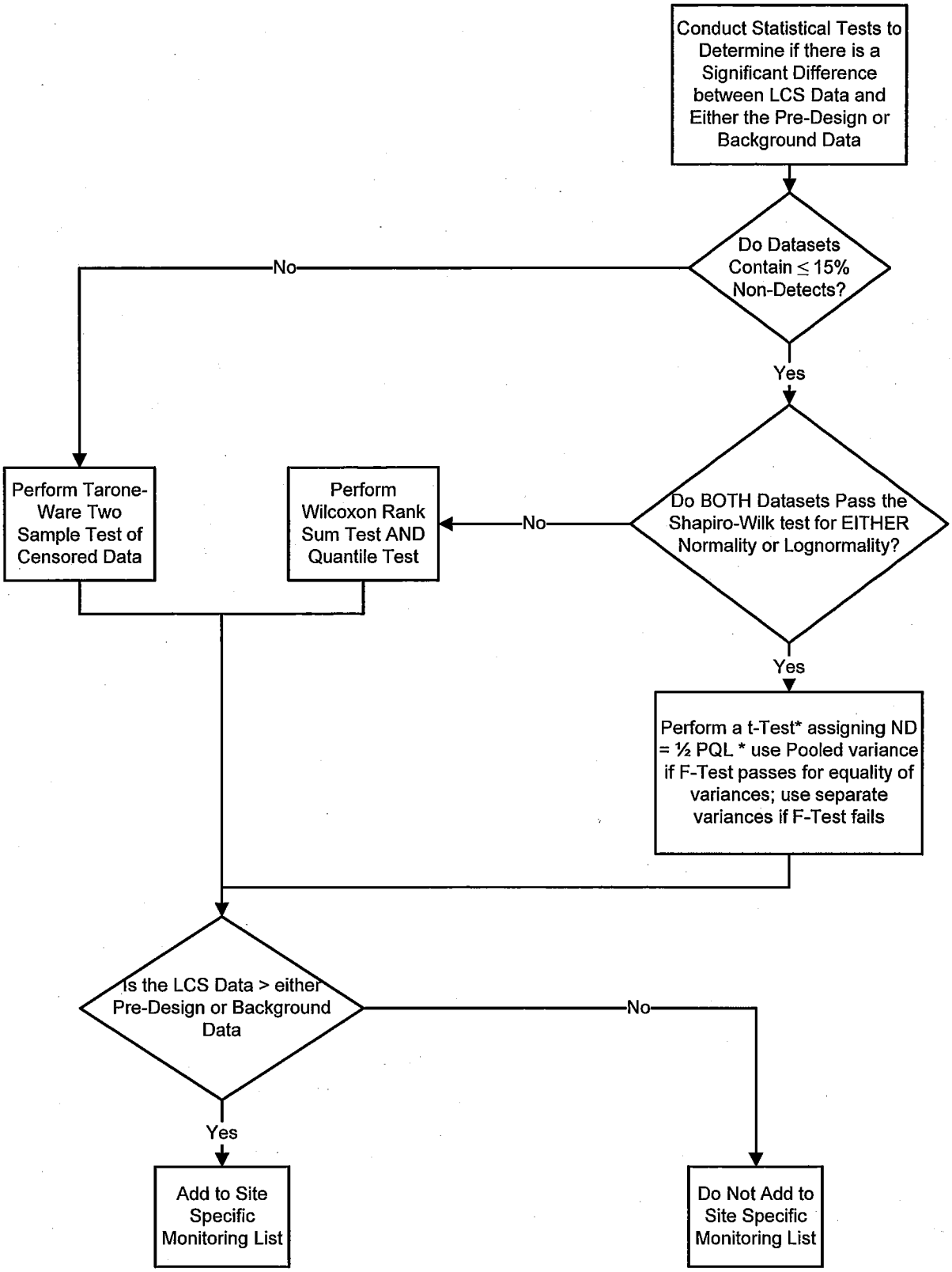


Figure A.5–5B. OSDF Site-Specific Leachate Monitoring Parameter Selection Approach

Sub-attachment A.5.1

Sub-attachment A.5.1

Cell 1

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The following information is provided in this sub-attachment:

- Quarterly monitoring summary statistics (refer to Table A.5.1–1)
- Annual LCS sample summary information for detected parameters (refer to Table A.5.1–2)
- LCS monthly accumulation volumes (refer to Figure A.5.1–1)
- LDS monthly accumulation volumes (refer to Figure A.5.1–2)
- OSDF horizontal till well 12338 water yield (refer to Figure A.5.1–3)
- GMA water levels and uranium concentration versus time (refer to Figures A.5.1–4 and A.5.1–5)
- Plots of concentration versus time (refer to Figures A.5.1–6A to A.5.1–28B)
- A bivariate plot for uranium-sodium (refer to Figure A.5.1–29)
- Control charts (refer to Figures A.5.1–30 to A.5.1–49)

A.5.1.1 Quarterly Monitoring Results

Quarterly water quality monitoring takes place in the LCS, LDS, HTW, and GMA wells of each cell for the purpose of determining if the OSDF is operating as designed. Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentrations versus time plots, bivariate plots, and control charts are used to help interpret and present the results.

In the first quarter of 2011, 23 parameters were sampled in the LCS, LDS, HTW, and GMA wells of each cell. In the second, third, and fourth quarters tritium was added to the analyte list for all horizons (LCS, LDS, HTW, and GMA Wells), and the analyte list for the HTWs in all cells was changed to just four parameters: arsenic, uranium, tritium, and sodium. These changes were agreed to via the comment resolution process between Ohio EPA and DOE on revision 4 of the LMICP (DOE 2010b). Tritium results are for all cells are reported in Section A.5.5.

The LDS of Cell 1 was dry during the second, third, and fourth quarters of 2011. As shown in Table A.5.1–1, 6 of the 23 parameters sampled quarterly in the LCS, LDS, HTW, and GMA wells, (uranium, alkalinity, total organic carbon [TOC], arsenic, boron, and selenium) have upward trends in the HTW and/or the GMA wells based on the Mann-Kendall test for trend.

Horizontal Till Wells

The HTW is located beneath the liner penetration box of each cell by design. The liner penetration box is considered to be potentially the weakest point in the cell design. If a leak were to develop, it should be detected beneath the liner penetration box first. Therefore, the water quality in the HTW represents the first line of evidence that a potential leak from the cell might be occurring. A leak would be indicated by an increasing concentration in the HTW.

Of the 23 parameters monitored quarterly in the LCS, LDS, HTW, and GMA wells, three (uranium, TOC, and alkalinity) are increasing in the HTW of Cell 1 (as indicated in the table below). The bivariate plot for the Cell 1 LCS, LDS, and HTW (uranium-sodium) is provided in Figure A.5.1–29. The plot shows that the chemical signature for uranium-sodium in the LCS

LDS, and HTW are separate and distinct; indicating that mixing between the horizons is not occurring. Therefore, the increasing concentrations measured in the HTW of Cell 1 are attributed to fluctuating ambient concentrations beneath the cell that are not related to cell performance.

Parameter	HTW[a]	GMA-U[a]	GMA-D[a]
Uranium	Up	Up	Up
TOC[q]	Up		
Alkalinity	Up		
Arsenic			Up
Boron		Up	
Selenium			Up

[a]HTW = horizontal till well, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer; TOC = total organic carbon. No entry indicates that the trend was not up.

The plot of concentrations versus time for uranium in the HTW of Cell 1 is presented in Figure A.5.1–6A. The data indicate that concentrations in the overall dataset (1997 to 2011) are increasing; however, when the data collected prior to the fourth quarter of 2006 are removed, the data become normally distributed with no Mann-Kendall trend. The same observation does not apply to the TOC and alkalinity data sets from Cell 1.

Great Miami Aquifer Wells

GMA monitoring wells are positioned for post-aquifer-remediation flow conditions, when flow directions will be from west to east. However, water levels measured in 2011 indicate that groundwater in the GMA in most of the area of the OSDF is moving in a general direction of northeast to south/southwest in response to the active groundwater remediation taking place to the west and southwest. Pumping for the groundwater remediation is scheduled to last until 2023. Because bivariate plots (discussed above) indicate that LCS, LDS, and HTW monitoring horizons are not mixing, the increasing concentrations seen in the GMA wells, for uranium, arsenic, boron, and selenium, are attributed to fluctuating ambient conditions that are not related to cell performance.

The table below provides a summary of the average concentration (as reported in Table A.5.1–1) measured in the LDS and GMA wells for parameters with increasing concentrations in the Cell 1 GMA wells.

Parameter	LDS[a]	GMA-U[a]	GMA-D[a]
Uranium (µg/L)	**10.8**	3.08	5.12
Arsenic (mg/L)	**0.0125**[b]	0.00250	0.00150
Boron (mg/L)	**0.243**	0.112	0.060
Selenium (mg/L)	**0.00724**[c]	ND[d]	0.00165

Note: The highest averages are shown in bold.
[a] LDS = leak detection system, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer.
[b] Arsenic has only been detected once in the LDS of Cell 1 (0.0125 mg/L).
[c] Selenium has only been detected once in the LDS of Cell 1 (second quarter 2009, 0.00724 mg/L).
[d] ND = not detected

A.5.1.2 Control Charts

Intrawell control charts employ historical measurements from a compliance point as background. The *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance* (EPA 2009) defines the process of creating a Shewart-CUSUM control chart. Appropriate background data are used to define a baseline for the well. The baseline parameters for the chart, estimates of the mean, and standard deviation are obtained from the background data. These baseline measurements characterize the expected background concentrations at the monitoring point. As future concentrations are collected, the baseline parameters are used to standardize the newly gathered data. After these measurements are standardized and plotted, a control chart is declared "out of control" if future concentrations exceed the baseline control limit. This is indicated on the control chart when either the Shewart or CUSUM plot traces begin to exceed a control limit. The limit is based on the rationale that if the monitoring point remains unchanged from the baseline condition, new standardized observations should not deviate substantially from the baseline mean. If a change occurs, the standardized values will deviate significantly from the baseline and tend to exceed the control limit. Usually, two parameters are used to compute standardized limits; the decision value (h) and the Shewart Control Limit (SCL).

A minimum of eight samples are recommended for use in ChemStat® software to define the baseline for a control chart. Therefore, only sample sets with greater than eight samples were selected for control charts. By default, the ChemStat® software plots both a CUSUM control limit (h) and a SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit (h) and a value of 4.5 for the SCL.

EPA Unified Guidance suggests that to simplify the interpretation of the control chart that an out of control condition be based on the CUSUM (h) limit alone. Plotting the SCL limit is not needed. The ChemStat® software though, by default, plots both the SCL and CUSUM (h) control limit on the charts. As a "work-a-round," the SCL limit was defined as 5 to match the recommended CUSUM limit. On the charts the combined limit is identified as hCL. For interpretation purposes, regard hCL as the CUSUM limit (h).

As shown in Table A.5.1–1 in gray shading, fifteen parameters in the HTW and GMA wells of Cell 1 meet the criteria for control charts (i.e., more than 8 samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in 20 control charts.

These twenty control charts are presented in Figures A.5.1–30 to A.5.1–49. All of the control charts for Cell 1 indicate "in control" conditions. Past "out of control" conditions exist for total organic halogen (TOX) and cobalt, but as shown in the control charts, data collected since the out of control conditions indicate that the out of control conditions did not persist.

Parameter and Monitoring Point[a]	Assessment
Nitrate in the HTW	In Control
TDS in the GMA-U	In Control
TDS in the GMA-D	In Control
TOX in the HTW	In Control
Barium in the HTW	In Control
Calcium in the HTW	In Control
Cobalt in the HTW	In Control
Cobalt in the GMA-D	In Control
Copper in the HTW	In Control
Iron in the HTW	In Control
Iron in the GMA-U	In Control
Lithium in the GMA-U	In Control
Lithium in the GMA-D	In Control
Magnesium in the HTW	In Control
Manganese in the HTW	In Control
Manganese in the GMA-U	In Control
Nickel in the GMA-U	In Control
Potassium in the HTW	In Control
Sodium in the GMA-D	In Control
Zinc in the GMA-U	In Control

[a] HTW = horizontal till well; TDS = total dissolved solids; TOX = total organic halogens; GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer

A.5.1.3 Annual LCS Sample Results

Annual LCS sampling results for Cell 1 are provided in Table A.5.1–2 for those parameters that have been detected at least once and are not being sampled quarterly. No new Appendix I or PCB parameters were detected in the LCS of Cell 1 in 2011.

A.5.1.4 Summary and Conclusions

- Six parameters have an upward concentration trend in the HTW and/or GMA wells of Cell 1 (uranium, TOC, Alkalinity, arsenic, boron, and selenium).
- Separate and distinct chemical signatures for uranium and sodium in the LCS, LDS, and HTW of Cell 1 indicate that water is not mixing between the horizons. Concentration increases in the HTW and GMA wells of Cell 1 are attributed to fluctuating ambient concentrations beneath the cell and not to cell performance.
- Twenty control charts were constructed for Cell 1 parameters. All of the control charts exhibit "in control" conditions.
- No new Appendix I or PCB parameters were detected in the LCS of Cell 1 in 2011.

Table A.5.1-1. Summary Statistics for Cell 1

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12338C	53	54	98.1	ND	206	79.2	37.6	Normal	Up	Detected	
	LDS	12338D	37	37	100.0	1.5	37.0	10.8	6.8	Undefined	Up	Detected	
	HTW	12338	50	52	96.2	0.608	12.7	5.56	3.89	Undefined	Up	Detected	
	GMA-U	22201	55	59	93.2	ND	11.2	3.08	2.91	Undefined	Up	Detected	
	GMA-D	22198	59	59	100.0	0.574	15.2	5.12	2.98	Undefined	Up	Detected	
Alkalinity as CaCO3 (mg/L)	LCS	12338C	23	23	100.0	227	721	422	151	Lognormal	Down	Not Detected	
	LDS	12338D	7	7	100.0	206	528	362	109	Normal	None	Not Detected	
	HTW	12338	10	10	100.0	195	289	237	26	Normal	Up	Not Detected	
	GMA-U	22201	4	4	100.0	420	563	486	66	Normal	None	Insuff	
	GMA-D	22198	4	4	100.0	224	383	304	78	Normal	None	Insuff	
Chloride (mg/L)	LCS	12338C	23	23	100.0	21.8	55	38.7	7.0	Undefined	Up	Detected	
	LDS	12338D	7	7	100.0	87.1	202	128	39	Normal	None	Not Detected	
	HTW	12338	10	10	100.0	16.3	32	25.6	4.3	Normal	Down	Not Detected	
	GMA-U	22201	4	4	100.0	35.9	75	48.4	18.2	Normal	None	Insuff	
	GMA-D	22198	4	4	100.0	22.0	22.6	22.3	0.3	Normal	None	Insuff	
Nitrate/Nitrite as Nitrogen (mg/L)	LCS	12338C	22	34	64.7	ND	49	0.55	18	Undefined	None	Detected	
	LDS	12338D	5	10	50.0	ND	359	0.0536	113	Undefined	None	Not Detected	
	HTW	12338	4	10	40.0	ND	1.73	0.395	0.576	Lognormal	None	Not Detected	
	GMA-U	22201	1	4	25.0	ND	0.192	Insuff	Insuff	Lognormal	None	Insuff	
	GMA-D	22198	7	24	29.2	ND	0.55	0.169	0.227	Undefined	None	Detected	
Sulfate (mg/L)	LCS	12338C	40	40	100.0	707	2510	1290	576	Undefined	Up	Detected	
	LDS	12338D	19	19	100.0	675	3500	1850	780	Lognormal	Up	Detected	
	HTW	12338	32	32	100.0	549	907	705	98	Normal	Down	Detected	
	GMA-U	22201	35	35	100.0	91.8	1980	324	323	Lognormal	None	Detected	
	GMA-D	22198	35	35	100.0	101	506	224	107	Lognormal	Down	Not Detected	
Total Dissolved Solids (mg/L)	LCS	12338C	33	33	100.0	1790	5200	2420	900	Undefined	Up	Detected	
	LDS	12338D	6	6	100.0	2430	7540	5170	2000	Normal	None	Not Detected	
	HTW	12338	8	8	100.0	1190	1310	1260	40	Normal	None	Not Detected	
	GMA-U	22201	11	11	100.0	978	1260	1080	90	Normal	None	Not Detected	
	GMA-D	22198	11	11	100.0	577	805	687	81	Normal	None	Not Detected	
Total Organic Carbon (mg/L)	LCS	12338C	52	54	96.3	9.99	51.8	19.6	8.9	Undefined	Down	Detected	123 (Q2-98) 0.9 (Q1-99) 0.85 (Q2-99)
	LDS	12338D	34	38	89.5	ND	15.7	6.51	2.96	Normal	None	Not Detected	80.9 (Q2-98)
	HTW	12338	35	48	72.9	ND	7.24	1.73	1.02	Undefined	Up	Not Detected	
	GMA-U	22201	46	59	78.0	ND	17.6	2.49	3.55	Undefined	None	Not Detected	59.7 (Q2-98)
	GMA-D	22198	40	58	69.0	ND	15.8	1.39	2.78	Undefined	None	Not Detected	52.5 (Q2-98)
Total Organic Halogens (mg/L)	LCS	12338C	50	55	90.9	ND	1.52	0.197	0.231	Undefined	None	Detected	
	LDS	12338D	28	38	73.7	ND	0.361	0.0527	0.0587	Lognormal	None	Not Detected	
	HTW	12338	27	49	55.1	ND	0.063	0.00970	0.00960	Lognormal	None	Not Detected	
	GMA-U	22201	23	59	39.0	ND	0.078	0.00860	0.0116	Undefined	Down	Not Detected	0.308 (Q2-00)
	GMA-D	22198	10	58	17.2	ND	0.1	0.00386	0.0182	Undefined	Down	Detected	
Arsenic (mg/L)	LCS	12338C	9	28	32.1	ND	0.0786	0.00736	0.0148	Normal	None	Not Detected	
	LDS	12338D	1	9	11.1	ND	0.0125	INSUFF	Insuff	Lognormal	None	Not Detected	
	HTW	12338	3	20	15.0	ND	0.0607	0.00250	Insuff	Undefined	None	Not Detected	
	GMA-U	22201	3	11	27.3	ND	0.04	0.00250	Insuff	Undefined	None	Not Detected	
	GMA-D	22198	6	44	13.6	0.000113	0.0372	0.00150	0.00789	Undefined	Up	Detected	
Barium (mg/L)	LCS	12338C	23	23	100.0	0.0241	0.205	0.0785	0.0497	Normal	Down	Detected	
	LDS	12338D	7	7	100.0	0.0146	0.0173	0.0156	0.001	Normal	None	Not Detected	
	HTW	12338	10	10	100.0	0.0258	0.0764	0.0465	0.0149	Normal	None	Not Detected	
	GMA-U	22201	5	5	100.0	0.0399	0.124	0.0798	0.0325	Normal	Down	Insuff	
	GMA-D	22198	6	6	100.0	0.0562	0.138	0.0802	0.0292	Lognormal	None	Not Detected	

Table A.5.1–1 (continued). Summary Statistics for Cell 1

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Boron (mg/L)	LCS	12338C	54	55	98.2	0.0642	2.81	1.05	0.53	Undefined	None	Not Detected	
	LDS	12338D	37	38	97.4	0.169	0.345	0.243	0.043	Lognormal	None	Not Detected	0.0296 (Q1-98) 0.00100 (Q3-00)
	HTW	12338	46	49	93.9	ND	0.271	0.162	0.064	Undefined	None	Detected	
	GMA-U	22201	57	59	96.6	ND	0.158	0.112	0.028	Normal	Up	Detected	
	GMA-D	22198	54	58	93.1	0.0264	0.131	0.060	0.017	Undefined	None	Not Detected	
Calcium (mg/L)	LCS	12338C	23	23	100.0	377	939	548	146	Lognormal	None	Not Detected	1500 (Q3-05)
	LDS	12338D	7	7	100.0	324	553	396	78	Normal	Up	Not Detected	
	HTW	12338	10	10	100.0	230	349	273	37	Normal	None	Not Detected	
	GMA-U	22201	4	4	100.0	237	271	254	14	Normal	None	Insuff	
	GMA-D	22198	4	4	100.0	148	192	173	19	Normal	None	Insuff	
Cobalt (mg/L)	LCS	12338C	17	28	60.7	ND	0.0575	0.0029	0.0142	Undefined	Down	Detected	
	LDS	12338D	6	9	66.7	ND	0.0019	0.0011	0.0005	Normal	None	Not Detected	
	HTW	12338	10	17	58.8	ND	0.00349	0.00121	0.00079	Lognormal	None	Not Detected	0.0126 (Q3-09)
	GMA-U	22201	3	11	27.3	ND	0.00223	0.0005	Insuff	Undefined	None	Not Detected	
	GMA-D	22198	6	31	19.4	ND	0.0045	0.00078	0.00091	Lognormal	None	Not Detected	
Copper (mg/L)	LCS	12338C	20	24	83.3	0.00094	0.0285	0.0102	0.0073	Normal	None	Not Detected	
	LDS	12338D	6	8	75.0	ND	0.0231	0.0098	0.0070	Normal	None	Not Detected	
	HTW	12338	8	11	72.7	ND	0.0166	0.0095	0.0056	Normal	None	Not Detected	
	GMA-U	22201	4	4	100.0	0.00229	0.0105	0.0072	0.0035	Normal	None	Insuff	
	GMA-D	22198	4	5	80.0	ND	0.00888	0.00640	0.00355	Lognormal	None	Insuff	
Iron (mg/L)	LCS	12338C	25	28	89.3	ND	101	19.8	19.4	Lognormal	Down	Detected	
	LDS	12338D	7	9	77.8	ND	2.55	1.30	1.00	Normal	None	Detected	
	HTW	12338	17	17	100.0	0.271	13.9	5.26	3.82	Lognormal	None	Not Detected	
	GMA-U	22201	11	11	100.0	0.0479	4.42	2.73	1.76	Lognormal	None	Not Detected	
	GMA-D	22198	24	24	100.0	0.531	6.92	3.42	1.66	Normal	None	Detected	
Lithium (mg/L)	LCS	12338C	20	20	100.0	0.103	0.197	0.140	0.031	Lognormal	Up	Detected	
	LDS	12338D	9	9	100.0	0.0333	0.075	0.0561	0.0137	Normal	None	Not Detected	
	HTW	12338	13	17	76.5	ND	0.00943	0.00797	0.00149	Undefined	None	Not Detected	
	GMA-U	22201	11	11	100.0	0.00723	0.0153	0.0111	0.0027	Normal	None	Not Detected	
	GMA-D	22198	11	11	100.0	0.00739	0.0107	0.00934	0.00091	Normal	None	Not Detected	
Magnesium (mg/L)	LCS	12338C	23	23	100.0	71.4	482	169	137	Undefined	Up	Detected	
	LDS	12338D	7	7	100.0	120	326	179	69	Lognormal	None	Not Detected	
	HTW	12338	10	10	100.0	74.5	95.4	85.0	5.6	Normal	None	Not Detected	
	GMA-U	22201	4	4	100.0	44.6	54.7	48.8	4.5	Normal	None	Insuff	
	GMA-D	22198	4	4	100.0	39	47.8	44.6	4.0	Normal	None	Insuff	
Manganese (mg/L)	LCS	12338C	16	28	57.1	ND	7.7	0.249	1.81	Undefined	Down	Detected	
	LDS	12338D	8	9	88.9	0.00245	0.184	0.0275	0.0579	Lognormal	None	Not Detected	
	HTW	12338	16	17	94.1	ND	0.136	0.0477	0.0366	Normal	None	Not Detected	
	GMA-U	22201	13	13	100.0	0.0322	2.06	0.928	0.743	Normal	None	Not Detected	
	GMA-D	22198	43	44	97.7	0.178	1.09	0.512	0.210	Lognormal	None	Detected	
Nickel (mg/L)	LCS	12338C	25	28	89.3	ND	0.0535	0.0188	0.0167	Undefined	Down	Detected	
	LDS	12338D	9	9	100.0	0.00486	0.0353	0.0169	0.0082	Normal	None	Not Detected	
	HTW	12338	8	17	47.1	ND	0.0116	0.00439	0.00312	Normal	Down	Not Detected	
	GMA-U	22201	10	11	90.9	ND	0.01115	0.005119	0.00306	Normal	None	Not Detected	
	GMA-D	22198	17	44	38.6	ND	0.0100	0.0011	0.0025	Undefined	Down	Not Detected	0.13 (Q4-99)
Potassium (mg/L)	LCS	12338C	23	23	100.0	10.8	30	20.2	5.4	Normal	Up	Detected	
	LDS	12338D	7	7	100.0	13.2	35.4	19.8	7.4	Lognormal	None	Not Detected	
	HTW	12338	10	10	100.0	2.89	3.77	3.31	0.27	Normal	None	Not Detected	
	GMA-U	22201	4	4	100.0	2.28	3.97	3.35	0.78	Normal	None	Insuff	
	GMA-D	22198	4	4	100.0	1.89	2.07	2.00	0.08	Normal	None	Insuff	

Table A.5.1–1 (continued). Summary Statistics for Cell 1

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Selenium (mg/L)	LCS	12338C	12	28	42.9	ND	0.0715	0.00981	0.0177	Lognormal	Up	Not Detected	
	LDS	12338D	1	9	11.1	ND	0.00724	Insuff	Insuff	Undefined	Up	Not Detected	0.076 (Q1-10)
	HTW	12338	0	17	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	0.025 (Q3-09)
	GMA-U	22201	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22198	3	31	9.7	ND	0.00364	0.00165	Insuff	Undefined	Up	Detected	
Sodium (mg/L)	LCS	12338C	28	28	100.0	11.7	29.3	17.9	3.8	Normal	Up	Detected	
	LDS	12338D	9	9	100.0	335	896	571	216	Normal	Up	Not Detected	
	HTW	12338	20	20	100.0	11.9	23.8	16.9	3.5	Normal	Down	Detected	
	GMA-U	22201	11	11	100.0	47.9	65.5	62.9	5.9	Undefined	Down	Detected	
	GMA-D	22198	11	11	100.0	14.1	17.1	15.3	1.0	Normal	None	Not Detected	
Zinc (mg/L)	LCS	12338C	18	28	64.3	ND	0.575	0.116	0.145	Lognormal	None	Not Detected	
	LDS	12338D	9	9	100.0	0.0557	0.671	0.239	0.190	Lognormal	None	Not Detected	
	HTW	12338	13	17	76.5	ND	0.618	0.0151	0.171	Undefined	None	Detected	
	GMA-U	22201	5	11	45.5	ND	0.0127	0.00589	0.00898	Normal	None	Not Detected	
	GMA-D	22198	15	44	34.1	ND	0.0474	0.00444	0.00709	Lognormal	None	Detected	

Note: Shading identifies a horizontal till well or Great Miami Aquifer well with at least 8 samples, normal or lognormal distribution, no trend, and no serial correlation. These wells achieve control chart criteria.

Note: For results where the concentrations are below the detection limit, the results used in the Average, Standard Deviation, Distribution Type, Trend, Serial Correlation, and Outliers are each set at half the detection limit.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption and requires $n \geq 3$. In addition, Standard Deviation requires $n \geq 4$.

[d]"Insuff" = Insufficient and is used for Average, Standard Deviation, Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic (where $3 \leq n \leq 50$) or Shapiro Francia (where $n > 50$).

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the lognormal assumption.

Lognormal: Lognormal assumption could not be rejected at the 5 percent level and has a higher probability value than the normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25% detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure. Trend testing requires a sample with $n \geq 4$.

[g]Serial correlation based on Rank Von Neumann test. Serial Correlation testing requires a sample with $n \geq 6$.

[h]Outliers determined by Rosner's (where $n > 25$) or Dixon procedure (where $4 \leq n \leq 25$).

[i]Q = quarterly

Table A.5.1-2. Cell 1 Annual LCS Sample Summary Information for Detected Parameters

PARAMETER (UNIT)	NUMBER OF SAMPLES[a,b]	NUMBER OF SAMPLES WITH DETECTIONS[a,b]	PERCENT OF DETECTIONS[a,b]	DETECTED IN 2011	MIN DETECTED CONCENTRATION[a,b,c]	MAX DETECTED CONCENTRATION[a,b,c]	AVG DETECTED CONCENTRATION[a,b,c]	GW FRL[d] (#OF SAMPLES>GWFRL)	GW BACKGROUND[a,b,e] (SAMPLES>GW BACKGROUND)	PW BACKGROUND[a,b,e] (SAMPLES>PW BACKGROUND)	MAX PW DETECTED CONCENTRATION [a,b,f] (SAMPLES>MAX PW)
General Chemistry											
Ammonia (mg/L)	14	10	71.4	Yes	0.03	4.5	0.774	-	4.2 mg/L(1)	4.34 mg/L(1)	220 mg/L(0)
Inorganic											
Beryllium (mg/L)	14	2	14.3	No	0.0000674	0.00012	0.0001	0.004 mg/L(0)	-	-	0.0343 mg/L(0)
Cadmium (mg/L)	14	4	28.6	Yes	0.00014	0.00084	0.0004	0.014 mg/L(0)	0.014 mg/L(0)	-	0.05 mg/L(0)
Chromium (mg/L)	14	6	42.9	Yes	0.0012	0.00365	0.0023	0.022 mg/L[g](0)	0.021 mg/L(0)	0.0046 mg/L(0)	0.818 mg/L(0)
Lead (mg/L)	14	2	14.3	No	0.00066	0.0222	0.0114	0.015 mg/L(1)	0.022 mg/L(1)	0.0016 mg/L(1)	0.0114 mg/L(1)
Mercury (mg/L)	28	2	7.1	No	0.00000024	0.00047	0.0002	0.002 mg/L(0)	-	-	0.0018 mg/L(0)
Silver (mg/L)	14	1	7.1	No	0.00014	-	-	0.05 mg/L(0)	0.0117 mg/L(0)	0.0031 mg/L(0)	0.264 mg/L(0)
Thallium (mg/L)	14	2	14.3	No	0.0007	0.00756	0.0041	-	-	-	0.0028 mg/L(1)
Radionuclide											
Technetium-99 (pCi/L)	30	7	23.3	No	1.81	18.3	9.92	94 pCi/L(0)	22 pCi/L(0)	30 pCi/L(0)	6130 pCi/L(0)
Organic											
4-Nitroaniline (ug/L)	27	1	3.7	No	1.01	-	-	-	-	-	-

Note: Shading indicates that at least one detected sample is greater than the FRL, groundwater background, PW background, or PW maximum.

[a]If more than one sample is collected per well per day (e.g., duplicates), then only one sample is counted for the total number of samples, and the sample with the maximum representative concentration is used for all the summary information.

[b]Rejected data qualified with an R or Z were not included.

[c]If the number of detected samples is equal to two, then the minumun and maximumn are reported. If the number of detected is equal to one, then the data point is reported as the minimum. The "AVG DETECTED CONCENTRATION" is not reported for either of these cases.

[d]From Operable Unit 5 Record of Decision, Table 9-4.

[e]From the Characterization of Background Water Quality for Streams and Groundwater which was developed for Operable Unit 5 RI/FS documents.

[f]Max PW - maximum detected concentration in perched water as defined in the Remedial Investigation Report for Operable Unit 5.

[g]FRL based on hexavalent chromium from Operable Unit 5 Record of Decision, Table 9-4.

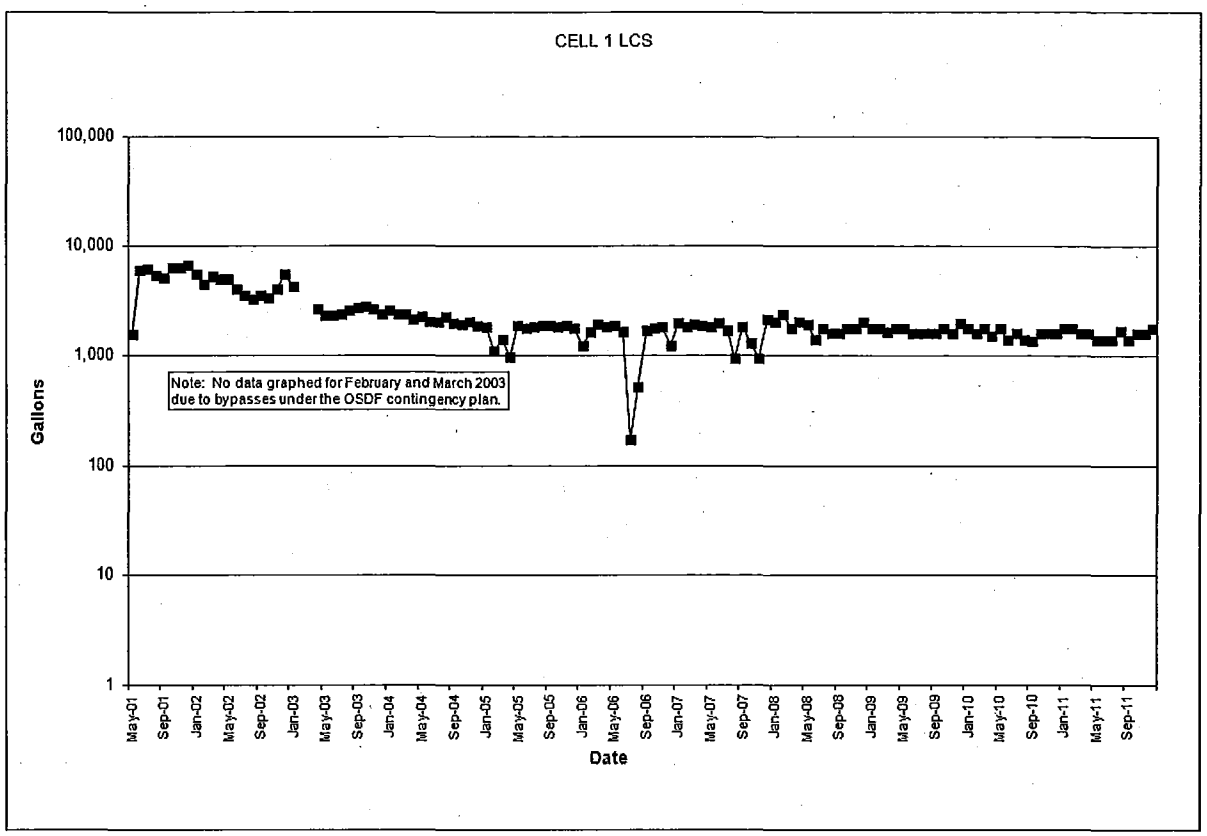


Figure A.5.1–1. Monthly Accumulation Volumes For Cell 1 LCS

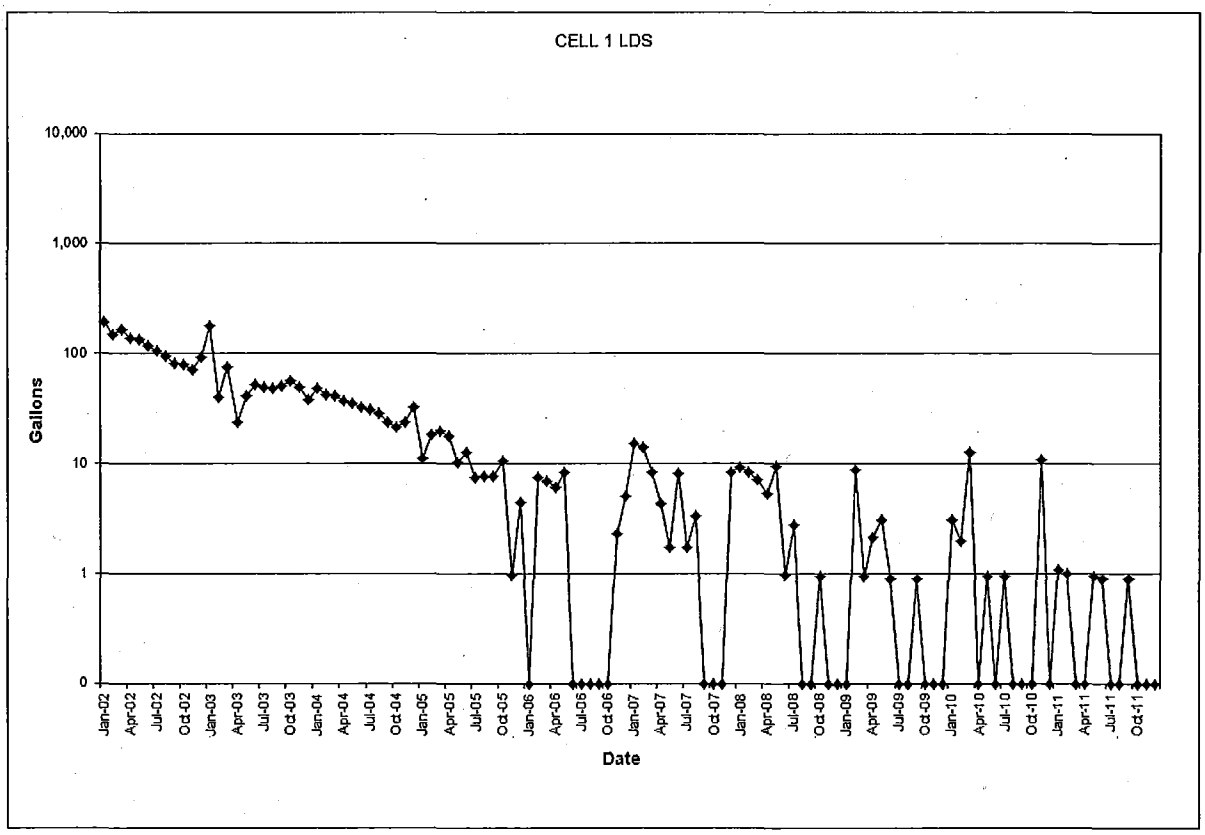
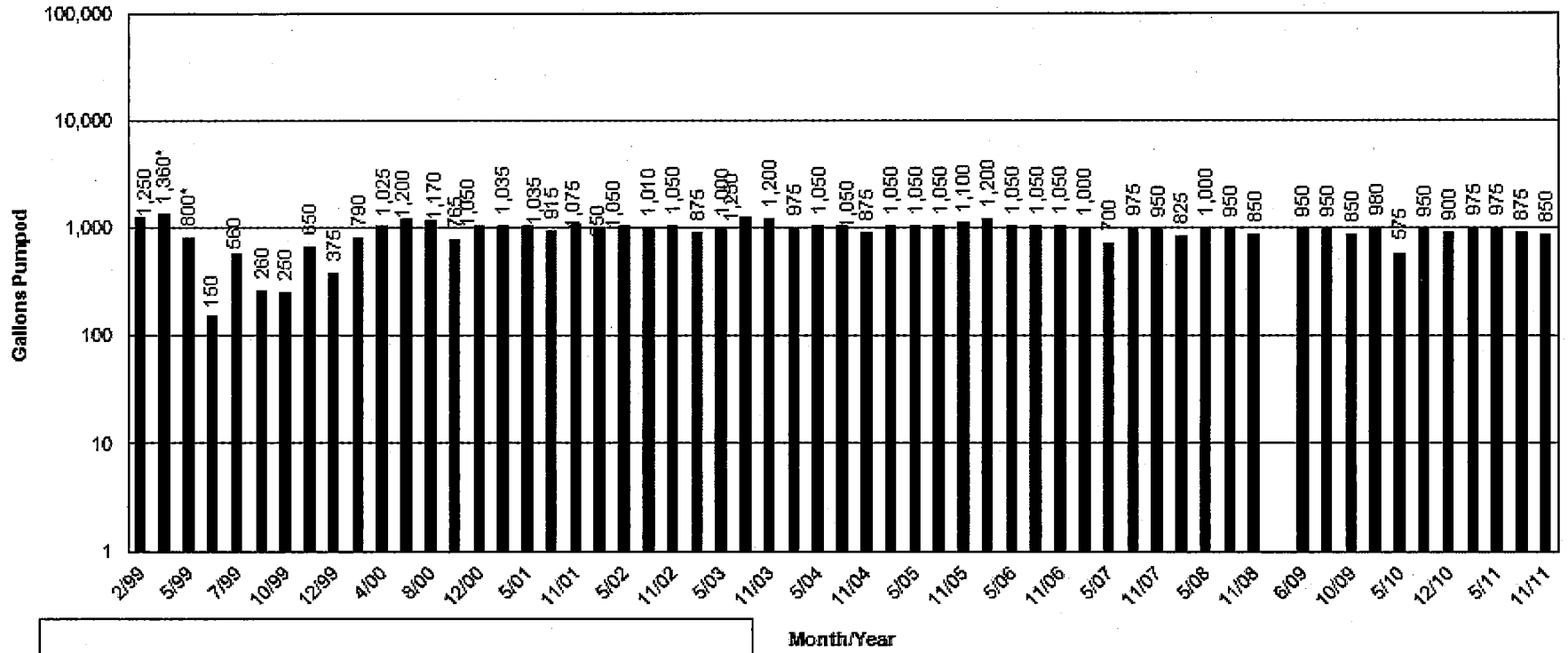


Figure A.5.1–2. Monthly Accumulation Volumes For Cell 1 LDS



12338 Purge Information

Year	Total Volumes (gal.)	Months Purged	Avg. Monthly Purge (gal.)
1999:	5655	n=9	628
2000:	6000	n=6	1000
2001:	4060	n=4	1015
2002:	4060	n=4	1015
2003:	4325	n=4	1081
2004:	3950	n=4	988
2005:	4250	n=4	1063
2006:	4350	n=4	1088
2007:	3625	n=4	906
2008:	3625	n=4	906
2009:	2750	n=3	917
2010:	3405	n=4	851
2011:	3675	n=4	919
Overall:			926

*More than one purge of the well was completed during these months to help evaluate well yield.

Figure A.5.1–3. OSDF Horizontal Till Well 12338 (Cell 1) Water Yield

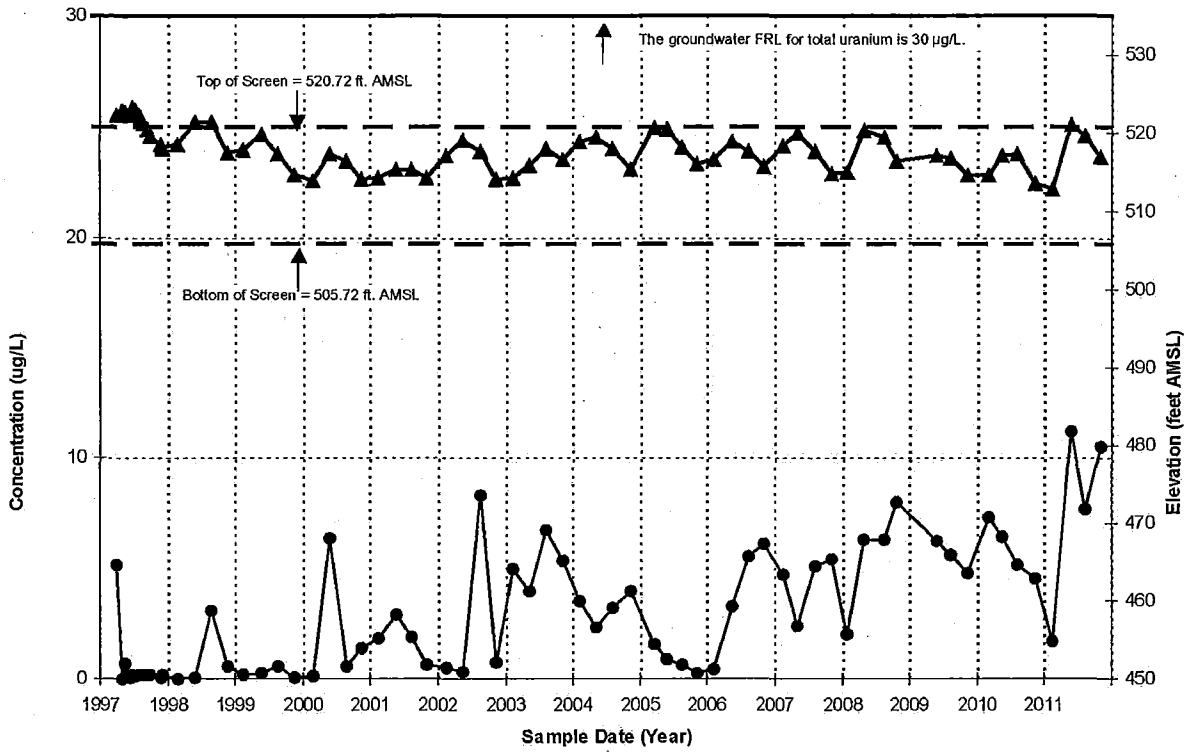


FIGURE A.5.1-4. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 1 Upgradient Monitoring Well 22201

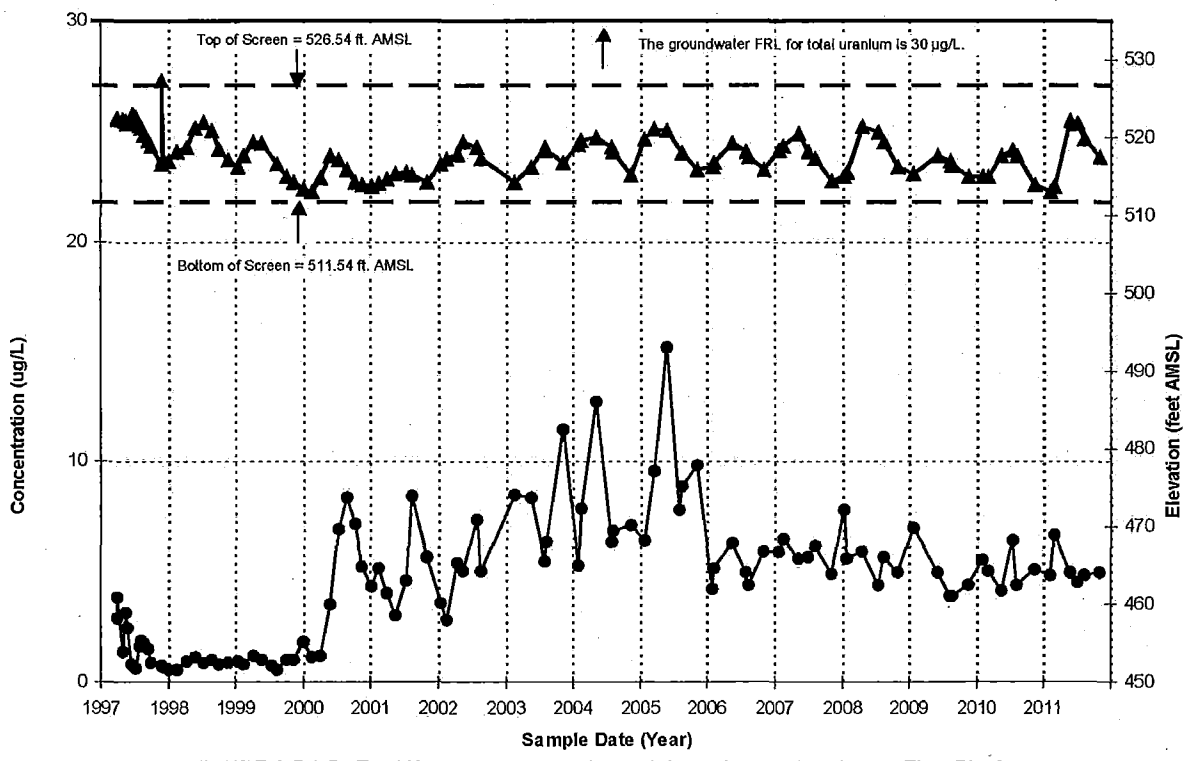


FIGURE A.5.1-5. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 1 Downgradient Monitoring Well 22198

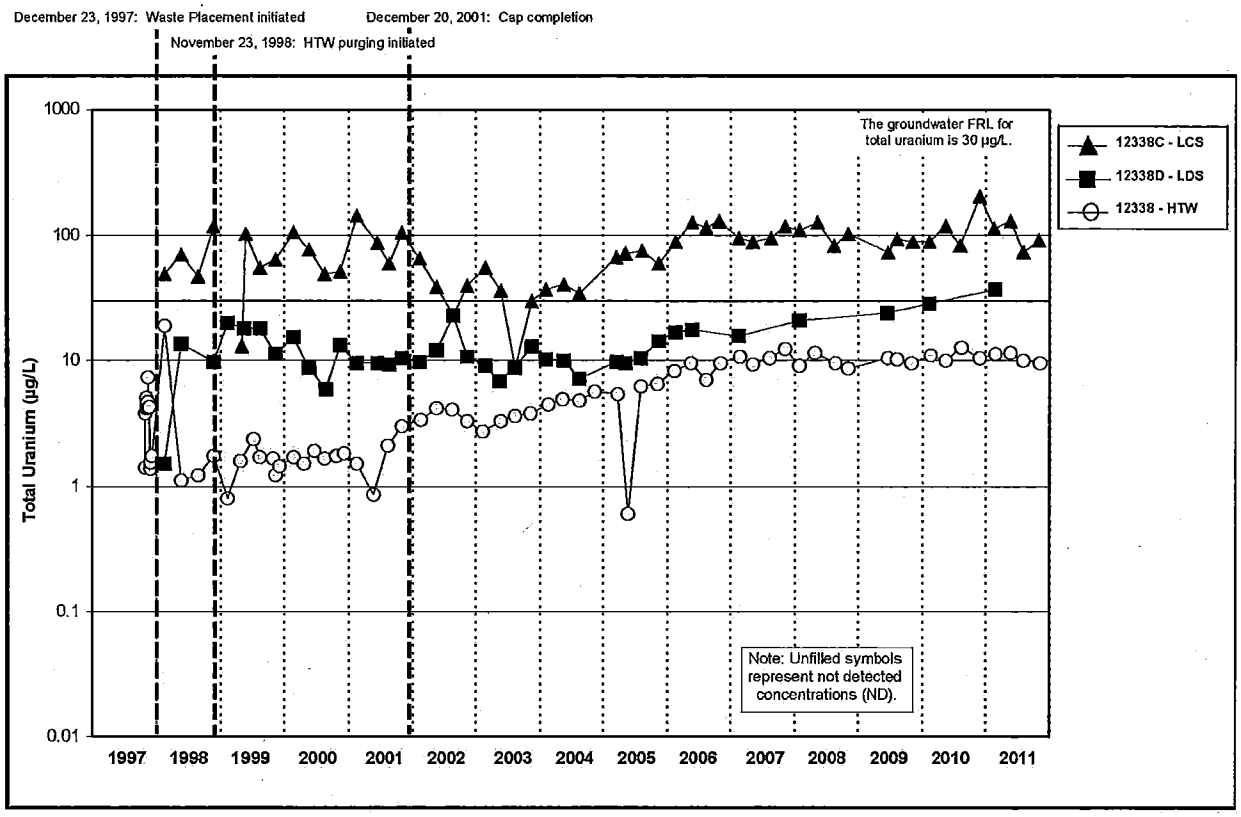


Figure A.5.1-6A. Cell 1 Total Uranium Concentration vs. Time Plot for LCS, LDS, and HTW

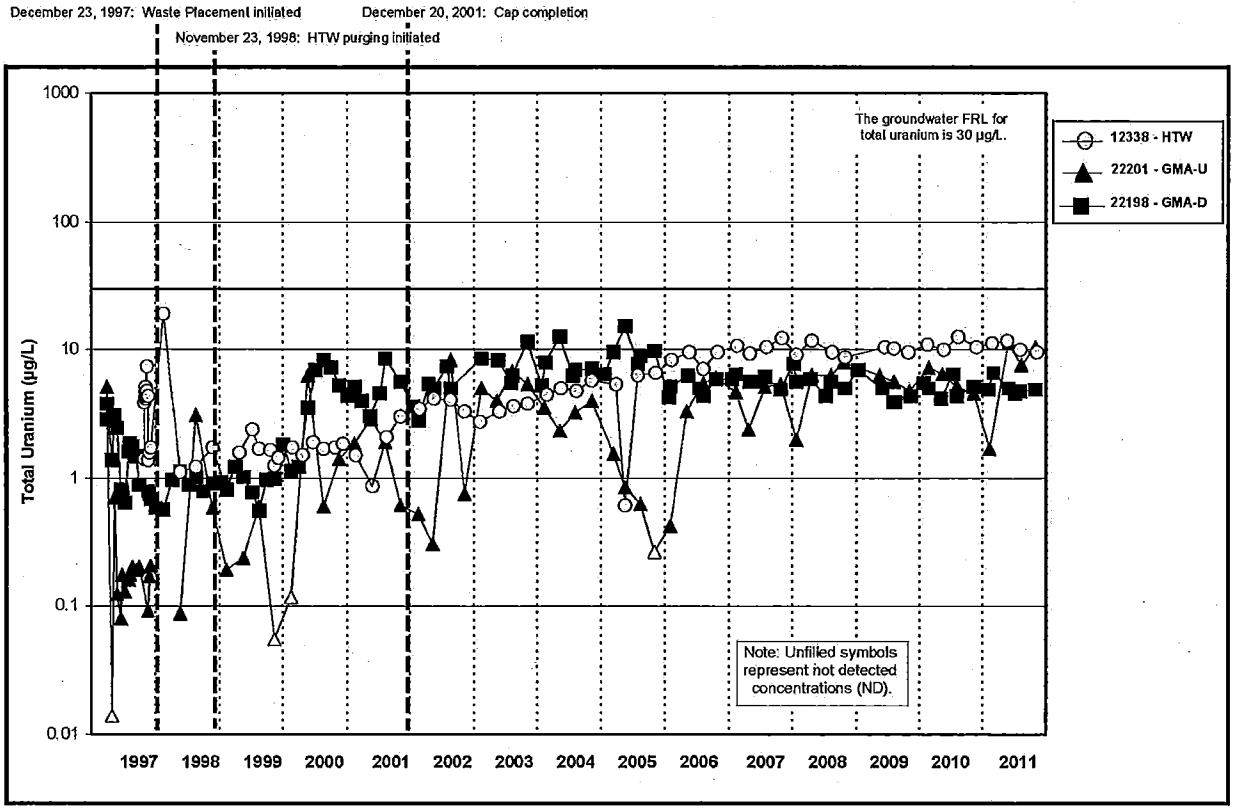


Figure A.5.1-6B. Cell 1 Total Uranium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

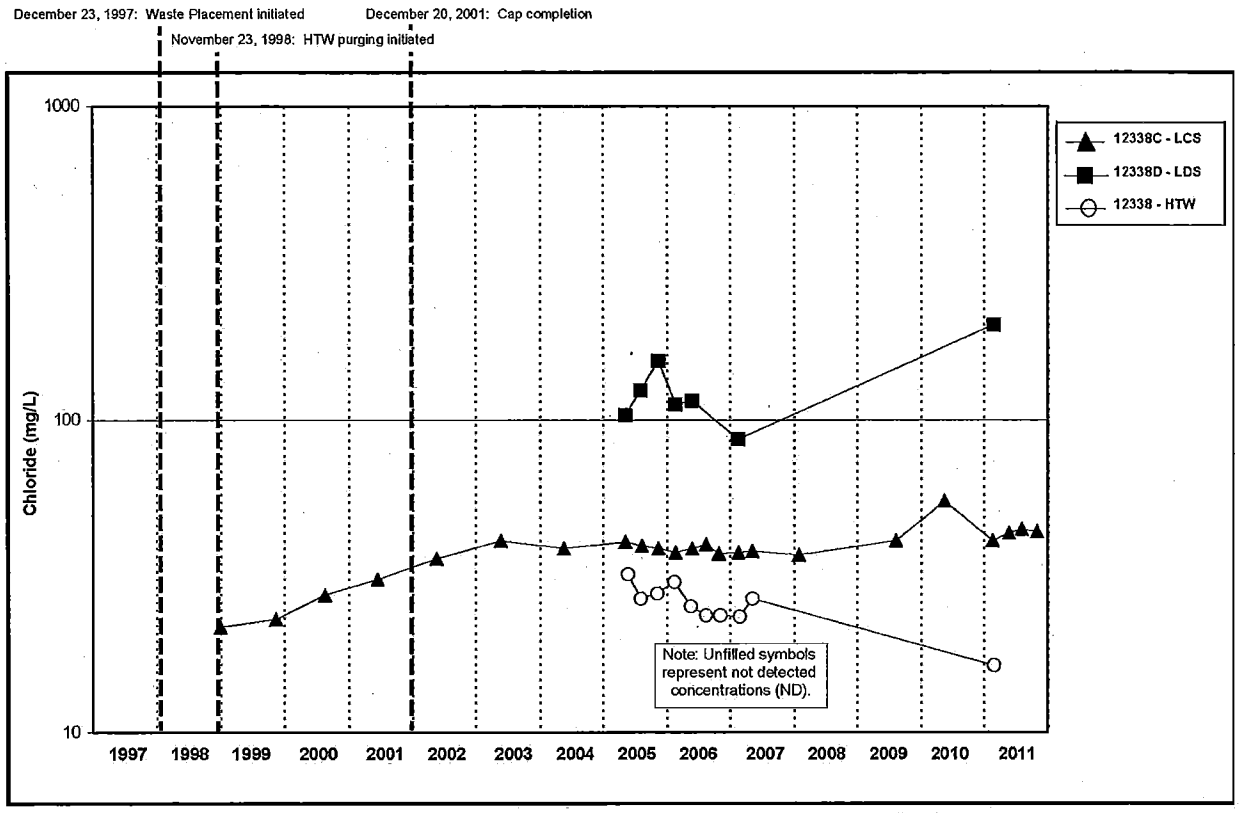


Figure A.5.1-7A. Cell 1 Chloride Concentration vs. Time Plot for LCS, LDS, and HTW

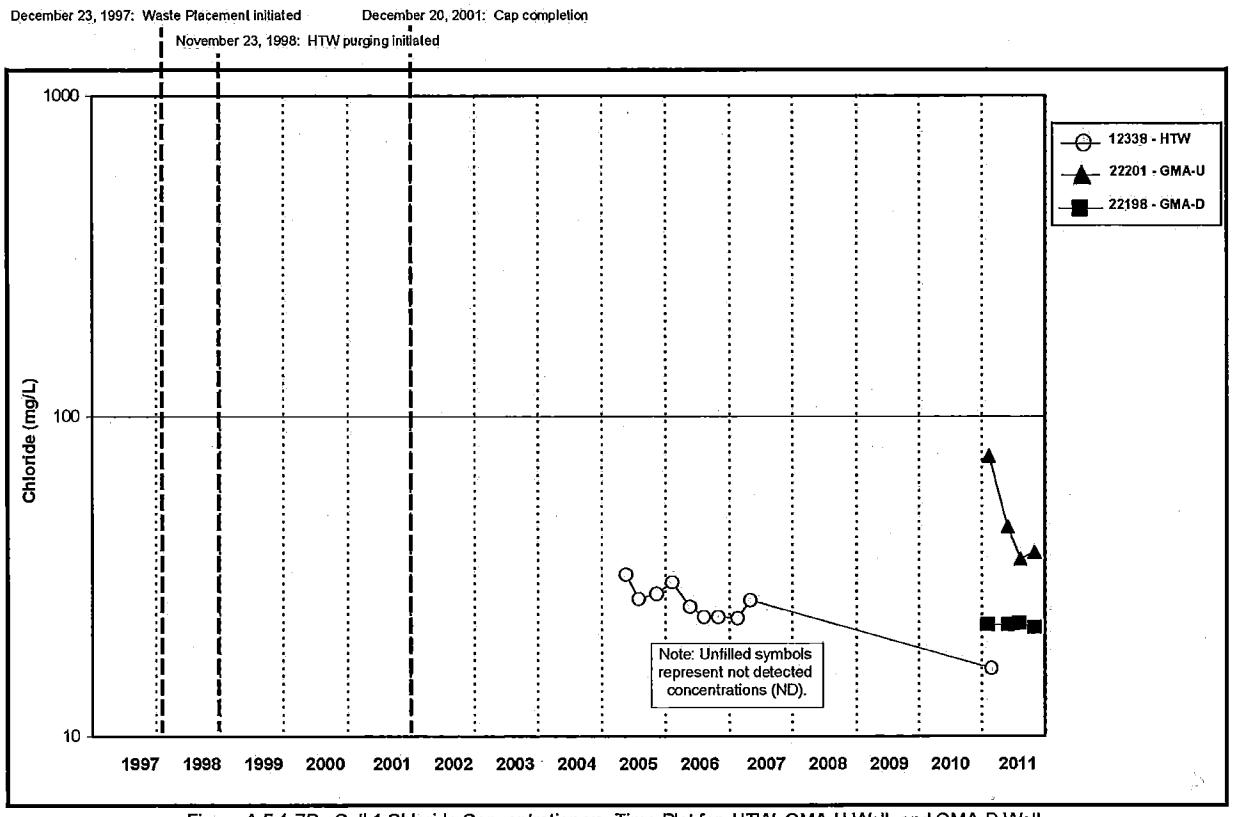


Figure A.5.1-7B. Cell 1 Chloride Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

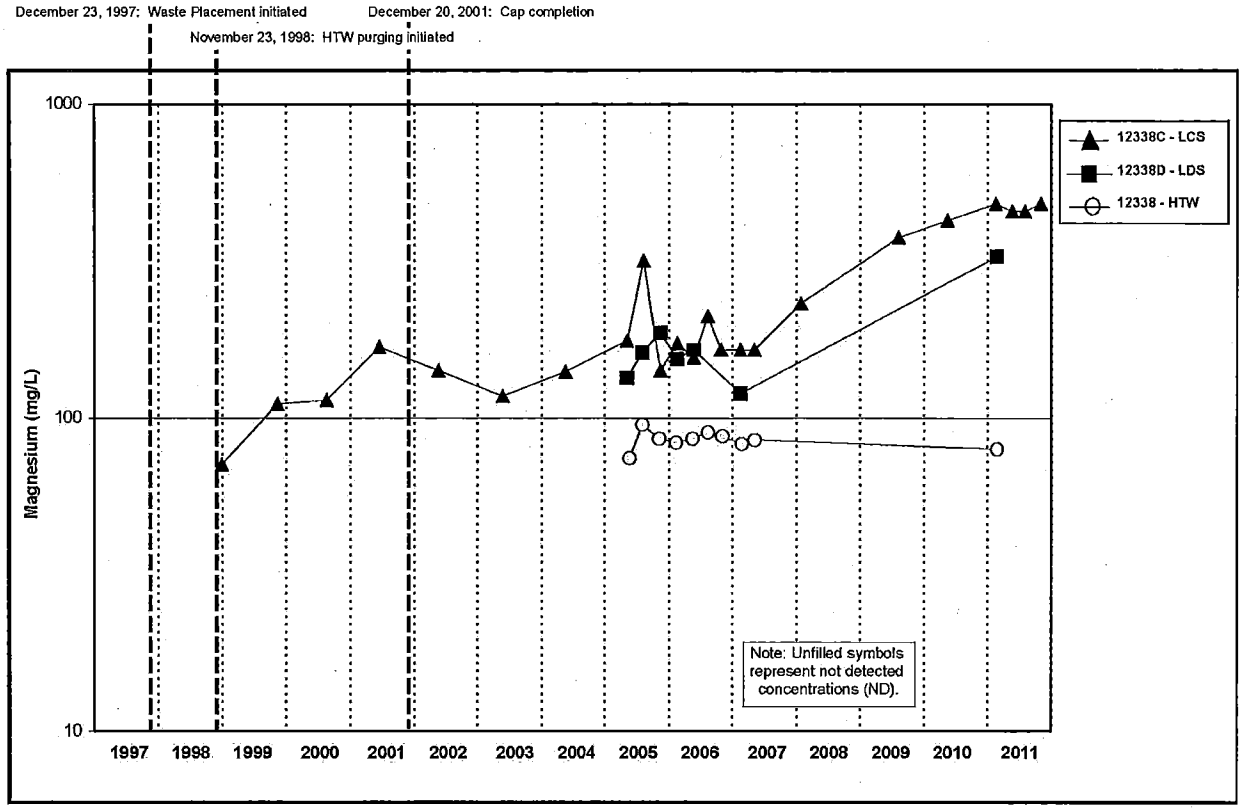


Figure A.5.1-8A. Cell 1 Magnesium Concentration vs. Time Plot for LCS, LDS, and HTW

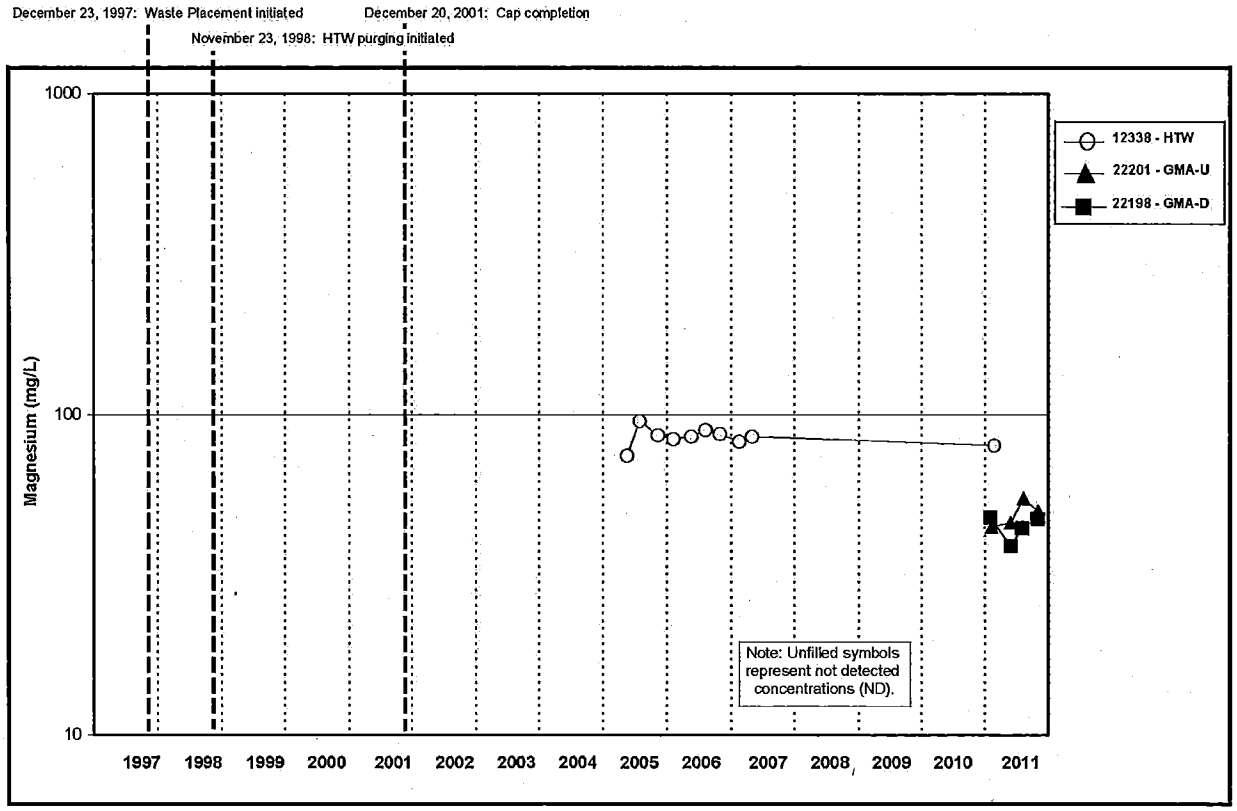


Figure A.5.1-8B. Cell 1 Magnesium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

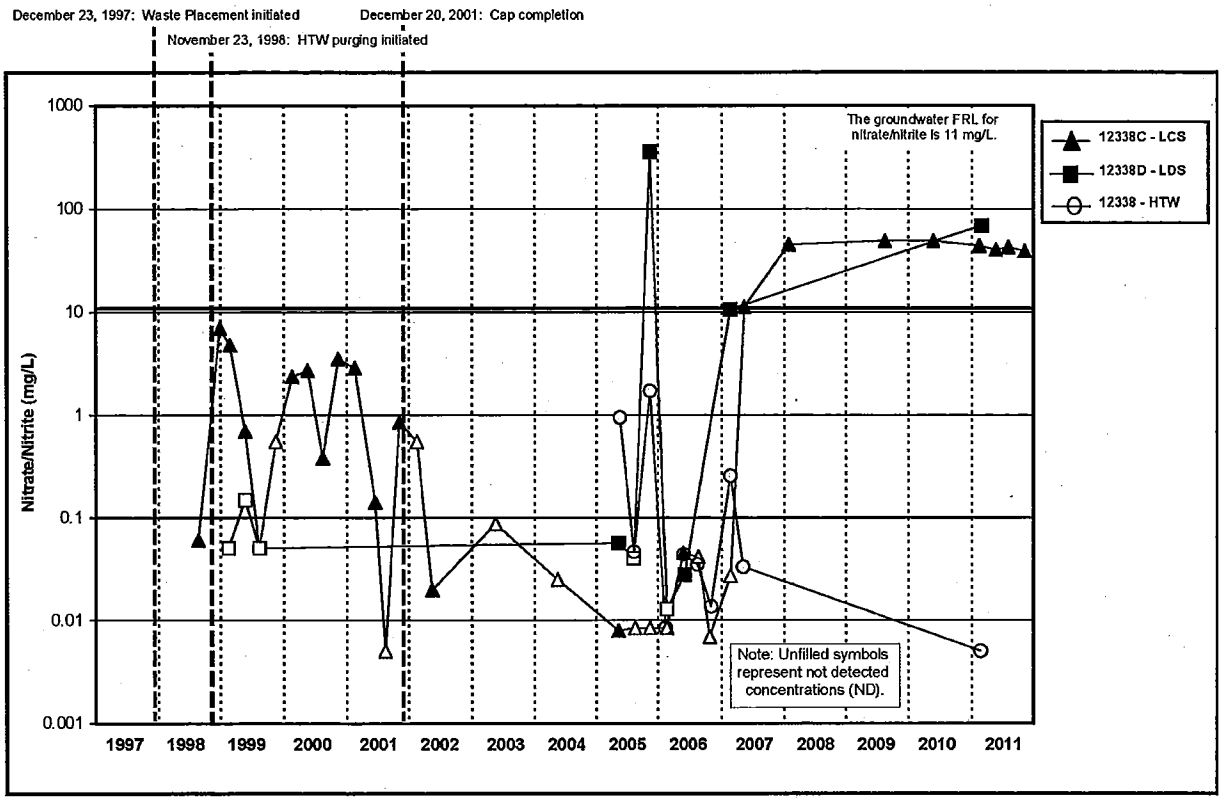


Figure A.5.1-9A. Cell 1 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for LCS, LDS, and HTW

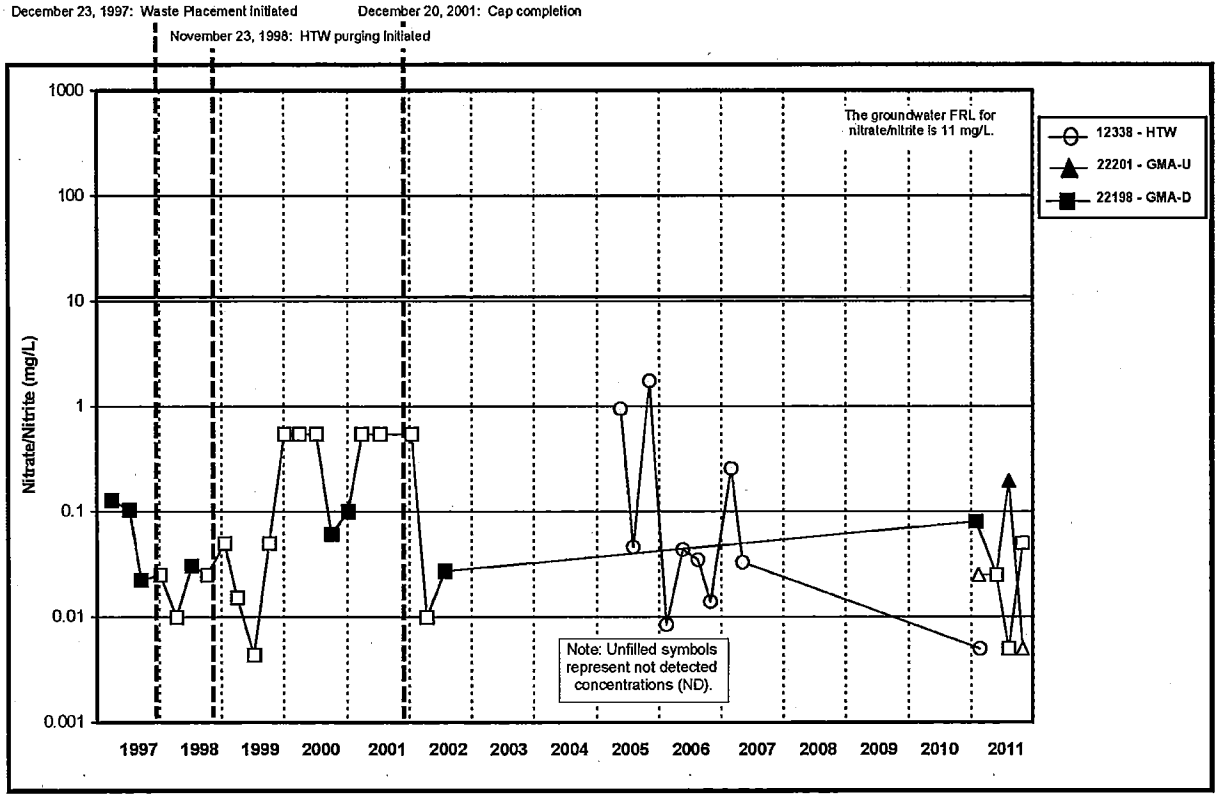


Figure A.5.1-9B. Cell 1 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

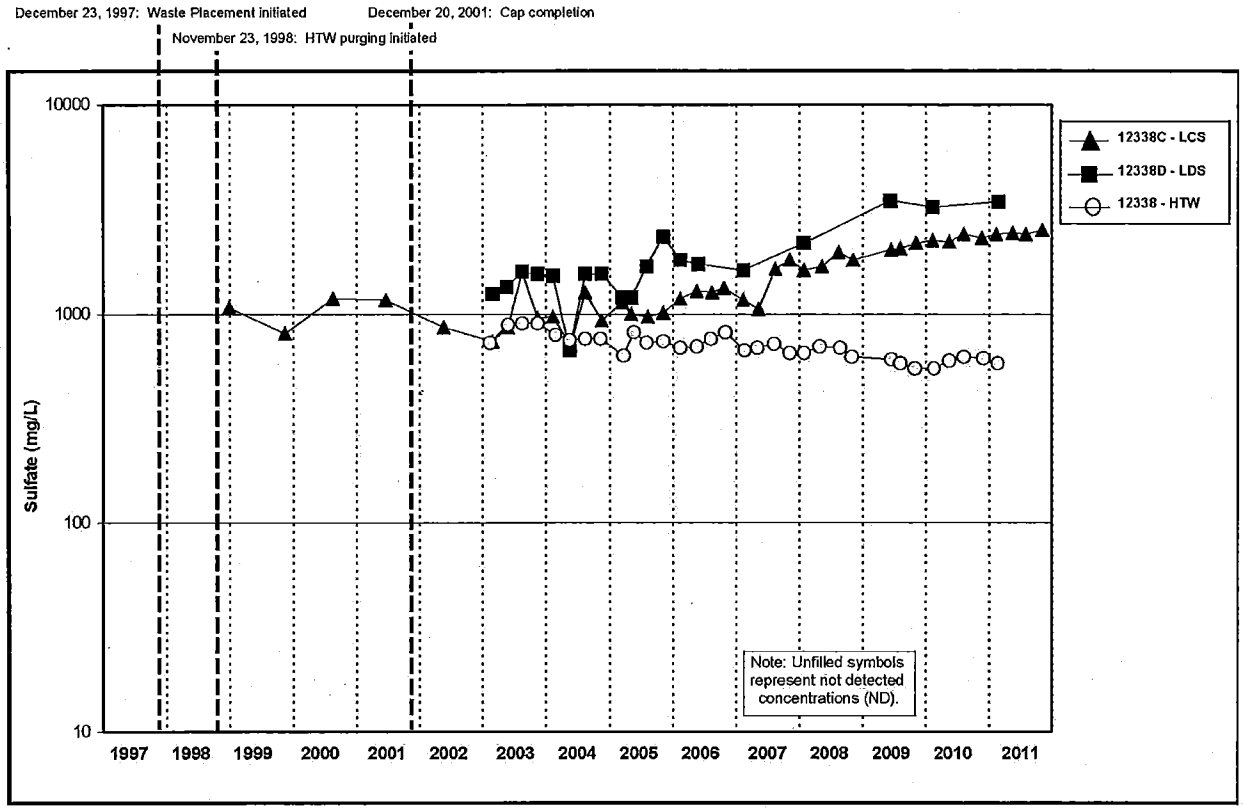


Figure A.5.1-10A. Cell 1 Sulfate Concentration vs. Time Plot for LCS, LDS, and HTW

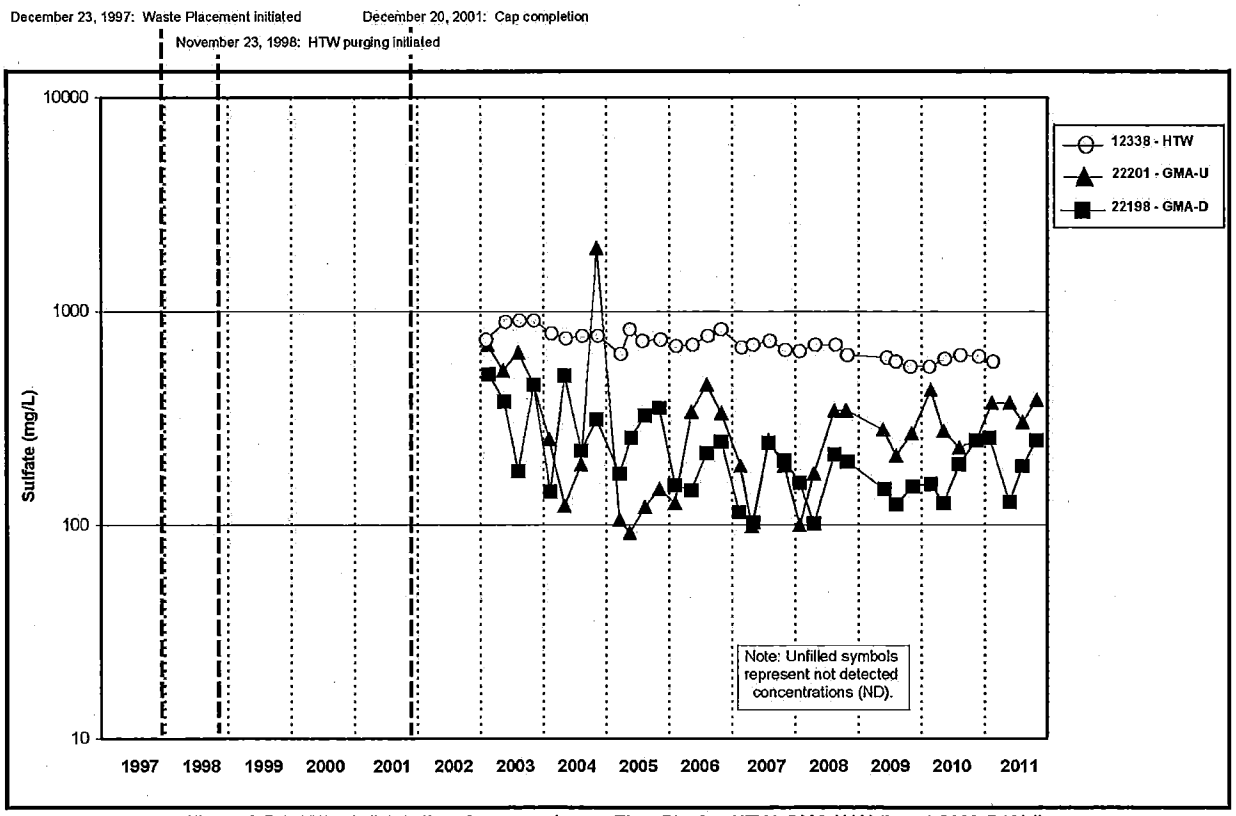


Figure A.5.1-10B. Cell 1 Sulfate Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

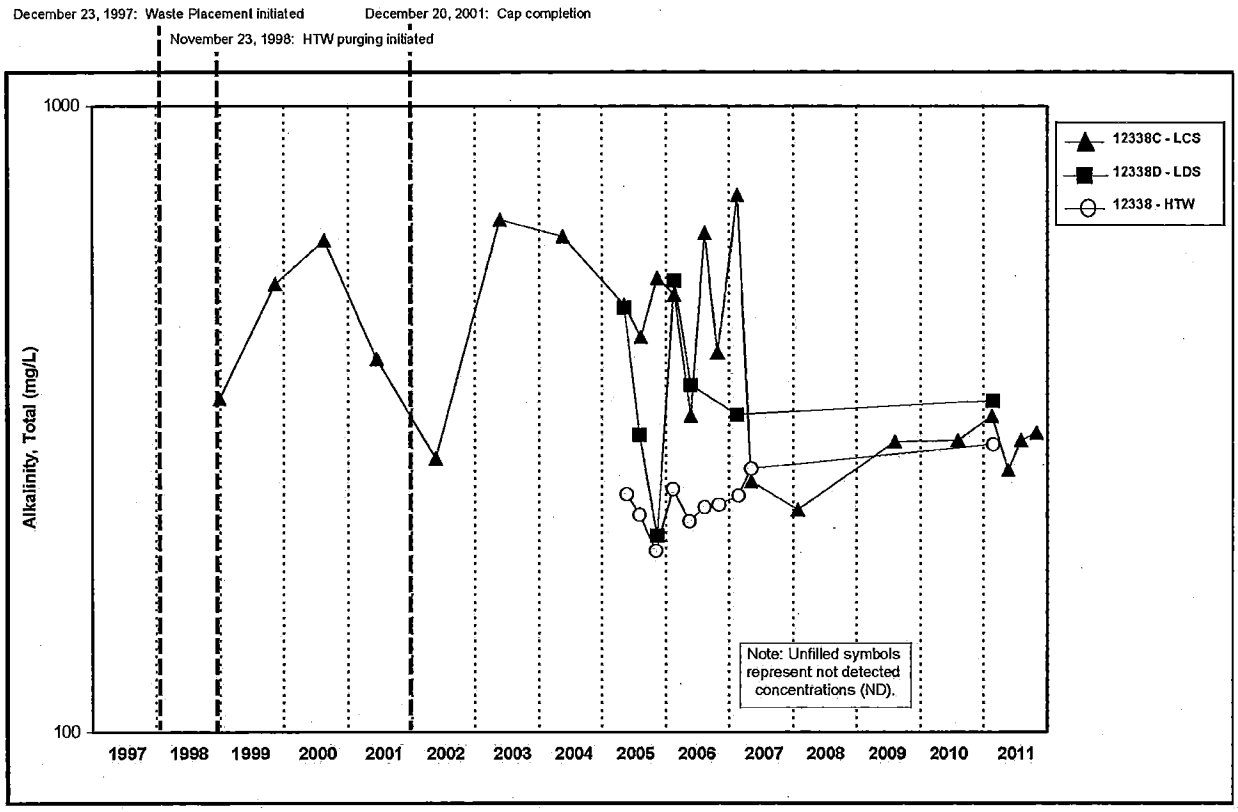


Figure A.5.1-11A. Cell 1 Alkalinity, Total (As CaCO3) Concentration vs. Time Plot for LCS, LDS, and HTW

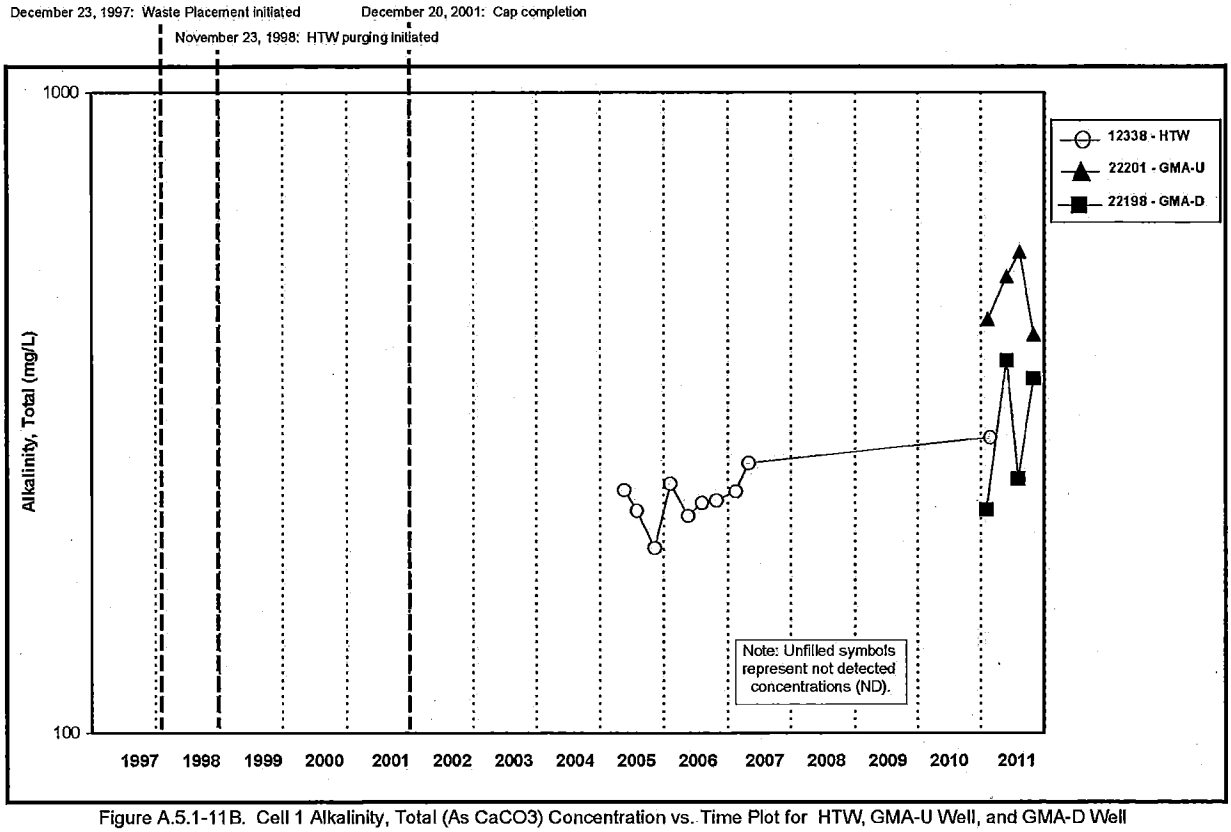


Figure A.5.1-11B. Cell 1 Alkalinity, Total (As CaCO3) Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

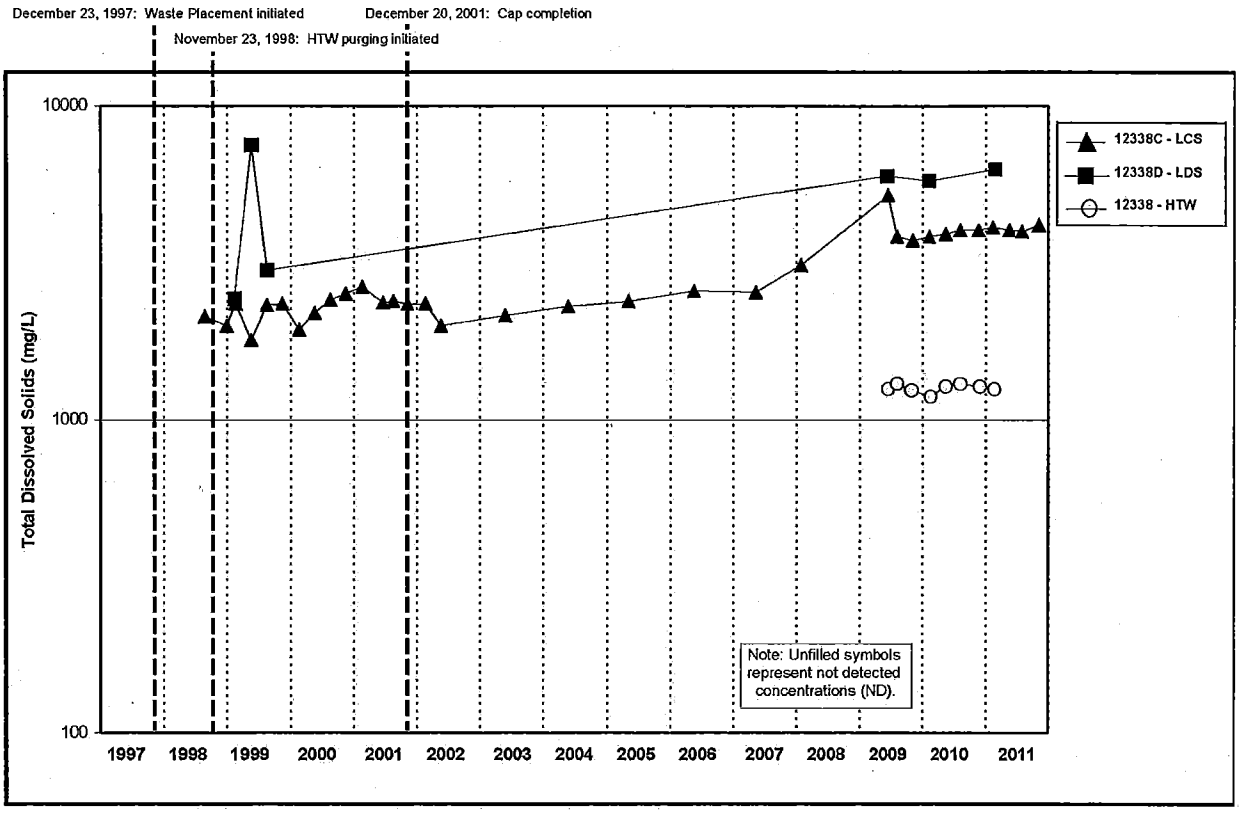


Figure A.5.1-12A. Cell 1 Total Dissolved Solids Concentration vs. Time Plot for LCS, LDS, and HTW

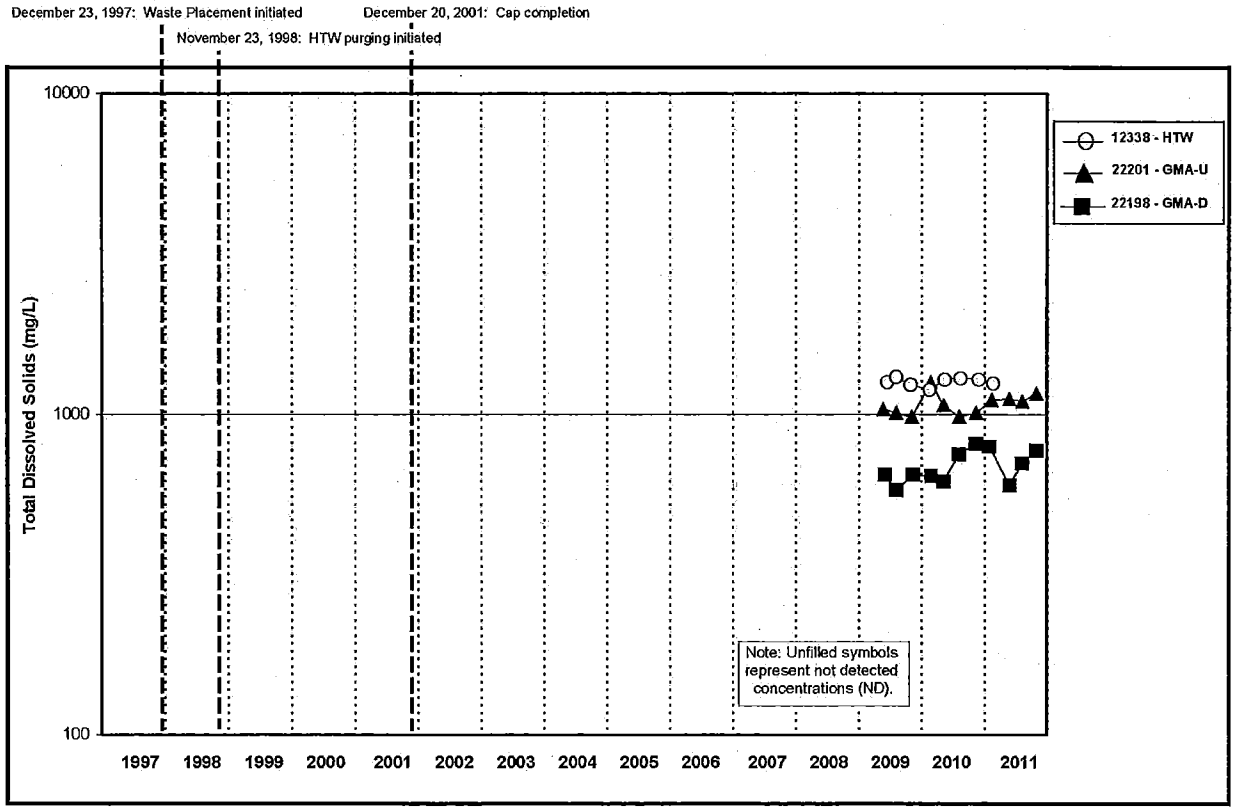


Figure A.5.1-12B. Cell 1 Total Dissolved Solids Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

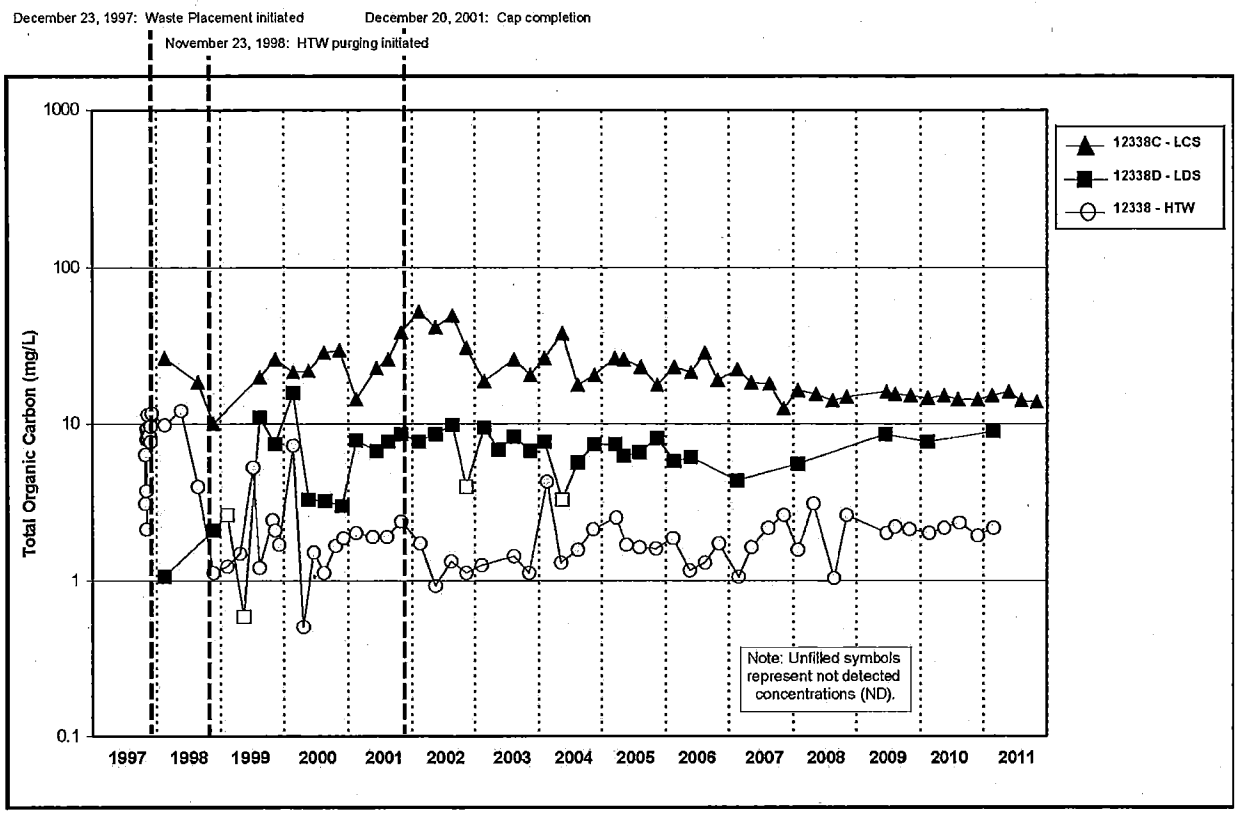


Figure A.5.1-13A. Cell 1 Total Organic Carbon Concentration vs. Time Plot for LCS, LDS, and HTW

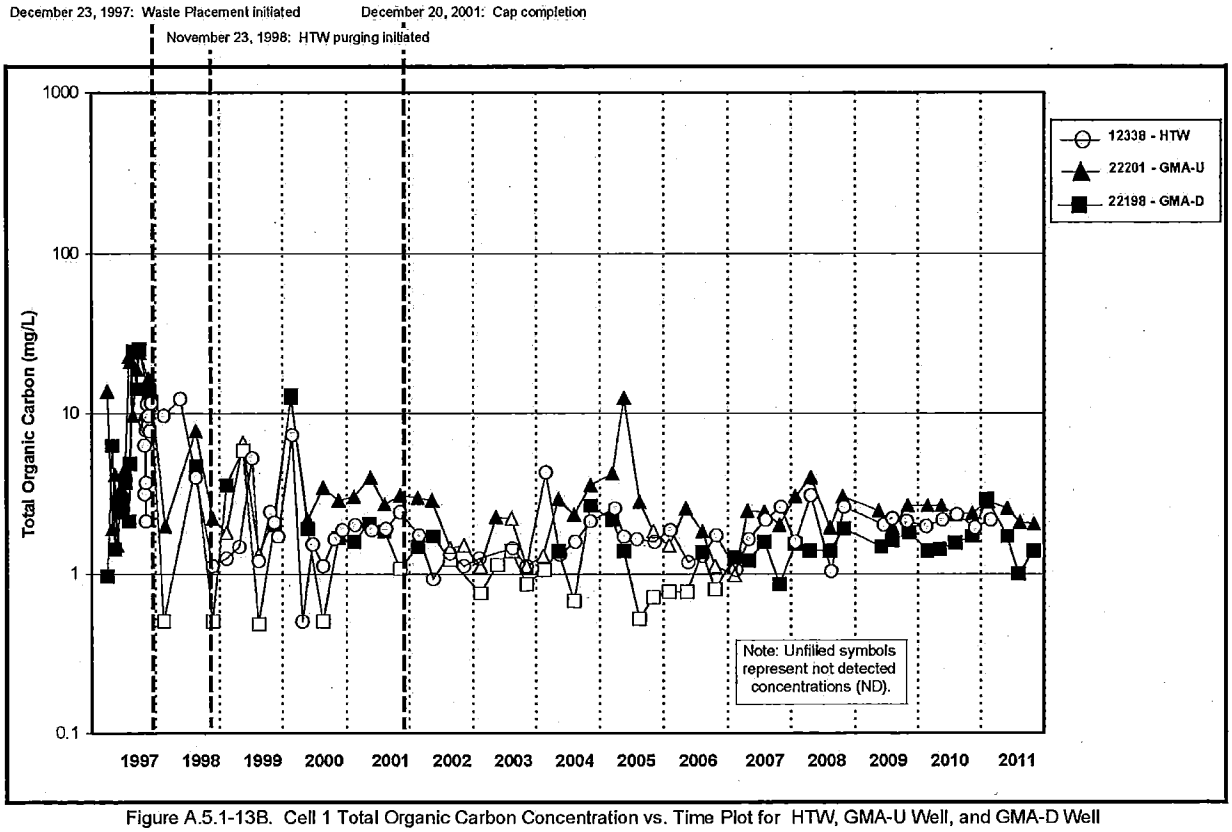


Figure A.5.1-13B. Cell 1 Total Organic Carbon Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

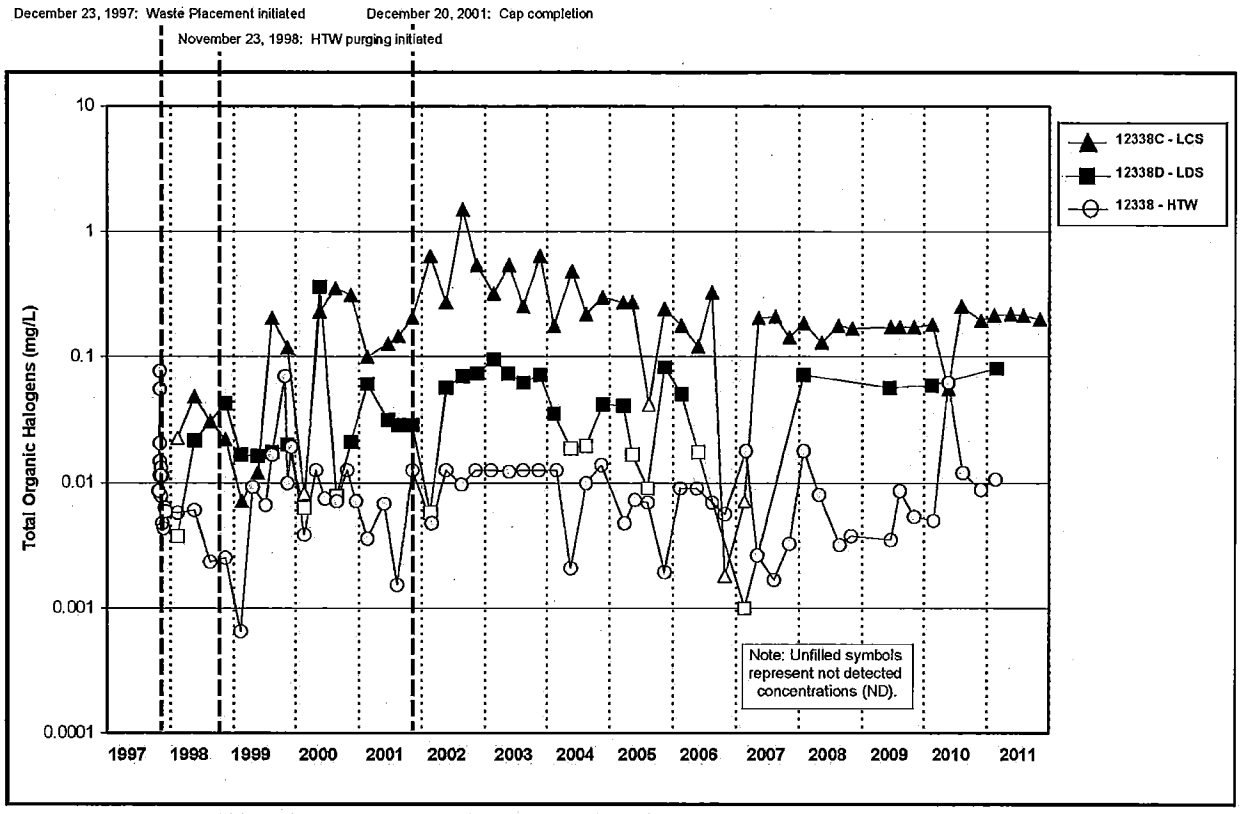


Figure A.5.1-14A. Cell 1 Total Organic Halogens Concentration vs. Time Plot for LCS, LDS, and HTW

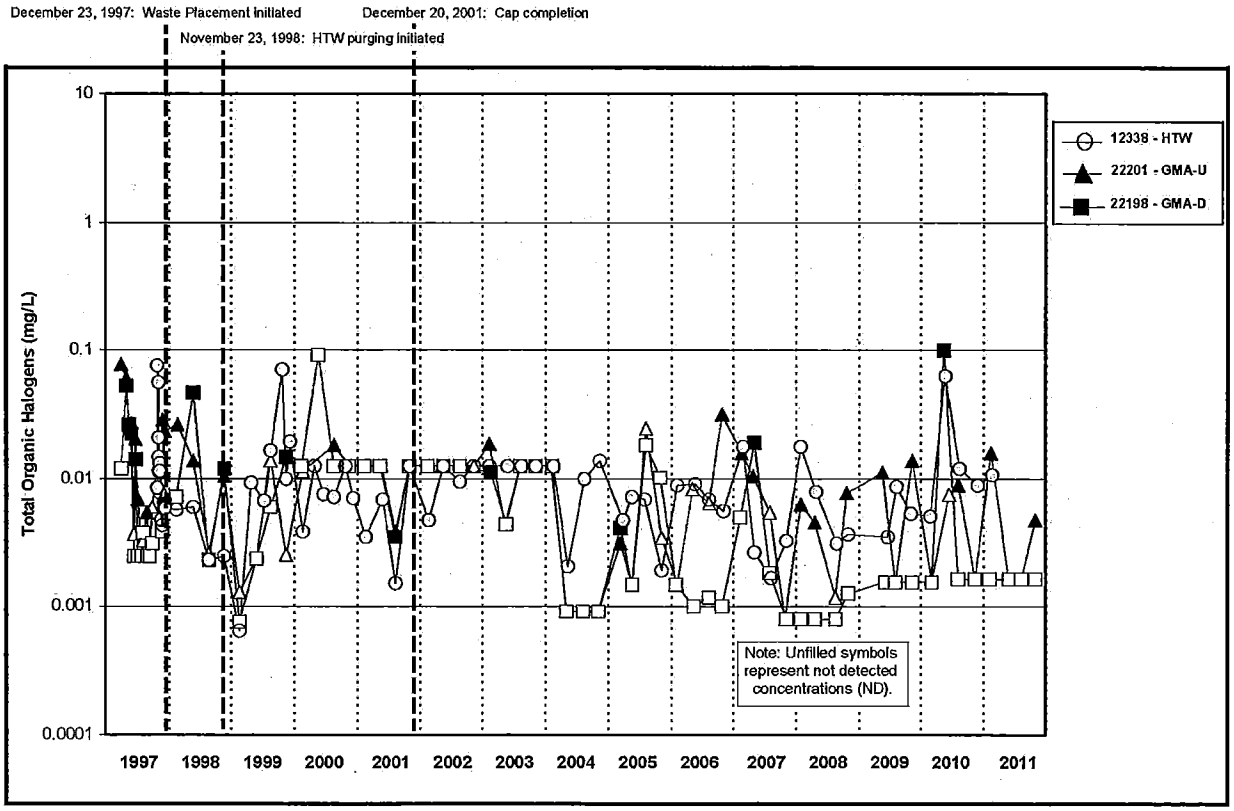


Figure A.5.1-14B. Cell 1 Total Organic Halogens Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

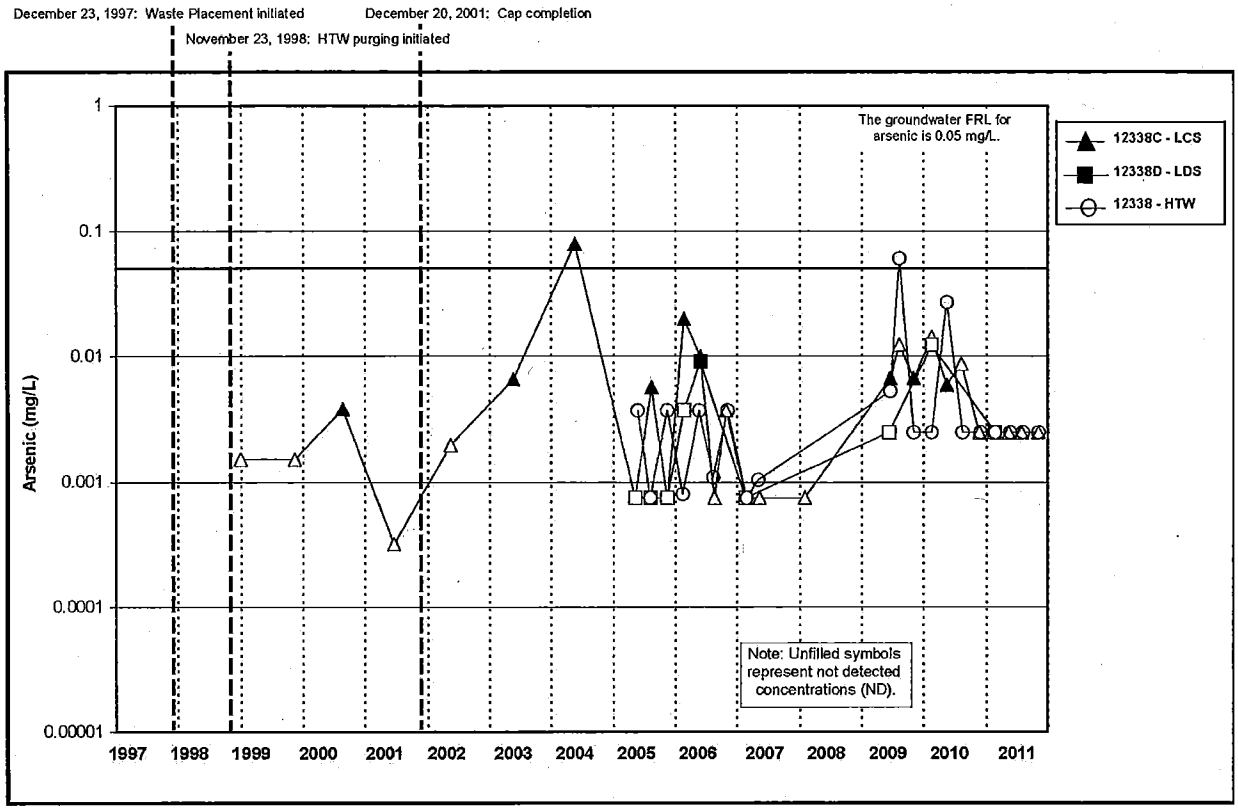


Figure A.5.1-15A. Cell 1 Arsenic Concentration vs. Time Plot for LCS, LDS, and HTW

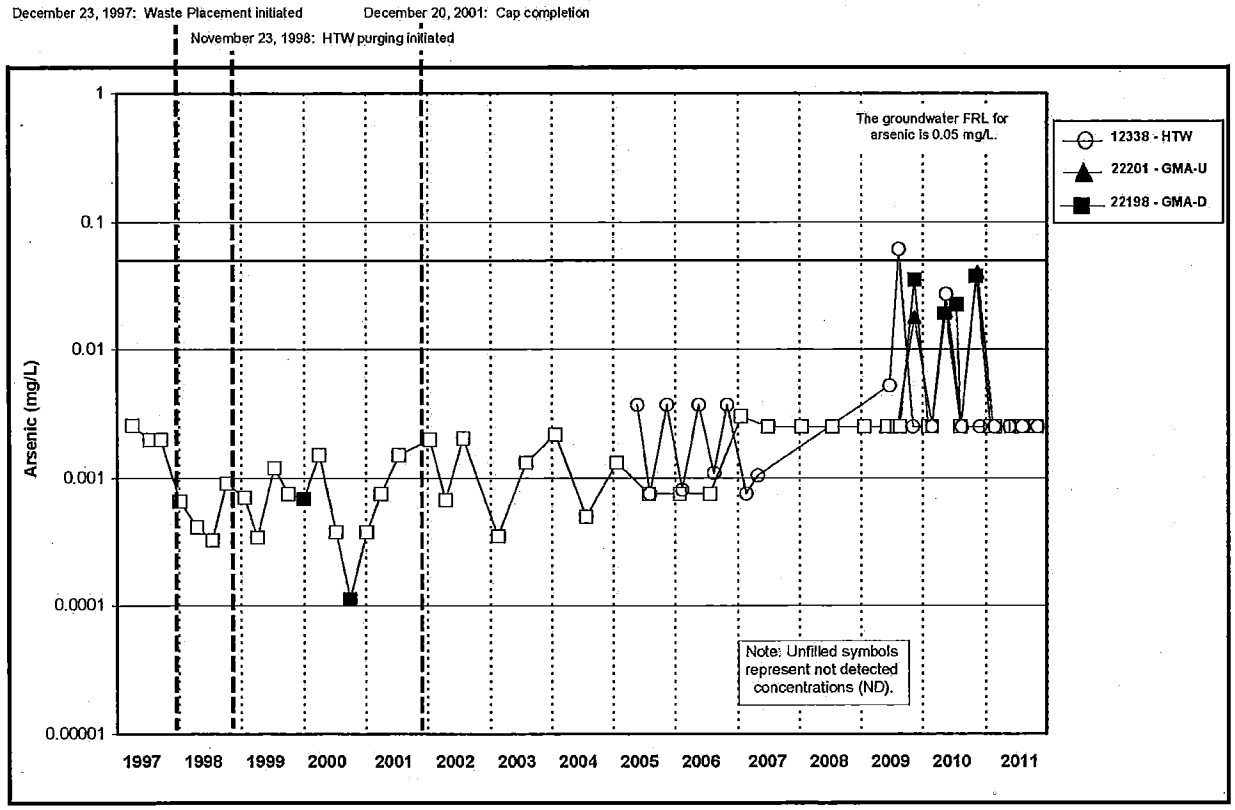


Figure A.5.1-15B. Cell 1 Arsenic Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

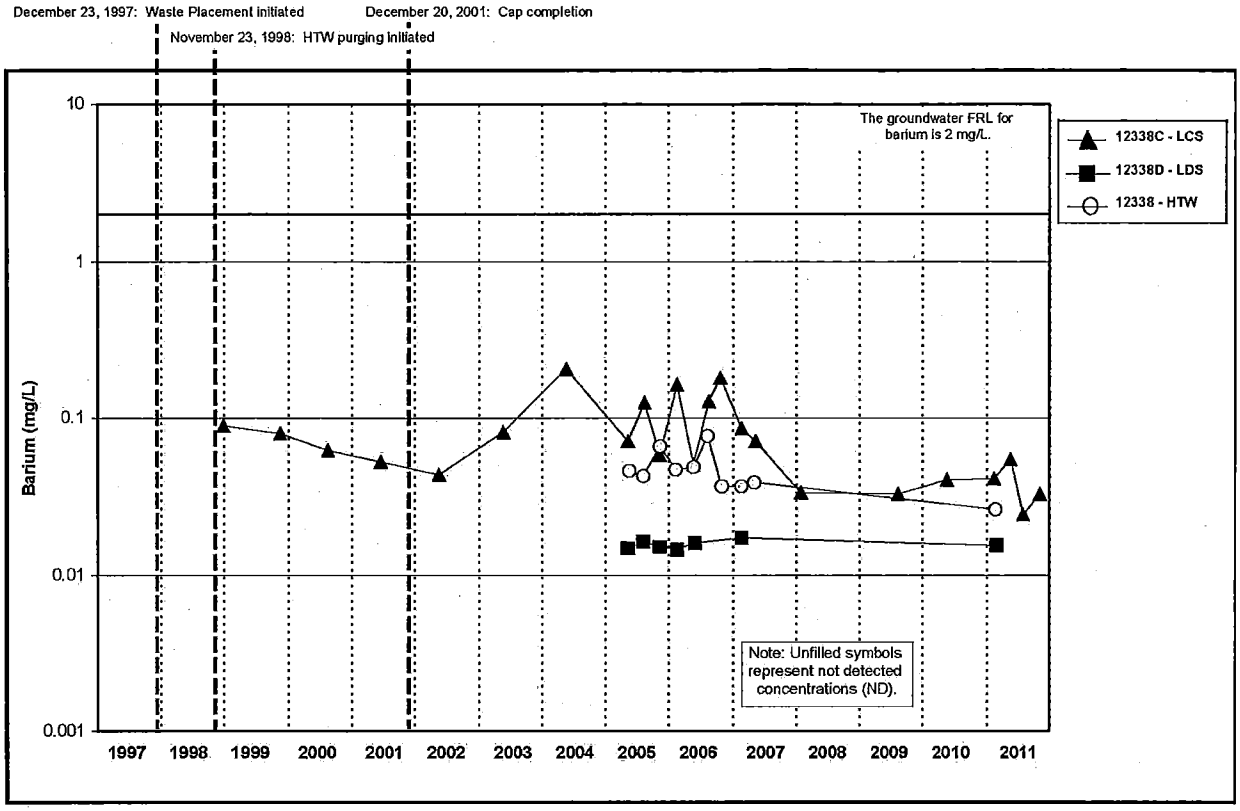


Figure A.5.1-16A. Cell 1 Barium Concentration vs. Time Plot for LCS, LDS, and HTW

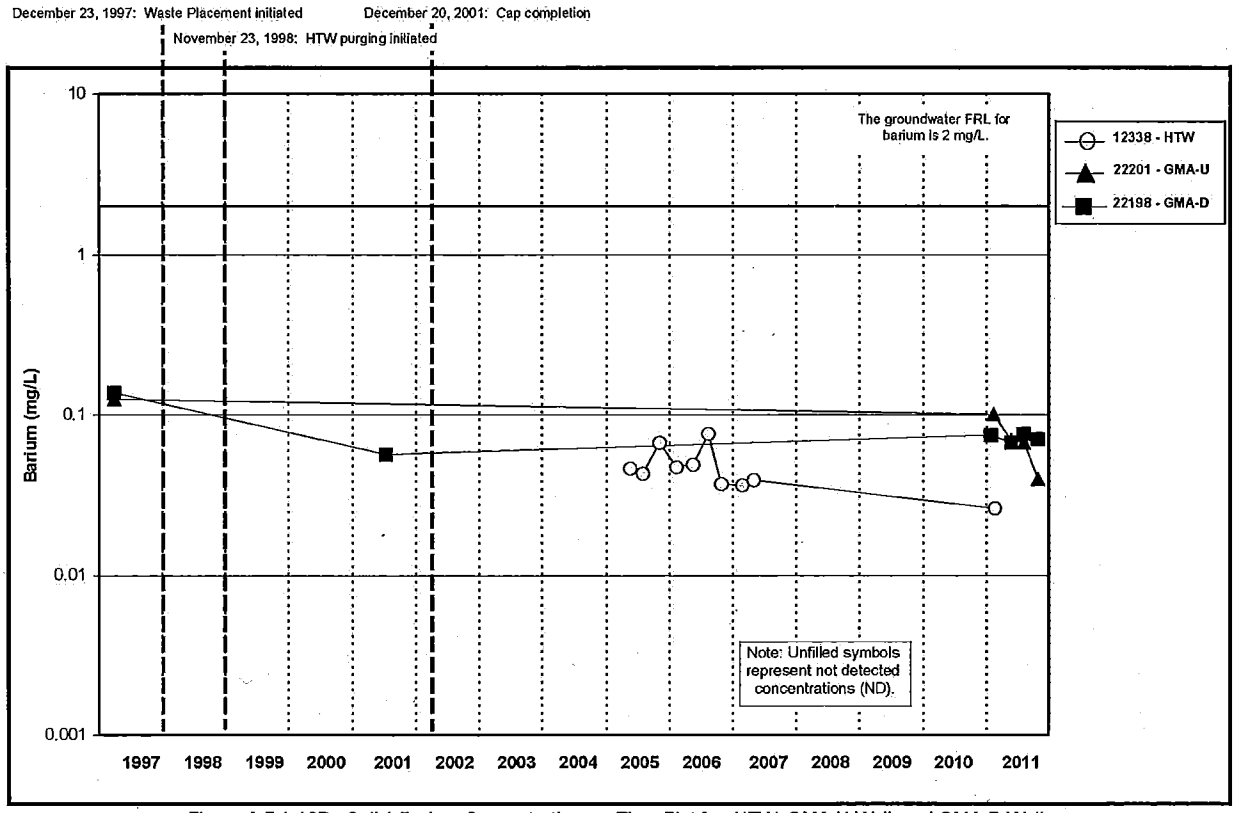


Figure A.5.1-16B. Cell 1 Barium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

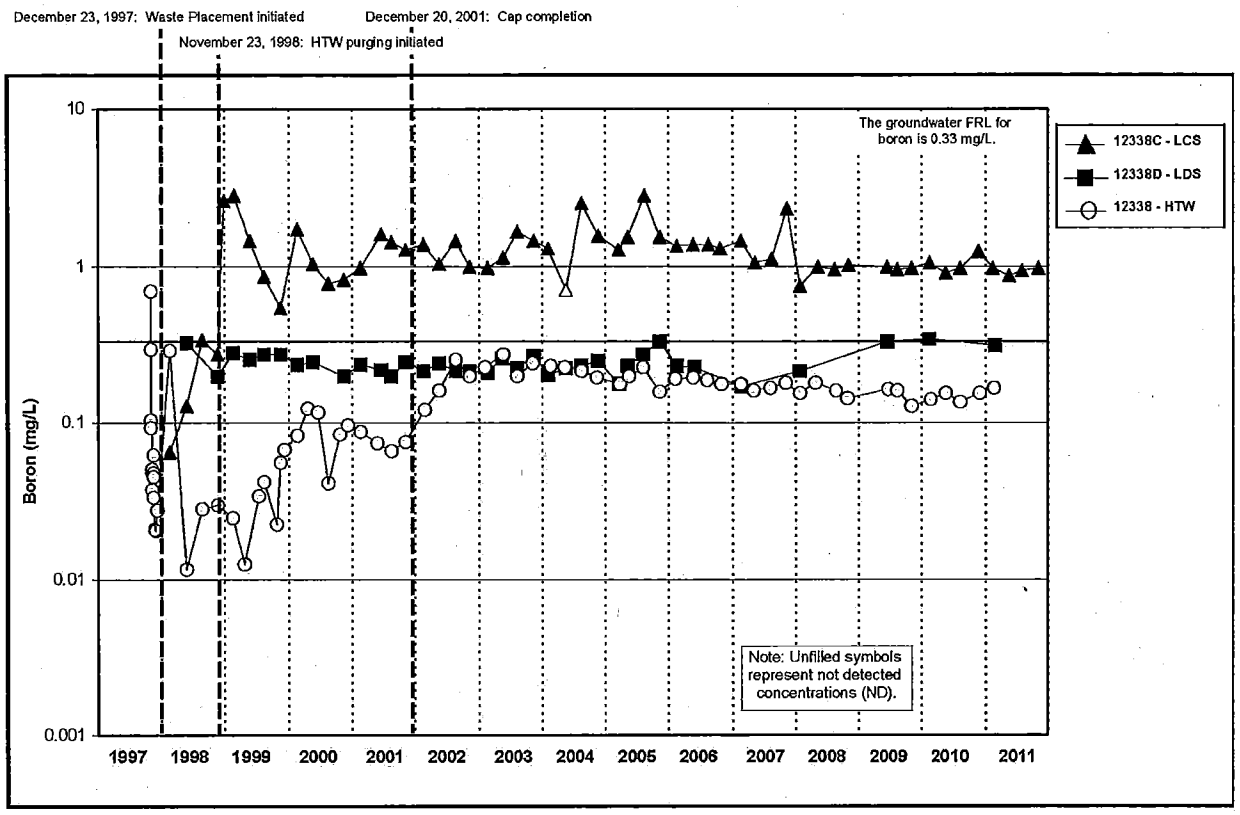


Figure A.5.1-17A. Cell 1 Boron Concentration vs. Time Plot for LCS, LDS, and HTW

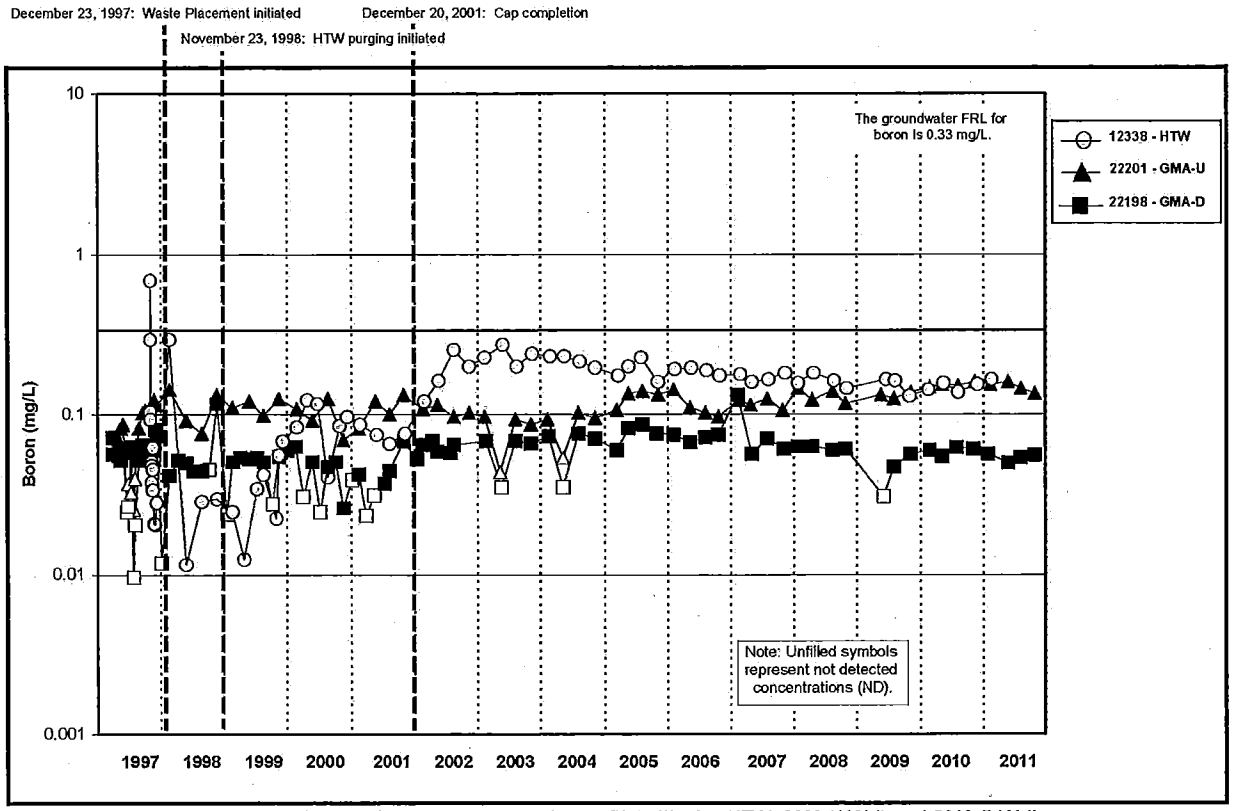


Figure A.5.1-17B. Cell 1 Boron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

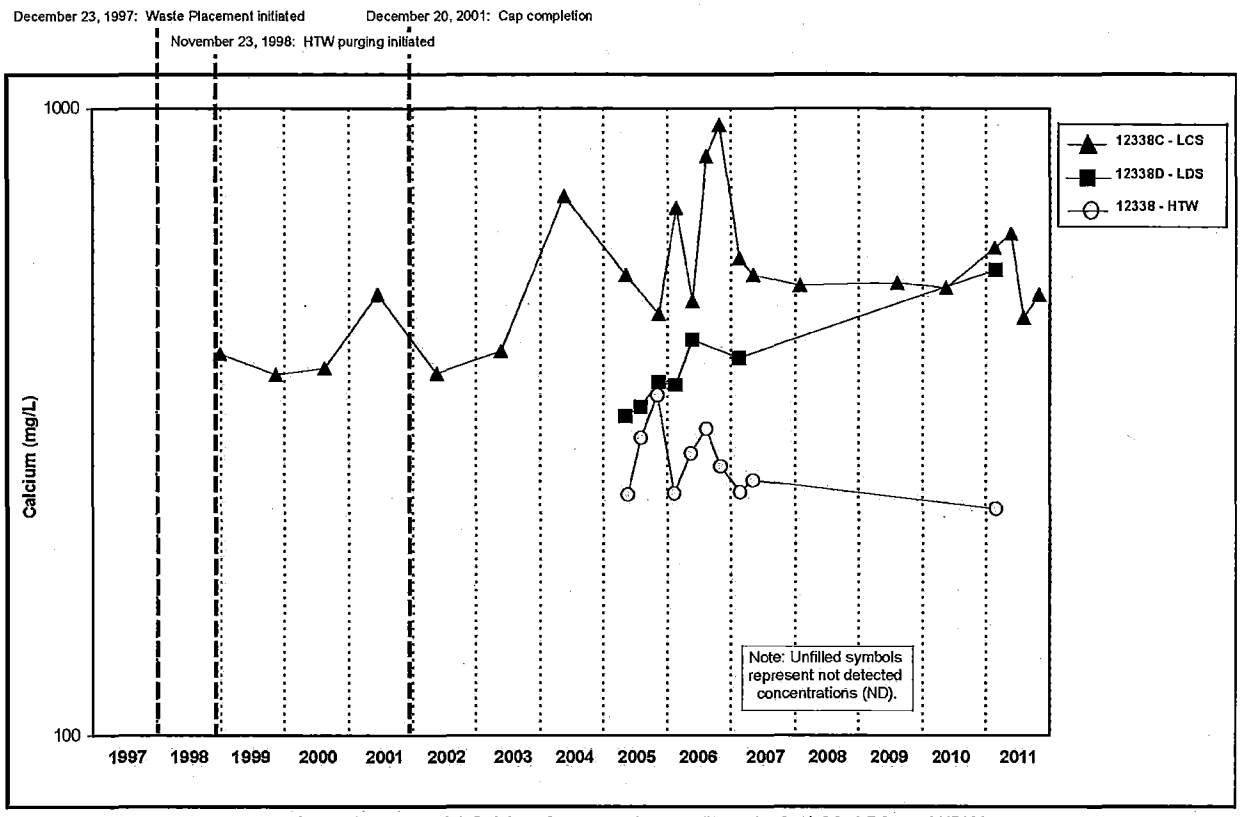


Figure A.5.1-18A. Cell 1 Calcium Concentration vs. Time Plot for LCS, LDS, and HTW

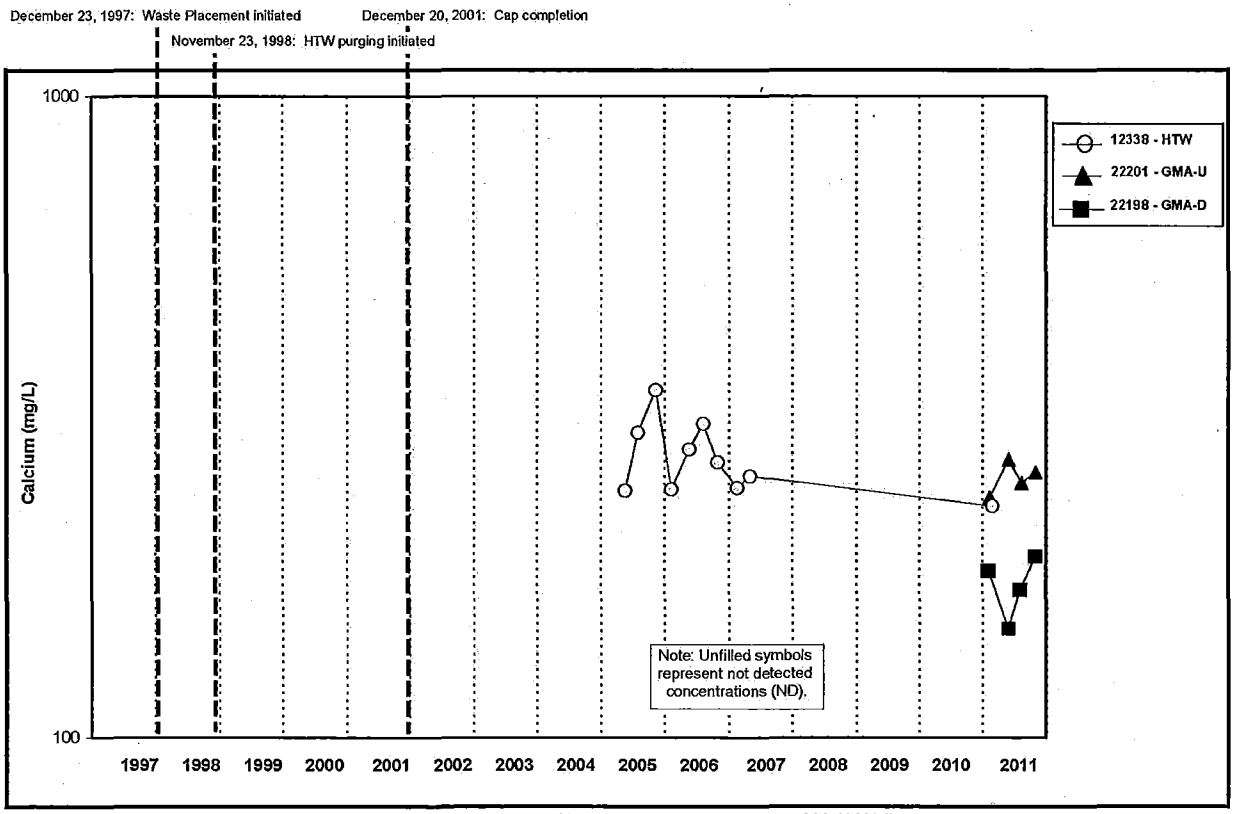


Figure A.5.1-18B. Cell 1 Calcium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

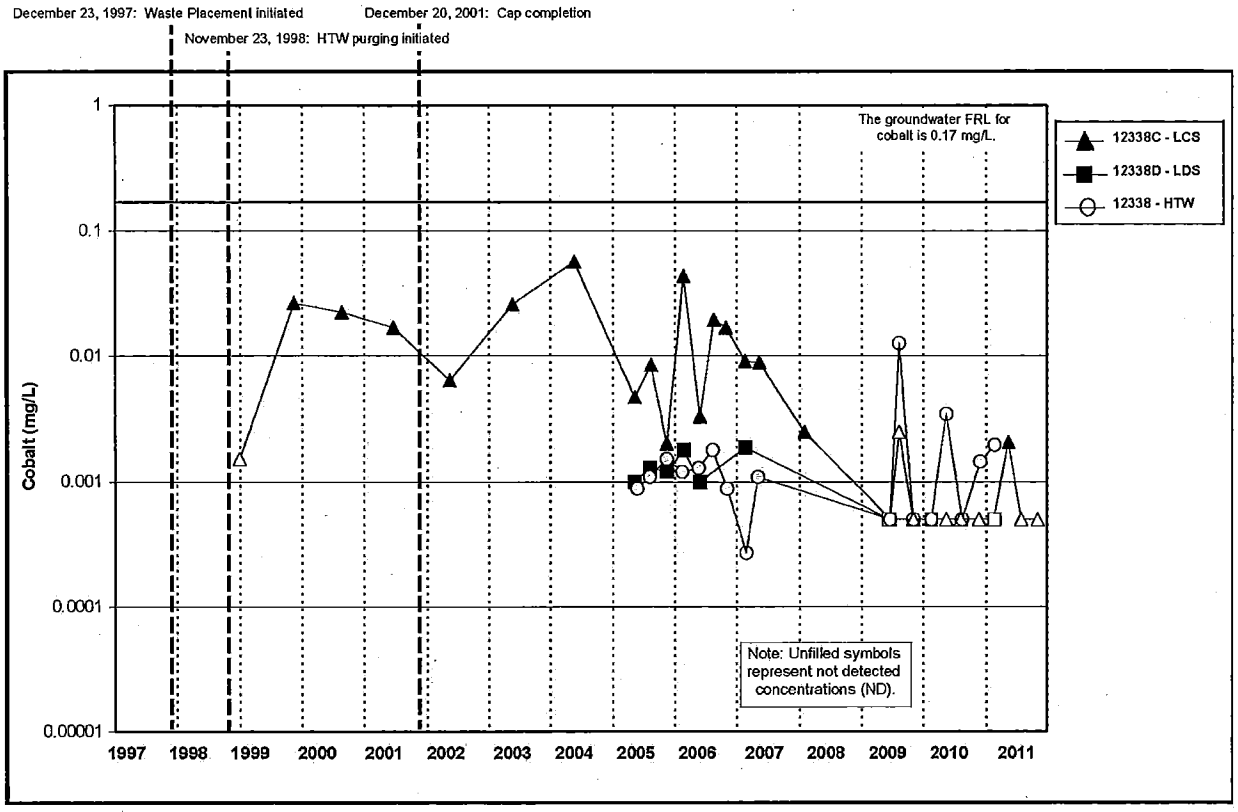


Figure A.5.1-19A. Cell 1 Cobalt Concentration vs. Time Plot for LCS, LDS, and HTW

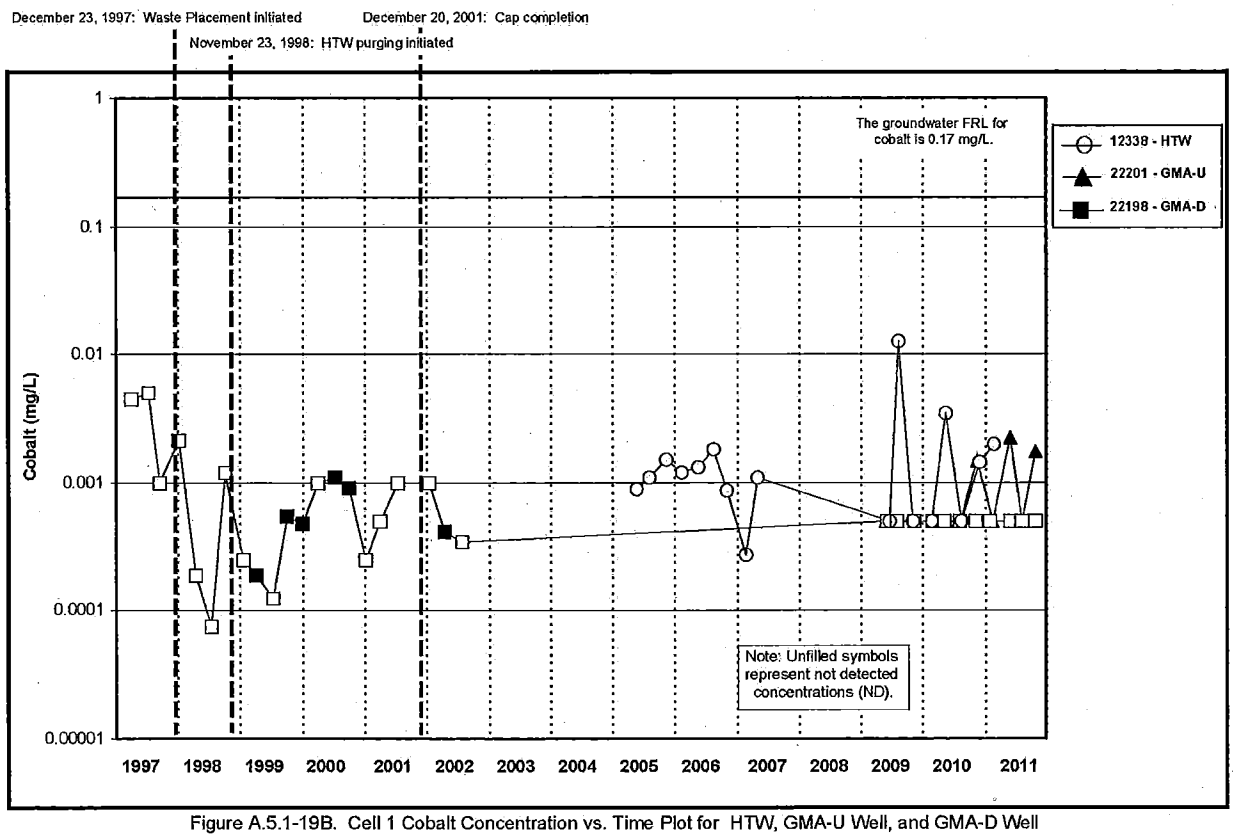


Figure A.5.1-19B. Cell 1 Cobalt Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

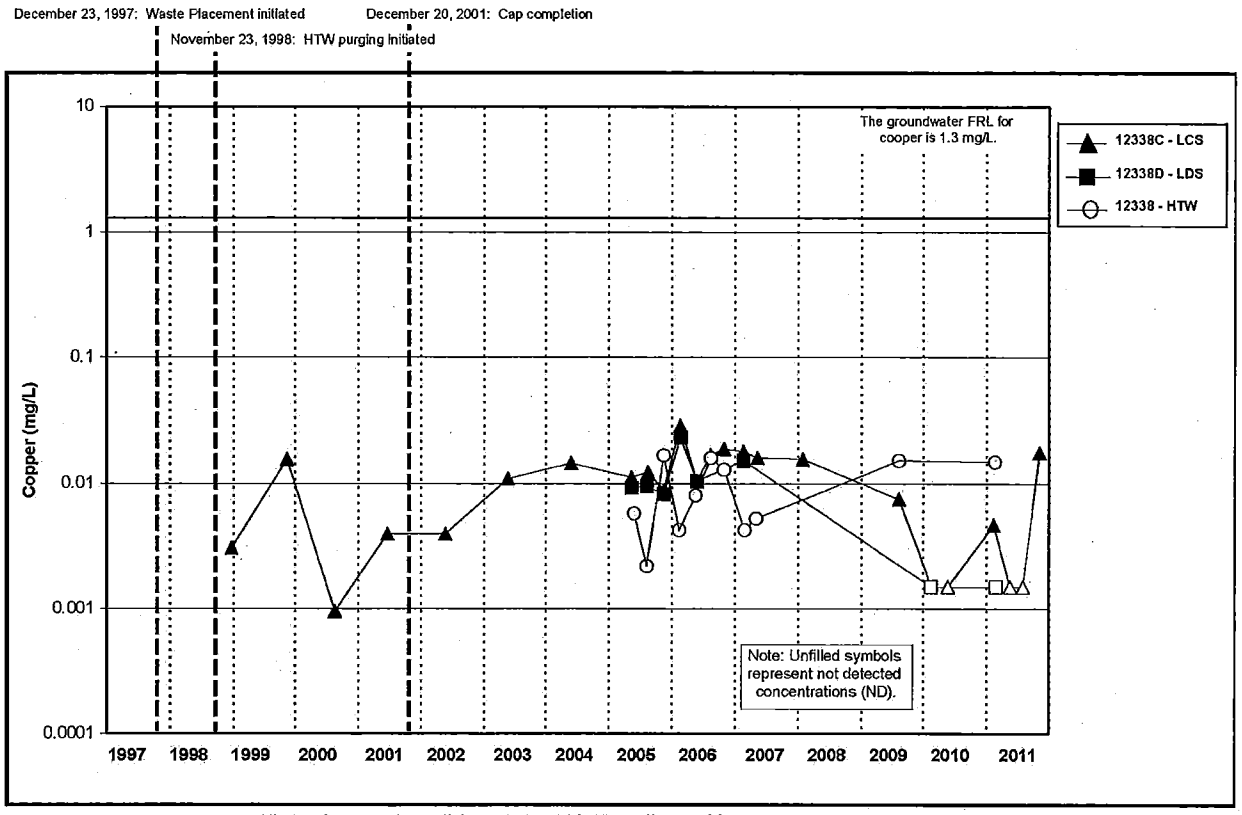


Figure A.5.1-20A. Cell 1 Copper Concentration vs. Time Plot for LCS, LDS, and HTW

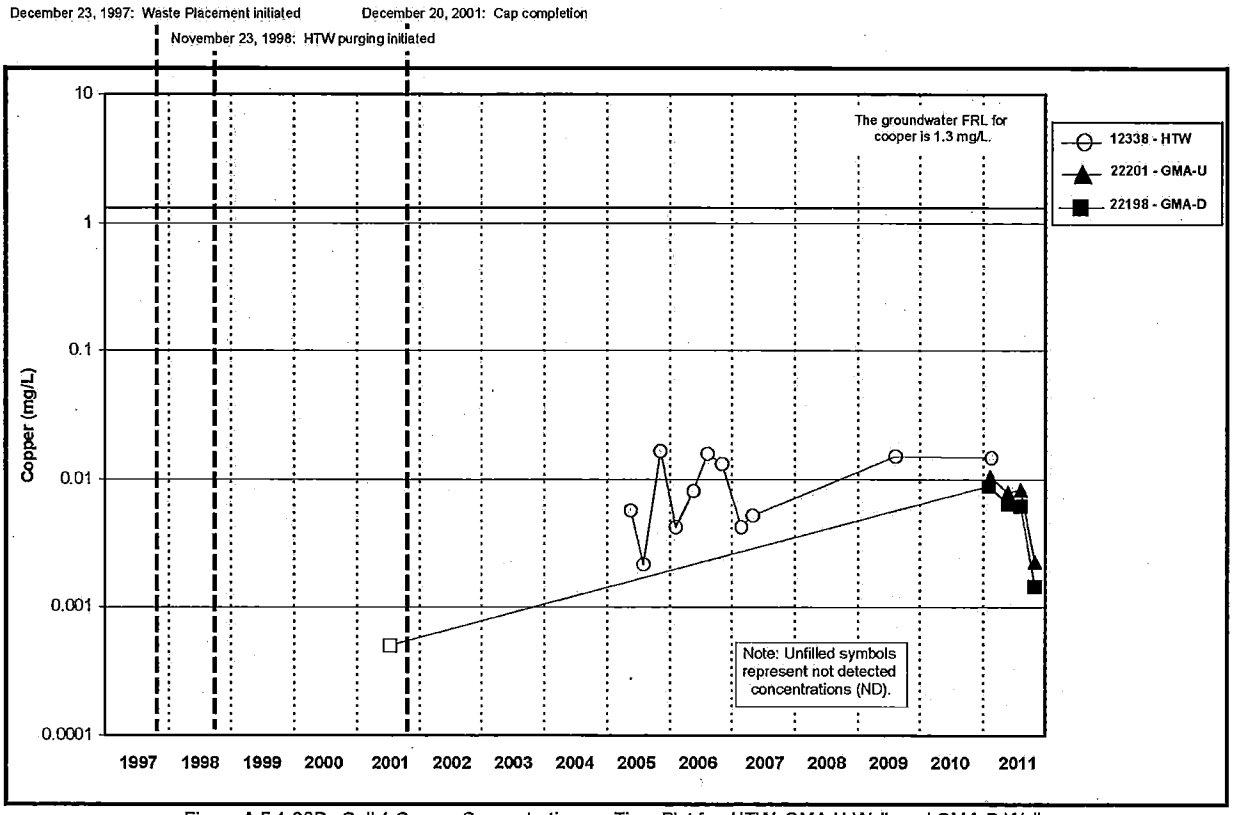


Figure A.5.1-20B. Cell 1 Copper Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

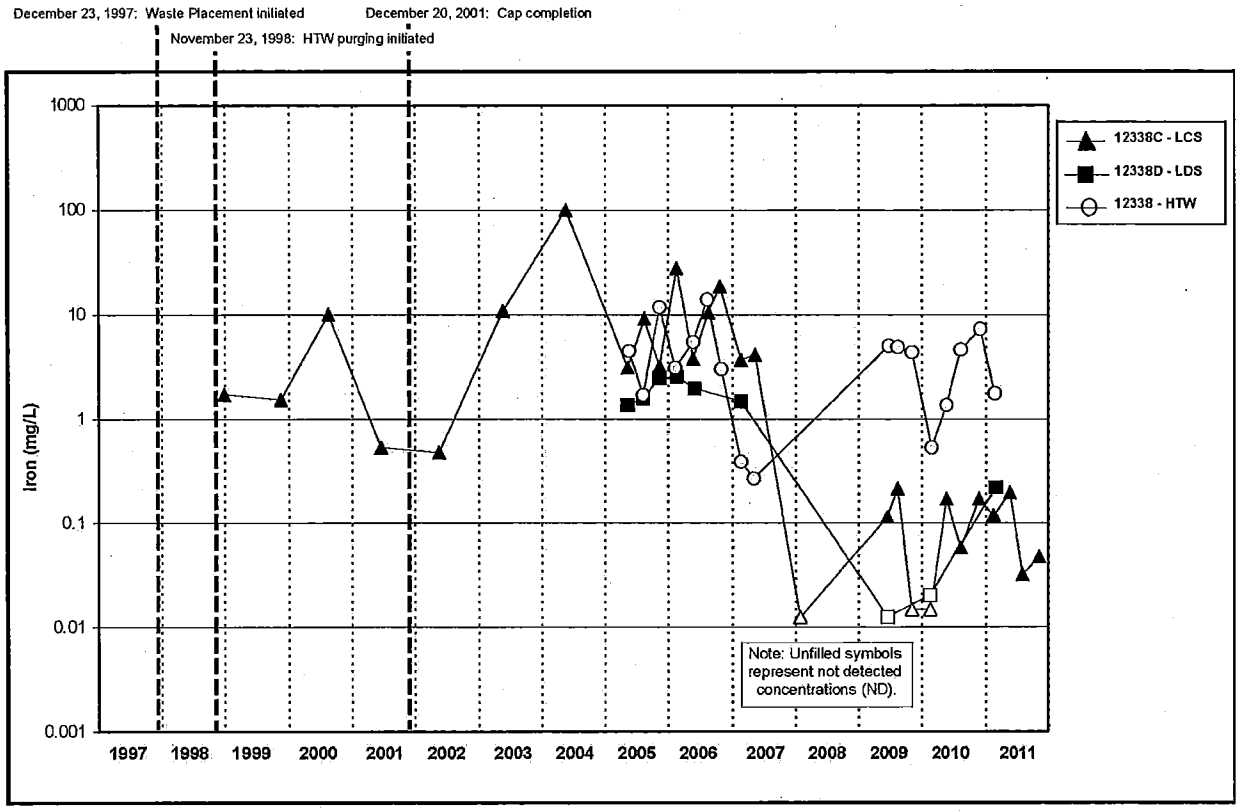


Figure A.5.1-21A. Cell 1 Iron Concentration vs. Time Plot for LCS, LDS, and HTW

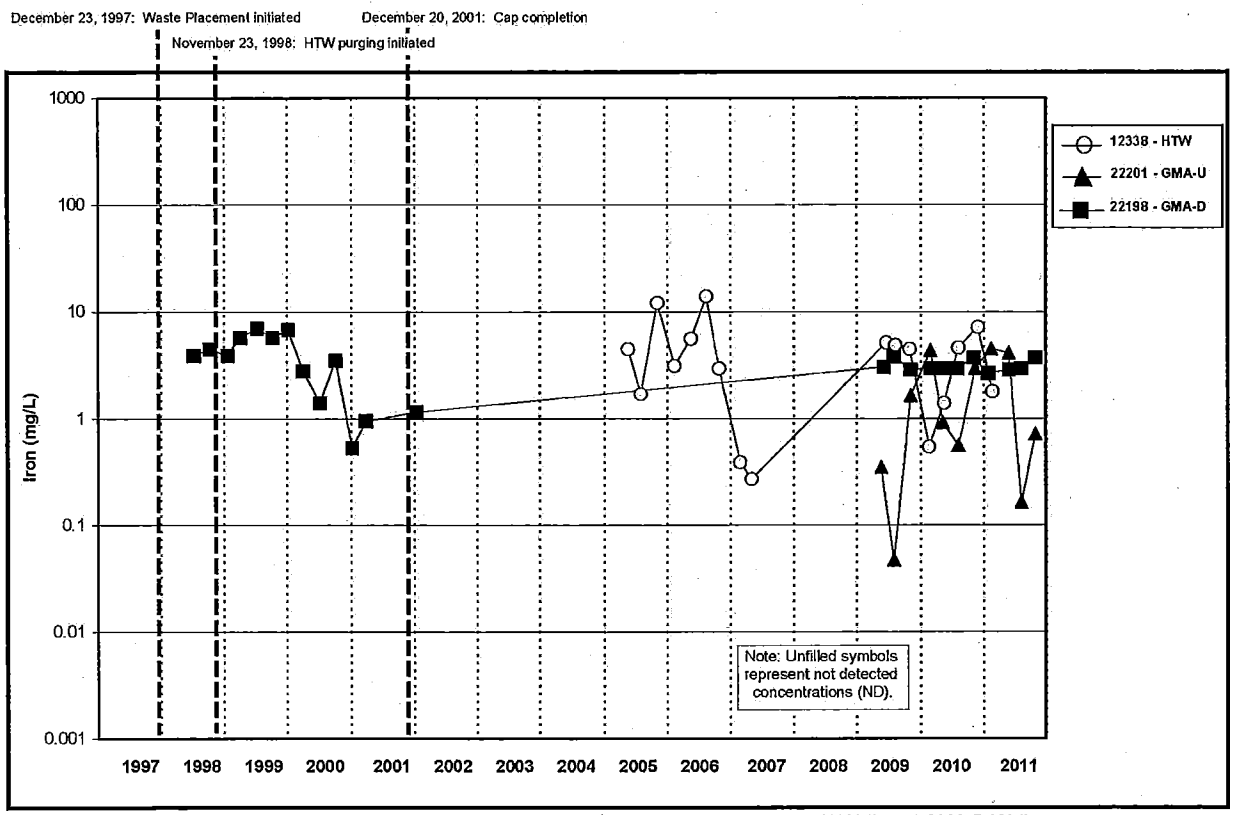


Figure A.5.1-21B. Cell 1 Iron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

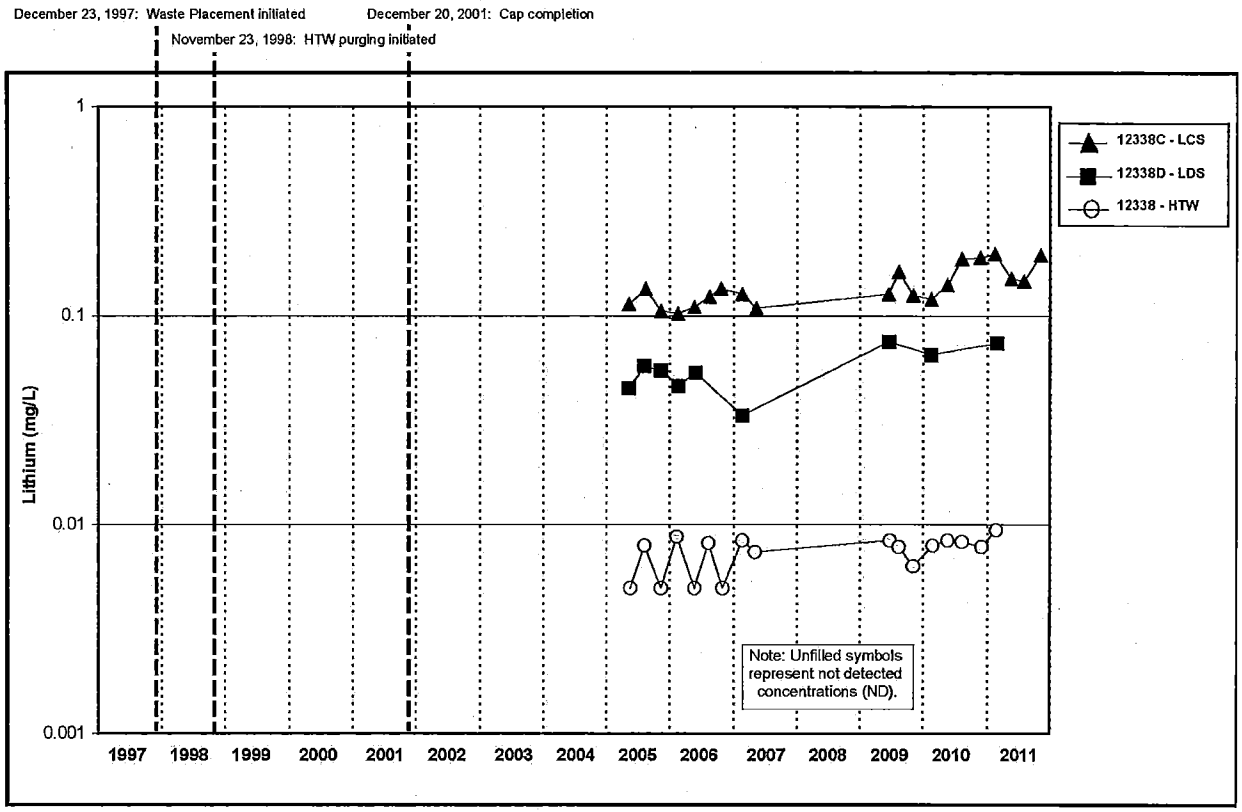


Figure A.5.1-22A. Cell 1 Lithium Concentration vs. Time Plot for LCS, LDS, and HTW

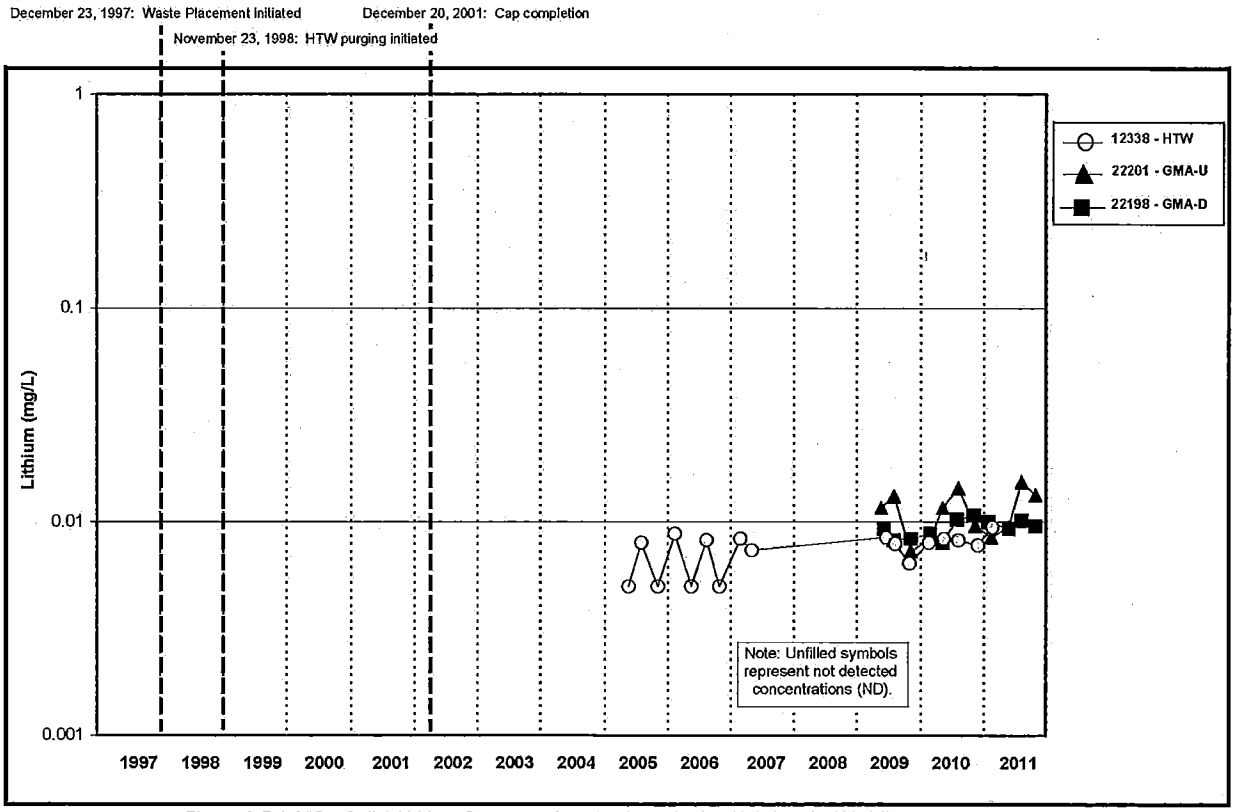


Figure A.5.1-22B. Cell 1 Lithium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

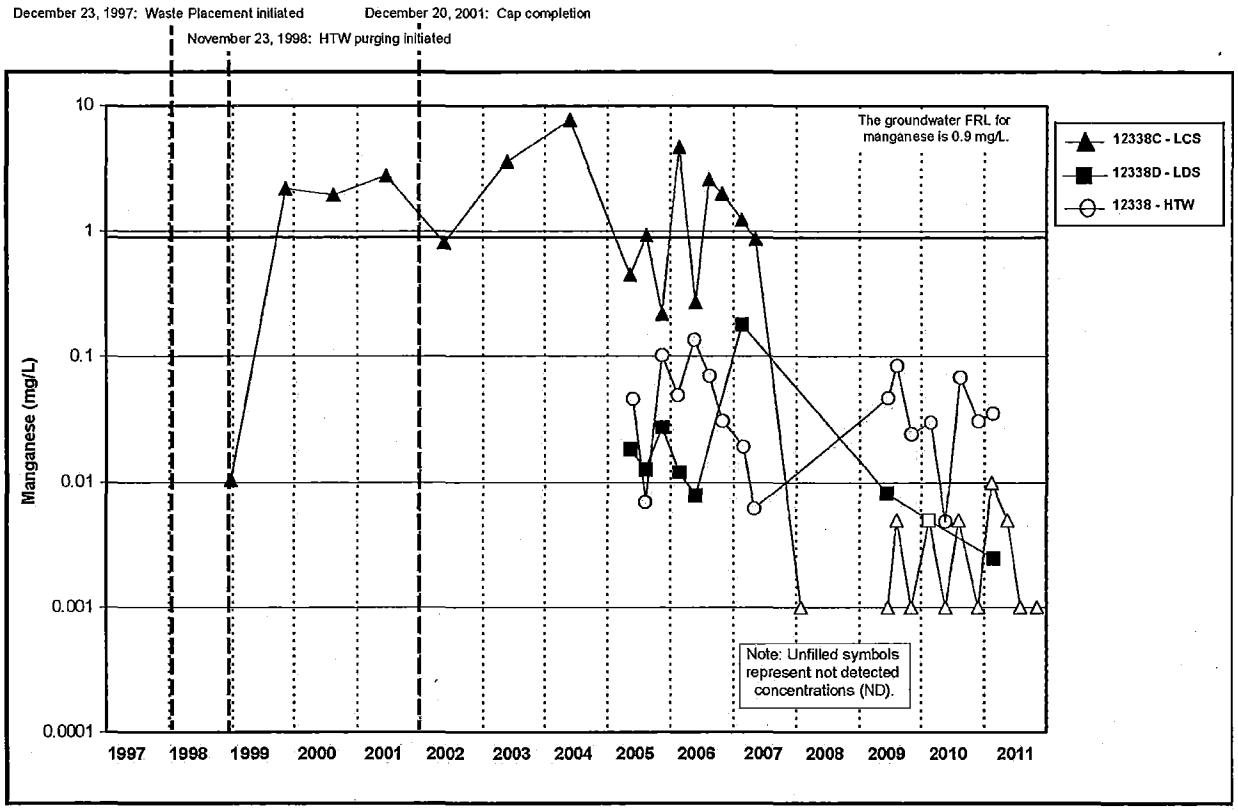


Figure A.5.1-23A. Cell 1 Manganese Concentration vs. Time Plot for LCS, LDS, and HTW

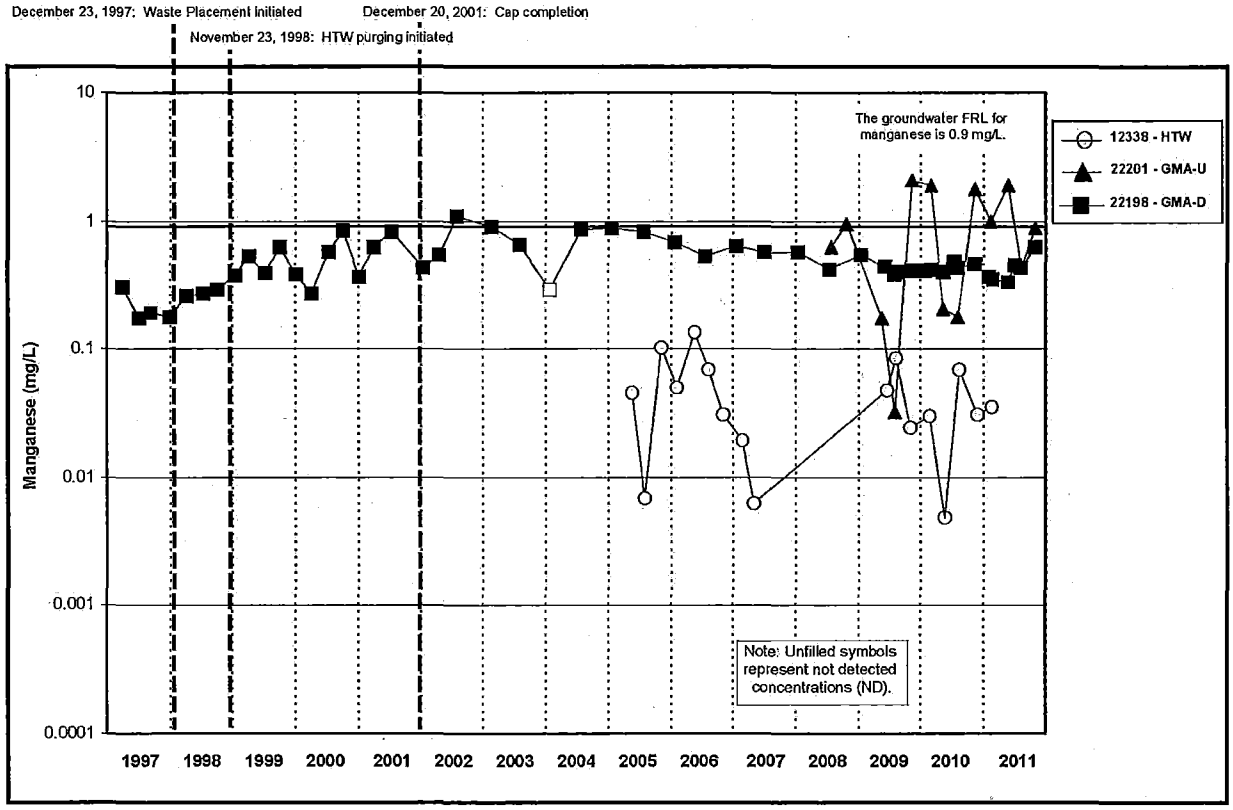


Figure A.5.1-23B. Cell 1 Manganese Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

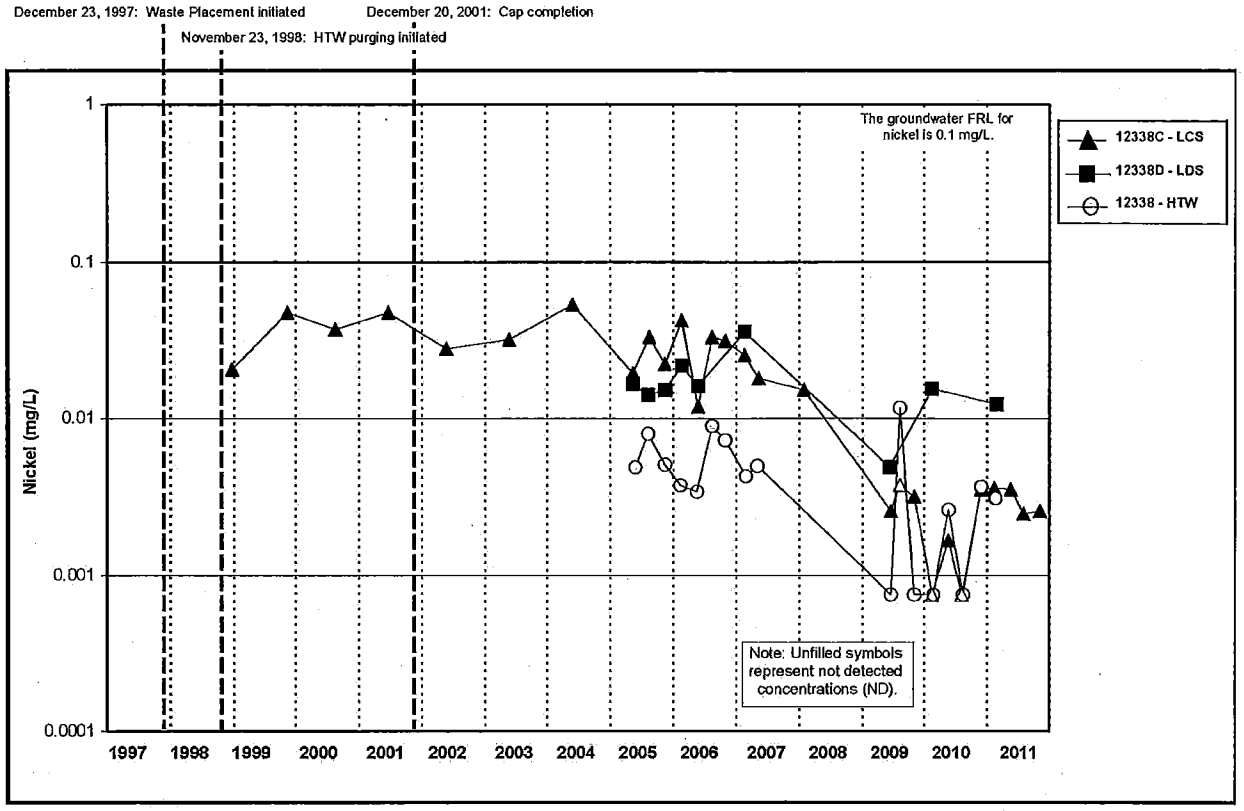


Figure A.5.1-24A. Cell 1 Nickel Concentration vs. Time Plot for LCS, LDS, and HTW

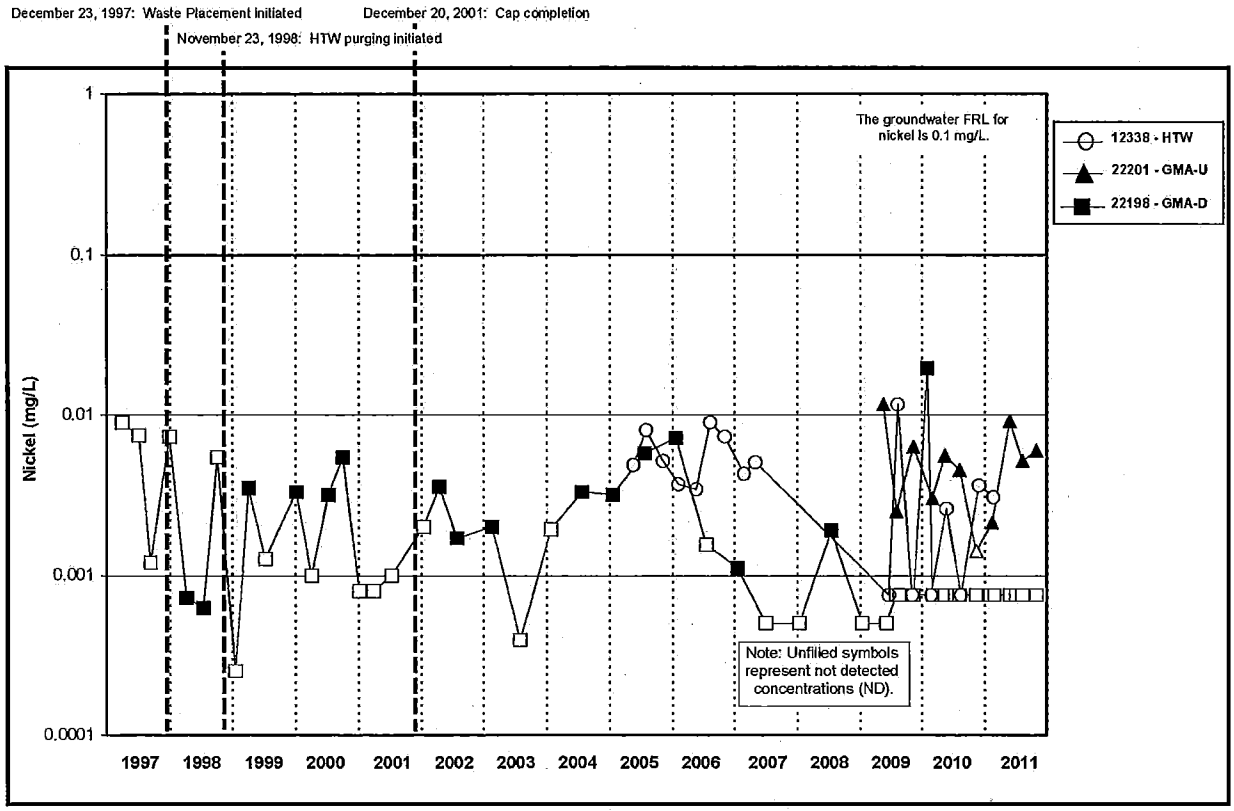


Figure A.5.1-24B. Cell 1 Nickel Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

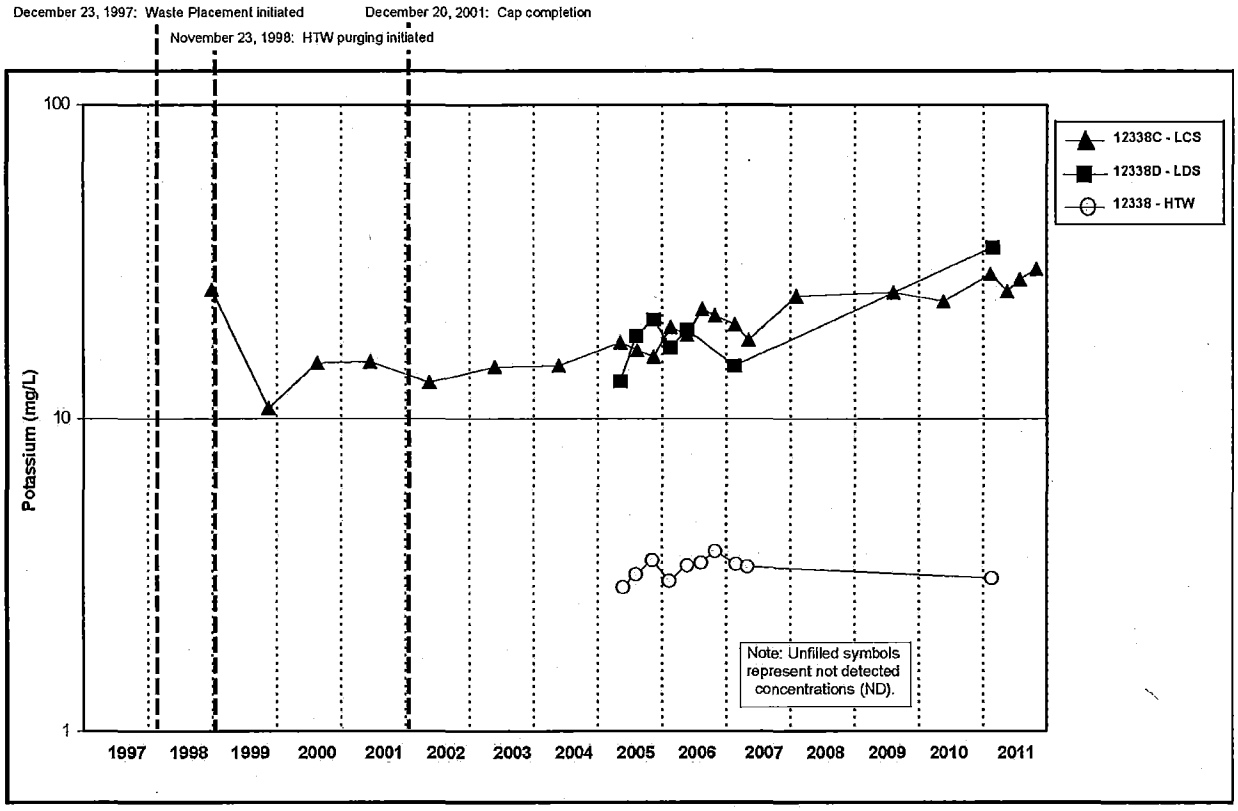


Figure A.5.1-25A. Cell 1 Potassium Concentration vs. Time Plot for LCS, LDS, and HTW

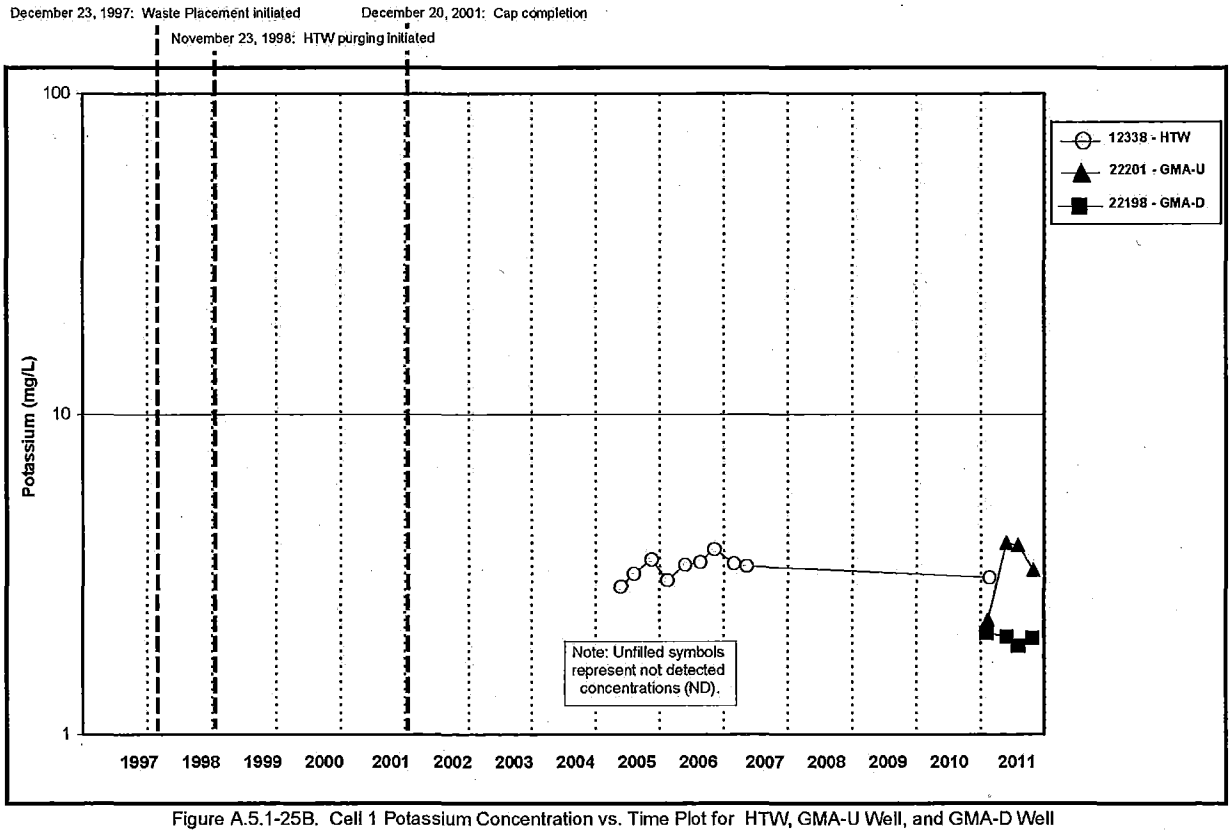


Figure A.5.1-25B. Cell 1 Potassium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

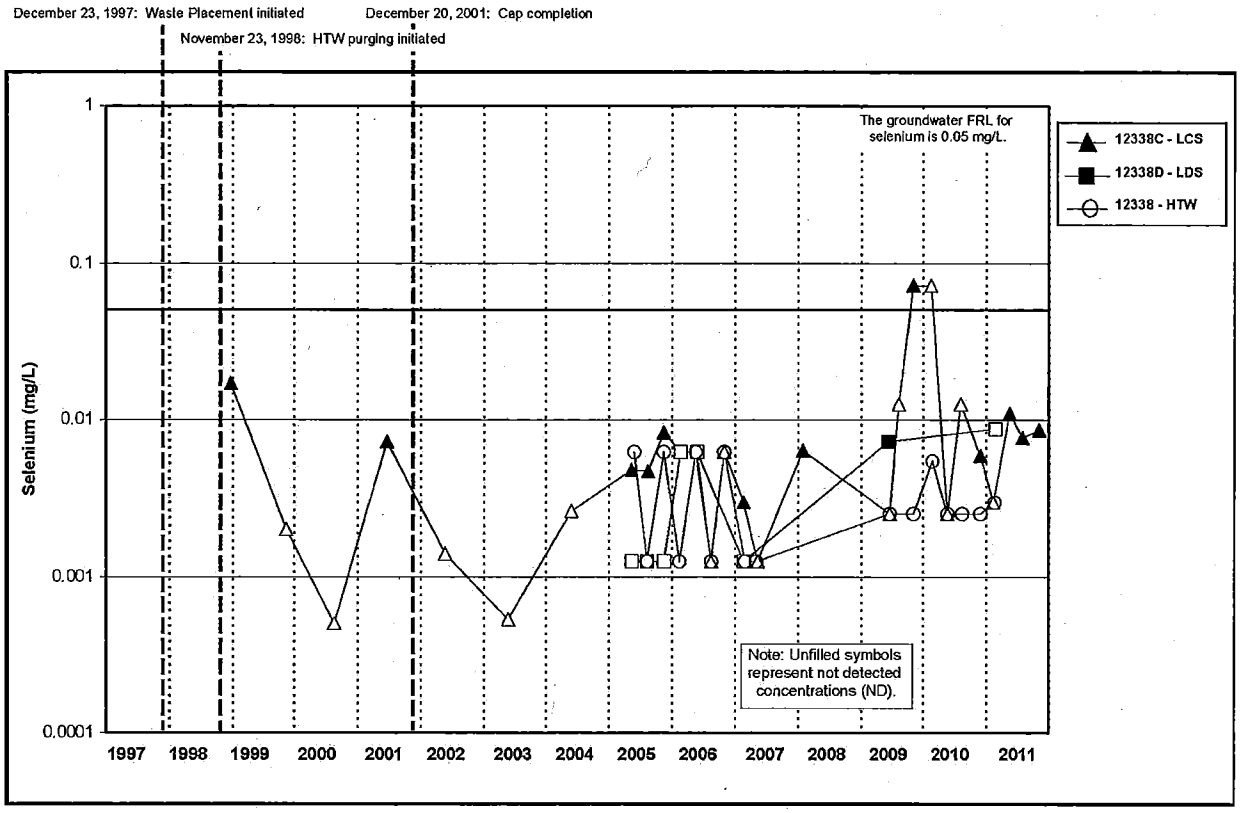


Figure A.5.1-26A. Cell 1 Selenium Concentration vs. Time Plot for LCS, LDS, and HTW

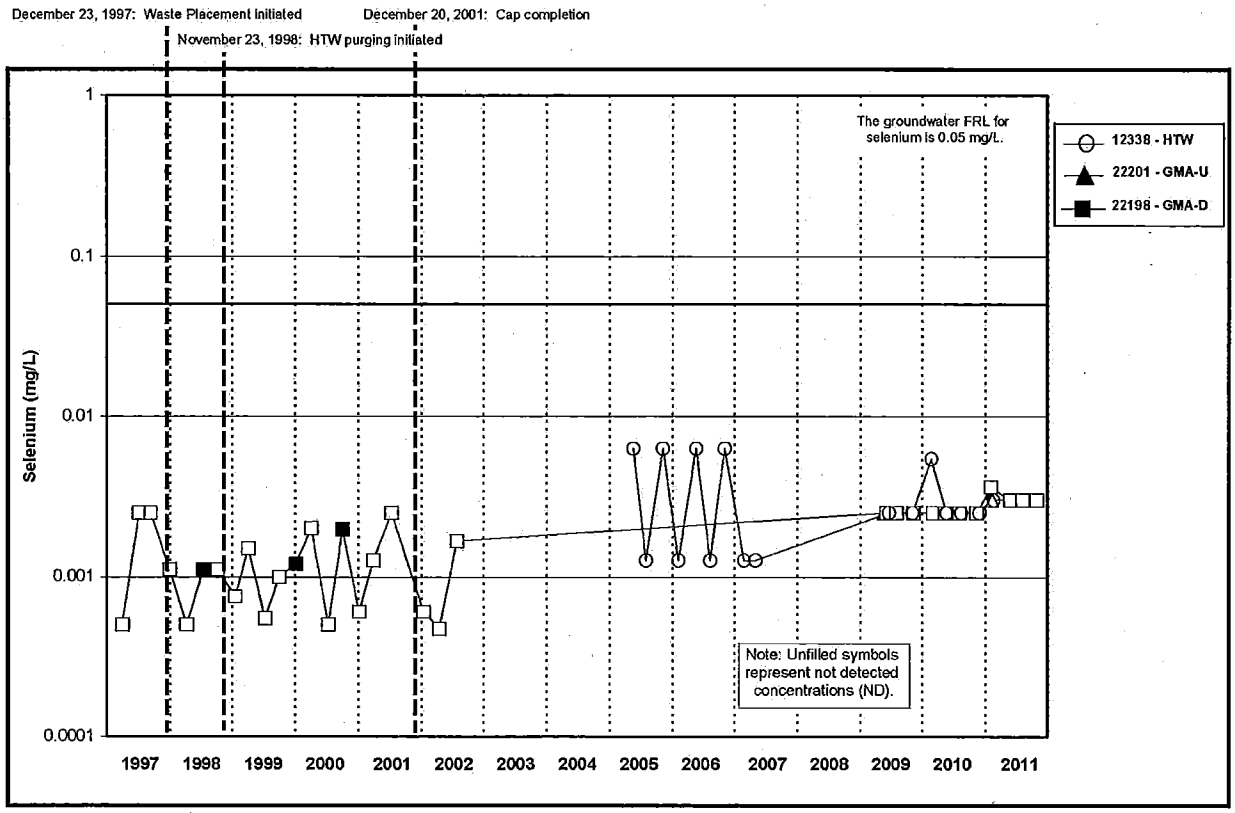


Figure A.5.1-26B. Cell 1 Selenium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

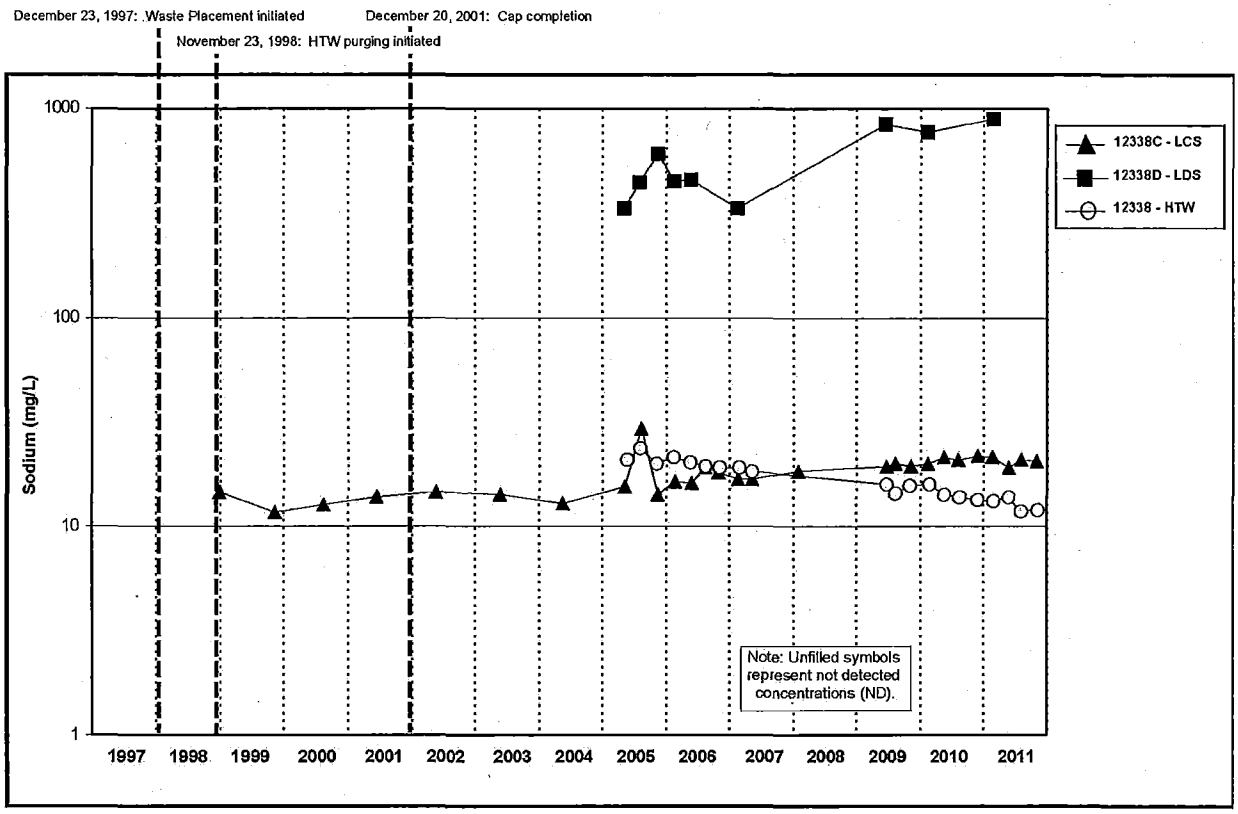


Figure A.5.1-27A. Cell 1 Sodium Concentration vs. Time Plot for LCS, LDS, and HTW

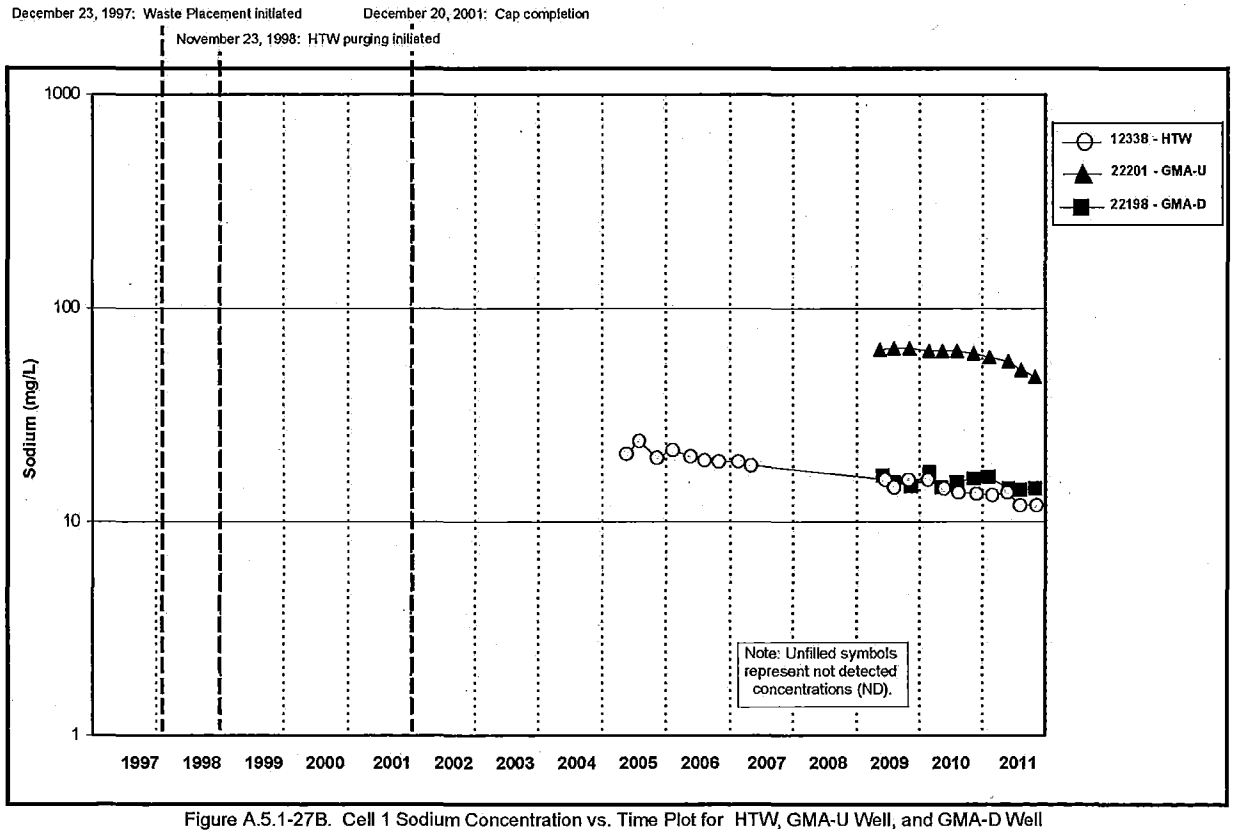


Figure A.5.1-27B. Cell 1 Sodium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

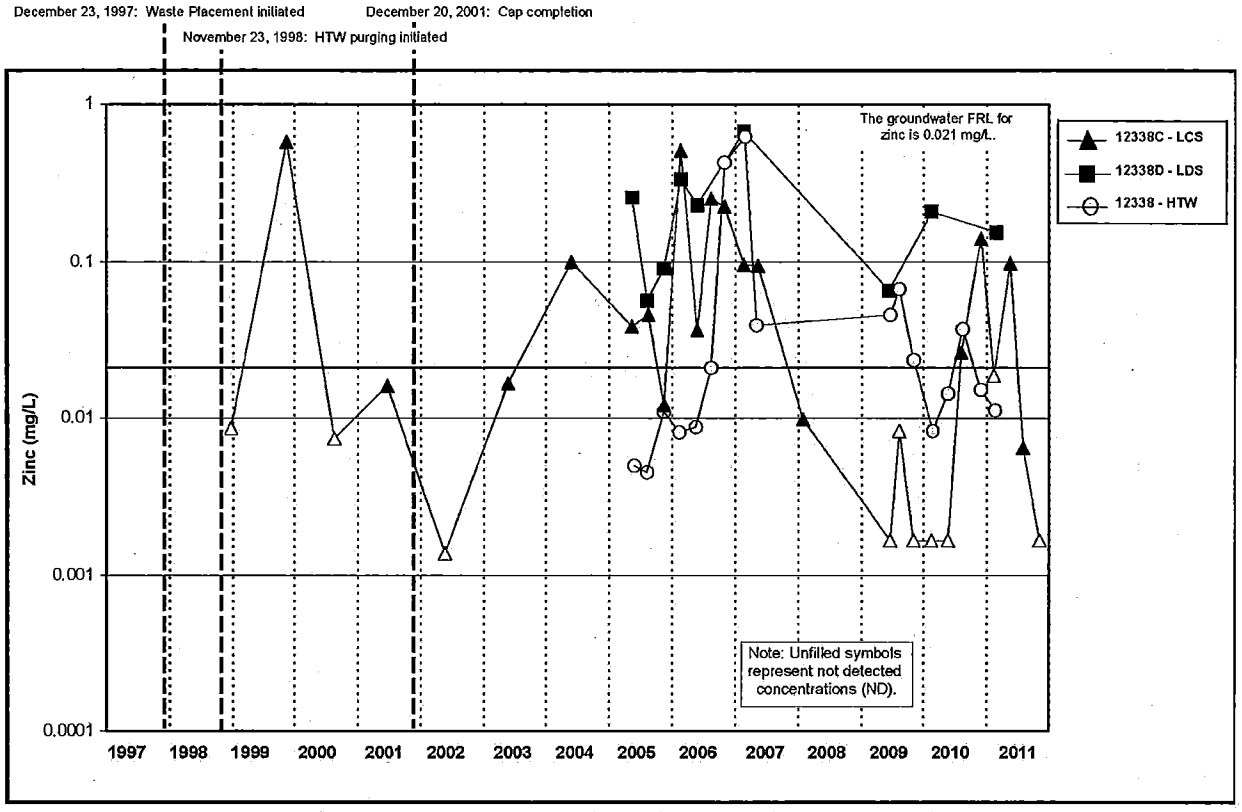


Figure A.5.1-28A. Cell 1 Zinc Concentration vs. Time Plot for LCS, LDS, and HTW

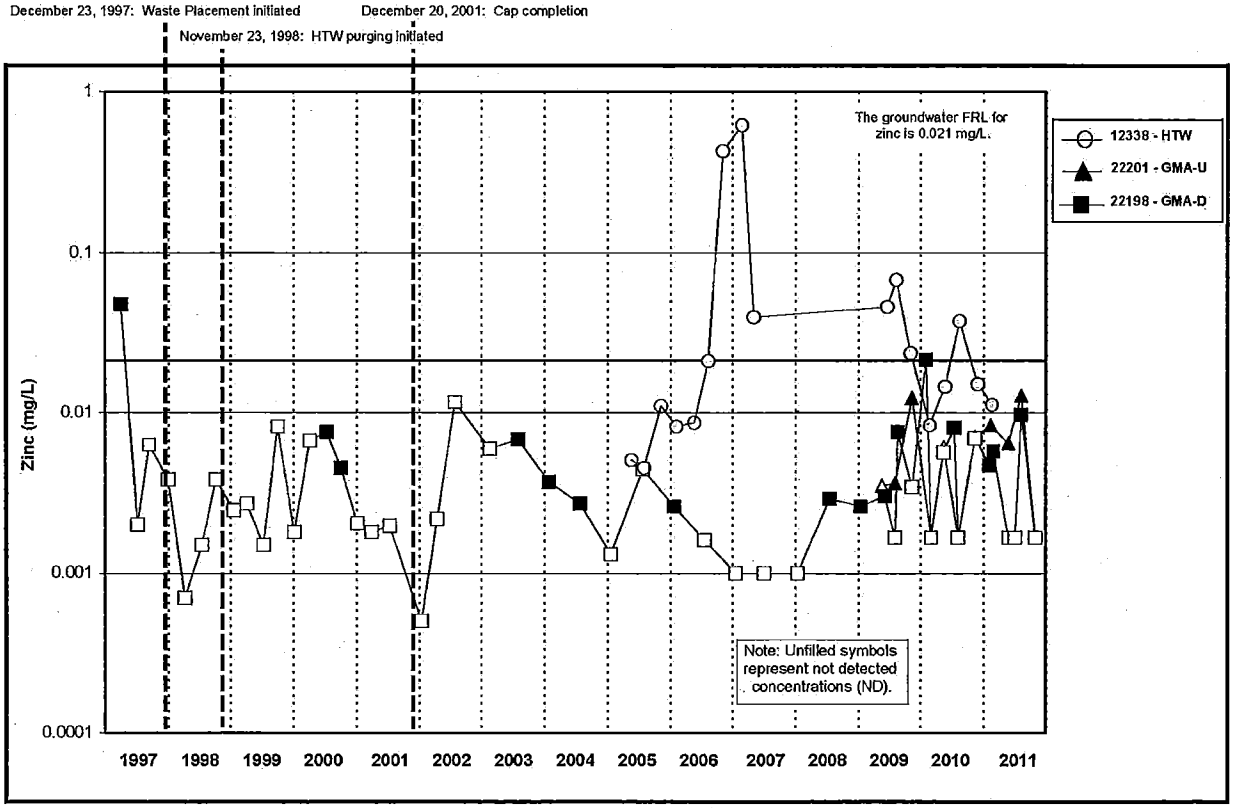


Figure A.5.1-28B. Cell 1 Zinc Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

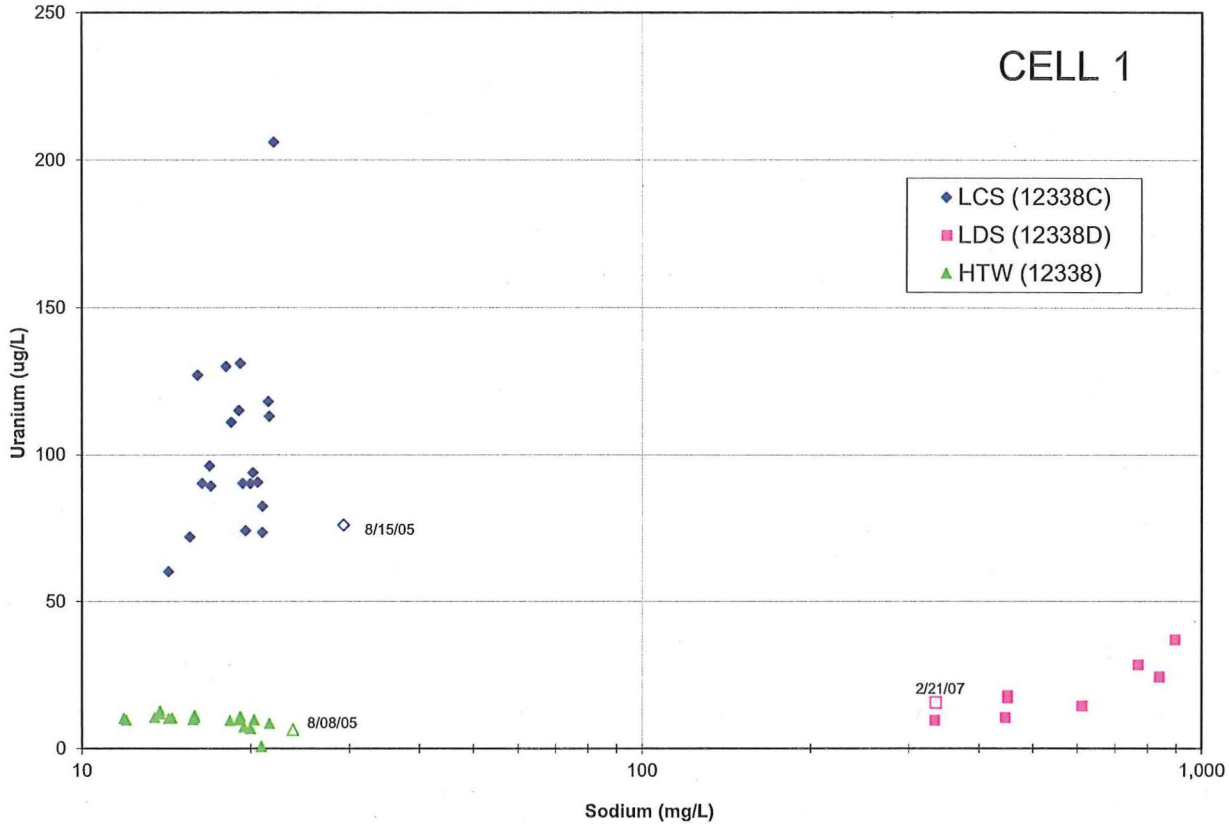


Figure A.5.1–29. Cell 1 Bivariate Plot for Uranium and Sodium

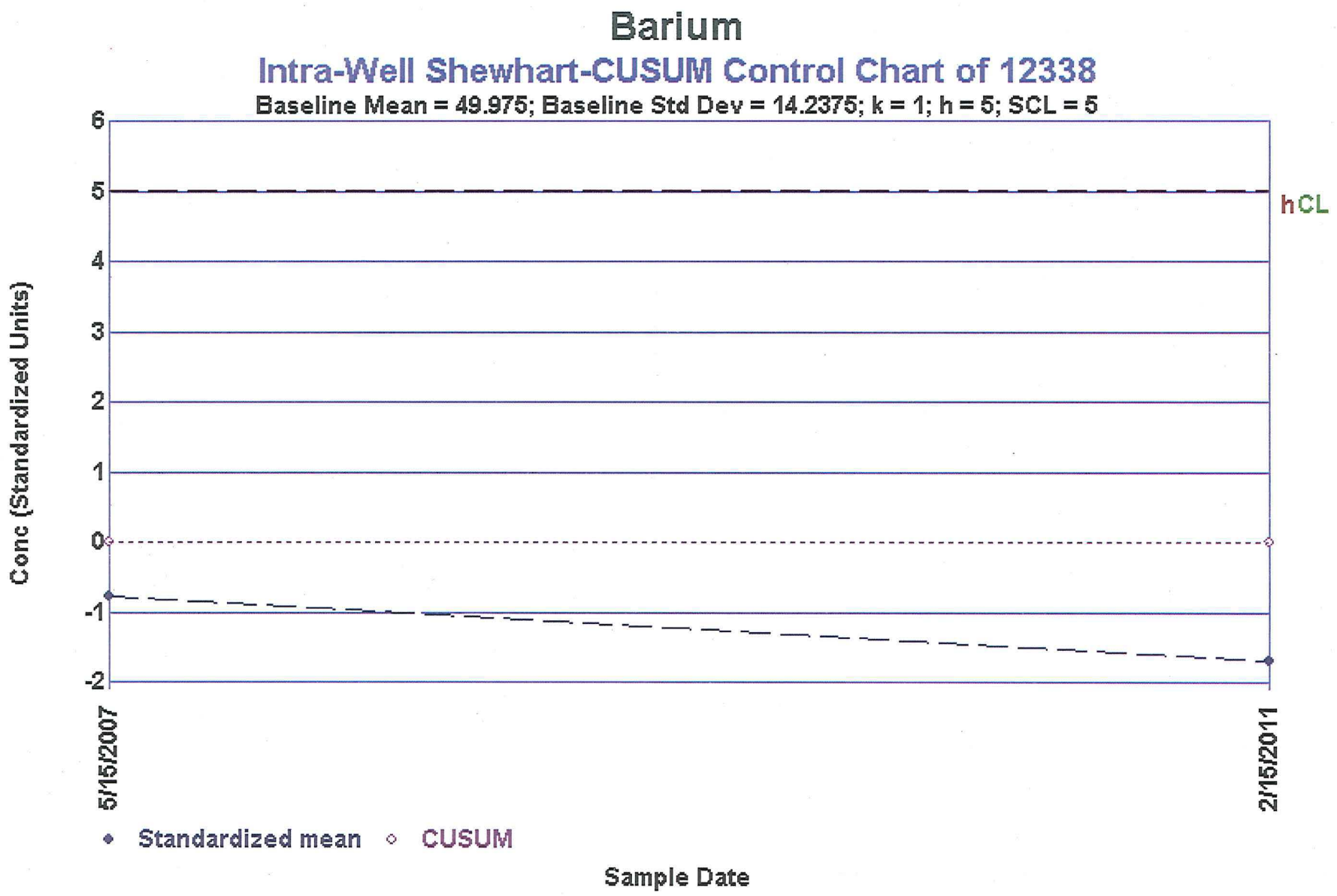


Figure A.5.1 –30. Intra-Well Shewhart-CUSUM Control Chart (Barium 12338)

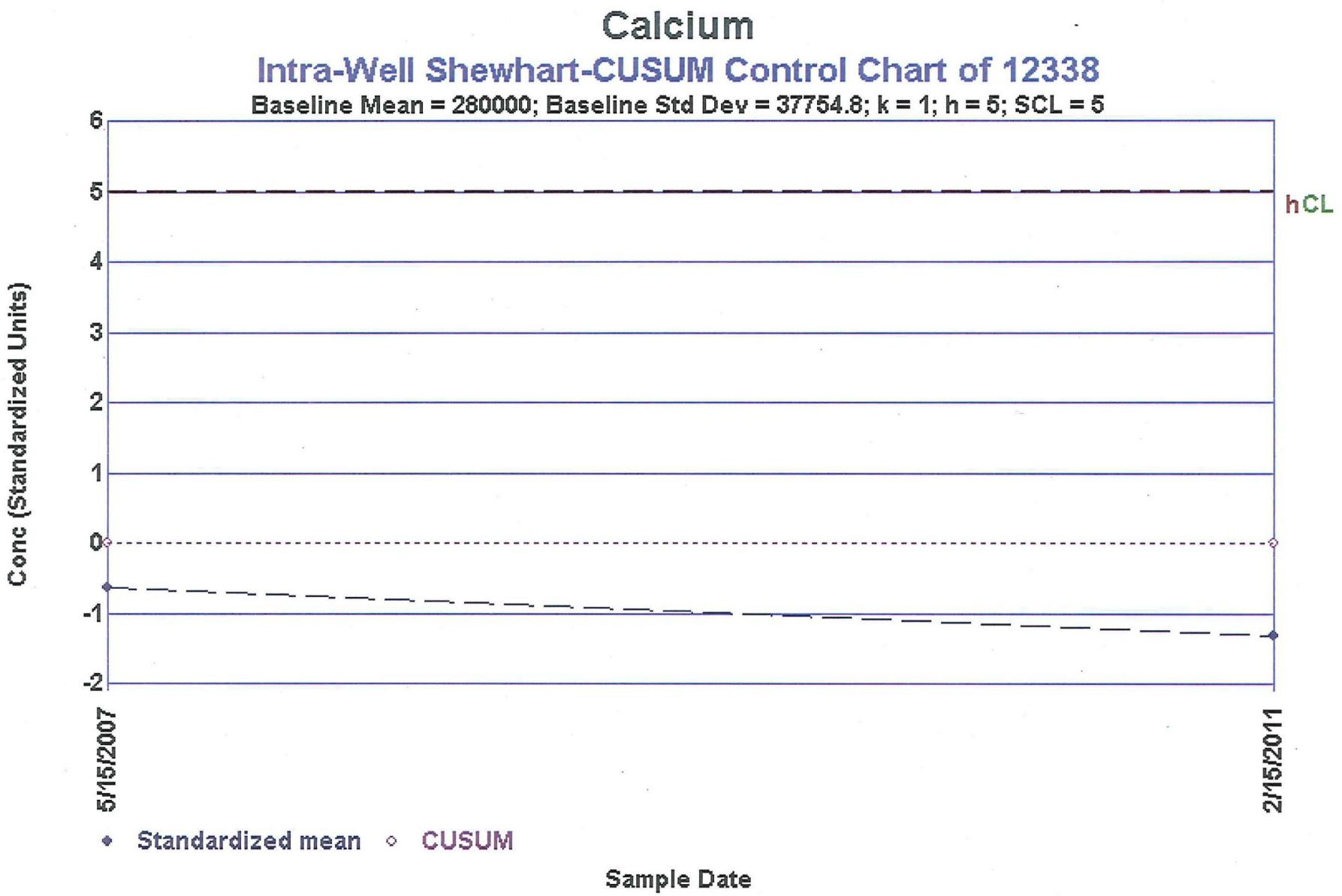


Figure A.5.1–31. Intra-Well Shewhart-CUSUM Control Chart (Calcium 12338)

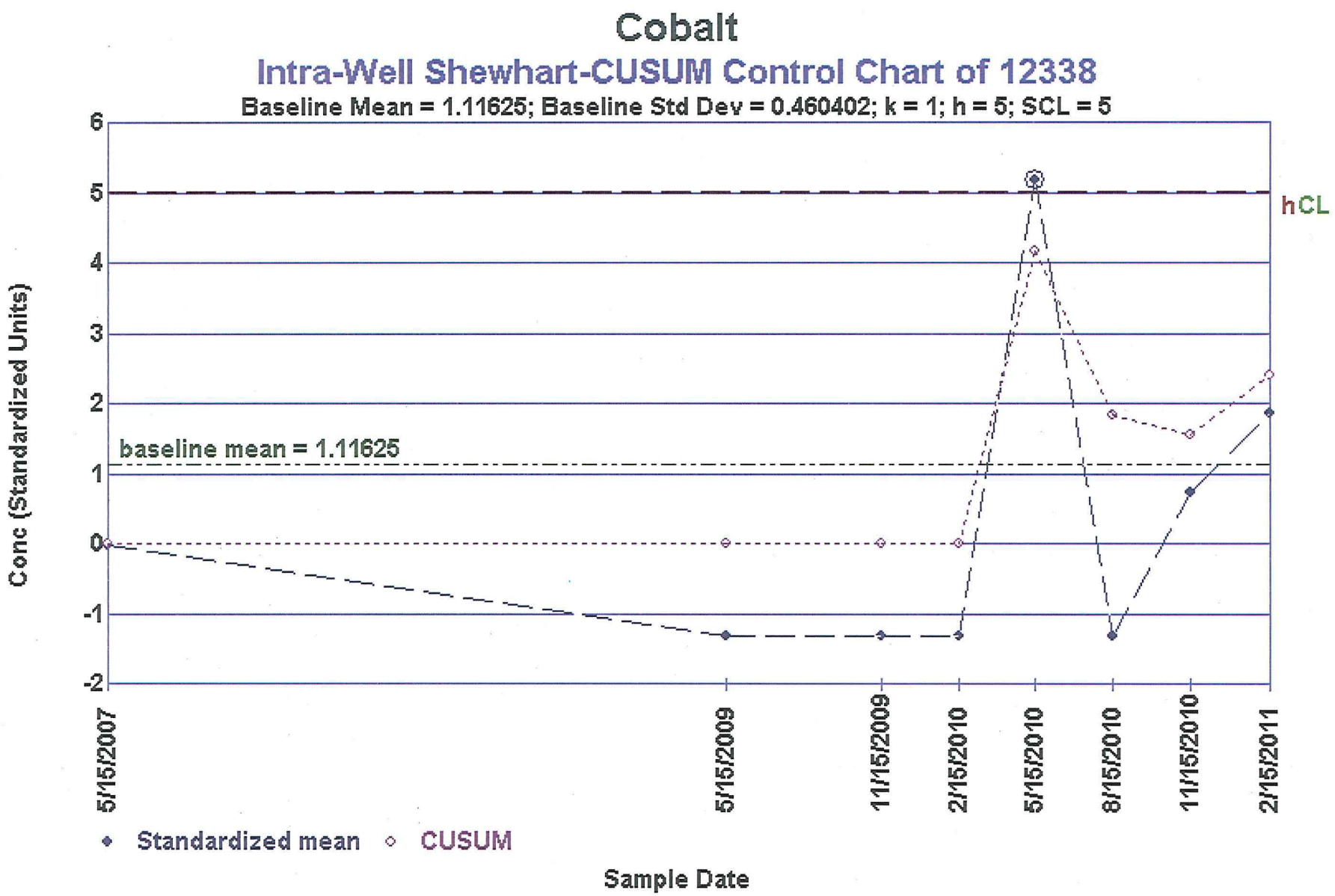


Figure A.5.1–32. Intra-Well Shewhart-CUSUM Control Chart (Cobalt 12338)

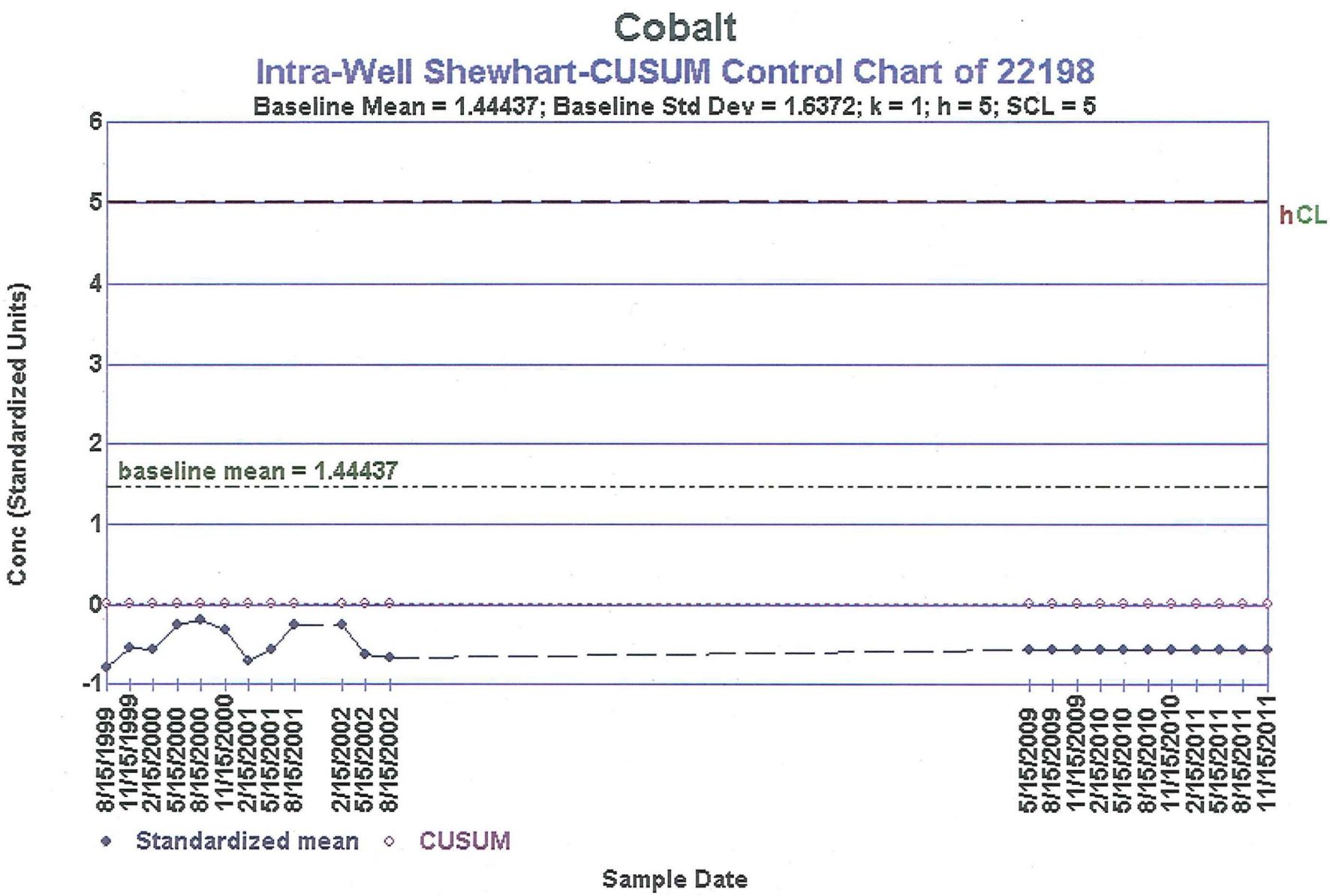


Figure A.5.1–33. Intra-Well Shewhart-CUSUM Control Chart (Cobalt 22198)

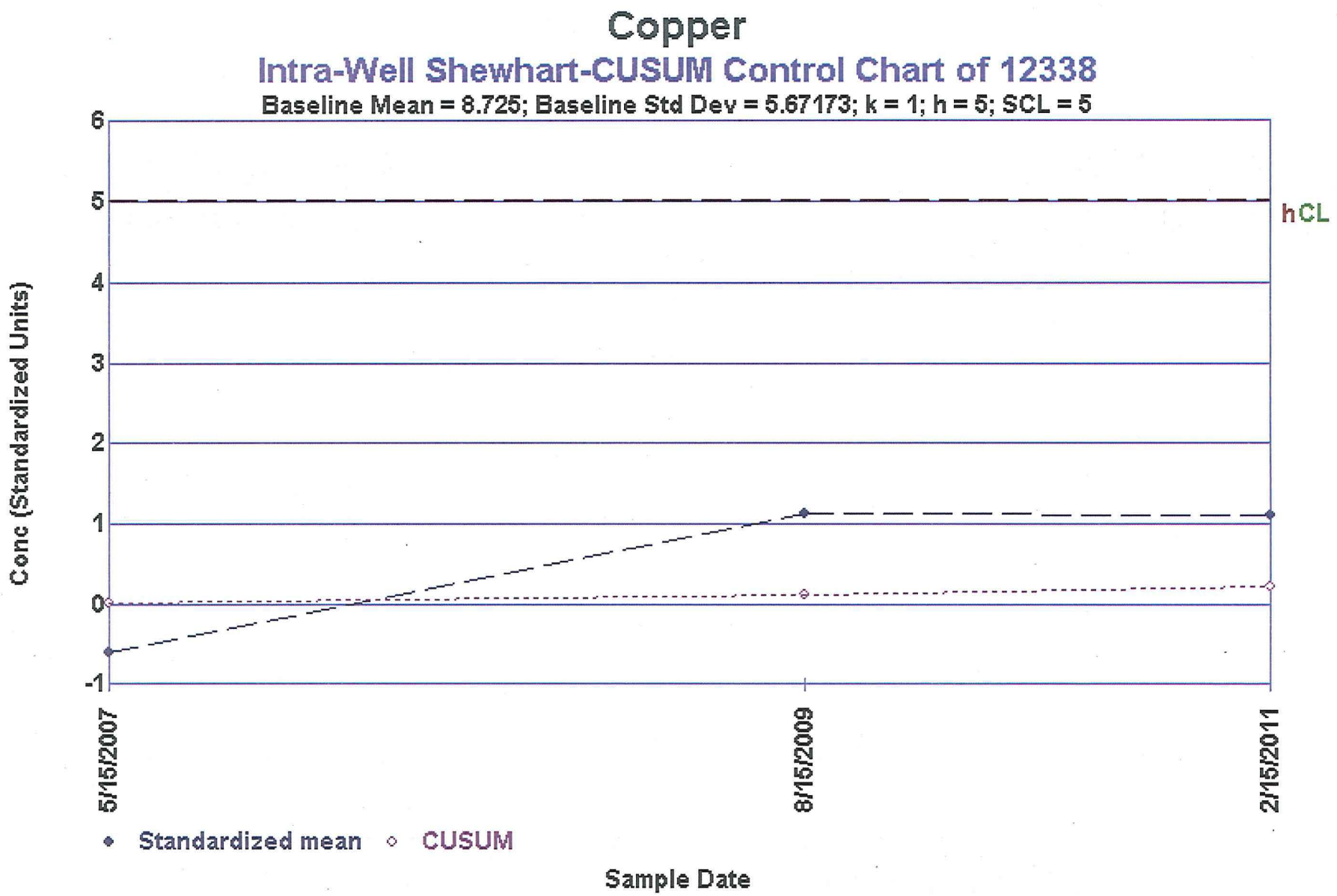


Figure A.5.1 –34. Intra-Well Shewhart-CUSUM Control Chart (Copper 12338)

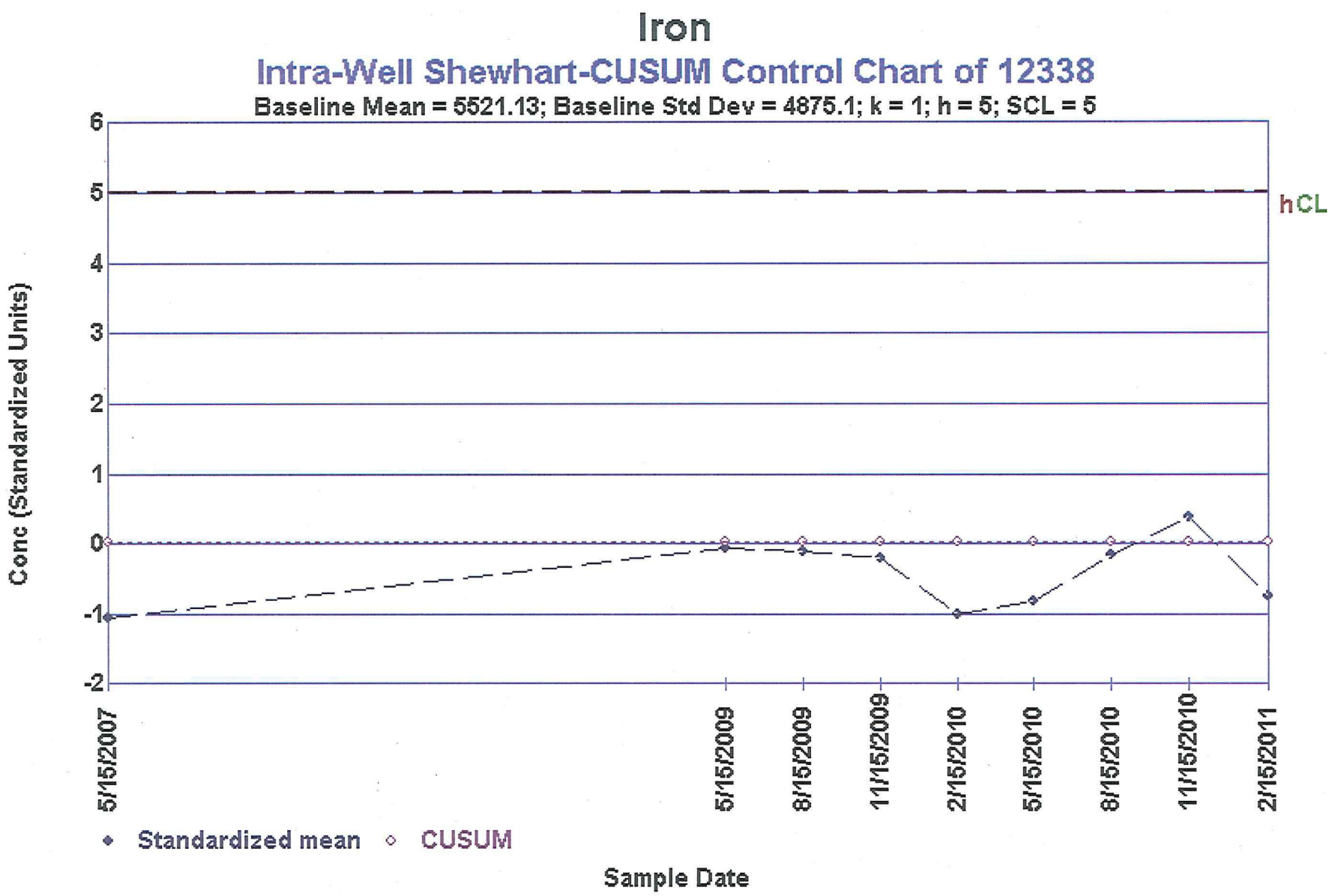


Figure A.5.1 –35. Intra-Well Shewhart-CUSUM Control Chart (Iron 12338)

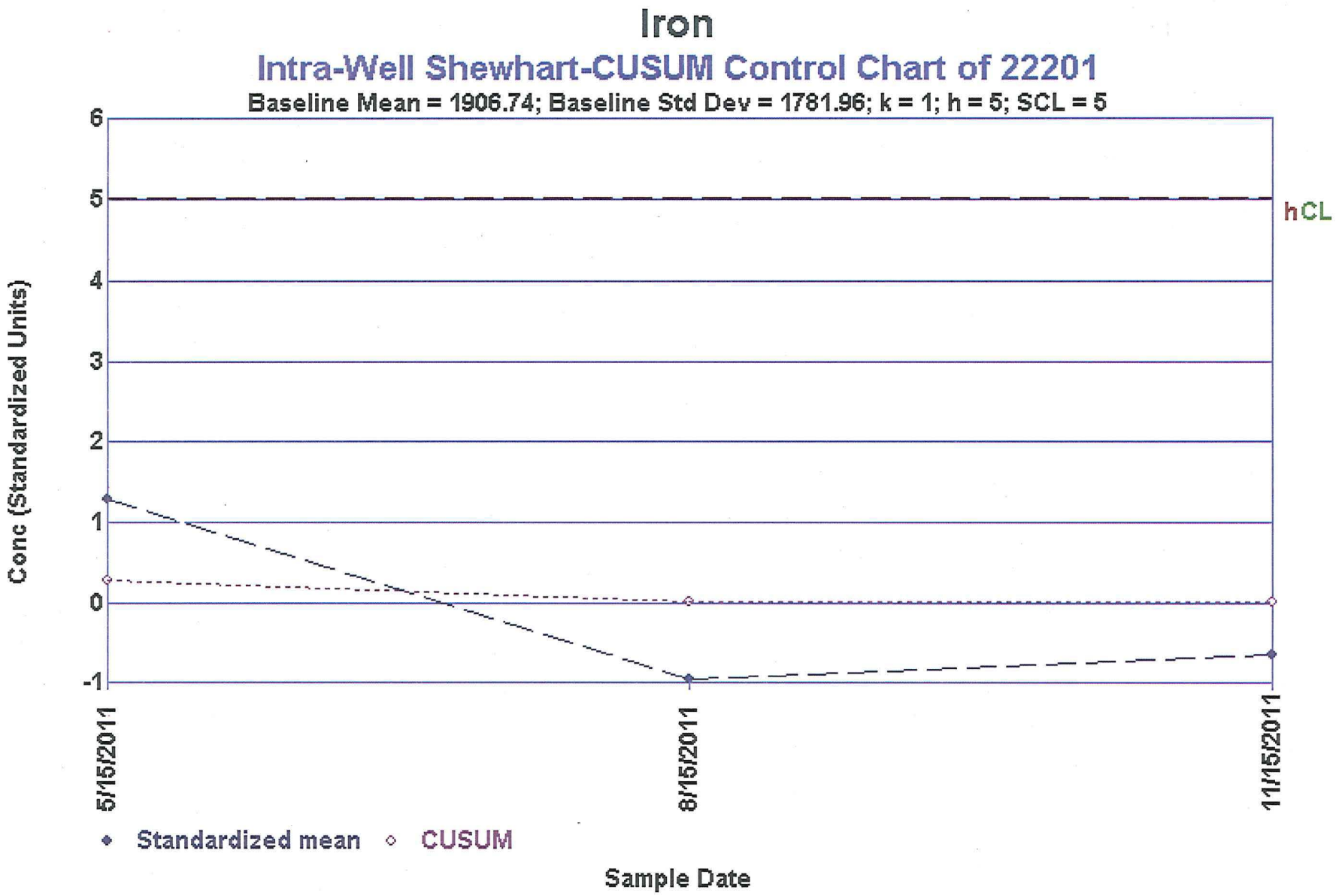


Figure A.5.1–36. Intra-Well Shewhart-CUSUM Control Chart (Iron 22201)

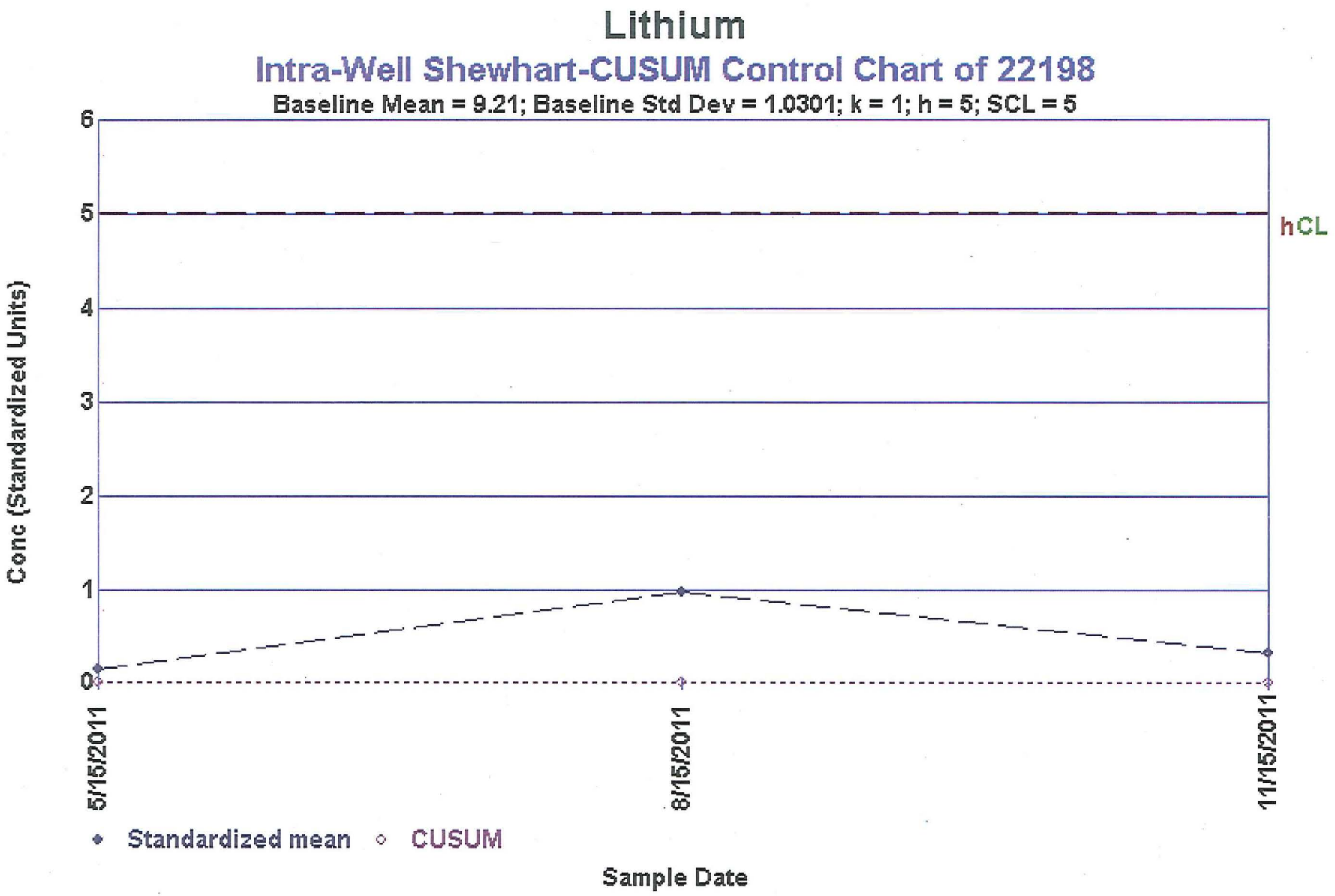


Figure A.5.1–37. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22198)

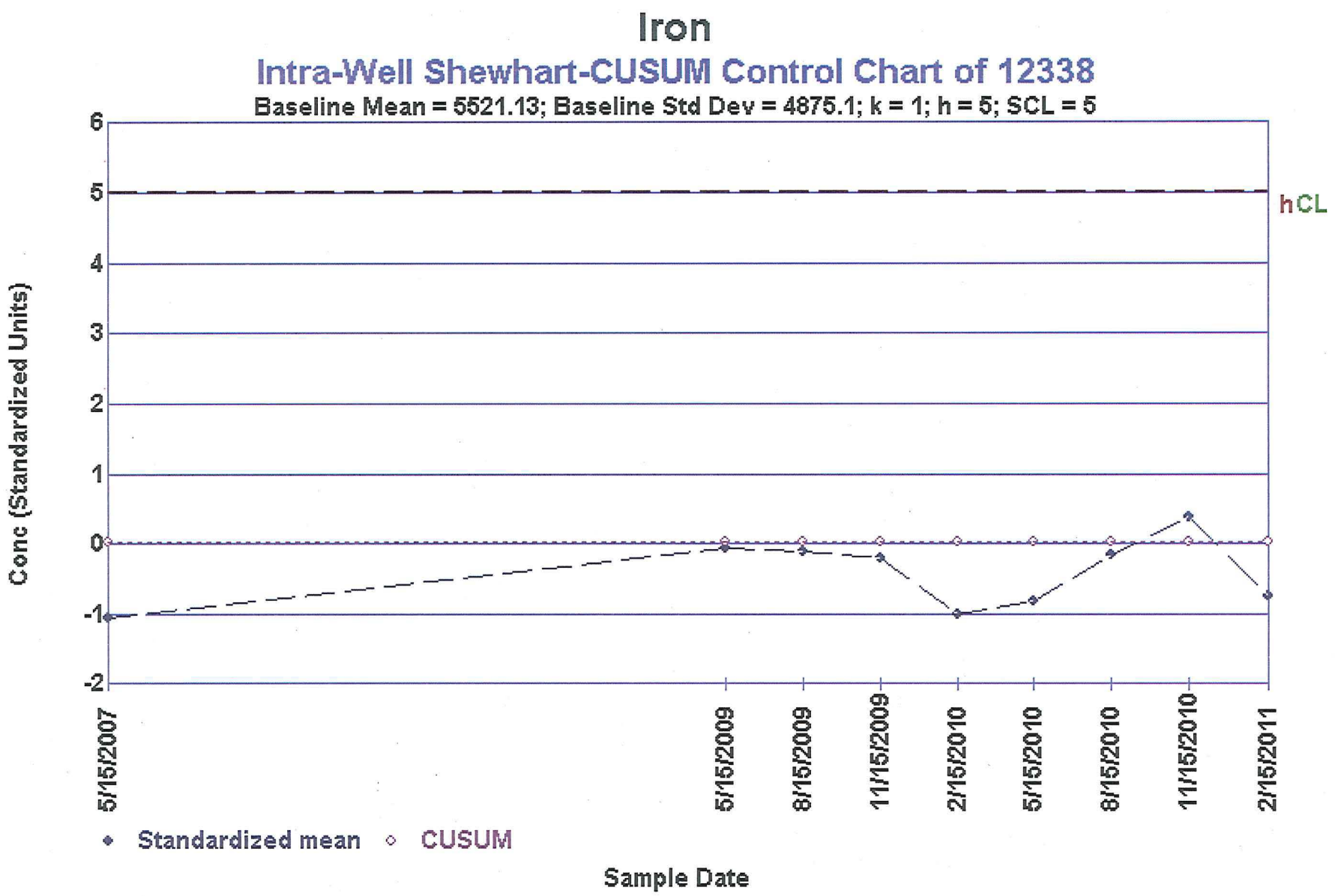


Figure A.5.1 –35. Intra-Well Shewhart-CUSUM Control Chart (Iron 12338)

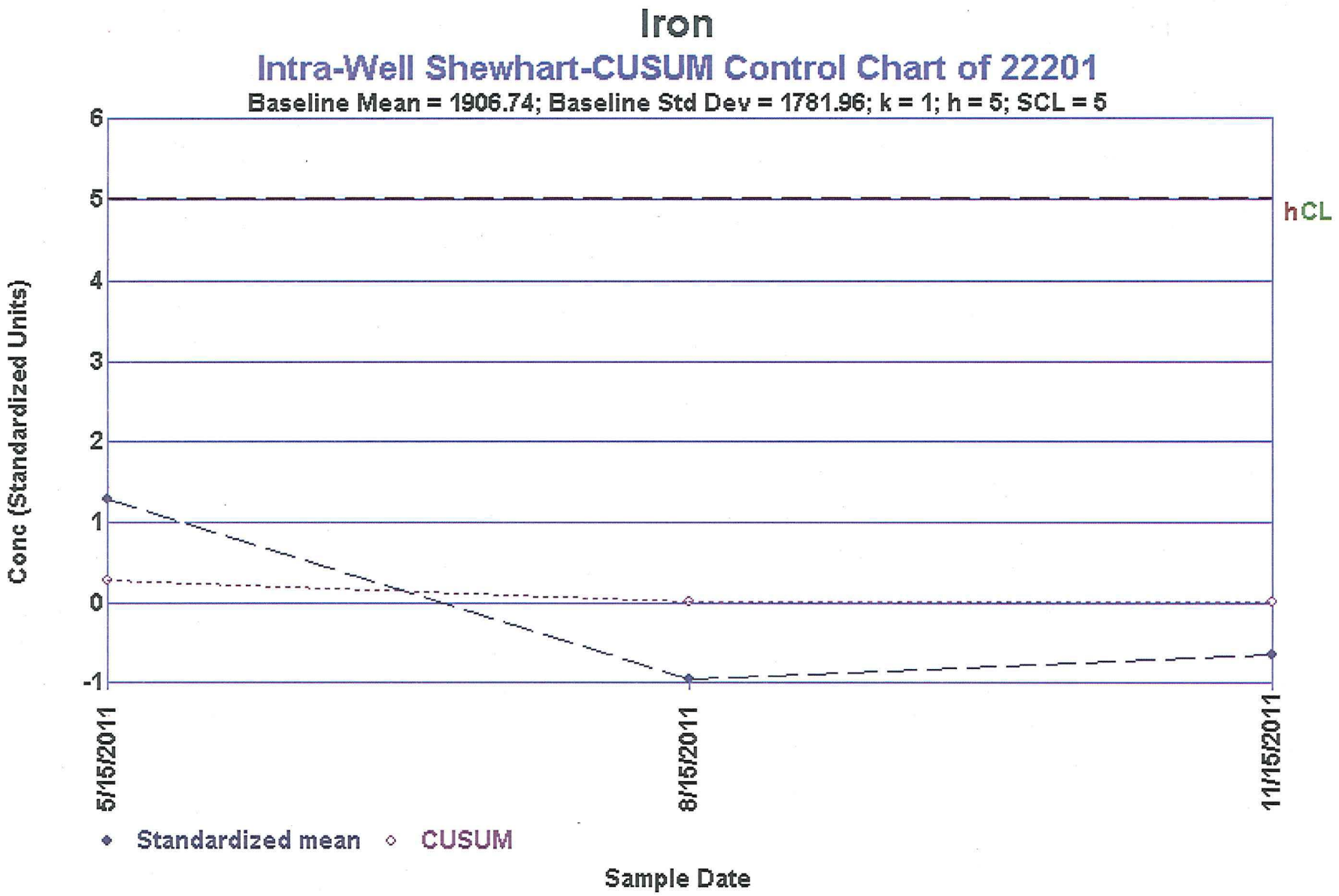


Figure A.5.1–36. Intra-Well Shewhart-CUSUM Control Chart (Iron 22201)

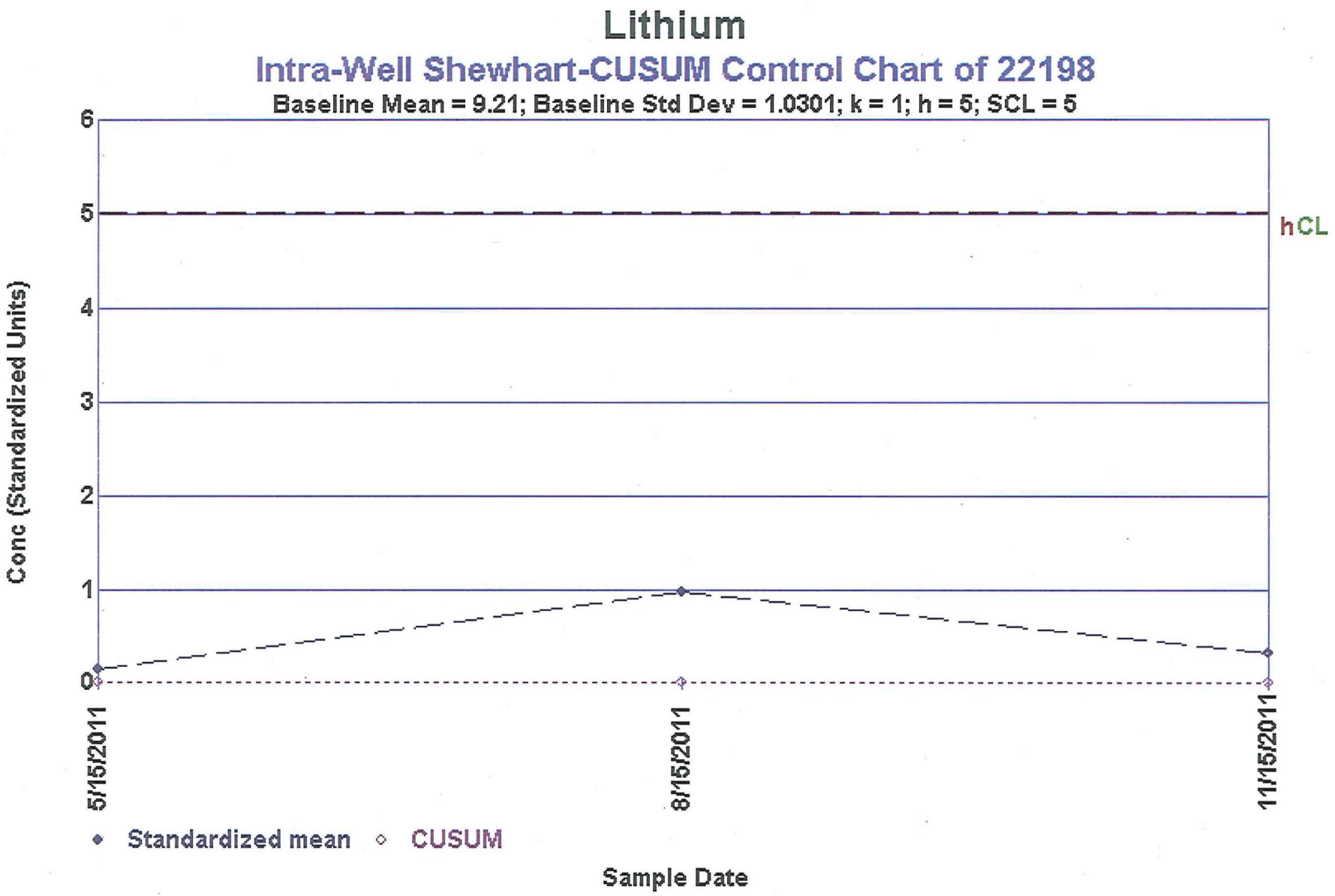


Figure A.5.1–37. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22198)

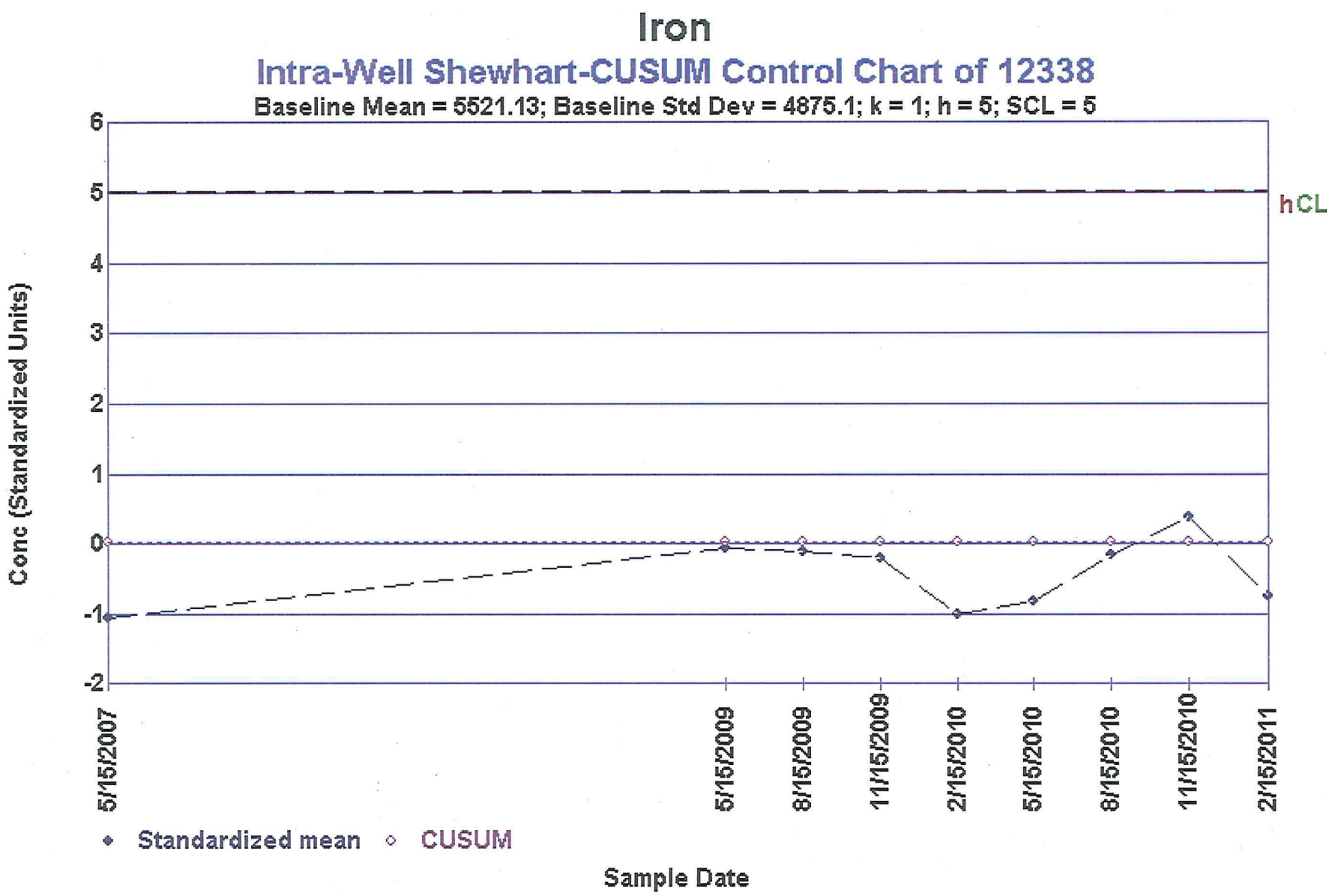


Figure A.5.1 –35. Intra-Well Shewhart-CUSUM Control Chart (Iron 12338)

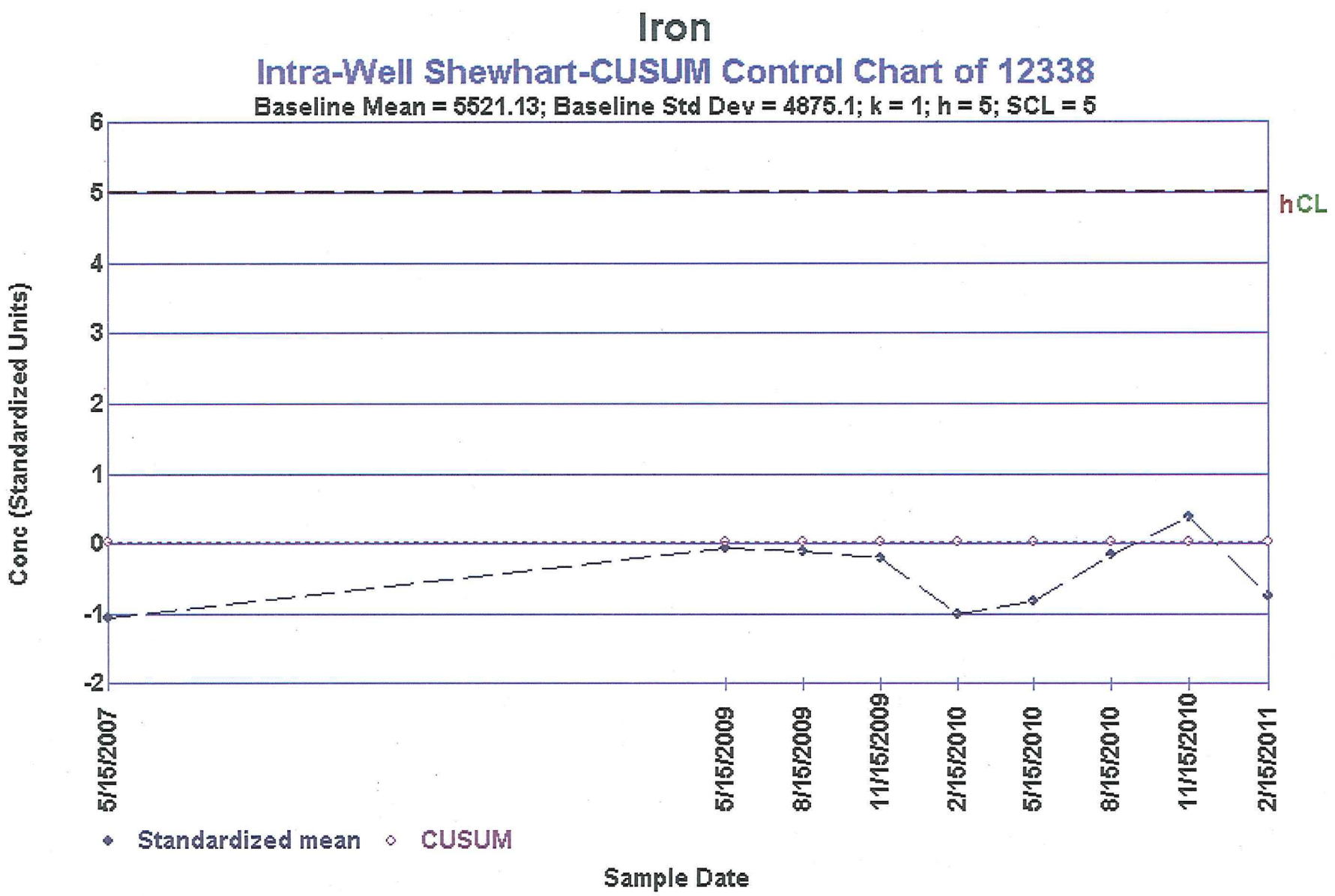


Figure A.5.1 –35. Intra-Well Shewhart-CUSUM Control Chart (Iron 12338)

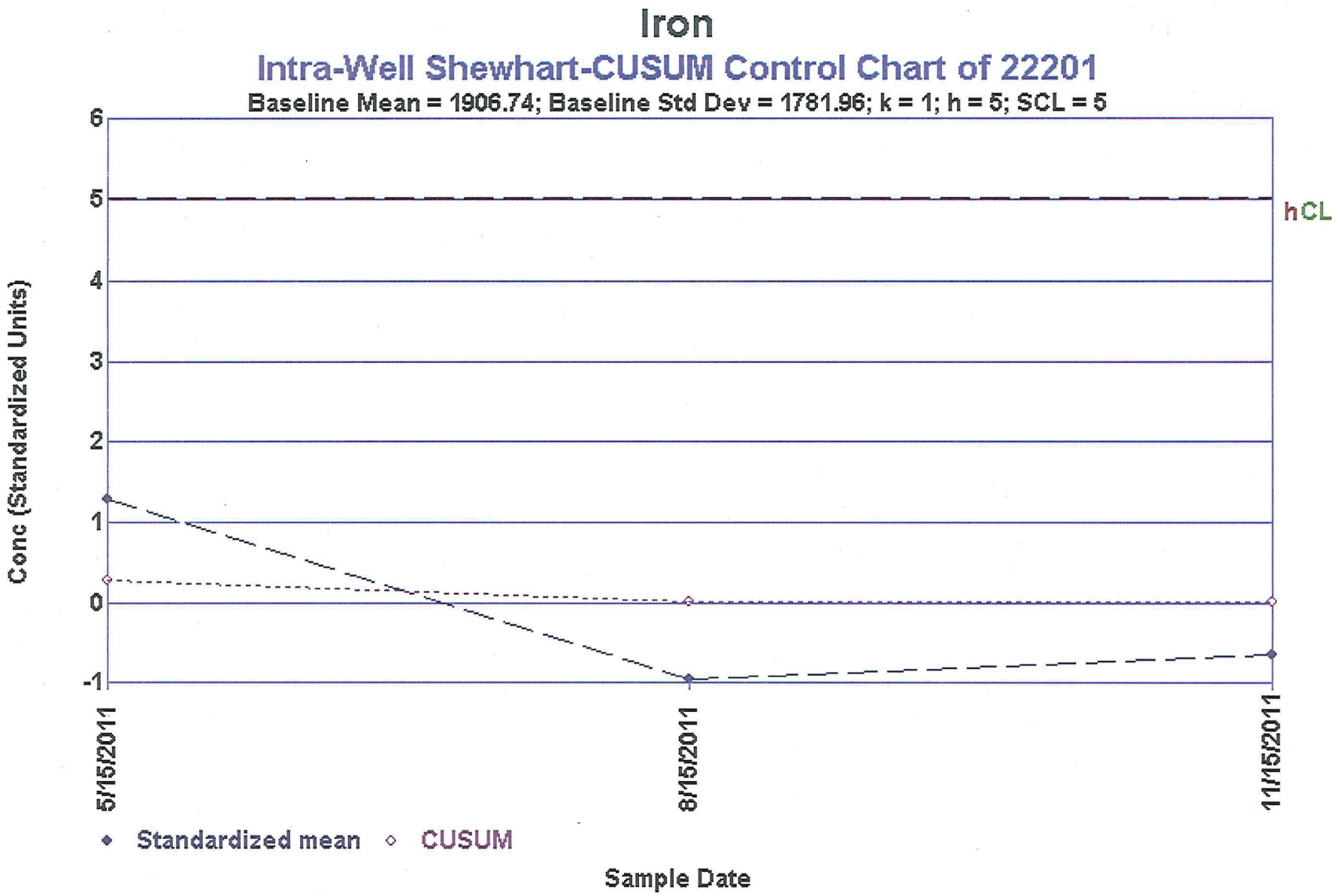


Figure A.5.1–36. Intra-Well Shewhart-CUSUM Control Chart (Iron 22201)

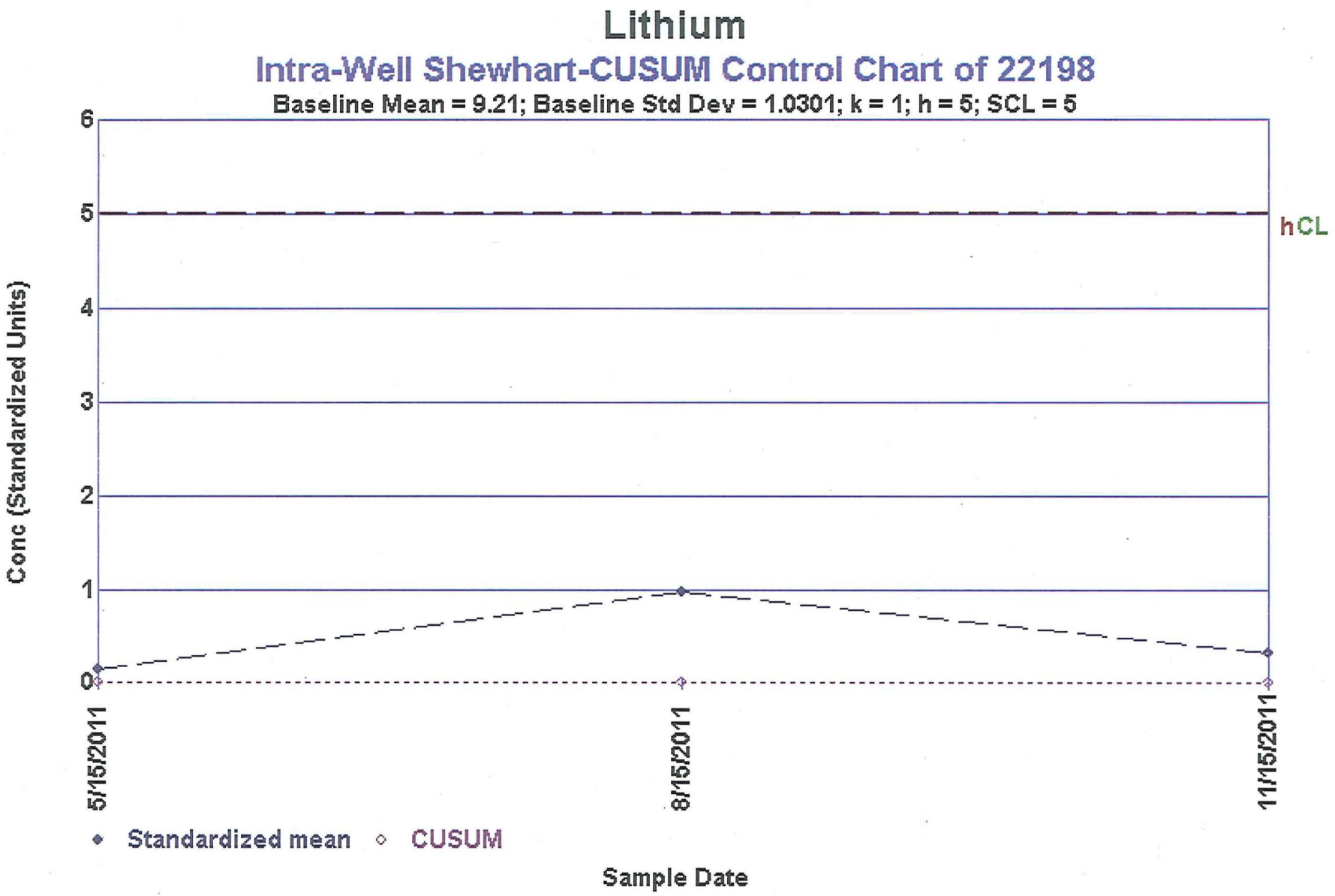


Figure A.5.1–37. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22198)

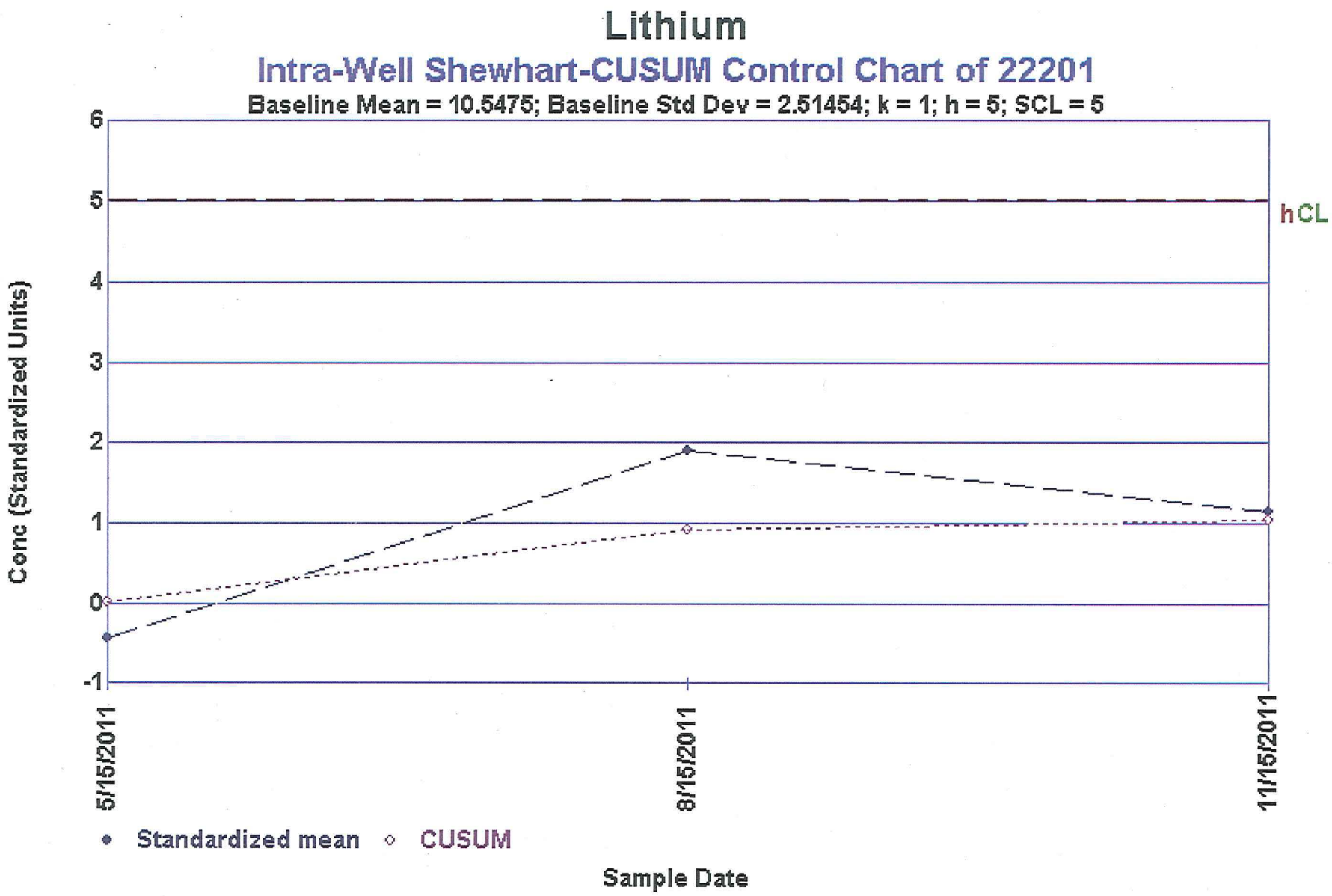


Figure A.5.1–38. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22201)

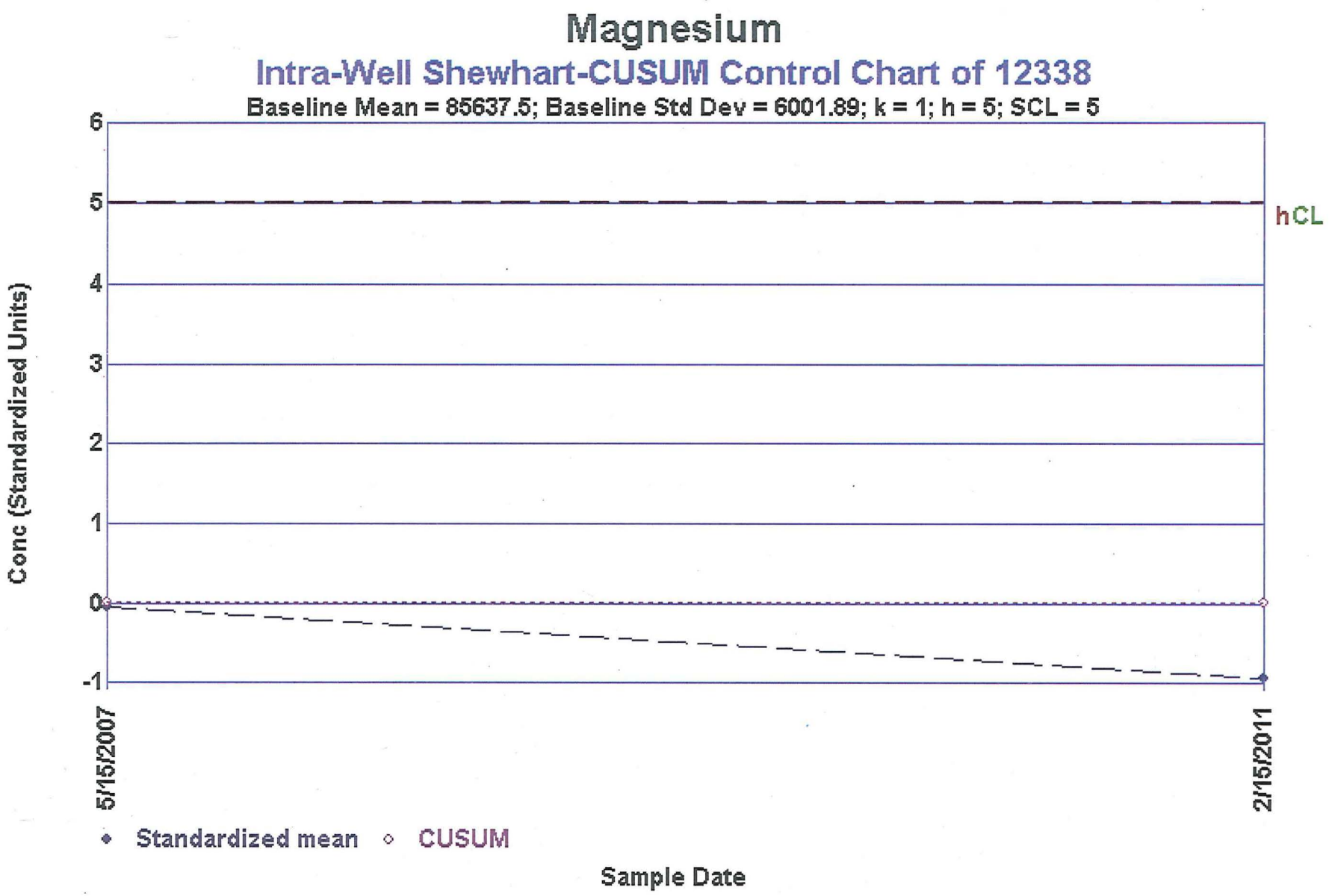


Figure A.5.1–39. Intra-Well Shewhart-CUSUM Control Chart (Magnesium 12338)

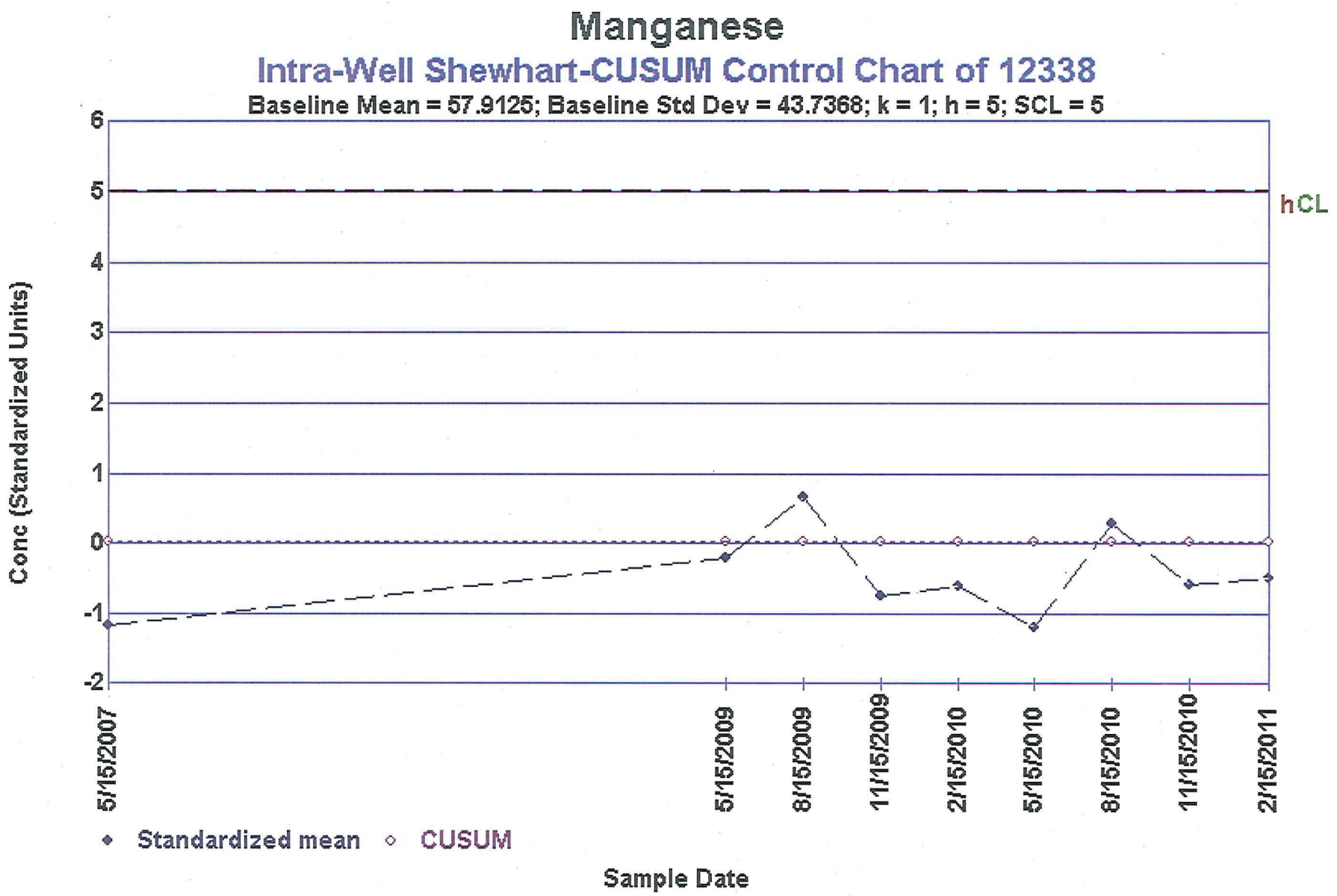


Figure A.5.1 –40. Intra-Well Shewhart-CUSUM Control Chart (Manganese 12338)

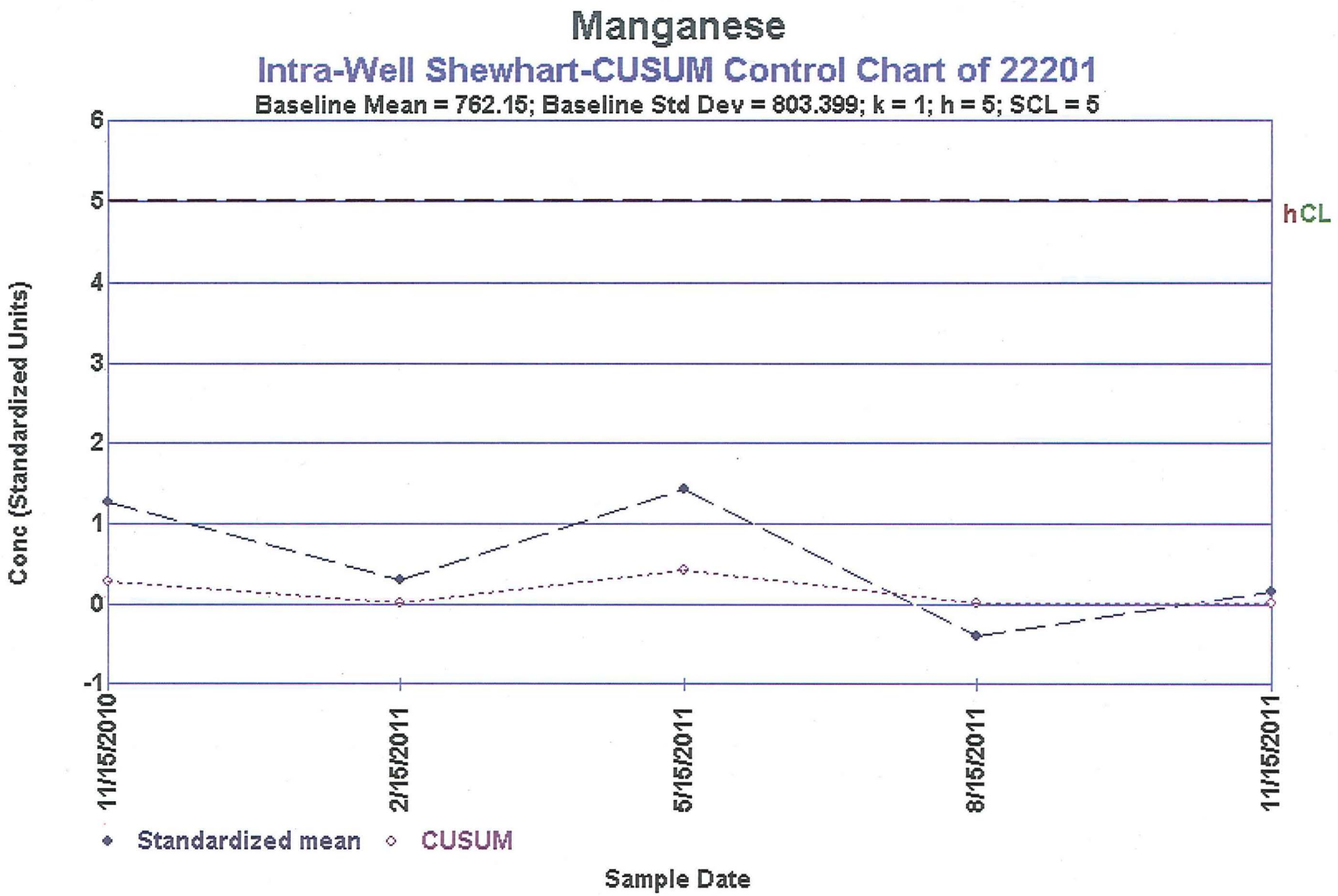


Figure A.5.1 –41. Intra-Well Shewhart-CUSUM Control Chart (Manganese 22201)

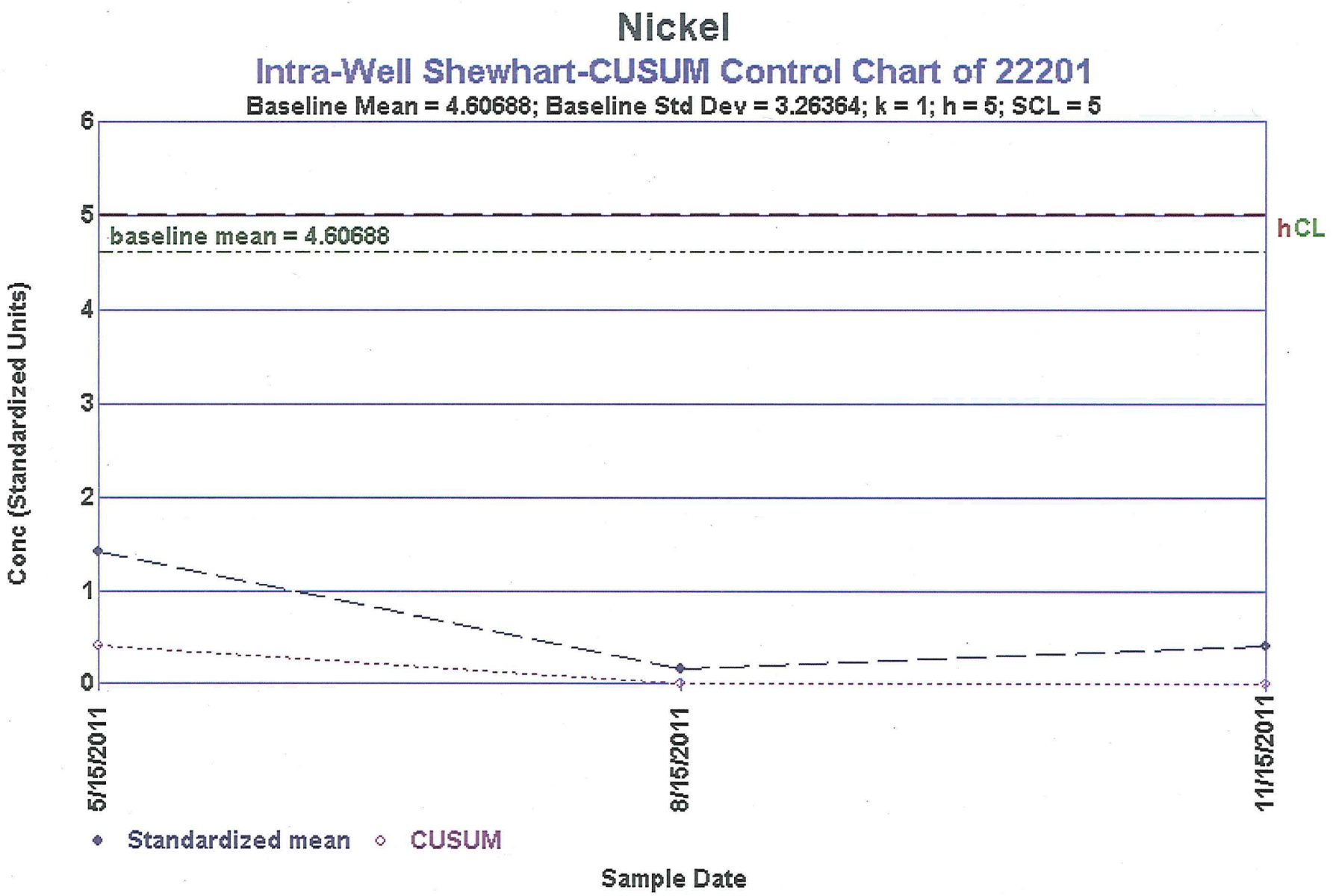


Figure A.5.1–42. Intra-Well Shewhart-CUSUM Control Chart (Nickel 22201)

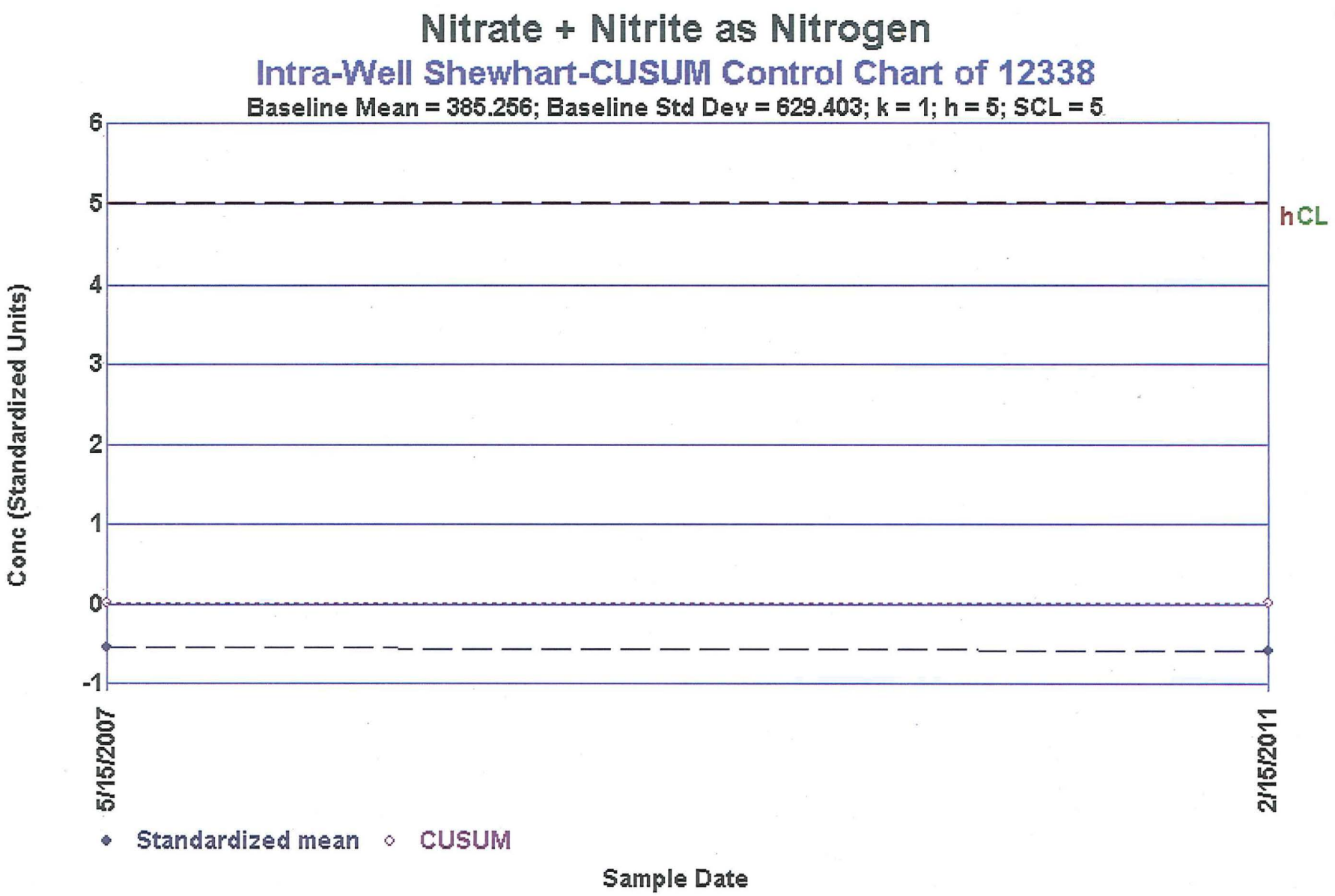


Figure A.5.1–43. Intra-Well Shewhart-CUSUM Control Chart (Nitrate 12338)

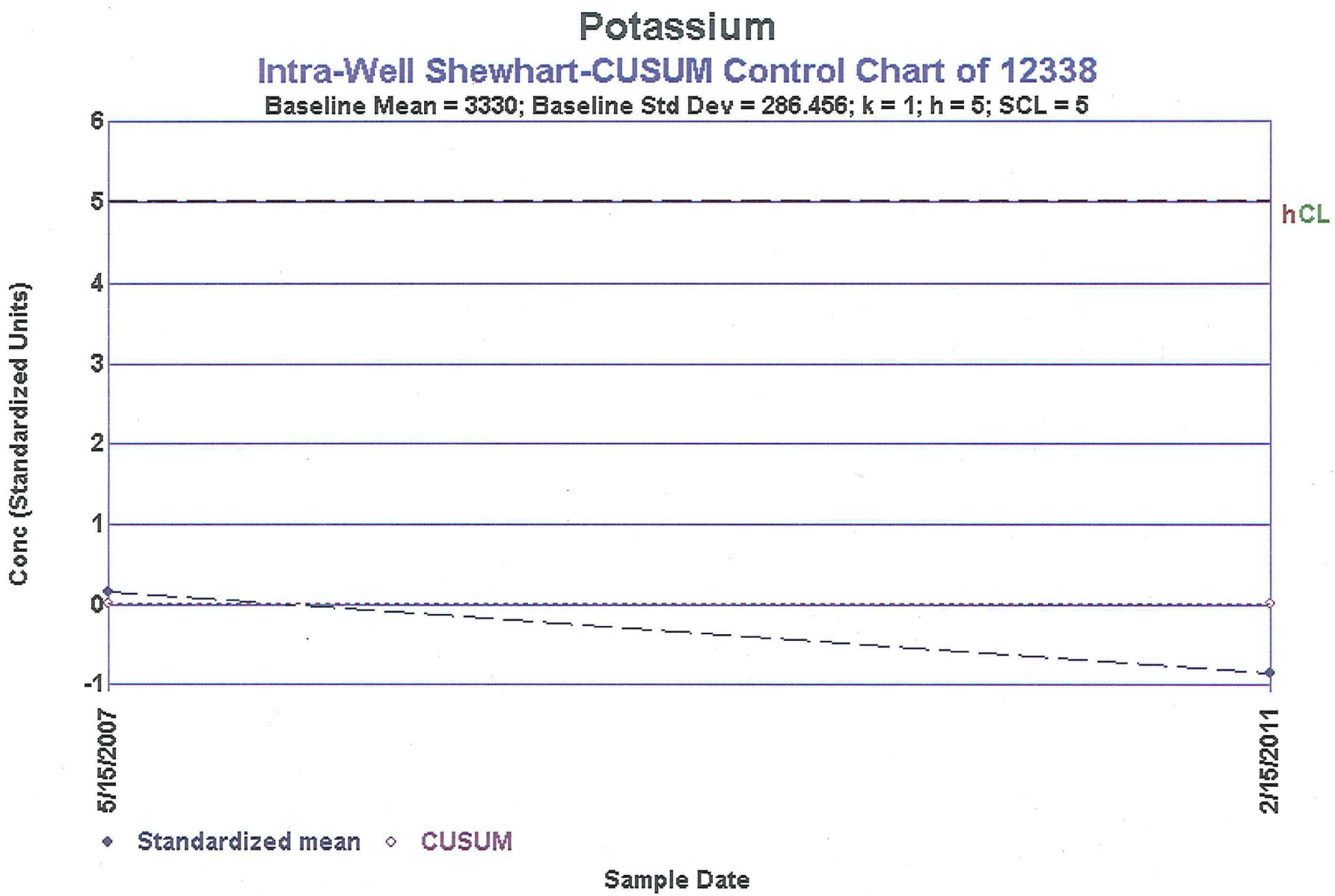


Figure A.5.1–44. Intra-Well Shewhart-CUSUM Control Chart (Potassium 12338)

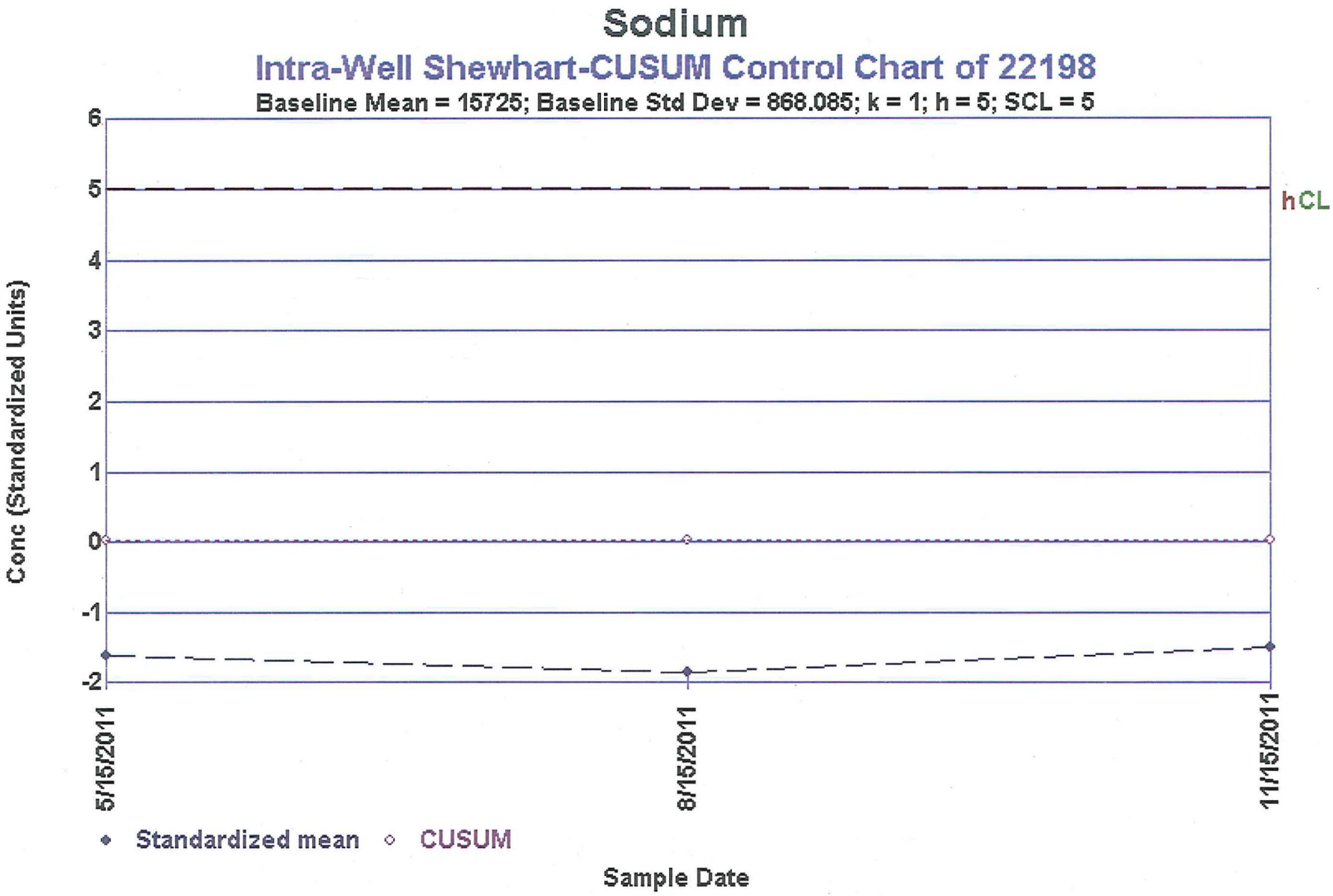


Figure A.5.1 –45. Intra-Well Shewhart-CUSUM Control Chart (Sodium 22198)

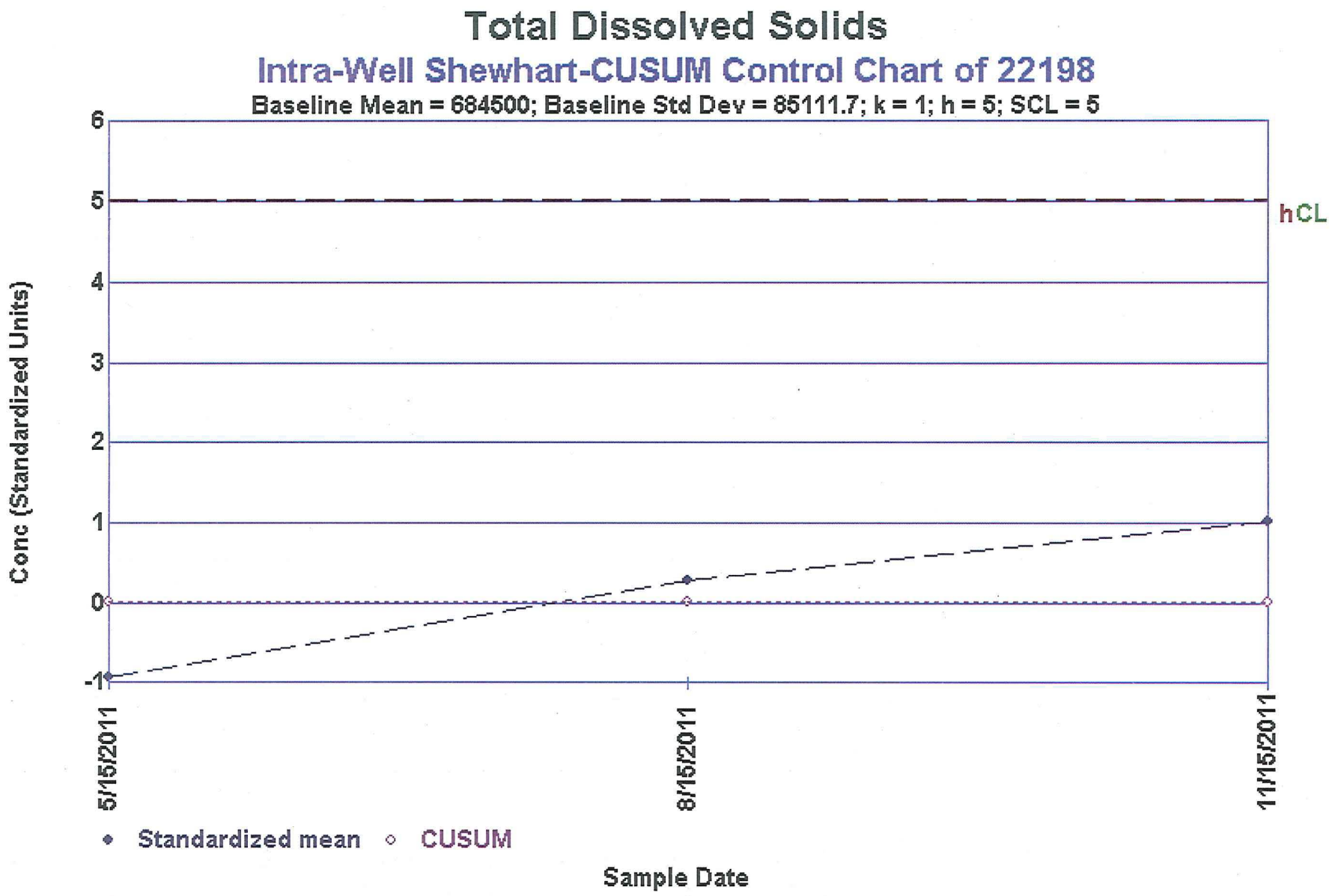


Figure A.5.1–46. Intra-Well Shewhart-CUSUM Control Chart (TDS 22198)

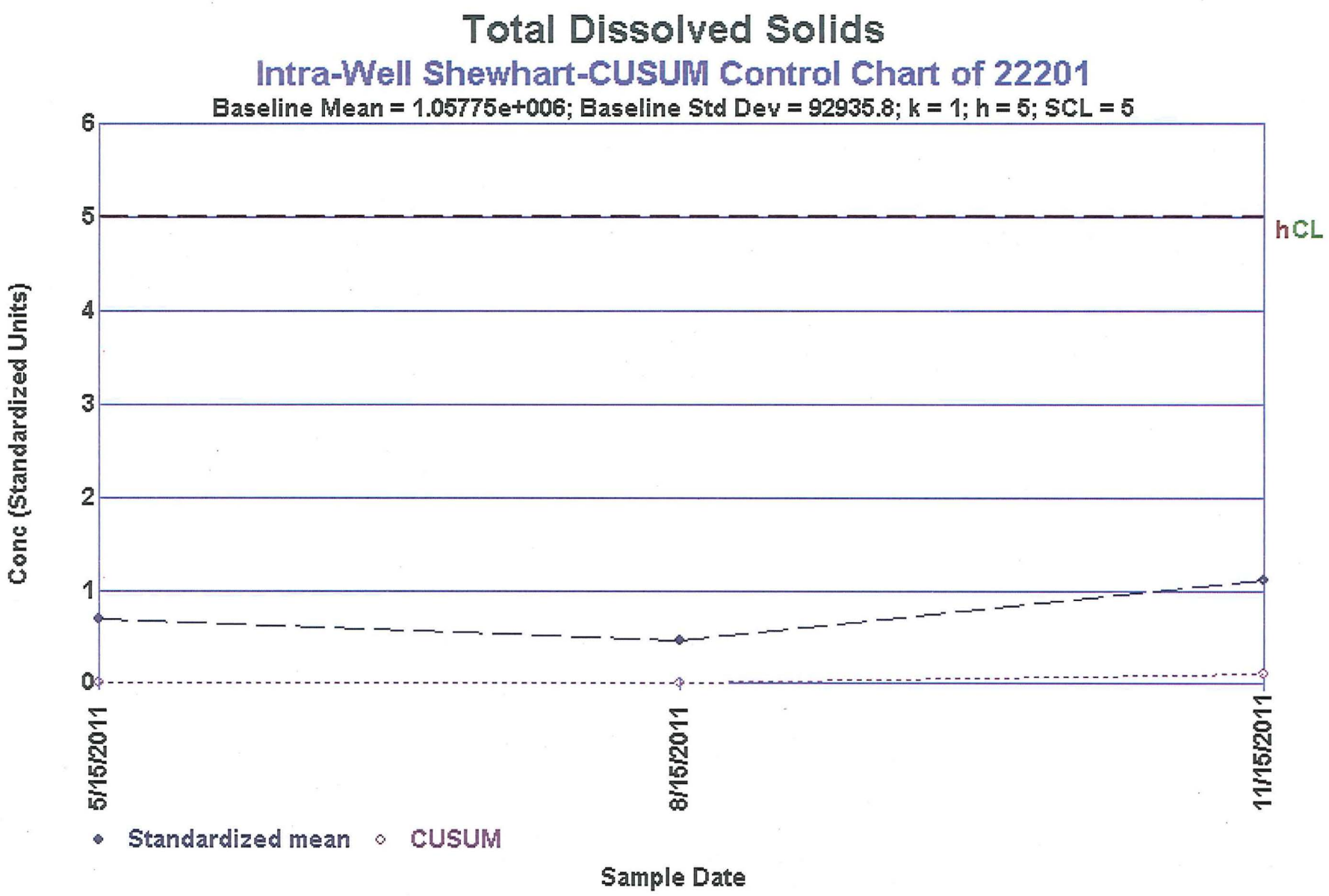


Figure A.5.1–47. Intra-Well Shewhart-CUSUM Control Chart (TDS 22201)

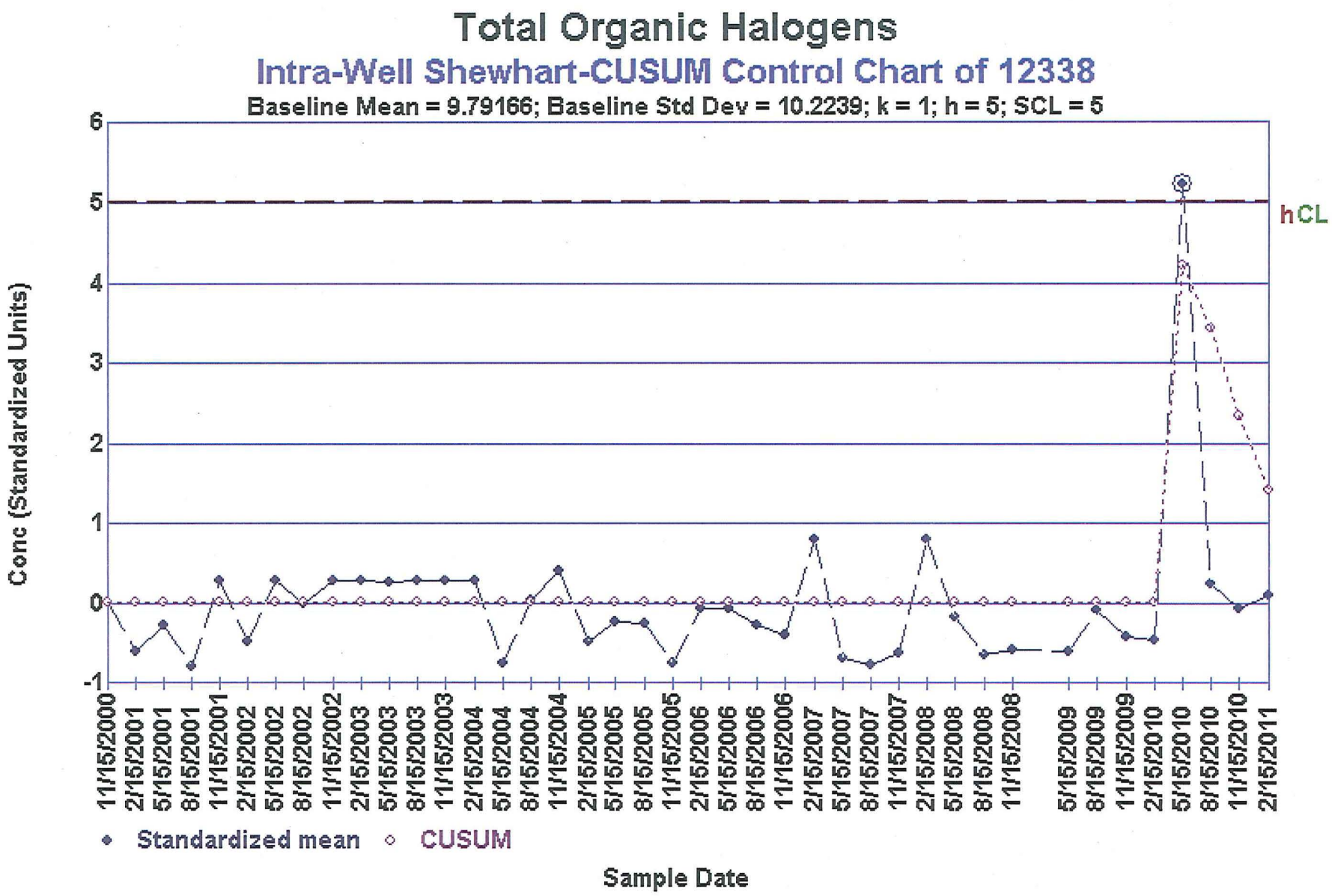


Figure A.5.1–48. Intra-Well Shewhart-CUSUM Control Chart (TOX 12338)

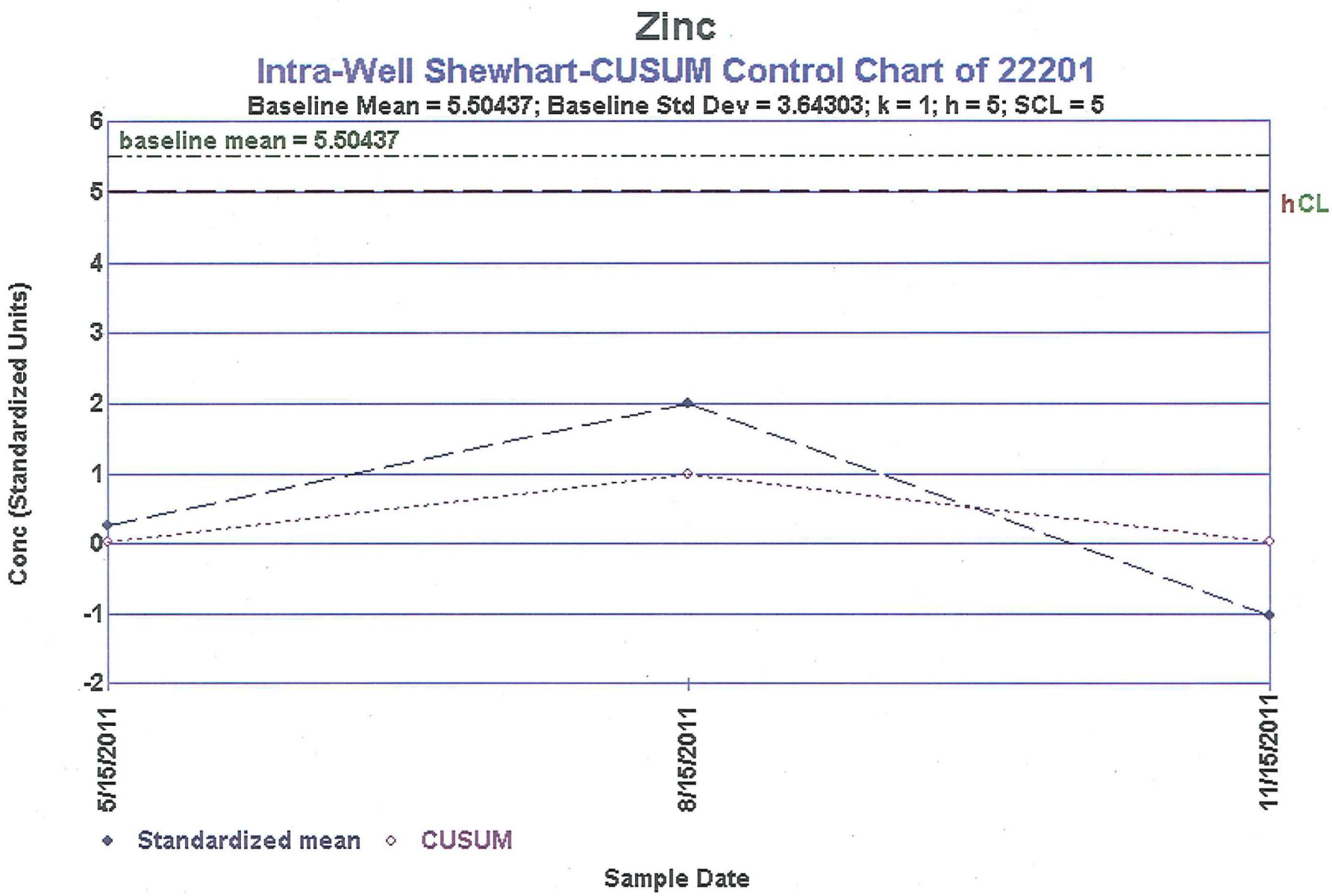


Figure A.5.1–49. Intra-Well Shewhart-CUSUM Control Chart (Zinc 22201)

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Sub-attachment A.5.2

Sub-attachment A.5.2

Cell 2

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The following information is provided in this sub-attachment:

- Quarterly monitoring summary statistics (refer to Table A.5.2–1)
- Annual LCS sample summary information for detected parameters (refer to Table A.5.2–2)
- LCS monthly accumulation volumes (refer to Figure A.5.2–1)
- LDS monthly accumulation volumes (refer to Figure A.5.2–2)
- OSDF horizontal till well 12339 water yield (refer to Figure A.5.2–3)
- GMA water levels and uranium concentration versus time (refer to Figures A.5.2–4 and A.5.2–5)
- Plots of concentration versus time (refer to Figures A.5.2–6A to A.5.2–28B)
- A bivariate plot for uranium-sodium (refer to Figure A.5.2–29)
- Control charts (refer to Figures A.5.2–30 to A.5.2–47)

A.5.2.1 Quarterly Monitoring Results

Quarterly water quality monitoring takes place in the LCS, LDS, HTW, and GMA wells of each cell for the purpose of determining if the OSDF is operating as designed. Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentrations versus time plots, bivariate plots, and control charts are used to help interpret and present the results.

In the first quarter of 2011, 23 parameters were sampled in the LCS, LDS, HTW, and GMA wells of each cell. In the second, third, and fourth quarters tritium was added to the analyte list for all horizons (LCS, LDS, HTW, and GMA wells), and the analyte list for the HTWs in all cells was changed to just four parameters: arsenic, uranium, tritium, and sodium. These changes were agreed to via the comment resolution process between Ohio EPA and DOE on revision 4 of the LMICP (DOE 2010b). Tritium results for all cells are reported in Section A.5.5.

The LDS of Cell 2 was dry during the first, second, and third quarters of 2011. As shown in Table A.5.2–1, 5 of the 23 parameters sampled quarterly in the LCS, LDS, HTW, and GMA wells (uranium, TOC, arsenic, boron, and sodium) have upward trends in the HTW and/or the GMA wells based on the Mann-Kendall test for trend.

Horizontal Till Wells

The HTW is located beneath the liner penetration box of each cell by design. The liner penetration box is considered to be potentially the weakest point in the cell design. If a leak were to develop, it should be detected beneath the liner penetration box first. Therefore, the water quality in the HTW represents the first line of evidence that a potential leak from the cell might be occurring. A leak would be indicated by an increasing concentration in the HTW.

Of the 23 parameters monitored quarterly in the LCS, LDS, HTW, and GMA wells, uranium, TOC, and boron are increasing in the HTW of Cell 2 (as indicated in the table below). The bivariate plot for the Cell 2 LCS, LDS, and HTW (uranium-sodium) is provided in Figure A.5.2–29. There are only two data points for the HTW of Cell 2 shown in

Figure A.5.2–29 because the LDS has routinely been dry since the first quarter of 2006. A sample was collected during the fourth quarter of 2011. The plot shows that the chemical signature for uranium-sodium in the LCS, LDS, and the HTW are separate and distinct; indicating that mixing between the horizons is not occurring. Therefore, the increasing concentrations measured in the HTW of Cell 2 are attributed to fluctuating ambient concentrations beneath the cell that are not related to cell performance.

Parameter	HTW[a]	GMA-U[a]	GMA-D[a]
Uranium	Up	Up	
TOC	Up		
Arsenic			Up
Boron	Up	Up	Up
Sodium		Up	

[a]HTW = horizontal till well, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer.
No entry indicates that the trend was not up.

The plot of concentrations versus time for boron in the HTW is presented in Figure A.5.2–17A. If data prior to 2006 is removed from the dataset, the Mann-Kendall trend test indicates no statistical significant evidence for a trend.

Great Miami Aquifer Wells

GMA monitoring wells are positioned for post-aquifer-remediation flow conditions, when flow directions will be from west to east. However, water levels measured in 2011 indicate that groundwater in the GMA in most of the area of the OSDF is moving in a general direction of northeast to south/southwest in response to the active groundwater remediation taking place to the west and southwest. Pumping for the groundwater remediation is scheduled to last until 2023. Because bivariate plots (discussed above) indicate that LCS, LDS, and HTW monitoring horizons are not mixing, the increasing concentrations seen in the GMA wells, for uranium, arsenic, boron, and selenium, are attributed to fluctuating ambient conditions that are not related to cell performance.

The table below provides a summary of the average concentration (as reported in Table A.5.2–1) measured in the LDS and GMA wells for parameters with increasing concentrations in the Cell 2 GMA wells.

Parameter	LDS[a]	GMA-U[a]	GMA-D[a]
Uranium (µg/L)	**19.2**	0.86	0.734
Arsenic (mg/L)	ND	**0.0025**	**0.0015**
Boron (mg/L)	**0.510**	0.0503	0.0501
Sodium (mg/L)	**826**[b]	26.8	17.0

Note: The highest averages are shown in bold
[a] LDS = leak detection system, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer.
[b] Sodium has only been detected twice in the LDS of Cell 2 (fourth quarter 2005, 989 mg/L and fourth quarter 2011, 664 mg/L).
ND = not detected

As shown above, arsenic has never been detected in the LDS of Cell 2. It should be noted that the LDS of Cell 2 was dry between 2006 and the fourth quarter of 2011.

A.5.2.2 Control Charts

Intrawell control charts employ historical measurements from a compliance point as background. The *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance* (EPA 2009) defines the process of creating a Shewart-CUSUM control chart. Appropriate background data are used to define a baseline for the well. The baseline parameters for the chart, estimates of the mean, and standard deviation are obtained from the background data. These baseline measurements characterize the expected background concentrations at the monitoring point. As future concentrations are collected, the baseline parameters are used to standardize the newly gathered data. After these measurements are standardized and plotted, a control chart is declared "out of control" if future concentrations exceed the baseline control limit. This is indicated on the control chart when either the Shewart or CUSUM plot traces begin to exceed a control limit. The limit is based on the rationale that if the monitoring point remains unchanged from the baseline condition, new standardized observations should not deviate substantially from the baseline mean. If a change occurs, the standardized values will deviate significantly from the baseline and tend to exceed the control limit. Usually, two parameters are used to compute standardized limits; the decision value (h) and the Shewart Control Limit (SCL).

A minimum of eight samples are recommended for use in ChemStat® software to define the baseline for a control chart. Therefore, only sample sets with greater than eight samples were selected for control charts. By default, the ChemStat® software plots both a CUSUM control limit (h) and a SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit (h) and a value of 4.5 for the SCL.

EPA Unified Guidance suggests that to simplify the interpretation of the control chart that an out of control condition be based on the CUSUM (h) limit alone. Plotting the SCL limit is not needed. The ChemStat® software though, by default, plots both the SCL and CUSUM (h) control limits on the charts. As a "work-a-round", the SCL limit was defined as 5 to match the recommended CUSUM limit. On the charts the combined limit is identified as hCL. For interpretation purposes, regard hCL as the CUSUM limit (h).

As shown in Table A.5.2–1 in gray shading, 14 parameters in the HTW and/or GMA wells of Cell 2 meet the criteria for control charts (i.e., more than 8 samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in 18 control charts.

These 18 control charts are presented in Figures A.5.2–30 to A.5.2–47. All of the control charts for Cell 2 indicate "in control" conditions. Previous "out of control" conditions were no longer present in 2011.

Parameter and Monitoring Point[a]	Assessment
Alkalinity in the HTW	In Control
Nitrate in the HTW	In Control
TDS in the GMA-U	In Control
TDS in the GMA-D	In Control
TOC in the GMA-D	In Control
Barium in the HTW	In Control
Calcium in the HTW	In Control
Cobalt in the HTW	In Control
Copper in the HTW	In Control
Iron in the GMA-U	In Control
Iron in the GMA-D	In Control
Lithium in the GMA-U	In Control
Lithium in the GMA-D	In Control
Magnesium in the HTW	In Control
Manganese in the GMA-U	In Control
Potassium in the HTW	In Control
Zinc in the GMA-U	In Control
Zinc in the GMA-D	In Control

[a]HTW = horizontal till well; TDS = total dissolved solids; TOC = total organic carbon; GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer

A.5.2.3 Annual LCS Sample Results

Annual LCS sampling results for Cell 2 are provided in Table A.5.2–2 for those parameters that have been detected at least once and are not being sampled quarterly. No new Appendix I or PCB parameters were detected in the LCS of Cell 2 in 2011.

A.5.2.4 Summary and Conclusions

- Five parameters monitored quarterly have an upward concentration trend in the HTW and/or GMA wells of Cell 2 (uranium, TOC, arsenic, boron, and sodium).
- Separate and distinct chemical signatures for uranium and sodium in the LCS, LDS, and HTW of Cell 2 indicate that water is not mixing between the horizons. The LDS of Cell 2 has been dry between the first quarter of 2006 and the fourth quarter of 2011. Concentration increases in the HTW and GMA wells of Cell 2 are attributed to fluctuating ambient concentrations beneath the cell, and not to cell performance.
- Eighteen control charts were constructed for Cell 2 parameters. All of the control charts exhibit "in control" conditions.
- No new Appendix I or PCB parameters were detected in the LCS of Cell 2 in 2011.

Table A.5.2–1. Summary Statistics for Cell 2

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12339C	51	51	100.0	4.51	404	92.5	75.9	Lognormal	Up	Detected	
	LDS	12339D	27	27	100.0	4.08	71	19.2	14.9	Lognormal	None	Detected	
	HTW	12339	51	52	98.1	ND	36.9	7.80	5.71	Undefined	Up	Detected	
	GMA-U	22200	41	58	70.7	ND	1.11	0.286	0.250	Undefined	Up	Not Detected	
	GMA-D	22199	57	59	96.6	ND	12.1	0.734	2.58	Undefined	None	Not Detected	
Alkalinity as CaCO3 (mg/L)	LCS	12339C	23	23	100.0	60.5	683	552	180	Undefined	Up	Not Detected	
	LDS	12339D	2	2	100.0	131	198	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	10	10	100.0	199	278	245	23	Normal	None	Not Detected	
	GMA-U	22200	4	4	100.0	402	426	418	11	Normal	None	Insuff	
	GMA-D	22199	4	4	100.0	344	378	360	15	Normal	None	Insuff	
Chloride (mg/L)	LCS	12339C	23	23	100.0	3.95	41.2	13.3	6.5	Undefined	Up	Detected	
	LDS	12339D	2	2	100.0	44	112	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	10	10	100.0	128	252	196	43	Normal	Down	Detected	
	GMA-U	22200	4	4	100.0	31.5	41.4	36.6	4.3	Normal	None	Insuff	
	GMA-D	22199	4	4	100.0	23.2	25.3	23.8	1.0	Normal	None	Insuff	
Nitrate/Nitrite as N (mg/L)	LCS	12339C	22	33	66.7	ND	4.1	0.177	1.23	Undefined	Down	Detected	
	LDS	12339D	4	5	80.0	ND	5.4	2.75	2.10	Normal	None	Insuff	
	HTW	12339	2	10	20.0	ND	0.0778	Insuff	Insuff	Lognormal	None	Not Detected	
	GMA-U	22200	0	4	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22199	0	4	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Sulfate (mg/L)	LCS	12339C	40	40	100.0	155	1870	1550	370	Undefined	Up	Detected	
	LDS	12339D	10	10	100.0	2290	3420	2950	350	Normal	None	Not Detected	8110 (Q3-05)
	HTW	12339	32	32	100.0	489	850	637	88	Normal	Down	Detected	
	GMA-U	22200	35	35	100.0	61.1	434	192	102	Lognormal	Down	Not Detected	
	GMA-D	22199	35	35	100.0	101	540	170	105	Undefined	None	Not Detected	
Total Dissolved Solids (mg/L)	LCS	12339C	32	32	100.0	557	3430	2790	988	Undefined	Up	Detected	
	LDS	12339D	4	4	100.0	1894	5780	3420	1670	Normal	None	Insuff	
	HTW	12339	8	8	100.0	1210	1480	1340	100	Normal	Down	Detected	
	GMA-U	22200	11	11	100.0	545	771	629	73	Normal	None	Not Detected	
	GMA-D	22199	11	11	100.0	576	818	651	74	Normal	None	Not Detected	
Total Organic Carbon (mg/L)	LCS	12339C	41	51	80.4	ND	6.6	2.86	1.40	Normal	Up	Detected	
	LDS	12339D	19	27	70.4	ND	26.1	4.20	4.98	Lognormal	Down	Detected	
	HTW	12339	34	47	72.3	ND	3.04	1.83	0.62	Normal	Up	Not Detected	11.1 (Q1-00)
	GMA-U	22200	46	58	79.3	ND	40.1	1.78	5.99	Undefined	None	Not Detected	
	GMA-D	22199	42	58	72.4	ND	3.7	1.54	0.62	Lognormal	None	Not Detected	16.5 (Q3-97) 10.5 (Q4-97) 48.1 (Q2-98) 9.68 (Q1-00)
Total Organic Halogens (mg/L)	LCS	12339C	24	52	46.2	ND	0.0826	0.0180	0.0203	Lognormal	None	Detected	
	LDS	12339D	9	28	32.1	ND	0.069	0.0122	0.0124	Undefined	None	Not Detected	
	HTW	12339	36	49	73.5	ND	0.0435	0.0210	0.0121	Undefined	None	Not Detected	0.78 (Q2-10)
	GMA-U	22200	17	58	29.3	ND	0.0138	0.00472	0.00468	Undefined	Down	Detected	0.124 (Q4-98) 0.177 (Q2-00) 0.073 (Q2-10)
	GMA-D	22199	12	58	20.7	ND	0.0272	0.00448	0.00595	Undefined	Down	Detected	0.0775 (Q2-00) 0.067 Q2-10)
Arsenic (mg/L)	LCS	12339C	17	28	60.7	ND	0.225	0.00931	0.0662	Undefined	Up	Detected	
	LDS	12339D	1	2	50.0	ND	0.00842	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	1	20	5.0	ND	0.025	Insuff	Insuff	Undefined	None	Not Detected	
	GMA-U	22200	3	11	27.3	ND	0.0355	0.0025	Insuff	Undefined	None	Not Detected	
	GMA-D	22199	6	24	25.0	ND	0.0429	0.0015	0.0113	Undefined	Up	Detected	
Barium (mg/L)	LCS	12339C	23	23	100.0	0.0362	0.283	0.0750	0.0745	Undefined	None	Detected	
	LDS	12339D	2	2	100.0	0.0167	0.0203	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	10	10	100.0	0.0208	0.13	0.0516	0.0838	Lognormal	None	Not Detected	
	GMA-U	22200	4	4	100.0	0.0866	0.156	0.119	0.029	Normal	None	Insuff	
	GMA-D	22199	4	4	100.0	0.0641	0.131	0.101	0.031	Normal	None	Insuff	

Table A.5.2–1 (continued). Summary Statistics for Cell 2

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Boron (mg/L)	LCS	12339C	52	52	100.0	0.207	4.78	1.93	1.05	Undefined	Up	Detected	
	LDS	12339D	27	27	100.0	0.289	2.22	0.510	0.380	Undefined	None	Not Detected	
	HTW	12339	46	49	93.9	ND	0.213	0.101	0.058	Undefined	Up	Detected	
	GMA-U	22200	46	58	79.3	ND	0.0888	0.0503	0.0166	Normal	Up	Detected	
	GMA-D	22199	49	58	84.5	ND	0.0775	0.0501	0.0159	Normal	Up	Detected	
Calcium (mg/L)	LCS	12339C	23	23	100.0	165	1320	607	256	Normal	Up	Detected	
	LDS	12339D	2	2	100.0	420	458	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	10	10	100.0	211	431	301	56	Normal	None	Not Detected	
	GMA-U	22200	4	4	100.0	130	161	148	14	Normal	None	Insuff	
	GMA-D	22199	4	4	100.0	132	193	154	28	Normal	None	Insuff	
Cobalt (mg/L)	LCS	12339C	24	28	85.7	ND	0.306	0.0192	0.0738	Undefined	None	Detected	
	LDS	12339D	1	2	50.0	ND	0.0035	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	10	17	58.8	ND	0.005	0.001125	0.001111	Lognormal	None	Not Detected	
	GMA-U	22200	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22199	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Copper (mg/L)	LCS	12339C	19	24	79.2	ND	0.0328	0.0058	0.0087	Undefined	None	Detected	
	LDS	12339D	2	2	100.0	0.0145	0.0221	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	8	11	72.7	ND	0.015	0.0077	0.0048	Normal	None	Not Detected	
	GMA-U	22200	4	4	100.0	0.00413	0.0144	0.00878	0.00428	Normal	None	Insuff	
	GMA-D	22199	4	4	100.0	0.000991	0.00794	0.00569	0.00324	Normal	None	Insuff	
Iron (mg/L)	LCS	12339C	27	28	96.4	ND	253	17.6	67.4	Undefined	Up	Detected	
	LDS	12339D	2	2	100.0	0.331	3.61	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	16	17	94.1	0.61	42.8	1.75	12.6	Undefined	None	Not Detected	
	GMA-U	22200	11	11	100.0	3.24	10	6.31	2.56	Normal	None	Not Detected	
	GMA-D	22199	11	11	100.0	3.46	5.82	4.34	0.61	Normal	None	Not Detected	
Lithium (mg/L)	LCS	12339C	20	20	100.0	0.377	0.967	0.564	0.170	Lognormal	Up	Detected	
	LDS	12339D	2	2	100.0	0.226	0.31	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	17	17	100.0	0.0132	0.0199	0.0163	0.0020	Normal	Down	Detected	
	GMA-U	22200	11	11	100.0	0.0039	0.00562	0.0045	0.0005	Normal	None	Not Detected	
	GMA-D	22199	11	11	100.0	0.0065	0.00878	0.0075	0.0007	Normal	None	Not Detected	
Magnesium (mg/L)	LCS	12339C	23	23	100.0	32.4	375	205	85	Normal	Up	Detected	
	LDS	12339D	2	2	100.0	393	468	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	10	10	100.0	79.7	138	98.4	14.4	Normal	None	Not Detected	
	GMA-U	22200	4	4	100.0	33.1	42.5	38.5	4.2	Normal	None	Insuff	
	GMA-D	22199	4	4	100.0	38	54.8	39.4	8.0	Undefined	None	Insuff	
Manganese (mg/L)	LCS	12339C	26	28	92.9	ND	12.7	2.06	3.94	Undefined	None	Detected	
	LDS	12339D	2	2	100.0	0.418	0.812	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	15	17	88.2	0.00414	0.364	0.0552	0.0848	Lognormal	Down	Detected	
	GMA-U	22200	13	13	100.0	0.204	0.507	0.328	0.088	Normal	None	Not Detected	
	GMA-D	22199	23	24	95.8	ND	0.791	0.319	0.160	Lognormal	Down	Not Detected	
Nickel (mg/L)	LCS	12339C	28	28	100.0	0.00495	0.421	0.0780	0.0930	Lognormal	None	Detected	
	LDS	12339D	2	2	100.0	0.00906	0.0215	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	8	17	47.1	ND	0.0111	0.00474	0.00375	Undefined	Down	Not Detected	
	GMA-U	22200	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22199	6	24	25.0	ND	0.0066	0.00152	0.00173	Undefined	None	Detected	
Potassium (mg/L)	LCS	12339C	23	23	100.0	3.93	49.7	20.4	13.2	Undefined	Up	Detected	
	LDS	12339D	2	2	100.0	29.8	38	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	10	10	100.0	3.27	5.05	3.77	0.58	Lognormal	None	Not Detected	
	GMA-U	22200	4	4	100.0	1.5	1.7	1.62	0.09	Normal	None	Insuff	
	GMA-D	22199	4	4	100.0	1.34	1.58	1.48	0.10	Normal	None	Insuff	

Table A.5.2–1 (continued). Summary Statistics for Cell 2

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Selenium (mg/L)	LCS	12339C	10	28	35.7	ND	0.0522	0.00999	0.0134	Lognormal	None	Not Detected	
	LDS	12339D	1	2	50.0	ND	0.0191	insuff	insuff	Insuff	Insuff	Insuff	
	HTW	12339	1	17	5.9	ND	0.0367	Insuff	Insuff	Undefined	None	Not Detected	
	GMA-U	22200	0	11	0.0	ND	NA	insuff	insuff	Insuff	Insuff	Insuff	
	GMA-D	22199	0	11	0.0	ND	NA	insuff	insuff	Insuff	Insuff	Insuff	
Sodium (mg/L)	LCS	12339C	28	28	100.0	3.32	26.7	17.4	5.6	Normal	Up	Detected	
	LDS	12339D	2	2	100.0	664	989	insuff	insuff	Insuff	Insuff	Insuff	
	HTW	12339	20	20	100.0	44.3	119	72.6	23.8	Lognormal	Down	Detected	
	GMA-U	22200	11	11	100.0	20.4	32.9	26.8	4.3	Normal	Up	Detected	
	GMA-D	22199	11	11	100.0	14.1	19.5	17.0	1.7	Normal	Down	Not Detected	
Zinc (mg/L)	LCS	12339C	19	28	67.9	ND	0.353	0.0594	0.0857	Lognormal	None	Detected	
	LDS	12339D	2	2	100.0	0.0747	0.284	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12339	9	17	52.9	ND	0.284	0.00512	0.0781	Undefined	None	Detected	
	GMA-U	22200	9	11	81.8	ND	0.0377	0.0164	0.0107	Normal	None	Not Detected	
	GMA-D	22199	15	24	62.5	ND	0.0255	0.00800	0.00488	Lognormal	None	Not Detected	

Note: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least 8 samples, normal or lognormal distribution, no trend, and no serial correlation. These wells achieve control chart criteria.

Note: For results where the concentrations are below the detection limit, the results used in the Average, Standard Deviation, Distribution Type, Trend, Serial Correlation, and Outliers are each set at half the detection limit.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption and requires $n \geq 3$. In addition, Standard Deviation requires $n \geq 4$.

[d]"Insuff" = Insufficient and is used for Average, Standard Deviation, Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic (where $3 \leq n \leq 50$) or Shapiro Francia (where $n > 50$).

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the lognormal assumption.

Lognormal: Lognormal assumption could not be rejected at the 5 percent level and has a higher probability value than the normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25% detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure. Trend testing requires a sample with $n \geq 4$.

[g]Serial correlation based on Rank Von Neumann test. Serial Correlation testing requires a sample with $n \geq 6$.

[h]Outliers determined by Rosner's (where $n > 25$) or Dixon procedure (where $4 \leq n \leq 25$).

[i]Q = quarterly

Table A.5.2–2. Cell 2 Annual LCS Sample Summary Information for Detected Parameters

PARAMETER(UNIT)	NUMBER OF SAMPLES[a,b]	NUMBER OF SAMPLES WITH DETECTIONS[a,b]	PERCENT OF DETECTIONS[a,b]	DETECTED IN 2011	MIN DETECTED CONCENTRATION[a,b,c]	MAX DETECTED CONCENTRATION[a,b,c]	AVG DETECTED CONCENTRATION[a,b,c]	GW FRL[d] (#OF SAMPLES>GWFRL)	GW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	PW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	MAX PW DETECTED CONCENTRATION [a,b,f] (# OF SAMPLES>MAX PW)
General Chemistry											
Ammonia (mg/L)	14	6	42.9	Yes	0.076	0.2	0.13	-	4.2 mg/L(0)	4.34 mg/L(0)	220 mg/L(0)
Inorganics											
Antimony ((mg/L))	14	3	21.4	Yes	0.00053	0.00629	0.0025	0.006 mg/L((1))	-	-	0.0937 mg/L((0))
Cadmium (mg/L)	14	5	35.7	Yes	0.000091	0.00128	0.0005	0.014 mg/L(0)	0.014 mg/L(0)	-	0.05 mg/L(0)
Chromium ((mg/L))	14	6	42.9	Yes	0.00008	0.0069	0.004	0.022 mg/L[g]((0))	0.0271 mg/L((0))	0.0046 mg/L((3))	0.818 mg/L((0))
Lead ((mg/L))	14	4	28.6	Yes	0.0007	0.0275	0.0093	0.015 mg/L((1))	0.022 mg/L((1))	0.0016 mg/L((3))	0.0114 mg/L((1))
Thallium ((mg/L))	14	4	28.6	Yes	0.00057	0.0107	0.0083	-	-	-	0.0028 mg/L((1))
Vanadium ((mg/L))	14	3	21.4	Yes	0.00158	0.0116	0.0066	0.038 mg/L((0))	0.0012 mg/L((0))	0.005 mg/L((2))	0.299 mg/L((0))
Radionuclides											
Technetium-99 (pCi/L)	25	1	4.0	No	21.2	-	-	94 pCi/L(0)	22 pCi/L(0)	30 pCi/L(0)	6130 pCi/L(0)
Organic											
Trichlorofluoromethane (ug/L)	11	1	9.1	No	0.27	-	-	-	-	-	-

Note: Shading indicates that at least one detected sample is greater than the FRL, groundwater background, PW background, or PW maximum.

[a]If more than one sample is collected per well per day (e.g., duplicates), then only one sample is counted for the total number of samples, and the sample with the maximum representative concentration is used for all the summary information

[b]Rejected data qualified with an R or Z were not included.

[c]If the number of detected samples is equal to two, then the minumun and maximumn are reported. If the number of detected is equal to one, then the data point is reported as the minimum. The "AVG DETECTED CONCENTRATION" is not reported for either of these cases.

[d]From Operable Unit 5 Record of Decision, Table 9-4.

[e]From the Characterization of Background Water Quality for Streams and Groundwater which was developed for Operable Unit 5 RI/FS documents.

[f]Max PW - maximum detected concentration in perched water as defined in the Remedial Investigation Report for Operable Unit 5.

[g]FRL based on hexavalent chromium from Operable Unit 5 Record of Decision, Table 9-4.

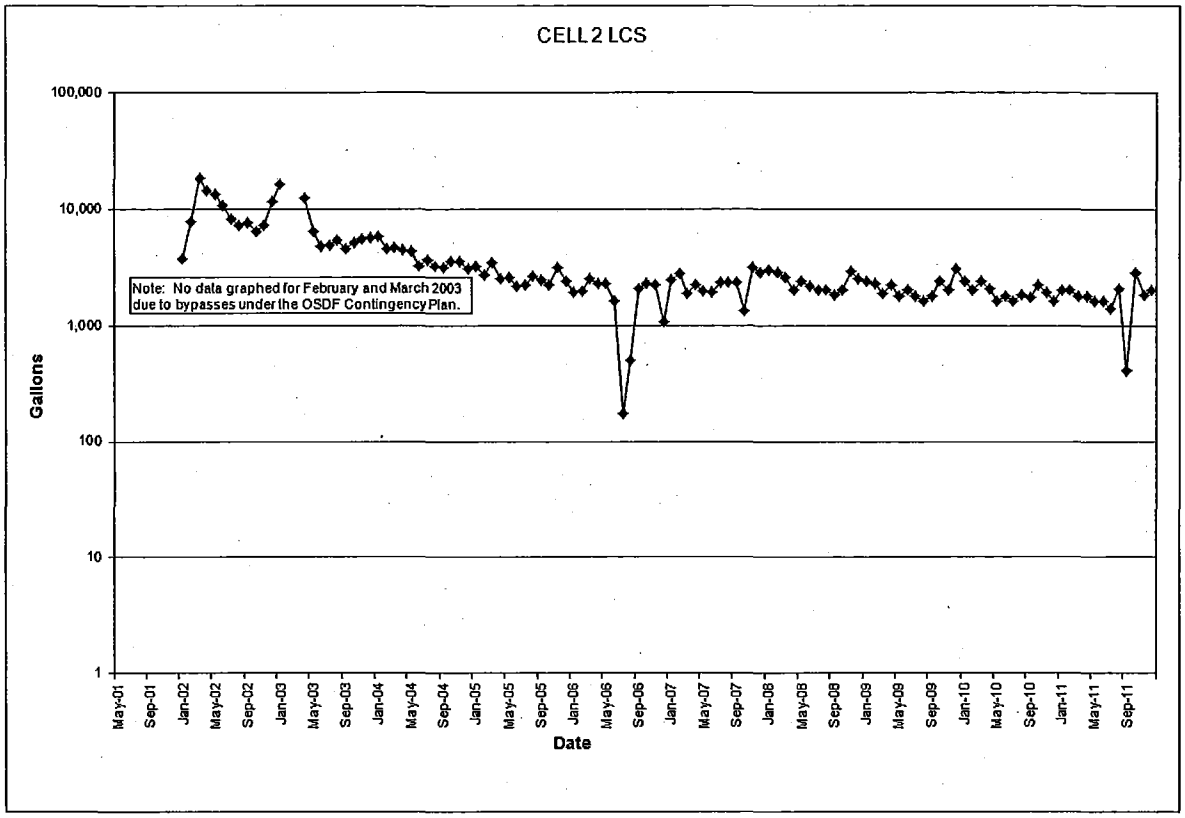


Figure A.5.2–1. Monthly Accumulation Volumes For Cell 2 LCS

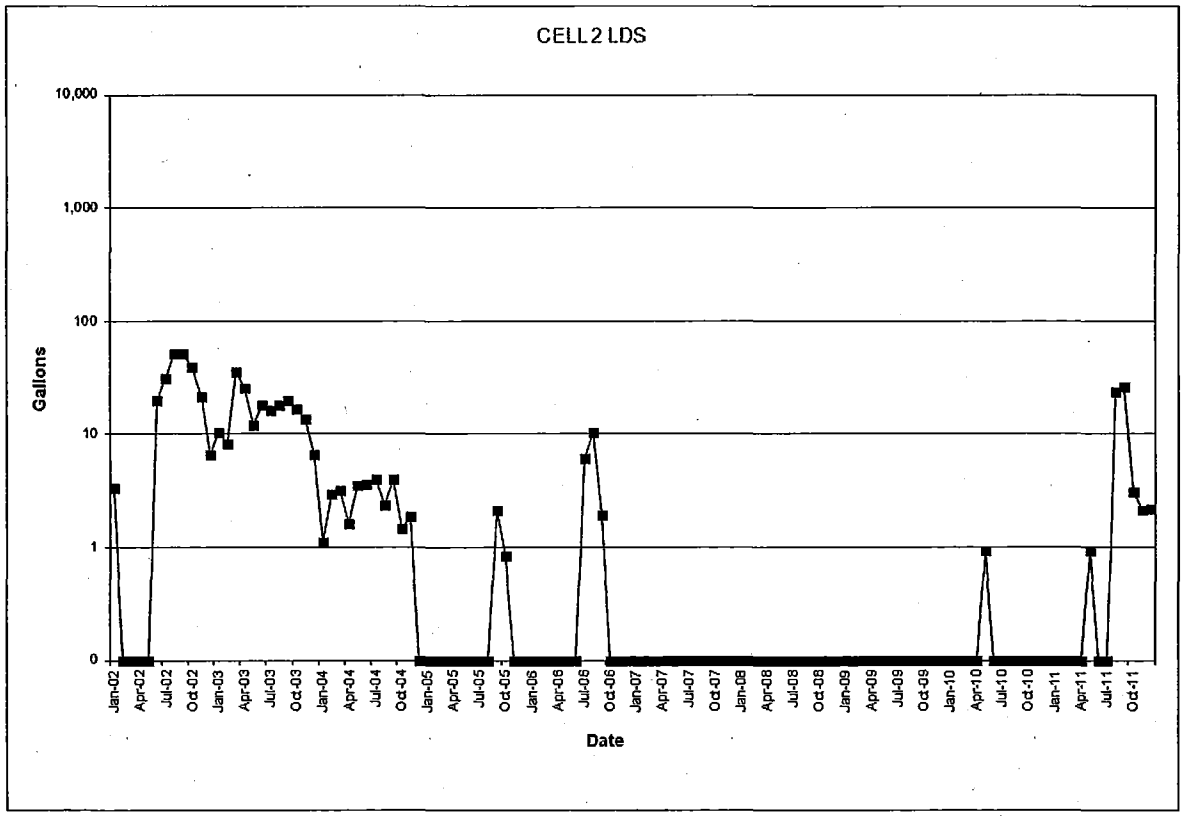
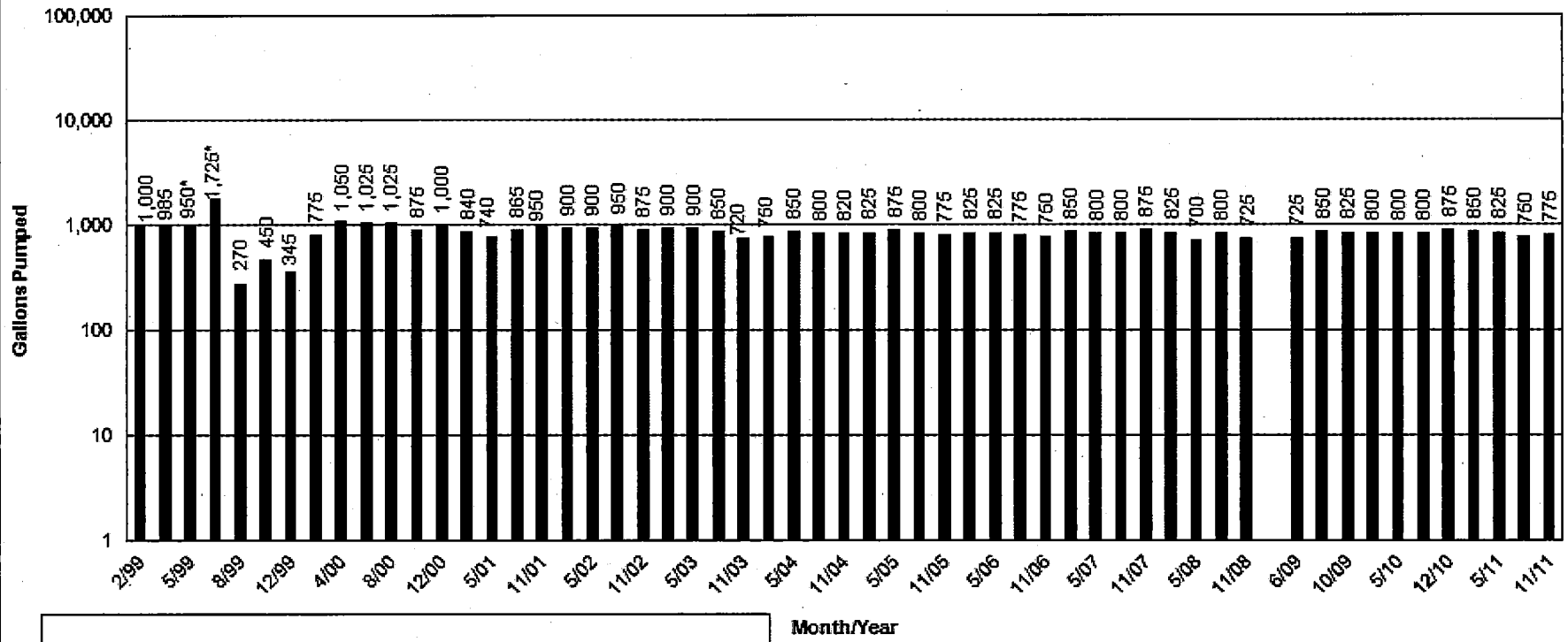


Figure A.5.2–2. Monthly Accumulation Volumes For Cell 2 LDS



12339 Purge Information

Year	Total Volumes (gal.)	Months Purged	Avg. Monthly Purge (gal.)
1999:	5725	n=7	818
2000:	5750	n=6	958
2001:	3395	n=4	849
2002:	3625	n=4	906
2003:	3370	n=4	843
2004:	3220	n=4	805
2005:	3275	n=4	819
2006:	3175	n=4	1088
2007:	3325	n=4	831
2008:	3050	n=4	763
2009:	2400	n=3	800
2010:	3275	n=4	819
2011:	3200	n=4	800
Overall:			835

*More than one purge of the well was completed during these months to help evaluate well yield.

Figure A.5.2–3. OSDF Horizontal Till Well 12339 (Cell 2) Water Yield

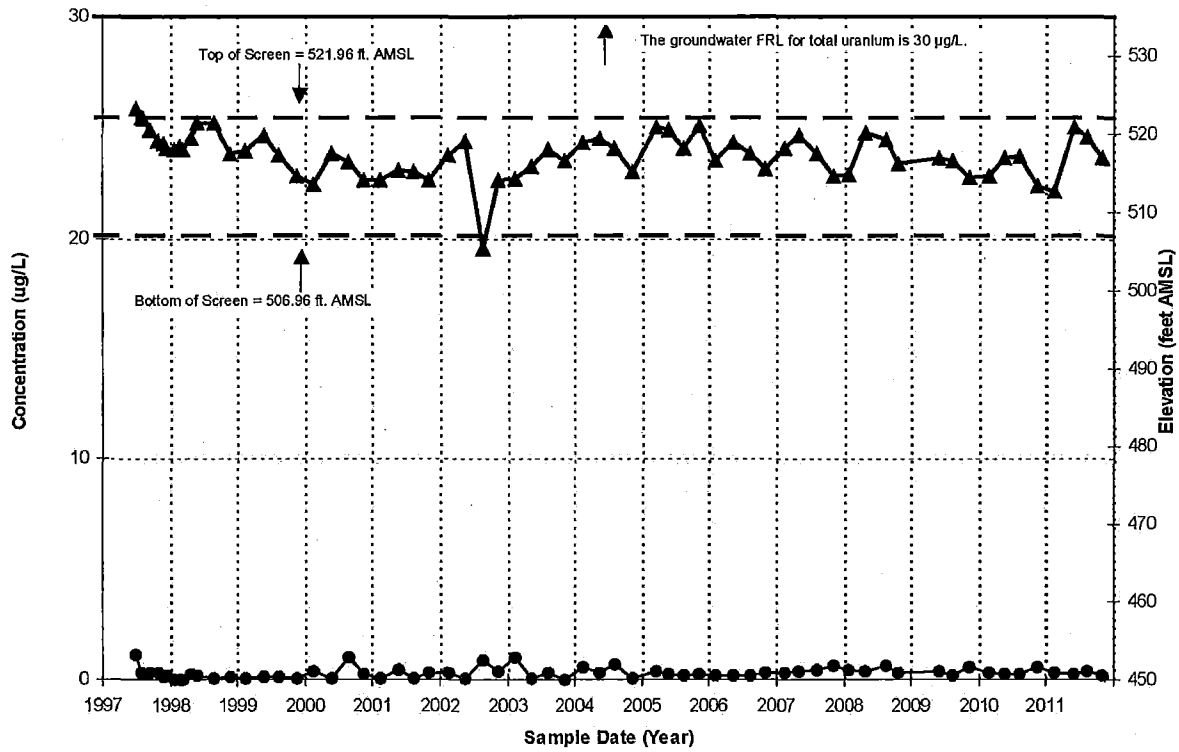


FIGURE A.5.2-4. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 2 Upgradient Monitoring Well 22200

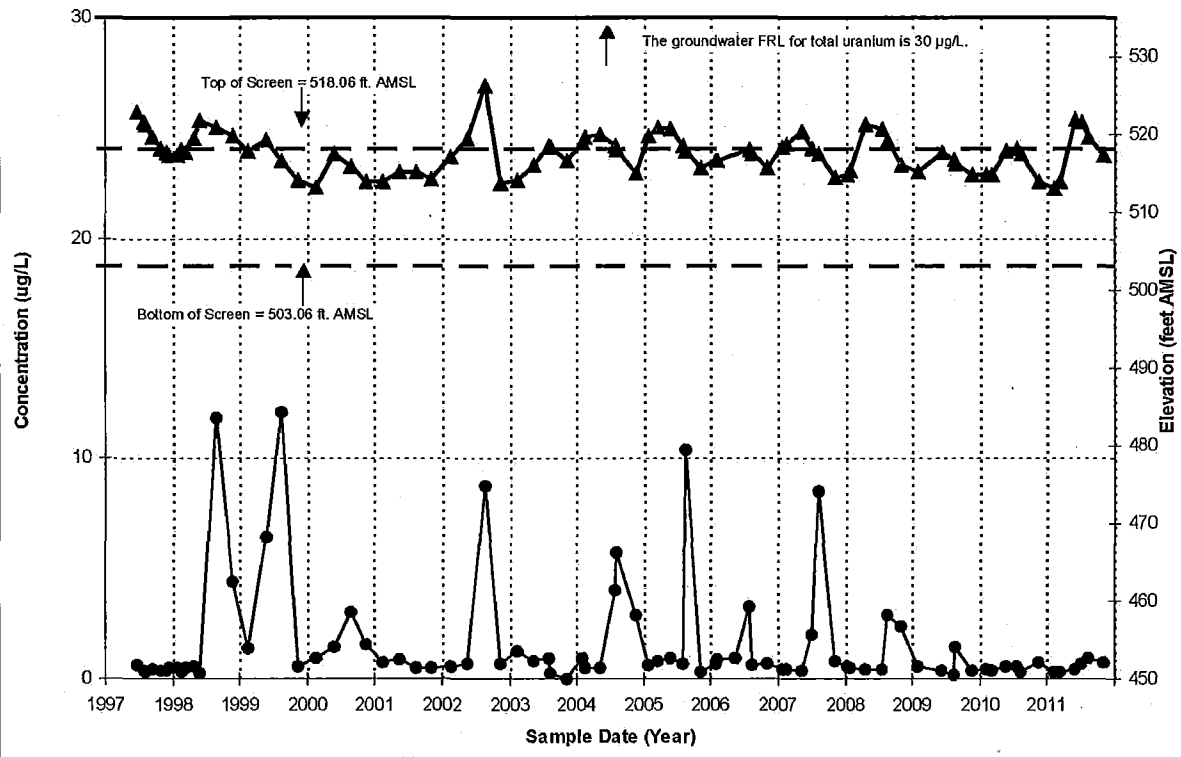


FIGURE A.5.2-5. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 2 Downgradient Monitoring Well 22199

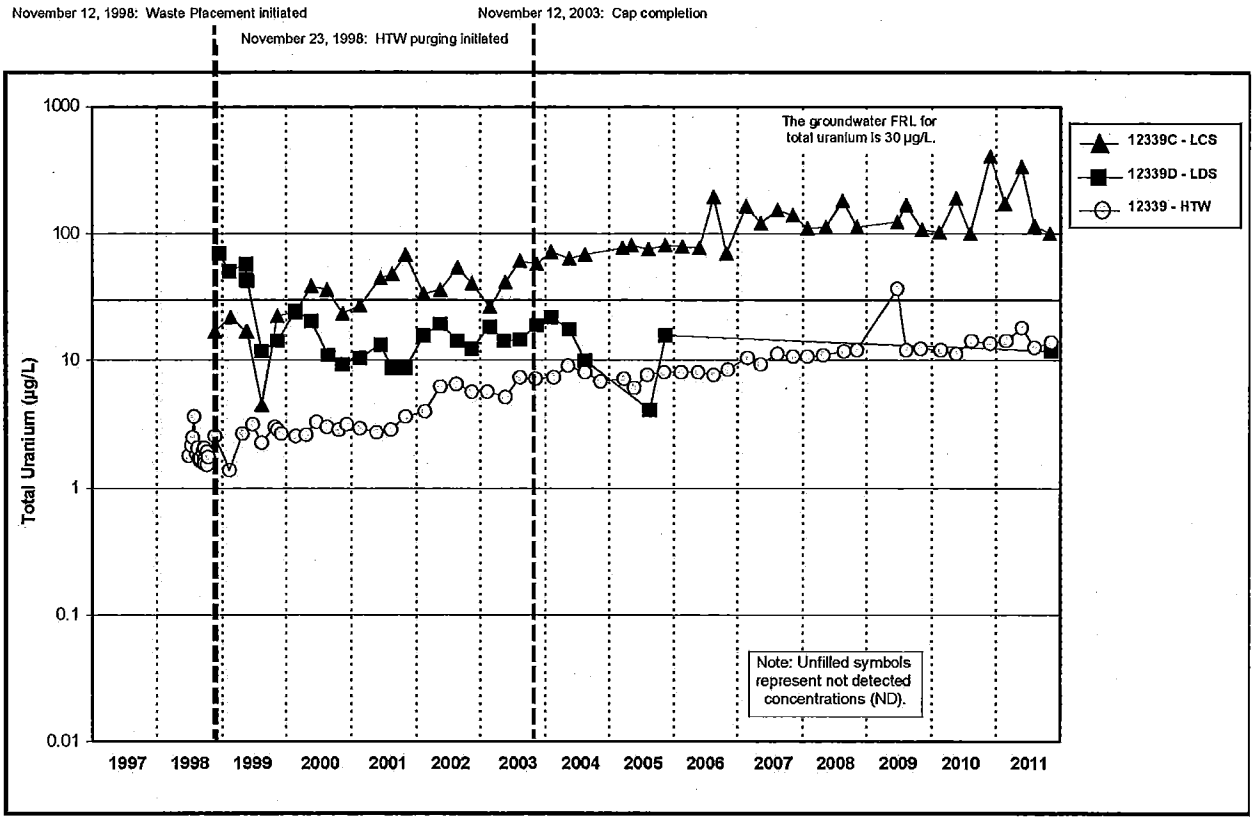


Figure A.5.2-6A. Cell 2 Total Uranium Concentration vs. Time Plot for LCS, LDS, and HTW

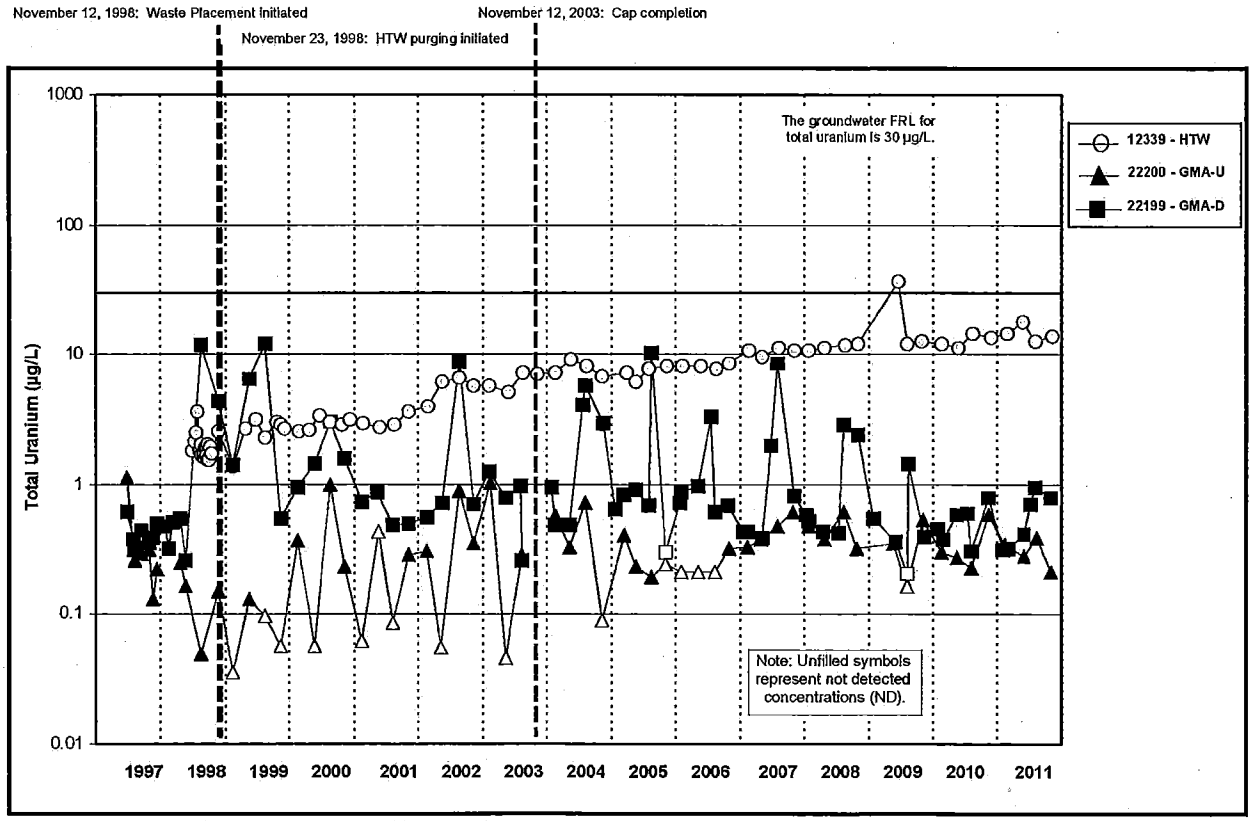


Figure A.5.2-6B. Cell 2 Total Uranium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

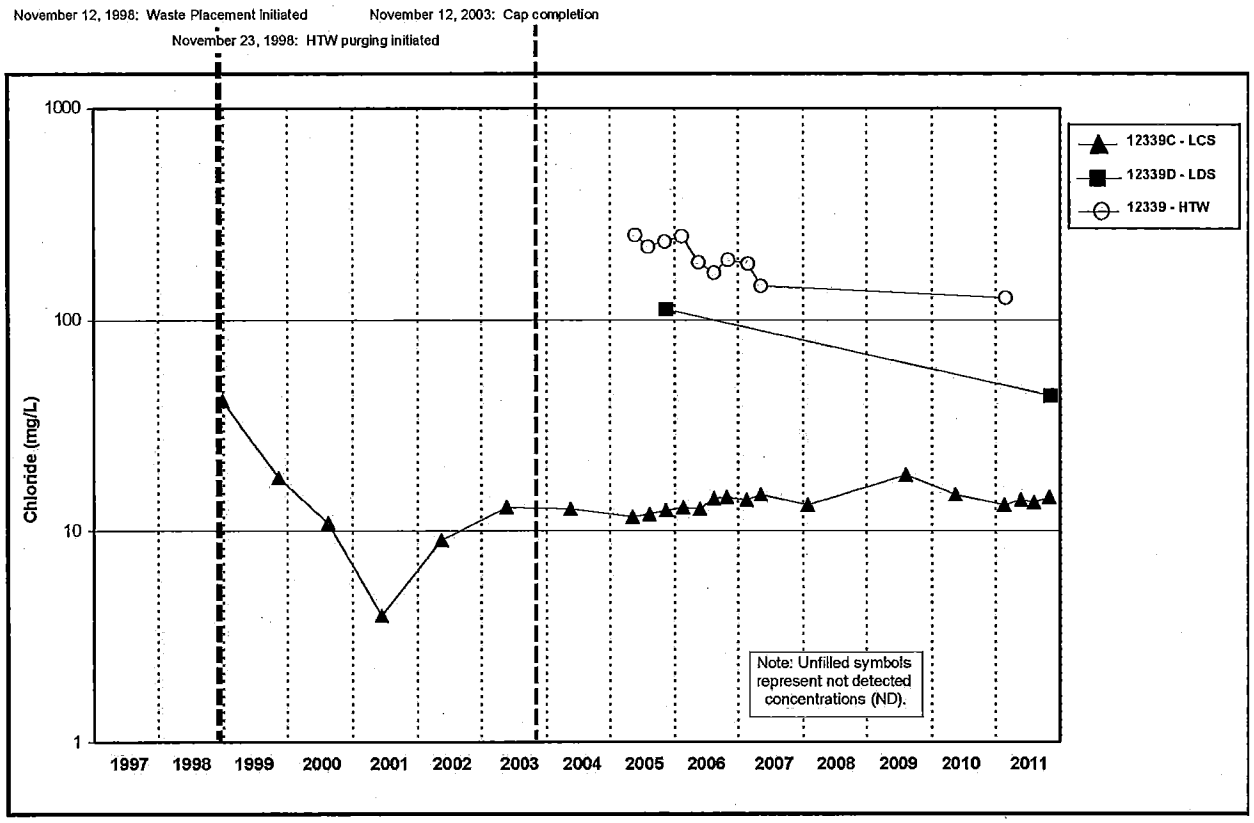


Figure A.5.2-7A. Cell 2 Chloride Concentration vs. Time Plot for LCS, LDS, and HTW

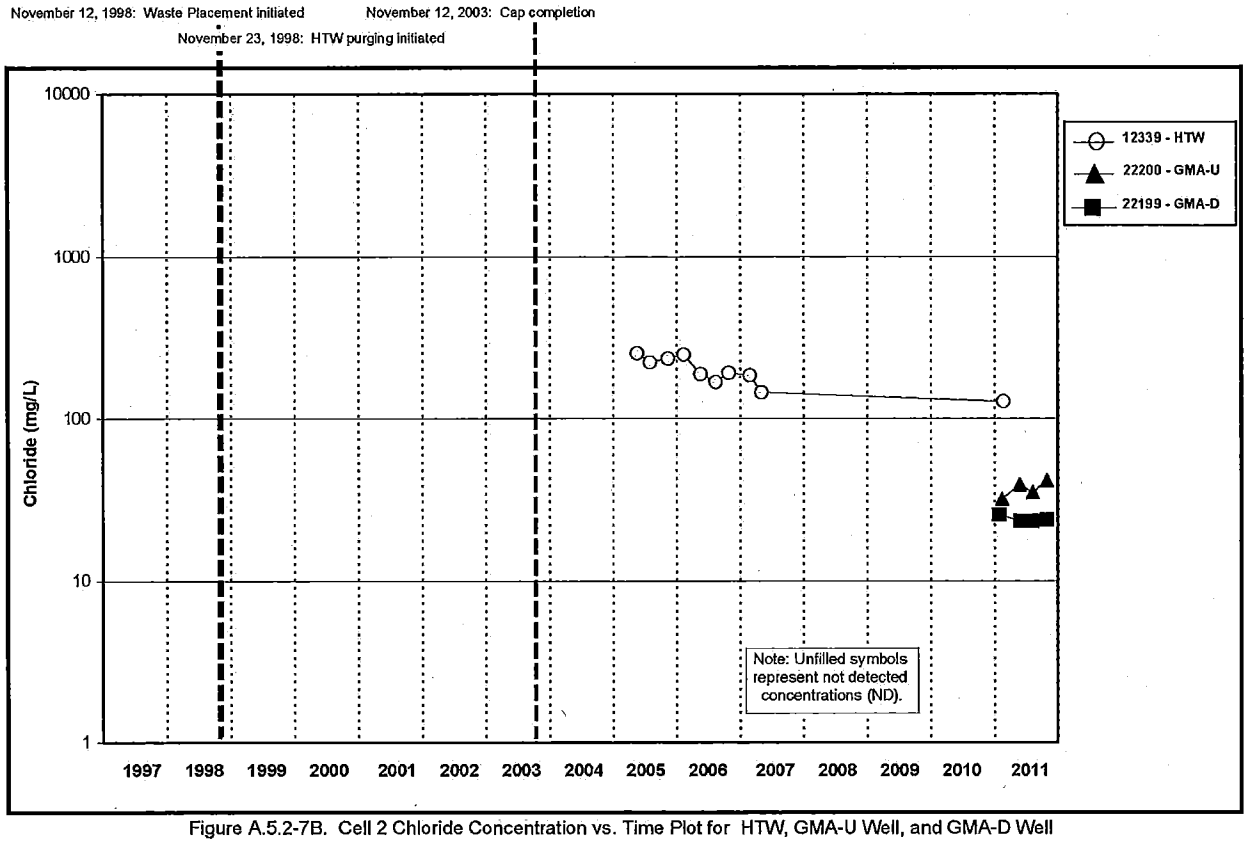


Figure A.5.2-7B. Cell 2 Chloride Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

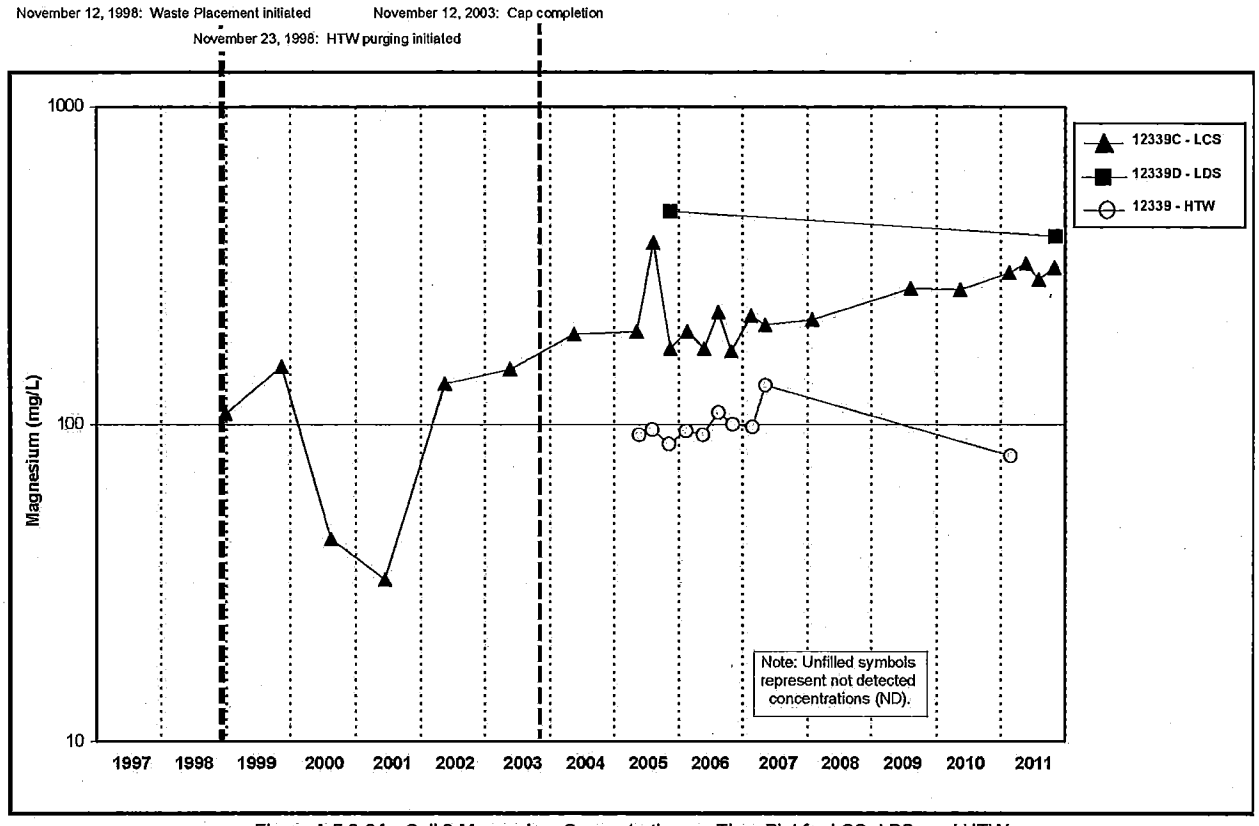


Figure A.5.2-8A. Cell 2 Magnesium Concentration vs. Time Plot for LCS, LDS, and HTW

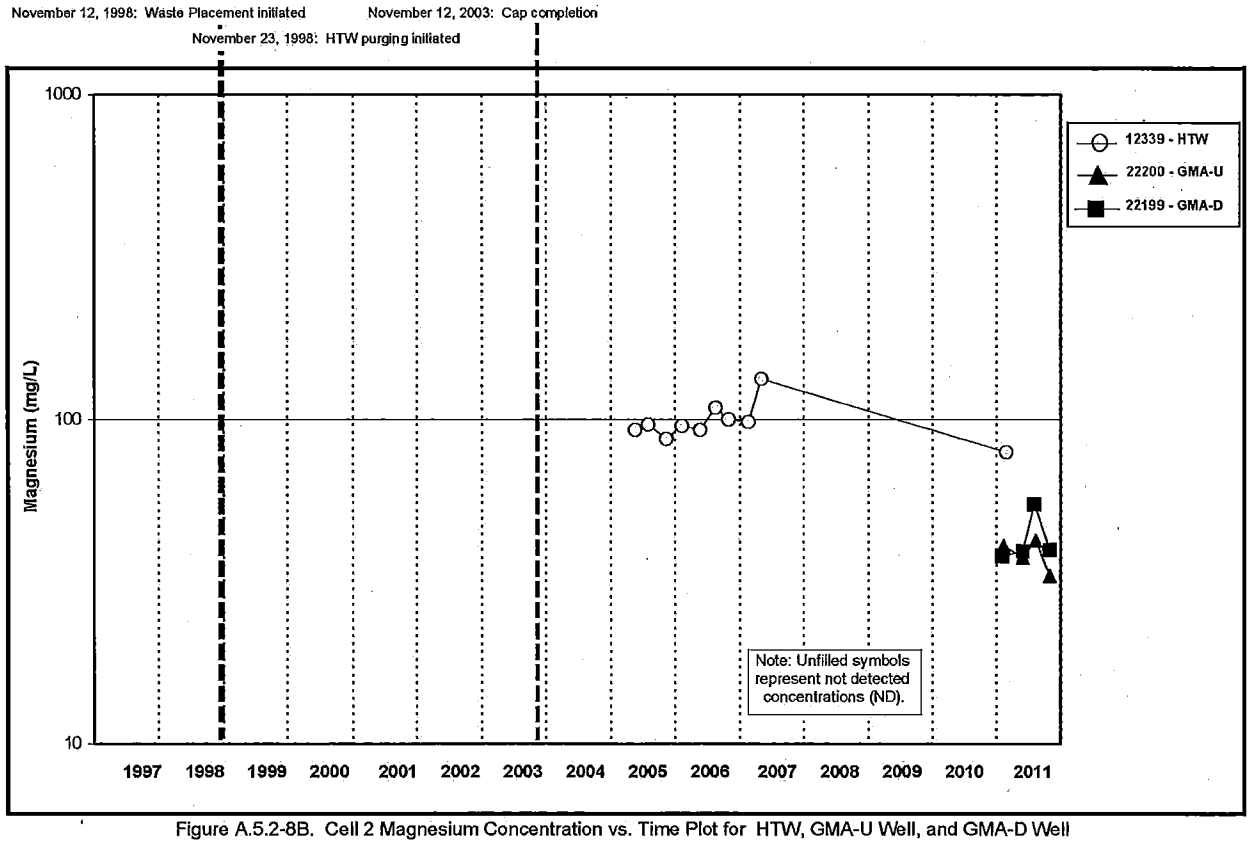


Figure A.5.2-8B. Cell 2 Magnesium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

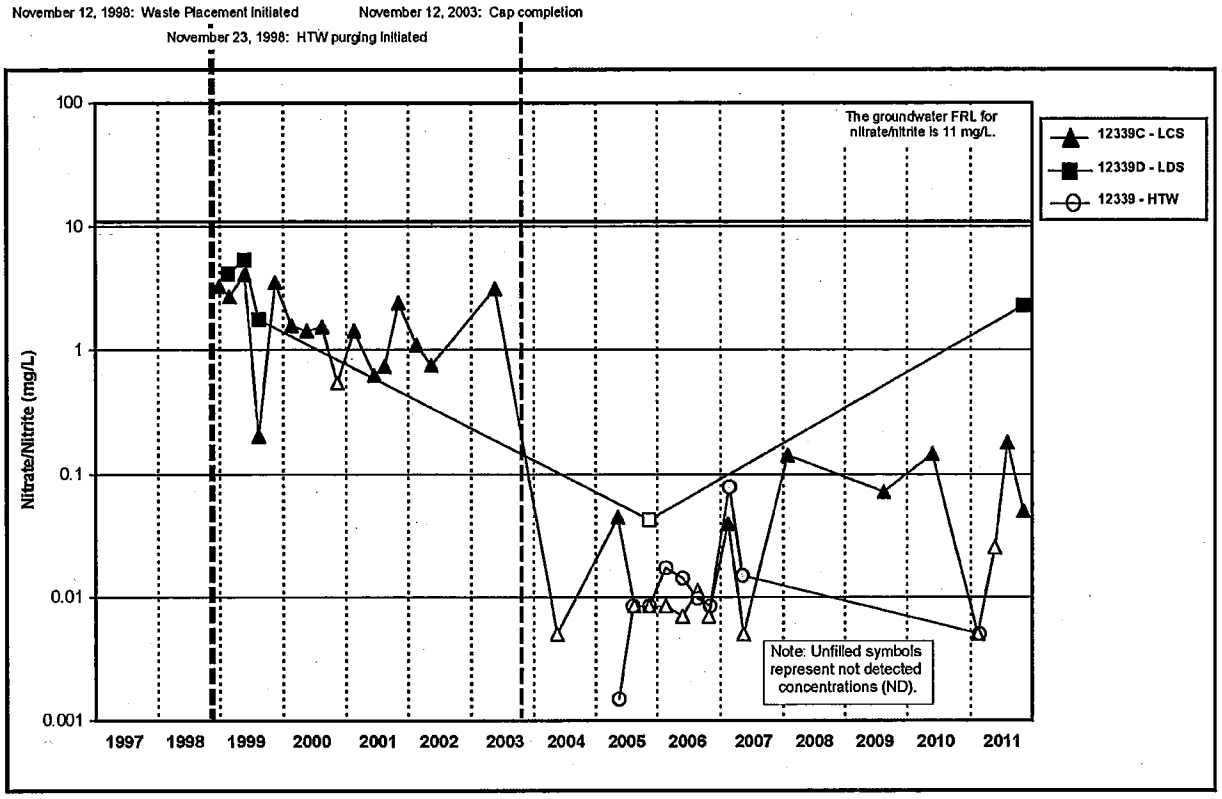


Figure A.5.2-9A. Cell 2 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for LCS, LDS, and HTW

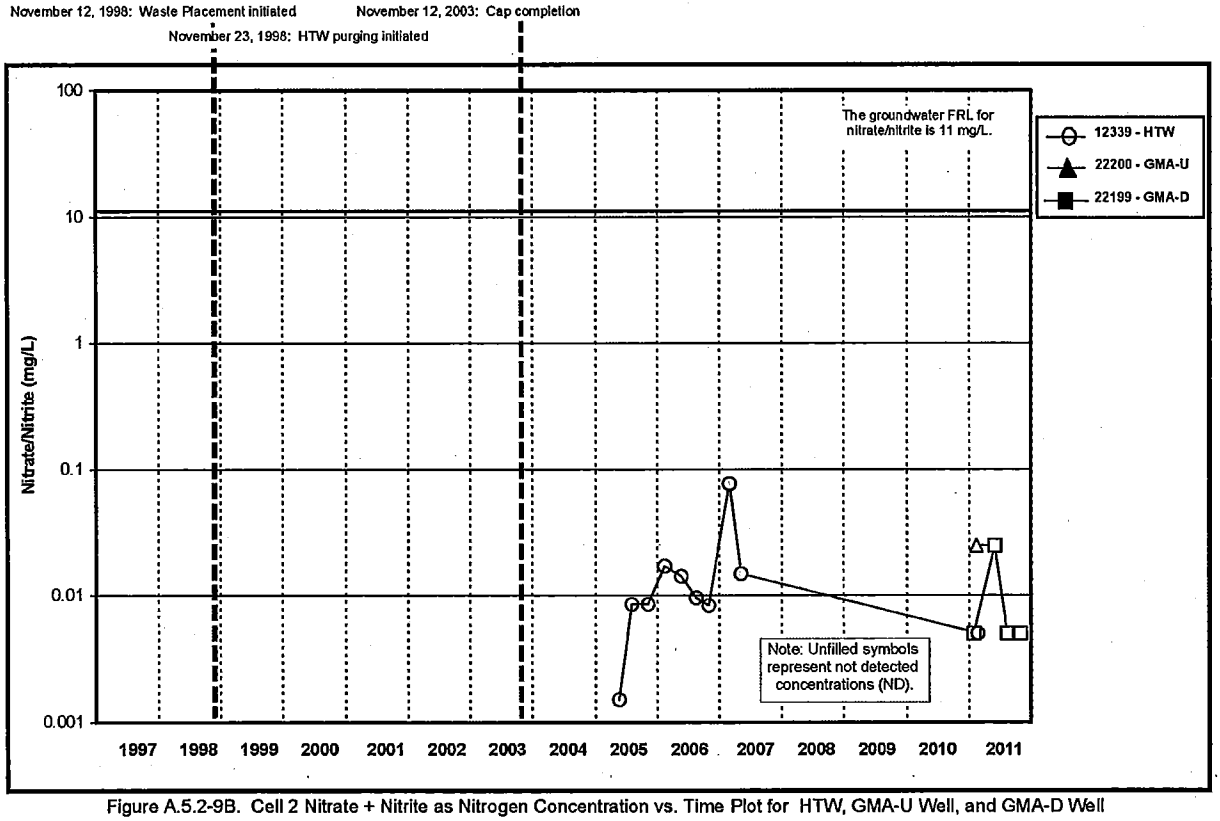


Figure A.5.2-9B. Cell 2 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

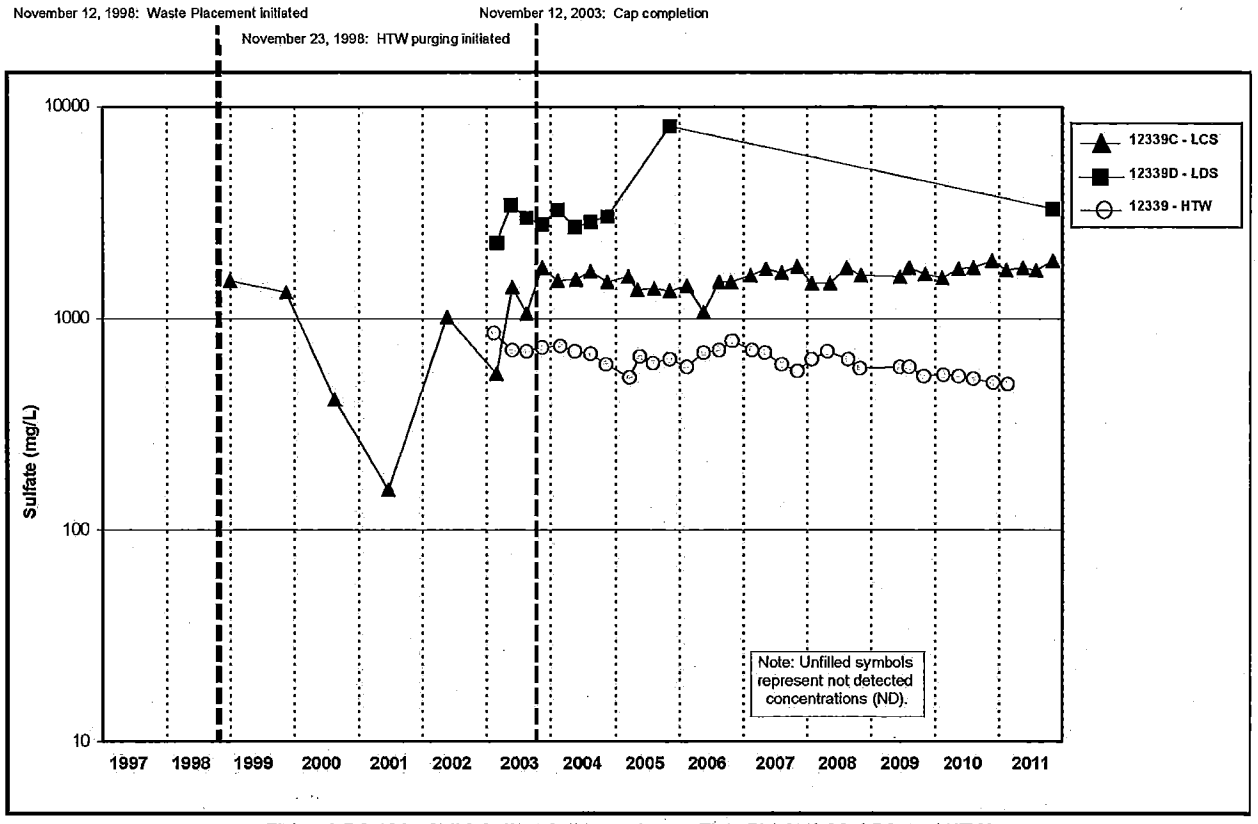


Figure A.5.2-10A. Cell 2 Sulfate Concentration vs. Time Plot for LCS, LDS, and HTW

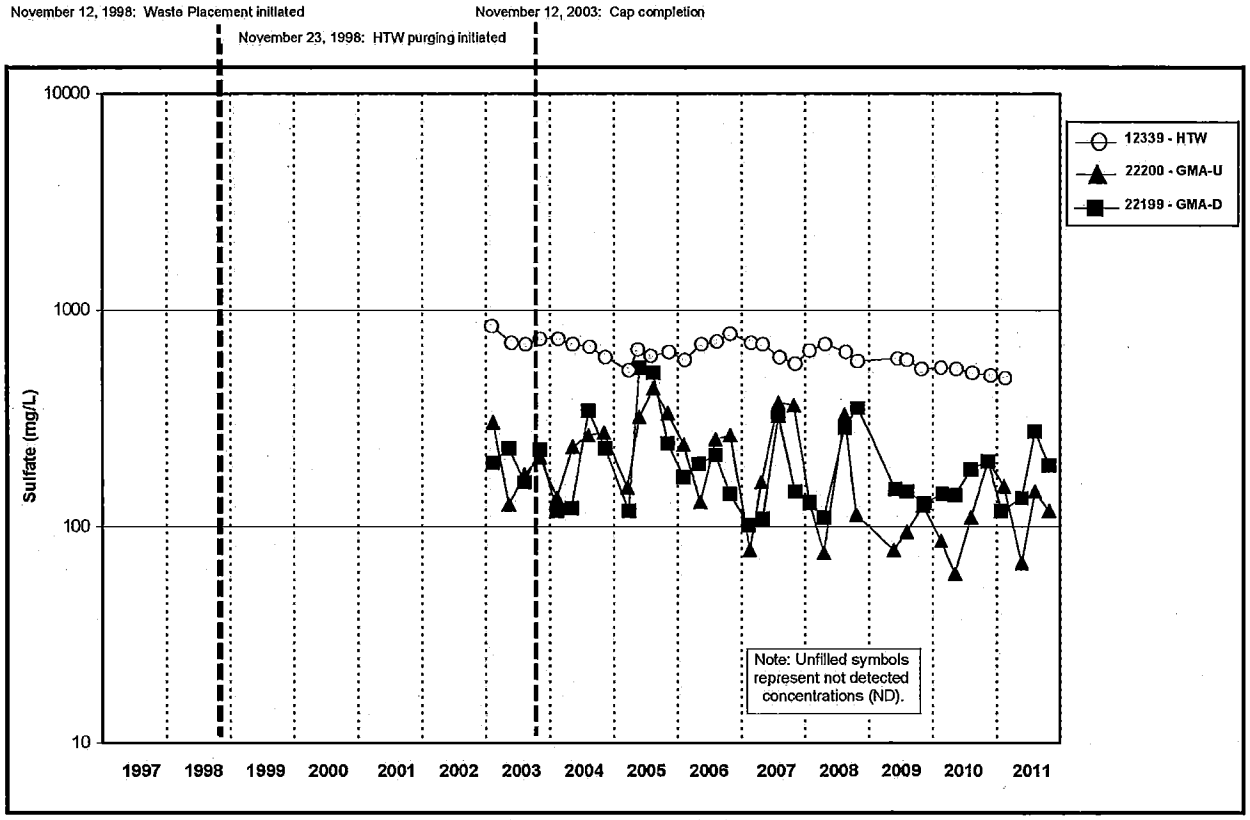


Figure A.5.2-10B. Cell 2 Sulfate Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

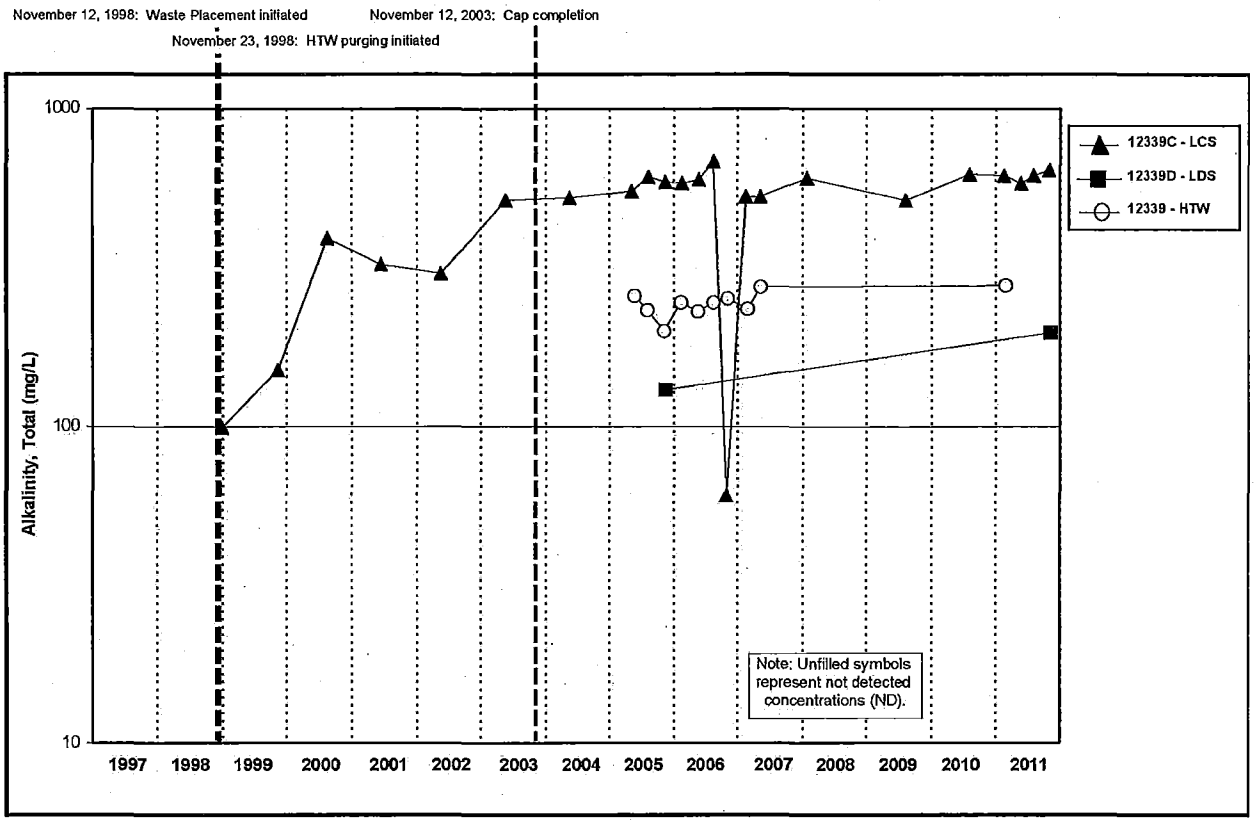


Figure A.5.2-11A. Cell 2 Alkalinity, Total (As CaCO3) Concentration vs. Time Plot for LCS, LDS, and HTW

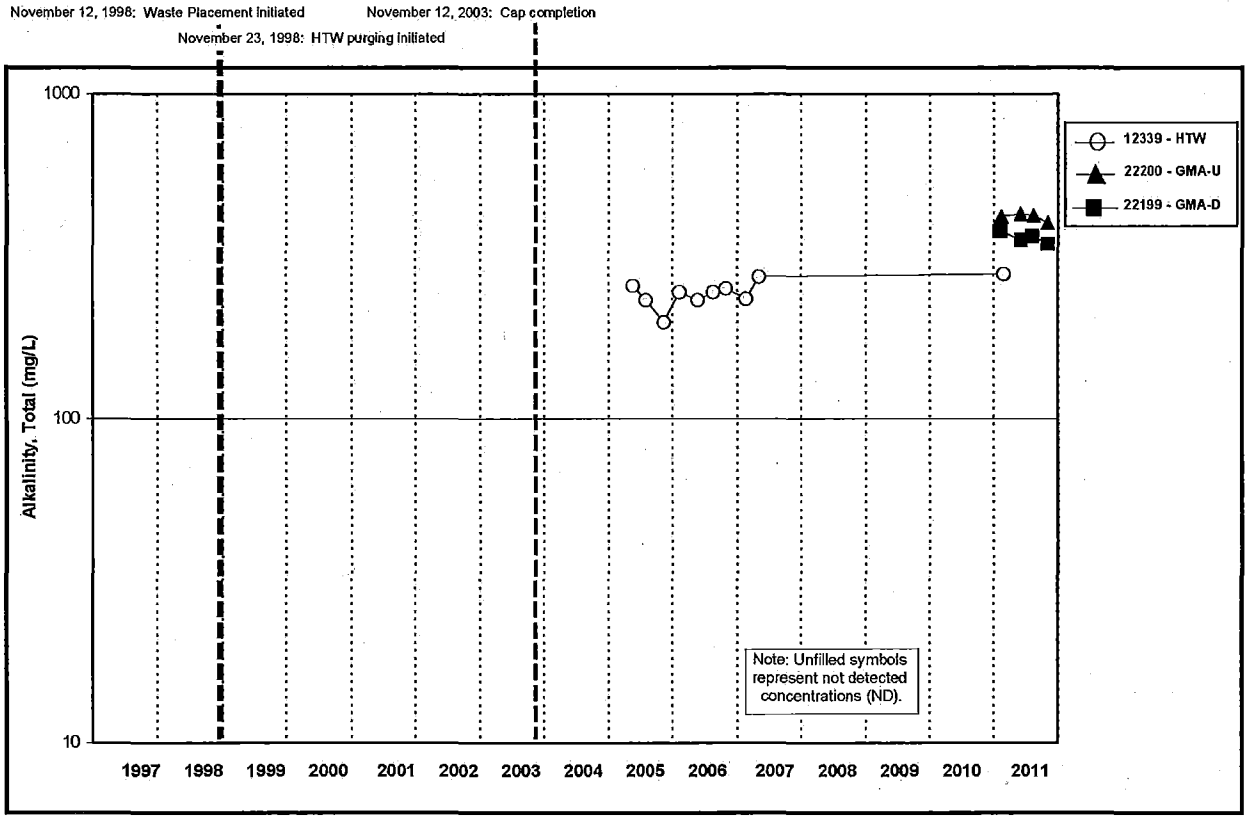


Figure A.5.2-11B. Cell 2 Alkalinity, Total (As CaCO3) Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

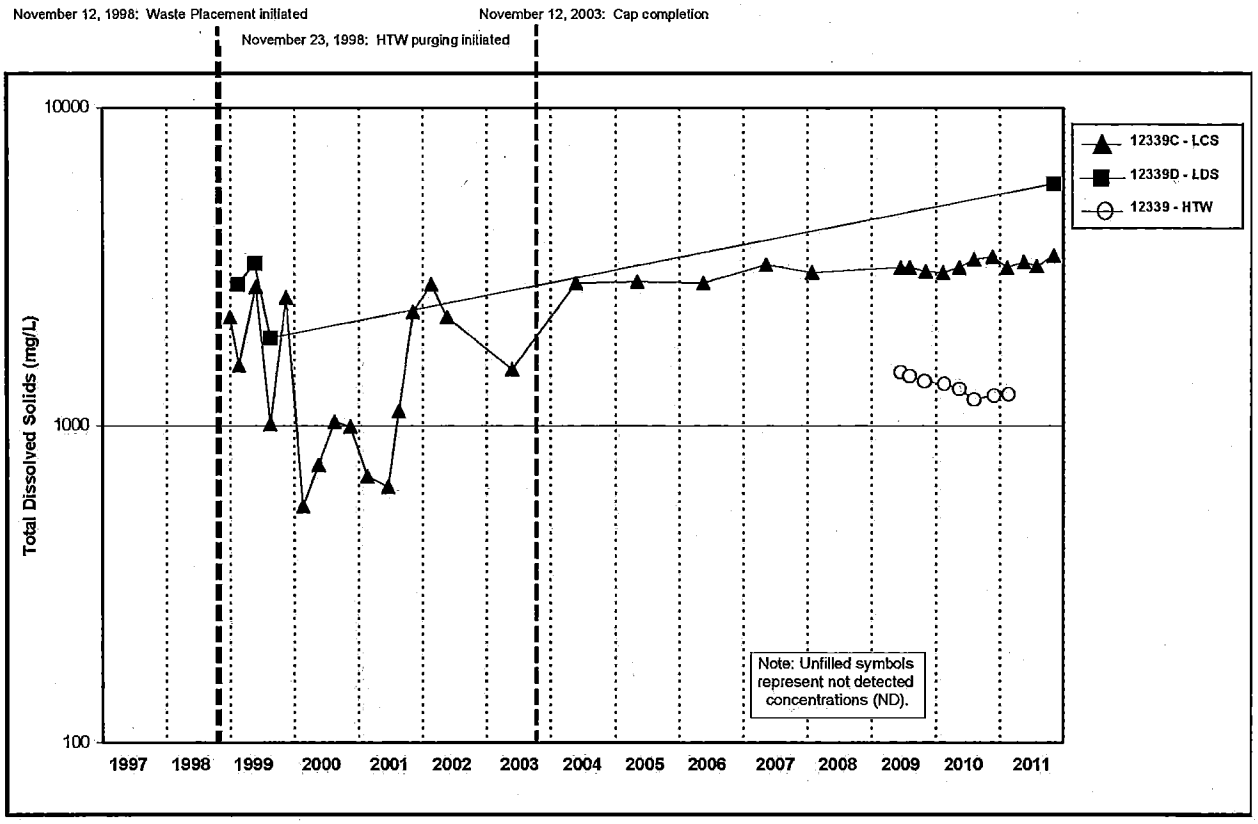


Figure A.5.2-12A. Cell 2 Total Dissolved Solids Concentration vs. Time Plot for LCS, LDS, and HTW

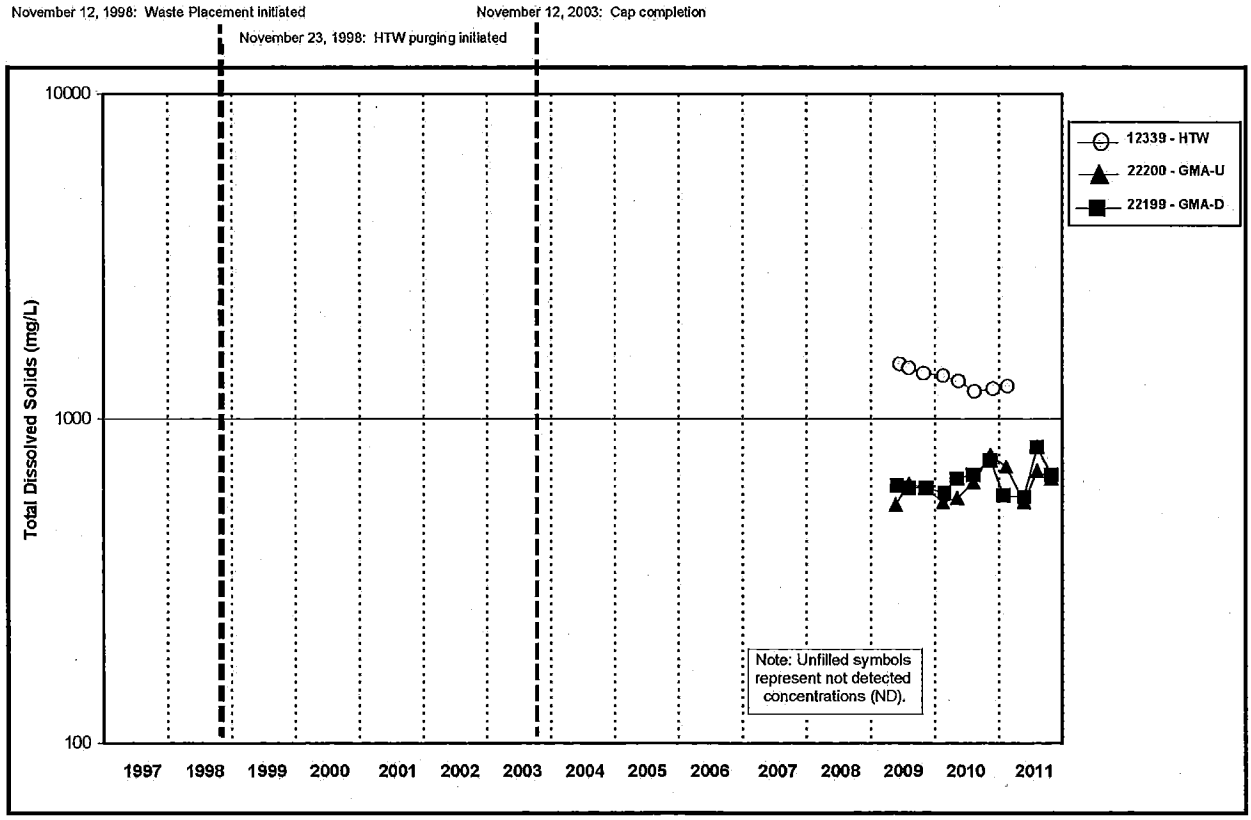


Figure A.5.2-12B. Cell 2 Total Dissolved Solids Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

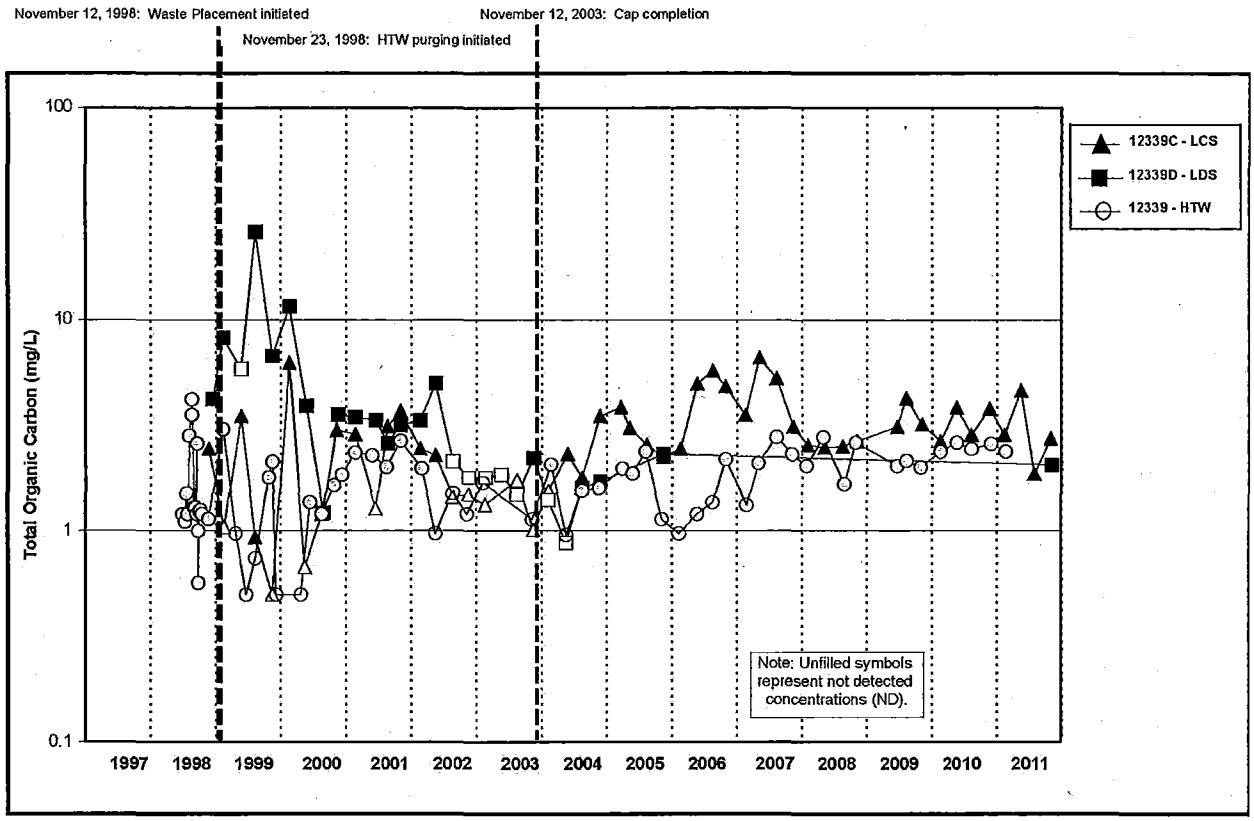


Figure A.5.2-13A. Cell 2 Total Organic Carbon Concentration vs. Time Plot for LCS, LDS, and HTW

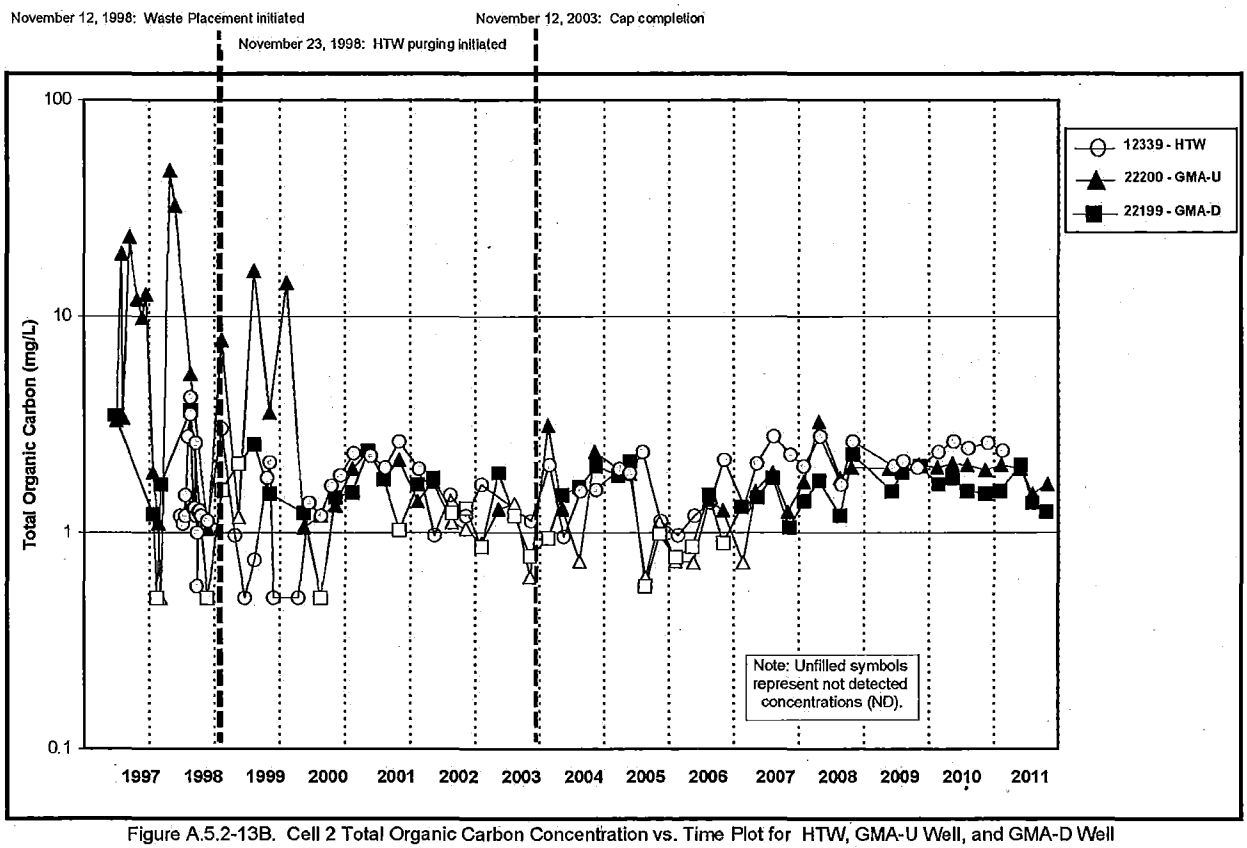


Figure A.5.2-13B. Cell 2 Total Organic Carbon Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

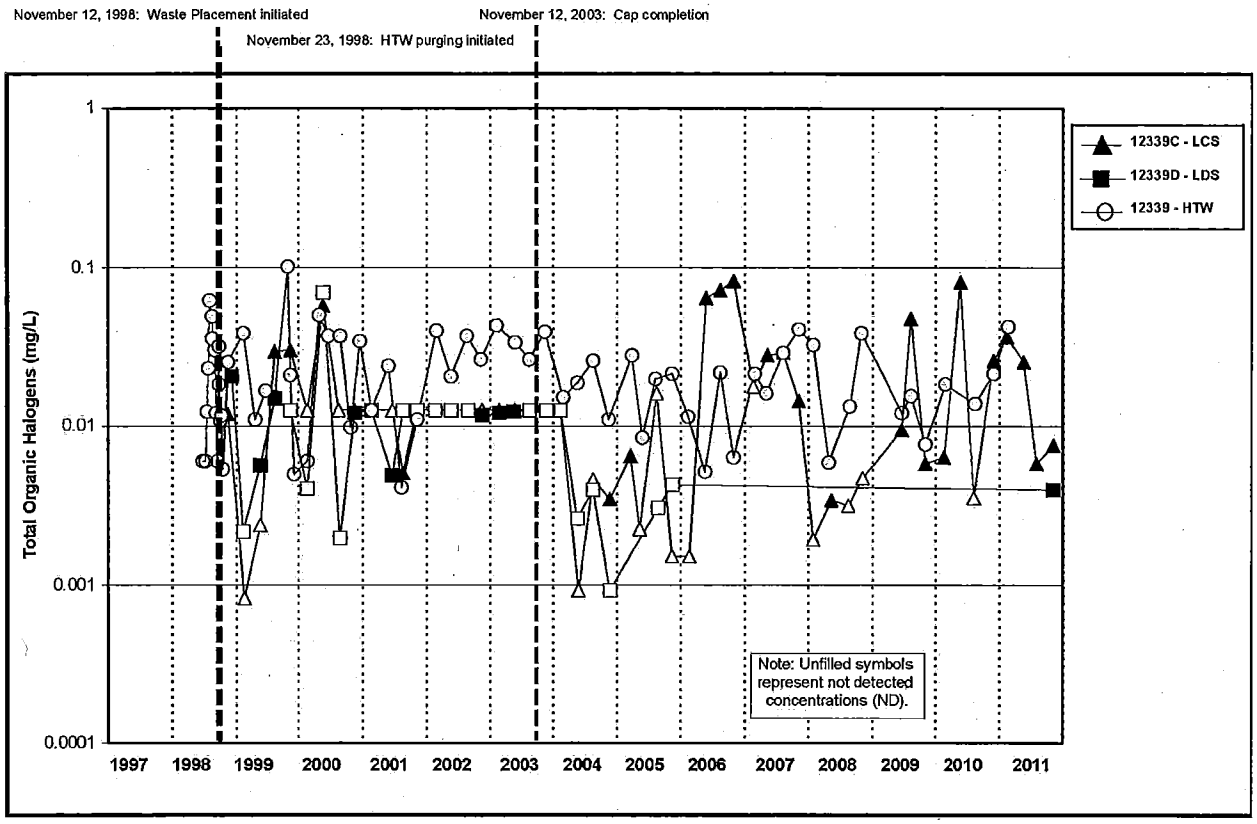


Figure A.5.2-14A. Cell 2 Total Organic Halogens Concentration vs. Time Plot for LCS, LDS, and HTW

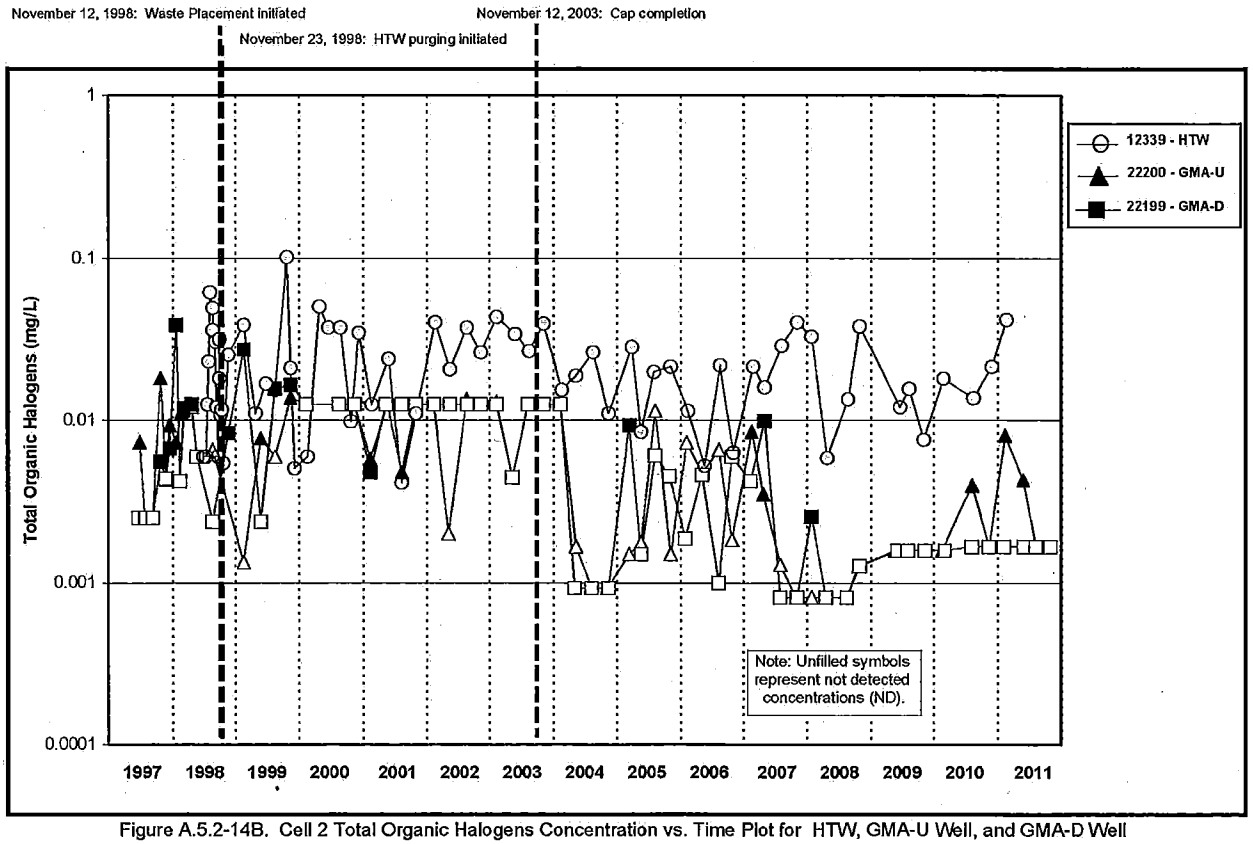


Figure A.5.2-14B. Cell 2 Total Organic Halogens Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

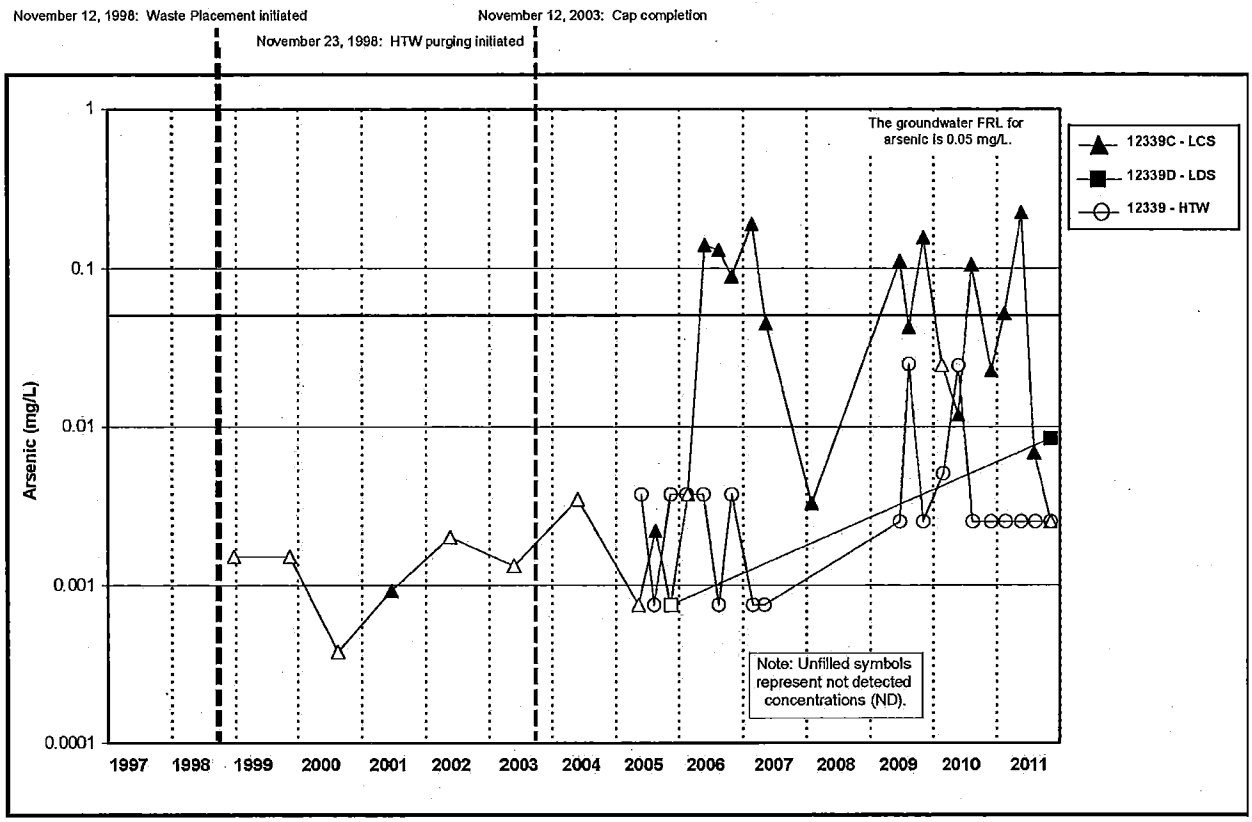


Figure A.5.2-15A. Cell 2 Arsenic Concentration vs. Time Plot for LCS, LDS, and HTW

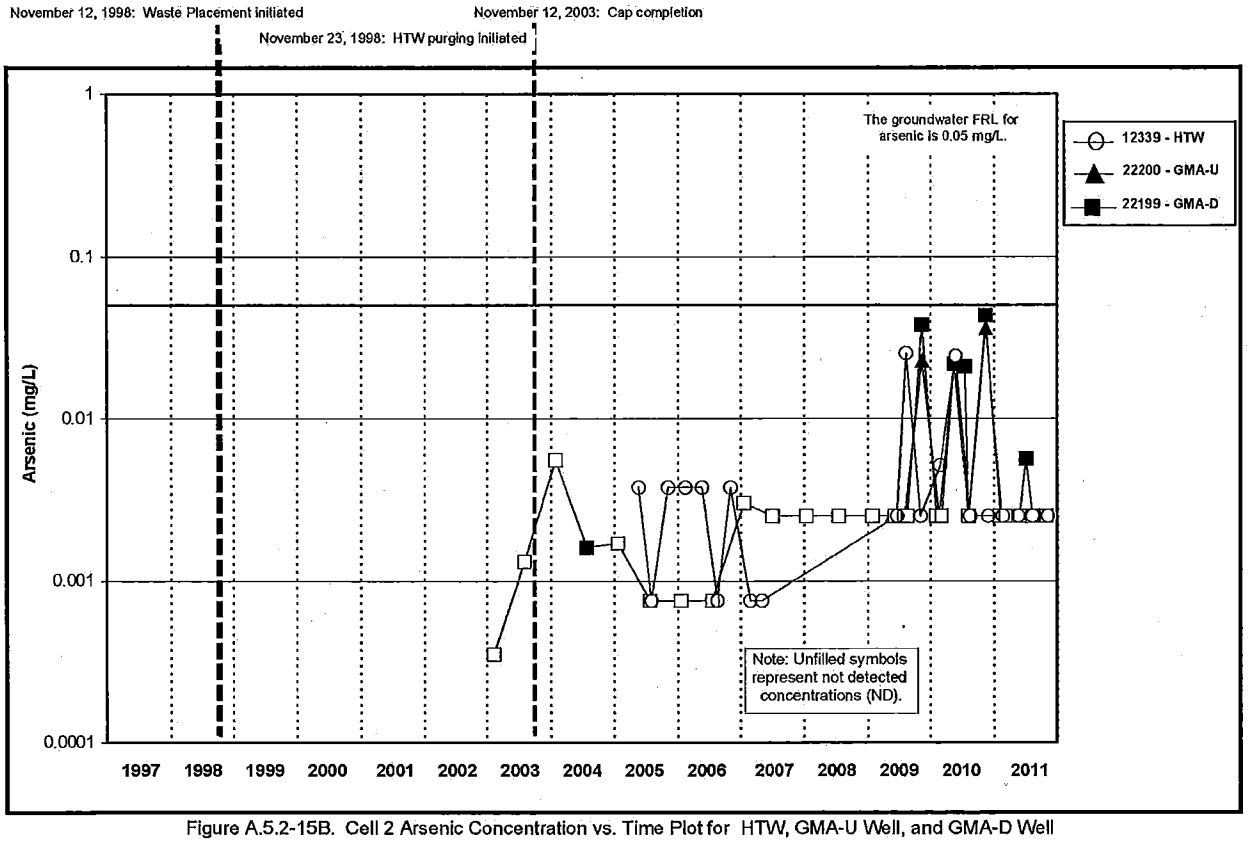


Figure A.5.2-15B. Cell 2 Arsenic Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

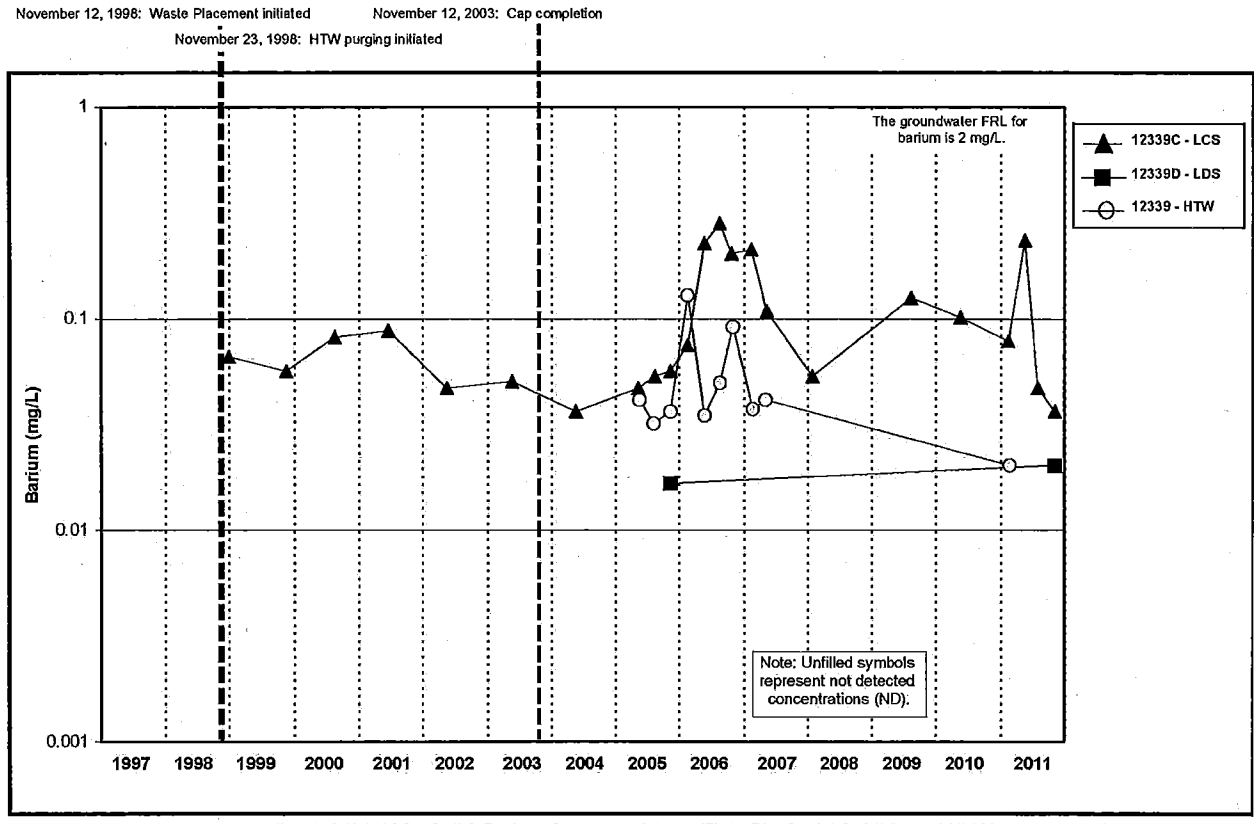


Figure A.5.2-16A. Cell 2 Barium Concentration vs. Time Plot for LCS, LDS, and HTW

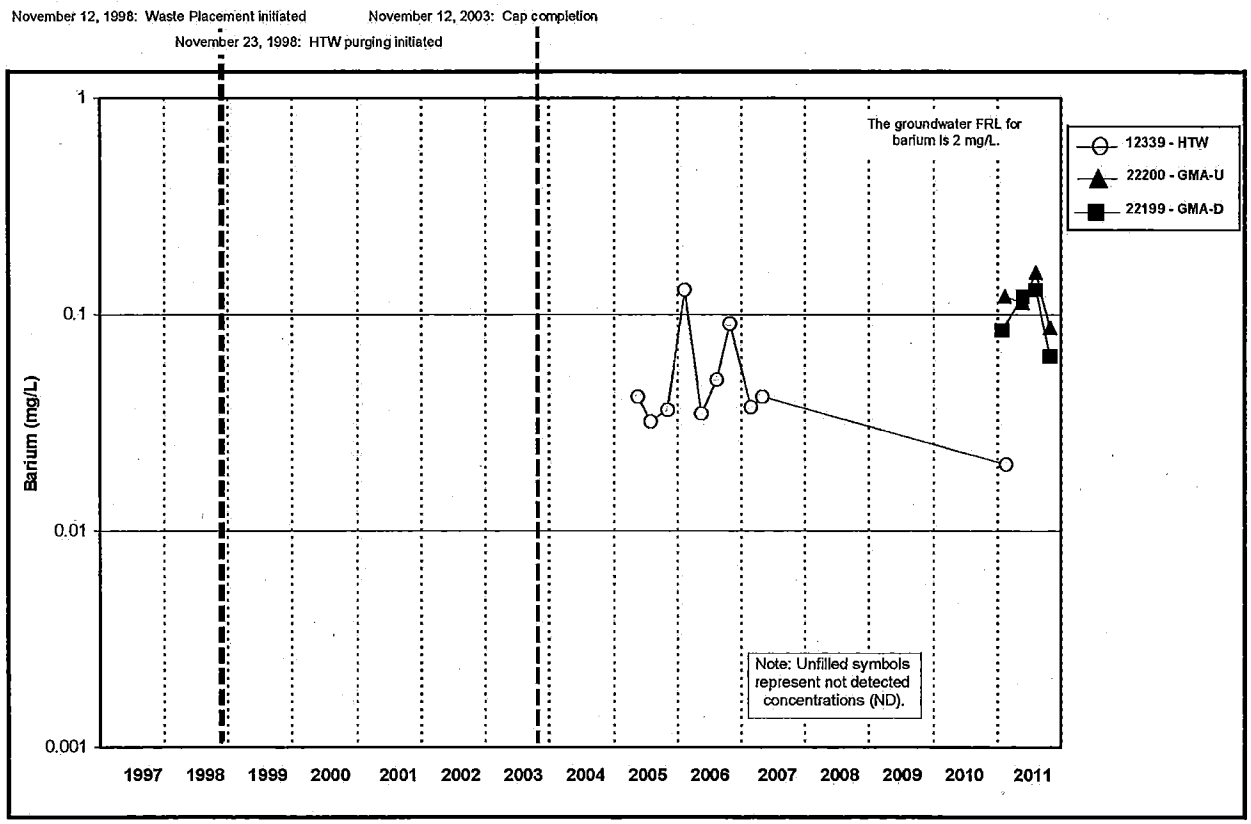


Figure A.5.2-16B. Cell 2 Barium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

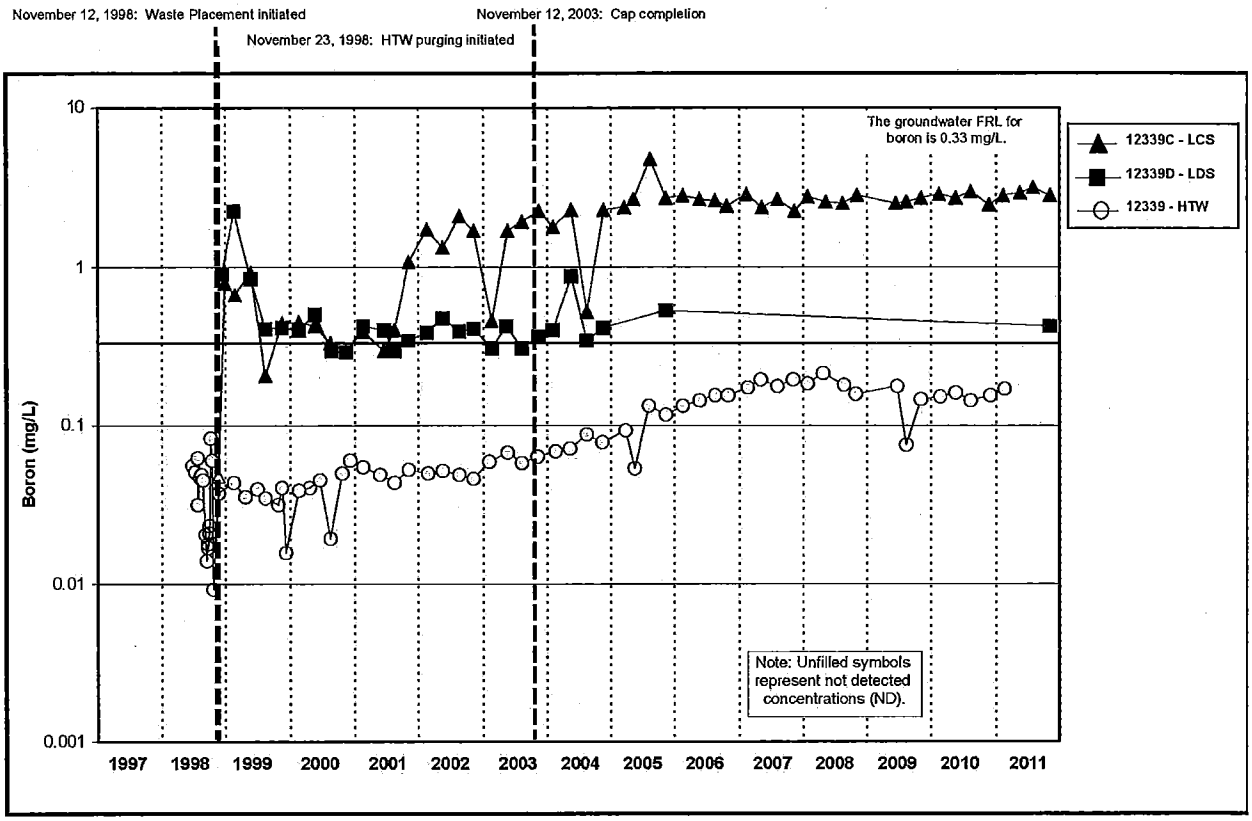


Figure A.5.2-17A. Cell 2 Boron Concentration vs. Time Plot for LCS, LDS, and HTW

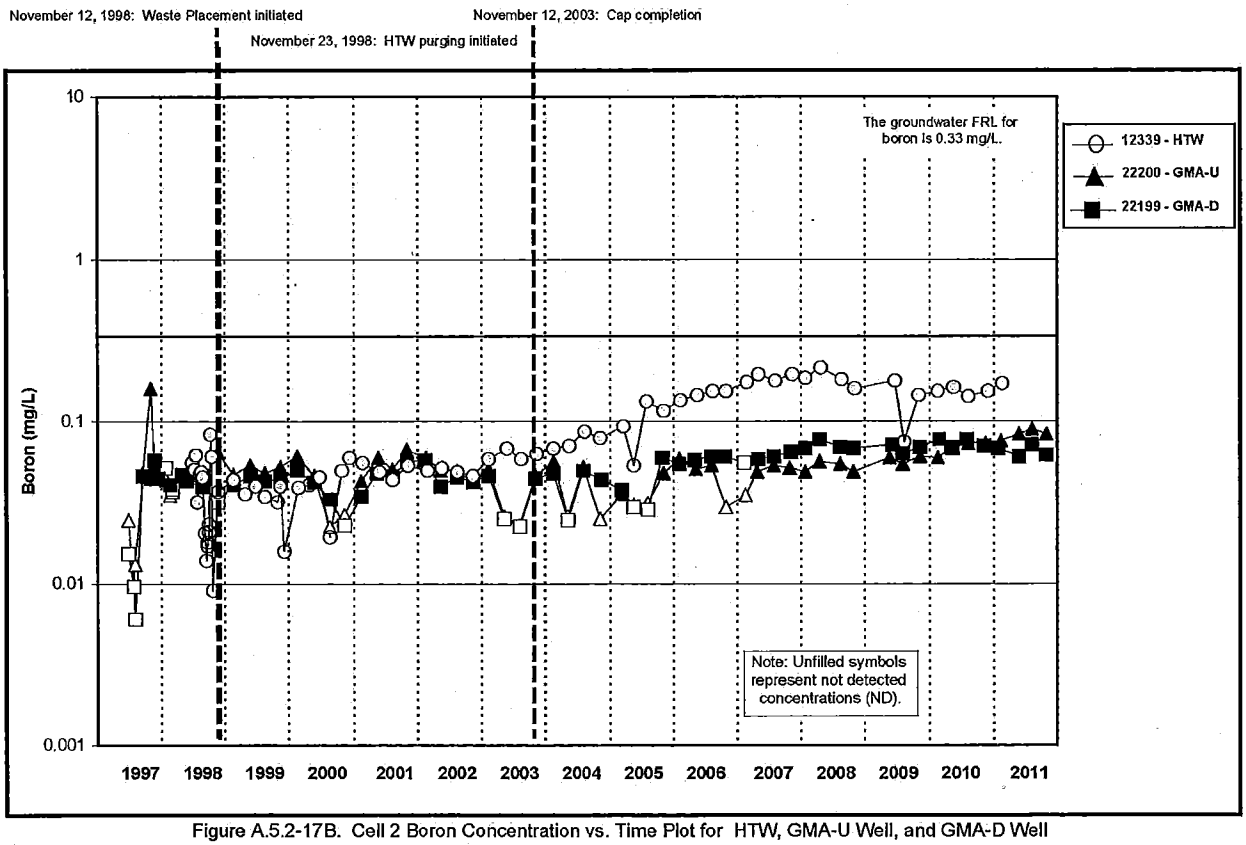


Figure A.5.2-17B. Cell 2 Boron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

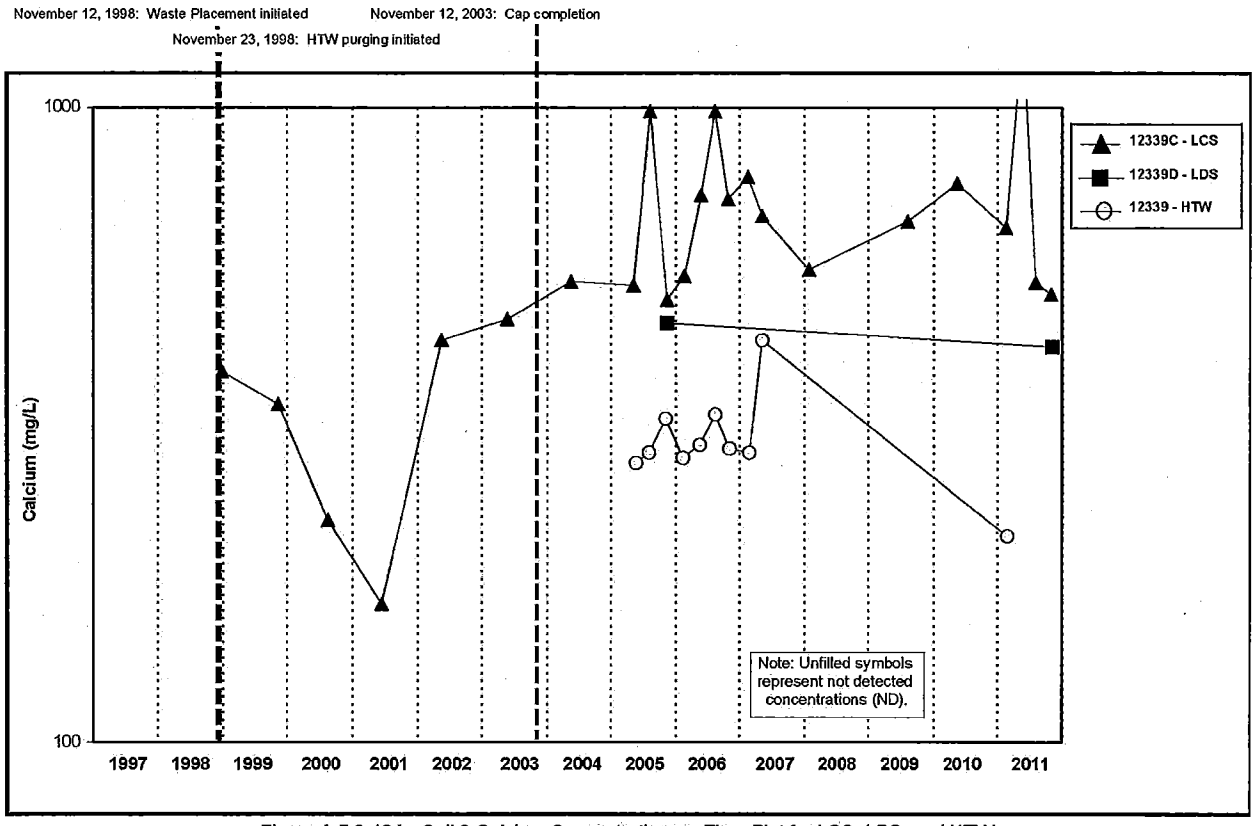


Figure A.5.2-18A. Cell 2 Calcium Concentration vs. Time Plot for LCS, LDS, and HTW

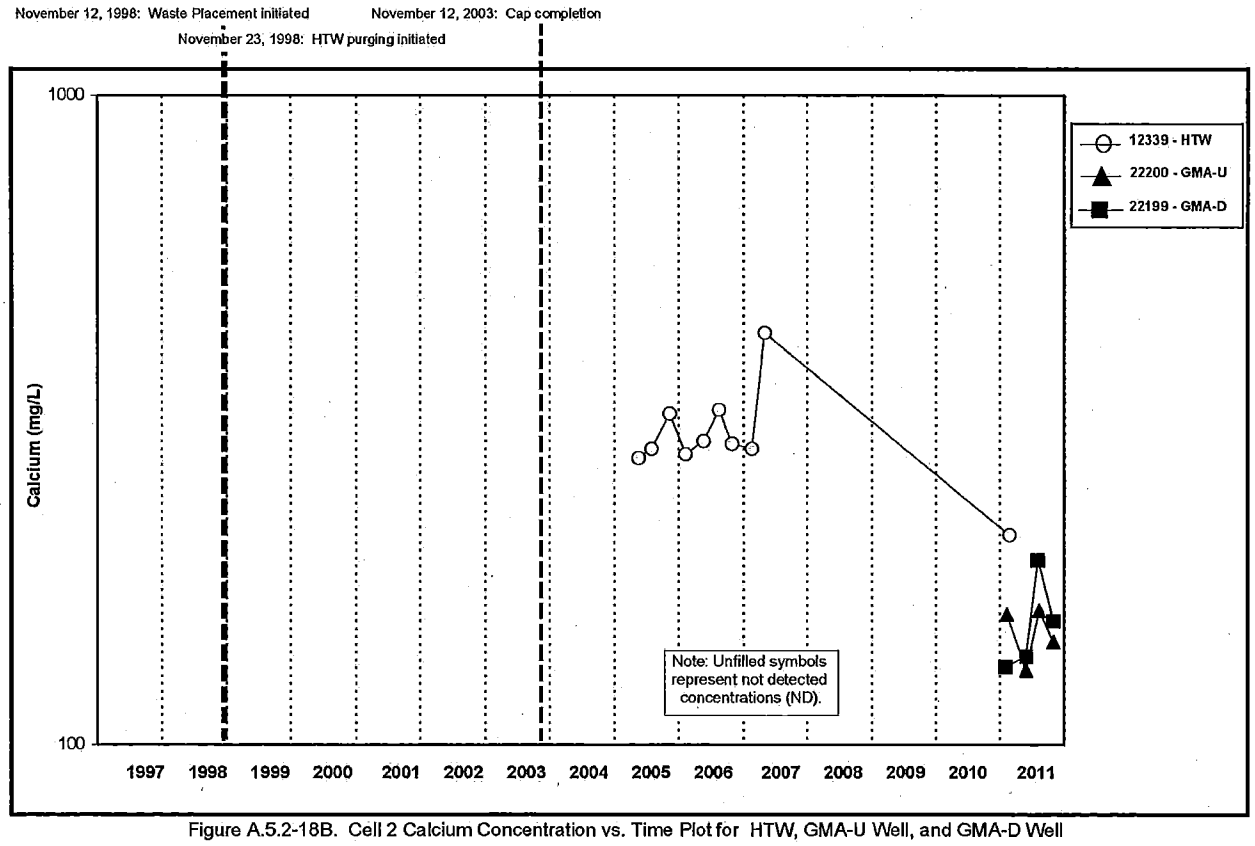


Figure A.5.2-18B. Cell 2 Calcium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

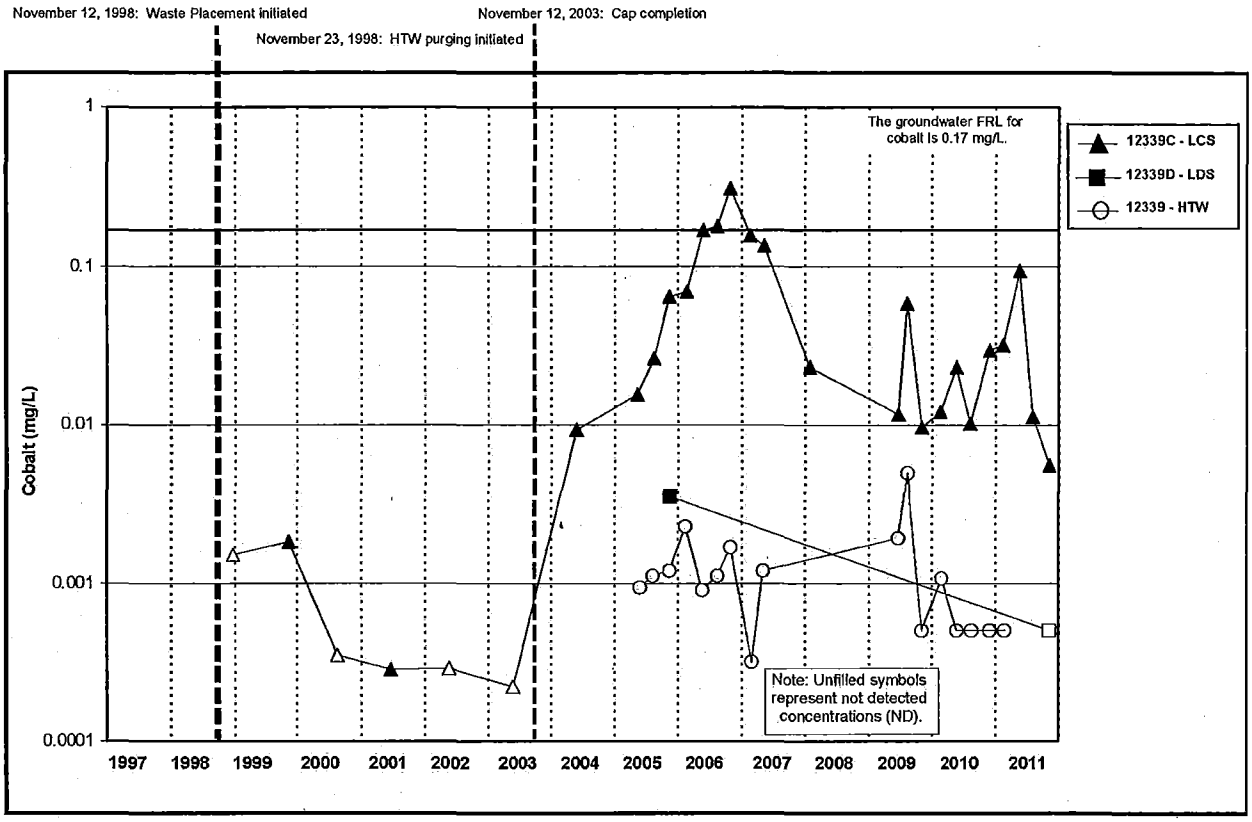


Figure A.5.2-19A. Cell 2 Cobalt Concentration vs. Time Plot for LCS, LDS, and HTW

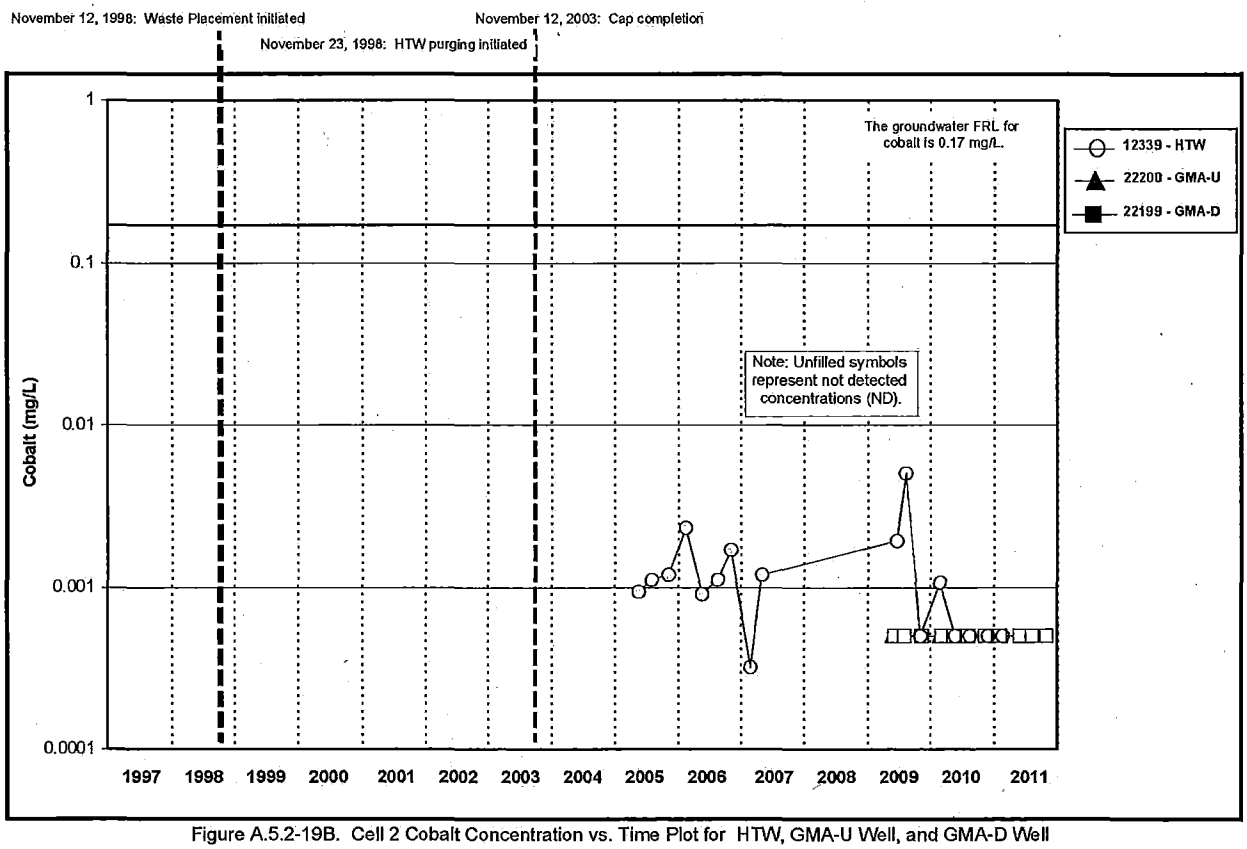


Figure A.5.2-19B. Cell 2 Cobalt Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

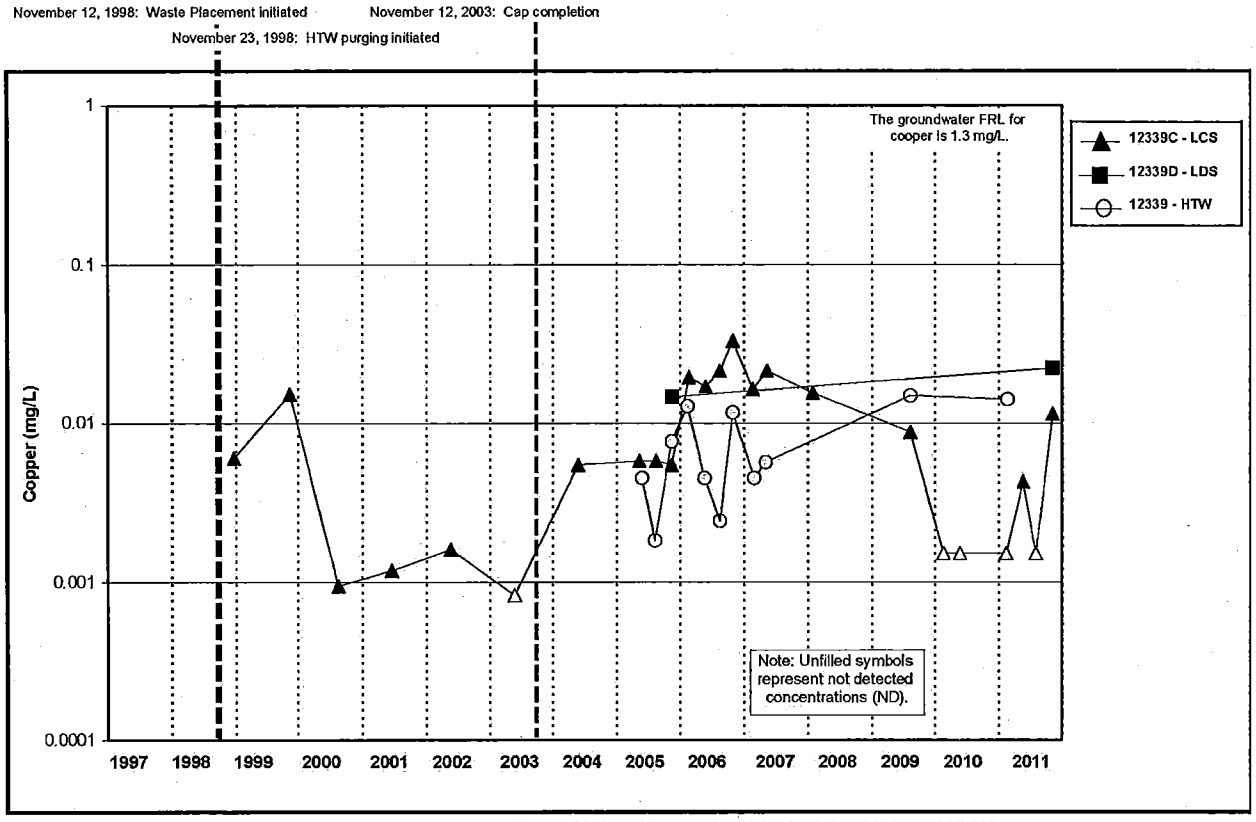


Figure A.5.2-20A. Cell 2 Copper Concentration vs. Time Plot for LCS, LDS, and HTW

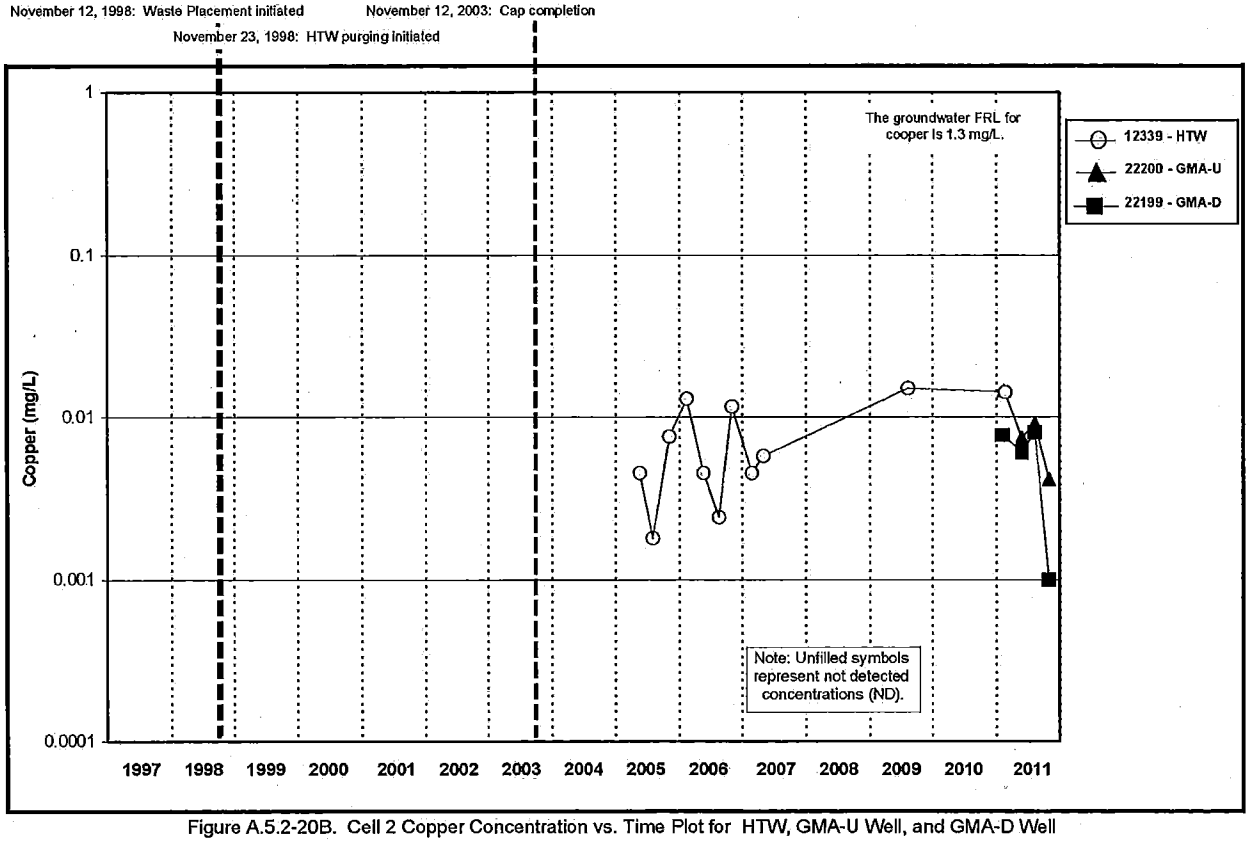


Figure A.5.2-20B. Cell 2 Copper Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

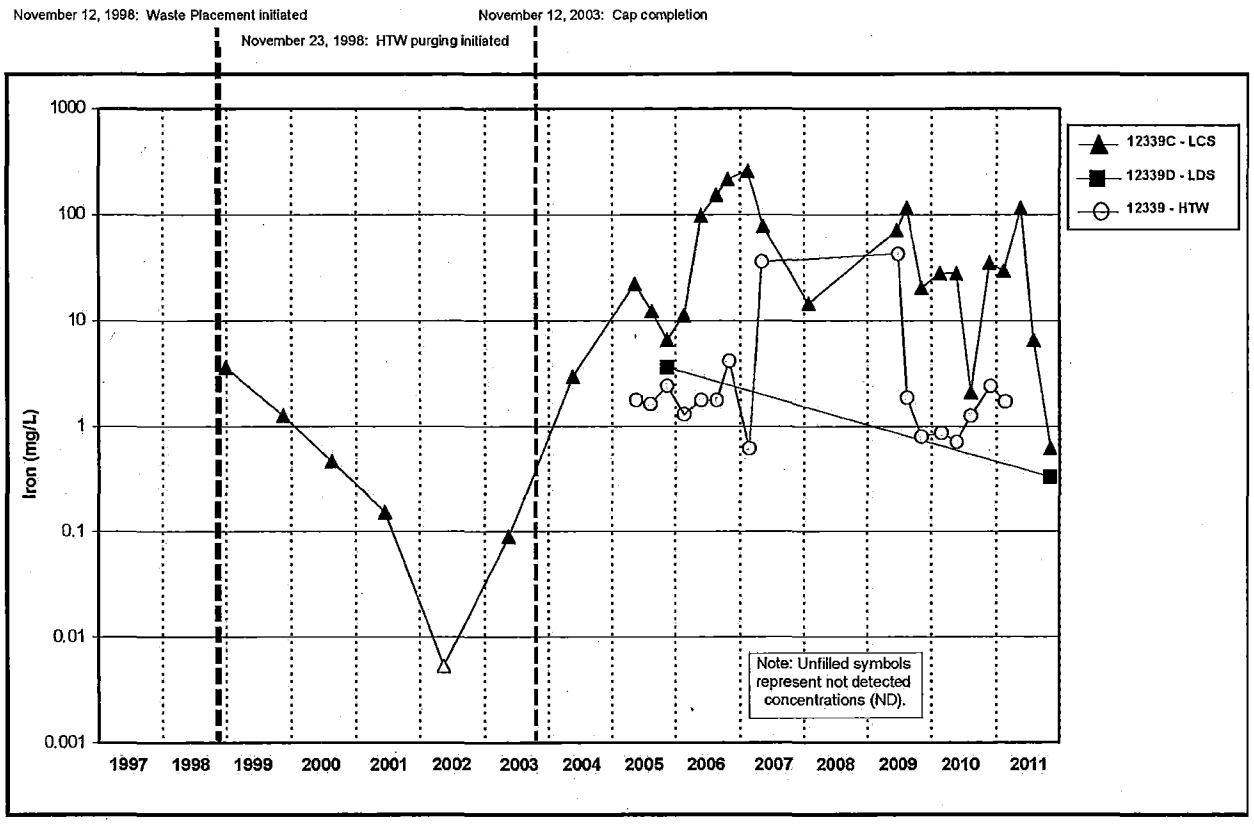


Figure A.5.2-21A. Cell 2 Iron Concentration vs. Time Plot for LCS, LDS, and HTW

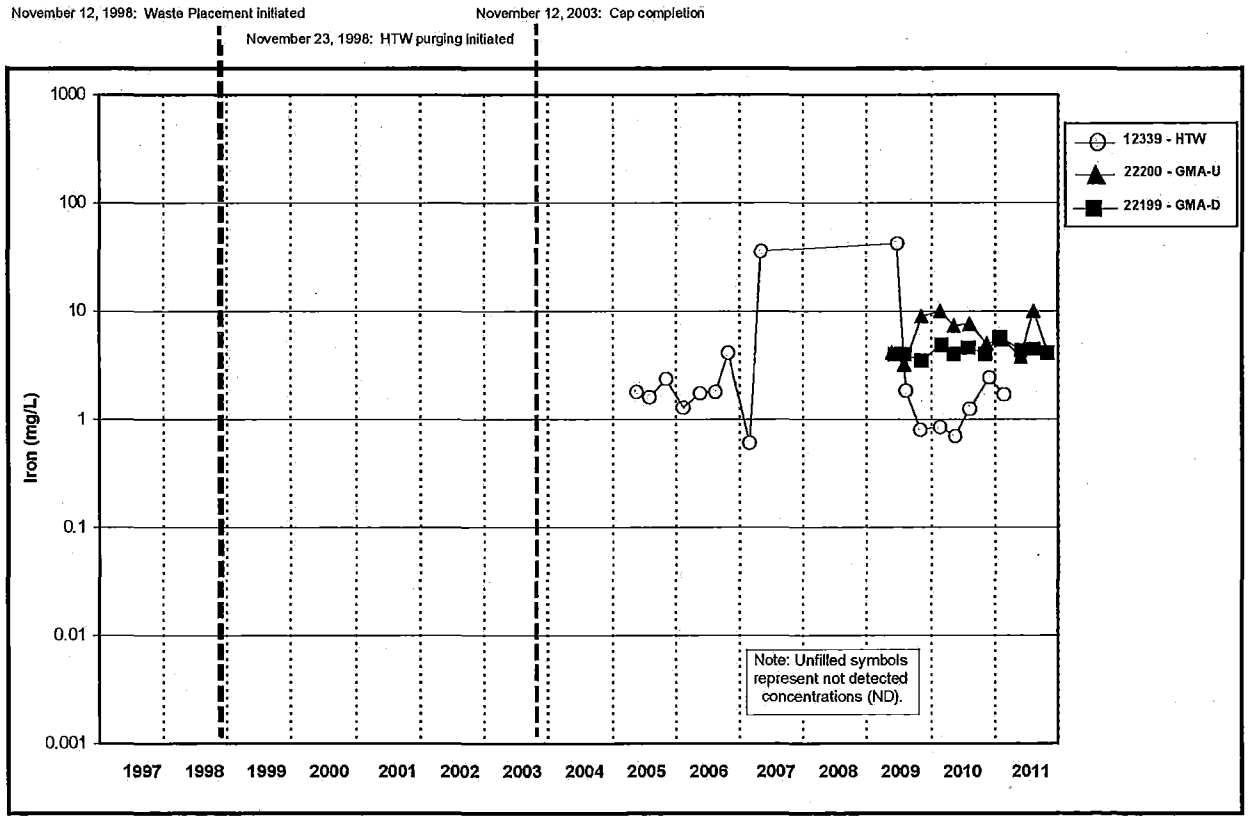


Figure A.5.2-21B. Cell 2 Iron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

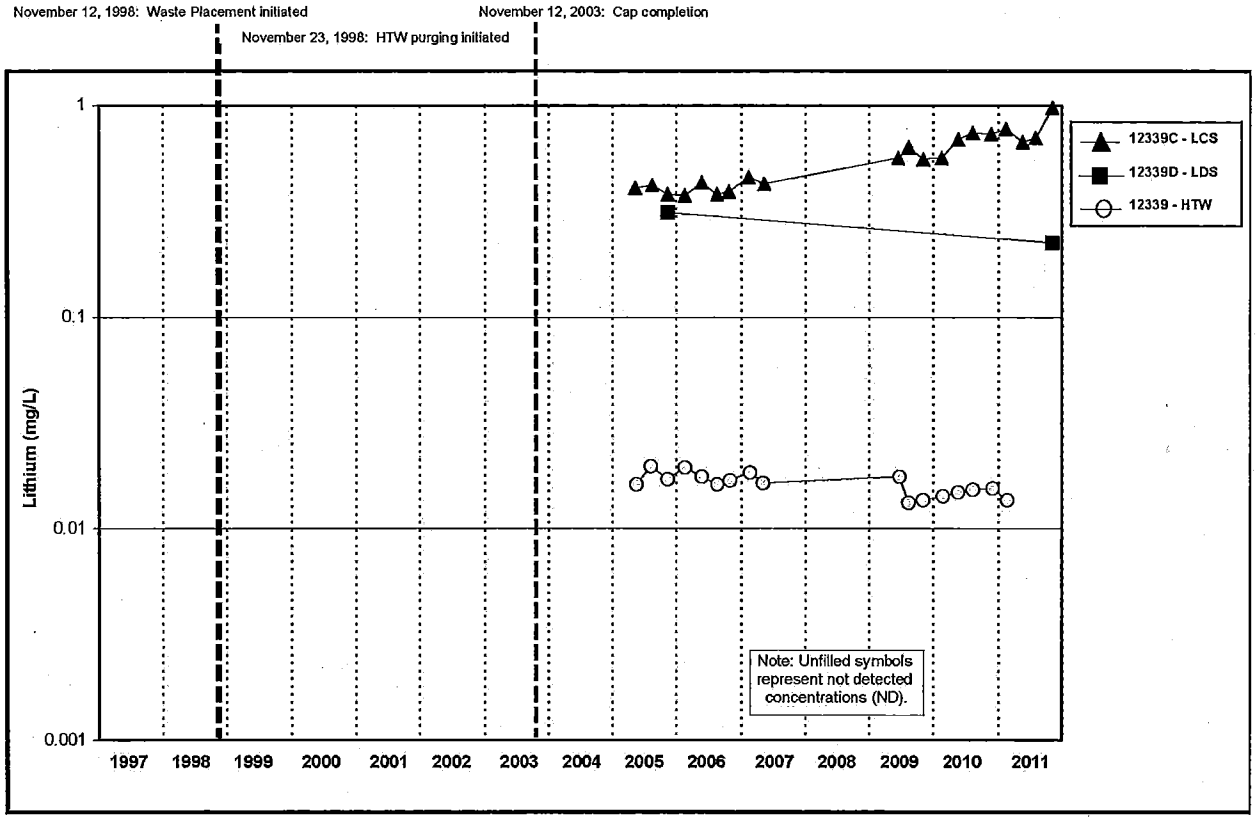


Figure A.5.2-22A. Cell 2 Lithium Concentration vs. Time Plot for LCS, LDS, and HTW

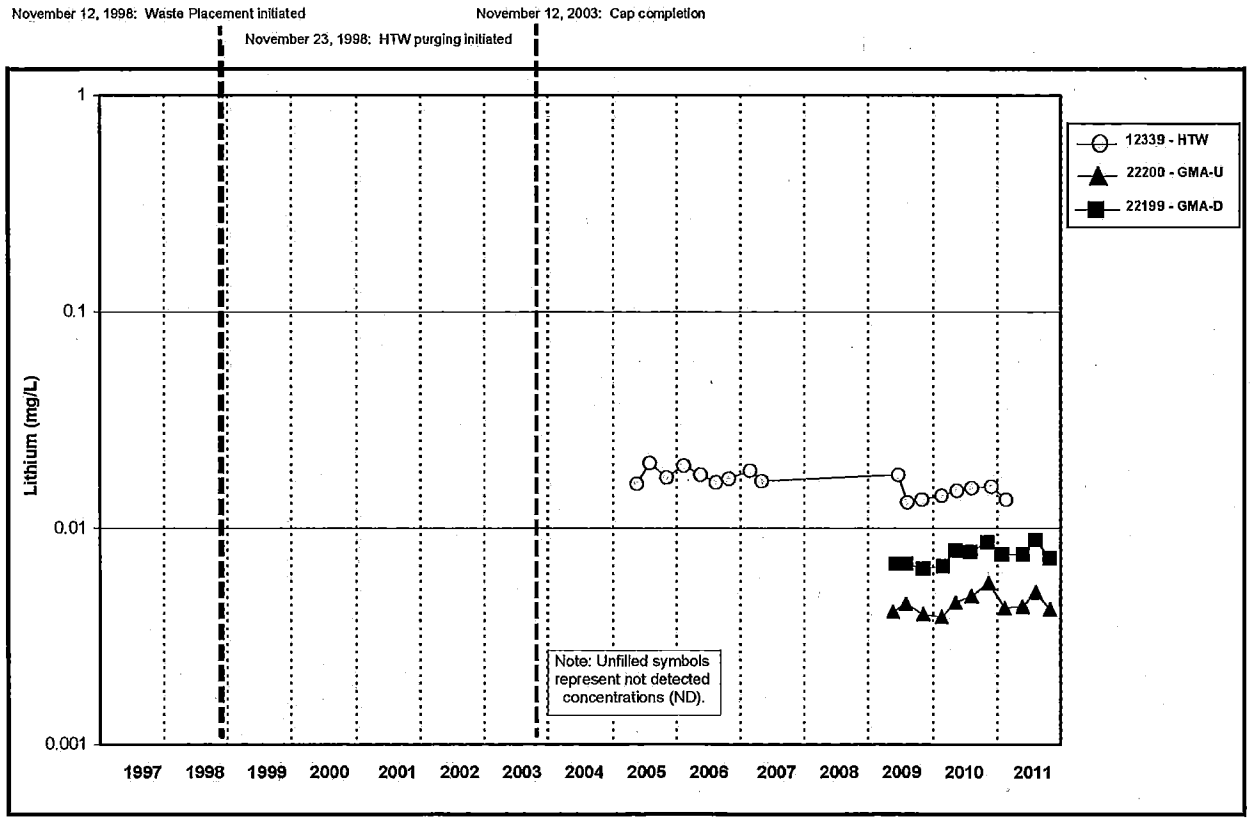


Figure A.5.2-22B. Cell 2 Lithium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

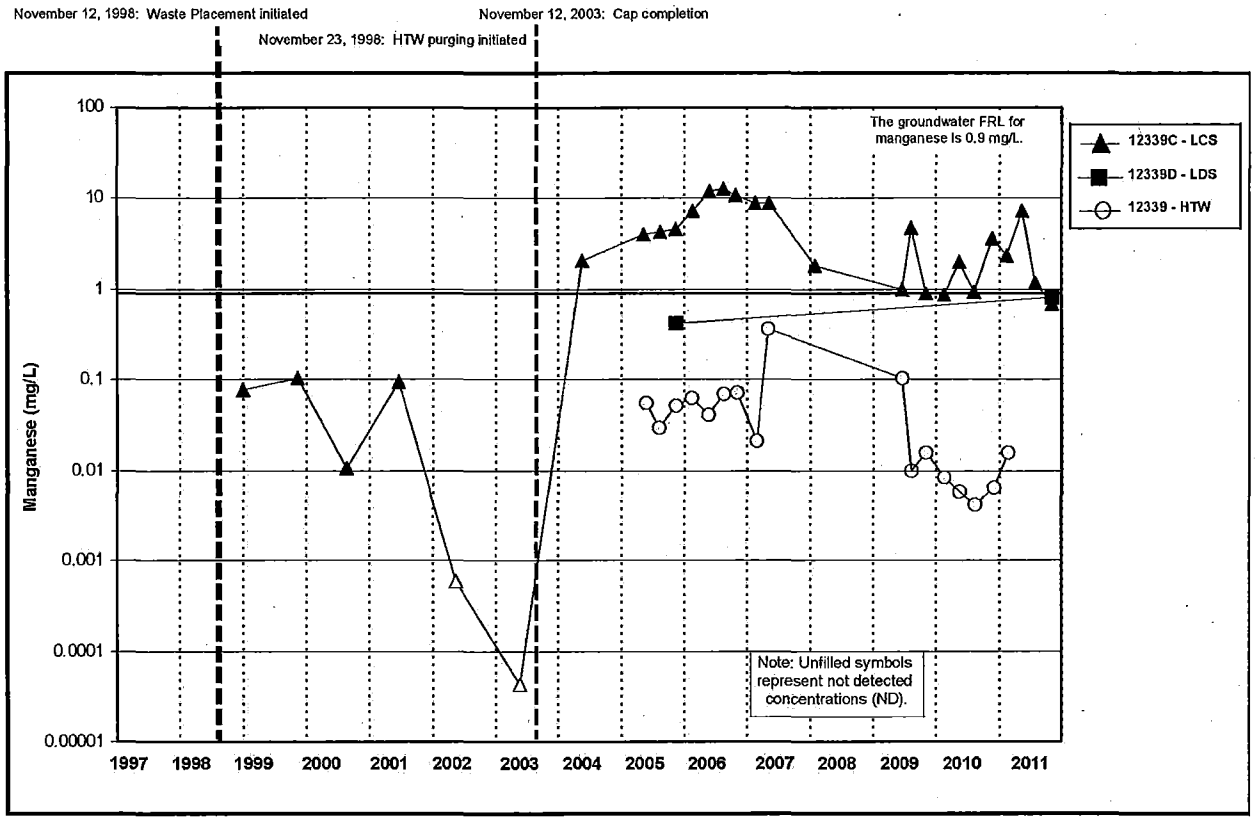


Figure A.5.2-23A. Cell 2 Manganese Concentration vs. Time Plot for LCS, LDS, and HTW

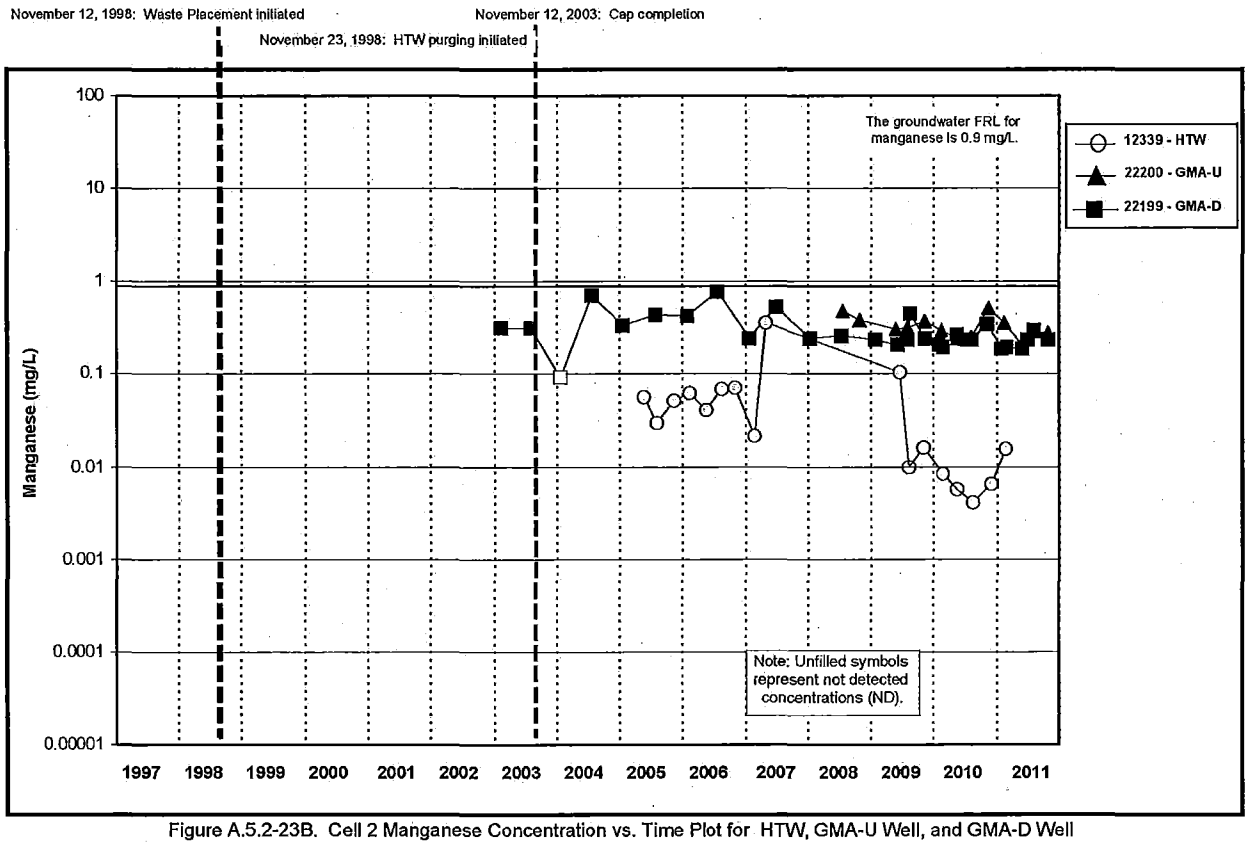


Figure A.5.2-23B. Cell 2 Manganese Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

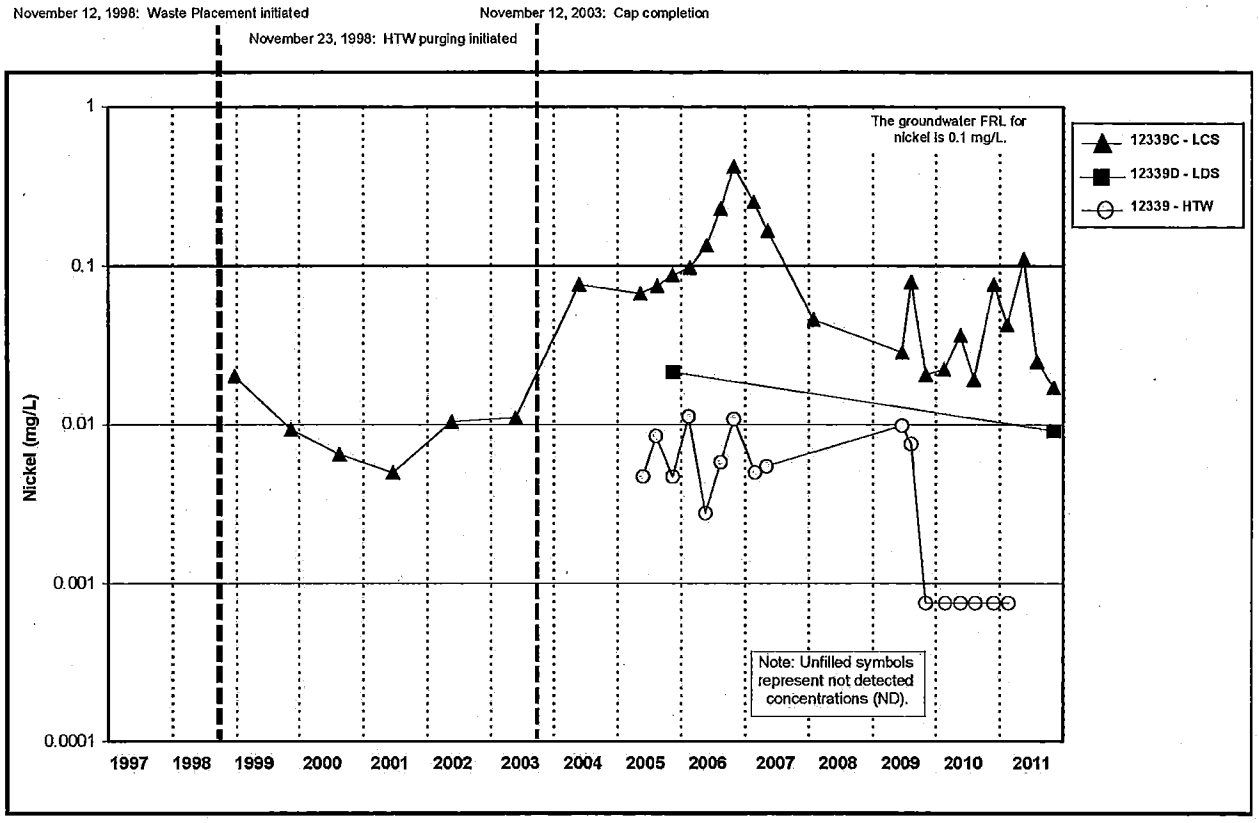


Figure A.5.2-24A. Cell 2 Nickel Concentration vs. Time Plot for LCS, LDS, and HTW

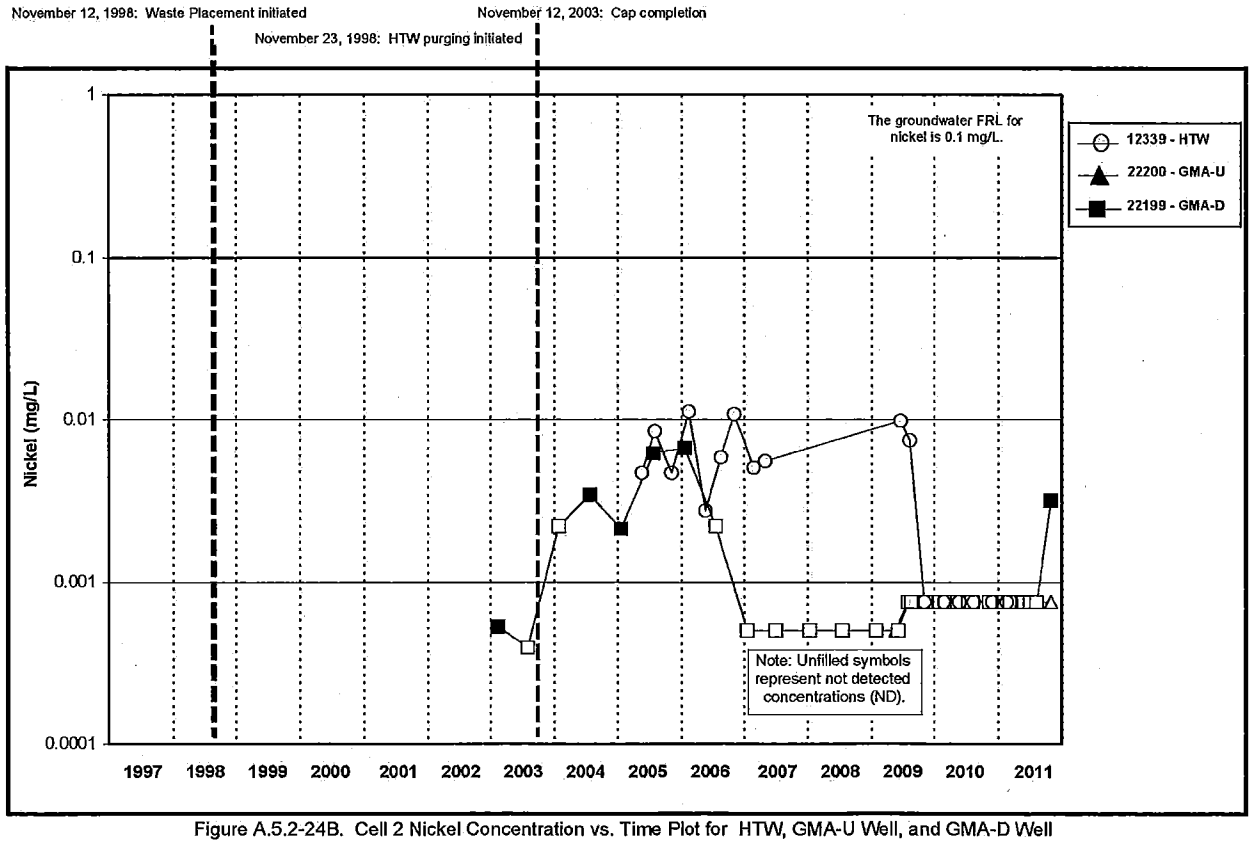


Figure A.5.2-24B. Cell 2 Nickel Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

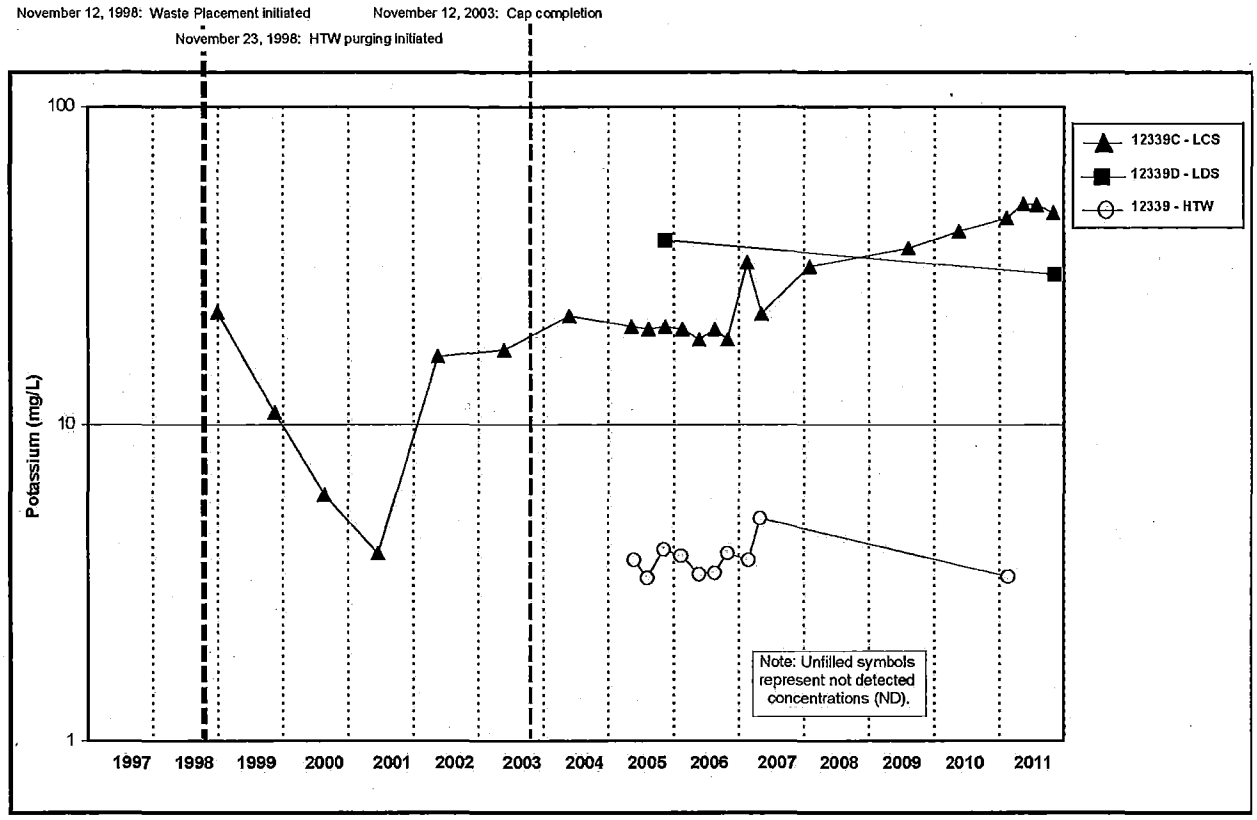


Figure A.5.2-25A. Cell 2 Potassium Concentration vs. Time Plot for LCS, LDS, and HTW

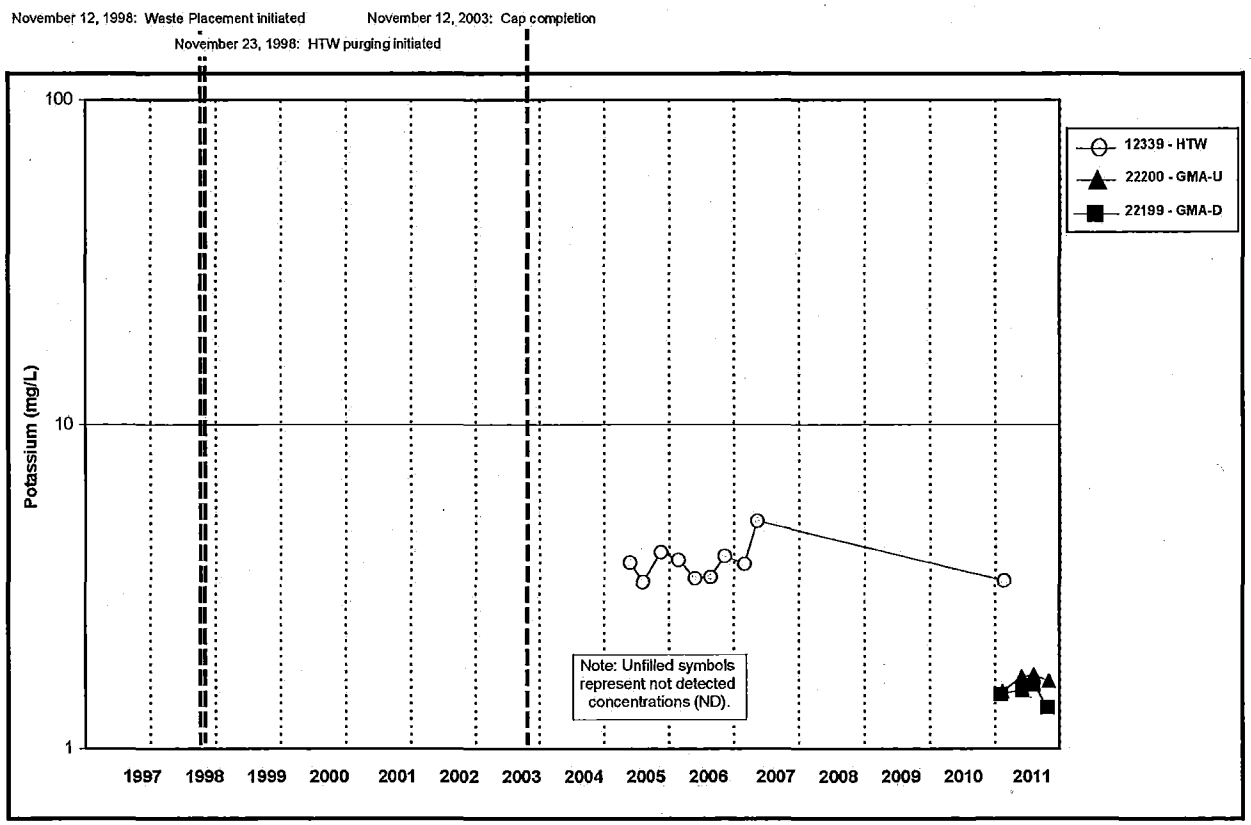


Figure A.5.2-25B. Cell 2 Potassium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

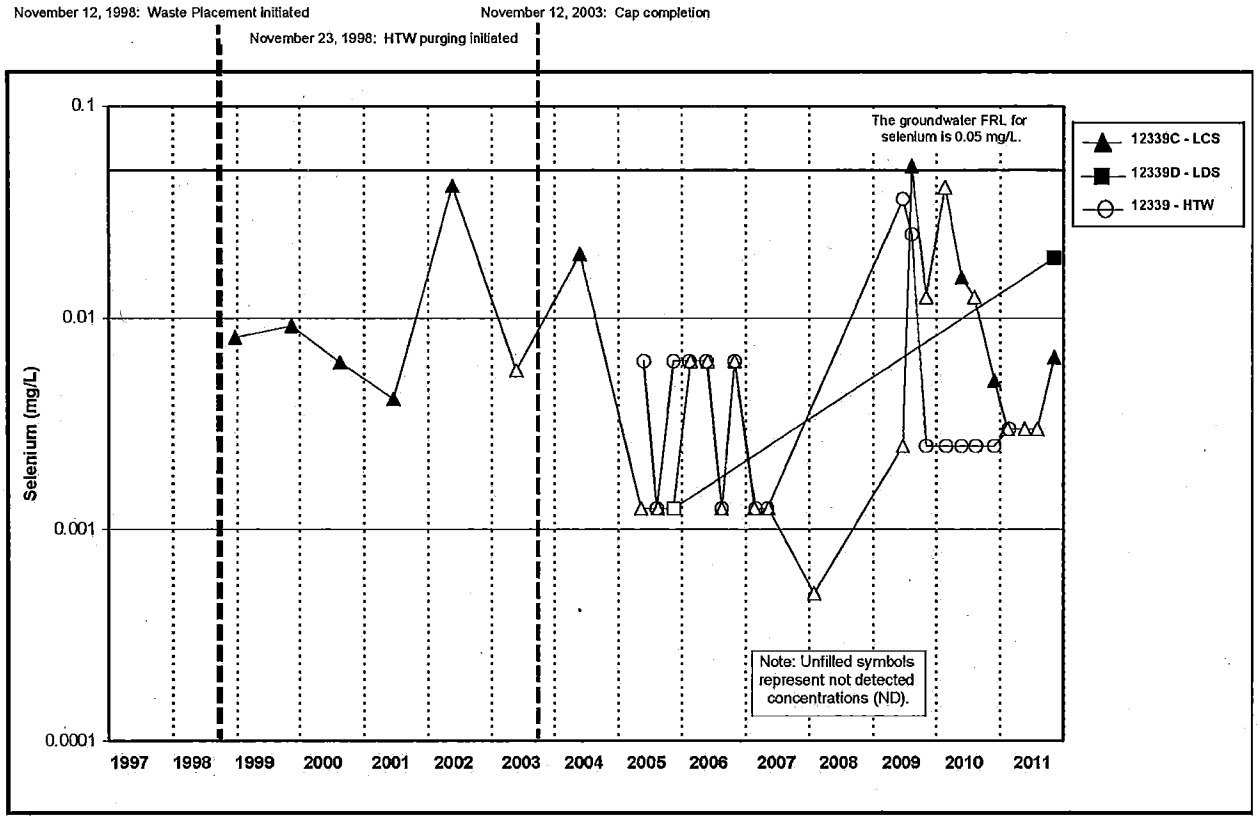


Figure A.5.2-26A. Cell 2 Selenium Concentration vs. Time Plot for LCS, LDS, and HTW

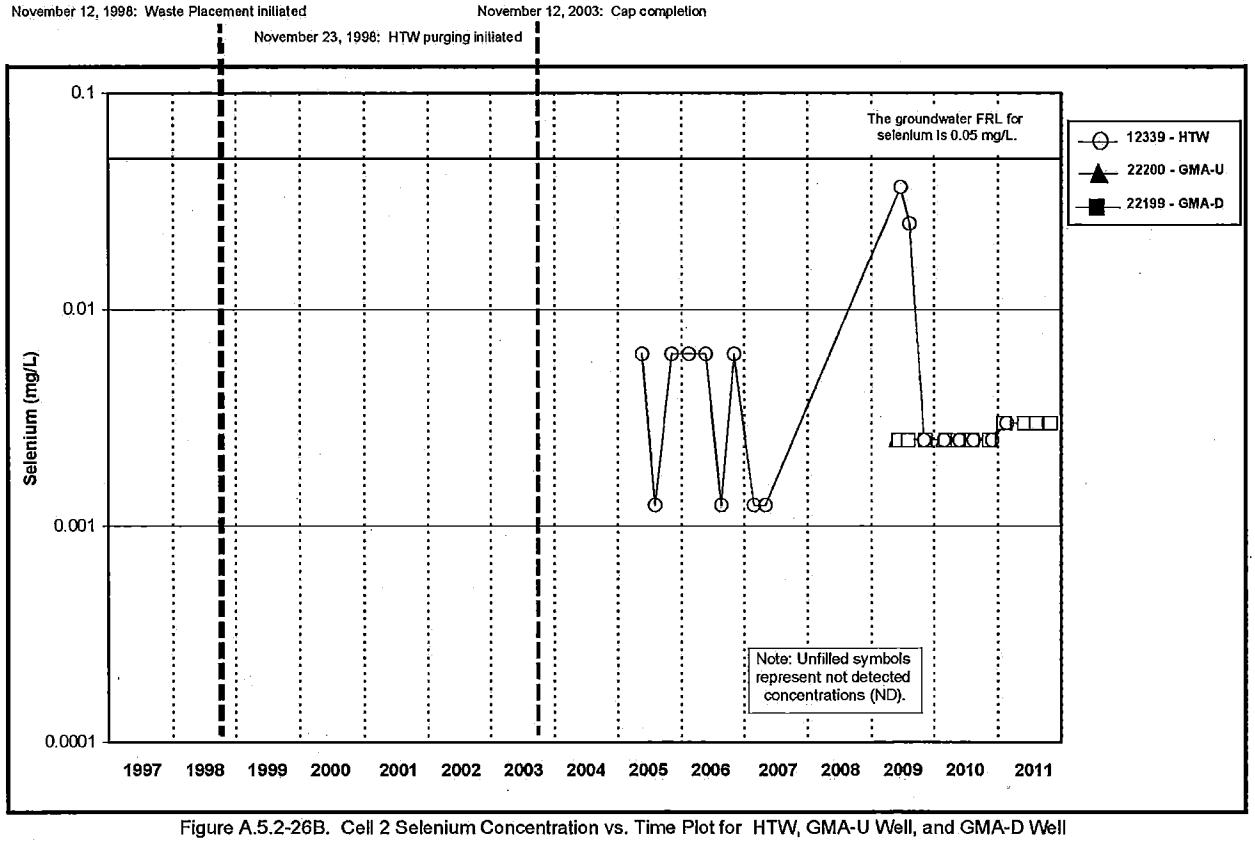


Figure A.5.2-26B. Cell 2 Selenium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

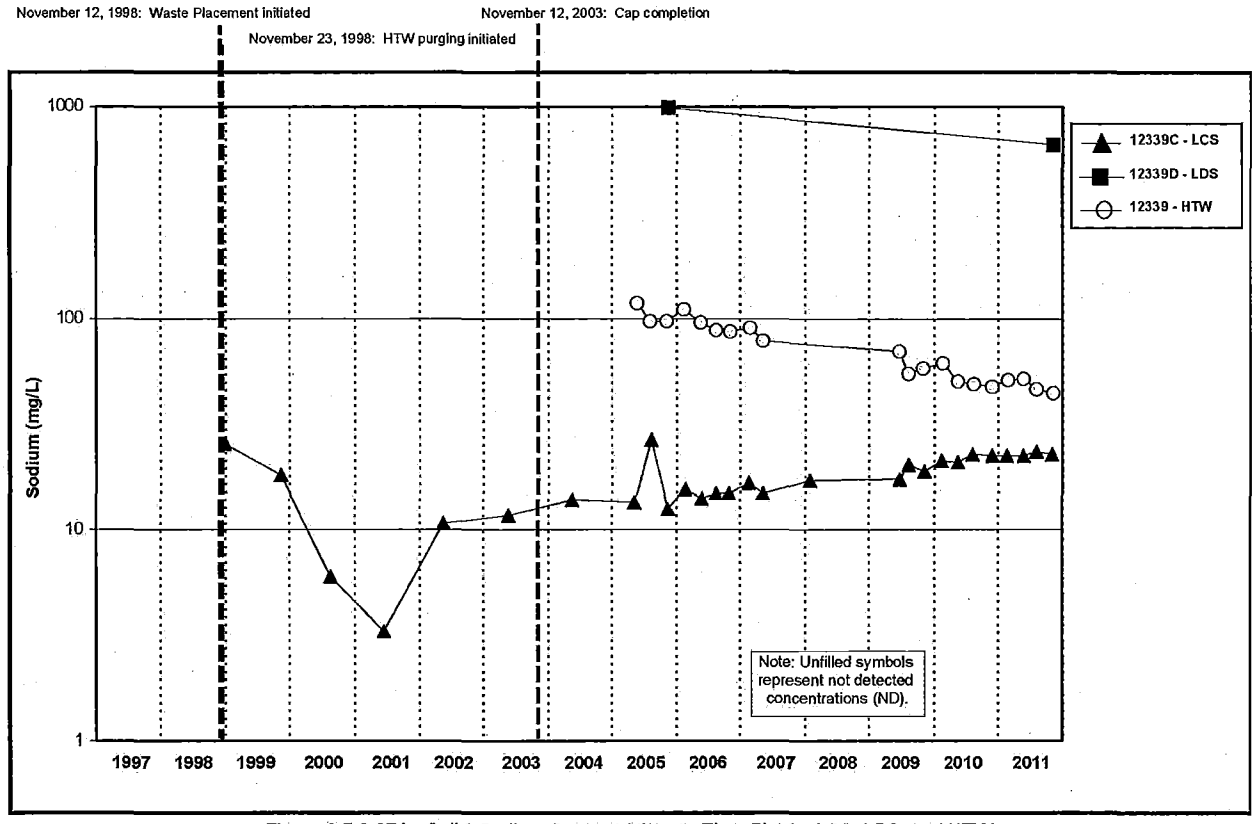


Figure A.5.2-27A. Cell 2 Sodium Concentration vs. Time Plot for LCS, LDS, and HTW

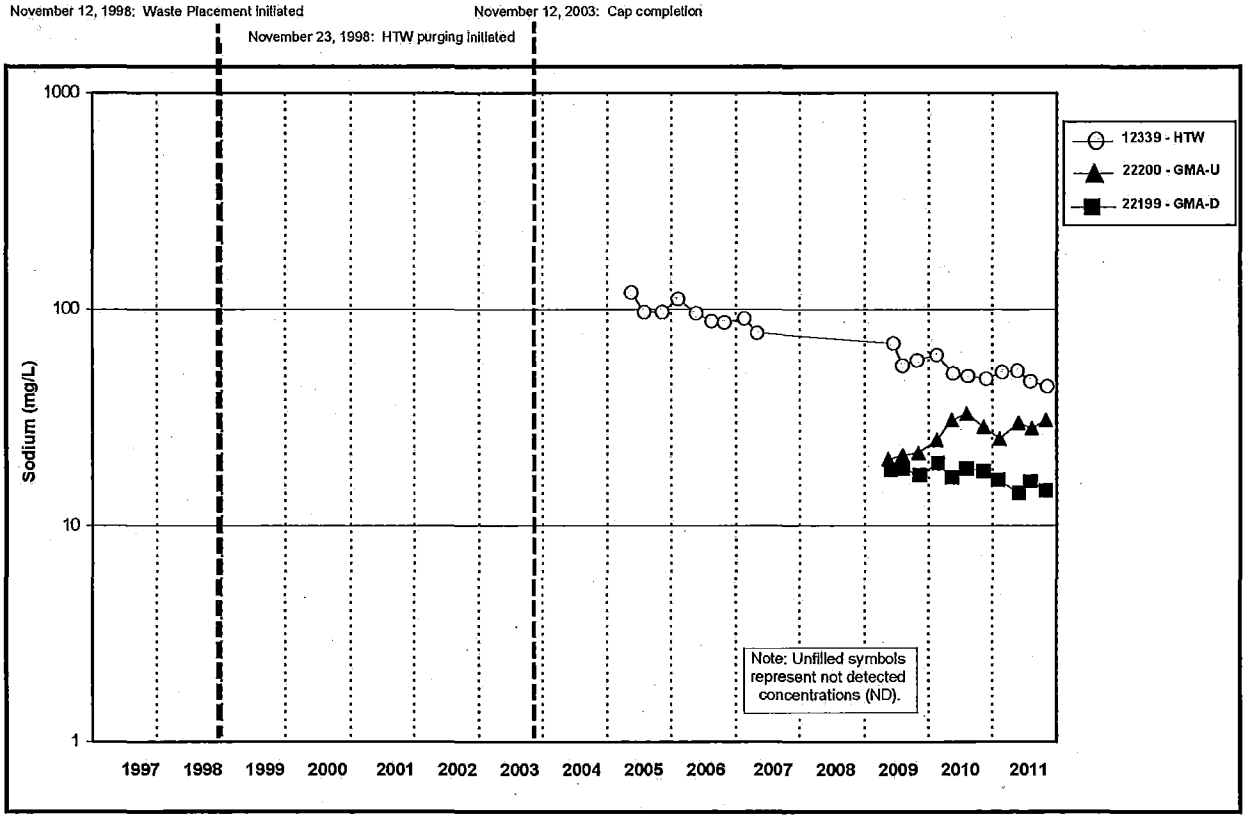


Figure A.5.2-27B. Cell 2 Sodium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

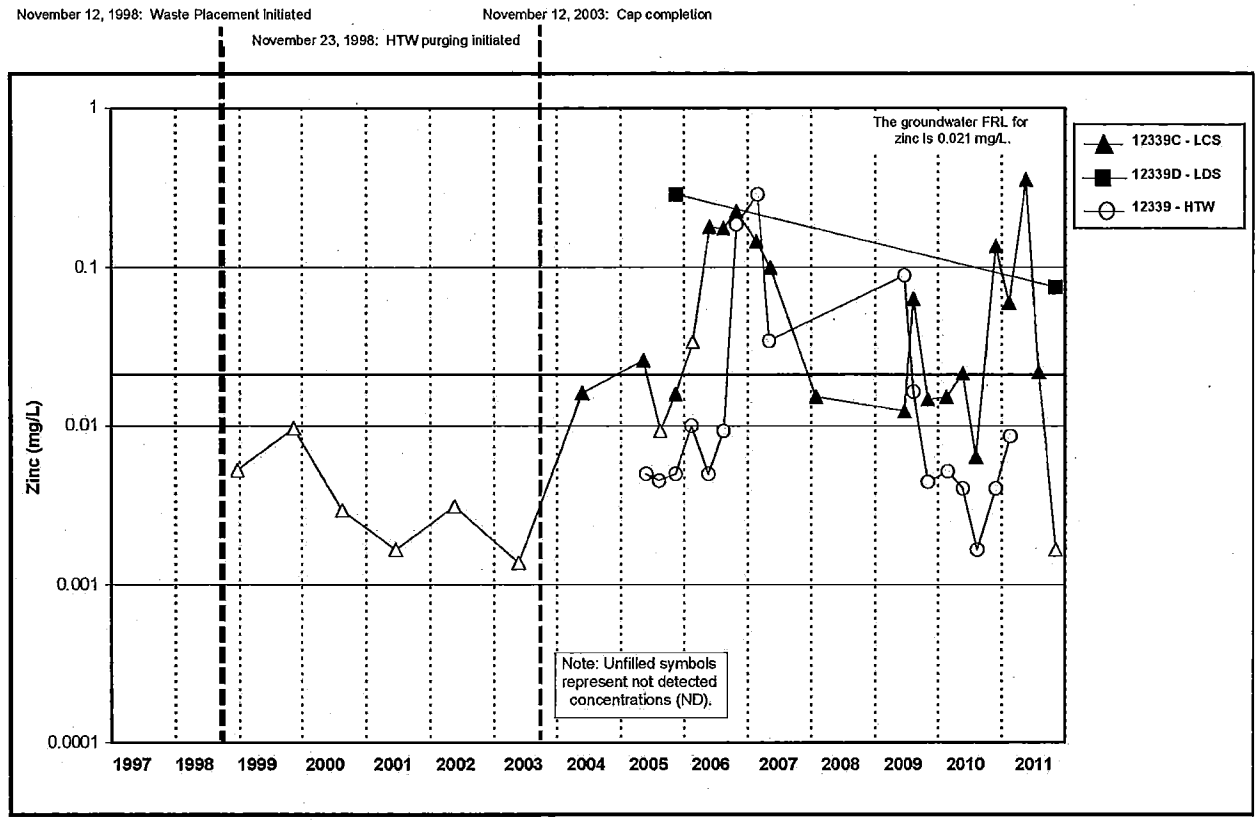


Figure A.5.2-28A. Cell 2 Zinc Concentration vs. Time Plot for LCS, LDS, and HTW

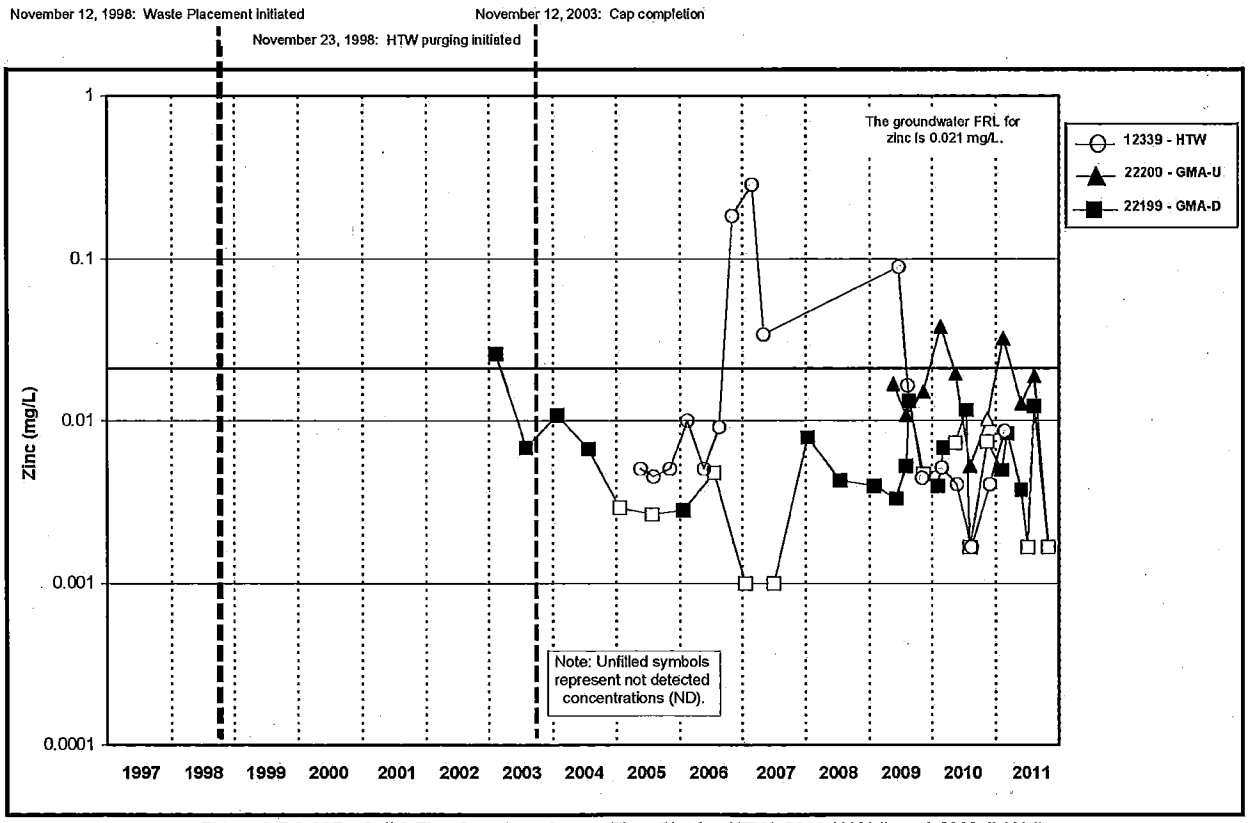


Figure A.5.2-28B. Cell 2 Zinc Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

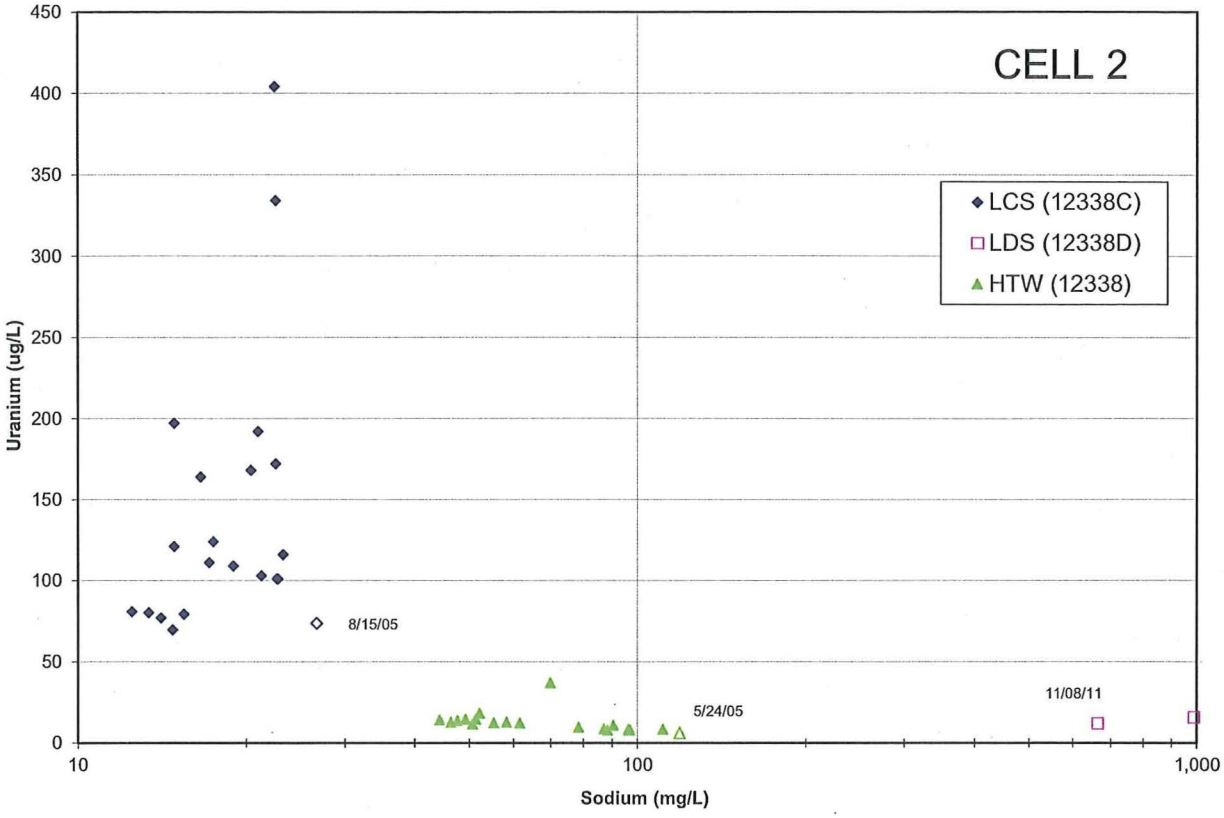


Figure A.5.2−29. Cell 2 Bivariate Plot for Uranium and Sodium

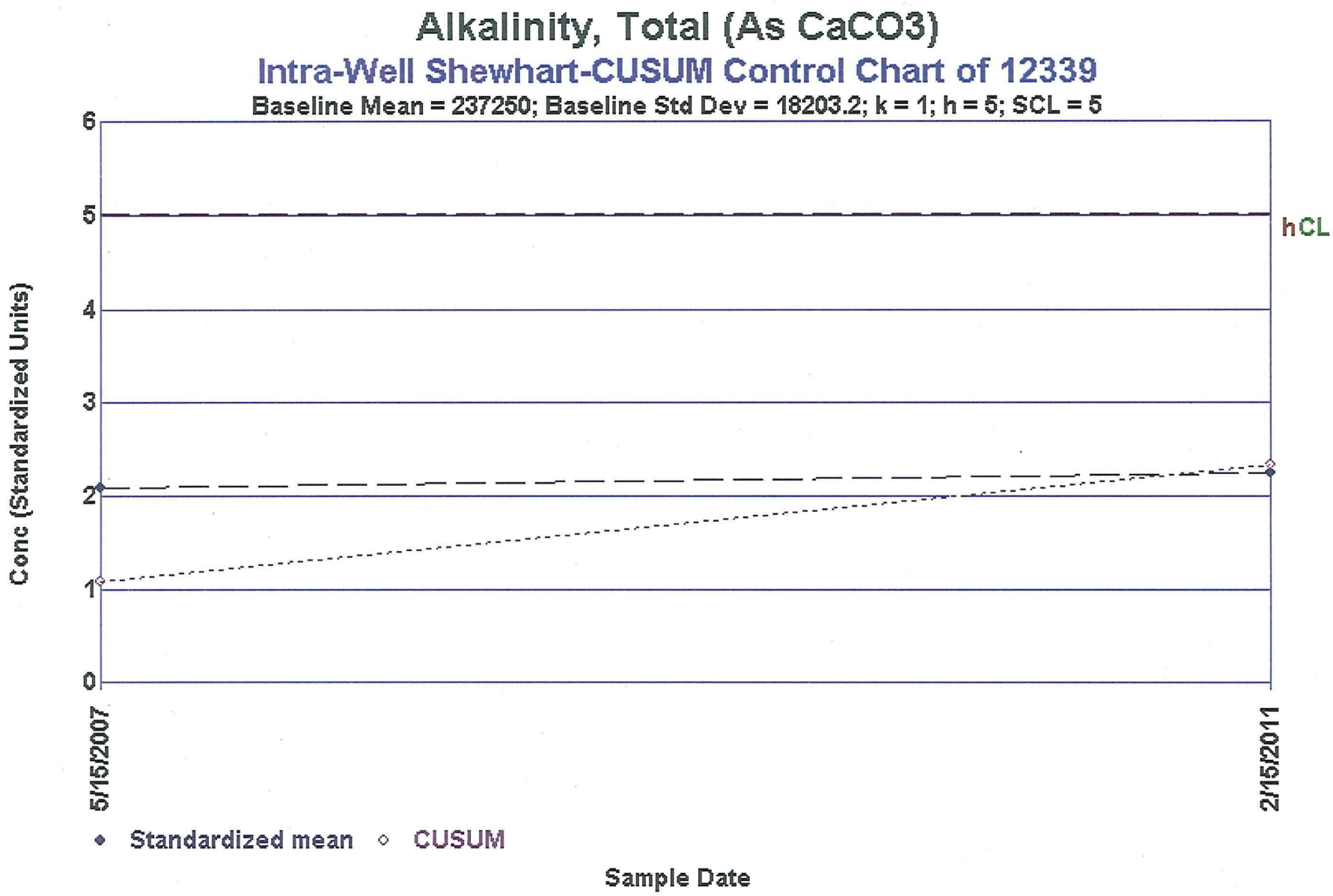


Figure A.5.2–30. Intra-Well Shewhart-CUSUM Control Chart (Alkalinity 12339)

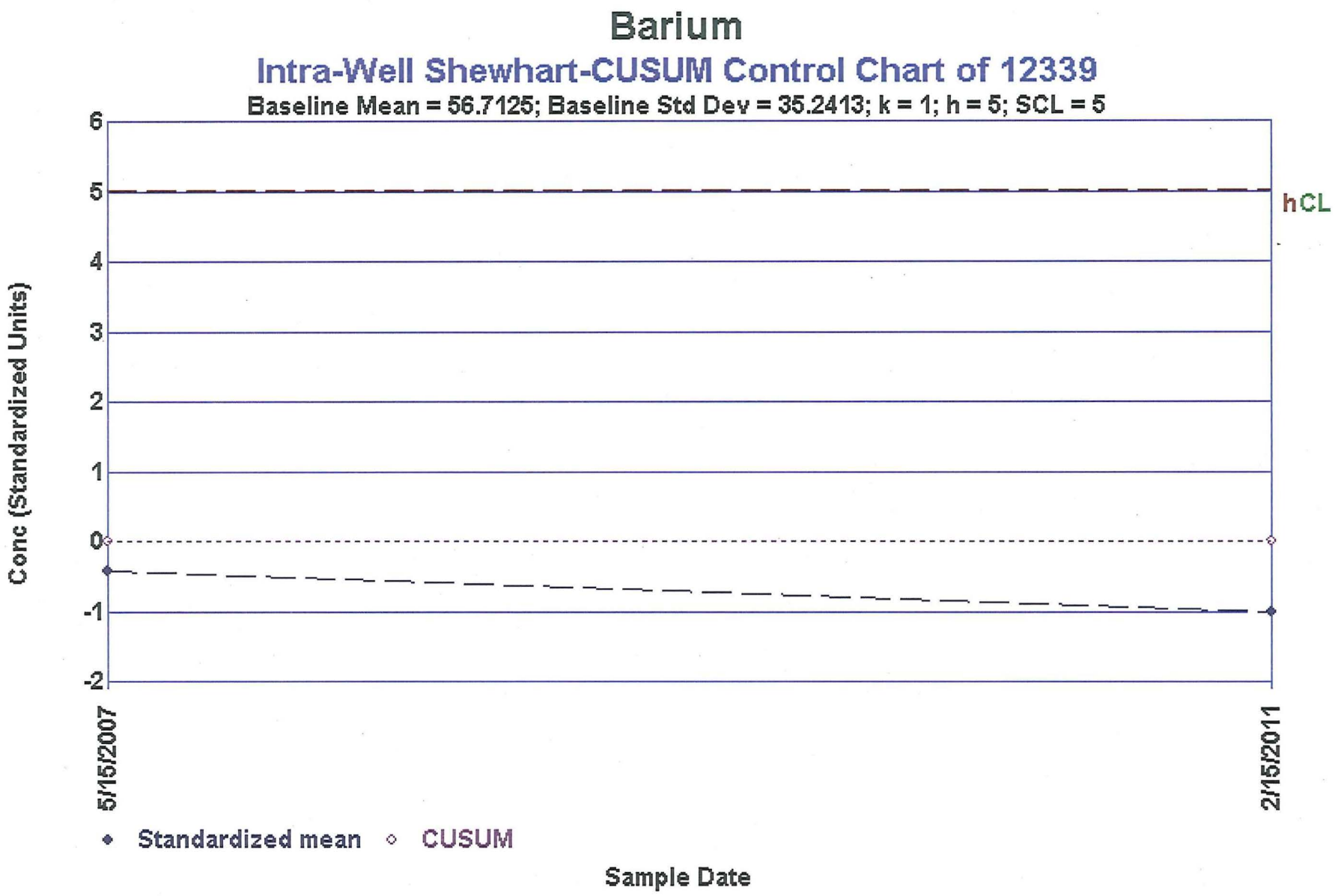


Figure A.5.2−31. Intra-Well Shewhart-CUSUM Control Chart (Barium 12339)

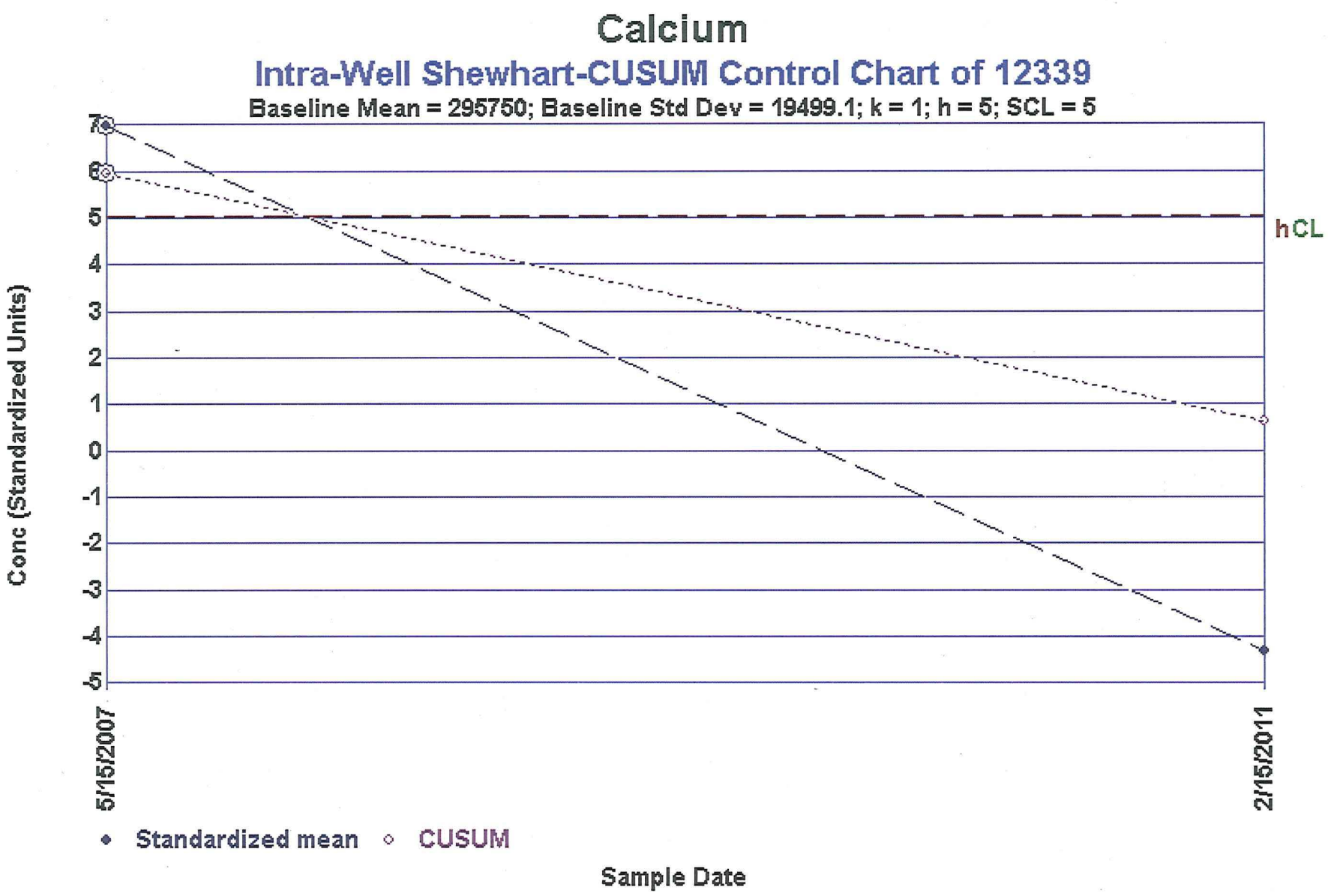


Figure A.5.2−32. Intra-Well Shewhart-CUSUM Control Chart (Calcium 12339)

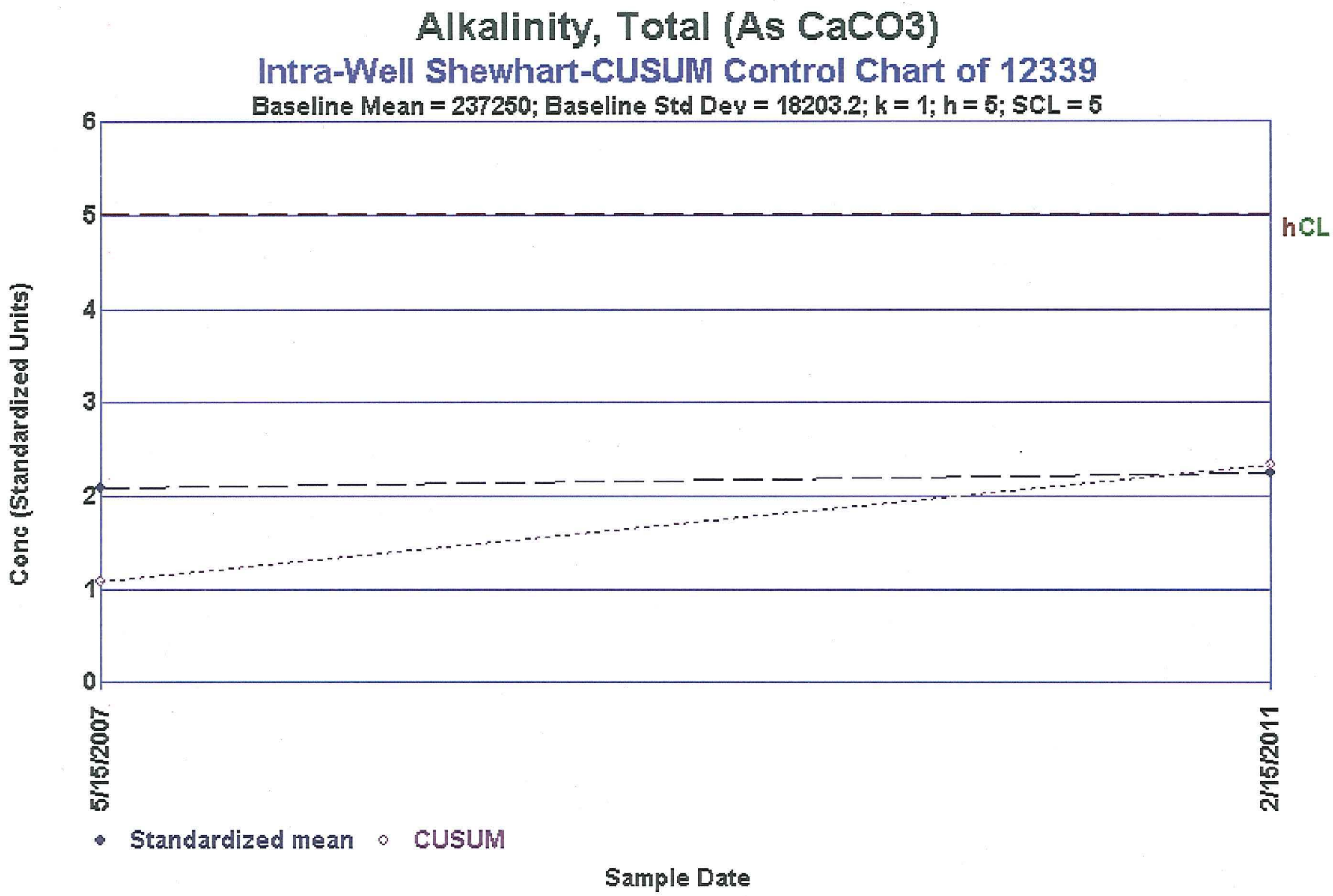


Figure A.5.2–30. Intra-Well Shewhart-CUSUM Control Chart (Alkalinity 12339)

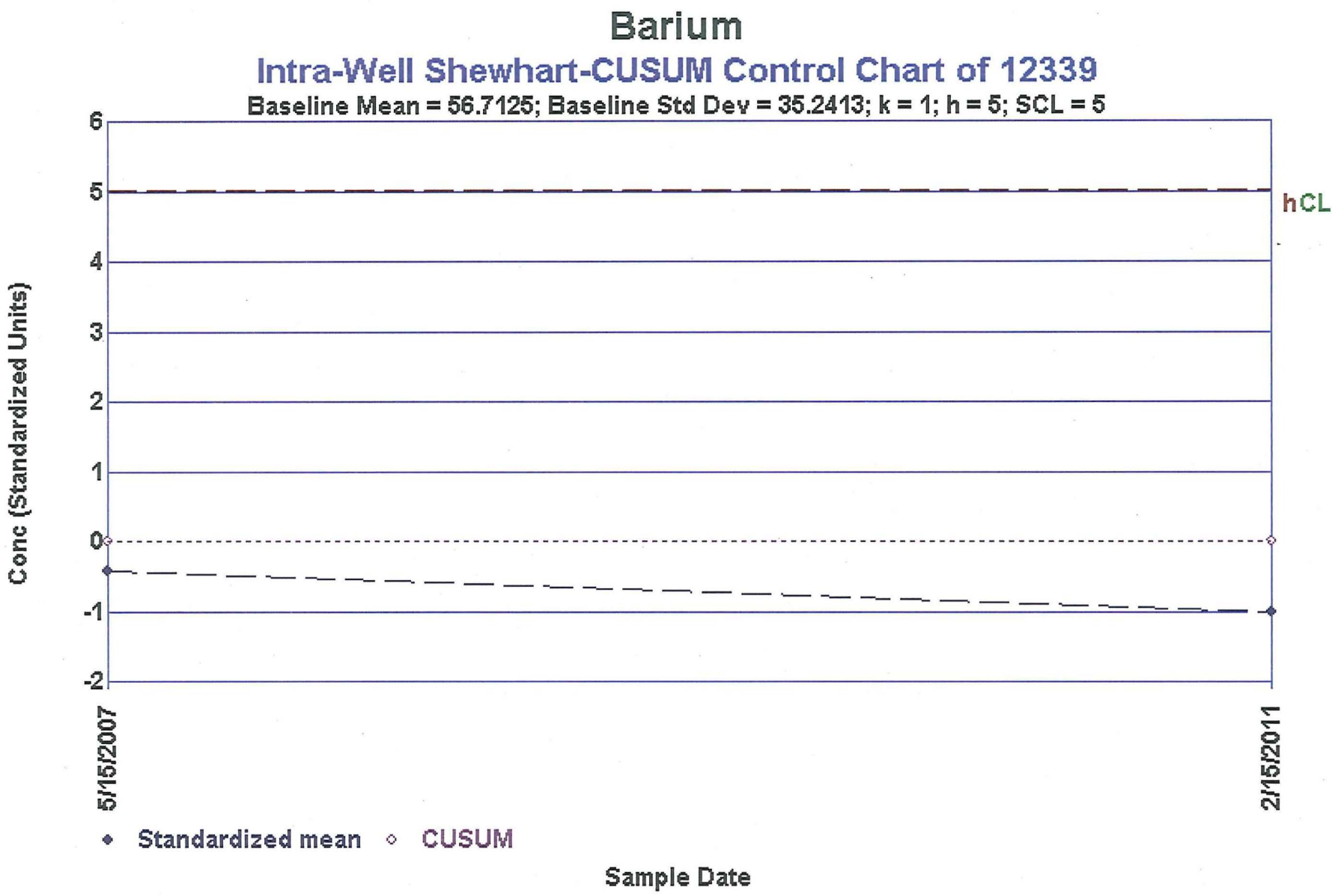


Figure A.5.2−31. Intra-Well Shewhart-CUSUM Control Chart (Barium 12339)

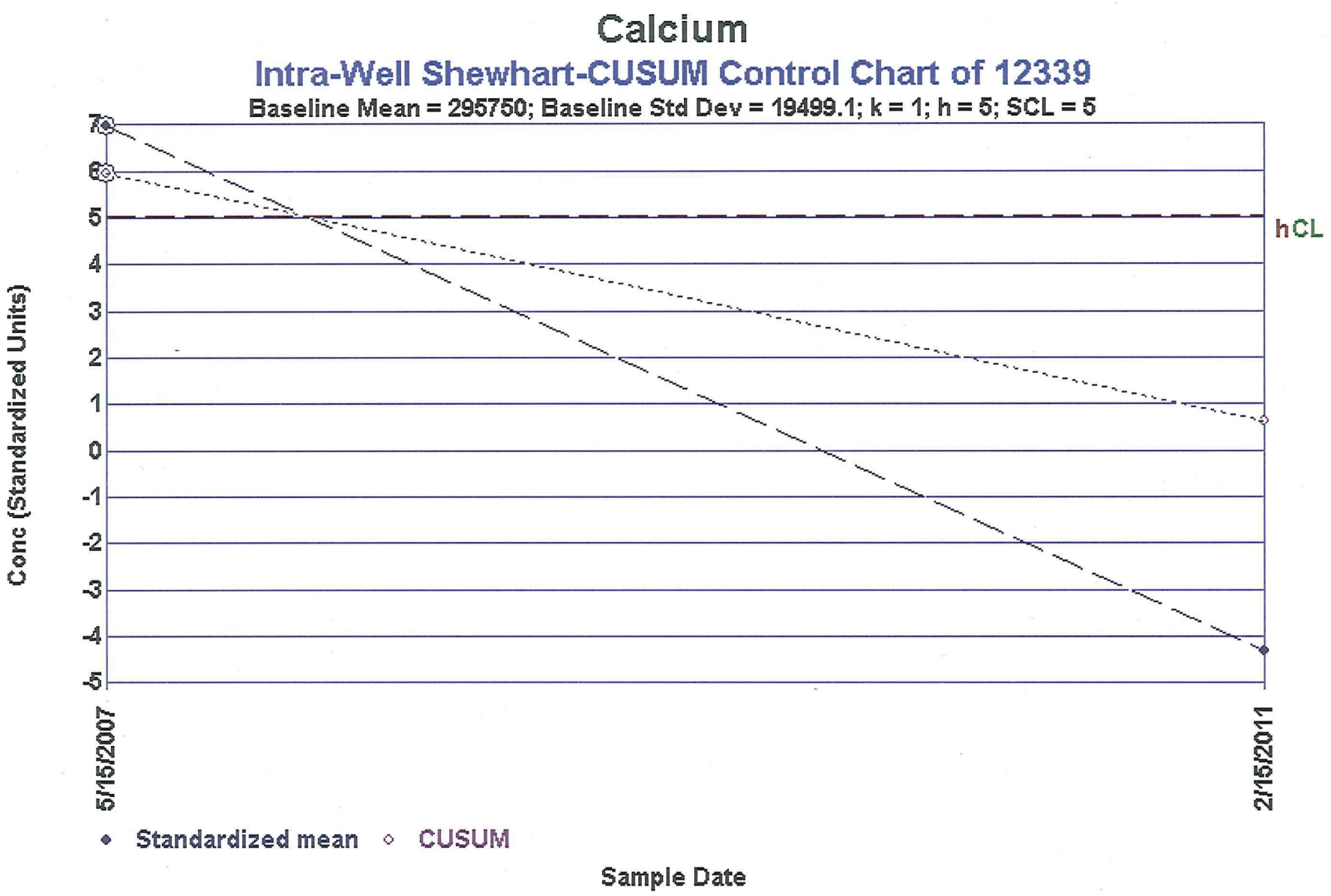


Figure A.5.2−32. Intra-Well Shewhart-CUSUM Control Chart (Calcium 12339)

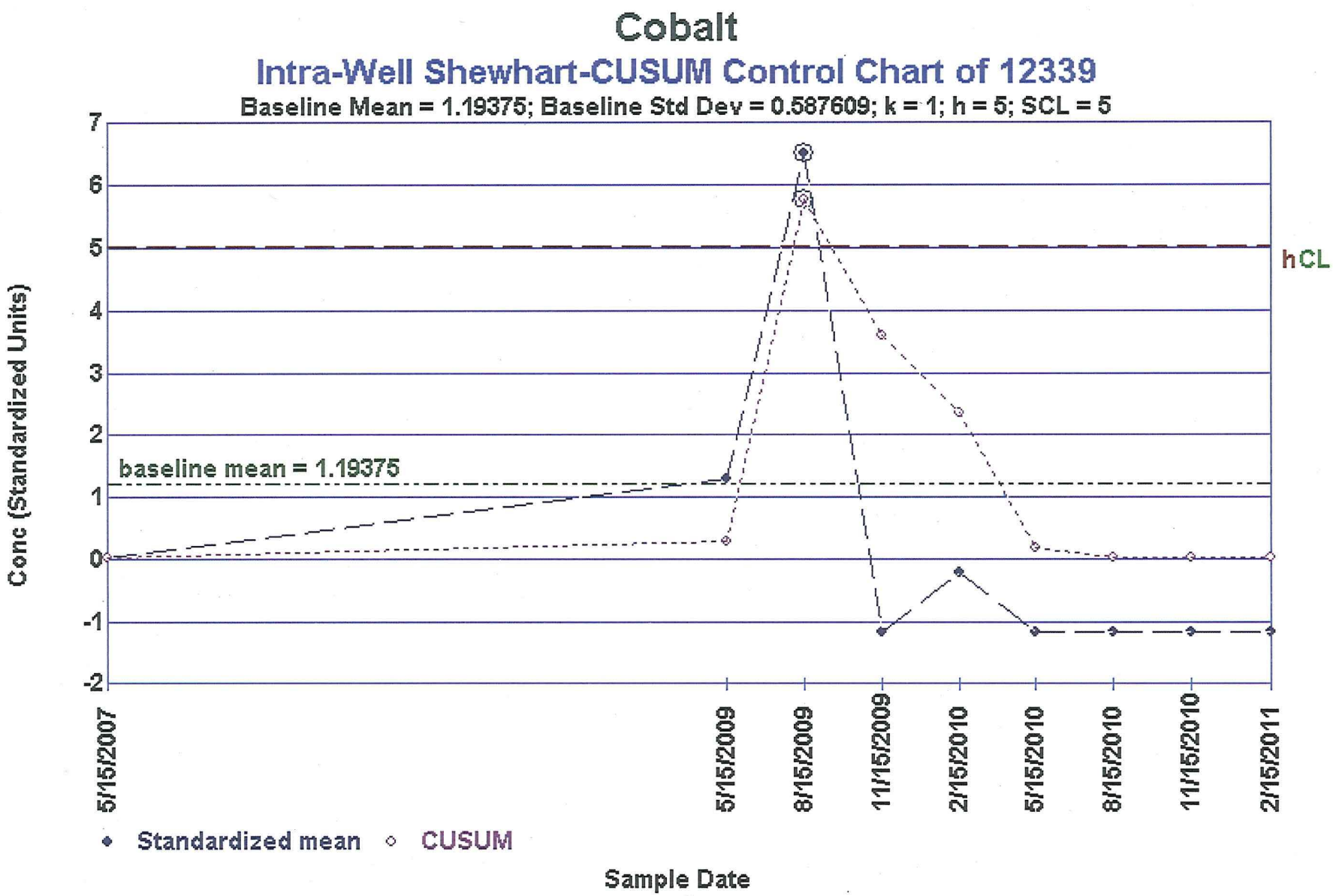


Figure A.5.2–33. Intra-Well Shewhart-CUSUM Control Chart (Cobalt 12339)

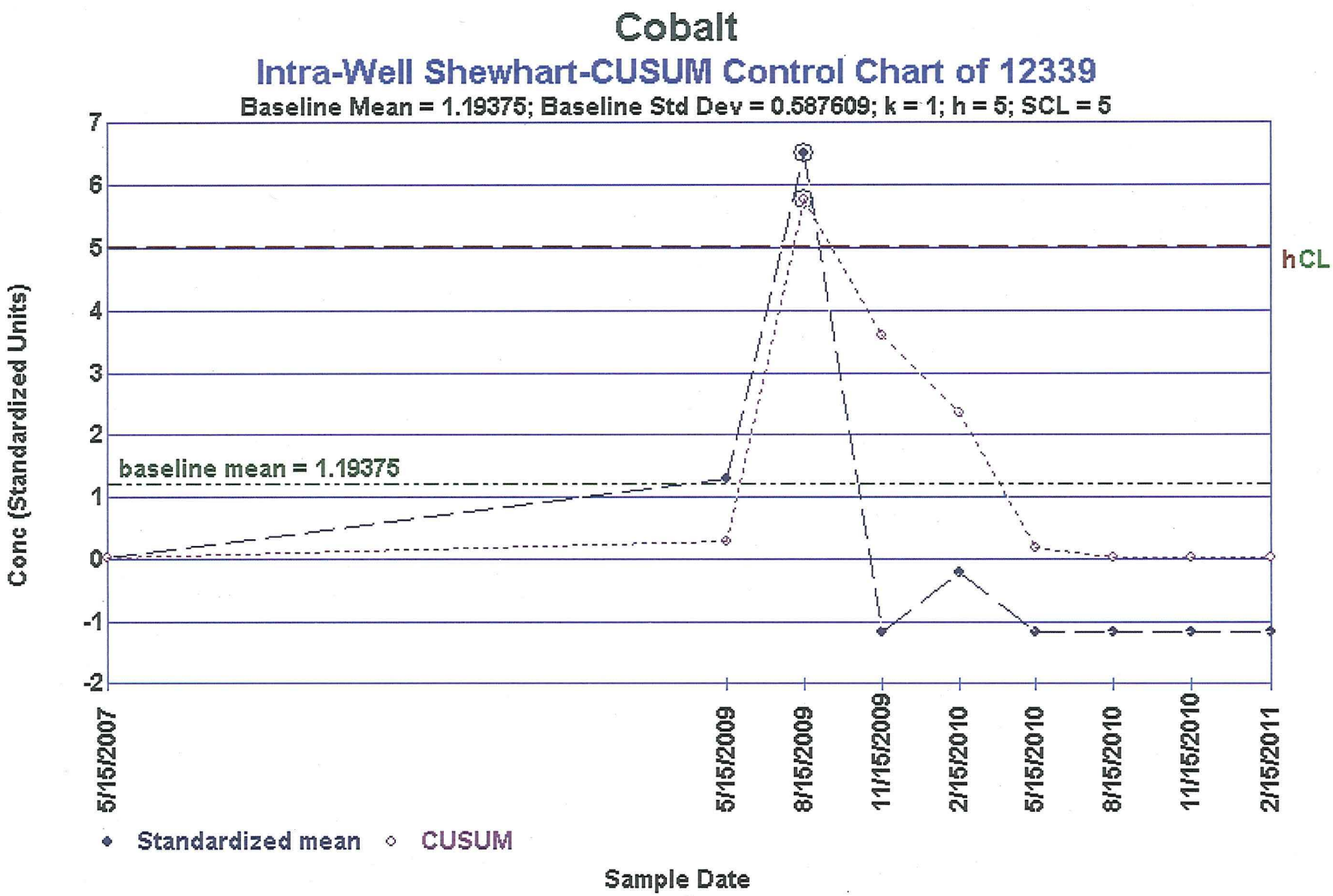


Figure A.5.2–33. Intra-Well Shewhart-CUSUM Control Chart (Cobalt 12339)

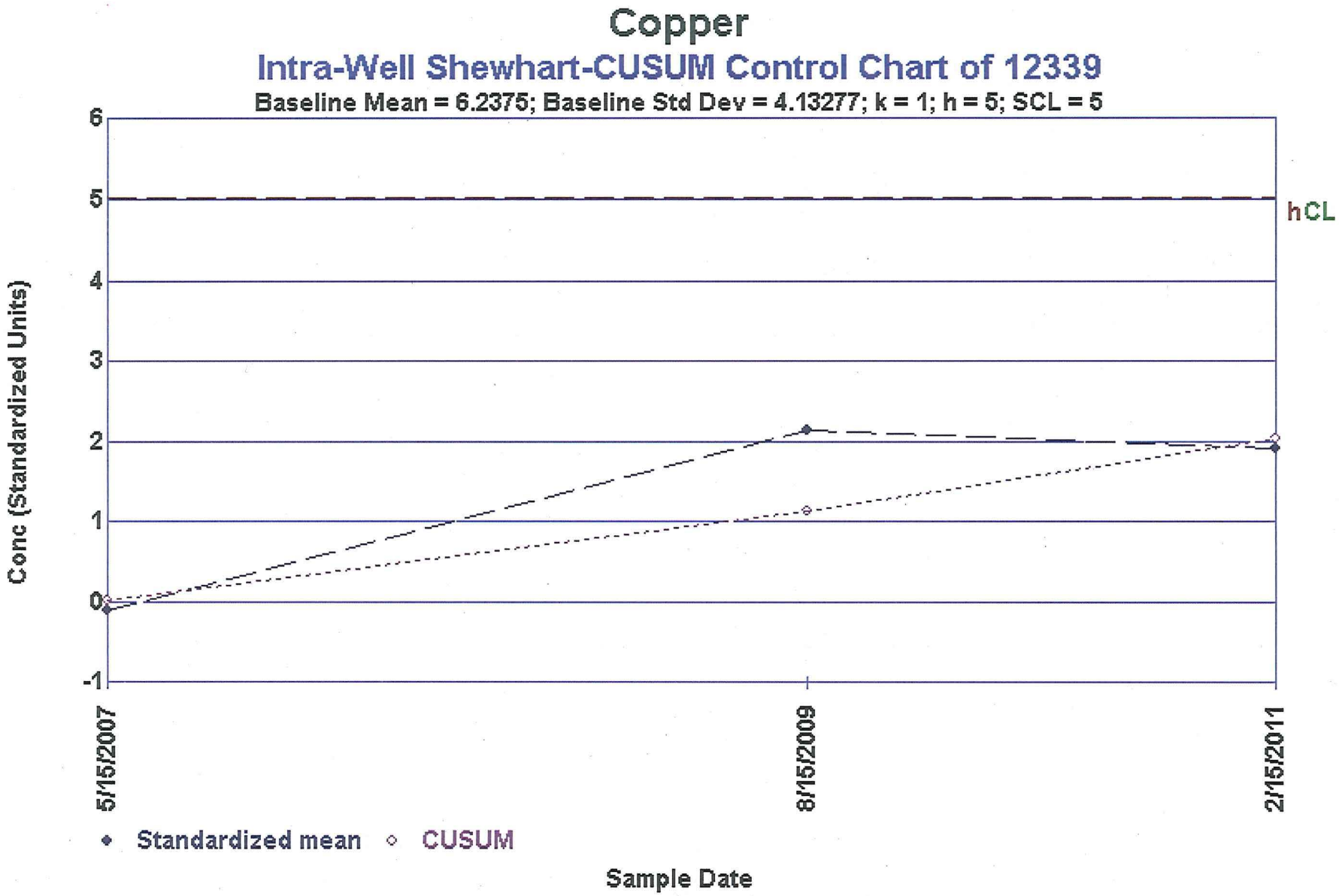


Figure A.5.2–34. Intra-Well Shewhart-CUSUM Control Chart (Copper 12339)

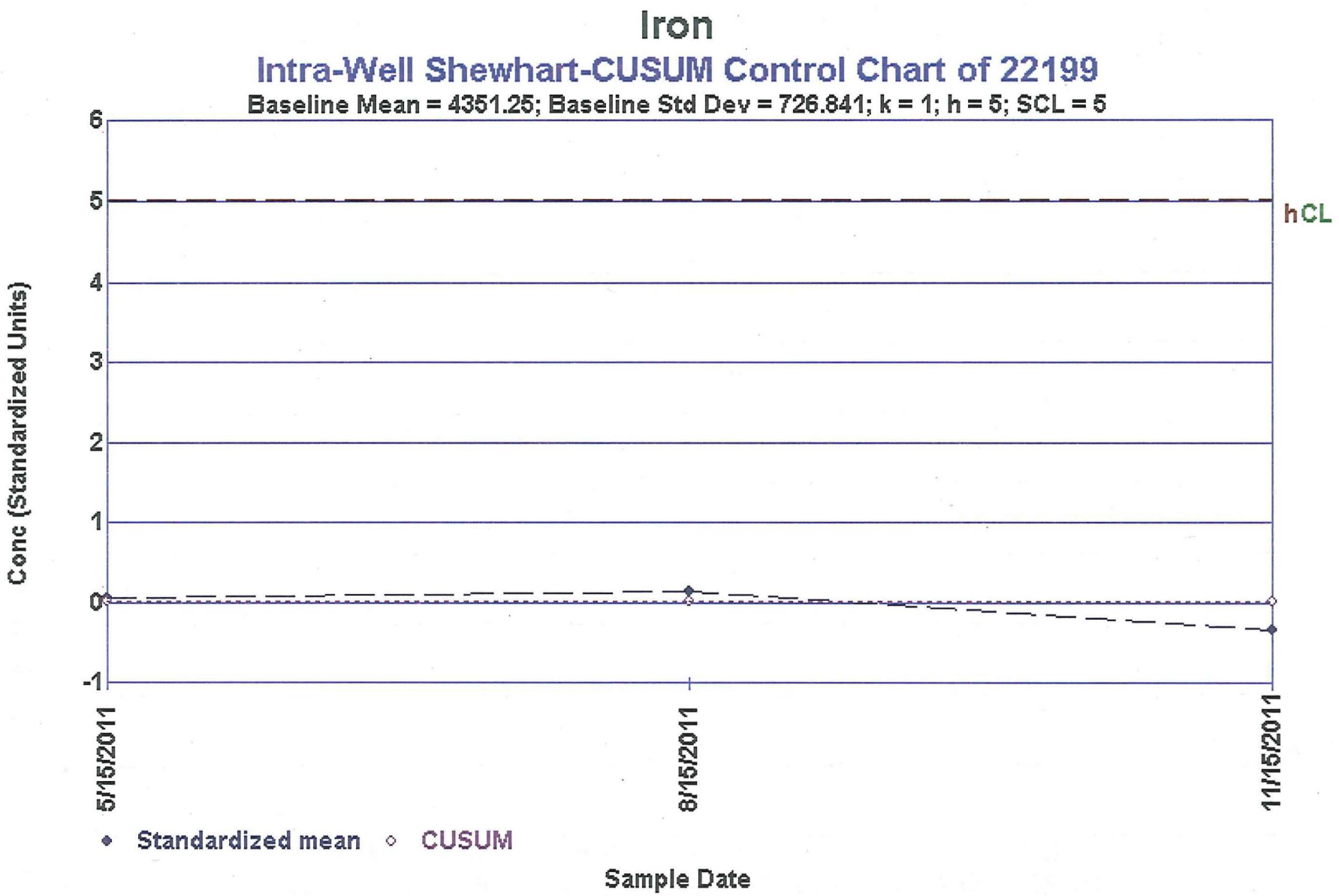


Figure A.5.2−35. Intra-Well Shewhart-CUSUM Control Chart (Iron 22199)

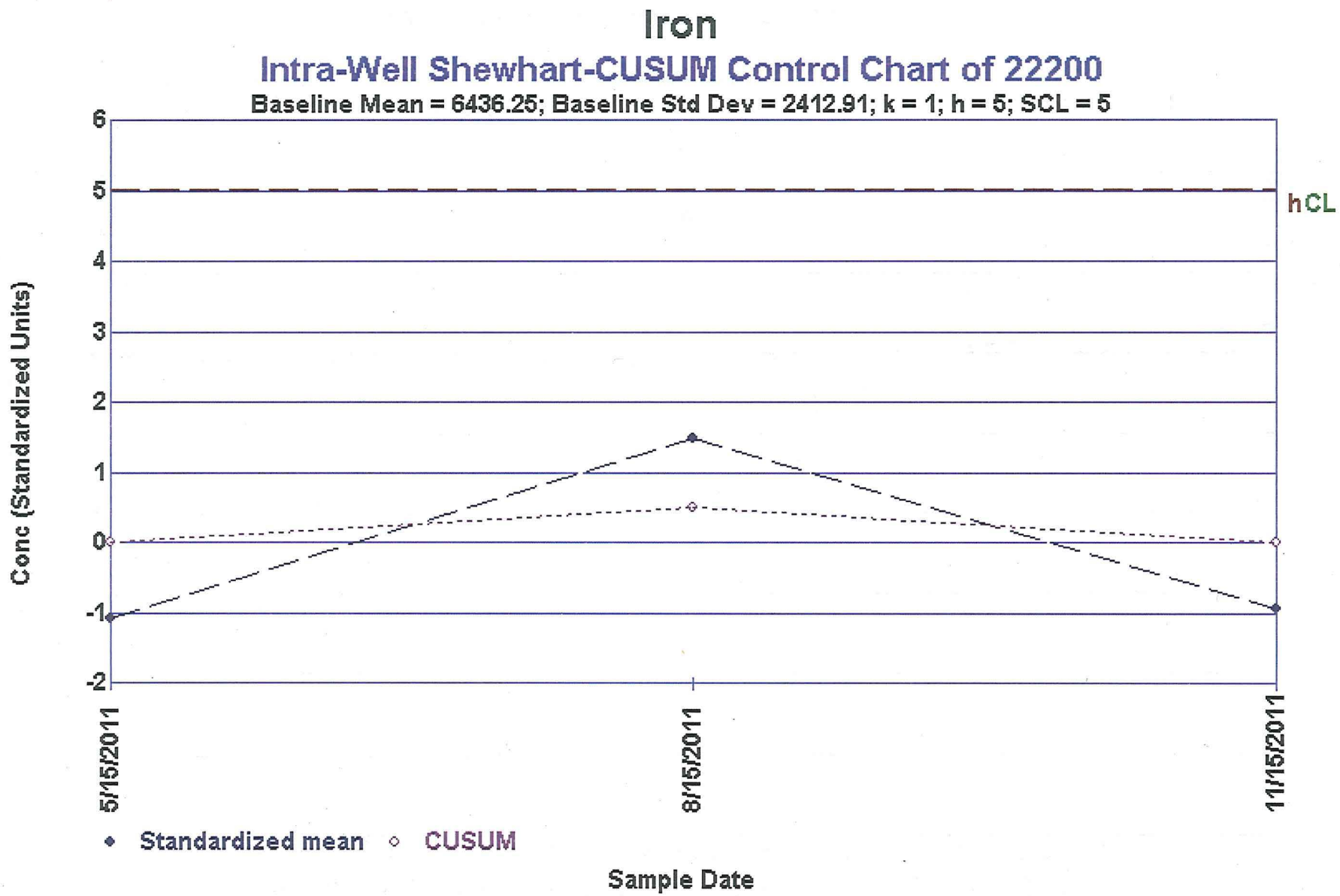


Figure A.5.2–36. Intra-Well Shewhart-CUSUM Control Chart (Iron 22200)

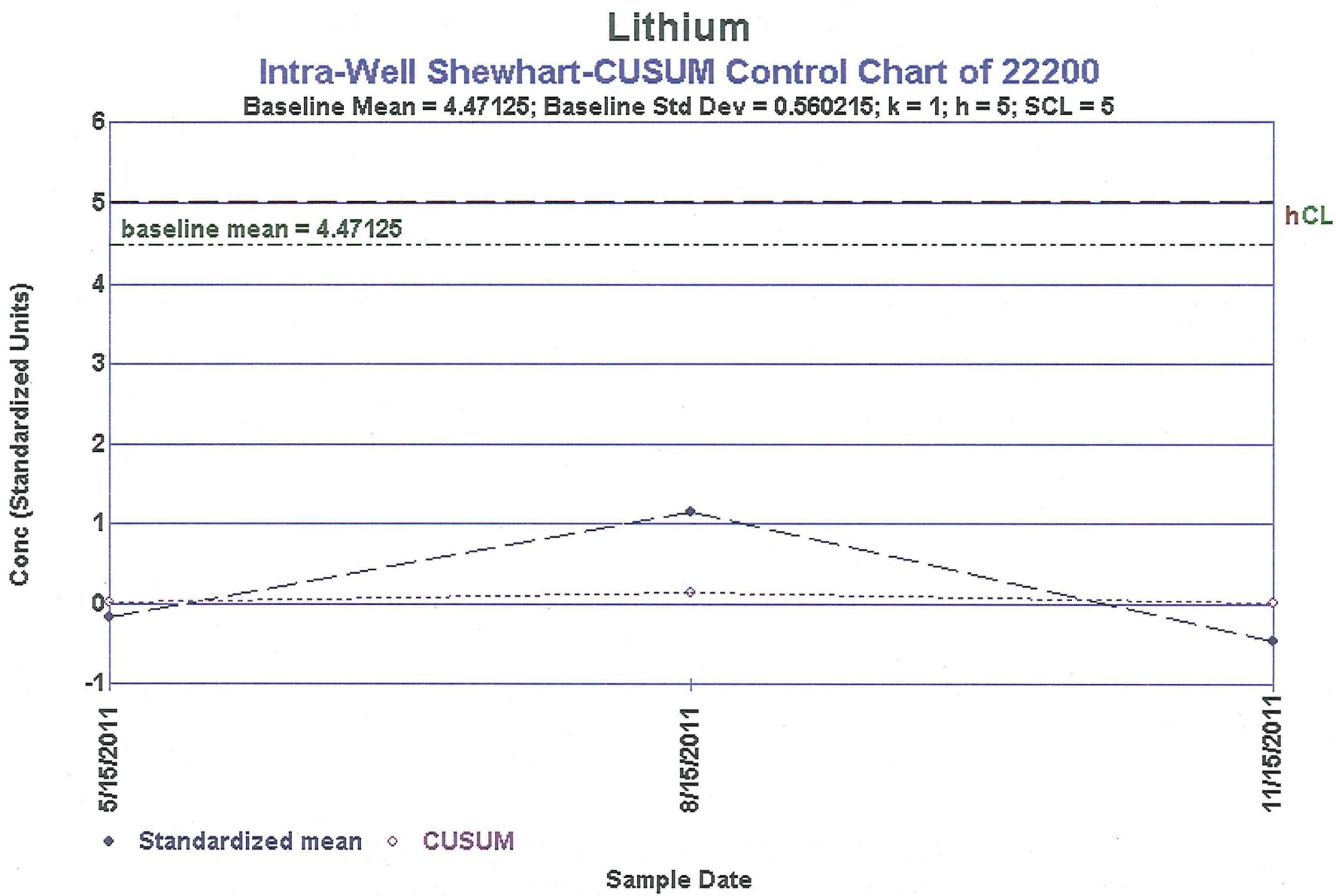


Figure A.5.2–37. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22200)

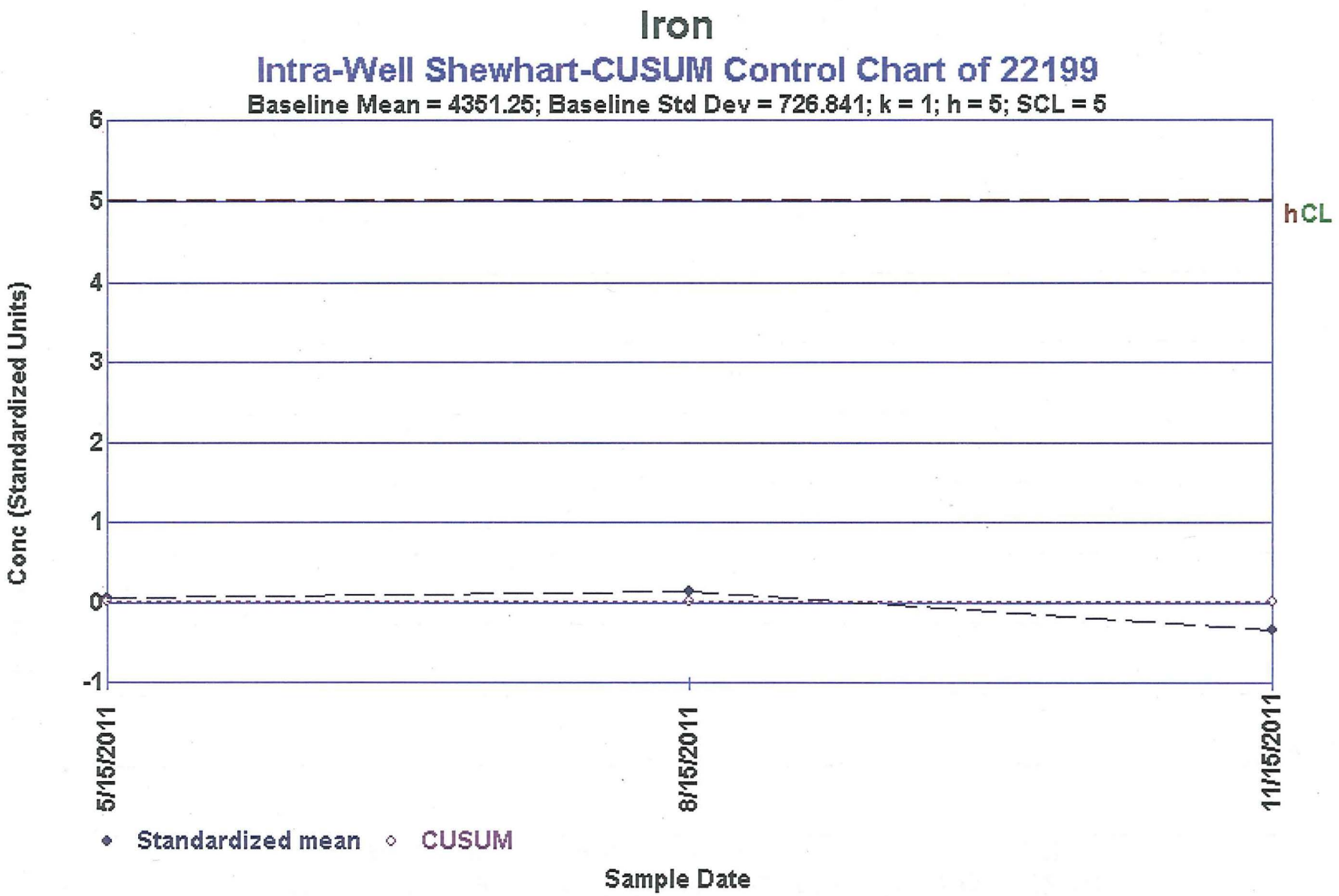


Figure A.5.2−35. Intra-Well Shewhart-CUSUM Control Chart (Iron 22199)

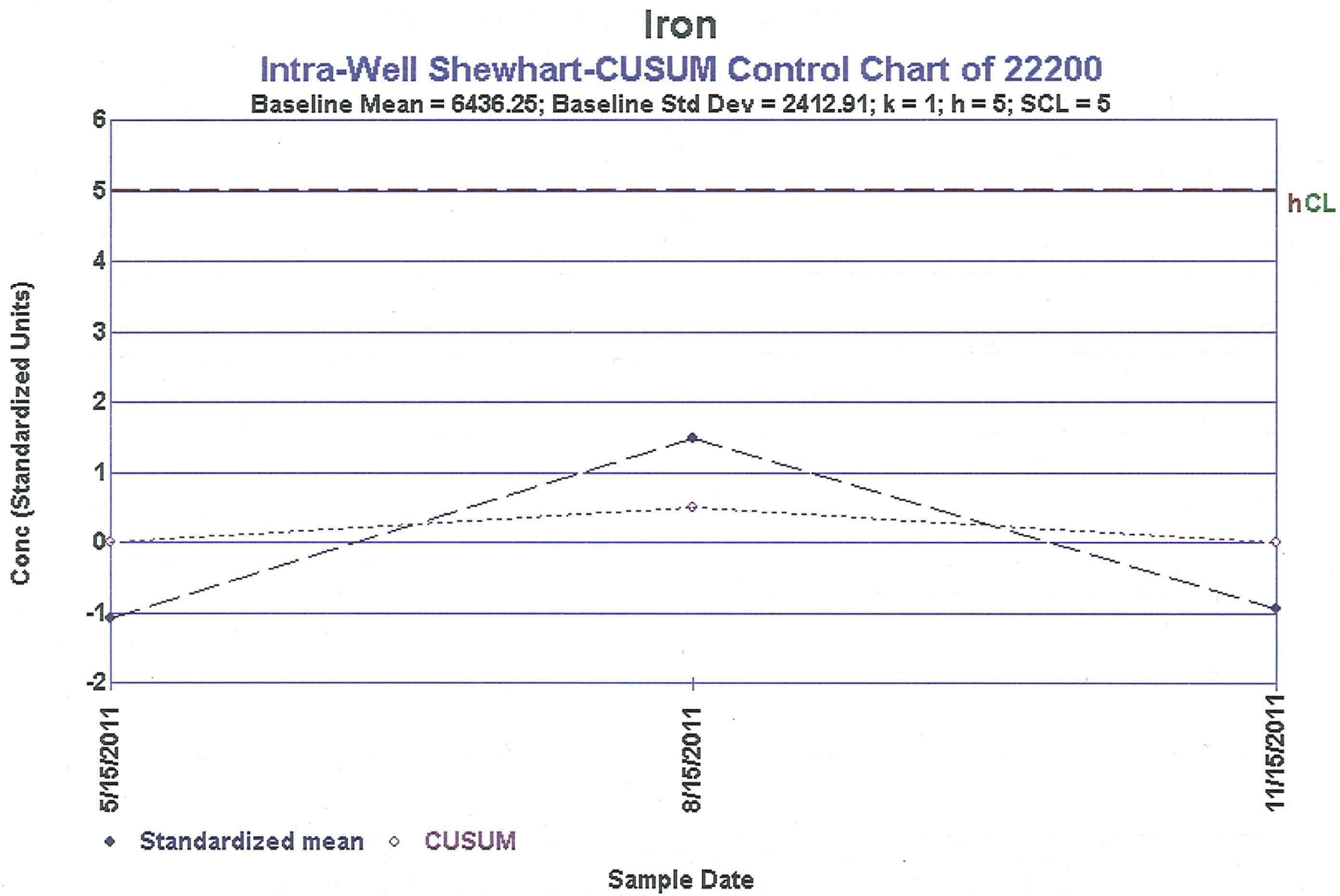


Figure A.5.2–36. Intra-Well Shewhart-CUSUM Control Chart (Iron 22200)

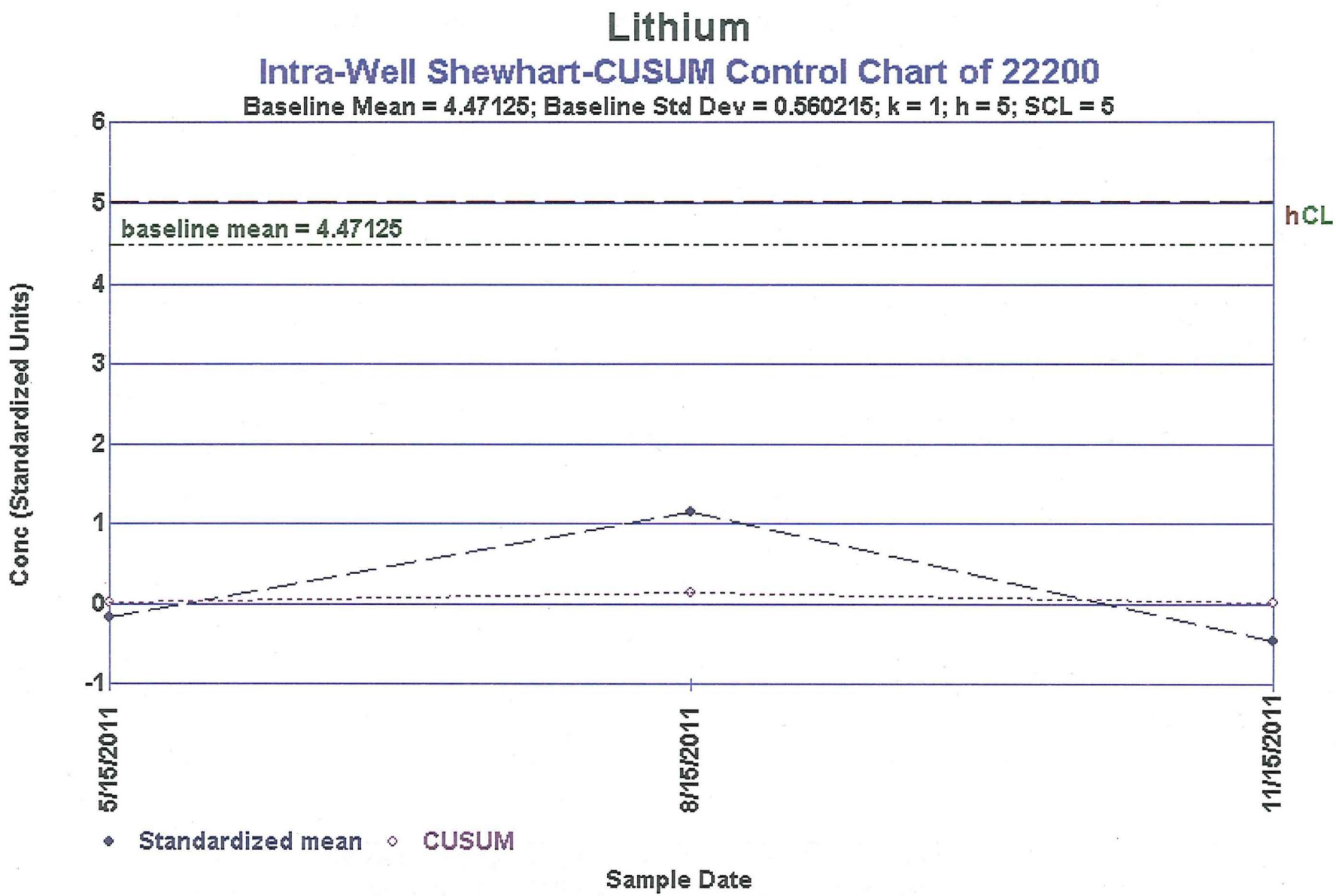


Figure A.5.2–37. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22200)

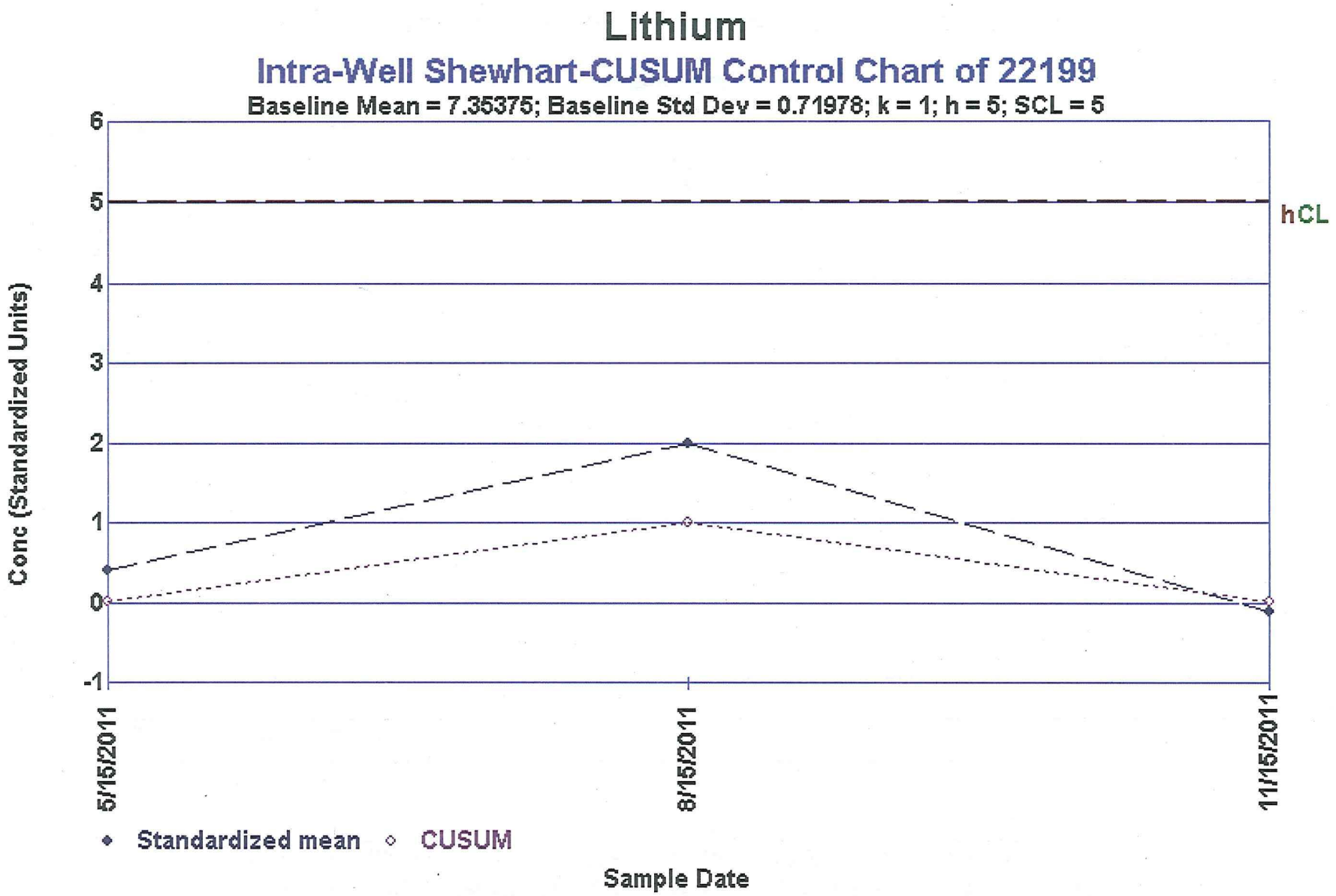


Figure A.5.2−38. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22199)

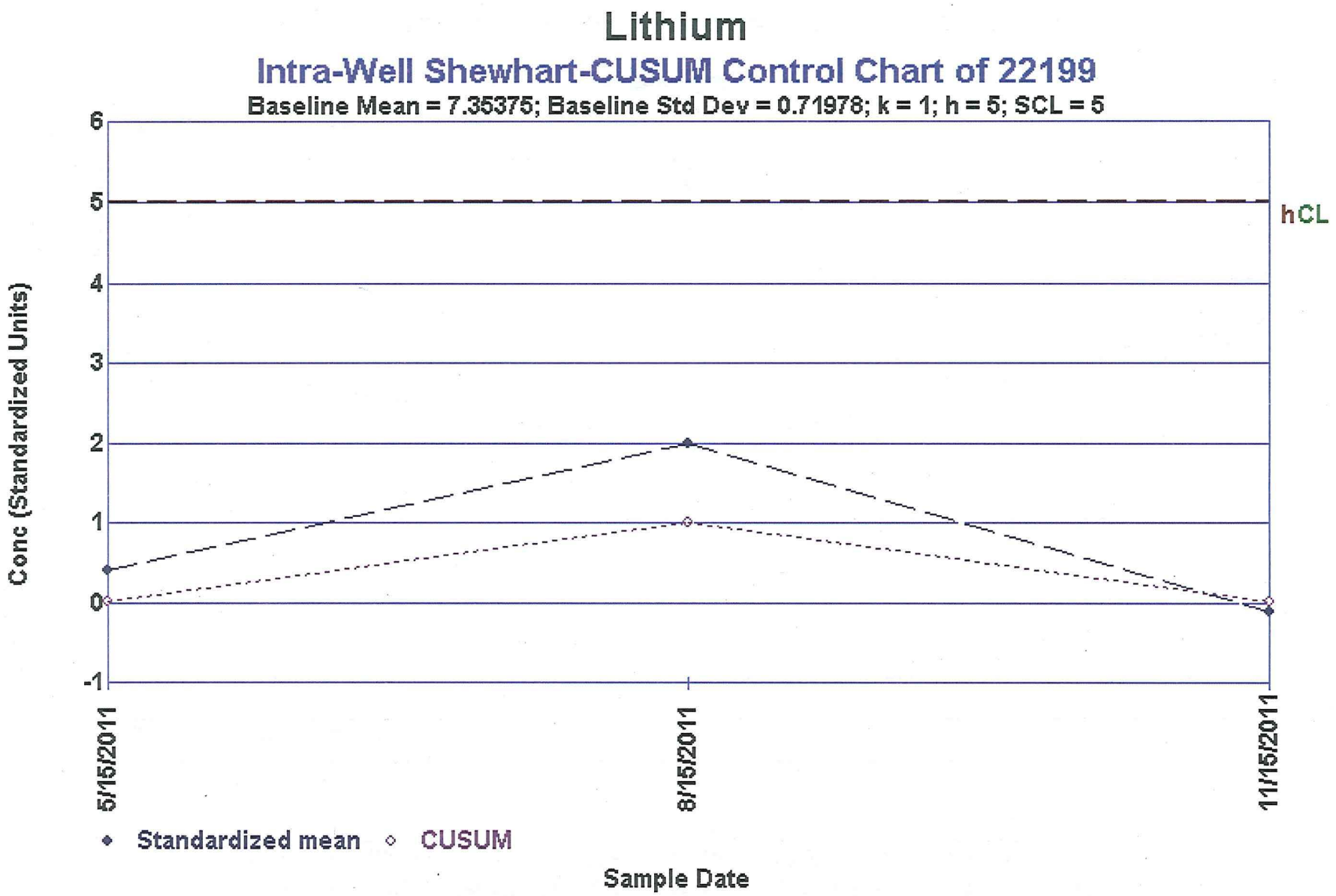


Figure A.5.2−38. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22199)

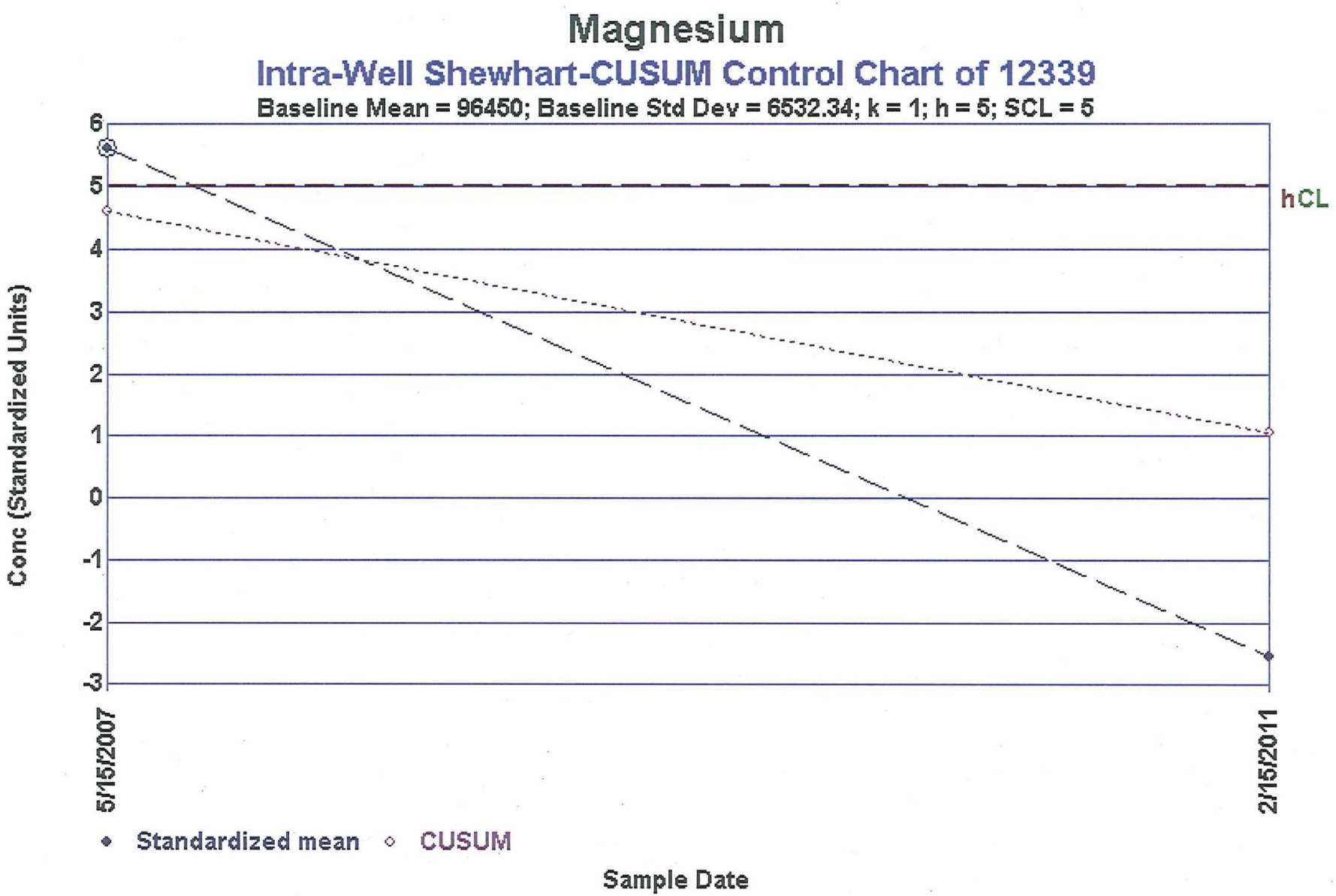


Figure A.5.2−39. Intra-Well Shewhart-CUSUM Control Chart (Magnesium 12339)

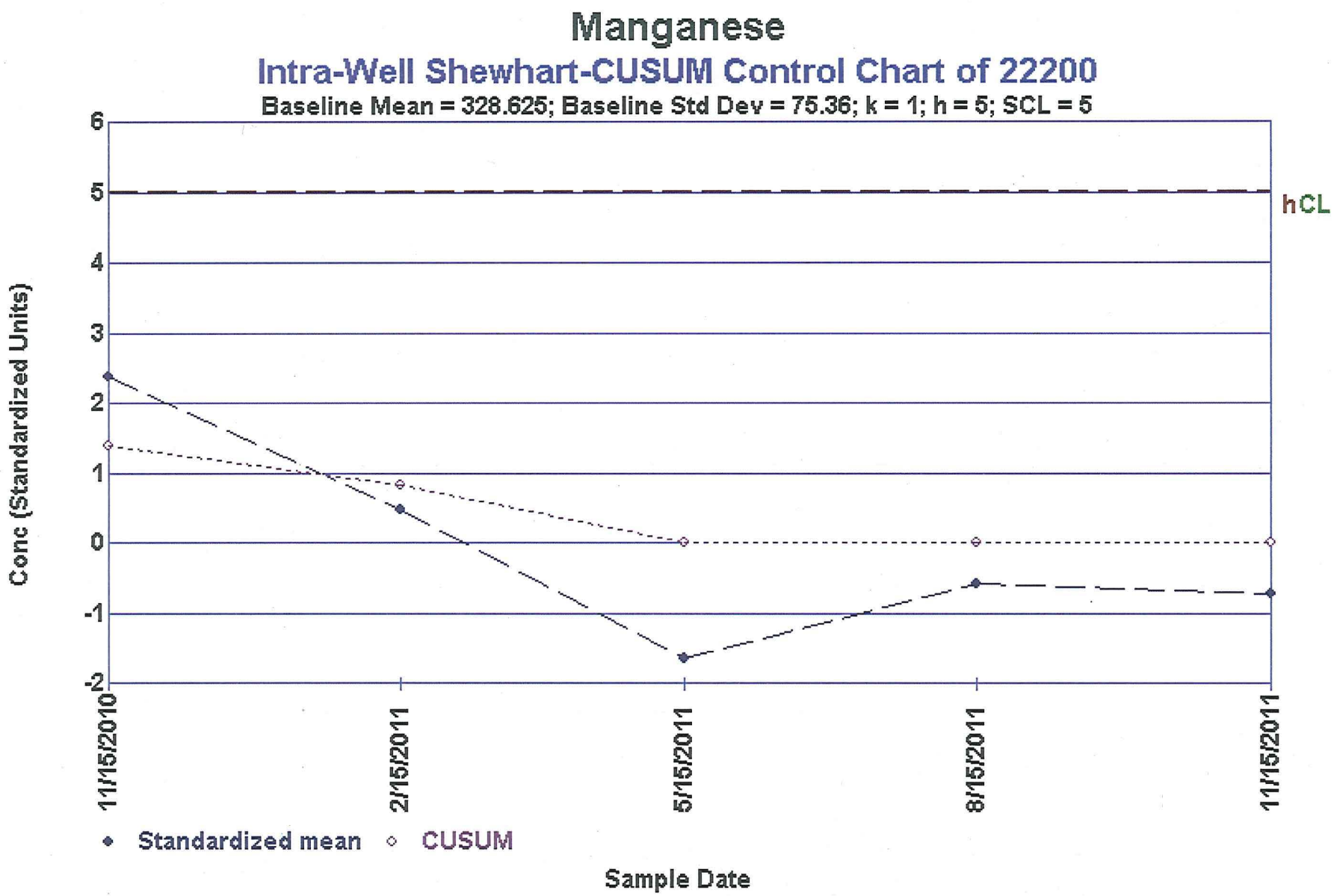


Figure A.5.2−40. Intra-Well Shewhart-CUSUM Control Chart (Manganese 22200)

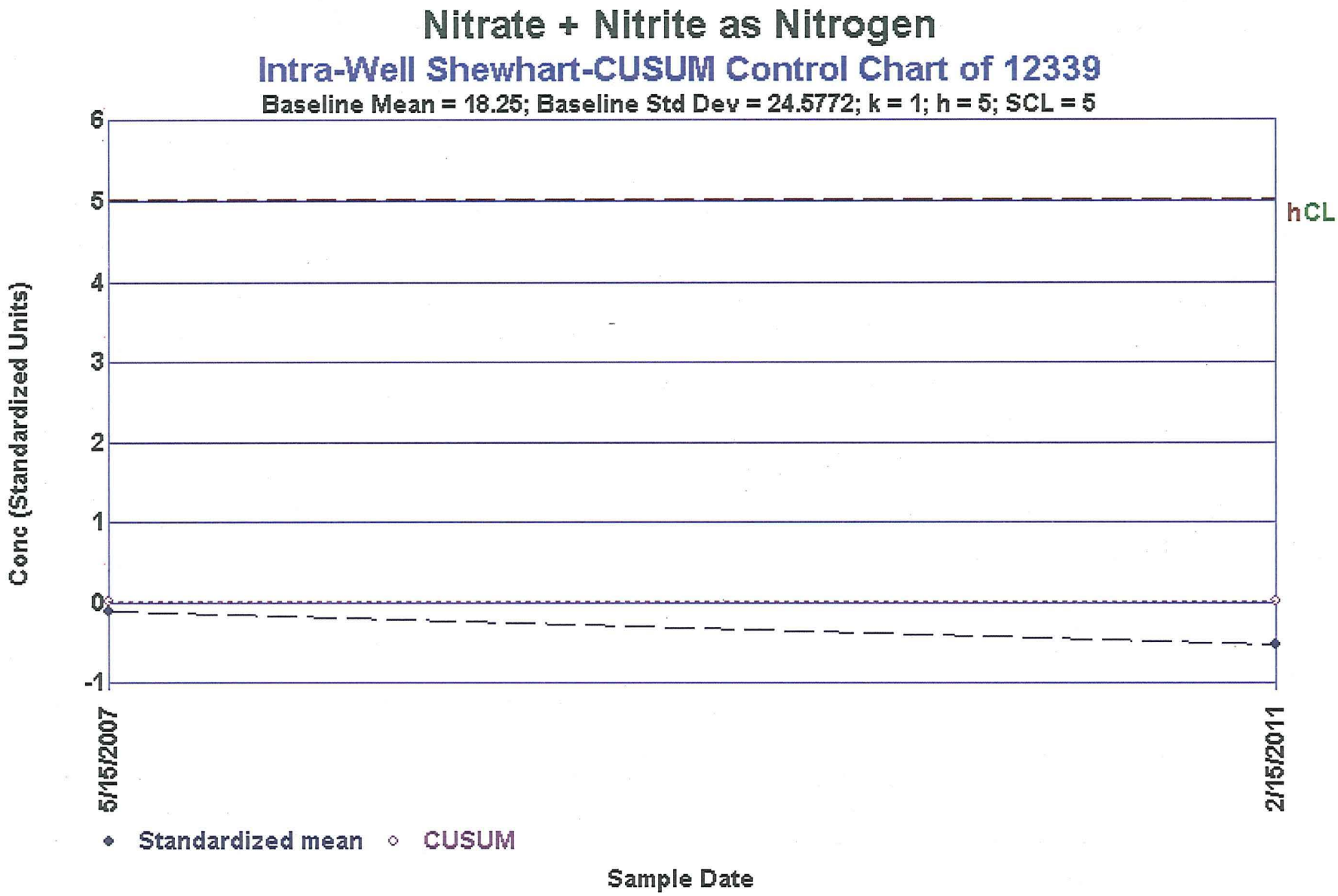


Figure A.5.2−41. Intra-Well Shewhart-CUSUM Control Chart (Nitrate 12339)

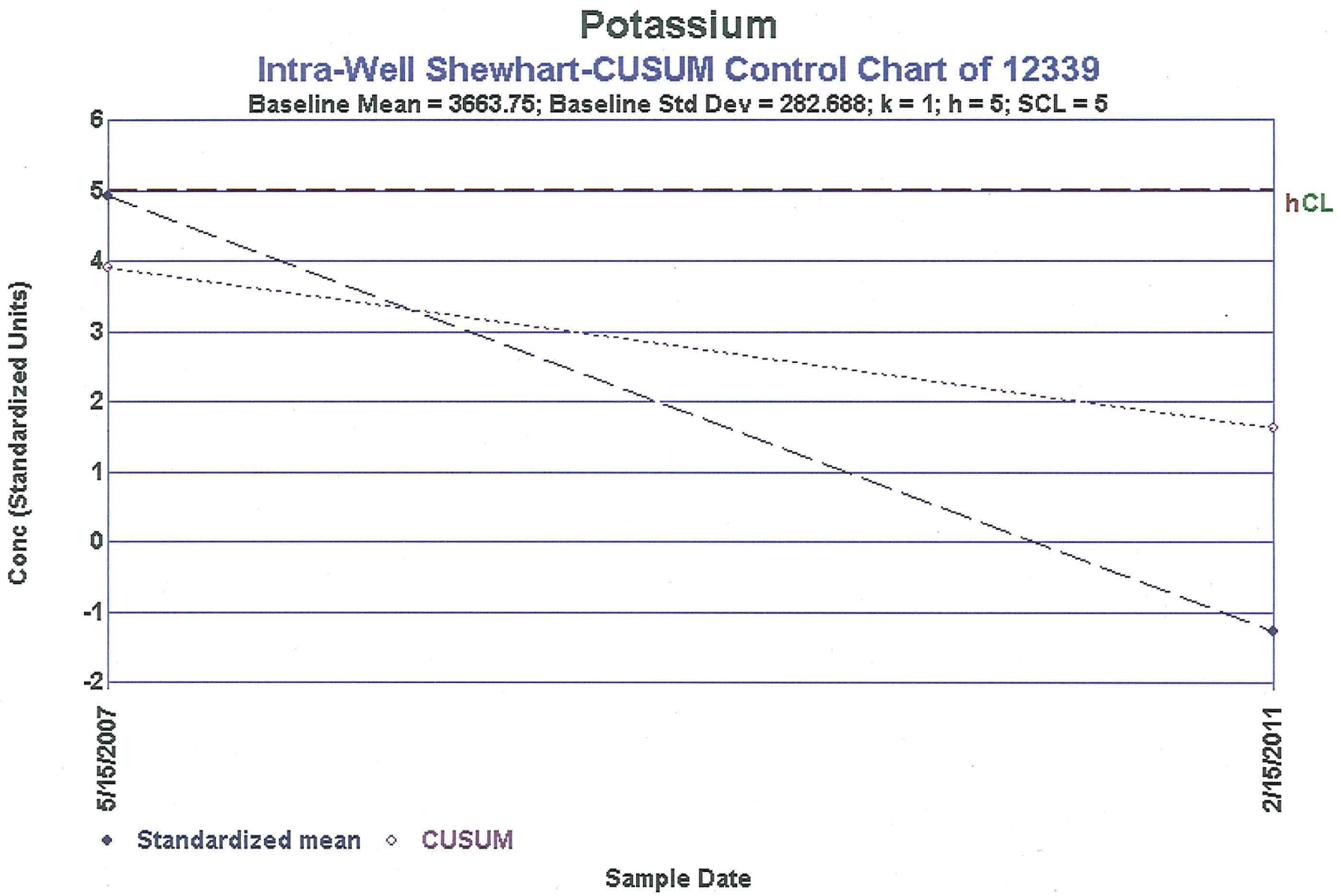


Figure A.5.2–42. Intra-Well Shewhart-CUSUM Control Chart (Potassium 12339)

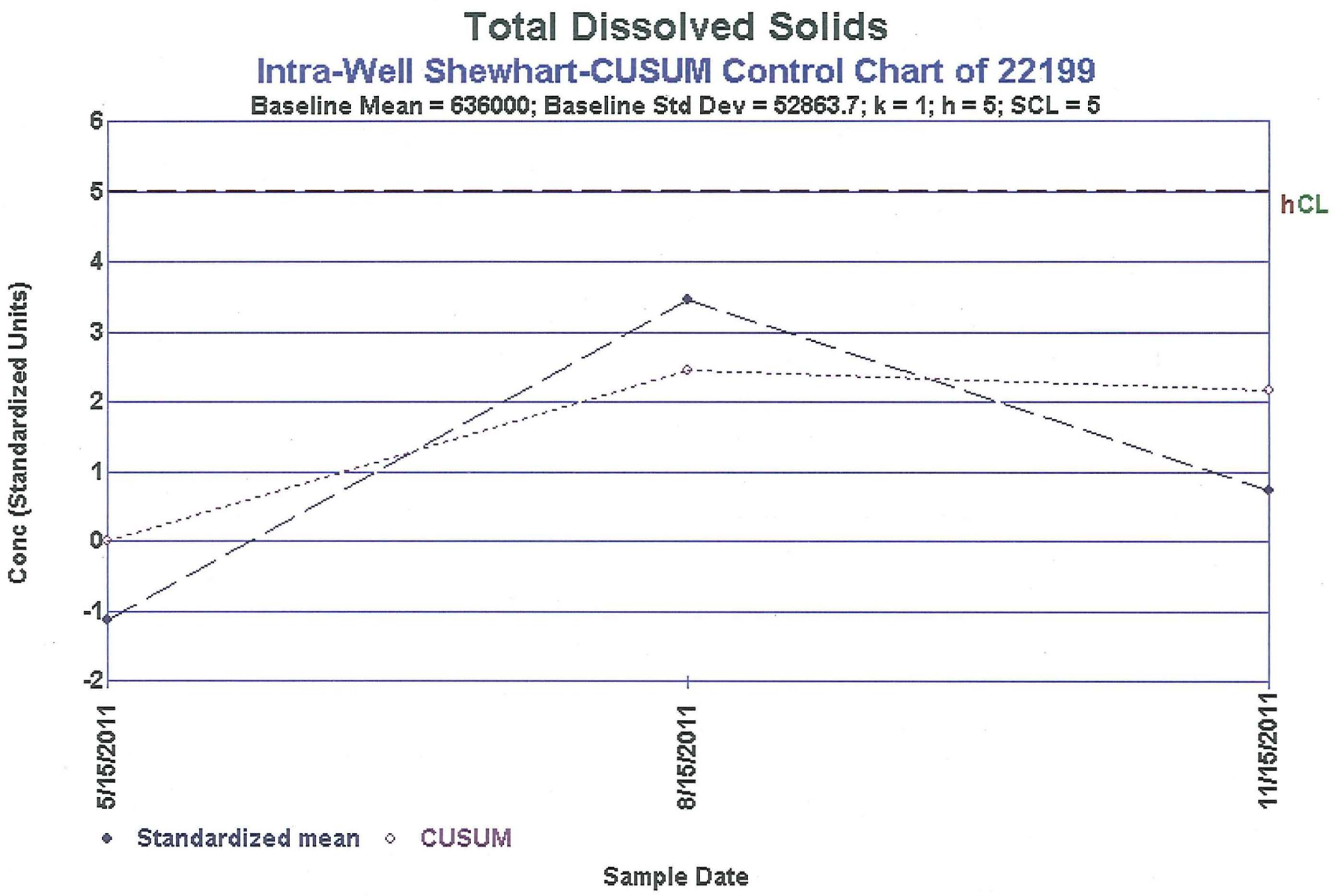


Figure A.5.2−43. Intra-Well Shewhart-CUSUM Control Chart (TDS 22199)

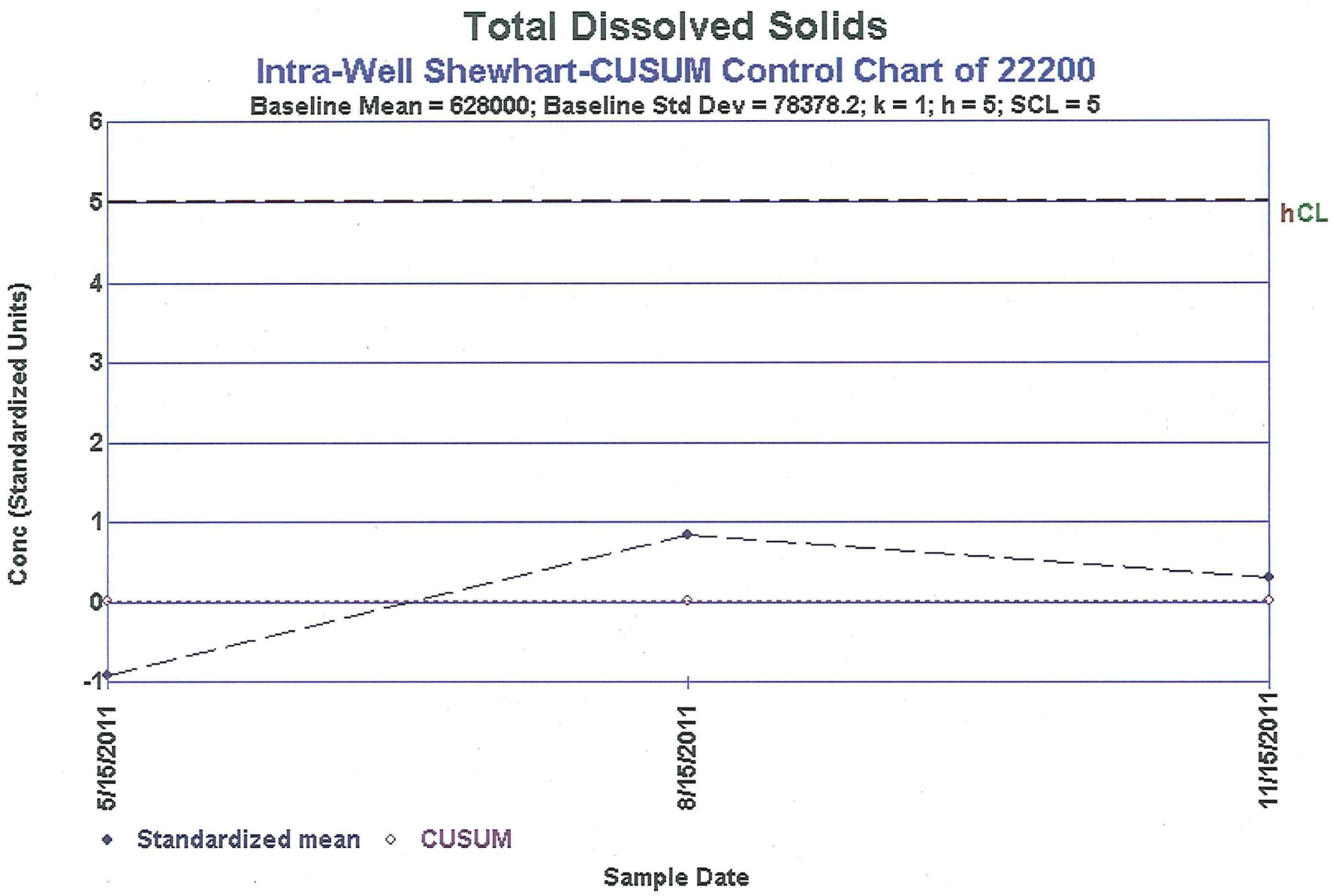


Figure A.5.2−44. Intra-Well Shewhart-CUSUM Control Chart (TDS 22200)

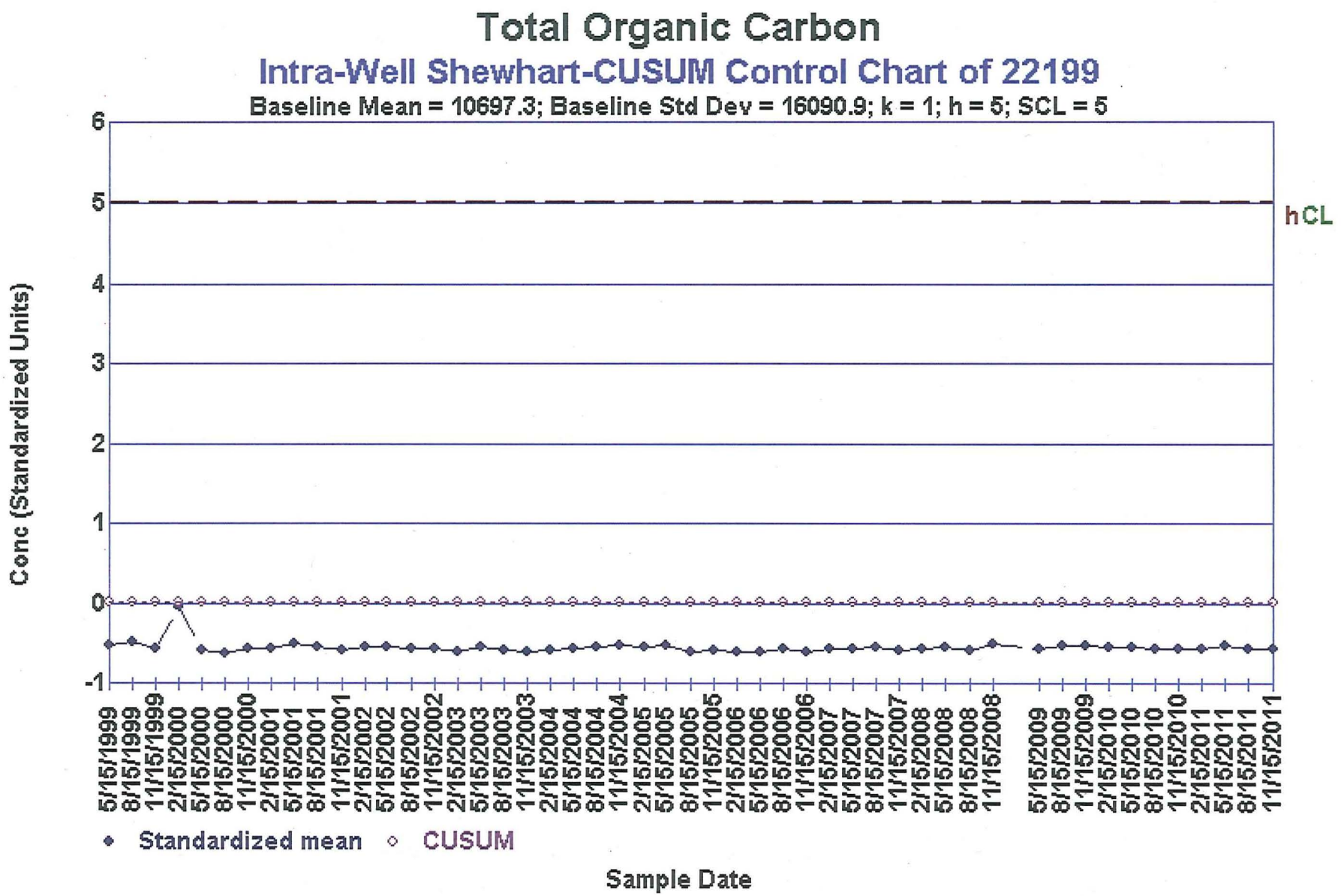


Figure A.5.2–45. Intra-Well Shewhart-CUSUM Control Chart (TOC 22199)

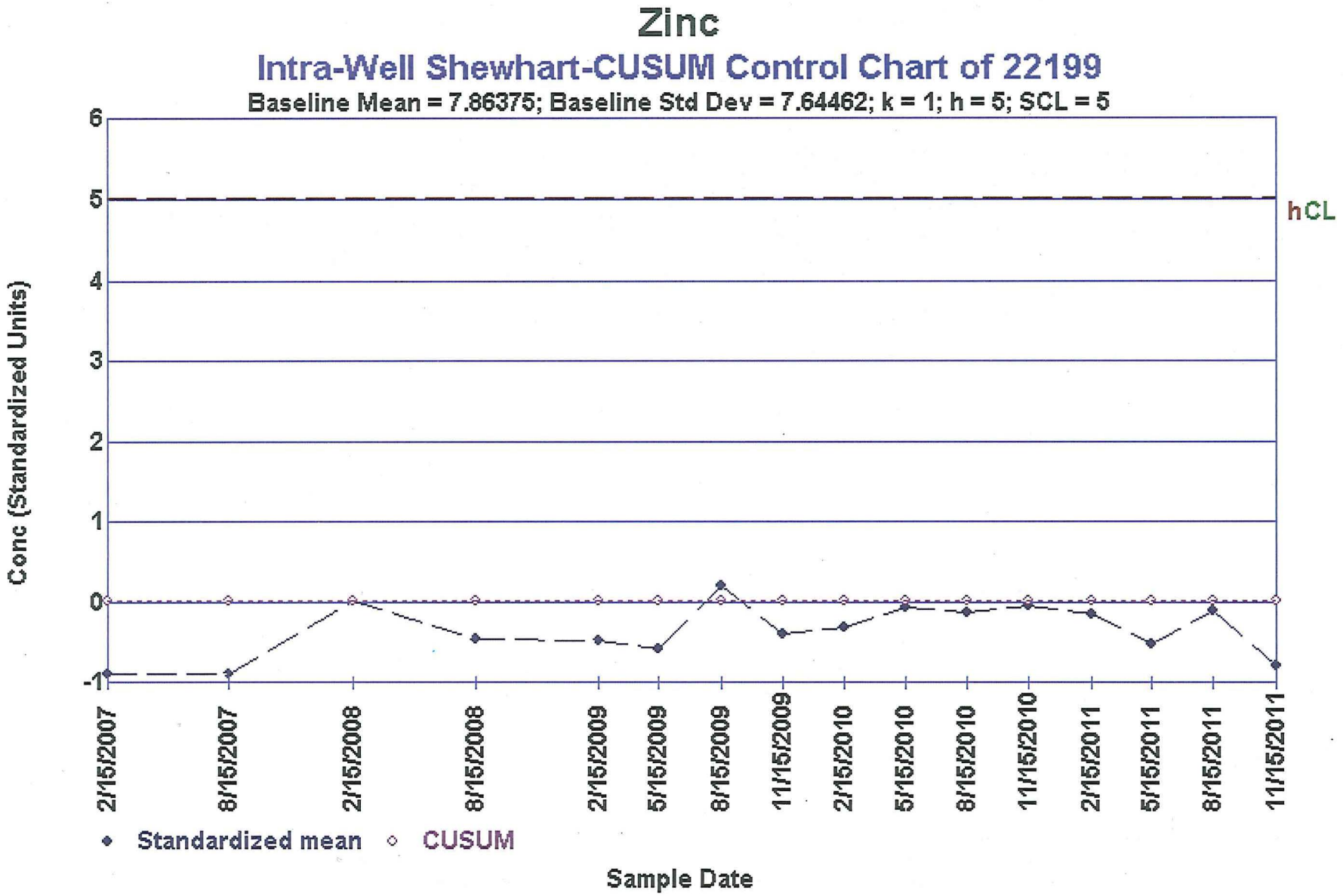


Figure A.5.2−46. Intra-Well Shewhart-CUSUM Control Chart (Zinc 22199)

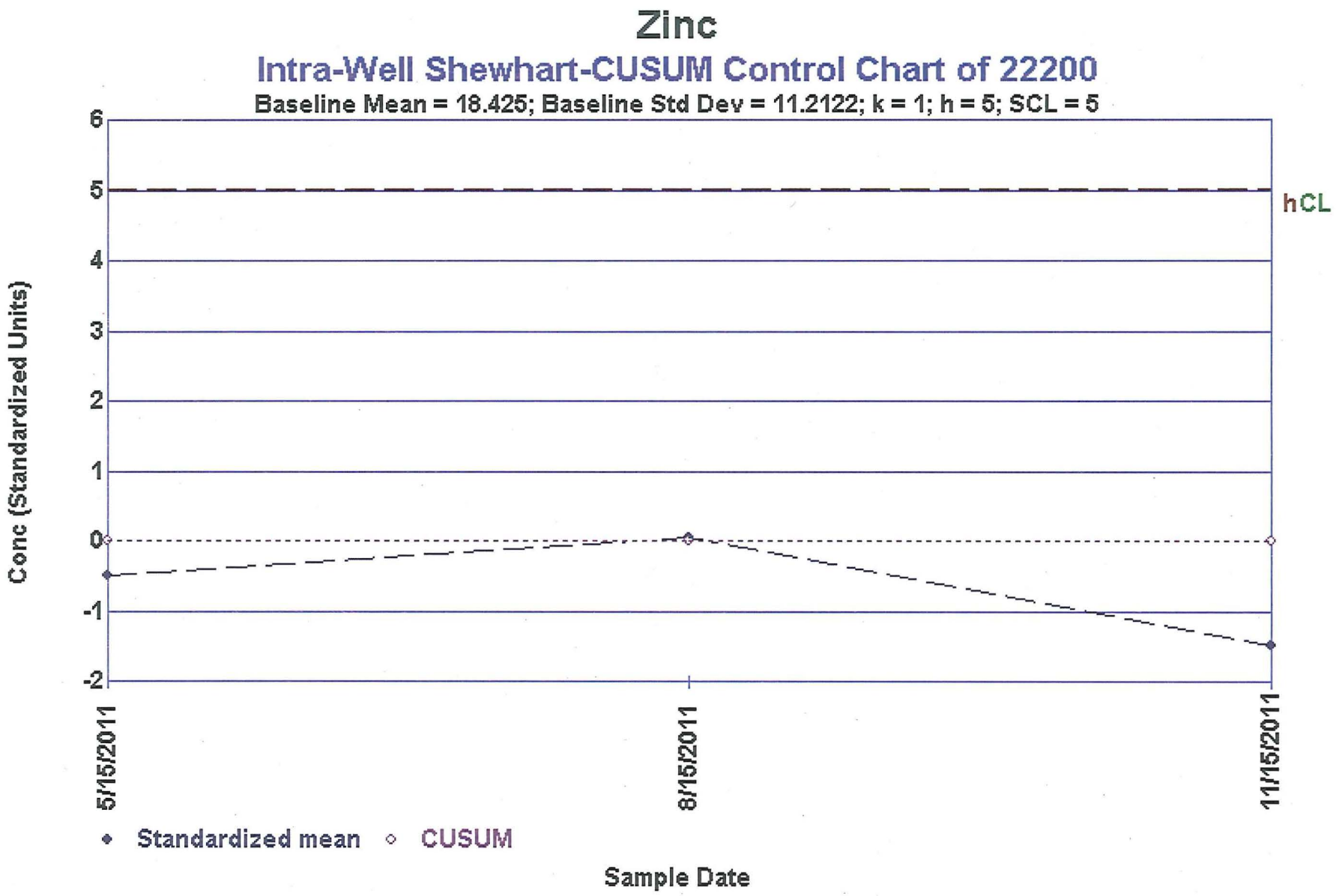


Figure A.5.2−47. Intra-Well Shewhart-CUSUM Control Chart (Zinc 22200)

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Sub-attachment A.5.3

Sub-attachment A.5.3

Cell 3

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The following information is provided in this sub-attachment:

- Quarterly monitoring summary statistics (refer to Table A.5.3–1)
- Annual LCS sample summary information for detected parameters (refer to Table A.5.3–2)
- LCS monthly accumulation volumes (refer to Figure A.5.3–1)
- LDS monthly accumulation volumes (refer to Figure A.5.3–2)
- OSDF horizontal till well 12340 water yield (refer to Figure A.5.3–3)
- GMA water levels and uranium concentration versus time (refer to Figures A.5.3–4 and A.5.3–5)
- Plots of concentration versus time (refer to Figures A.5.3–6A to A.5.3–28B)
- A bivariate plot for uranium-sodium (refer to Figure A.5.3–29)
- Control charts (refer to Figures A.5.3–30 to A.5.3–47)

A.5.3.1 Quarterly Monitoring Results

Quarterly water quality monitoring takes place in the LCS, LDS, HTW, and GMA wells of each cell for the purpose of determining if the OSDF is operating as designed. Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentrations versus time plots, bivariate plots, and control charts are used to help interpret and present the results.

In the first quarter of 2011, 23 parameters were sampled in the LCS, LDS, HTW, and GMA wells of each cell. In the second, third, and fourth quarters tritium was added to the analyte list for all horizons (LCS, LDS, HTW, and GMA wells), and the analyte list for the HTWs in all cells was changed to just four parameters: arsenic, uranium, tritium, and sodium. These changes were agreed to via the comment resolution process between Ohio EPA and DOE on LMICP (revision 4). Tritium results for all cells are reported in Section A.5.5.

The LDS of Cell 3 has been dry since 2007. As shown in Table A.5.3–1, 7 of the 23 parameters sampled quarterly in the LCS, LDS, HTW, and GMA wells, (uranium, TOC, TOX, arsenic, boron, copper, and sodium) have upward trends in the HTW and/or GMA wells based on the Mann-Kendall Test for trend.

Horizontal Till Well

The HTW is located beneath the liner penetration box of each cell by design. The liner penetration box is considered to be potentially the weakest point in the cell design. If a leak were to develop, it should be detected beneath the liner penetration box first. Therefore, the water quality in the HTW represents the first line of evidence that a potential leak from the cell might be occurring. A leak would be indicated by an increasing concentration in the HTW.

Of the 23 parameters monitored quarterly in the LCS, LDS, HTW, and GMA wells, uranium, TOC, TOX, boron, and copper are increasing in the HTW of Cell 3 (as indicated in the table below). The bivariate plot for the Cell 3 LCS, LDS, and HTW (uranium-sodium) is provided in Figure A.5.3–29. The plot shows that the chemical signature for uranium-sodium in the LCS

LDS, and HTW are separate and distinct; indicating that mixing between the horizons is not occurring. Therefore, the increasing concentrations measured in the HTW of Cell 3 are attributed to fluctuating ambient concentrations beneath the cell that are not related to cell performance.

Parameter	HTW[a]	GMA-U[a]	GMA-D[a]
Uranium	Up		Up
TOC	Up		Up
TOX	Up		
Arsenic			Up
Boron	Up	Up	Up
Copper	Up		
Sodium		Up	

[a]HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer;
GMA-D = downgradient Great Miami Aquifer. No entry indicates that the trend was not up.

The plot of uranium concentrations versus time in the HTW of Cell 3 is presented in Figure A.5.3–6A to A.5.3–6B. The data indicate that concentrations in the overall dataset (1997 to 2011) are increasing; however, when the data collected prior to cap completion (September 20, 2004) and the outlier collected on August 15, 2009, (58.5 µg/L) are removed, the data become normally distributed with no Mann-Kendall trend.

Great Miami Aquifer Wells

GMA monitoring wells are positioned and labeled for post-aquifer-remediation flow conditions, when flow directions will be from west to east. Water levels measured in 2011 indicate that groundwater in the GMA in most of the area of the OSDF is moving in a general direction of northeast to south/southwest in response to the active remediation taking place to the west and southwest. Pumping for the groundwater remediation is scheduled to last until 2023. Because bivariate plots (discussed above) indicate that LCS, LDS, and HTW monitoring horizons are not mixing, the increasing concentrations seen in the GMA wells, for uranium, TOC, arsenic, boron, and sodium, are attributed to fluctuating ambient conditions that are not related to cell performance.

The table below provides a summary of the average concentration (as reported in Table A.5.3–1) measured in the LDS, and GMA wells for parameters with increasing concentrations in the Cell 3 GMA wells.

Parameter	LDS[a]	GMA-U[a]	GMA-D[a]
Uranium (µg/L)	**17.0**	1.93	4.86
TOC (mg/L)	**5.77**	1.55	1.44
Arsenic (mg/L)	**0.0085**[b]	0.0025	0.0025
Boron (mg/L)	**0.128**	0.0416	0.0424
Sodium (mg/L)	**315**	21.0	18.0

Note: The highest averages are shown in bold.
[a] LDS = leak detection system, GMA-U = upgradient Great Miami Aquifer,
GMA-D = downgradient Great Miami Aquifer.
[b] Arsenic has only been detected once in the LDS of Cell 3 (second quarter 2006, 0.0085 mg/L).

A.5.3.2 Control Charts

Intrawell control charts employ historical measurements from a compliance point as background. The *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance* (EPA 2009) defines the process of creating a Shewart-CUSUM control chart. Appropriate background data are used to define a baseline for the well. The baseline parameters for the chart, estimates of the mean, and standard deviation are obtained from the background data. These baseline measurements characterize the expected background concentrations at the monitoring point. As future concentrations are collected, the baseline parameters are used to standardize the newly gathered data. After these measurements are standardized and plotted, a control chart is declared "out of control" if future concentrations exceed the baseline control limit. This is indicated on the control chart when either the Shewart or CUSUM plot traces begin to exceed a control limit. The limit is based on the rationale that if the monitoring point remains unchanged from the baseline condition, new standardized observations should not deviate substantially from the baseline mean. If a change occurs, the standardized values will deviate significantly from the baseline and tend to exceed the control limit.

A minimum of eight samples are recommended for use in ChemStat® software to define the baseline for a control chart. Therefore, only sample sets with greater than eight samples were selected for control charts. By default, the ChemStat® software plots both a CUSUM control limit (h) and a SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit (h) and a value of 4.5 for the SCL.

EPA Unified Guidance suggests that to simplify the interpretation of the control chart that an out of control condition be based on the CUSUM (h) limit alone. Plotting the SCL limit is not needed. The ChemStat® software though, by default, plots both the SCL and CUSUM (h) control limit on the charts. As a "work-a-round", the SCL limit was defined as 5 to match the recommended CUSUM limit. On the charts the combined limit is identified as hCL. For interpretation purposes, regard hCL as the CUSUM limit (h).

As shown in Table A.5.3–1 in gray shading, 12 parameters in the HTW and GMA wells of Cell 3 meet the criteria for control charts (i.e., more than 8 samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in 18 control charts.

These 18 control charts are presented in Figures A.5.3–30 through A.5.3–47. Sixteen of the control charts for Cell 3 exhibit "in control" conditions. Two control charts exhibit "out of control" conditions; TDS in the GMA-U and Iron in the HTW. Both charts are "out of control" because the CUSUM plot trace exceeds the CUSUM control limit. As discussed above, separate and distinct signatures for uranium and sodium in the LCS, LDS, and HTW of Cell 3 indicate that water is not mixing between the horizons, so the out of control conditions are attributed to fluctuating ambient conditions beneath the cell, and not to cell performance.

Parameter and Monitoring Point[a]	Assessment
Alkalinity in the HTW	In Control
Nitrate in the HTW	In Control
Sulfate in the GMA-D	In Control
TDS in the GMA-U	**Out of Control**
TDS in the GMA-D	In Control
Barium in the HTW	In Control
Calcium in the HTW	In Control
Iron in the HTW	**Out of Control**
Iron in the GMA-U	In Control
Iron in the GMA-D	In Control
Lithium in the GMA-U	In Control
Lithium in the GMA-D	In Control
Magnesium in the HTW	In Control
Manganese in the GMA-U	In Control
Manganese in the GMA-D	In Control
Potassium in the HTW	In Control
Zinc in the GMA-U	In Control
Zinc in the GMA-D	In Control

[a]HTW = horizontal till well; GMA-D = downgradient Great Miami Aquifer; GMA-U = upgradient Great Miami Aquifer

A.5.3.3 Annual LCS Sample Results

Annual LCS sampling results for Cell 3 are provided in Table A.5.3–2 for those parameters that have been detected at least once and are not being sampled quarterly. No new Appendix I or PCB parameters were detected in the LCS of Cell 3 in 2011.

A.5.3.4 Summary and Conclusions

- Seven parameters monitored quarterly have an upward concentration trend in the HTW and/or GMA wells of Cell 3 (uranium, TOC, TOX, arsenic, boron, copper, and sodium).
- Separate and distinct chemical signatures for uranium and sodium in the LCS, LDS, and HTW of Cell 3 indicate that water is not mixing between the horizons. Concentration increases in the HTW and GMA wells of Cell 3 are attributed to fluctuating ambient concentrations beneath the cell, and not to cell performance.
- Eighteen control charts were constructed for Cell 3 parameters. Sixteen of the eighteen charts exhibit "in control" conditions. Out of control conditions are exhibited by TDS in the GMA-U well and iron in the HTW.
- No new Appendix I or PCB parameters were detected in the LCS of Cell 3 in 2011.

Table A.5.3-1. Summary Statistics for Cell 3

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12340C	48	48	100.0	9.35	113	63.1	26.1	Normal	Up	Detected	
	LDS	12340D	21	21	100.0	8.90	27.7	17.0	5.0	Normal	Down	Not Detected	72.4 Q3-04)
	HTW	12340	51	51	100.0	3.89	29.3	20.1	7.2	Undefined	Up	Detected	58.5 (Q3-09)
	GMA-U	22203	50	53	94.3	0.118	7.92	1.93	1.93	Lognormal	None	Detected	
	GMA-D	22204	53	54	98.2	ND	22.9	4.86	4.87	Lognormal	Up	Detected	
Alkalinity as CaCO3 (mg/L)	LCS	12340C	23	23	100.0	72	1080	480	212	Undefined	None	Detected	
	LDS	12340D	9	9	100.0	108	267	161	54	Normal	None	Not Detected	693 (Q4-05)
	HTW	12340	10	10	100.0	256	333	306	25	Normal	None	Not Detected	
	GMA-U	22203	4	4	100.0	389	451	413	28	Normal	None	Insuff	
	GMA-D	22204	4	4	100.0	359	381	371	9	Normal	None	Insuff	
Choride (mg/L)	LCS	12340C	23	23	100.0	4.7	52.1	34.2	14.2	Undefined	Up	Detected	
	LDS	12340D	9	9	100.0	54.1	74.2	61.8	6.5	Normal	None	Not Detected	
	HTW	12340	10	10	100.0	40.4	186	156	42	Undefined	Down	Detected	
	GMA-U	22203	4	4	100.0	29.8	44.0	37.3	6.3	Normal	None	Insuff	
	GMA-D	22204	4	4	100.0	20.7	22.3	21.4	0.7	Normal	None	Insuff	
Nitrate/Nitrite as N (mg/L)	LCS	12340C	20	30	66.7	ND	2.20	0.220	0.614	Undefined	Down	Detected	
	LDS	12340D	6	9	66.7	ND	5.71	1.06	1.92	Lognormal	None	Not Detected	
	HTW	12340	1	9	11.1	ND	0.0519	Insuff	INsuff	Lognormal	None	Not Detected	
	GMA-U	22203	0	4	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22204	0	4	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Sulfate (mg/L)	LCS	12340C	40	40	100.0	26.1	2650	1700	590	Undefined	Up	Detected	
	LDS	12340D	19	19	100.0	112	2510	1250	700	Undefined	Down	Not Detected	
	HTW	12340	32	32	100.0	352	958	696	155	Normal	None	Detected	
	GMA-U	22203	35	35	100.0	67.3	735	252	152	Normal	Down	Detected	
	GMA-D	22204	35	35	100.0	232	779	490	152	Normal	None	Not Detected	
Total Dissolved Solids (mg/L)	LCS	12340C	29	29	100.0	233	3490	3120	1200	Undefined	Up	Detected	
	LDS	12340D	0	0	0.0	NA	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12340	8	8	100.0	1280	1650	1430	130	Normal	Down	Not Detected	
	GMA-U	22203	11	11	100.0	524	1190	686	188	Normal	None	Not Detected	
	GMA-D	22204	11	11	100.0	724	1530	1070	250	Normal	None	Not Detected	
Total Organic Carbon (mg/L)	LCS	12340C	35	47	74.5	ND	4.21	2.01	0.75	Normal	Up	Detected	17.4 (Q4-99)
	LDS	12340D	17	21	81.0	ND	8.02	5.77	2.26	Undefined	None	Not Detected	
	HTW	12340	37	47	78.7	ND	3.21	2.22	0.64	Undefined	Up	Detected	9.81 (Q1-00)
	GMA-U	22203	39	53	73.6	ND	2.9	1.55	0.54	Normal	None	Detected	5.66 (Q1-00) 14.1 (Q4-00)
	GMA-D	22204	36	53	67.9	ND	2.92	1.44	0.52	Normal	Up	Not Detected	8.83 (Q1-00)
Total Organic Halogens (mg/L)	LCS	12340C	16	48	33.3	ND	0.0590	0.0125	0.0137	Undefined	Down	Detected	0.141 (Q4-99)
	LDS	12340D	10	21	47.6	ND	0.0838	0.0251	0.0187	Lognormal	None	Not Detected	
	HTW	12340	36	49	73.5	ND	0.0960	0.0138	0.0176	Undefined	Up	Detected	
	GMA-U	22203	23	53	43.4	ND	0.0231	0.00535	0.00605	Undefined	Down	Detected	0.213 (Q2-00) 0.075 (Q2-10)
	GMA-D	22204	10	53	18.9	ND	0.0194	0.00572	0.00525	Undefined	Down	Detected	0.165 (Q2-00)
Arsenic (mg/L)	LCS	12340C	5	28	17.9	ND	0.131	0.0025	0.0303	Undefined	None	Not Detected	
	LDS	12340D	1	9	11.1	ND	0.0085	Insuff	Insuff	Undefined	None	Not Detected	
	HTW	12340	3	20	15.0	ND	0.025	0.0025	Insuff	Undefined	None	Not Detected	
	GMA-U	22203	3	11	27.3	ND	0.0372	0.0025	Insuff	Undefined	None	Not Detected	
	GMA-D	22204	4	24	16.7	ND	0.0382	0.0025	0.0111	Undefined	Up	Detected	
Barium (mg/L)	LCS	12340C	23	23	100.0	0.0295	0.118	0.045	0.019	Undefined	None	Detected	
	LDS	12340D	9	9	100.0	0.0135	0.0386	0.0196	0.0078	Lognormal	None	Not Detected	
	HTW	12340	10	10	100.0	0.0173	0.0558	0.0352	0.0098	Normal	None	Not Detected	
	GMA-U	22203	4	4	100.0	0.0766	0.141	0.115	0.027	Normal	None	Insuff	
	GMA-D	22204	4	4	100.0	0.0396	0.0592	0.050	0.008	Normal	None	Insuff	

Table A.5.3–1 (continued). Summary Statistics for Cell 3

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Boron (mg/L)	LCS	12340C	48	49	98.0	ND	9.19	4.47	2.13	Undefined	Up	Detected	
	LDS	12340D	20	21	95.2	ND	0.557	0.128	0.149	Undefined	Down	Detected	
	HTW	12340	48	48	100.0	0.0481	0.259	0.135	0.056	Undefined	Up	Detected	0.960 (Q3-06)
	GMA-U	22203	42	53	79.2	ND	0.0709	0.0416	0.0127	Normal	Up	Detected	
	GMA-D	22204	45	53	84.9	ND	0.0887	0.0424	0.0168	Lognormal	Up	Detected	
Calcium (mg/L)	LCS	12340C	23	23	100.0	50.3	666	596	208	Undefined	Up	Detected	1200 (Q3-05)
	LDS	12340D	9	9	100.0	121	363	199	71	Normal	None	Not Detected	
	HTW	12340	10	10	100.0	218	318	274	37	Normal	None	Not Detected	
	GMA-U	22203	4	4	100.0	135	264	187	59	Normal	None	Insuff	
	GMA-D	22204	4	4	100.0	179	365	297	81	Normal	None	Insuff	
Cobalt (mg/L)	LCS	12340C	19	28	67.9	ND	0.0666	0.00239	0.0187	Undefined	None	Detected	
	LDS	12340D	8	9	88.9	ND	0.0011	0.00071	0.00026	Normal	None	Not Detected	
	HTW	12340	13	17	76.5	ND	0.0019	0.00118	0.00041	Normal	Down	Not Detected	0.00655 (Q3-09)
	GMA-U	22203	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22204	2	11	18.2	ND	0.00176	Insuff	Insuff	Undefined	None	Not Detected	
Copper (mg/L)	LCS	12340C	20	24	83.3	0.00118	0.0311	0.0064	0.0073	Undefined	None	Detected	
	LDS	12340D	6	9	66.7	ND	0.016	0.0081	0.0049	Normal	None	Not Detected	
	HTW	12340	8	11	72.3	ND	0.015	0.00736	0.00448	Normal	Up	Detected	
	GMA-U	22203	4	4	100.0	0.00178	0.00924	0.00658	0.00337	Normal	None	Insuff	
	GMA-D	22204	4	4	100.0	0.00306	0.0107	0.00702	0.00327	Normal	None	Insuff	
Iron (mg/L)	LCS	12340C	27	28	96.4	0.0757	16.6	3.91	3.77	Lognormal	None	Detected	
	LDS	12340D	8	9	88.9	0.622	2.14	1.22	0.53	Normal	None	Not Detected	
	HTW	12340	17	17	100.0	0.513	22.8	3.77	5.28	Lognormal	None	Not Detected	
	GMA-U	22203	11	11	100.0	2.9	22.2	9.89	5.23	Normal	None	Not Detected	
	GMA-D	22204	11	11	100.0	3.15	11.3	6.2	2.3	Normal	None	Not Detected	
Lithium (mg/L)	LCS	12340C	20	20	100.0	0.683	1.02	0.778	0.094	Undefined	None	Not Detected	
	LDS	12340D	9	9	100.0	0.0313	0.0645	0.0427	0.0106	Normal	Down	Not Detected	
	HTW	12340	17	17	100.0	0.0129	0.0305	0.0205	0.0065	Undefined	Down	Detected	
	GMA-U	22203	11	11	100.0	0.00577	0.0119	0.00797	0.00183	Normal	None	Not Detected	
	GMA-D	22204	11	11	100.0	0.00694	0.0102	0.0085	0.0012	Normal	None	Not Detected	
Magnesium (mg/L)	LCS	12340C	23	23	100.0	10.2	380	195	88	Undefined	Up	Detected	
	LDS	12340D	9	9	100.0	87.2	138	110	15	Normal	None	Not Detected	
	HTW	12340	10	10	100.0	81.1	111	93.3	11.0	Normal	None	Not Detected	
	GMA-U	22203	4	4	100.0	32.5	58.1	42.2	11.3	Normal	None	Insuff	
	GMA-D	22204	4	4	100.0	40.4	66.6	58.1	12.2	Normal	None	Insuff	
Manganese (mg/L)	LCS	12340C	27	28	96.4	0.0014	7.27	0.368	2.75	Undefined	None	Detected	
	LDS	12340D	8	9	88.9	0.0015	0.146	0.0256	0.0463	Lognormal	None	Not Detected	
	HTW	12340	17	17	100.0	0.0315	0.288	0.121	0.076	Normal	Down	Detected	0.697 (Q3-05)
	GMA-U	22203	13	13	100.0	0.202	0.634	0.359	0.138	Normal	None	Not Detected	
	GMA-D	22204	23	24	95.8	ND	3.01	1.33	0.54	Lognormal	None	Not Detected	
Nickel (mg/L)	LCS	12340C	28	28	100.0	0.0021	0.102	0.0116	0.0361	Undefined	None	Detected	
	LDS	12340D	9	9	100.0	0.0034	0.0097	0.0062	0.0019	Normal	None	Not Detected	
	HTW	12340	7	17	41.2	ND	0.0107	0.00355	0.00362	Undefined	Down	Not Detected	
	GMA-U	22203	1	11	9.1	ND	0.00219	Insuff	Insuff	Undefined	None	Detected	
	GMA-D	22204	9	24	37.5	ND	0.0127	0.000828	0.00324	Undefined	None	Not Detected	
Potassium (mg/L)	LCS	12340C	23	23	100.0	0.575	35	25.9	10.4	Undefined	Up	Detected	
	LDS	12340D	9	9	100.0	9.47	15.7	11.8	1.8	Normal	None	Not Detected	
	HTW	12340	9	10	90.0	3.40	4.36	3.92	0.34	Normal	None	Not Detected	1.70 (Q1-06)
	GMA-U	22203	4	4	100.0	2.12	3.1	2.62	0.40	Normal	None	Insuff	
	GMA-D	22204	4	4	100.0	2.03	3.07	2.65	0.44	Normal	None	Insuff	

Table A.5.3–1 (continued). Summary Statistics for Cell 3

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Selenium (mg/L)	LCS	12340C	5	28	17.9	ND	0.0392	0.00642	0.0077	Lognormal	None	Not Detected	
	LDS	12340D	0	9	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	HTW	12340	0	17	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-U	22203	1	11	9.1	ND	NA	Insuff	Insuff	Undefined	None	Detected	0.00617 (Q2-09) 0.00386 (Q1-10)
	GMA-D	22204	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Sodium (mg/L)	LCS	12340C	28	28	100.0	4.35	49.9	25.4	9.8	Undefined	Up	Not Detected	
	LDS	12340D	9	9	100.0	263	344	315	27	Normal	None	Not Detected	
	HTW	12340	20	20	100.0	33.4	74.1	50.2	13.8	Lognormal	Down	Detected	
	GMA-U	22203	11	11	100.0	18.5	23.8	21.0	1.8	Normal	Up	Detected	
	GMA-D	22204	11	11	100.0	15.5	20.5	18.0	1.5	Normal	Down	Not Detected	
Zinc (mg/L)	LCS	12340C	21	28	75.0	ND	0.042	0.0164	0.0093	Normal	None	Detected	
	LDS	12340D	8	9	88.9	ND	0.499	0.161	0.175	Lognormal	Up	Not Detected	
	HTW	12340	13	17	76.5	0.0045	0.569	0.0156	0.153	Undefined	None	Detected	
	GMA-U	22203	6	11	54.6	ND	0.013	0.00712	0.00391	Normal	None	Not Detected	
	GMA-D	22204	17	24	70.8	ND	0.0405	0.0114	0.0095	Lognormal	None	Not Detected	

Note: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least 8 samples, normal or lognormal distribution, no trend, and no serial correlation. These wells achieve control chart criteria.

Note: For results where the concentrations are below the detection limit, the results used in the Average, Standard Deviation, Distribution Type, Trend, Serial Correlation, and Outliers are each set at half the detection limit.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption and requires $n \geq 3$. In addition, Standard Deviation requires $n \geq 4$.

[d]"Insuff" = Insufficient and is used for Average, Standard Deviation, Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic (where $3 \leq n \leq 50$) or Shapiro Francia (where $n > 50$).

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the lognormal assumption.

Lognormal: Lognormal assumption could not be rejected at the 5 percent level and has a higher probability value than the normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25% detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure. Trend testing requires a sample with $n \geq 4$.

[g]Serial correlation based on Rank Von Neumann test. Serial Correlation testing requires a sample with $n \geq 6$.

[h]Outliers determined by Rosner's (where $n > 25$) or Dixon procedure (where $4 \leq n \leq 25$).

[i]Q = quarterly

Table A.5.3-2. Cell 3 Annual LCS Sample Summary Information for Detected Parameters

PARAMETER(UNIT)	NUMBER OF SAMPLES[a,b]	NUMBER OF SAMPLES WITH DETECTIONS[a,b]	PERCENT OF DETECTIONS[a,b]	DETECTED IN 2011	MIN DETECTED CONCENTRATION[a,b,c]	MAX DETECTED CONCENTRATION[a,b,c]	AVG DETECTED CONCENTRATION[a,b,c]	GW FRL[d] (#OF SAMPLES>GWFRL)	GW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	PW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	MAX PW DETECTED CONCENTRATION [a,b,f] (# OF SAMPLES>MAX PW)
General Chemistry											
Ammonia (mg/L)	14	3	21.4	Yes	0.0242	0.103	0.0647	-	4.2 mg/L(0)	4.34 mg/L(0)	220 mg/L(0)
Inorganics											
Beryllium (mg/L)	14	1	7.1	No	0.0002	-	-	0.004 mg/L(0)	-	-	0.0343 mg/L(0)
Cadmium (mg/L)	14	3	21.4	No	0.000065	0.00044	0.0002	0.014 mg/L(0)	0.014 mg/L(0)	-	0.05 mg/L(0)
Chromium (mg/L)	14	8	57.1	Yes	0.00093	0.006	0.0026	0.022 mg/L[g](0)	0.021 mg/L(0)	0.0046 mg/L(2)	0.818 mg/L(0)
Lead (mg/L)	14	2	14.3	No	0.00146	0.0266	0.014	0.015 mg/L(1)	0.022 mg/L(1)	0.0016 mg/L(1)	0.0114 mg/L(1)
Thallium (mg/L)	14	1	7.1	No	0.0021	-	-	-	-	-	0.0028 mg/L(0)
Vanadium (mg/L)	14	3	21.4	No	0.0034	0.00959	0.0056	0.038 mg/L(0)	0.012 mg/L(0)	0.005 mg/L(1)	0.299 mg/L(0)
Radionuclides											
Technetium-99 (pCi/L)	24	2	8.3	No	3.84	9.89	6.86	94 pCi/L(0)	22 pCi/L(0)	30 pCi/L(0)	6130 pCi/L(0)
Organics											
1,1-Dichloroethane (ug/L)	10	2	20.0	No	0.351	0.79	0.57	280 ug/L(0)	-	-	-
1,1-Dichloroethene (ug/L)	31	10	32.3	No	0.112	13.1	4.45	7 ug/L(3)	-	-	-
1,1,1-Trichloroethane (ug/L)	11	2	18.2	No	0.54	0.64	0.59	-	-	-	-
4-Nitroaniline	22	1	4.5	No	2.94	-	-	-	-	-	-
Bromodichloromethane (ug/L)	23	1	4.3	No	0.5	-	-	100 ug/L(0)	-	-	-
Chlorodibromomethane (ug/L)	11	1	9.1	No	1	-	-	-	-	-	-
Trans-1,3-dichloropropene (ug/L)	10	1	10.0	No	1	-	-	-	-	-	-
Vinyl chloride (ug/L)	23	2	8.7	No	0.539	16.1	8.32	2 ug/L(1)	-	-	-

Note: Shading indicates that at least one detected sample is greater than the FRL, groundwater background, PW background, or PW maximum.

[a]If more than one sample is collected per well per day (e.g., duplicates), then only one sample is counted for the total number of samples, and the sample with the maximum representative concentration is used for all the summary information

[b]Rejected data qualified with an R or Z were not included.

[c]If the number of detected samples is equal to two, then the minumun and maximumn are reported. If the number of detected is equal to one, then the data point is reported as the minimum. The "AVG DETECTED CONCENTRATION" is not reported for either of these cases.

[d]From Operable Unit 5 Record of Decision, Table 9-4.

[e]From the Characterization of Background Water Quality for Streams and Groundwater which was developed for Operable Unit 5 RI/FS documents.

[f]Max PW - maximum detected concentration in perched water as defined in the Remedial Investigation Report for Operable Unit 5.

[g]FRL based on hexavalent chromium from Operable Unit 5 Record of Decision, Table 9-4.

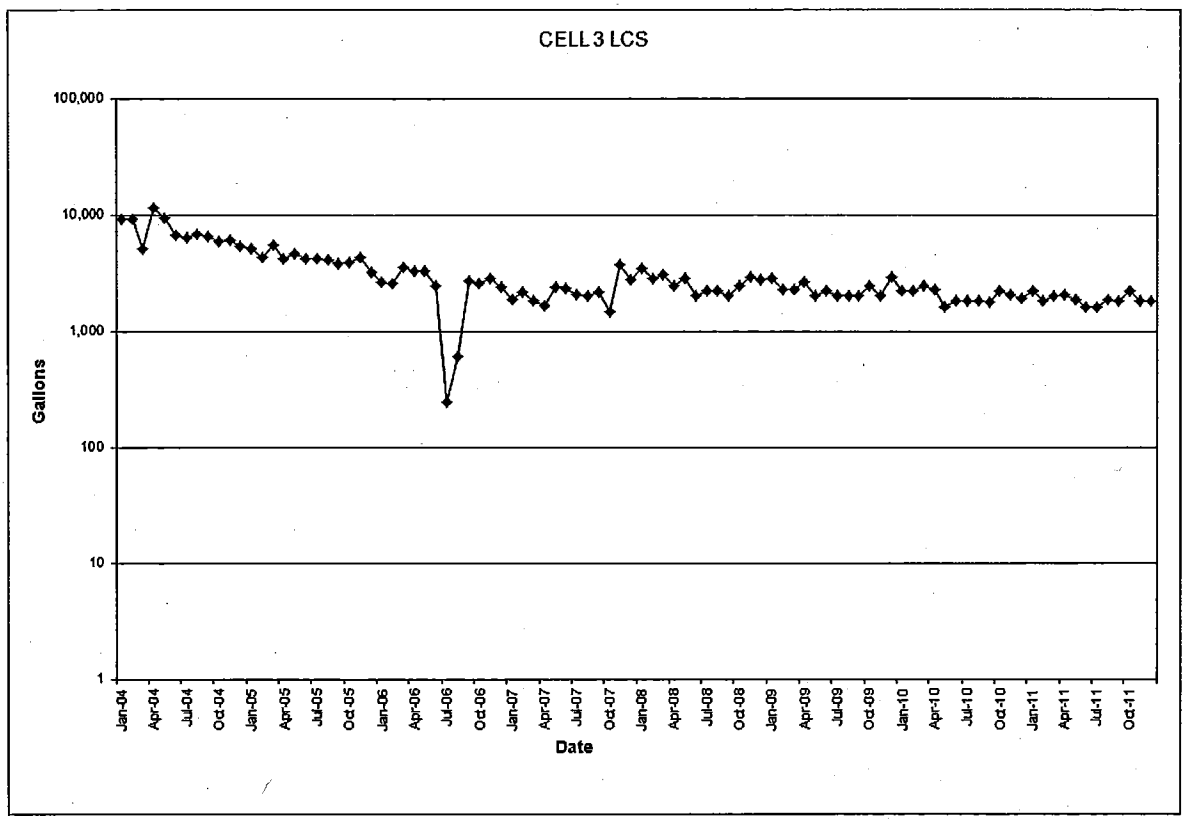


Figure A.5.3–1. Monthly Accumulation Volumes For Cell 3 LCS

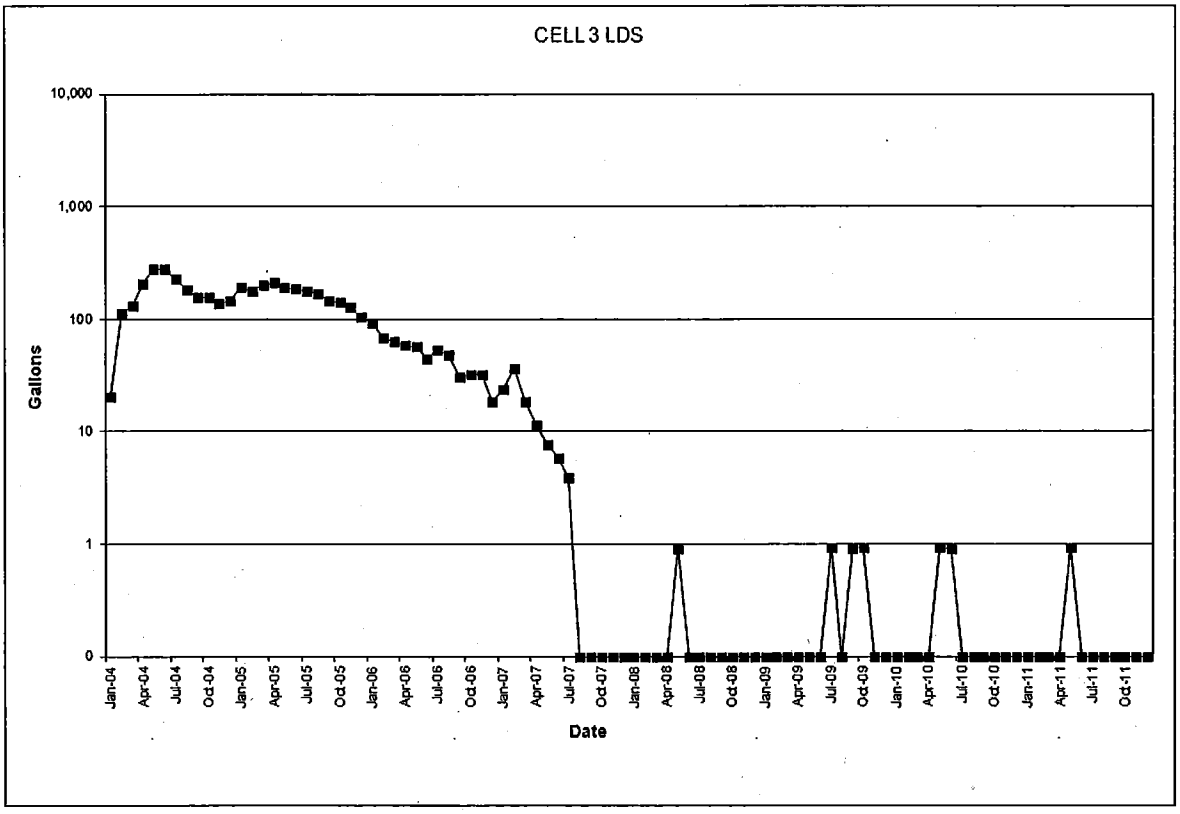
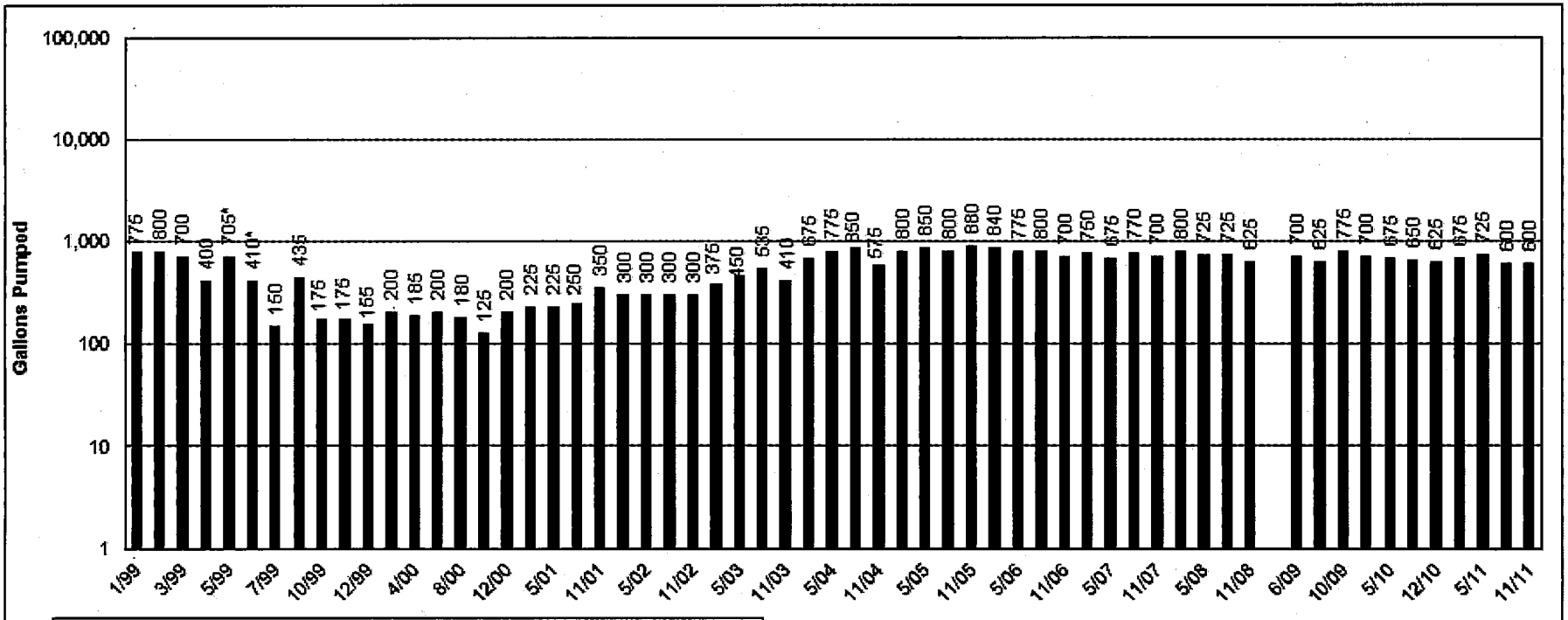


Figure A.5.3–2. Monthly Accumulation Volumes For Cell 3 LDS



12340 Purge Information

Year	Total Volumes (gal.)	Months Purged	Avg. Monthly Purge (gal.)
1999:	4880	n=11	444
2000:	1090	n=6	182
2001:	1050	n=4	263
2002:	1200	n=4	300
2003:	1770	n=4	443
2004:	2875	n=4	719
2005:	3330	n=4	833
2006:	3115	n=4	779
2007:	2895	n=4	724
2008:	2875	n=4	719
2009:	2100	n=3	700
2010:	2650	n=4	663
2011:	2600	n=4	650
Overall:			541

*More than one purge of the well was completed during these months to help evaluate well yield.

Figure A.5.3–3. OSDF Horizontal Till Well 12340 (Cell 3) Water Yield

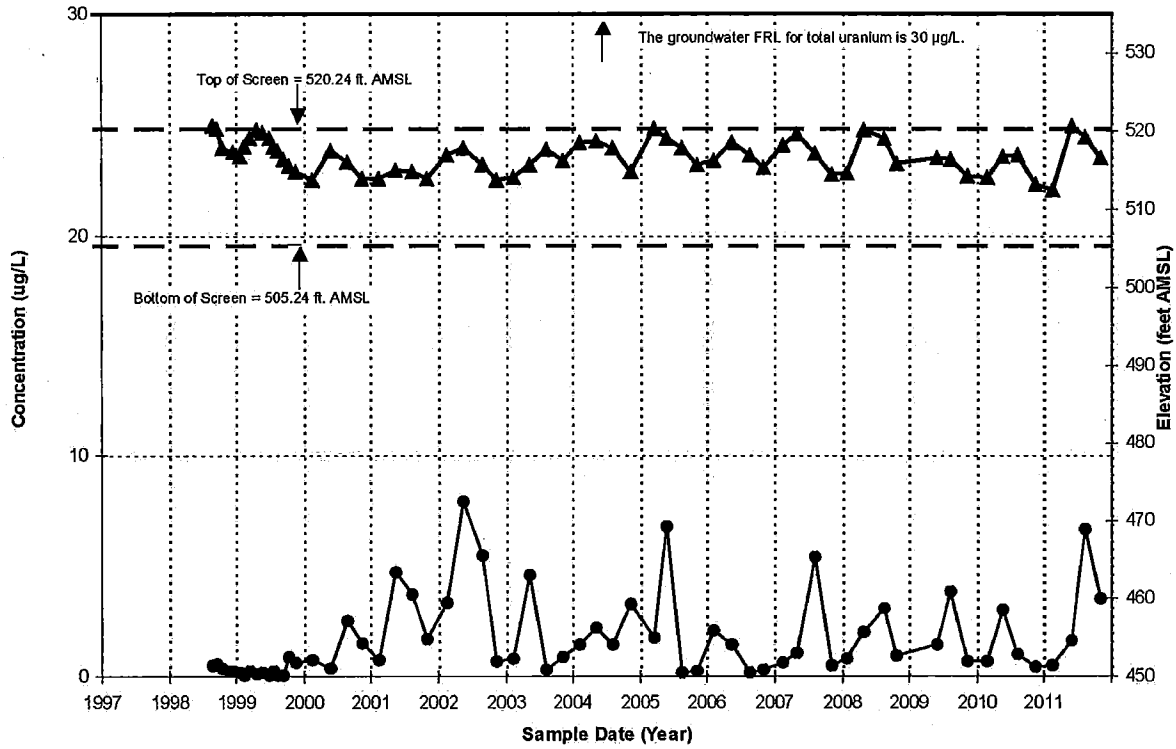


FIGURE A.5.3-4. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 3 Upgradient Monitoring Well 22203

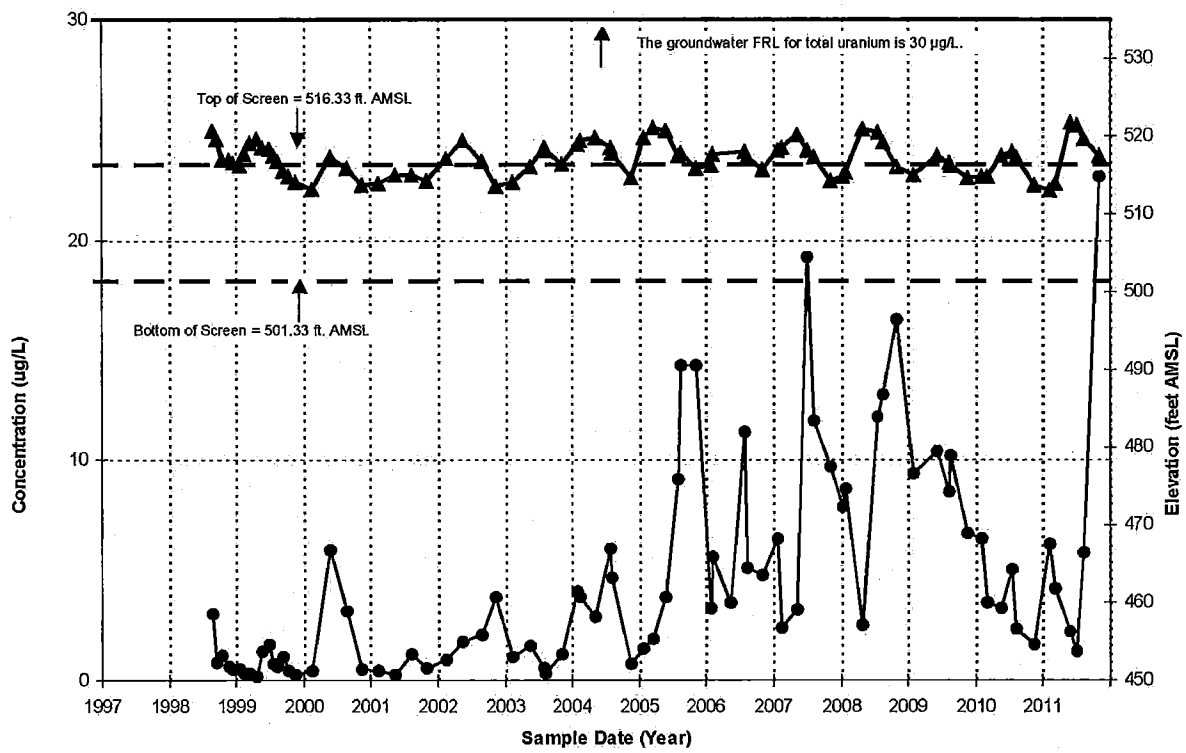


FIGURE A.5.3-5. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 3 Downgradient Monitoring Well 22204

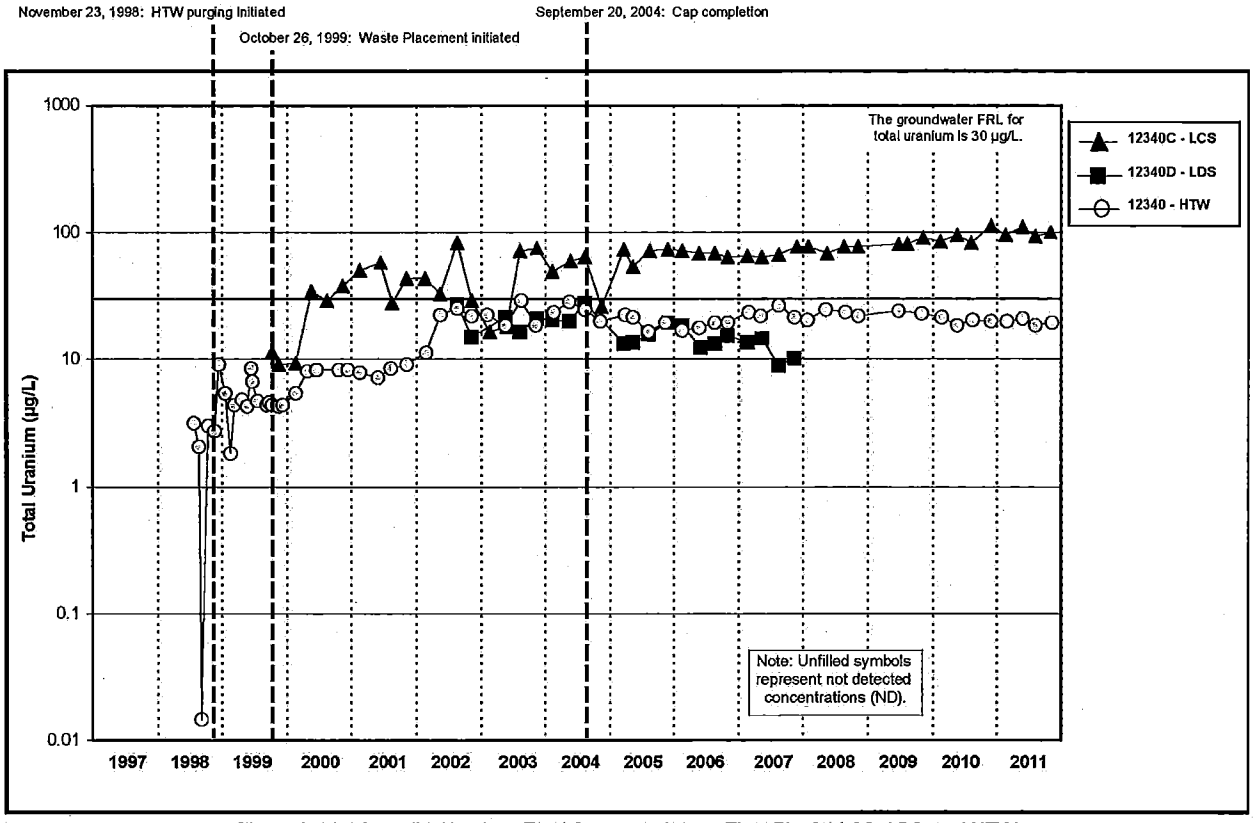


Figure A.5.3-6A. Cell 3 Uranium, Total Concentration vs. Time Plot for LCS, LDS, and HTW

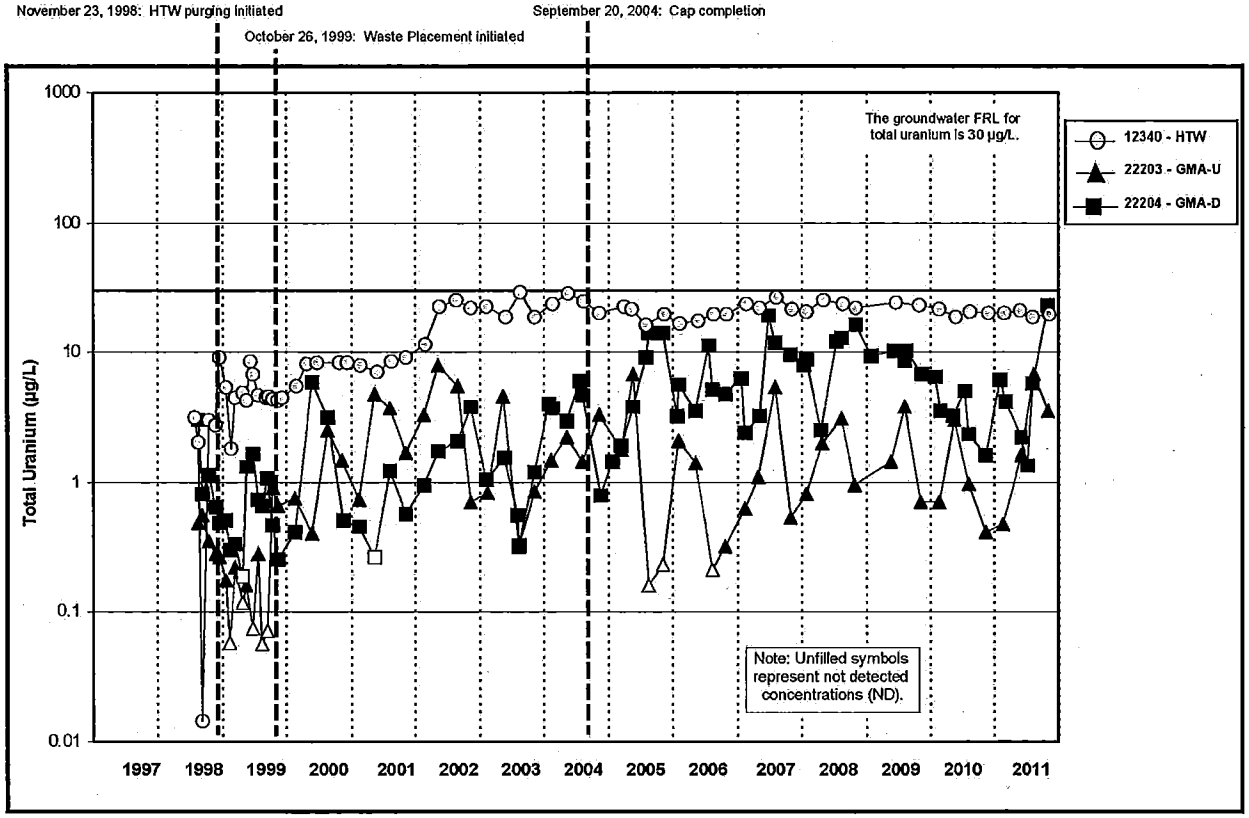


Figure A.5.3-6B. Cell 3 Uranium, Total Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

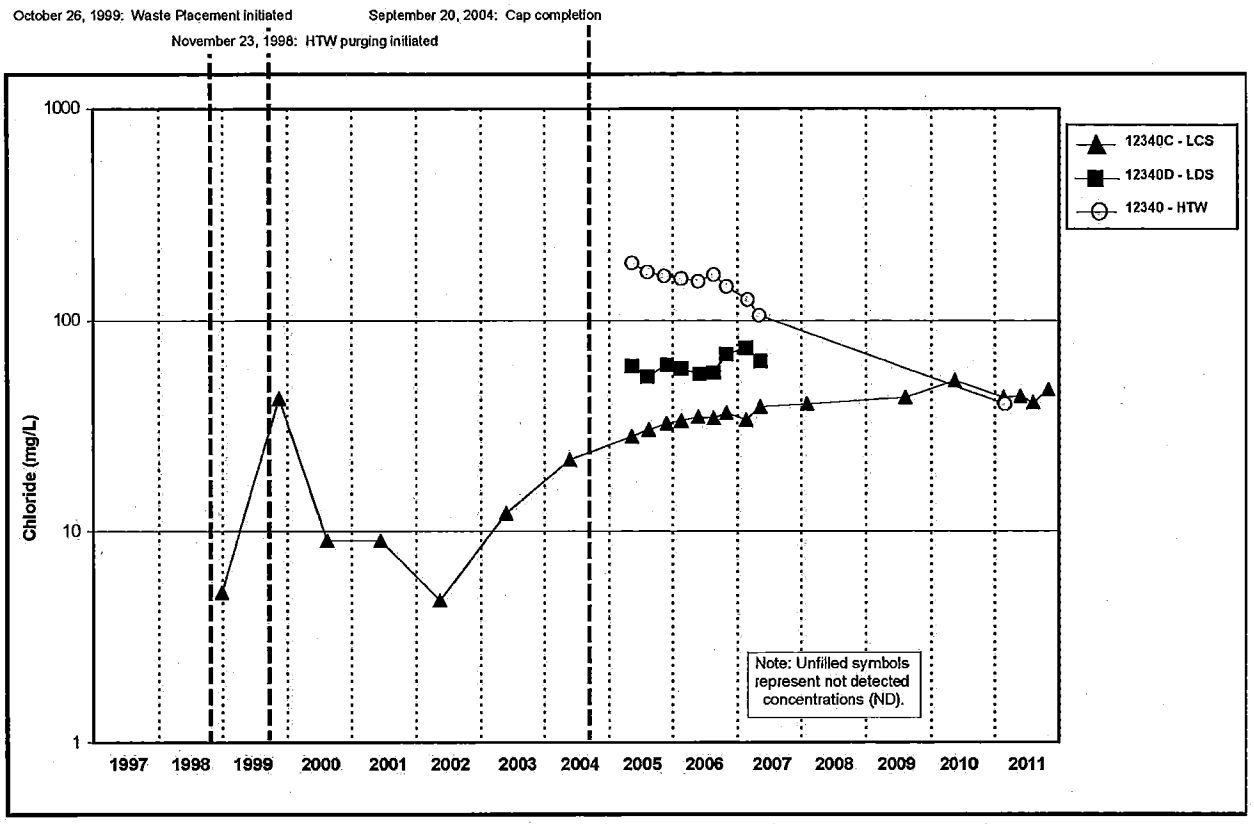


Figure A.5.3-7A. Cell 3 Chloride Concentration vs. Time Plot for LCS, LDS, and HTW

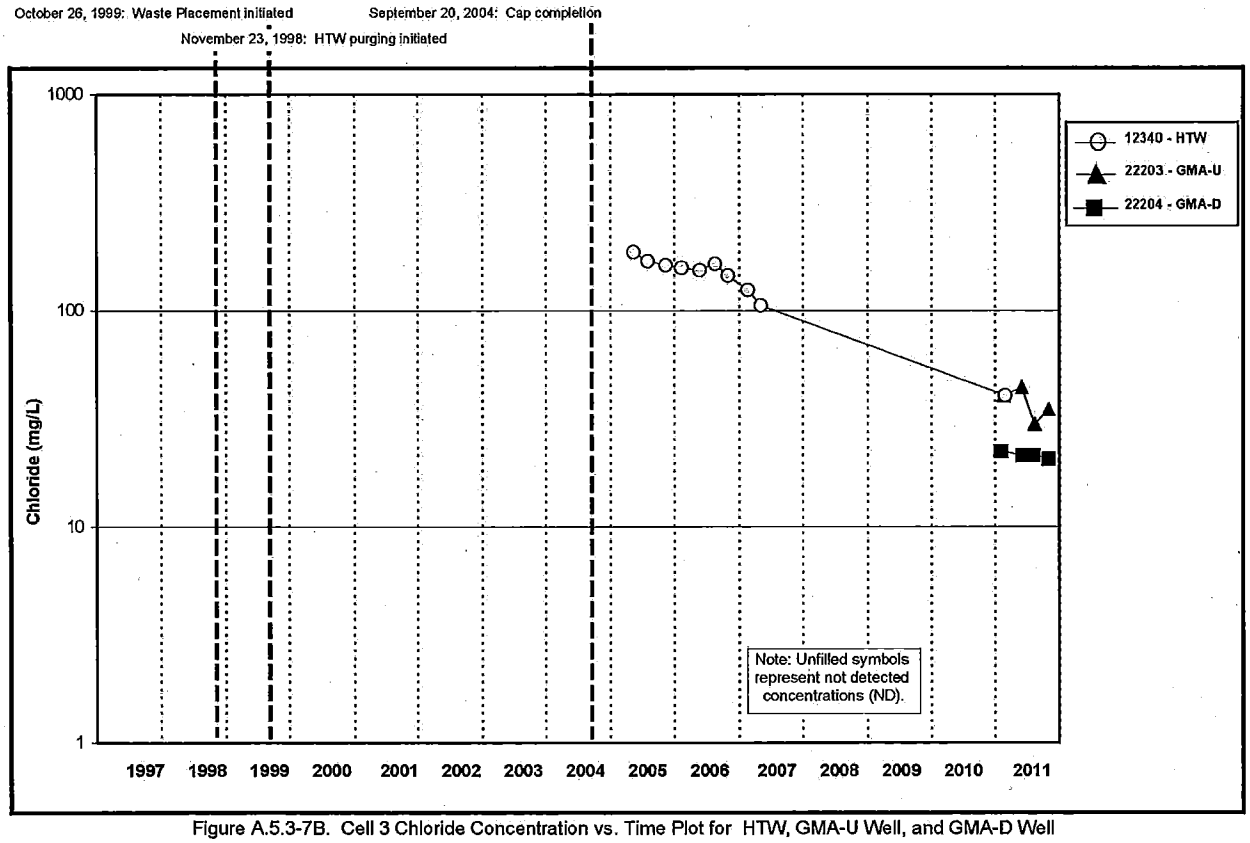


Figure A.5.3-7B. Cell 3 Chloride Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

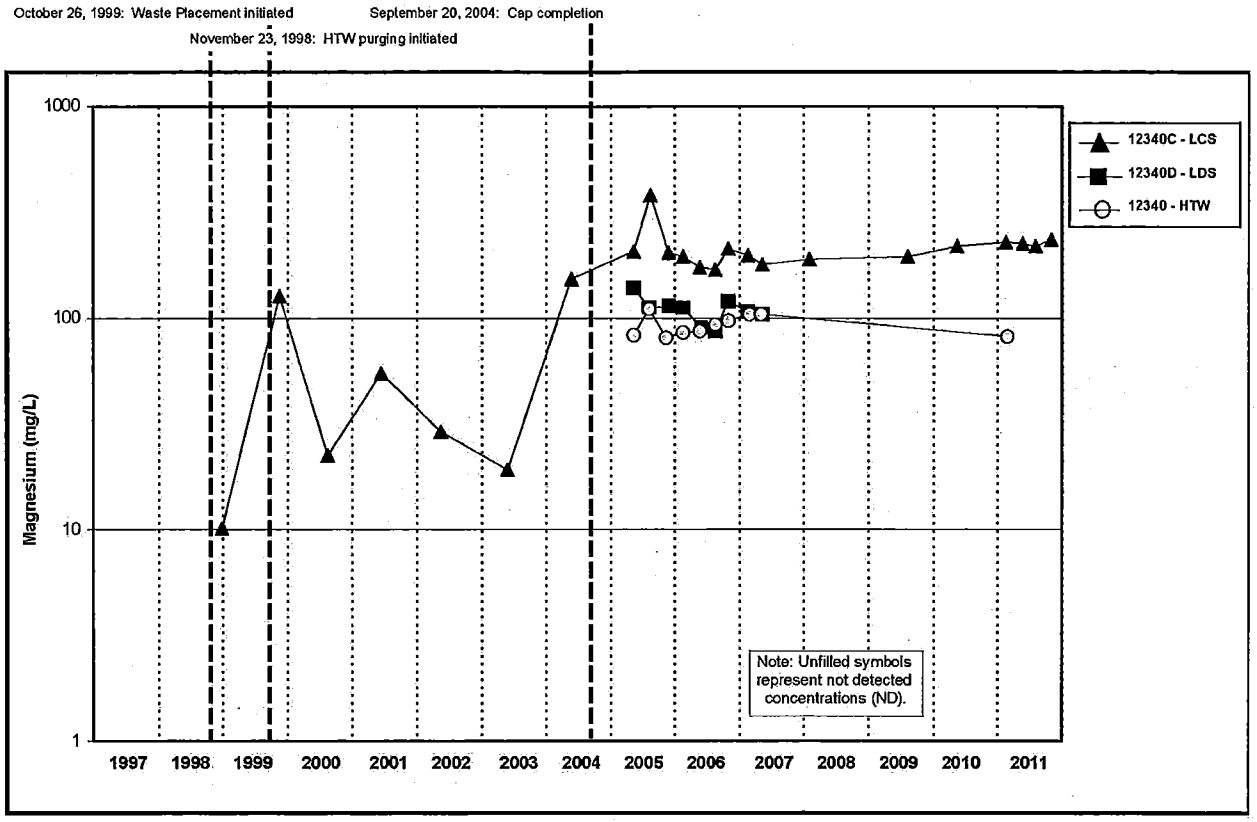


Figure A.5.3-8A. Cell 3 Magnesium Concentration vs. Time Plot for LCS, LDS, and HTW

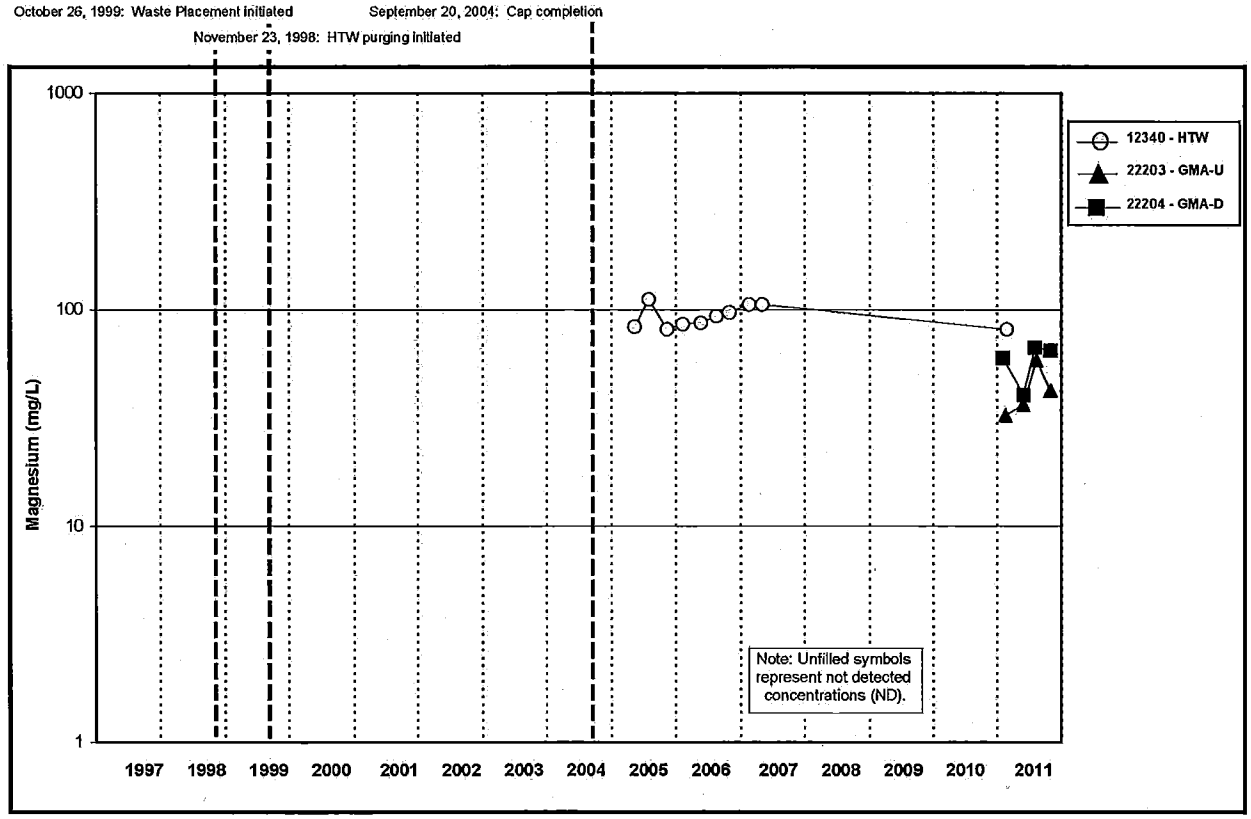


Figure A.5.3-8B. Cell 3 Magnesium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

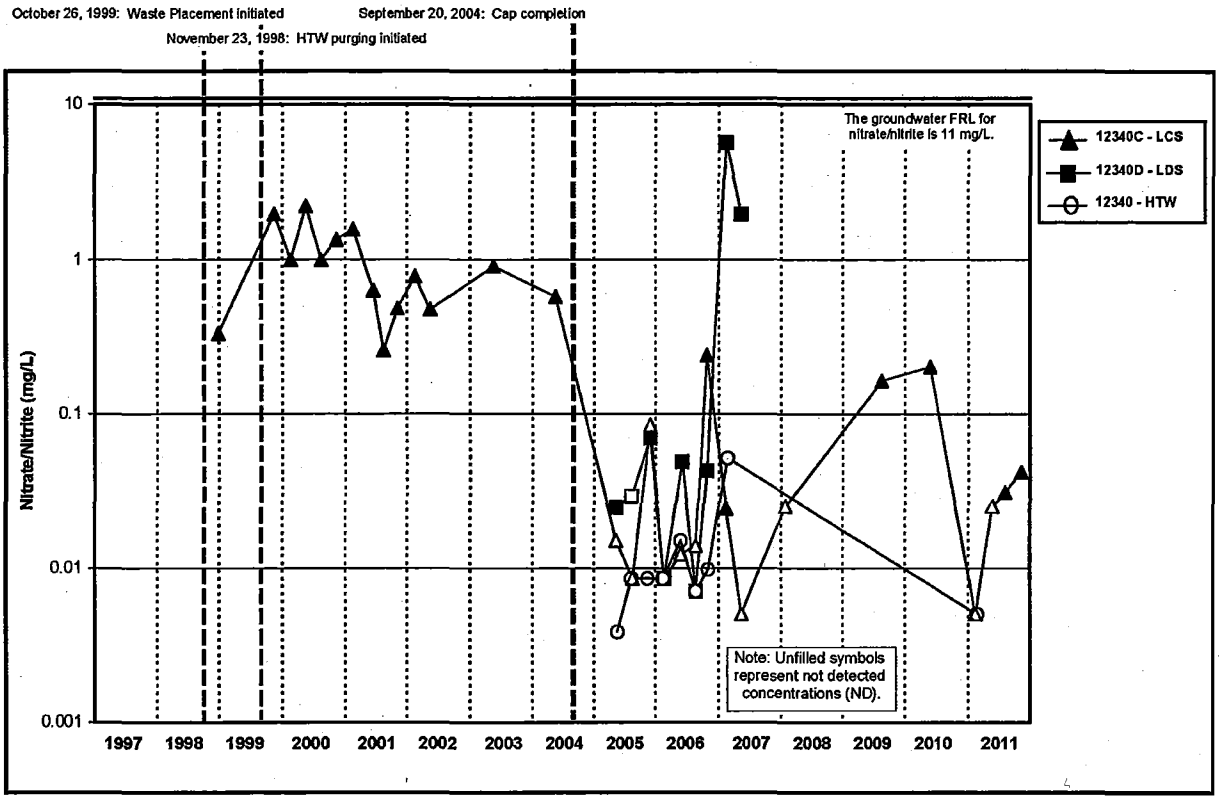


Figure A.5.3-9A. Cell 3 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for LCS, LDS, and HTW

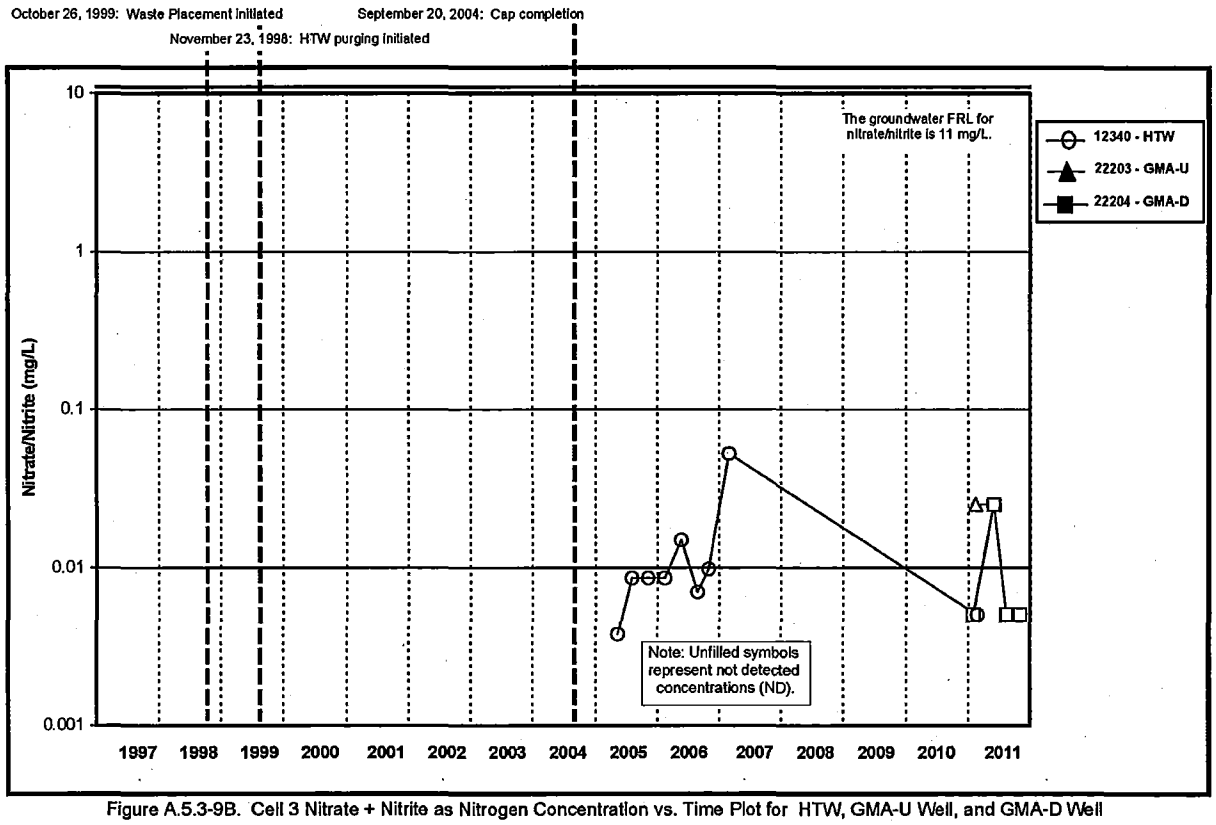


Figure A.5.3-9B. Cell 3 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

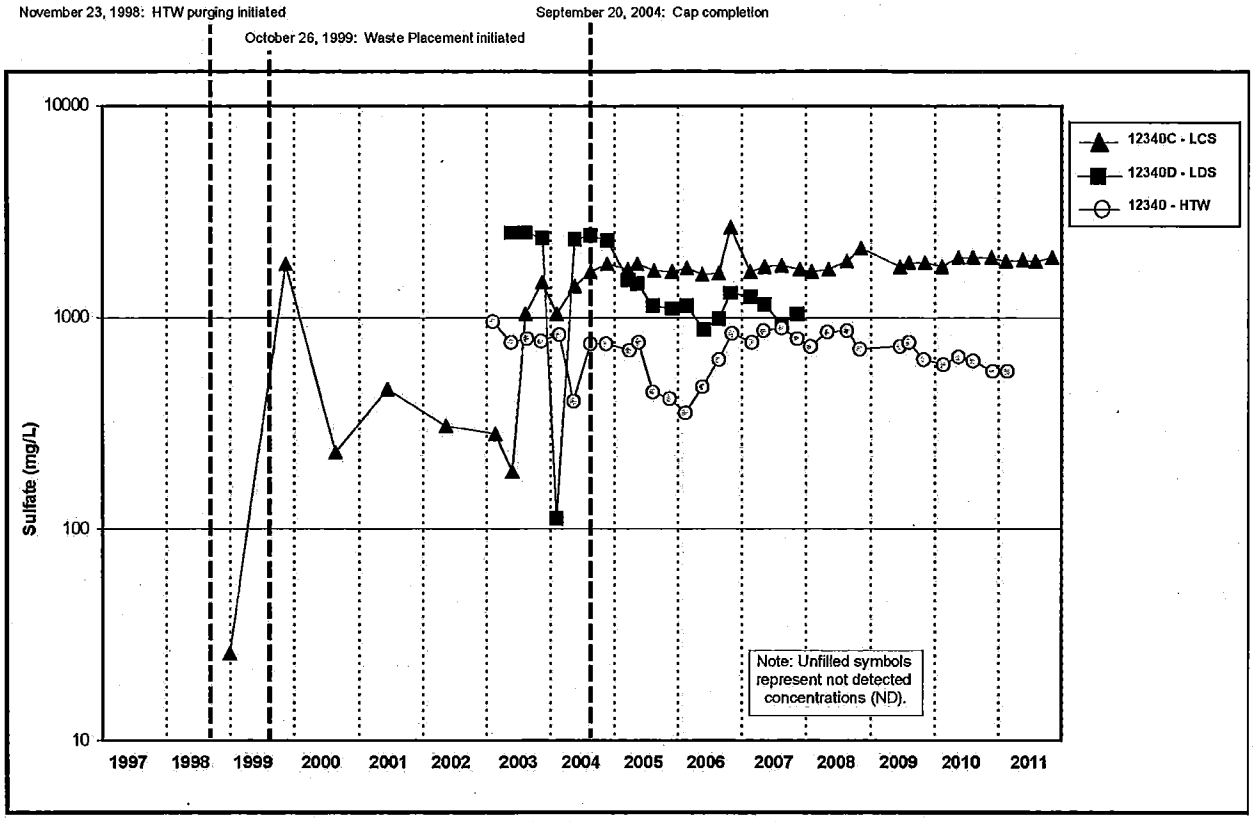


Figure A.5.3-10A. Cell 3 Sulfate Concentration vs. Time Plot for LCS, LDS, and HTW

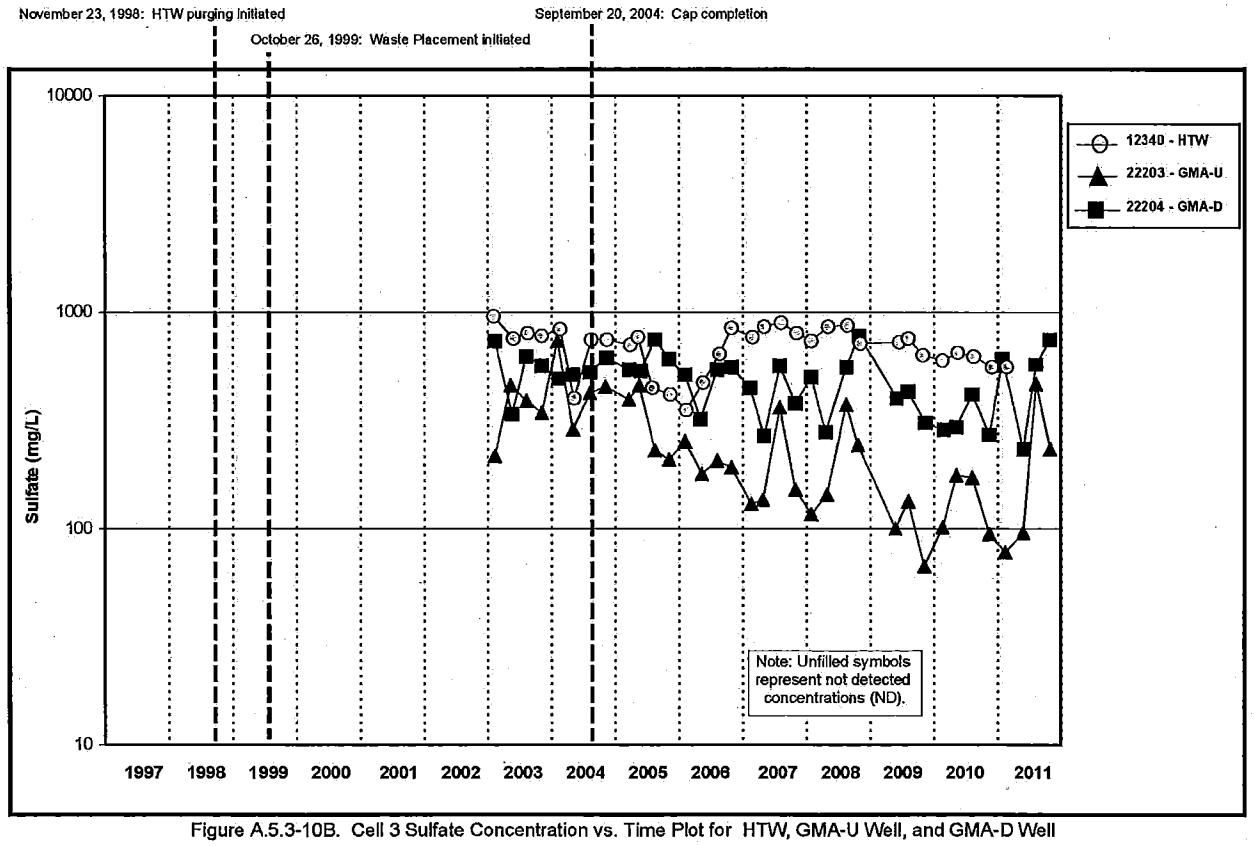


Figure A.5.3-10B. Cell 3 Sulfate Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

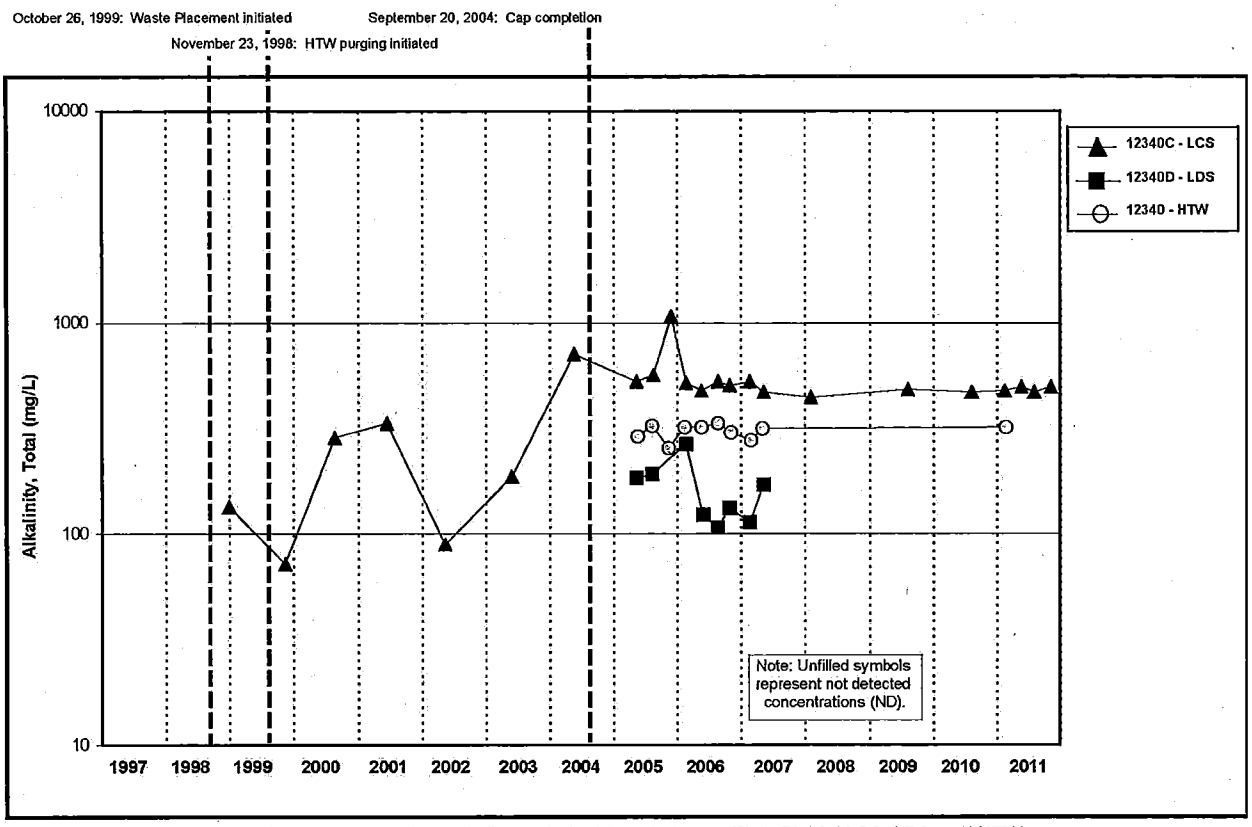


Figure A.5.3-11A. Cell 3 Alkalinity, Total Concentration vs. Time Plot for LCS, LDS, and HTW

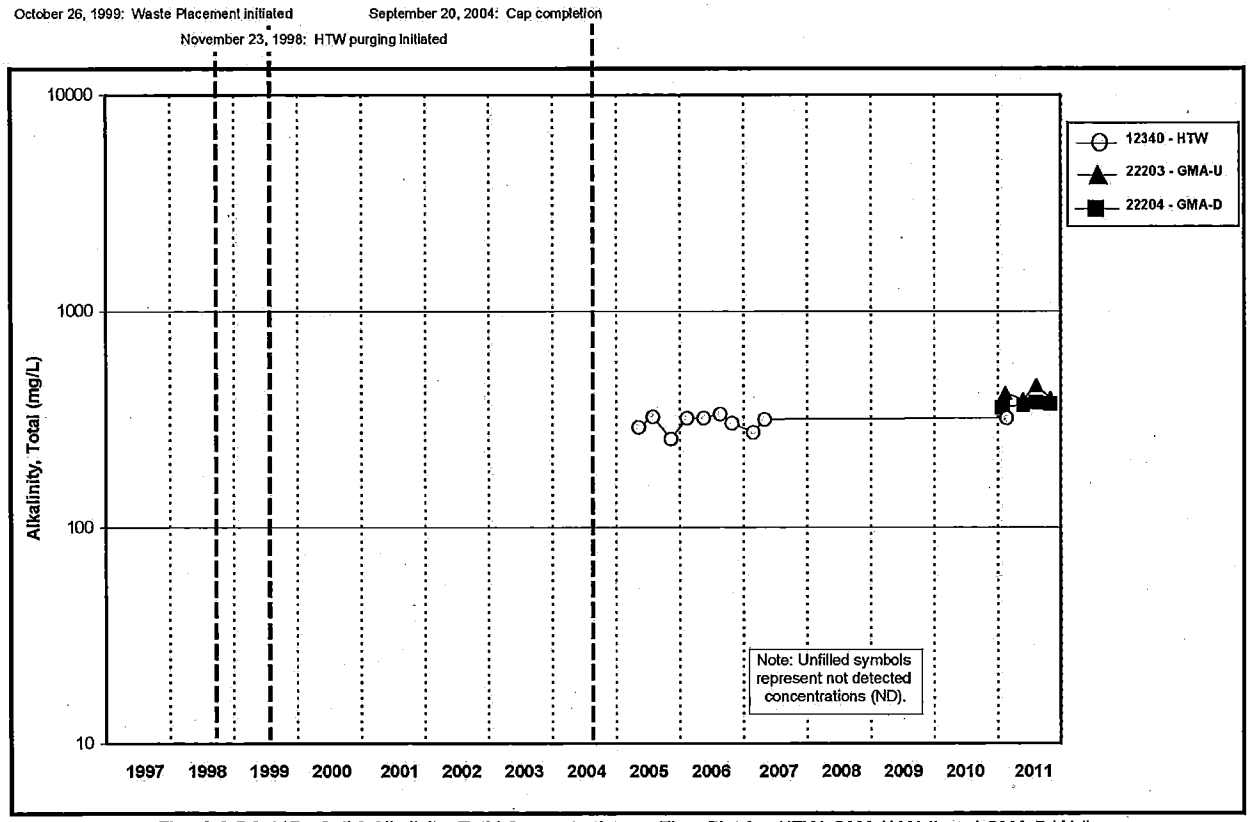


Figure A.5.3-11B. Cell 3 Alkalinity, Total Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

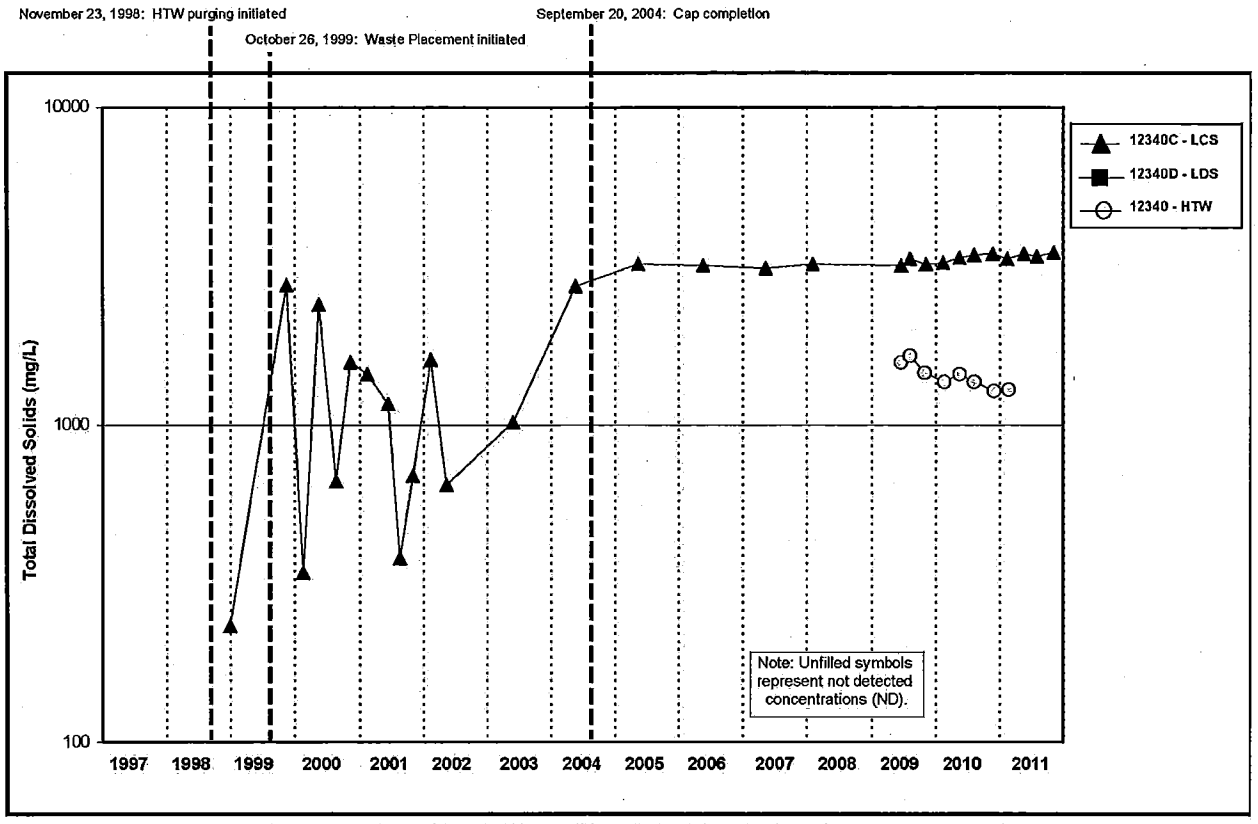


Figure A.5.3-12A. Cell 3 Total Dissolved Solids Concentration vs. Time Plot for LCS, LDS, and HTW

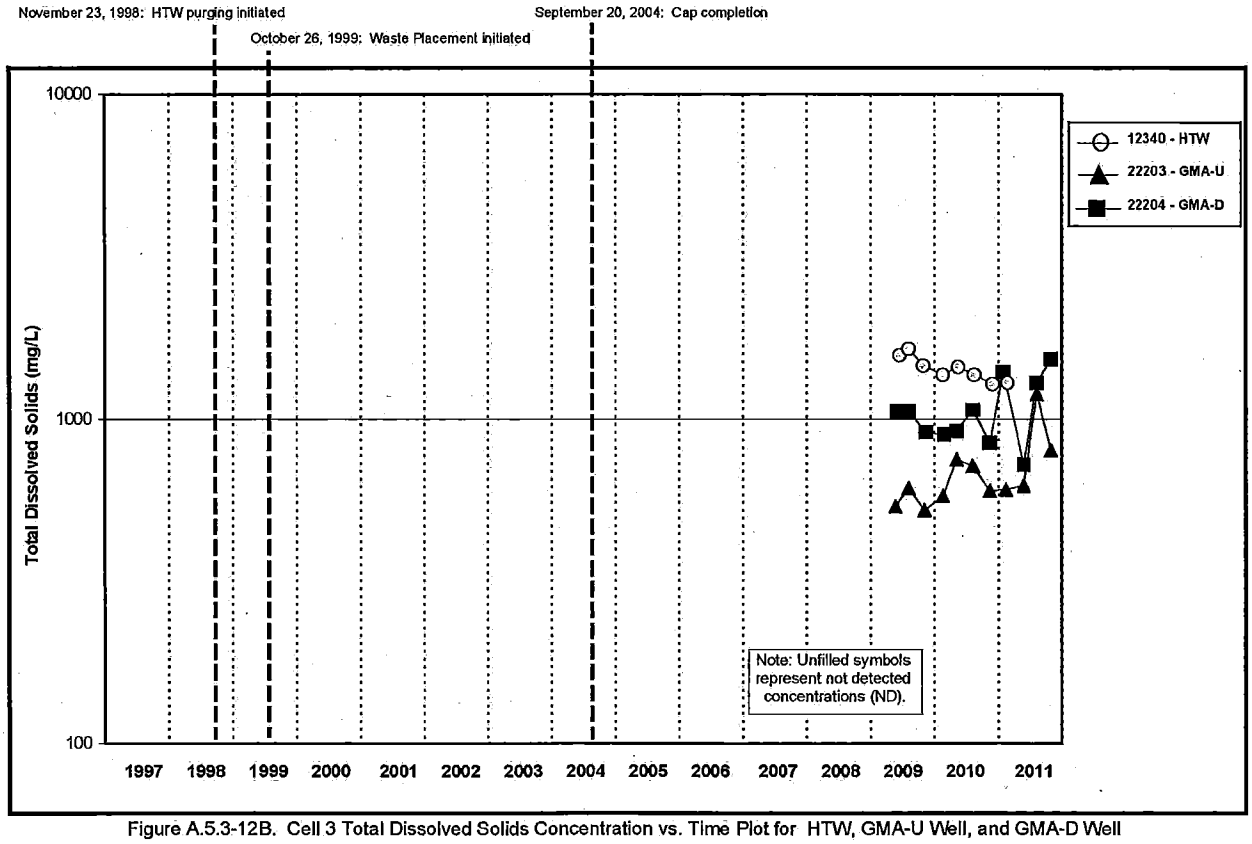


Figure A.5.3-12B. Cell 3 Total Dissolved Solids Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

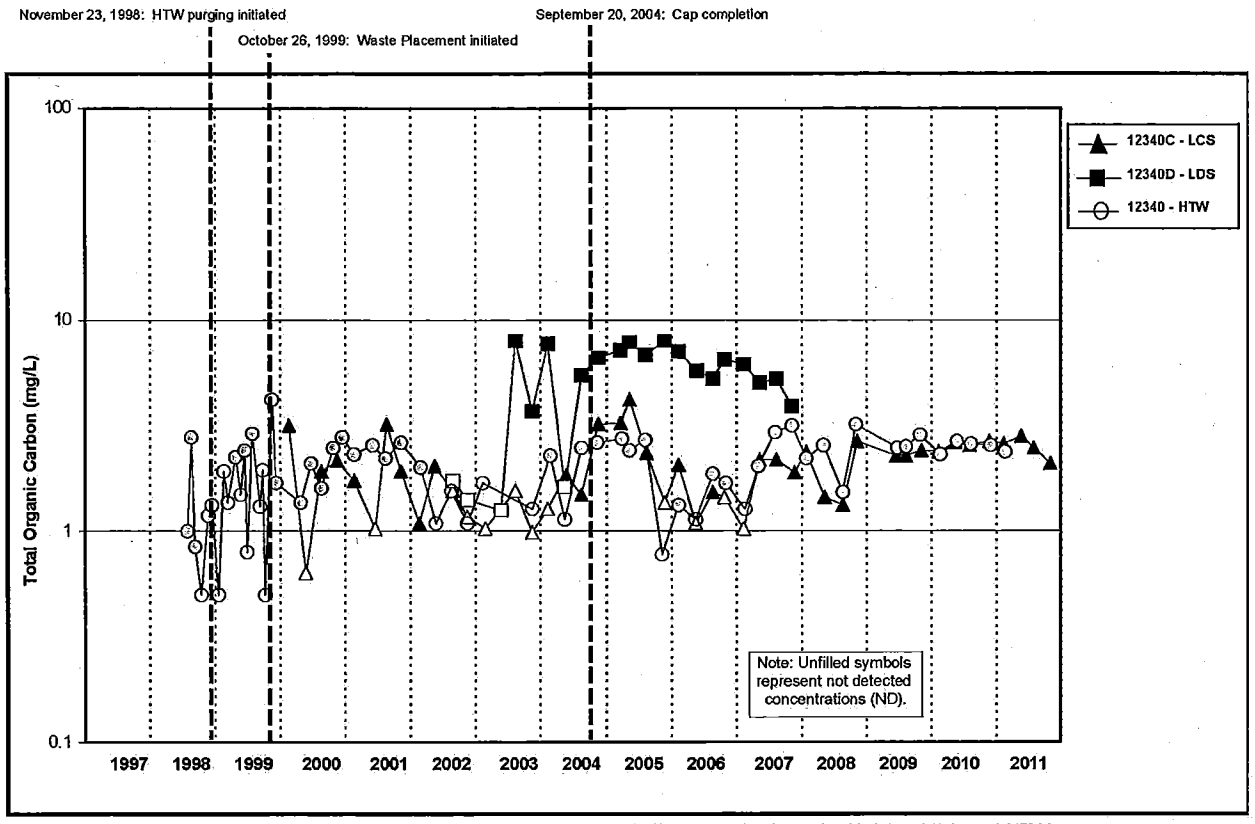


Figure A.5.3-13A. Cell 3 Total Organic Carbon Concentration vs. Time Plot for LCS, LDS, and HTW

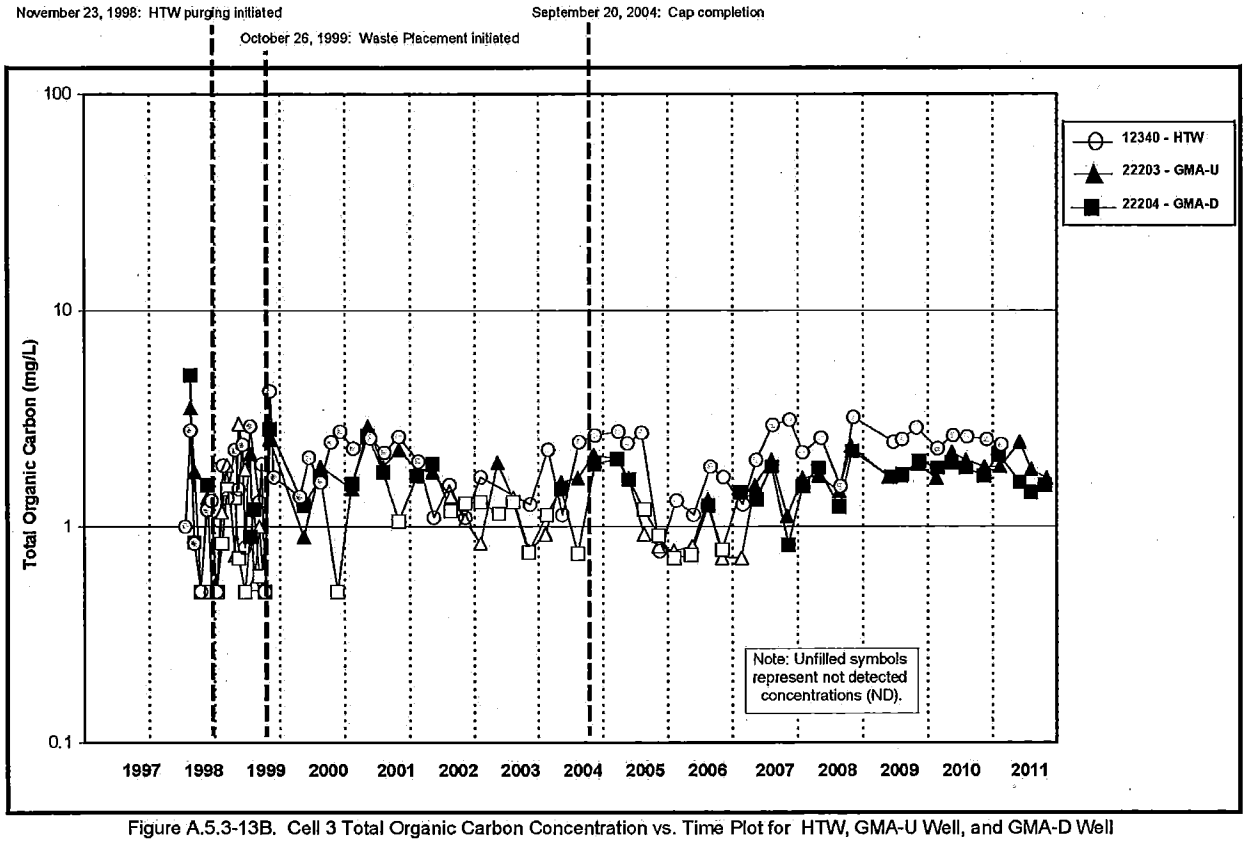


Figure A.5.3-13B. Cell 3 Total Organic Carbon Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

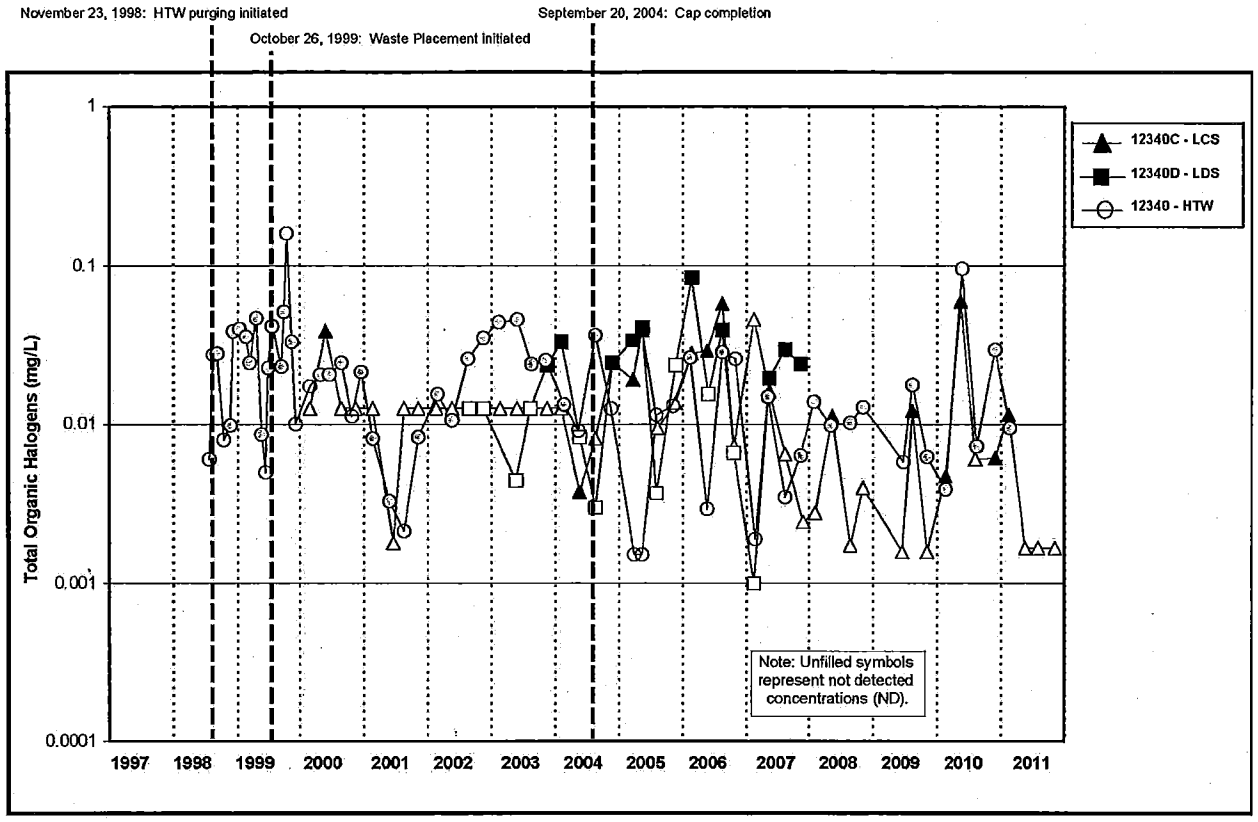


Figure A.5.3-14A. Cell 3 Total Organic Halogens Concentration vs. Time Plot for LCS, LDS, and HTW

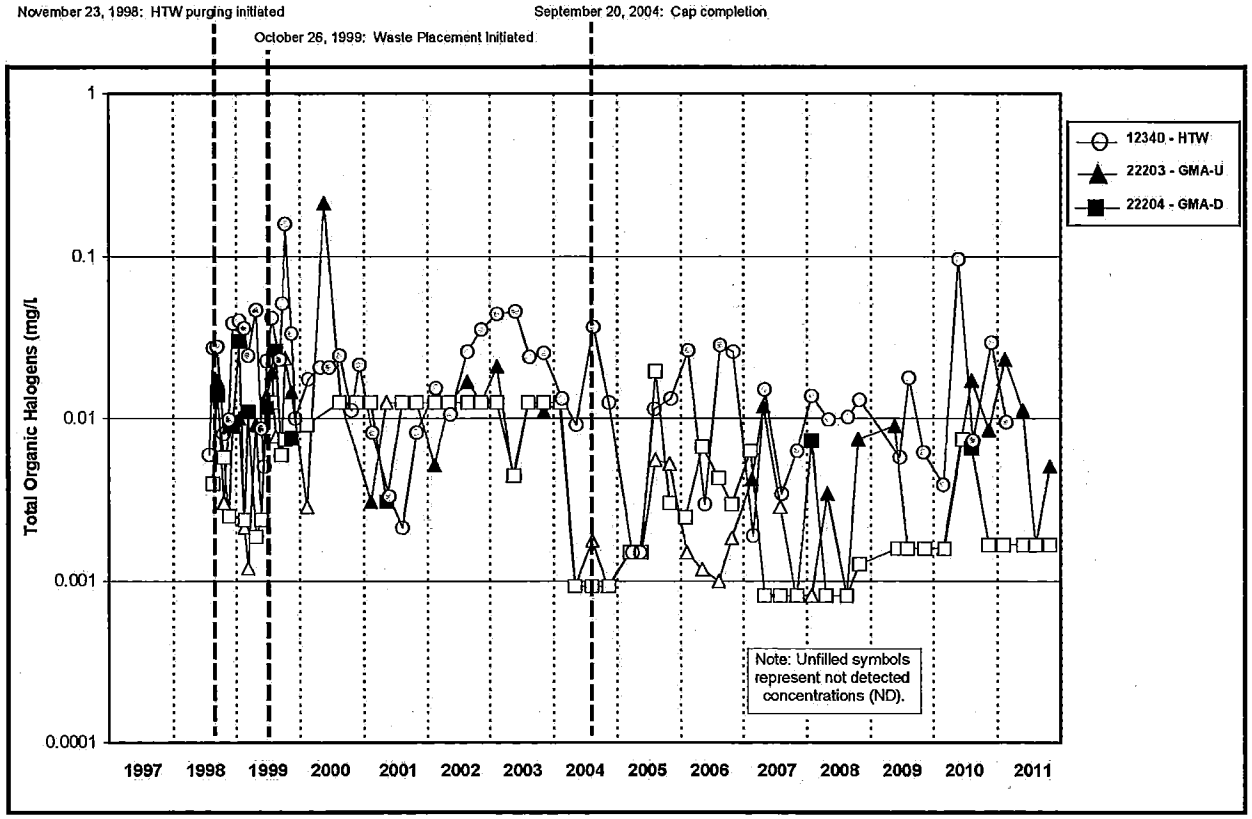


Figure A.5.3-14B. Cell 3 Total Organic Halogens Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

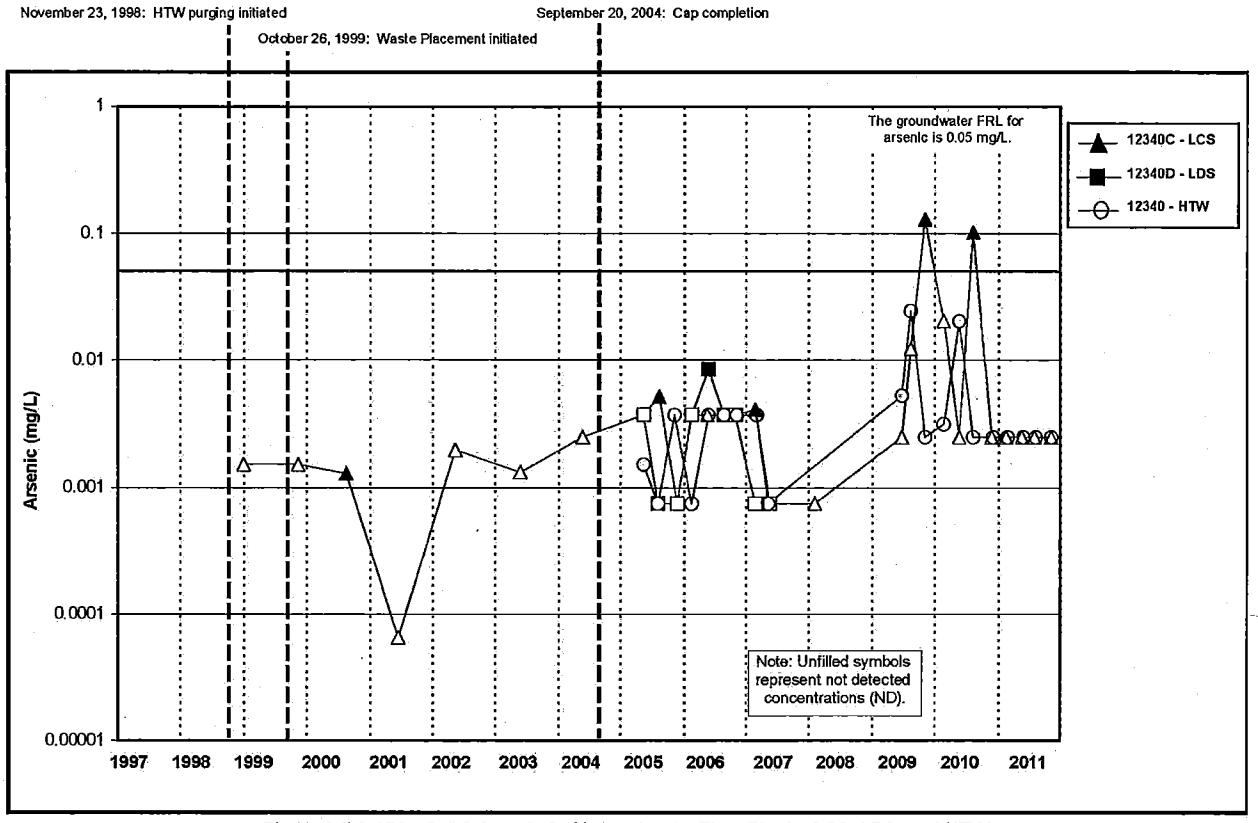


Figure A.5.3-15A. Cell 3 Arsenic Concentration vs. Time Plot for LCS, LDS, and HTW

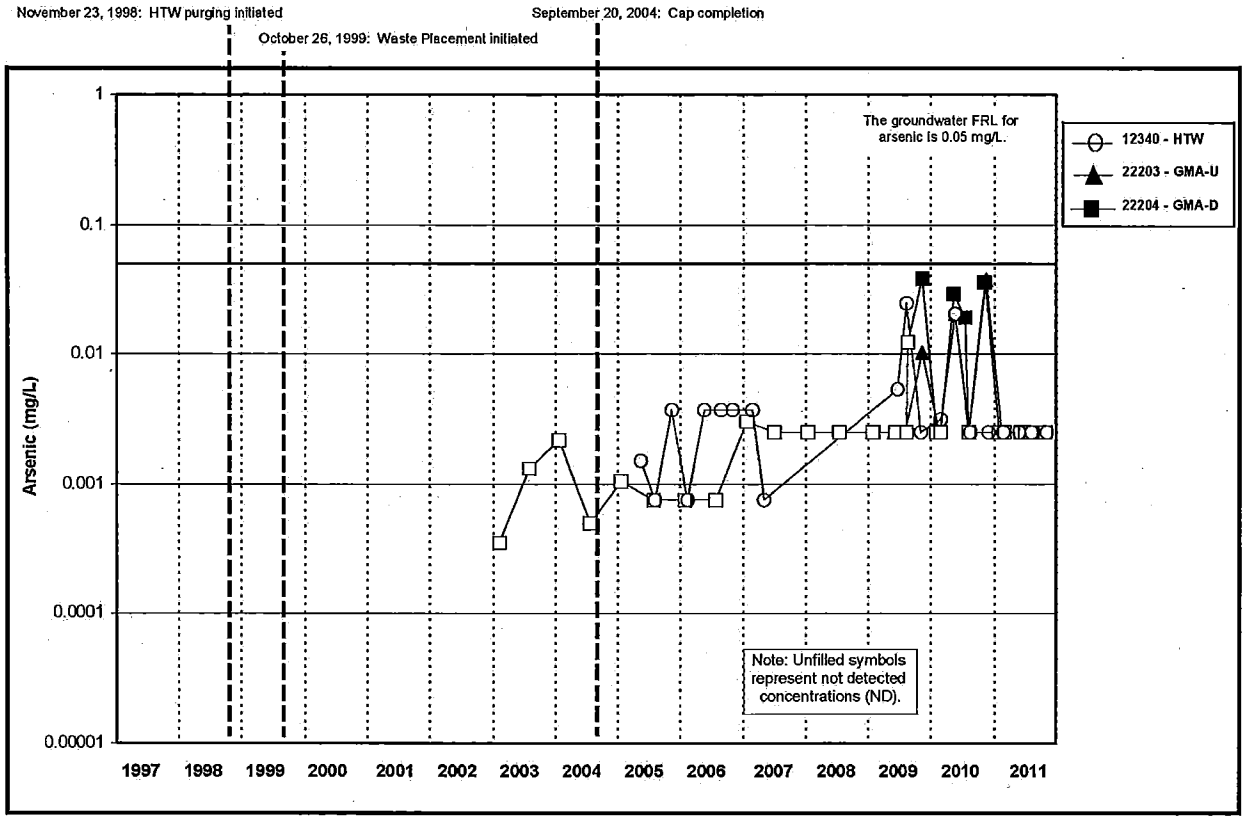


Figure A.5.3-15B. Cell 3 Arsenic Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

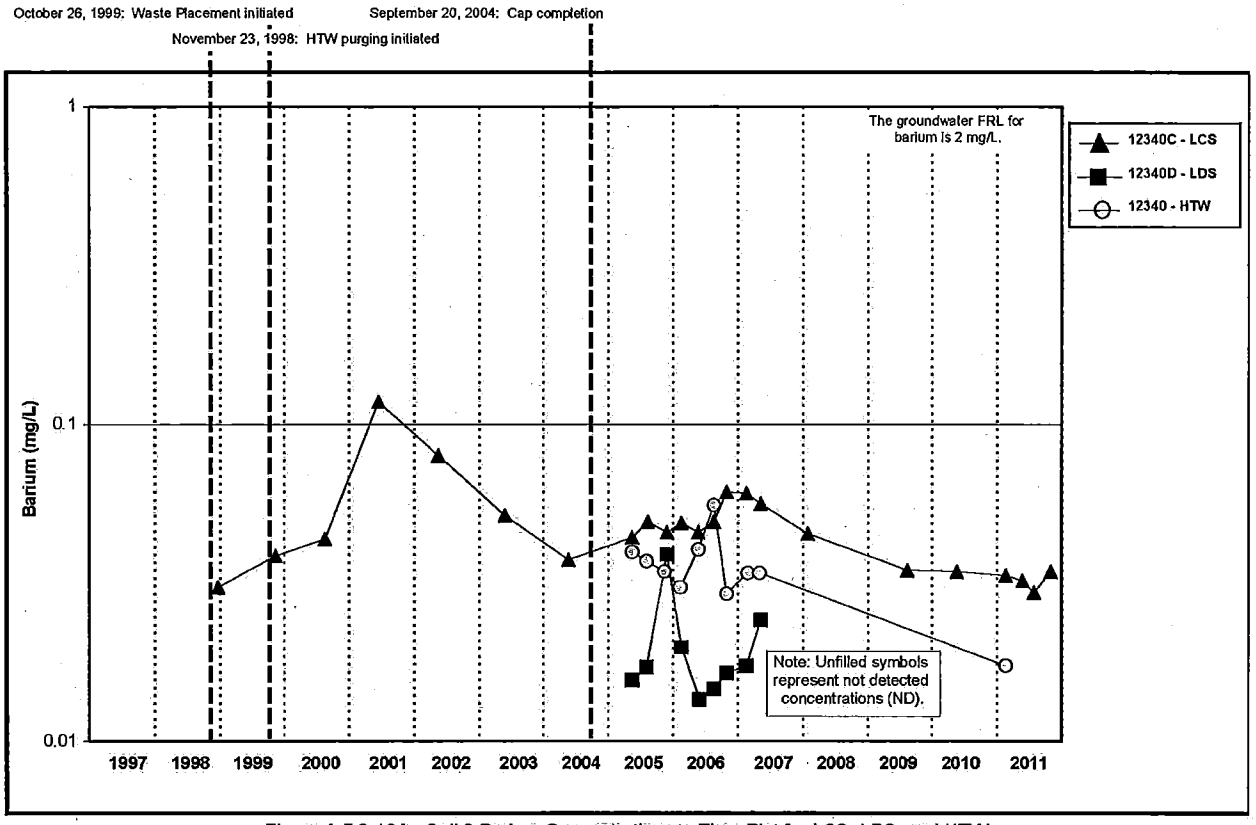


Figure A.5.3-16A. Cell 3 Barium Concentration vs. Time Plot for LCS, LDS, and HTW

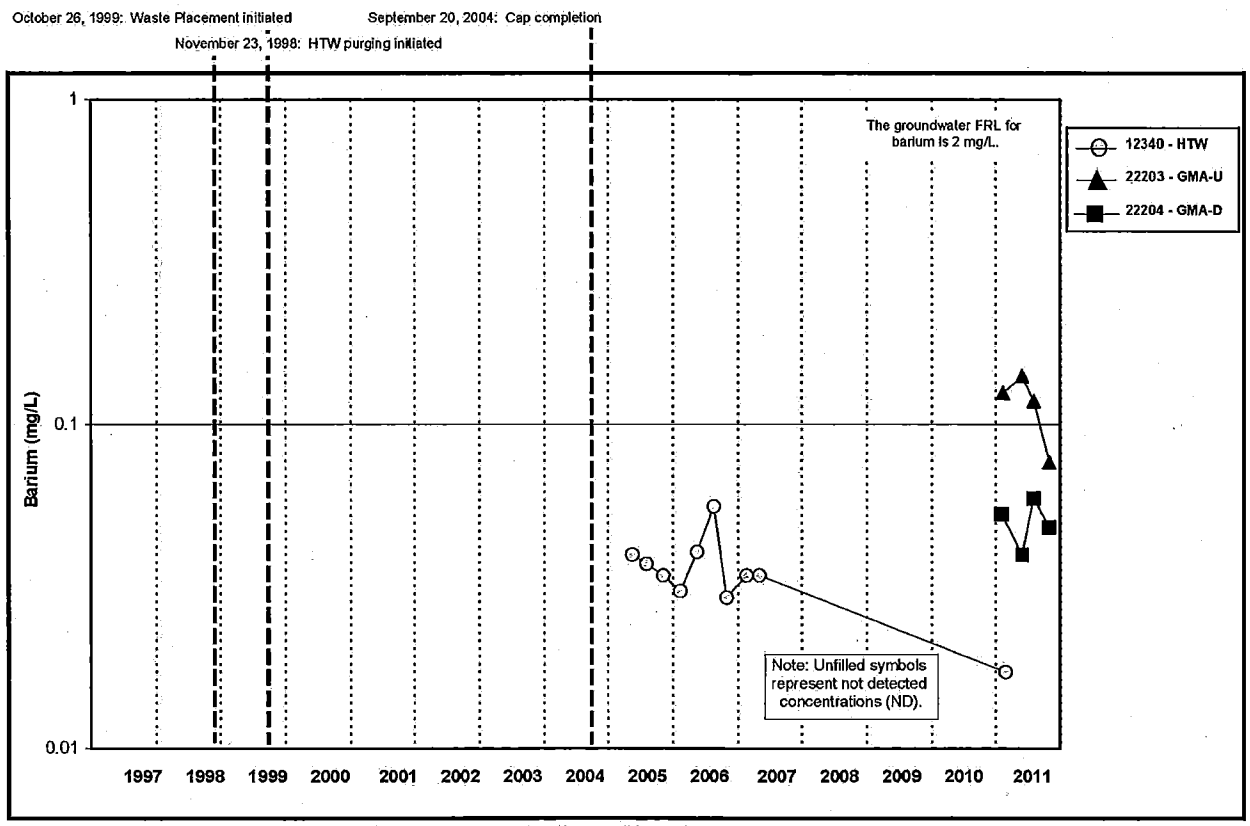


Figure A.5.3-16B. Cell 3 Barium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

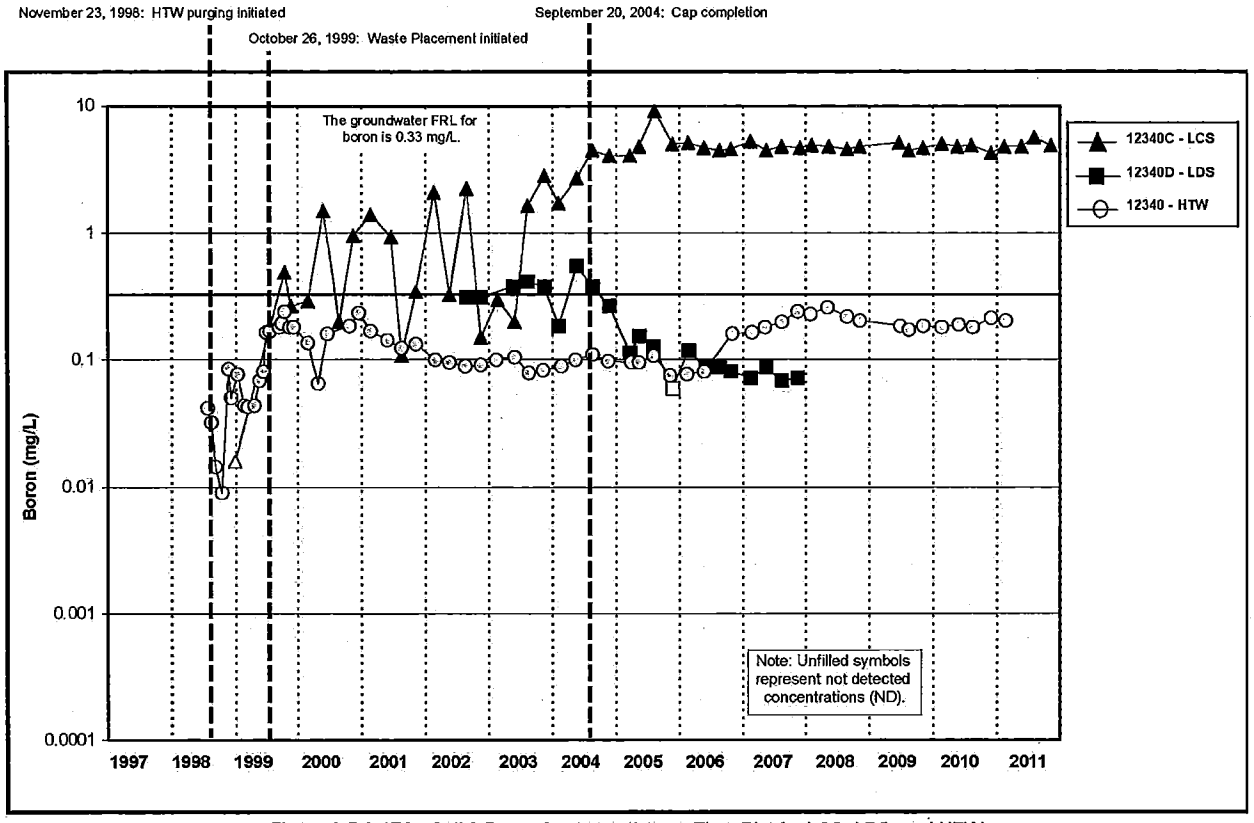


Figure A.5.3-17A. Cell 3 Boron Concentration vs. Time Plot for LCS, LDS, and HTW

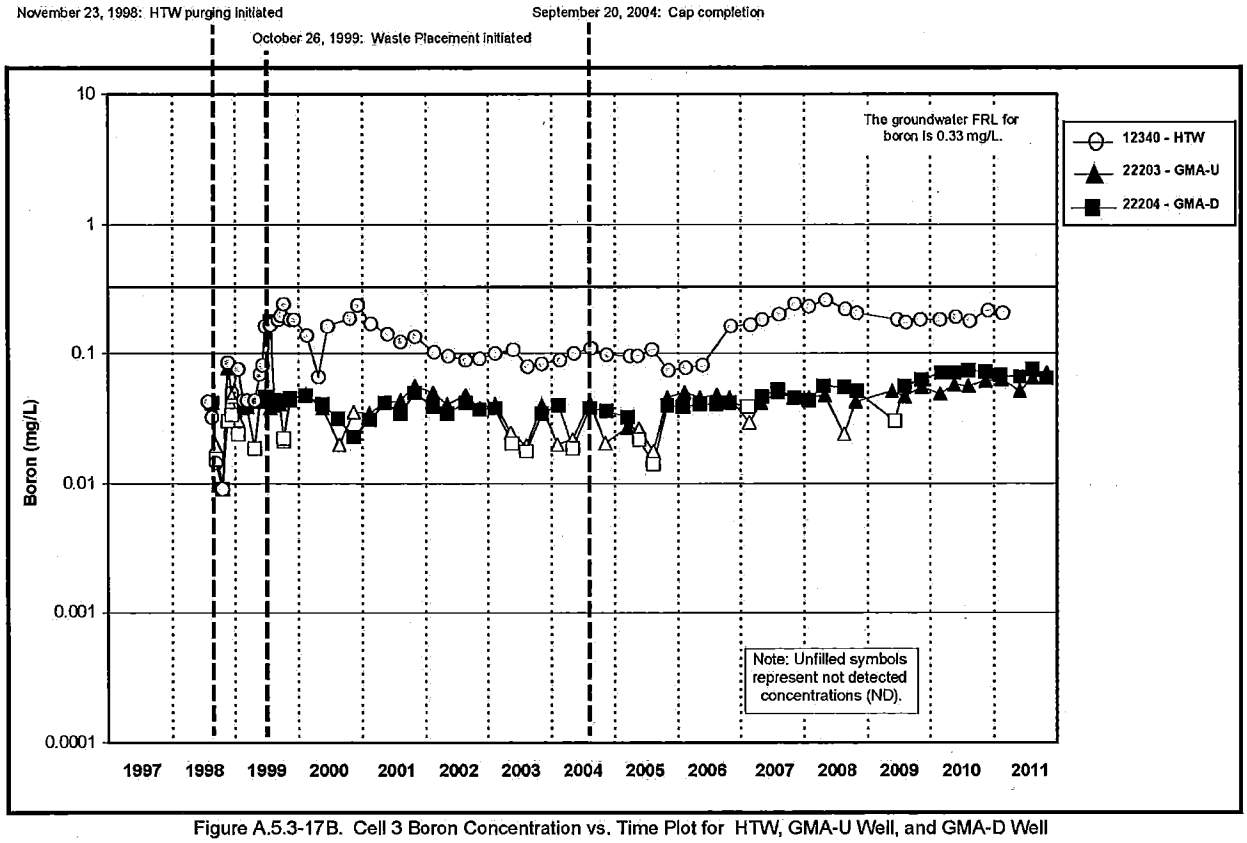


Figure A.5.3-17B. Cell 3 Boron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

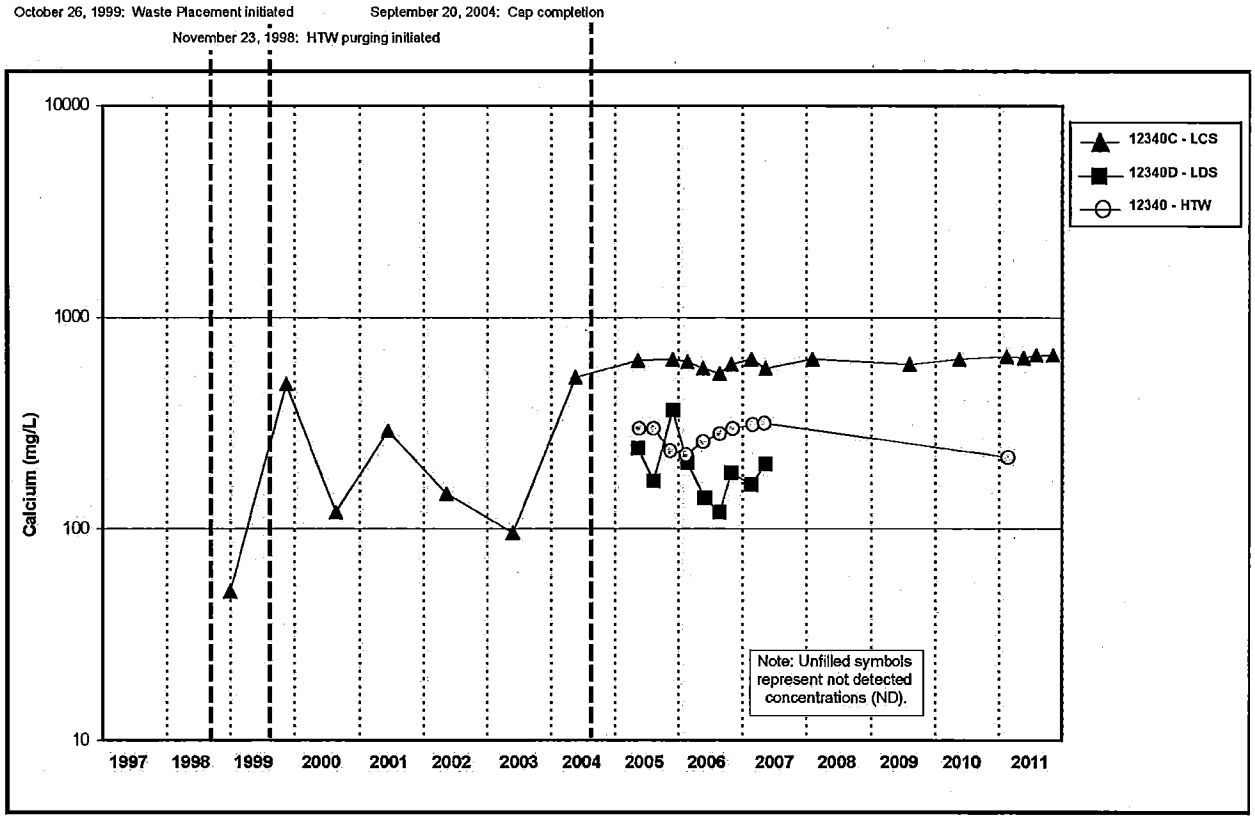


Figure A.5.3-18A. Cell 3 Calcium Concentration vs. Time Plot for LCS, LDS, and HTW

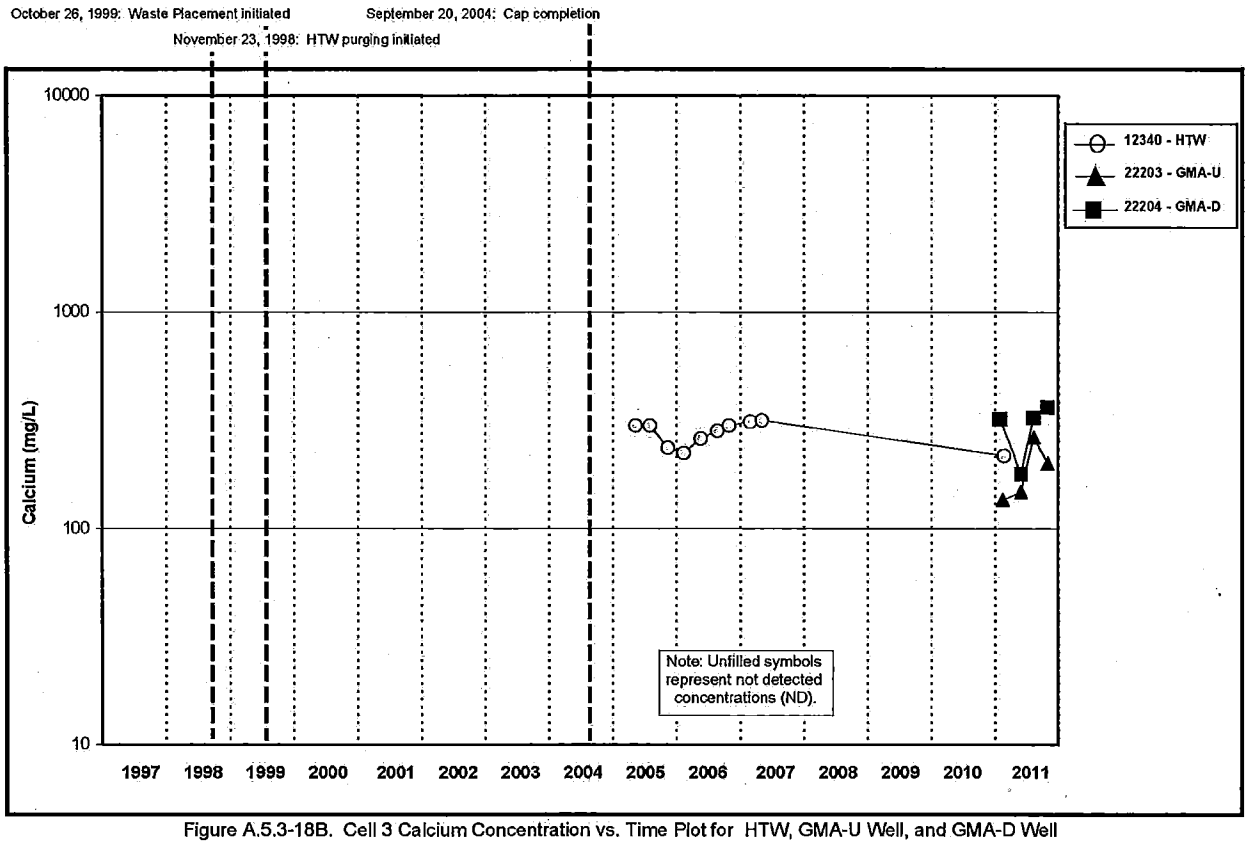


Figure A.5.3-18B. Cell 3 Calcium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

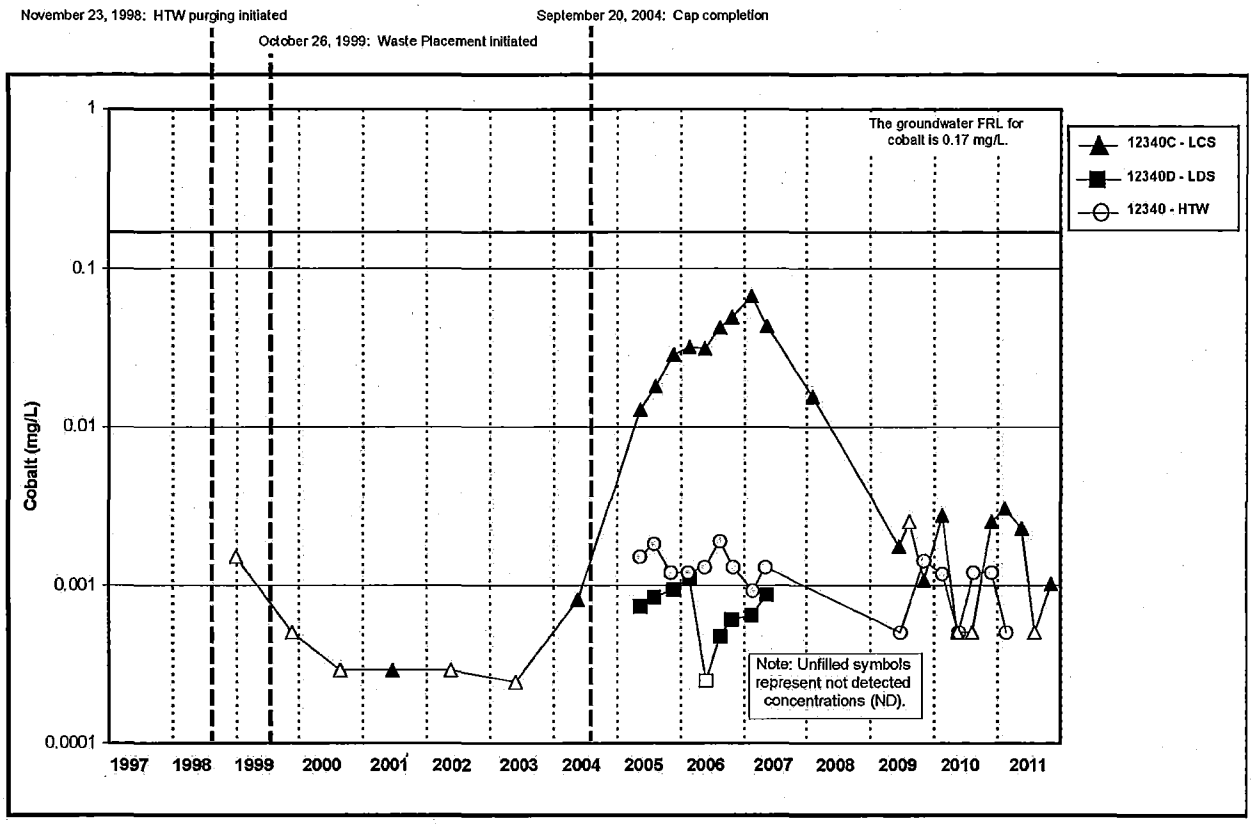


Figure A.5.3-19A. Cell 3 Cobalt Concentration vs. Time Plot for LCS, LDS, and HTW

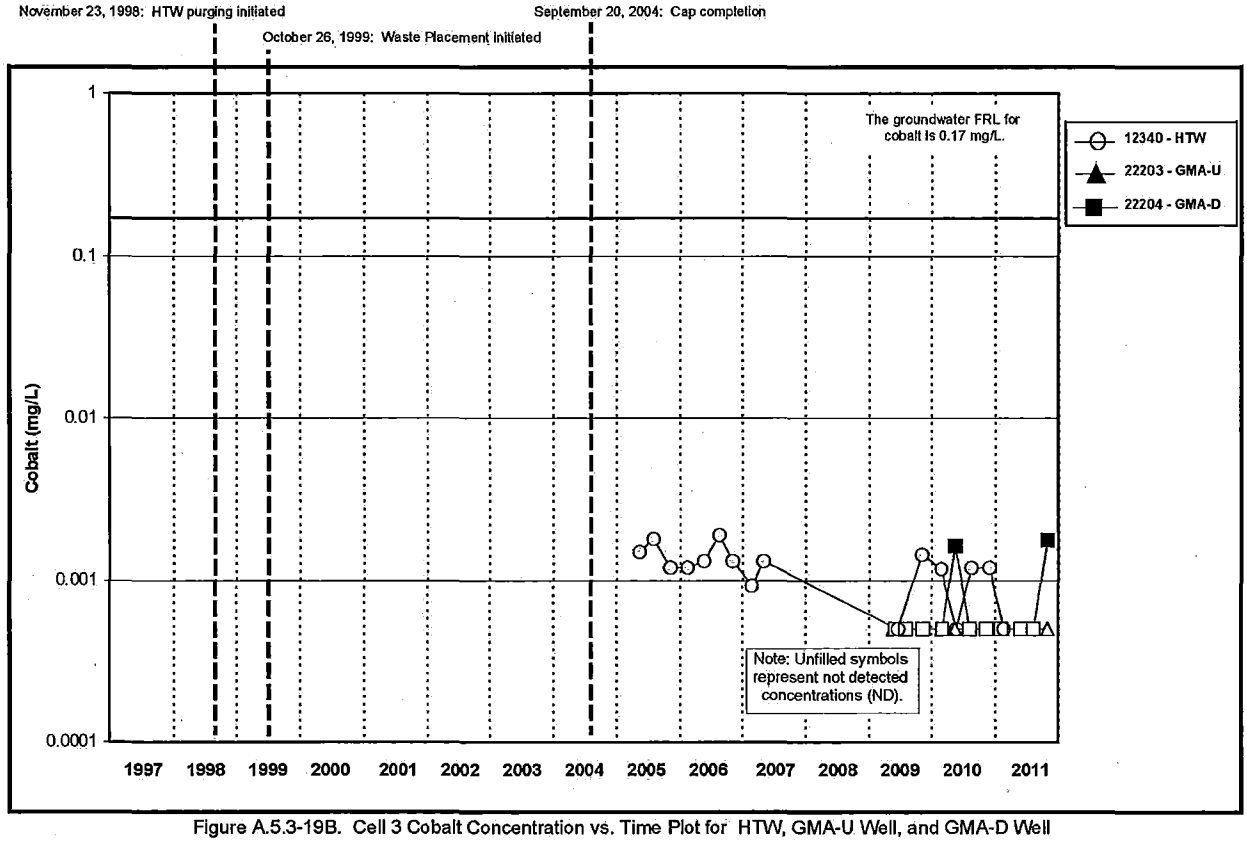


Figure A.5.3-19B. Cell 3 Cobalt Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

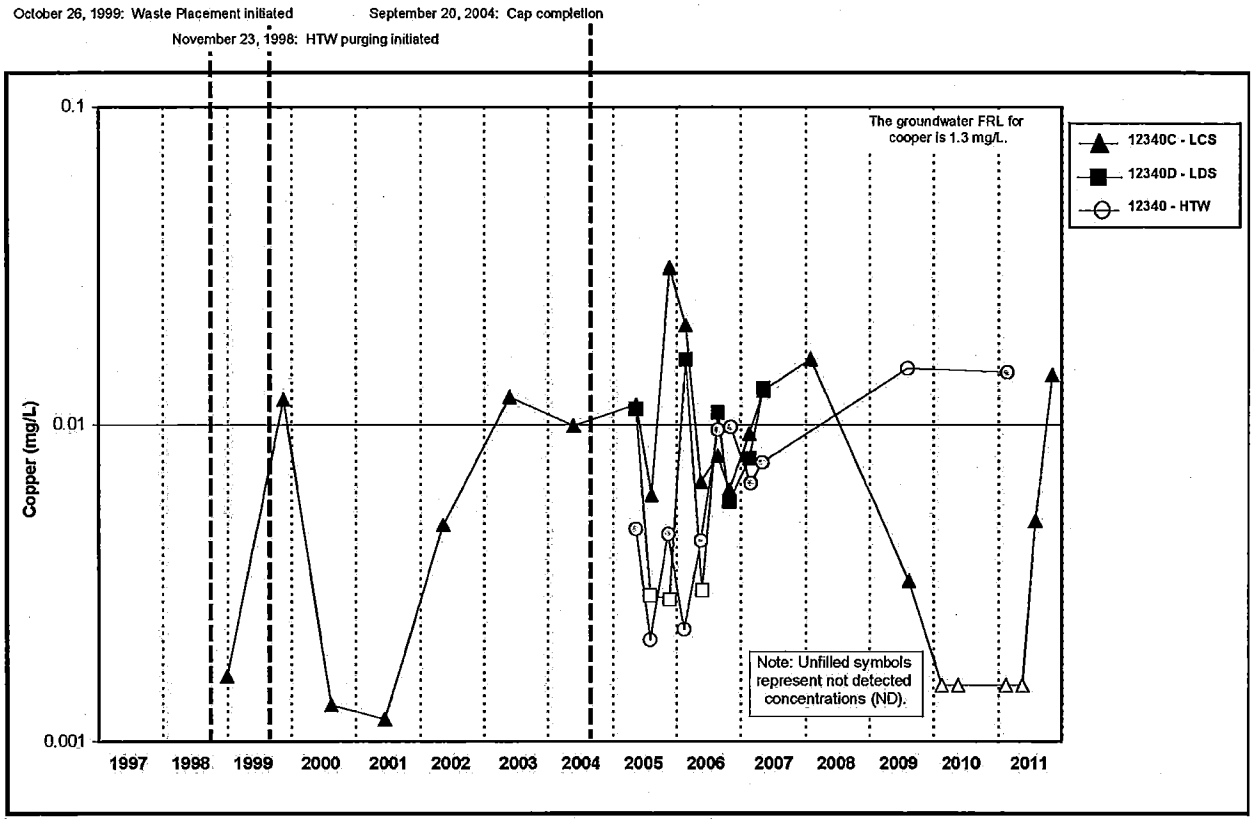


Figure A.5.3-20A. Cell 3 Copper Concentration vs. Time Plot for LCS, LDS, and HTW

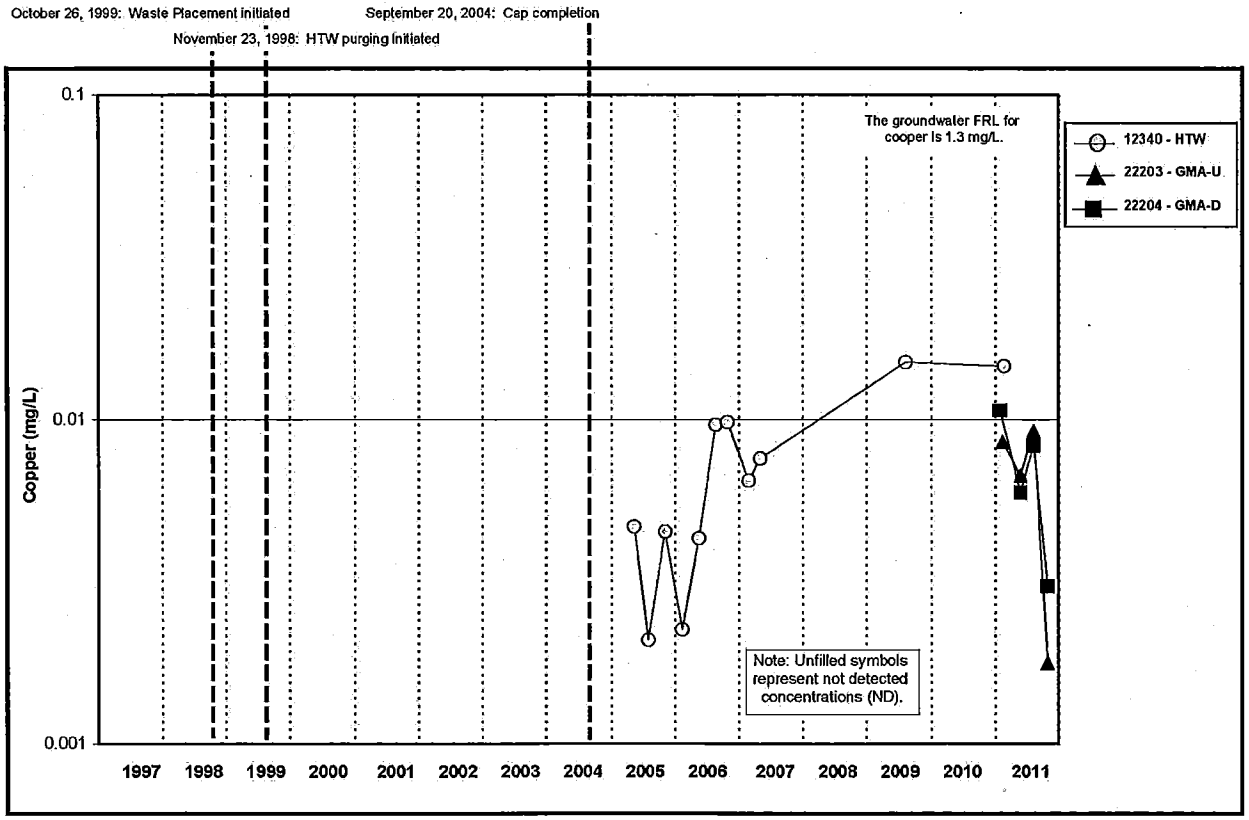


Figure A.5.3-20B. Cell 3 Copper Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

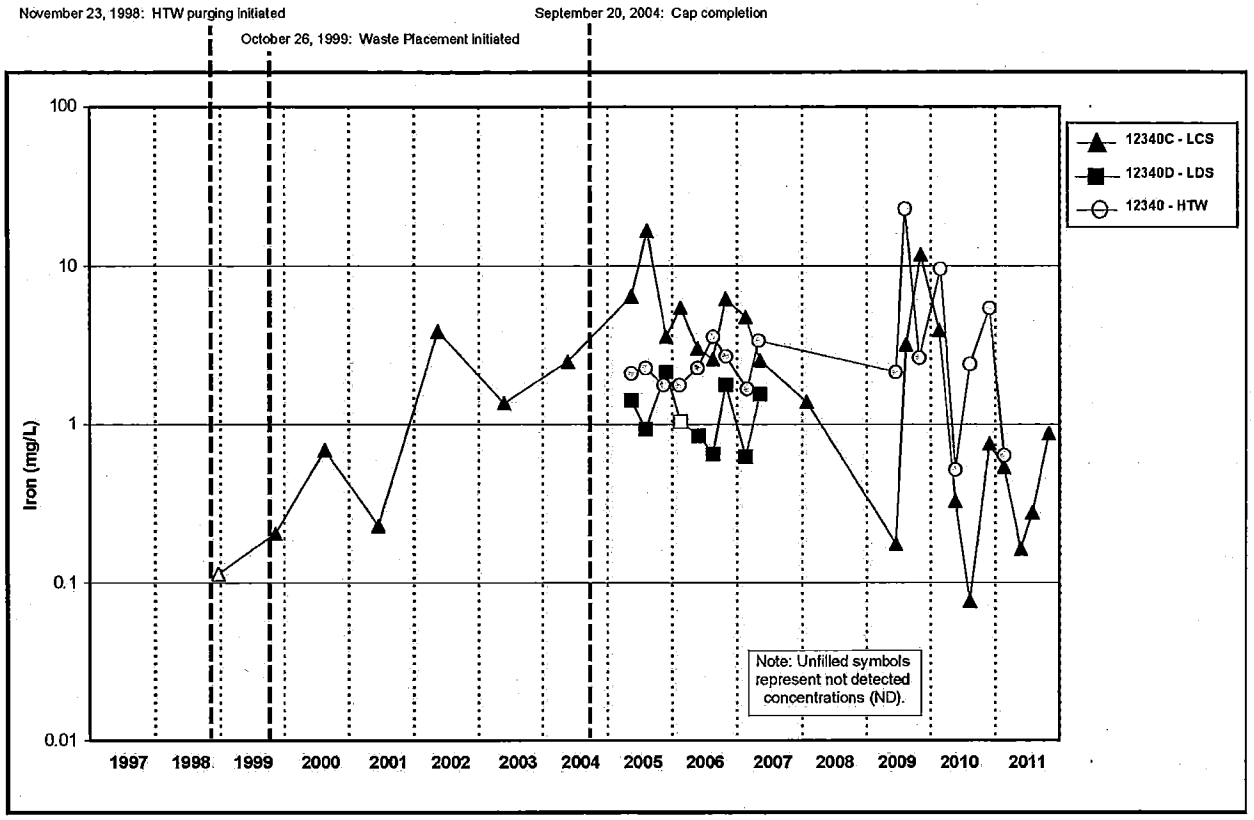


Figure A.5.3-21A. Cell 3 Iron Concentration vs. Time Plot for LCS, LDS, and HTW

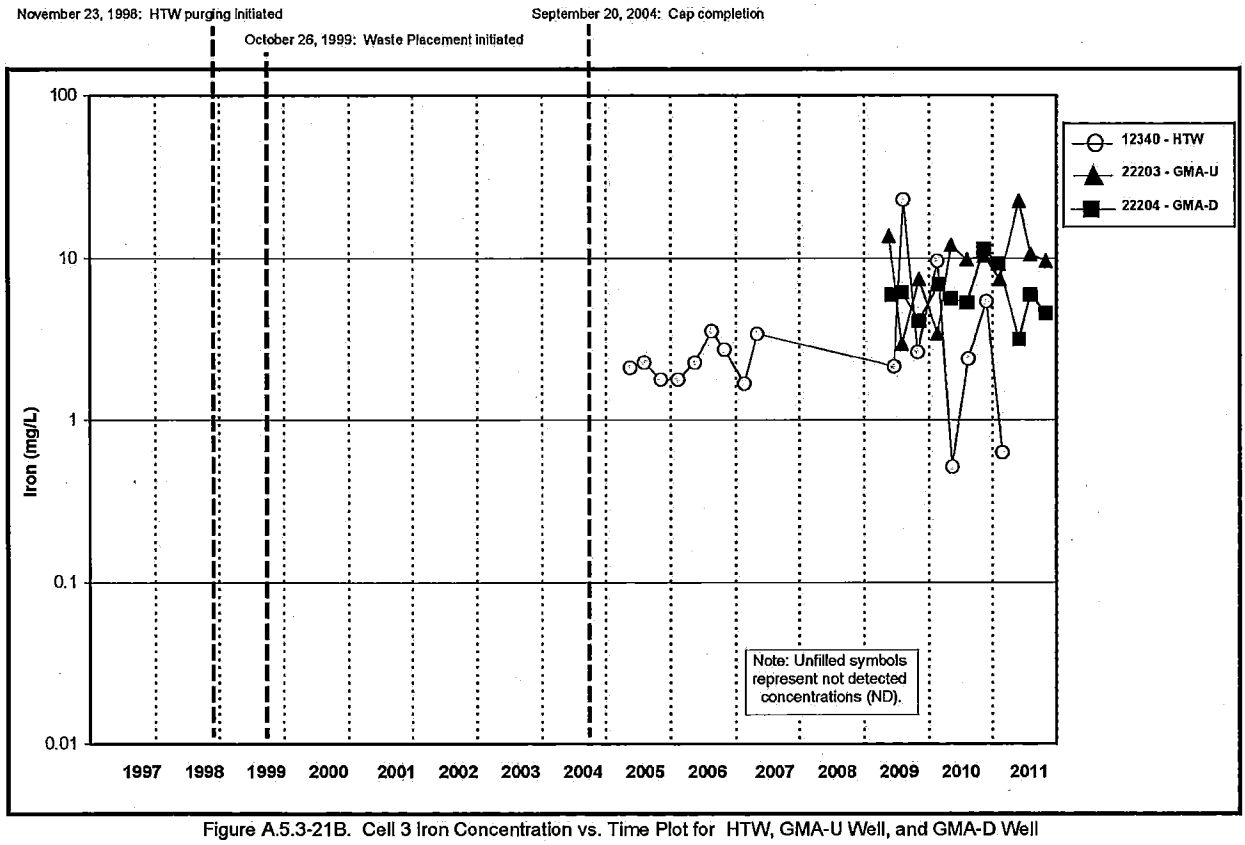


Figure A.5.3-21B. Cell 3 Iron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

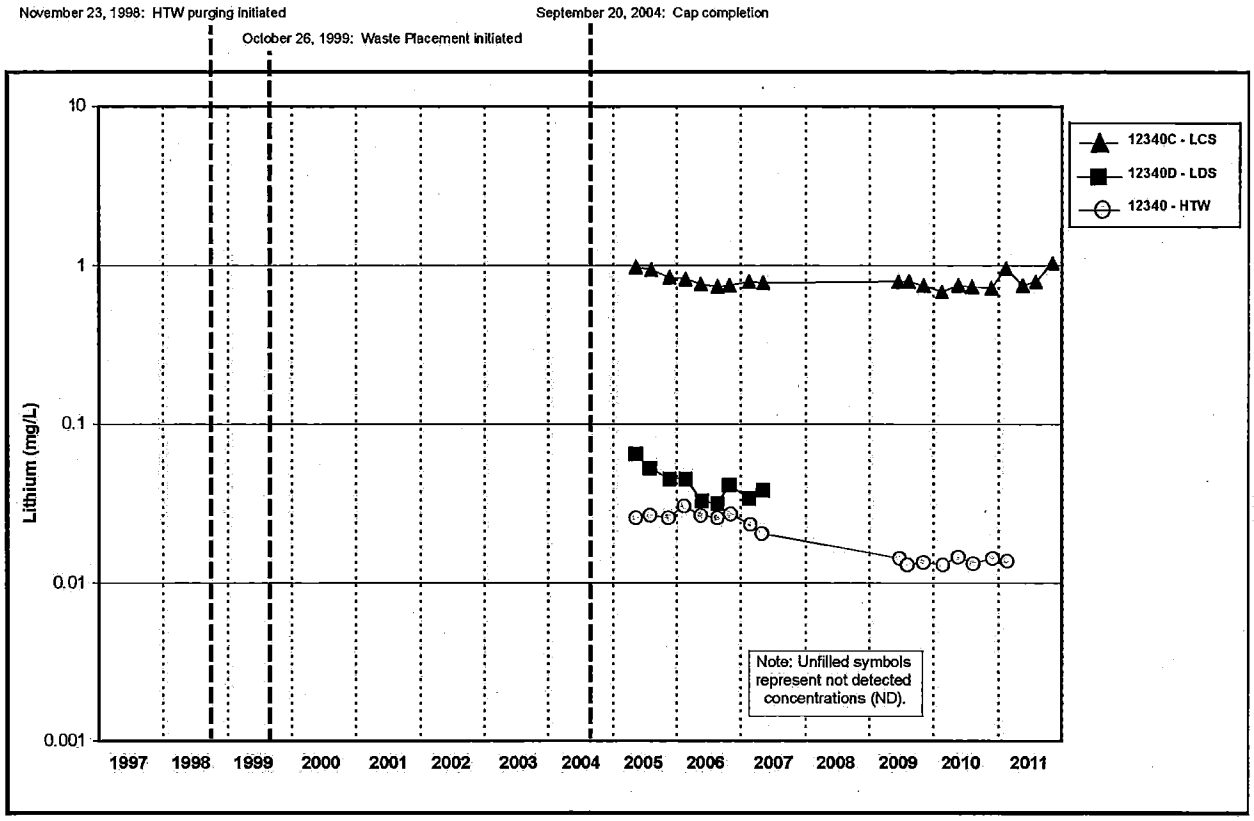


Figure A.5.3-22A. Cell 3 Lithium Concentration vs. Time Plot for LCS, LDS, and HTW

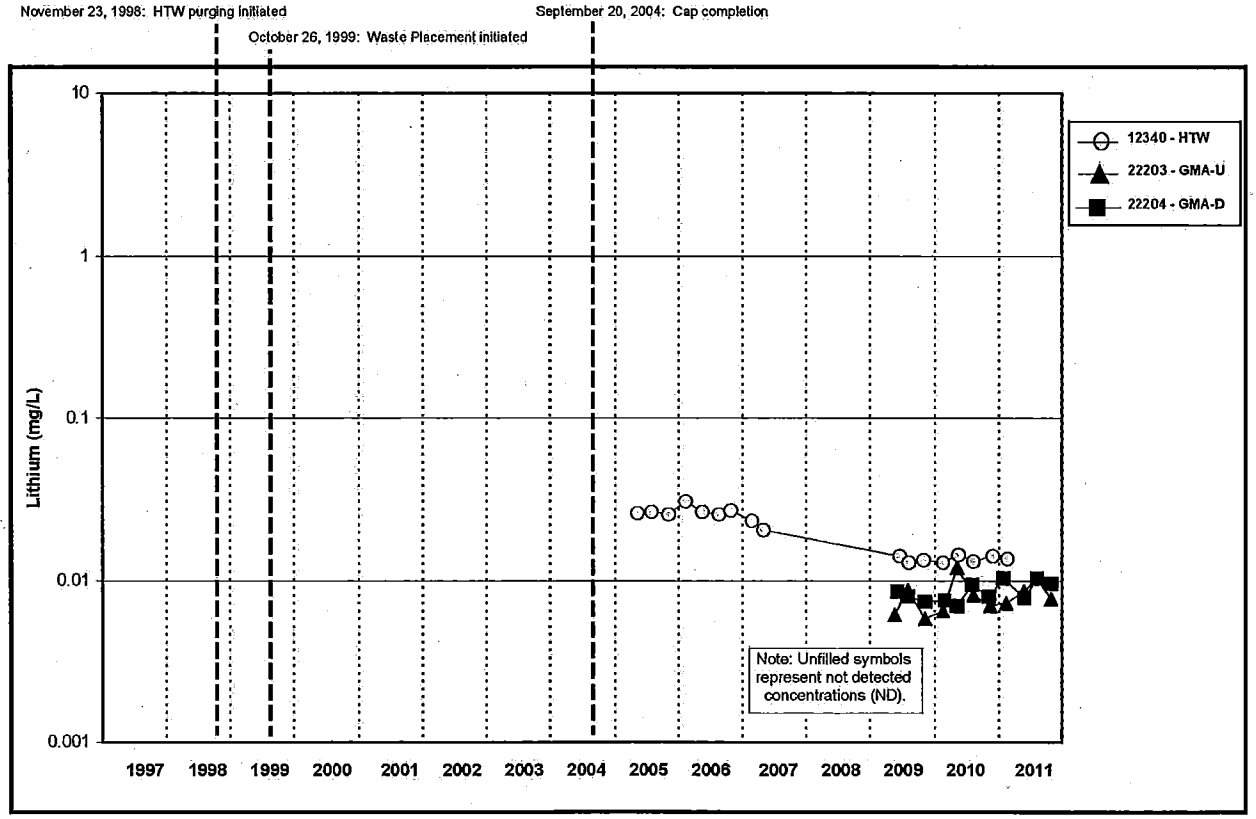


Figure A.5.3-22B. Cell 3 Lithium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

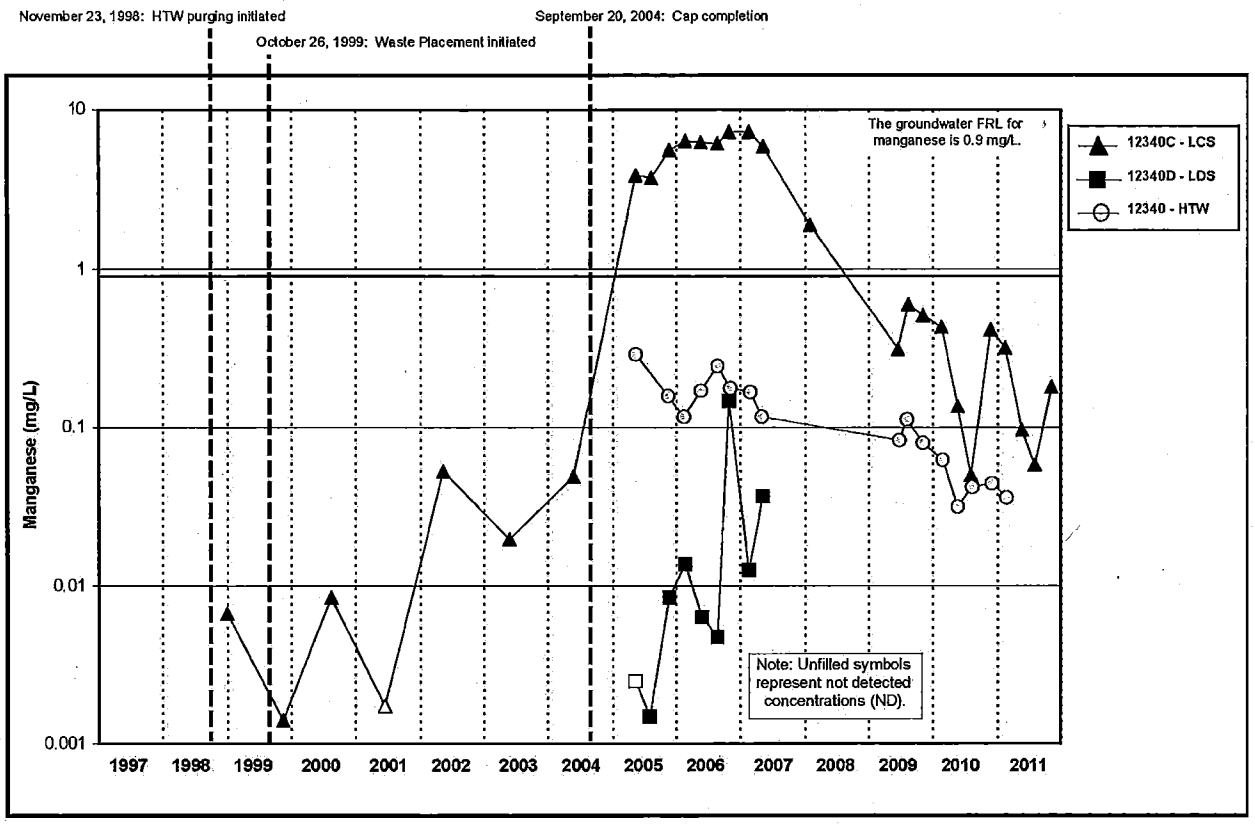


Figure A.5.3-23A. Cell 3 Manganese Concentration vs. Time Plot for LCS, LDS, and HTW

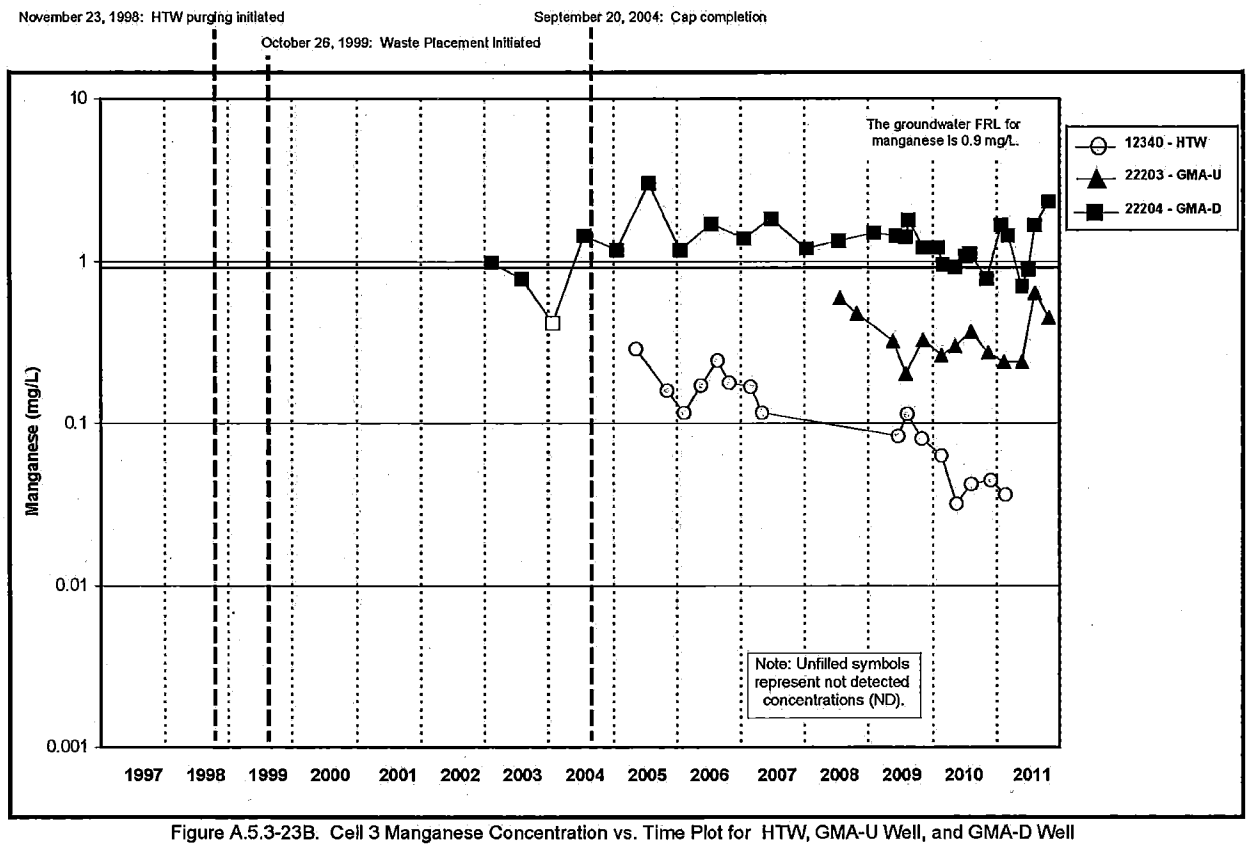


Figure A.5.3-23B. Cell 3 Manganese Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

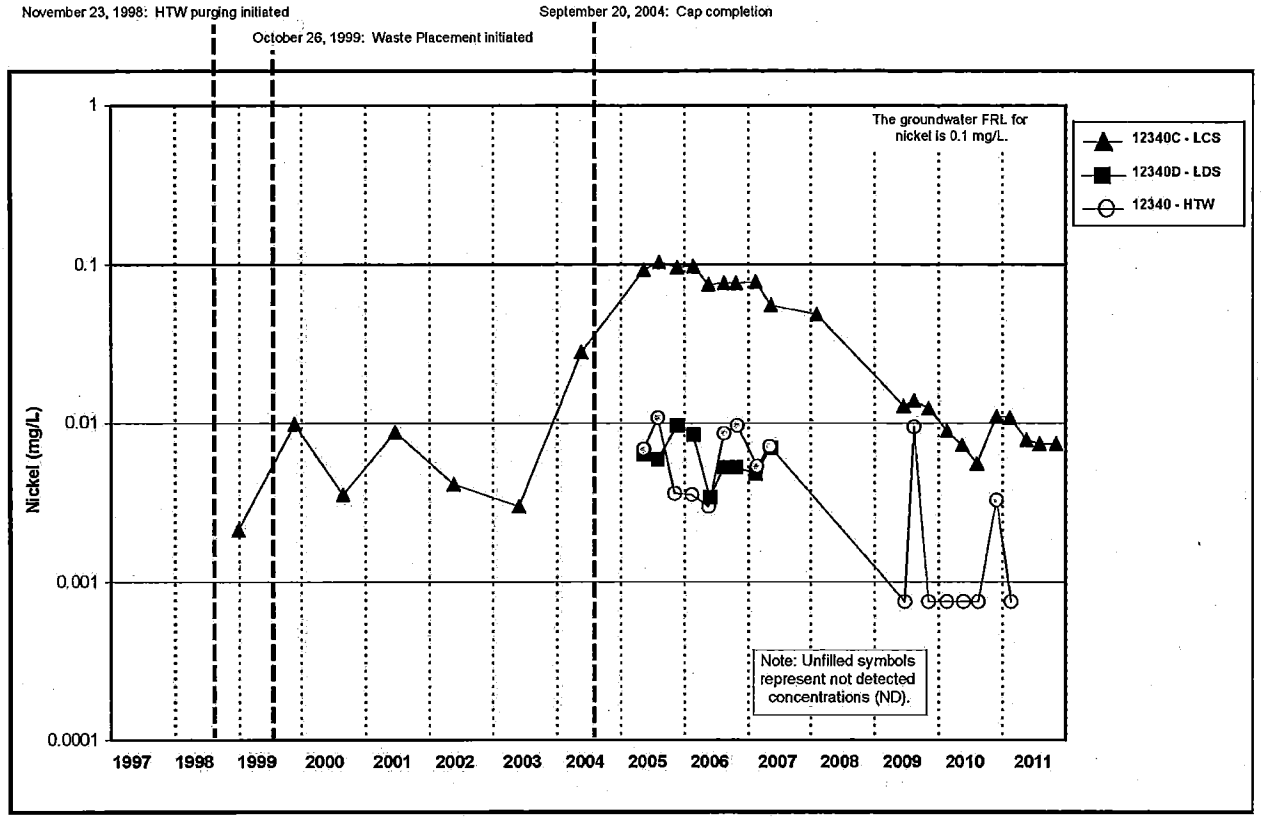


Figure A.5.3-24A. Cell 3 Nickel Concentration vs. Time Plot for LCS, LDS, and HTW

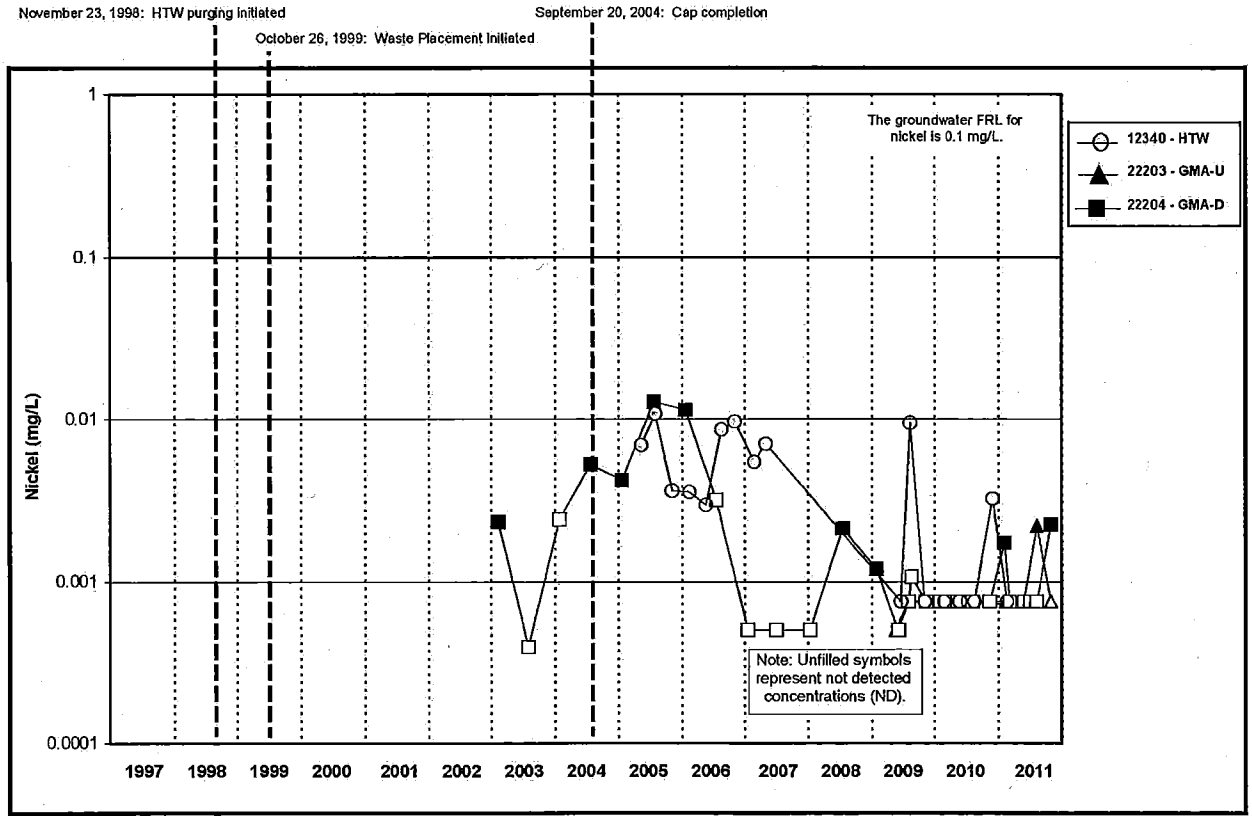


Figure A.5.3-24B. Cell 3 Nickel Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

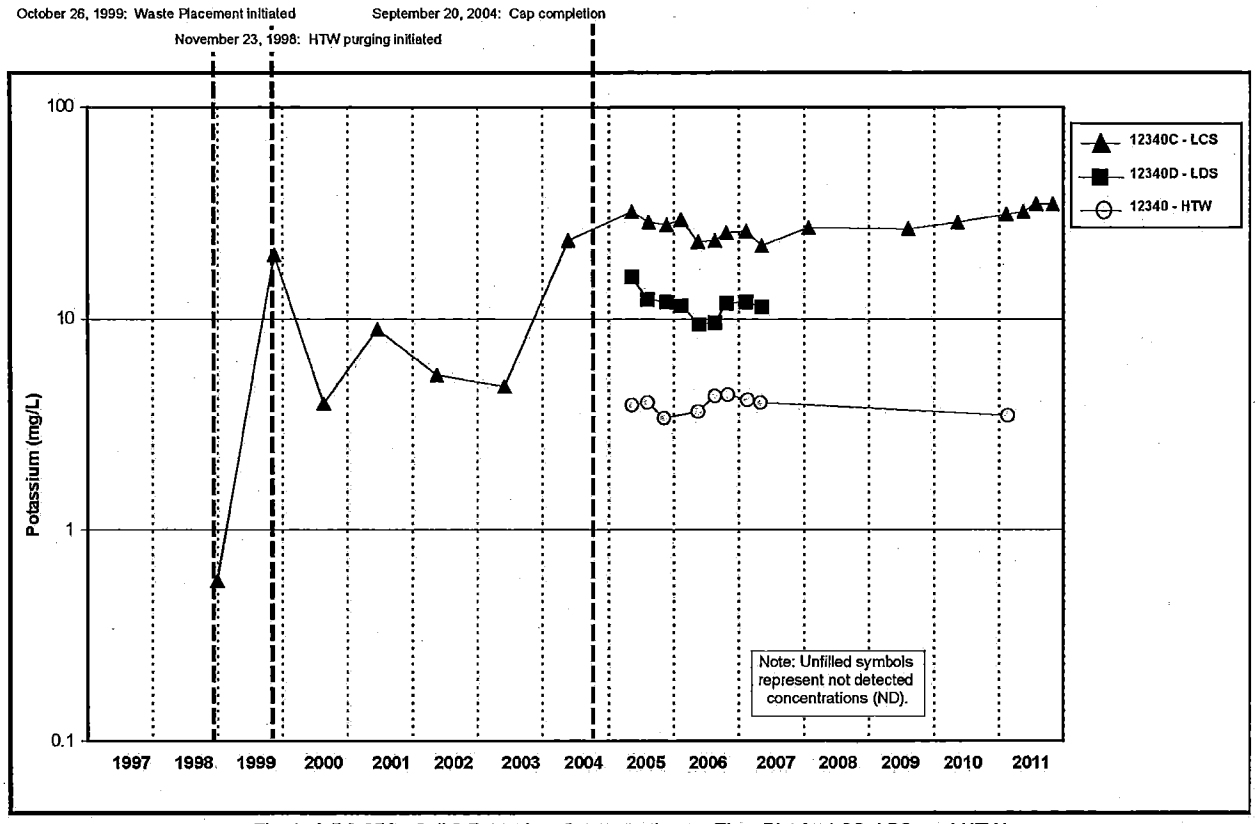


Figure A.5.3-25A. Cell 3 Potassium Concentration vs. Time Plot for LCS, LDS, and HTW

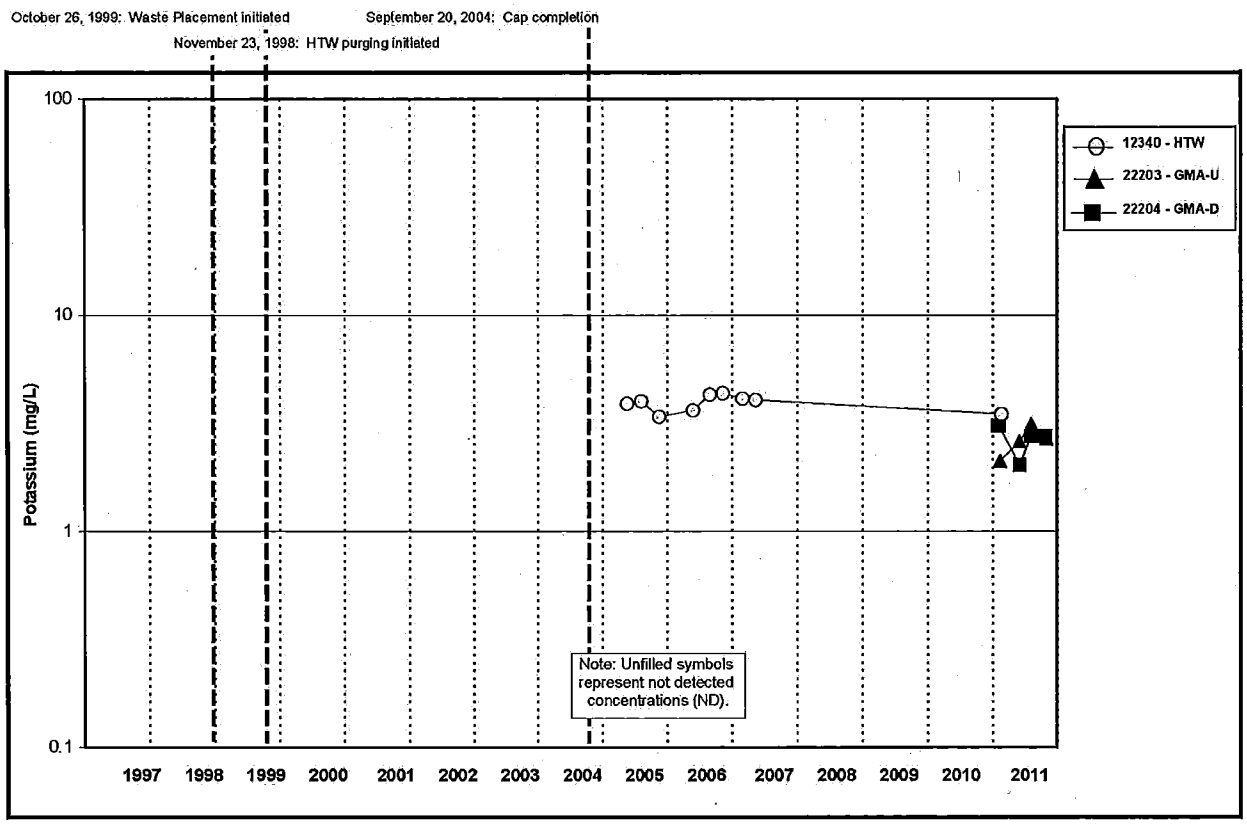


Figure A.5.3-25B. Cell 3 Potassium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

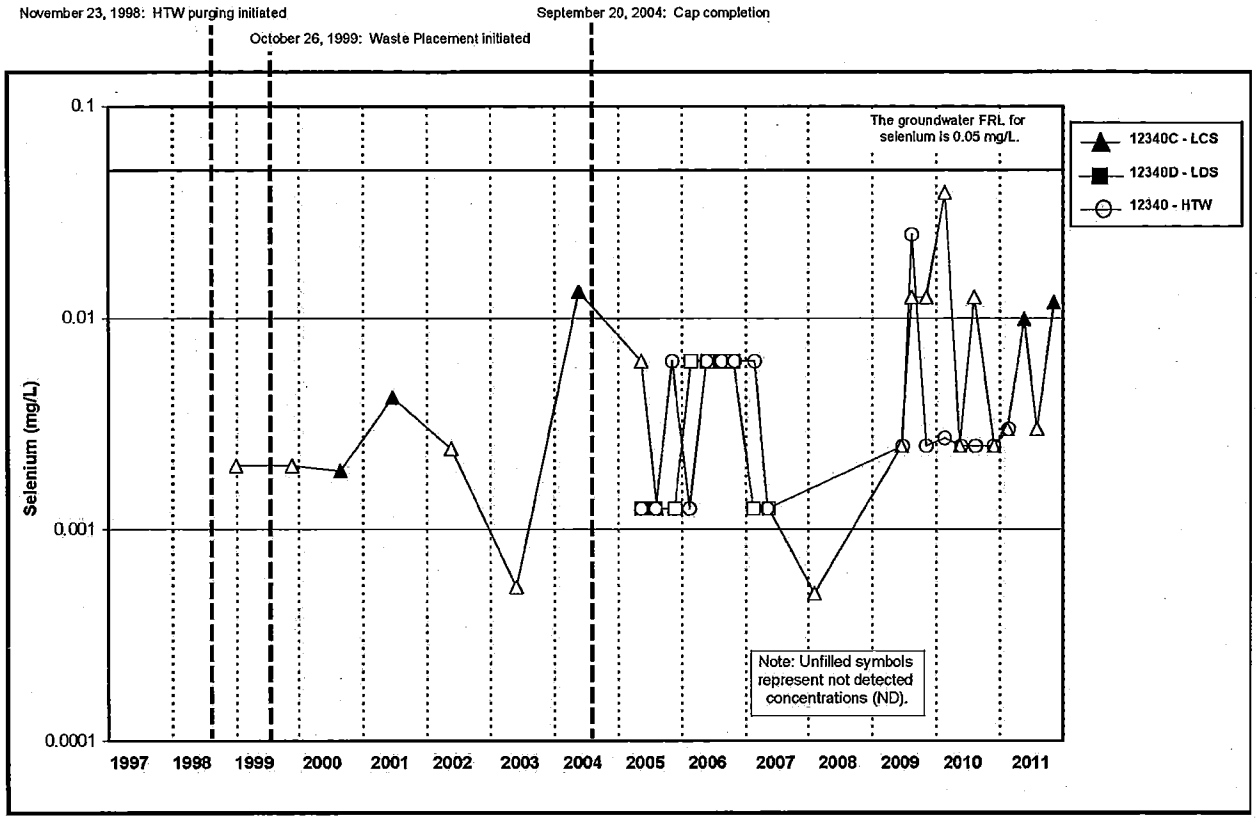


Figure A.5.3-26A. Cell 3 Selenium Concentration vs. Time Plot for LCS, LDS, and HTW

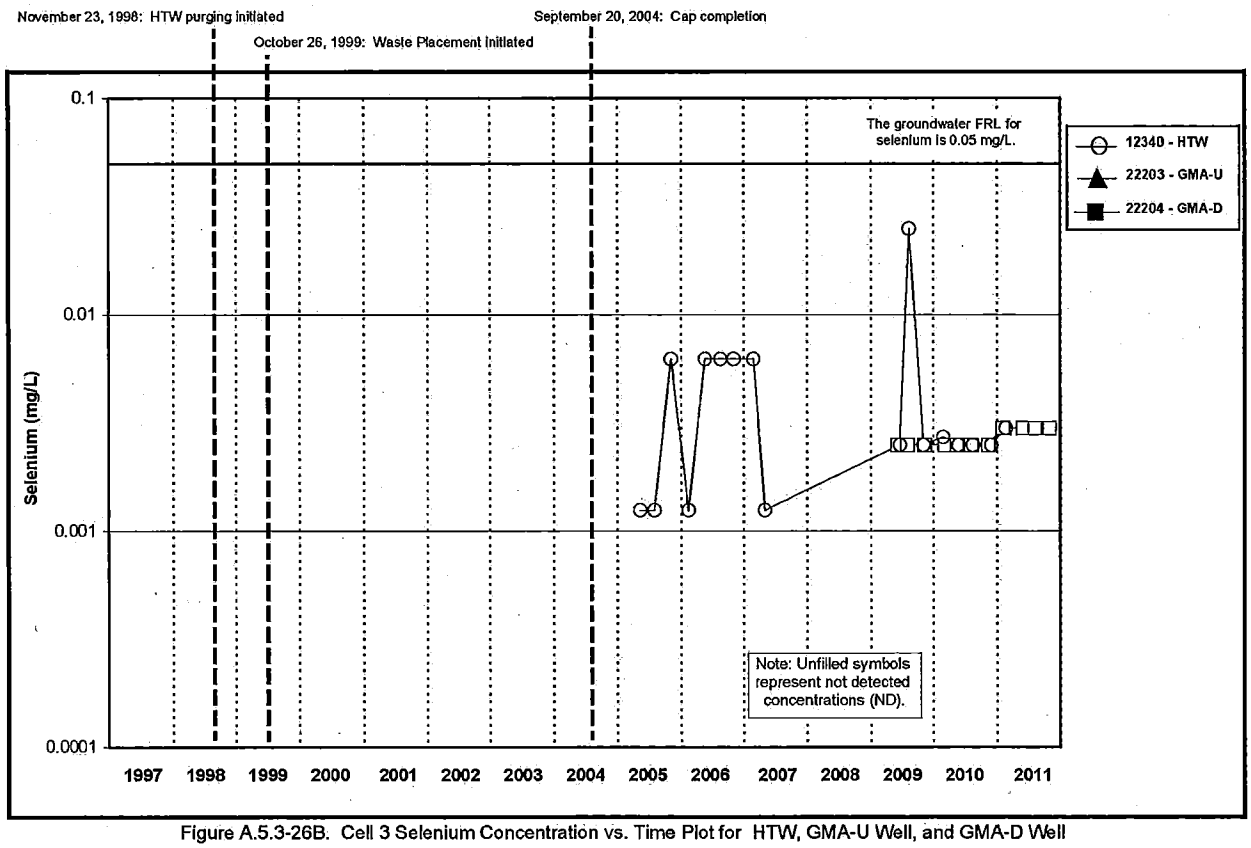


Figure A.5.3-26B. Cell 3 Selenium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

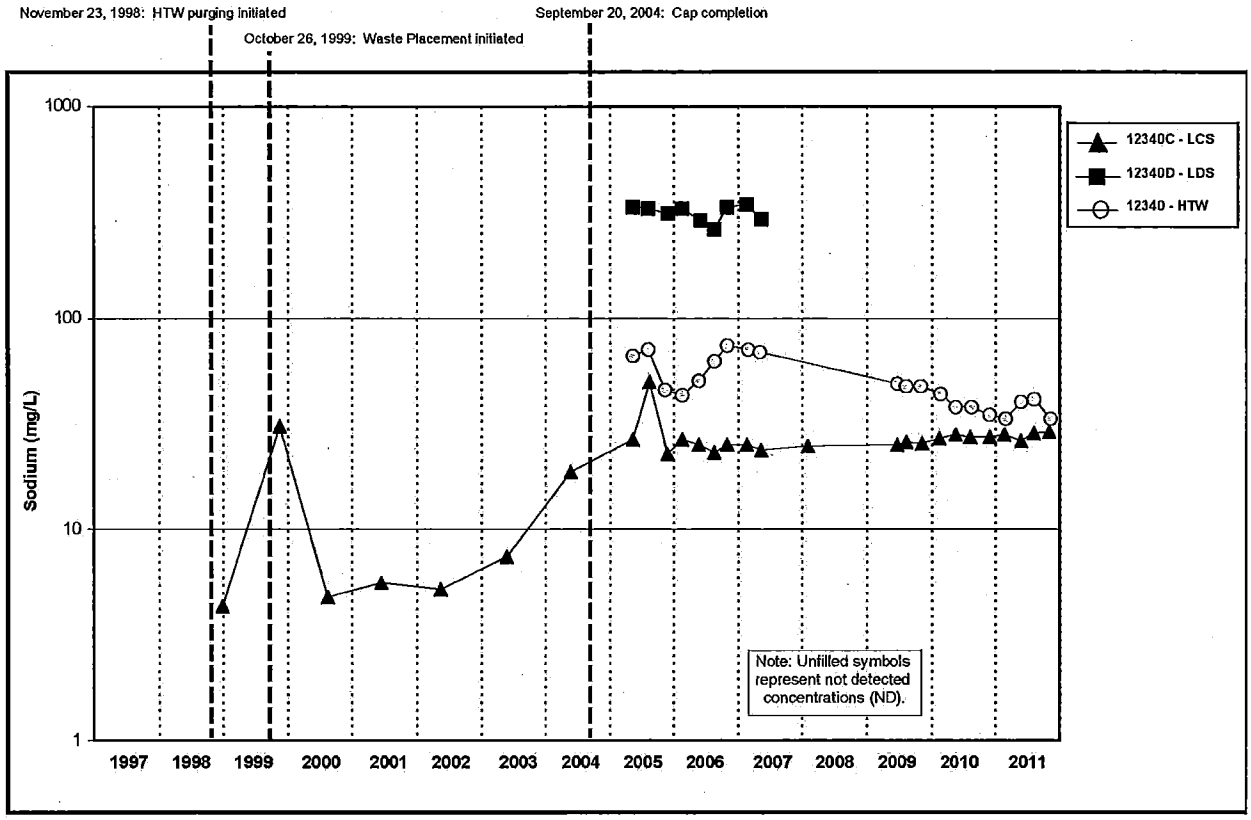


Figure A.5.3-27A. Cell 3 Sodium Concentration vs. Time Plot for LCS, LDS, and HTW

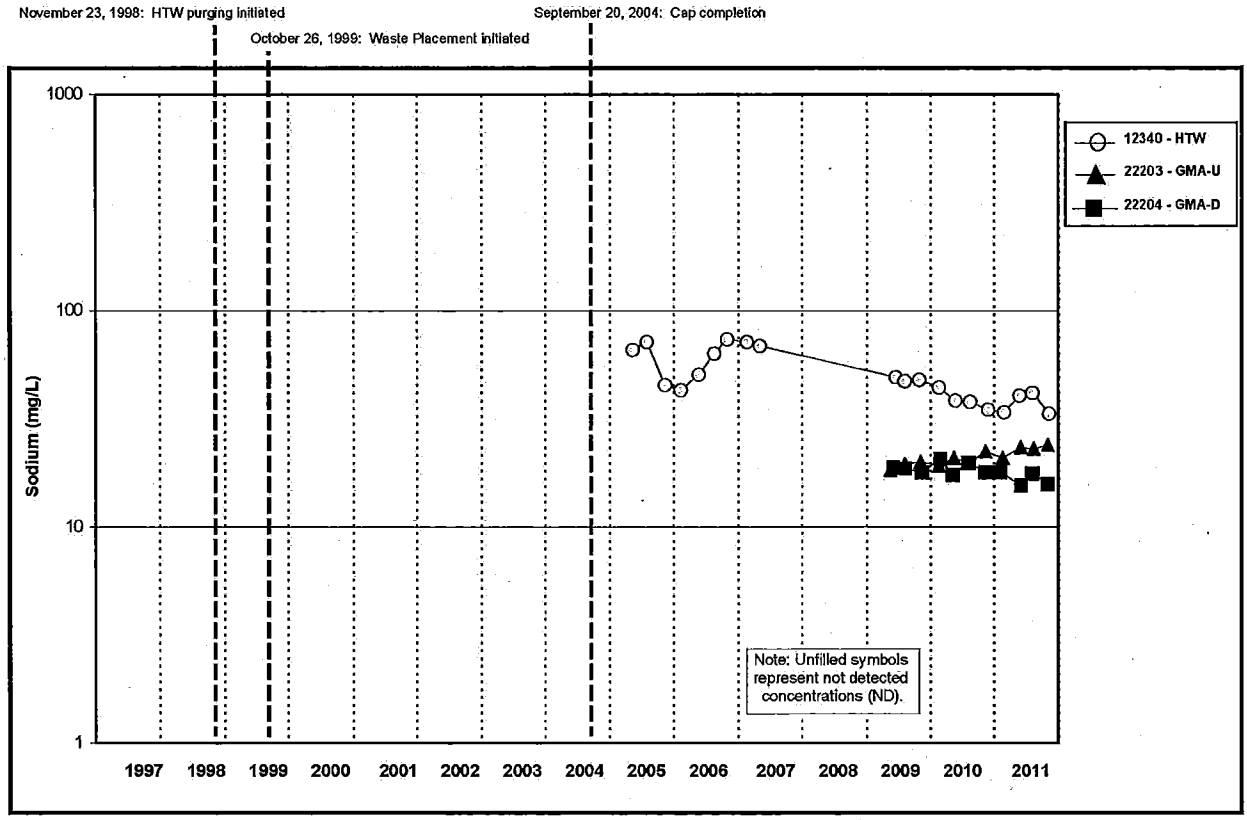


Figure A.5.3-27B. Cell 3 Sodium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

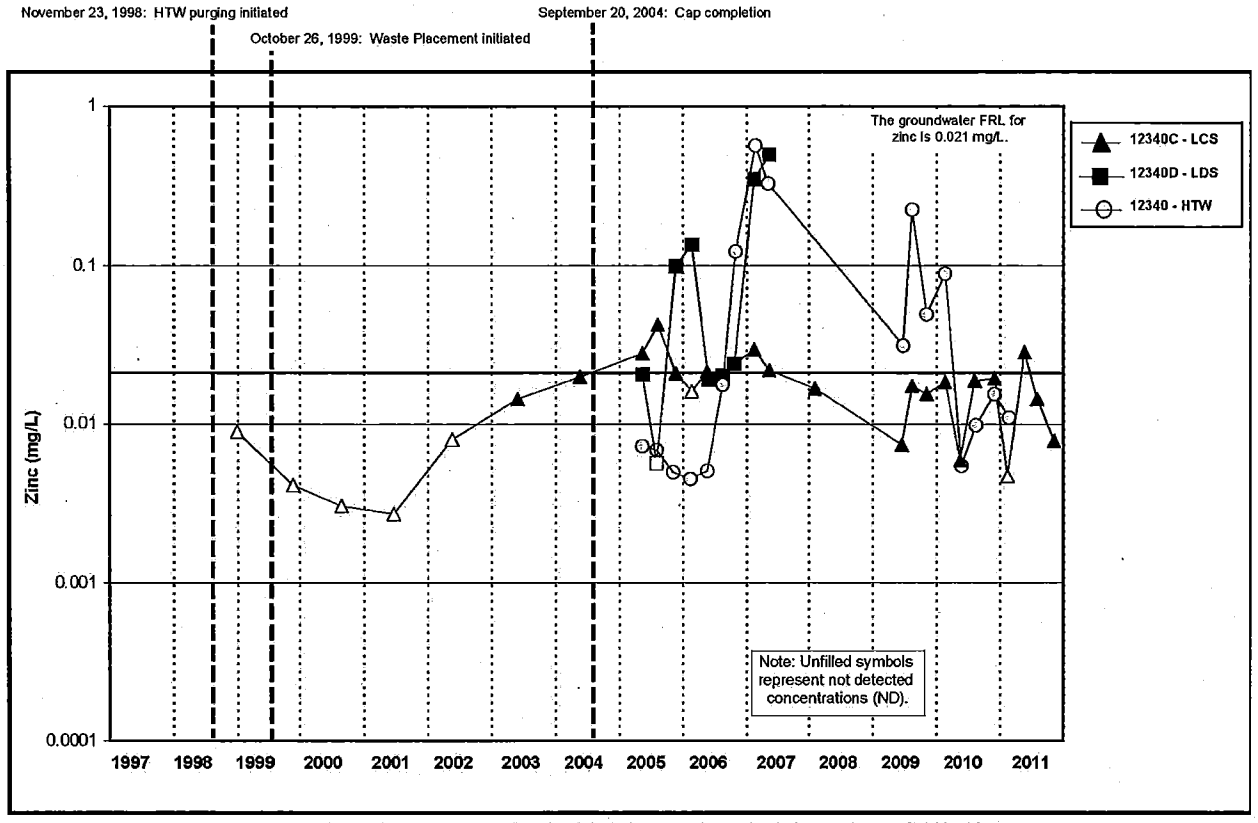


Figure A.5.3-28A. Cell 3 Zinc Concentration vs. Time Plot for LCS, LDS, and HTW

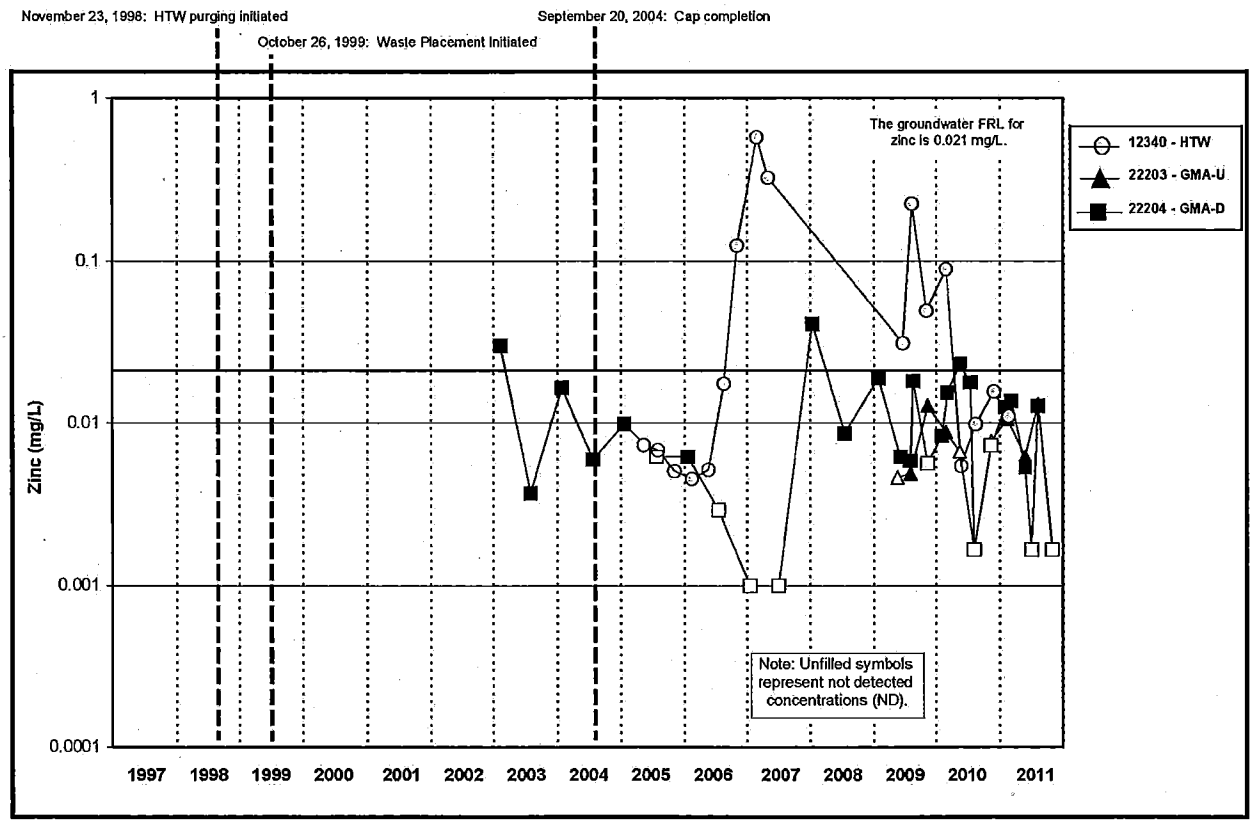


Figure A.5.3-28B. Cell 3 Zinc Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

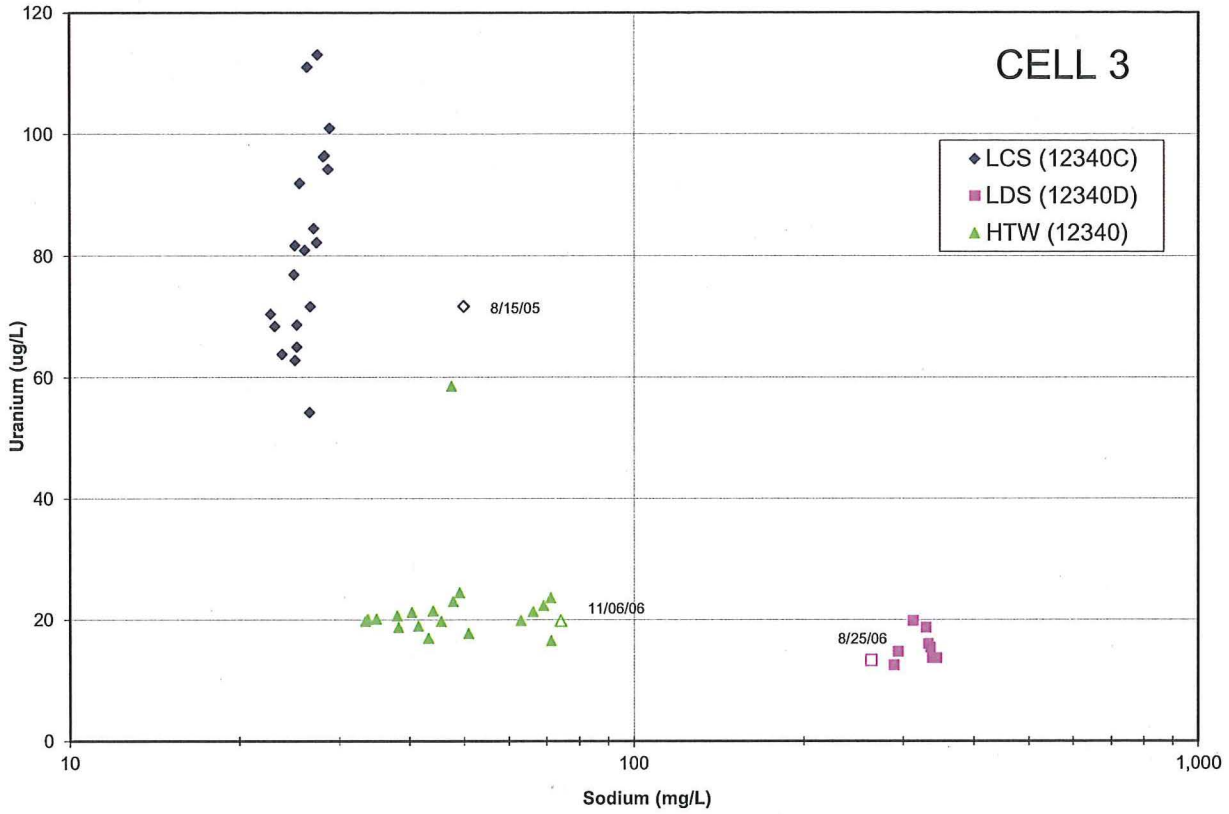


Figure A.5.3–29. Cell 3 Bivariate Plot for Uranium and Sodium

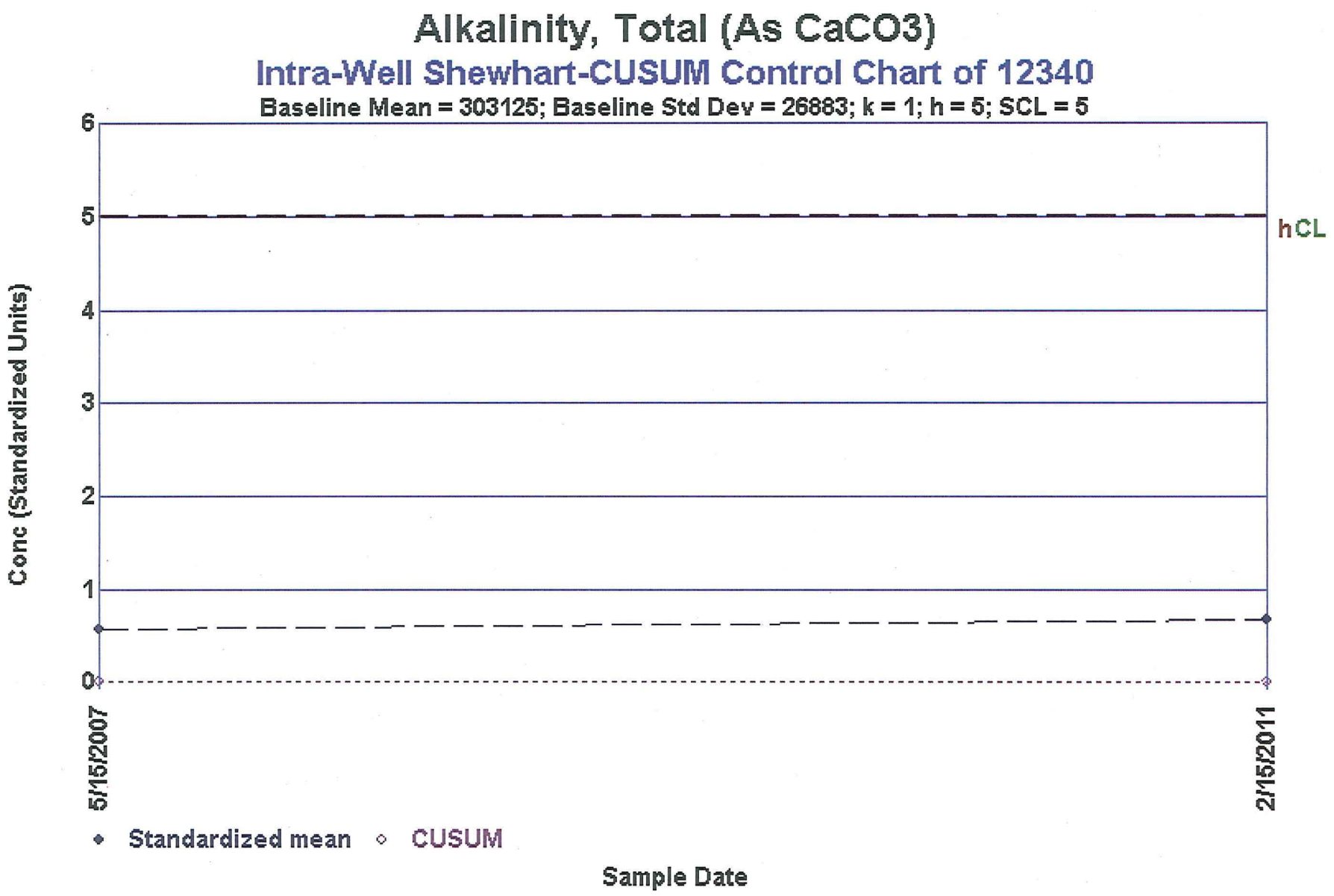


Figure A.5.3−30. Intra-Well Shewhart-CUSUM Control Chart (Alkalinity 12340)

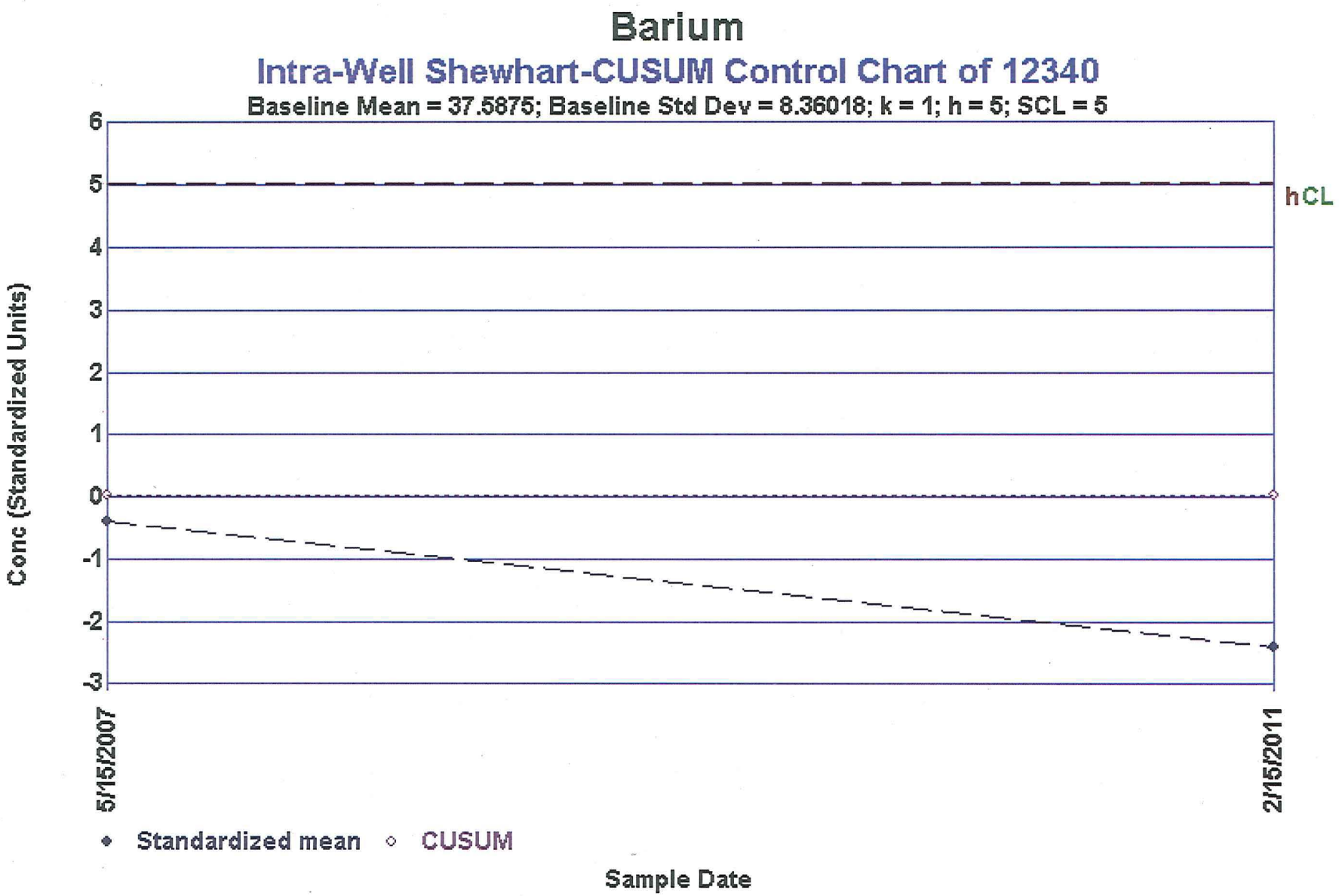


Figure A.5.3−31. Intra-Well Shewhart-CUSUM Control Chart (Barium 12340)

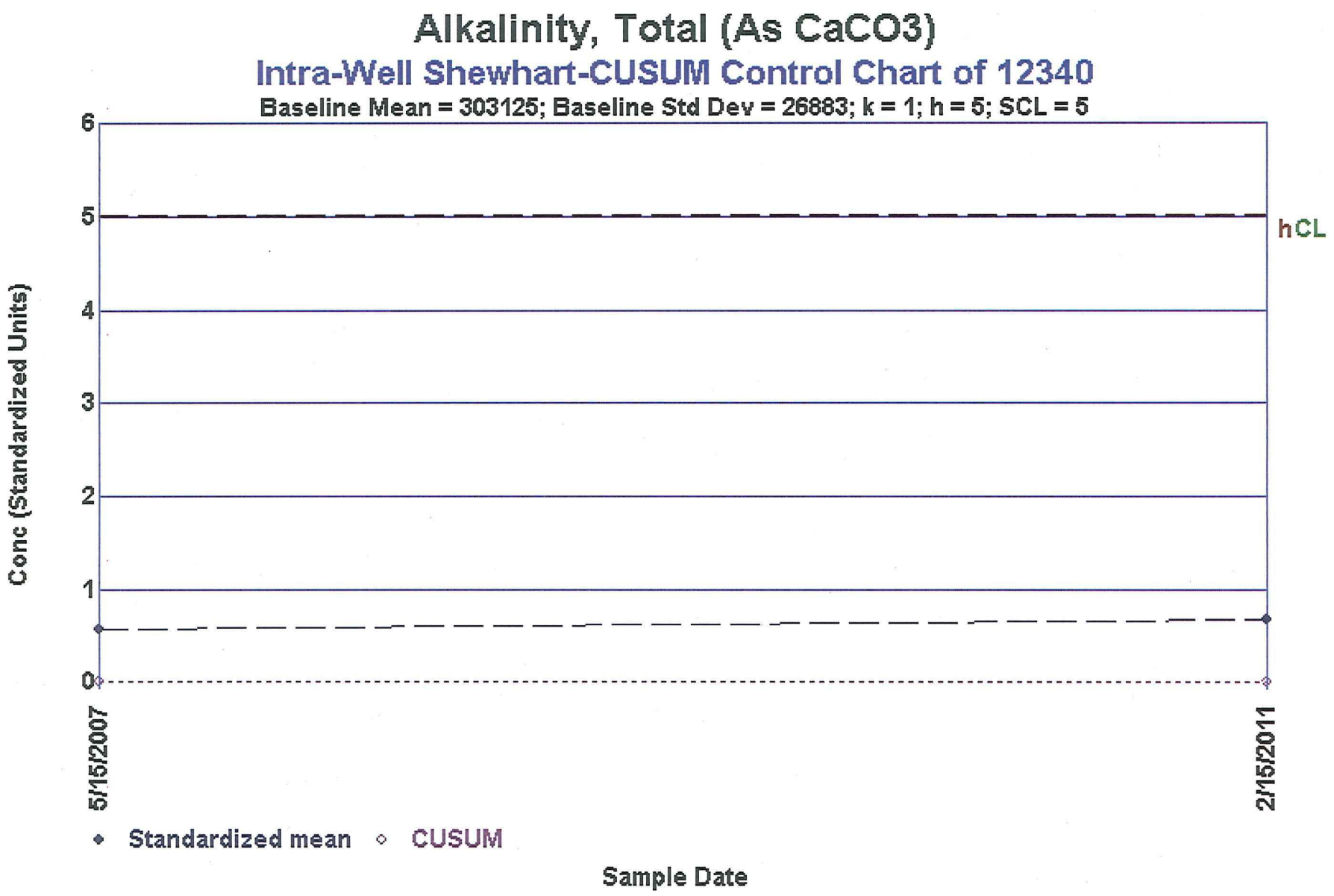


Figure A.5.3−30. Intra-Well Shewhart-CUSUM Control Chart (Alkalinity 12340)

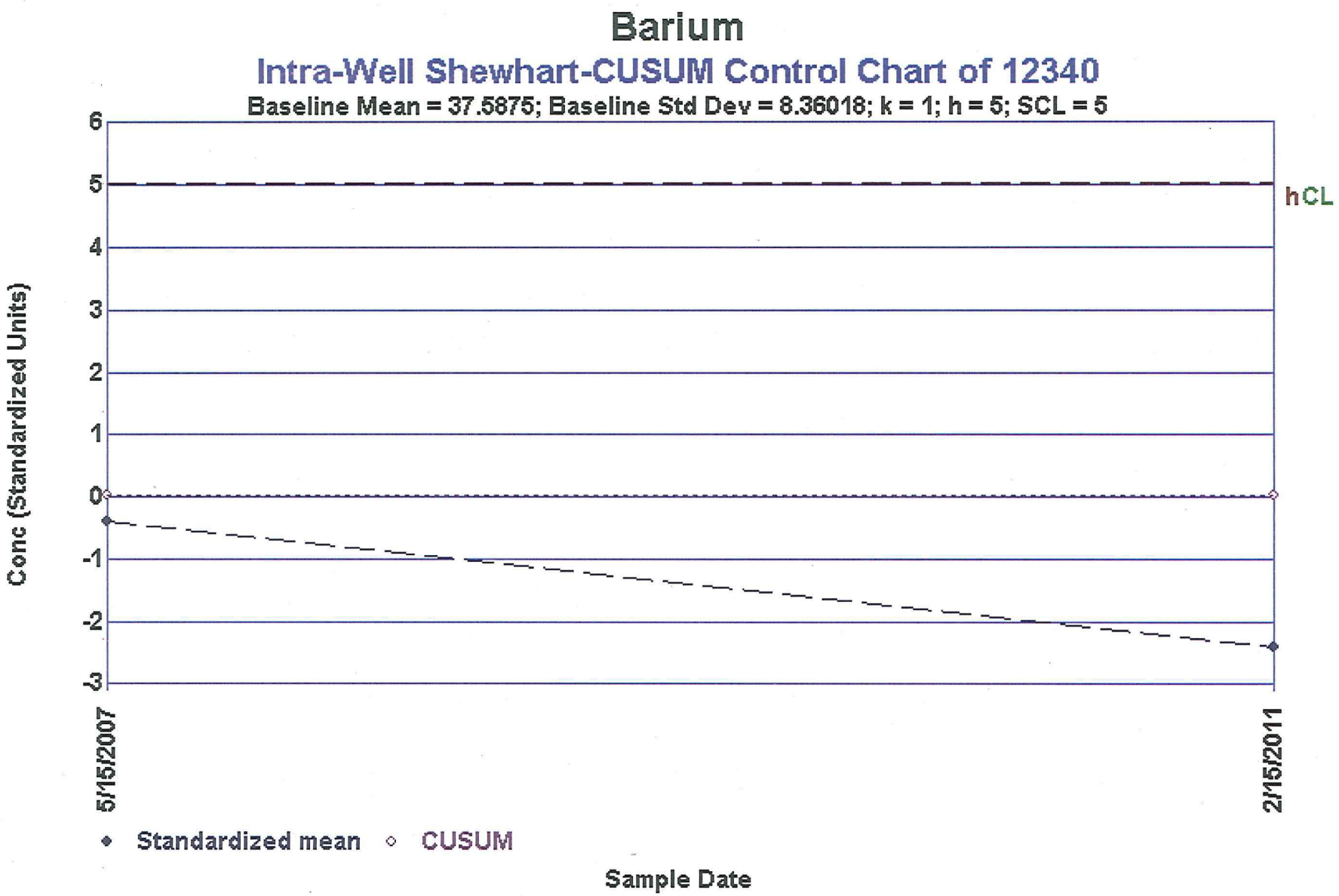


Figure A.5.3−31. Intra-Well Shewhart-CUSUM Control Chart (Barium 12340)

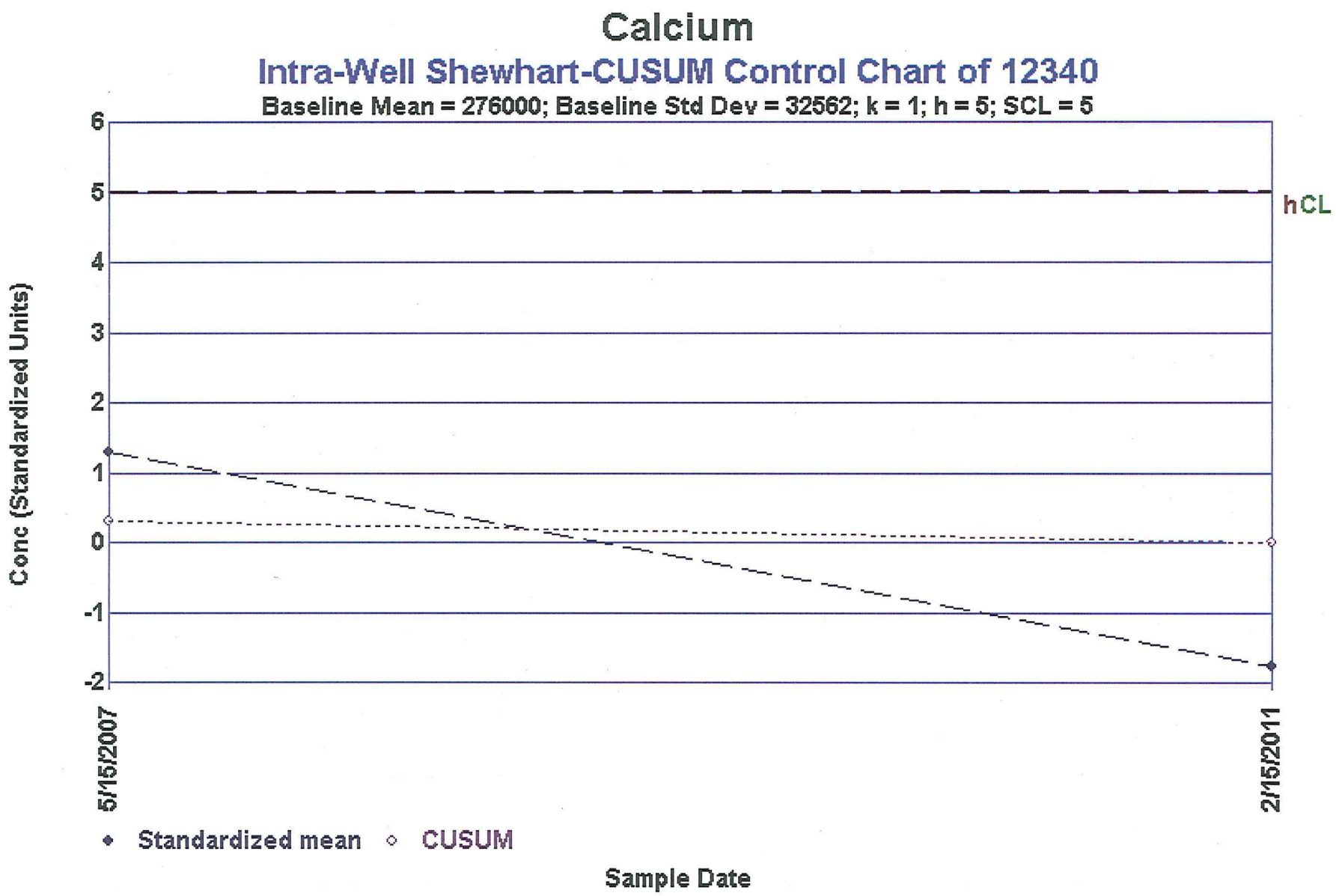


Figure A.5.3–32. Intra-Well Shewhart-CUSUM Control Chart (Calcium 12340)

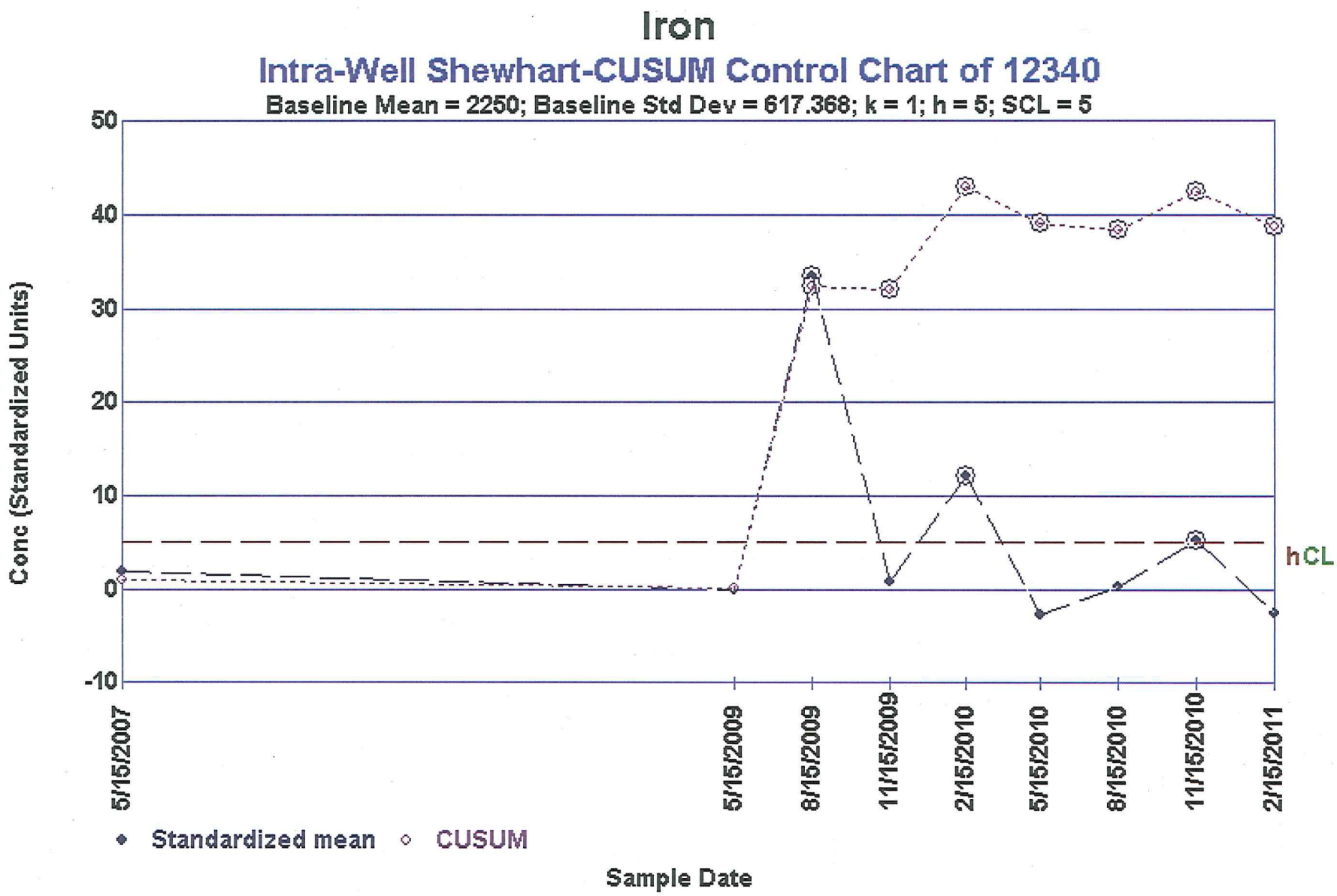


Figure A.5.3−33. Intra-Well Shewhart-CUSUM Control Chart (Iron 12340)

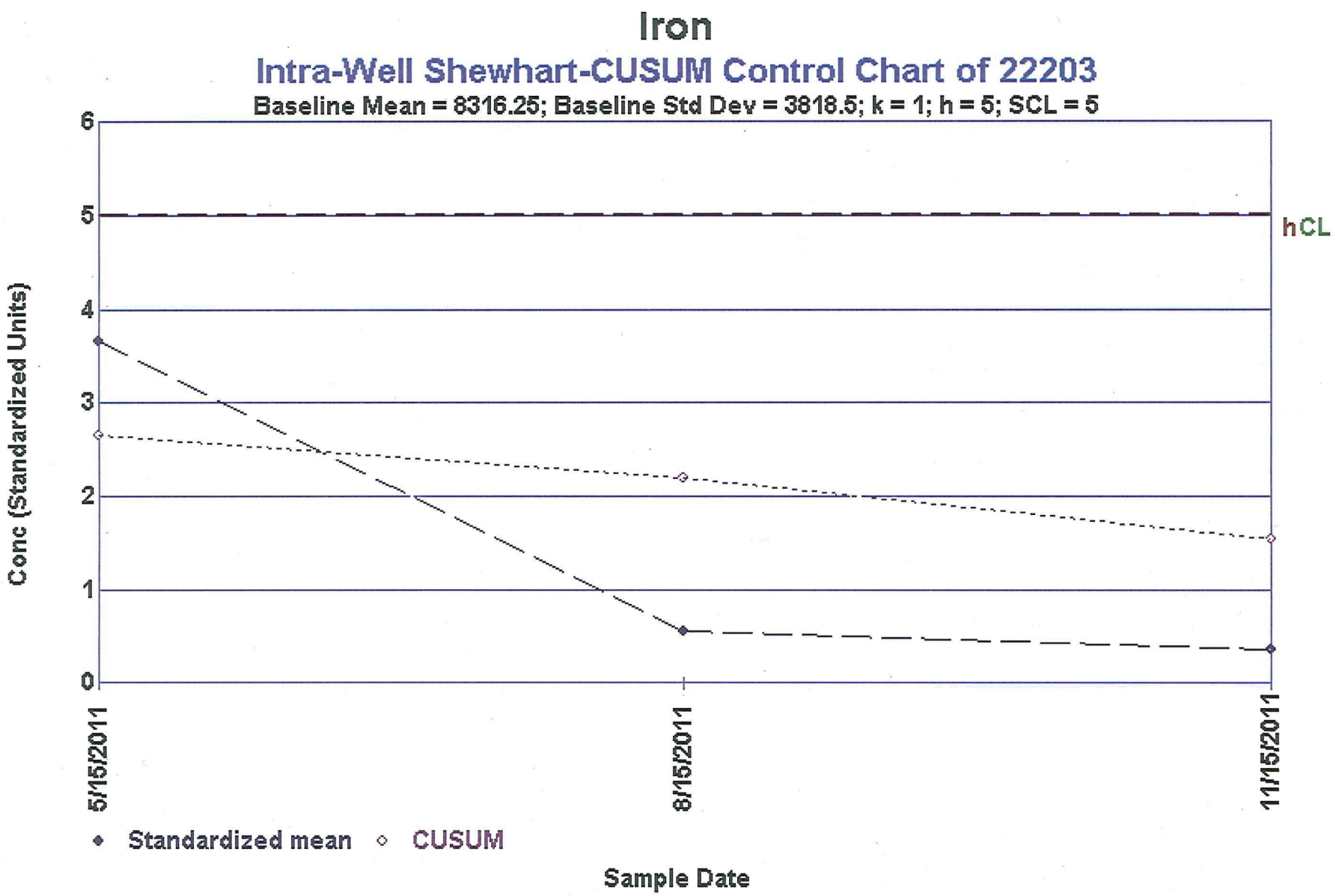


Figure A.5.3−34. Intra-Well Shewhart-CUSUM Control Chart (Iron 22203)

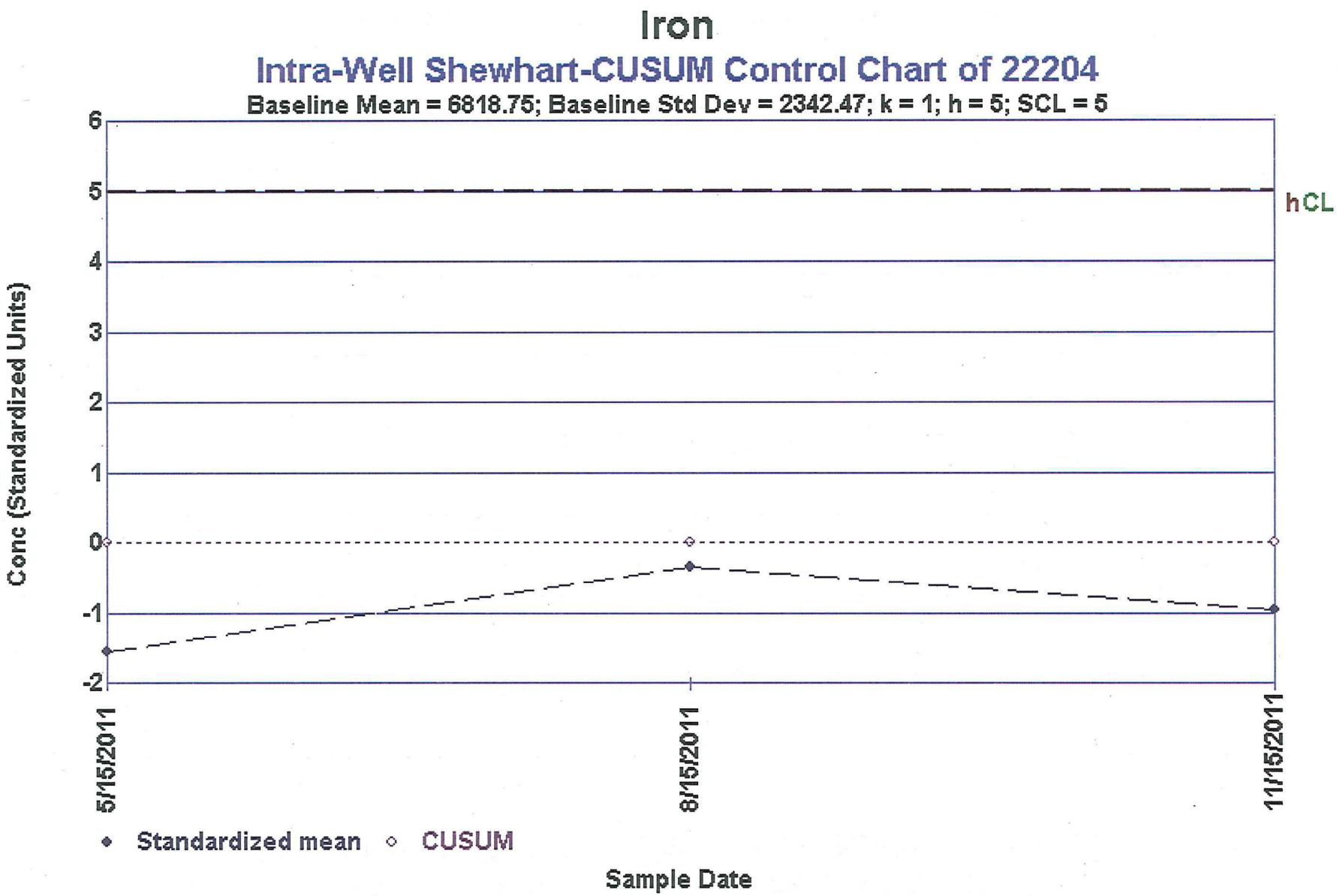


Figure A.5.3−35. Intra-Well Shewhart-CUSUM Control Chart (Iron 22204)

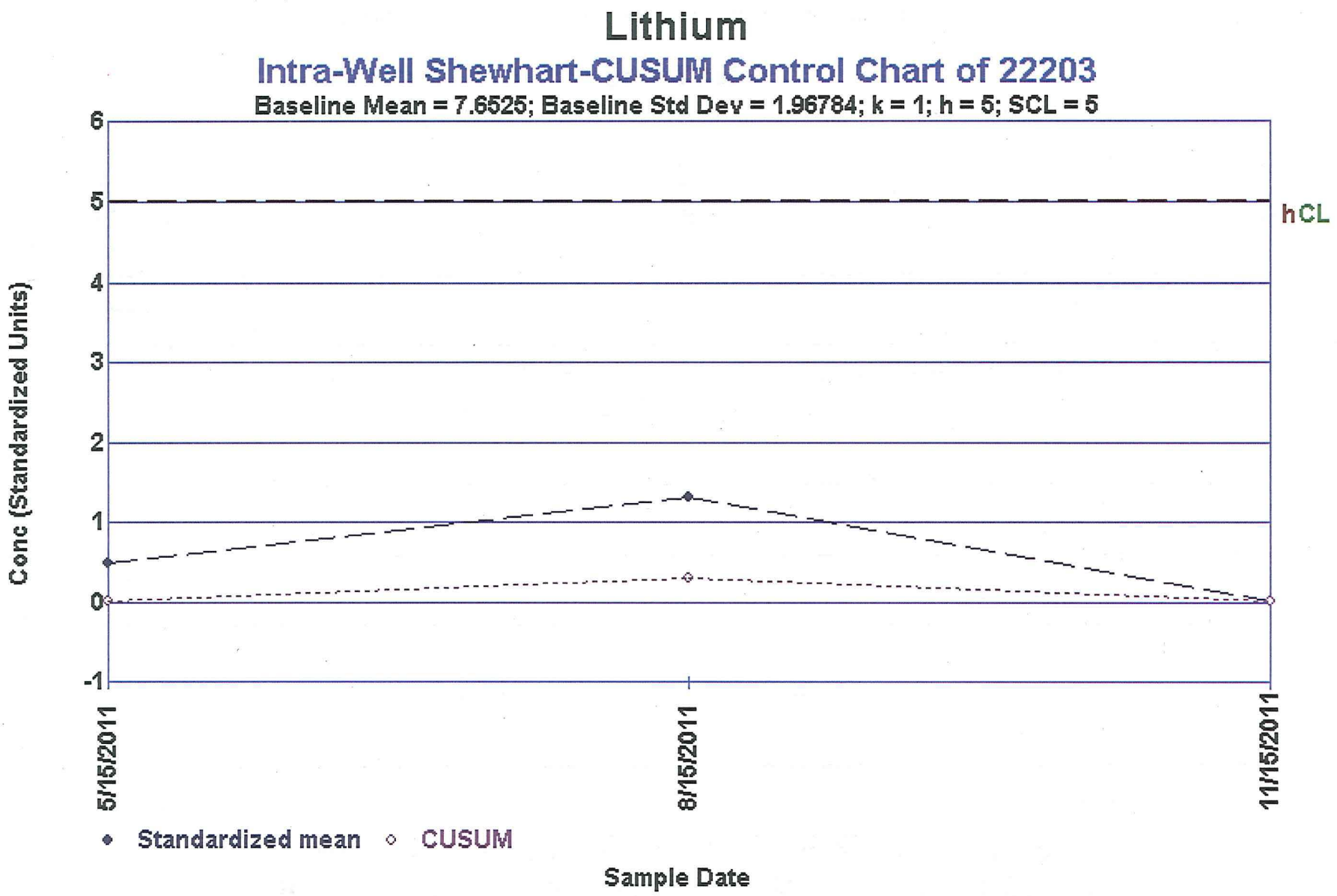


Figure A.5.3−36. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22203)

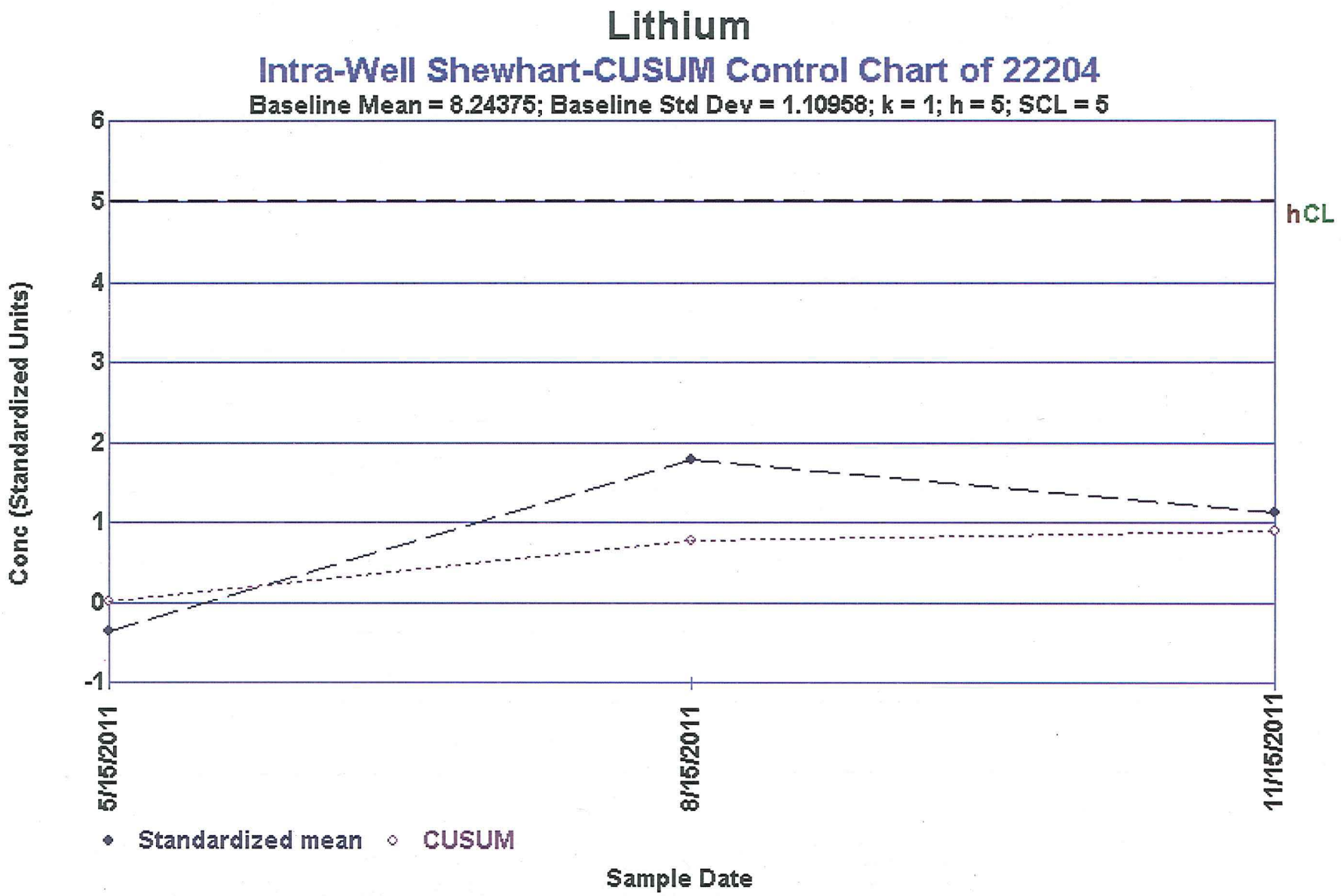


Figure A.5.3−37. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22204)

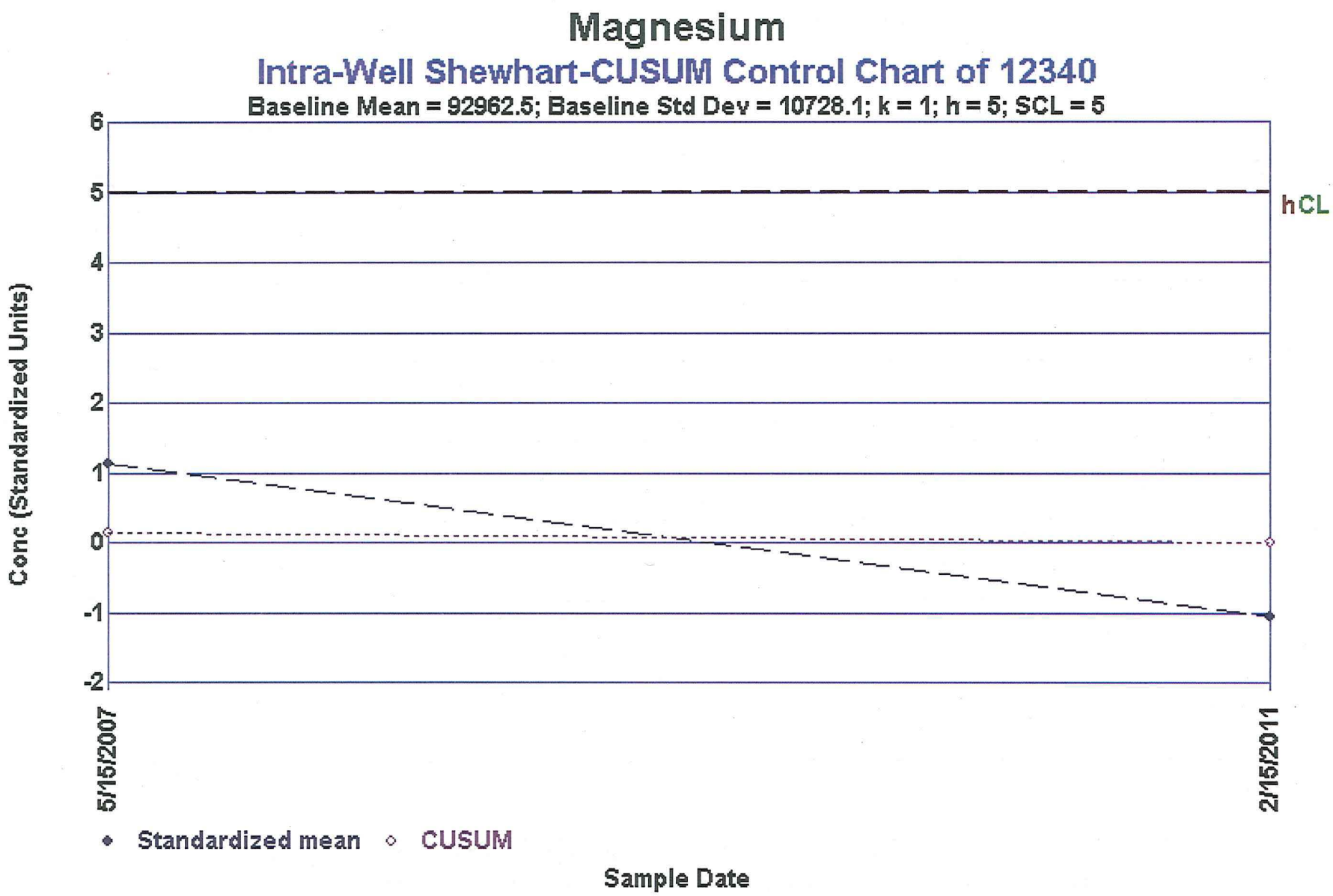


Figure A.5.3−38. Intra-Well Shewhart-CUSUM Control Chart (Magnesium 12340)

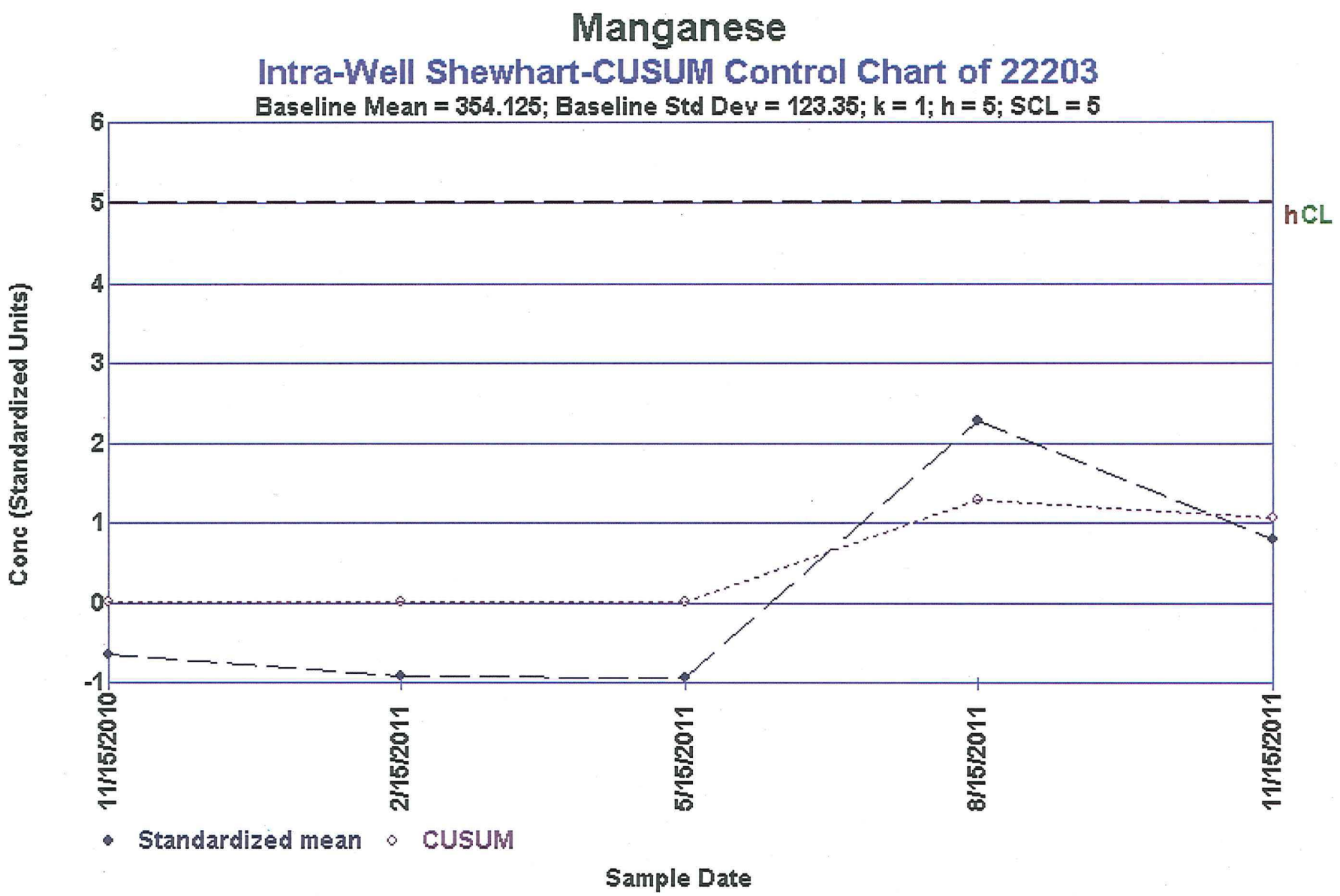


Figure A.5.3−39. Intra-Well Shewhart-CUSUM Control Chart (Manganese 22203)

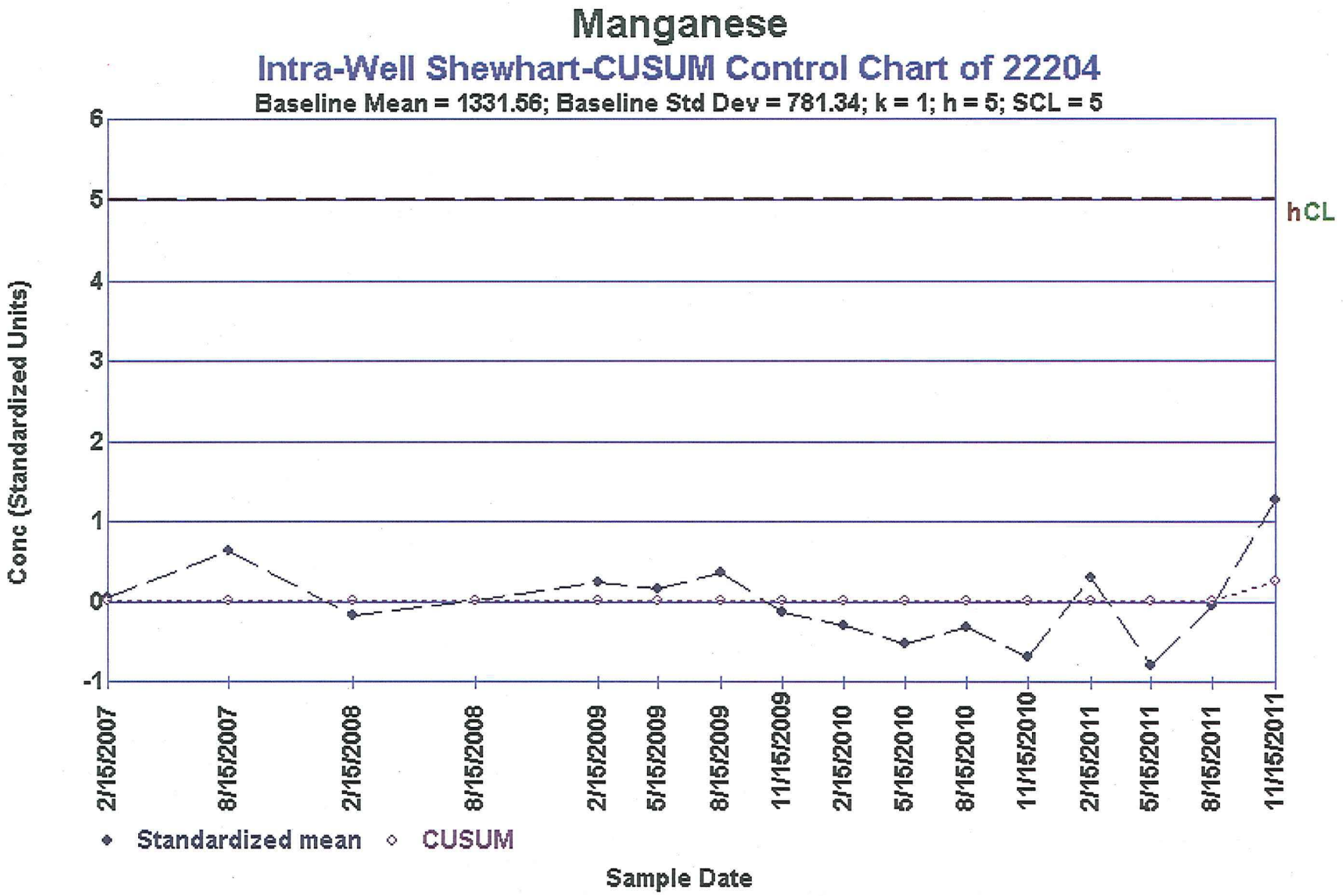


Figure A.5.3−40. Intra-Well Shewhart-CUSUM Control Chart (Manganese 22204)

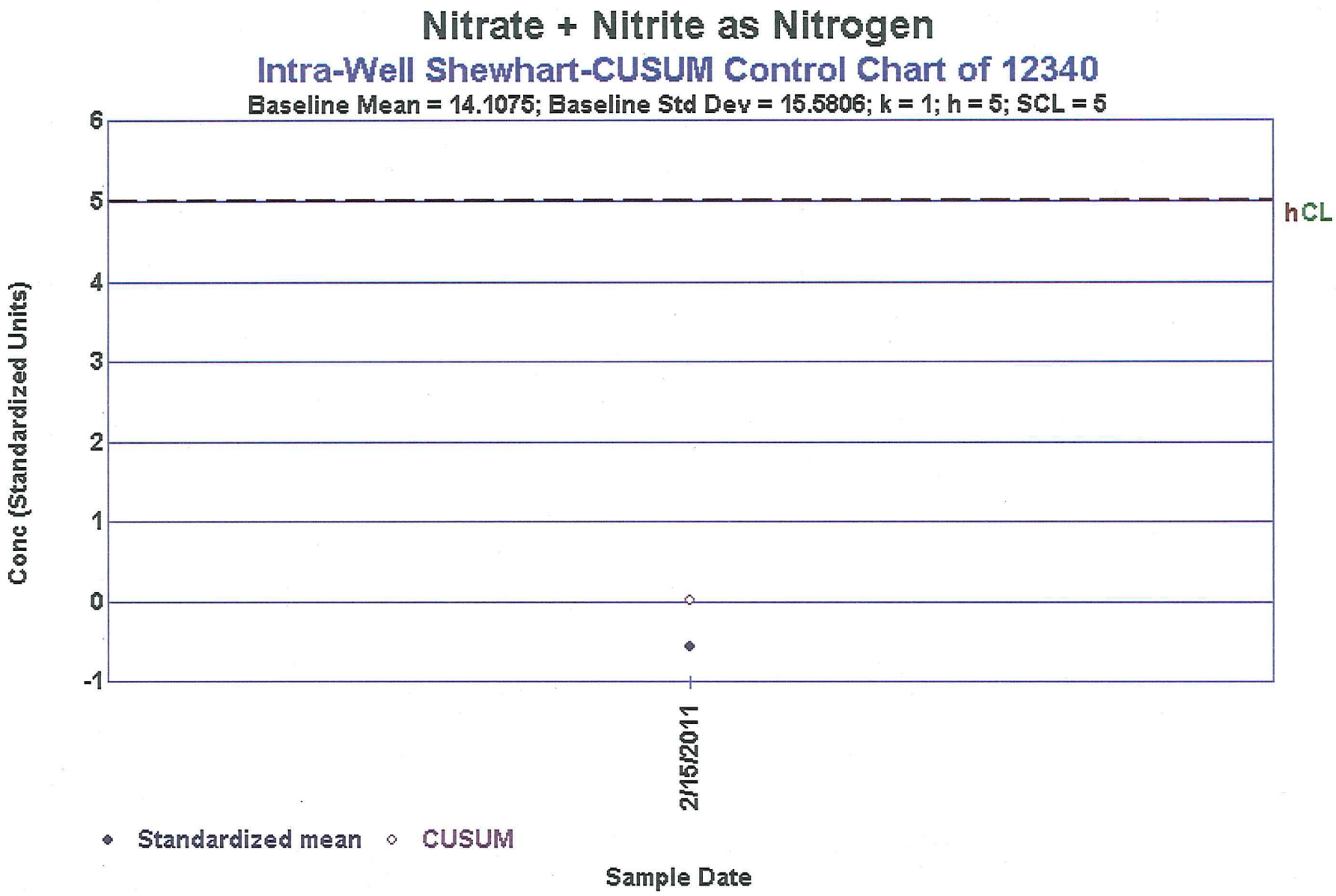


Figure A.5.3−41. Intra-Well Shewhart-CUSUM Control Chart (Nitrate 12340)

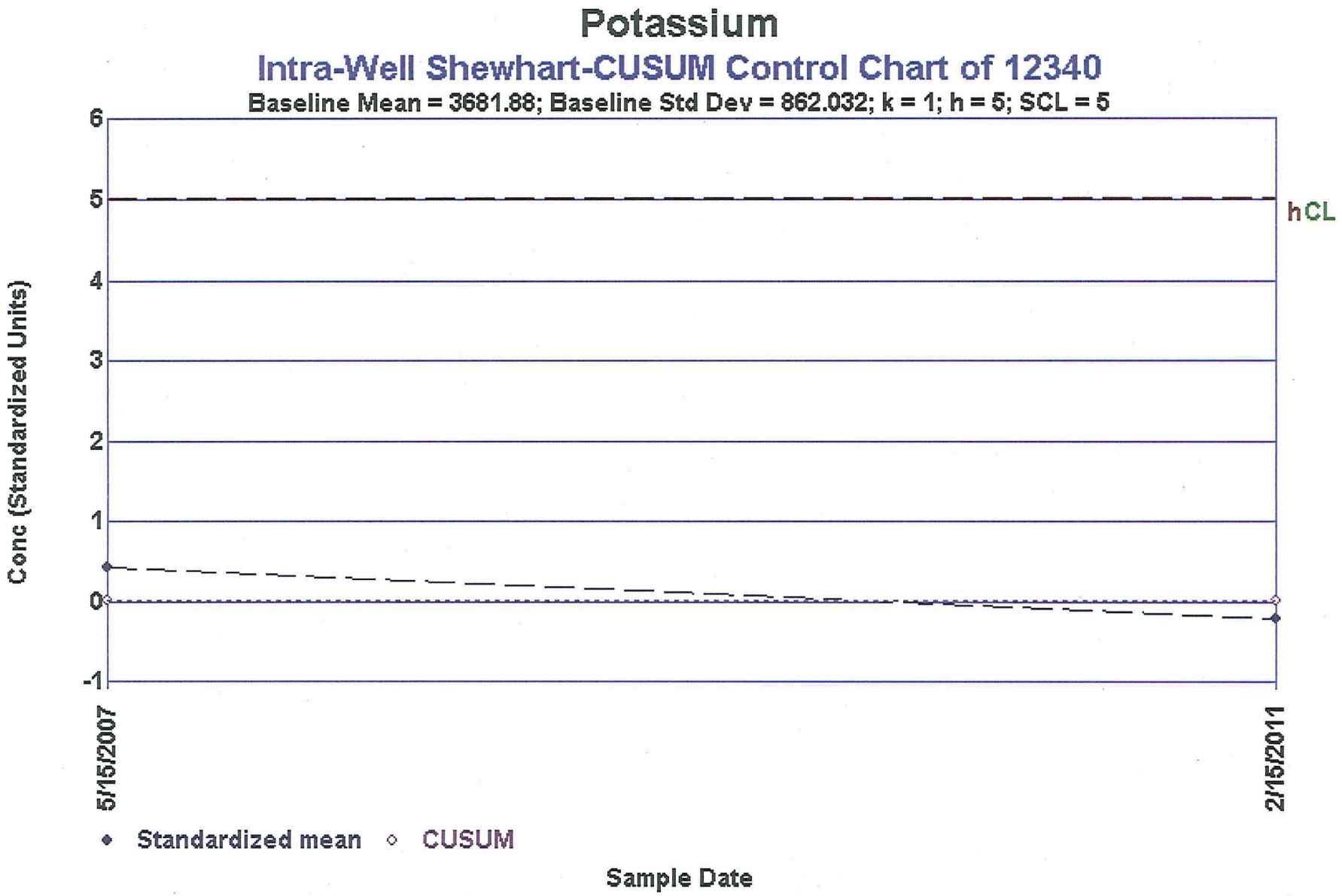


Figure A.5.3–42. Intra-Well Shewhart-CUSUM Control Chart (Potassium 12340)

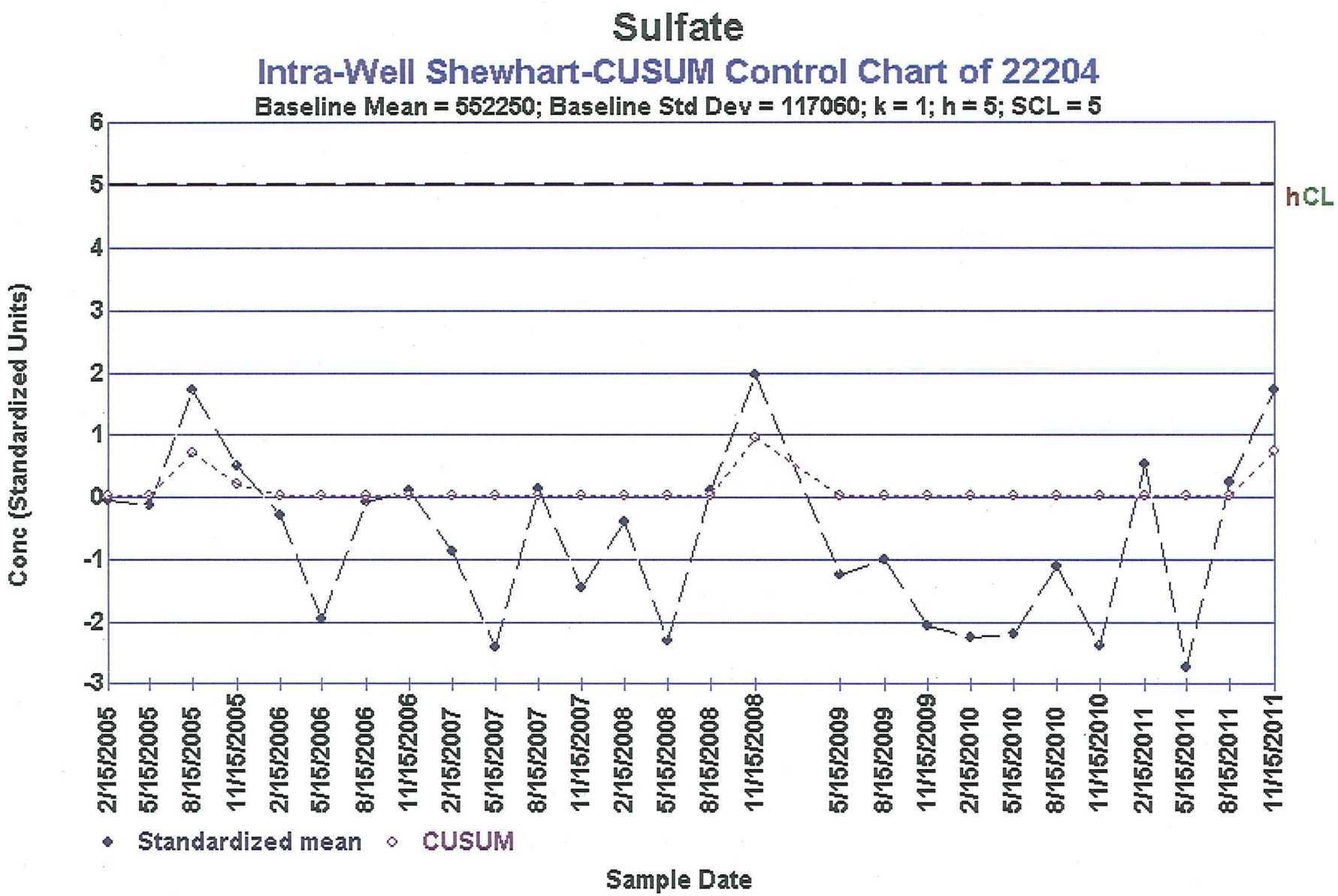


Figure A.5.3−43. Intra-Well Shewhart-CUSUM Control Chart (Sulfate 22204)

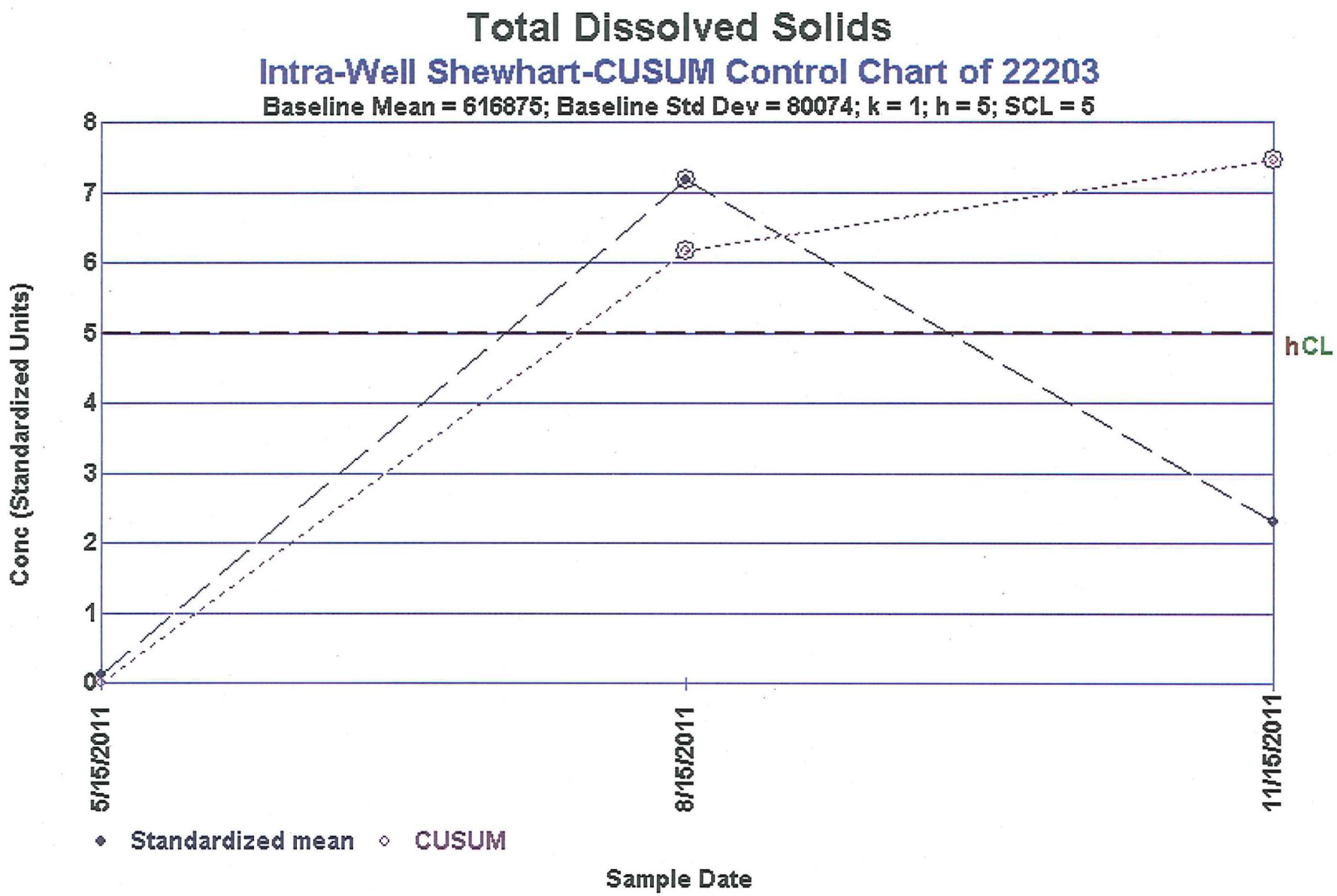


Figure A.5.3–44. Intra-Well Shewhart-CUSUM Control Chart (TDS 22203)

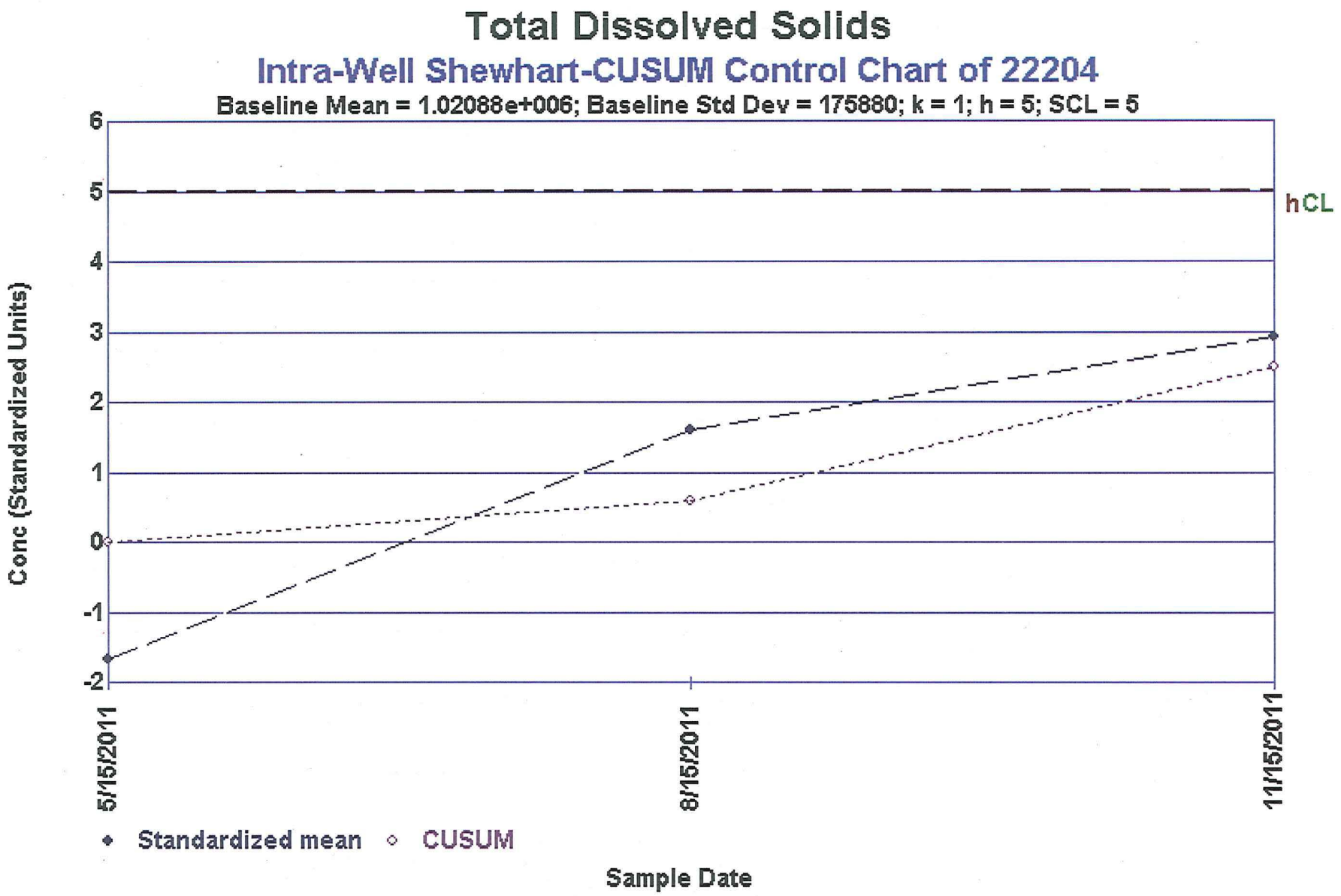


Figure A.5.3–45. Intra-Well Shewhart-CUSUM Control Chart (TDS 22204)

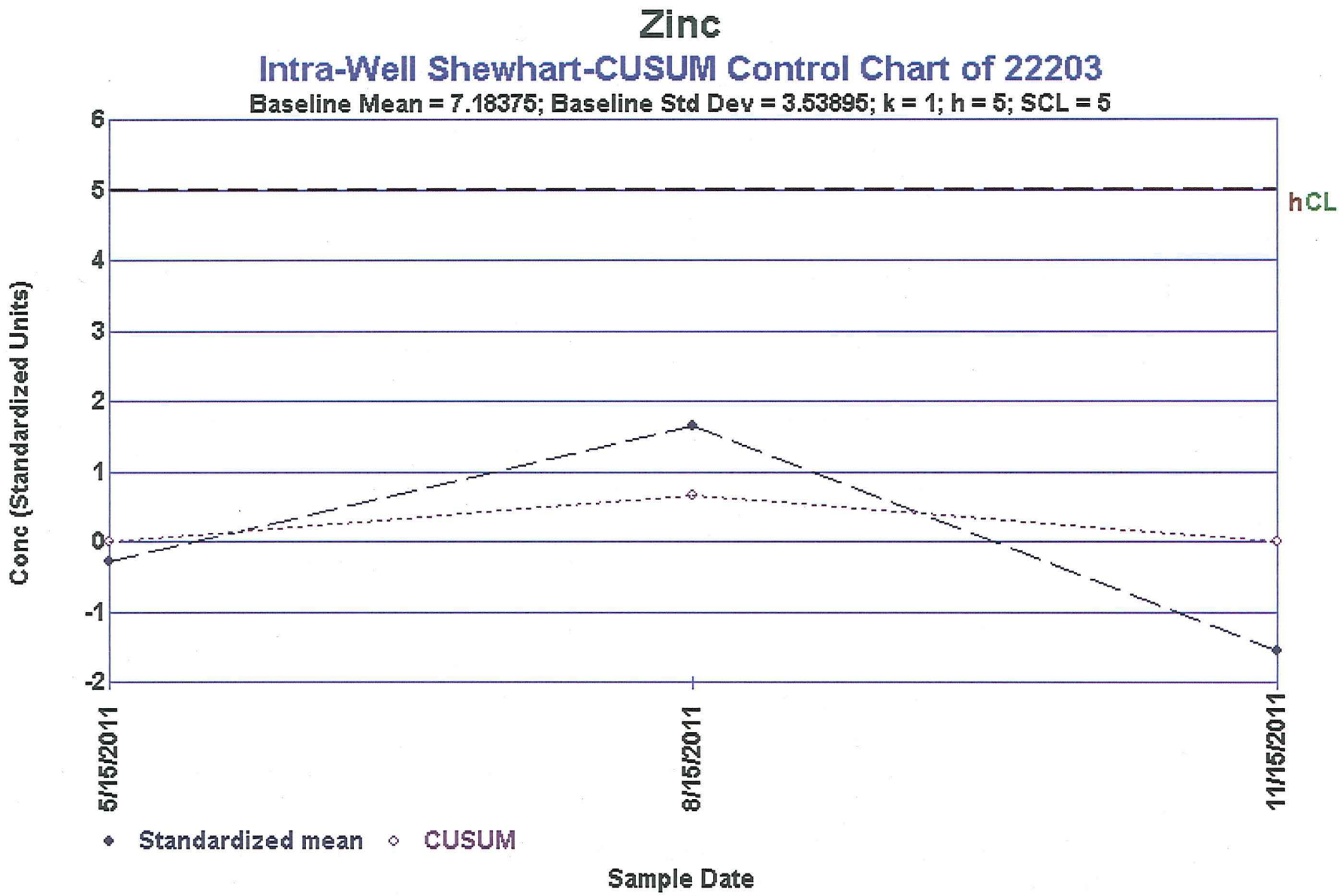


Figure A.5.3−46. Intra-Well Shewhart-CUSUM Control Chart (Zinc 22203)

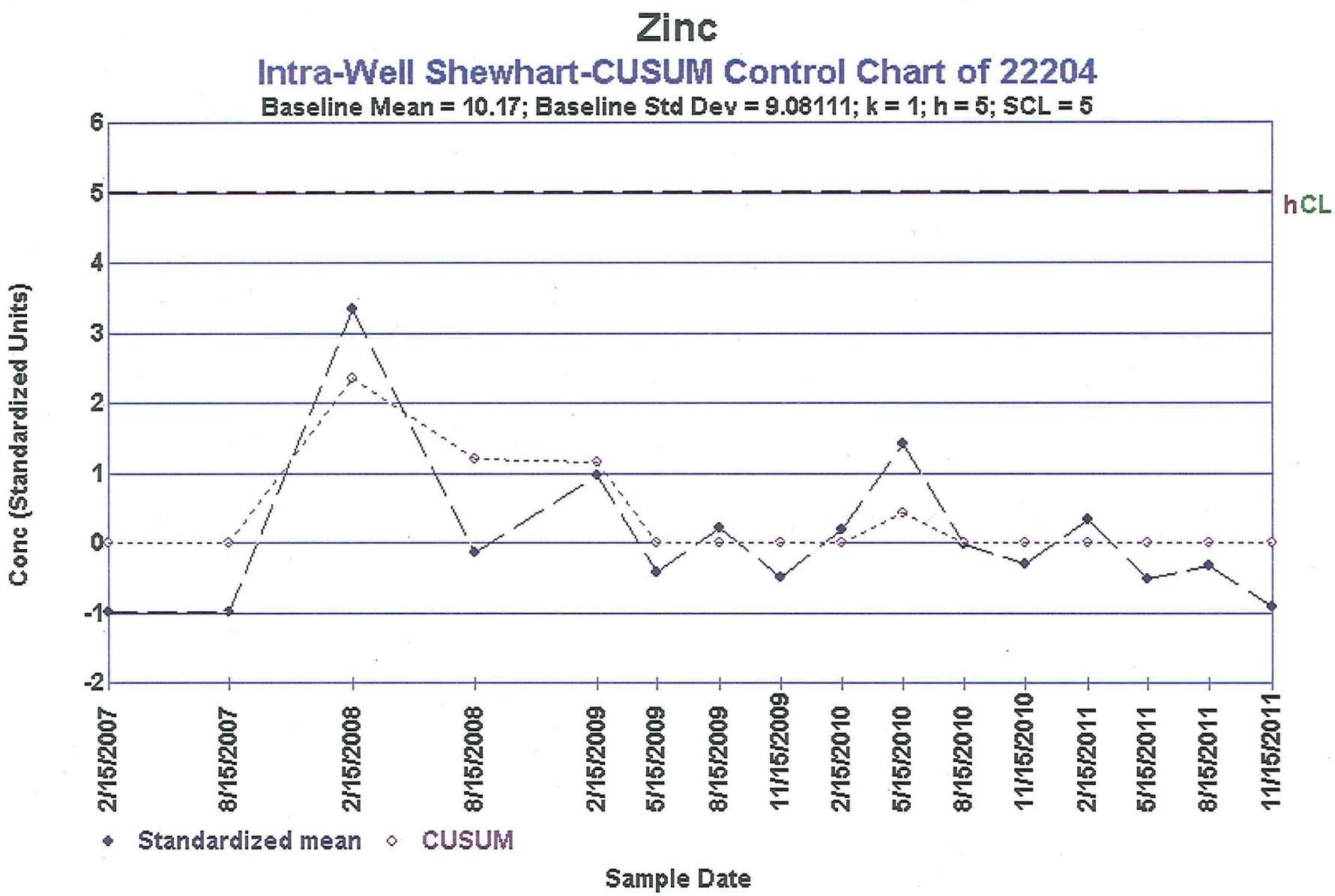


Figure A.5.3−47. Intra-Well Shewhart-CUSUM Control Chart (Zinc 22204)

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Sub-attachment A.5.4

Sub-attachment A.5.4

Cell 4

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The following information is provided in this sub-attachment:

- Quarterly monitoring summary statistics (refer to Table A.5.4–1)
- Annual LCS sample summary information for detected parameters (refer to Table A.5.4–2)
- LCS monthly accumulation volumes (refer to Figure A.5.4–1)
- LDS monthly accumulation volumes (refer to Figure A.5.4–2)
- OSDF horizontal till well 12341 water yield (refer to Figure A.5.4–3)
- GMA water levels and uranium concentration versus time (refer to Figures A.5.4–4 and A.5.4–5)
- Plots of concentration versus time (refer to Figures A.5.4–6A to A.5.4–28B)
- A bivariate plot for uranium-sodium (refer to Figure A.5.4–29)
- Control charts (refer to Figures A.5.4–30 to A.5.4–45)

A.5.4.1 Quarterly Monitoring Results

Quarterly water quality monitoring takes place in the LCS, LDS, HTW, and GMA wells of each cell for the purpose of determining if the OSDF is operating as designed. Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentrations versus time plots, bivariate plots, and control charts are used to help interpret and present the results.

In the first quarter of 2011, 23 parameters were sampled in the LCS, LDS, HTW, and GMA wells of each cell. In the second, third, and fourth quarters tritium was added to the analyte list for all horizons (LCS, LDS, HTW, and GMA Wells), and the analyte list for the HTWs in all cells was changed to just four parameters: arsenic, uranium, tritium, and sodium. These changes were agreed to via the comment resolution process between Ohio EPA and DOE on LMICP (revision 4). Tritium results for all cells are reported in Section A.5.5.

The LDS of Cell 4 was dry during the fourth quarter of 2011. As shown in Table A.5.4–1, 5 of the 23 parameters sampled quarterly in the LCS, LDS, HTW, and GMA wells (alkalinity, sulfate, TDS, TOC, arsenic, boron, calcium, cobalt, copper, iron, lithium, magnesium, manganese, sodium, and zinc) have upward trends in the HTW and/or GMA wells based on the Mann-Kendall test for trend.

Horizontal Till Well

The HTW is located beneath the liner penetration box of each cell by design. The liner penetration box is considered to be potentially the weakest point in the cell design. If a leak were to develop, it should be detected beneath the liner penetration box first. Therefore, the water quality in the HTW represents the first line of evidence that a potential leak from the cell might be occurring. A leak would be indicated by an increasing concentration in the HTW.

Of the 23 parameters monitored quarterly in the LCS, LDS, HTW, and GMA wells, alkalinity, sulfate, calcium, cobalt, copper, iron, magnesium, and manganese are increasing in the HTW of Cell 4 (as indicated in the table below). The bivariate plot for the Cell 4 LCS, LDS, and HTW (uranium-sodium) is provided in Figure A.5.4–29. The plot shows that the chemical signature for uranium-sodium in the LCS, LDS, and HTW are separate and distinct; indicating that mixing

between the horizons is not occurring. Therefore the increasing concentrations measured in the HTW of Cell 4 are attributed to fluctuating ambient concentrations beneath the cell that are not related to cell performance.

Parameter	HTW[a]	GMA-U[a]	GMA-D[a]
Alkalinity	Up		
Sulfate	Up		
TDS			Up
TOC		Up	Up
Arsenic			Up
Boron			Up
Calcium	Up		
Cobalt	Up		
Copper	Up		
Iron	Up		
Lithium			Up
Magnesium	Up		
Manganese	Up		
Sodium			Up
Zinc			Up

[a] HTW = horizontal till well, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer, TDS = total dissolved solids; TOC = total organic carbon. No entry indicates that the trend was not up.

Great Miami Aquifer Wells

GMA monitoring wells are positioned for post-aquifer-remediation flow conditions, when flow directions will be from west to east. However, water levels measured in 2011 indicate that groundwater in the GMA in most of the area of the OSDF is moving in a general direction of northeast to south/southwest in response to the active groundwater remediation taking place to the west and southwest. Pumping for the groundwater remediation is scheduled to last until 2023. Because bivariate plots (discussed above) indicate that LCS, LDS, and HTW monitoring horizons are not mixing, the increasing TDS and arsenic concentrations seen in the GMA wells, are attributed to fluctuating ambient conditions that are not related to cell performance.

The table below provides a summary of the average concentration (as reported in Table A.5.4–1) measured in the LDS, and GMA wells for parameters with increasing concentrations in the Cell 4 GMA wells.

Parameter	LDS[a]	GMA-U[a]	GMA-D[a]
TDS (mg/L)	**5920**	624	955
TOC (mg/L)	**4.52**	1.41	1.52
Arsenic (mg/L)	**0.00682**	0.0025	0.0025
Boron (mg/L)	**0.634**	0.0409	0.0395
Lithium (mg/L)	**0.174**	0.0149	0.00828
Sodium (mg/L)	**458**	13.8	19.0
Zinc (mg/L)	**0.311**	0.00908	0.00396

Note: The highest averages are shown in bold.
[a] LDS = leak detection system, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer.

A.5.4.2 Control Charts

Intrawell control charts employ historical measurements from a compliance point as background The *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance* (EPA 2009) defines the process of creating a Shewart-CUSUM control chart. Appropriate background data are used to define a baseline for the well. The baseline parameters for the chart, estimates of the mean, and standard deviation are obtained from the background data. These baseline measurements characterize the expected background concentrations at the monitoring point. As future concentrations are collected, the baseline parameters are used to standardize the newly gathered data. After these measurements are standardized and plotted, a control chart is declared "out of control" if future concentrations exceed the baseline control limit. This is indicated on the control chart when either the Shewart or CUSUM plot traces begin to exceed a control limit. The limit is based on the rationale that if the monitoring point remains unchanged from the baseline condition, new standardized observations should not deviate substantially from the baseline mean. If a change occurs, the standardized values will deviate significantly from the baseline and tend to exceed the control limit.

A minimum of eight samples are recommended for use in ChemStat® software to define the baseline for a control chart. Therefore, only sample sets with greater than eight samples were selected for control charts. By default, the ChemStat® software plots both a CUSUM control limit (h) and a SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit (h) and a value of 4.5 for the SCL.

EPA Unified Guidance suggests that to simplify the interpretation of the control chart that an out of control condition be based on the CUSUM (h) limit alone. Plotting the SCL limit is not needed. The ChemStat® software though, by default, plots both the SCL and CUSUM (h) control limits on the charts. As a "work-a-round", the SCL limit was defined as 5 to match the recommended CUSUM limit. On the charts the combined limit is identified as hCL. For interpretation purposes, regard hCL as the CUSUM limit (h).

As shown in Table A.5.4–1 in gray shading, twelve parameters in the HTW and/or GMA wells of Cell 4 (uranium, nitrate, sulfate, TOX, barium, iron, lithium, manganese, nickel, potassium, sodium and zinc) meet the criteria for control charts (i.e., 8 samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in 16 control charts.

These 16 control charts are presented in Figures A.5.4–30 to A.5.4–45. All of the control charts for Cell 4 (with the exception of TOX in the HTW) exhibit "in control" conditions. The CUSUM trace for TOX in the HTW exceeds the CUSUM control limit beginning in 2010. As discussed above, separate and distinct signatures for uranium and sodium in the LCS, LDS, and HTW of Cell 4 indicate that water is not mixing between horizons, so the out of control condition is attributed to fluctuating ambient conditions beneath the cell, and not to cell performance.

Parameter and Monitoring Point[a]	Assessment
Uranium in the GMA-U	In Control
Uranium in the GMA-D	In Control
Nitrate in the HTW	In Control
Sulfate in the GMA-D	In Control
TOX in the HTW	**Out of Control**
Barium in the HTW	In Control
Iron in the GMA-U	In Control
Iron in the GMA-D	In Control
Lithium in the GMA-U	In Control
Manganese in the GMA-U	In Control
Manganese in the GMA-D	In Control
Nickel in the HTW	In Control
Potassium in the HTW	In Control
Sodium in the HTW	In Control
Sodium in the GMA-U	In Control
Zinc in the GMA-U	In Control

[a]HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer; TOX = total organic halogen

A.5.4.3 Annual LCS Sample Results

Annual LCS sampling results for Cell 4 are provided in Table A.5.4–2 for those parameters that have been detected at least once and are not being sampled quarterly. No new Appendix J or PCB parameters were detected in the LCS of Cell 4 in 2011.

A.5.4.4 Summary and Conclusions

- The concentrations of 15 parameters monitored quarterly are increasing in either the HTW and/or GMA wells of Cell 4 (alkalinity, sulfate, TDS, TOC, arsenic, boron, calcium, cobalt, copper, iron, lithium, magnesium, manganese, sodium, and zinc).
- Separate and distinct chemical signatures for uranium and sodium in the LCS, LDS, and HTW of Cell 4 indicate that water is not mixing between the horizons. Concentration increases in the HTW and GMA wells of Cell 4 are attributed to fluctuating ambient concentrations beneath the cell, and not to cell performance.
- Sixteen control charts were constructed for Cell 4 parameters. All but one (TOX in the HTW) exhibit "in control" conditions.
- No new Appendix I or PCB parameters were detected in the LCS of Cell 4 in 2011.

Table A.5.4–1. Summary Statistics for Cell 4

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12341C	34	34	100.0	4.41	171	90.4	35.3	Undefined	None	Detected	
	LDS	12341D	34	34	100.0	5.74	21.3	14.2	2.9	Normal	None	Detected	
	HTW	12341	39	39	100.0	4.82	7.89	5.70	0.83	Undefined	Down	Not Detected	
	GMA-U	22206	36	40	90.0	ND	4.67	1.15	1.05	Lognormal	None	Not Detected	
	GMA-D	22205	41	41	100.0	0.525	12.1	2.73	2.80	Lognormal	None	Not Detected	
Alkalinity as CaCO3 (mg/L)	LCS	12341C	19	19	100.0	48.0	583	352	141	Normal	None	Detected	
	LDS	12341D	13	13	100.0	142	450	305	106	Normal	None	Not Detected	
	HTW	12341	10	10	100.0	357	513	376	120	Undefined	Up	Not Detected	744 (4Q-05)
	GMA-U	22206	4	4	100.0	356	377	368	9	Normal	None	Insuff	
	GMA-D	22205	4	4	100.0	397	426	414	12	Normal	None	Insuff	
Chloride (mg/L)	LCS	12341C	18	19	94.7	ND	131	102	37	Undefined	Up	Detected	
	LDS	12341D	13	13	100.0	62.8	146	75.8	65.8	Undefined	Up	Not Detected	298 (Q4-02)
	HTW	12341	10	10	100.0	25.1	43.0	34.5	4.5	Normal	None	Not Detected	
	GMA-U	22206	4	4	100.0	29.3	36.5	32.4	3.3	Normal	None	Insuff	
	GMA-D	22205	4	4	100.0	21.4	22.9	22.2	0.6	Normal	Down	Insuff	
Nitrate/Nitrite as N (mg/L)	LCS	12341C	14	23	60.9	ND	6.34	0.81	1.76	Undefined	None	Not Detected	
	LDS	12341D	5	13	38.5	ND	2.28	1.01	0.78	Lognormal	Up	Detected	
	HTW	12341	1	9	11.1	ND	0.0304	Insuff	Insuff	Lognormal	None	Not Detected	
	GMA-U	22206	0	4	0.0	NA	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22205	1	4	25.0	ND	0.0326	Insuff	Insuff	Normal	None	Insuff	
Sulfate (mg/L)	LCS	12341C	34	34	100.0	140	3940	2400	850	Undefined	Up	Detected	
	LDS	12341D	34	34	100.0	1470	4490	2480	850	Lognormal	Up	Detected	7870 (Q2-11)
	HTW	12341	32	32	100.0	153	313	222	43	Normal	Up	Detected	
	GMA-U	22206	35	35	100.0	90.4	559	259	110	Normal	Down	Detected	
	GMA-D	22205	35	35	100.0	199	535	362	89	Normal	None	Not Detected	
Total Dissolved Solids (mg/L)	LCS	12341C	22	22	100.0	351	5020	4440	1600	Undefined	Up	Detected	
	LDS	12341D	11	11	100.0	4810	7140	5920	890	Normal	Up	Detected	
	HTW	12341	8	8	100.0	929	1060	1010	50	Normal	None	Not Detected	
	GMA-U	22206	11	11	100.0	560	877	624	110	Undefined	None	Not Detected	
	GMA-D	22205	11	11	100.0	753	1180	955	141	Normal	Up	Not Detected	
Total Organic Carbon (mg/L)	LCS	12341C	27	34	79.4	ND	5.39	2.6	1.1	Normal	None	Not Detected	
	LDS	12341D	31	34	91.2	ND	8.0	4.52	1.52	Normal	Down	Detected	
	HTW	12341	29	35	82.9	ND	4.42	2.43	0.85	Normal	None	Detected	
	GMA-U	22206	29	40	72.5	ND	2.39	1.41	0.47	Normal	Up	Detected	9.84 (Q2-03)
	GMA-D	22205	29	40	72.5	ND	2.74	1.52	0.50	Normal	Up	Detected	
Total Organic Halogens (mg/L)	LCS	12341C	22	34	64.7	ND	0.060	0.0146	0.0123	Undefined	None	Not Detected	
	LDS	12341D	26	34	76.5	ND	0.0445	0.0206	0.0112	Normal	None	Not Detected	0.070 (2Q-10)
	HTW	12341	23	36	63.9	ND	0.0777	0.01316	0.01143	Lognormal	None	Not Detected	
	GMA-U	22206	15	40	37.5	ND	0.064	0.00776	0.0107	Lognormal	Down	Not Detected	
	GMA-D	22205	7	40	17.5	ND	0.0142	0.00304	0.00451	Undefined	Down	Detected	
Arsenic (mg/L)	LCS	12341C	4	24	16.7	ND	0.126	0.00338	0.0297	Undefined	None	Detected	
	LDS	12341D	6	20	30.0	ND	0.0274	0.00682	0.00761	Lognormal	None	Not Detected	
	HTW	12341	8	20	40.0	ND	0.0307	0.0036	0.0207	Undefined	None	Not Detected	0.0938 (Q3-09)
	GMA-U	22206	4	11	36.4	ND	0.0365	0.0025	0.0118	Undefined	None	Not Detected	
	GMA-D	22205	4	24	16.7	ND	0.0344	0.0025	0.0102	Undefined	Up	Detected	
Barium (mg/L)	LCS	12341C	19	19	100.0	0.0155	0.0580	0.0275	0.0107	Undefined	Down	Detected	
	LDS	12341D	13	13	100.0	0.0167	0.0775	0.0388	0.0201	Normal	Down	Detected	
	HTW	12341	10	10	100.0	0.0439	0.0675	0.0537	0.0054	Normal	None	Not Detected	
	GMA-U	22206	4	4	100.0	0.0580	0.0782	0.0682	0.0095	Normal	None	Insuff	
	GMA-D	22205	4	4	100.0	0.0588	0.0703	0.0643	0.0056	Normal	None	Insuff	

Table A.5.4–1 (continued). Summary Statistics for Cell 4

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Boron (mg/L)	LCS	12341C	34	34	100.0	0.0626	1.27	0.891	0.296	Undefined	None	Detected	1.93 (Q3-05)
	LDS	12341D	34	34	100.0	0.415	1.81	0.634	0.310	Undefined	None	Detected	
	HTW	12341	33	36	91.7	ND	1.24	0.116	0.231	Undefined	Down	Detected	
	GMA-U	22206	35	40	87.5	ND	0.0617	0.0409	0.0094	Undefined	None	Not Detected	
	GMA-D	22205	33	40	82.5	ND	0.0807	0.0395	0.0129	Normal	Up	Detected	
Calcium (mg/L)	LCS	12341C	19	19	100.0	52.9	1110	556	201	Undefined	None	Not Detected	
	LDS	12341D	13	13	100.0	284	578	424	88	Normal	None	Not Detected	
	HTW	12341	10	10	100.0	127	224	151	29	Lognormal	Up	Not Detected	
	GMA-U	22206	4	4	100.0	141	217	179	42	Normal	None	Insuff	
	GMA-D	22205	4	4	100.0	233	268	250	16	Normal	None	Insuff	
Cobalt (mg/L)	LCS	12341C	13	24	54.2	ND	0.0057	0.0012	0.0015	Undefined	None	Detected	
	LDS	12341D	11	20	55.0	ND	0.0064	0.0015	0.0018	Undefined	Down	Detected	
	HTW	12341	15	17	88.2	ND	0.00634	0.00287	0.00138	Lognormal	Up	Not Detected	
	GMA-U	22206	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22205	2	11	18.2	ND	0.00211	Insuff	Insuff	Undefined	None	Detected	
Copper (mg/L)	LCS	12341C	13	20	65.0	0.00076	0.0309	0.00860	0.00846	Undefined	None	Detected	
	LDS	12341D	10	15	66.7	ND	0.0259	0.0115	0.0080	Normal	None	Not Detected	
	HTW	12341	5	11	45.4	ND	0.0158	0.0043	0.0056	Lognormal	Up	Detected	
	GMA-U	22206	4	4	100.0	0.00228	0.0106	0.00772	0.00385	Normal	None	Insuff	
	GMA-D	22205	4	4	100.0	0.00160	0.0102	0.00736	0.0039	Normal	None	Insuff	
Iron (mg/L)	LCS	12341C	18	24	75.0	ND	4.18	0.117	1.36	Undefined	Down	Detected	
	LDS	12341D	16	20	80.0	ND	27.8	9.02	6.39	Lognormal	Down	Detected	
	HTW	12341	17	17	100.0	0.922	13.4	2.62	2.97	Lognormal	Up	Detected	
	GMA-U	22206	11	11	100.0	0.986	15.0	9.03	3.98	Normal	None	Not Detected	
	GMA-D	22205	11	11	100.0	2.30	7.71	5.86	1.55	Normal	None	Not Detected	
Lithium (mg/L)	LCS	12341C	20	20	100.0	0.0818	0.187	0.122	0.028	Normal	Up	Detected	
	LDS	12341D	19	19	100.0	0.0951	0.331	0.174	0.066	Normal	Up	Detected	
	HTW	12341	17	17	100.0	0.00812	0.0134	0.0107	0.0018	Normal	Down	Detected	
	GMA-U	22206	11	11	100.0	0.0138	0.0175	0.0149	0.0013	Normal	None	Not Detected	
	GMA-D	22205	11	11	100.0	0.00685	0.00946	0.00828	0.00081	Normal	Up	Detected	0.0167 (Q3-11)
Magnesium (mg/L)	LCS	12341C	19	19	100.0	15.0	732	413	188	Normal	Up	Detected	
	LDS	12341D	13	13	100.0	159	548	189	158	Undefined	Up	Detected	
	HTW	12341	10	10	100.0	47.2	74.1	58.7	7.9	Normal	Up	Not Detected	
	GMA-U	22206	4	4	100.0	30.2	43.8	36.0	6.4	Normal	None	Insuff	
	GMA-D	22205	4	4	100.0	47.4	63.2	52.8	7.3	Normal	None	Insuff	
Manganese (mg/L)	LCS	12341C	15	24	62.5	ND	2.14	0.0138	0.484	Undefined	None	Detected	
	LDS	12341D	12	20	60.0	ND	1.85	0.955	0.496	Lognormal	Down	Detected	
	HTW	12341	17	17	100.0	0.182	0.564	0.307	0.136	Undefined	Up	Detected	
	GMA-U	22206	13	13	100.0	0.311	0.708	0.445	0.119	Normal	None	Not Detected	
	GMA-D	22205	23	24	95.8	ND	1.10	0.855	0.205	Normal	None	Not Detected	
Nickel (mg/L)	LCS	12341C	20	24	83.3	ND	0.0474	0.0132	0.0127	Lognormal	None	Detected	
	LDS	12341D	18	20	90.0	ND	0.0474	0.0178	0.0118	Normal	None	Detected	
	HTW	12341	13	17	76.5	ND	0.01101	0.00609	0.00192	Normal	None	Not Detected	
	GMA-U	22206	1	11	9.1	ND	0.00147	Insuff	Insuff	Undefined	None	Detected	
	GMA-D	22205	9	24	37.5	ND	0.0135	0.00075	0.00295	Undefined	None	Detected	
Potassium (mg/L)	LCS	12341C	19	19	100.0	3.81	78.4	21.6	14.5	Undefined	None	Not Detected	
	LDS	12341D	13	13	100.0	31.0	137	36.5	30.3	Undefined	None	Detected	
	HTW	12341	9	10	90.0	ND	2.29	1.87	0.37	Normal	None	Not Detected	
	GMA-U	22206	4	4	100.0	3.84	4.39	4.05	0.25	Normal	None	Insuff	
	GMA-D	22205	4	4	100.0	2.70	3.22	2.92	0.22	Normal	None	Insuff	

Table A.5.4-1 (continued). Summary Statistics for Cell 4

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Selenium (mg/L)	LCS	12341C	6	24	52.0	ND	0.231	0.0132	0.0484	Lognormal	None	Not Detected	
	LDS	12341D	2	20	10.0	ND	0.067	Insuff	Insuff	Undefined	None	Not Detected	
	HTW	12341	0	17	0.0	NA	NA	Insuff	Insuff	Undefined	None	Detected	
	GMA-U	22206	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22205	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Sodium (mg/L)	LCS	12341C	24	24	100.0	22.0	117	50.0	18.1	Undefined	Up	Not Detected	
	LDS	12341D	20	20	100.0	307	623	458	87	Normal	Up	Detected	
	HTW	12341	20	20	100.0	14.1	18.1	15.3	0.97	Lognormal	None	Not Detected	
	GMA-U	22206	11	11	100.0	12.3	15.8	13.8	0.97	Normal	None	Not Detected	
	GMA-D	22205	11	11	100.0	14.9	22.2	19.0	2.51	Normal	Up	Not Detected	
Zinc (mg/L)	LCS	12341C	11	24	45.8	ND	0.0446	0.0138	0.0100	Lognormal	Up	Not Detected	
	LDS	12341D	17	20	85.0	ND	0.775	0.311	0.251	Lognormal	None	Detected	
	HTW	12341	11	17	64.7	ND	0.351	0.00845	0.121	Undefined	None	Detected	
	GMA-U	22206	6	11	54.6	ND	0.0201	0.00908	0.00582	Normal	None	Not Detected	
	GMA-D	22205	12	24	50.0	ND	0.00859	0.00396	0.00214	Normal	Up	Not Detected	

Note: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least 8 samples, normal or lognormal distribution, no trend, and no serial correlation. These wells achieve control chart criteria.

Note: For results where the concentrations are below the detection limit, the results used in the Average, Standard Deviation, Distribution Type, Trend, Serial Correlation, and Outliers are each set at half the detection limit.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption and requires $n \geq 3$. In addition, Standard Deviation requires $n \geq 4$.

[d]"Insuff" = Insufficient and is used for Average, Standard Deviation, Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic (where $3 \leq n \leq 50$) or Shapiro Francia (where $n > 50$).

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the lognormal assumption.

Lognormal: Lognormal assumption could not be rejected at the 5 percent level and has a higher probability value than the normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25% detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure. Trend testing requires a sample with $n \geq 4$.

[g]Serial correlation based on Rank Von Neumann test. Serial Correlation testing requires a sample with $n \geq 6$.

[h]Outliers determined by Rosner's (where $n > 25$) or Dixon procedure (where $4 \leq n \leq 25$).

[i]Q = quarterly

Table A.5.4-2. Cell 4 Annual LCS Sample Summary Information for Detected Parameters

PARAMETER(UNIT)	NUMBER OF SAMPLES[a,b]	NUMBER OF SAMPLES WITH DETECTIONS[a,b]	PERCENT OF DETECTIONS[a,b]	DETECTED IN 2011	MIN DETECTED CONCENTRATION[a,b,c]	MAX DETECTED CONCENTRATION[a,b,c]	AVG DETECTED CONCENTRATION[a,b,c]	GW FRL[d] (#OF SAMPLES>GWFRL)	GW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	PW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	MAX PW DETECTED CONCENTRATION [a,b,f] (# OF SAMPLES>MAX PW)
General Chemistry											
Ammonia (mg/L)	10	4	40.0	Yes	0.0268	0.133	0.0556	-	4.2 mg/L(0)	4.34 mg/L(0)	220 mg/L(0)
Inorganic											
Chromium (mg/L)	10	4	40.0	Yes	0.003	0.0137	0.0065	0.022 mg/L[g](0)	0.021 mg/L(0)	0.0046 mg/L(2)	0.818 mg/L(0)
Lead (mg/L)	10	1	10.0	No	0.0185	-	-	0.015 mg/L(1)	0.022 mg/L(0)	0.0016 mg/L(1)	0.0114 mg/L(1)
Radionuclides											
Technetium-99 (pCi/L)	16	5	31.2	No	1.21	37.8	14.5	94 pCi/L(0)	22 pCi/L(1)	30 pCi/L(1)	6130 pCi/L(0)
Organics											
1,1-Dichloroethane (ug/L)	9	1	11.1	No	0.332	-	-	280 ug/L(0)	-	-	-
Acetone (ug/L)	9	1	11.1	No	2.35	-	-	-	-	-	-

Note: Shading indicates that at least one detected sample is greater than the FRL, groundwater background, PW background, or PW maximum.

[a]If more than one sample is collected per well per day (e.g., duplicates), then only one sample is counted for the total number of samples, and the sample with the maximum representative concentration is used for all the summary information

[b]Rejected data qualified with an R or Z were not included.

[c]If the number of detected samples is equal to two, then the minumun and maximumn are reported. If the number of detected is equal to one, then the data point is reported as the minimum. The "AVG DETECTED CONCENTRATION" is not reported for either of these cases.

[d]From Operable Unit 5 Record of Decision, Table 9-4.

[e]From the Characterization of Background Water Quality for Streams and Groundwater which was developed for Operable Unit 5 RI/FS documents.

[f]Max PW - maximum detected concentration in perched water as defined in the Remedial Investigation Report for Operable Unit 5.

[g]FRL based on hexavalent chromium from Operable Unit 5 Record of Decision, Table 9-4.

Figure A.5.4–1. Monthly Accumulation Volumes For Cell 4 LCS

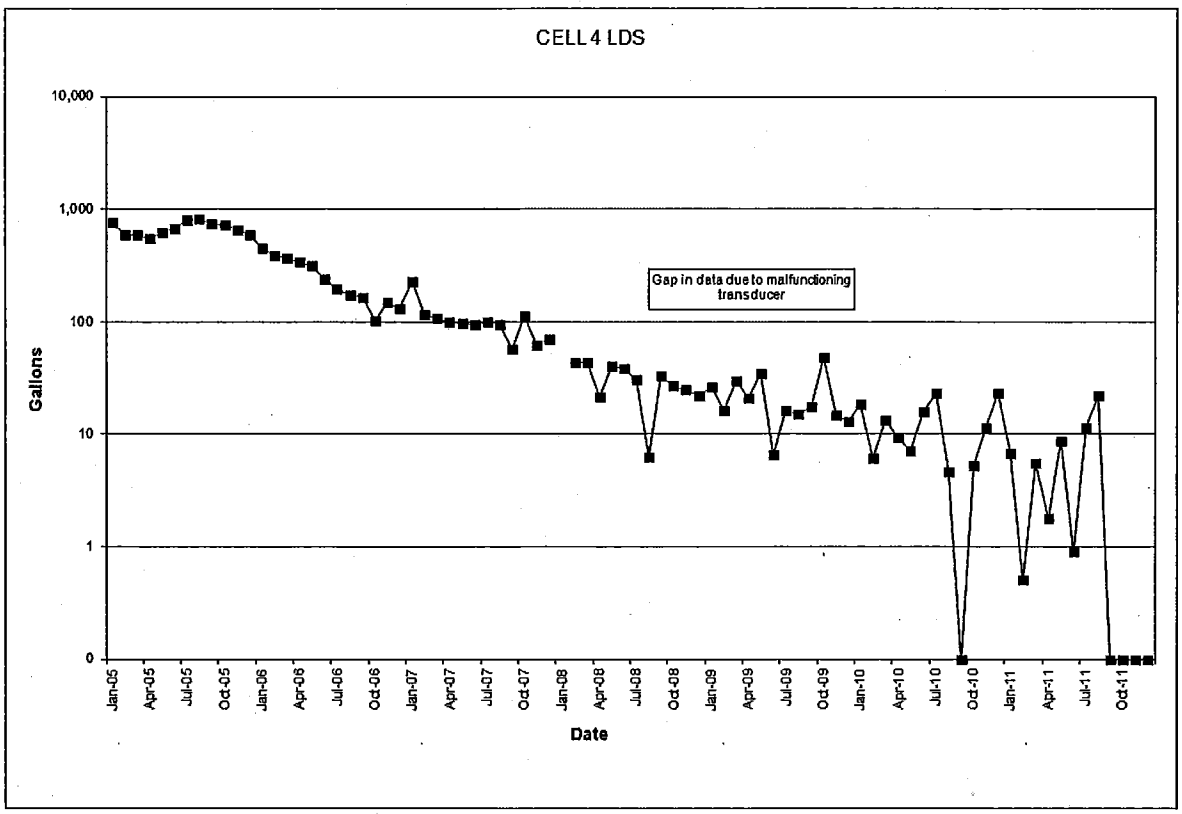
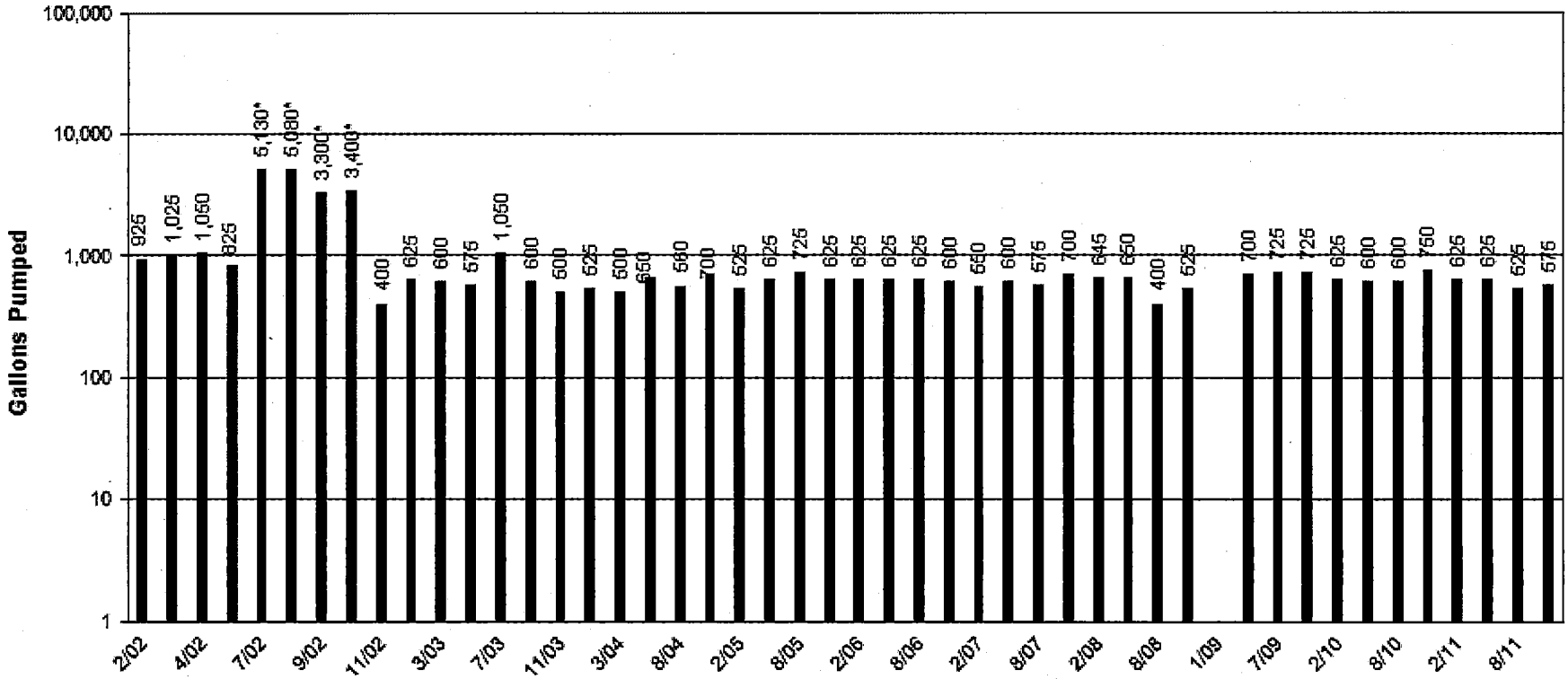


Figure A.5.4–2. Monthly Accumulation Volumes For Cell 4 LDS



12341 Purge Information

Year	Total Volumes (gal.)	Months Purged	Avg. Monthly Purge (gal.)
2002:	21115	n=9	2346
2003:	3950	n=6	658
2004:	2935	n=5	587
2005:	2500	n=4	625
2006:	2475	n=4	619
2007:	2425	n=4	606
2008:	2220	n=4	555
2009:	2150	n=3	717
2010:	2575	n=4	644
2011:	2350	n=4	588
Overall:			951

*More than one purge of the well was completed during these months to drain perched water and infiltrating surface water so the compacted clay liner could be constructed.

Figure A.5.4–3. OSDF Horizontal Till Well 12341 (Cell 4) Water Yield

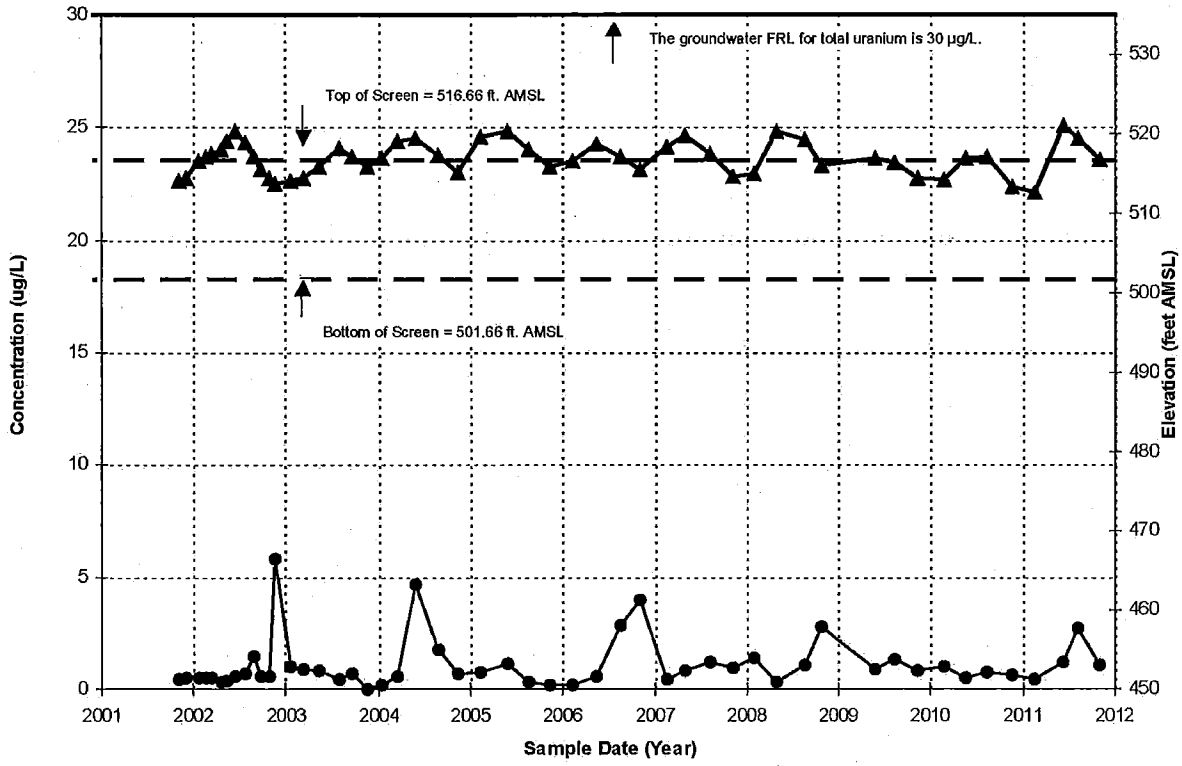


FIGURE A.5.4-4. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 4 Upgradient Monitoring Well 22206

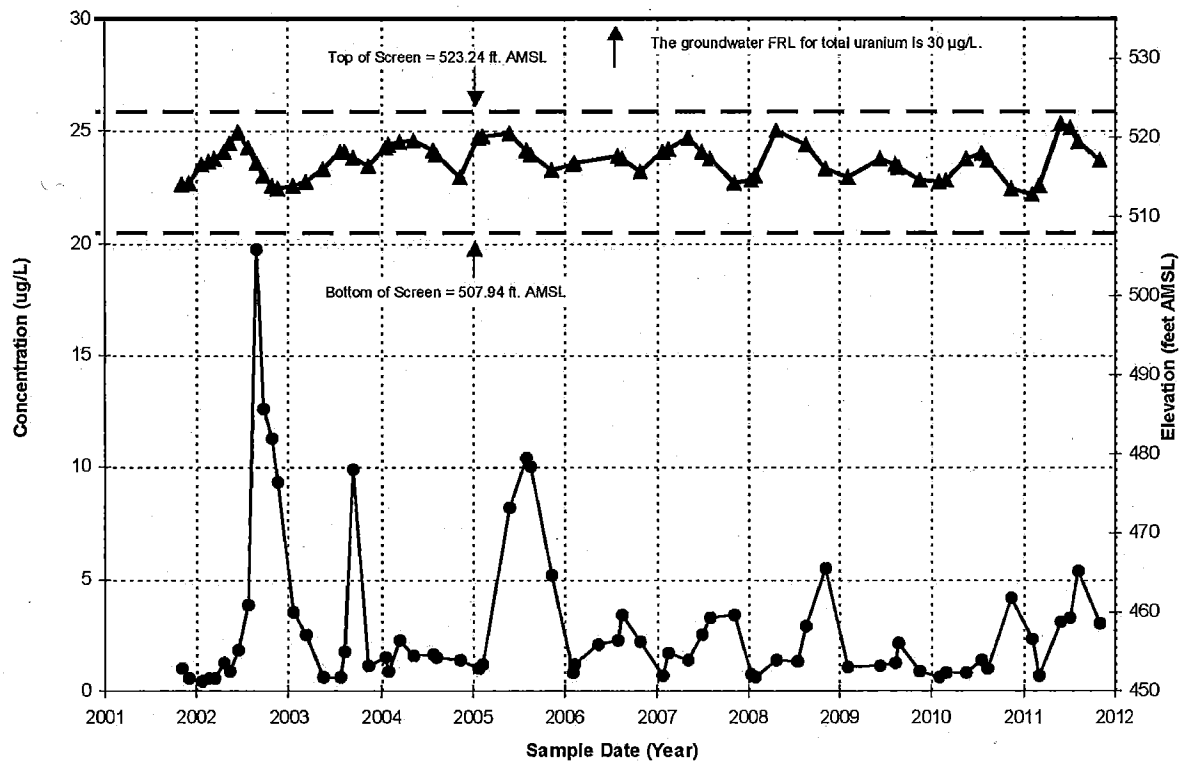


FIGURE A.5.4-5. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 4 Downgradient Monitoring Well 22205

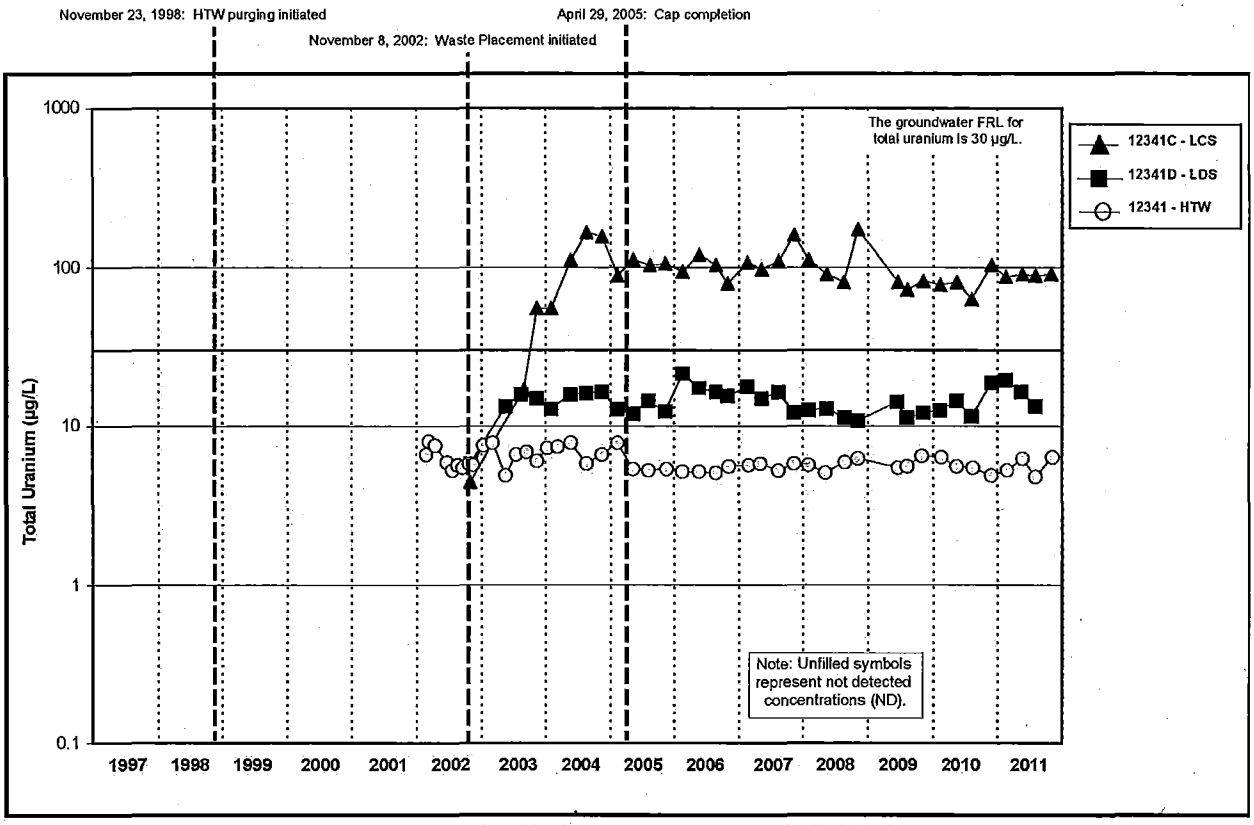


Figure A.5.4-6A. Cell 4 Uranium, Total Concentration vs. Time Plot for LCS, LDS, and HTW

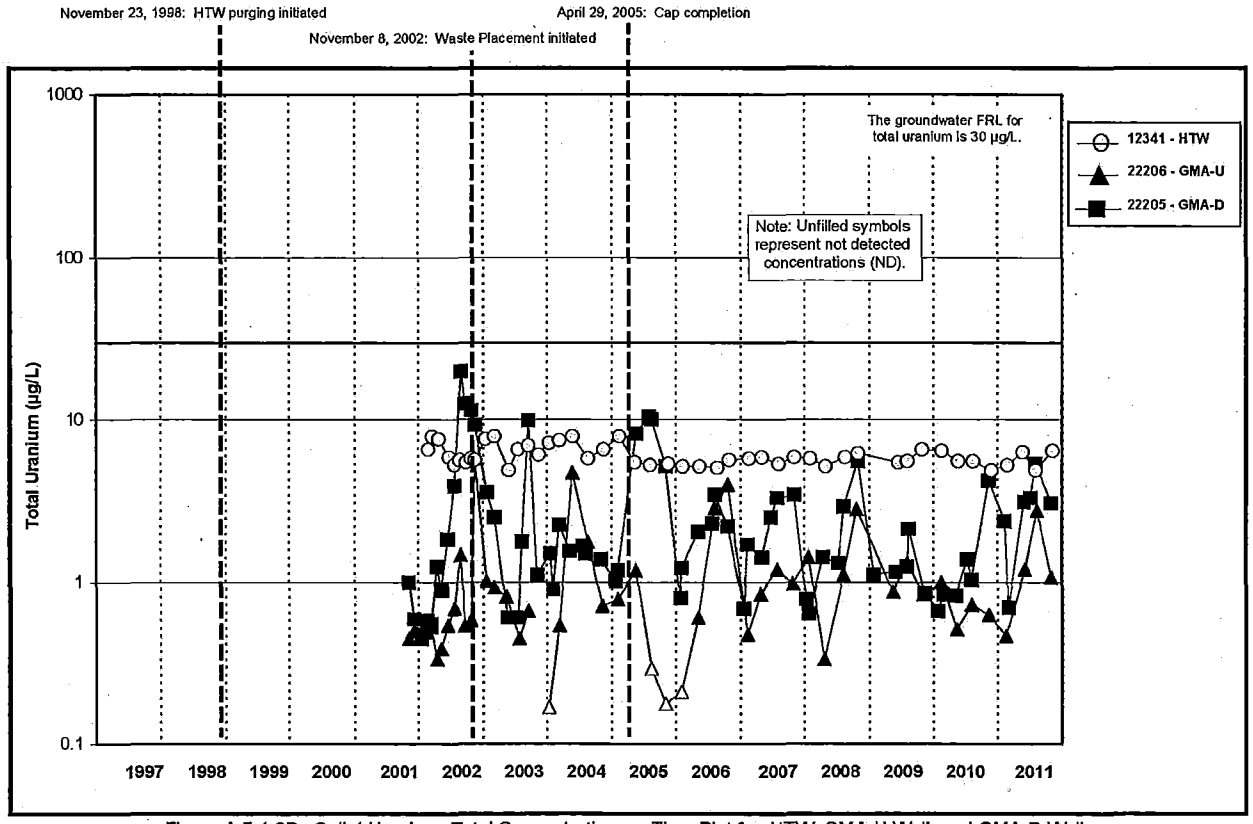


Figure A.5.4-6B. Cell 4 Uranium, Total Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

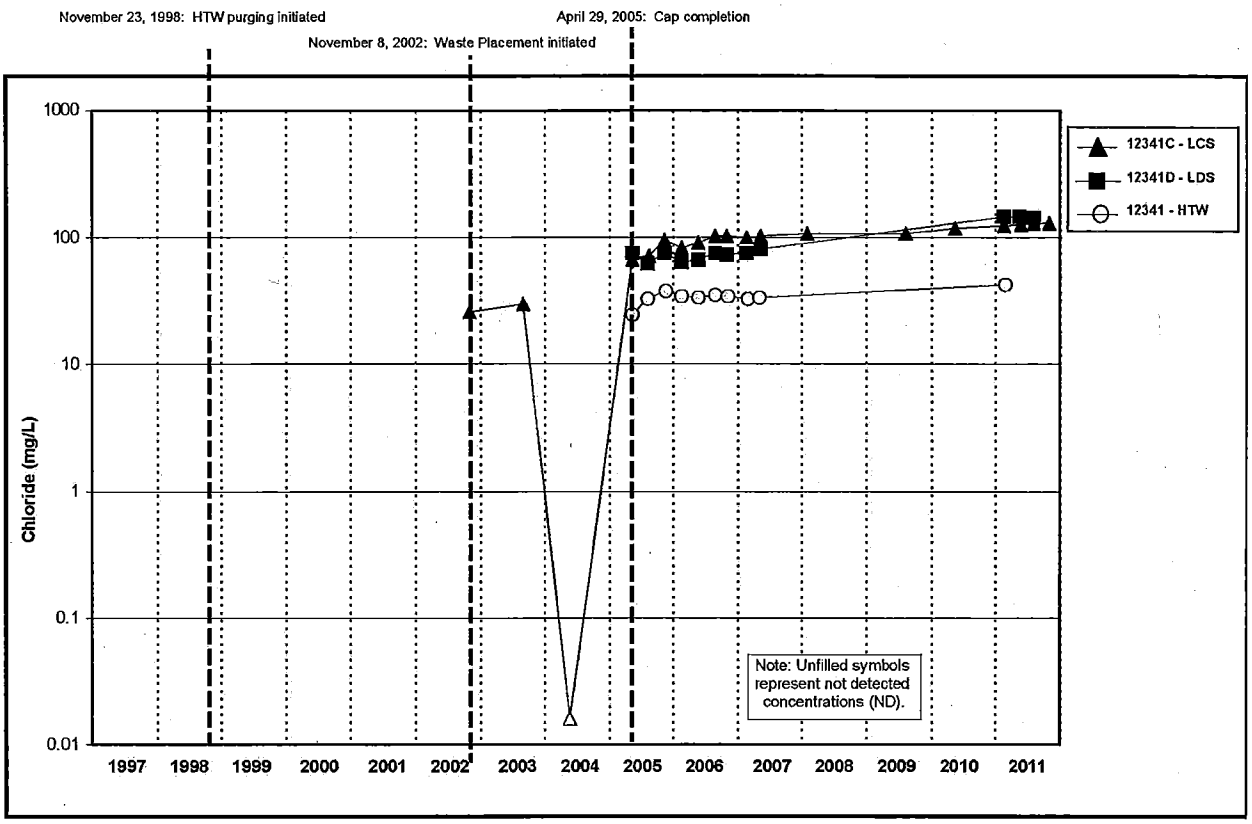


Figure A.5.4-7A. Cell 4 Chloride Concentration vs. Time Plot for LCS, LDS, and HTW

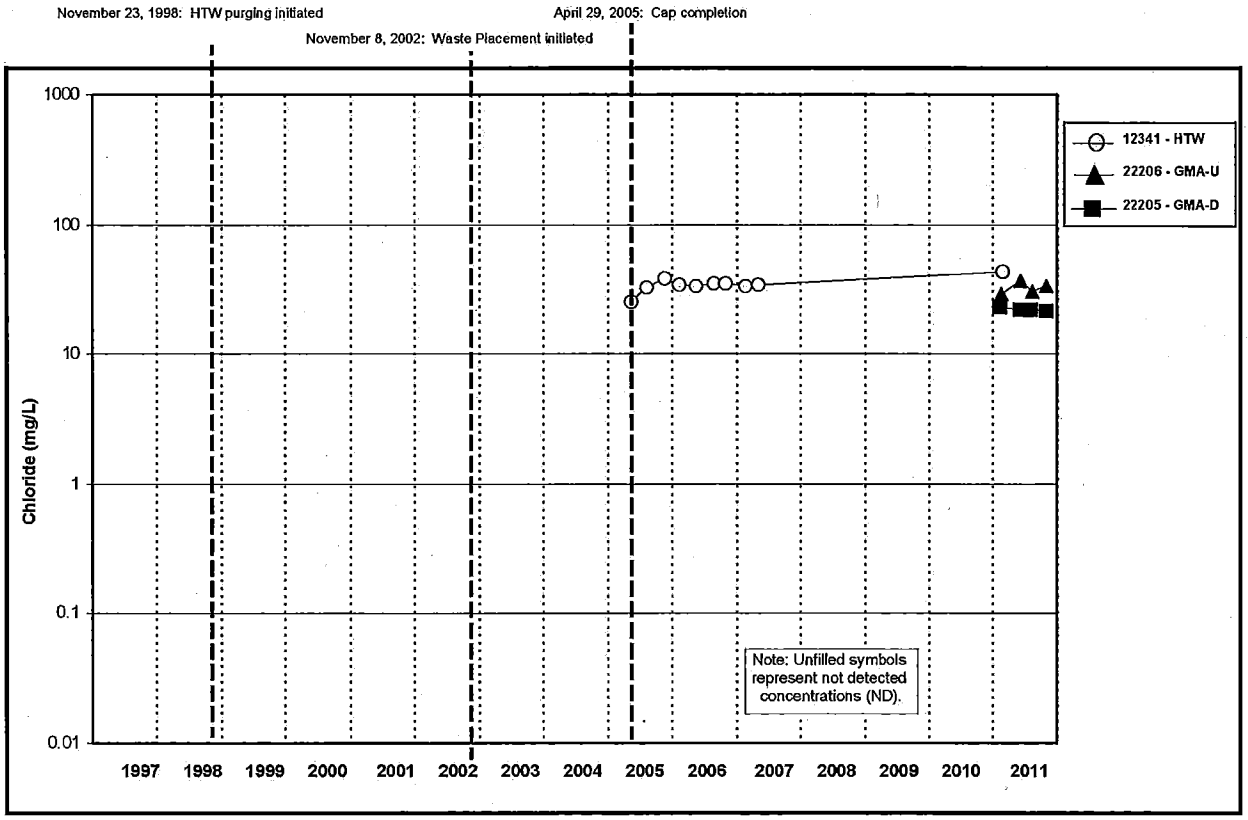


Figure A.5.4-7B. Cell 4 Chloride Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

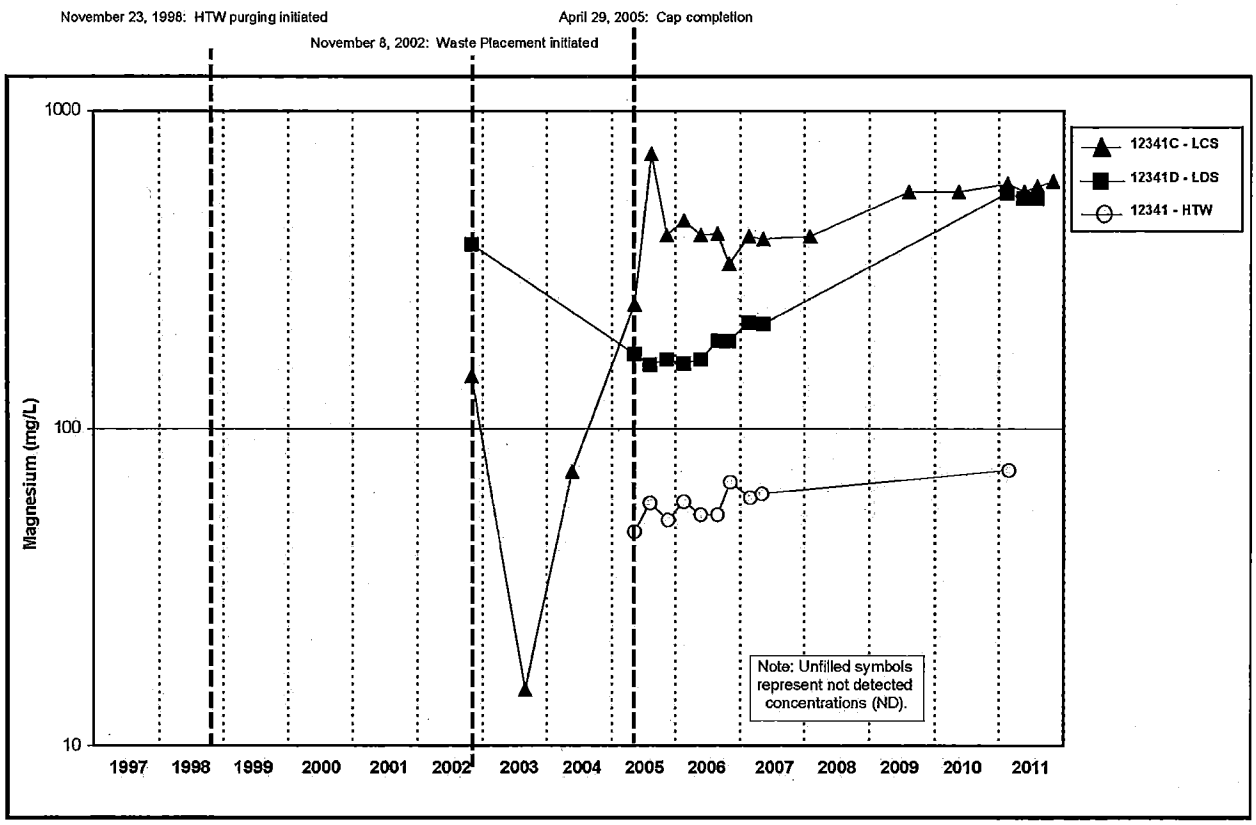


Figure A.5.4-8A. Cell 4 Magnesium Concentration vs. Time Plot for LCS, LDS, and HTW

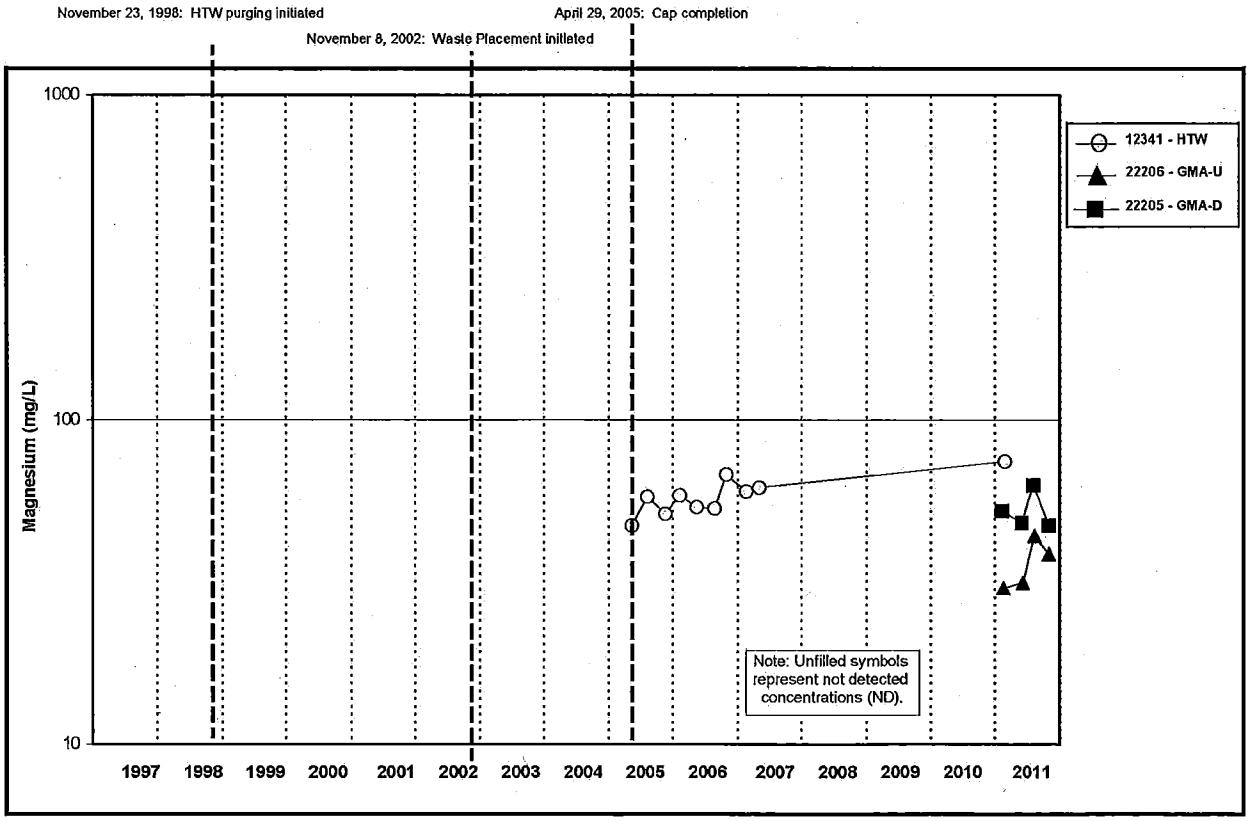


Figure A.5.4-8B. Cell 4 Magnesium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

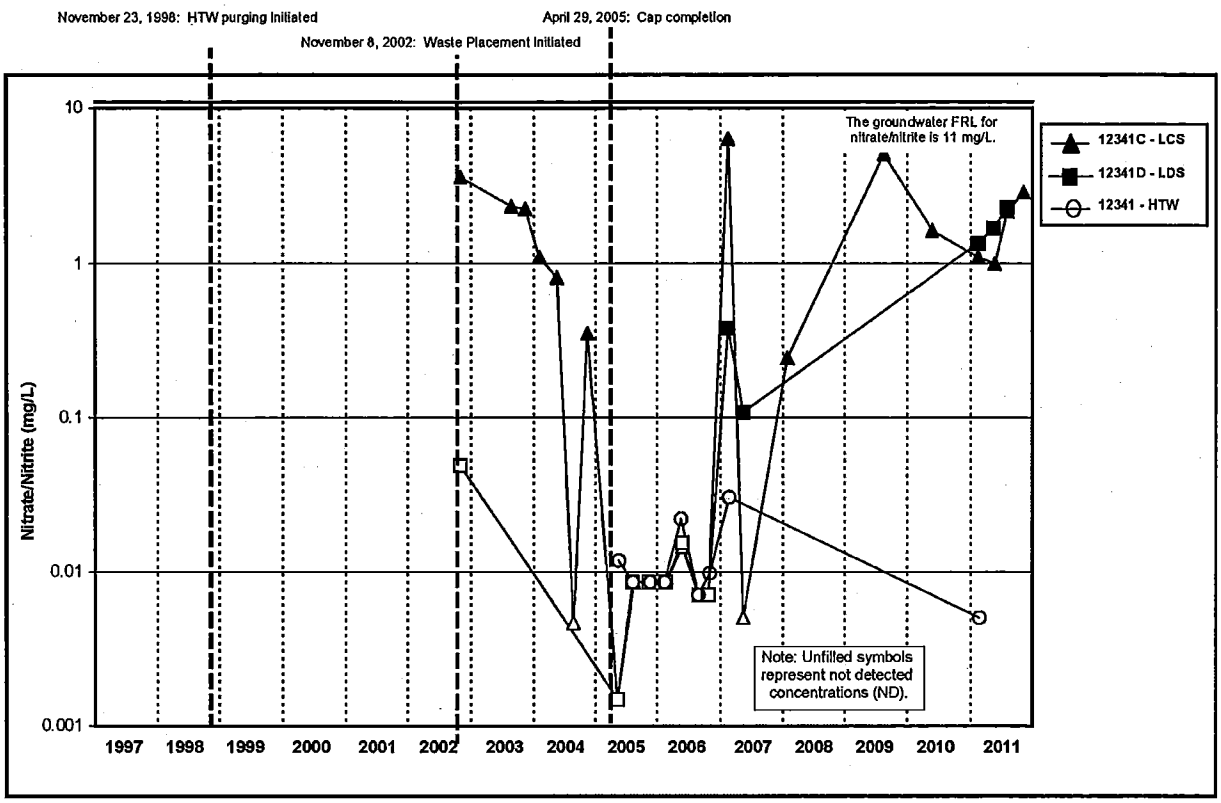


Figure A.5.4-9A. Cell 4 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for LCS, LDS, and HTW

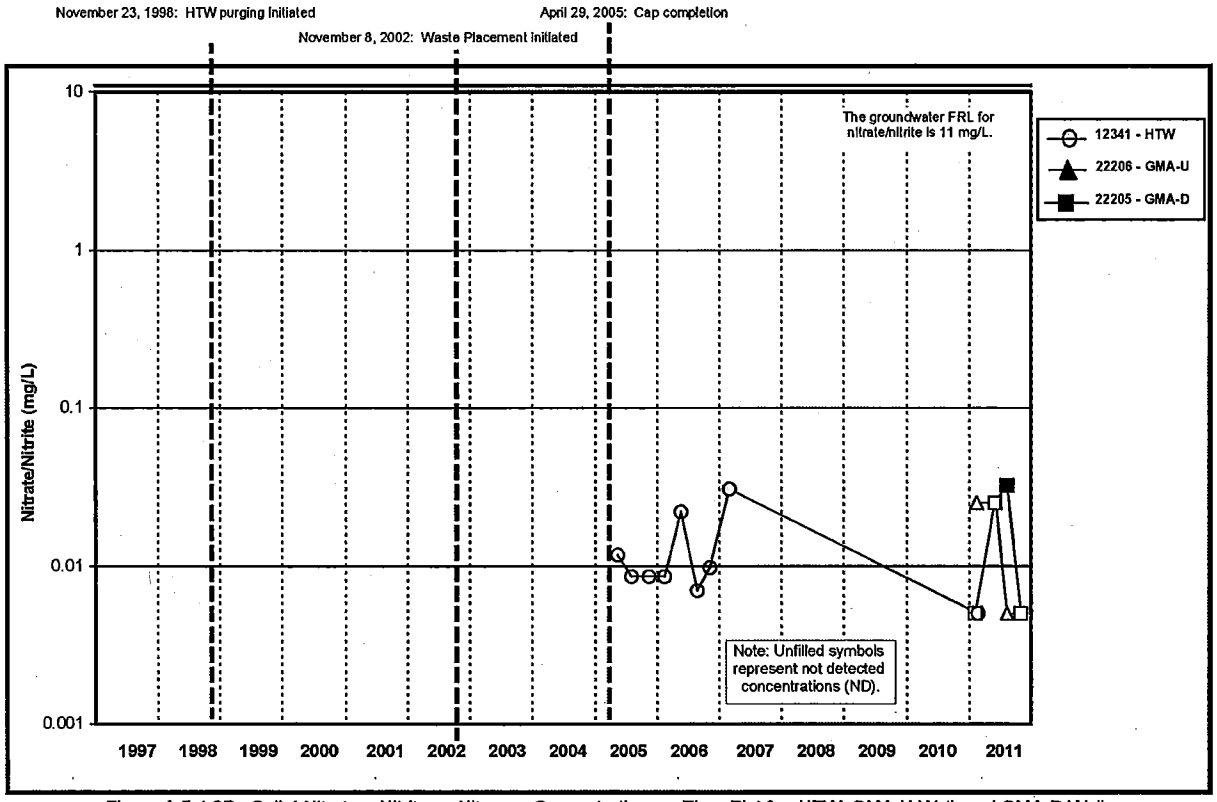


Figure A.5.4-9B. Cell 4 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

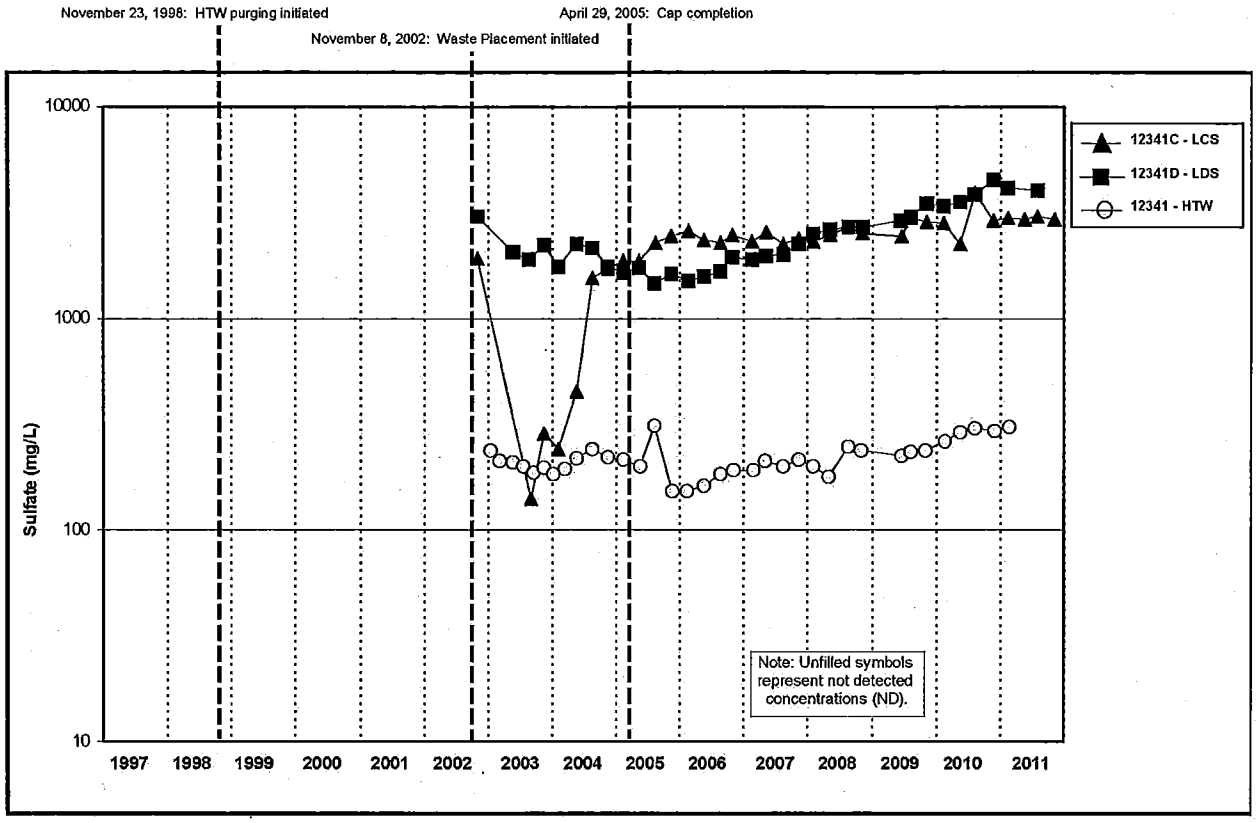


Figure A.5.4-10A. Cell 4 Sulfate Concentration vs. Time Plot for LCS, LDS, and HTW

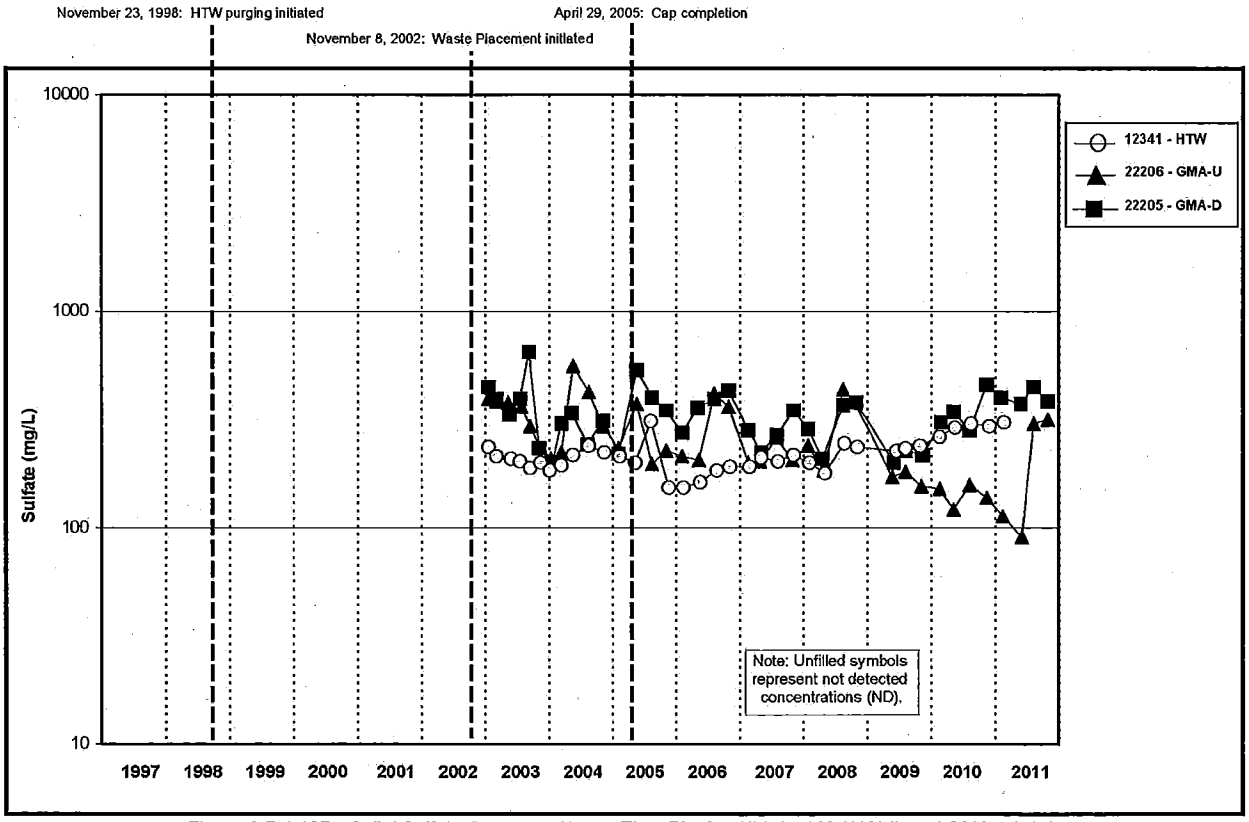


Figure A.5.4-10B. Cell 4 Sulfate Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

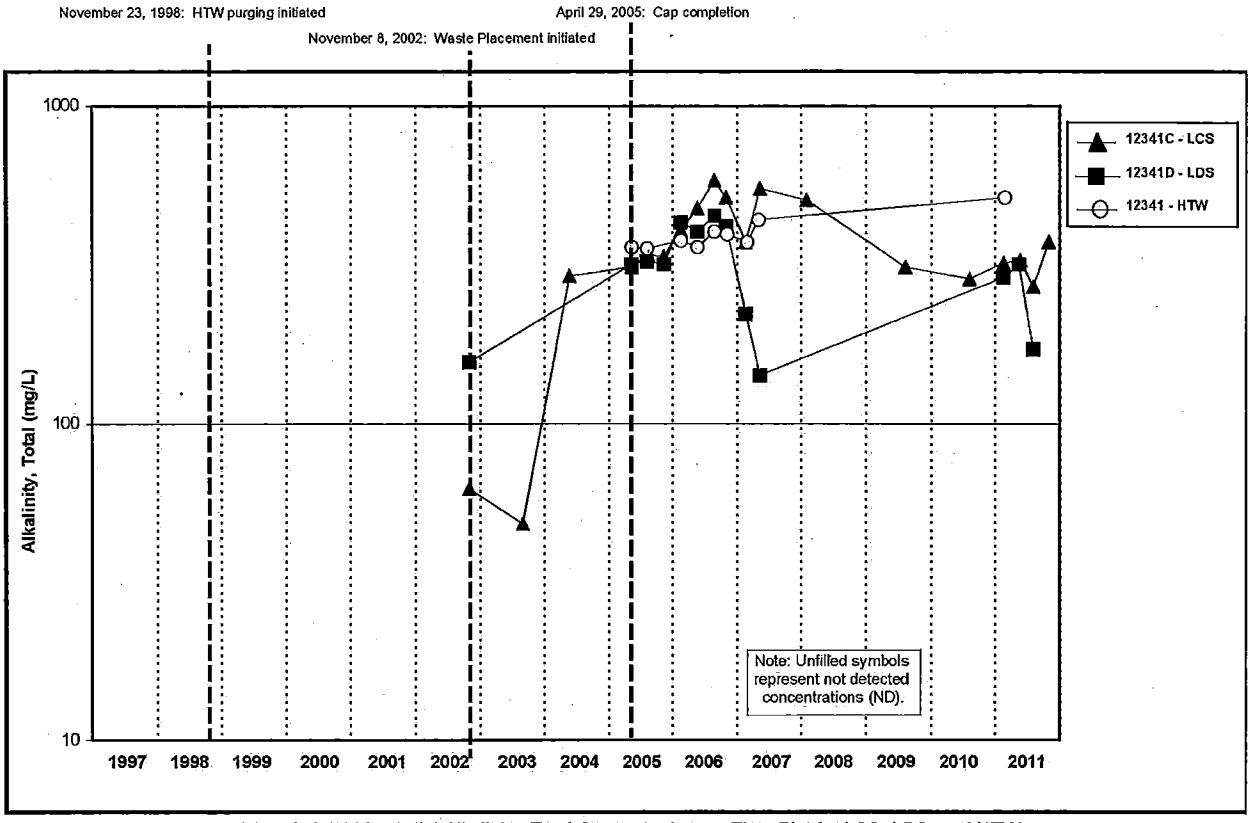


Figure A.5.4-11A. Cell 4 Alkalinity, Total Concentration vs. Time Plot for LCS, LDS, and HTW

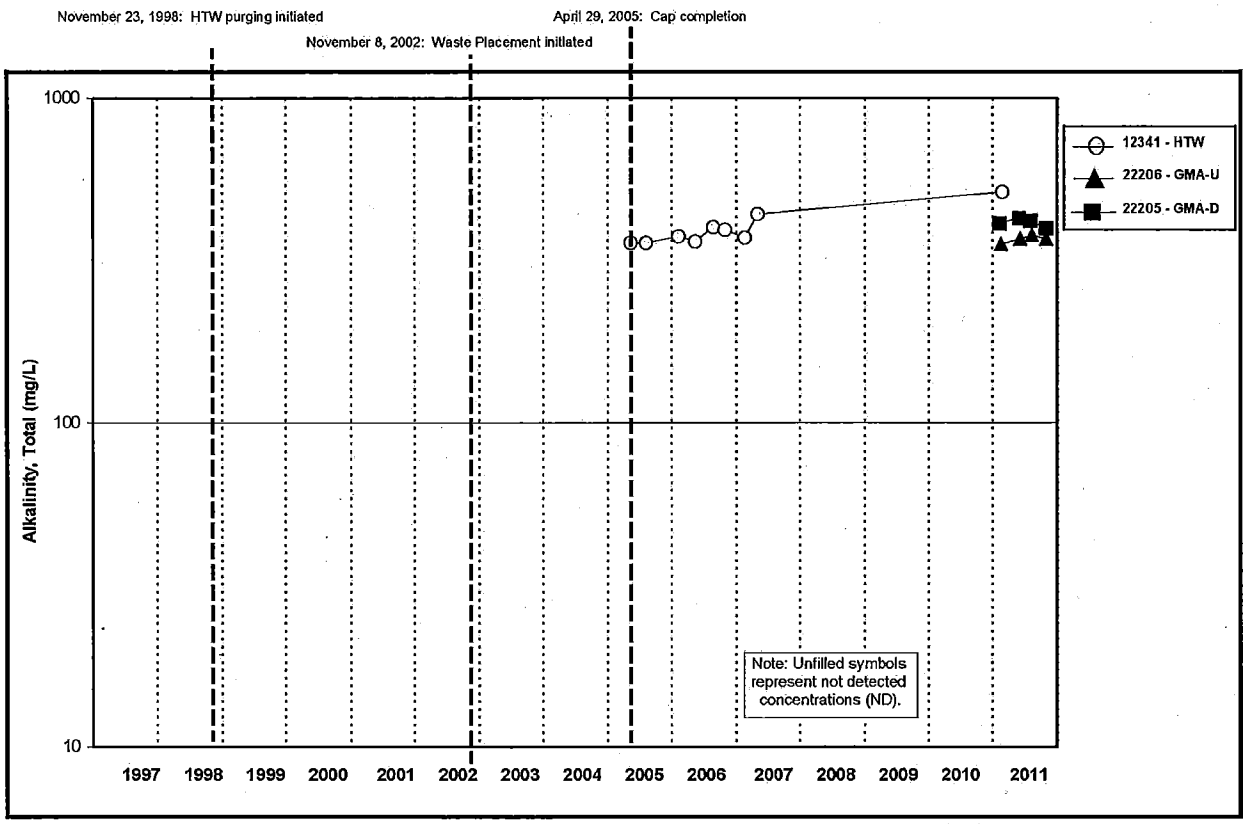


Figure A.5.4-11B. Cell 4 Alkalinity, Total Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

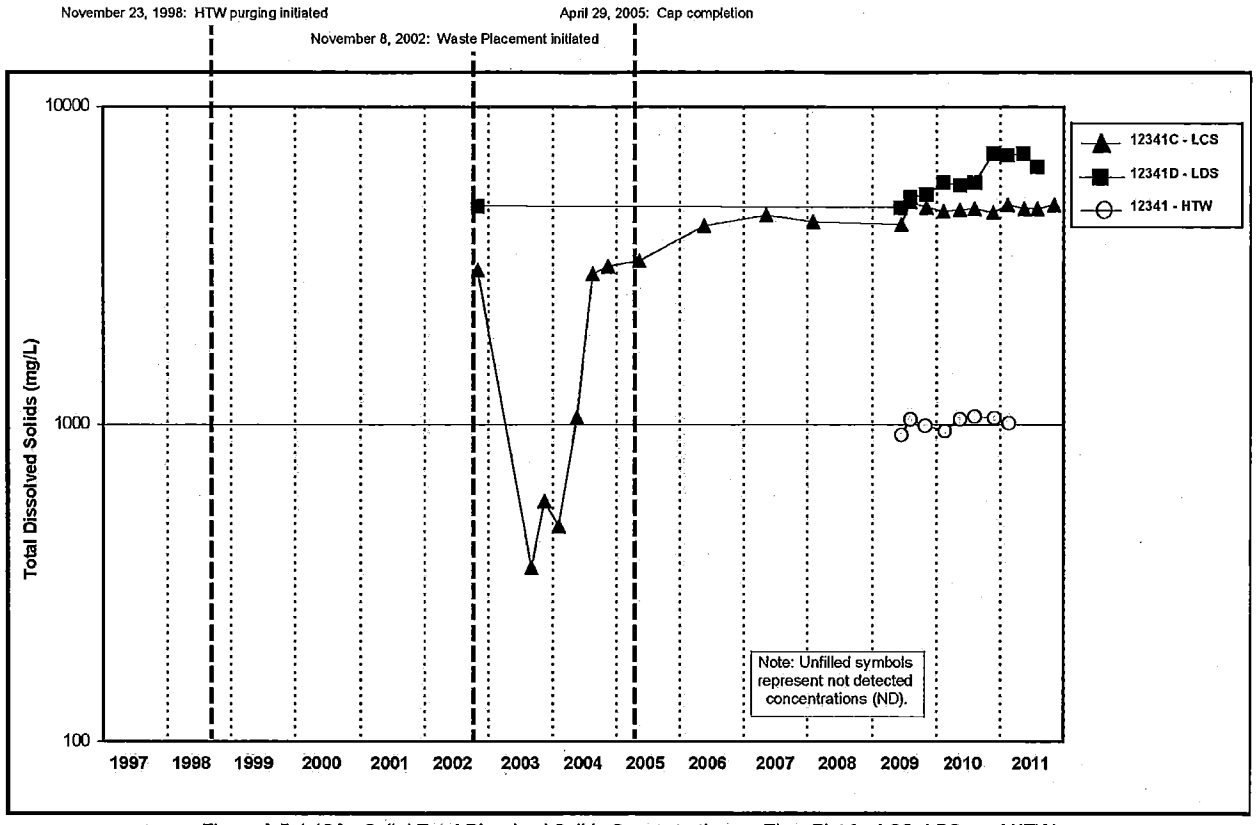


Figure A.5.4-12A. Cell 4 Total Dissolved Solids Concentration vs. Time Plot for LCS, LDS, and HTW

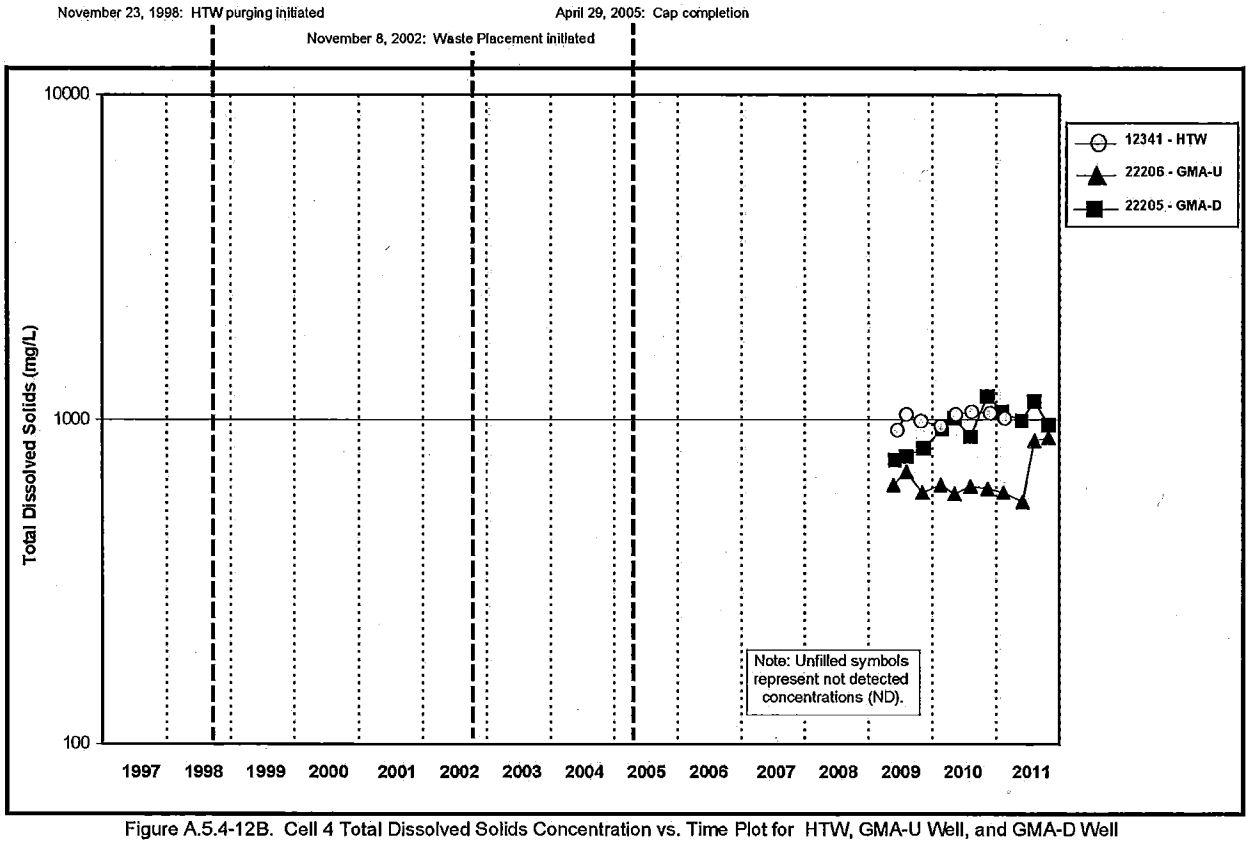


Figure A.5.4-12B. Cell 4 Total Dissolved Solids Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

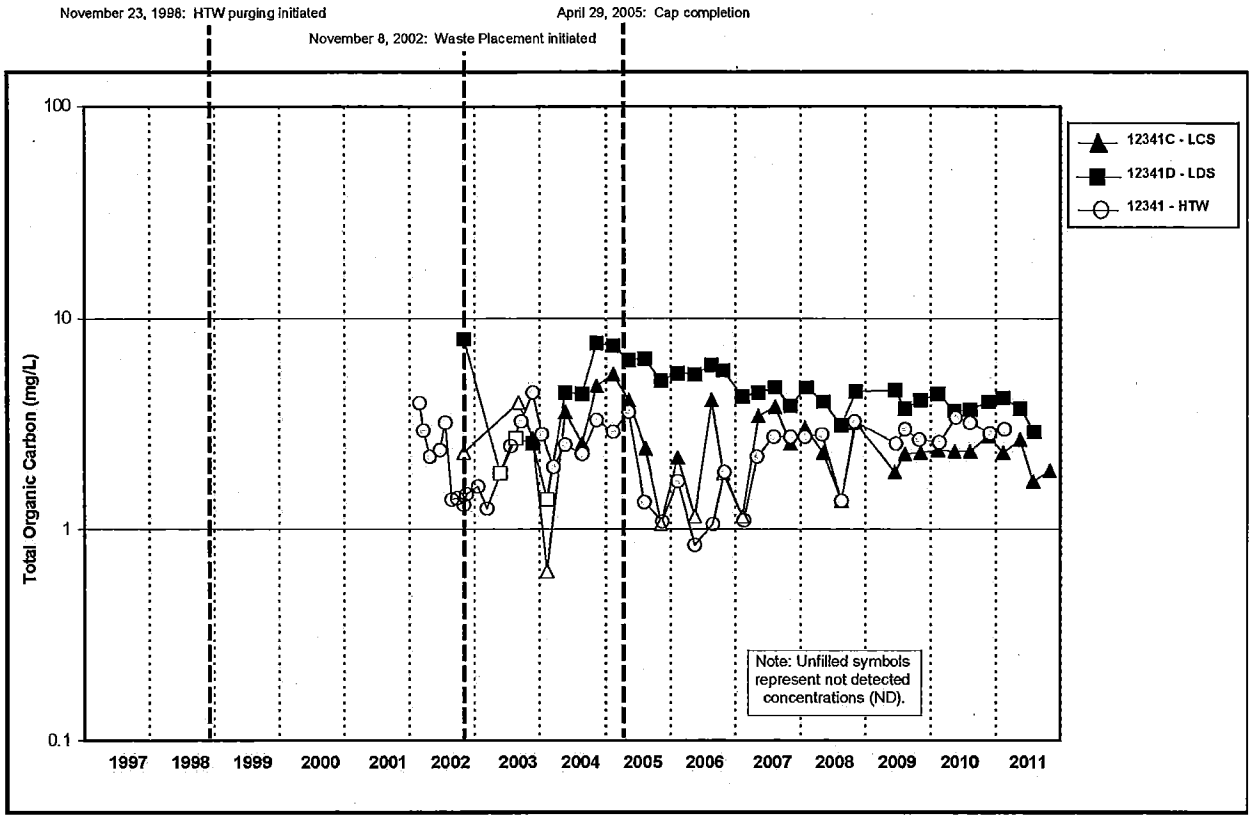


Figure A.5.4-13A. Cell 4 Total Organic Carbon Concentration vs. Time Plot for LCS, LDS, and HTW

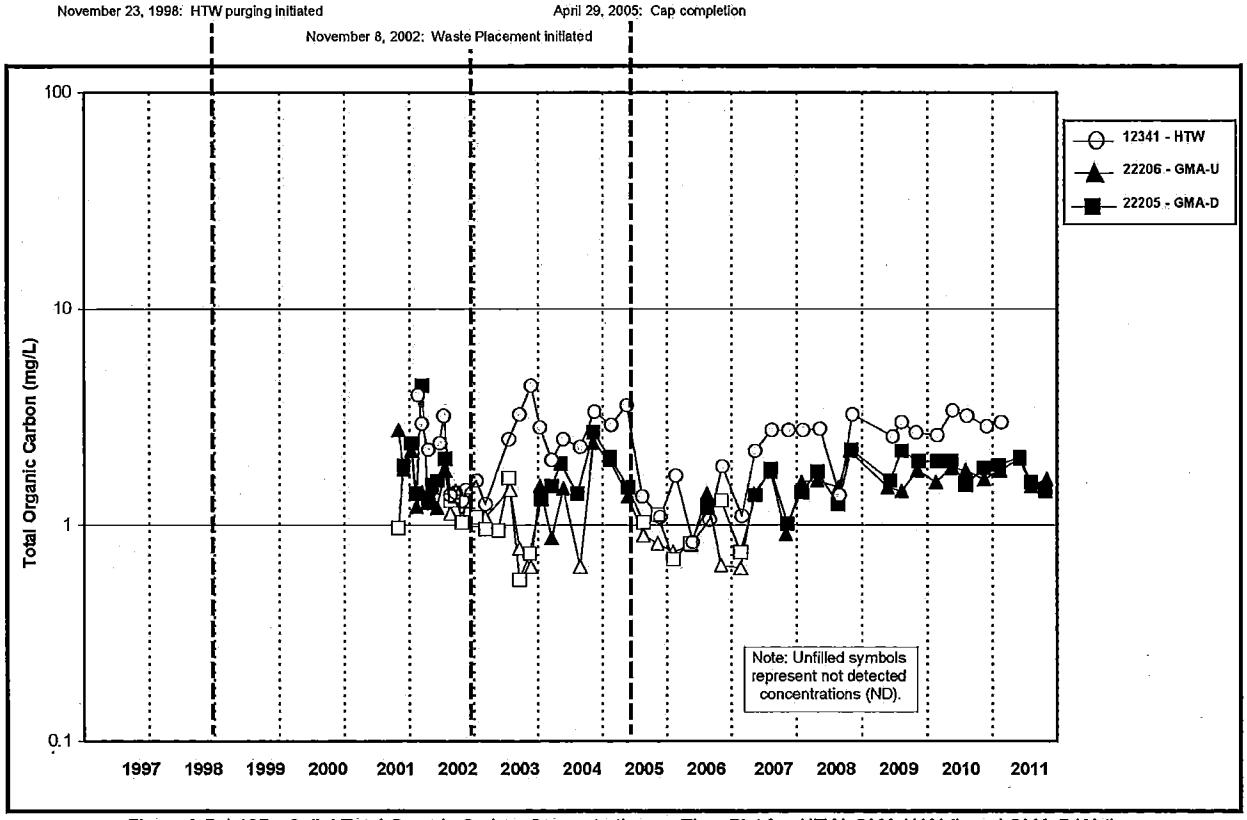


Figure A.5.4-13B. Cell 4 Total Organic Carbon Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

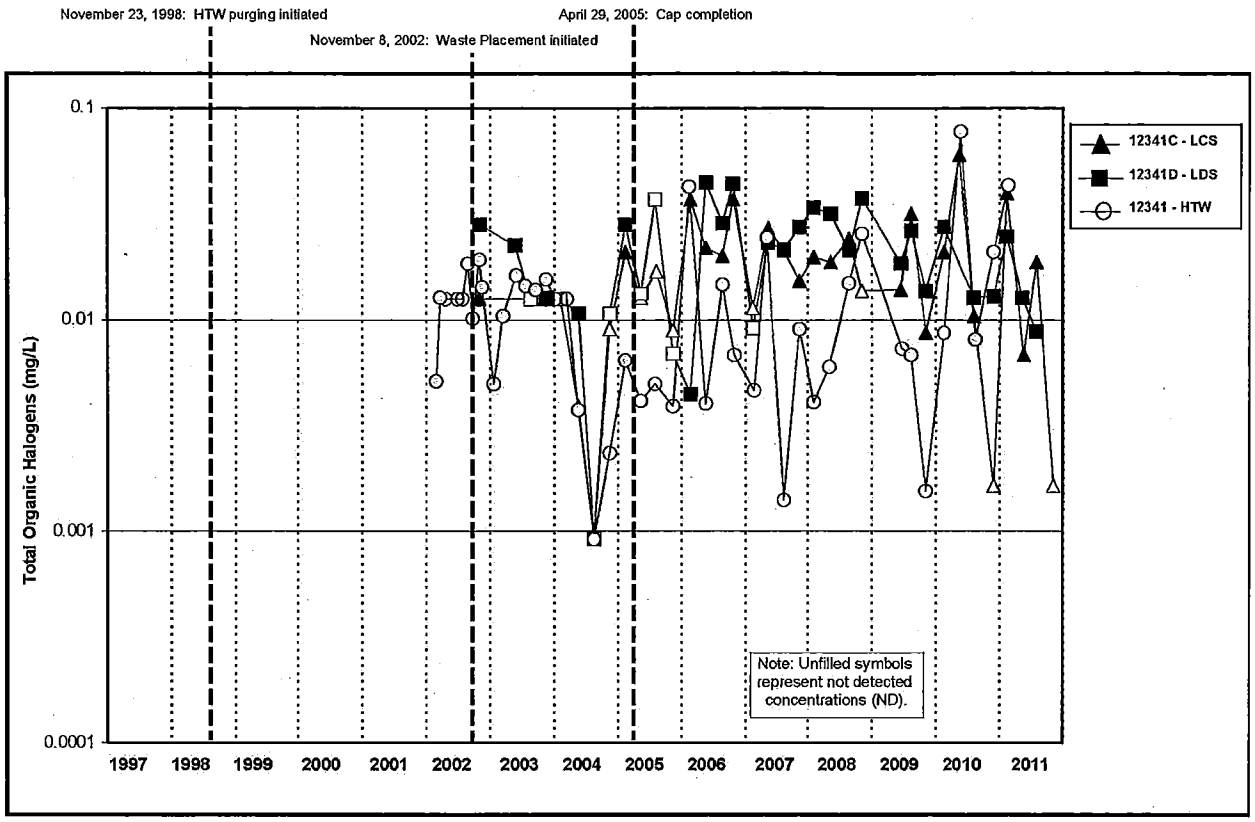


Figure A.5.4-14A. Cell 4 Total Organic Halogens Concentration vs. Time Plot for LCS, LDS, and HTW

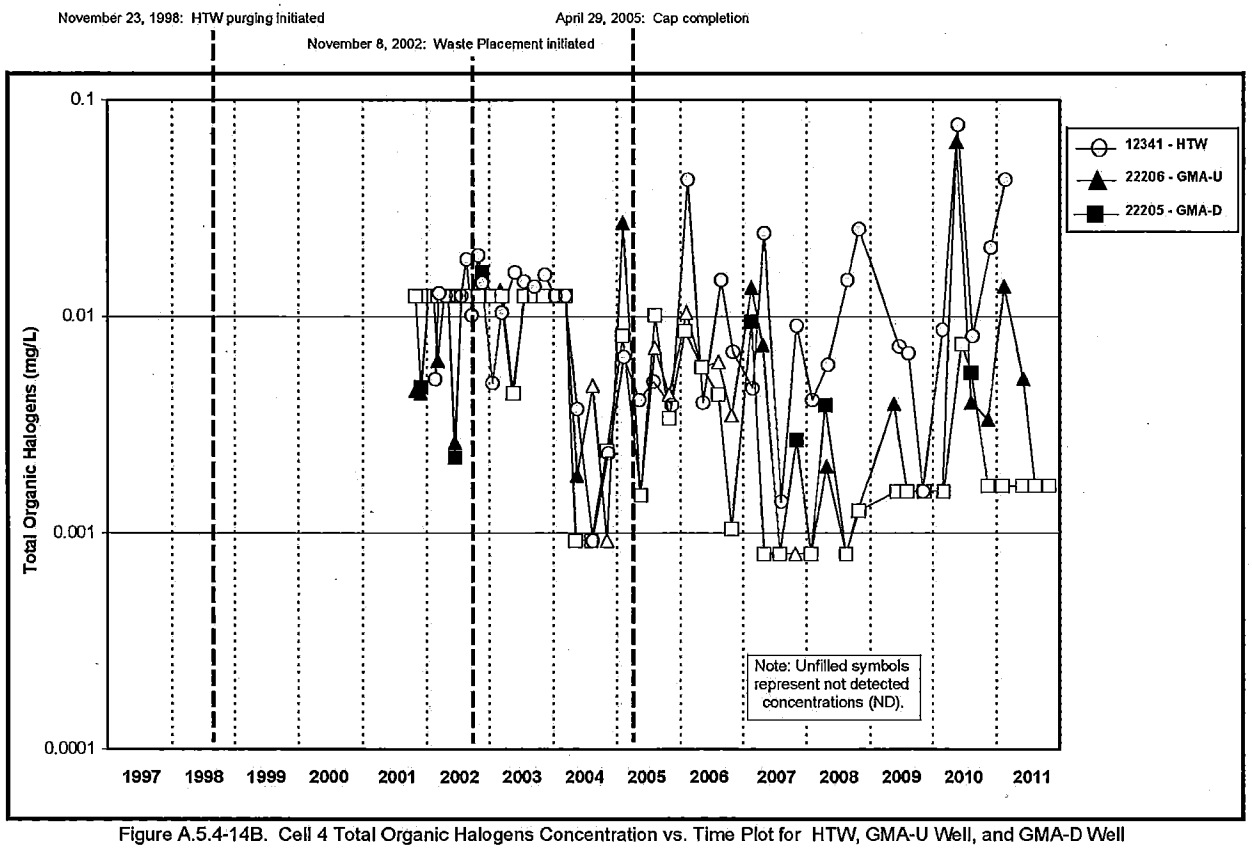


Figure A.5.4-14B. Cell 4 Total Organic Halogens Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

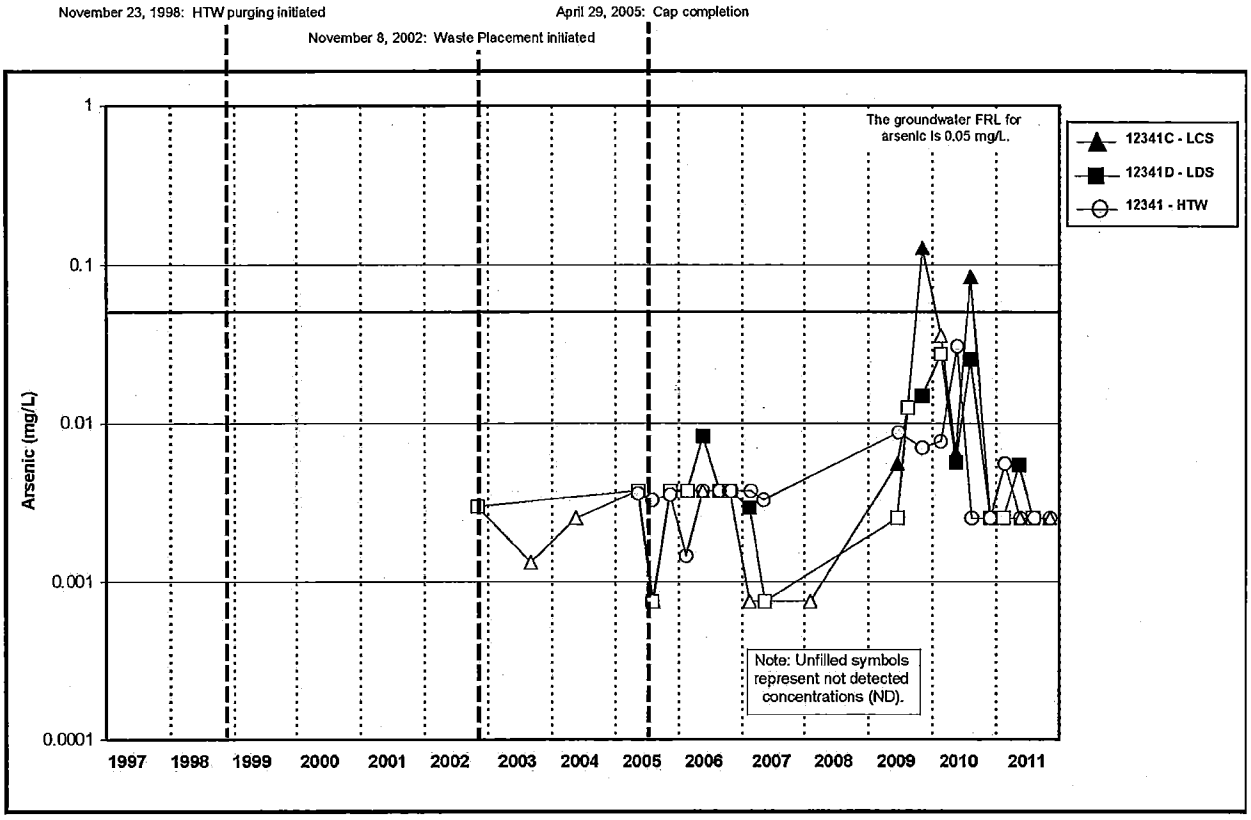


Figure A.5.4-15A. Cell 4 Arsenic Concentration vs. Time Plot for LCS, LDS, and HTW

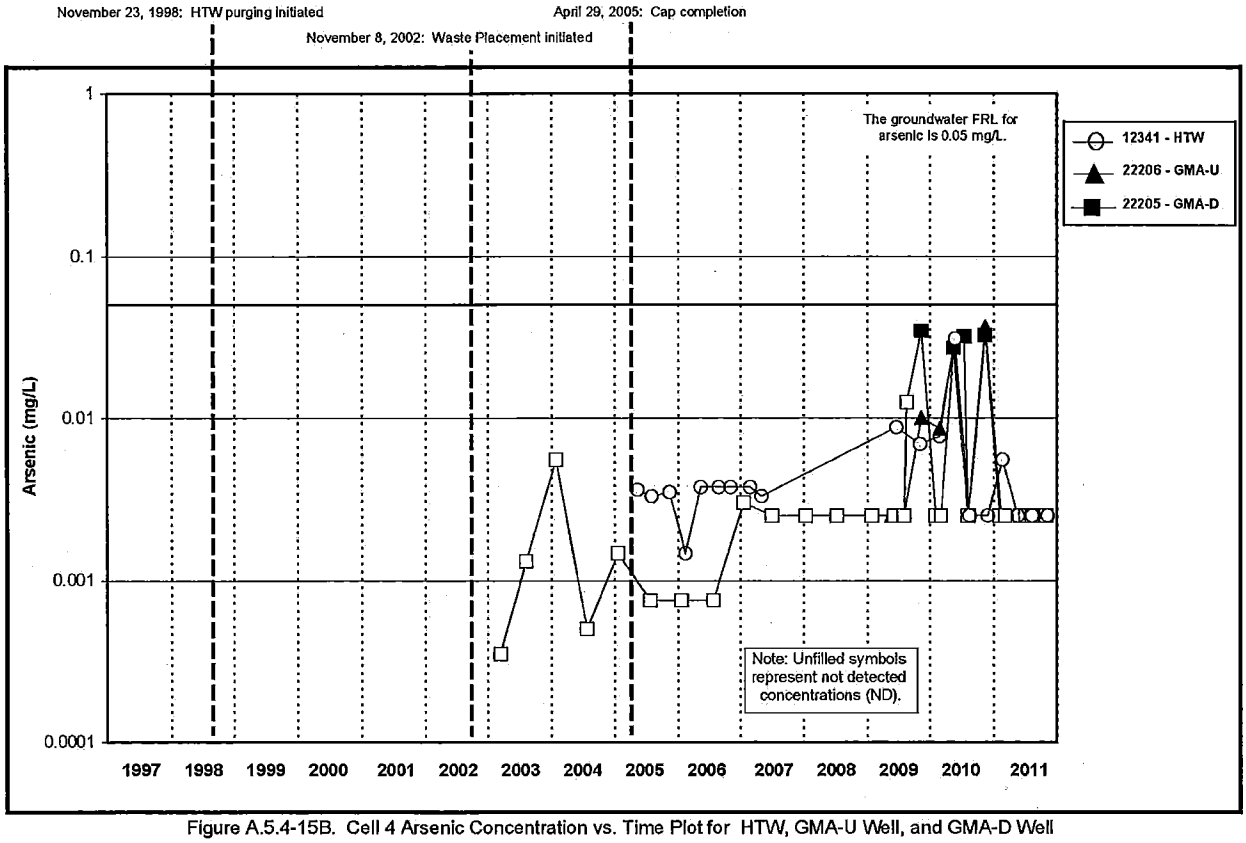


Figure A.5.4-15B. Cell 4 Arsenic Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

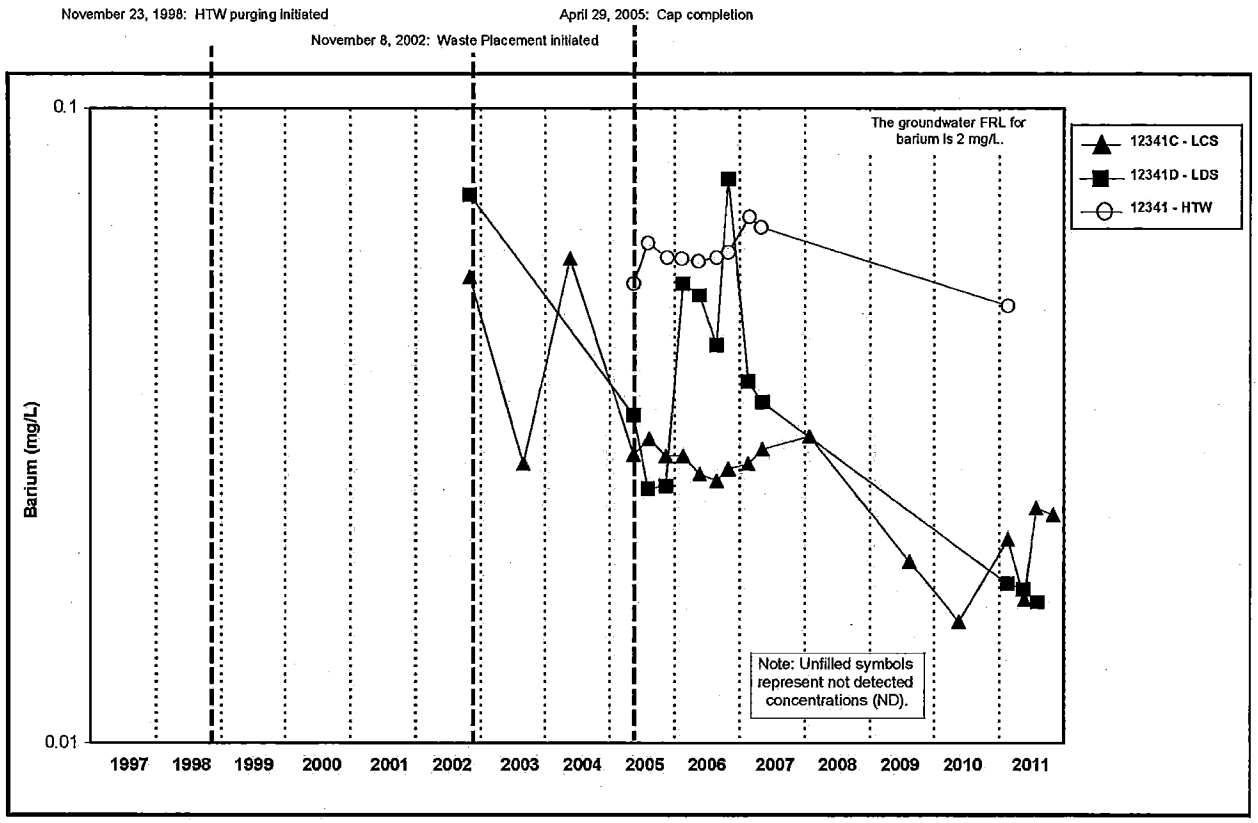


Figure A.5.4-16A. Cell 4 Barium Concentration vs. Time Plot for LCS, LDS, and HTW

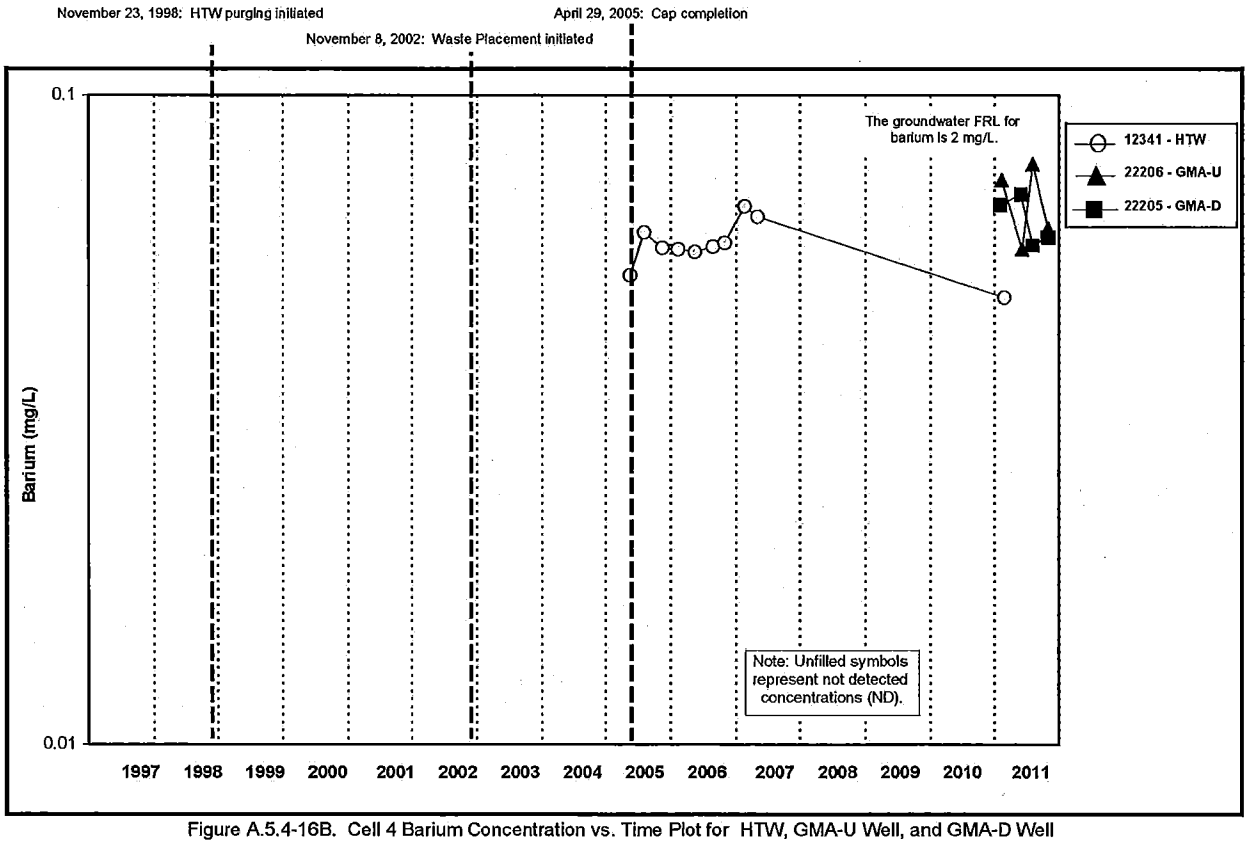


Figure A.5.4-16B. Cell 4 Barium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

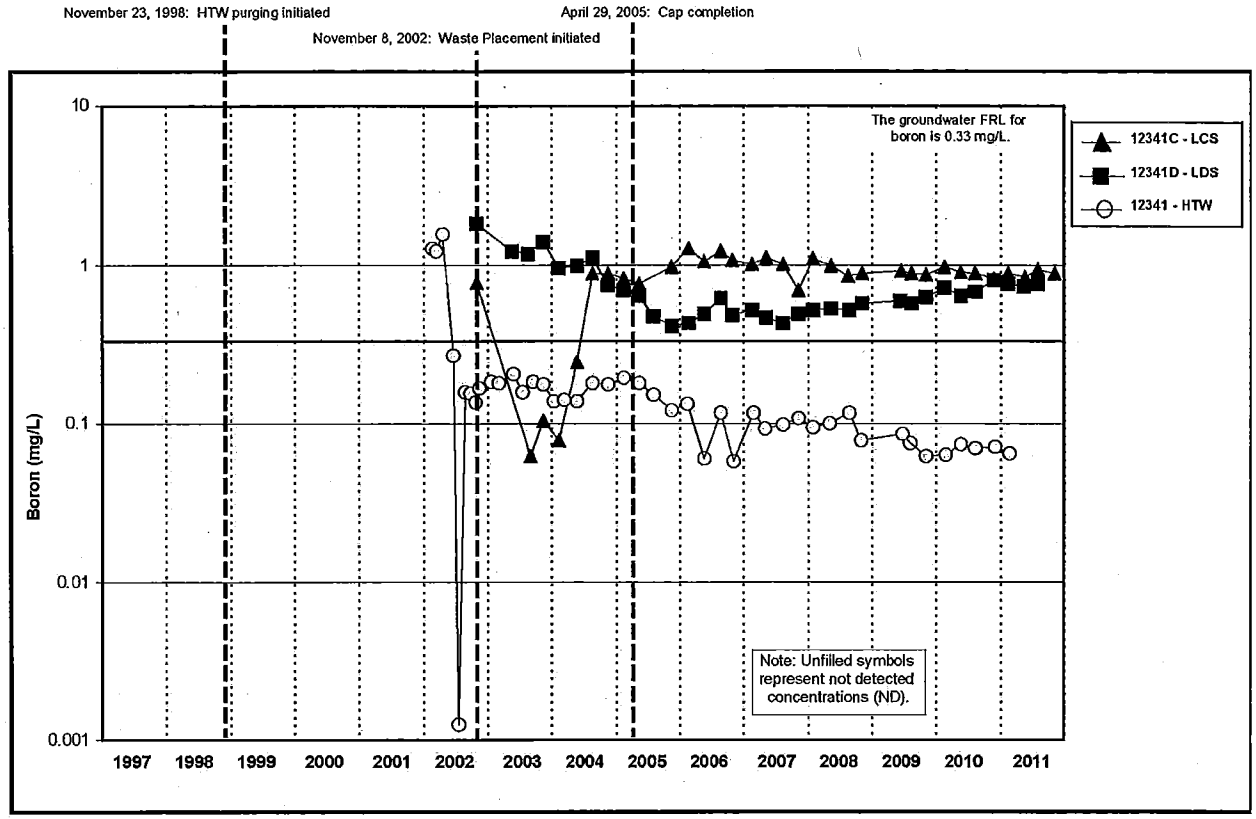


Figure A.5.4-17A. Cell 4 Boron Concentration vs. Time Plot for LCS, LDS, and HTW

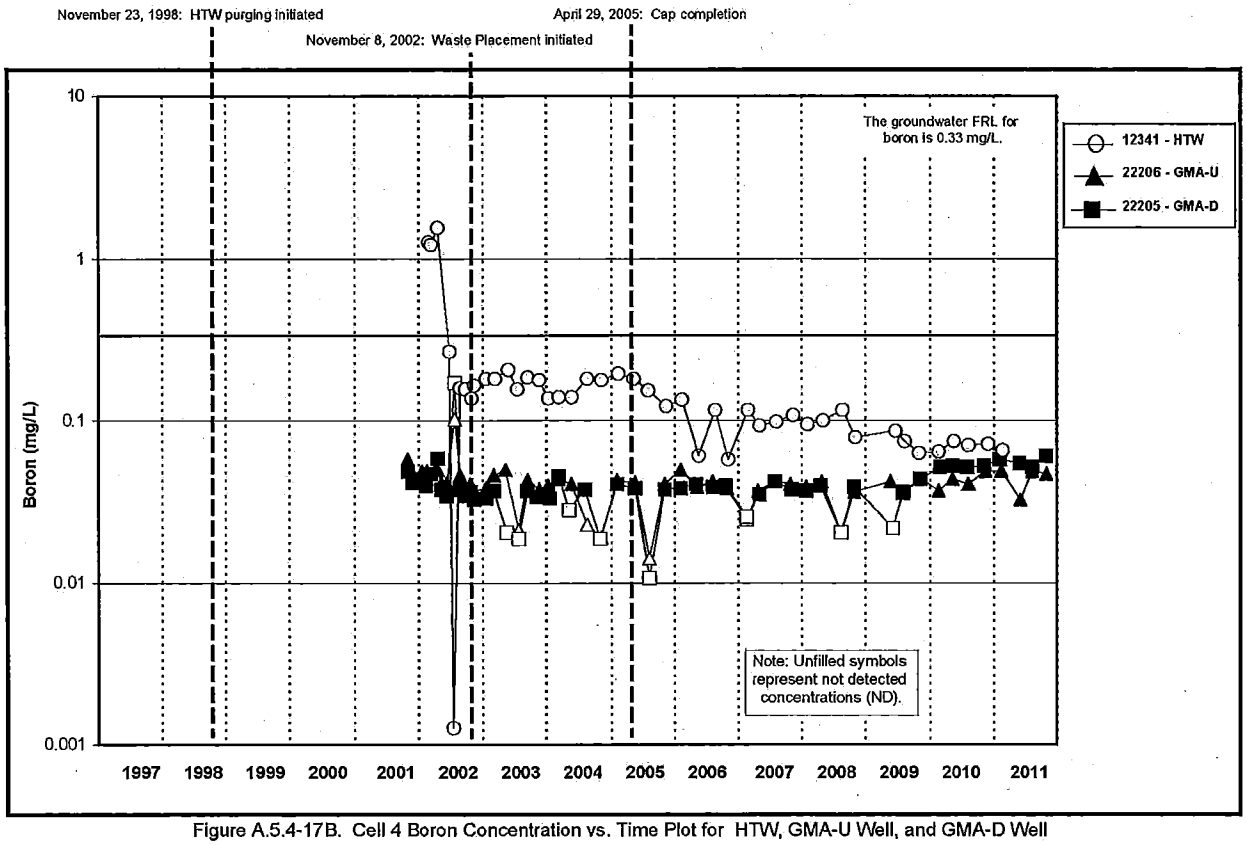


Figure A.5.4-17B. Cell 4 Boron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

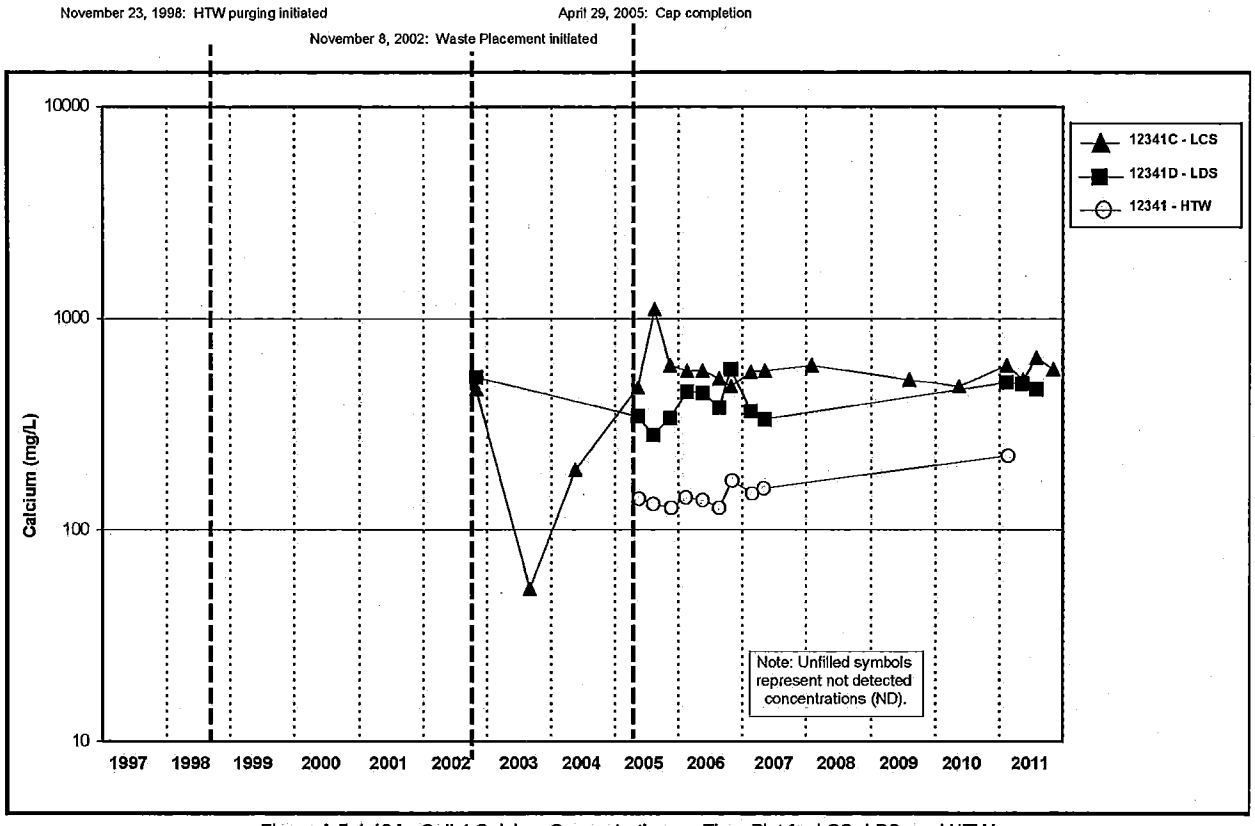


Figure A.5.4-18A. Cell 4 Calcium Concentration vs. Time Plot for LCS, LDS, and HTW

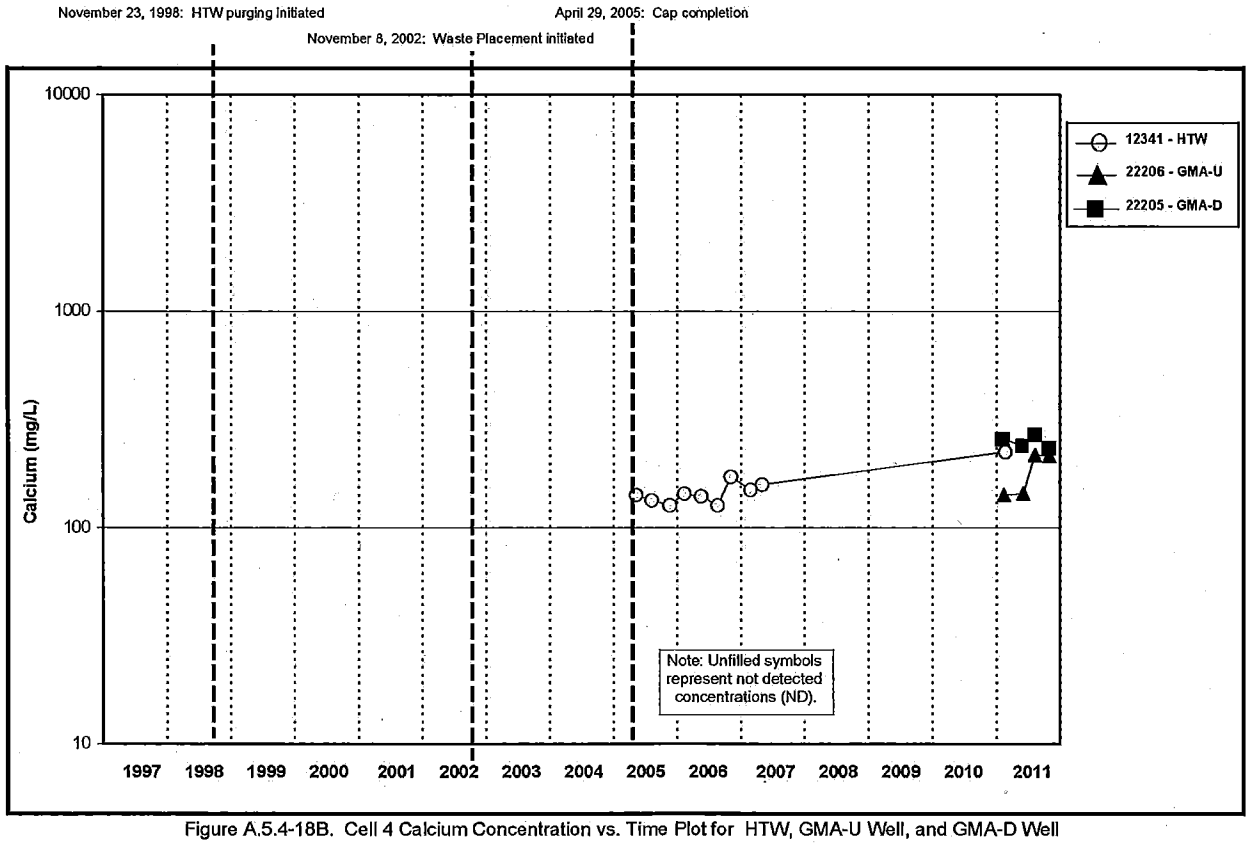


Figure A.5.4-18B. Cell 4 Calcium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

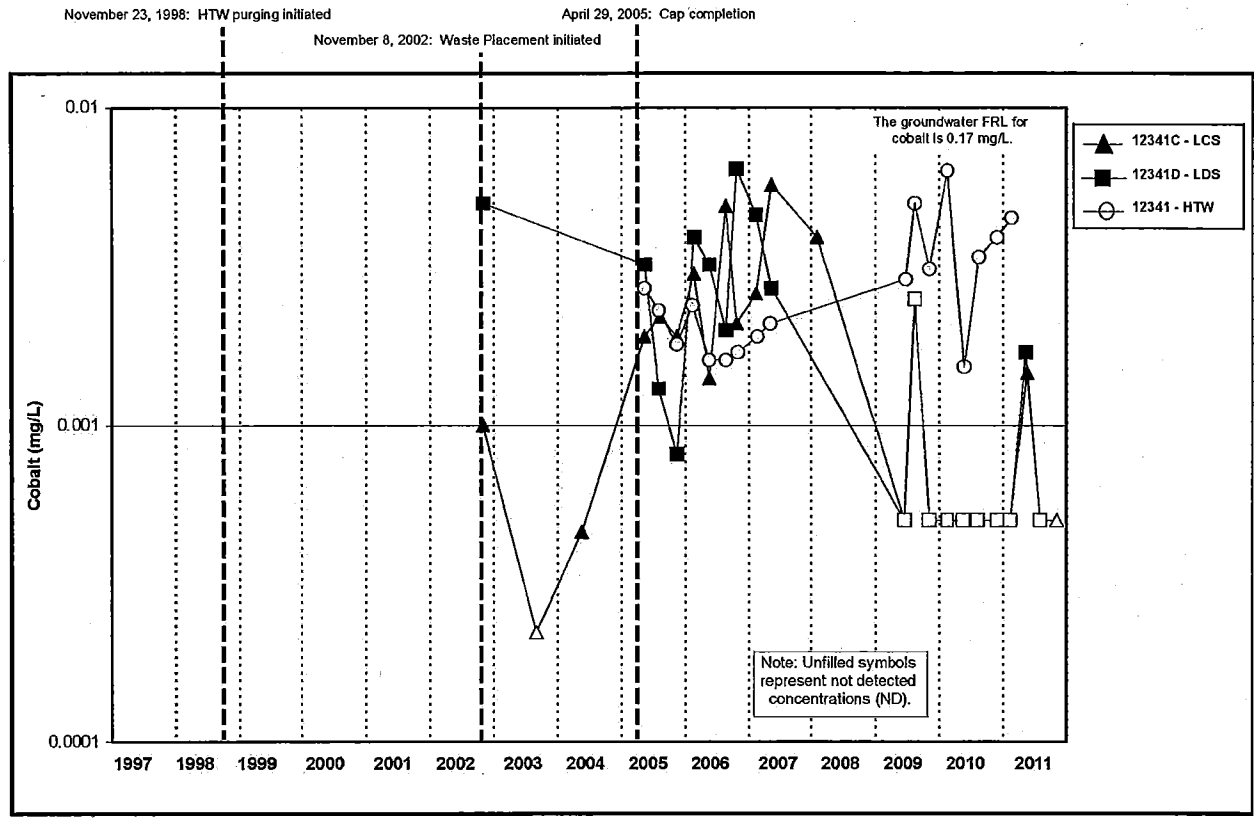


Figure A.5.4-19A. Cell 4 Cobalt Concentration vs. Time Plot for LCS, LDS, and HTW

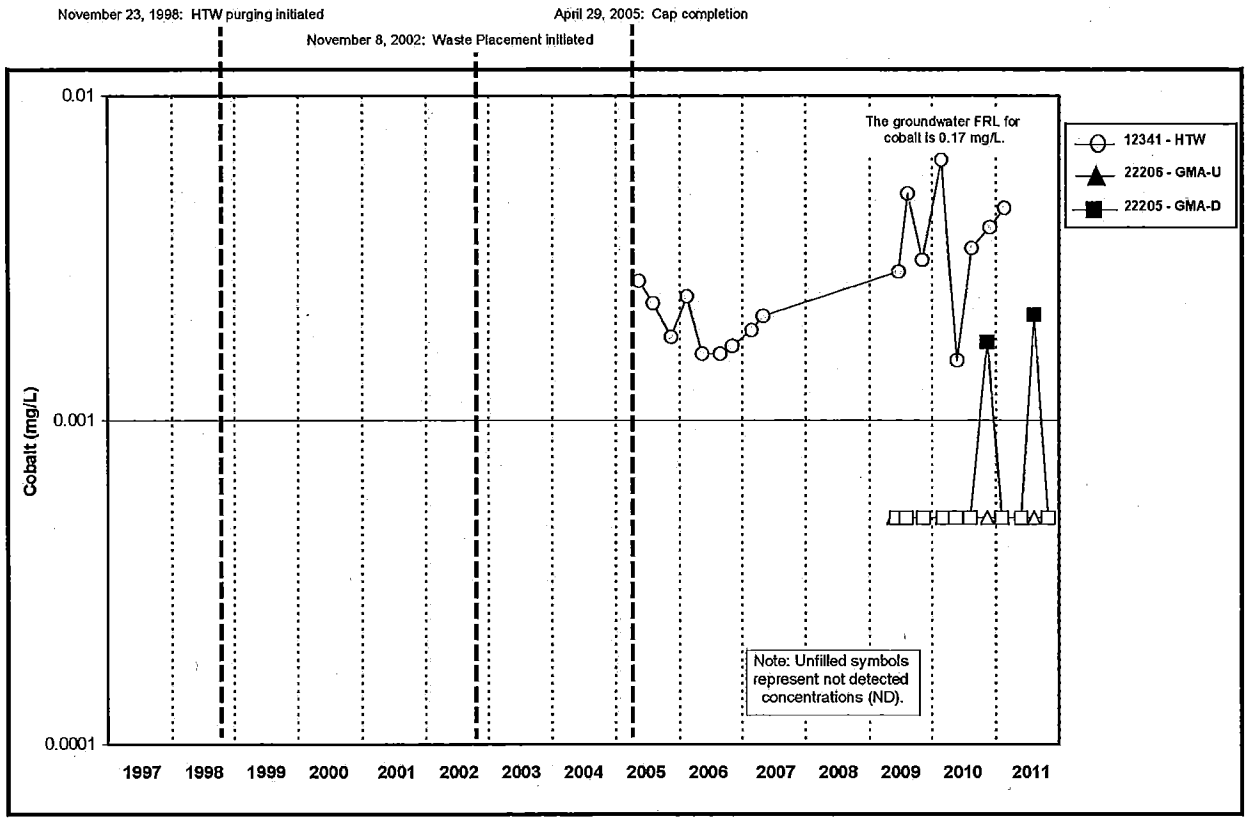


Figure A.5.4-19B. Cell 4 Cobalt Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

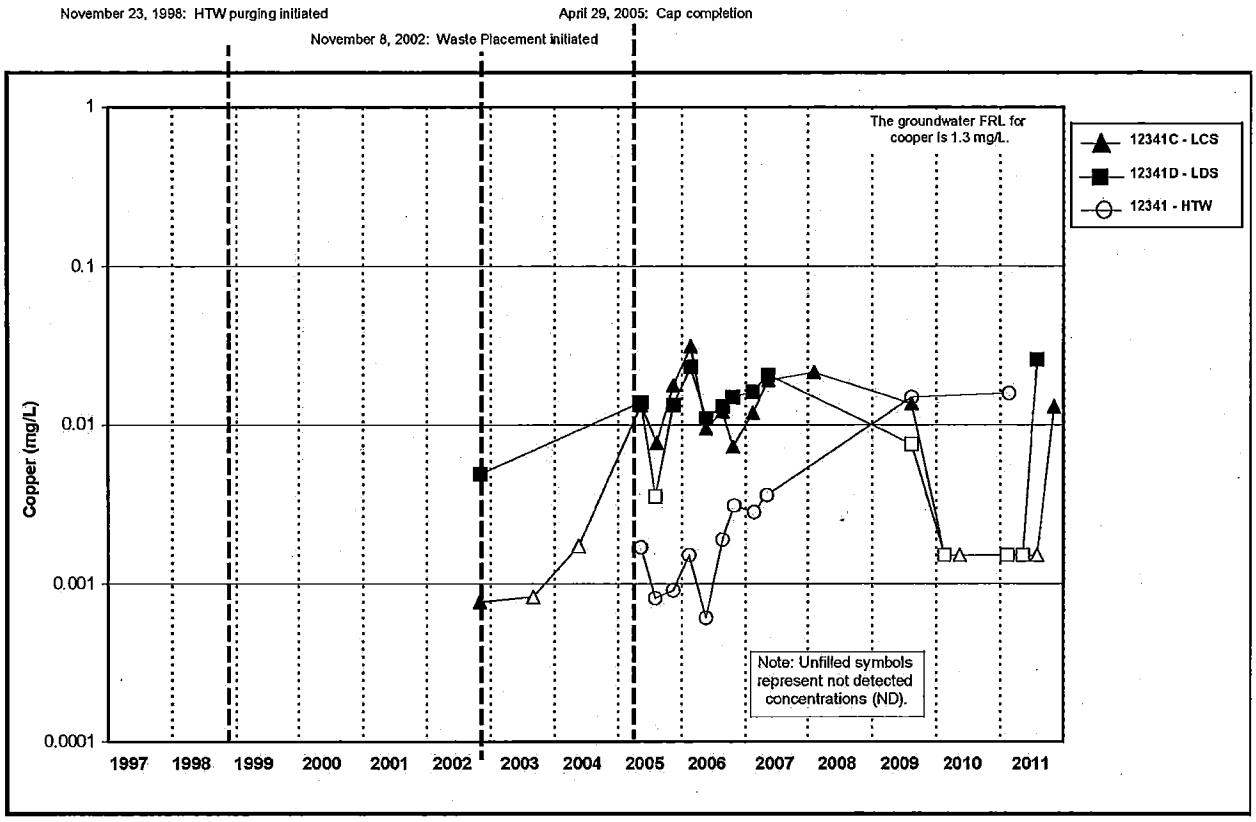


Figure A.5.4-20A. Cell 4 Copper Concentration vs. Time Plot for LCS, LDS, and HTW

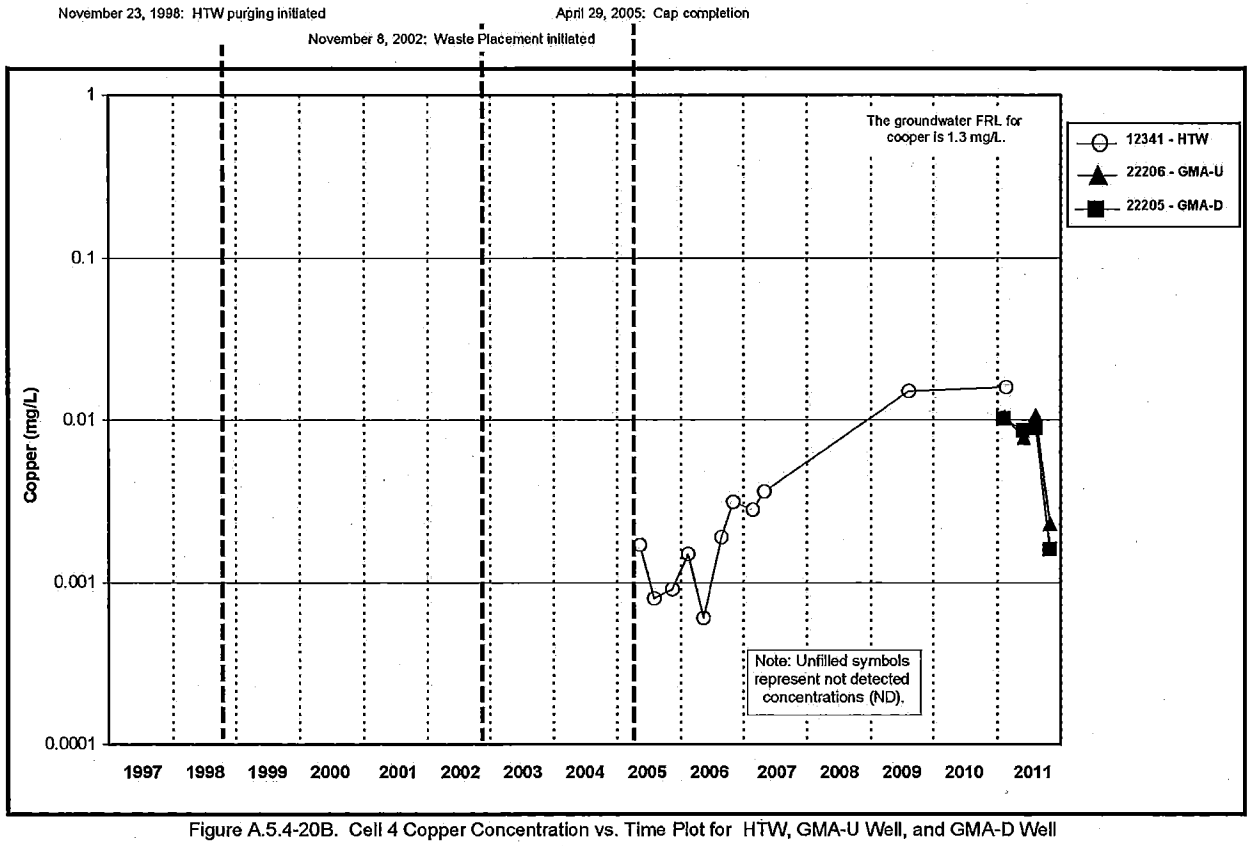


Figure A.5.4-20B. Cell 4 Copper Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

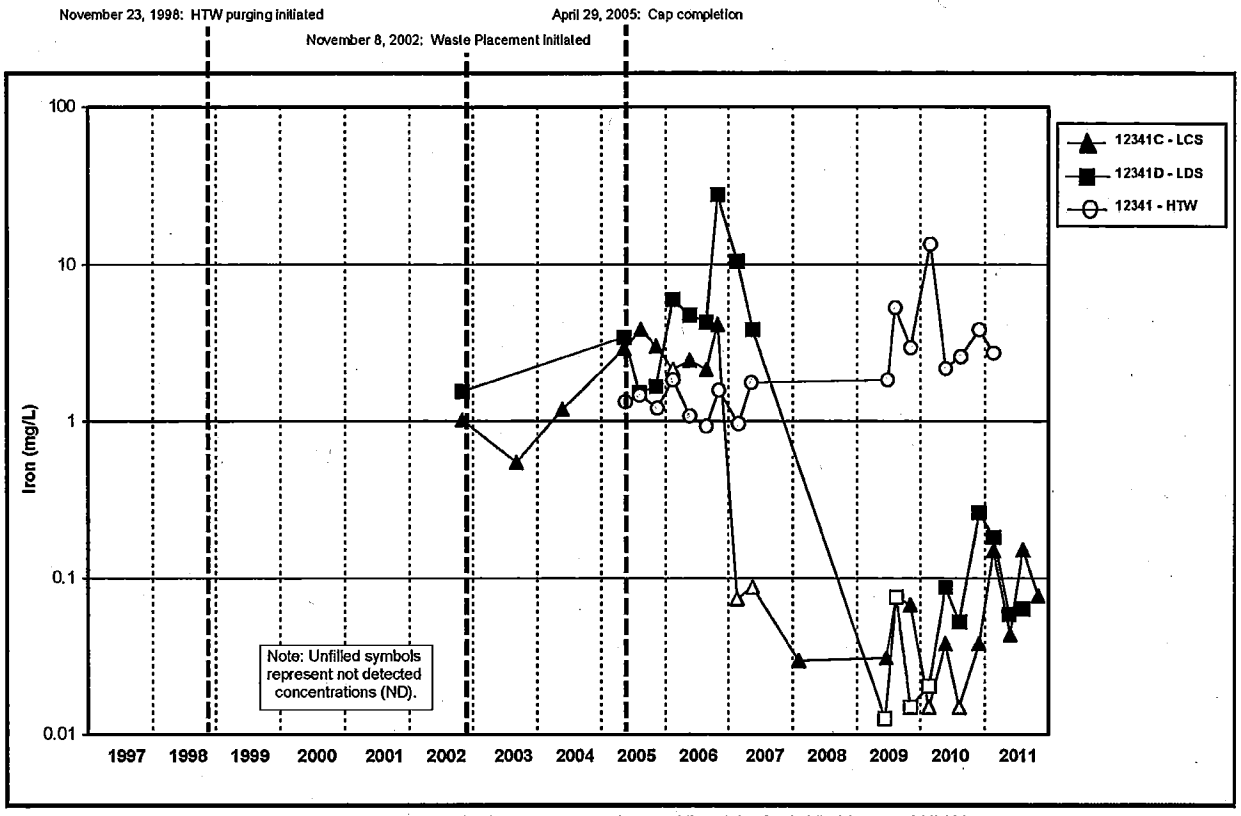


Figure A.5.4-21A. Cell 4 Iron Concentration vs. Time Plot for LCS, LDS, and HTW

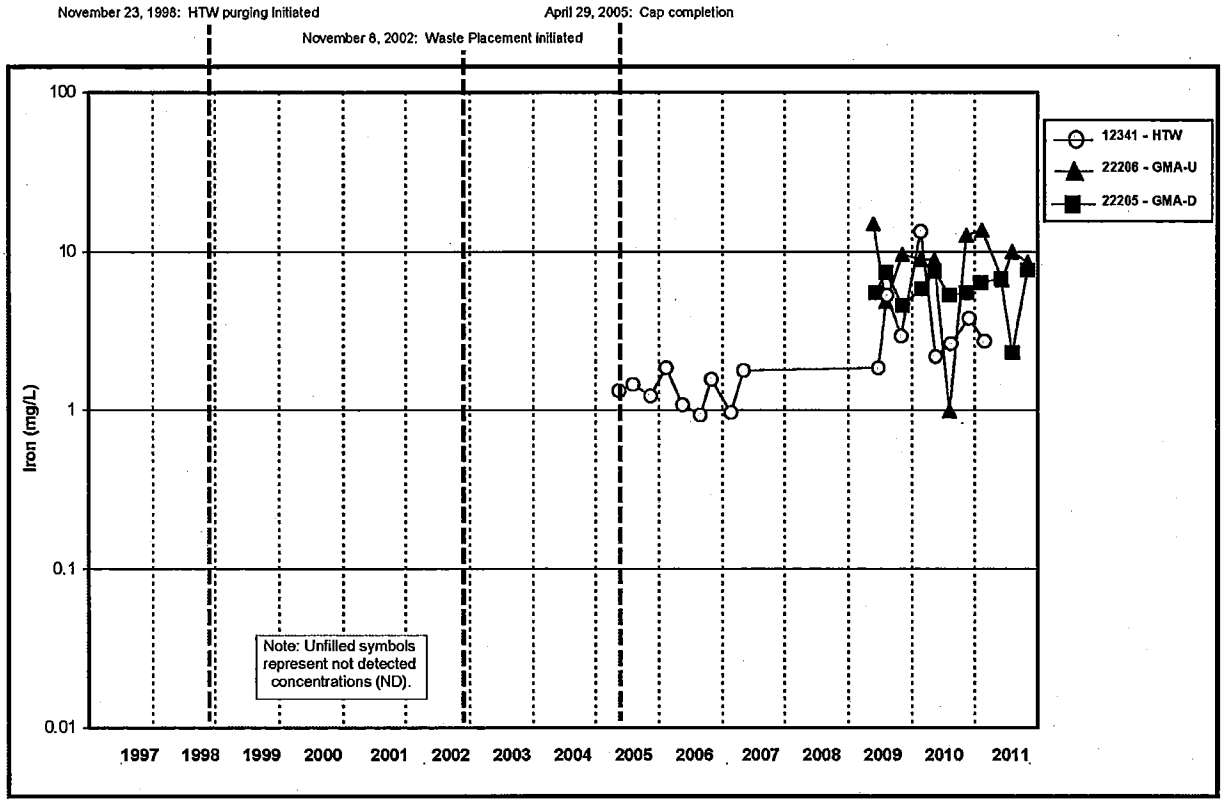


Figure A.5.4-21B. Cell 4 Iron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

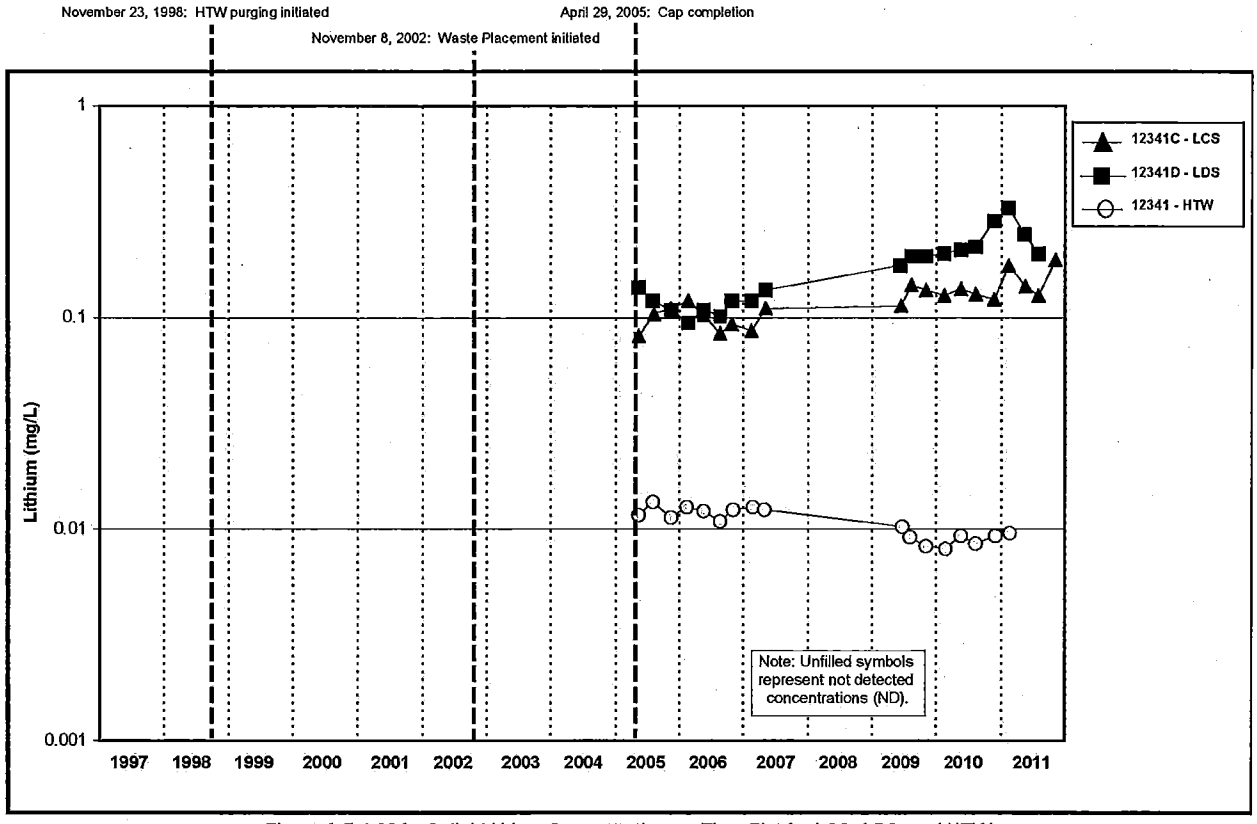


Figure A.5.4-22A. Cell 4 Lithium Concentration vs. Time Plot for LCS, LDS, and HTW

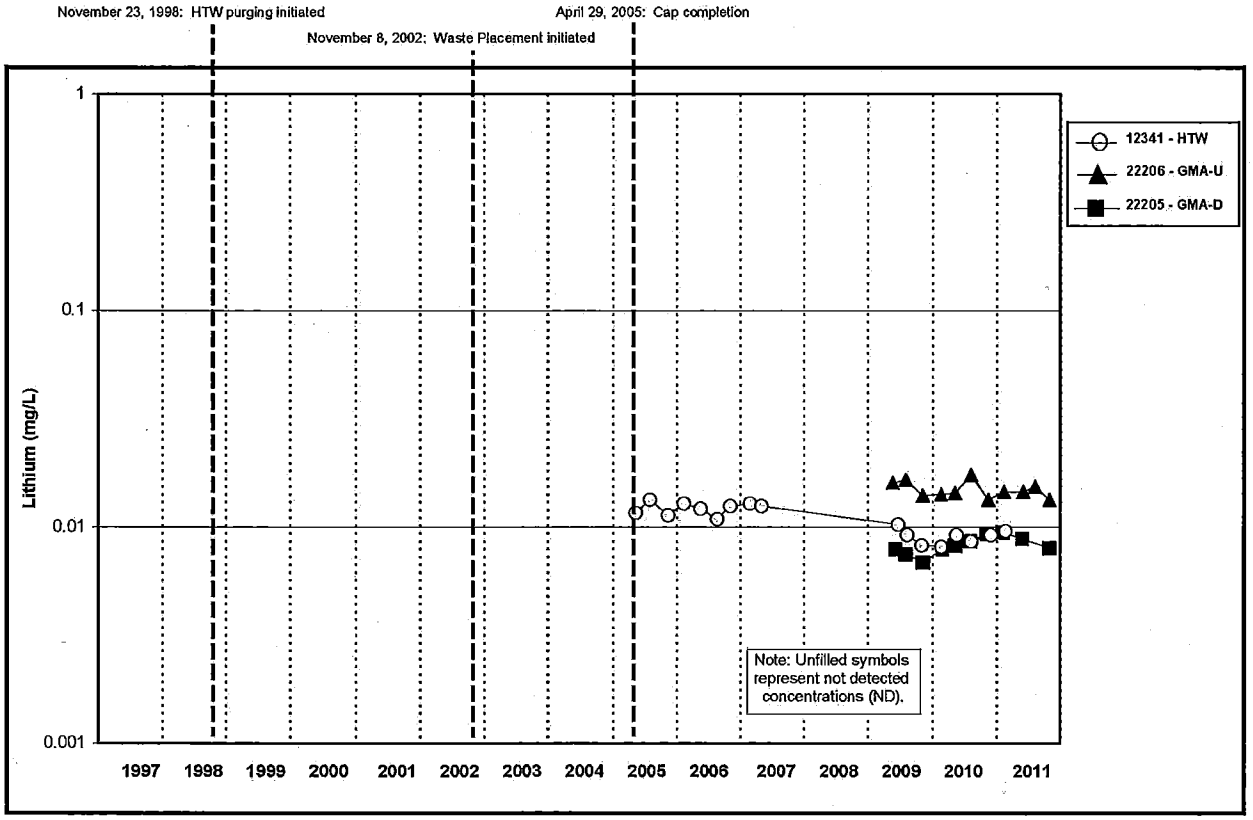


Figure A.5.4-22B. Cell 4 Lithium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

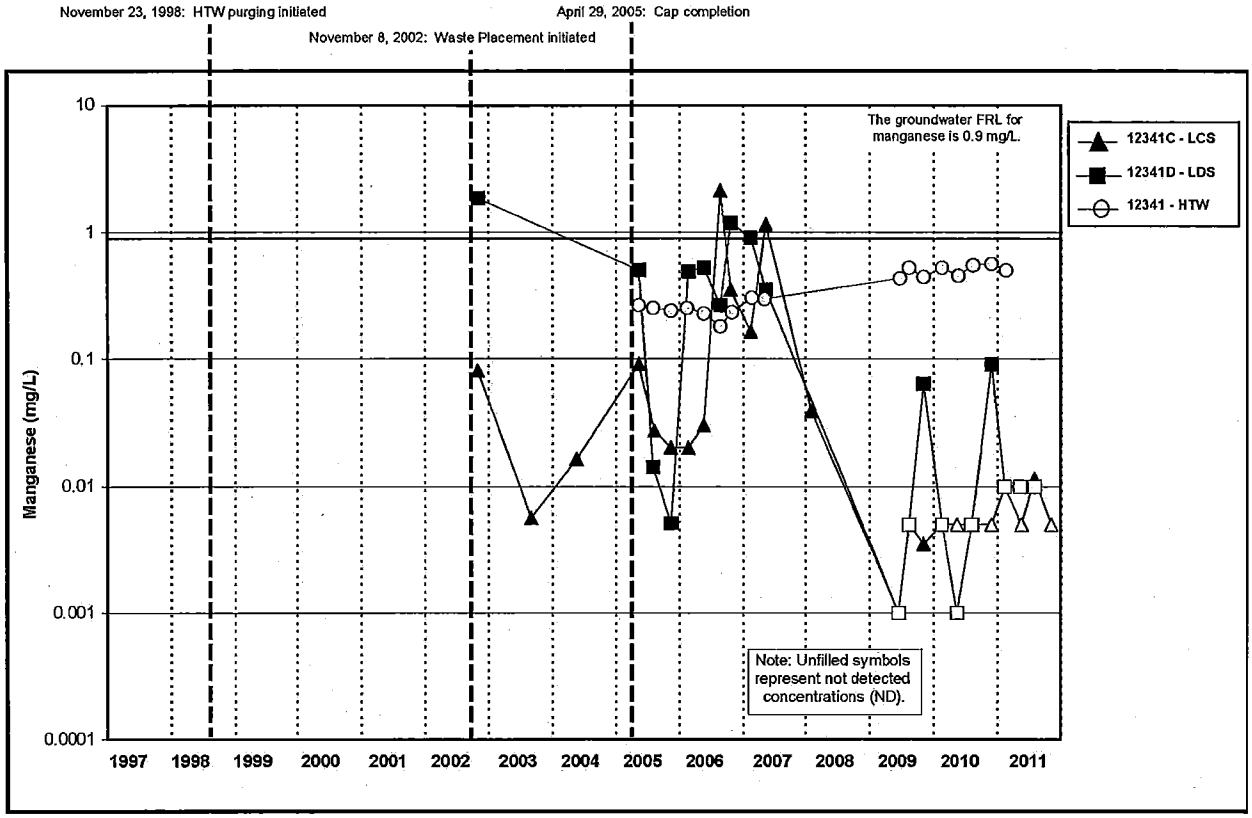


Figure A.5.4-23A. Cell 4 Manganese Concentration vs. Time Plot for LCS, LDS, and HTW

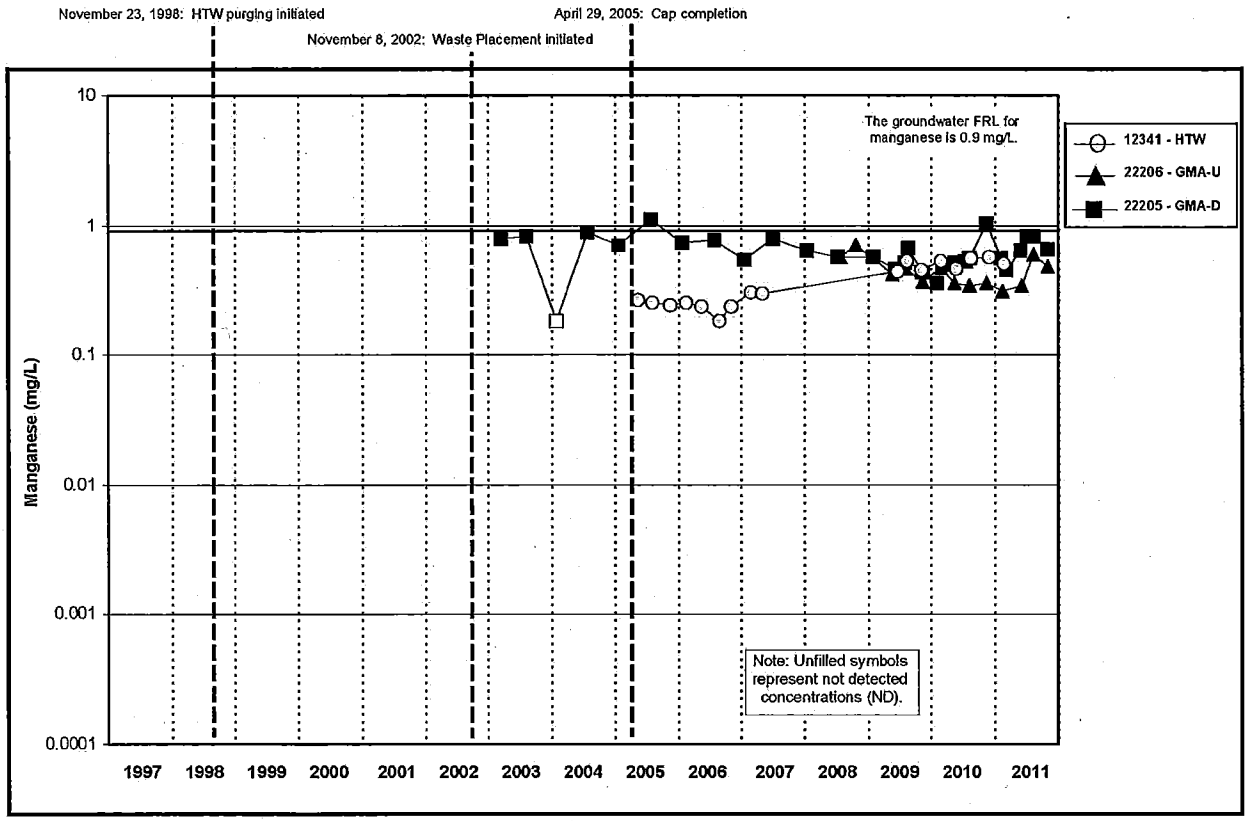


Figure A.5.4-23B. Cell 4 Manganese Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

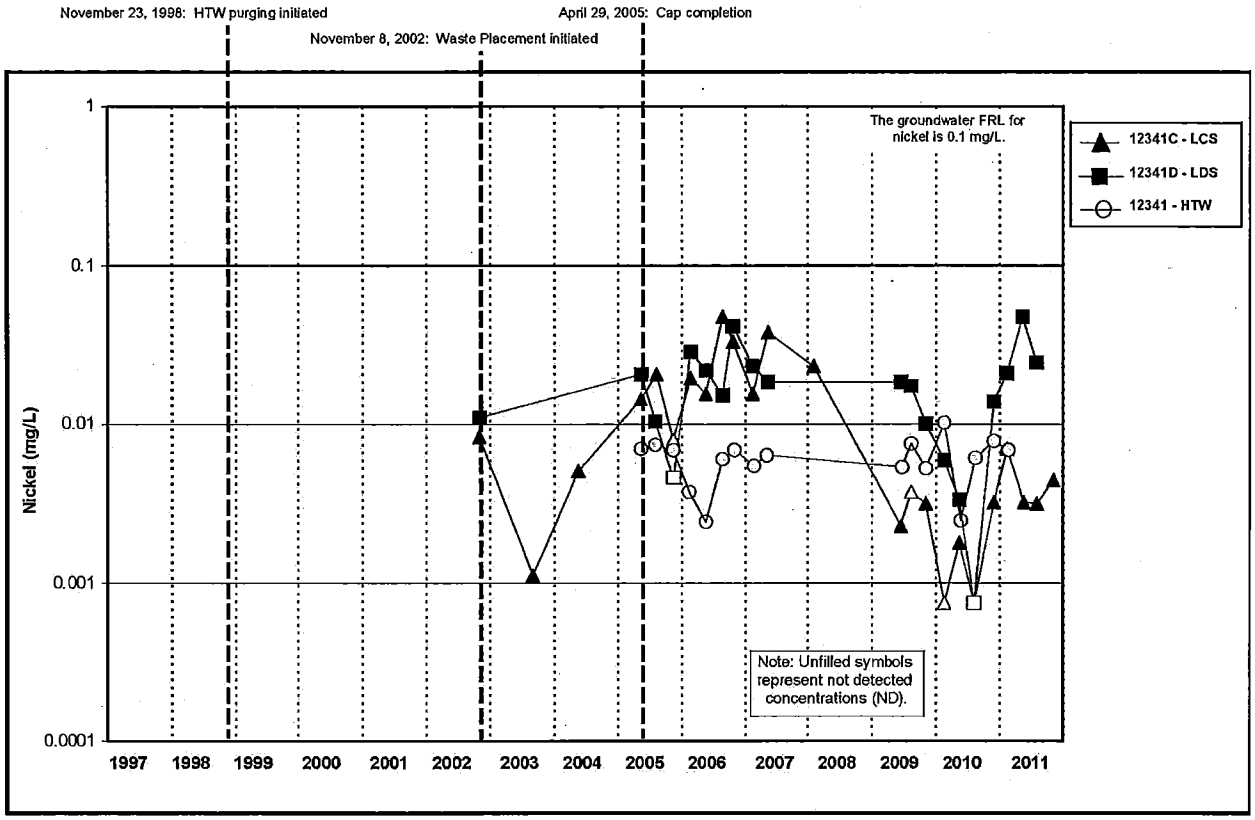


Figure A.5.4-24A. Cell 4 Nickel Concentration vs. Time Plot for LCS, LDS, and HTW

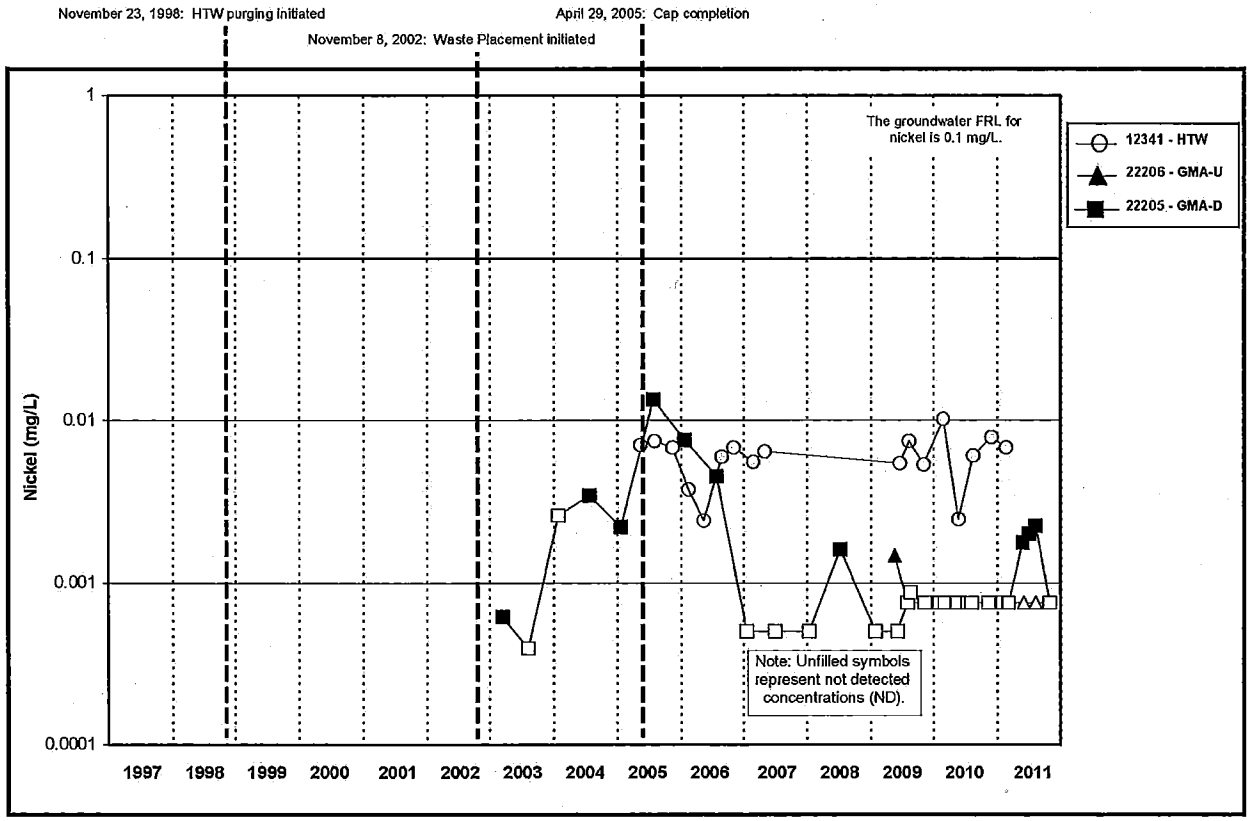


Figure A.5.4-24B. Cell 4 Nickel Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

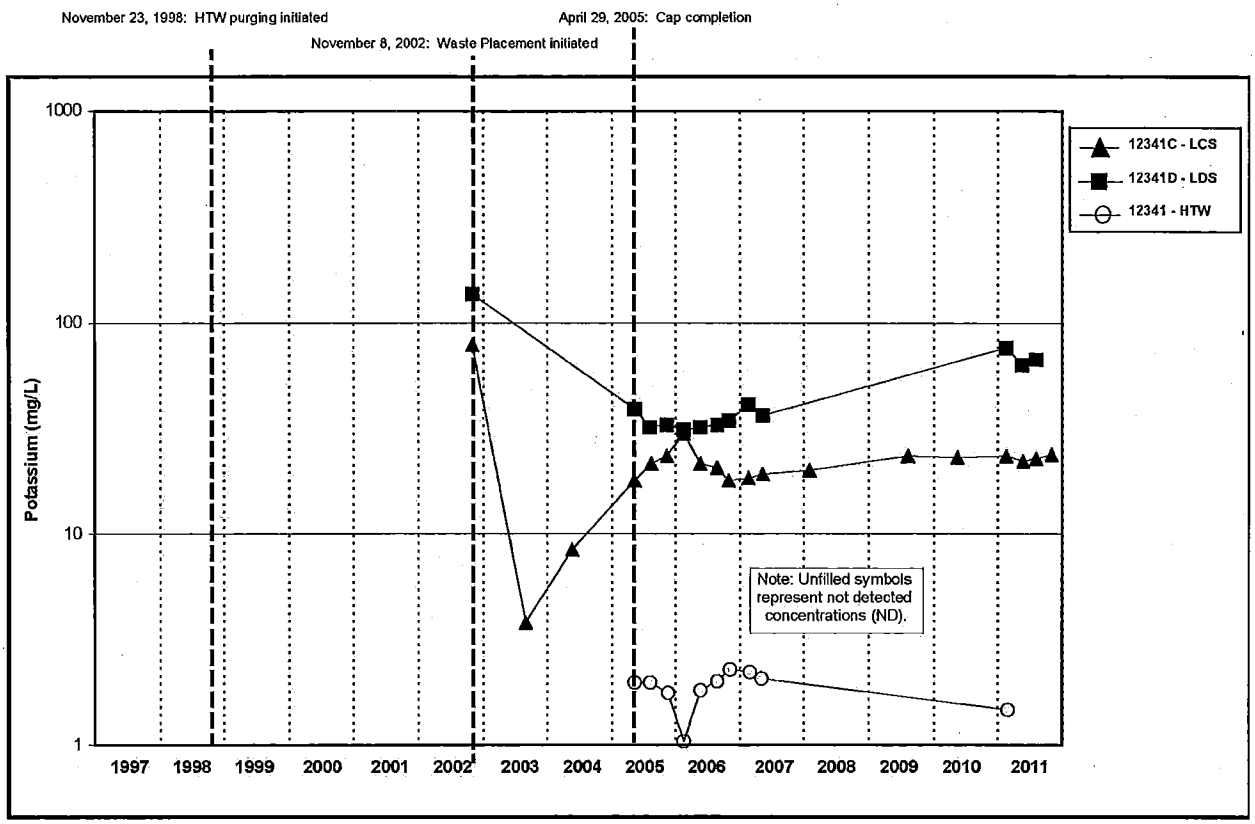


Figure A.5.4-25A. Cell 4 Potassium Concentration vs. Time Plot for LCS, LDS, and HTW

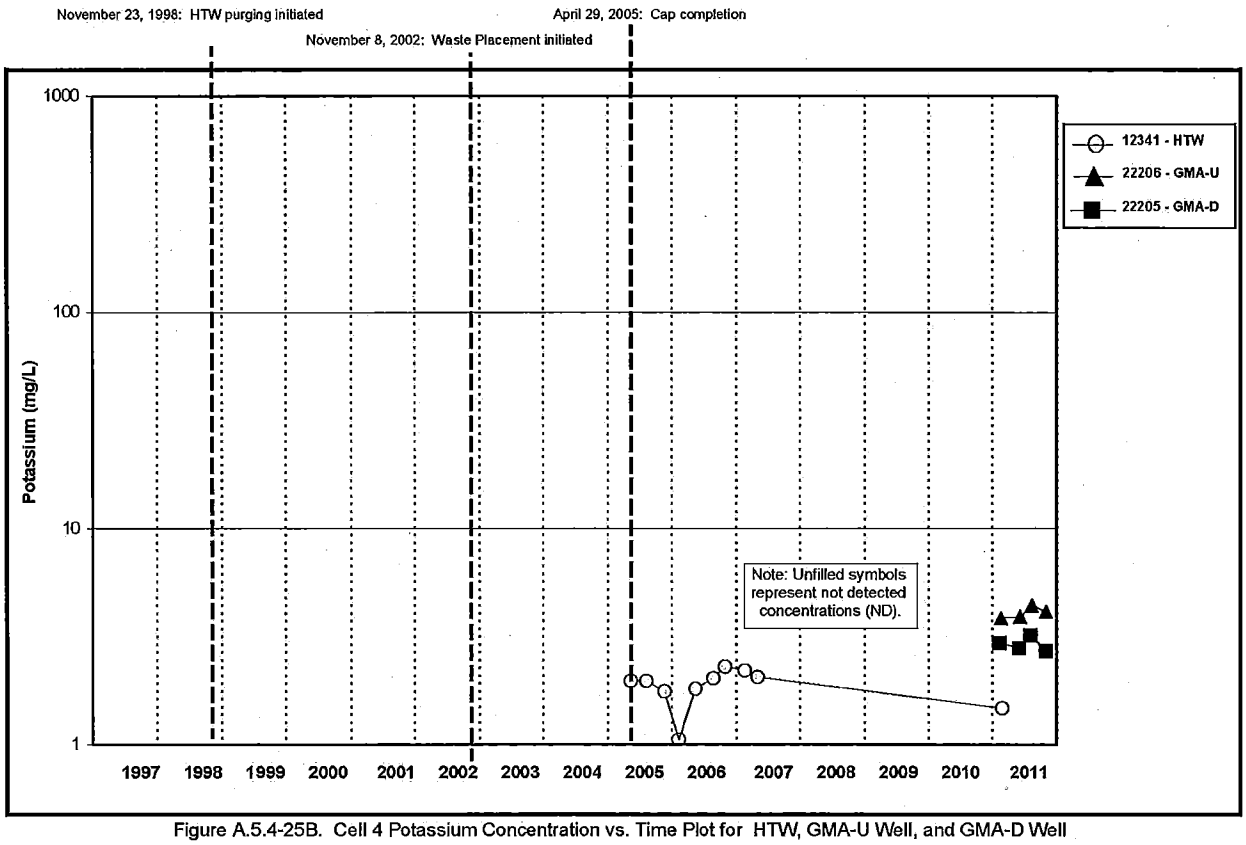


Figure A.5.4-25B. Cell 4 Potassium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

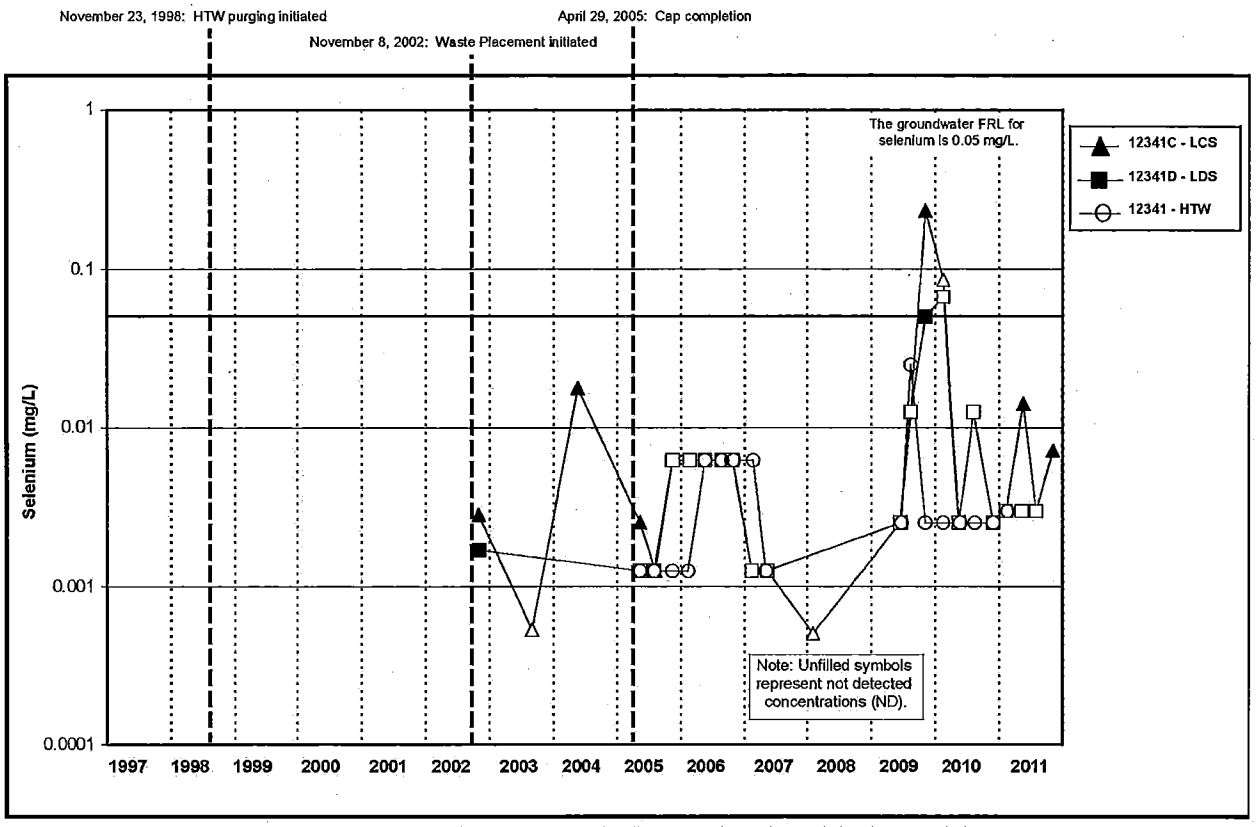


Figure A.5.4-26A. Cell 4 Selenium Concentration vs. Time Plot for LCS, LDS, and HTW

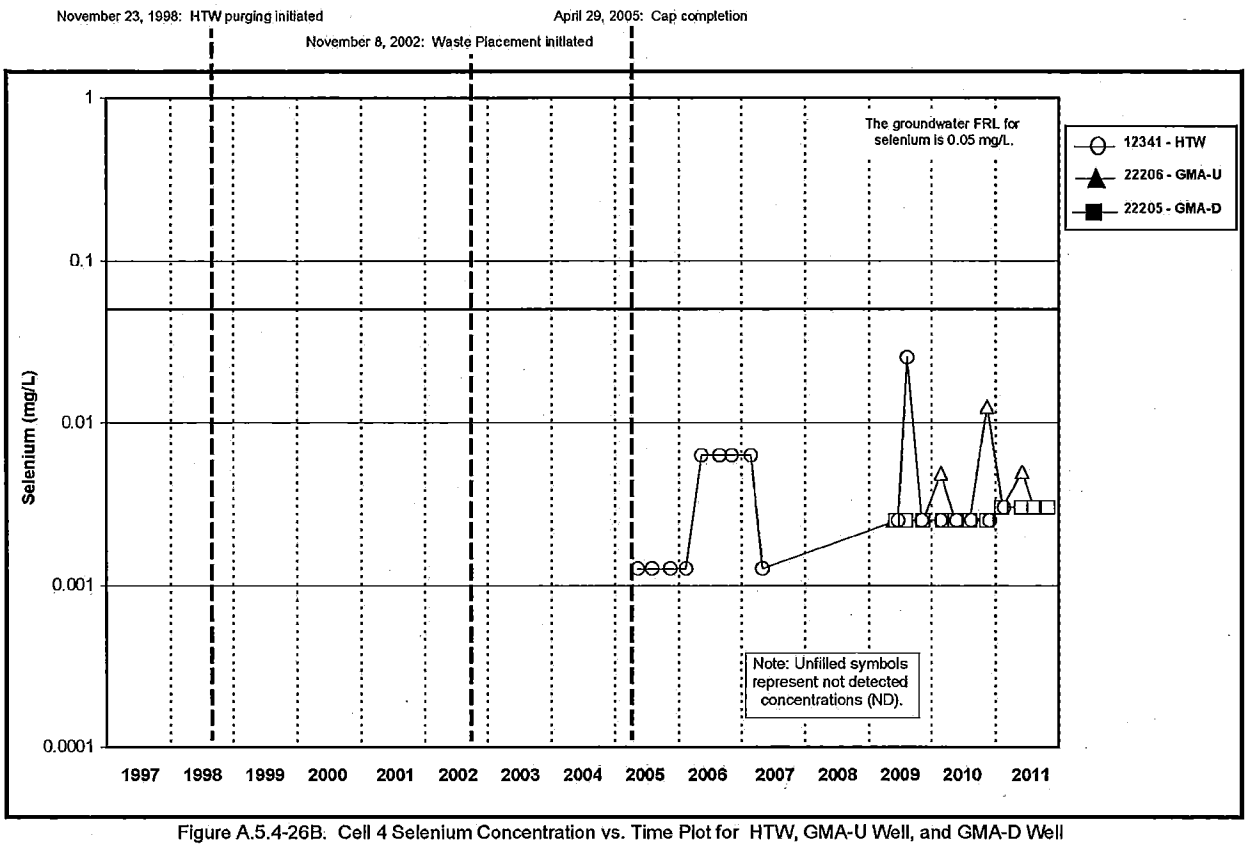


Figure A.5.4-26B. Cell 4 Selenium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

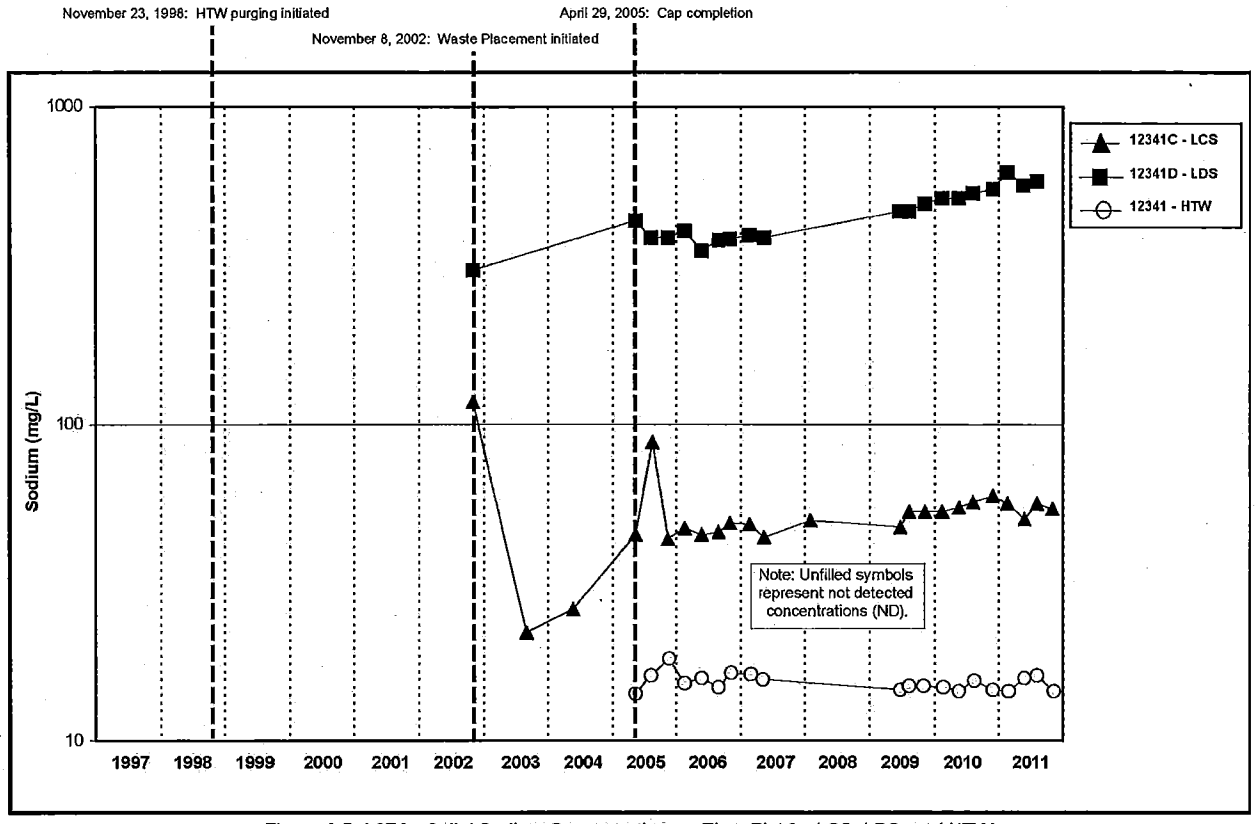


Figure A.5.4-27A. Cell 4 Sodium Concentration vs. Time Plot for LCS, LDS, and HTW

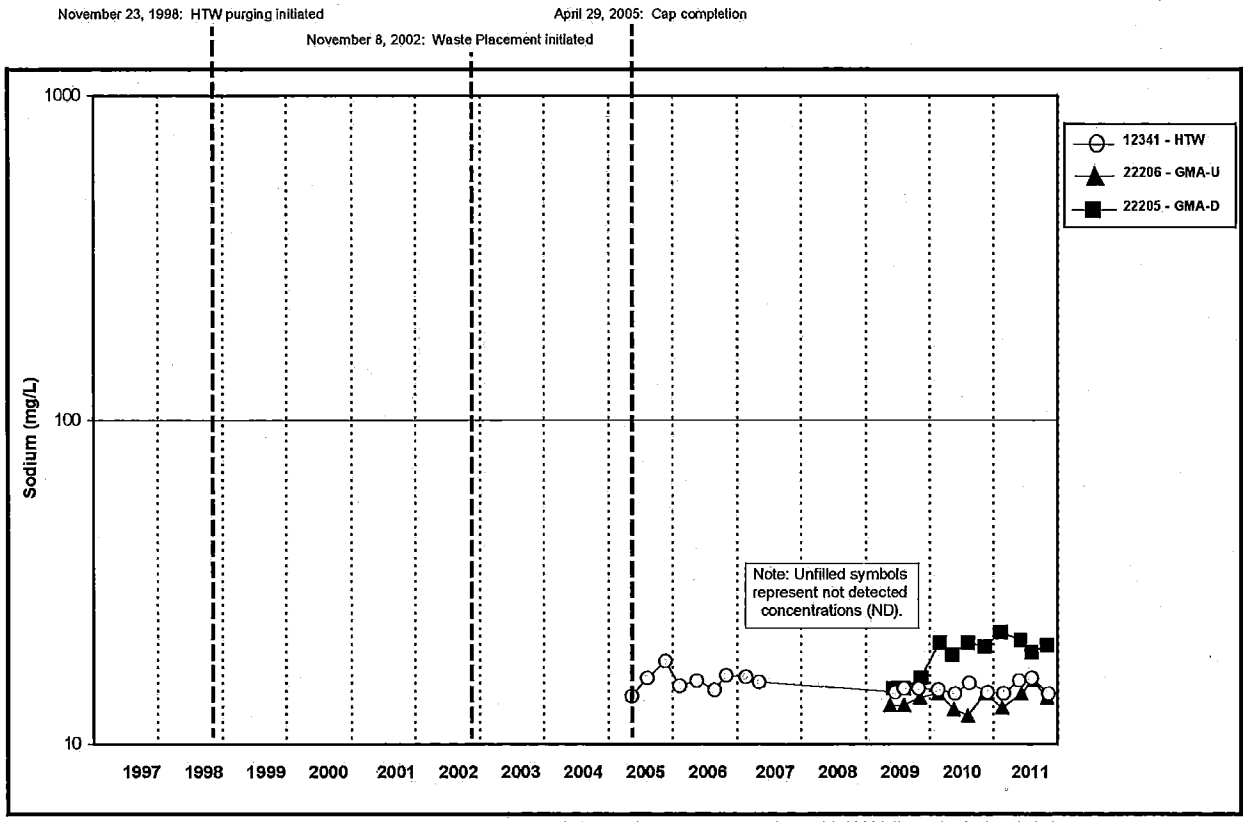


Figure A.5.4-27B. Cell 4 Sodium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

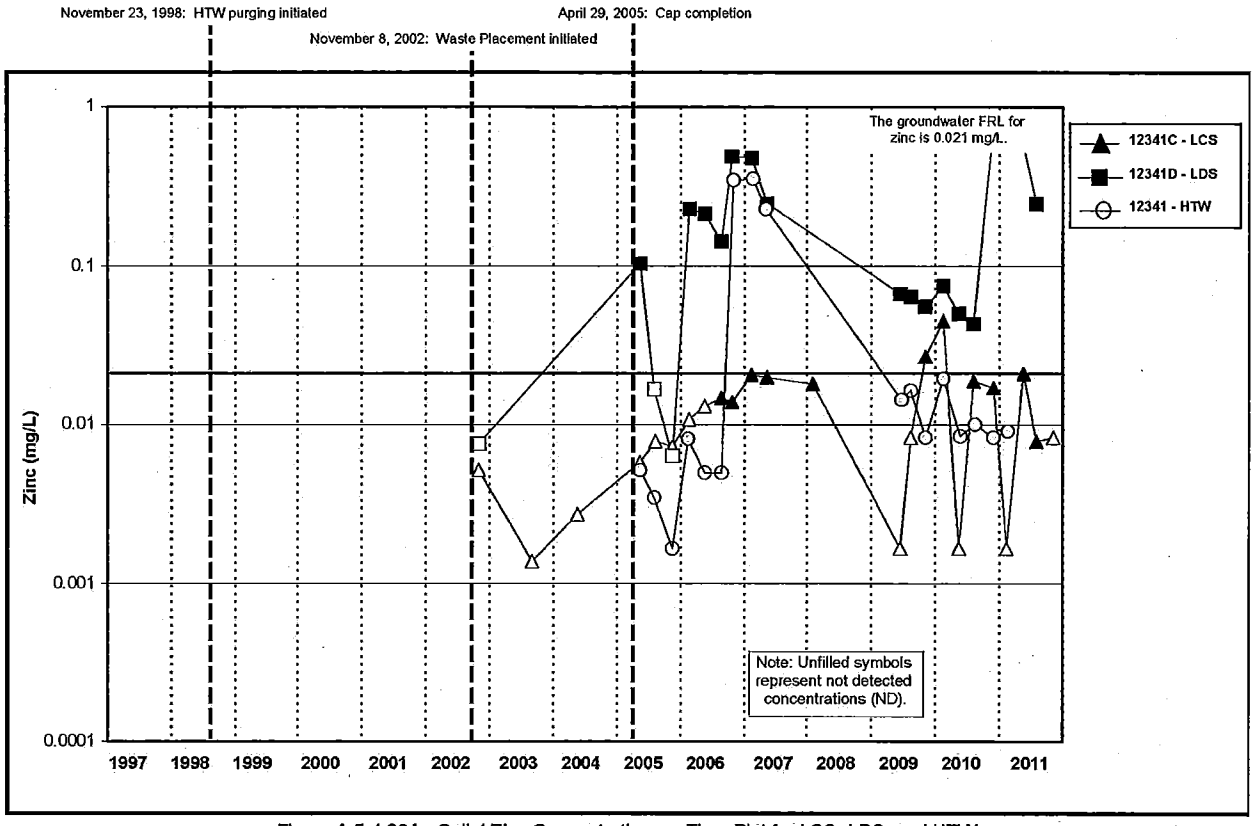


Figure A.5.4-28A. Cell 4 Zinc Concentration vs. Time Plot for LCS, LDS, and HTW

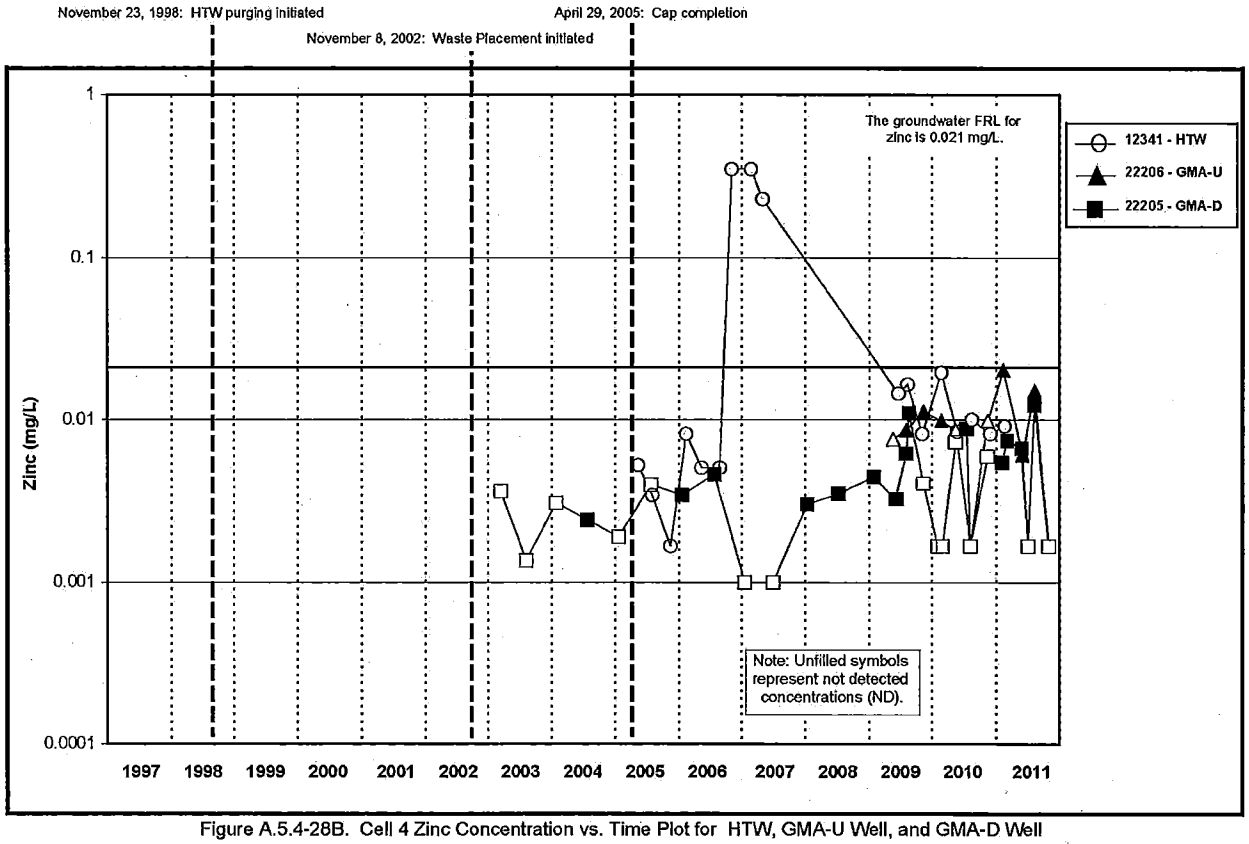


Figure A.5.4-28B. Cell 4 Zinc Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

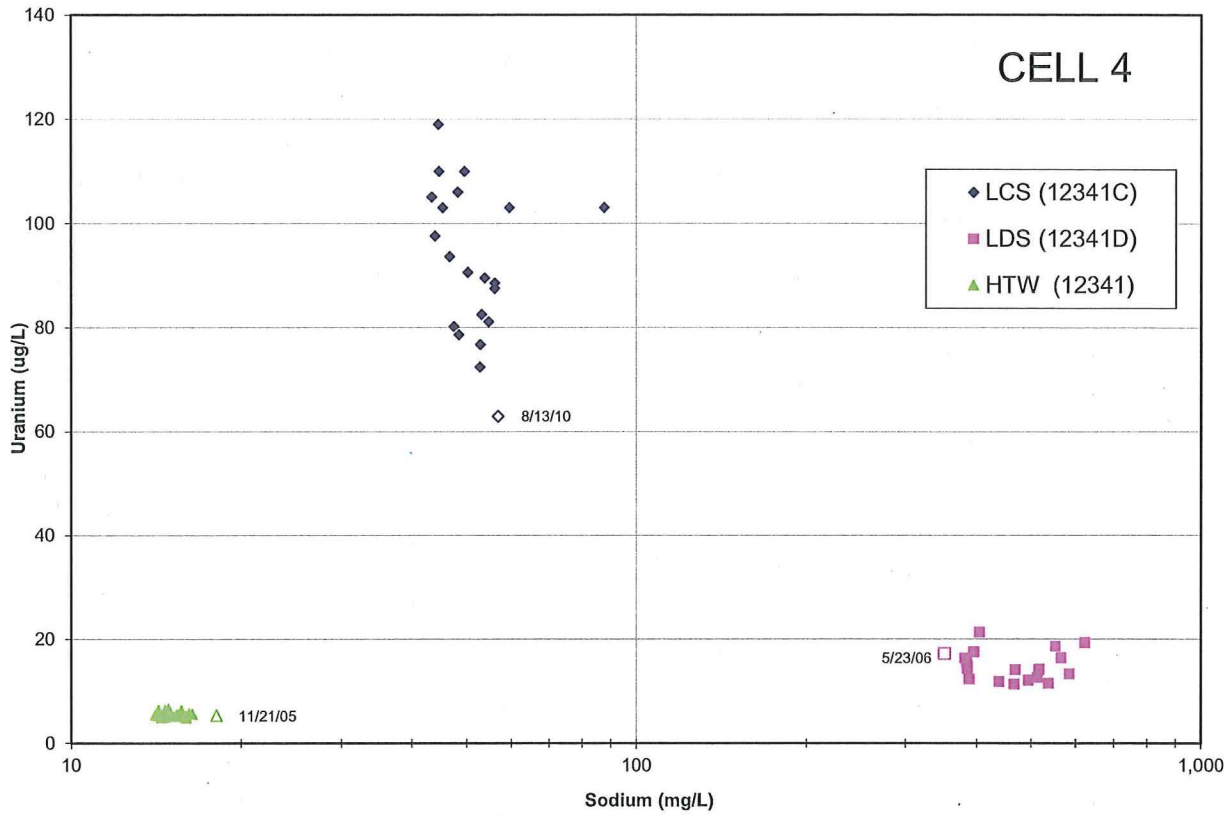


Figure A.5.4-29. Cell 4 Bivariate Plot for Uranium and Sodium

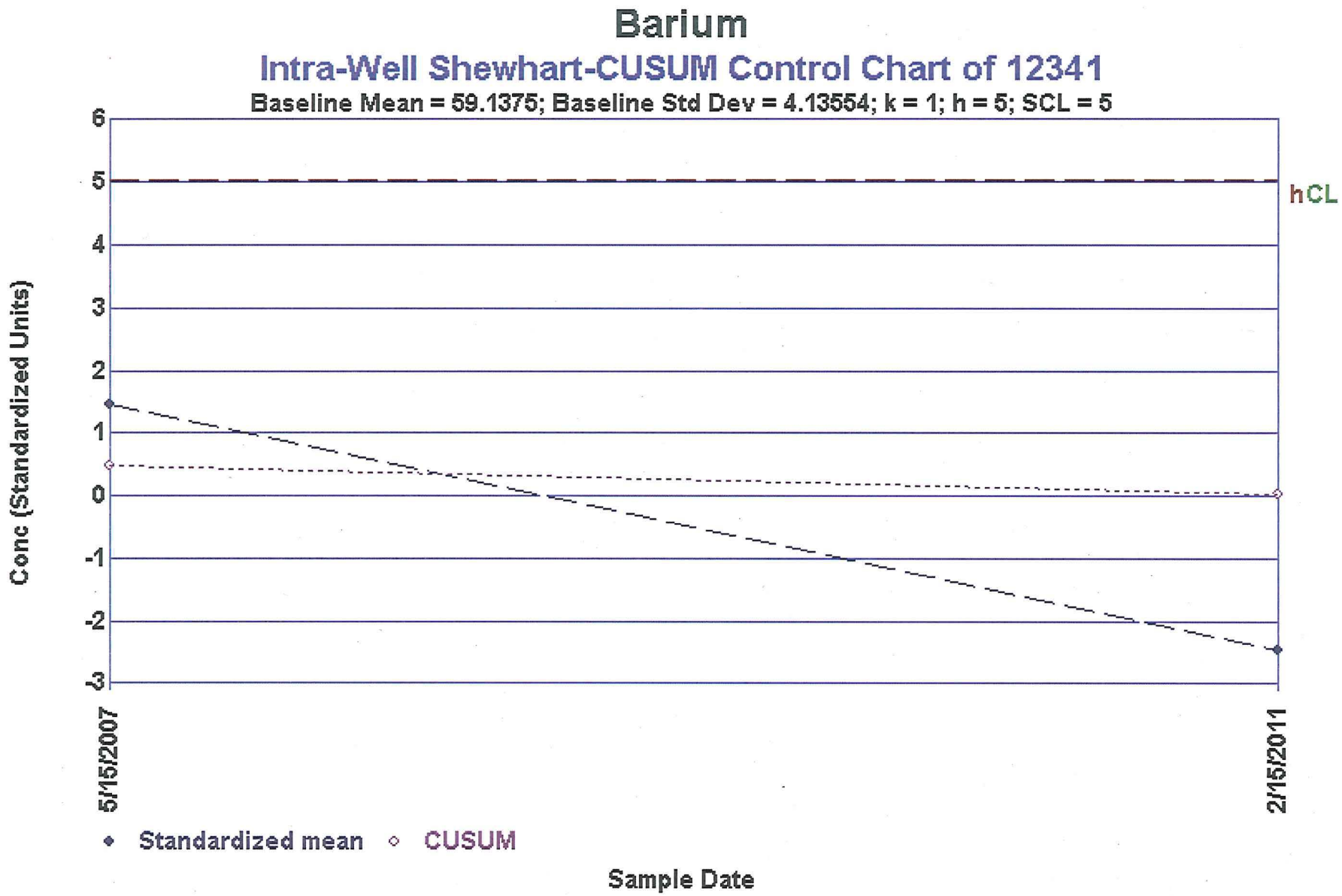


Figure A.5.4−30. Intra-Well Shewhart-CUSUM Control Chart (Barium 12341)

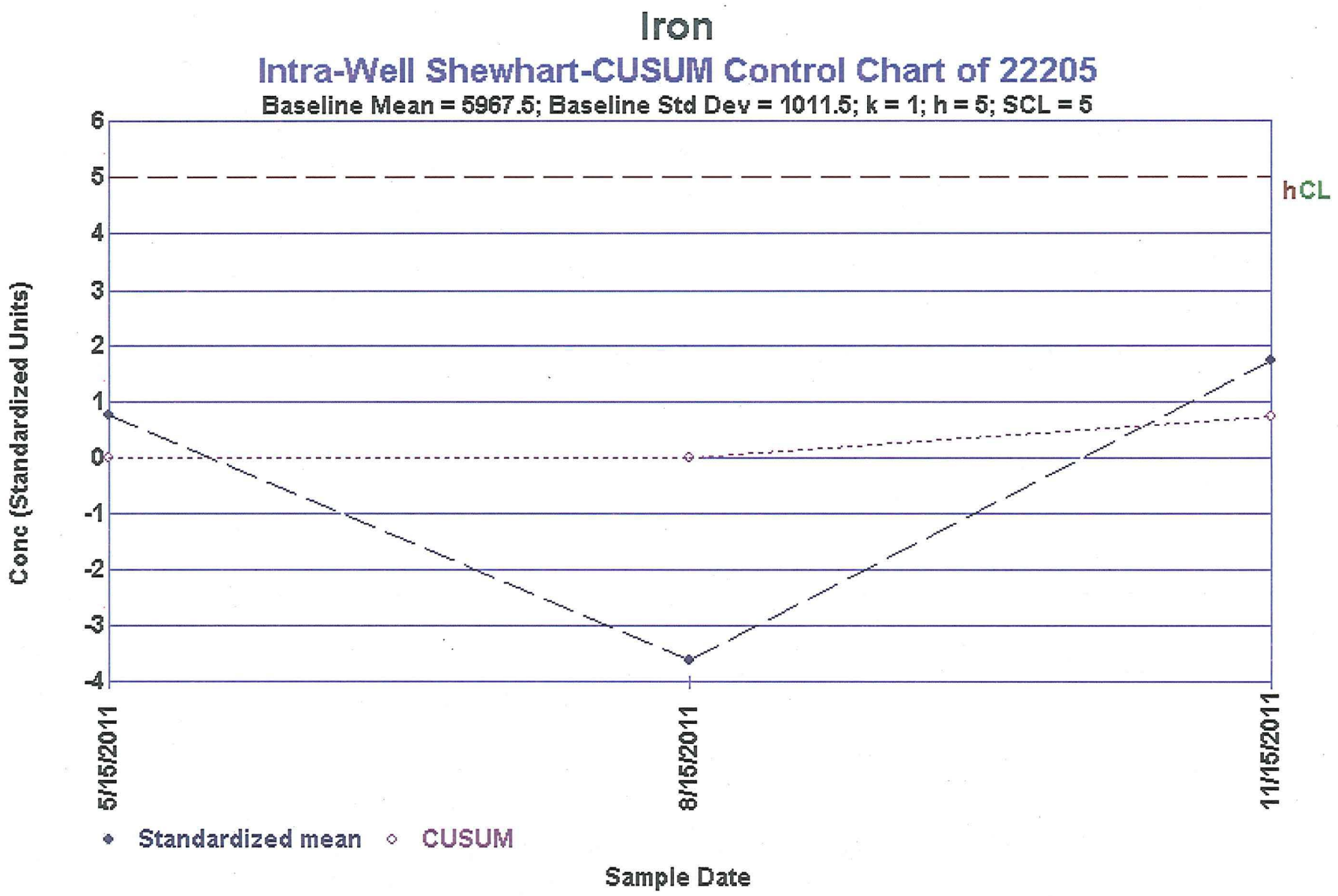


Figure A.5.4−31. Intra-Well Shewhart-CUSUM Control Chart (Iron 22205)

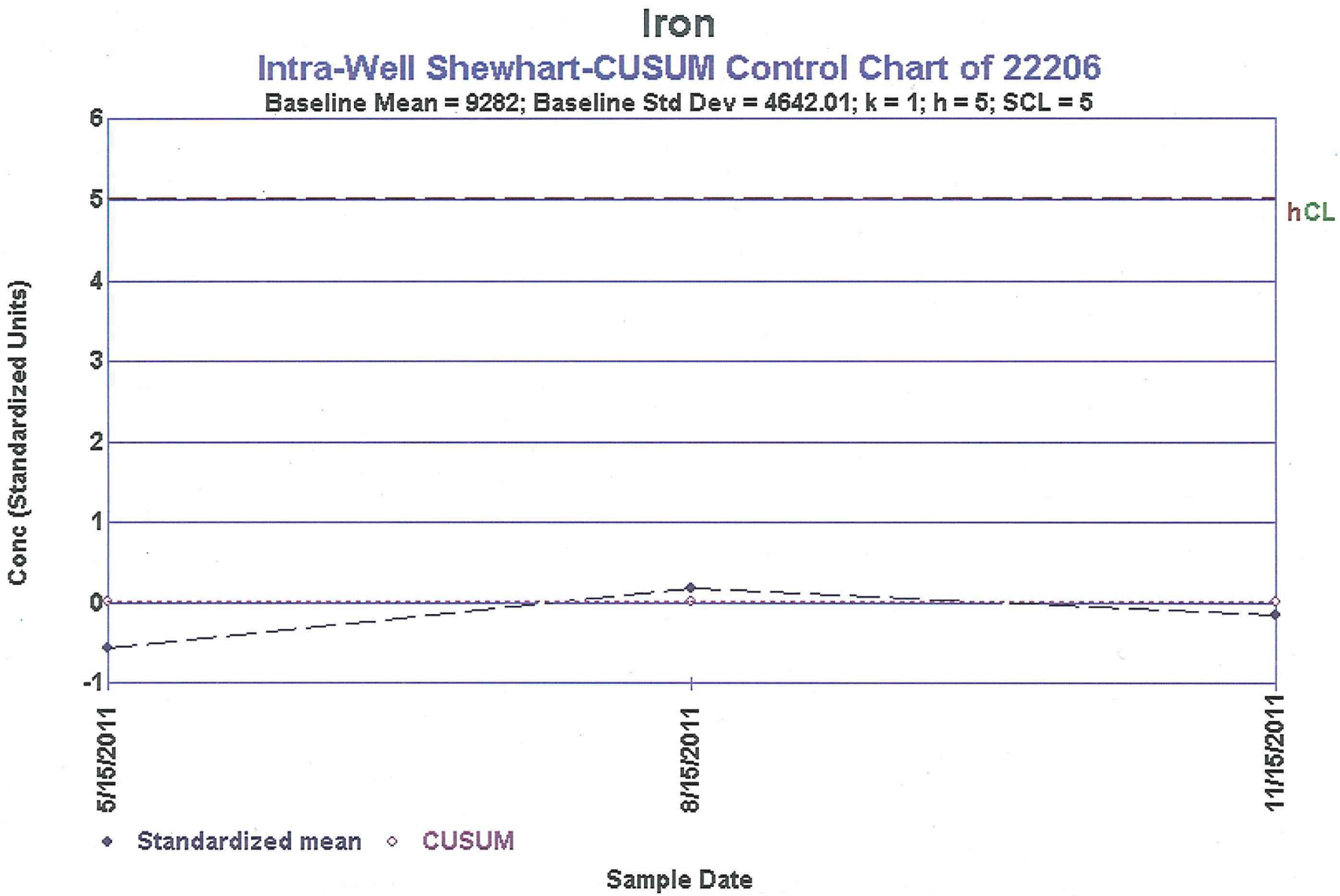


Figure A.5.4−32. Intra-Well Shewhart-CUSUM Control Chart (Iron 22206)

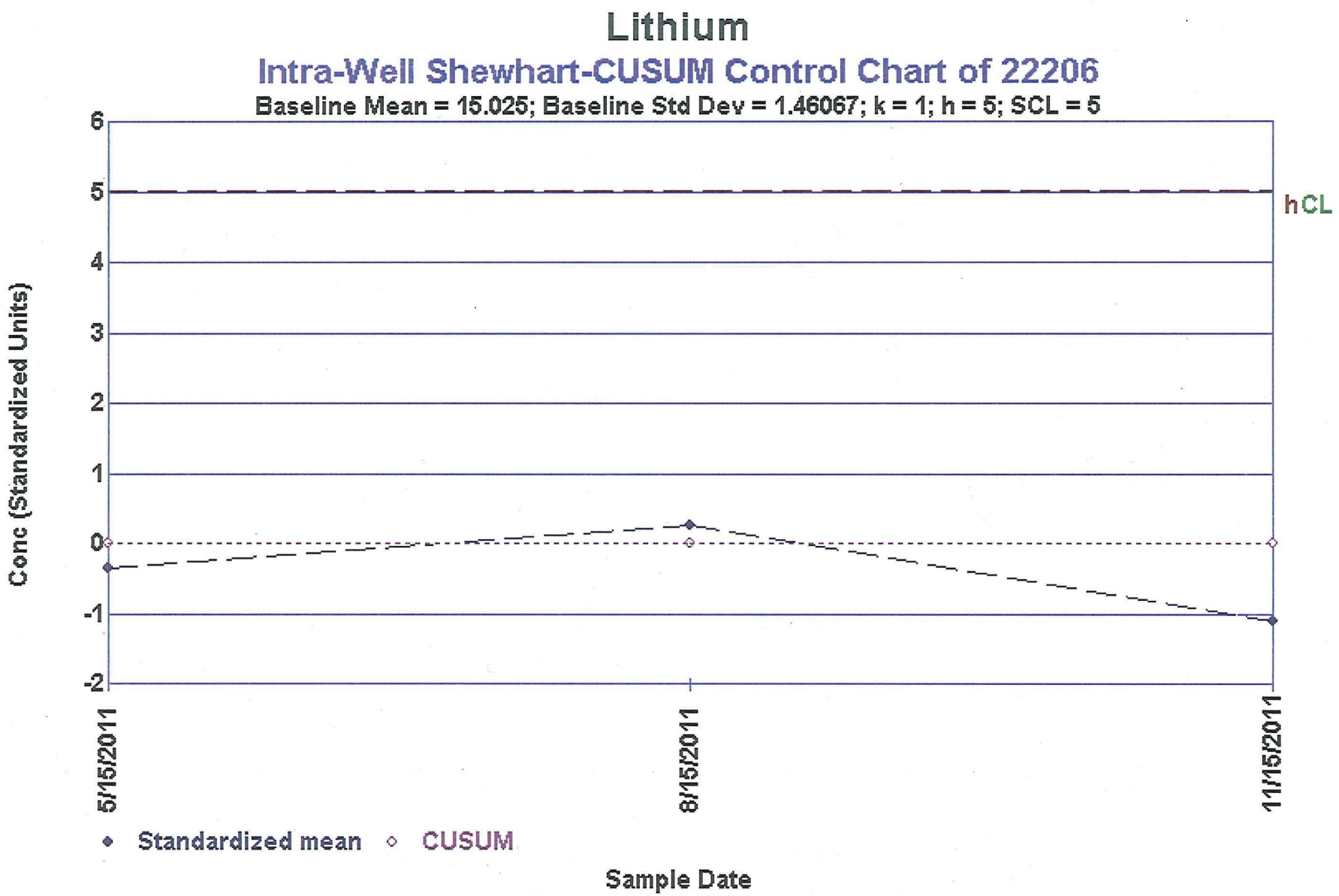


Figure A.5.4−33. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22206)

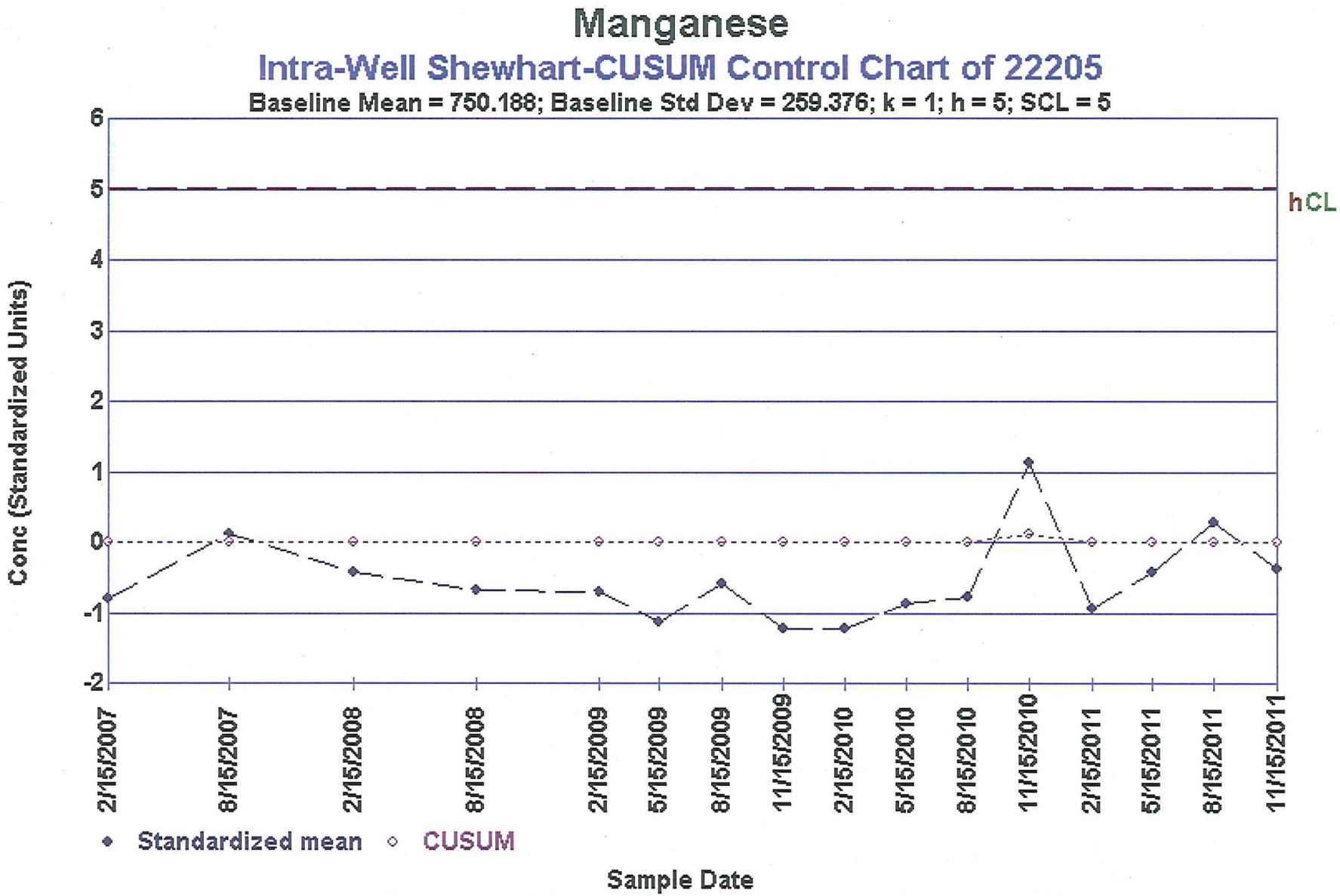


Figure A.5.4−34. Intra-Well Shewhart-CUSUM Control Chart (Manganese 22205)

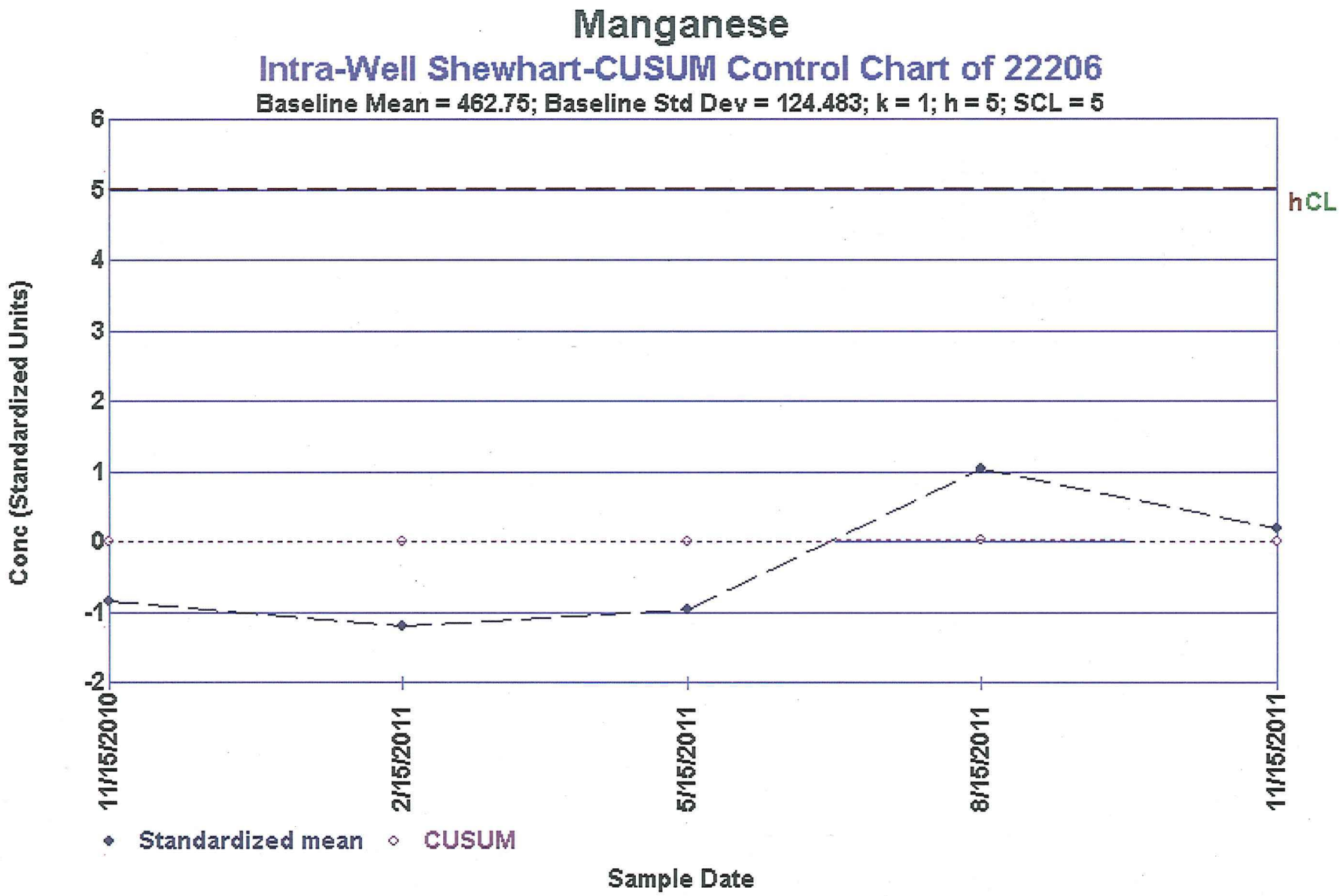


Figure A.5.4−35. Intra-Well Shewhart-CUSUM Control Chart (Manganese 22206)

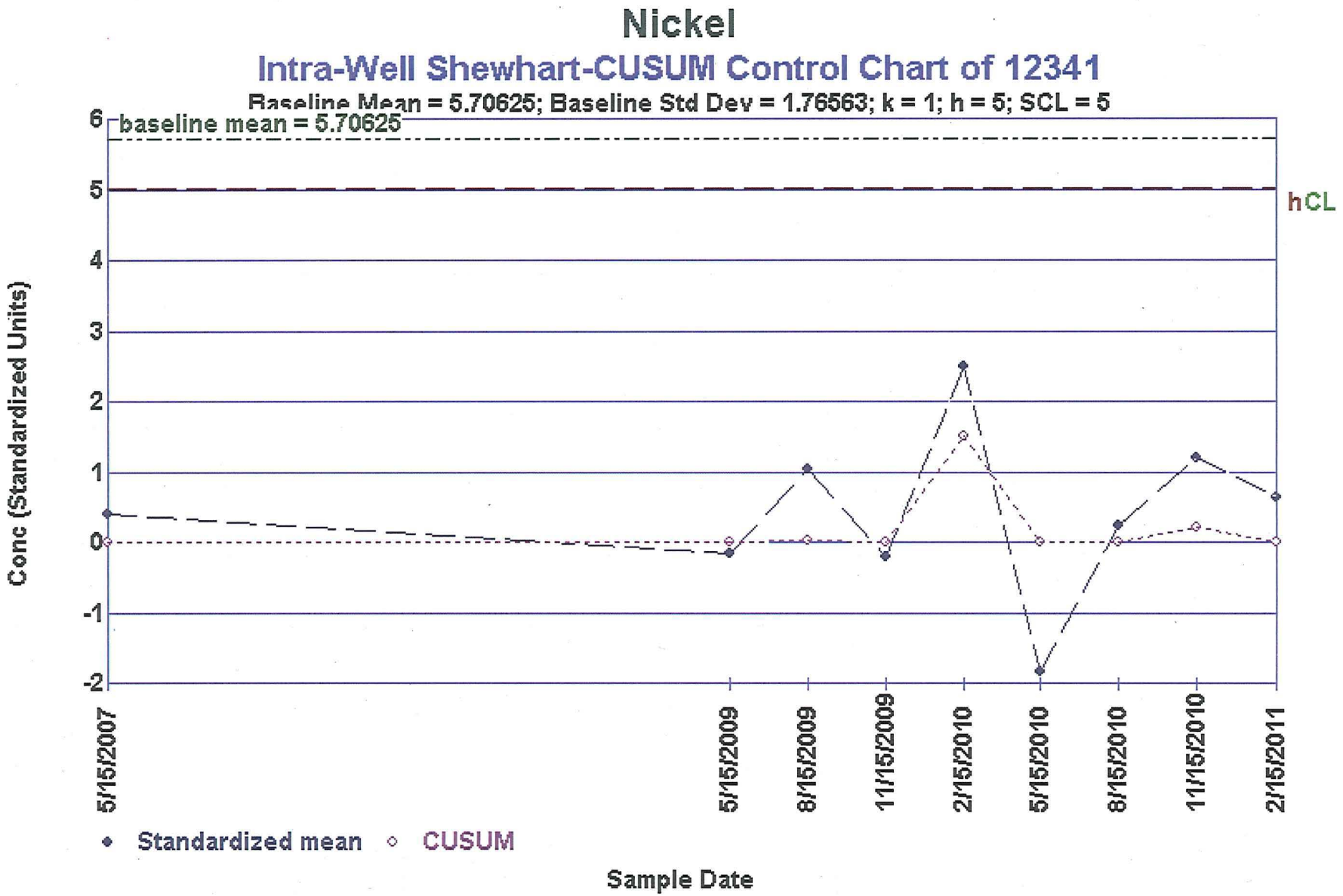


Figure A.5.4−36. Intra-Well Shewhart-CUSUM Control Chart (Nickel 12341)

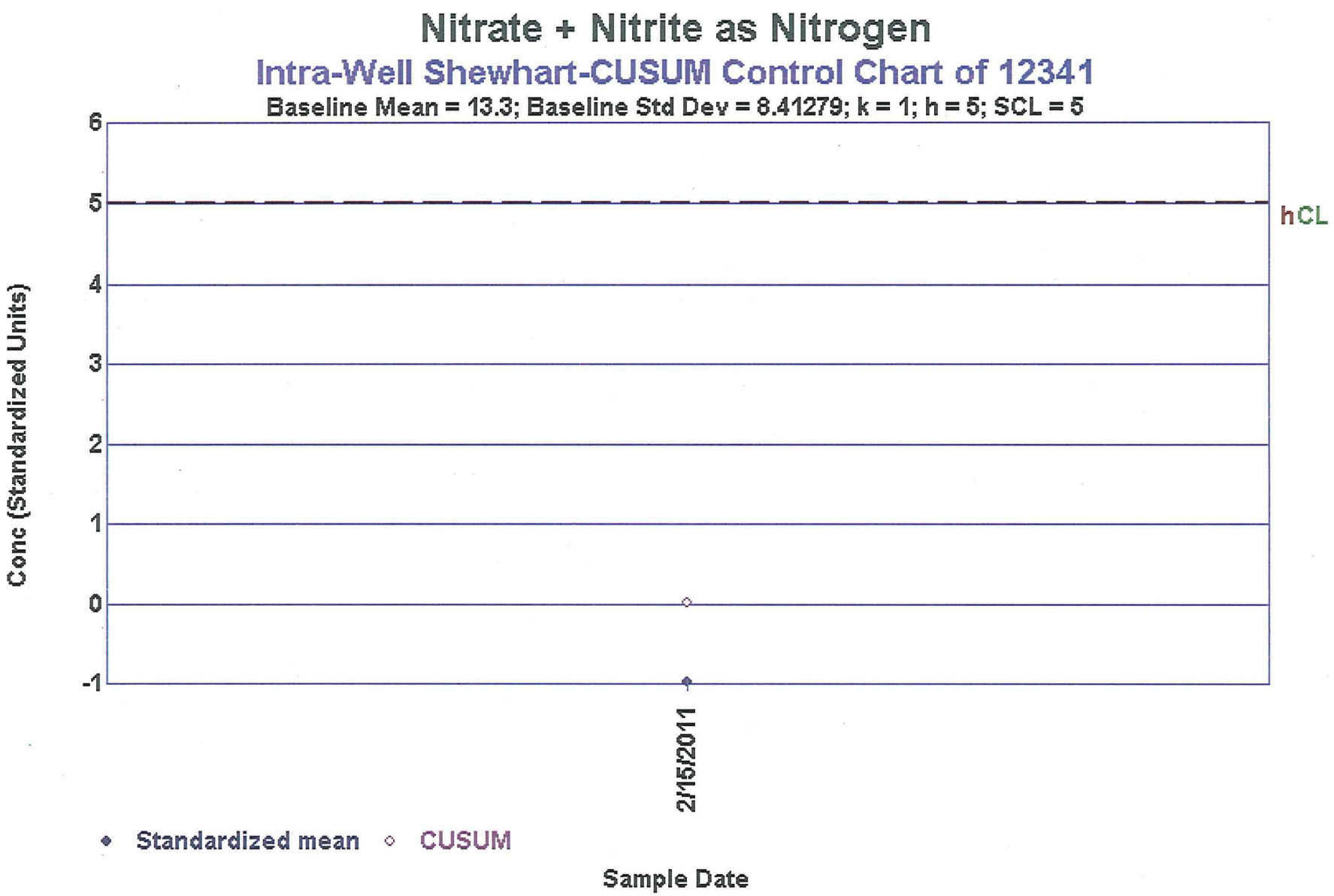


Figure A.5.4–37. Intra-Well Shewhart-CUSUM Control Chart (Nitrate 12341)

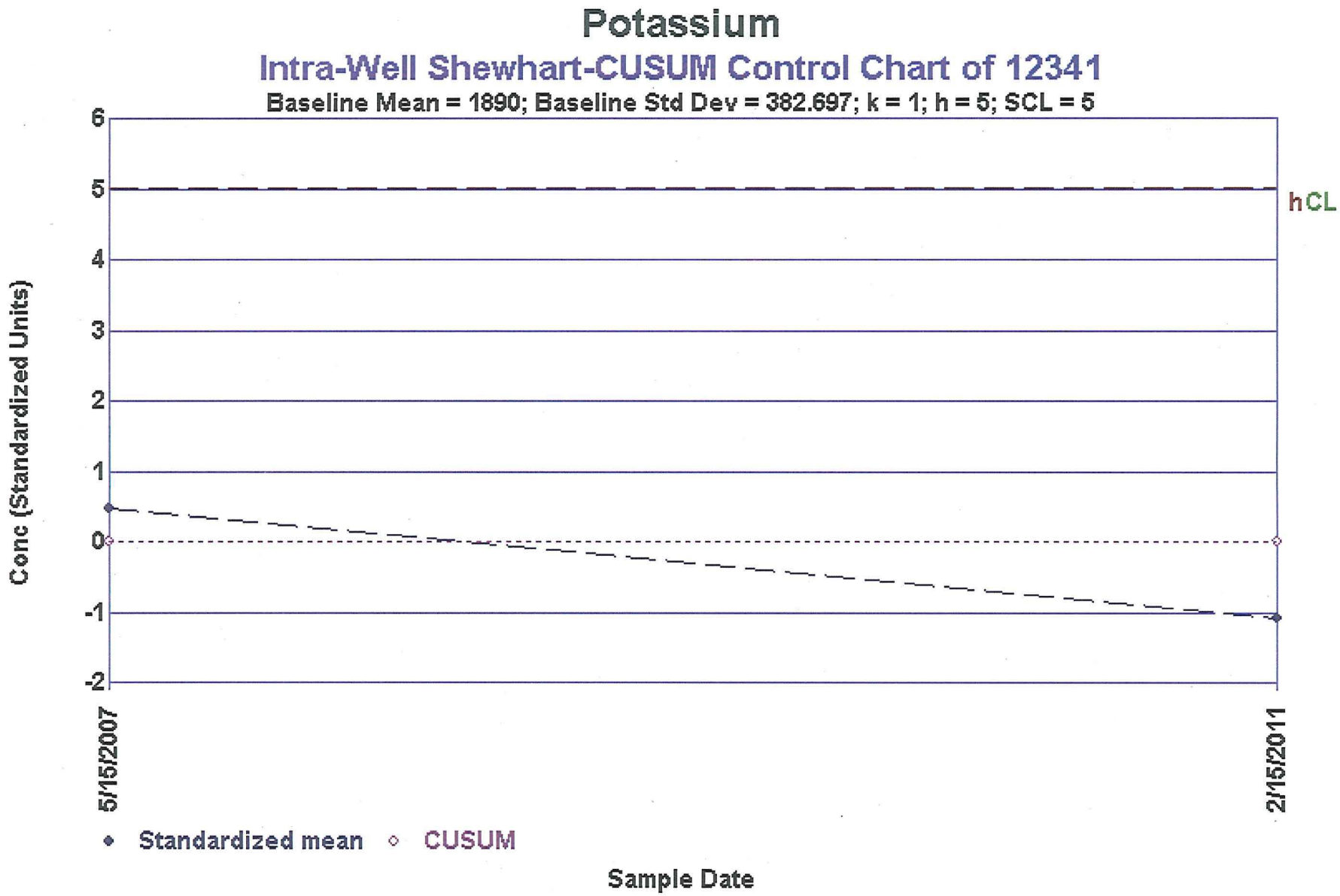


Figure A.5.4–38. Intra-Well Shewhart-CUSUM Control Chart (Potassium 12341)

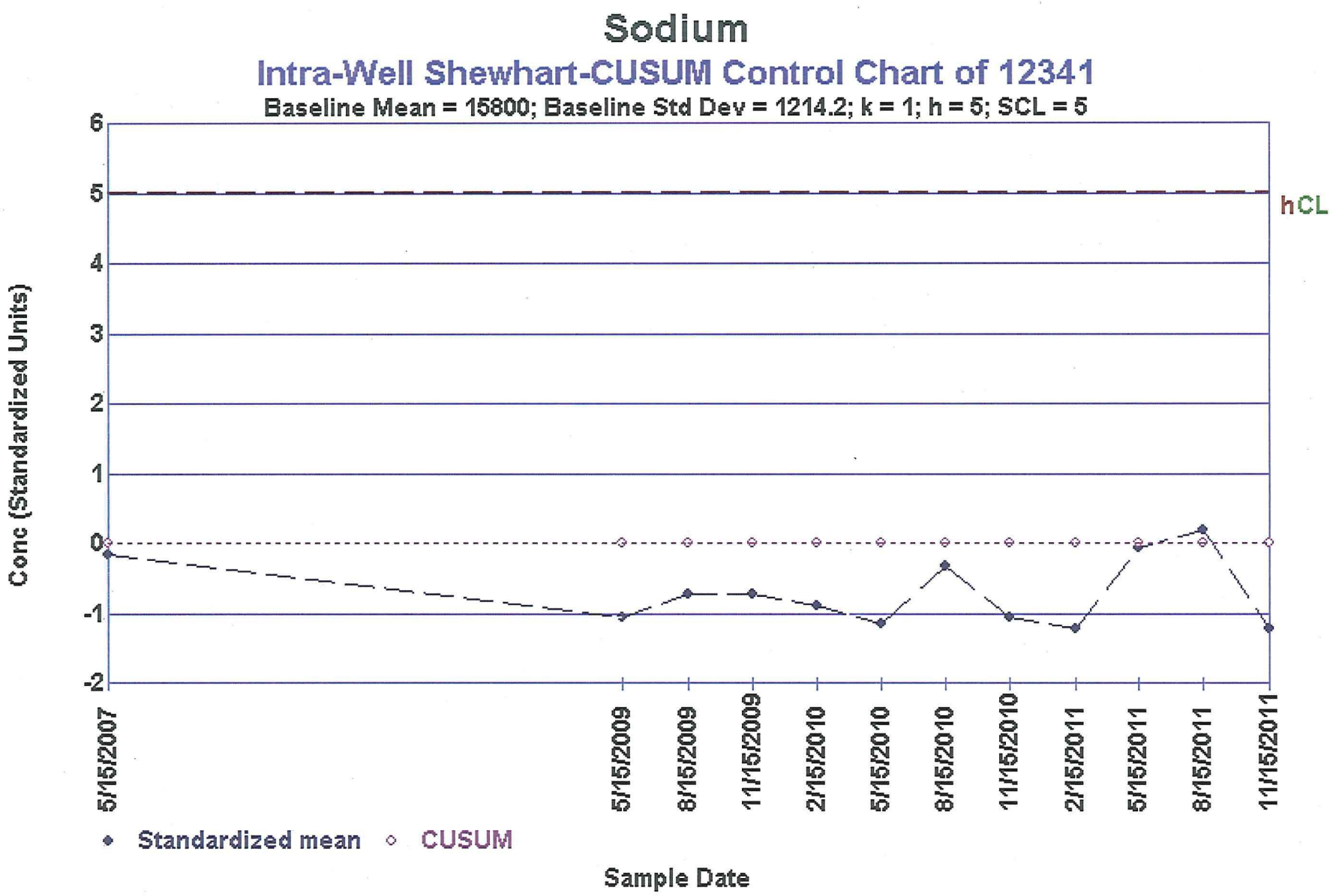


Figure A.5.4–39. Intra-Well Shewhart-CUSUM Control Chart (Sodium 12341)

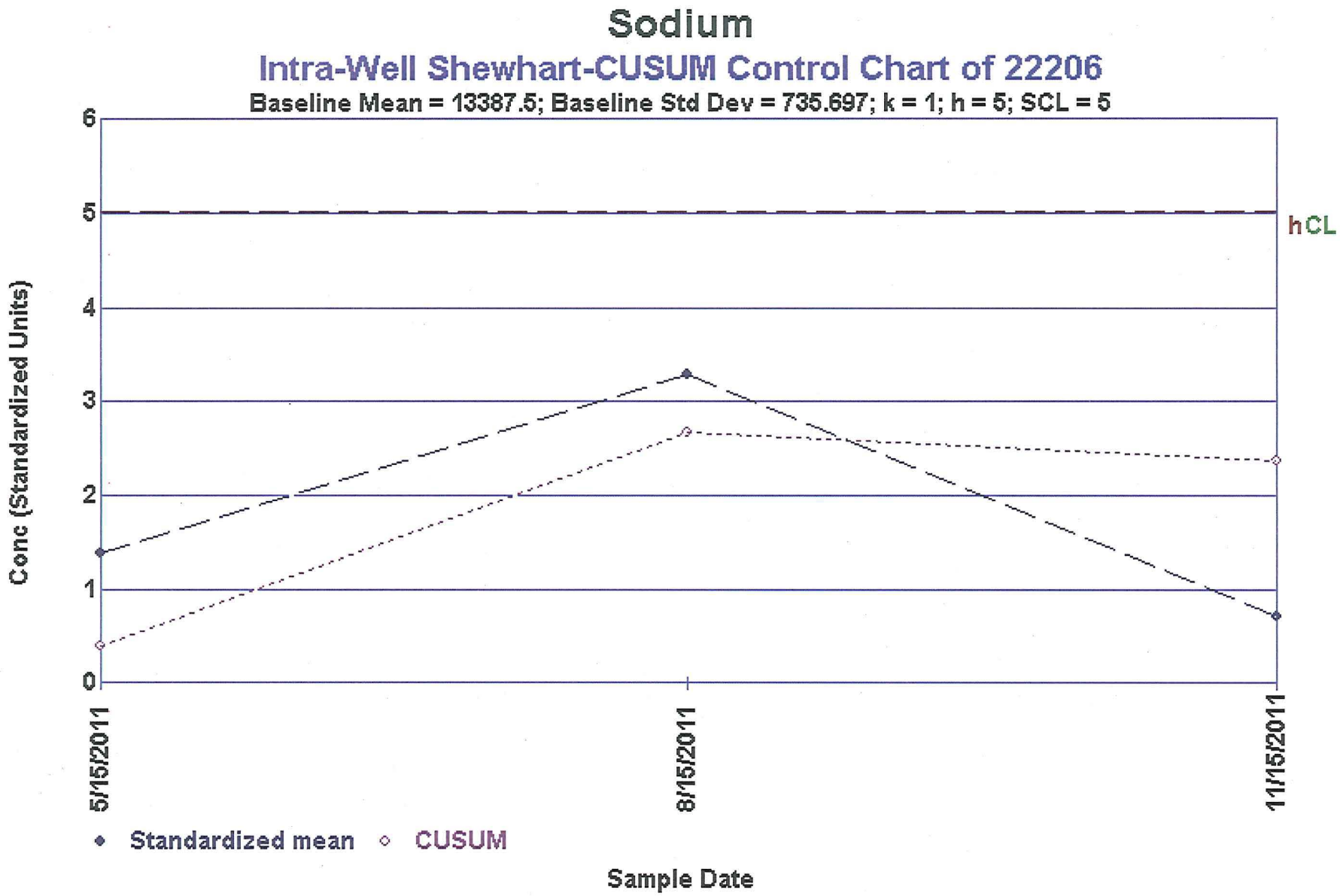


Figure A.5.4−40. Intra-Well Shewhart-CUSUM Control Chart (Sodium 22206)

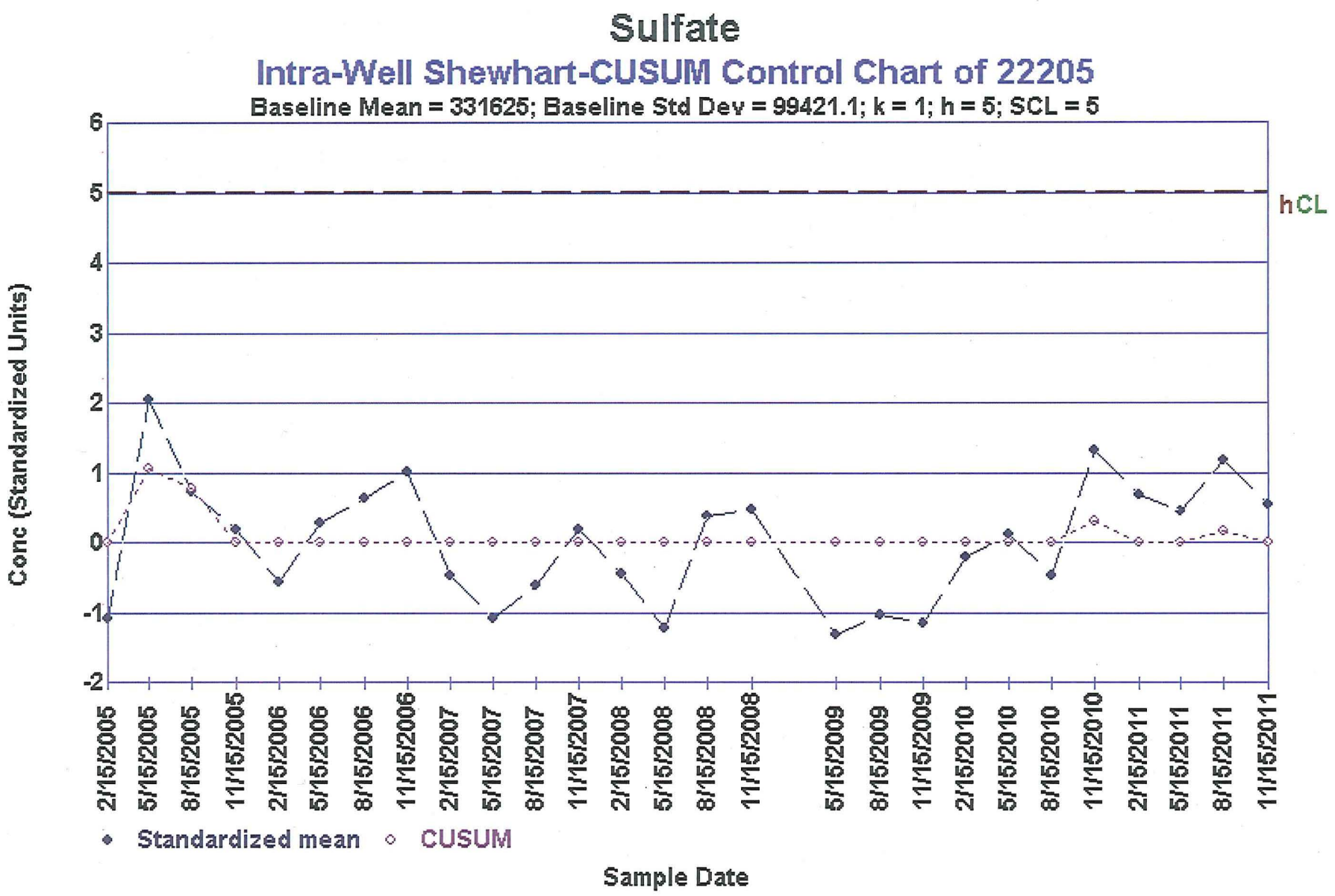


Figure A.5.4−41. Intra-Well Shewhart-CUSUM Control Chart (Sulfate 22205)

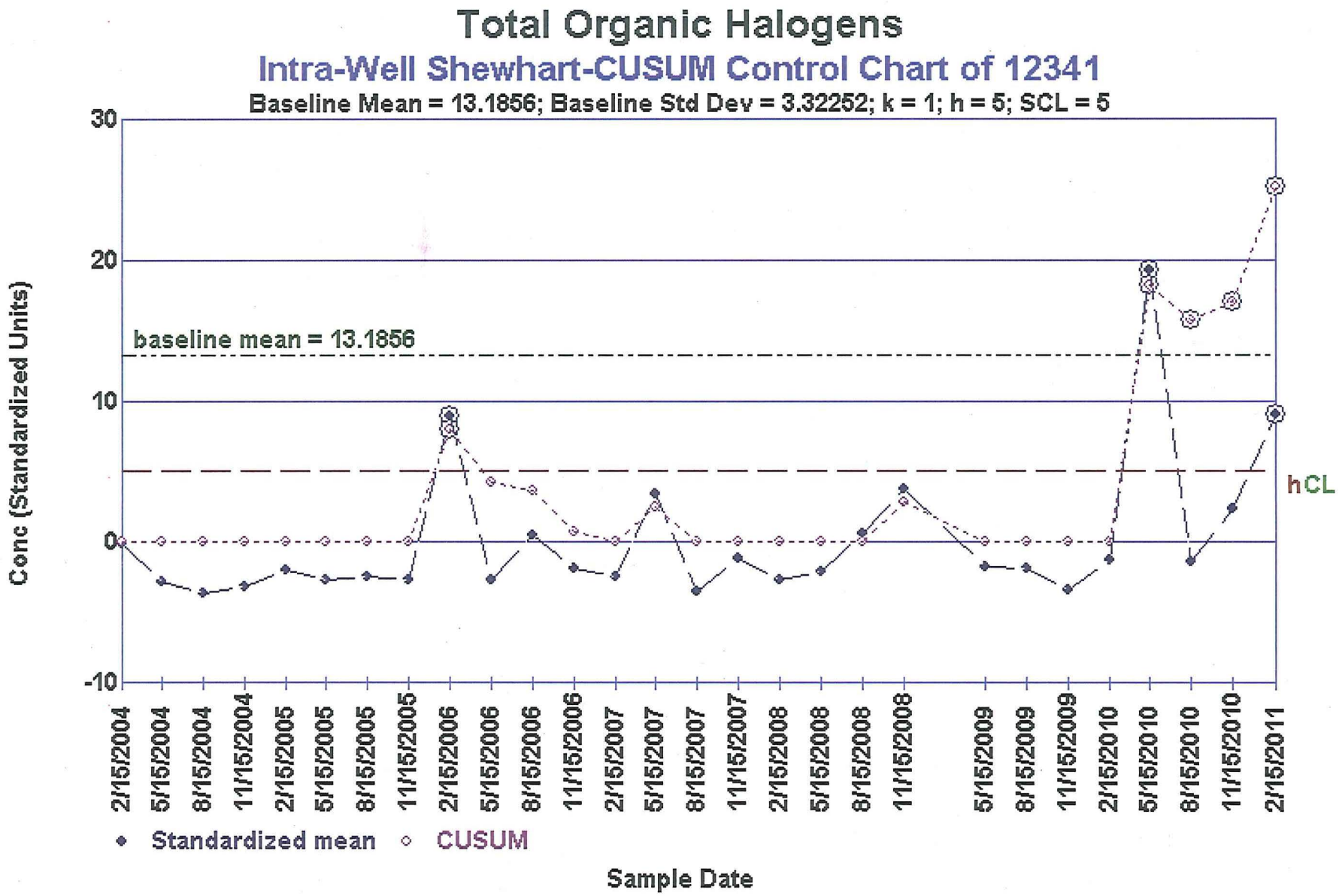


Figure A.5.4–42. Intra-Well Shewhart-CUSUM Control Chart (TOX 12341)

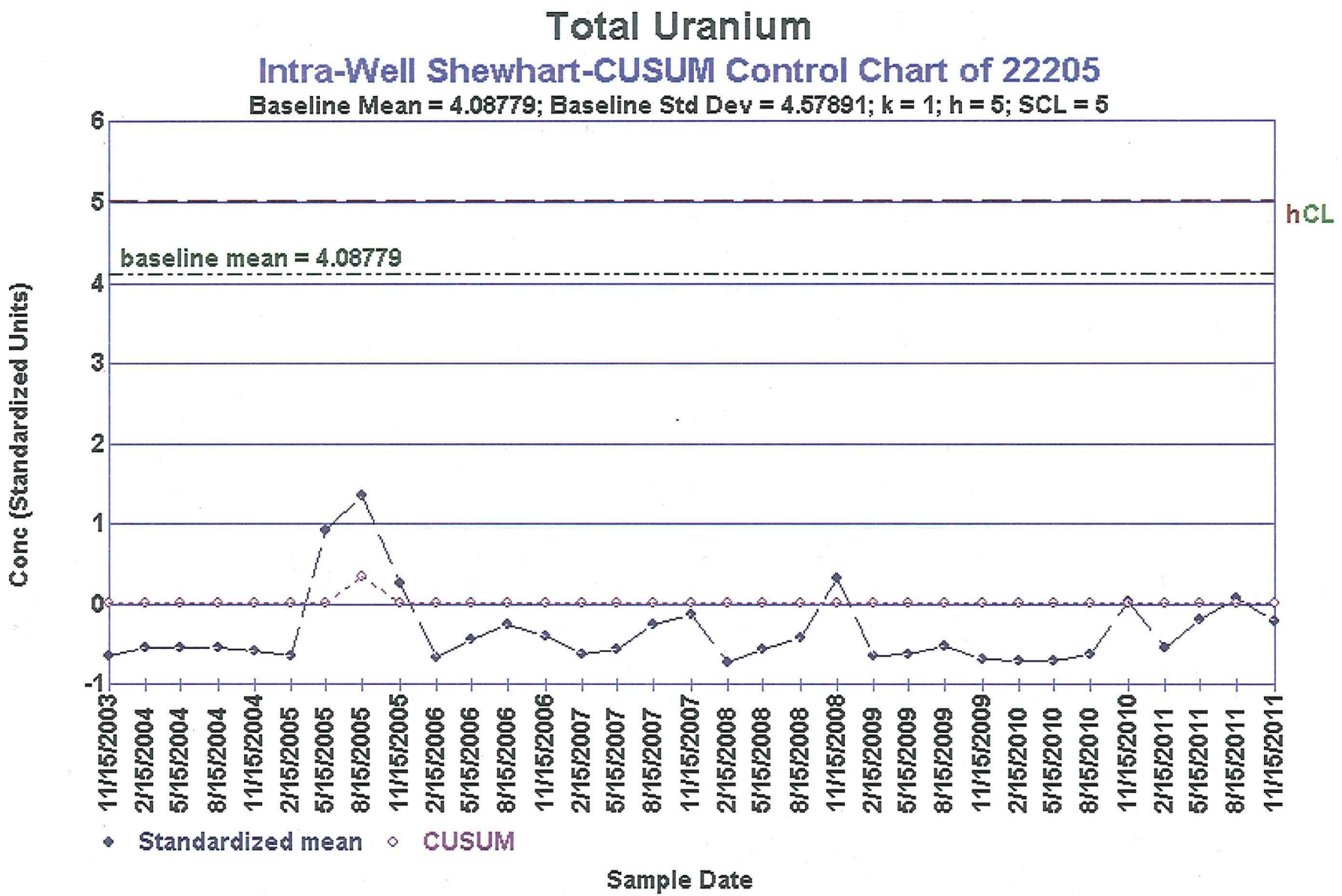


Figure A.5.4–43. Intra-Well Shewhart-CUSUM Control Chart (Uranium 22205)

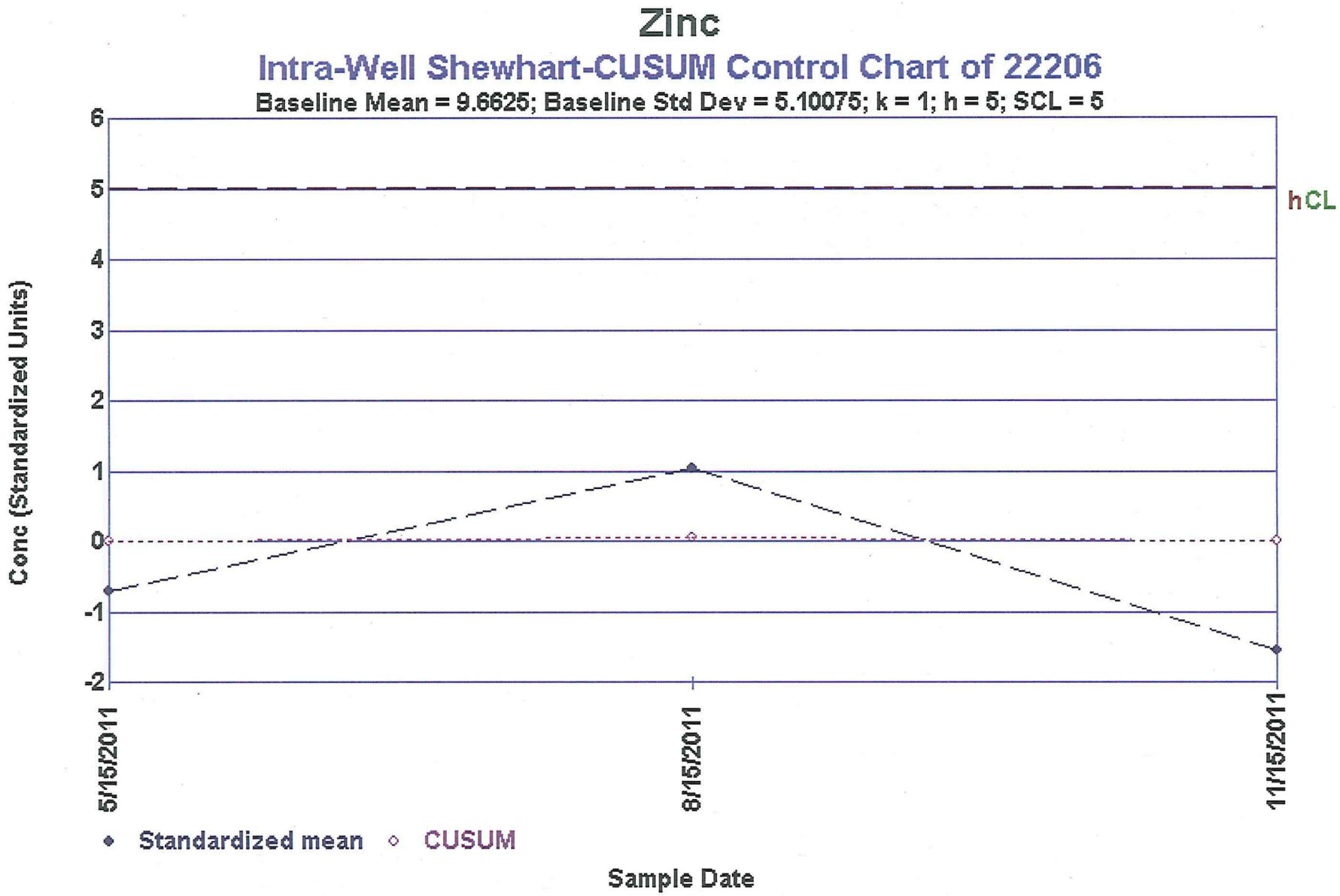


Figure A.5.4–44. Intra-Well Shewhart-CUSUM Control Chart (Zinc 22206)

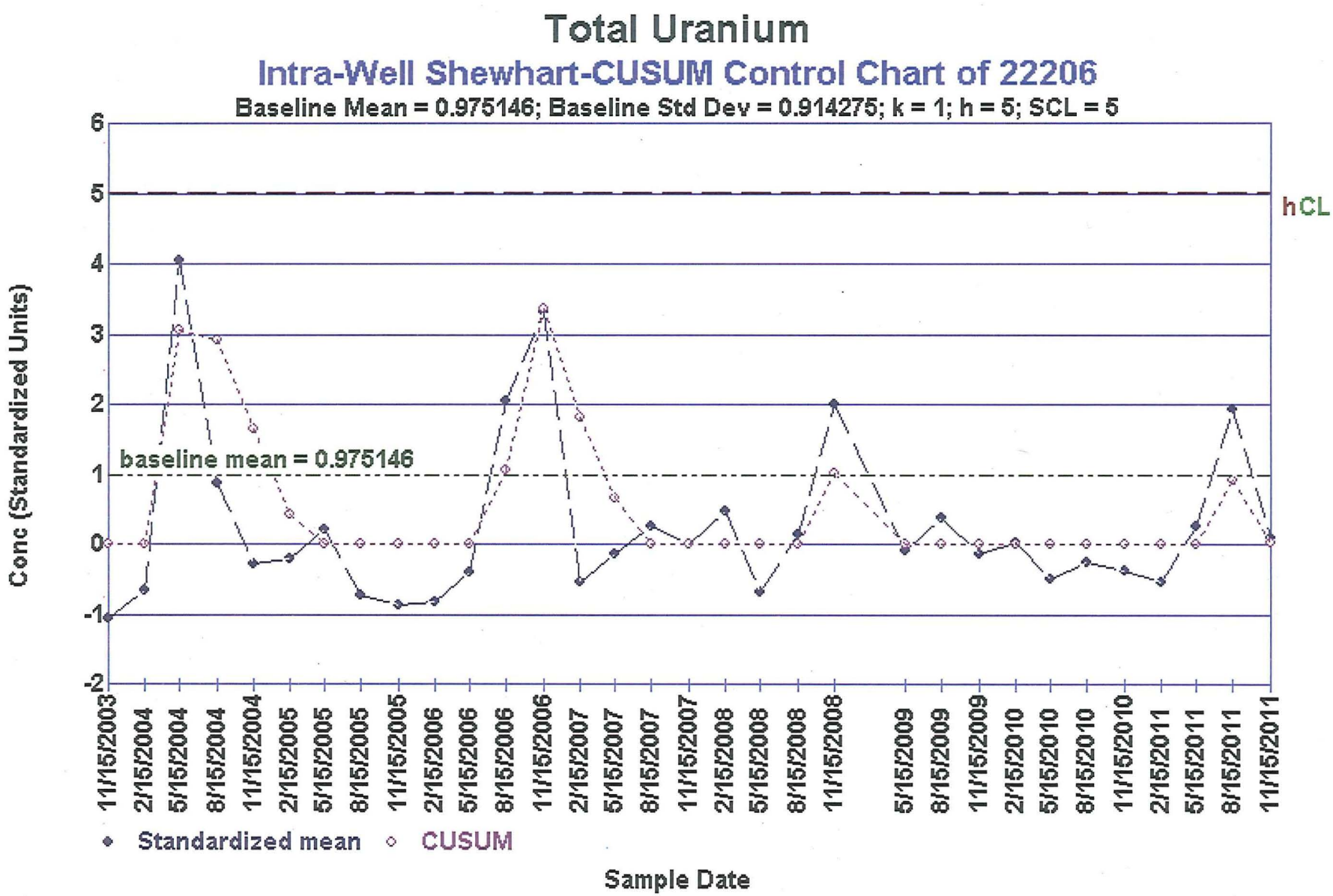


Figure A.5.4–45. Intra-Well Shewhart-CUSUM Control Chart (Uranium 22206)

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Sub-attachment A.5.5

Sub-attachment A.5.5

Cell 5

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The following information is provided in this sub-attachment:

- Quarterly monitoring summary statistics (refer to Table A.5.5–1)
- Annual LCS sample summary information for detected parameters (refer to Table A.5.5–2)
- LCS monthly accumulation volumes (refer to Figure A.5.5–1)
- LDS monthly accumulation volumes (refer to Figure A.5.5–2)
- OSDF horizontal till well 12342 water yield (refer to Figure A.5.5–3)
- GMA water levels and uranium concentration versus time (refer to Figures A.5.5–4 and A.5.5–5)
- Plots of concentration versus time (refer to Figures A.5.5–6A to A.5.5–28B)
- A bivariate plot for uranium-sodium (refer to Figure A.5.5–29)
- Control charts (refer to Figures A.5.5–30 to A.5.5–42)

A.5.5.1 Quarterly Monitoring Results

Quarterly water quality monitoring takes place in the LCS, LDS, HTW, and GMA wells of each cell for the purpose of determining if the OSDF is operating as designed. Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentrations versus time plots, bivariate plots, and control charts are used to help interpret and present the results.

In the first quarter of 2011, 23 parameters were sampled in the LCS, LDS, HTW, and GMA wells of each cell. In the second, third, and fourth quarters tritium was added to the analyte list for all horizons (LCS, LDS, HTW, and GMA wells), and the analyte list for the HTWs in all cells was changed to just four parameters: arsenic, uranium, tritium, and sodium. These changes were agreed to via the comment resolution process between Ohio EPA and DOE on LMICP (revision 4). Tritium results for all cells are reported in Section A.5.5.

The LDS of Cell 5 was dry during the fourth quarter of 2011. As shown in Table A.5.5–1, 8 of the 23 parameters sampled quarterly in the LCS, LDS, HTW, and GMA wells (sulfate, arsenic, boron, copper, iron, lithium, manganese, and sodium) have upward trends in the HTW and/or the GMA wells based on the Mann-Kendall test for trend.

Horizontal Till Well

The HTW is located beneath the liner penetration box of each cell by design. The liner penetration box is considered to be potentially the weakest point in the cell design. If a leak were to develop, it should be detected beneath the liner penetration box first. Therefore, the water quality in the HTW represents the first line of evidence that a potential leak from the cell might be occurring. A leak would be indicated by an increasing concentration in the HTW.

Of the 23 parameters monitored quarterly in the LCS, LDS, HTW, and GMA wells, sulfate copper, and sodium are increasing in the HTW of Cell 5 (as indicated in the table below). The bivariate plot for the Cell 5 LCS, LDS, and HTW (uranium-sodium) is provided in Figure A.5.5–29. The plot shows that the chemical signature for uranium-sodium in the LCS LDS, and HTW are separate and distinct; indicating that mixing between the horizons is not

occurring. Therefore, the increasing concentrations measured in the HTW of Cell 5 are attributed to fluctuating ambient concentrations beneath the cell that are not related to cell performance.

Parameter	HTW[a]	GMA-U[a]	GMA-D[a]
Sulfate	Up		
Arsenic			Up
Boron			Up
Copper	Up		
Iron			Up
Lithium		Up	
Manganese			Up
Sodium	Up		

[a] HTW = horizontal till well, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer.
No entry indicates that the trend was not up.

Great Miami Aquifer Wells

GMA monitoring wells are positioned for post-aquifer-remediation flow conditions, when flow directions will be from west to east. However, water levels measured in 2011 indicate that groundwater in the GMA in most of the area of the OSDF is moving in a general direction of northeast to south/southwest in response to the active groundwater remediation taking place to the west and southwest. Pumping for the groundwater remediation is scheduled to last until 2023. Because bivariate plots (discussed above) indicate that LCS, LDS, and HTW monitoring horizons are not mixing, the increasing concentrations seen in the GMA wells are attributed to fluctuating ambient conditions that are not related to cell performance.

The table below provides a summary of the average concentration (as reported in Table A.5.5–1) measured in the LDS and GMA wells for parameters with increasing concentrations in the Cell 5 GMA wells.

Parameter	LDS[a]	GMA-U[a]	GMA-D[a]
Arsenic (mg/L)	**0.0187**[b]	0.00250	0.00729
Boron (mg/L)	**0.359**	0.0370	0.0307
Iron (mg/L)	1.29	**10.4**	6.84
Lithium (mg/L)	**0.117**	0.00974	0.00785
Manganese (mg/L)	0.0348	0.329	**0.376**

Note: The highest averages are shown in bold.
[a] LDS = leak detection system, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer.
[b] Arsenic has only had one detect in the LDS (fourth quarter 2009, 0.0187 mg/L).

As shown in the table above, iron and manganese have higher concentrations in the GMA than in the LDS of Cell 5.

A.5.5.2 Control Charts

Intrawell control charts employ historical measurements from a compliance point as background The *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance* (EPA 2009) defines the process of creating a Shewart-CUSUM control chart.

Appropriate background data are used to define a baseline for the well. The baseline parameters for the chart, estimates of the mean, and standard deviation are obtained from the background data. These baseline measurements characterize the expected background concentrations at the monitoring point. As future concentrations are collected, the baseline parameters are used to standardize the newly gathered data. After these measurements are standardized and plotted, a control chart is declared "out of control" if future concentrations exceed the baseline control limit. This is indicated on the control chart when either the Shewart or CUSUM plot traces begin to exceed a control limit. The limit is based on the rationale that if the monitoring point remains unchanged from the baseline condition, new standardized observations should not deviate substantially from the baseline mean. If a change occurs, the standardized values will deviate significantly from the baseline and tend to exceed the control limit.

A minimum of eight samples are recommended for use in ChemStat® software to define the baseline for a control chart. Therefore, only sample sets with greater than eight samples were selected for control charts. By default, the ChemStat® software plots both a CUSUM control limit (h) and a SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit (h) and a value of 4.5 for the SCL.

EPA Unified Guidance suggests that to simplify the interpretation of the control chart that an out of control condition be based on the CUSUM (h) limit alone. Plotting the SCL limit is not needed. The ChemStat® software though, by default, plots both the SCL and CUSUM (h) control limit on the charts. As a "work-a-round", the SCL limit was defined as 5 to match the recommended CUSUM limit. On the charts the combined limit is identified as hCL. For interpretation purposes, regard hCL as the CUSUM limit (h).

As shown in Table A.5.5–1 in gray shading, thirteen parameters in the HTW and/or GMA wells of Cell 5 (nitrate, sulfate, TOC, calcium, cobalt, iron, lithium, magnesium, manganese, nickel, potassium, sodium, and zinc) meet the criteria for control charts (i.e., 8 samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in 13 control charts.

Parameter and Monitoring Point[a]	Assessment
Nitrate in the HTW	In Control
Sulfate in the GMA-D	In Control
TOC in the GMA-U	In Control
Calcium in the HTW	In Control
Cobalt in the HTW	**Out of Control**
Iron in the GMA-U	In Control
Lithium in the GMA-D	In Control
Magnesium in the HTW	In Control
Manganese in the HTW	**Out of Control**
Nickel in the HTW	In Control
Potassium in the HTW	In Control
Sodium in the GMA-D	In Control
Zinc in the GMA-D	In Control

[a] HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer; and TOC = total organic carbon.

These 13 control charts are presented in Figures A.5.5–30 to A.5.5–42. All of the control charts, with the exception of two, exhibit "in control" conditions. The two exceptions are cobalt and

manganese in the HTW. As discussed above, separate and distinct signatures for uranium and sodium in the LCS, LDS, and HTW of Cell 5 indicate that water is not mixing between the horizons, so the out of control conditions are attributed to fluctuating ambient conditions beneath the cell, and not to cell performance.

A.5.5.3 Annual LCS Sample Results

Annual LCS sampling results for Cell 5 are provided in Table A.5.5–2 for those parameters that have been detected at least once and are not being sampled quarterly. No new Appendix I of PCB parameters were detected in the LCS of Cell 5 in 2011.

A.5.5.4 Summary and Conclusions

- The concentrations of eight parameters monitored quarterly are increasing in either the HTW and/or GMA wells of Cell 5 (sulfate, arsenic, boron, copper, iron, lithium, manganese, and sodium).
- Separate and distinct chemical signatures for uranium and sodium in the LCS, LDS, and HTW of Cell 5 indicate that water is not mixing between the horizons. Concentration increases in the HTW and GMA wells of Cell 5 are attributed to fluctuating ambient concentrations beneath the cell and not to cell performance.
- Thirteen control charts were constructed for Cell 5 parameters. Eleven of the thirteen control charts exhibit "in control" conditions. Control charts for cobalt and manganese in the HTW are not in control.
- No new Appendix I or PCB parameters were detected in the LCS of Cell 5 in 2011.

Table A.5.5–1. Summary Statistics for Cell 5

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12342C	36	36	100.0	3.39	285	131	52	Normal	None	Detected	
	LDS	12342D	33	33	100.0	2.93	27.1	16.6	5.3	Normal	None	Detected	
	HTW	12342	39	39	100.0	7.45	19.2	9.47	2.54	Undefined	None	Detected	
	GMA-U	22207	33	40	82.5	ND	2.39	0.295	0.356	Undefined	Down	Detected	
	GMA-D	22208	34	41	82.9	ND	2.10	0.375	0.308	Undefined	None	Not Detected	
Alkalinity as CaCO3 (mg/L)	LCS	12342C	19	19	100.0	58.0	563	445	131	Undefined	None	Detected	
	LDS	12342D	13	13	100.0	120	651	493	197	Undefined	None	Not Detected	
	HTW	12342	10	10	100.0	497	1060	527	170	Undefined	None	Not Detected	
	GMA-U	22207	4	4	100.0	337	353	346	7	Normal	None	Insuff	
	GMA-D	22208	4	4	100.0	392	421	418	14	Undefined	None	Insuff	
Chloride (mg/L)	LCS	12342C	19	19	100.0	16.9	112	88.9	29.5	Undefined	Up	Detected	
	LDS	12342D	13	13	100.0	41.3	50.0	44.3	3.03	Lognormal	None	Not Detected	6.2 (Q2-02)
	HTW	12342	10	10	100.0	20.9	60.8	45.2	13.5	Normal	Down	Detected	
	GMA-U	22207	4	4	100.0	24.5	32.9	28.3	3.5	Normal	None	Insuff	
	GMA-D	22208	4	4	100.0	24.4	31.9	27.1	3.4	Normal	None	Insuff	
Nitrate/Nitrite as N (mg/L)	LCS	12342C	18	25	72.0	ND	4.18	0.957	1.01	Undefined	None	Detected	
	LDS	12342D	5	13	38.5	ND	0.953	0.429	0.320	Lognormal	Up	Not Detected	
	HTW	12342	2	9	22.2	ND	0.211	Insuff	Insuff	Lognormal	None	Not Detected	
	GMA-U	22207	0	4	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22208	0	4	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Sulfate (mg/L)	LCS	12342C	36	36	100.0	218	5910	2430	1300	Normal	Up	Detected	
	LDS	12342D	33	33	100.0	1130	3400	1860	590	Lognormal	Up	Detected	
	HTW	12342	32	32	100.0	101	399	228	110	Undefined	Up	Detected	
	GMA-U	22207	35	35	100.0	110	470	262	88	Lognormal	Down	Detected	552 (Q3-04) 770 (Q2-05)
	GMA-D	22208	35	35	100.0	221	583	377	93	Normal	None	Not Detected	
Total Dissolved Solids (mg/L)	LCS	12342C	24	24	100.0	436	6260	4700	2130	Undefined	Down	Detected	
	LDS	12342D	11	11	100.0	2080	4560	4300	710	Undefined	Up	Detected	
	HTW	12342	8	8	100.0	1090	1190	1140	30	Normal	None	Not Detected	
	GMA-U	22207	11	11	100.0	552	987	679	122	Normal	Down	Not Detected	
	GMA-D	22208	11	11	100.0	882	1290	945	119	Undefined	None	Not Detected	
Total Organic Carbon (mg/L)	LCS	12342C	27	35	77.1	ND	4.21	1.99	0.88	Normal	None	Not Detected	
	LDS	12342D	30	33	90.9	ND	10.7	6.02	2.37	Normal	None	Detected	
	HTW	12342	30	35	85.7	ND	5.27	2.89	0.92	Normal	None	Detected	
	GMA-U	22207	29	40	72.5	ND	4.15	1.44	0.66	Lognormal	None	Not Detected	
	GMA-D	22208	30	40	75.0	ND	2.45	1.43	0.47	Normal	None	Detected	8.93 (Q4-01)
Total Organic Halogens (mg/L)	LCS	12342C	19	36	52.8	ND	0.0604	0.0117	0.0122	Undefined	None	Not Detected	
	LDS	12342D	23	33	69.7	ND	0.0717	0.0309	0.0199	Normal	None	Not Detected	
	HTW	12342	23	36	63.9	ND	0.0320	0.00764	0.00696	Undefined	None	Not Detected	
	GMA-U	22207	11	40	27.5	ND	0.0150	0.00376	0.00487	Undefined	Down	Detected	0.047 (Q2-10)
	GMA-D	22208	9	40	22.5	ND	0.0132	0.0040	0.00436	Undefined	Down	Detected	
Arsenic (mg/L)	LCS	12342C	5	24	20.8	ND	0.140	0.00375	0.0373	Undefined	None	Not Detected	
	LDS	12342D	1	20	5.0	ND	0.0187	Insuff	Insuff	Undefined	None	Not Detected	
	HTW	12342	9	20	45.0	ND	0.0528	0.00375	0.0116	Undefined	None	Not Detected	
	GMA-U	22207	5	11	45.4	ND	0.0363	0.00250	0.0114	Undefined	None	Not Detected	
	GMA-D	22208	5	24	20.8	ND	0.0390	0.00729	0.0110	Lognormal	Up	Detected	
Barium (mg/L)	LCS	12342C	19	19	100.0	0.0176	0.0707	0.0318	0.0148	Lognormal	Down	Detected	
	LDS	12342D	13	13	100.0	0.00698	0.0659	0.0240	0.0148	Lognormal	Down	Not Detected	
	HTW	12342	10	10	100.0	0.0518	0.0902	0.0802	0.0107	Undefined	None	Not Detected	
	GMA-U	22207	4	4	100.0	0.0622	0.0738	0.0664	0.0053	Normal	None	Insuff	
	GMA-D	22208	4	4	100.0	0.0421	0.0617	0.0505	0.0085	Normal	None	Insuff	

Table A.5.5–1 (continued). Summary Statistics for Cell 5

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Boron (mg/L)	LCS	12342C	34	36	94.4	ND	1.59	0.759	0.335	Undefined	None	Detected	
	LDS	12342D	33	33	100.0	0.202	1.20	0.359	0.300	Undefined	None	Detected	
	HTW	12342	34	36	94.4	ND	0.221	0.110	0.047	Lognormal	None	Detected	
	GMA-U	22207	35	40	87.5	ND	0.0480	0.0370	0.0086	Undefined	None	Not Detected	
	GMA-D	22208	34	40	85.0	ND	0.0464	0.0307	0.0096	Normal	Up	Detected	
Calcium (mg/L)	LCS	12342C	19	19	100.0	163	990	520	165	Undefined	None	Not Detected	
	LDS	12342D	13	13	100.0	222	386	304	44	Normal	None	Not Detected	
	HTW	12342	10	10	100.0	184	233	201	18	Normal	None	Not Detected	
	GMA-U	22207	4	4	100.0	143	155	148	6	Normal	None	Insuff	
	GMA-D	22208	4	4	100.0	222	285	243	29	Normal	None	Insuff	
Cobalt (mg/L)	LCS	12342C	13	24	54.2	ND	0.0116	0.00111	0.00314	Undefined	None	Detected	
	LDS	12342D	9	20	45.0	ND	0.0034	0.00076	0.00092	Undefined	Down	Detected	
	HTW	12342	15	17	88.2	ND	0.0106	0.00333	0.00226	Lognormal	None	Not Detected	
	GMA-U	22207	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22208	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Copper (mg/L)	LCS	12342C	14	20	70.0	ND	0.0862	0.0112	0.0188	Undefined	None	Not Detected	
	LDS	12342D	8	15	53.3	ND	0.0209	0.0071	0.0065	Undefined	None	Not Detected	
	HTW	12342	6	11	54.6	ND	0.0150	0.00457	0.00514	Lognormal	Up	Detected	
	GMA-U	22207	4	4	100.0	0.00144	0.00762	0.0050	0.0026	Normal	None	Insuff	
	GMA-D	22208	4	4	100.0	0.00207	0.00925	0.00681	0.00322	Normal	None	Insuff	
Iron (mg/L)	LCS	12342C	20	24	83.3	ND	4.61	0.596	1.62	Undefined	Down	Detected	
	LDS	12342D	19	20	95.0	ND	3.67	1.29	1.07	Normal	Down	Not Detected	
	HTW	12342	17	17	100.0	1.74	18.9	3.31	5.21	Undefined	None	Not Detected	
	GMA-U	22207	11	11	100.0	5.54	18.2	10.4	4.5	Normal	None	Not Detected	
	GMA-D	22208	11	11	100.0	4.92	8.60	6.84	1.01	Normal	Up	Detected	
Lithium (mg/L)	LCS	12342C	20	20	100.0	0.107	0.293	0.178	0.055	Normal	Up	Detected	
	LDS	12342D	19	19	100.0	0.0484	0.218	0.117	0.052	Undefined	Up	Detected	
	HTW	12342	13	17	76.5	0.0026	0.0050	0.00348	0.00080	Undefined	None	Detected	
	GMA-U	22207	11	11	100.0	0.00642	0.0141	0.00974	0.00296	Normal	Up	Detected	
	GMA-D	22208	11	11	100.0	0.00659	0.00901	0.00785	0.00075	Normal	None	Not Detected	
Magnesium (mg/L)	LCS	12342C	19	19	100.0	57.7	913	512	267	Normal	Up	Detected	
	LDS	12342D	13	13	100.0	104	354	112	102	Undefined	None	Not Detected	
	HTW	12342	10	10	100.0	42.9	61.1	52.1	6.3	Normal	None	Not Detected	
	GMA-U	22207	4	4	100.0	27.1	31.5	29.6	2.2	Normal	None	Insuff	
	GMA-D	22208	4	4	100.0	52.5	66.4	57.0	6.4	Normal	None	Insuff	
Manganese (mg/L)	LCS	12342C	13	24	54.2	ND	2.96	0.0100	0.986	Undefined	None	Detected	
	LDS	12342D	16	20	80.0	ND	0.146	0.0348	0.0535	Undefined	Down	Not Detected	0.783 (Q2-02) 0.333 (Q1-06)
	HTW	12342	17	17	100.0	0.574	1.30	0.905	0.173	Normal	None	Not Detected	
	GMA-U	22207	11	11	100.0	0.276	0.650	0.329	0.108	Undefined	Down	Not Detected	
	GMA-D	22208	23	24	95.8	ND	0.513	0.376	0.094	Undefined	Up	Not Detected	
Nickel (mg/L)	LCS	12342C	20	24	83.3	ND	0.0452	0.0175	0.0161	Lognormal	None	Detected	
	LDS	12342D	18	20	90.0	0.00163	0.0230	0.00832	0.00630	Lognormal	Down	Detected	
	HTW	12342	15	17	88.2	0.00322	0.0172	0.00805	0.00346	Normal	None	Not Detected	
	GMA-U	22207	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22208	8	24	33.3	ND	0.0069	0.00075	0.00177	Undefined	None	Detected	
Potassium (mg/L)	LCS	12342C	19	19	100.0	6.22	65.5	25.4	11.5	Undefined	Up	Detected	
	LDS	12342D	13	13	100.0	10.0	42.7	12.2	10.0	Undefined	None	Detected	
	HTW	12342	9	10	90.0	ND	1.99	1.54	0.36	Normal	None	Not Detected	
	GMA-U	22207	4	4	100.0	2.75	3.09	2.92	0.14	Normal	None	Insuff	
	GMA-D	22208	4	4	100.0	3.14	3.41	3.30	0.12	Normal	None	Insuff	

Table A.5.5–1 (continued). Summary Statistics for Cell 5

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Selenium (mg/L)	LCS	12342C	6	24	25.0	ND	0.212	0.00625	0.0448	Undefined	None	Not Detected	
	LDS	12342D	2	20	10.0	0.00086	0.0525	Insuff	Insuff	Undefined	None	Not Detected	
	HTW	12342	0	17	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-U	22207	1	11	9.1	ND	0.00509	Insuff	Insuff	Undefined	None	Detected	
	GMA-D	22208	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Sodium (mg/L)	LCS	12342C	23	24	95.8	16.4	108	70.8	19.9	Undefined	Up	Not Detected	
	LDS	12342D	20	20	100.0	323	474	384	50	Normal	Up	Detected	84.6 (Q4-02)
	HTW	12342	20	20	100.0	17.0	33.6	26.1	5.4	Normal	Up	Detected	
	GMA-U	22207	11	11	100.0	13.0	17.1	14.9	1.2	Normal	Down	Not Detected	
	GMA-D	22208	11	11	100.0	14.3	17.7	16.0	1.1	Normal	None	Not Detected	
Zinc (mg/L)	LCS	12342C	9	24	37.5	ND	0.040	0.0142	0.0092	Lognormal	None	Not Detected	
	LDS	12342D	14	20	70.0	ND	0.131	0.0321	0.0299	Lognormal	None	Not Detected	
	HTW	12342	11	17	64.7	ND	0.0869	0.0180	0.0229	Lognormal	None	Detected	
	GMA-U	22207	3	11	27.3	ND	0.0123	0.00286	Insuff	Undefined	None	Not Detected	
	GMA-D	22208	13	24	54.2	ND	0.0124	0.00438	0.00267	Lognormal	None	Not Detected	

Note: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least 8 samples, normal or lognormal distribution, no trend, and no serial correlation. These wells achieve control chart criteria.

Note: For results where the concentrations are below the detection limit, the results used in the Average, Standard Deviation, Distribution Type, Trend, Serial Correlation, and Outliers are each set at half the detection limit.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption and requires n ≥ 3. In addition, Standard Deviation requires n ≥ 4.

[d]"Insuff" = Insufficient and is used for Average, Standard Deviation, Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic (where 3 ≤ n ≤ 50) or Shapiro Francia (where n > 50).

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the lognormal assumption.

Lognormal: Lognormal assumption could not be rejected at the 5 percent level and has a higher probability value than the normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25% detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure. Trend testing requires a sample with n ≥ 4.

[g]Serial correlation based on Rank Von Neumann test. Serial Correlation testing requires a sample with n ≥ 6.

[h]Outliers determined by Rosner's (where n > 25) or Dixon procedure (where 4 ≤ n ≤ 25).

[i]Q = quarterly

Table A.5.5-2. Cell 5 Annual LCS Sample Summary Information for Detected Parameters

PARAMETER(UNIT)	NUMBER OF SAMPLES[a,b]	NUMBER OF SAMPLES WITH DETECTIONS[a,b]	PERCENT OF DETECTIONS[a,b]	DETECTED IN 2011	MIN DETECTED CONCENTRATION[a,b,c]	MAX DETECTED CONCENTRATION[a,b,c]	AVG DETECTED CONCENTRATION[a,b,c]	GW FRL[d] (#OF SAMPLES>GWFRL)	GW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	PW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	MAX PW DETECTED CONCENTRATION [a,b,f] (# OF SAMPLES>MAX PW)
General Chemistry											
Ammonia (mg/L)	10	3	30.0	Yes	0.02	0.815	0.292	-	4.2 mg/L(0)	4.34 mg/L(0)	220 mg/L(0)
Inorganics											
Beryllium (mg/L)	10	1	10.0	No	0.000038	-	-	0.004 mg/L(0)	-	-	0.0343 mg/L(0)
Chromium (mg/L)	10	2	20.0	Yes	0.0013	0.00457	0.0029	0.022 mg/L[g](0)	0.021 mg/L(0)	0.0046 mg/L(0)	0.818 mg/L(0)
Radionuclides											
Technetium-99 (pCi/L)	18	8	44.4	No	2.04	19	10.3	94 pCi/L(0)	22 pCi/L(0)	30 pCi/L(0)	6130 pCi/L(0)
Organics											
1,1-Dichloroethane (ug/L)	9	1	11.1	No	0.498	-	-	280 ug/L(0)	-	-	-
1,1-Dichloroethene (ug/L)	18	1	5.6	No	0.744	-	-	7 ug/L(0)	-	-	-
4-Methyl-2-Pentanone (ug/L)	9	1	11.1	No	0.46	-	-	-	-	-	-
Acetone (ug/L)	9	1	11.1	No	2.7	-	-	-	-	-	-
Carbon Disulfide (ug/L)	9	1	11.1	No	0.33	-	-	5.5 ug/L(0)	-	-	-
Toluene (ug/L)	9	1	11.1	No	0.416	-	-	-	-	-	-

Note: Shading indicates that at least one detected sample is greater than the FRL, groundwater background, PW background, or PW maximum.

[a]If more than one sample is collected per well per day (e.g., duplicates), then only one sample is counted for the total number of samples, and the sample with the maximum representative concentration is used for all the summary information

[b]Rejected data qualified with an R or Z were not included.

[c]If the number of detected samples is equal to two, then the minumun and maximumn are reported. If the number of detected is equal to one, then the data point is reported as the minimum. The "AVG DETECTED CONCENTRATION" is not reported for either of these cases.

[d]From Operable Unit 5 Record of Decision, Table 9-4.

[e]From the Characterization of Background Water Quality for Streams and Groundwater which was developed for Operable Unit 5 RI/FS documents.

[f]Max PW - maximum detected concentration in perched water as defined in the Remedial Investigation Report for Operable Unit 5.

[g]FRL based on hexavalent chromium from Operable Unit 5 Record of Decision, Table 9-4.

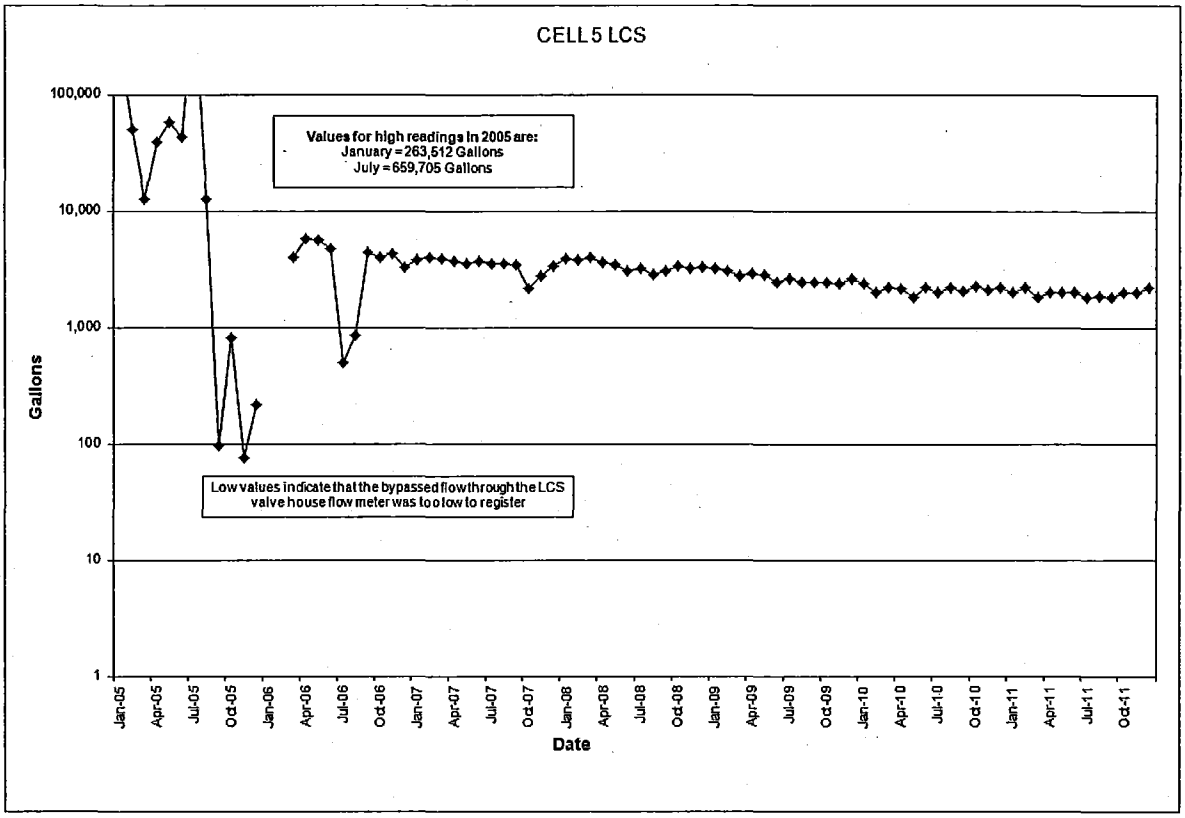


Figure A.5.5–1. Monthly Accumulation Volumes For Cell 5 LCS

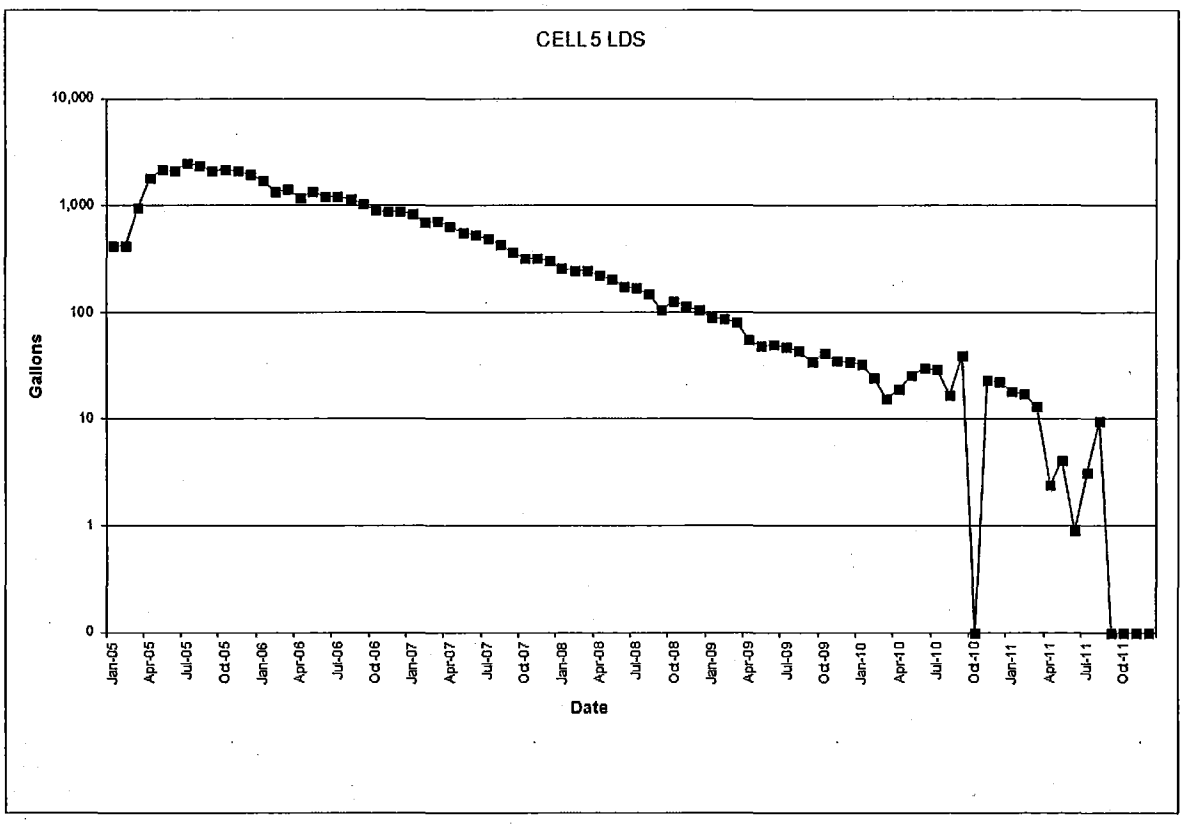
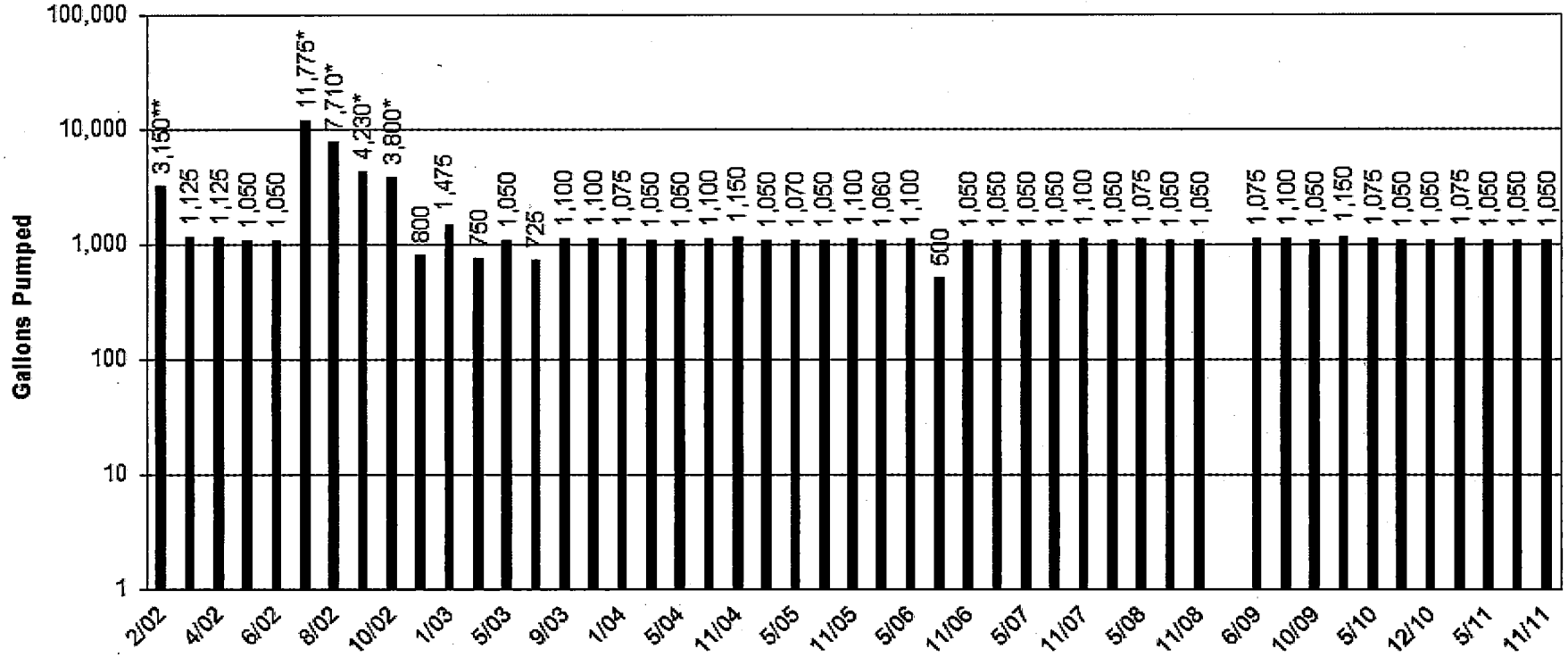


Figure A.5.5–2. Monthly Accumulation Volumes For Cell 5 LDS



12342 Purge Information

Year	Total Volumes (gal.)	Months Purged	Avg. Monthly Purge (gal.)
2002	35815	n=10	3582
2003:	6200	n=6	1033
2004:	5425	n=5	1085
2005:	4270	n=4	1068
2006:	3710	n=4	928
2007:	4250	n=4	1063
2008:	4225	n=4	1056
2009:	3225	n=3	1075
2010:	4325	n=4	1081
2011:	4225	n=4	1056
Overall:			1576

*More than one purge of the well was completed during these months to drain perched water and infiltrating surface water so the compacted clay liner could be constructed.

**Excess water was pumped from this well in February 2002 for well development.

Figure A.5.5–3. OSDF Horizontal Till Well 12342 (Cell 5) Water Yield

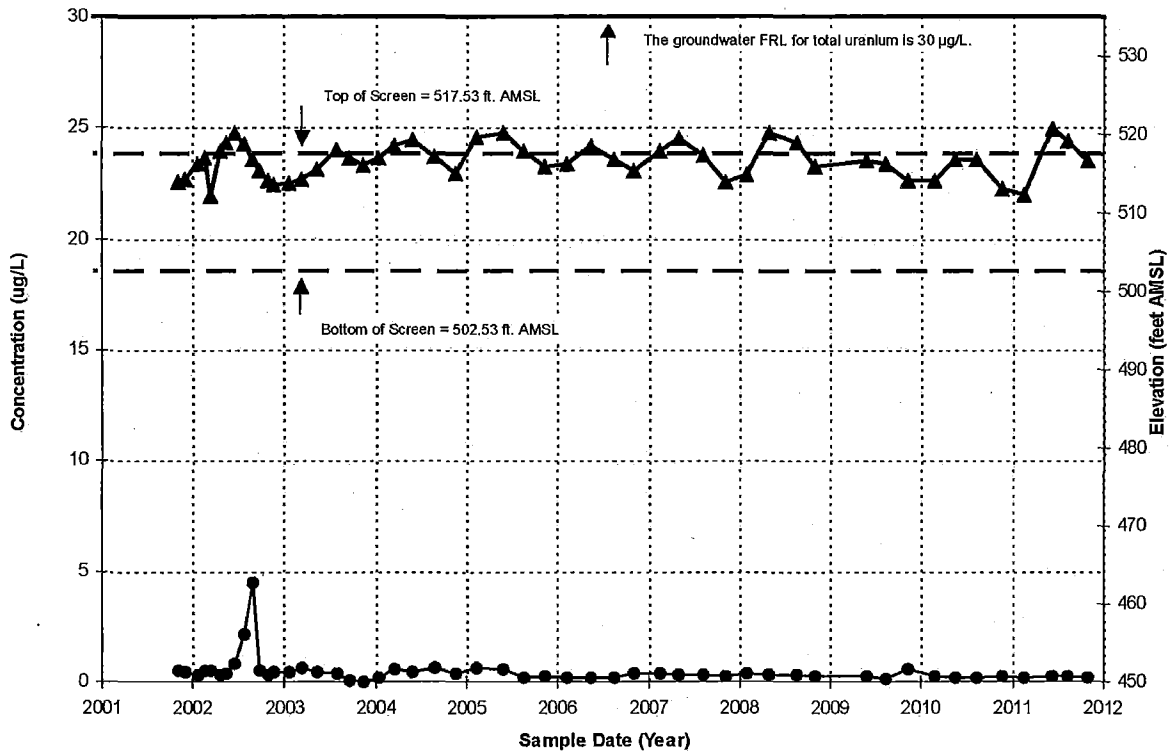


FIGURE A.5.5-4. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 5 Upgradient Monitoring Well 22207

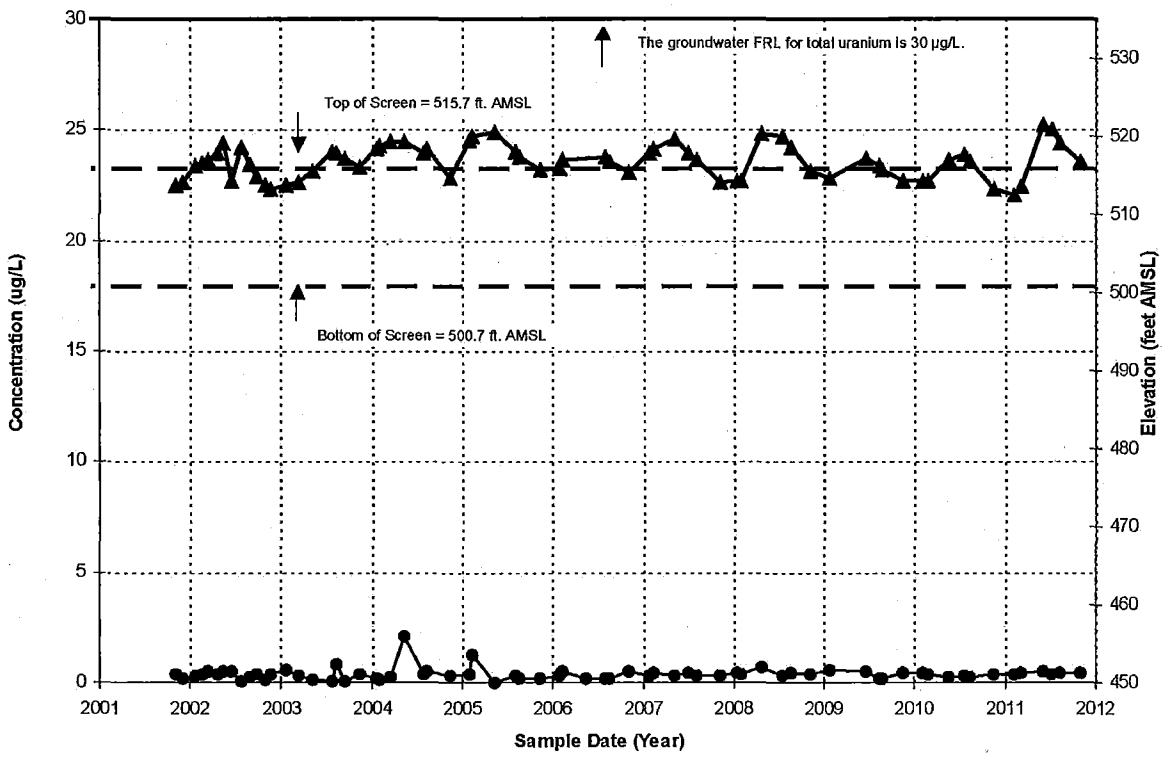


FIGURE A.5.5-5. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 5 Downgradient Monitoring Well 22208

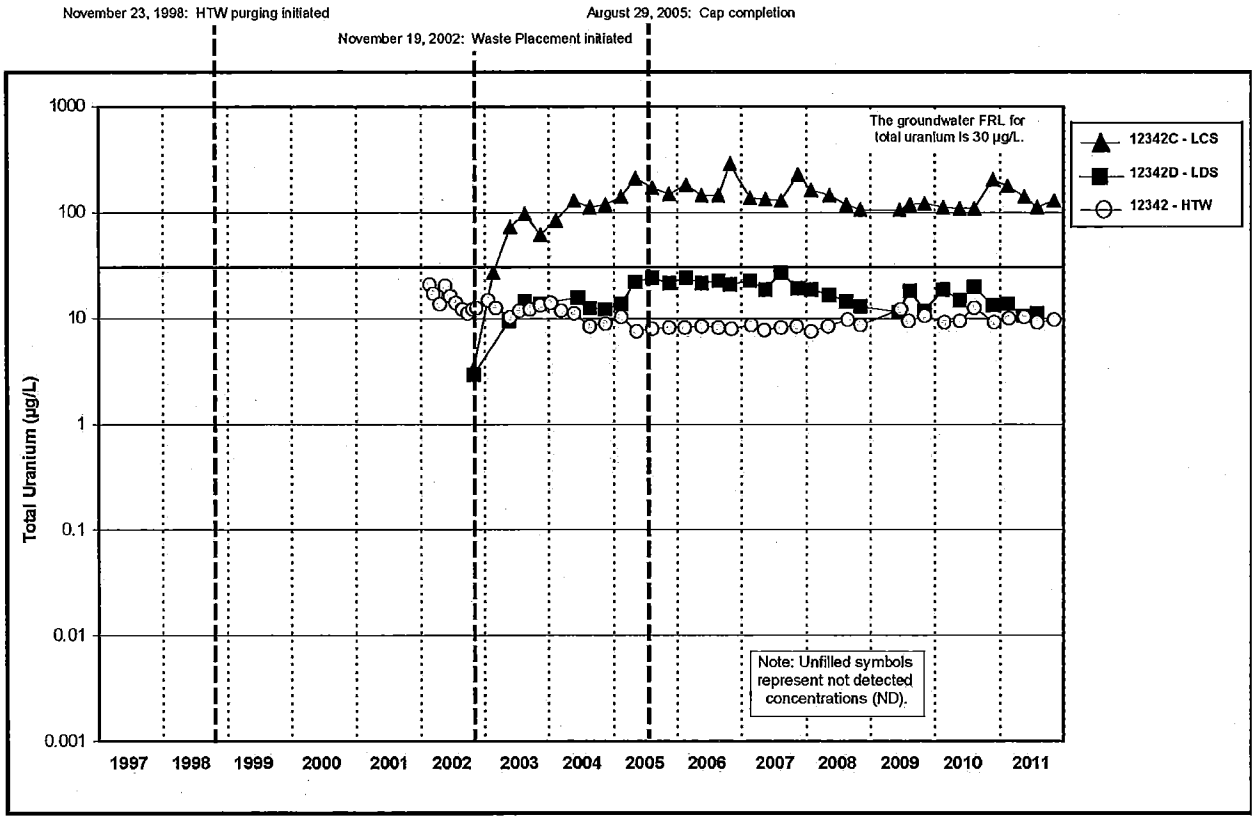


Figure A.5.5-6A. Cell 5 Uranium, Total Concentration vs. Time Plot for LCS, LDS, and HTW

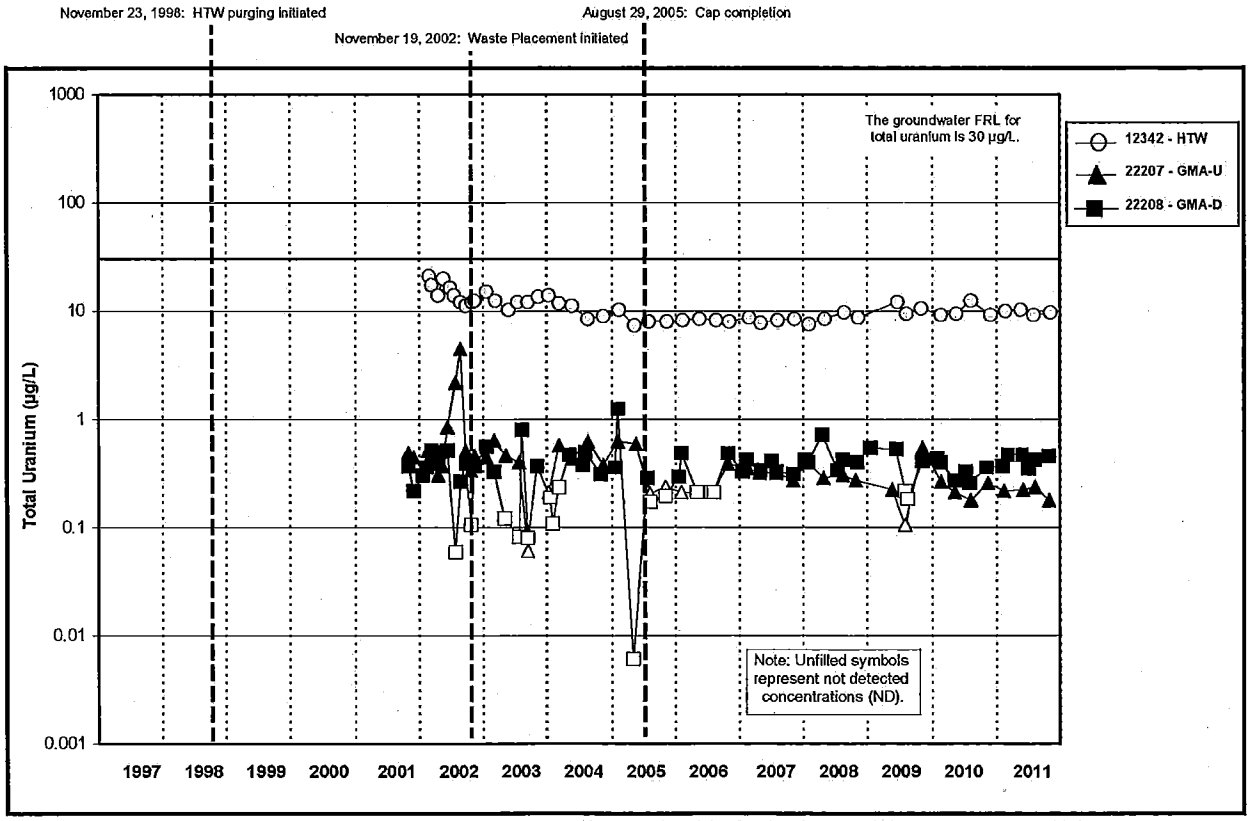


Figure A.5.5-6B. Cell 5 Uranium, Total Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

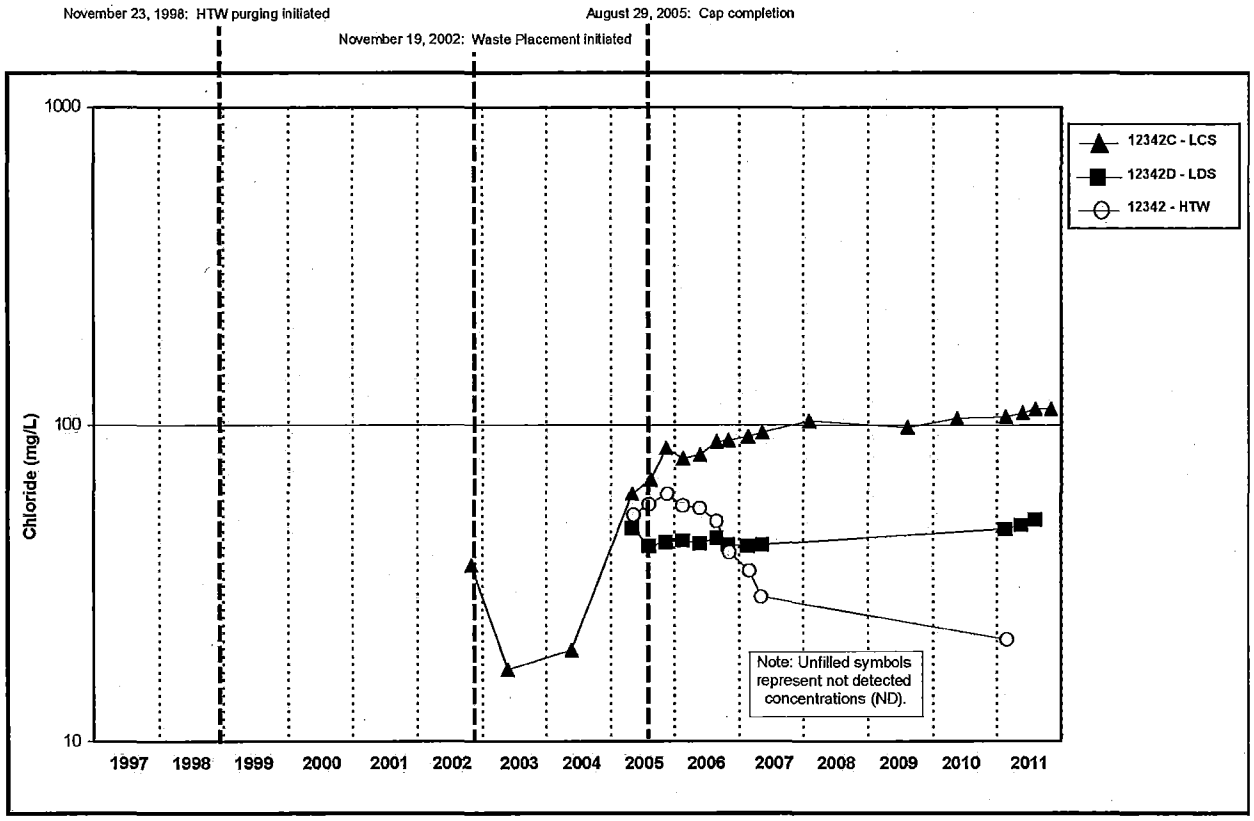


Figure A.5.5-7A. Cell 5 Chloride Concentration vs. Time Plot for LCS, LDS, and HTW

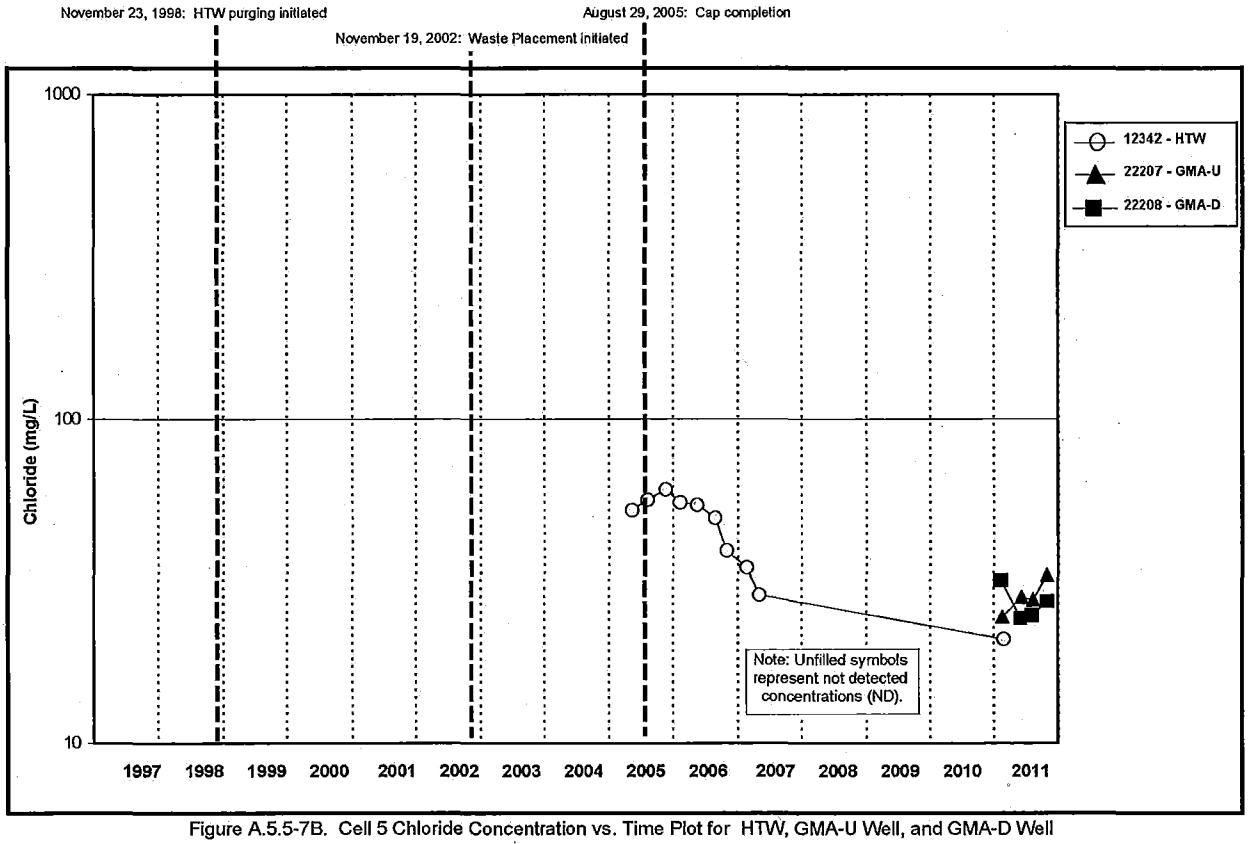


Figure A.5.5-7B. Cell 5 Chloride Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

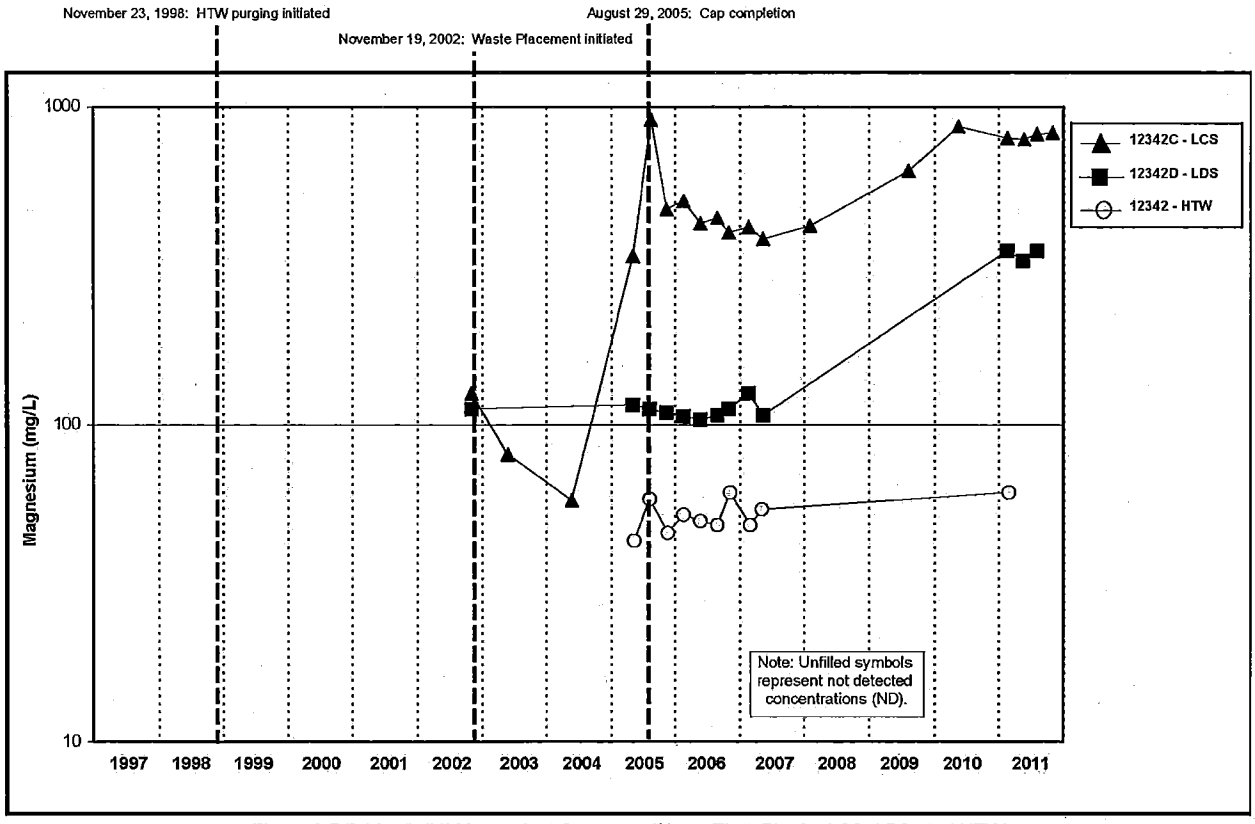


Figure A.5.5-8A. Cell 5 Magnesium Concentration vs. Time Plot for LCS, LDS, and HTW

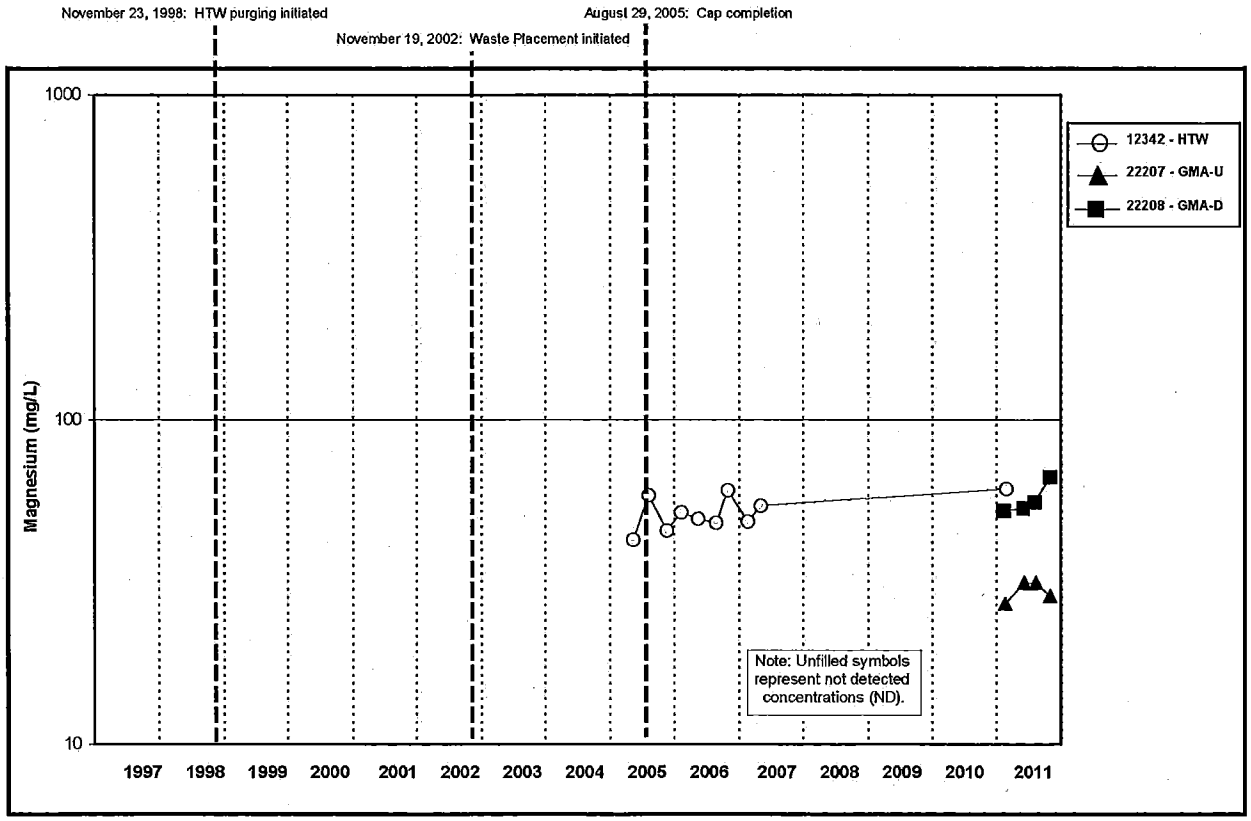


Figure A.5.5-8B. Cell 5 Magnesium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

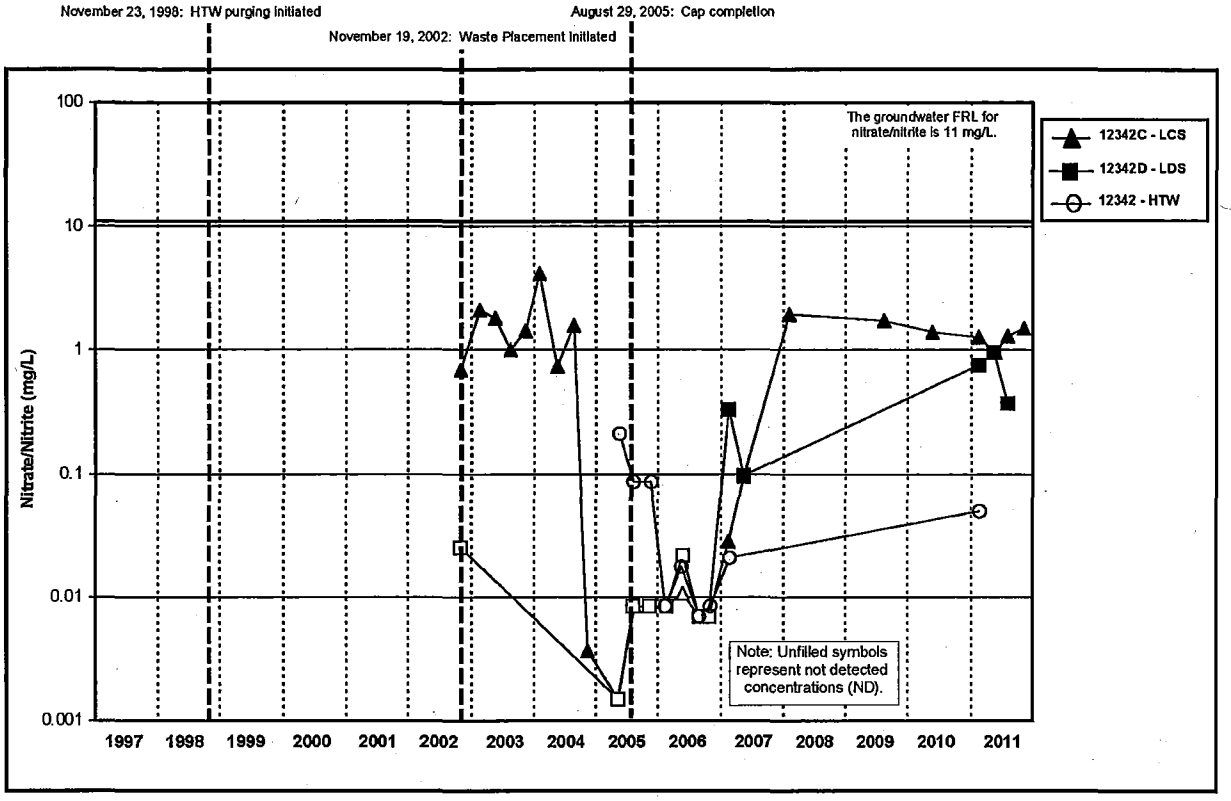


Figure A.5.5-9A. Cell 5 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for LCS, LDS, and HTW

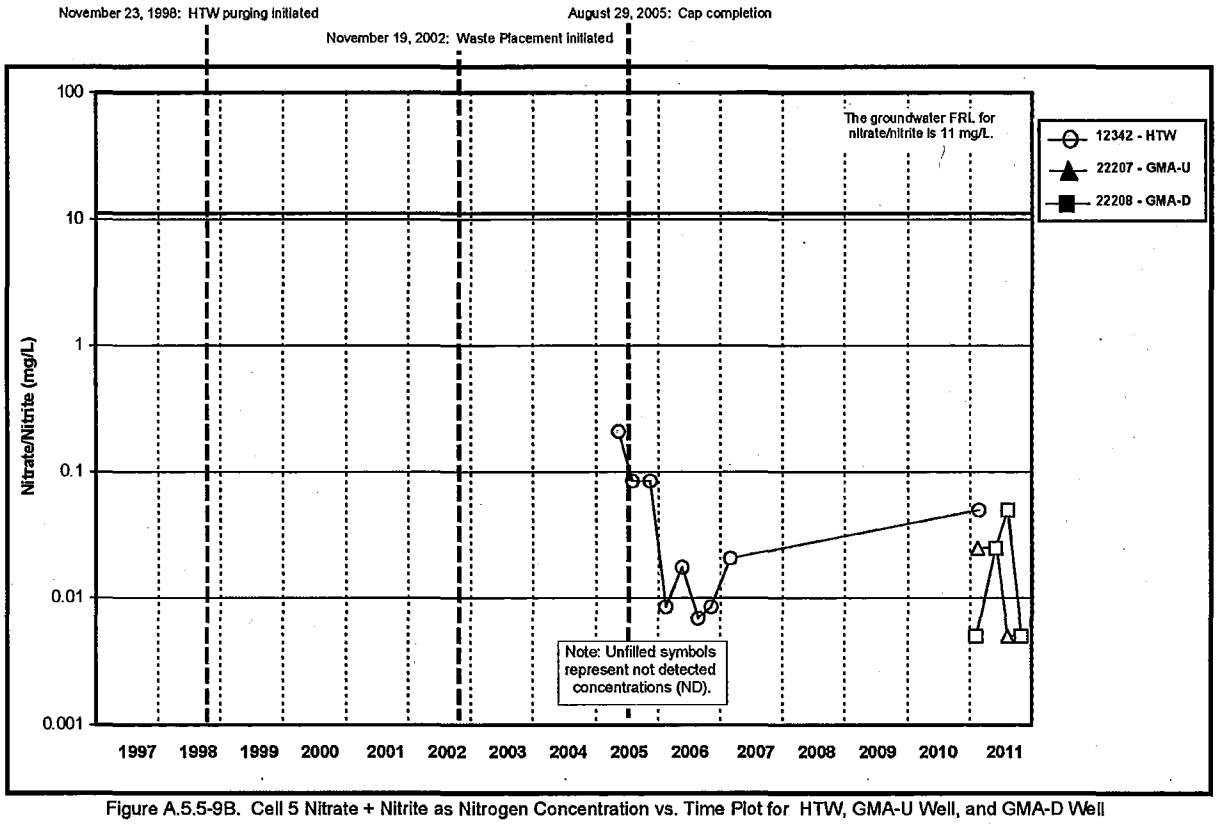


Figure A.5.5-9B. Cell 5 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

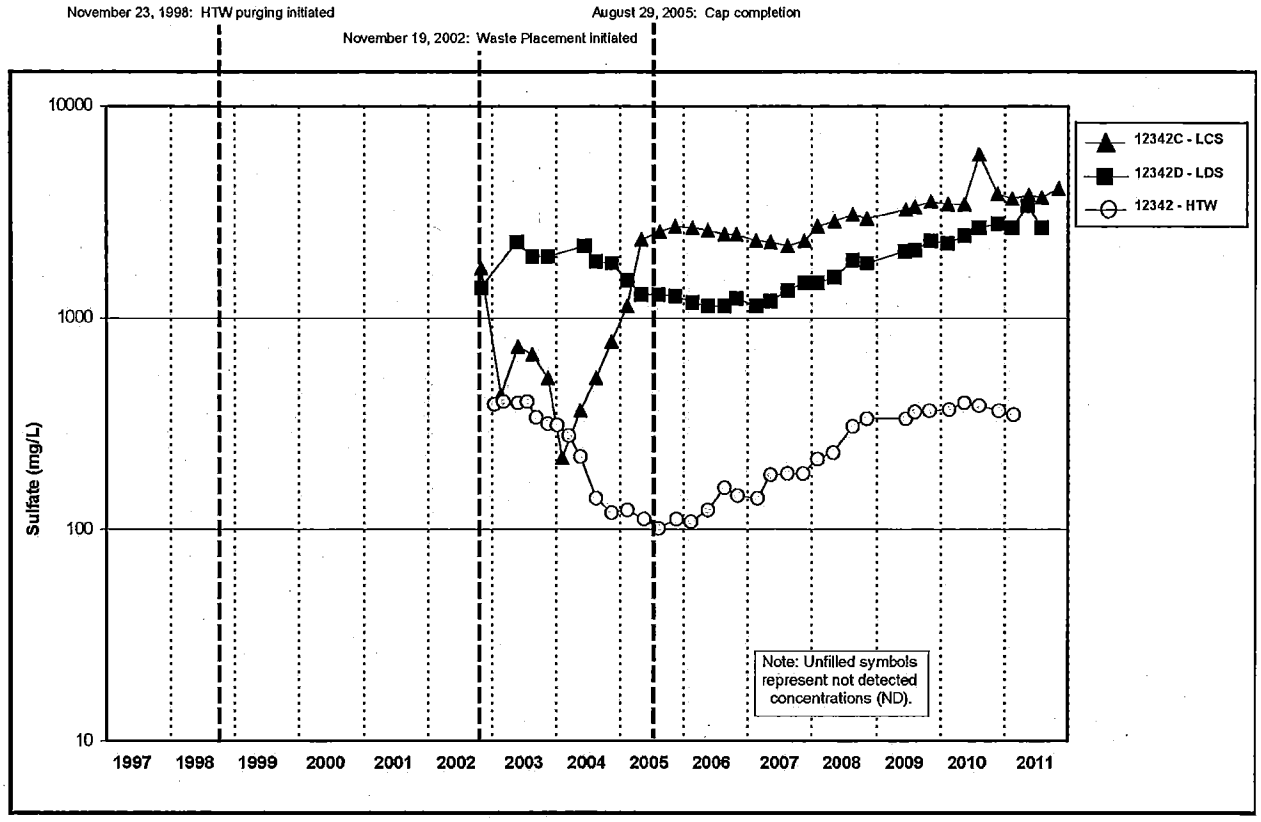


Figure A.5.5-10A. Cell 5 Sulfate Concentration vs. Time Plot for LCS, LDS, and HTW

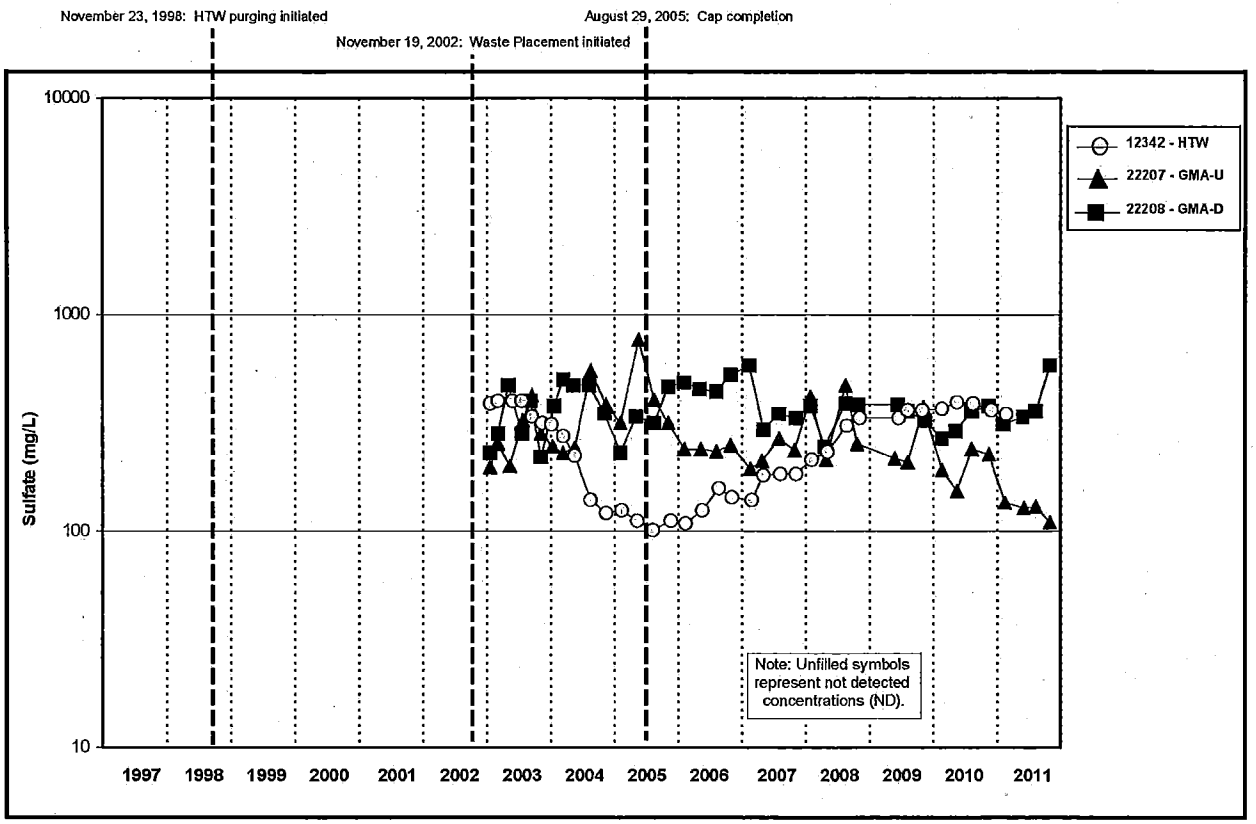


Figure A.5.5-10B. Cell 5 Sulfate Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

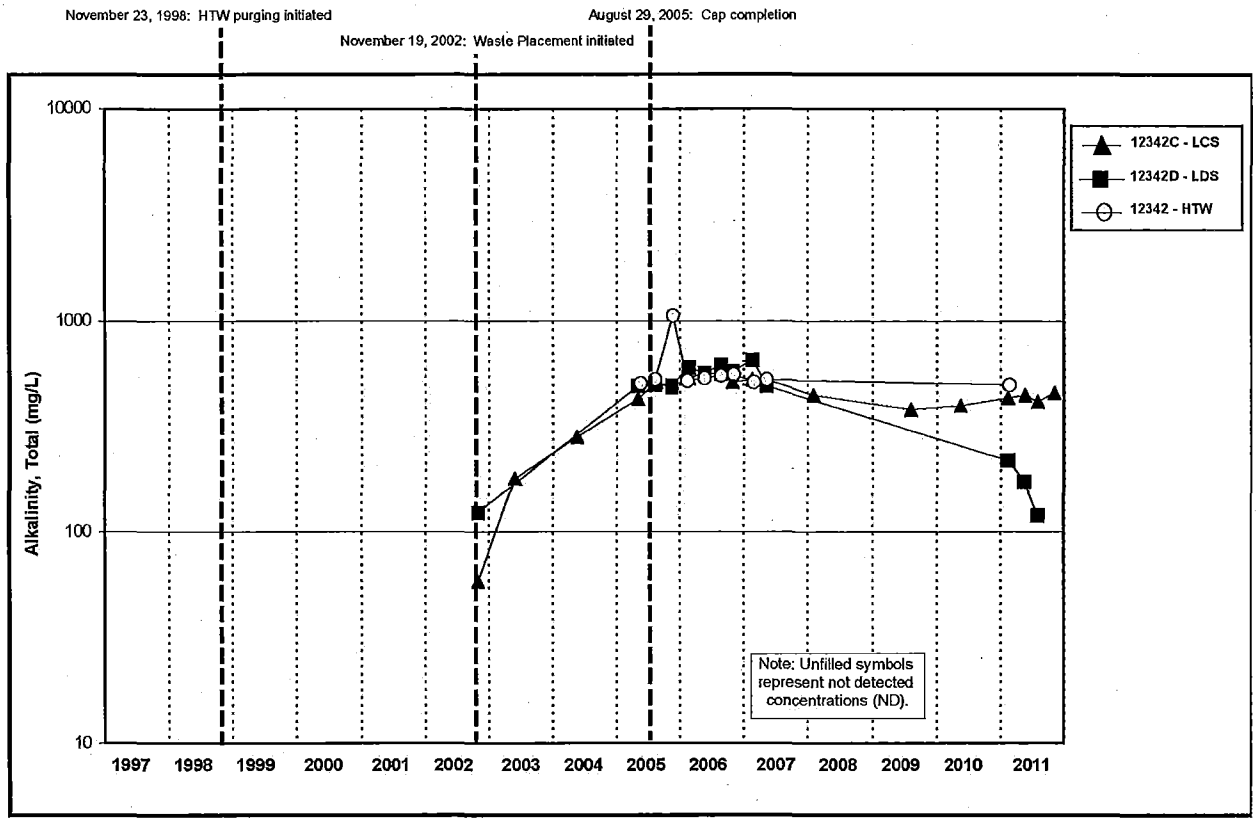


Figure A.5.5-11A. Cell 5 Alkalinity, Total Concentration vs. Time Plot for LCS, LDS, and HTW

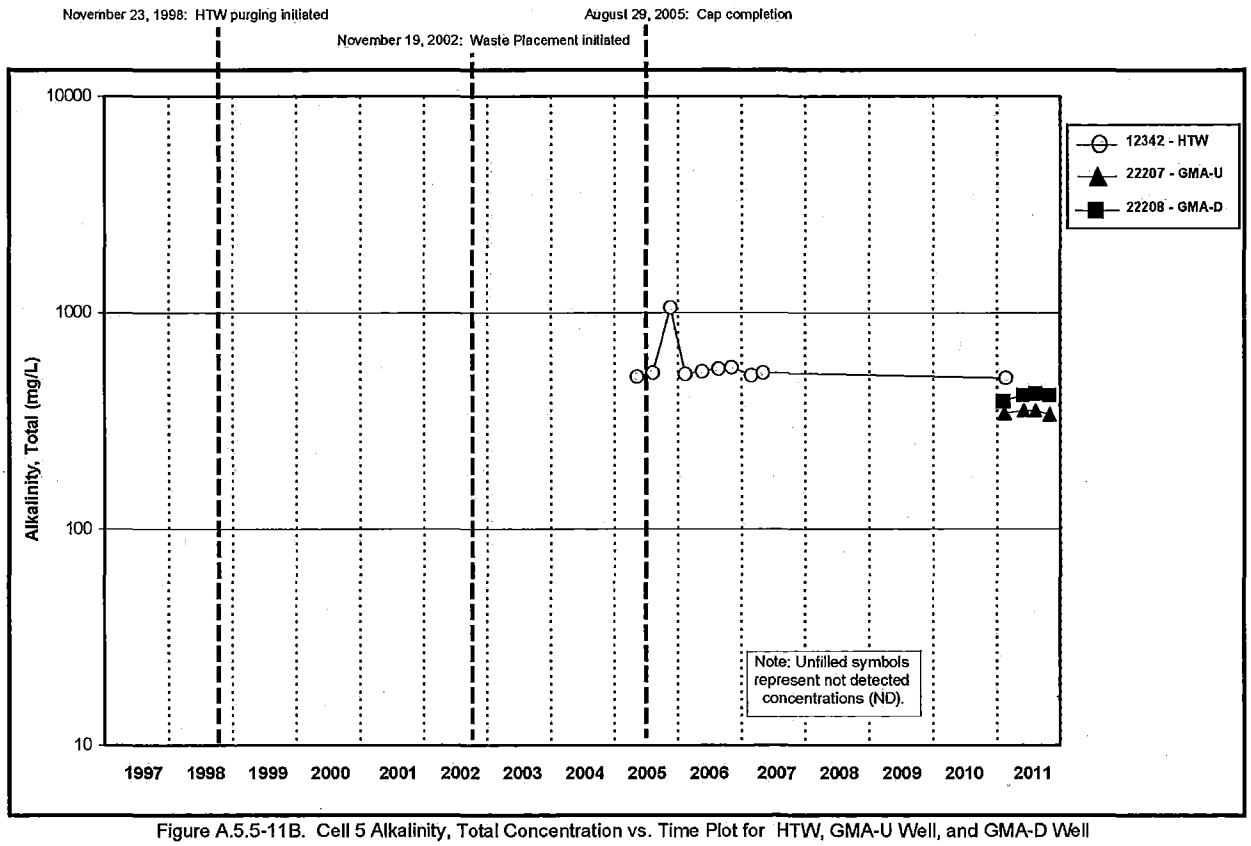


Figure A.5.5-11B. Cell 5 Alkalinity, Total Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

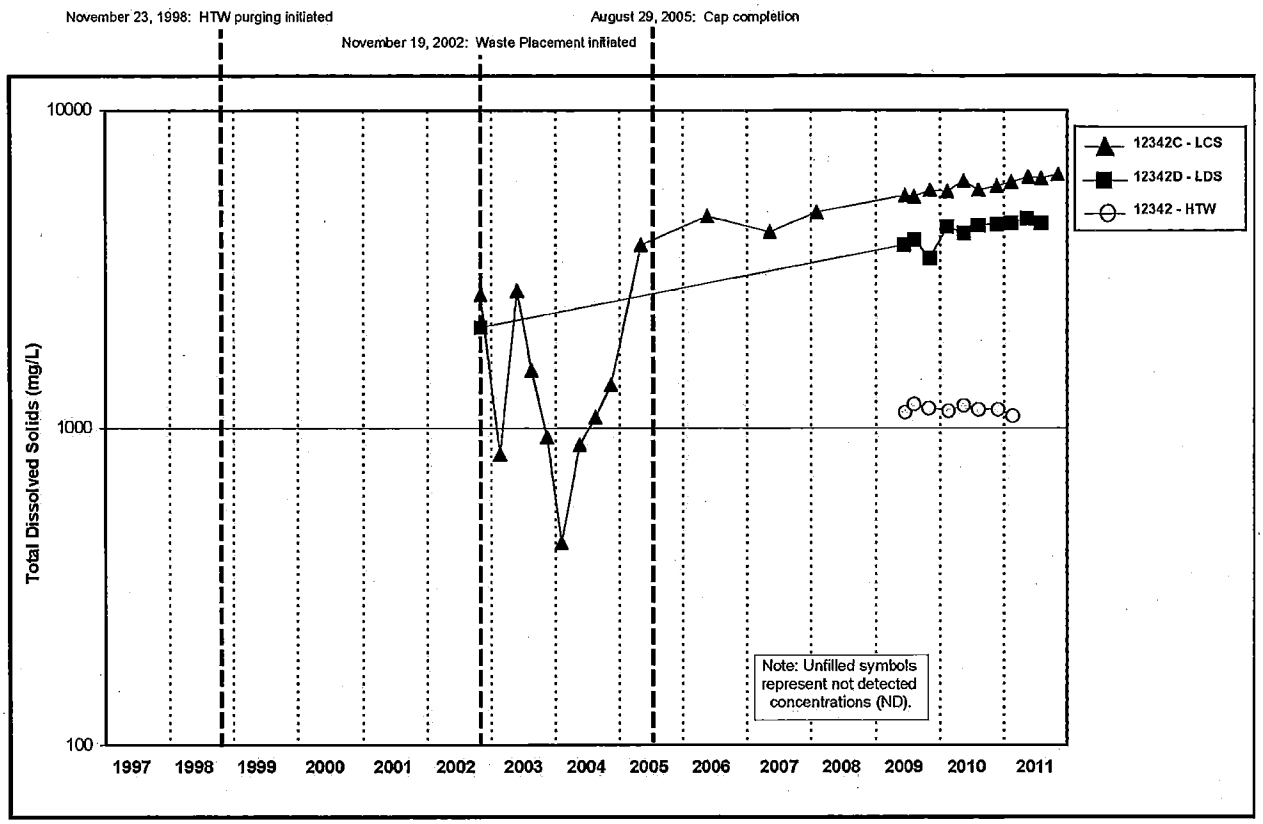


Figure A.5.5-12A. Cell 5 Total Dissolved Solids Concentration vs. Time Plot for LCS, LDS, and HTW

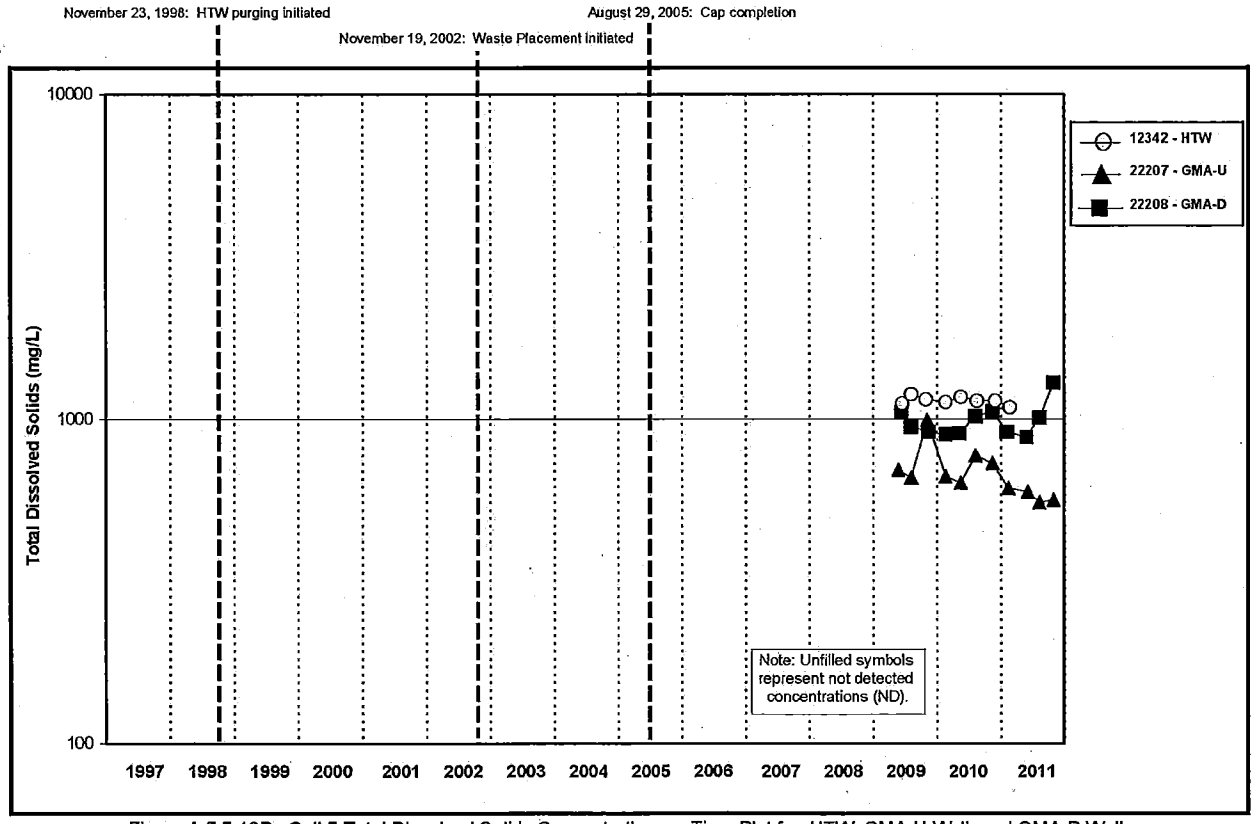


Figure A.5.5-12B. Cell 5 Total Dissolved Solids Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

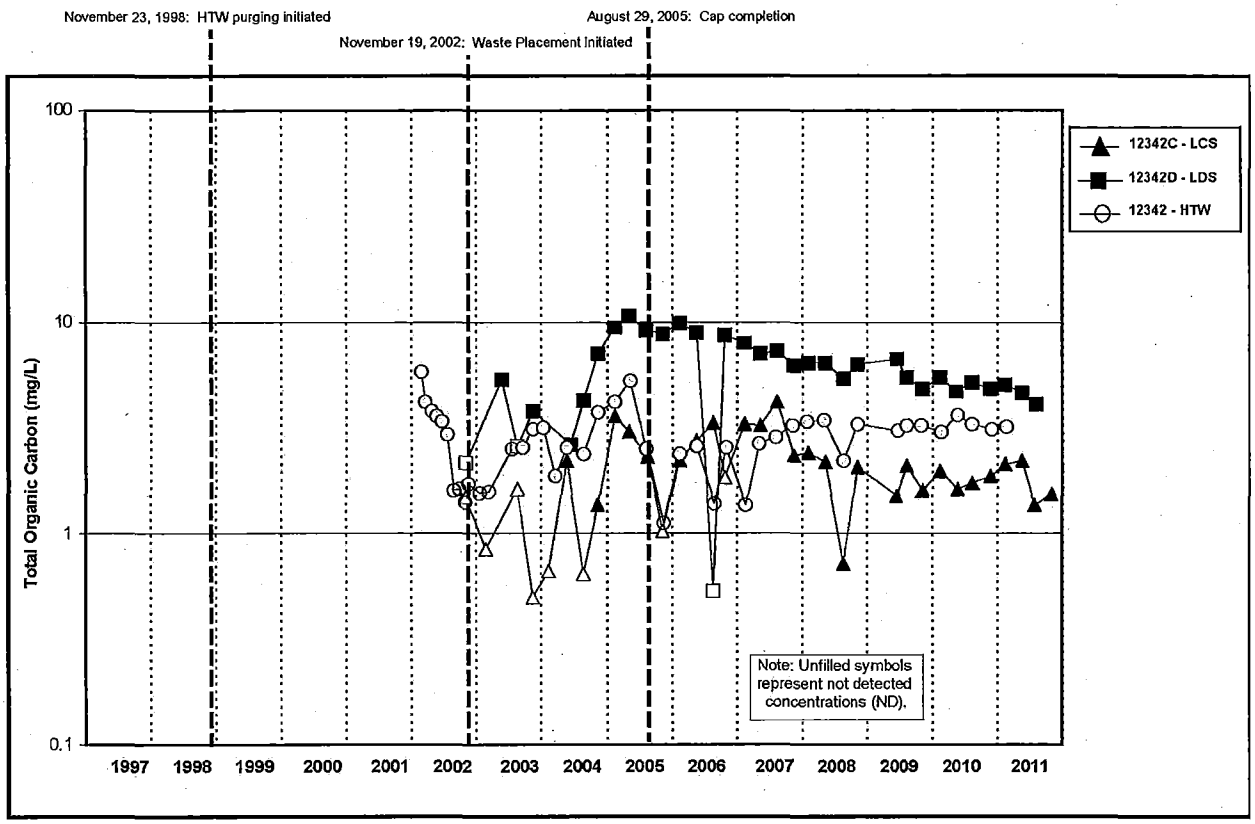


Figure A.5.5-13A. Cell 5 Total Organic Carbon Concentration vs. Time Plot for LCS, LDS, and HTW

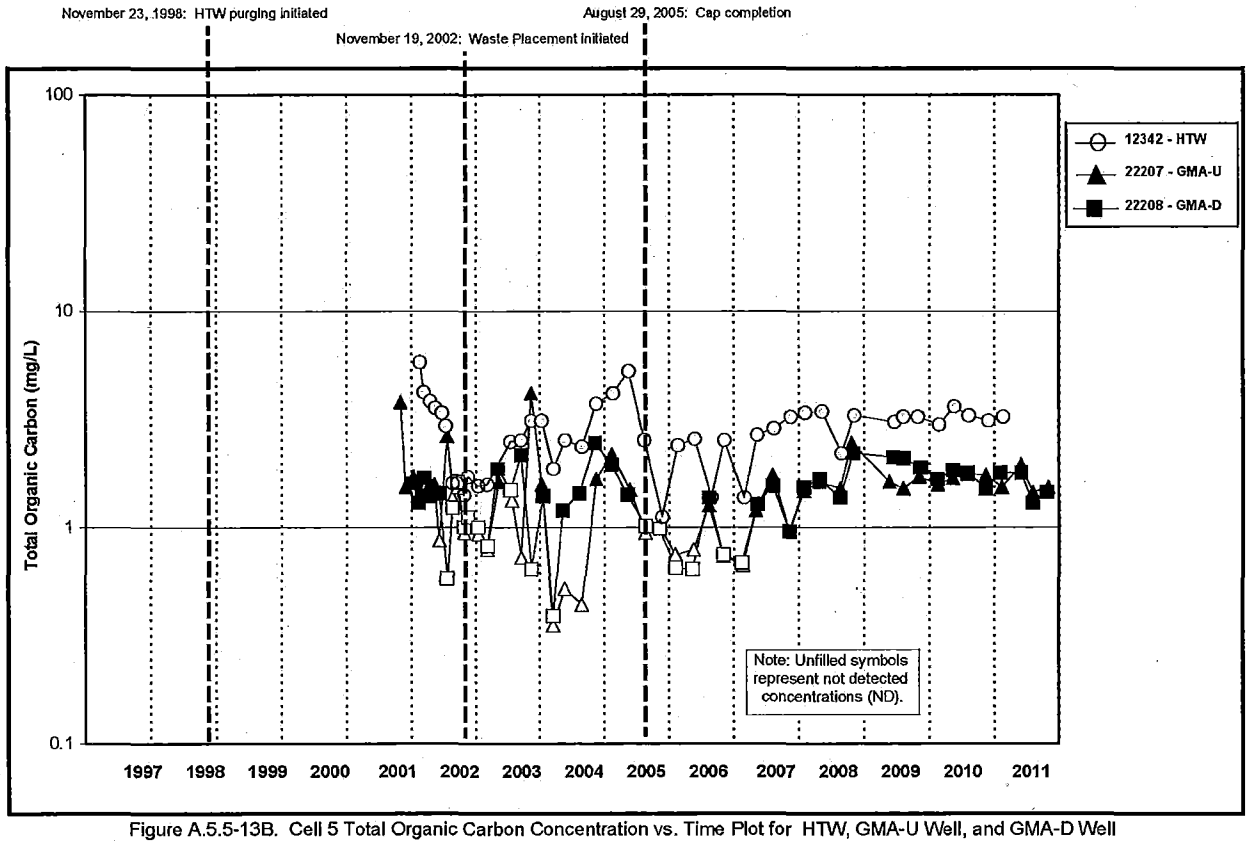


Figure A.5.5-13B. Cell 5 Total Organic Carbon Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

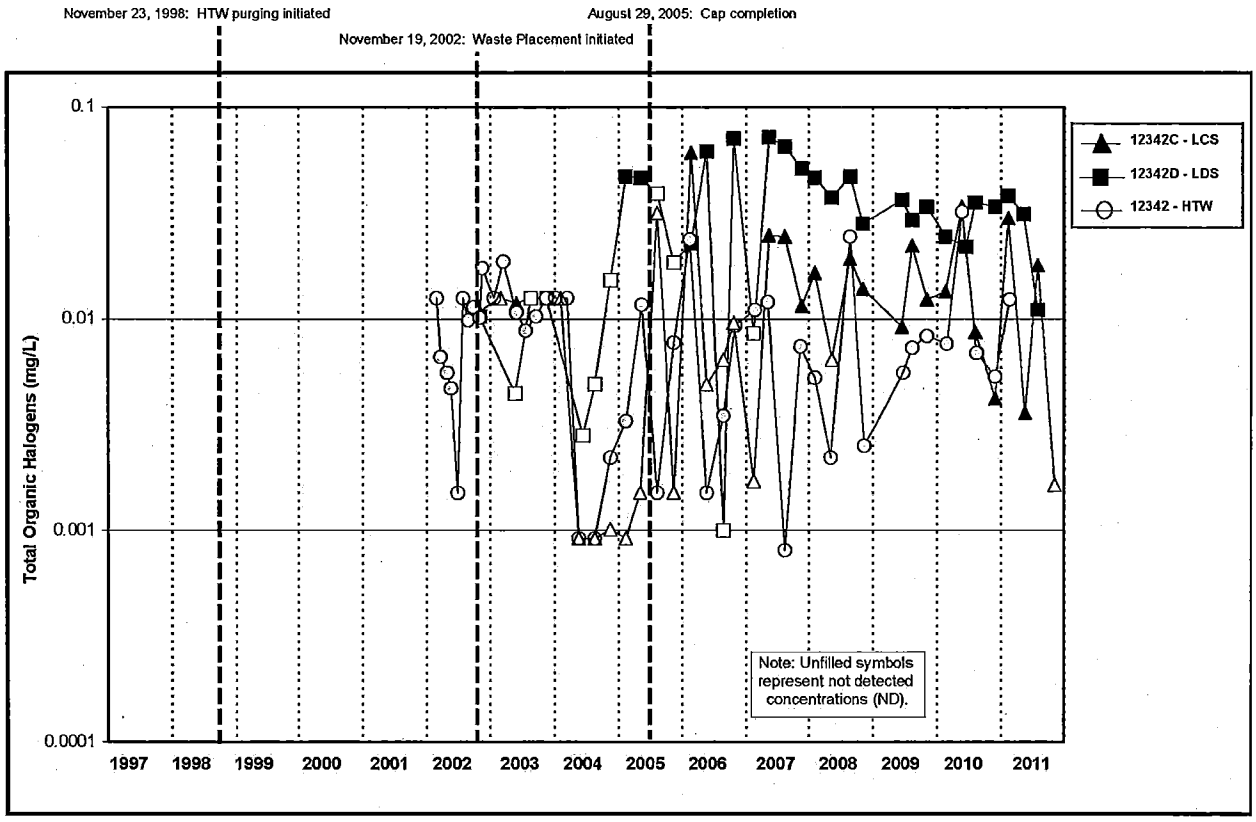


Figure A.5.5-14A. Cell 5 Total Organic Halogens Concentration vs. Time Plot for LCS, LDS, and HTW

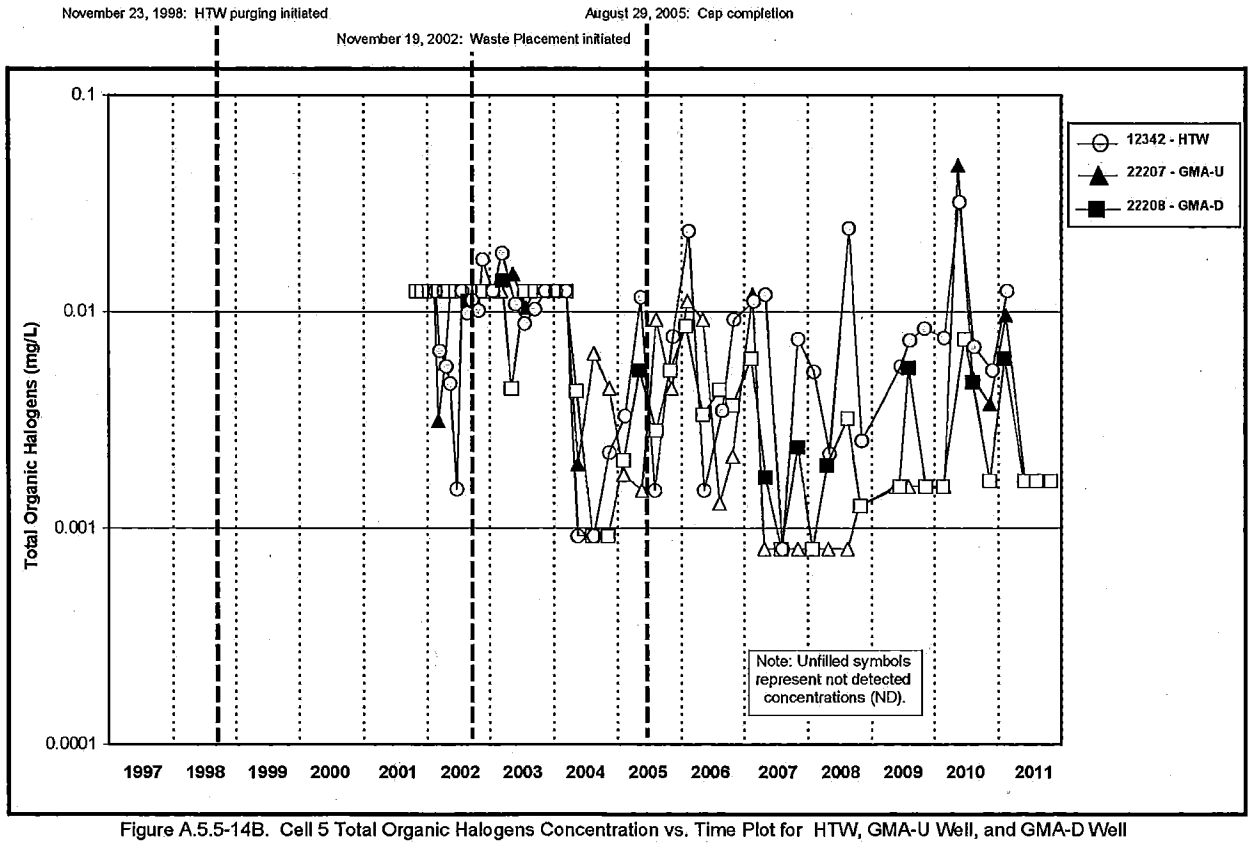


Figure A.5.5-14B. Cell 5 Total Organic Halogens Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

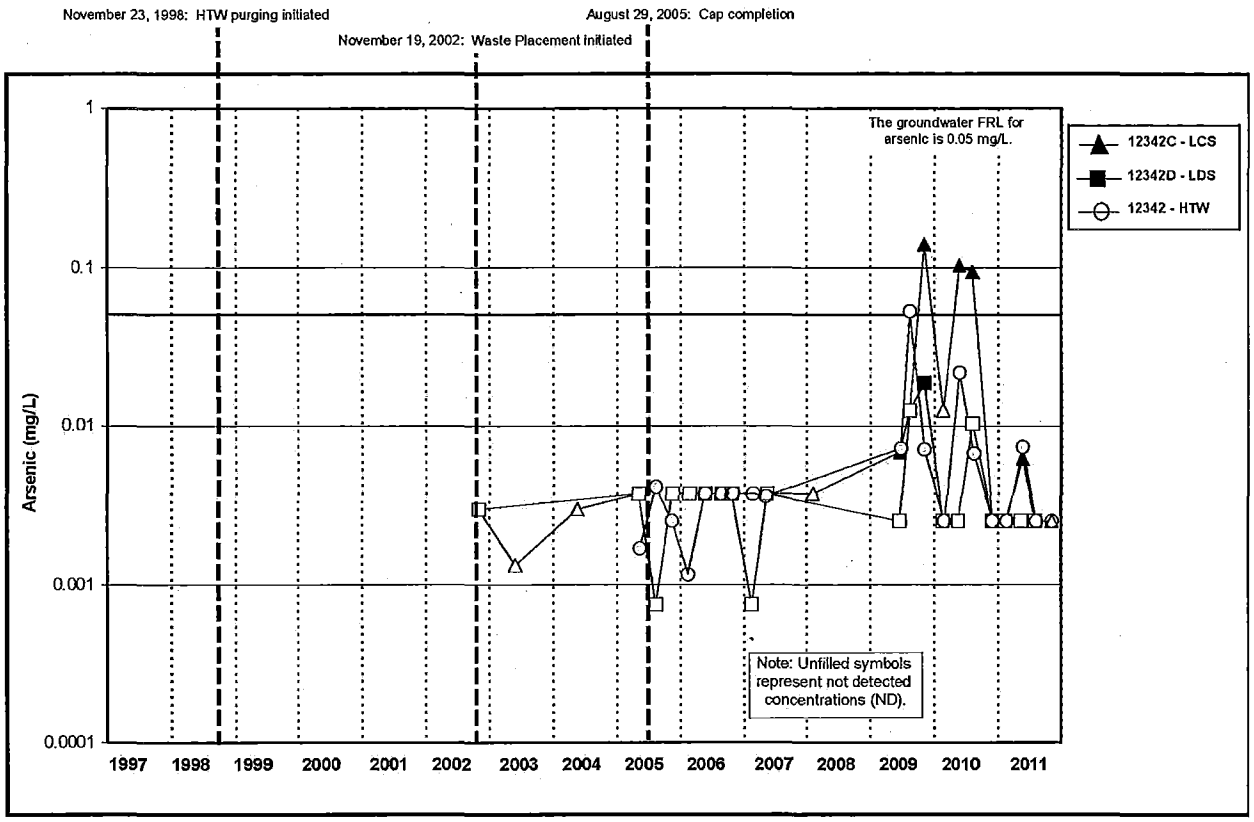


Figure A.5.5-15A. Cell 5 Arsenic Concentration vs. Time Plot for LCS, LDS, and HTW

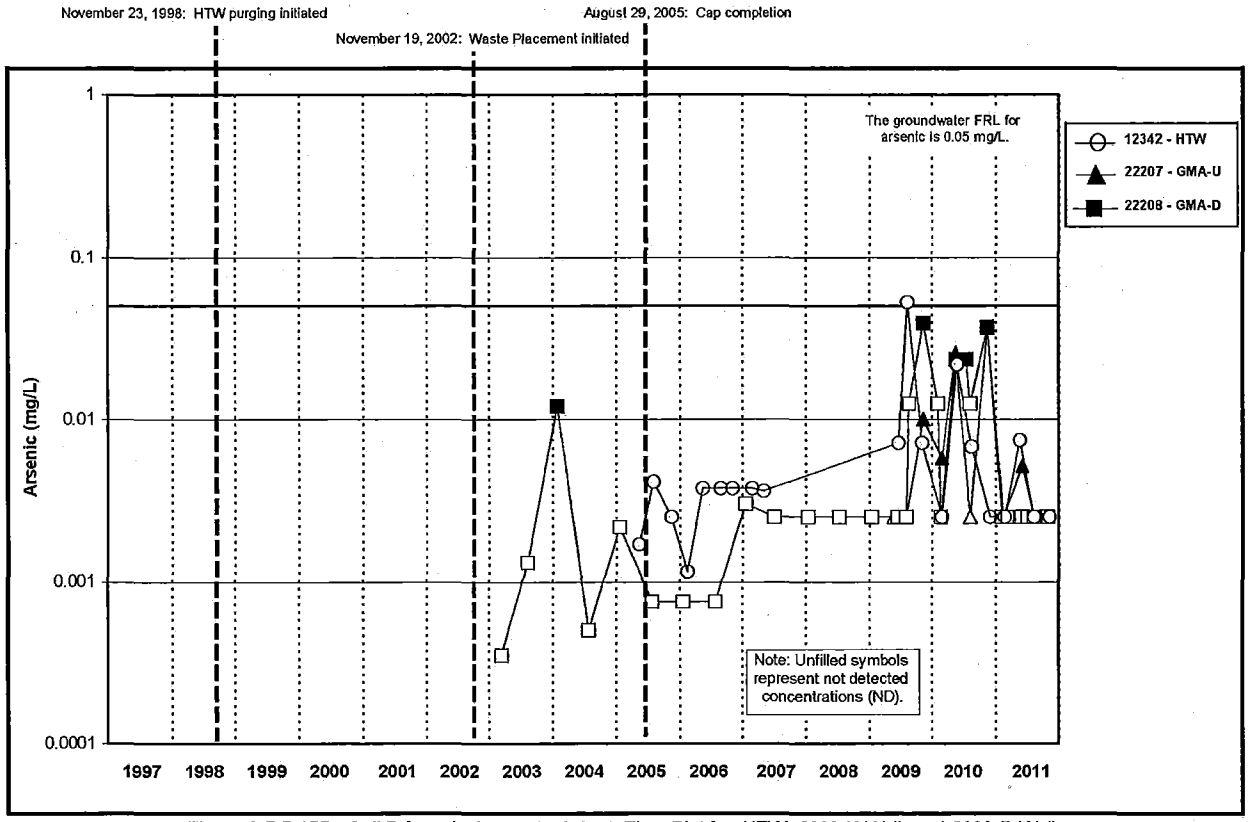


Figure A.5.5-15B. Cell 5 Arsenic Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

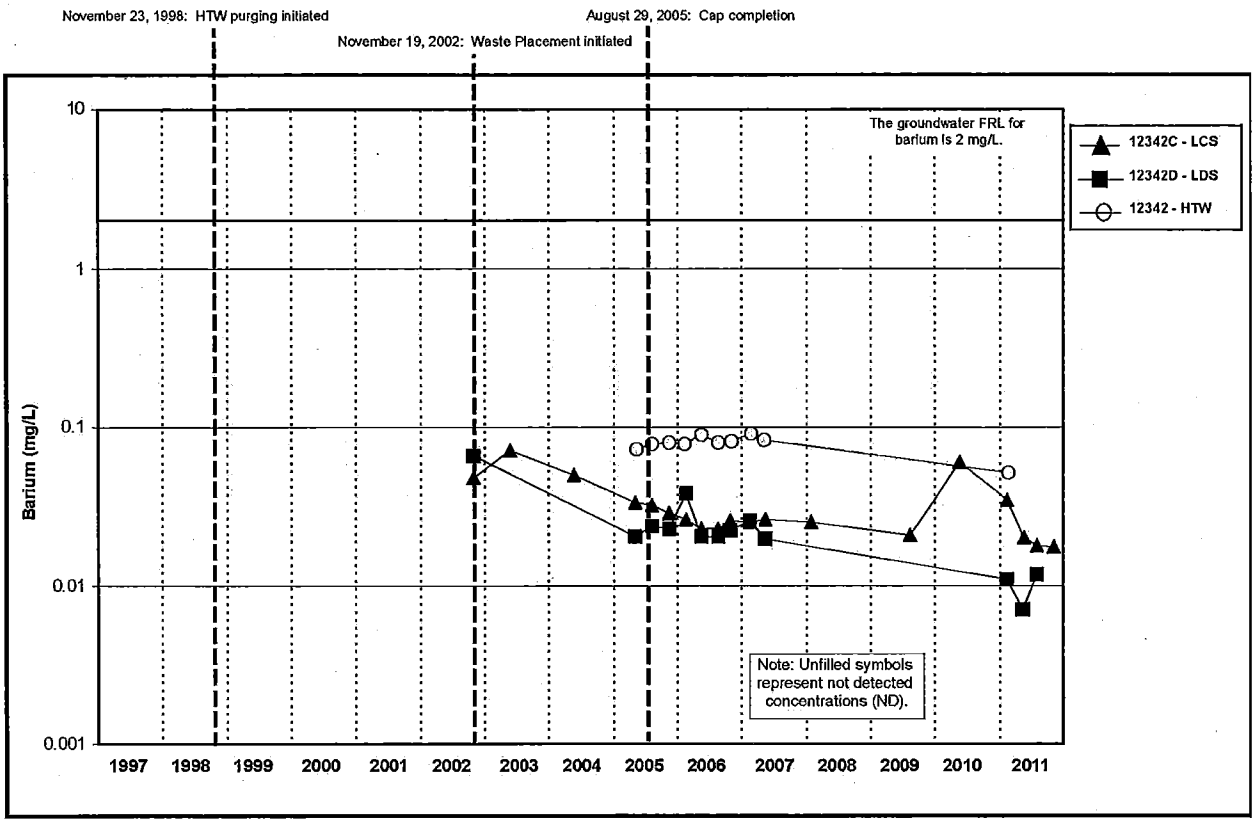


Figure A.5.5-16A. Cell 5 Barium Concentration vs. Time Plot for LCS, LDS, and HTW

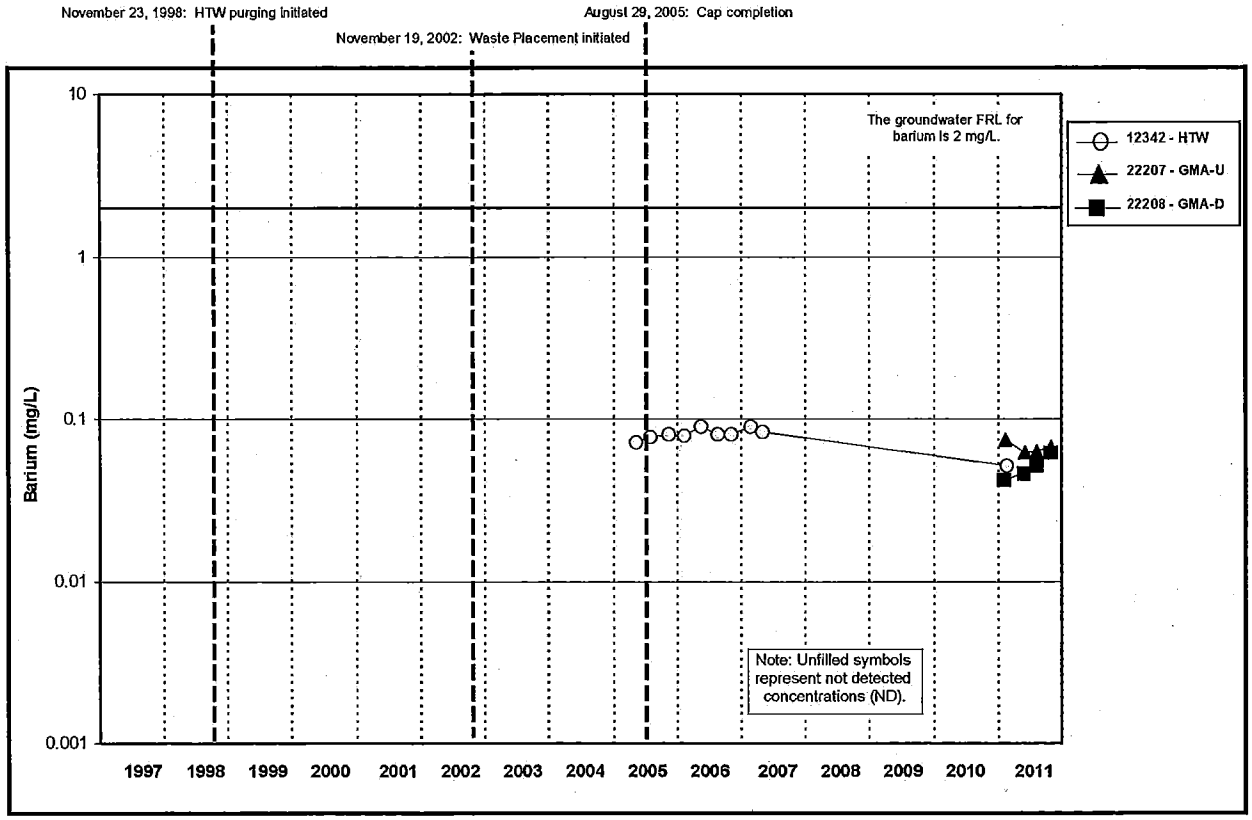


Figure A.5.5-16B. Cell 5 Barium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

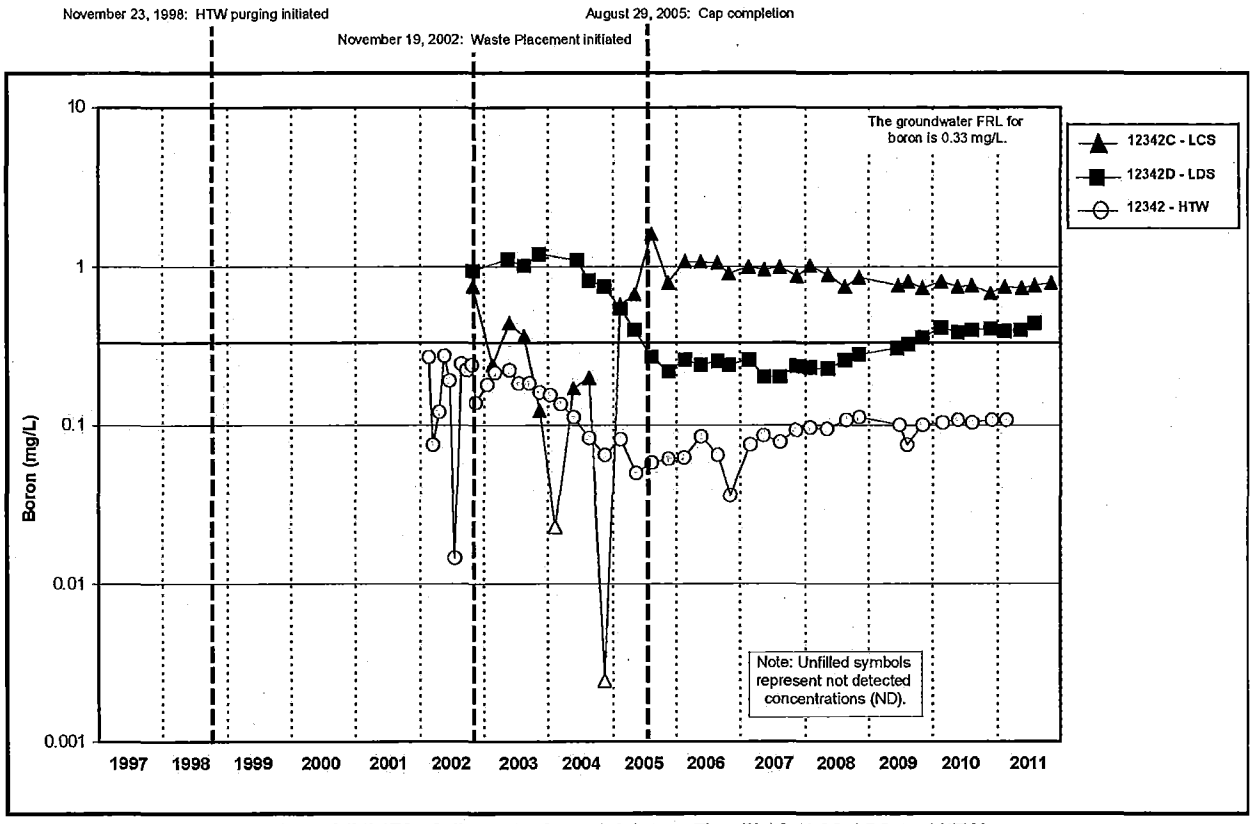


Figure A.5.5-17A. Cell 5 Boron Concentration vs. Time Plot for LCS, LDS, and HTW

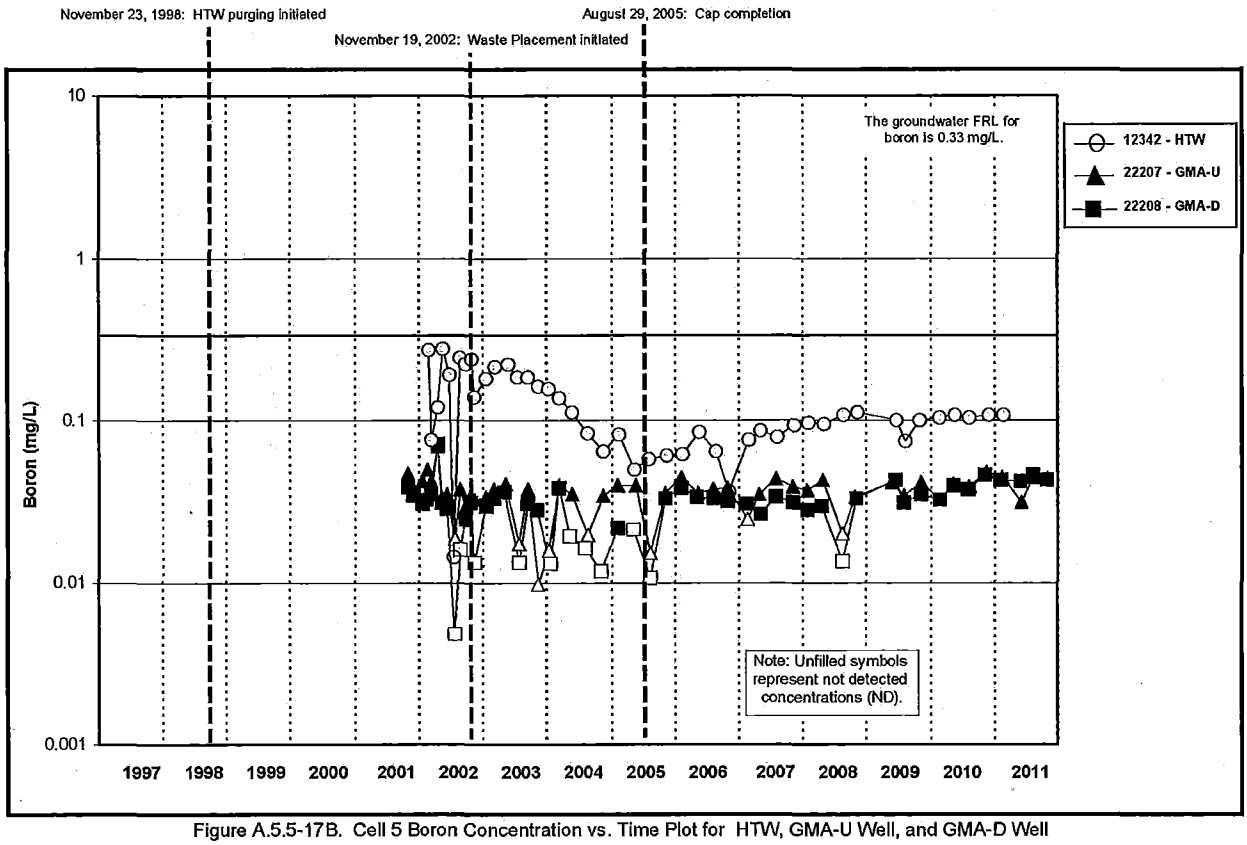


Figure A.5.5-17B. Cell 5 Boron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

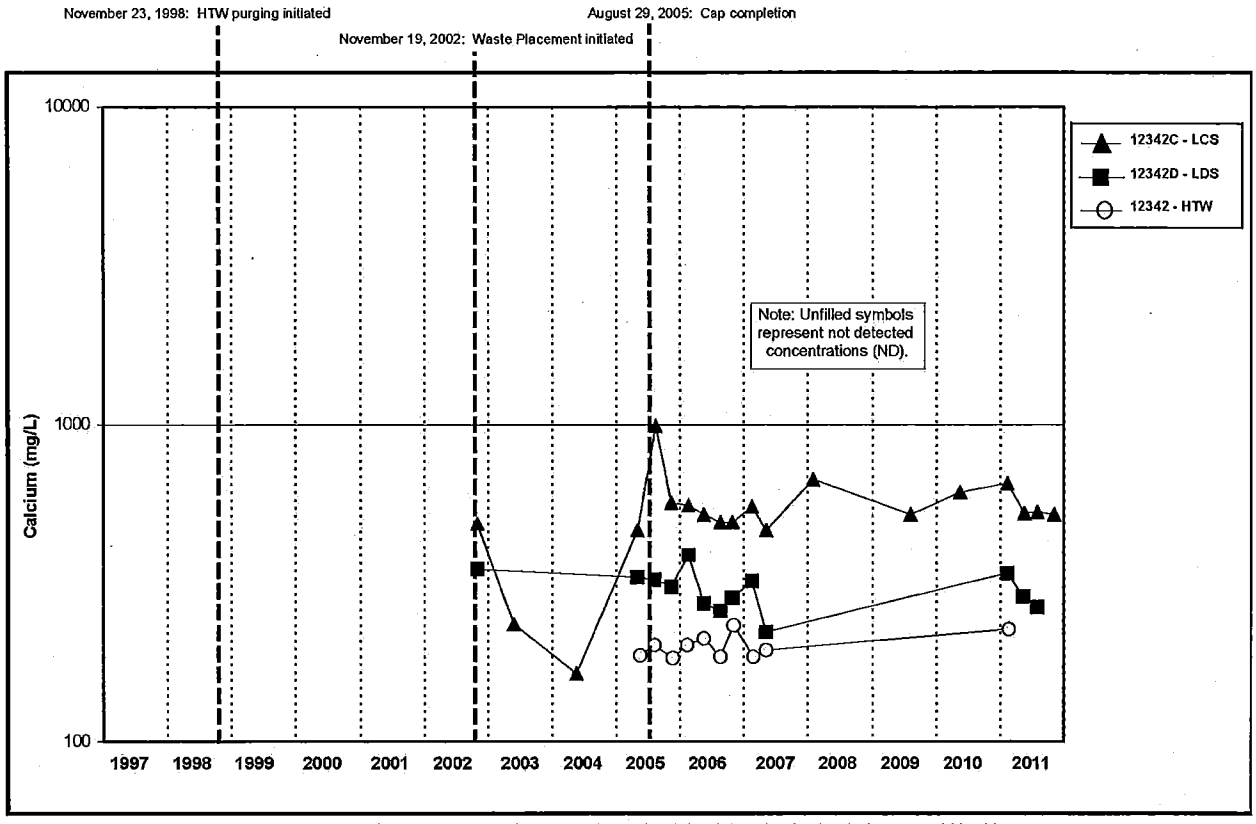


Figure A.5.5-18A. Cell 5 Calcium Concentration vs. Time Plot for LCS, LDS, and HTW

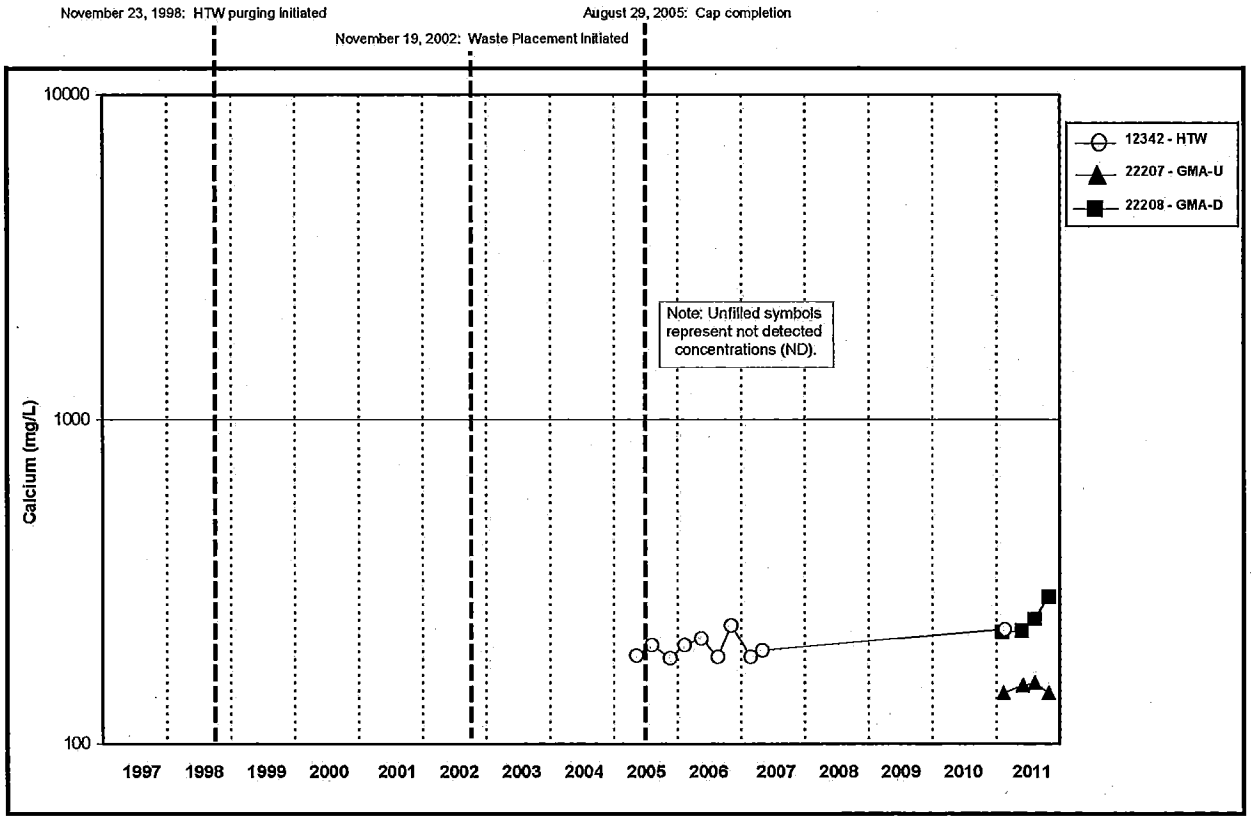


Figure A.5.5-18B. Cell 5 Calcium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

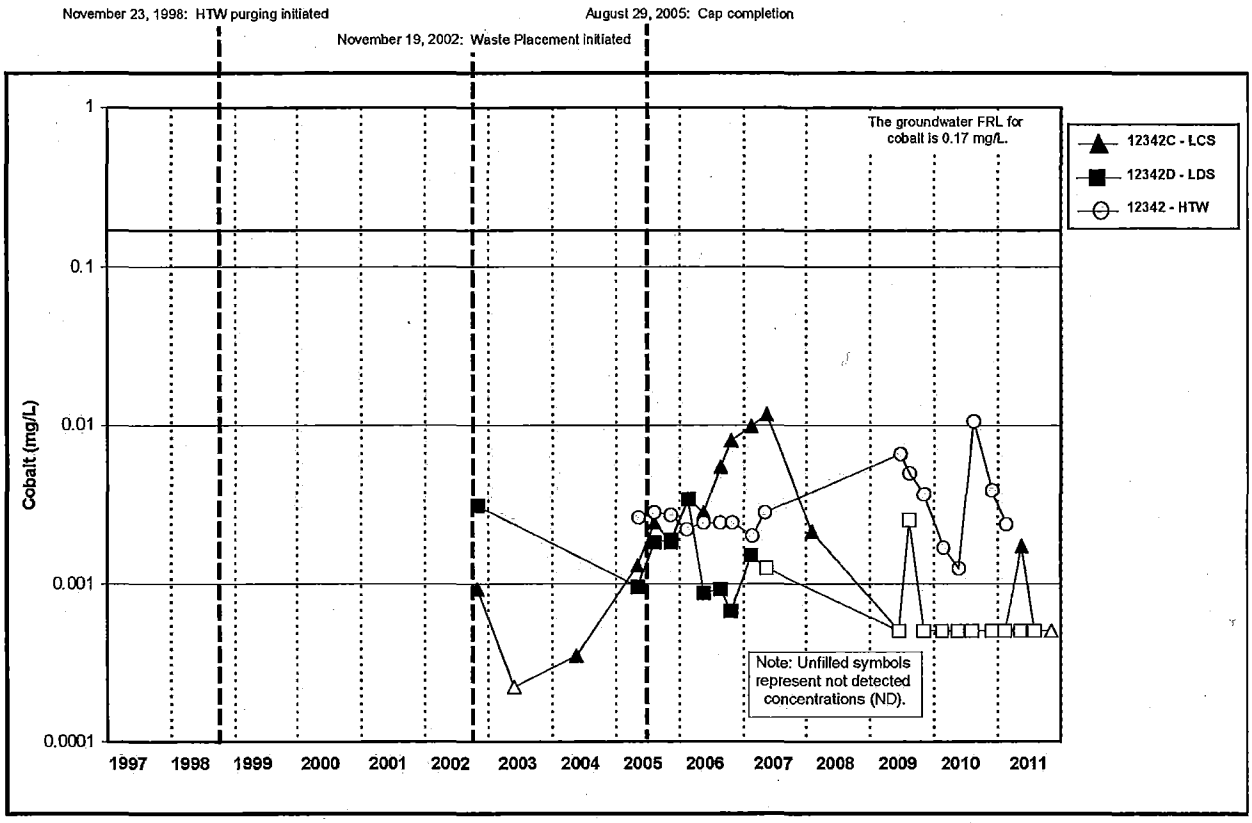


Figure A.5.5-19A. Cell 5 Cobalt Concentration vs. Time Plot for LCS, LDS, and HTW

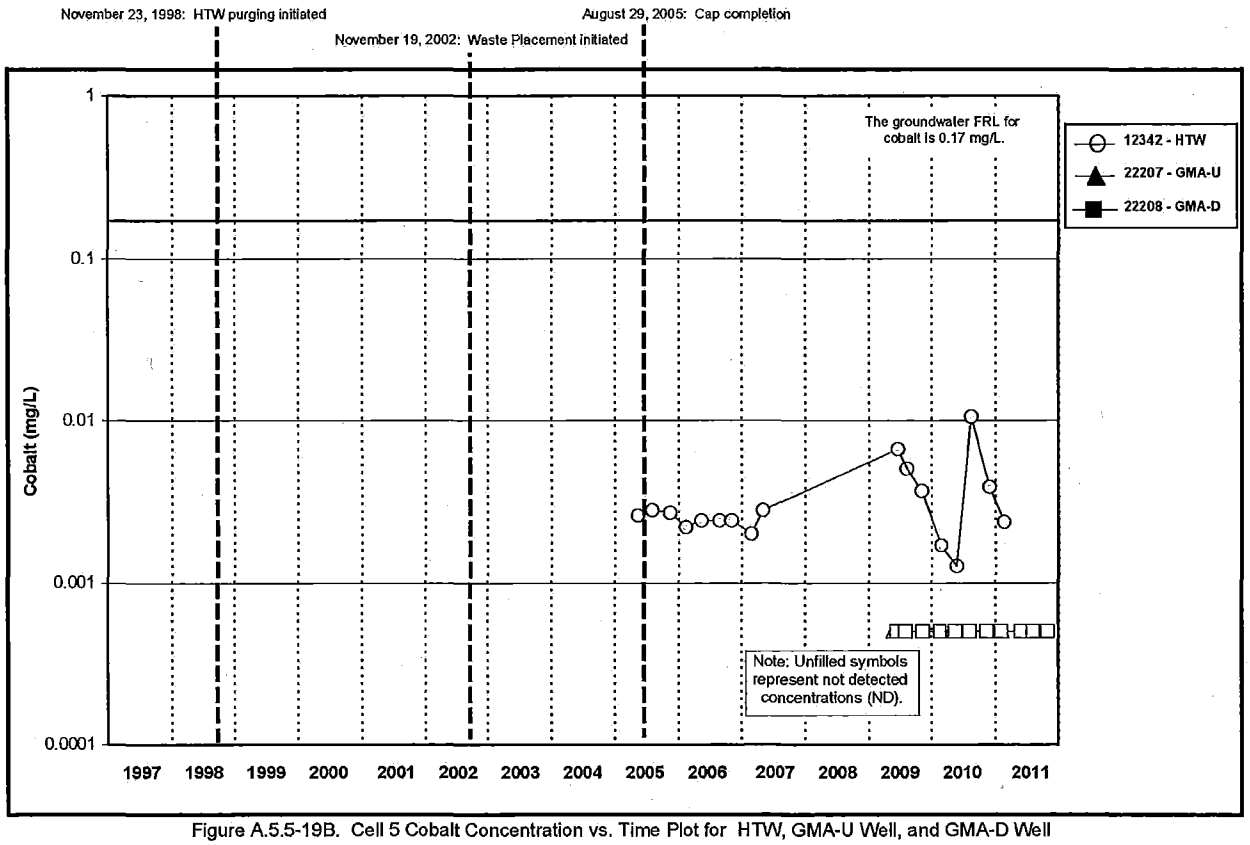


Figure A.5.5-19B. Cell 5 Cobalt Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

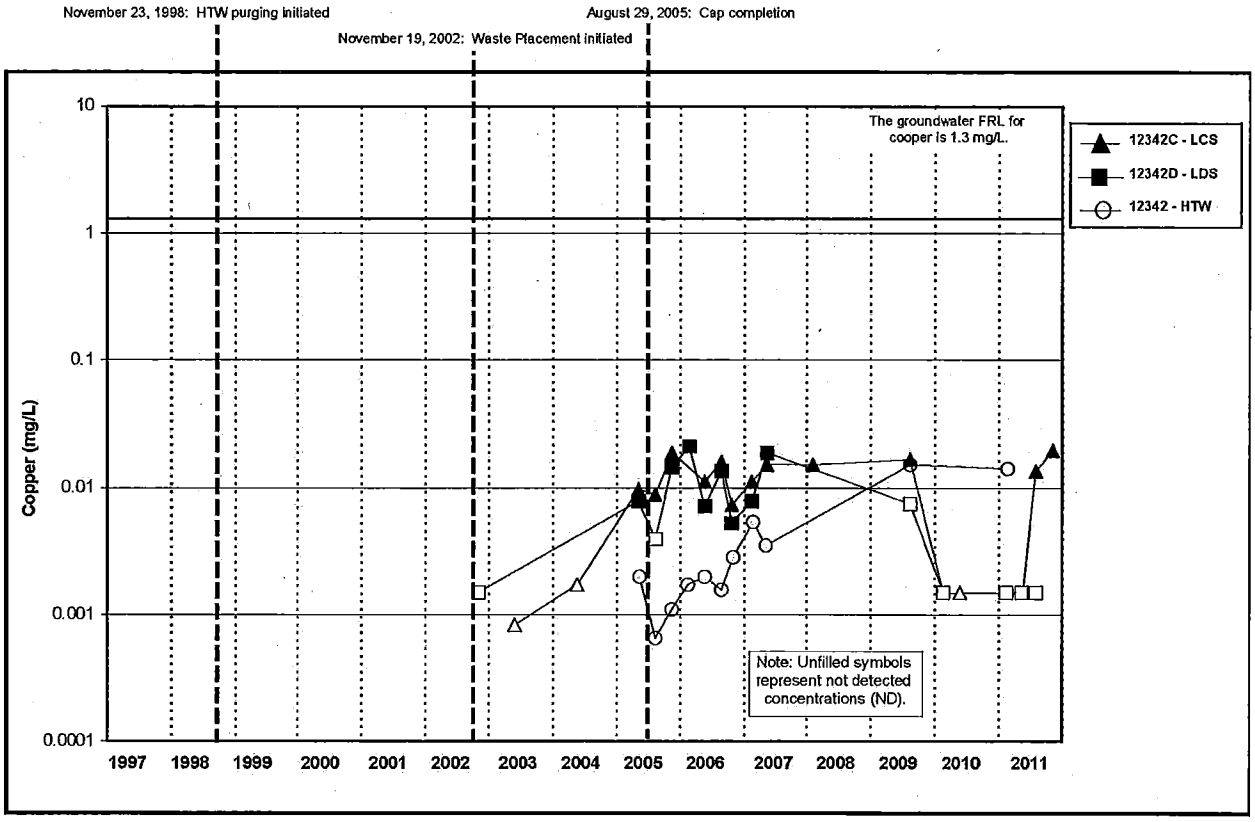


Figure A.5.5-20A. Cell 5 Copper Concentration vs. Time Plot for LCS, LDS, and HTW

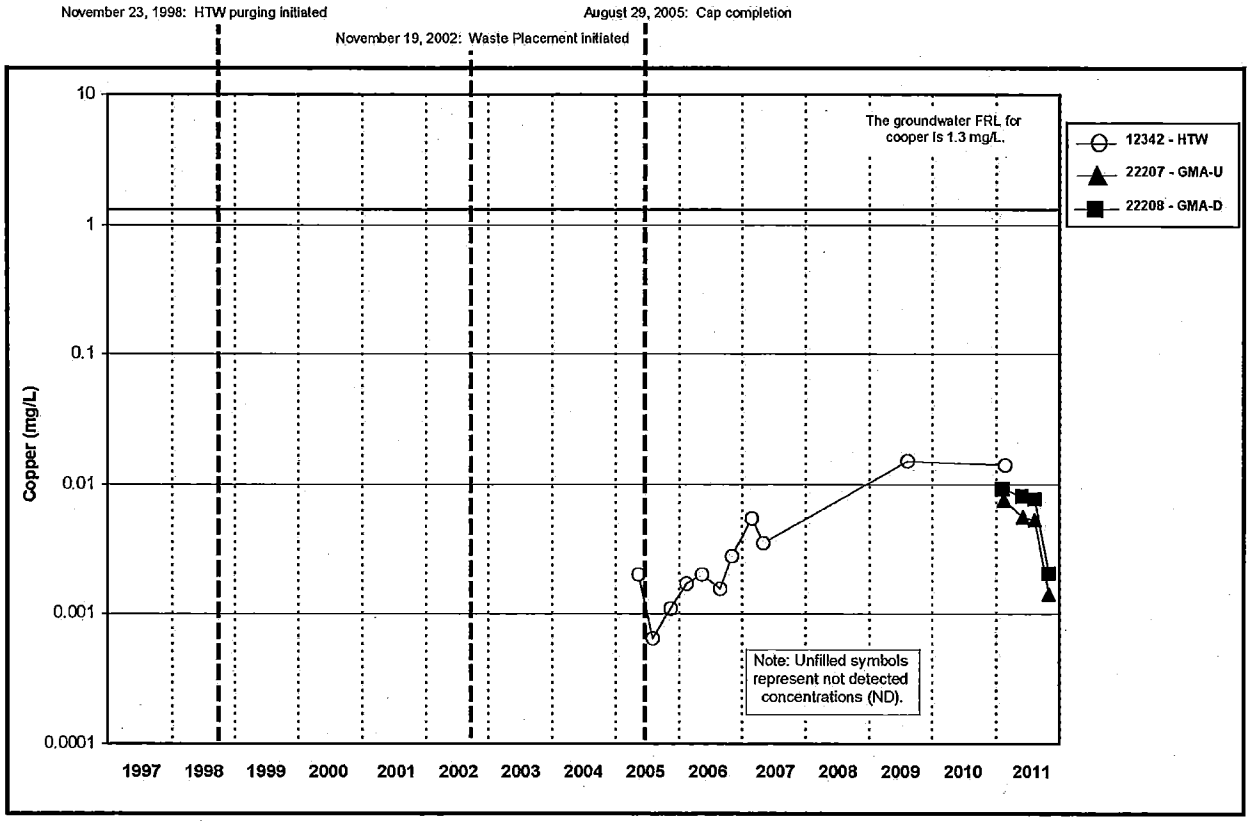


Figure A.5.5-20B. Cell 5 Copper Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

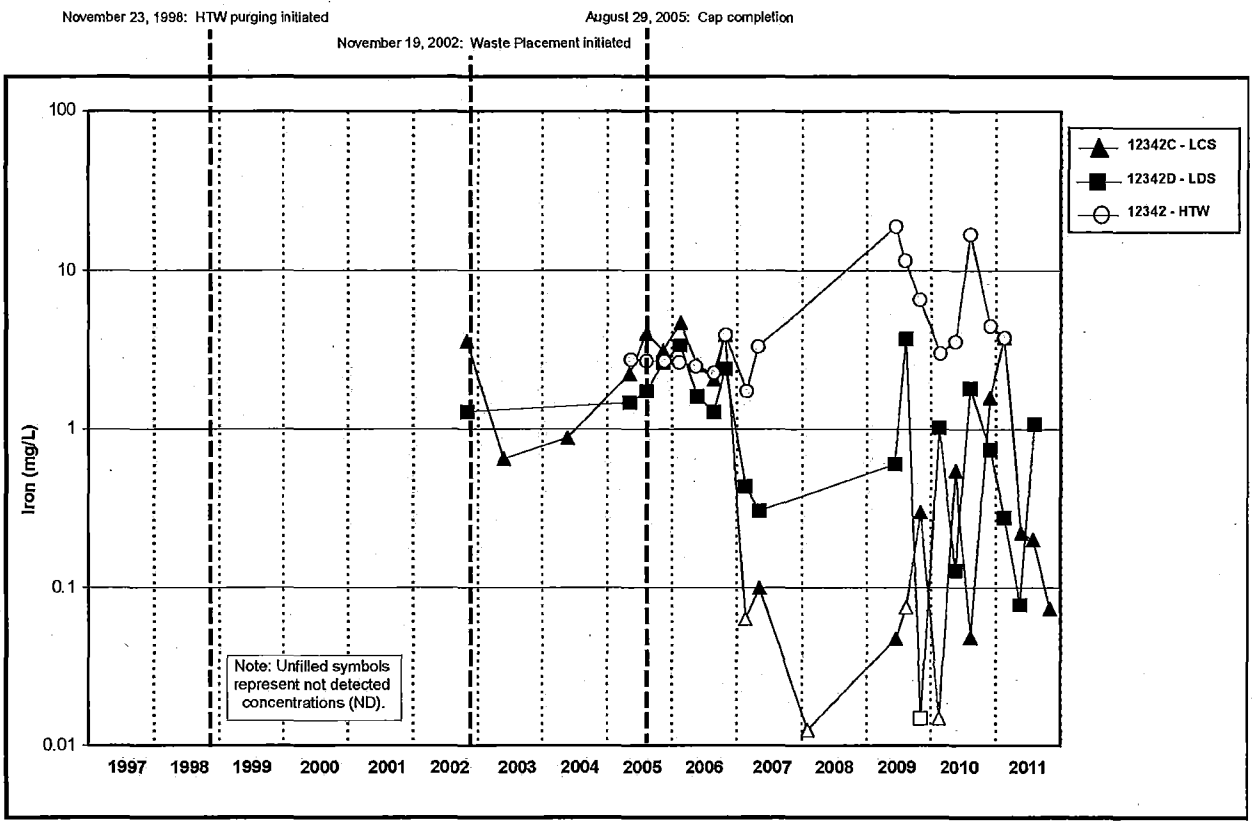


Figure A.5.5-21A. Cell 5 Iron Concentration vs. Time Plot for LCS, LDS, and HTW

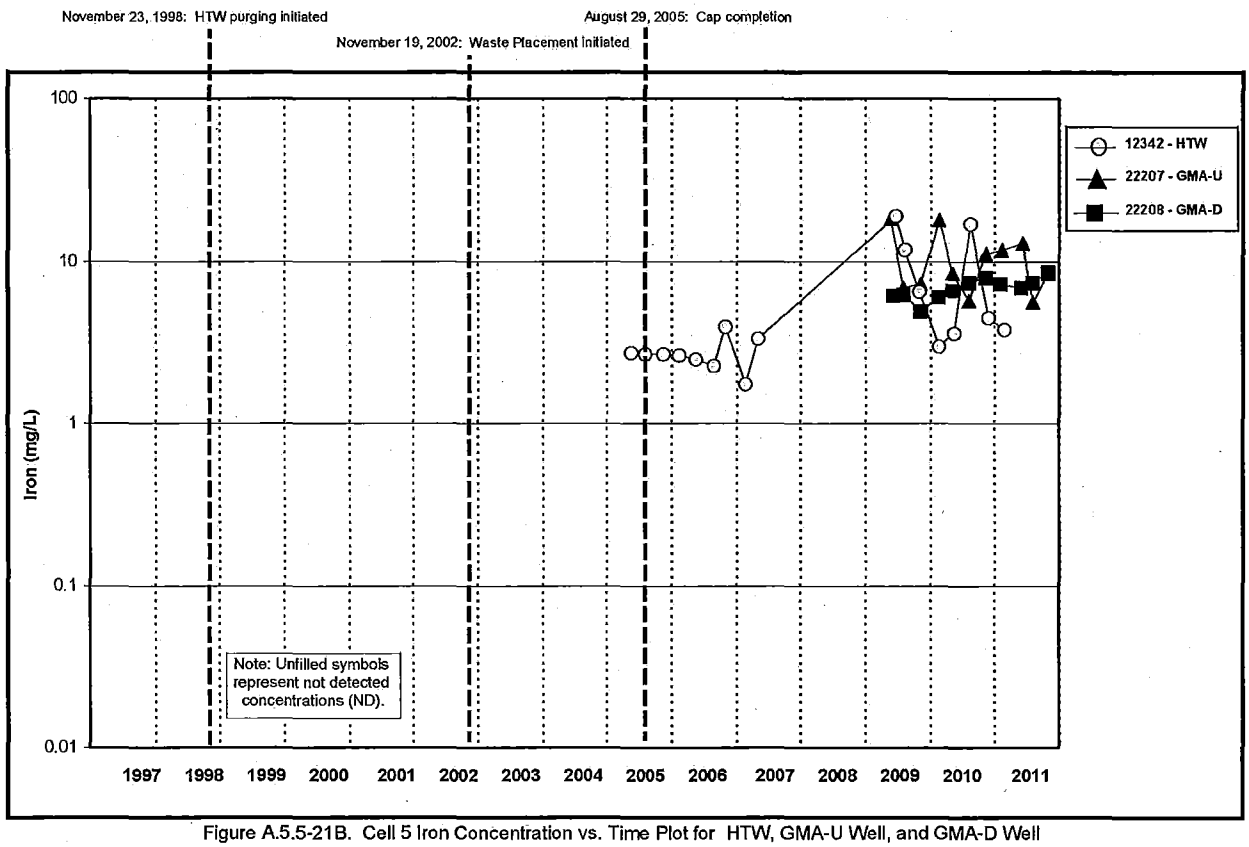


Figure A.5.5-21B. Cell 5 Iron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

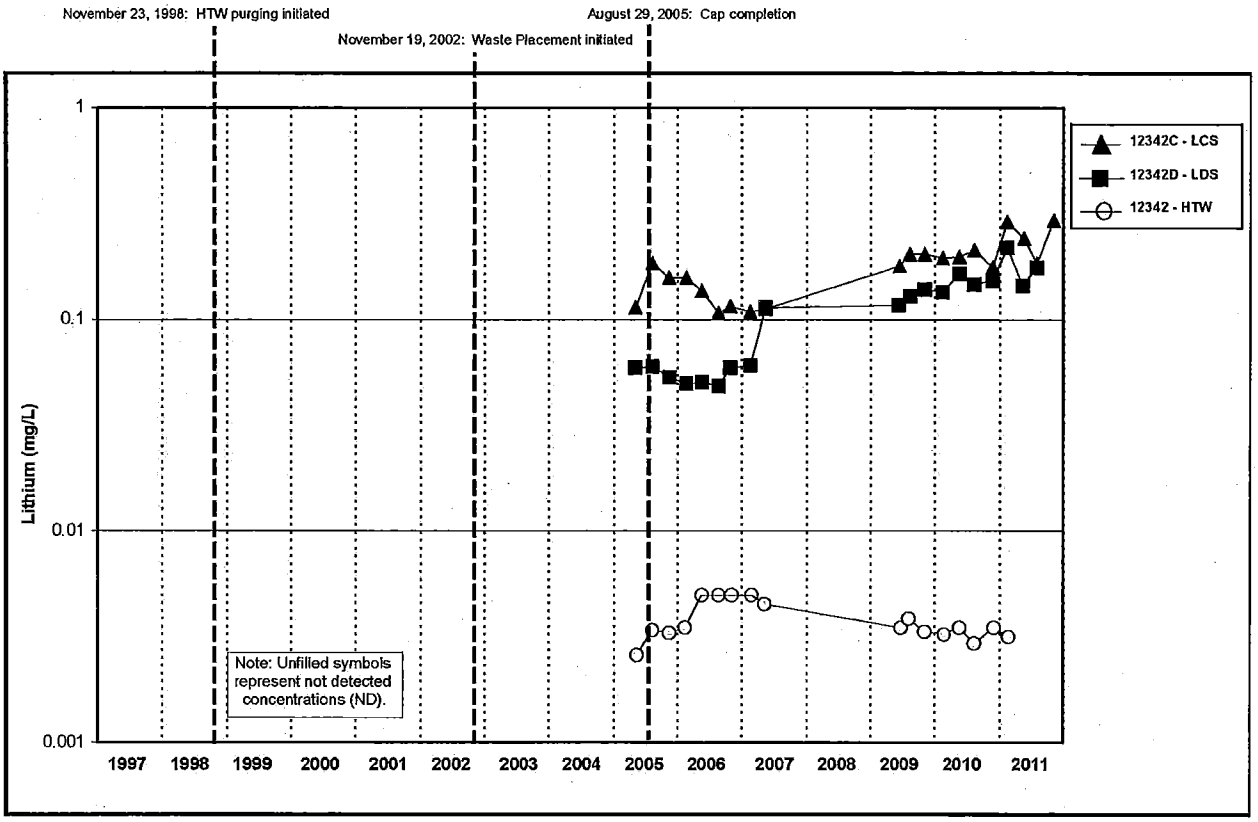


Figure A.5.5-22A. Cell 5 Lithium Concentration vs. Time Plot for LCS, LDS, and HTW

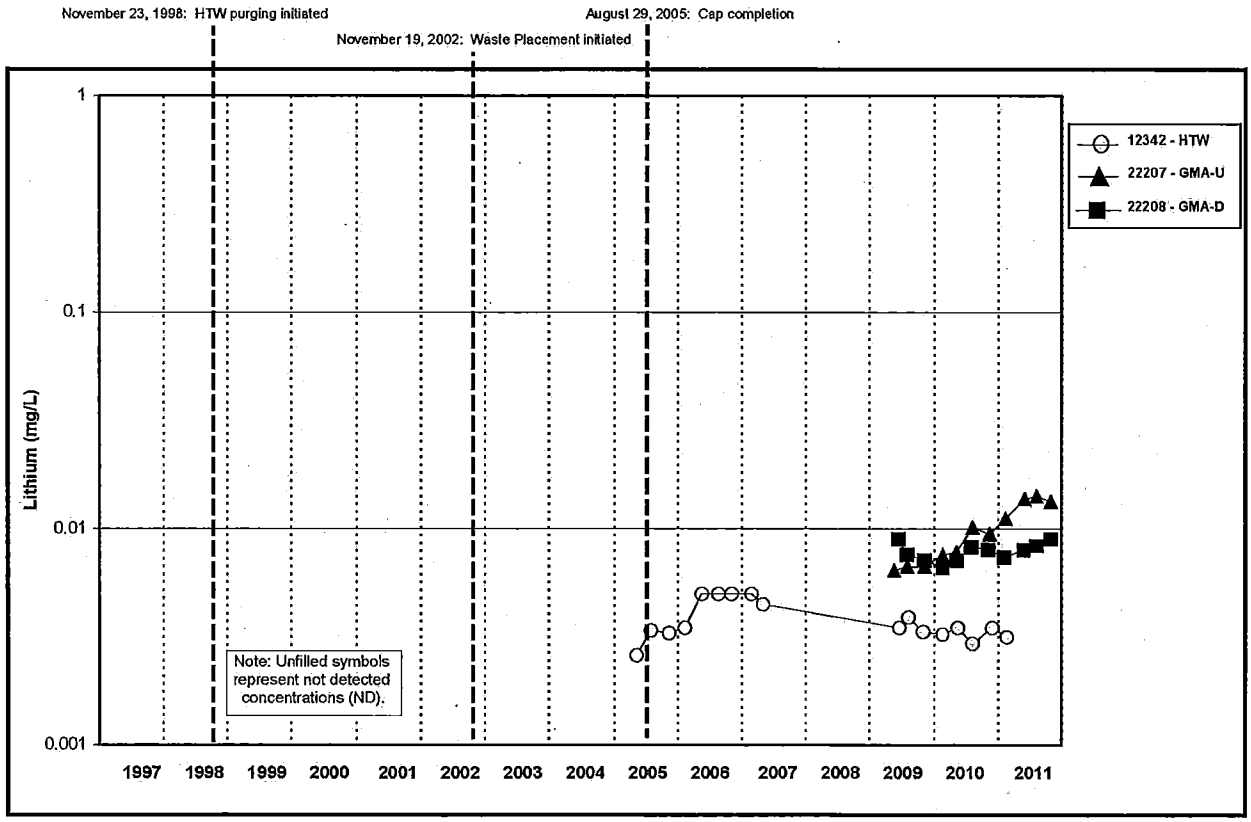


Figure A.5.5-22B. Cell 5 Lithium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

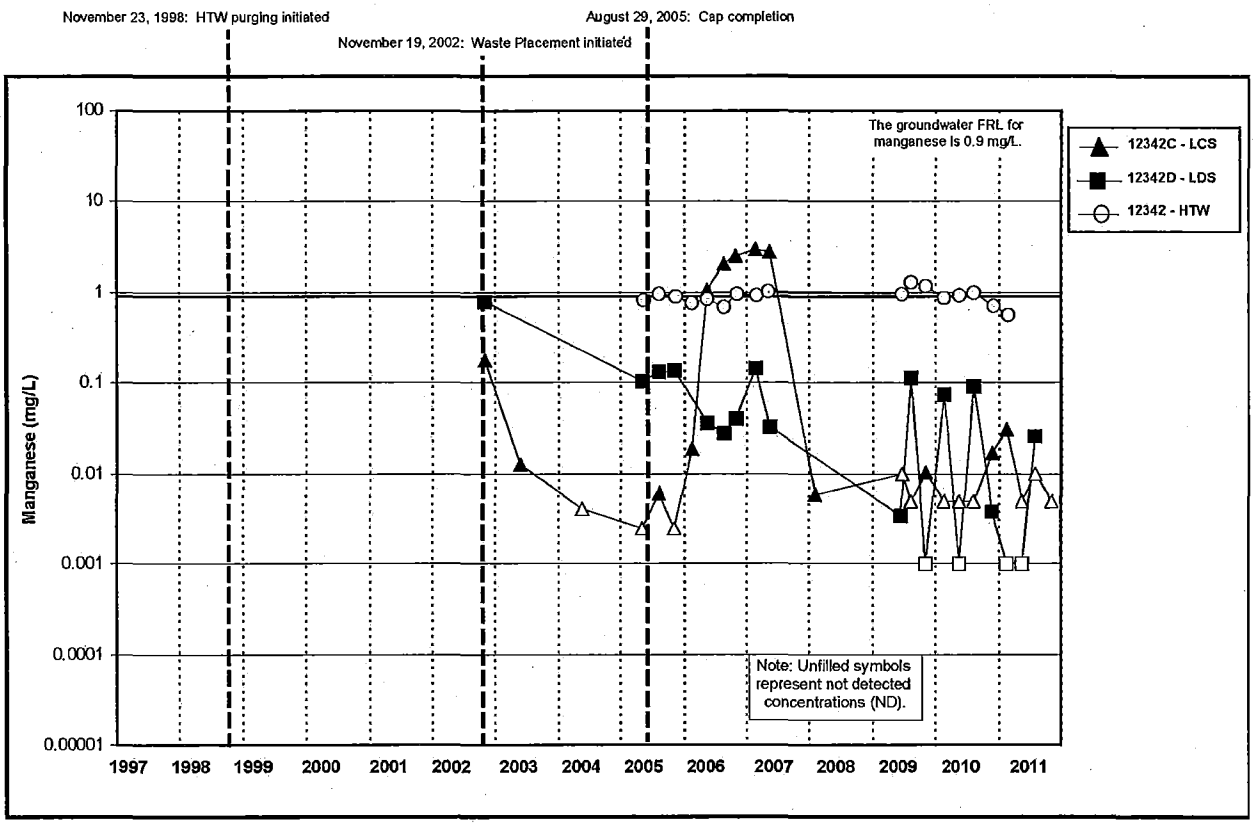


Figure A.5.5-23A. Cell 5 Manganese Concentration vs. Time Plot for LCS, LDS, and HTW

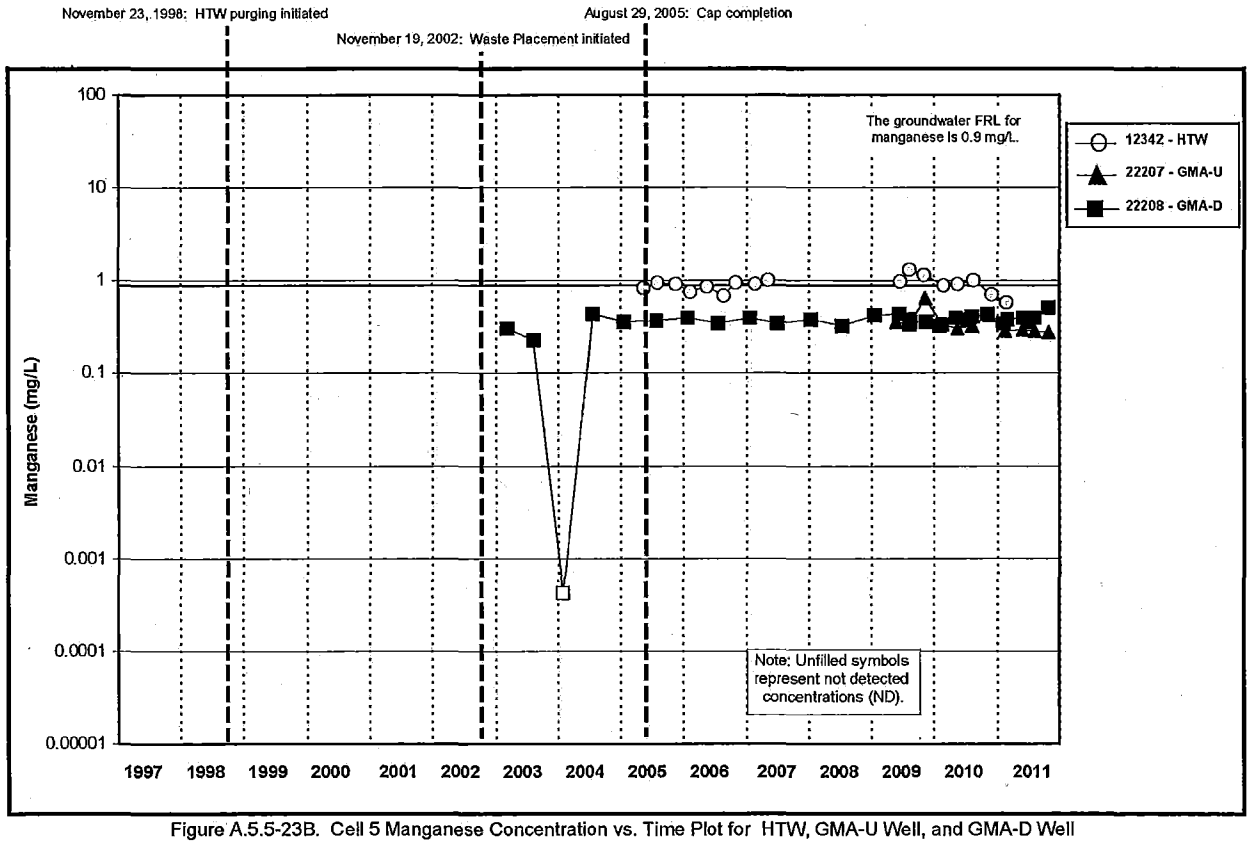


Figure A.5.5-23B. Cell 5 Manganese Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

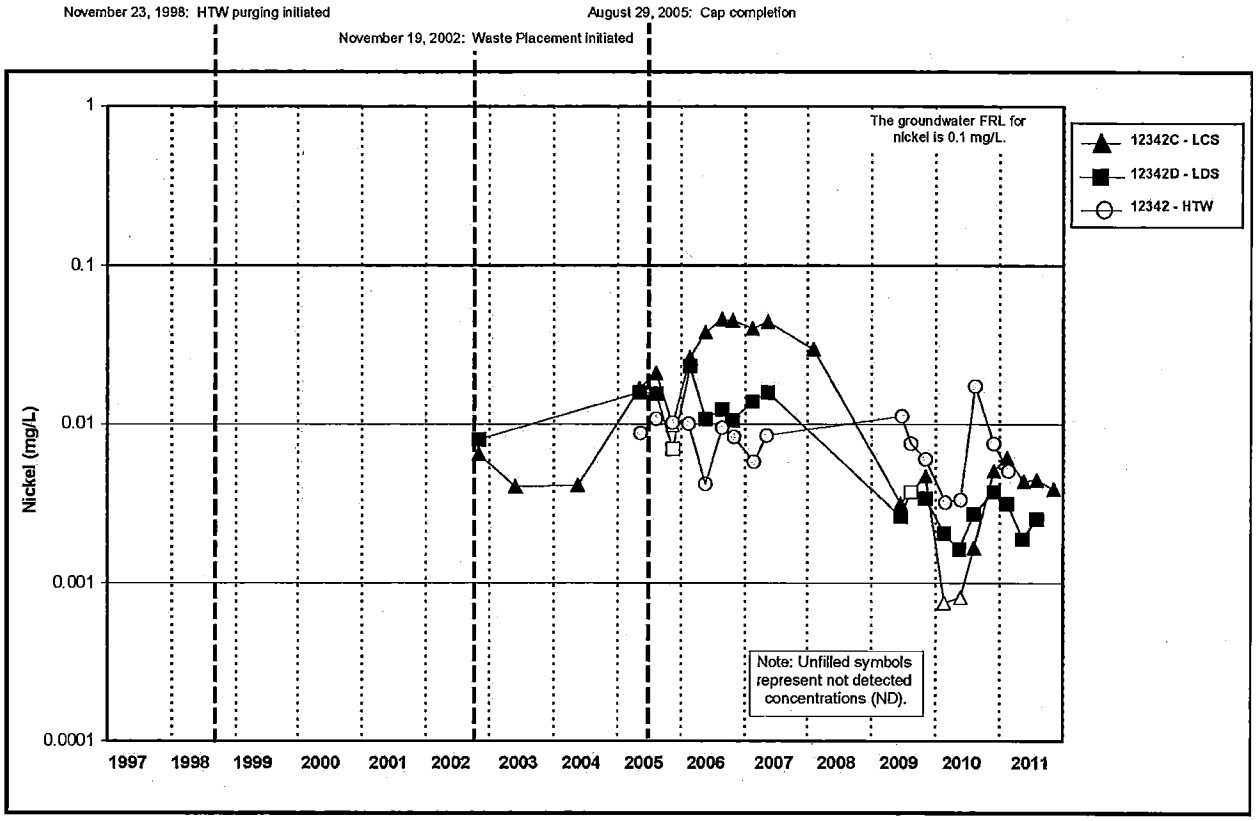


Figure A.5.5-24A. Cell 5 Nickel Concentration vs. Time Plot for LCS, LDS, and HTW

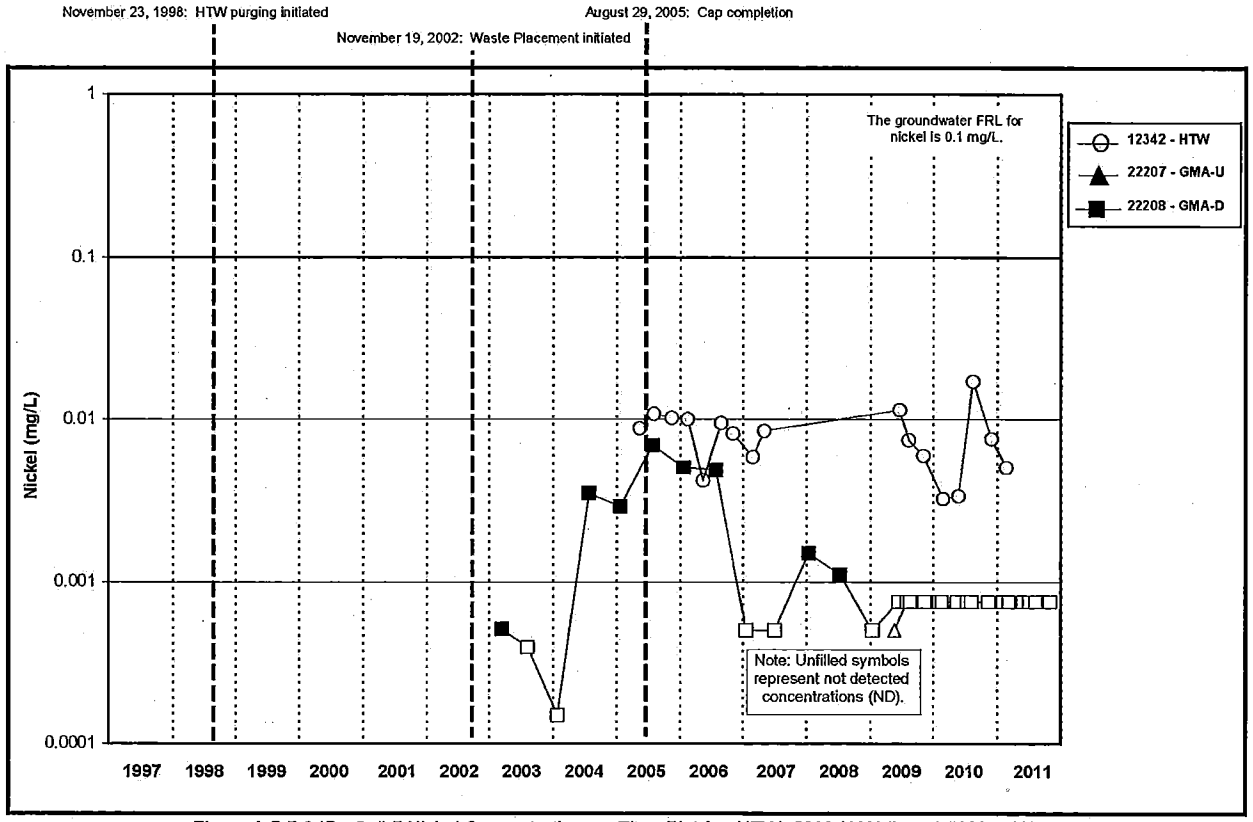


Figure A.5.5-24B. Cell 5 Nickel Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

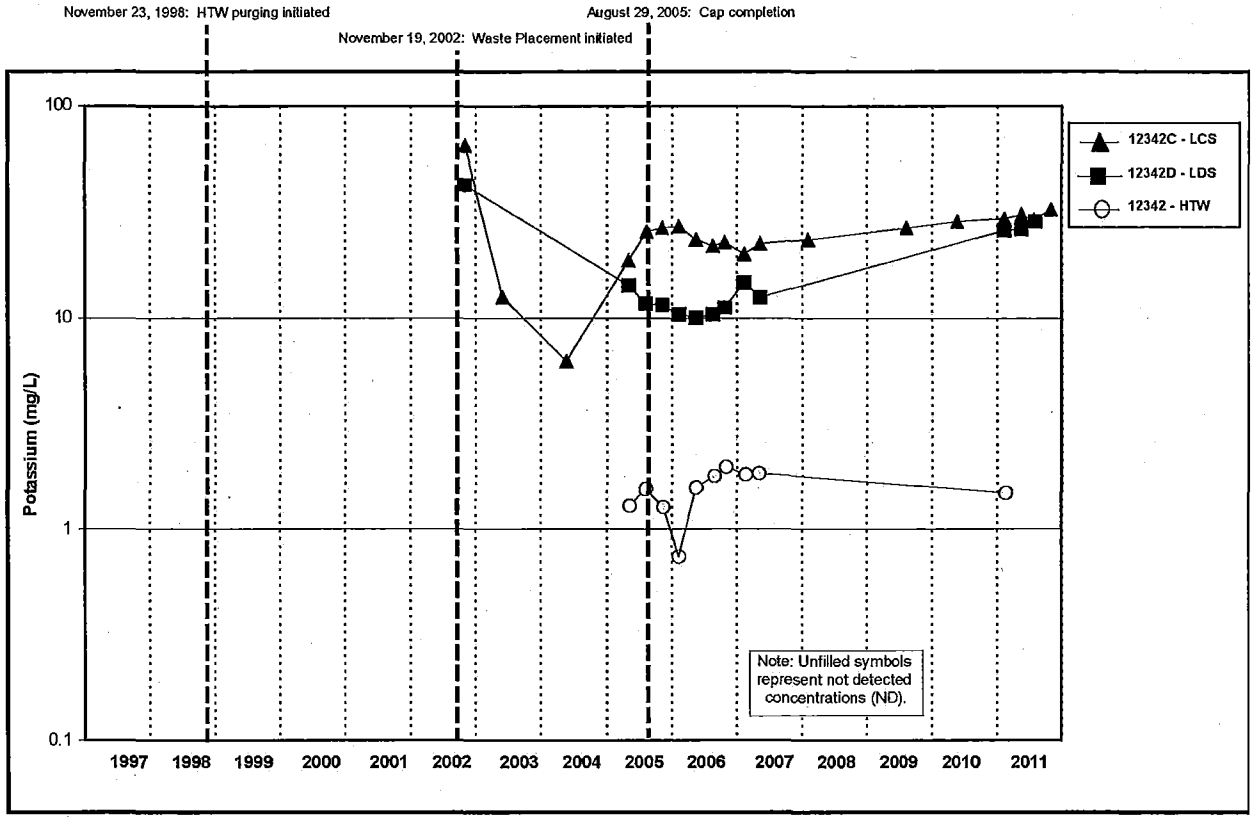


Figure A.5.5-25A. Cell 5 Potassium Concentration vs. Time Plot for LCS, LDS, and HTW

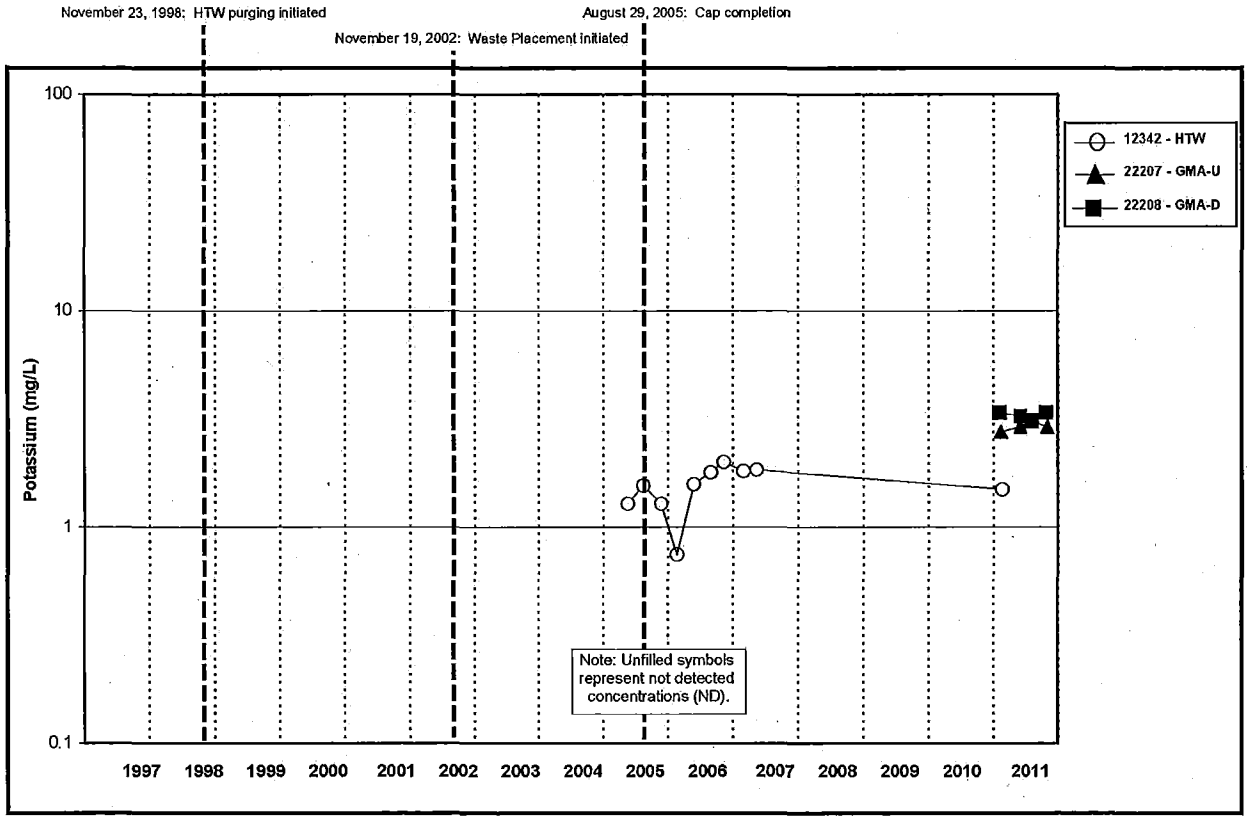


Figure A.5.5-25B. Cell 5 Potassium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

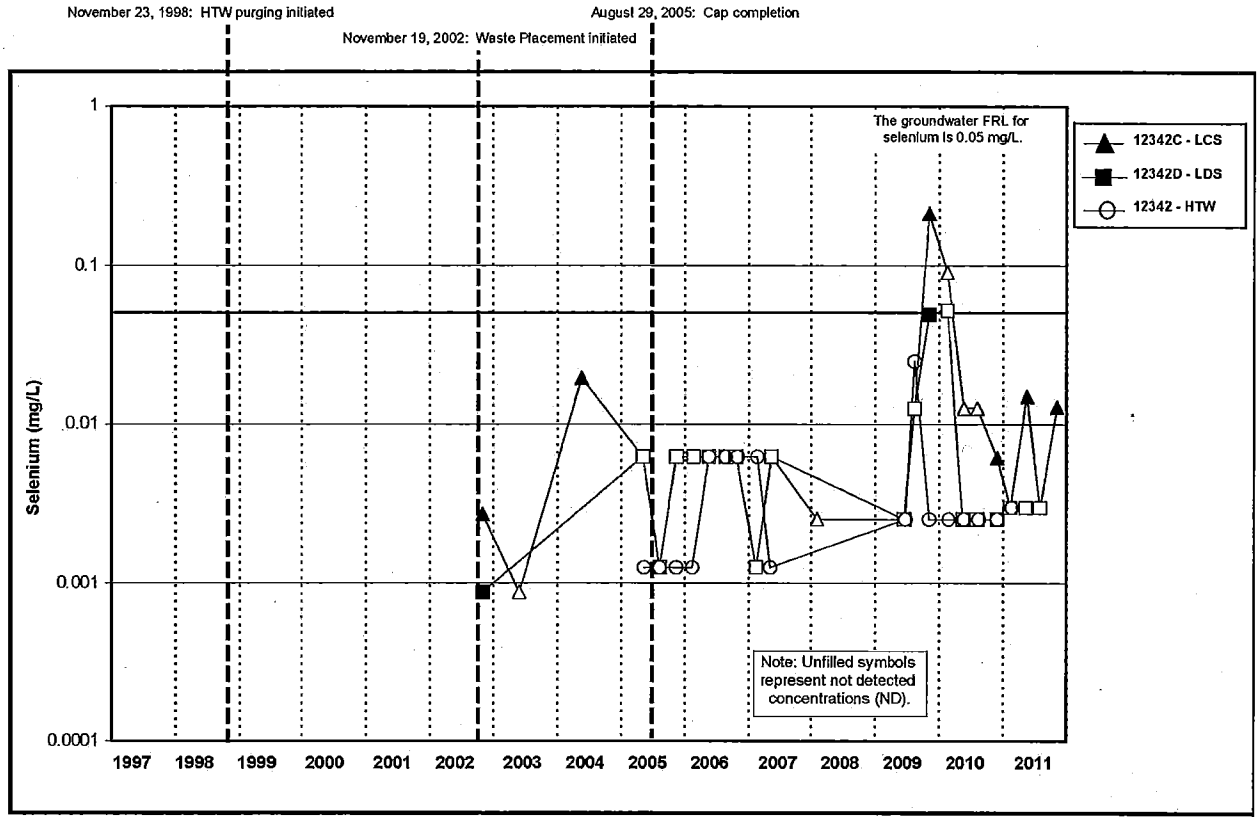


Figure A.5.5-26A. Cell 5 Selenium Concentration vs. Time Plot for LCS, LDS, and HTW

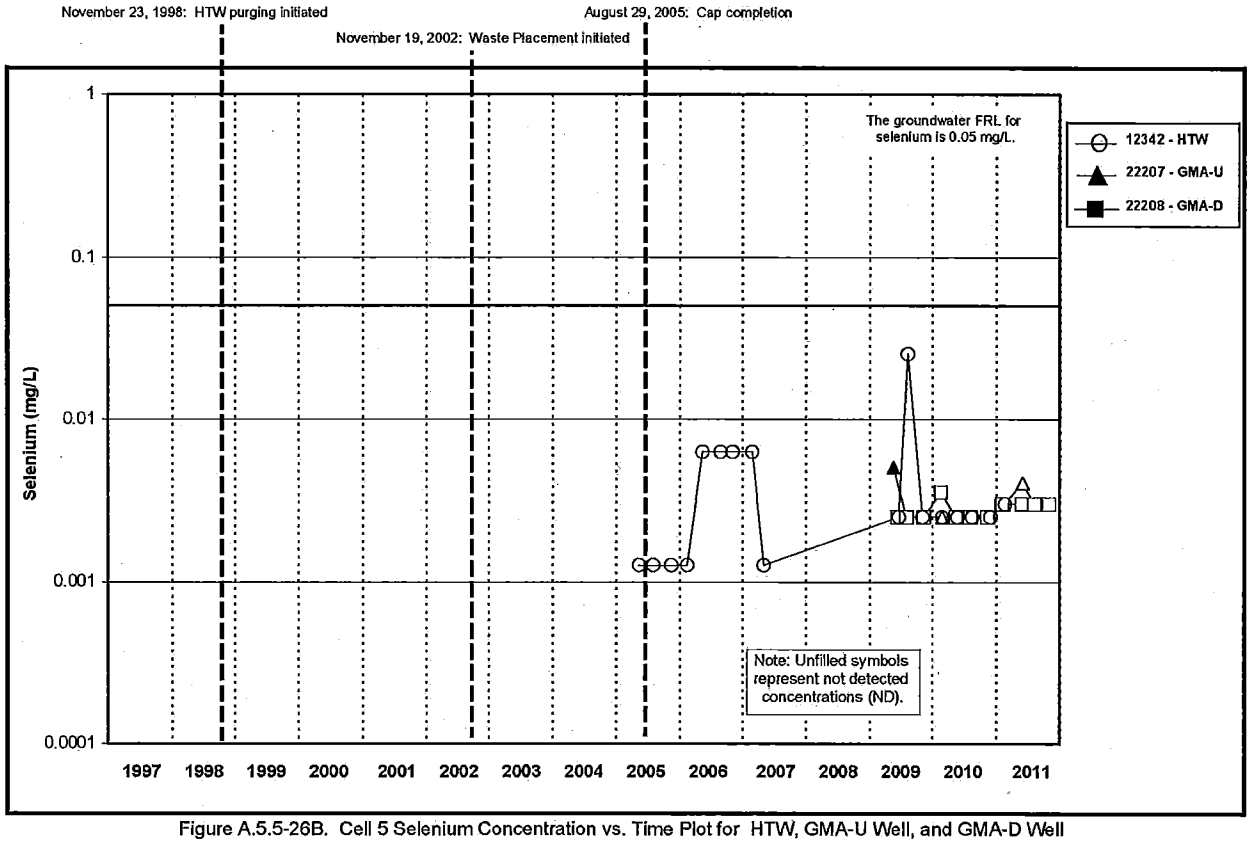


Figure A.5.5-26B. Cell 5 Selenium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

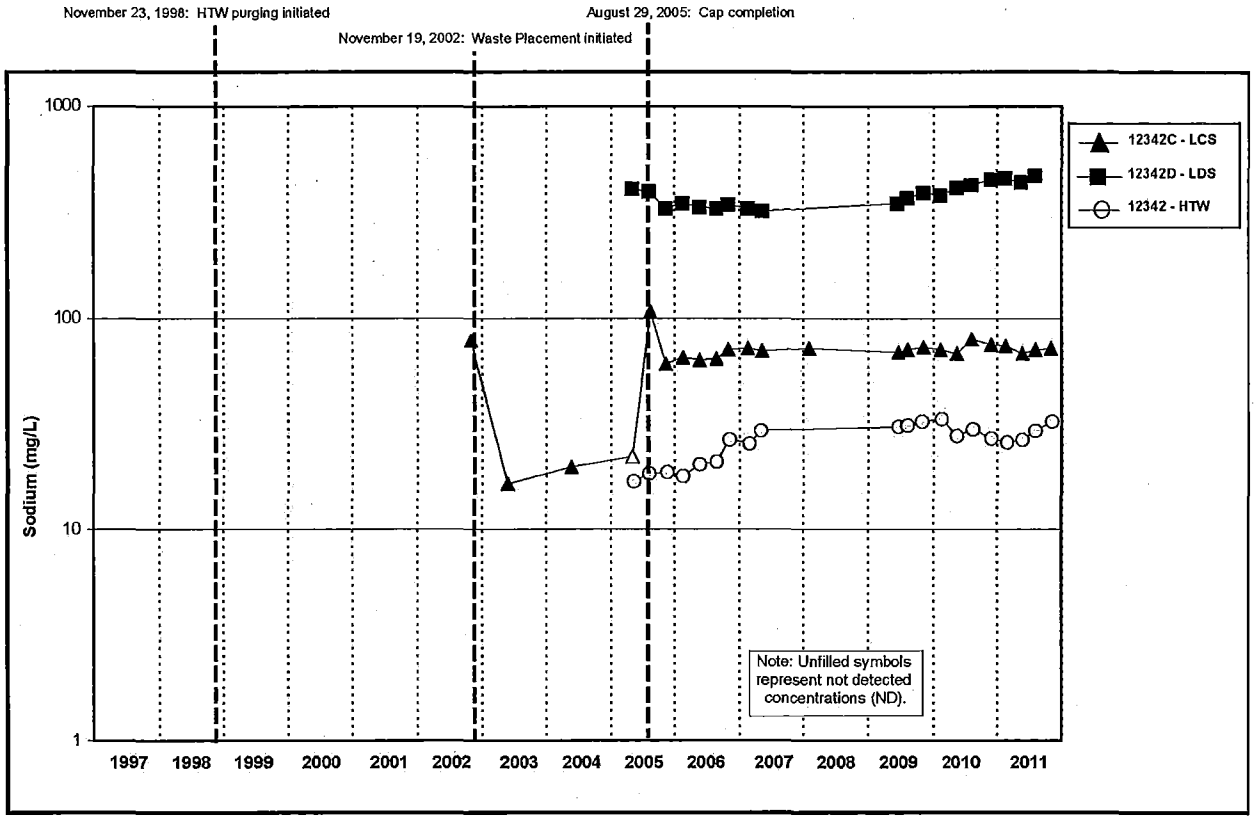


Figure A.5.5-27A. Cell 5 Sodium Concentration vs. Time Plot for LCS, LDS, and HTW

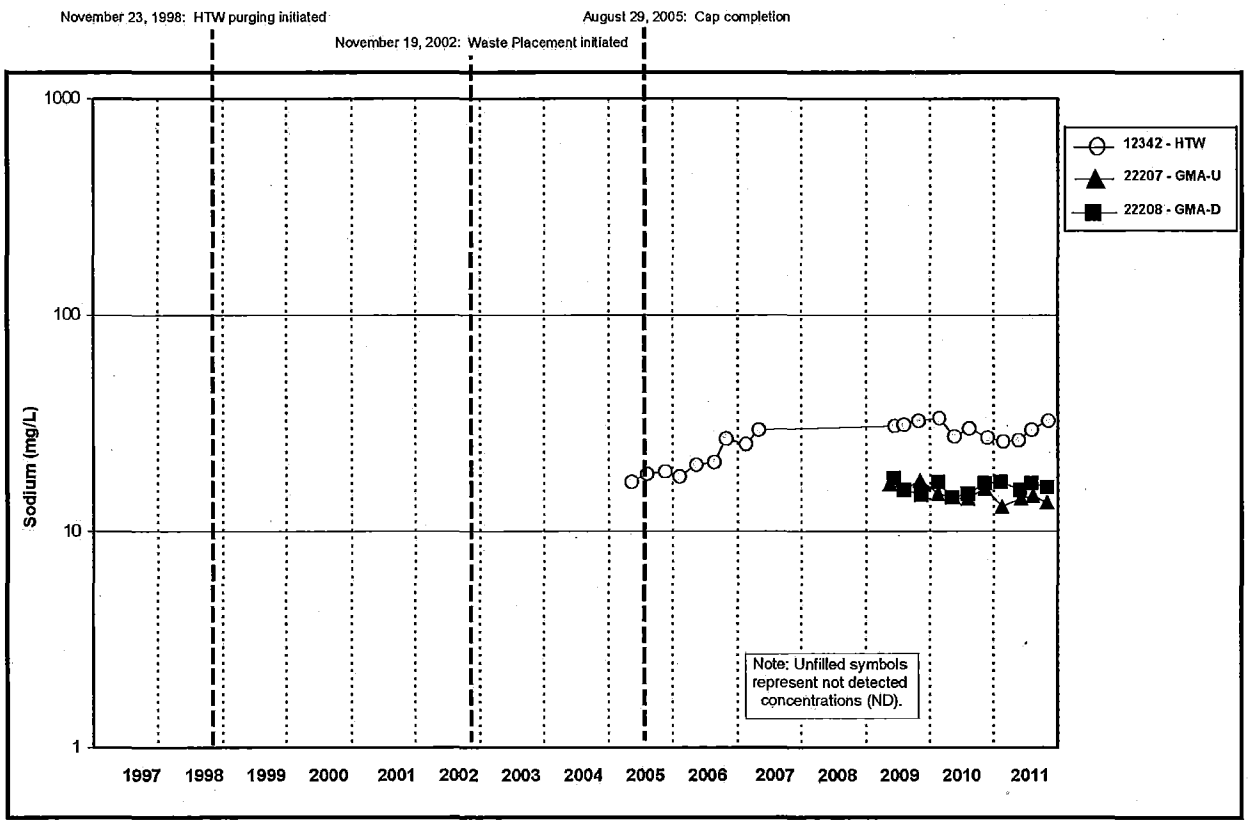


Figure A.5.5-27B. Cell 5 Sodium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

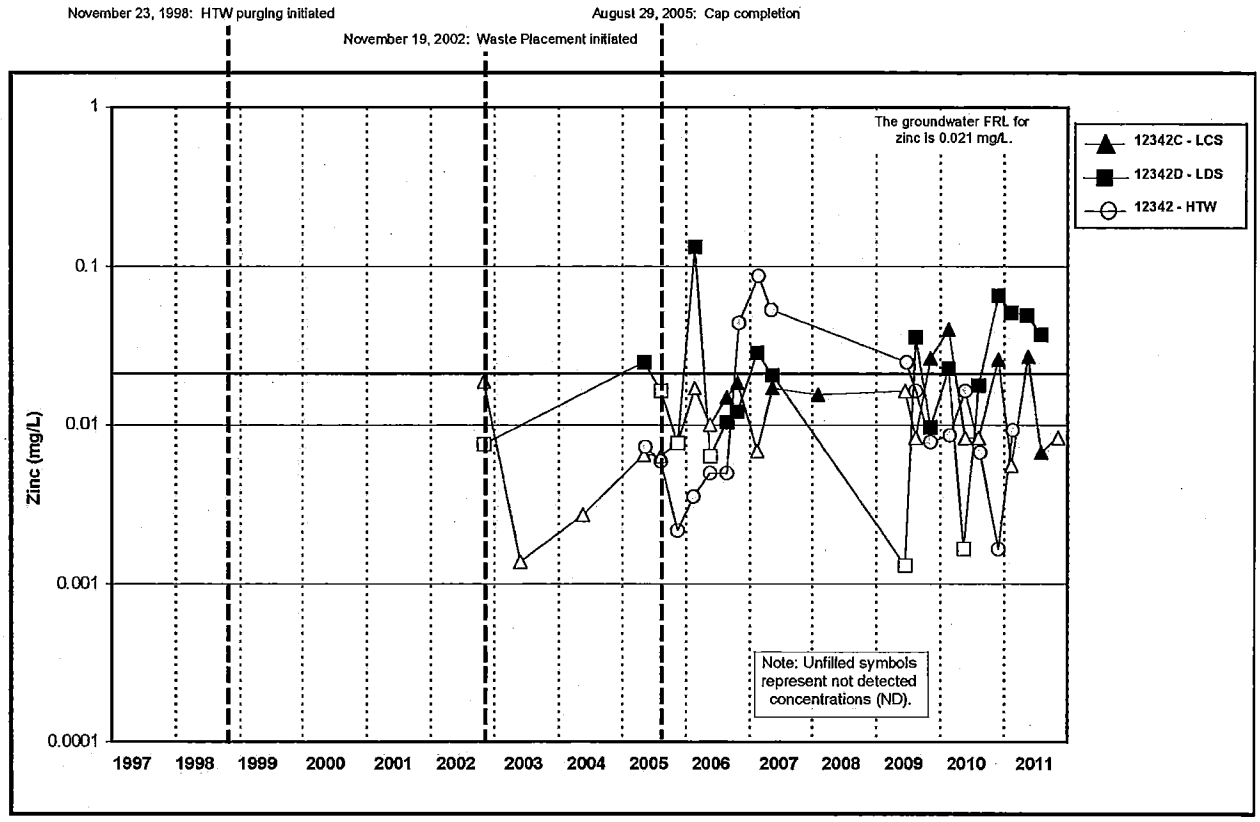


Figure A.5.5-28A. Cell 5 Zinc Concentration vs. Time Plot for LCS, LDS, and HTW

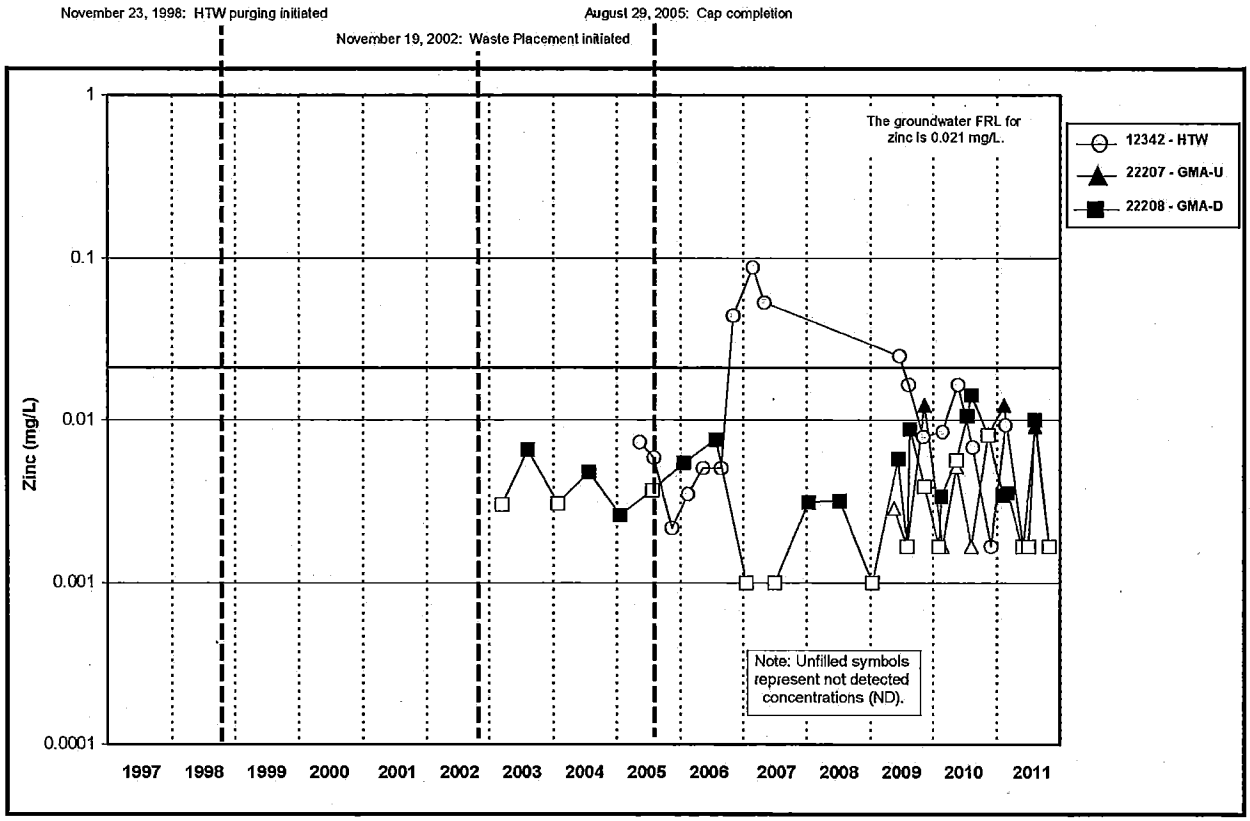


Figure A.5.5-28B. Cell 5 Zinc Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

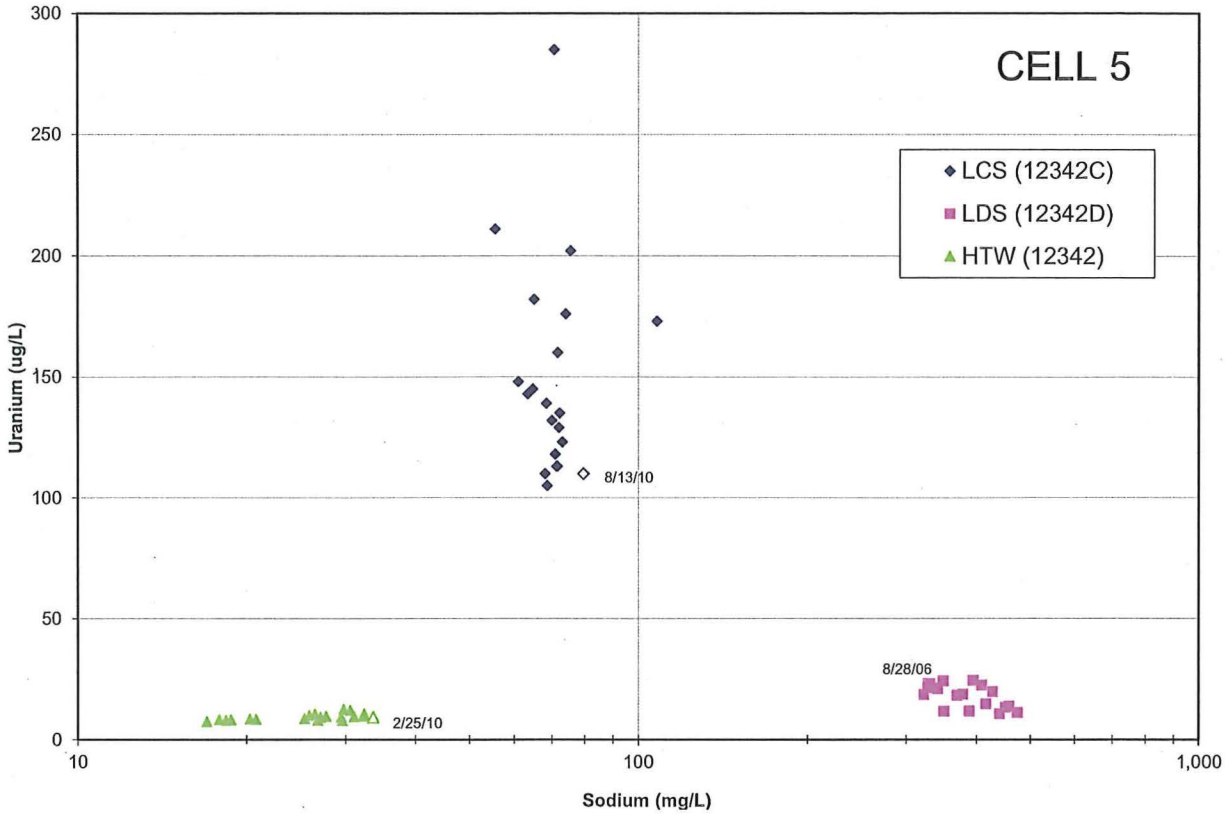


Figure A.5.5−29. Cell 5 Bivariate Plot for Uranium and Sodium

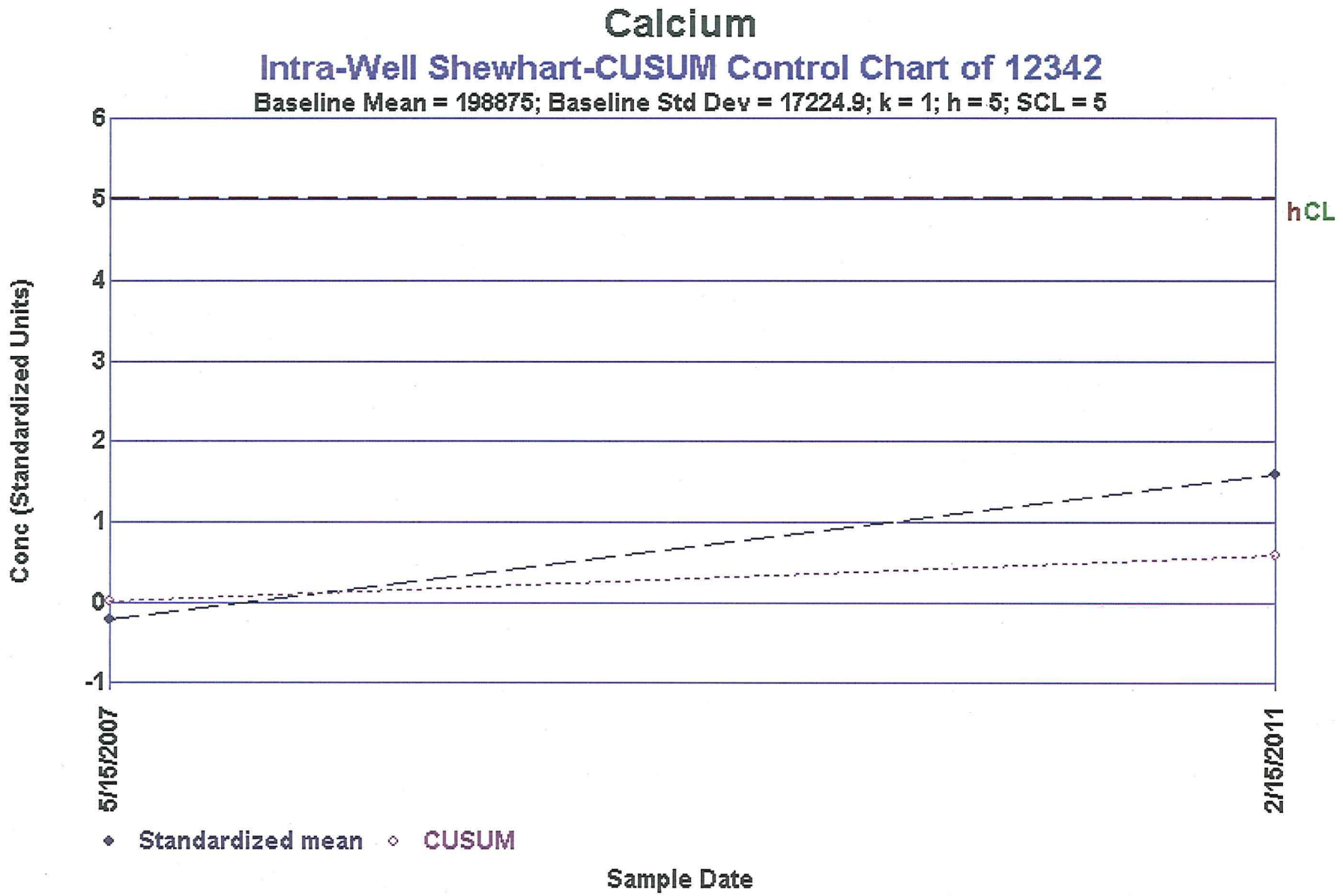


Figure A.5.5–30. Intra-Well Shewhart-CUSUM Control Chart (Calcium 12342)

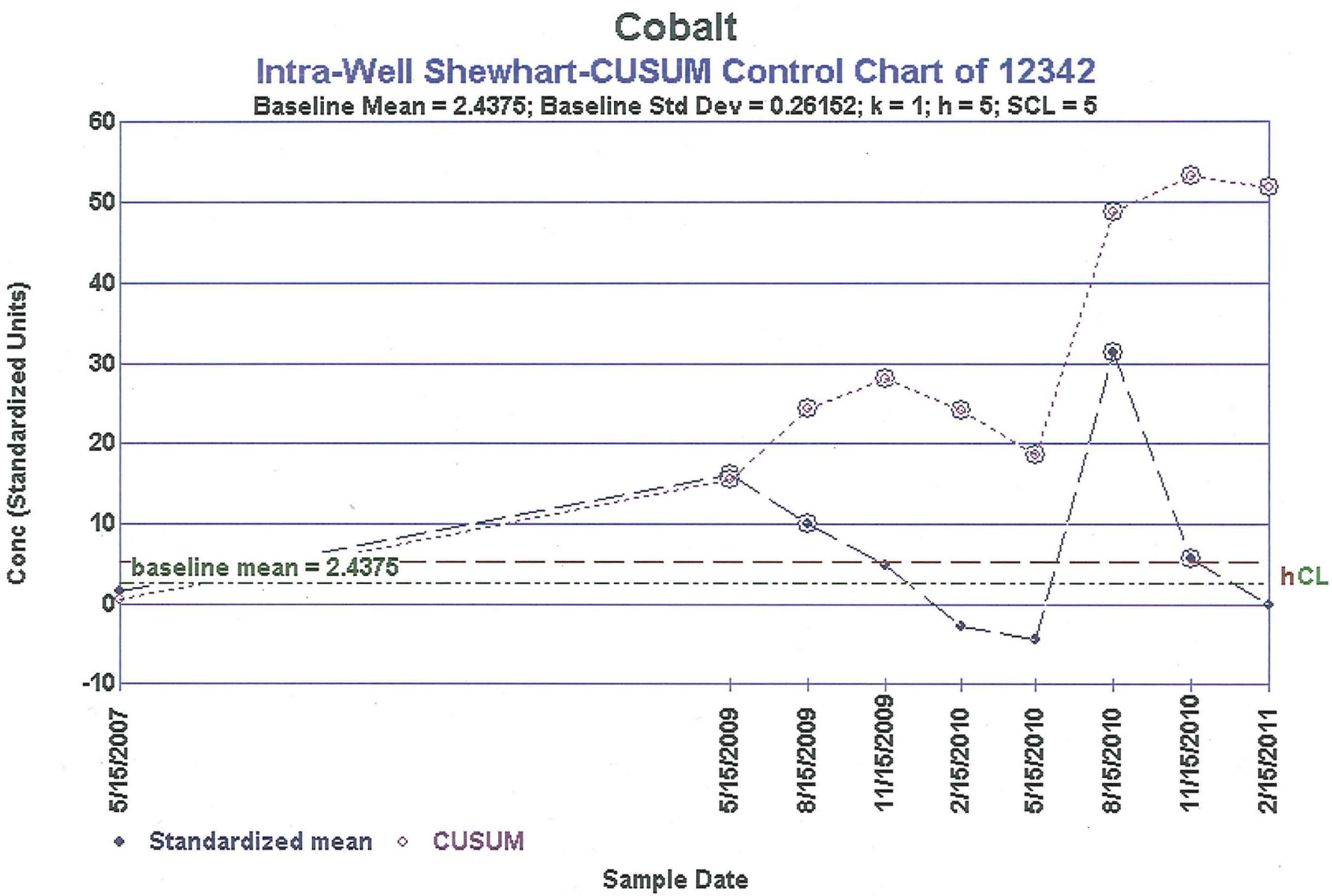


Figure A.5.5−31. Intra-Well Shewhart-CUSUM Control Chart (Cobalt 12342)

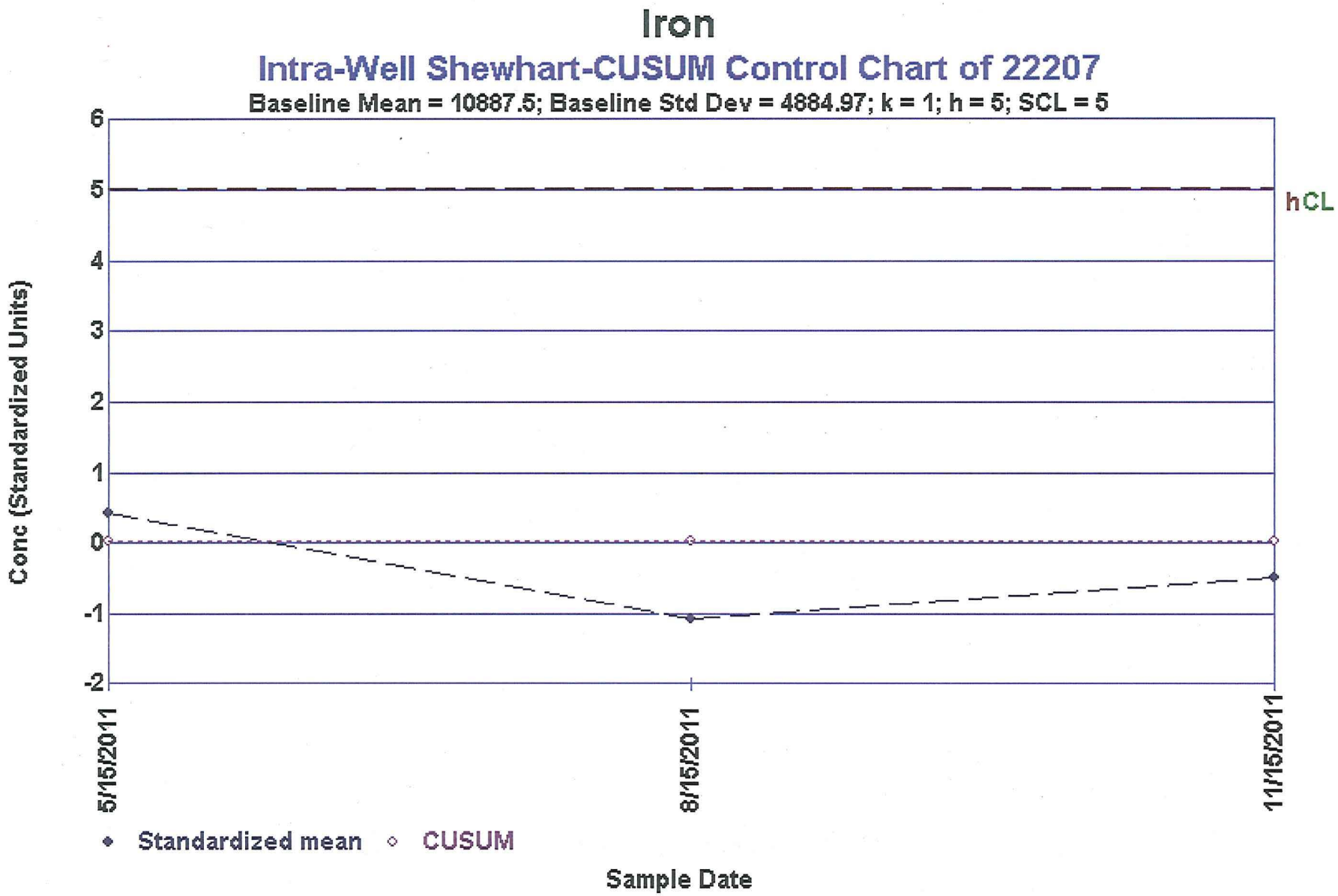


Figure A.5.5−32. Intra-Well Shewhart-CUSUM Control Chart (Iron 22207)

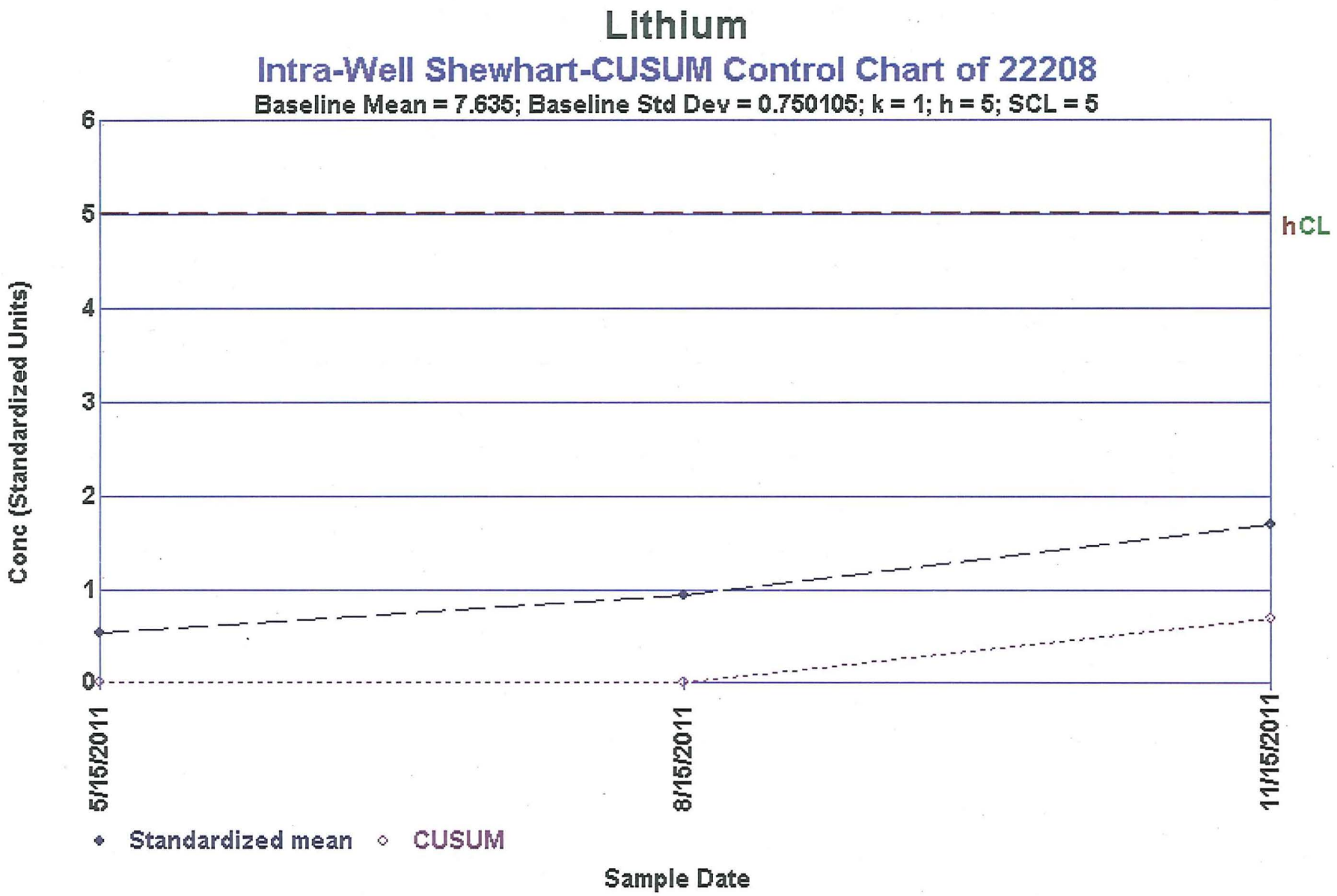


Figure A.5.5−33. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22208)

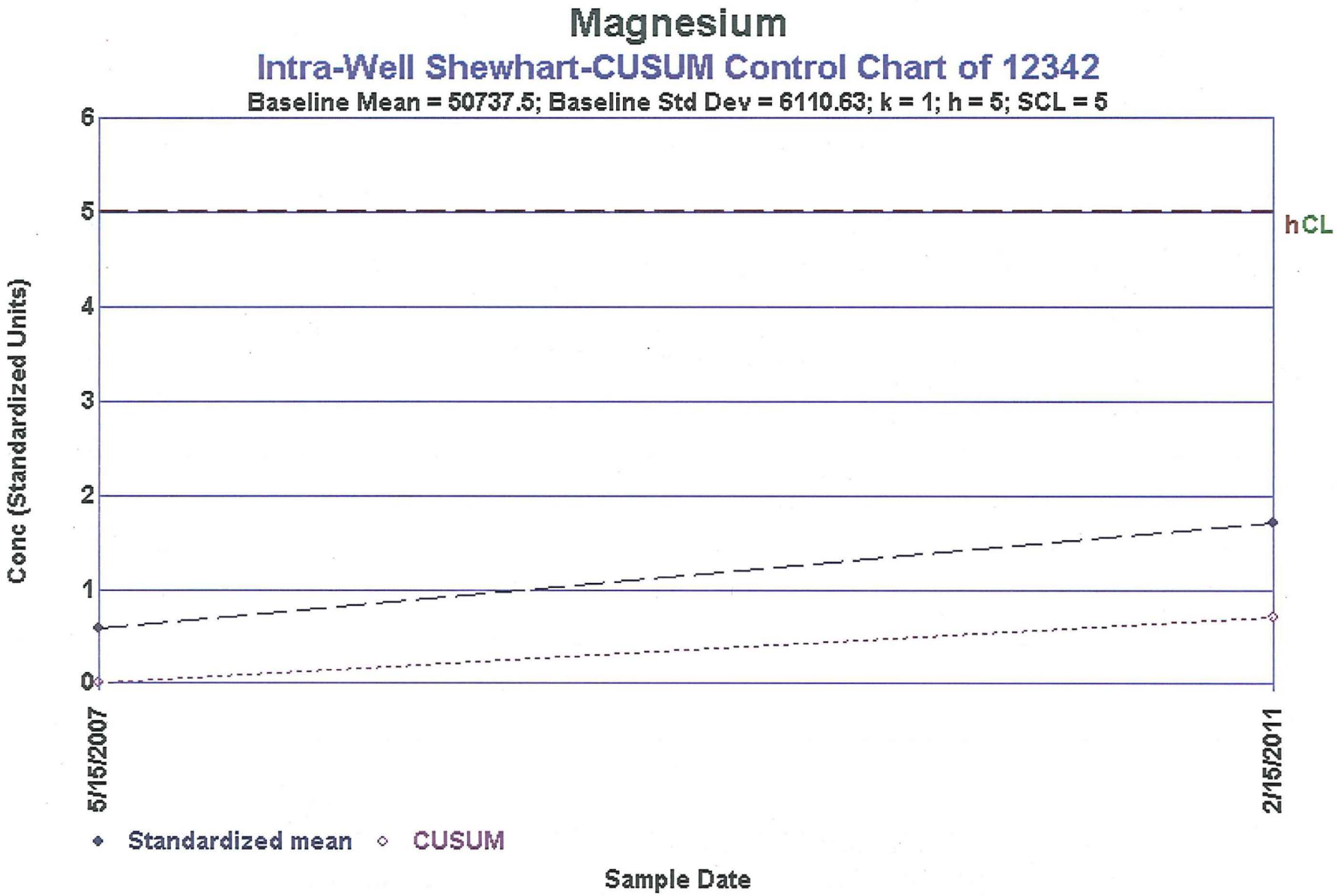


Figure A.5.5–34. Intra-Well Shewhart-CUSUM Control Chart (Magnesium 12342)

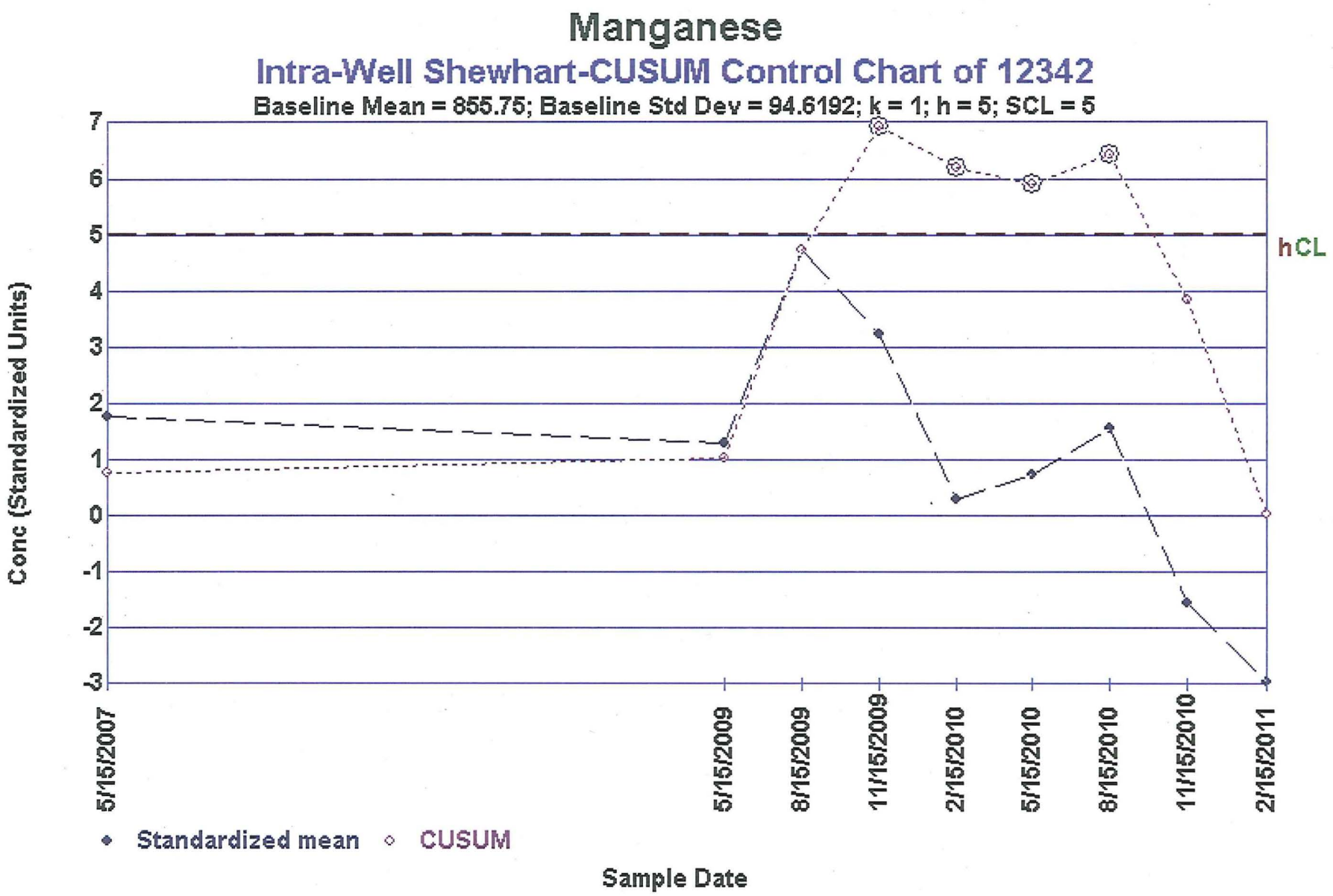


Figure A.5.5−35. Intra-Well Shewhart-CUSUM Control Chart (Manganese 12342)

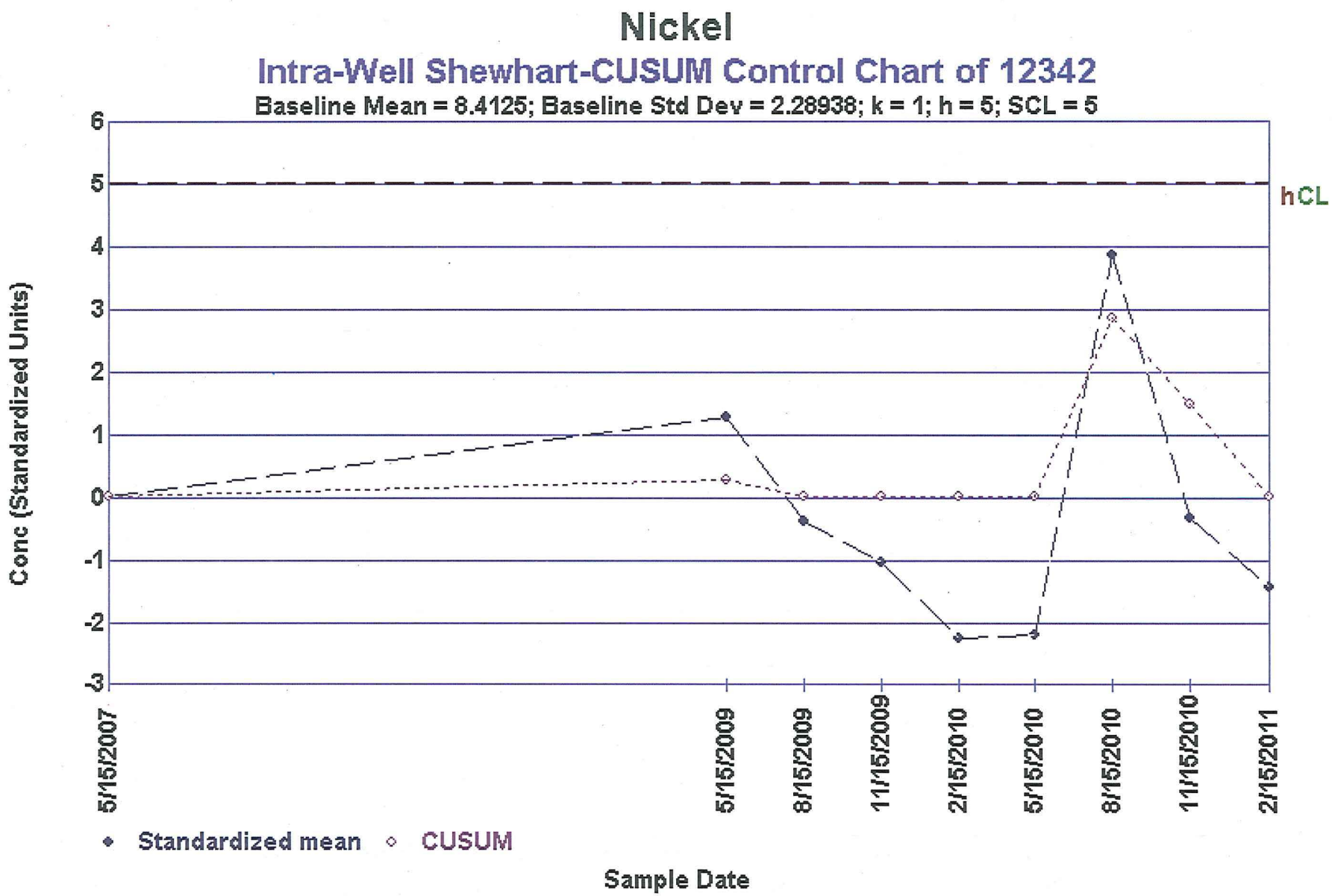


Figure A.5.5−36. Intra-Well Shewhart-CUSUM Control Chart (Nickel 12342)

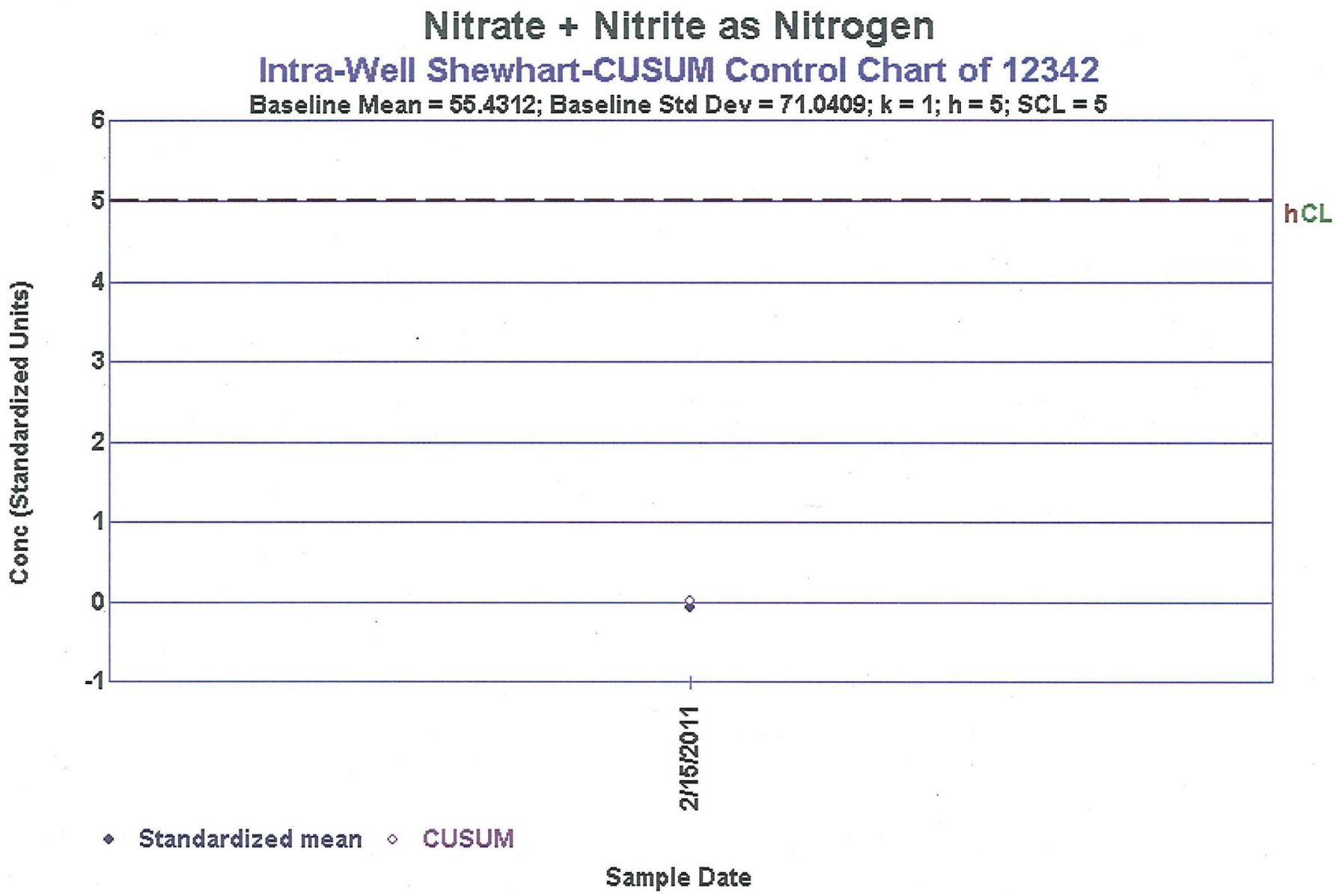


Figure A.5.5−37. Intra-Well Shewhart-CUSUM Control Chart (Nitrate 12342)

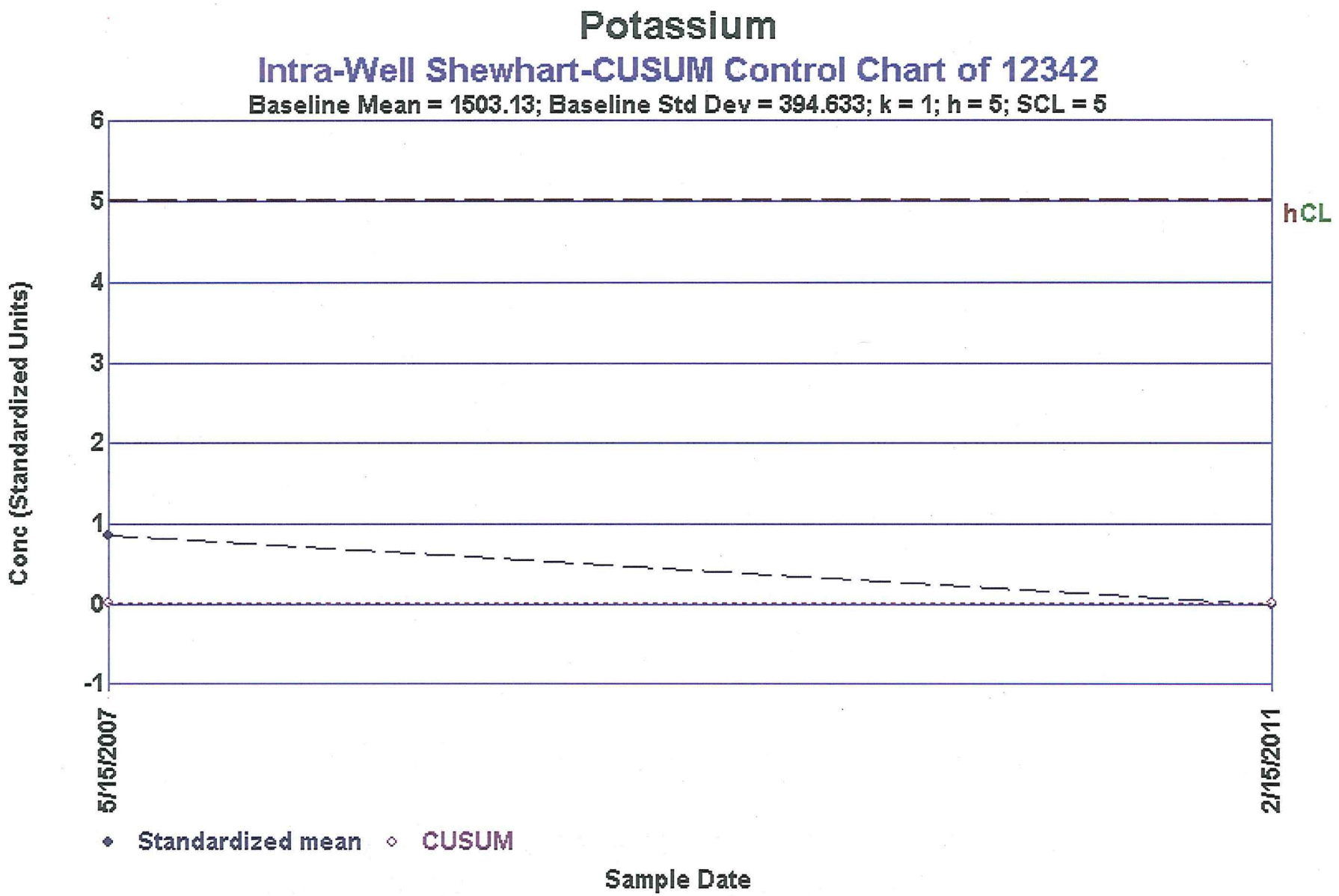


Figure A.5.5–38. Intra-Well Shewhart-CUSUM Control Chart (Potassium 12342)

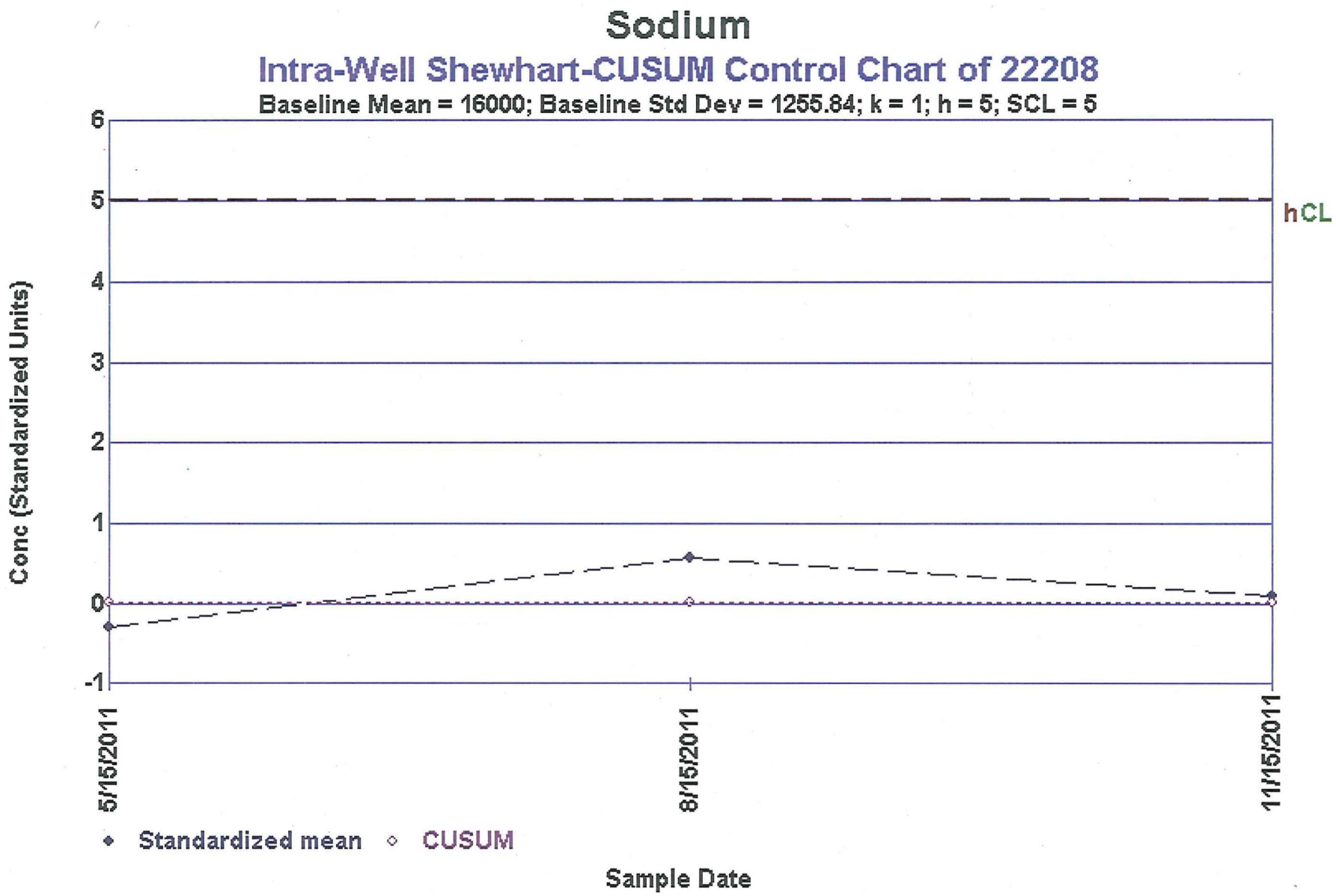


Figure A.5.5−39. Intra-Well Shewhart-CUSUM Control Chart (Sodium 22208)

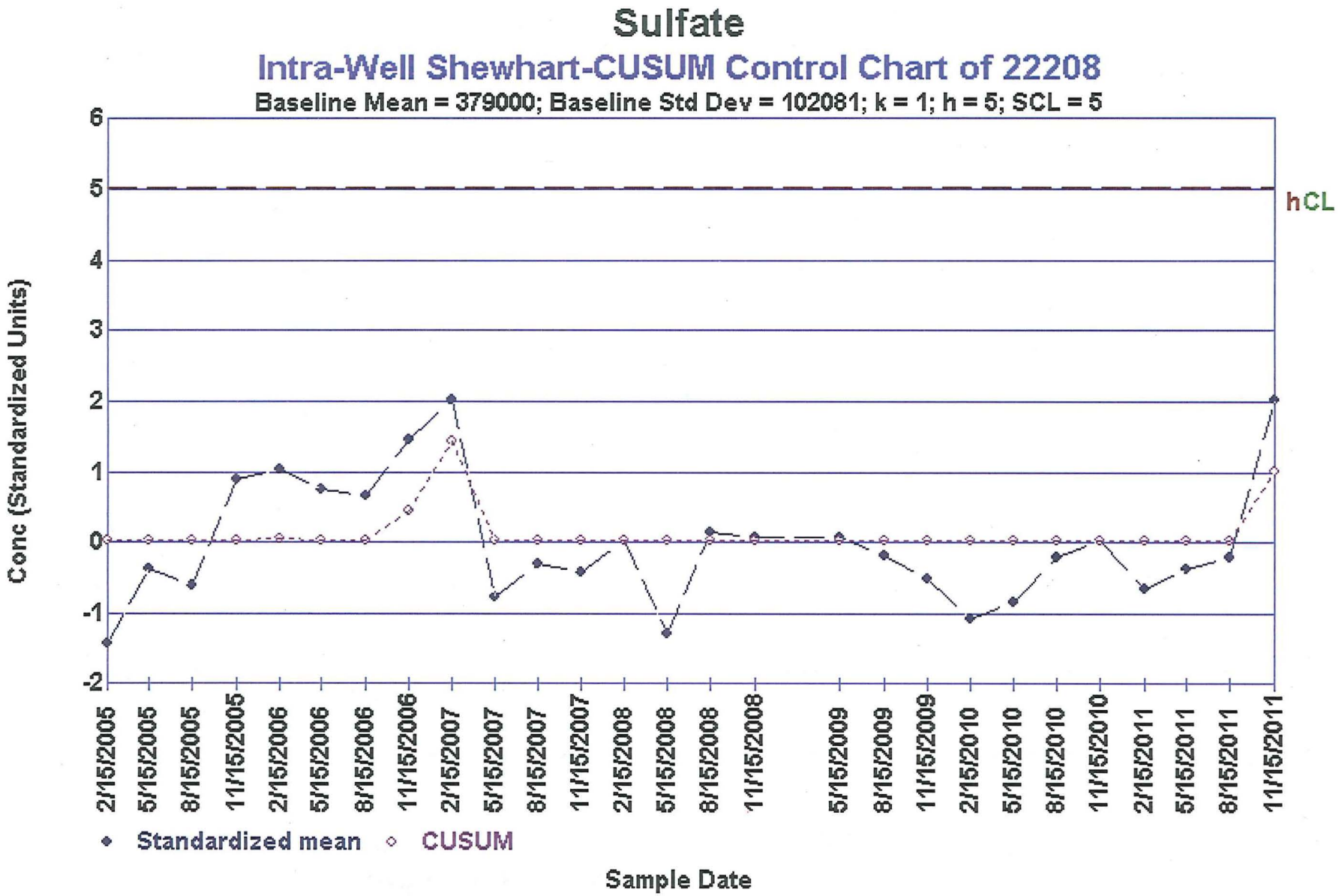


Figure A.5.5–40. Intra-Well Shewhart-CUSUM Control Chart (Sulfate 22208)

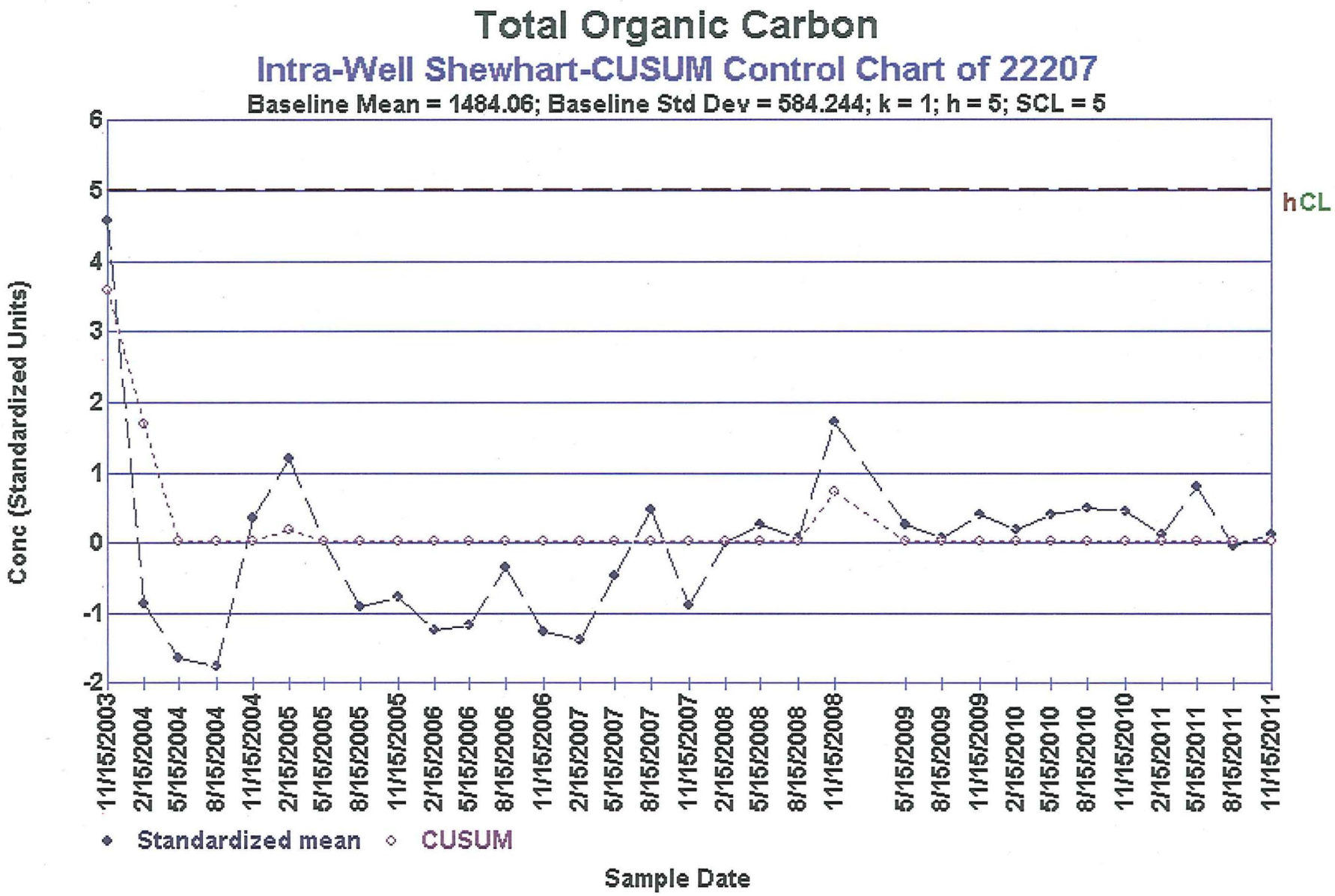


Figure A.5.5–41. Intra-Well Shewhart-CUSUM Control Chart (TOC 22207)

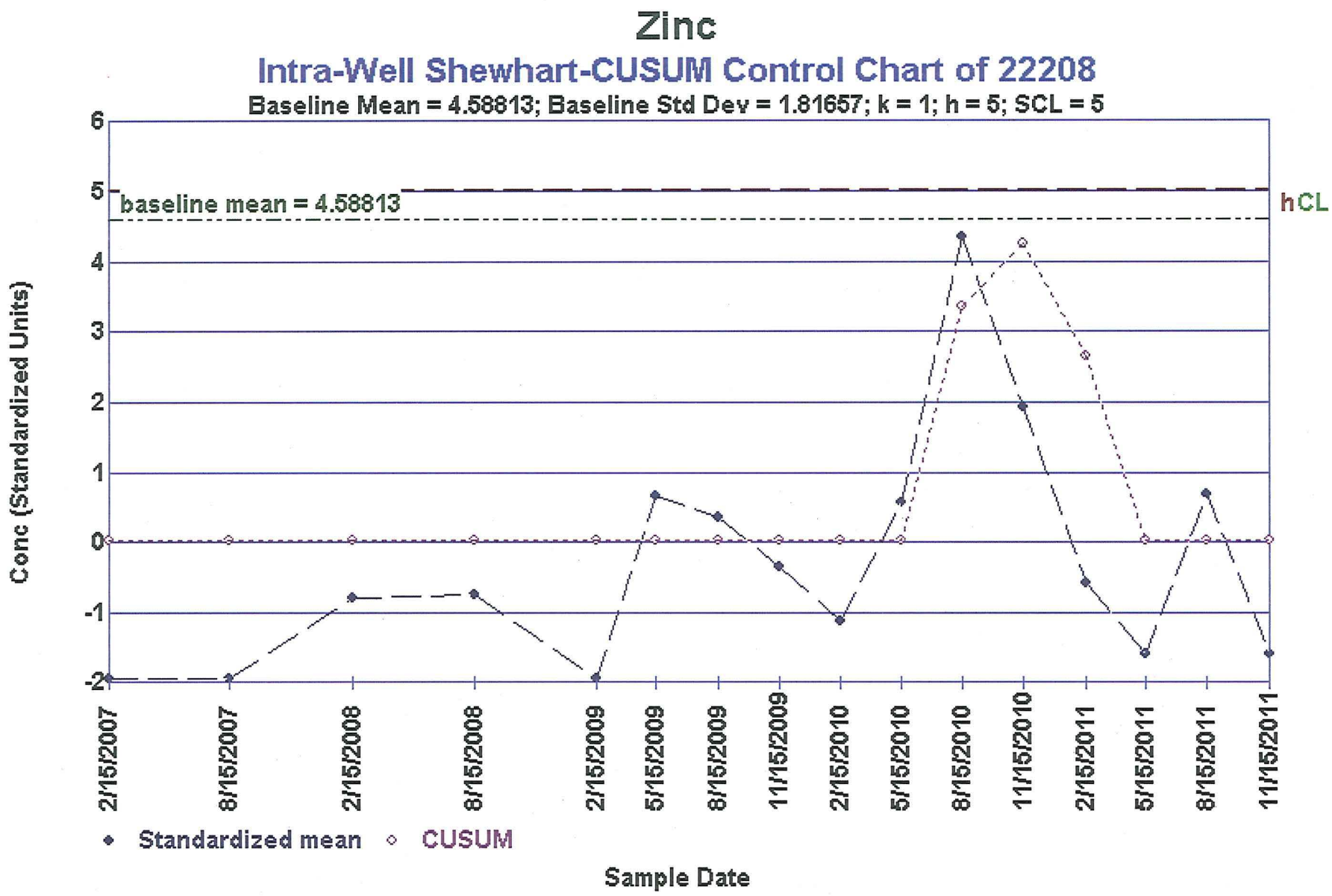


Figure A.5.5−42. Intra-Well Shewhart-CUSUM Control Chart (Zinc 22208)

Sub-attachment A.5.6

Sub-attachment A.5.6

Cell 6

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The following information is provided in this sub-attachment:

- Quarterly monitoring summary statistics (refer to Table A.5.6–1)
- Annual LCS sample summary information for detected parameters (refer to Table A.5.6–2)
- LCS monthly accumulation volumes (refer to Figure A.5.6–1)
- LDS monthly accumulation volumes (refer to Figure A.5.6–2)
- OSDF horizontal till well 12343 water yield (refer to Figure A.5.6–3)
- GMA water levels and uranium concentration versus time (refer to Figures A.5.6–4 and A.5.6–5)
- Plots of concentration versus time (refer to Figures A.5.6–6A to A.5.6–28B)
- A bivariate plot for uranium-sodium (refer to Figure A.5.6–29)
- Control charts (refer to Figures A.5.6–30 to A.5.6–46)

A.5.6.1 Quarterly Monitoring Results

Quarterly water quality monitoring takes place in the LCS, LDS, HTW, and GMA wells of each cell for the purpose of determining if the OSDF is operating as designed. Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentrations versus time plots, bivariate plots, and control charts are used to help interpret and present the results.

In the first quarter of 2011, 23 parameters were sampled in the LCS, LDS, HTW, and GMA wells of each cell. In the second, third, and fourth quarters tritium was added to the analyte list for all horizons (LCS, LDS, HTW, and GMA Wells), and the analyte list for the HTWs in all cells was changed to just four parameters: arsenic, uranium, tritium, and sodium. These changes were agreed to via the comment resolution process between Ohio EPA and DOE on LMICP (revision 4). Tritium results for all cells are reported in Section A.5.5.

As shown in Table A.5.6–1, 10 of the 23 parameters sampled quarterly in the LCS, LDS, HTW, and GMA wells, (uranium, sulfate, TDS, TOC, arsenic, boron, cobalt, copper, iron, and lithium) have upward trends in the HTW and/or the GMA wells based on the Mann-Kendall test for trend.

Horizontal Till Well

The HTW is located beneath the liner penetration box of each cell by design. This area of the liner penetration box is considered to be potentially the weakest point in the cell design. If a leak were to develop, it should be detected beneath the liner penetration box first. Therefore, the water quality in the HTW represents the first line of evidence that a potential leak from the cell might be occurring. A leak would be indicated by an increasing concentration in the HTW.

Of the 23 parameters monitored quarterly in the LCS, LDS, HTW, and GMA wells, uranium, sulfate, cobalt, copper, iron, and lithium are increasing in the HTW of Cell 6 (as indicated in the table below). The bivariate plot for the Cell 6 LCS, LDS, and HTW (uranium-sodium) is provided in Figure A.5.6–29. The plot shows that the chemical signature for uranium-sodium in

the LCS LDS, and HTW are separate and distinct; indicating that mixing between the horizons is not occurring. Therefore, the increasing concentrations measured in the HTW of Cell 6 are attributed to fluctuating ambient concentrations beneath the cell that are not related to cell performance.

Parameter	HTW[a]	GMA-U[a]	GMA-D[a]
Uranium	Up		
Sulfate	Up		Up
TDS			Up
TOC		Up	Up
Arsenic			Up
Boron			Up
Cobalt	Up		
Copper	Up		
Iron	Up		
Lithium	Up		

[a] HTW = horizontal till well, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer; TDS = total dissolved solids; TOC = total organic carbon.
No entry indicates that the trend was not up.

Great Miami Aquifer Wells

GMA monitoring wells are positioned for post-aquifer-remediation flow conditions, when flow directions will be from west to east. However, water levels measured in 2011 indicate that groundwater in the GMA in most of the area of the OSDF is moving in a general direction of northeast to south/southwest in response to the active groundwater remediation taking place to the west and southwest. Pumping for the groundwater remediation is scheduled to last until 2023. Because bivariate plots (discussed above) indicate that LCS, LDS, and HTW monitoring horizons are not mixing, the increasing concentrations seen in the GMA wells are attributed to fluctuating ambient conditions that are not related to cell performance.

The table below provides a summary of the average concentration (as reported in Table A.5.6–1) measured in the LDS, HTW, and GMA wells for parameters with increasing concentrations in the Cell 6 GMA wells.

Parameter	LDS[a]	GMA-U[a]	GMA-D[a]
Sulfate (mg/L)	**2140**	188	264
TDS (mg/L)	**5290**	672	911
TOC (mg/L)	**4.85**	1.23	1.30
Arsenic (mg/L)	0.00375	**0.00250**	**0.00250**
Boron (mg/L)	**0.392**	0.0363	0.0340

Note: The highest averages are shown in bold.
[a]LDS = leak detection system, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer; TDS = total dissolved solids, TOC = total organic carbon

As shown in the table above, the average concentration of arsenic in the GMA is higher than the average in the LDS of Cell 6.

A.5.6.2 Control Charts

Intrawell control charts employ historical measurements from a compliance point as background The *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance* (EPA 2009) defines the process of creating a Shewart-CUSUM control chart. Appropriate background data are used to define a baseline for the well. The baseline parameters for the chart, estimates of the mean, and standard deviation are obtained from the background data. These baseline measurements characterize the expected background concentrations at the monitoring point. As future concentrations are collected, the baseline parameters are used to standardize the newly gathered data. After these measurements are standardized and plotted, a control chart is declared "out of control" if future concentrations exceed the baseline control limit. This is indicated on the control chart when either the Shewart or CUSUM plot traces begin to exceed a control limit. The limit is based on the rationale that if the monitoring point remains unchanged from the baseline condition, new standardized observations should not deviate substantially from the baseline mean. If a change occurs, the standardized values will deviate significantly from the baseline and tend to exceed the control limit.

A minimum of eight samples are recommended for use in ChemStat® software to define the baseline for a control chart. Therefore, only sample sets with greater than eight samples were selected for control charts. By default, the ChemStat® software plots both a CUSUM control limit (h) and a SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit (h) and a value of 4.5 for the SCL.

EPA Unified Guidance suggests that to simplify the interpretation of the control chart that an out of control condition be based on the CUSUM (h) limit alone. Plotting the SCL limit is not needed. The ChemStat® software though, by default, plots both the SCL and CUSUM (h) control limits on the charts. As a "work-a-round", the SCL limit was defined as 5 to match the recommended CUSUM limit. On the charts the combined limit is identified as hCL. For interpretation purposes, regard hCL as the CUSUM limit (h).

As shown in Table A.5.6–1 in gray shading, thirteen parameters in the HTW and/or GMA wells of Cell 6 (uranium, chloride, TDS, TOC, barium, calcium, iron, lithium, magnesium, manganese, nickel, sodium, and zinc) meet the criteria for control charts (i.e., more than 8 samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in 17 control charts.

Control charts are presented in Figures A.5.6–30 to A.5.6–46. All of the control charts with the exception of one (i.e., iron in the GMA-D well) exhibit "in control" conditions. As discussed above, separate and distinct signatures for uranium and sodium in the LCS, LDS, and HTW of Cell 6 indicate that water is not mixing between the horizons, so out of control conditions are attributed to fluctuating ambient conditions beneath the cell, and not to cell performance.

Parameter and Monitoring Point[a]	Assessment
Uranium in the GMA-D	In Control
Chloride in the HTW	In Control
TDS in the GMA-U	In Control
TOC in the HTW	In Control
Barium in the HTW	In Control
Calcium in the HTW	In Control
Iron in the GMA-U	In Control
Iron in the GMA-D	**Out of Control**
Lithium in the GMA-U	In Control
Lithium in the GMA-D	In Control
Magnesium in the HTW	In Control
Manganese in the HTW	In Control
Manganese in the GMA-D	In Control
Nickel in the HTW	In Control
Sodium in the GMA-D	In Control
Zinc in the GMA-U	In Control
Zinc in the GMA-D	In Control

[a] HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer; TDS = total dissolved solids; TOC = total organic carbon

A.5.6.3 Annual LCS Sample Results

Annual LCS sampling results for Cell 6 are provided in Table A.5.6–2 for those parameters detected at least once, and not being sampled quarterly. One new Appendix I parameter (chromium) was detected in 2010 at Cell 6. Chromium was detected again in the LCS of Cell 6 in 2011. As directed in the GWLMP, detection of chromium again in the LCS of Cell 6 in 2011 triggers sampling for chromium in the LDS of Cell 6 during the subsequent next scheduled sampling event. No new Appendix I or PCB parameters were detected in the LCS of Cell 6 in 2011.

A.5.6.4 Summary and Conclusions

- The concentrations of ten parameters monitored quarterly are increasing in either the HTW and/or GMA wells of Cell 6 (uranium, sulfate, TDS, TOC, arsenic, boron, cobalt, copper, iron, and lithium).
- Separate and distinct chemical signatures for uranium and sodium in the LCS, LDS, and HTW of Cell 6 indicate that water is not mixing between the horizons. Concentration increases in the HTW and GMA wells of Cell 6 are attributed to fluctuating ambient concentrations beneath the cell and not to cell performance.
- Seventeen control charts were constructed for Cell 6 parameters. Sixteen of the control charts exhibit "in control" conditions. Iron in the GMA-D well exhibits "out of control" conditions.
- No new Appendix I or PCB parameters were detected in the LCS of Cell 6 in 2011.
- Chromium was detected in the LCS of Cell 6 for a second time in 2011. It was first detected in 2010. Because chromium has been detected two consecutive times in the LCS, chromium will be sampled for in the LDS of Cell 6 during the subsequent next scheduled sampling event.

Table A.5.6–1. Summary Statistics for Cell 6

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12343C	32	32	100.0	43.3	197	136	32	Undefined	None	Detected	
	LDS	12343D	32	32	100.0	3.10	43.7	23.2	9.0	Normal	Up	Detected	
	HTW	12343	32	32	100.0	6.32	24.2	12.1	3.8	Lognormal	Up	Detected	
	GMA-U	22209	32	36	88.9	ND	2.43	0.53	0.47	Undefined	None	Not Detected	
	GMA-D	22210	35	37	94.6	ND	0.95	0.63	0.18	Normal	None	Not Detected	
Alkalinity as CaCO3 (mg/L)	LCS	12343C	18	18	100.0	64.0	557	454	104	Normal	Down	Not Detected	
	LDS	12343D	14	14	100.0	161	549	356	129	Normal	None	Not Detected	
	HTW	12343	9	9	100.0	353	714	389	112	Undefined	None	Not Detected	
	GMA-U	22209	5	5	100.0	273	340	318	27	Normal	None	Insuff	
	GMA-D	22210	4	4	100.0	405	409	406	2	Normal	None	Insuff	
Chloride (mg/L)	LCS	12343C	18	18	100.0	20.1	139	114	35	Undefined	Up	Not Detected	
	LDS	12343D	14	14	100.0	51.5	149	59	41	Undefined	Up	Detected	
	HTW	12343	9	9	100.0	24.0	26.9	25.1	1.0	Normal	None	Not Detected	
	GMA-U	22209	5	5	100.0	22.2	33.4	25.6	4.6	Normal	None	Insuff	
	GMA-D	22210	4	4	100.0	28.6	34.6	30.6	2.7	Normal	None	Insuff	
Nitriate/Nitrite as N (mg/L)	LCS	12343C	14	21	66.7	ND	4.67	0.995	1.39	Undefined	None	Detected	
	LDS	12343D	6	14	42.9	ND	4.1	0.0138	1.16	Undefined	Up	Detected	
	HTW	12343	1	8	12.5	ND	0.0264	Insuff	Insuff	Lognormal	None	Not Detected	
	GMA-U	22209	0	5	0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22210	0	4	0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Sulfate (mg/L)	LCS	12343C	32	32	100.0	491	4800	2360	950	Normal	Up	Detected	
	LDS	12343D	32	32	100.0	1300	3910	2140	810	Undefined	Up	Detected	
	HTW	12343	28	29	96.6	ND	595	446	81	Normal	Up	Detected	
	GMA-U	22209	35	35	100.0	2.07	406	188	73	Undefined	None	Not Detected	
	GMA-D	22210	35	35	100.0	127	578	264	90	Lognormal	Up	Detected	
Total Dissolved Solids (mg/L)	LCS	12343C	20	20	100.0	267	5970	5040	1800	Undefined	Up	Detected	
	LDS	12343D	12	12	100.0	3690	6340	5290	770	Normal	Up	Detected	
	HTW	12343	8	8	100.0	1210	1350	1290	50	Normal	None	Not Detected	
	GMA-U	22209	11	11	100.0	573	876	672	78	Normal	None	Not Detected	876 (Q3-11)
	GMA-D	22210	11	11	100.0	827	992	911	40	Normal	Up	Detected	
Total Organic Carbon (mg/L)	LCS	12343C	29	32	90.6	ND	3.55	2.15	0.61	Normal	None	Not Detected	14.6 (Q4-03)
	LDS	12343D	30	32	93.8	ND	10.4	4.85	2.17	Normal	Down	Detected	
	HTW	12343	24	29	82.8	ND	4.93	2.34	0.71	Lognormal	None	Not Detected	
	GMA-U	22209	24	36	66.7	ND	2.28	1.23	0.46	Normal	Up	Detected	
	GMA-D	22210	25	36	69.4	ND	2.39	1.30	0.46	Normal	Up	Detected	
Total Organic Halogens (mg/L)	LCS	12343C	21	32	65.6	ND	0.060	0.0153	0.0119	Lognormal	None	Not Detected	
	LDS	12343D	24	32	75.0	ND	0.0446	0.0245	0.0109	Normal	None	Not Detected	0.091 (Q2-10)
	HTW	12343	14	29	48.3	ND	0.0560	0.00869	0.0105	Lognormal	Down	Not Detected	
	GMA-U	22209	8	36	22.2	ND	0.0377	0.00303	0.00883	Undefined	None	Detected	
	GMA-D	22210	6	36	16.7	ND	0.0125	0.00204	0.00415	Undefined	Down	Not Detected	0.059 (Q2-10)
Arsenic (mg/L)	LCS	12343C	4	23	17.4	ND	0.093	0.00375	0.0282	Undefined	None	Detected	
	LDS	12343D	4	21	19.0	ND	0.023	0.00375	0.00518	Undefined	None	Not Detected	
	HTW	12343	1	19	5.3	ND	0.033	Insuff	Insuff	Undefined	None	Not Detected	
	GMA-U	22209	5	11	45.4	ND	0.0396	0.00250	0.0133	Undefined	None	Not Detected	
	GMA-D	22210	5	20	25.0	ND	0.0381	0.00250	0.0116	Undefined	Up	Detected	
Barium (mg/L)	LCS	12343C	18	18	100.0	0.0190	0.0868	0.0373	0.0195	Lognormal	Down	Detected	
	LDS	12343D	14	14	100.0	0.0127	0.067	0.0298	0.0138	Lognormal	Down	Detected	
	HTW	12343	9	9	100.0	0.0307	0.0427	0.0354	0.0038	Normal	None	Not Detected	
	GMA-U	22209	4	4	100.0	0.0738	0.093	0.0855	0.0084	Normal	None	Insuff	
	GMA-D	22210	4	4	100.0	0.0332	0.0459	0.0403	0.0054	Normal	None	Insuff	

Table A.5.6-1 (continued). Summary Statistics for Cell 6

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Boron (mg/L)	LCS	12343C	32	32	100.0	0.0566	1.37	0.782	0.248	Undefined	None	Detected	
	LDS	12343D	32	32	100.0	0.289	2.38	0.392	0.385	Undefined	None	Detected	
	HTW	12343	25	29	86.2	ND	0.124	0.0857	0.0212	Normal	None	Detected	
	GMA-U	22209	31	36	86.1	ND	0.0447	0.0363	0.0080	Undefined	None	Not Detected	
	GMA-D	22210	33	36	91.7	ND	0.0468	0.0340	0.0075	Undefined	Up	Detected	
Calcium (mg/L)	LCS	12343C	18	18	100.0	225	996	516	159	Undefined	None	Not Detected	
	LDS	12343D	14	14	100.0	302	518	392	70	Normal	None	Not Detected	
	HTW	12343	9	9	100.0	150	228	176	23	Normal	None	Not Detected	
	GMA-U	22209	4	4	100.0	144	242	148	48	Undefined	None	Insuff	
	GMA-D	22210	4	4	100.0	212	235	221	10	Normal	None	Insuff	
Cobalt (mg/L)	LCS	12343C	11	23	47.8	ND	0.0029	0.00075	0.00076	Undefined	None	Detected	
	LDS	12343D	10	21	47.6	ND	0.0105	0.00076	0.00215	Undefined	Down	Not Detected	
	HTW	12343	12	16	75.0	ND	0.00666	0.00230	0.00224	Lognormal	Up	Not Detected	0.0333 (Q4-10)
	GMA-U	22209	0	11	0.0	NA	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22210	0	11	0.0	NA	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Copper (mg/L)	LCS	12343C	15	19	79.0	ND	0.0254	0.00992	0.00700	Normal	None	Not Detected	
	LDS	12343D	11	16	68.8	ND	0.0224	0.0104	0.0076	Normal	None	Not Detected	
	HTW	12343	6	10	60.0	ND	0.0150	0.00803	0.00507	Normal	Up	Not Detected	
	GMA-U	22209	4	4	100.0	0.000928	0.00815	0.00491	0.00302	Normal	None	Insuff	
	GMA-D	22210	4	4	100.0	0.00302	0.0109	0.00742	0.00329	Normal	None	Insuff	
Iron (mg/L)	LCS	12343C	12	23	52.2	ND	4.48	0.0719	1.58	Undefined	Down	Detected	
	LDS	12343D	15	21	71.4	ND	3.69	0.215	1.15	Undefined	Down	Detected	
	HTW	12343	16	16	100.0	0.23	31.9	6.88	8.46	Lognormal	Up	Not Detected	
	GMA-U	22209	11	11	100.0	3.35	5.58	4.21	0.72	Lognormal	None	Not Detected	
	GMA-D	22210	11	11	100.0	1.57	4.55	2.33	0.92	Lognormal	None	Not Detected	
Lithium (mg/L)	LCS	12343C	20	20	100.0	0.0234	0.267	0.134	0.063	Normal	Up	Detected	
	LDS	12343D	20	20	100.0	0.0703	0.193	0.114	0.036	Normal	Up	Detected	
	HTW	12343	15	16	93.8	ND	0.0124	0.0111	0.0018	Undefined	Up	Not Detected	
	GMA-U	22209	11	11	100.0	0.00524	0.00739	0.00597	0.00071	Normal	None	Not Detected	
	GMA-D	22210	11	11	100.0	0.00631	0.00797	0.0073	0.0006	Normal	None	Not Detected	
Magnesium (mg/L)	LCS	12343C	18	18	100.0	92.4	791	334	238	Undefined	Up	Detected	
	LDS	12343D	14	14	100.0	130	494	190	130	Undefined	Up	Detected	
	HTW	12343	9	9	100.0	65.1	83.5	76.7	5.4	Normal	None	Not Detected	
	GMA-U	22209	4	4	100.0	27.0	31.6	29.5	2.0	Normal	None	Insuff	
	GMA-D	22210	4	4	100.0	50.8	55.5	52.3	2.2	Normal	None	Insuff	
Manganese (mg/L)	LCS	12343C	9	23	39.1	ND	1.41	0.0069	0.307	Undefined	None	Not Detected	
	LDS	12343D	10	21	47.6	ND	0.0913	0.0152	0.0202	Lognormal	None	Not Detected	3.24 (Q4-03)
	HTW	12343	16	16	100.0	0.0212	1.18	0.305	0.305	Lognormal	None	Not Detected	
	GMA-U	22209	11	11	100.0	0.243	0.287	0.267	0.014	Normal	Down	Not Detected	0.748 (Q3-11)
	GMA-D	22210	20	20	100.0	0.0735	0.420	0.203	0.102	Lognormal	None	Not Detected	
Nickel (mg/L)	LCS	12343C	18	23	78.3	ND	0.0319	0.0128	0.0101	Lognormal	Down	Detected	
	LDS	12343D	15	21	71.4	ND	0.0572	0.0111	0.0119	Lognormal	Down	Detected	
	HTW	12343	12	16	75.0	0.00151	0.0472	0.00959	0.011	Normal	None	Not Detected	47.2 (Q3-10)
	GMA-U	22209	0	11	0.0	NA	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22210	18	20	90.0	ND	0.0099	0.00376	0.00274	Lognormal	Down	Detected	
Potassium (mg/L)	LCS	12343C	18	18	100.0	9.0	75.5	25.5	14.0	Lognormal	Up	Detected	
	LDS	12343D	14	14	100.0	24.5	69.8	29.4	13.8	Undefined	None	Detected	
	HTW	12343	9	9	100.0	2.66	4.27	3.31	0.49	Normal	None	Detected	
	GMA-U	22209	4	4	100.0	3.0	3.78	3.33	0.33	Normal	None	Insuff	
	GMA-D	22210	4	4	100.0	3.14	3.62	3.39	0.20	Normal	None	Insuff	

Table A.5.6–1 (continued). Summary Statistics for Cell 6

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Selenium (mg/L)	LCS	12343C	5	23	21.7	ND	0.140	0.00625	0.0304	Undefined	None	Not Detected	
	LDS	12343D	3	21	14.3	ND	0.0545	0.00893	Insuff	Lognormal	None	Not Detected	
	HTW	12343	0	16	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-U	22209	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22210	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Sodium (mg/L)	LCS	12343C	23	23	100.0	23.1	107	61.0	18.3	Normal	Up	Not Detected	
	LDS	12343D	21	21	100.0	109	532	430	84	Undefined	Up	Detected	
	HTW	12343	19	19	100.0	33.9	66.0	52.1	9.7	Normal	None	Detected	
	GMA-U	22209	11	11	100.0	15.2	22.5	19.0	2.1	Normal	Down	Detected	
	GMA-D	22210	11	11	100.0	17.4	20.4	18.6	0.9	Normal	None	Not Detected	
Zinc (mg/L)	LCS	12343C	8	23	34.8	ND	0.0432	0.0127	0.0096	Lognormal	None	Not Detected	
	LDS	12343D	13	21	61.9	ND	2.61	0.0321	0.626	Undefined	Up	Detected	
	HTW	12343	14	16	87.5	0.0108	7.19	0.0228	1.78	Undefined	None	Not Detected	
	GMA-U	22209	4	11	36.4	ND	0.0133	0.00576	0.00420	Normal	None	Not Detected	
	GMA-D	22210	15	20	75.0	ND	0.0244	0.0117	0.0061	Lognormal	None	Not Detected	

Note: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least 8 samples, normal or lognormal distribution, no trend, and no serial correlation. These wells achieve control chart criteria.

Note: For results where the concentrations are below the detection limit, the results used in the Average, Standard Deviation, Distribution Type, Trend, Serial Correlation, and Outliers are each set at half the detection limit.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption and requires $n \geq 3$. In addition, Standard Deviation requires $n \geq 4$.

[d]"Insuff" = Insufficient and is used for Average, Standard Deviation, Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic (where $3 \leq n \leq 50$) or Shapiro Francia (where $n > 50$).

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the lognormal assumption.

Lognormal: Lognormal assumption could not be rejected at the 5 percent level and has a higher probability value than the normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25% detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure. Trend testing requires a sample with $n \geq 4$.

[g]Serial correlation based on Rank Von Neumann test. Serial Correlation testing requires a sample with $n \geq 6$.

[h]Outliers determined by Rosner's (where $n > 25$) or Dixon procedure (where $4 \leq n \leq 25$).

[i]Q = quarterly

Table A.5.6-2. Cell 6 Annual LCS Sample Summary Information for Detected Parameters

PARAMETER(UNIT)	NUMBER OF SAMPLES[a,b]	NUMBER OF SAMPLES WITH DETECTIONS[a,b]	PERCENT OF DETECTIONS[a,b]	DETECTED IN 2011	MIN DETECTED CONCENTRATION[a,b,c]	MAX DETECTED CONCENTRATION[a,b,c]	AVG DETECTED CONCENTRATION[a,b,c]	GW FRL[d] (#OF SAMPLES>GWFRL)	GW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	PW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	MAX PW DETECTED CONCENTRATION [a,b,f] (# OF SAMPLES>MAX PW)
General Chemistry											
Ammonia (mg/L)	9	3	33.3	Yes	0.0198	1	0.369	-	4.2 mg/L(0)	4.34 mg/L(0)	220 mg/L(0)
Inorganic											
Chromium (mg/L)	9	2	22.2	Yes	0.00288	0.0058	0.0043	0.022 mg/L[g](0)	0.021 mg/L(0)	0.0046 mg/L(1)	0.818 mg/L(0)
Mercury (mg/L)	15	1	6.7	No	0.000338	-	-	0.002 mg/L(0)	-	-	0.0018 mg/L(0)
Vanadium (mg/L)	9	1	11.1	No	0.00088	-	-	0.038 mg/L(0)	0.012 mg/L(0)	0.005 mg/L(0)	0.299 mg/L(0)
Radionuclides											
Technetium-99 (pCi/L)	15	4	26.7	No	1.83	11.7	7.22	94 pCi/L(0)	22 pCi/L(0)	30 pCi/L(0)	6130 pCi/L(0)
Organics											
Acetone (ug/L)	9	1	11.1	No	2.66	-	-	-	-	-	-
Toluene (ug/L)	9	1	11.1	No	0.716	-	-	-	-	-	-

Note: Shading indicates that at least one detected sample is greater than the FRL, groundwater background, PW background, or PW maximum.

[a]If more than one sample is collected per well per day (e.g., duplicates), then only one sample is counted for the total number of samples, and the sample with the maximum representative concentration is used for all the summary information

[b]Rejected data qualified with an R or Z were not included.

[c]If the number of detected samples is equal to two, then the minumun and maximumn are reported. If the number of detected is equal to one, then the data point is reported as the minimum. The "AVG DETECTED CONCENTRATION" is not reported for either of these cases.

[d]From Operable Unit 5 Record of Decision, Table 9-4.

[e]From the Characterization of Background Water Quality for Streams and Groundwater which was developed for Operable Unit 5 RI/FS documents.

[f]Max PW - maximum detected concentration in perched water as defined in the Remedial Investigation Report for Operable Unit 5.

[g]FRL based on hexavalent chromium from Operable Unit 5 Record of Decision, Table 9-4.

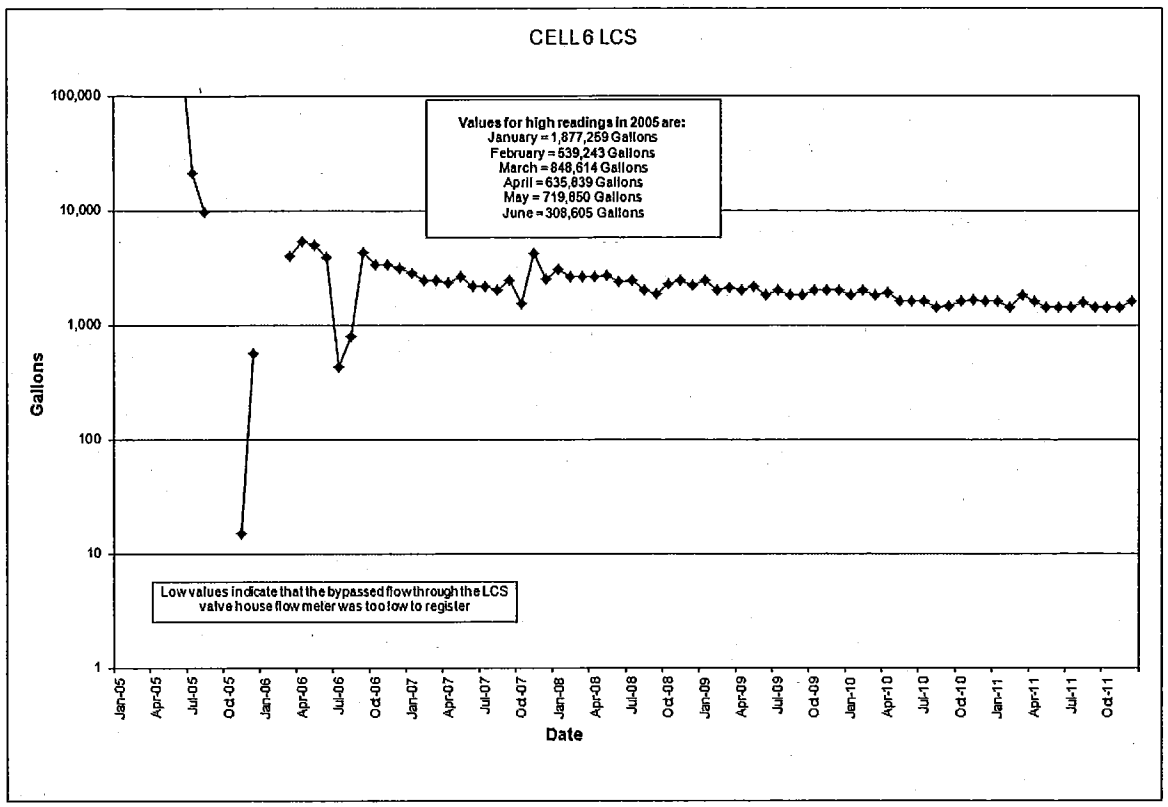


Figure A.5.6–1. Monthly Accumulation Volumes for Cell 6 LCS

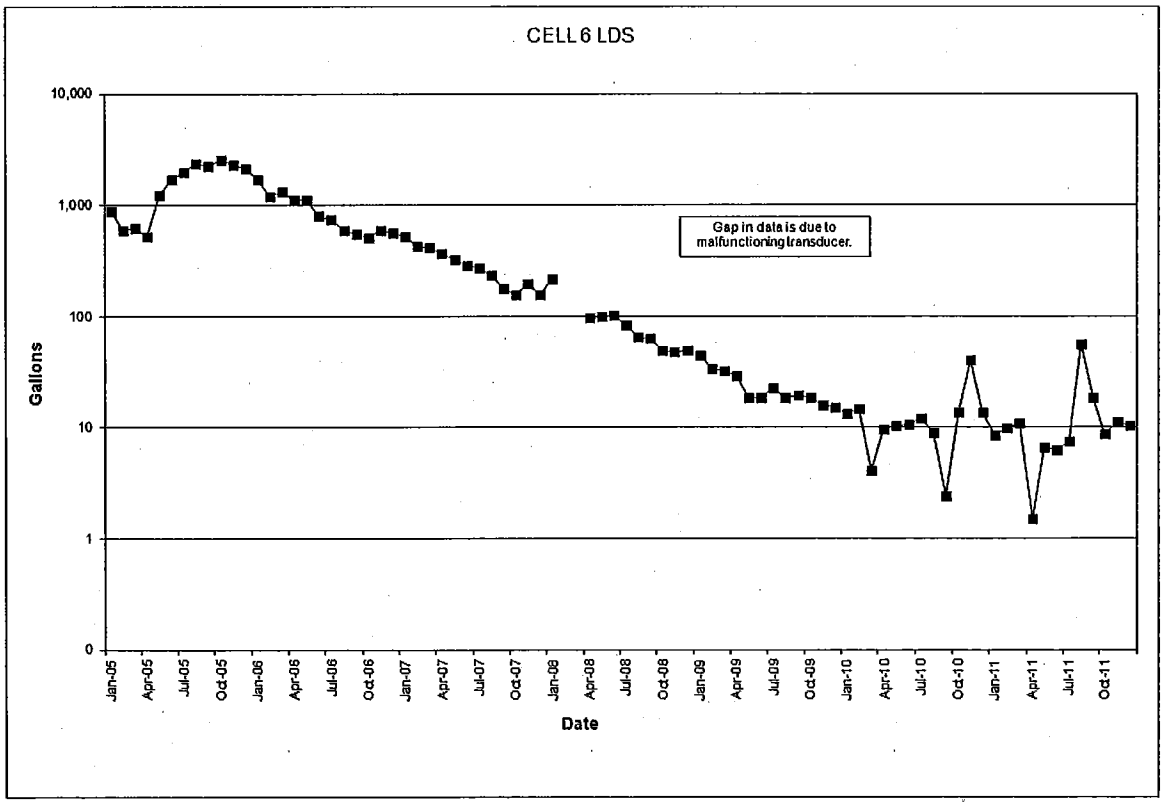
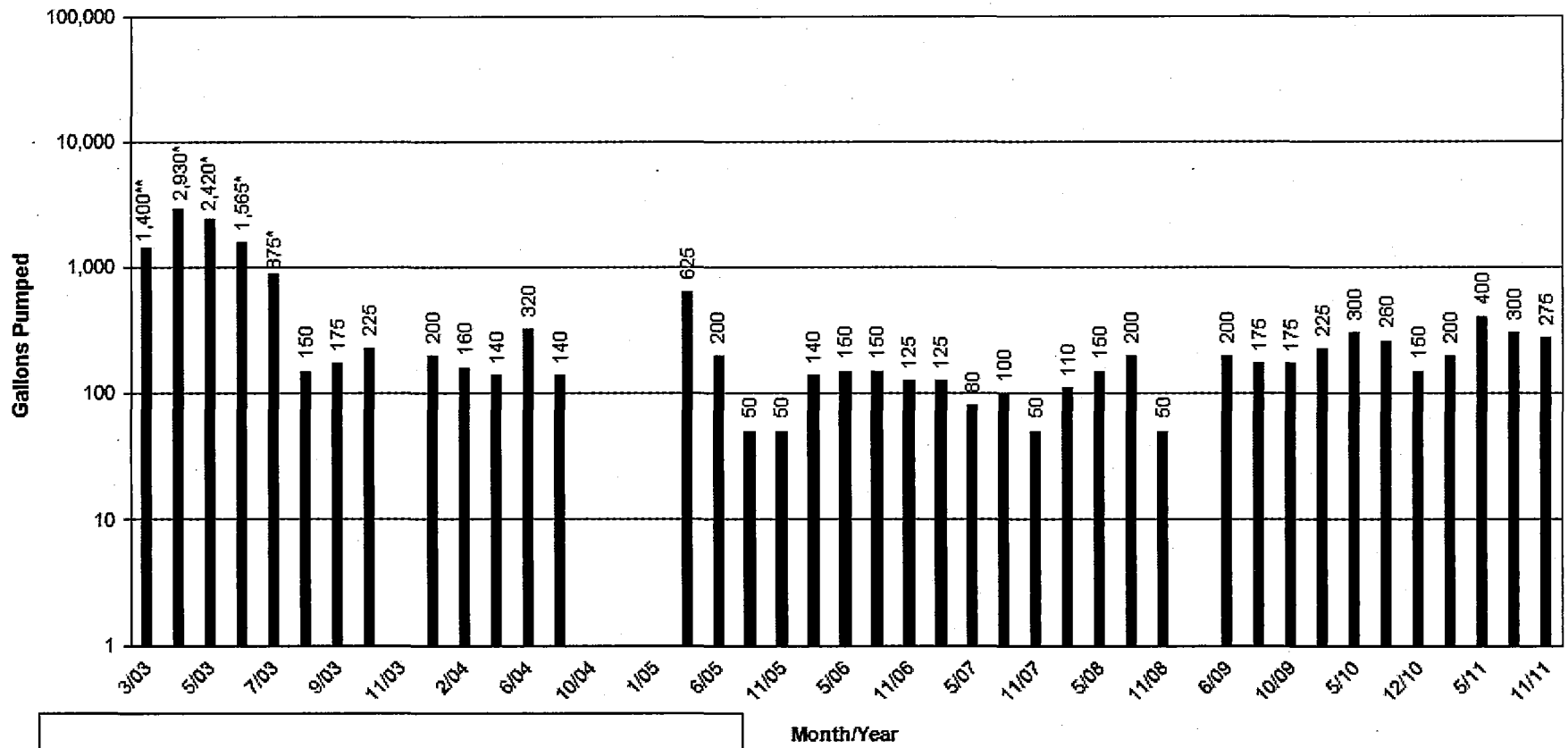


Figure A.5.6–2. Monthly Accumulation Volumes for Cell 6 LDS



12343 Purge Information

Year	Total Volumes (gal.)	Months Purged	Avg. Monthly Purge (gal.)
2003:	9940	n=10	994
2004:	760	n=6	127
2005:	925	n=5	185
2006:	565	n=4	141
2007:	355	n=4	89
2008:	510	n=4	128
2009:	550	n=3	183
2010:	935	n=4	234
2011:	1175	n=4	294
Overall:			357

*More than one purge of the well was completed during these months to drain perched water and infiltrating surface water so the compacted clay liner could be constructed.

**Excess water was pumped from this well in March 2003 for well development.

Figure A.5.6–3. OSDF Horizontal Till Well 12343 (Cell 6) Water Yield

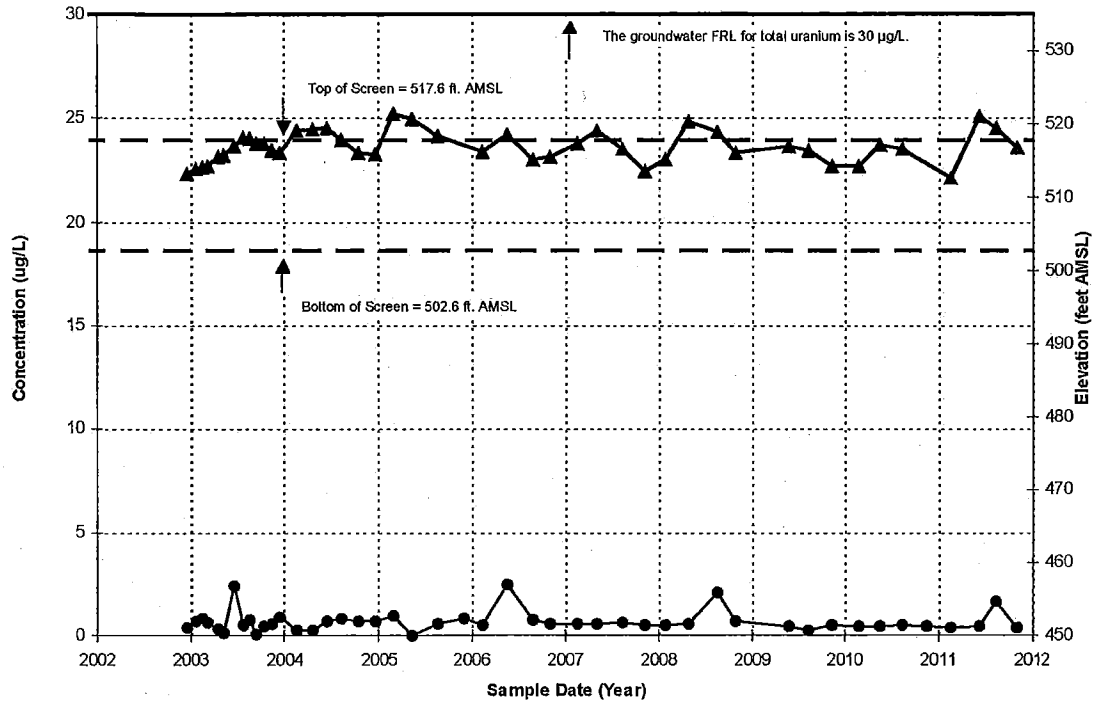


FIGURE A.5.6-4. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 6 Upgradient Monitoring Well 22209

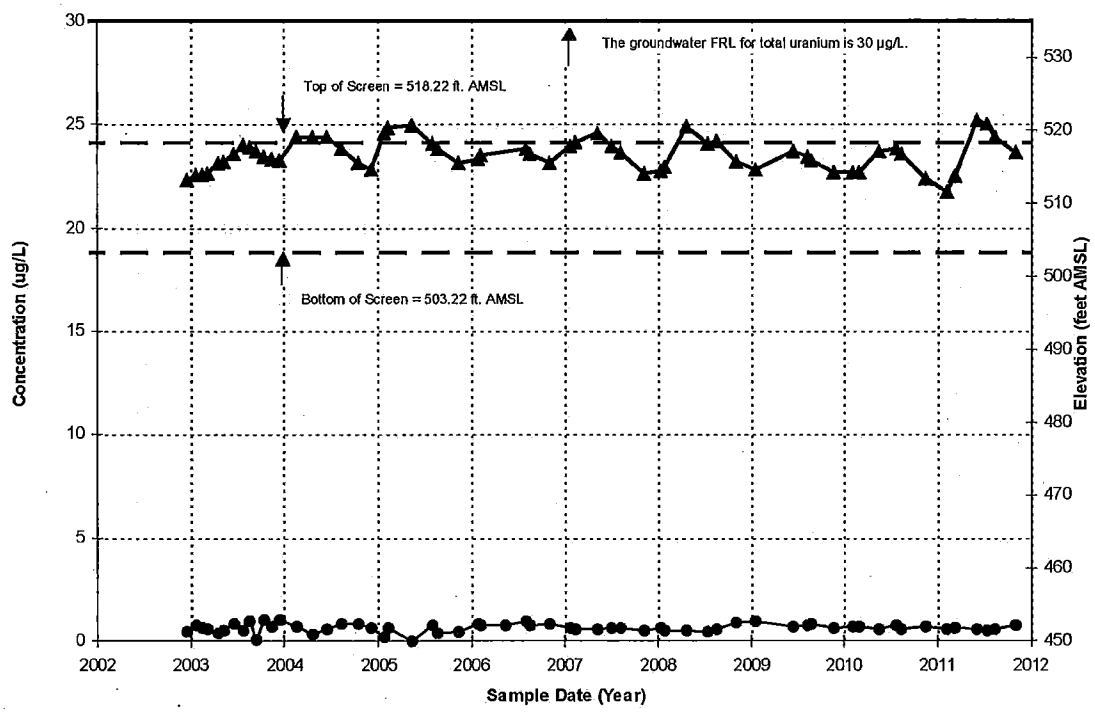


FIGURE A.5.6-5. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 6 Downgradient Monitoring Well 22210

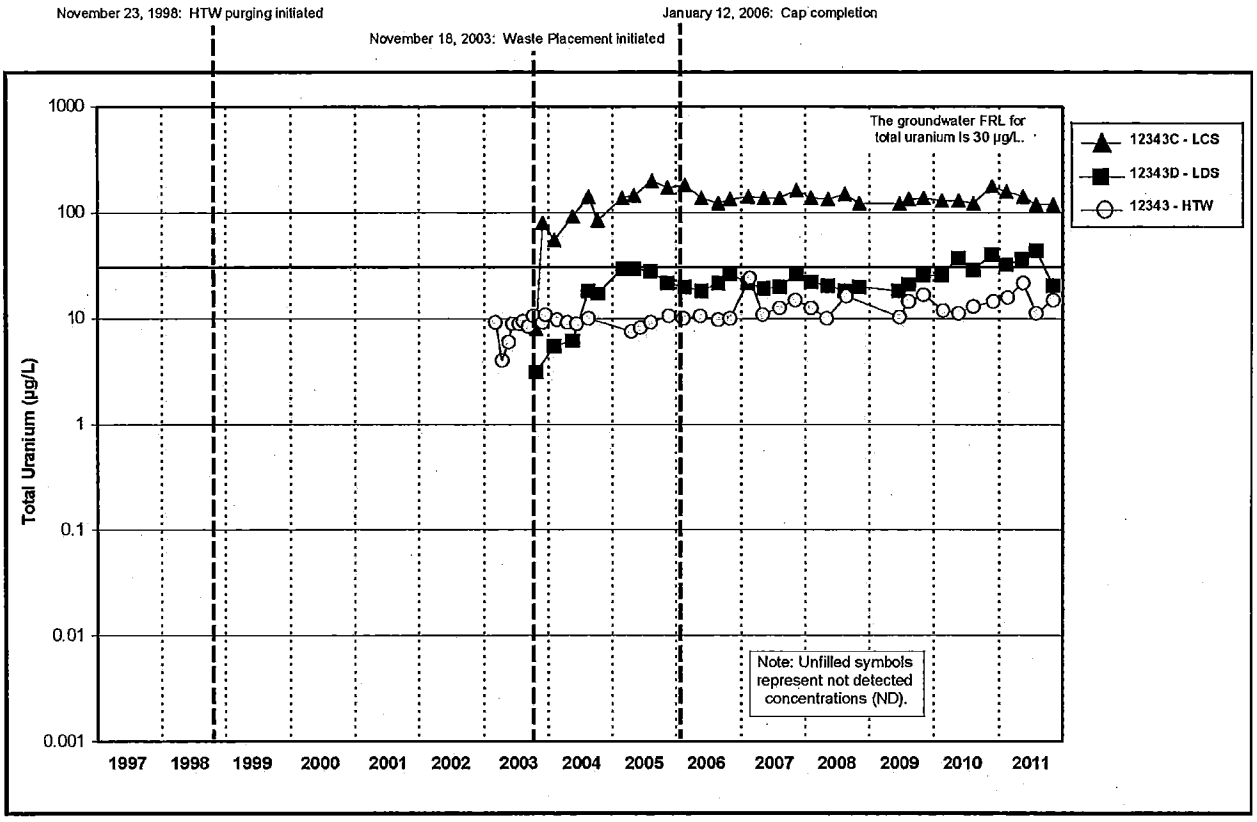


Figure A.5.6-6A. Cell 6 Uranium, Total Concentration vs. Time Plot for LCS, LDS, and HTW

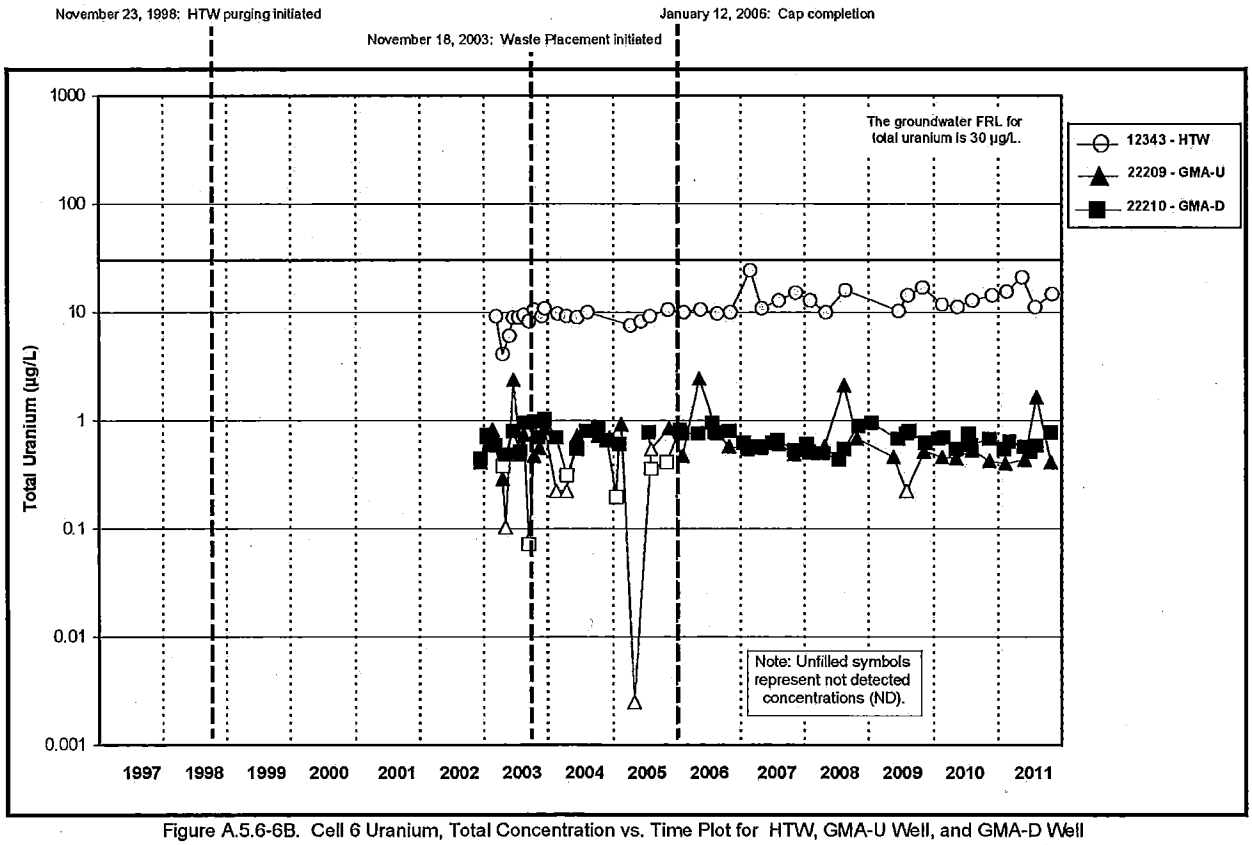


Figure A.5.6-6B. Cell 6 Uranium, Total Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

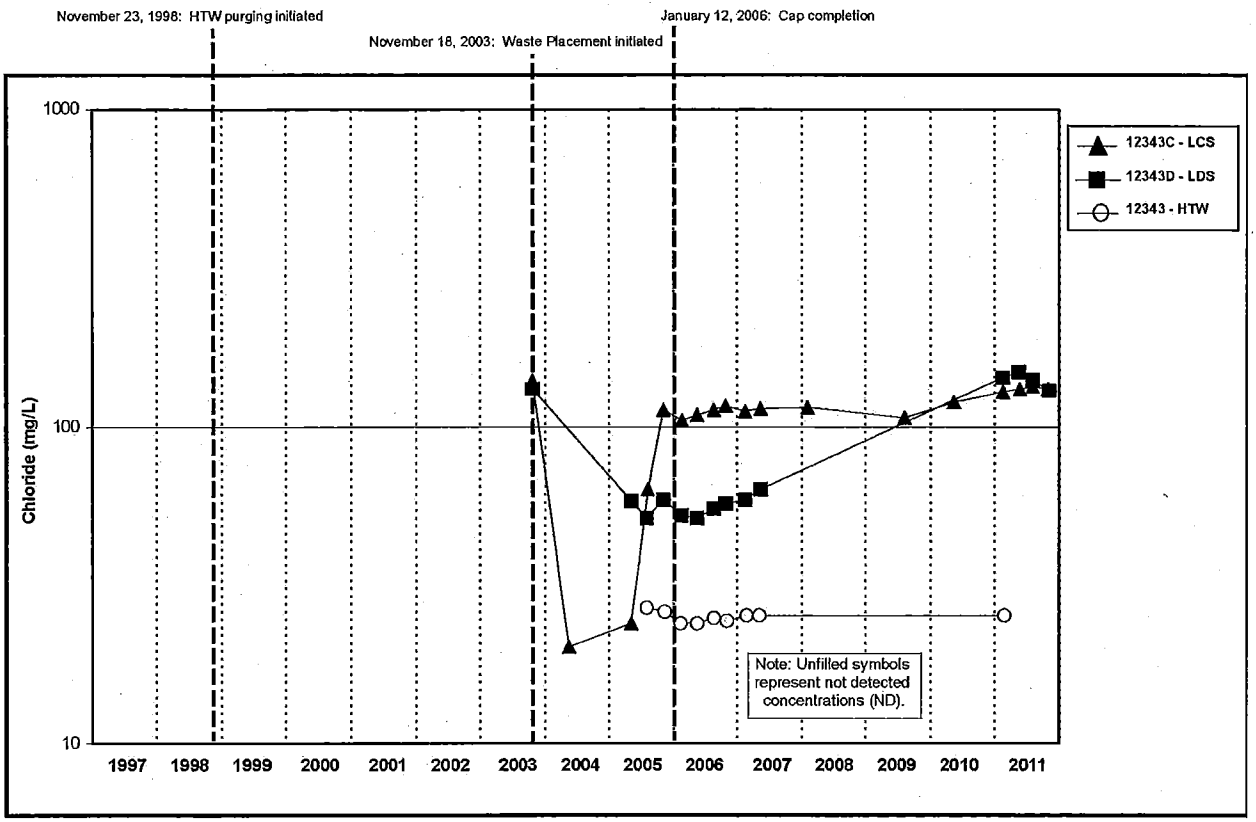


Figure A.5.6-7A. Cell 6 Chloride Concentration vs. Time Plot for LCS, LDS, and HTW

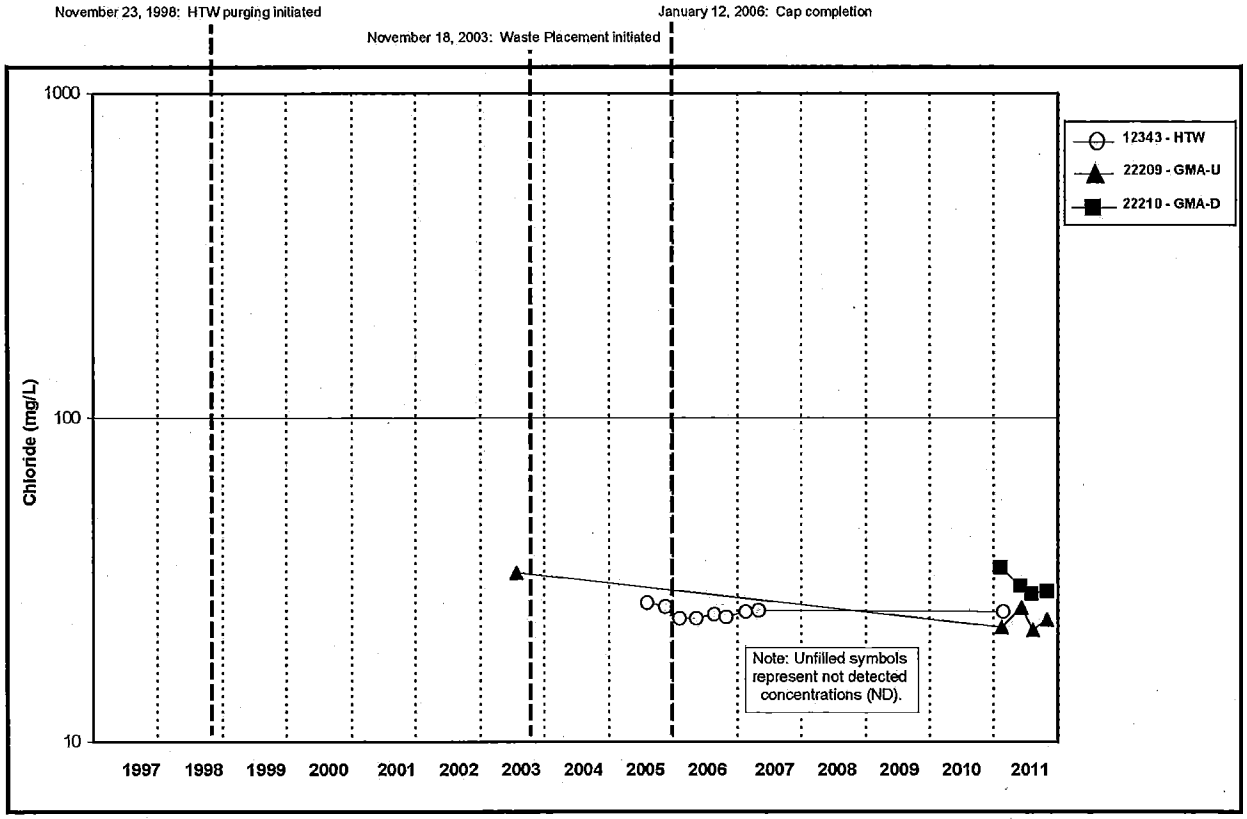


Figure A.5.6-7B. Cell 6 Chloride Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

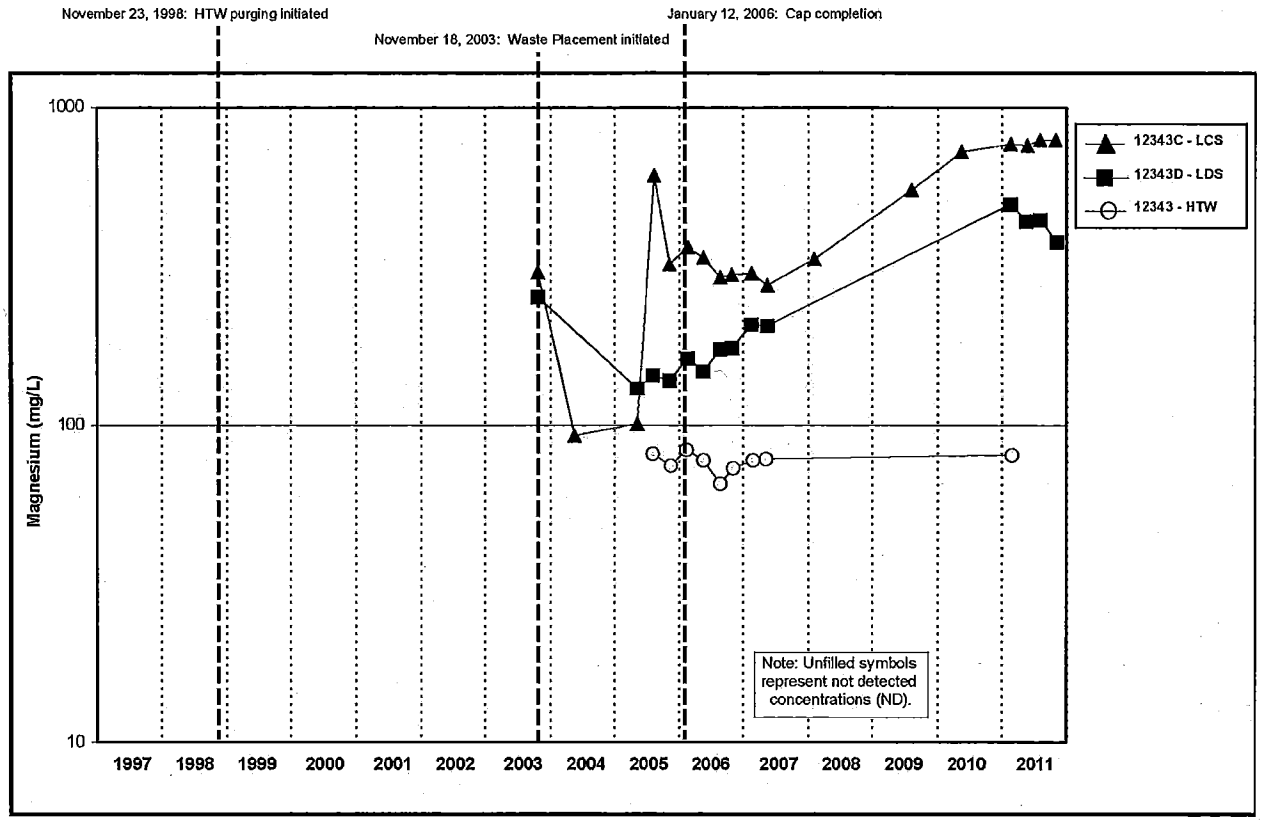


Figure A.5.6-8A. Cell 6 Magnesium Concentration vs. Time Plot for LCS, LDS, and HTW

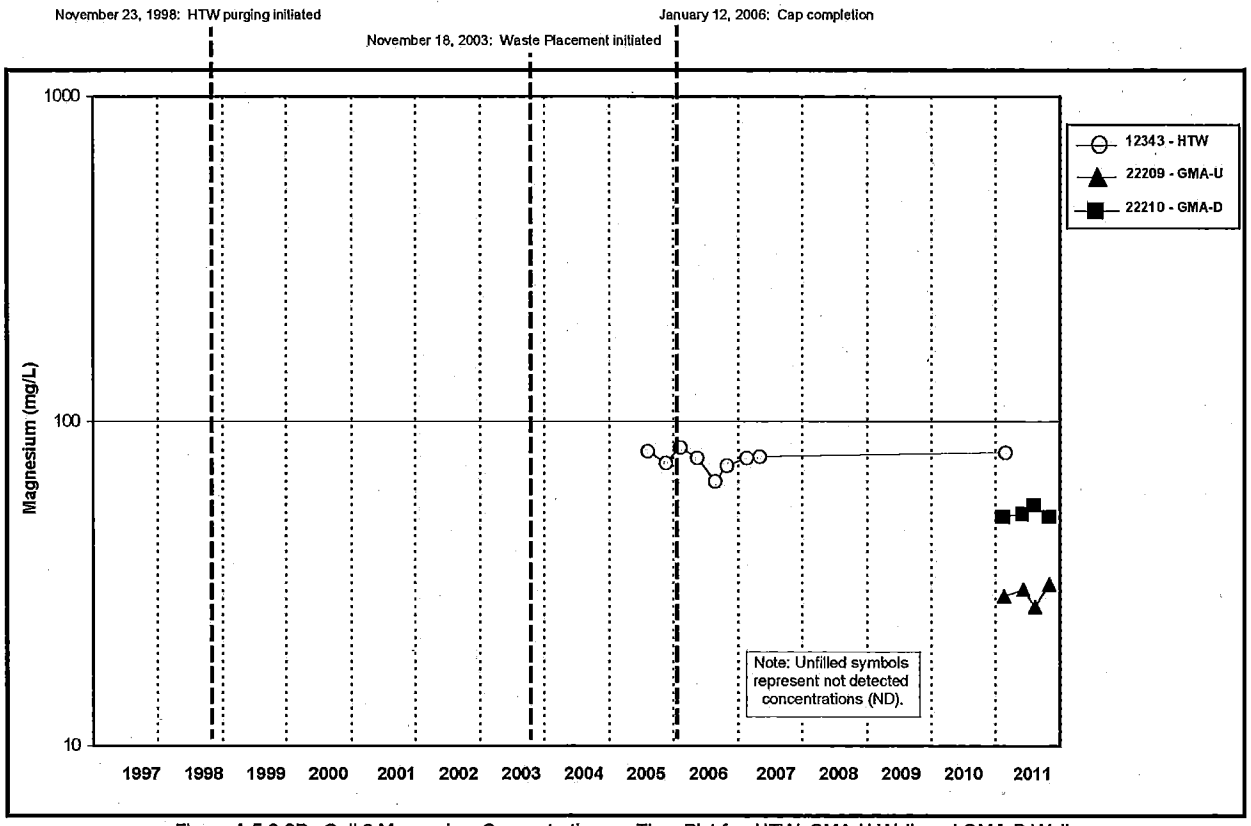


Figure A.5.6-8B. Cell 6 Magnesium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

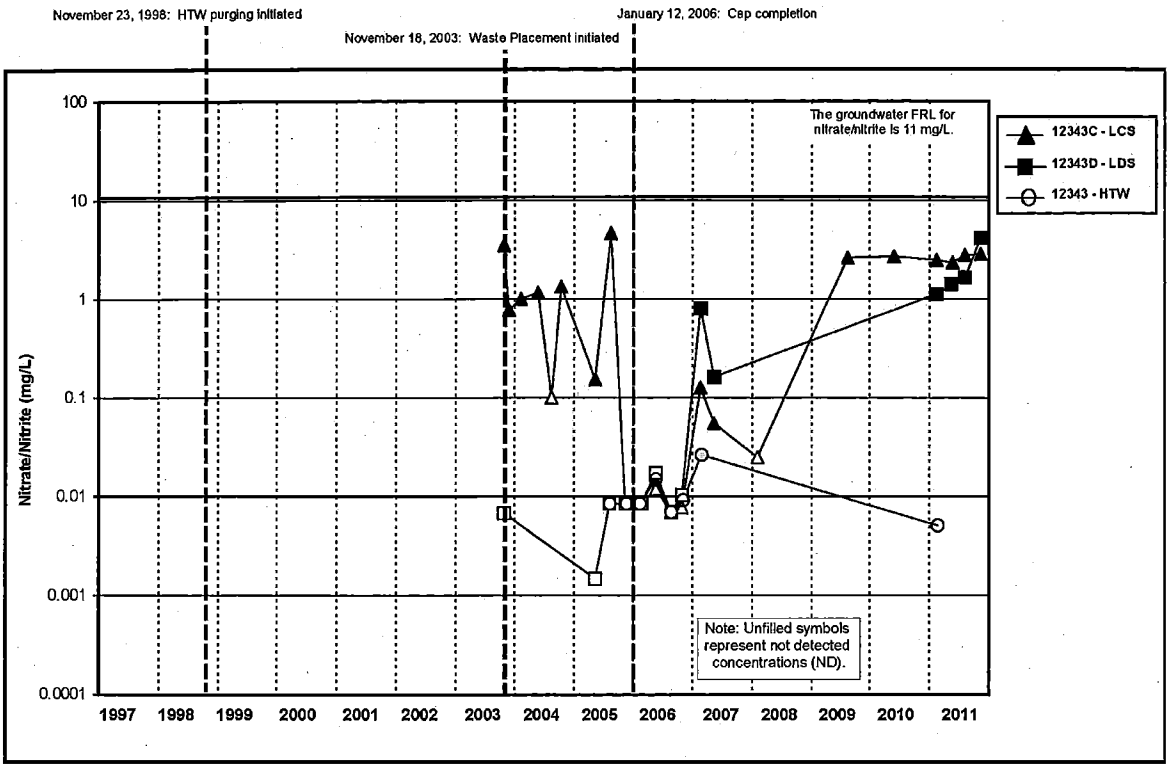


Figure A.5.6-9A. Cell 6 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for LCS, LDS, and HTW

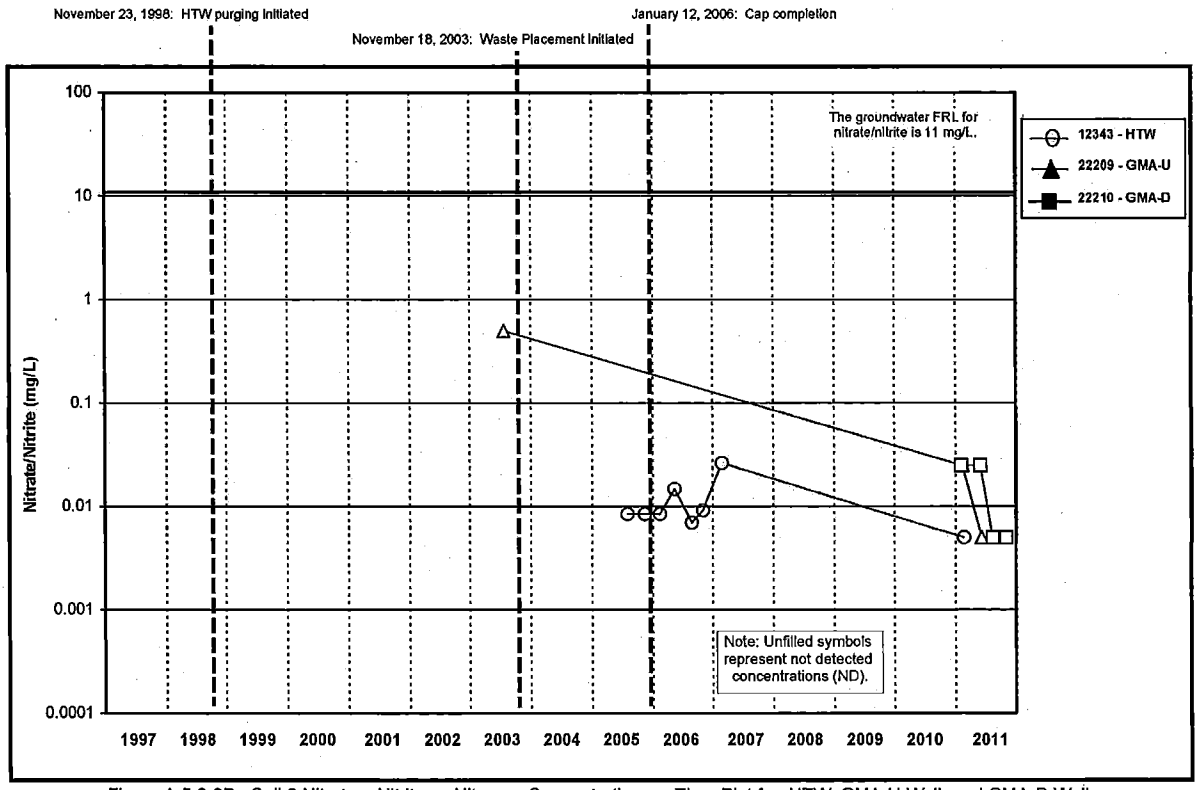


Figure A.5.6-9B. Cell 6 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

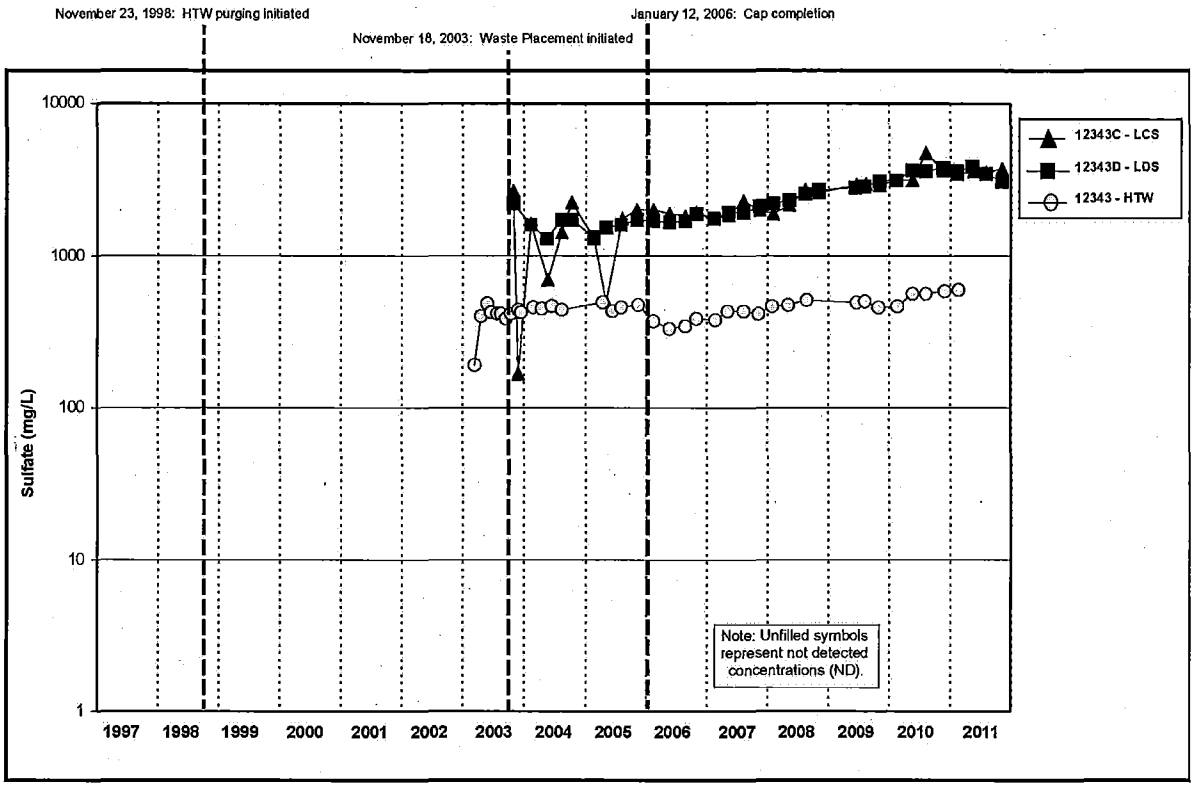


Figure A.5.6-10A. Cell 6 Sulfate Concentration vs. Time Plot for LCS, LDS, and HTW

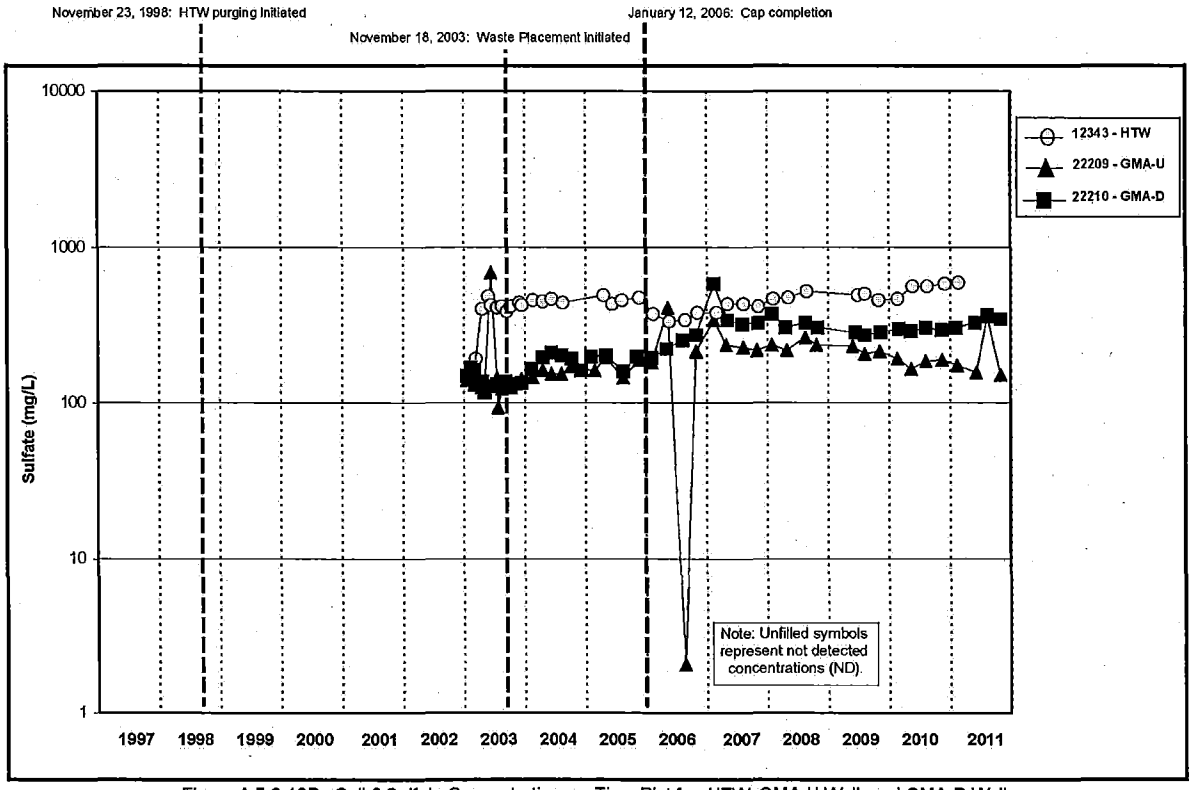


Figure A.5.6-10B. Cell 6 Sulfate Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

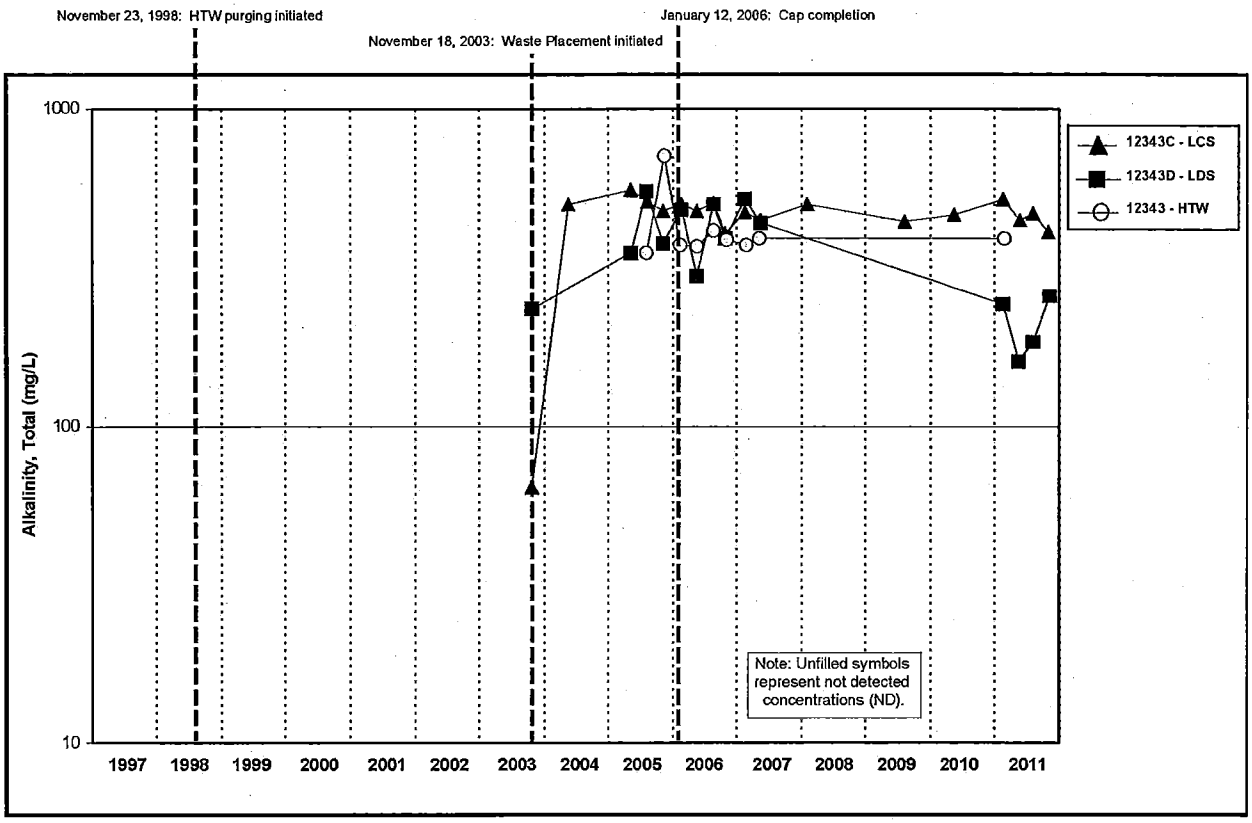


Figure A.5.6-11A. Cell 6 Alkalinity, Total Concentration vs. Time Plot for LCS, LDS, and HTW

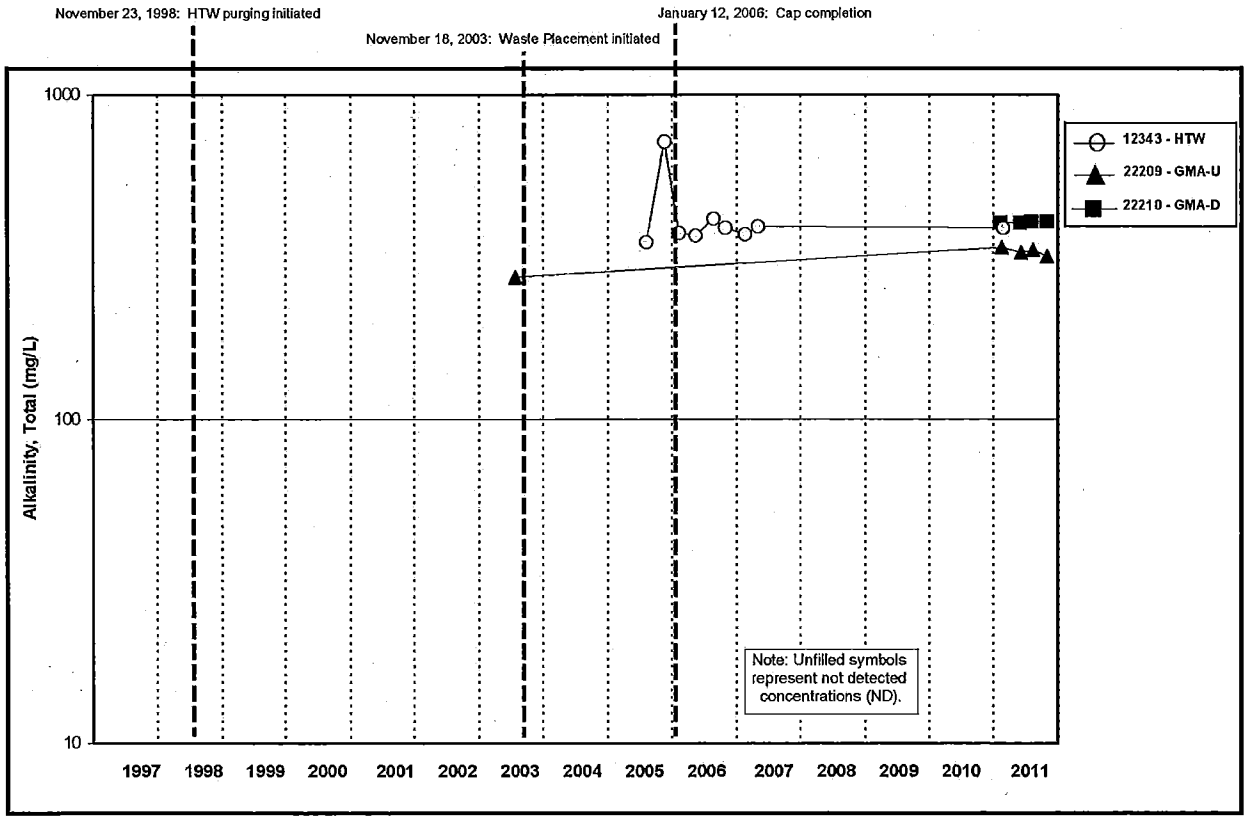


Figure A.5.6-11B. Cell 6 Alkalinity, Total Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

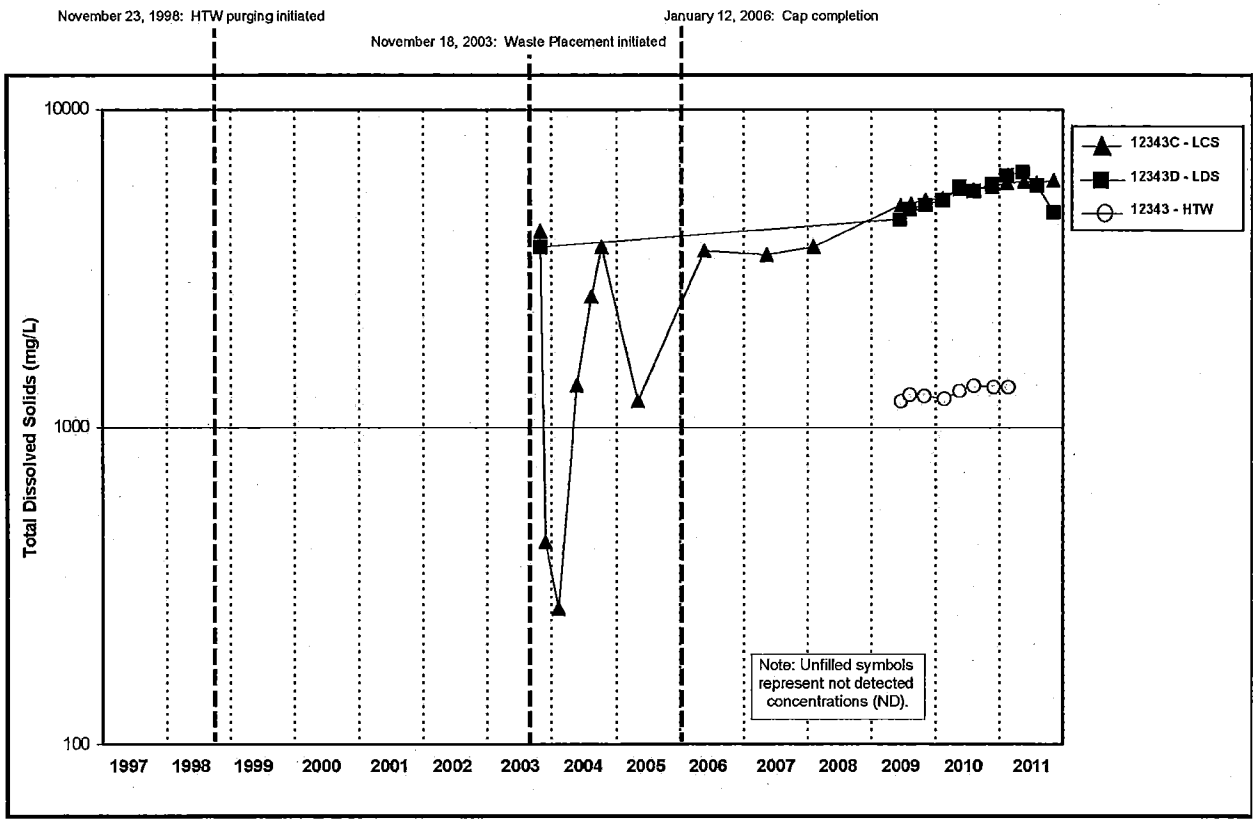


Figure A.5.6-12A. Cell 6 Total Dissolved Solids Concentration vs. Time Plot for LCS, LDS, and HTW

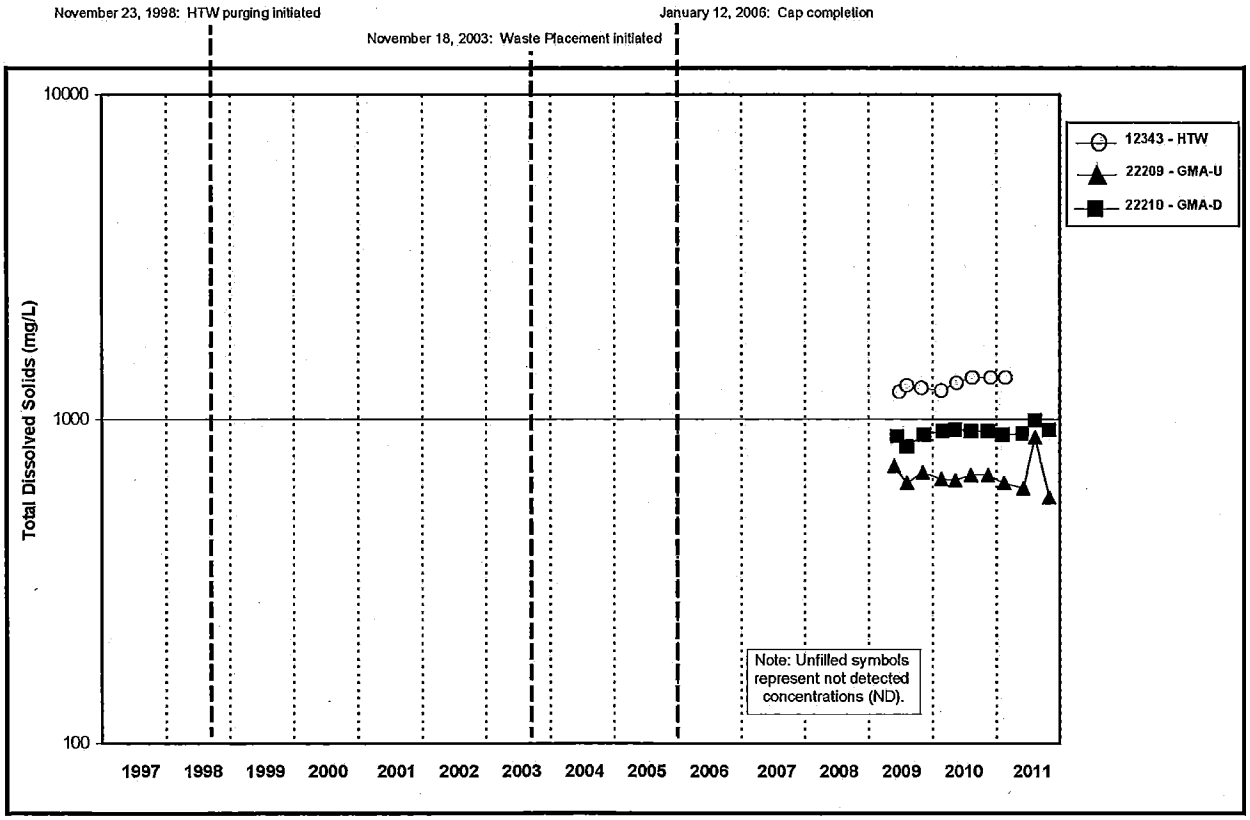


Figure A.5.6-12B. Cell 6 Total Dissolved Solids Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

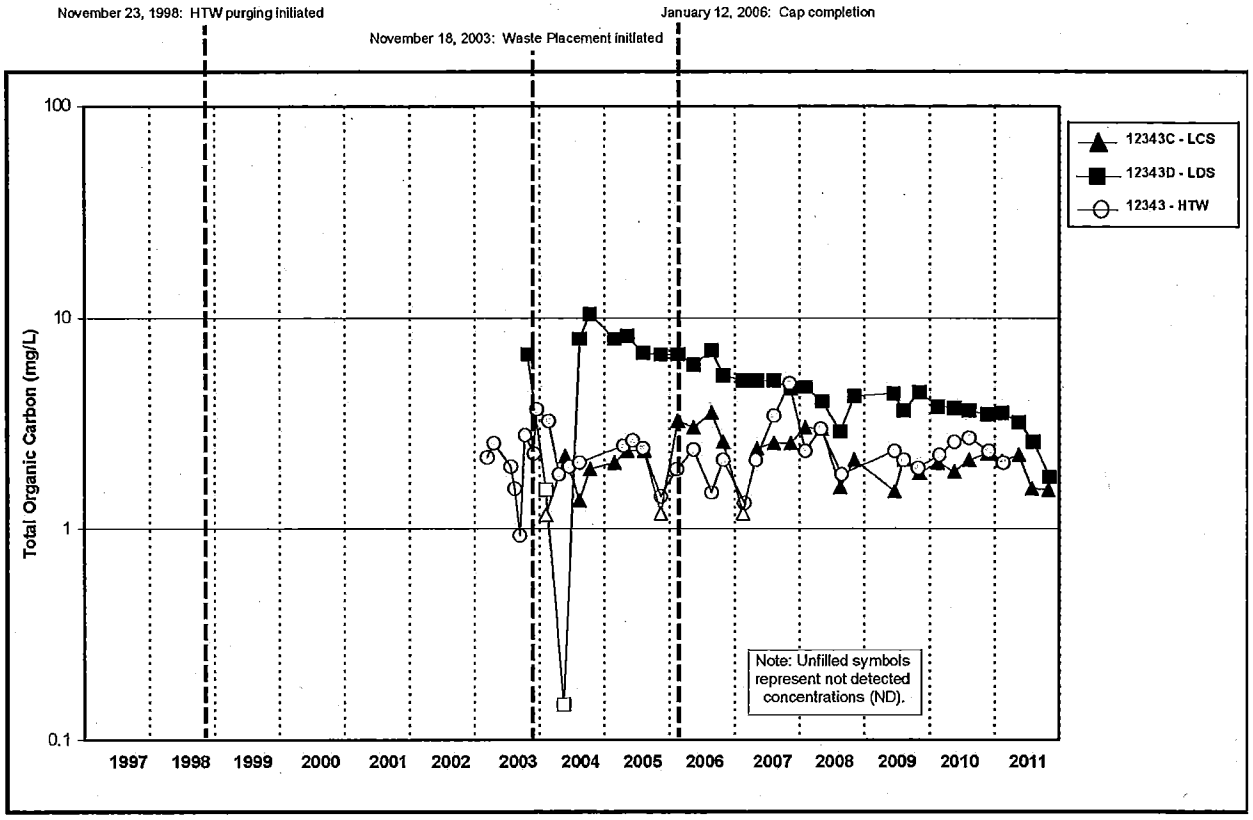


Figure A.5.6-13A. Cell 6 Total Organic Carbon Concentration vs. Time Plot for LCS, LDS, and HTW

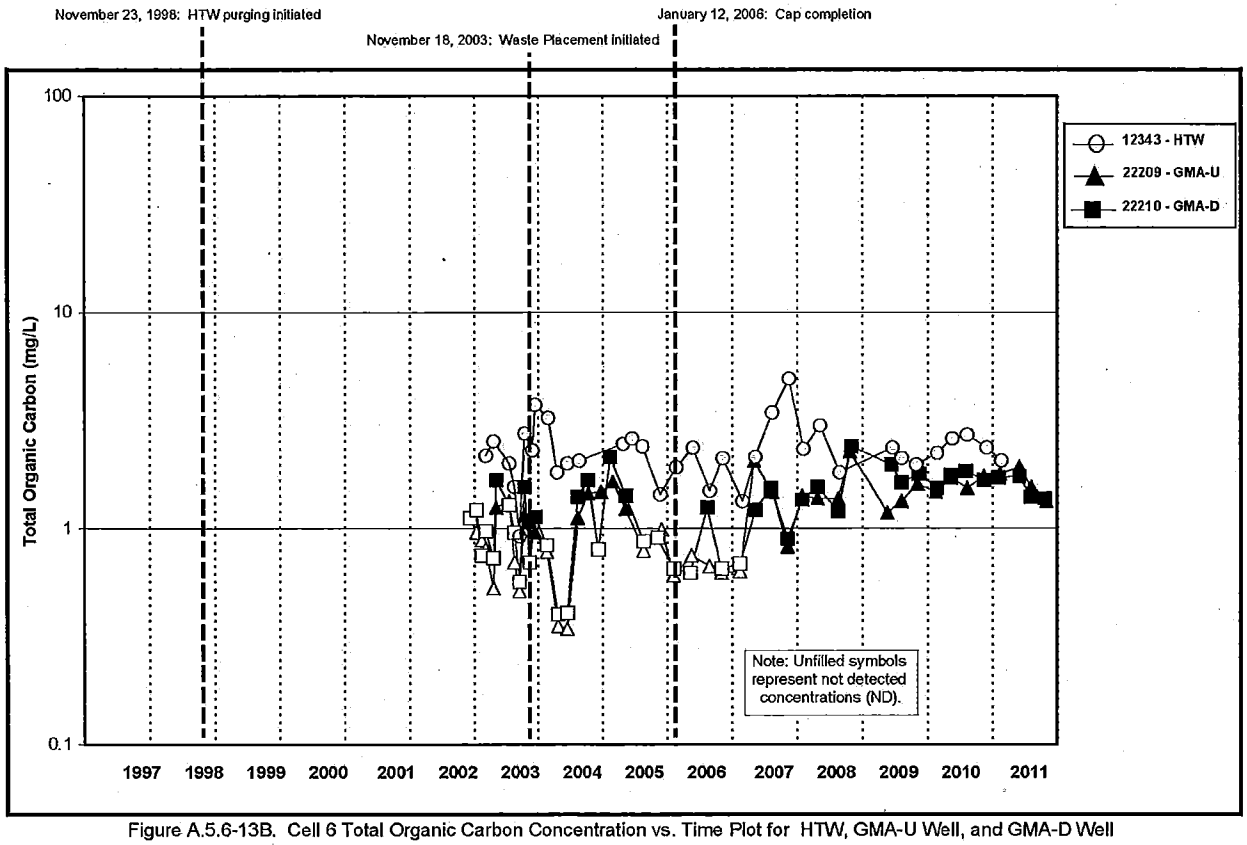


Figure A.5.6-13B. Cell 6 Total Organic Carbon Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

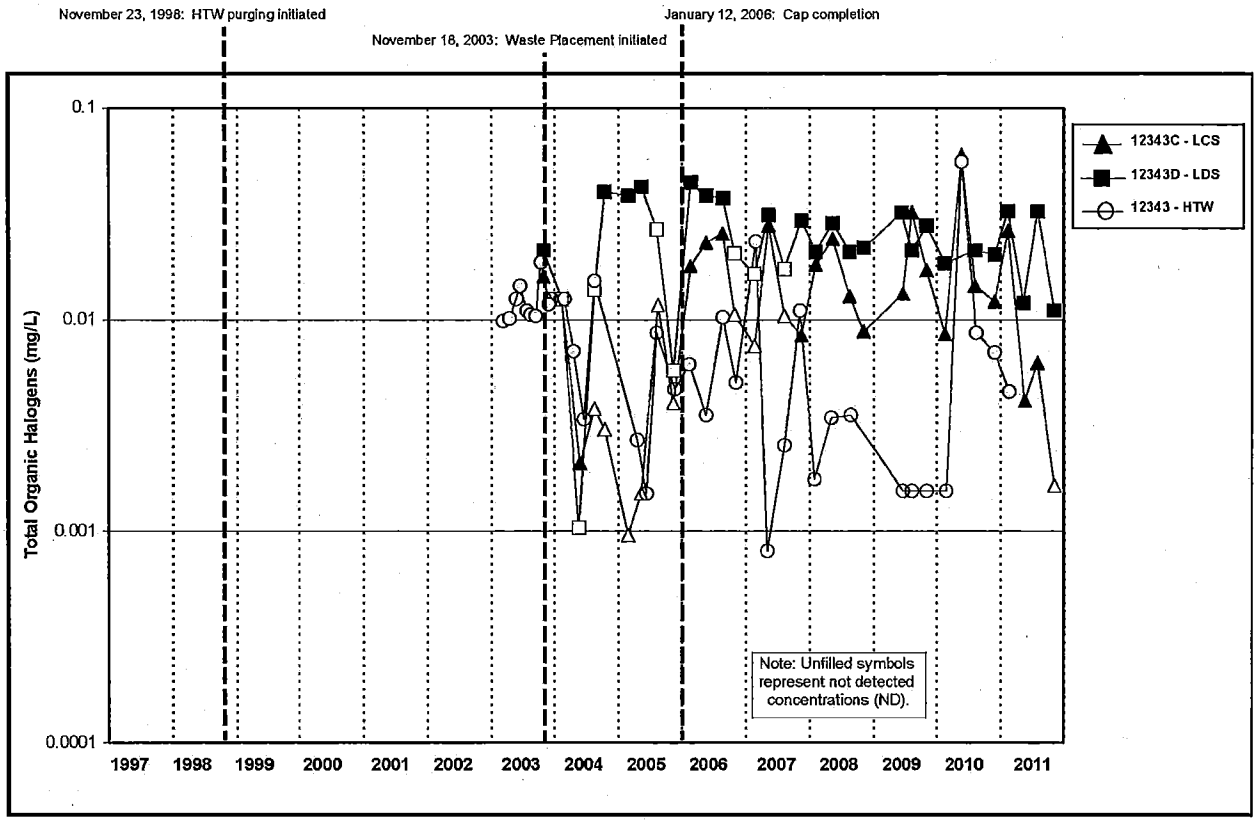


Figure A.5.6-14A. Cell 6 Total Organic Halogens Concentration vs. Time Plot for LCS, LDS, and HTW

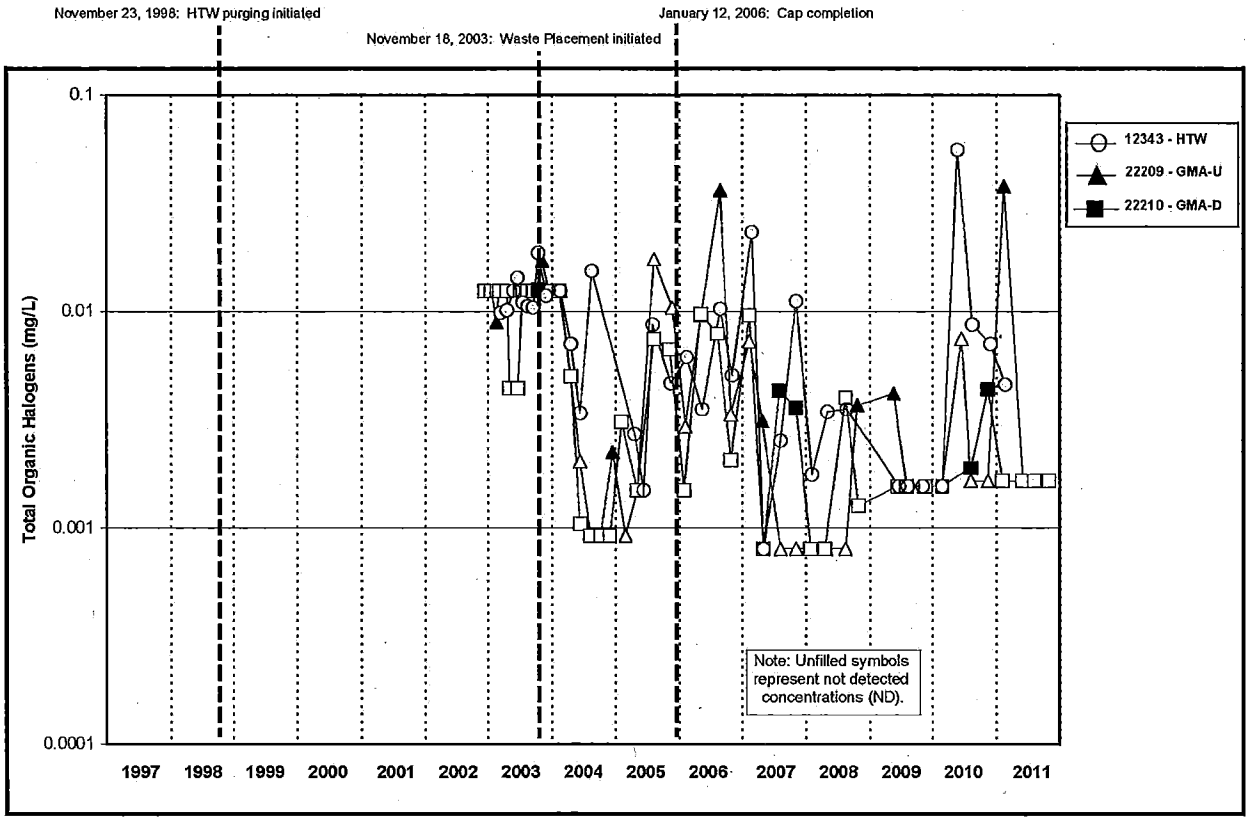


Figure A.5.6-14B. Cell 6 Total Organic Halogens Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

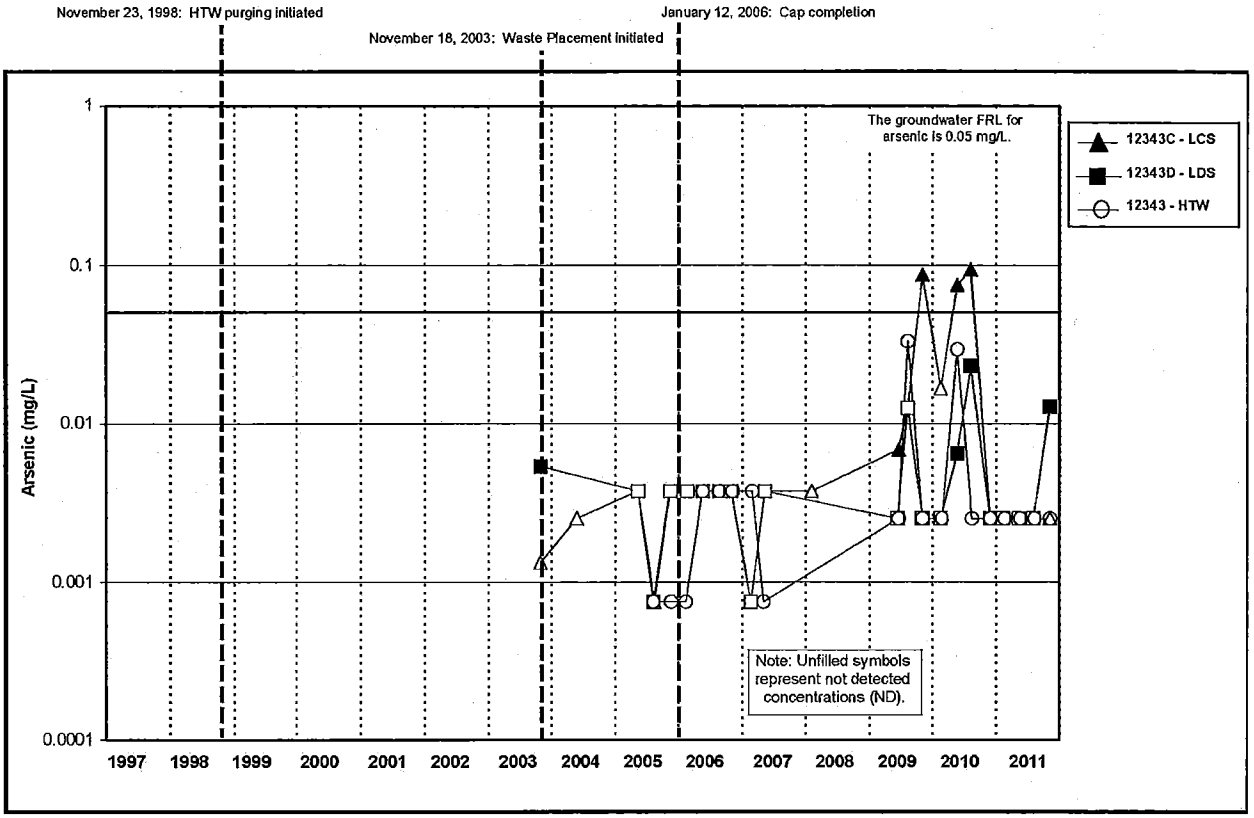


Figure A.5.6-15A. Cell 6 Arsenic Concentration vs. Time Plot for LCS, LDS, and HTW

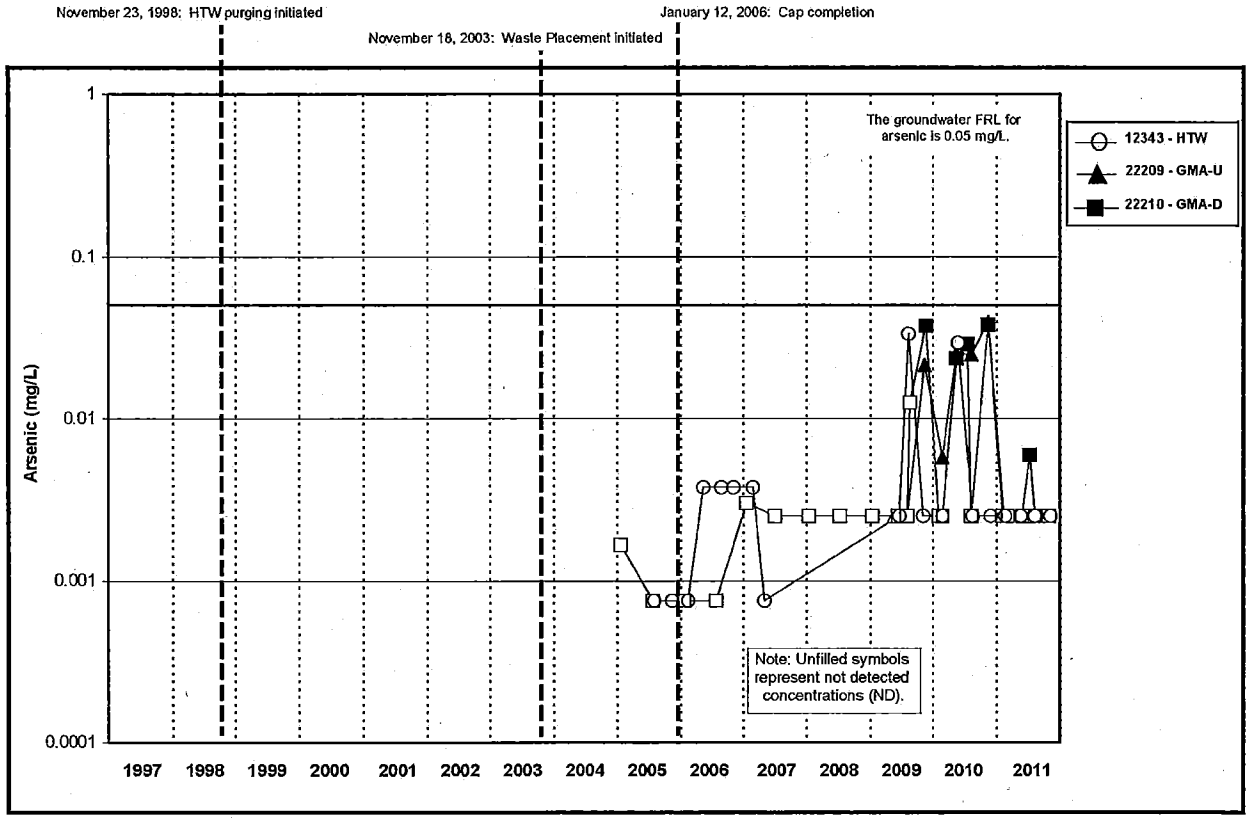


Figure A.5.6-15B. Cell 6 Arsenic Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

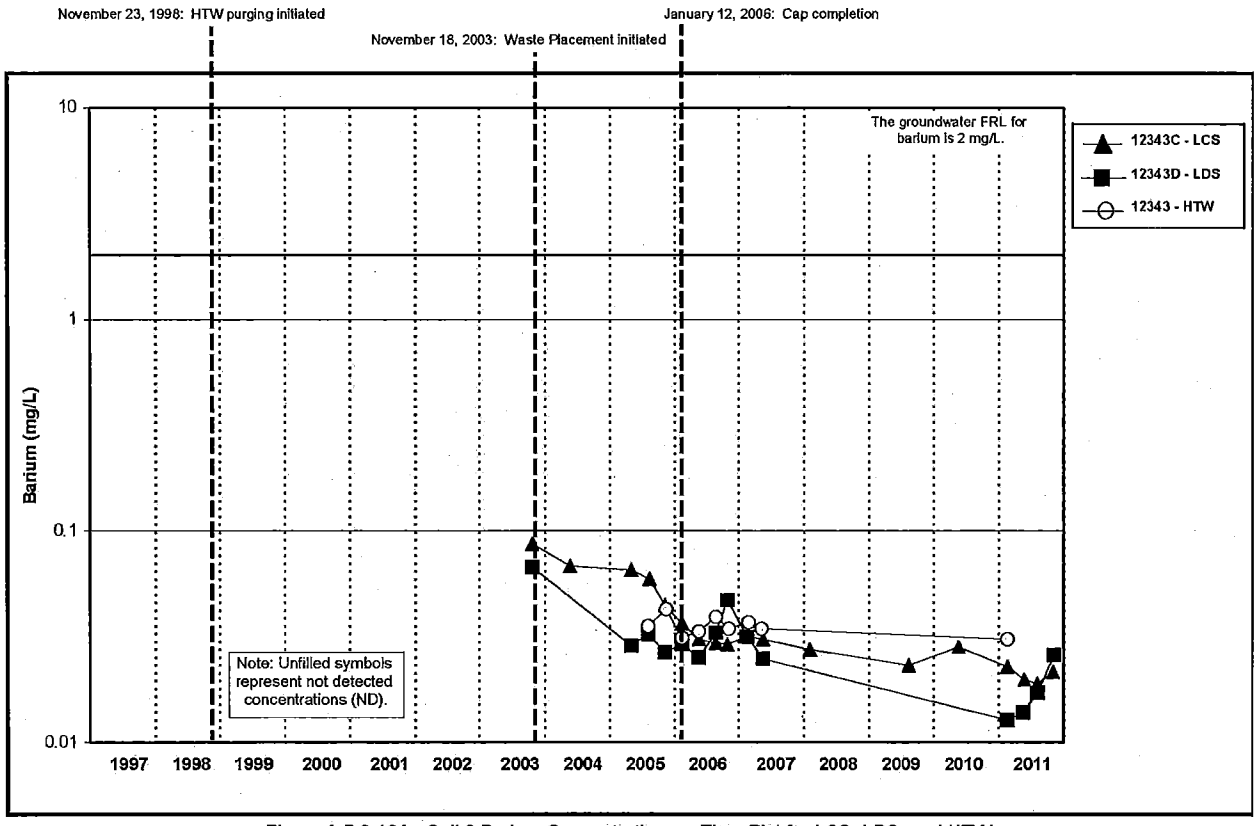


Figure A.5.6-16A. Cell 6 Barium Concentration vs. Time Plot for LCS, LDS, and HTW

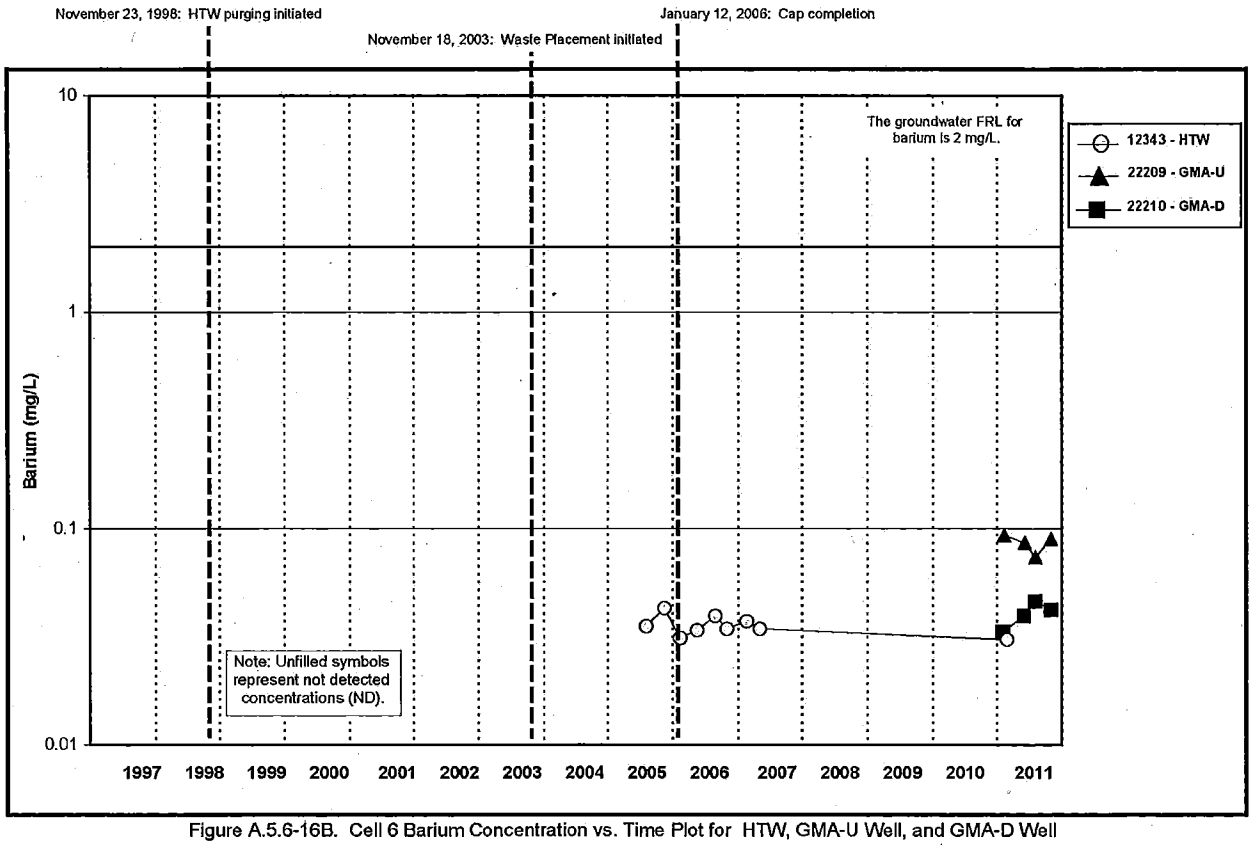


Figure A.5.6-16B. Cell 6 Barium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

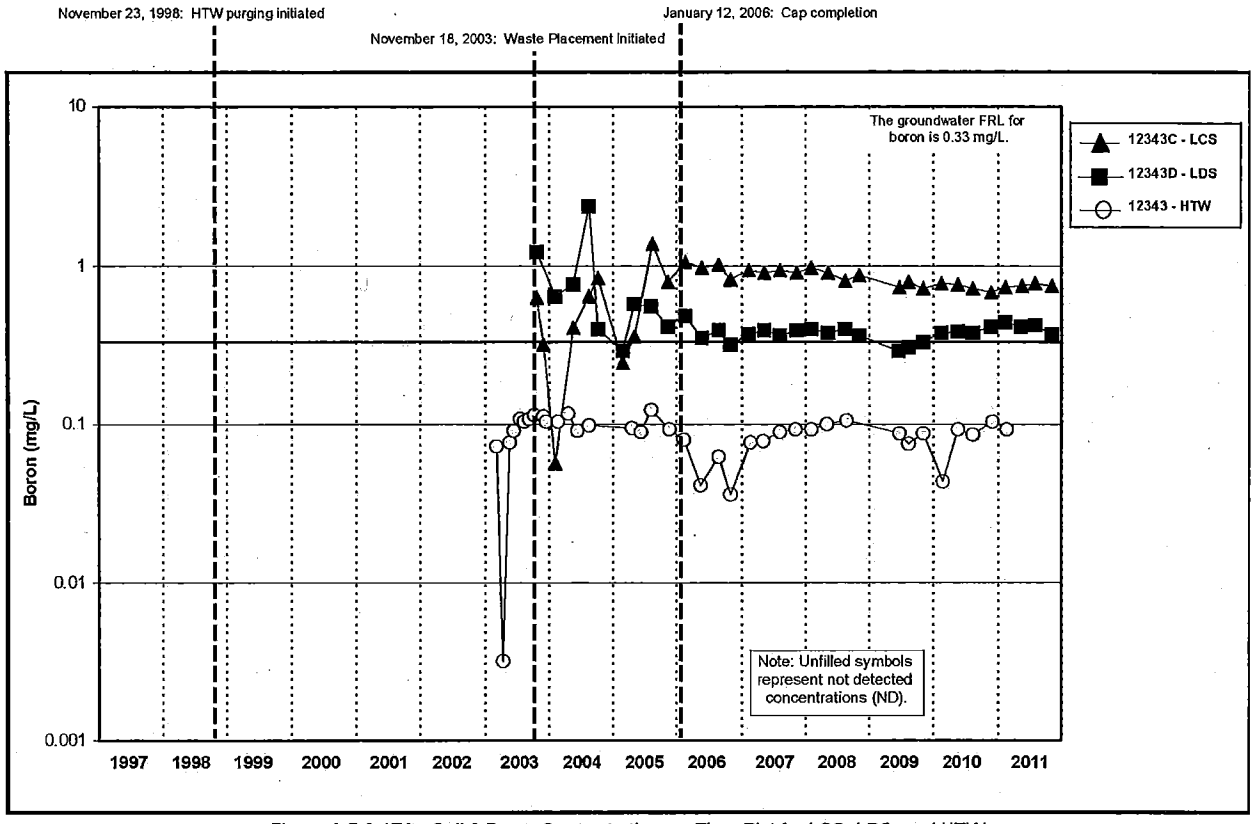


Figure A.5.6-17A. Cell 6 Boron Concentration vs. Time Plot for LCS, LDS, and HTW

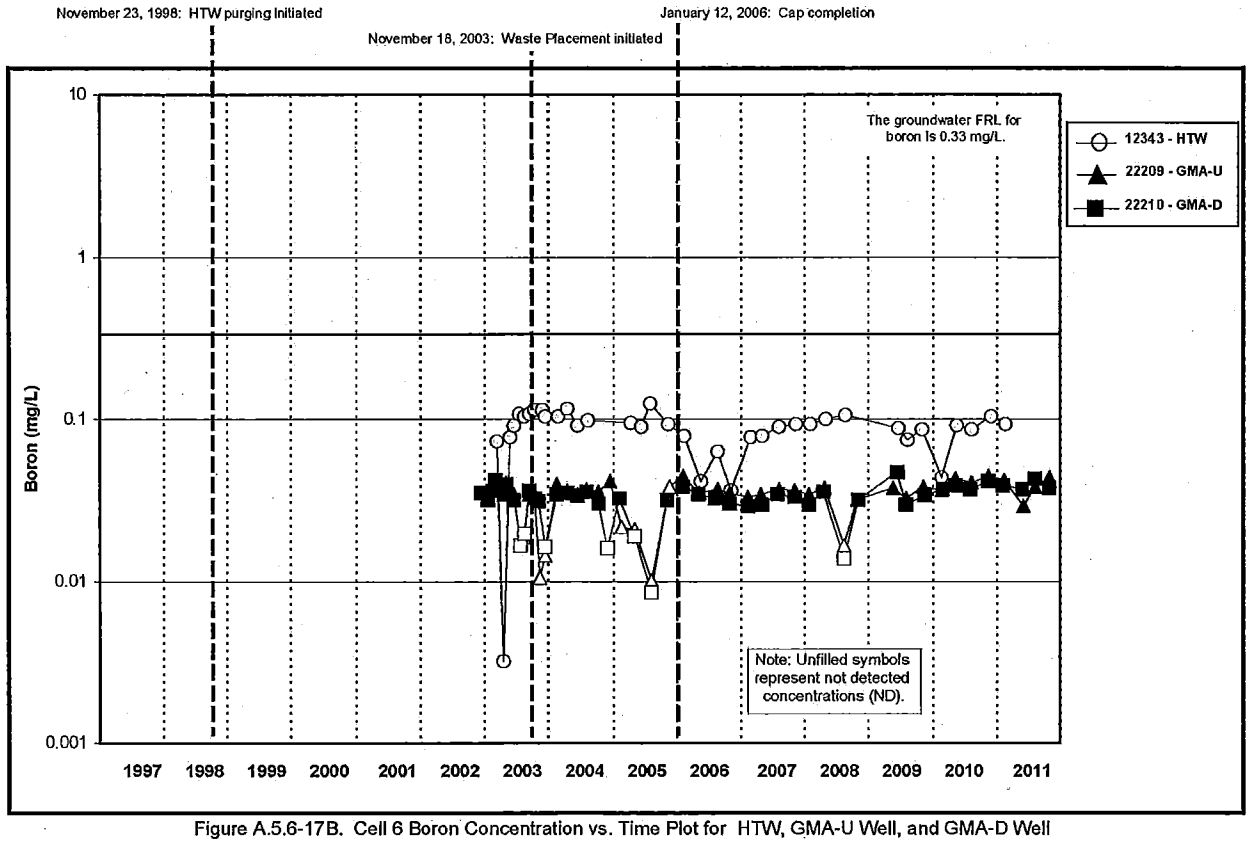


Figure A.5.6-17B. Cell 6 Boron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

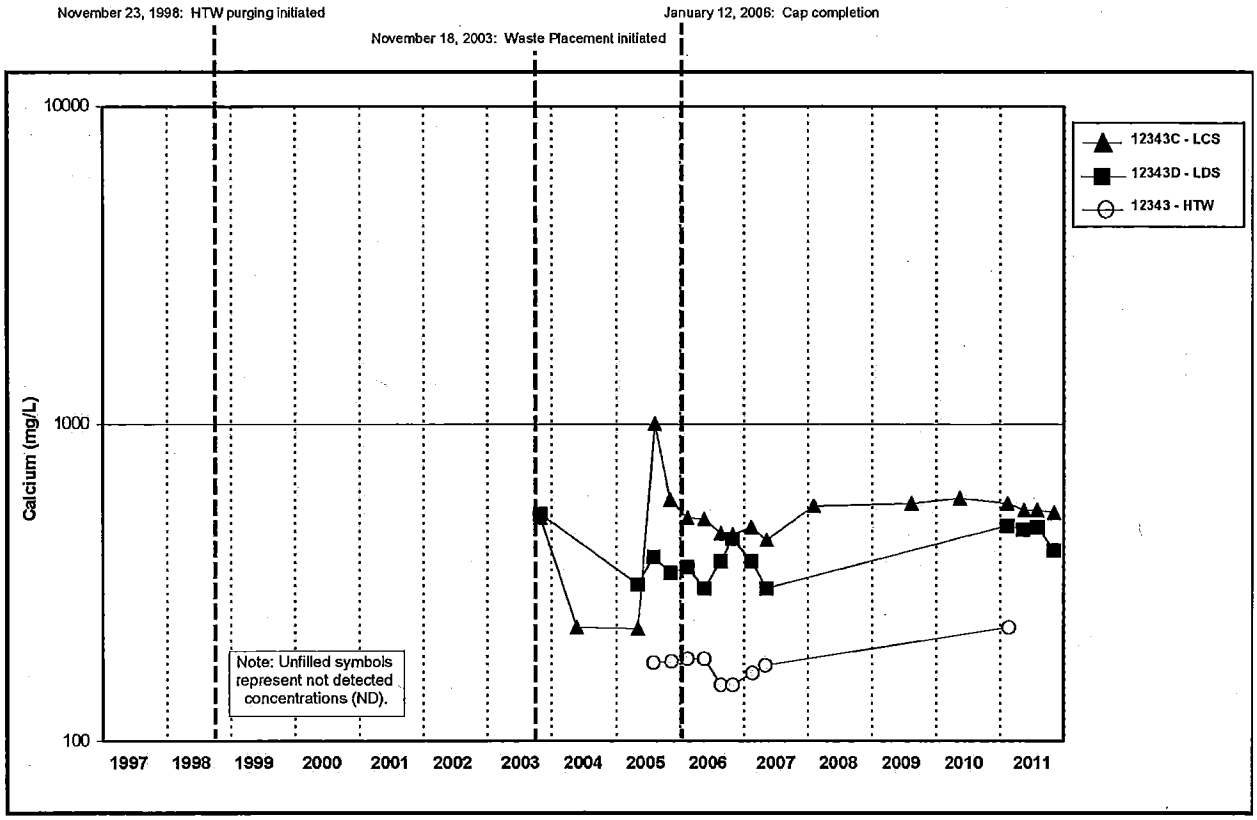


Figure A.5.6-18A. Cell 6 Calcium Concentration vs. Time Plot for LCS, LDS, and HTW

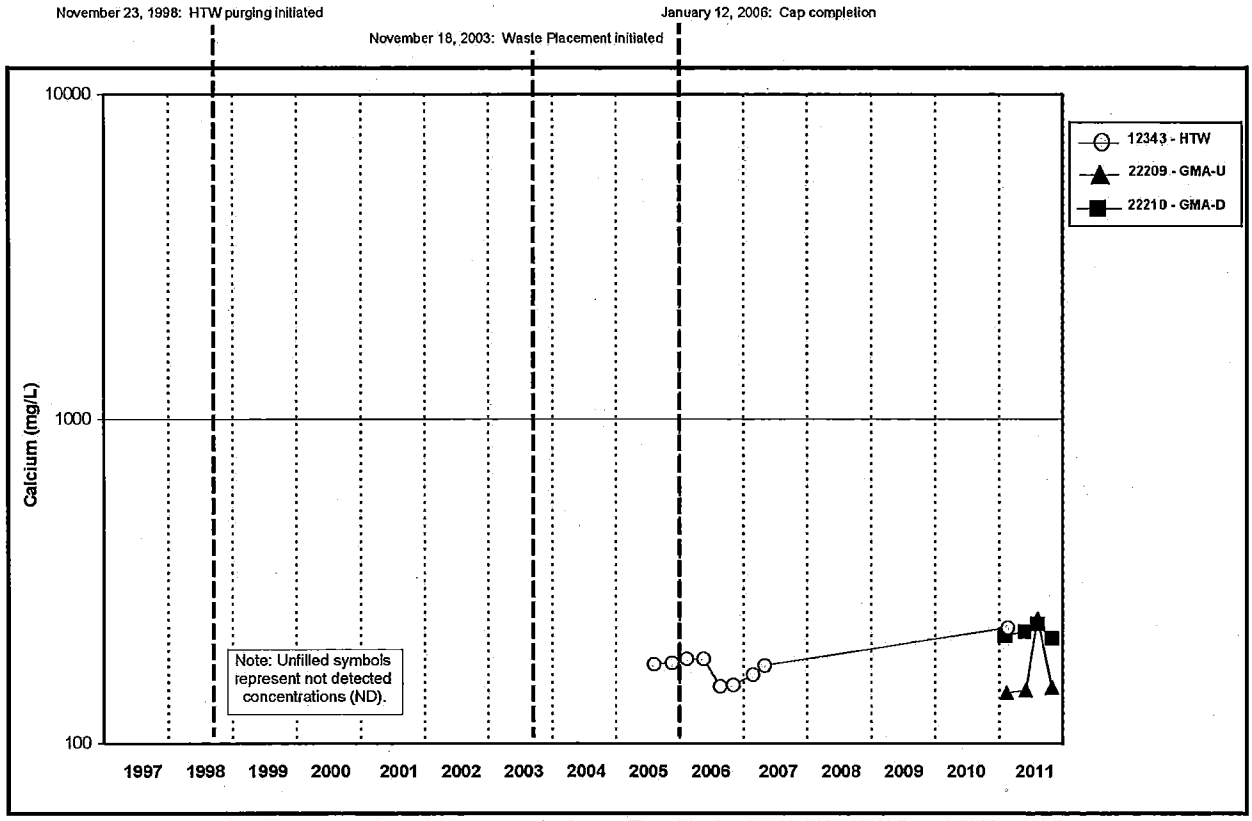


Figure A.5.6-18B. Cell 6 Calcium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

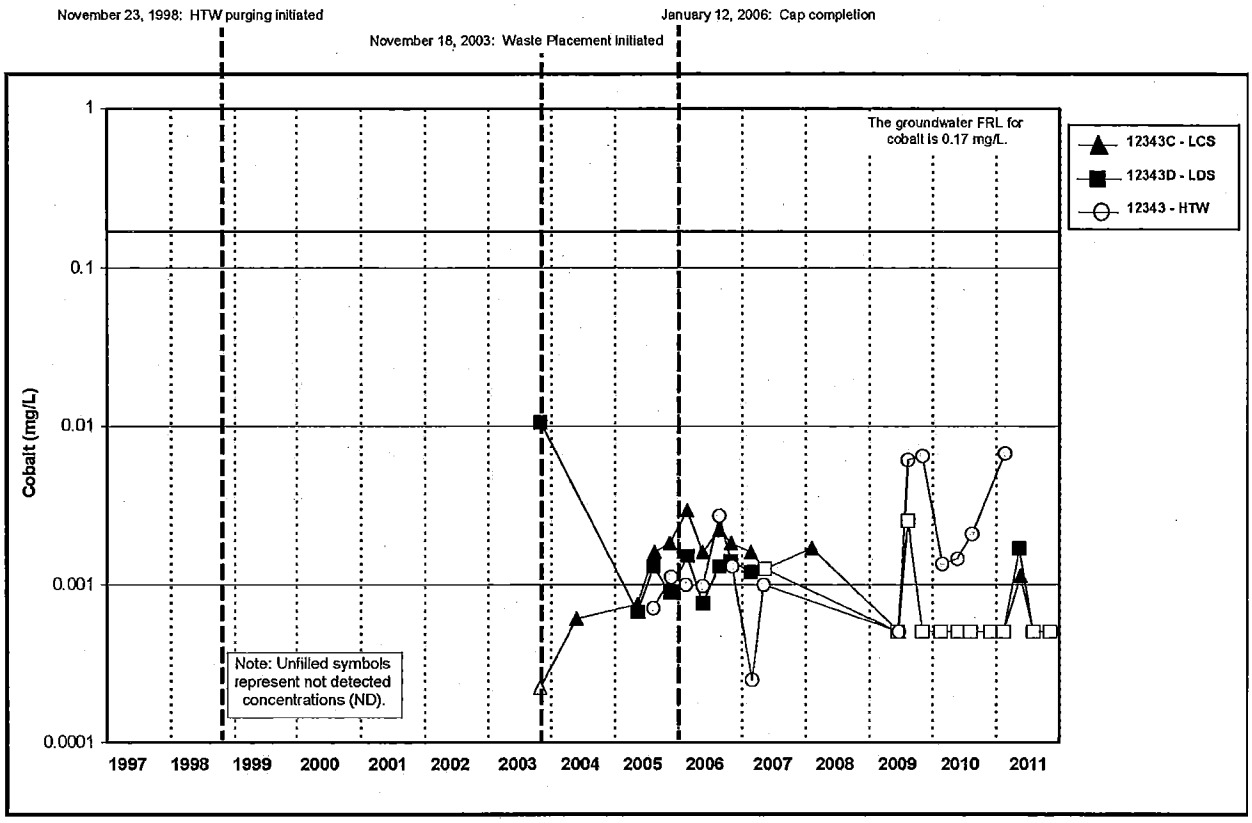


Figure A.5.6-19A. Cell 6 Cobalt Concentration vs. Time Plot for LCS, LDS, and HTW

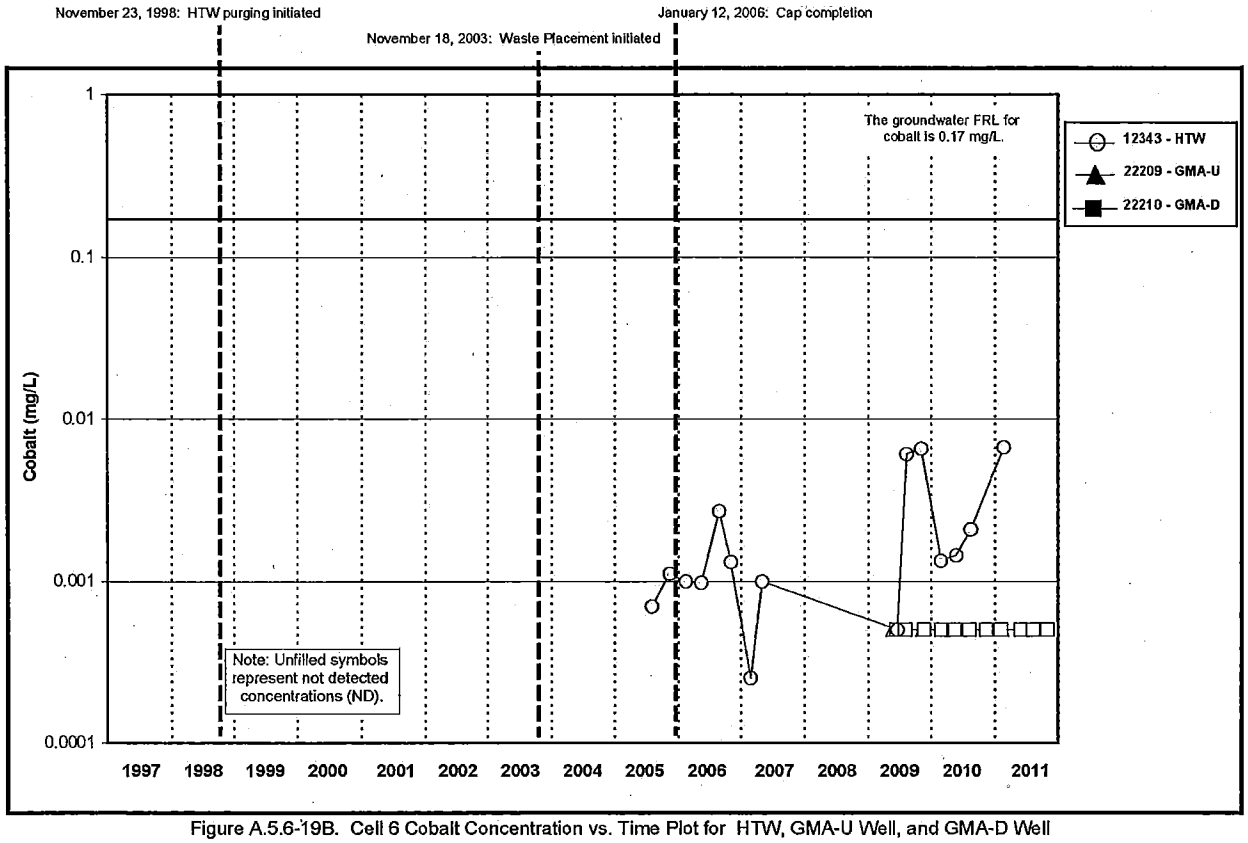


Figure A.5.6-19B. Cell 6 Cobalt Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

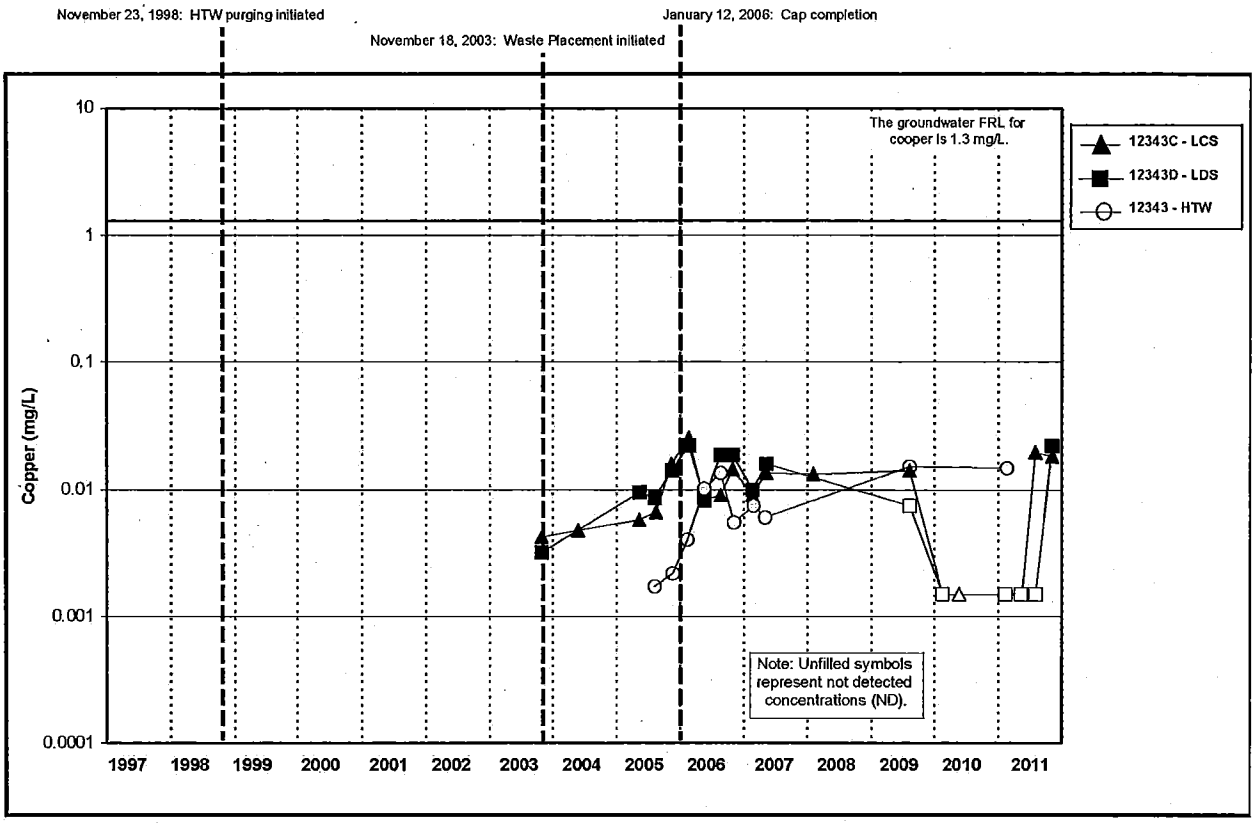


Figure A.5.6-20A. Cell 6 Copper Concentration vs. Time Plot for LCS, LDS, and HTW

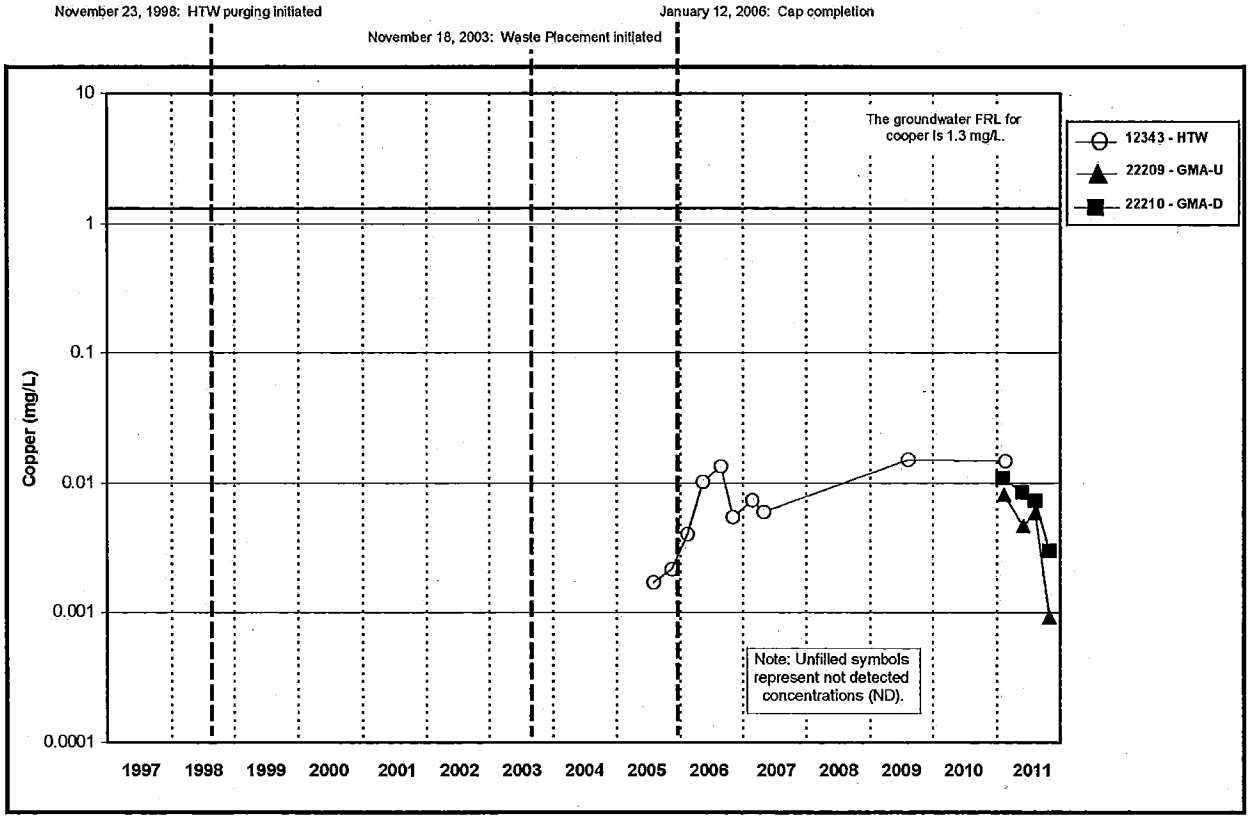


Figure A.5.6-20B. Cell 6 Copper Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

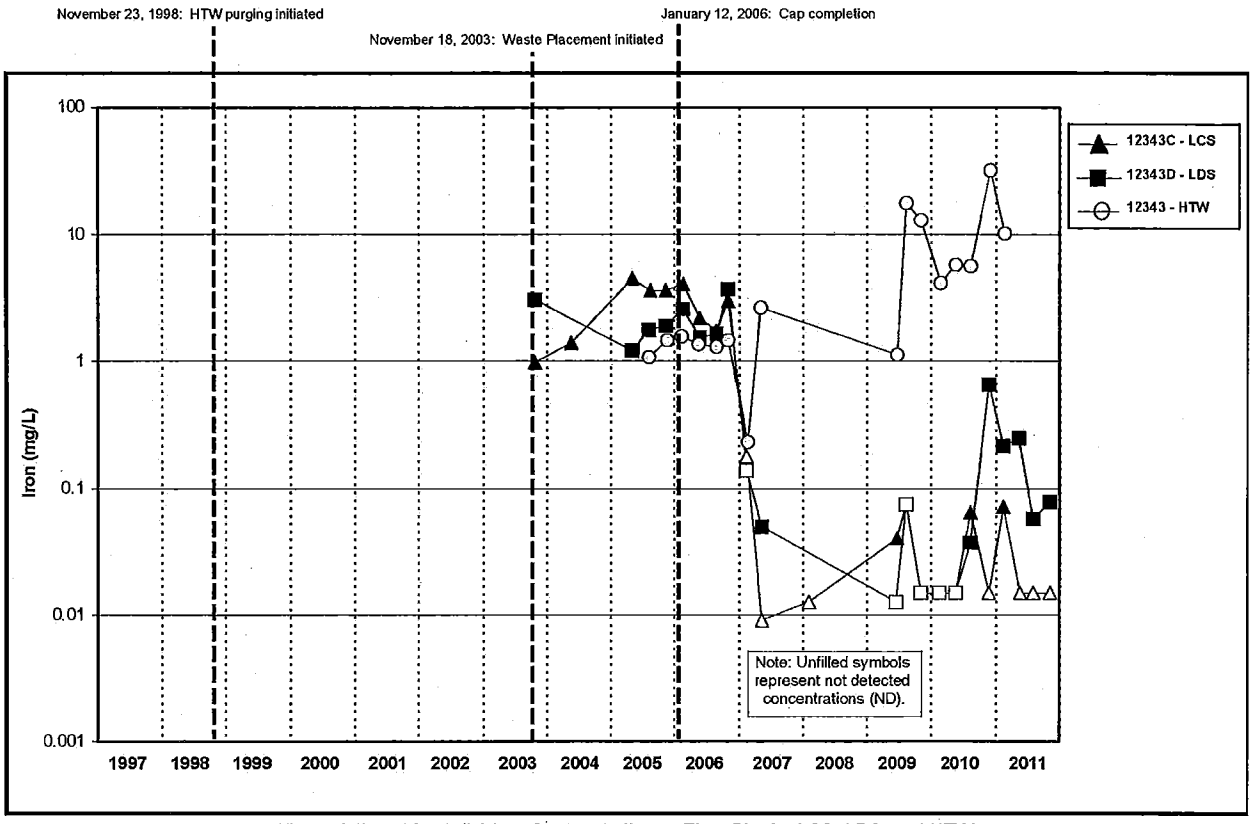


Figure A.5.6-21A. Cell 6 Iron Concentration vs. Time Plot for LCS, LDS, and HTW

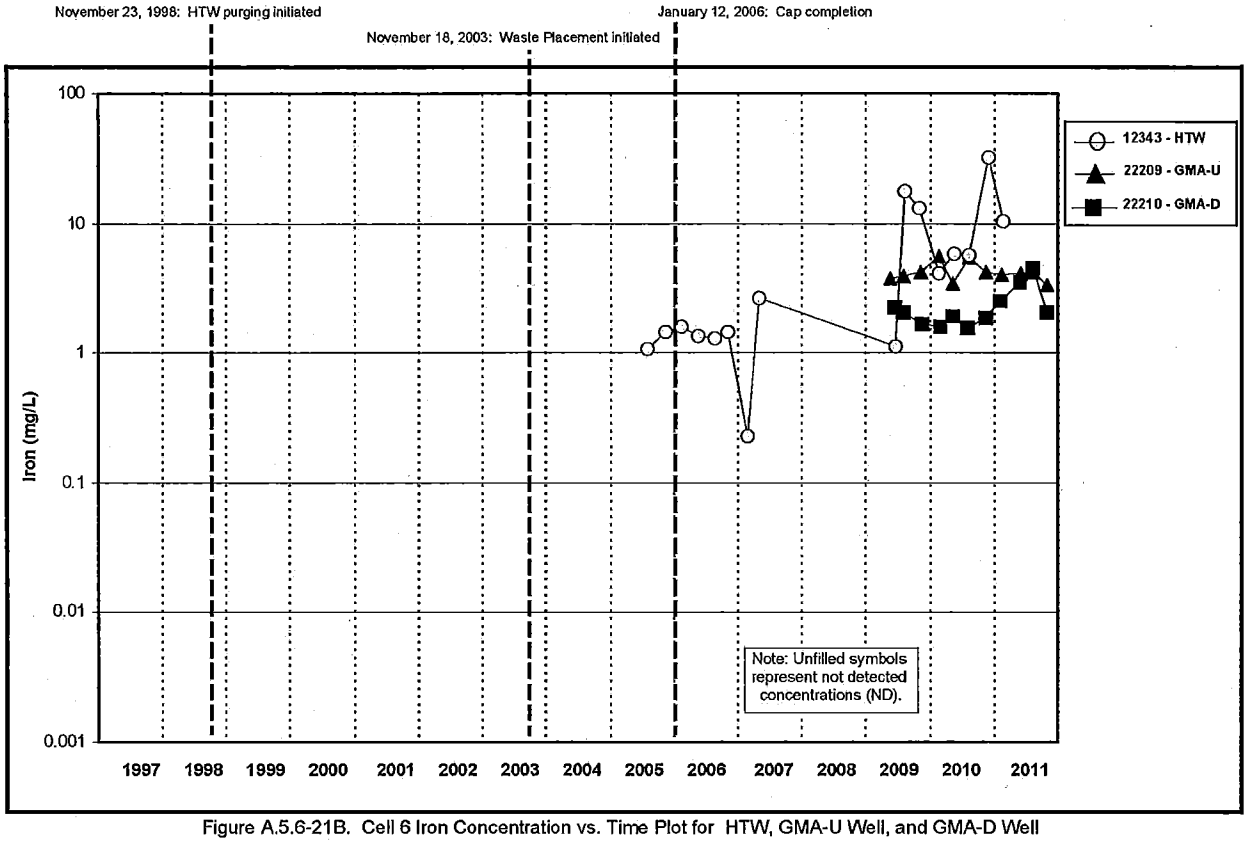


Figure A.5.6-21B. Cell 6 Iron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

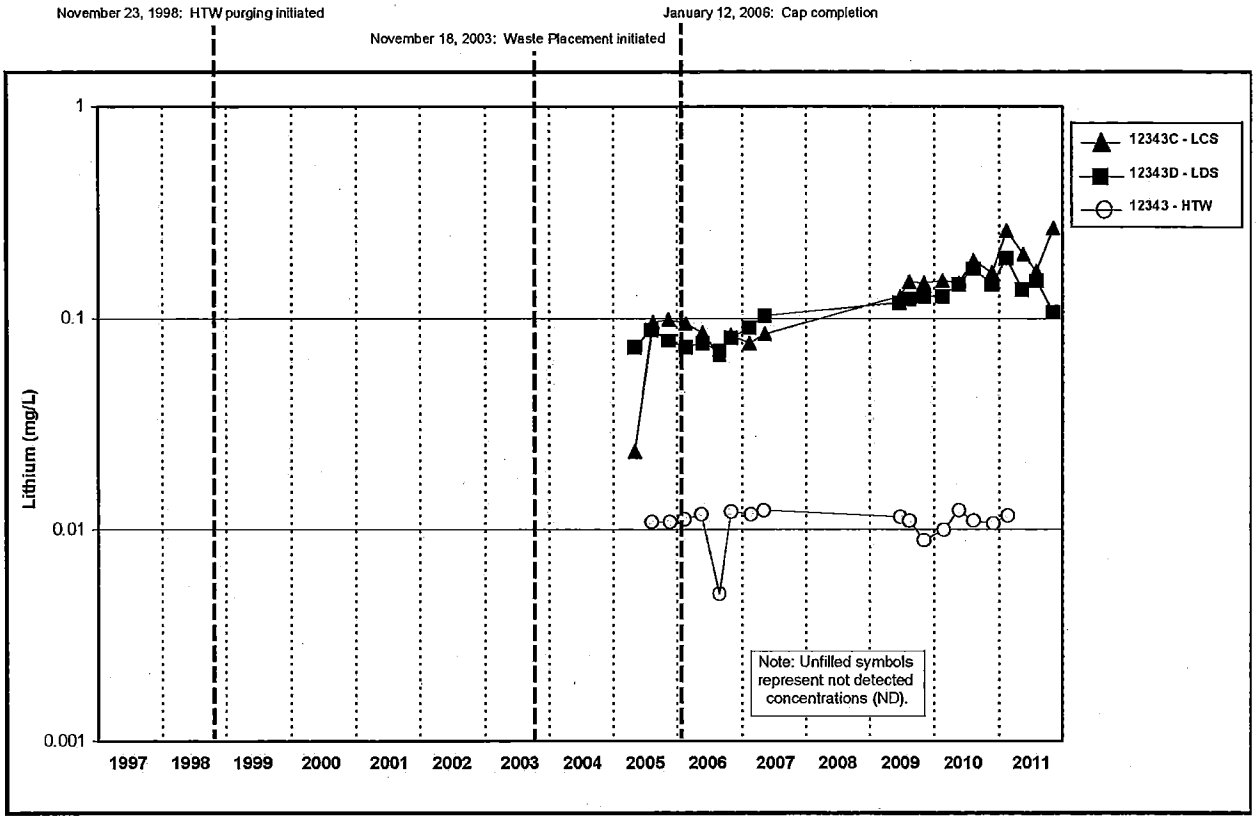


Figure A.5.6-22A. Cell 6 Lithium Concentration vs. Time Plot for LCS, LDS, and HTW

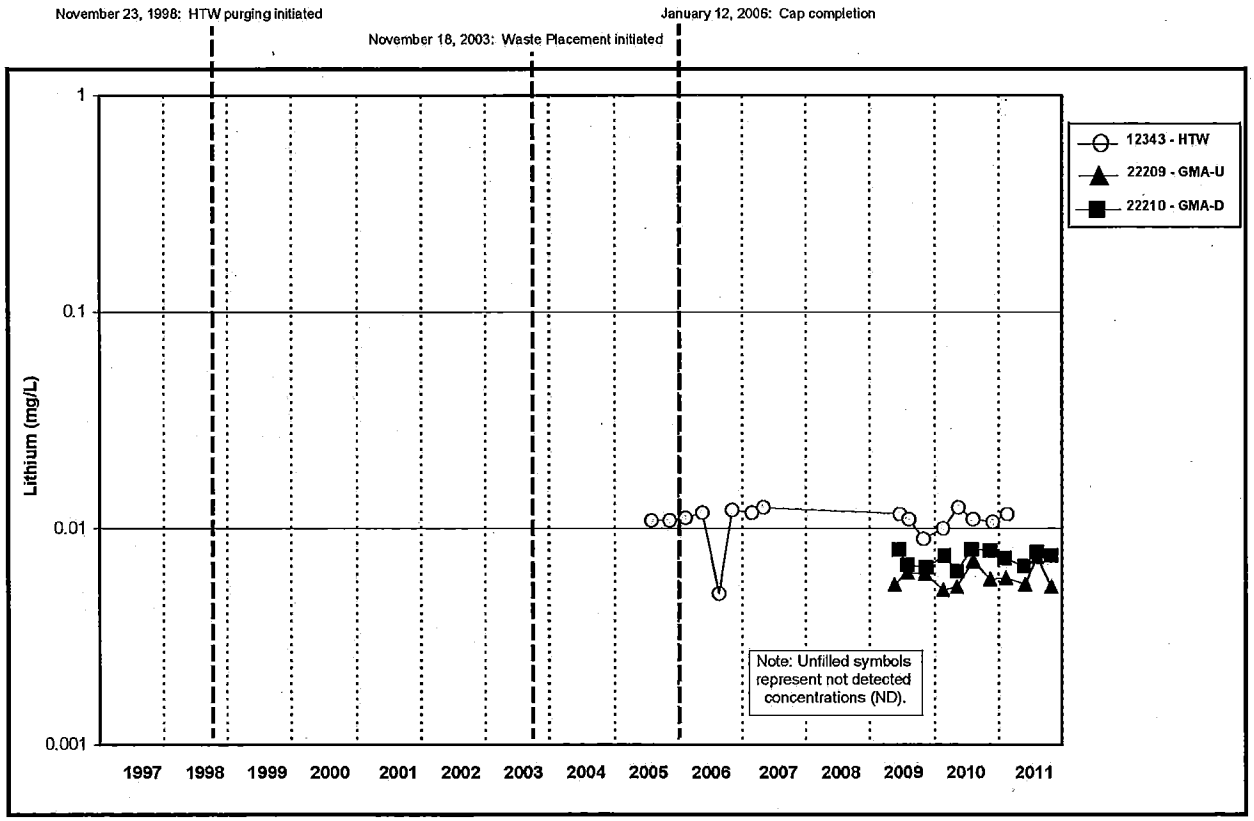


Figure A.5.6-22B. Cell 6 Lithium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

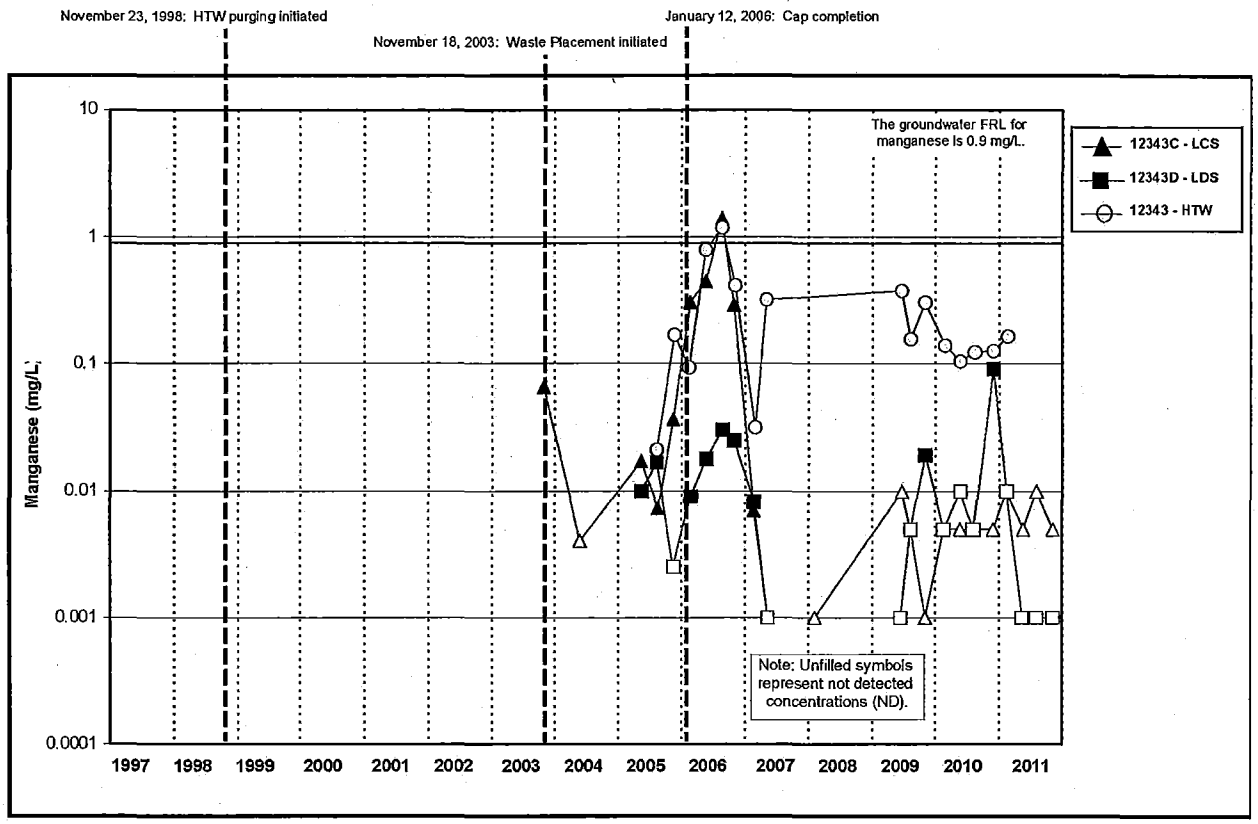


Figure A.5.6-23A. Cell 6 Manganese Concentration vs. Time Plot for LCS, LDS, and HTW

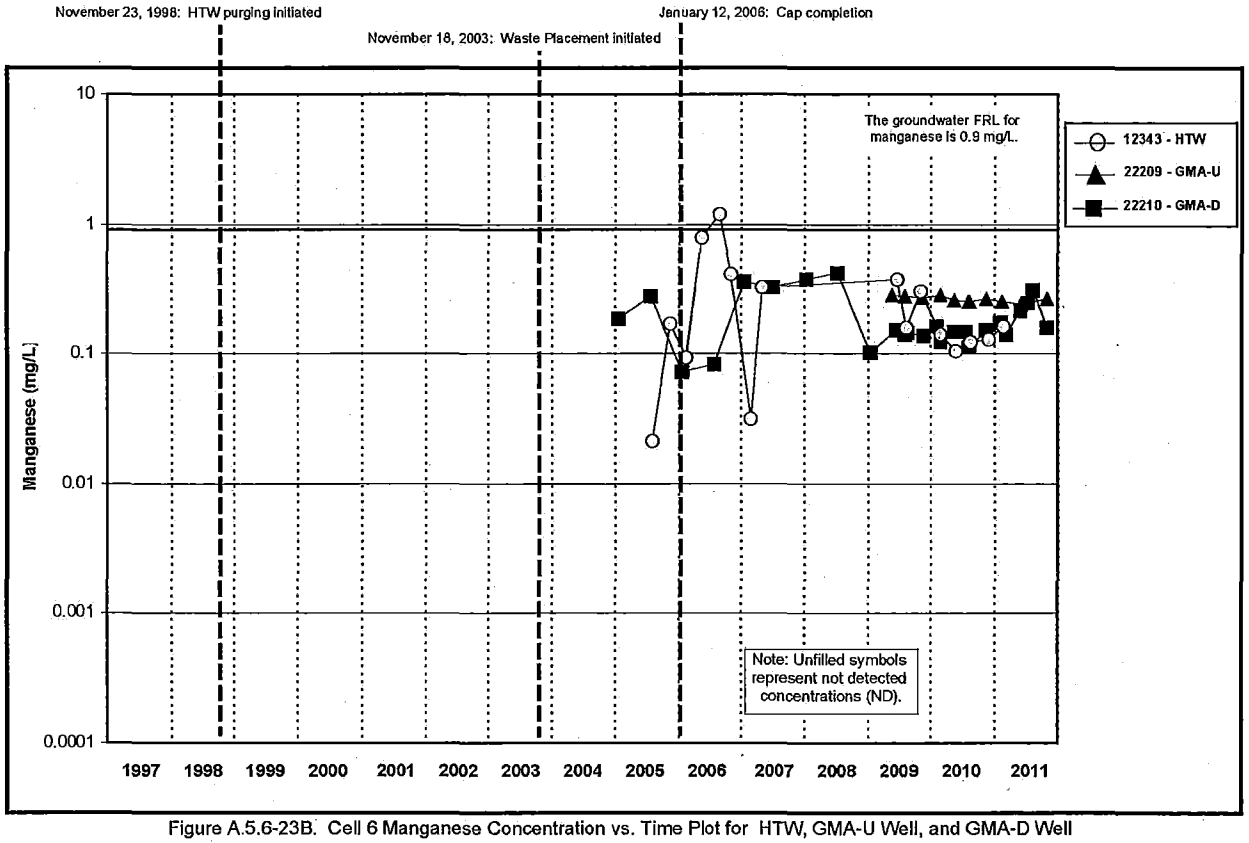


Figure A.5.6-23B. Cell 6 Manganese Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

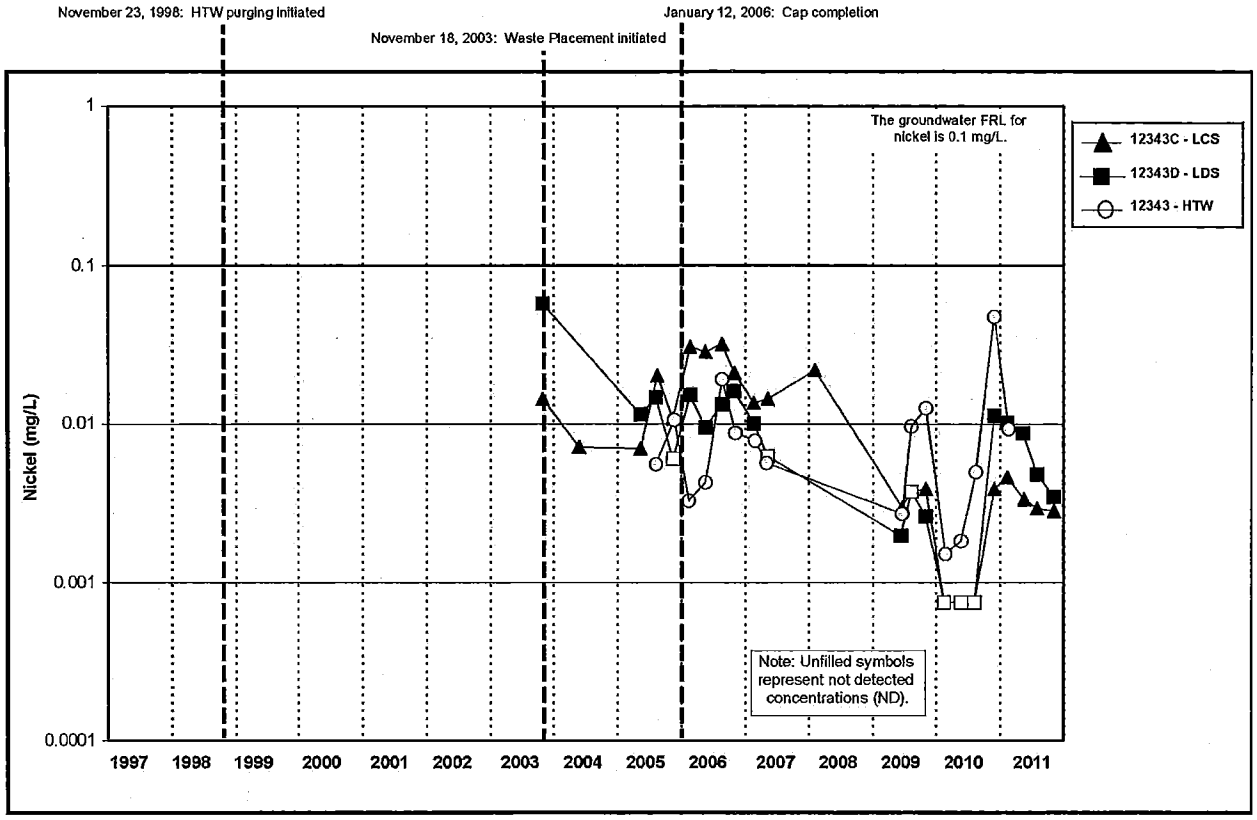


Figure A.5.6-24A. Cell 6 Nickel Concentration vs. Time Plot for LCS, LDS, and HTW

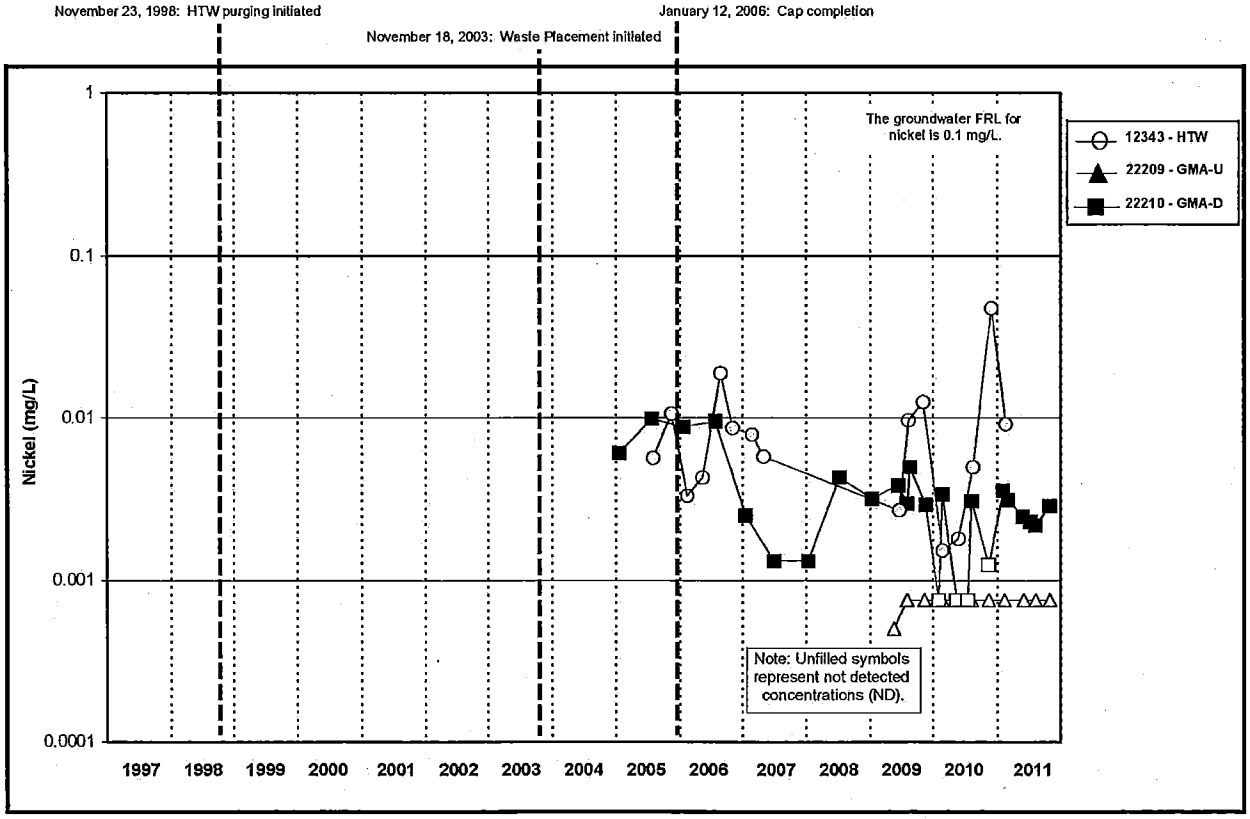


Figure A.5.6-24B. Cell 6 Nickel Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

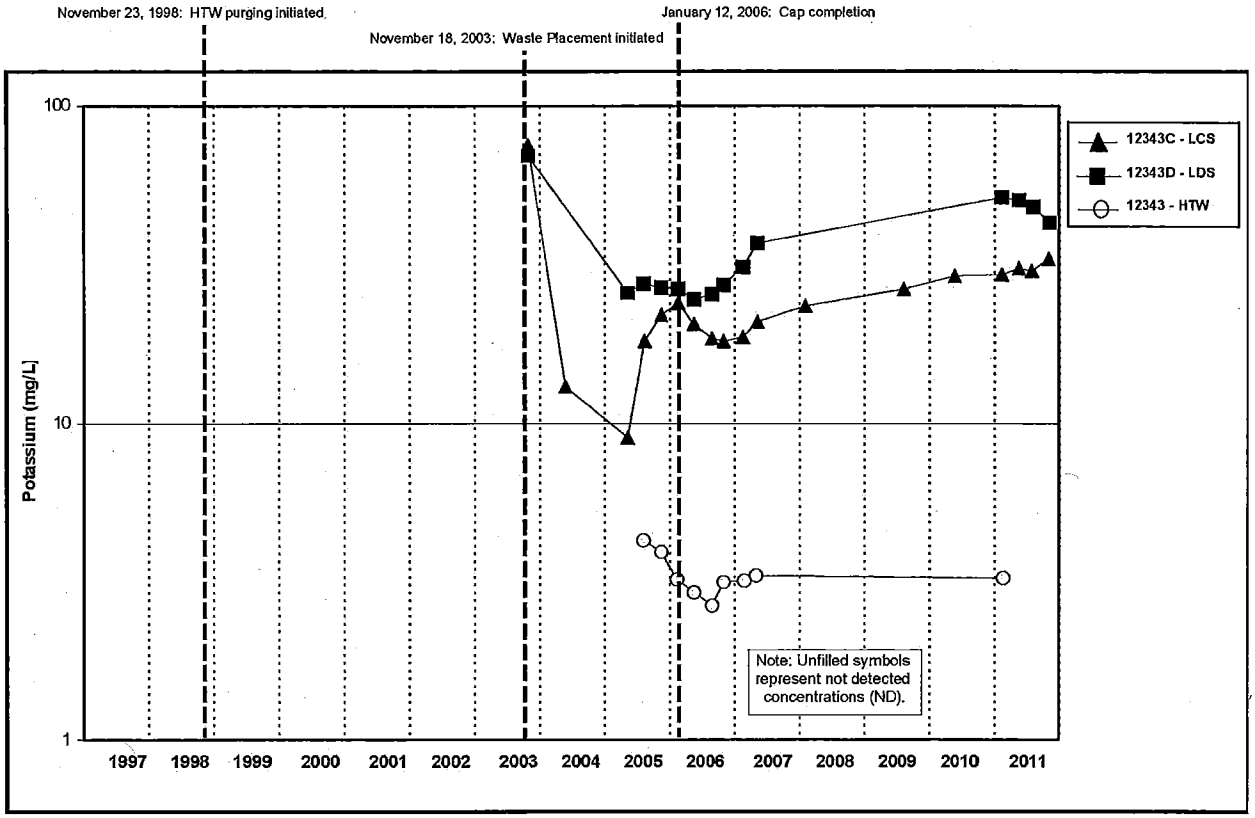


Figure A.5.6-25A. Cell 6 Potassium Concentration vs. Time Plot for LCS, LDS, and HTW

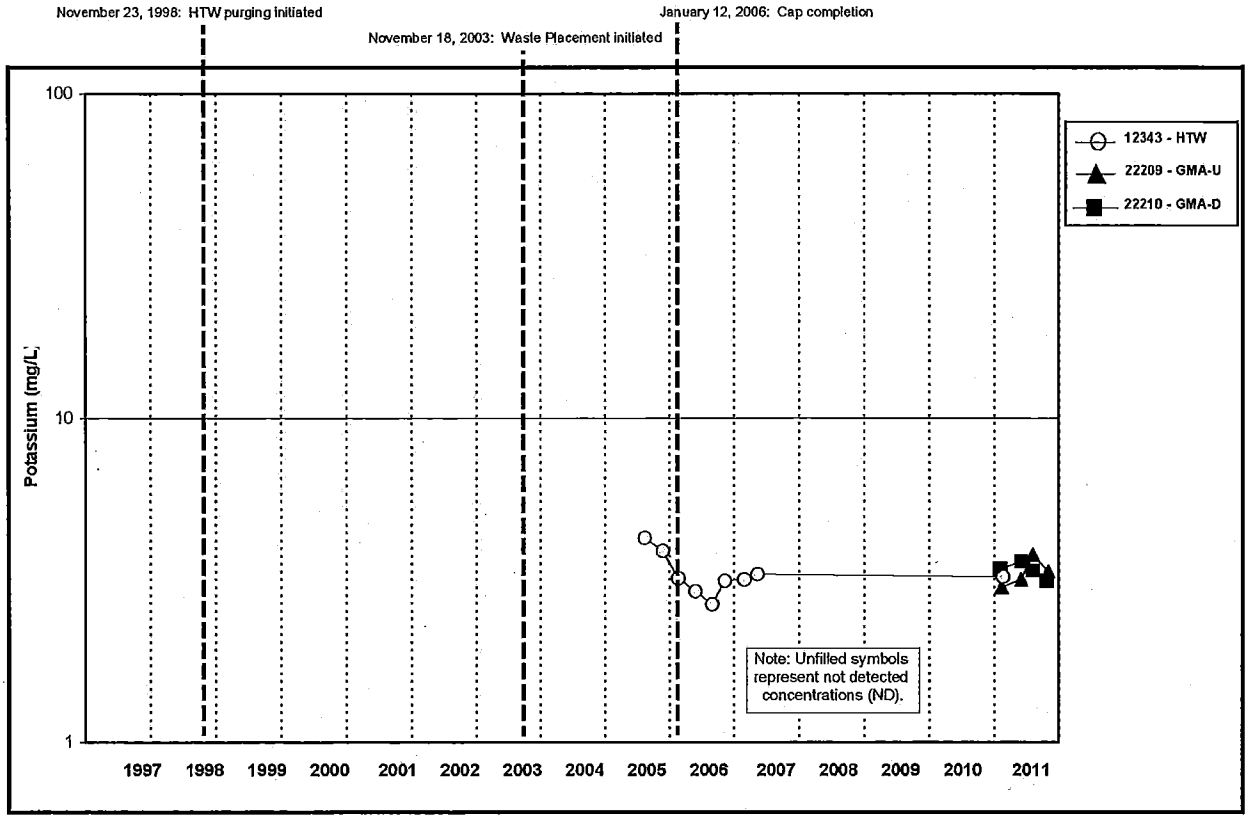


Figure A.5.6-25B. Cell 6 Potassium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

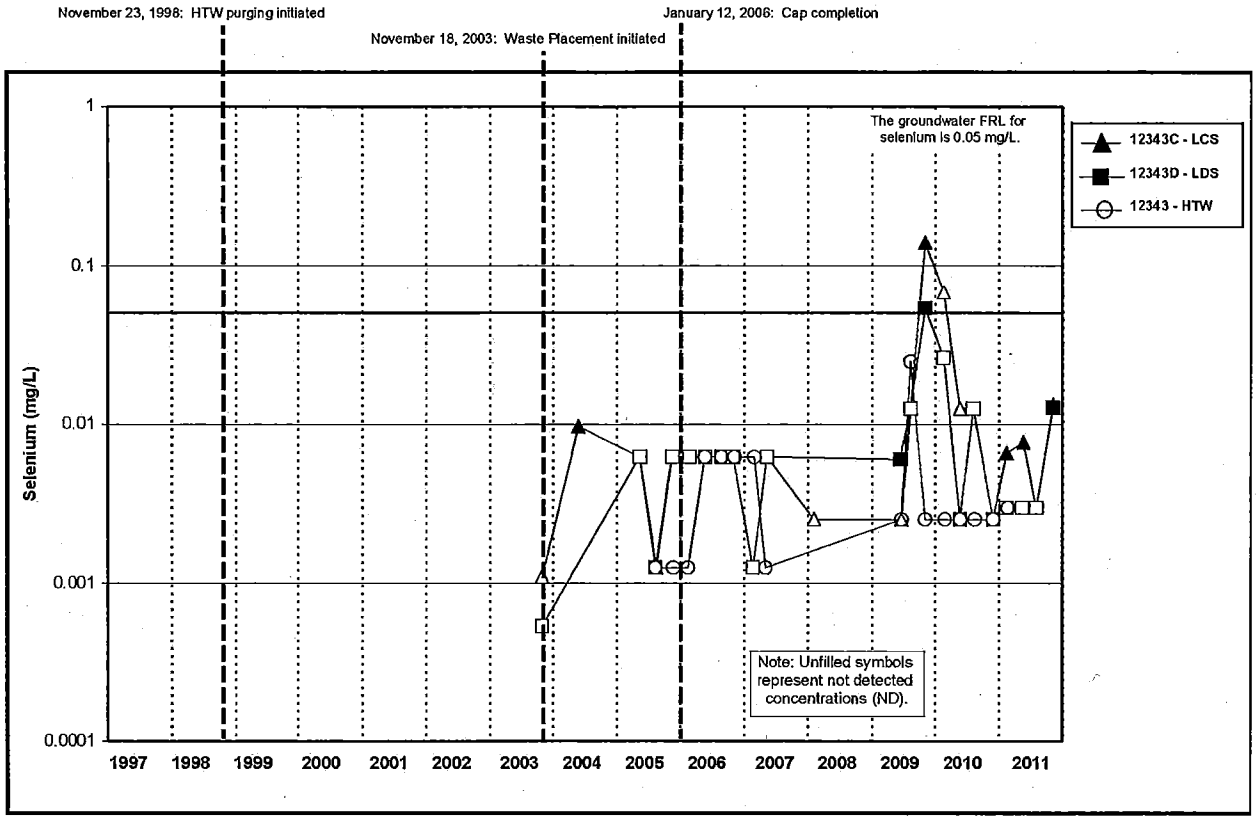


Figure A.5.6-26A. Cell 6 Selenium Concentration vs. Time Plot for LCS, LDS, and HTW

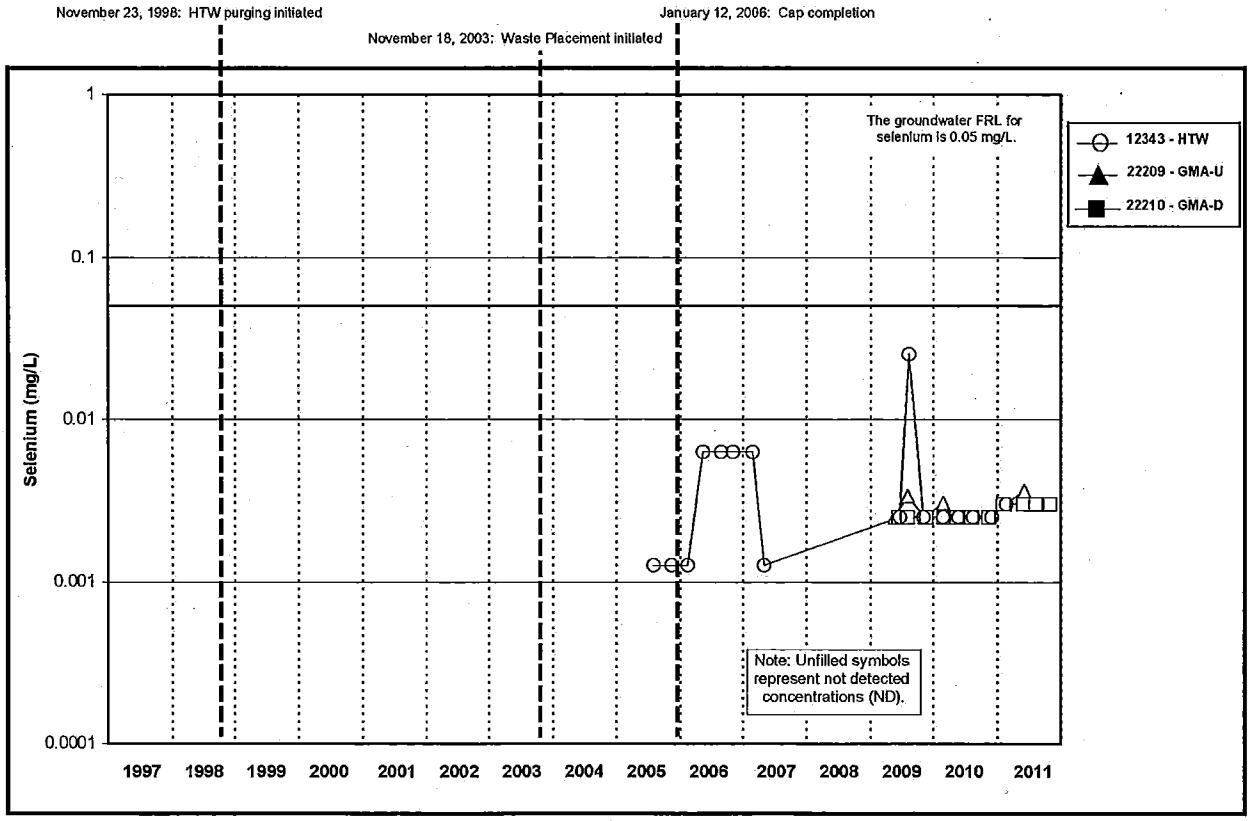


Figure A.5.6-26B. Cell 6 Selenium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

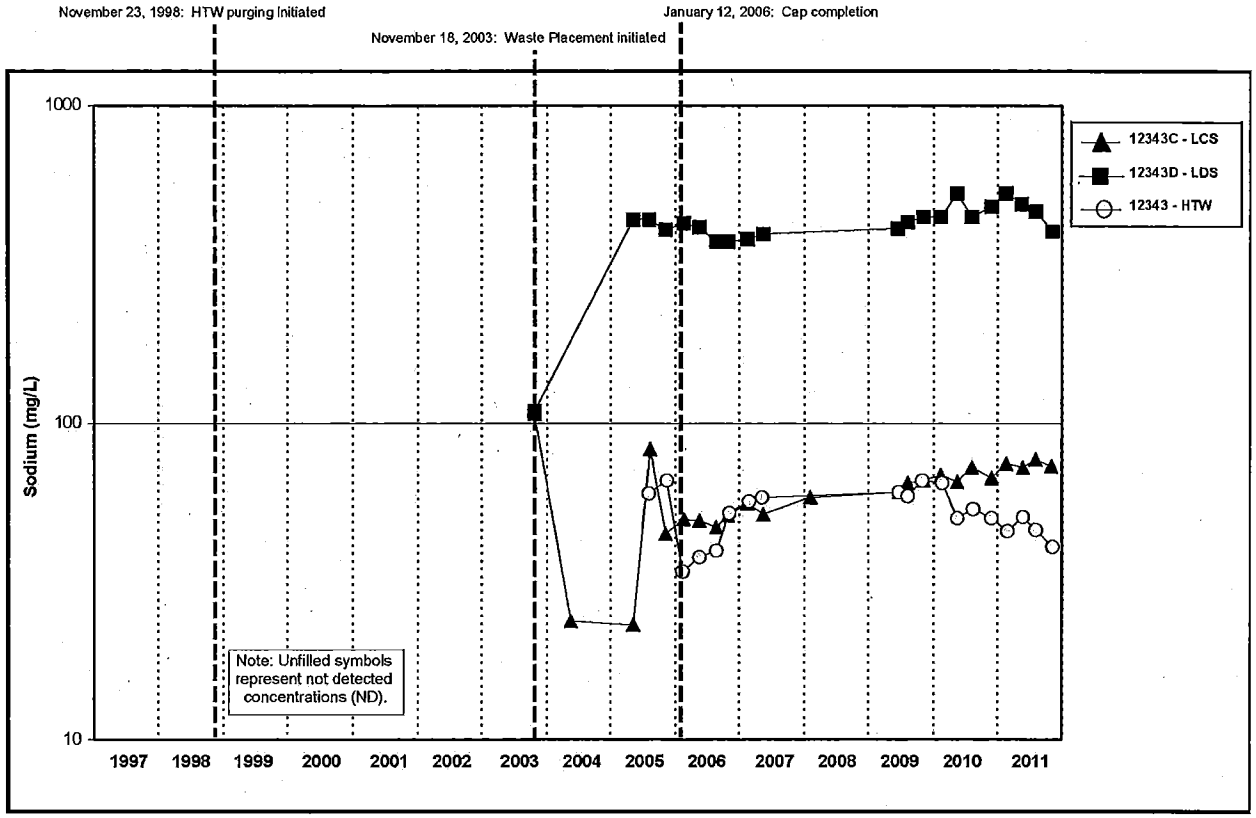


Figure A.5.6-27A. Cell 6 Sodium Concentration vs. Time Plot for LCS, LDS, and HTW

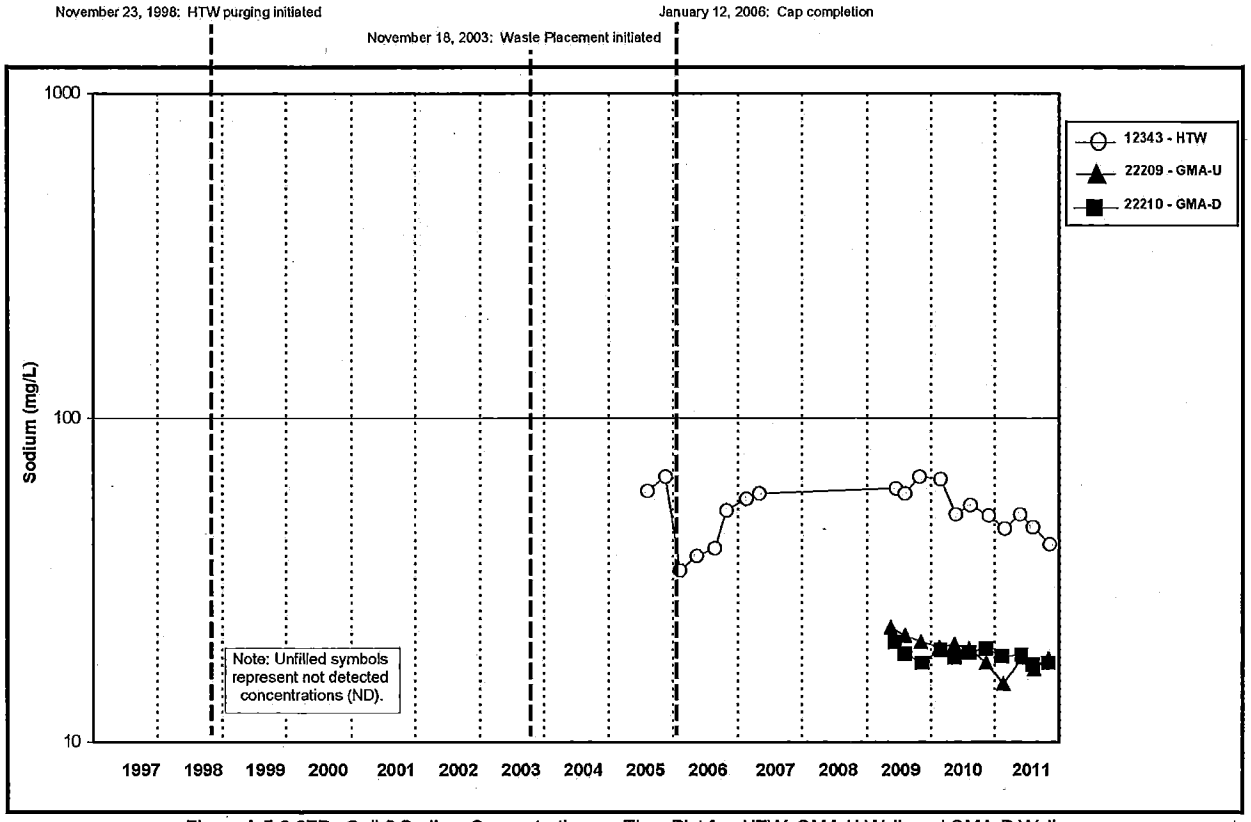


Figure A.5.6-27B. Cell 6 Sodium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

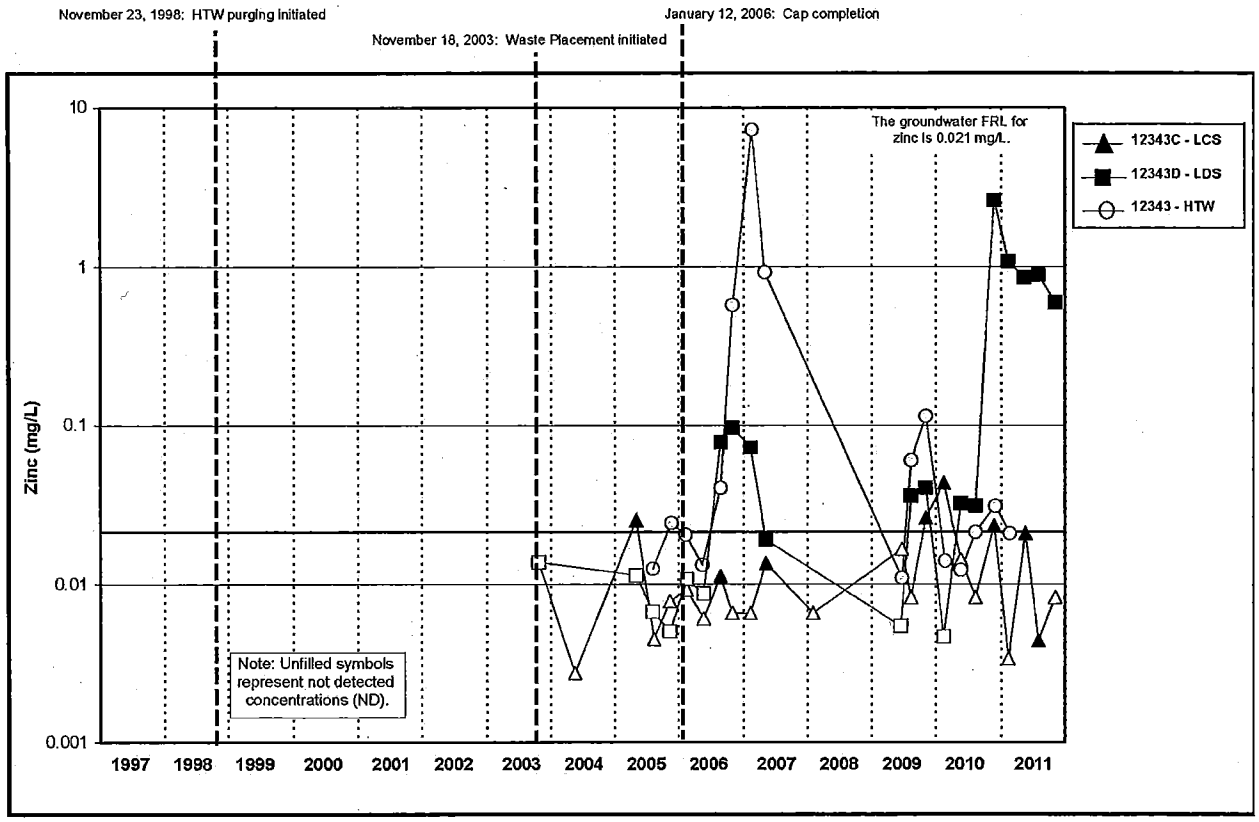


Figure A.5.6-28A. Cell 6 Zinc Concentration vs. Time Plot for LCS, LDS, and HTW

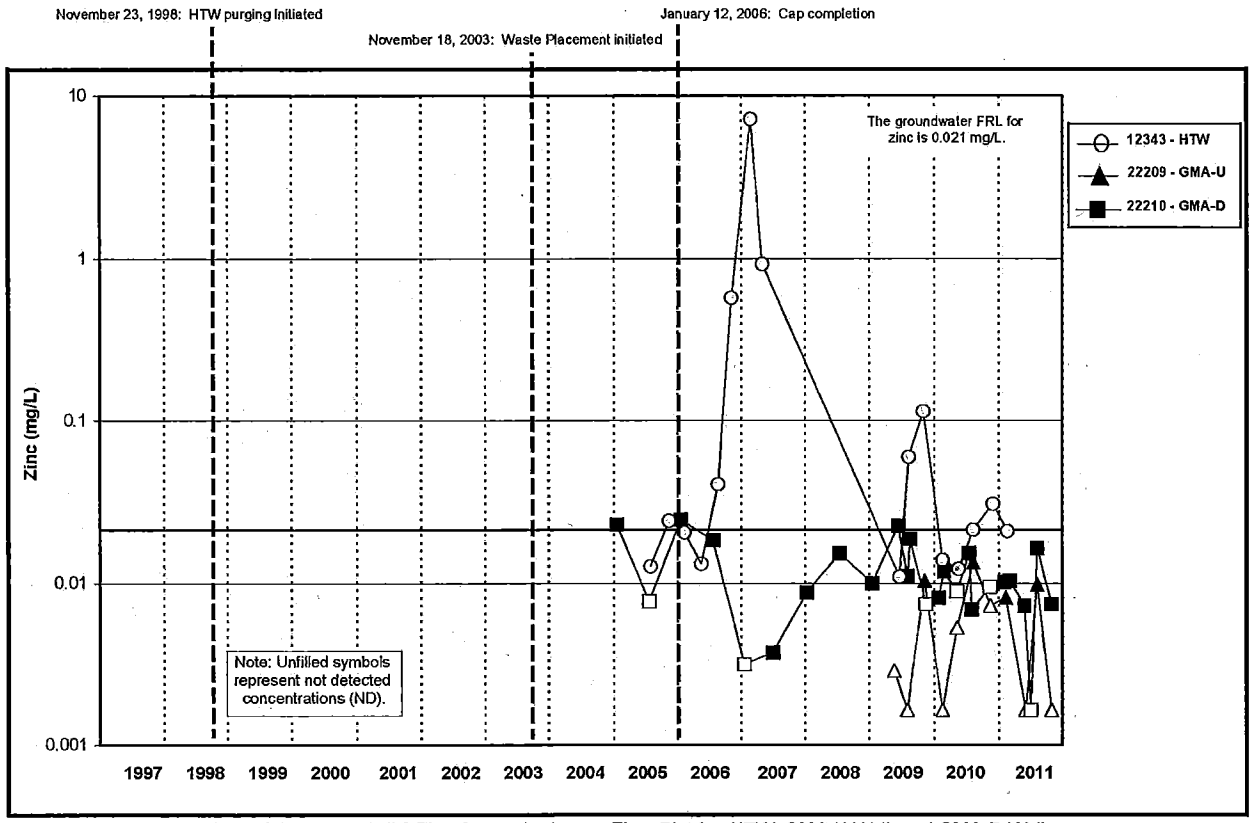


Figure A.5.6-28B. Cell 6 Zinc Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

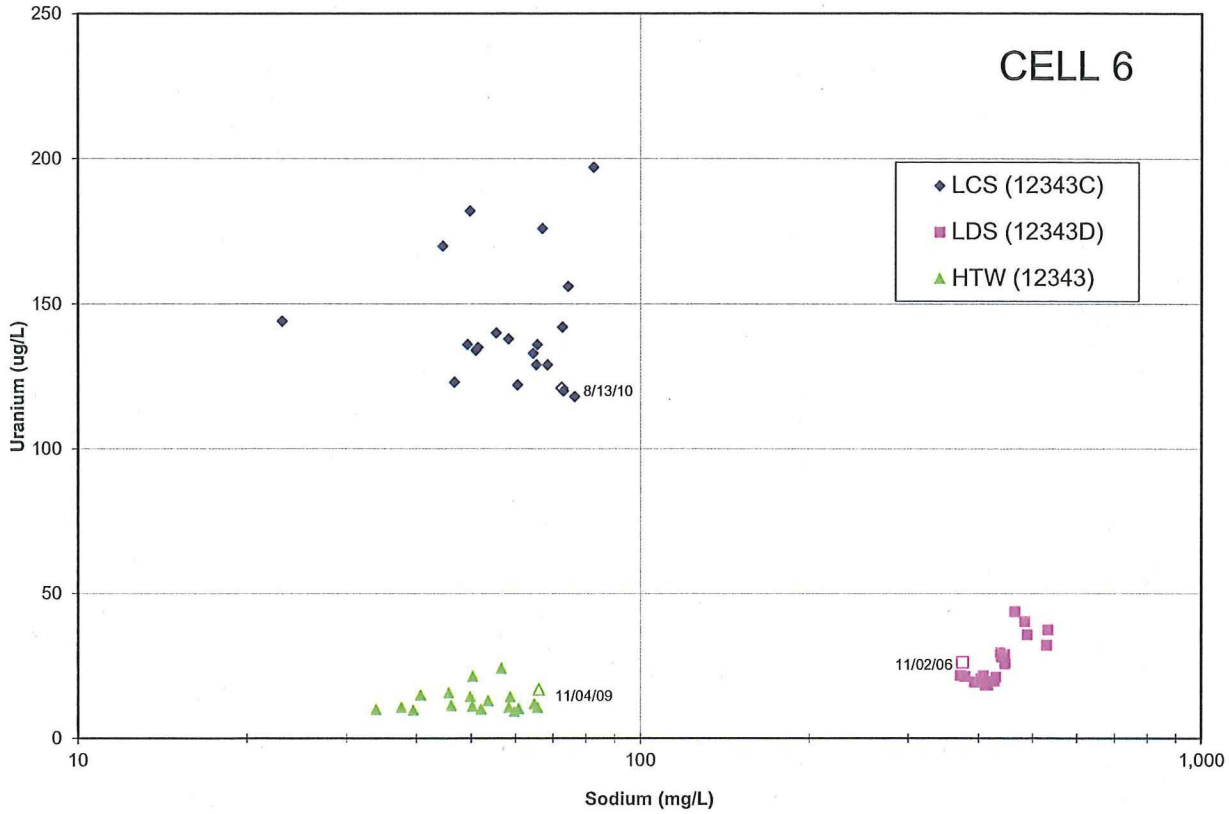


Figure A.5.6-29. Cell 6 Bivariate Plot for Uranium and Sodium

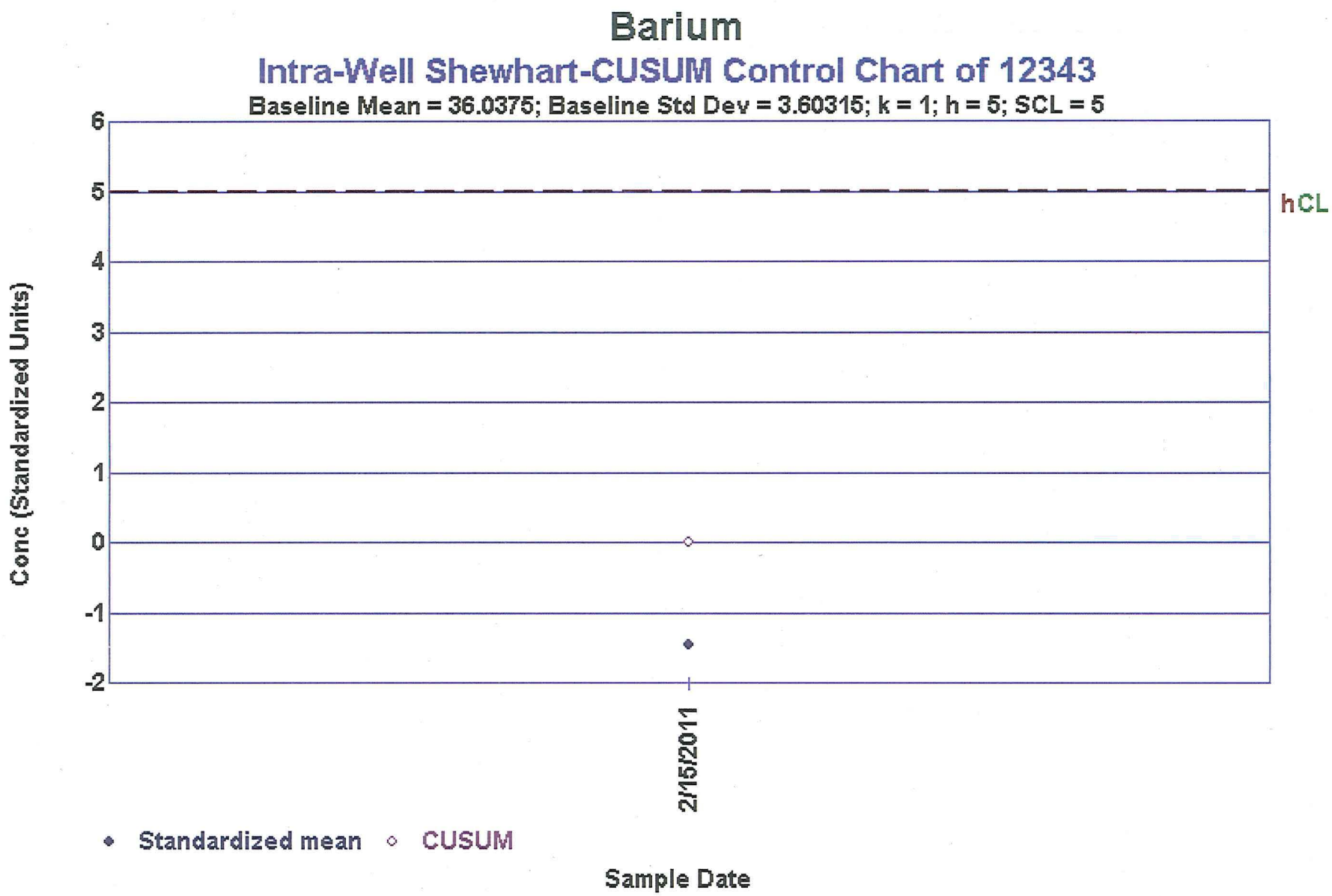


Figure A.5.6−30. Intra-Well Shewhart-CUSUM Control Chart (Barium 12343)

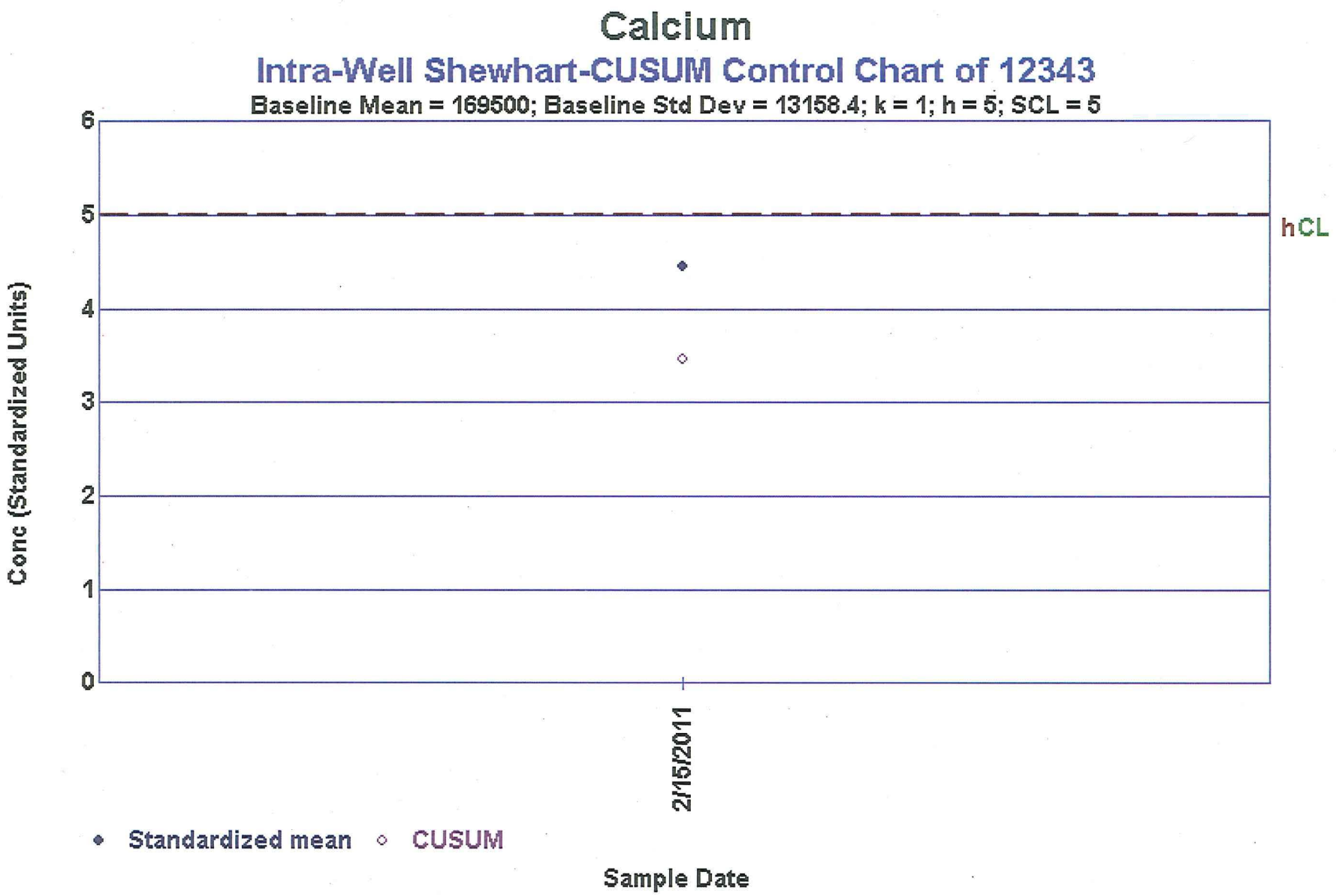


Figure A.5.6−31. Intra-Well Shewhart-CUSUM Control Chart (Calcium 12343)

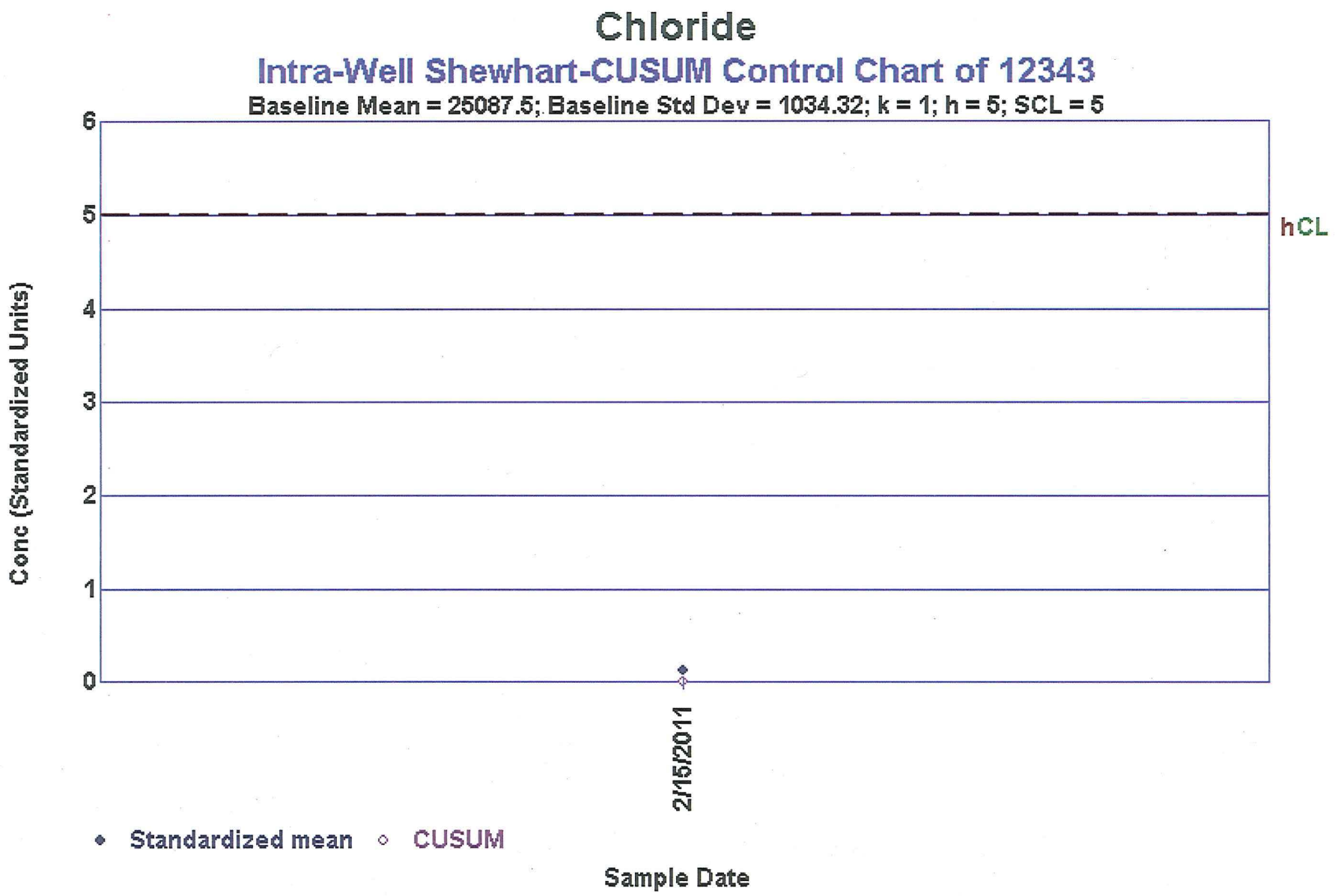


Figure A.5.6–32. Intra-Well Shewhart-CUSUM Control Chart (Chloride 12343)

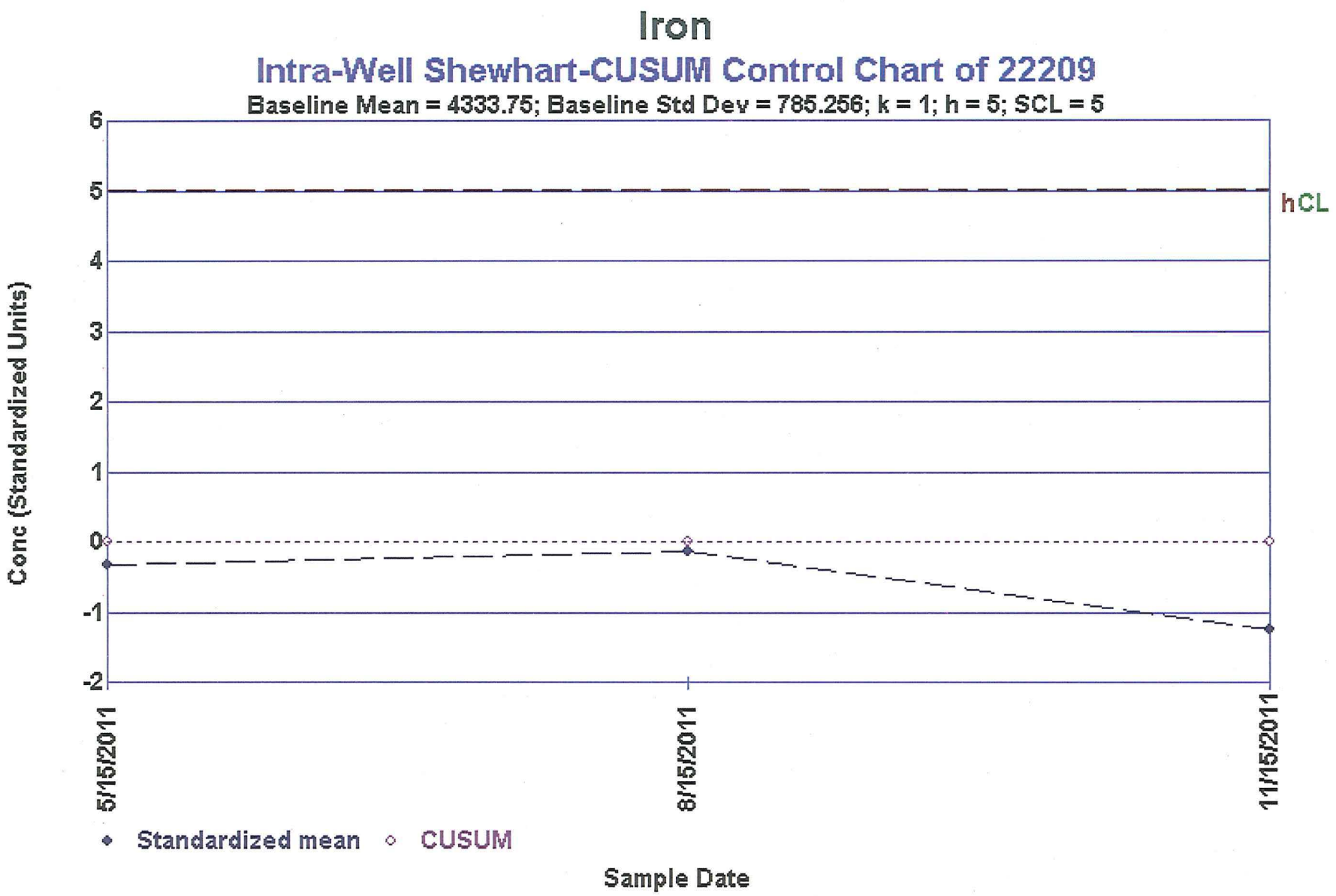


Figure A.5.6–33. Intra-Well Shewhart-CUSUM Control Chart (Iron 22209)

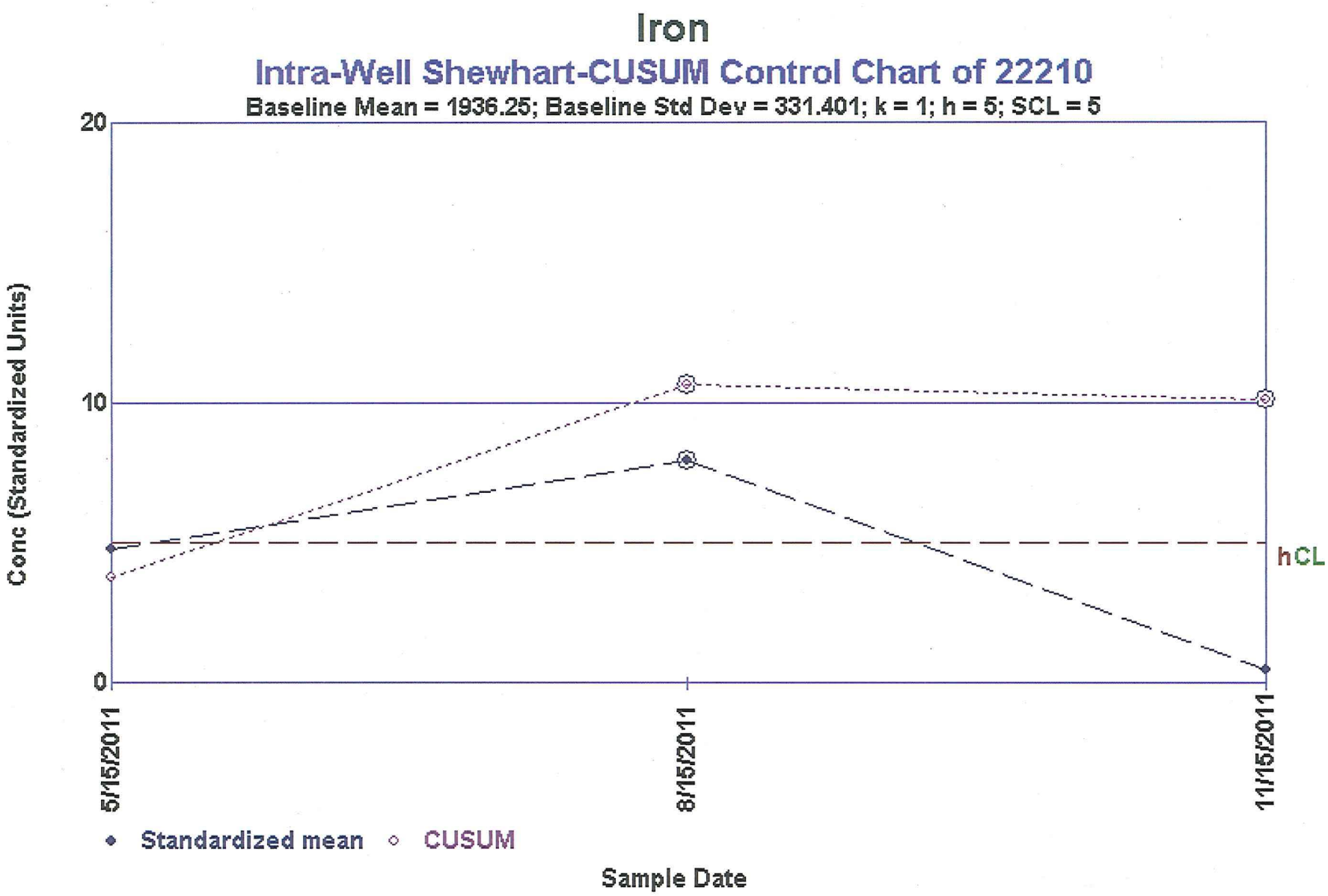


Figure A.5.6−34. Intra-Well Shewhart-CUSUM Control Chart (Iron 22210)

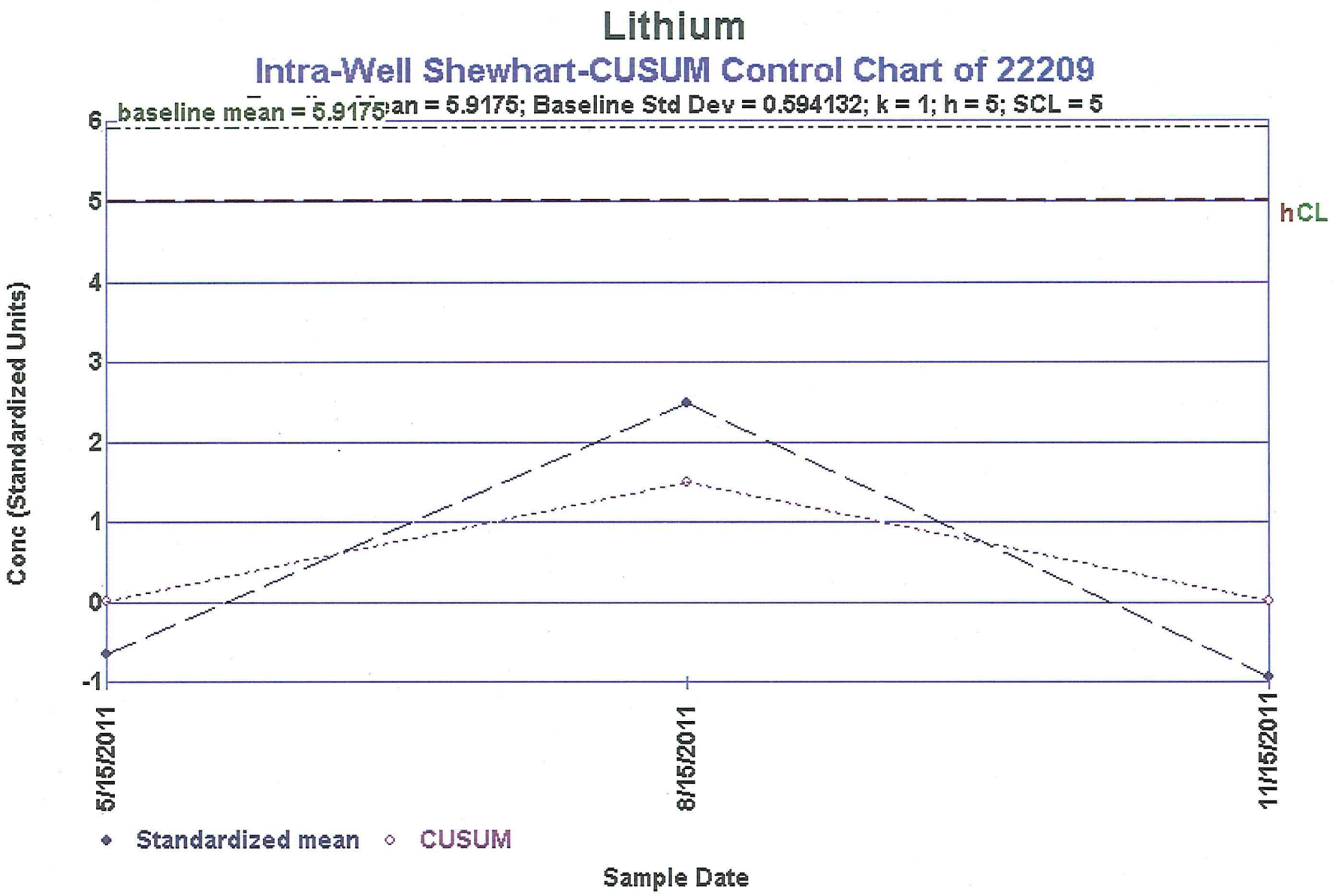


Figure A.5.6−35. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22209)

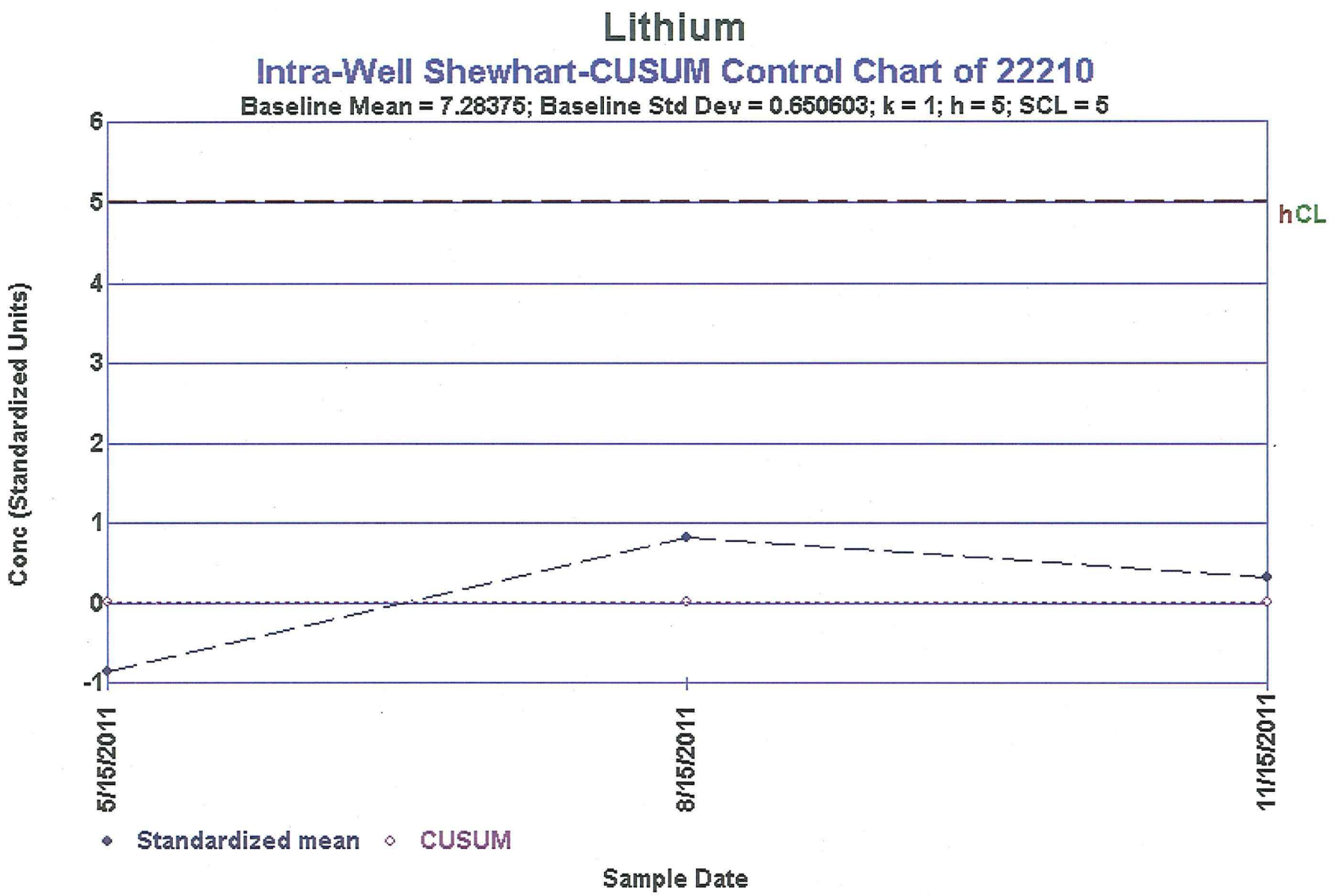


Figure A.5.6−36. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22210)

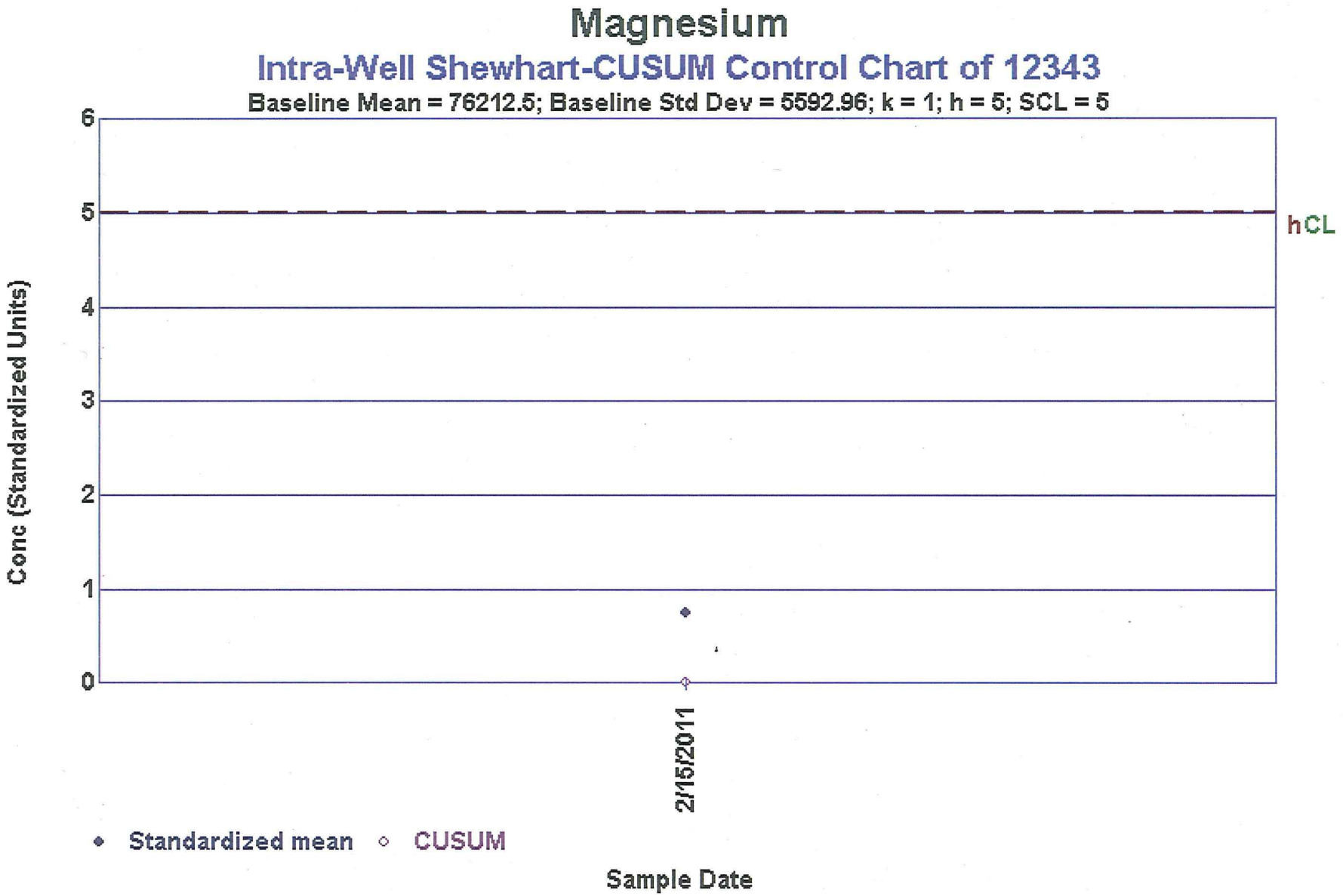


Figure A.5.6–37. Intra-Well Shewhart-CUSUM Control Chart (Magnesium 12343)

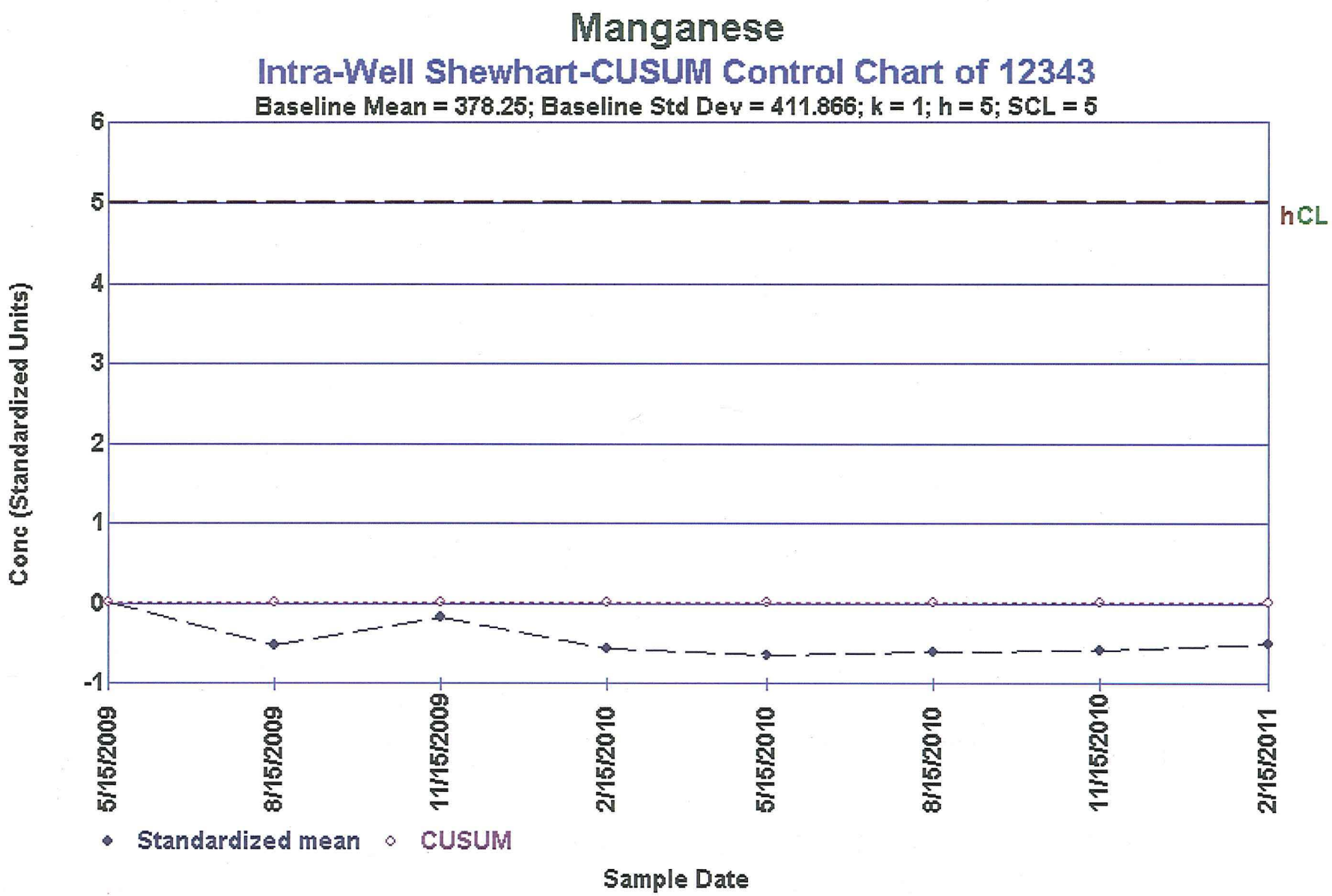


Figure A.5.6−38. Intra-Well Shewhart-CUSUM Control Chart (Manganese 12343)

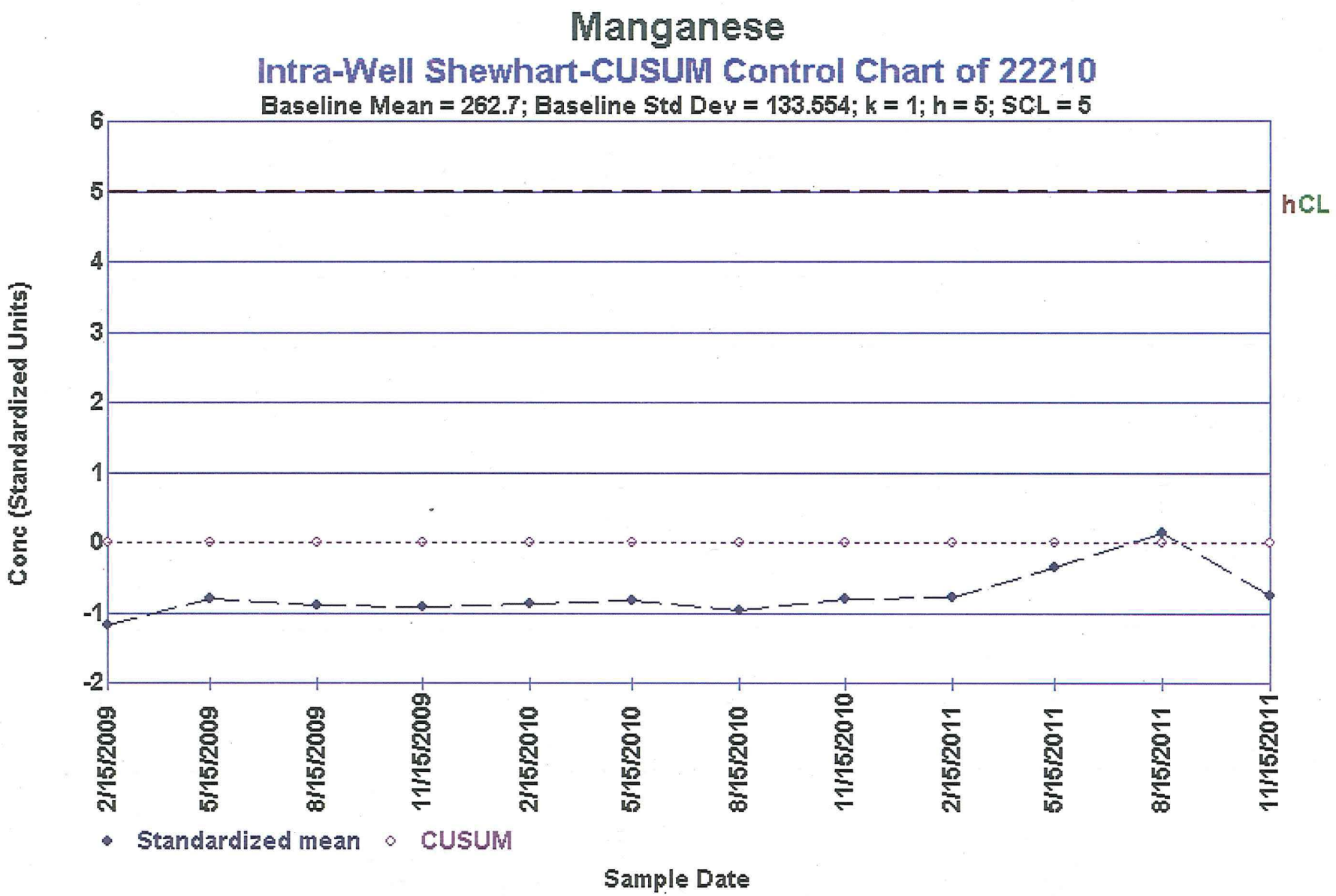


Figure A.5.6−39. Intra-Well Shewhart-CUSUM Control Chart (Manganese 22210)

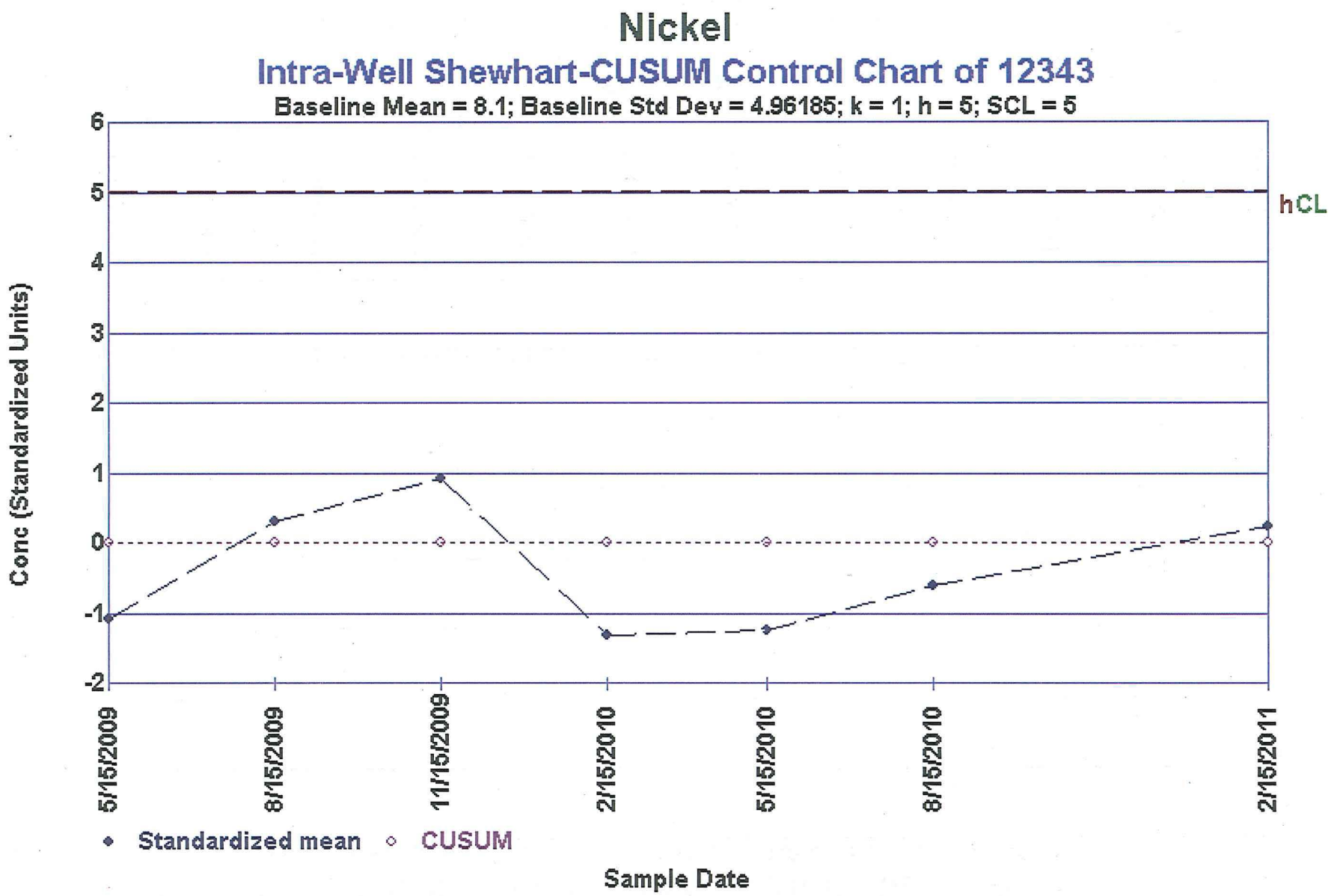


Figure A.5.6-40. Intra-Well Shewhart-CUSUM Control Chart (Nickel 12343)

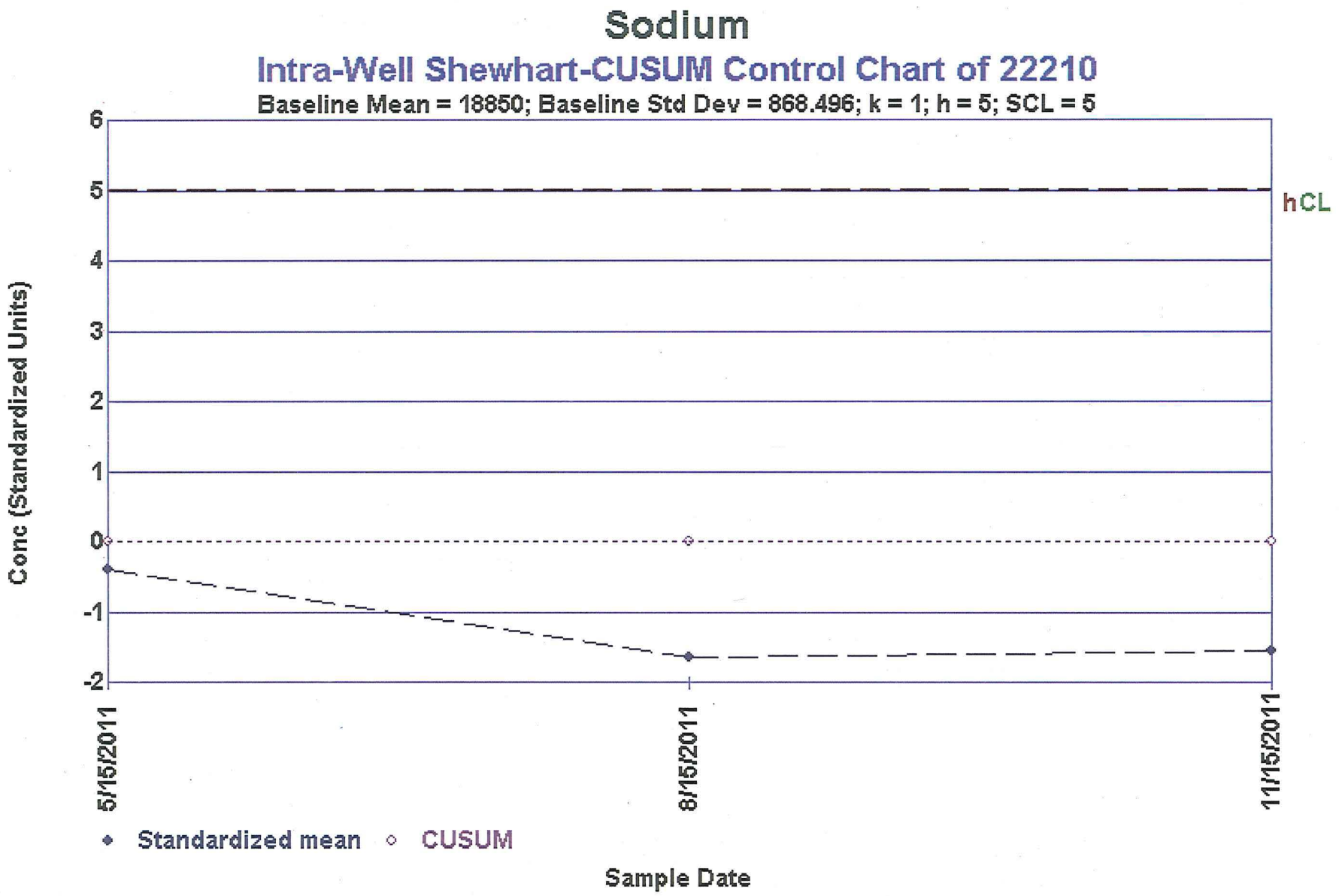


Figure A.5.6−41. Intra-Well Shewhart-CUSUM Control Chart (Sodium 22210)

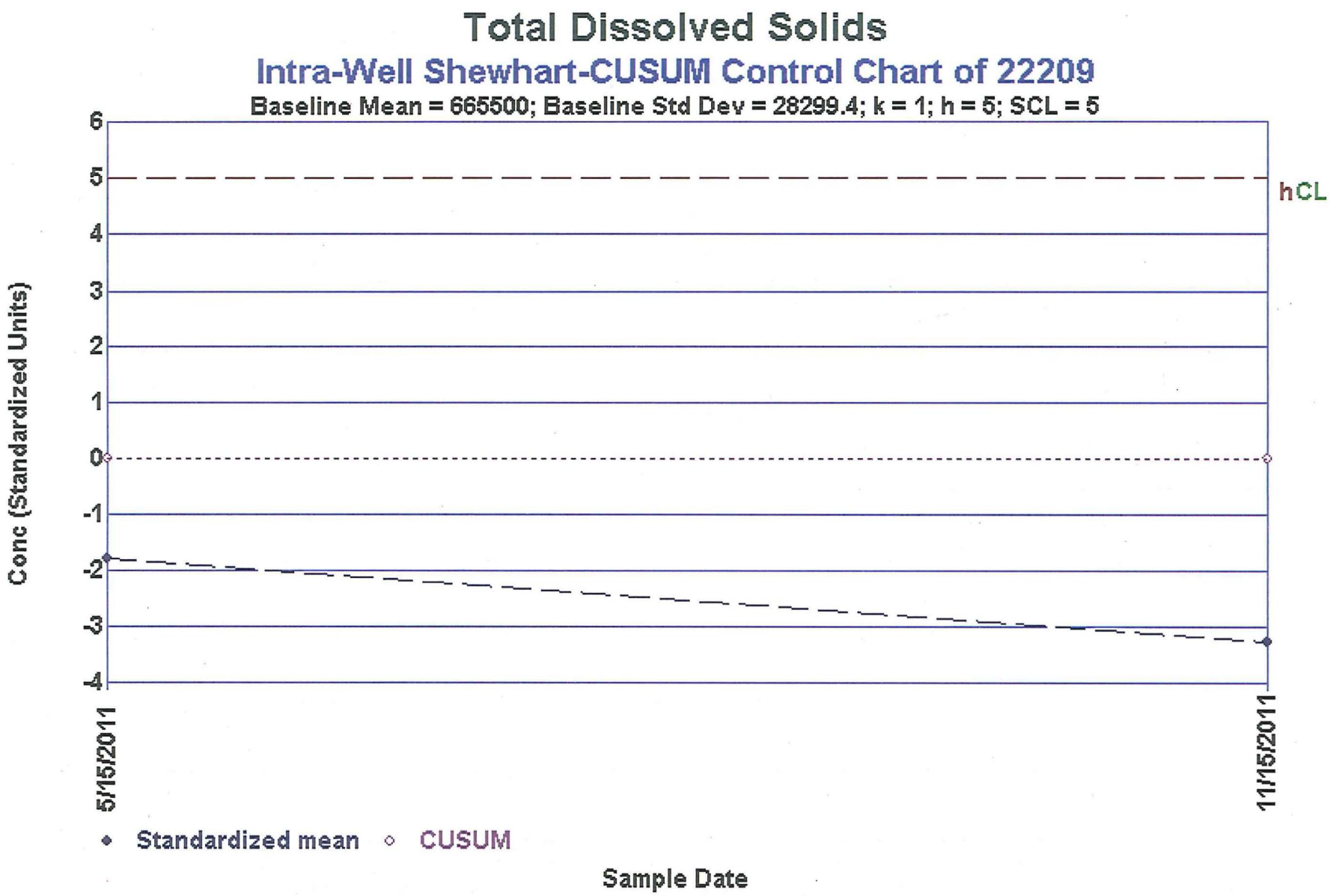


Figure A.5.6–42. Intra-Well Shewhart-CUSUM Control Chart (TDS 22209)

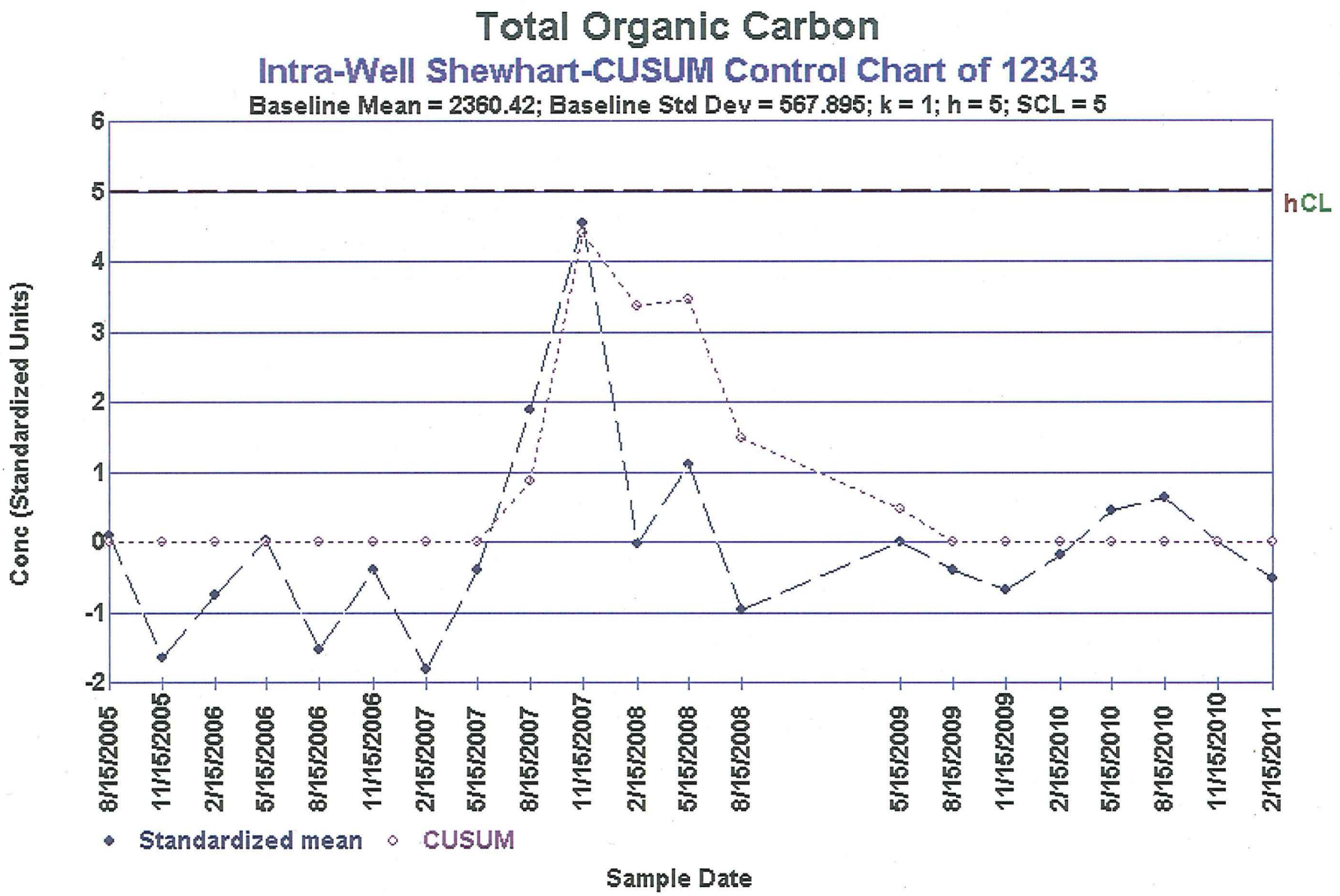


Figure A.5.6−43. Intra-Well Shewhart-CUSUM Control Chart (TOC 12343)

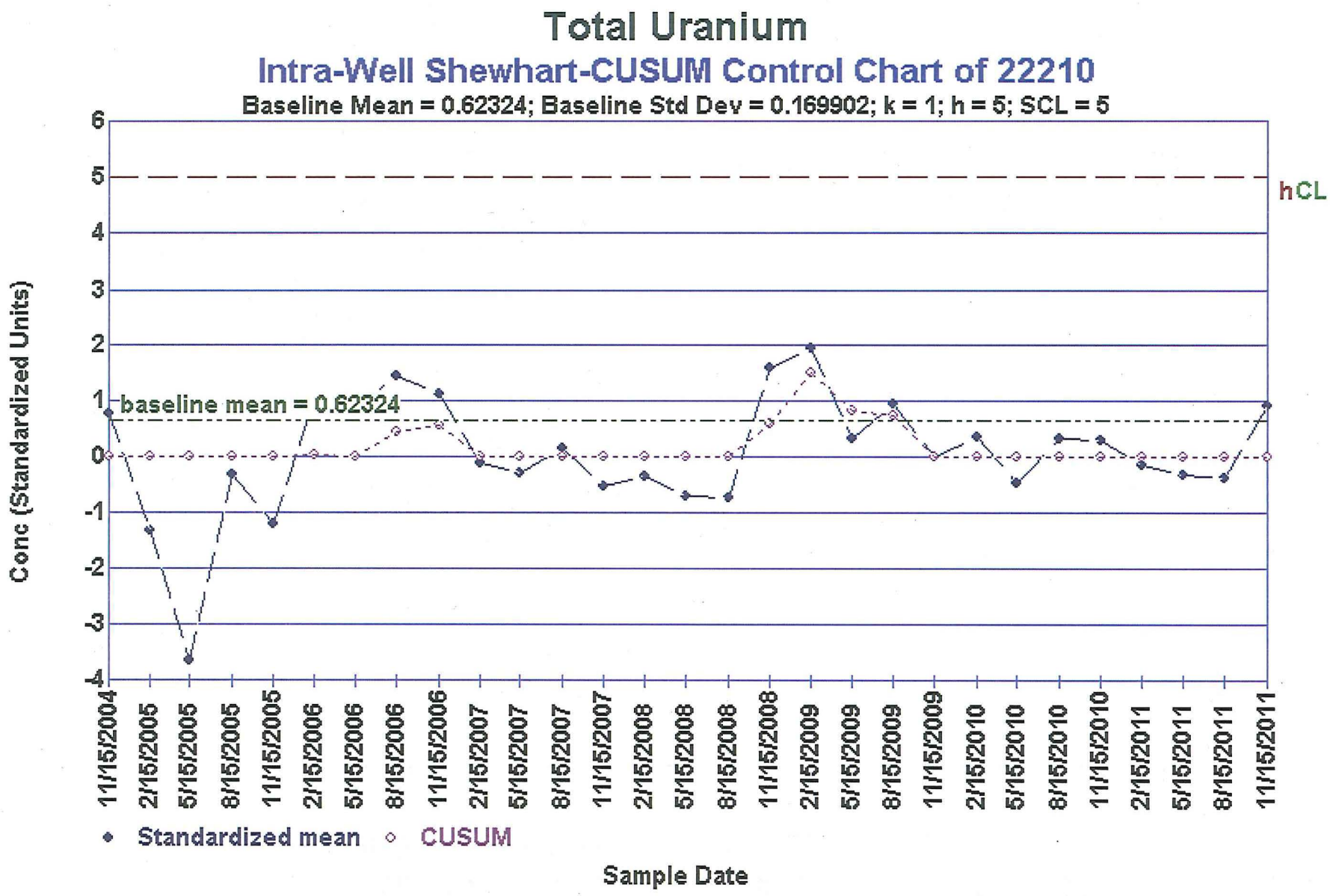


Figure A.5.6−44. Intra-Well Shewhart-CUSUM Control Chart (Uranium 22210)

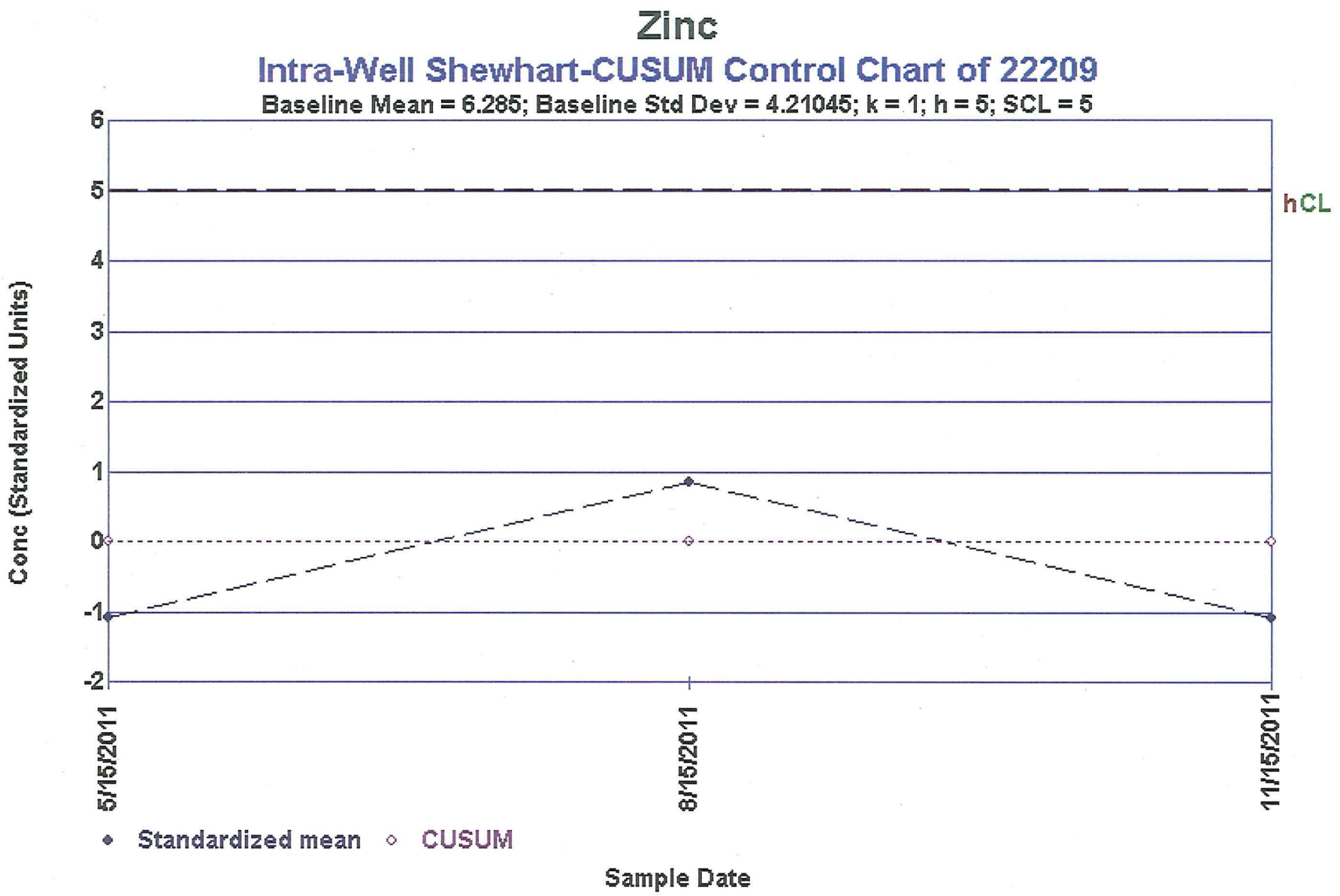


Figure A.5.6−45. Intra-Well Shewhart-CUSUM Control Chart (Zinc 22209)

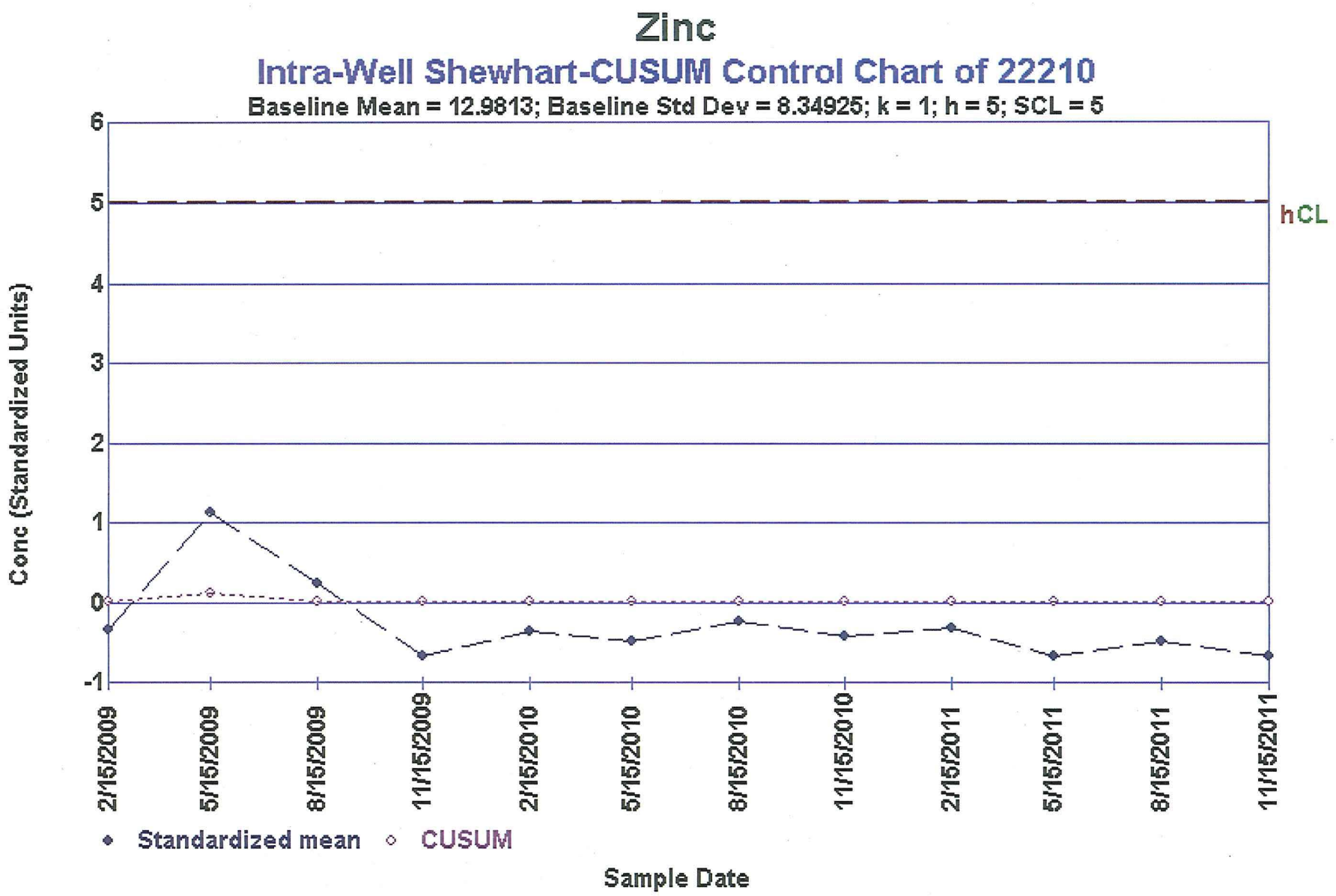


Figure A.5.6−46. Intra-Well Shewhart-CUSUM Control Chart (Zinc 22210)

Sub-attachment A.5.7

Sub-attachment A.5.7

Cell 7

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The following information is provided in this sub-attachment:

- Quarterly monitoring summary statistics (refer to Table A.5.7–1)
- Annual LCS sample summary information for detected parameters (refer to Table A.5.7–2)
- Site-specific parameter selection results (refer to Table A.5.7–3)
- LCS monthly accumulation volumes (refer to Figure A.5.7–1)
- LDS monthly accumulation volumes (refer to Figure A.5.7–2)
- OSDF horizontal till well 12344 water yield (refer to Figure A.5.7–3)
- GMA water levels and uranium concentration versus time (refer to Figures A.5.7–4 and A.5.7–5)
- Plots of concentration versus time (refer to Figures A.5.7–6A to A.5.7–28B)
- A bivariate plot for uranium-sodium (refer to Figure A.5.7–29)
- Control charts (refer to Figures A.5.7–30 to A.5.7–43)

A.5.7.1 Quarterly Monitoring Results

Quarterly water quality monitoring takes place in the LCS, LDS, HTW, and GMA wells of each cell for the purpose of determining if the OSDF is operating as designed. Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentrations versus time plots, bivariate plots, and control charts are used to help interpret and present the results.

In the first quarter of 2011, 23 parameters were sampled in the LCS, LDS, HTW, and GMA wells of each cell. In the second, third, and fourth quarters tritium was added to the analyte list for all horizons (LCS, LDS, HTW, and GMA Wells), and the analyte list for the HTWs in all cells was changed to just four parameters: arsenic, uranium, tritium, and sodium. These changes were agreed to via the comment resolution process between Ohio EPA and DOE on LMICP (revision 4). Tritium results for all cells are reported in Section A.5.5.

The Cell 7 HTW was dry during the first quarter of 2011, and the Cell 7 LDS was dry during the fourth quarter of 2011. As shown in Table A.5.7–1, 8 of the 23 constituents sampled quarterly in the LCS, LDS, HTW, and GMA wells (uranium, sulfate, TOC, boron, cobalt, iron, manganese, and sodium) have upward concentration trends in the HTW and/or GMA wells based on the Mann-Kendall test for trend.

Horizontal Till Well

The HTW is located beneath the liner penetration box of each cell by design. This area of the liner penetration box is considered to be potentially the weakest point in the cell design. If a leak were to develop, it should be detected beneath the liner penetration box first. Therefore, the water quality in the HTW represents the first line of evidence that a potential leak from the cell might be occurring. A leak would be indicated by an increasing concentration in the HTW.

Of the 23 parameters monitored quarterly in the LCS, LDS, HTW, and GMA wells, uranium, sulfate, cobalt, iron, sodium, and zinc concentrations are increasing in the HTW of Cell 7 (as indicated in the table below). The bivariate plot for the Cell 7 LCS, LDS, and HTW

(uranium-sodium) is provided in Figure A.5.7–29. The plot shows that the chemical signature for uranium-sodium in the LCS, LDS, and HTW are separate and distinct; indicating that mixing between the horizons is not occurring. Therefore, the increasing concentrations measured in the HTW of Cell 7 are attributed to fluctuating ambient concentrations beneath the cell that are not related to cell performance.

Parameter	HTW[a]	GMA-U[a]	GMA-D[a]
Uranium	Up		
Sulfate	Up	Up	Up
TOC		Up	Up
Boron			Up
Cobalt	Up		
Iron	Up	Up	
Manganese			Up
Sodium	Up		

[a] HTW = horizontal till well, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer; TOC = total organic carbon. No entry indicates that the trend was not up.

Great Miami Aquifer Wells

GMA monitoring wells are positioned for post-aquifer-remediation flow conditions, when flow directions will be from west to east. However, water levels measured in 2011 though indicate that groundwater in the GMA in most of the area of the OSDF is moving in a general direction of northeast to south/southwest in response to the active groundwater remediation taking place to the west and southwest. Pumping for the groundwater remediation is scheduled to last until 2023. Because bivariate plots (discussed above) indicate that LCS, LDS, and HTW monitoring horizons are not mixing, the increasing concentrations seen in the GMA wells are attributed to fluctuating ambient conditions that are not related to cell performance.

The table below provides a summary of the average concentration (as reported in Table A.5.7–1) measured in the LDS and GMA wells for parameters with increasing concentrations in the Cell 7 GMA wells.

Parameter	LDS[a]	GMA-U[a]	GMA-D[a]
Sulfate (mg/L)	**1740**	241	331
TOC (mg/L)	**5.60**	1.26	1.36
Boron (mg/L)	**0.309**	0.0344	0.0286
Iron (mg/L)	0.987	**9.17**	8.19
Manganese (mg/L)	0.083	0.310	**0.459**

Note: The highest averages are shown in bold.
[a] LDS = leak detection system, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer; TOC = total organic carbon

As shown above, both iron and manganese have higher concentration averages in the GMA than they do in the LDS of Cell 7.

A.5.7.2 Control Charts

Intrawell control charts employ historical measurements from a compliance point as background The *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance* (EPA 2009) defines the process of creating a Shewart-CUSUM control chart. Appropriate background data are used to define a baseline for the well. The baseline parameters for the chart, estimates of the mean, and standard deviation are obtained from the background data. These baseline measurements characterize the expected background concentrations at the monitoring point. As future concentrations are collected, the baseline parameters are used to standardize the newly gathered data. After these measurements are standardized and plotted, a control chart is declared "out of control" if future concentrations exceed the baseline control limit. This is indicated on the control chart when either the Shewart or CUSUM plot traces begin to exceed a control limit. The limit is based on the rationale that if the monitoring point remains unchanged from the baseline condition, new standardized observations should not deviate substantially from the baseline mean. If a change occurs, the standardized values will deviate significantly from the baseline and tend to exceed the control limit.

A minimum of eight samples are recommended for use in ChemStat® software to define the baseline for a control chart. Therefore, only sample sets with greater than eight samples were selected for control charts. By default, the ChemStat® software plots both a CUSUM control limit (h) and a SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit (h) and a value of 4.5 for the SCL.

EPA Unified Guidance suggests that to simplify the interpretation of the control chart that an out of control condition be based on the CUSUM (h) limit alone. Plotting the SCL limit is not needed. The ChemStat® software though, by default, plots both the SCL and CUSUM control limit on the charts. As a "work-a-round", the SCL limit was defined as 5 to match the recommended CUSUM limit. On the charts the combined limit is identified as hCL. For interpretation purposes, regard hCL as the CUSUM limit (h).

As shown in Table A.5.7–1 in gray shading, 10 constituents in the HTW and GMA wells of Cell 7 (TDS, TOX, barium, boron, copper, lithium, manganese, nickel, sodium, and zinc) meet the criteria for control charts (i.e., more than 8 samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in fourteen control charts.

Constituent and Monitoring Point[a]	Assessment
TDS in the GMA-U	In Control
TDS in the GMA-D	In Control
TOX in the HTW	In Control
TOX in the GMA-U	In Control
TOX in the GMA-D	In Control
Boron in the HTW	In Control
Copper in the HTW	**Out of Control**
Lithium in the GMA-U	In Control
Lithium in the GMA-D	In Control
Manganese in the HTW	**Out of Control**
Nickel in the HTW	**Out of Control**
Sodium in the GMA-D	In Control
Zinc in the HTW	In Control
Zinc in the GMA-D	In Control

[a] HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer; TDS = total dissolved solids; TOX = total organic halogens

The control charts are presented in Figures A.5.7–30 to A.5.7–43. All but three of the fourteen control charts exhibit "in control" conditions. Out of control conditions are indicated for copper, manganese, and nickel in the HTW. As discussed above, separate and distinct signatures for uranium and sodium in the LCS, LDS, and HTW of Cell 7 indicate that water is not mixing between the horizons, so the out of control conditions are attributed to fluctuating ambient conditions beneath the cell, and not to cell performance.

A.5.7.3 Annual LCS Sample Results

Annual LCS sampling results for Cell 7 are provided in Table A.5.7–2 for those parameters that have been detected at least once, and are not being sampled quarterly. No new Appendix I or PCB parameters were detected in the LCS of Cell 7 in 2011.

As reported in the 2009 SER, 1,1-dichloroethene was detected for the first time in the LCS of Cell 7 in 2009. In 2010, 1,1-dichloroethene was detected again in the LCS of Cell 7. As stated in Appendix B of the GWLMP (DOE 2010a) "two consecutive detects in a cell's LCS triggers sampling in the cell's LDS during the next scheduled sampling round." Sampled for twice in the LDS of Cell 7 in 2011, 1,1-dichloroethene was not detected in the LDS of Cell 7. Since it continues to be detected in the LCS of Cell 7 sampling in the LDS will continue.

A.5.7.4 Site-Specific Parameter Selection for Cell 7

The sample size of the Cell 7 dataset reached a minimum of eight samples at the end of 2011; therefore, the site-specific leachate monitoring parameter selection approach presented in Figures A.5–5A and A.5–5B was followed to determine if any of the Appendix I and PCB parameters detected in Cell 7 should be selected as site-specific monitoring parameters.

As discussed in Attachment A.5, the objective of the selection process is to determine if the mean concentration of an Appendix I or PCB parameter (that has been sampled eight times and detected more than 25 percent of the time) is statistically greater than the mean of either the pre-design or background data for the parameter. If the mean is greater, then the parameter is selected for more quarterly monitoring in the LCS, LDS, HTW, and GMA wells of the cell.

The null hypothesis used for each statistical test is that the mean of the concentration of the LCS dataset is less than or equal to the mean of the pre-design or background dataset. Failure of the null hypothesis indicates that the mean of the LCS dataset is greater than the mean of the pre-design or background dataset.

As shown in Table A.5.7-2 four of the Appendix I parameters not already being sampled for quarterly have been detected at least 25 percent of the time (ammonia, beryllium, chromium, and technetium-99). As reported in the *Fernald Preserve 2009 Site Environmental Report* (DOE 2010b), technetium was already evaluated for Cell 7 and passed the null hypothesis therefore it was not evaluated again this year.

Pre-design and/or background data does not exist for beryllium so parameter selection statistics could not be conducted. The low beryllium detections (maximum of 0.00025 mg/L) indicate that adding the constituent to the quarterly sampling program would not significantly enhance the

early detection capability of the monitoring program. Therefore, beryllium will not be added to the quarterly sampling list.

Parameter selection statistics were conducted for the remaining two parameters (ammonia and chromium). Results for Cell 7 are presented in Table A.5.7–3. Ammonia passed the null hypothesis and chromium failed the null hypothesis for the Tarone-Ware Test. Based on those results, chromium will be added to the quarterly sampling list for the LCS, LDS, and GMA wells of each cell beginning in January 2013.

A.5.7.5 Summary and Conclusions

- The concentrations of 8 parameters monitored quarterly are increasing in either the HTW and/or GMA wells of Cell 7 (uranium, sulfate, TOC, boron, cobalt, iron, manganese, and sodium).
- Separate and distinct chemical signatures for uranium and sodium in the LCS, LDS, and HTW of Cell 7 indicate that water is not mixing between the horizons. Concentration increases in the HTW and GMA wells of Cell 7 are attributed to fluctuating ambient concentrations beneath the cell, and not to cell performance.
- Fourteen control charts were constructed for Cell 7 parameters. Eleven of the fourteen control charts exhibit "in control" conditions. Control charts for copper, manganese, and nickel in the HTW are not in control.
- No new Appendix I or PCB parameters were detected in the LCS of Cell 7 in 2011.
- Chromium has been sampled at least 8 times in the LCS of Cell 7 and detected at least 25 percent of the time. It failed the null hypothesis of the Tarone-Ware test and will be added to the quarterly sampling list for the LCS, LDS, and GMA wells of each cell beginning in January 2013.
- Ammonia has been sampled at least 8 times in the LCS of Cell 7 and detected at least 25 percent of the time. It passed the null hypothesis of the Tarone-Ware test and will not be added to the quarterly sampling list.
- Beryllium has been sampled 8 times in the LCS of Cell 7 and detected at least 25 percent of the time. Parameter selection statistics were not conducted because no pre-design or background data sets exist. The small concentrations detected (maximum of 0.00025 mg/L) imply that the adding the constituent to the quarterly sampling program would not significantly enhance the early detection capability of the monitoring program. Therefore, beryllium will not be added to the quarterly sampling list.

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Table A.5.7–1. Summary Statistics for Cell 7

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12344C	29	29	100.0	4.72	355	175	61	Normal	None	Not Detected	
	LDS	12344D	27	27	100.0	12.2	33.7	24.5	5.4	Normal	None	Not Detected	
	HTW	12344	30	30	100.0	2.00	8.61	3.54	1.54	Lognormal	Up	Detected	
	GMA-U	22212	29	31	93.6	ND	5.53	0.490	1.17	Undefined	None	Not Detected	
	GMA-D	22211	31	32	96.9	0.131	2.30	0.328	0.535	Undefined	None	Not Detected	
Alkalinity as CaCO3 (mg/L)	LCS	12344C	17	17	100.0	86.0	822	432	174	Undefined	None	Not Detected	
	LDS	12344D	13	13	100.0	155	586	383	122	Normal	None	Not Detected	
	HTW	12344	8	8	100.0	377	455	414	26	Normal	None	Not Detected	
	GMA-U	22212	4	4	100.0	316	345	333	13	Normal	None	Insuff	
	GMA-D	22211	4	4	100.0	284	399	360	51	Normal	None	Insuff	
Chloride (mg/L)	LCS	12344C	17	17	100.0	26.7	175	114	49	Normal	Up	Detected	
	LDS	12344D	13	13	100.0	43.0	197	46.4	47.2	Undefined	None	Detected	
	HTW	12344	8	8	100.0	69.4	84.0	76.7	5.8	Normal	None	Not Detected	
	GMA-U	22212	4	4	100.0	24.2	31.9	26.9	3.4	Normal	None	Insuff	
	GMA-D	22211	4	4	100.0	19.7	31.7	25.2	5.1	Normal	None	Insuff	
Nitrate/Nitrite as N (mg/L)	LCS	12344C	13	18	72.2	ND	4.89	0.796	1.92	Undefined	Up	Detected	10.7 (Q4-05)
	LDS	12344D	10	13	76.9	ND	3.61	0.908	1.41	Normal	Up	Not Detected	9.03 (Q3-04)
	HTW	12344	5	8	62.5	ND	0.34	0.172	0.108	Lognormal	None	Not Detected	
	GMA-U	22212	0	4	0.0	NA	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22211	0	4	0.0	NA	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Sulfate (mg/L)	LCS	12344C	29	29	100.0	122	3920	2850	1120	Undefined	Up	Detected	
	LDS	12344D	27	27	100.0	1280	4030	1740	780	Undefined	Up	Detected	
	HTW	12344	27	27	100.0	80.4	465	208	135	Normal	Up	Detected	
	GMA-U	22212	31	31	100.0	96.7	731	241	136	Lognormal	Up	Detected	
	GMA-D	22211	31	31	100.0	152	572	331	126	Normal	Up	Detected	
Total Dissolved Solids (mg/L)	LCS	12344C	17	17	100.0	960	6400	5710	1810	Undefined	Up	Detected	
	LDS	12344D	11	11	100.0	2590	6870	4440	1450	Normal	Up	Not Detected	
	HTW	12344	7	7	100.0	1020	1200	1120	60	Normal	None	Not Detected	
	GMA-U	22212	11	11	100.0	609	1510	870	299	Lognormal	None	Not Detected	
	GMA-D	22211	11	11	100.0	602	1350	1050	230	Normal	None	Not Detected	
Total Organic Carbon (mg/L)	LCS	12344C	25	29	86.2	ND	5.55	2.33	0.88	Lognormal	None	Not Detected	
	LDS	12344D	27	27	100.0	2.99	8.80	5.60	1.36	Normal	None	Not Detected	
	HTW	12344	24	27	88.9	ND	3.72	2.24	0.72	Normal	None	Detected	
	GMA-U	22212	26	31	83.9	ND	2.24	1.26	0.51	Normal	Up	Detected	
	GMA-D	22211	25	31	80.6	0.555	2.15	1.36	0.50	Undefined	Up	Detected	
Total Organic Halogens (mg/L)	LCS	12344C	20	29	69.0	ND	0.039	0.0130	0.0114	Undefined	Up	Detected	
	LDS	12344D	20	27	74.1	ND	0.064	0.0291	0.0140	Normal	None	Not Detected	
	HTW	12344	12	27	44.4	ND	0.035	0.0101	0.0098	Lognormal	None	Not Detected	
	GMA-U	22212	10	31	32.3	ND	0.050	0.00532	0.00876	Lognormal	None	Not Detected	
	GMA-D	22211	7	31	22.6	0.00062	0.0134	0.00352	0.00341	Lognormal	None	Not Detected	0.054 (Q2-10)
Arsenic (mg/L)	LCS	12344C	6	22	27.3	ND	0.179	0.00375	0.0470	Undefined	None	Not Detected	
	LDS	12344D	4	20	20.0	ND	0.048	0.0025	0.0108	Undefined	None	Not Detected	
	HTW	12344	1	18	5.6	ND	0.0298	Insff	Insuff	Undefined	None	Not Detected	
	GMA-U	22212	3	11	27.3	ND	0.0394	0.0025	Insuff	Undefined	None	Not Detected	
	GMA-D	22211	5	20	25.0	ND	0.0323	0.0025	0.0094	Undefined	None	Detected	
Barium (mg/L)	LCS	12344C	17	17	100.0	0.0234	0.112	0.0509	0.0283	Lognormal	Down	Not Detected	
	LDS	12344D	13	13	100.0	0.0197	0.0891	0.0362	0.0193	Lognormal	Down	Not Detected	
	HTW	12344	8	8	100.0	0.0922	0.121	0.111	0.010	Normal	None	Not Detected	
	GMA-U	22212	4	4	100.0	0.0508	0.0971	0.0770	0.0218	Normal	None	Insuff	
	GMA-D	22211	4	4	100.0	0.0429	0.0693	0.0558	0.0111	Normal	None	Insuff	

Table A.5.7-1 (continued). Summary Statistics for Cell 7

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Boron (mg/L)	LCS	12344C	29	29	100.0	0.926	1.35	1.18	0.10	Normal	None	Not Detected	0.299 (Q4-04) 0.0625 (Q1-05) 0.288 (Q2-05) 0.249 (Q3-05) 0.249 (Q4-05)
	LDS	12344D	27	27	100.0	0.168	2.10	0.309	0.382	Undefined	Up	Detected	
	HTW	12344	19	27	70.4	ND	0.075	0.0248	0.0137	Normal	None	Not Detected	
	GMA-U	22212	29	31	93.6	ND	0.0458	0.0344	0.0063	Normal	None	Detected	
	GMA-D	22211	28	31	90.3	ND	0.0433	0.0286	0.0069	Undefined	Up	Not Detected	
Calcium (mg/L)	LCS	12344C	17	17	100.0	153	759	577	178	Undefined	Up	Not Detected	
	LDS	12344D	13	13	100.0	155	474	312	121	Lognormal	None	Detected	
	HTW	12344	8	8	100.0	149	187	164	13	Normal	None	Not Detected	
	GMA-U	22212	4	4	100.0	146	377	156	112	Undefined	None	Insuff	
	GMA-D	22211	4	4	100.0	153	263	206	45	Normal	None	Insuff	
Cobalt (mg/L)	LCS	12344C	12	22	54.6	ND	0.0080	0.0017	0.0022	Undefined	Down	Not Detected	
	LDS	12344D	10	20	50.0	ND	0.0025	0.000826	0.00053	Lognormal	None	Not Detected	
	HTW	12344	10	15	66.7	ND	0.0433	0.00675	0.0132	Normal	Up	Detected	
	GMA-U	22212	1	11	9.1	ND	0.00138	Insuff	Insuff	Undefined	None	Detected	
	GMA-D	22211	0	11	0.0	NA	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Copper (mg/L)	LCS	12344C	16	22	72.7	ND	0.0266	0.0108	0.0089	Undefined	None	Not Detected	
	LDS	12344D	13	20	65.0	ND	0.0239	0.00833	0.00657	Lognormal	Down	Detected	
	HTW	12344	5	9	55.6	ND	0.015	0.00358	0.00434	Lognormal	None	Not Detected	
	GMA-U	22212	4	4	100.0	0.00106	0.00966	0.00636	0.00393	Normal	None	Insuff	
	GMA-D	22211	4	4	100.0	0.00599	0.00956	0.00754	0.00151	Normal	None	Insuff	
Iron (mg/L)	LCS	12344C	21	22	95.4	ND	18.7	5.18	4.99	Lognormal	Down	Not Detected	
	LDS	12344D	18	20	90.0	ND	2.74	0.987	0.820	Undefined	Down	Detected	
	HTW	12344	14	15	93.3	0.119	66.1	21.2	18.2	Lognormal	Up	Detected	
	GMA-U	22212	11	11	100.0	4.15	20.5	9.17	4.68	Lognormal	Up	Not Detected	
	GMA-D	22211	11	11	100.0	4.88	11.2	8.19	2.00	Normal	None	Detected	
Lithium (mg/L)	LCS	12344C	20	20	100.0	0.0188	0.393	0.171	0.095	Normal	Up	Detected	
	LDS	12344D	19	19	100.0	0.0529	0.226	0.119	0.053	Lognormal	Up	Detected	
	HTW	12344	10	15	66.7	ND	0.00874	0.00716	0.00143	Undefined	None	Not Detected	
	GMA-U	22212	11	11	100.0	0.00495	0.00892	0.00620	0.00125	Lognormal	None	Not Detected	
	GMA-D	22211	11	11	100.0	0.00566	0.00827	0.00690	0.00083	Normal	None	Not Detected	
Magnesium (mg/L)	LCS	12344C	17	17	100.0	60.5	834	448	276	Normal	Up	Detected	
	LDS	12344D	13	13	100.0	61.1	369	88.8	117	Undefined	None	Detected	
	HTW	12344	8	8	100.0	46.0	58.9	51	4	Normal	None	Not Detected	
	GMA-U	22212	4	4	100.0	28.6	54.6	38.2	11.3	Normal	None	Insuff	
	GMA-D	22211	4	4	100.0	34.6	60.6	47.6	10.6	Normal	None	Insuff	
Manganese (mg/L)	LCS	12344C	14	22	63.6	0.0041	0.991	0.0351	0.276	Undefined	Down	Detected	
	LDS	12344D	13	20	65.0	ND	1.20	0.083	0.266	Normal	None	Not Detected	
	HTW	12344	14	15	93.3	ND	0.223	0.0525	0.0565	Lognormal	None	Not Detected	
	GMA-U	22212	11	11	100.0	0.219	1.23	0.310	0.299	Undefined	None	Not Detected	
	GMA-D	22211	20	20	100.0	0.256	0.680	0.459	0.136	Normal	Up	Detected	
Nickel (mg/L)	LCS	12344C	19	22	86.4	ND	0.0265	0.00999	0.00795	Lognormal	Down	Detected	
	LDS	12344D	16	20	80.0	ND	0.0138	0.00681	0.00384	Normal	None	Not Detected	
	HTW	12344	11	15	73.3	ND	0.0761	0.0114	0.0215	Lognormal	None	Not Detected	
	GMA-U	22212	4	11	36.4	ND	0.00493	0.00075	0.00148	Undefined	None	Not Detected	
	GMA-D	22211	3	20	15.0	ND	0.00520	0.00075	Insuff	Undefined	None	Detected	
Potassium (mg/L)	LCS	12344C	17	17	100.0	8.12	61.4	44.3	15.5	Undefined	Up	Detected	
	LDS	12344D	13	13	100.0	13.2	97.9	32.6	24.3	Lognormal	None	Not Detected	
	HTW	12344	7	8	87.5	ND	2.89	2.15	0.57	Normal	None	Not Detected	
	GMA-U	22212	4	4	100.0	3.47	4.81	3.58	0.64	Undefined	None	Insuff	
	GMA-D	22211	4	4	100.0	2.74	3.40	3.04	0.32	Normal	None	Insuff	

Table A.5.7-1 (continued). Summary Statistics for Cell 7

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Selenium (mg/L)	LCS	12344C	4	22	18.2	ND	0.171	0.00625	0.0368	Undefined	None	Not Detected	
	LDS	12344D	3	20	15.0	ND	0.0477	0.00712	Insuff	Lognormal	None	Not Detected	
	HTW	12344	1	15	6.7	ND	0.0292	Insuff	Insuff	Undefined	None	Not Detected	
	GMA-U	22212	1	11	9.1	ND	0.00827	Insuff	Insuff	Undefined	None	Detected	
	GMA-D	22211	0	11	0.0	NA	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Sodium (mg/L)	LCS	12344C	22	22	100.0	18.1	102	80.7	25.3	Undefined	Up	Detected	
	LDS	12344D	20	20	100.0	186	913	584	166	Normal	None	Not Detected	
	HTW	12344	18	18	100.0	19.8	37.4	27.6	7.1	Undefined	Up	Detected	
	GMA-U	22212	11	11	100.0	19.6	27.0	23.1	2.6	Normal	Down	Detected	
	GMA-D	22211	11	11	100.0	11.1	19.2	15.5	2.5	Normal	None	Not Detected	
Zinc (mg/L)	LCS	12344C	14	22	63.6	ND	0.154	0.0294	0.0401	Lognormal	None	Not Detected	
	LDS	12344D	17	20	85.0	ND	5.16	0.0255	1.43	Undefined	Up	Detected	
	HTW	12344	14	15	93.3	0.0048	0.655	0.211	0.213	Lognormal	None	Not Detected	
	GMA-U	22212	6	11	54.6	ND	0.0148	0.00659	0.00429	Normal	None	Not Detected	
	GMA-D	22211	10	20	50.0	ND	0.0205	0.00462	0.00446	Lognormal	None	Not Detected	

Note: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least 8 samples, normal or lognormal distribution, no trend, and no serial correlation. These wells achieve control chart criteria.

Note: For results where the concentrations are below the detection limit, the results used in the Average, Standard Deviation, Distribution Type, Trend, Serial Correlation, and Outliers are each set at half the detection limit.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption and requires $n \geq 3$. In addition, Standard Deviation requires $n \geq 4$.

[d]"Insuff" = Insufficient and is used for Average, Standard Deviation, Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic (where $3 \leq n \leq 50$) or Shapiro Francia (where $n > 50$).

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the lognormal assumption.

Lognormal: Lognormal assumption could not be rejected at the 5 percent level and has a higher probability value than the normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25% detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure. Trend testing requires a sample with $n \geq 4$.

[g]Serial correlation based on Rank Von Neumann test. Serial Correlation testing requires a sample with $n \geq 6$.

[h]Outliers determined by Rosner's (where $n > 25$) or Dixon procedure (where $4 \leq n \leq 25$).

[i]Q = quarterly

Table A.5.7-2. Cell 7 Annual LCS Sample Summary Information for Detected Parameters

PARAMETER(UNIT)	NUMBER OF SAMPLES[a,b]	NUMBER OF SAMPLES WITH DETECTIONS[a,b]	PERCENT OF DETECTIONS[a,b]	DETECTED IN 2011	MIN DETECTED CONCENTRATION[a,b,c]	MAX DETECTED CONCENTRATION[a,b,c]	AVG DETECTED CONCENTRATION[a,b,c]	GW FRL[d] (#OF SAMPLES>GWFRL)	GW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	PW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	MAX PW DETECTED CONCENTRATION [a,b,f] (# OF SAMPLES>MAX PW)
General Chemistry											
Ammonia (mg/L)	8	3	37.5	Yes	0.026	0.254	0.113	-	4.2 mg/L(0)	4.34 mg/L(0)	220 mg/L(0)
Inorganics											
Beryllium (mg/L)	8	2	25.0	No	0.00017	0.00025	0.0002	0.004 mg/L(0)	-	-	0.0343 mg/L(0)
Cadmium (mg/L)	8	1	12.5	No	0.0002	-	-	0.014 mg/L(0)	0.014 mg/L(0)	-	0.05 mg/L(0)
Chromium (mg/L)	8	2	25	Yes	0.0055	0.0292	0.0174	0.022 mg/L[g](1)	0.021 mg/L(1)	0.0046 mg/L(2)	0.818 mg/L(0)
Lead (mg/L)	8	1	12.5	No	0.0061	-	-	0.015 mg/L(0)	0.022 mg/L(0)	0.0016 mg/L(1)	0.0114 mg/L(0)
Thallium (mg/L)	8	1	12.5	No	0.00046	-	-	-	-	-	0.0028 mg/L(0)
Vanadium (mg/L)	8	1	12.5	No	0.0051	-	-	0.038 mg/L(0)	0.012 mg/L(0)	0.005 mg/L(1)	0.299 mg/L(0)
Radionuclides											
Technetium-99 (pCi/L)	16	6	37.5	No	0.86	16.2	9.05	94 pCi/L(0)	22 pCi/L(0)	30 pCi/L(0)	6130 pCi/L(0)
Organics											
1,1-Dichloroethene (ug/L)	14	3	21.4	Yes	0.455	0.72	0.558	7 ug/L(0)	-	-	-
Acetone (ug/L)	8	1	12.5	No	3.5	-	-	-	-	-	-
Total Xylenes (ug/L)	8	1	12.5	No	1.01	-	-	-	-	-	-

Note: Shading indicates that at least one detected sample is greater than the FRL, groundwater background, PW background, or PW maximum.

[a]If more than one sample is collected per well per day (e.g., duplicates), then only one sample is counted for the total number of samples, and the sample with the maximum representative concentration is used for all the summary information

[b]Rejected data qualified with an R or Z were not included.

[c]If the number of detected samples is equal to two, then the minumun and maximumn are reported. If the number of detected is equal to one, then the data point is reported as the minimum. The "AVG DETECTED CONCENTRATION" is not reported for either of these cases.

[d]From Operable Unit 5 Record of Decision, Table 9-4.

[e]From the Characterization of Background Water Quality for Streams and Groundwater which was developed for Operable Unit 5 RI/FS documents.

[f]Max PW - maximum detected concentration in perched water as defined in the Remedial Investigation Report for Operable Unit 5.

[g]FRL based on hexavalent chromium from Operable Unit 5 Record of Decision, Table 9-4.

Table A.5.7–3. Site-Specific Parameter Selection Results

					t-Test												Wilcoxon + Quantile		Tarone-Ware Test
Parameter	**Dataset**	**Samples**	**Detects**	**Detect %**	**Shapiro-Wilk (N)**	**Shapiro-Wilk (LN)**	**Min**	**Max**	**Mean (mg/L)**	**Median**	**Variance**	**Std. Dev.**	**Log Mean**	**Log SD**	**F-Test**	**t-Test Prob**	**Wilcoxen Group Comparison**	**Quantile Test**	
Ammonia	LCS	8	3	38%			0.005	0.254	0.0518	0.0205	0.0070	0.0837							
	PreDesign**	9	7	78%			0.015	450	54.98	0.604	22100	149							Pass
	* before 2/10/95																		
	** after 2/10/95																		
Chromium	LCS	8	2	25%			0.0010	0.0292	0.0067	0.0038	0.0000858	0.0093							
	PreDesign	40	19	48%			0.002	0.478	0.046	0.004	0.008	0.087							Pass
	PreDesign*	19	17	89%			0.004	0.478	0.093	0.051	0.012	0.110							Pass
	PreDesign**	21	2	10%			0.002	0.012	0.004	0.004	0.000	0.002							Failed
	* before 2/10/95																		
	** after 2/10/95																		

No significant difference (Pass)
LCS significantly GREATER than PreDesign (Fail)

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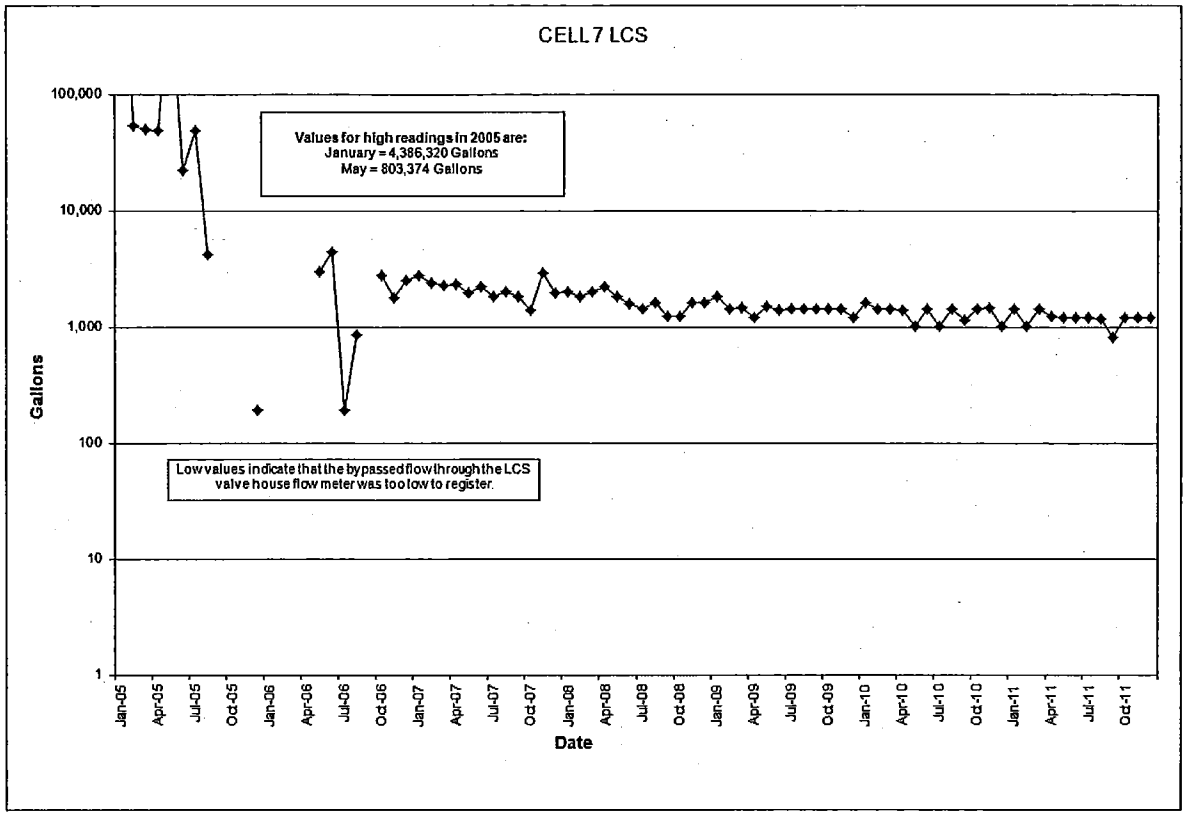


Figure A.5.7-1. Monthly Accumulation Volumes for Cell 7 LCS

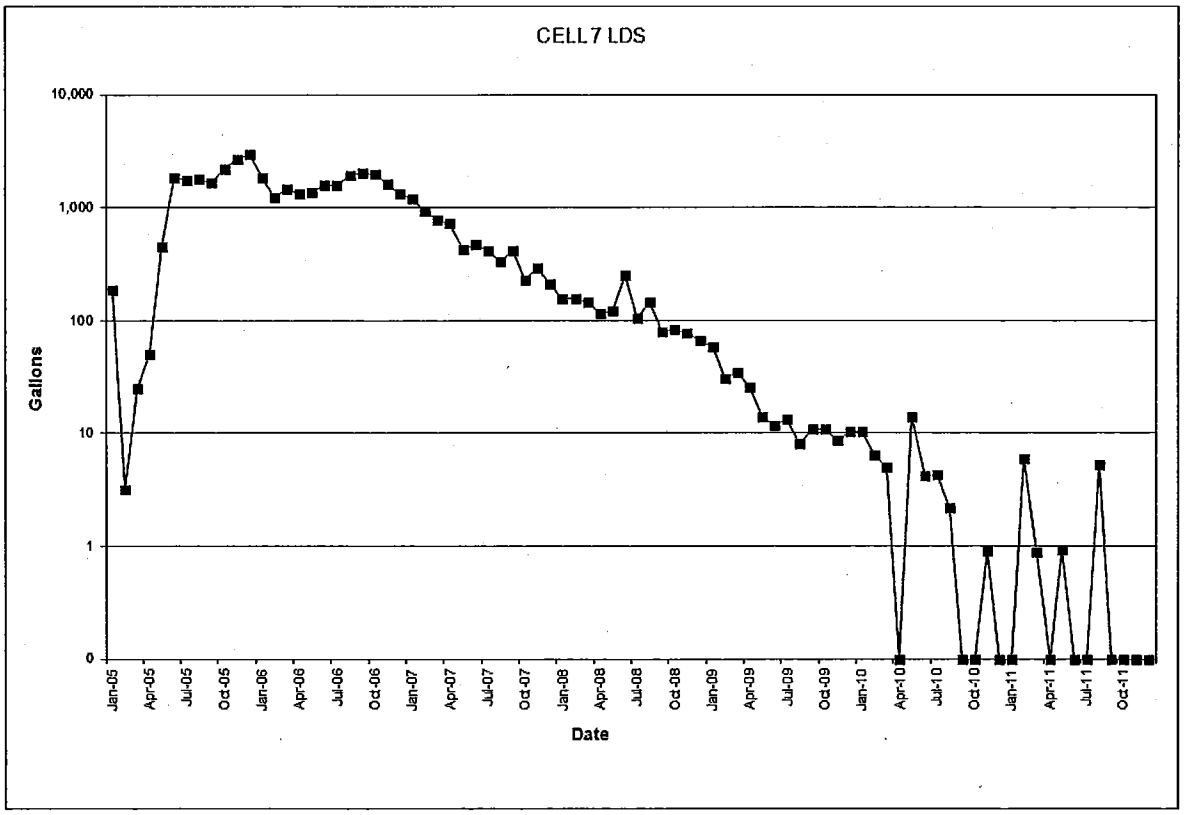
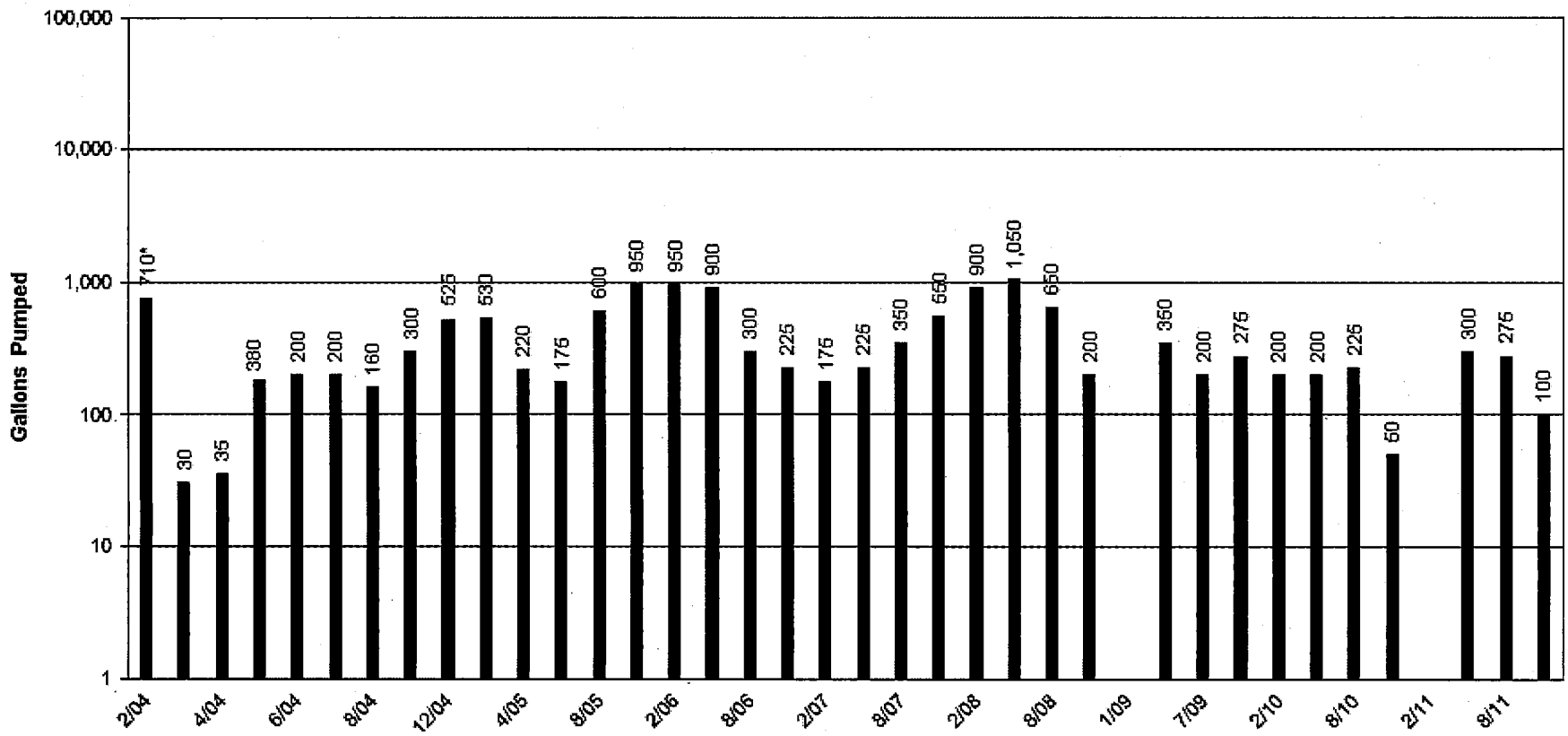


Figure A.5.7-2. Monthly Accumulation Volumes for Cell 7 LDS



12344 Purge Information

Year	Total Volumes (gal.)	Months Purged	Avg. Monthly Purge (gal.)
2004:	2380	n=9	264
2005:	2475	n=5	495
2006:	2375	n=4	594
2007:	1300	n=4	325
2008:	2800	n=4	700
2009:	825	n=3	275
2010:	675	n=4	169
2011:	675	n=4	169
Overall:			365

*More than one purge of the well was completed during this month to drain perched water and infiltrating surface water so the compacted clay liner could be constructed.

Figure A.5.7-3. OSDF Horizontal Till Well 12343 (Cell 7) Water Yield

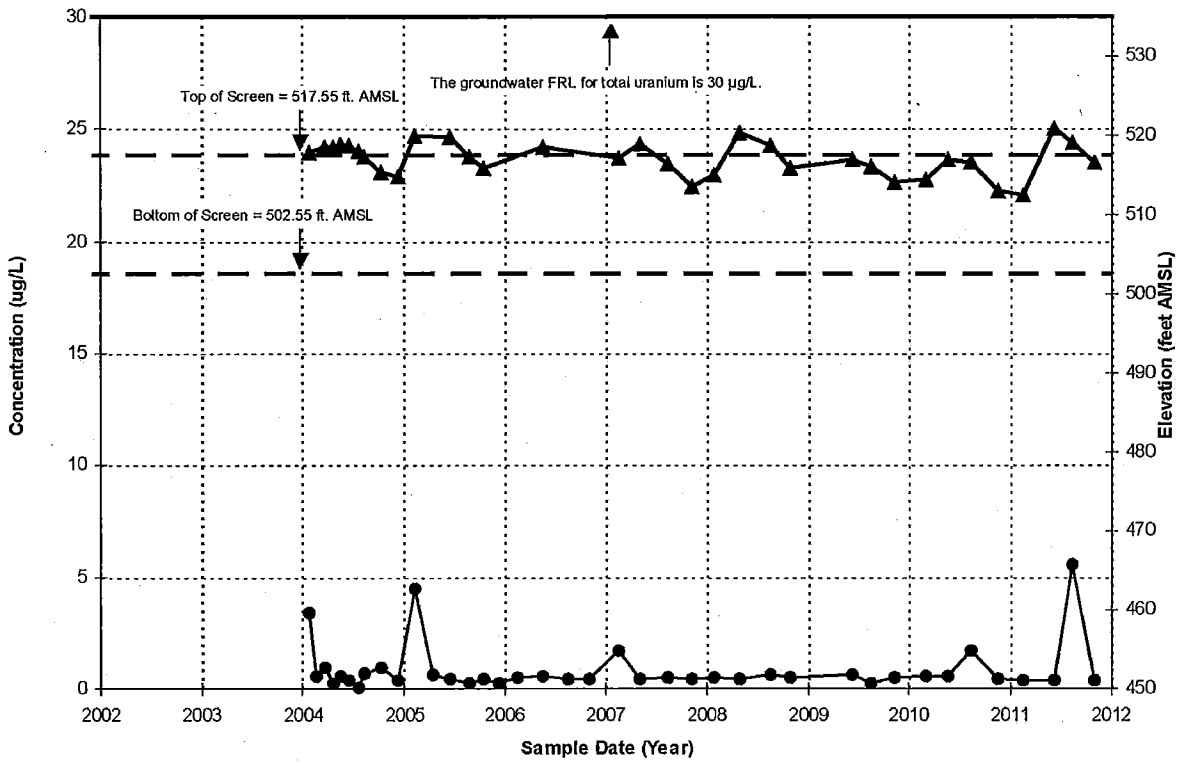


FIGURE A.5.7-4. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 7 Upgradient Monitoring Well 22212

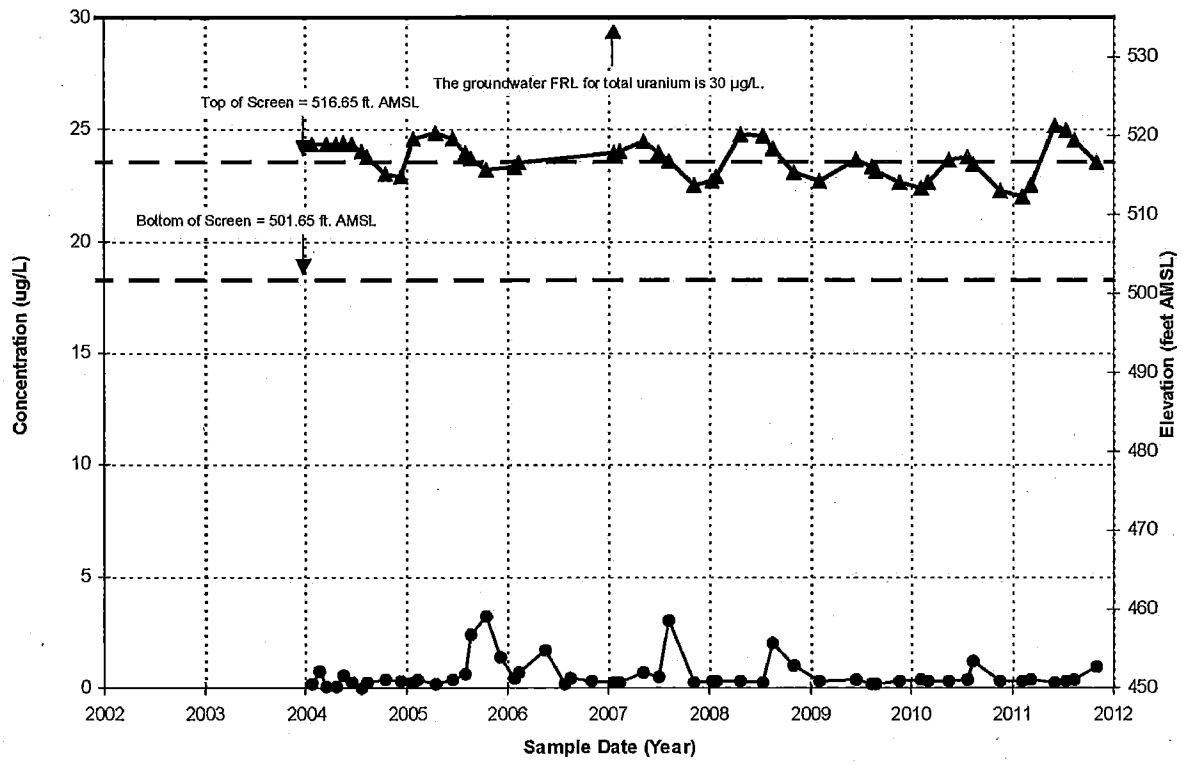


FIGURE A.5.7-5. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 7 Downgradient Monitoring Well 22211

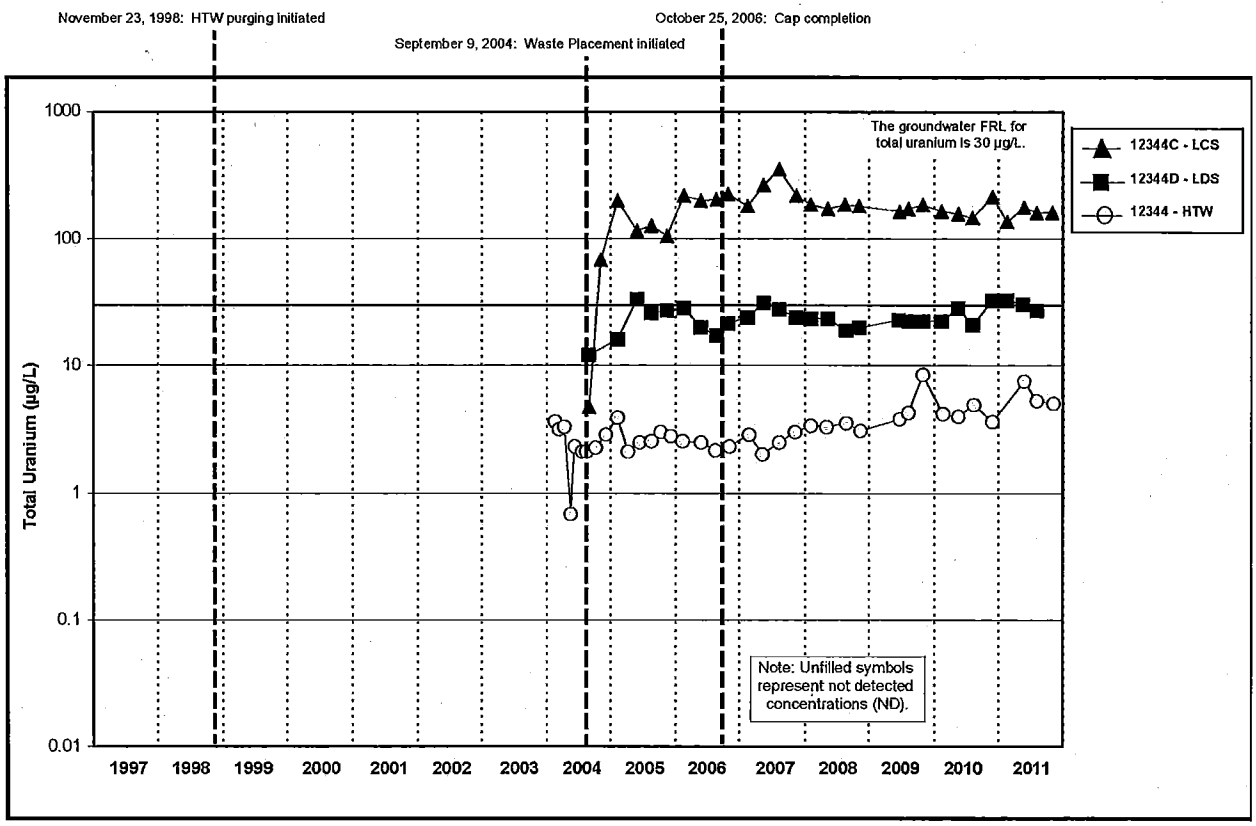


Figure A.5.7-6A. Cell 7 Uranium, Total Concentration vs. Time Plot for LCS, LDS, and HTW

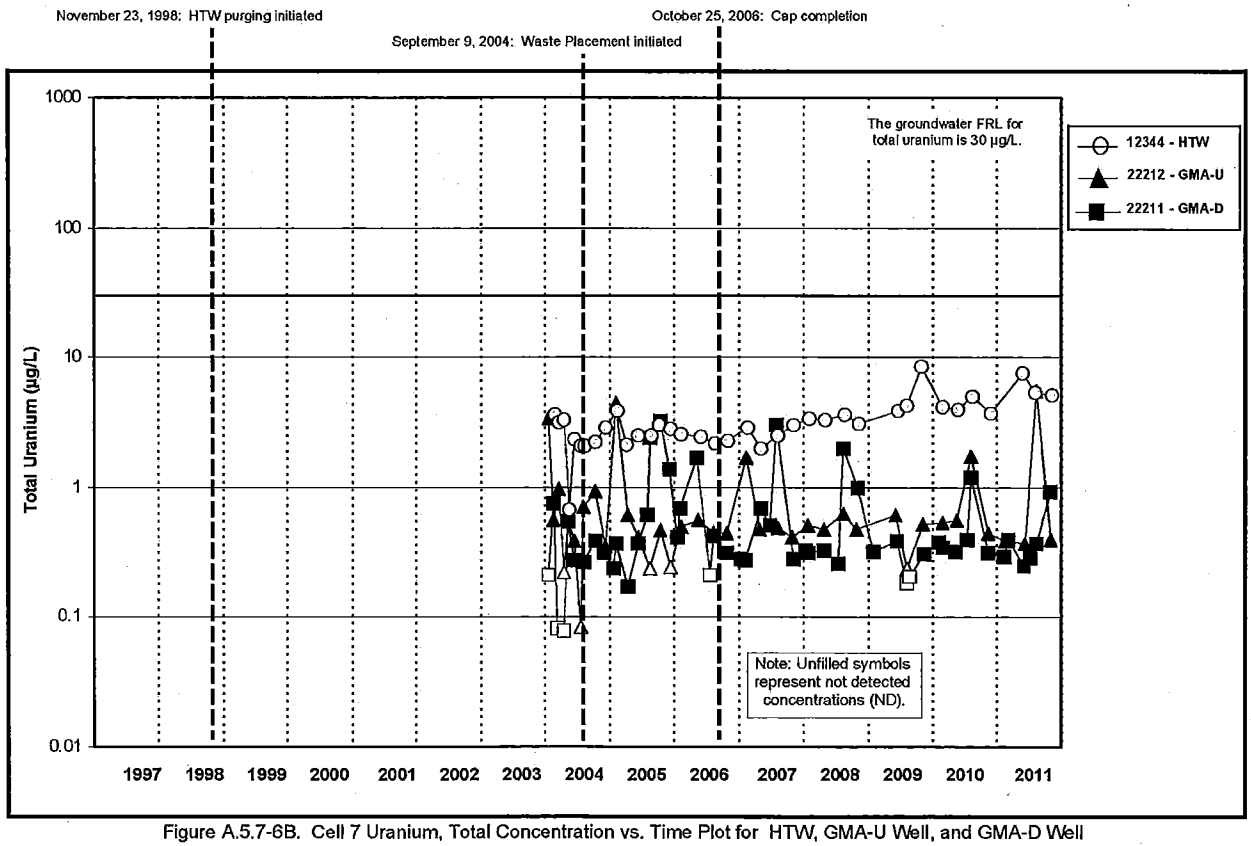


Figure A.5.7-6B. Cell 7 Uranium, Total Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

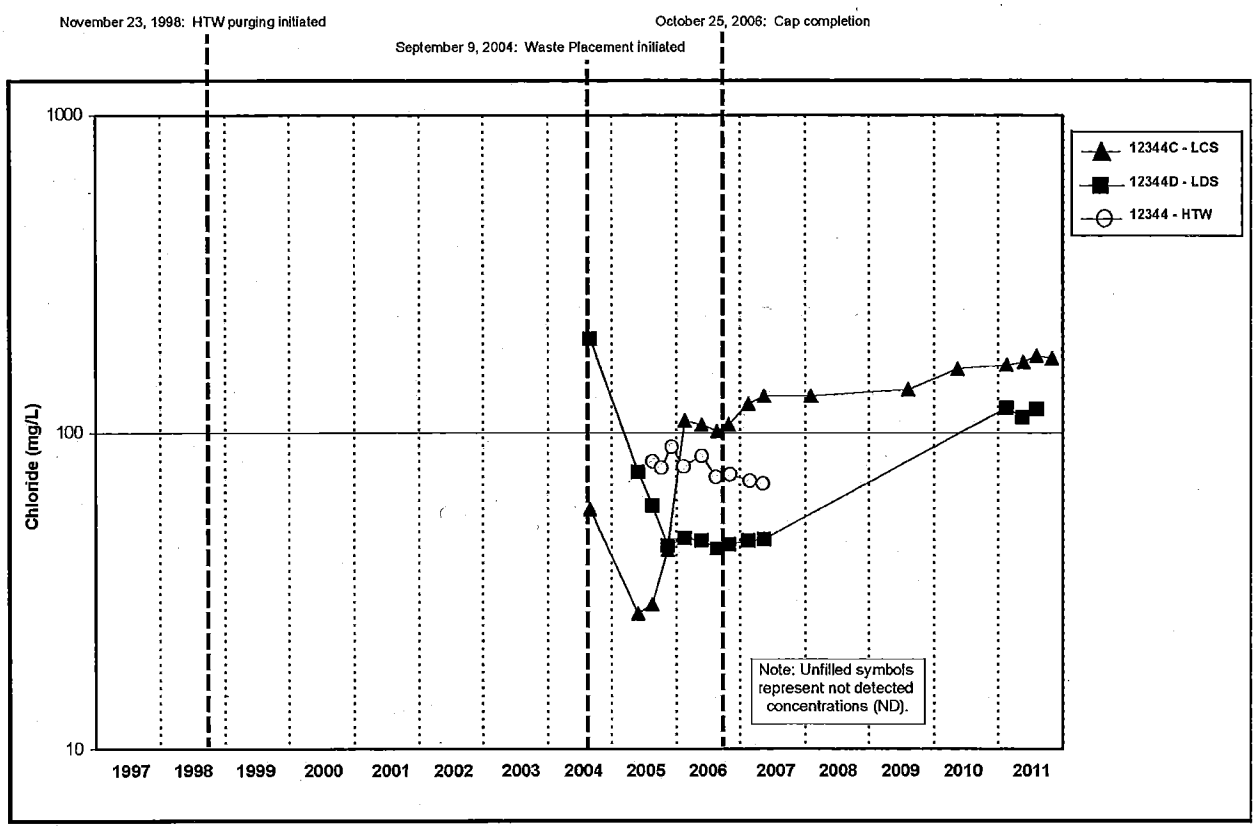


Figure A.5.7-7A. Cell 7 Chloride Concentration vs. Time Plot for LCS, LDS, and HTW

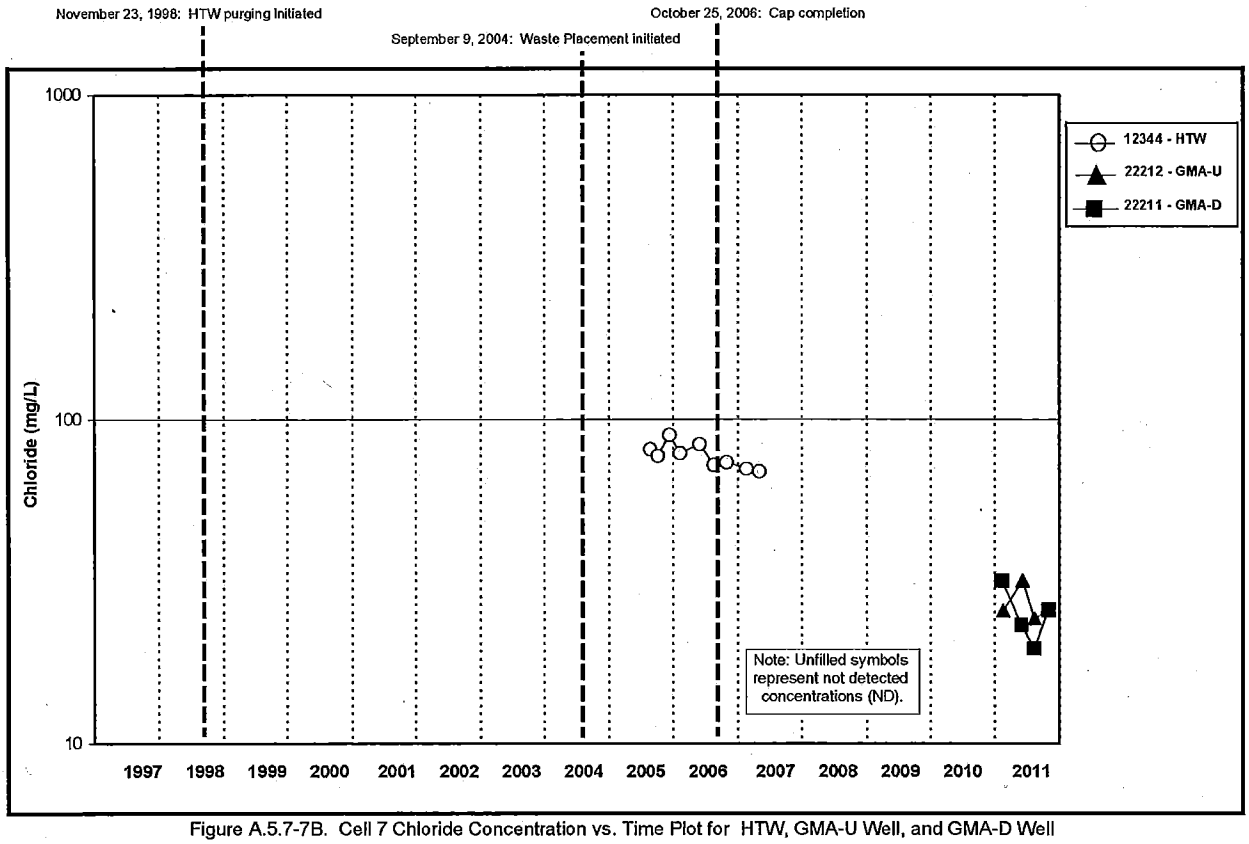


Figure A.5.7-7B. Cell 7 Chloride Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

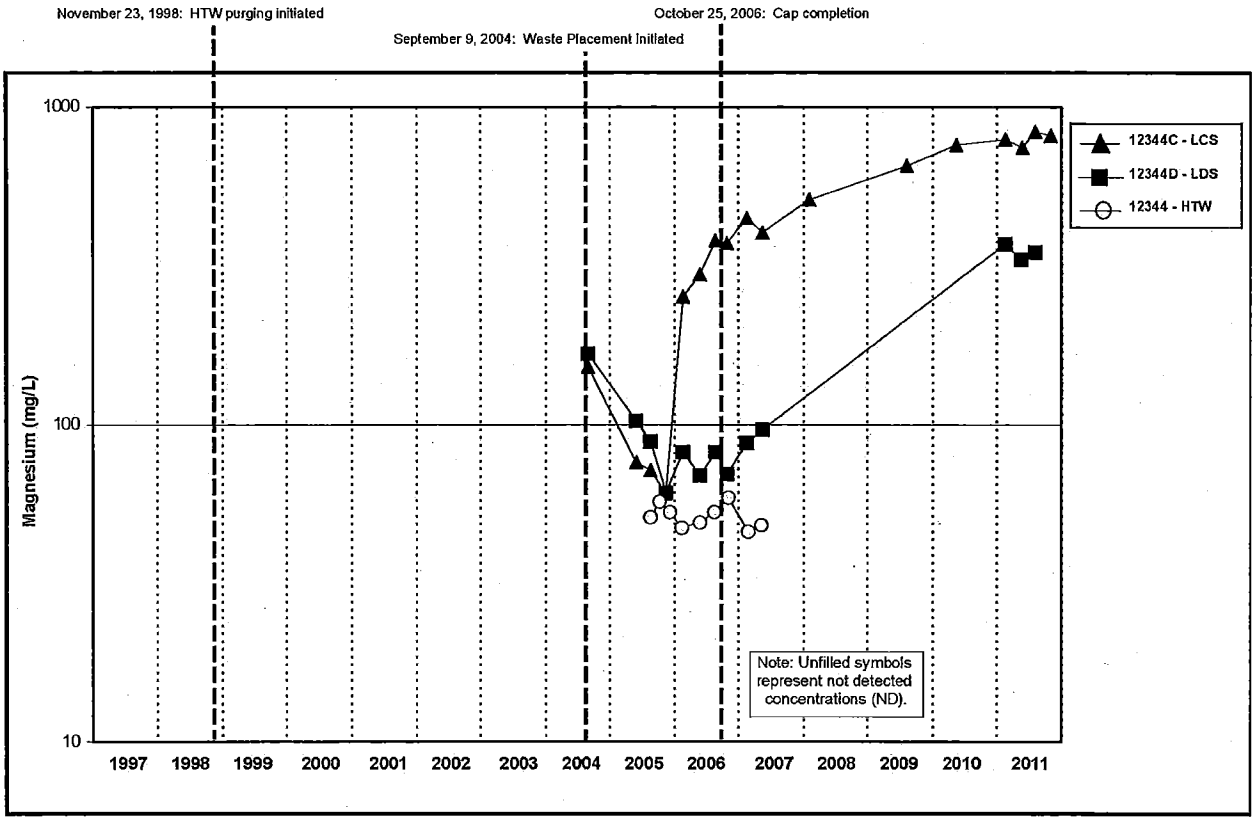


Figure A.5.7-8A. Cell 7 Magnesium Concentration vs. Time Plot for LCS, LDS, and HTW

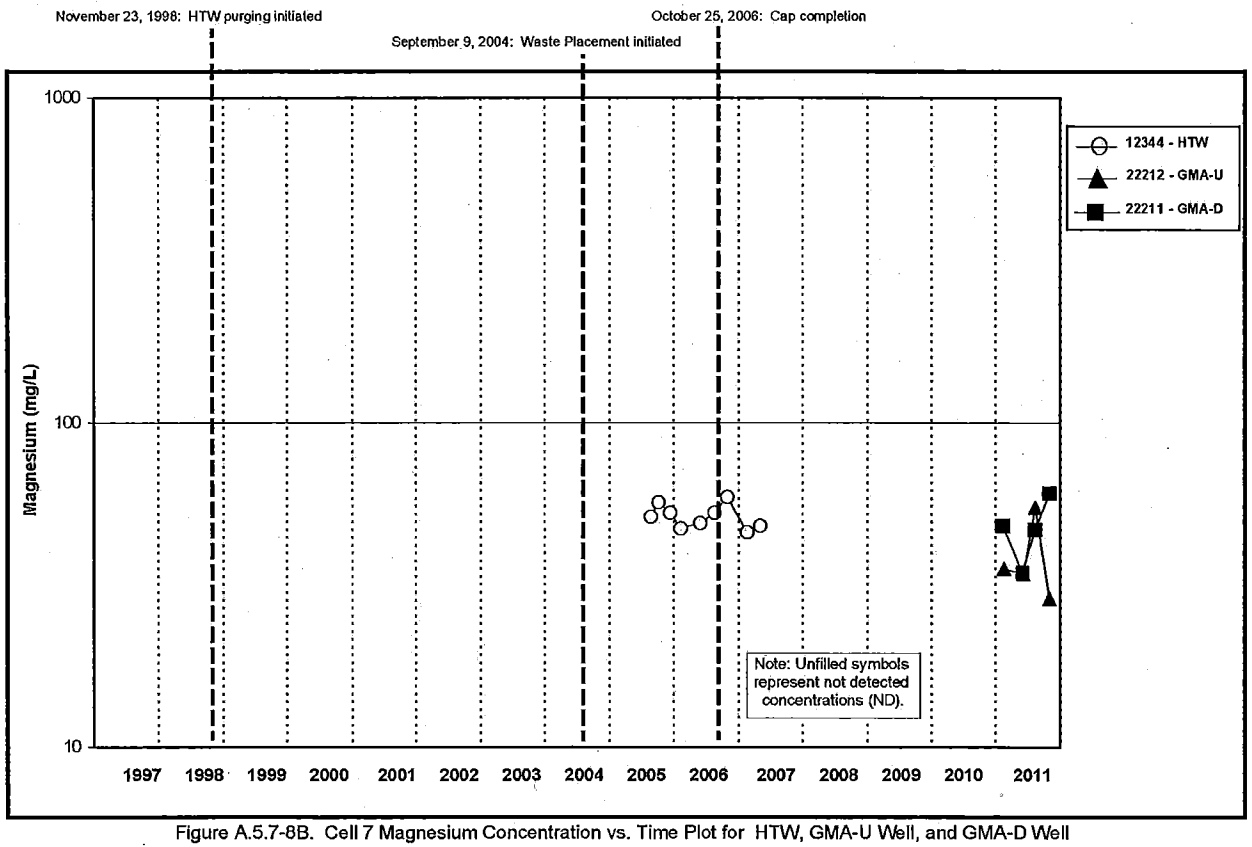


Figure A.5.7-8B. Cell 7 Magnesium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

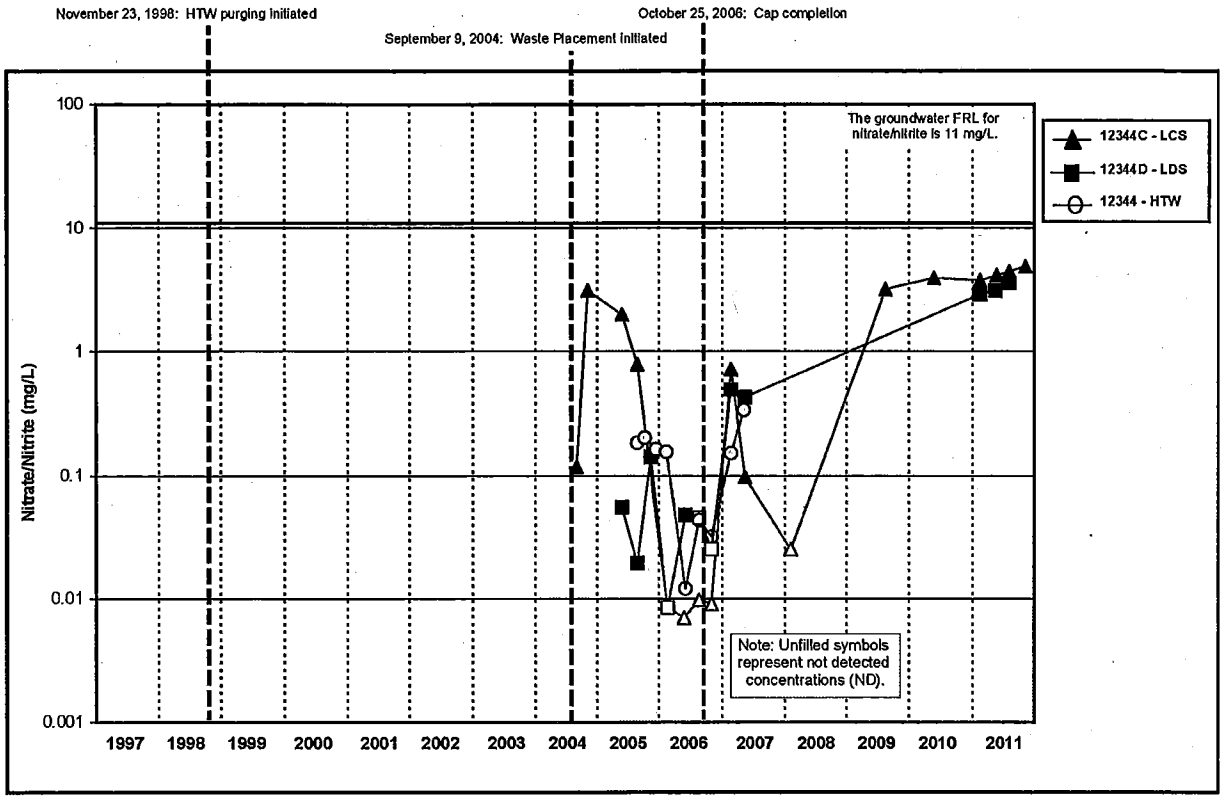


Figure A.5.7-9A. Cell 7 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for LCS, LDS, and HTW

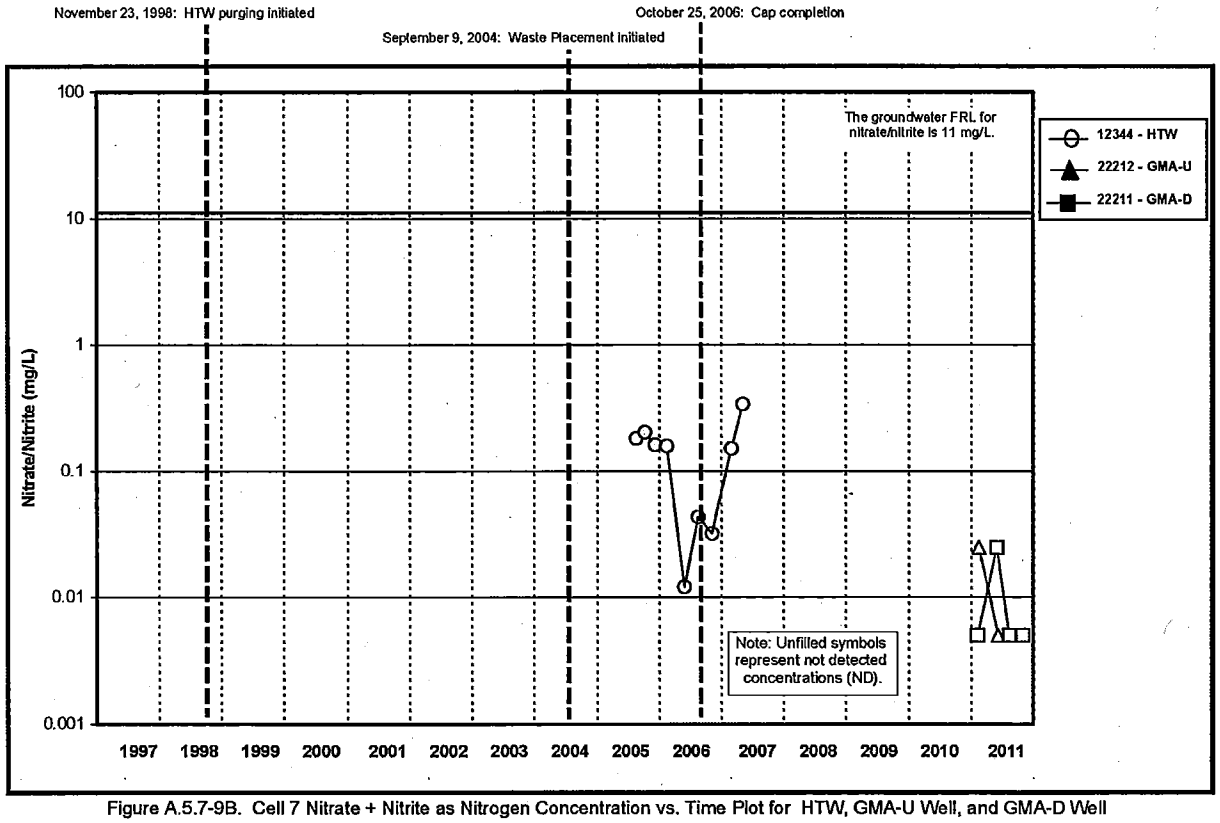


Figure A.5.7-9B. Cell 7 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

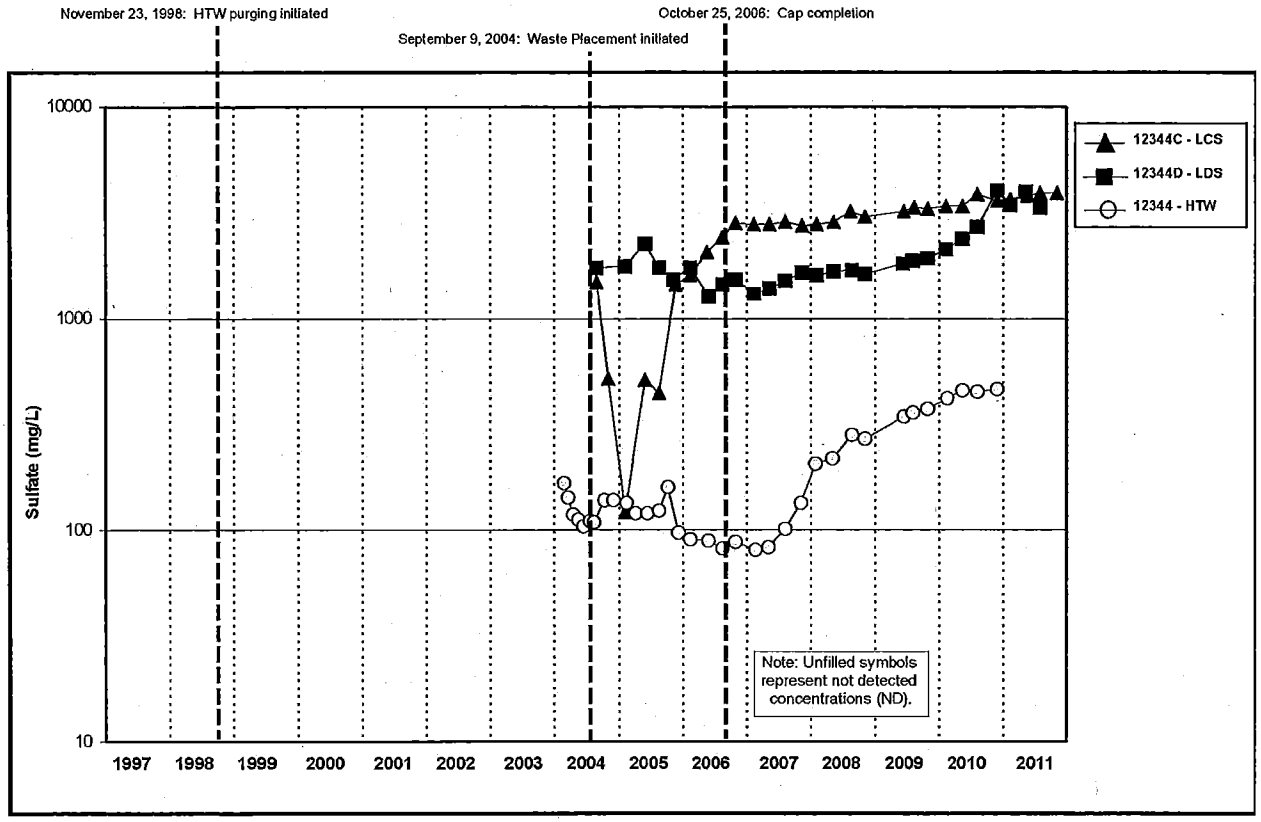


Figure A.5.7-10A. Cell 7 Sulfate Concentration vs. Time Plot for LCS, LDS, and HTW

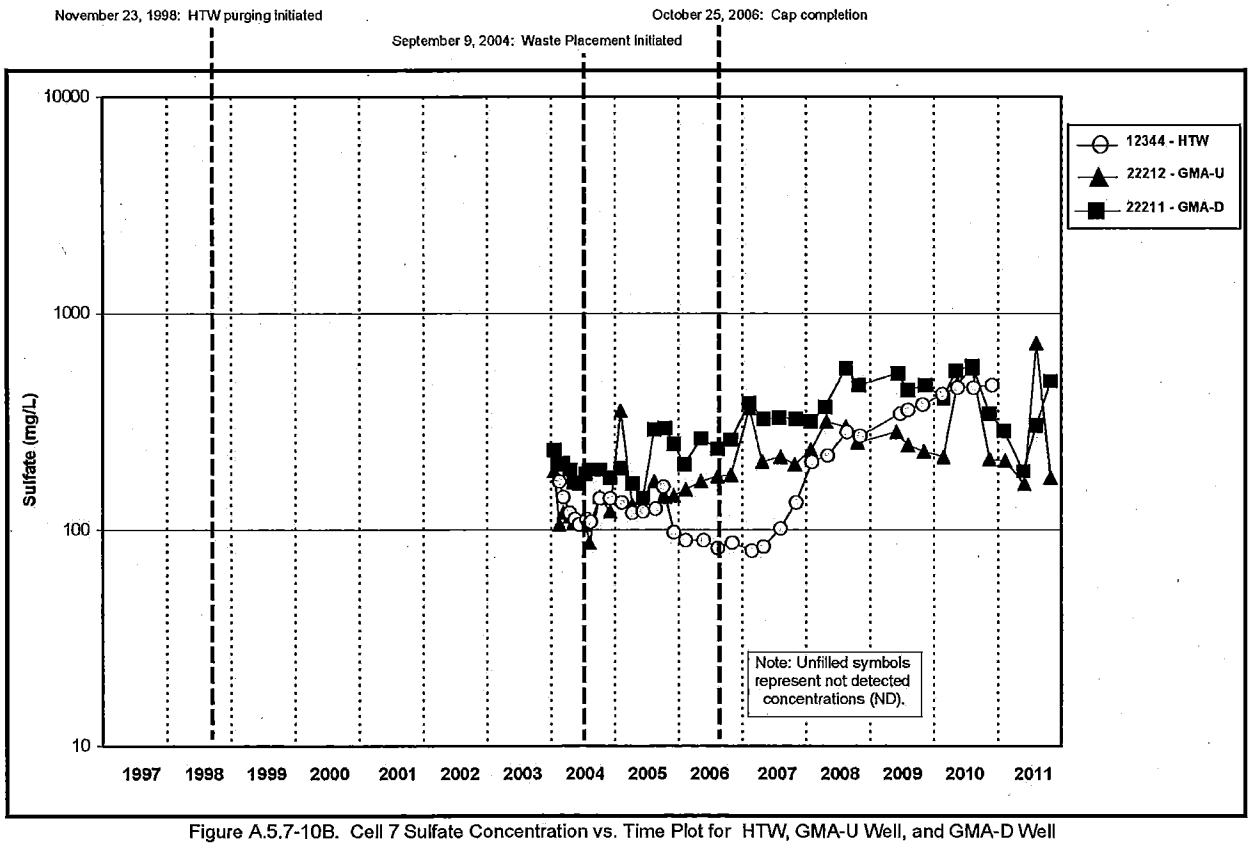


Figure A.5.7-10B. Cell 7 Sulfate Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

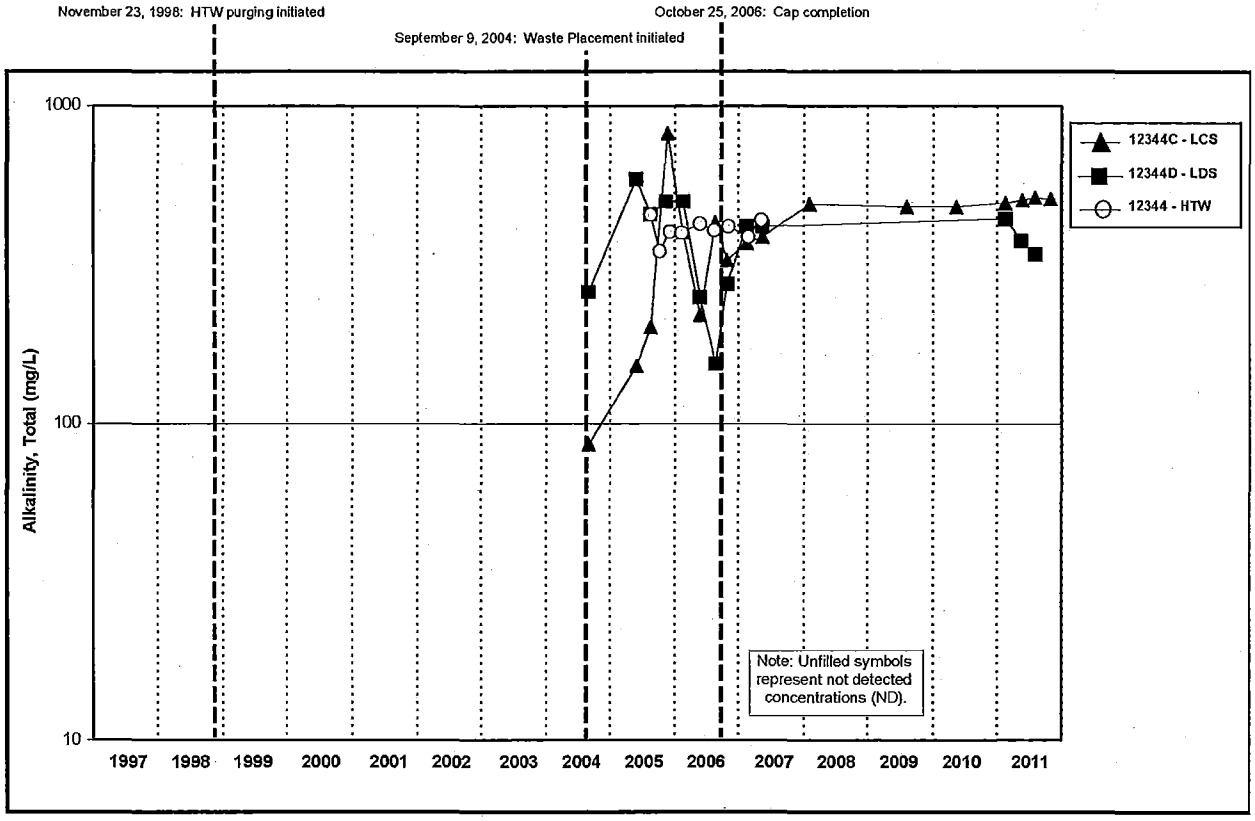


Figure A.5.7-11A. Cell 7 Alkalinity, Total Concentration vs. Time Plot for LCS, LDS, and HTW

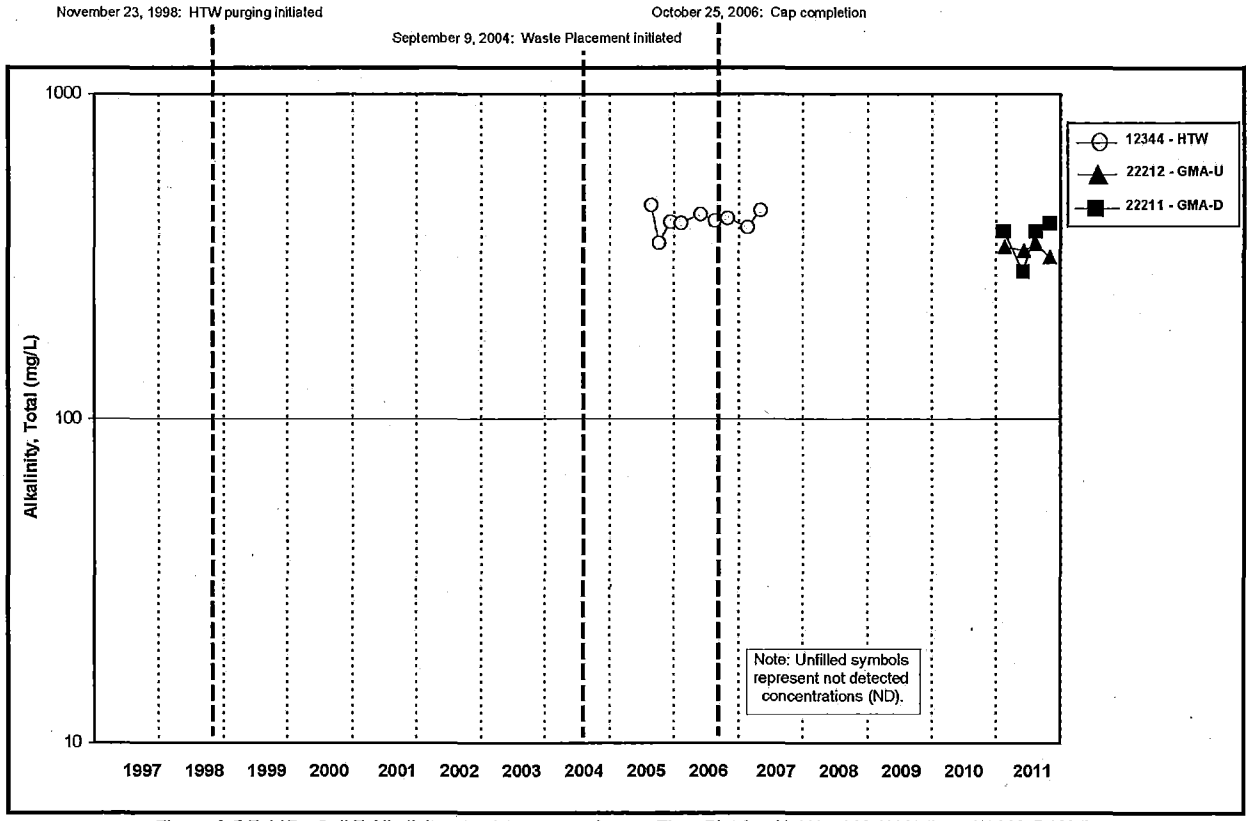


Figure A.5.7-11B. Cell 7 Alkalinity, Total Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

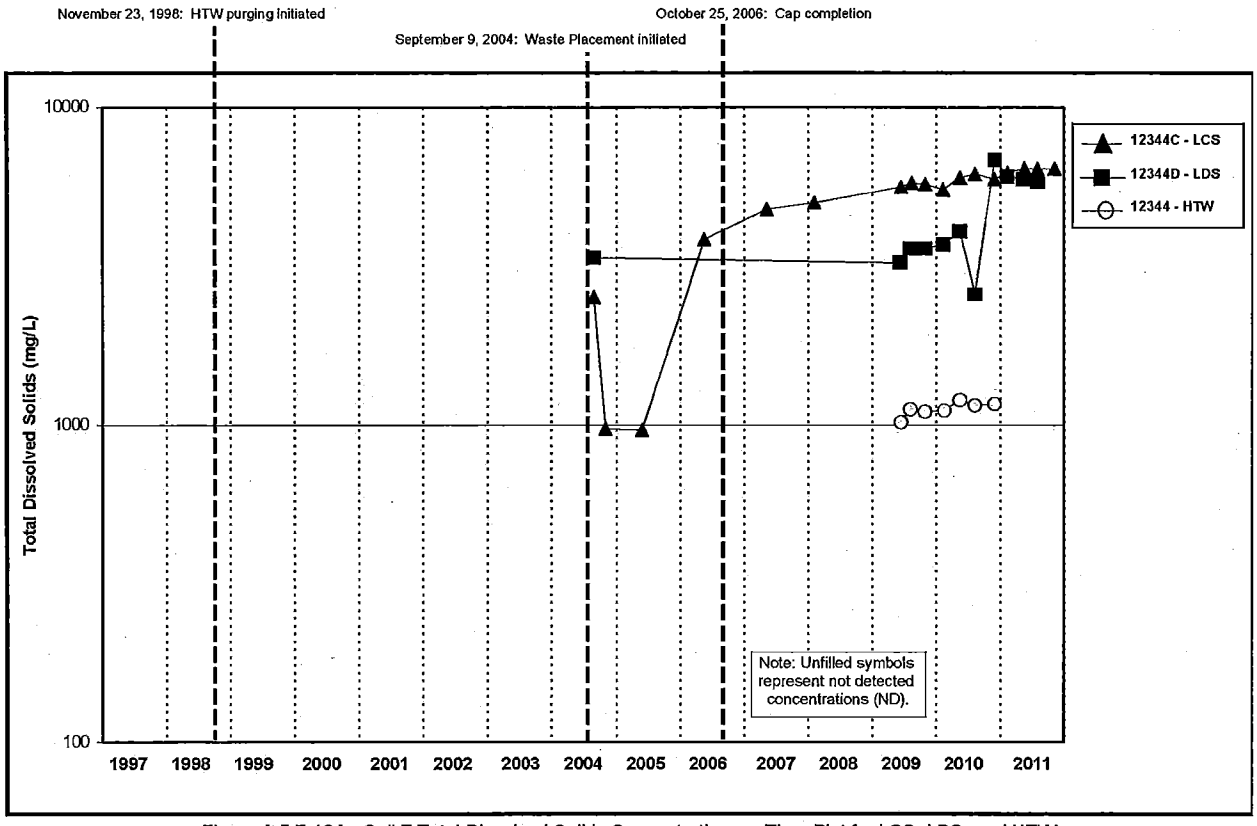


Figure A.5.7-12A. Cell 7 Total Dissolved Solids Concentration vs. Time Plot for LCS, LDS, and HTW

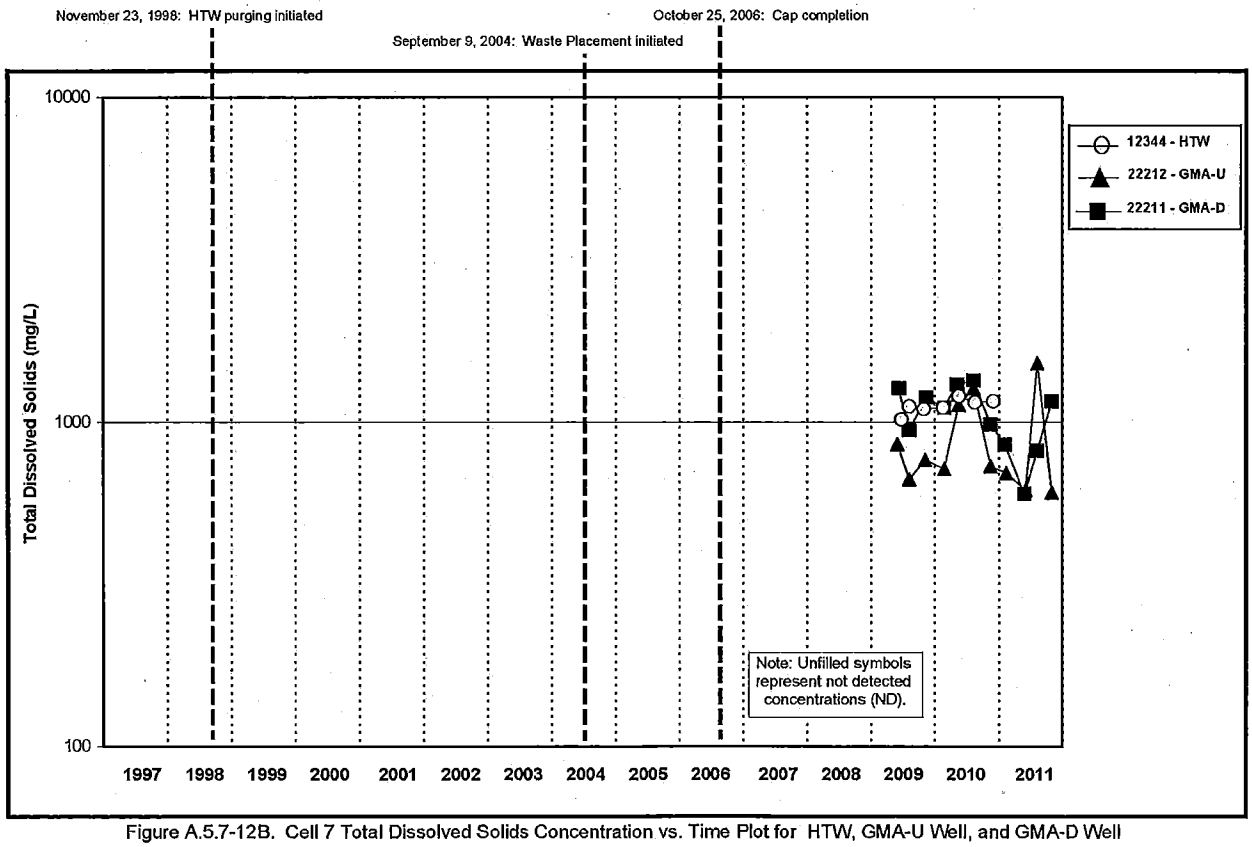


Figure A.5.7-12B. Cell 7 Total Dissolved Solids Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

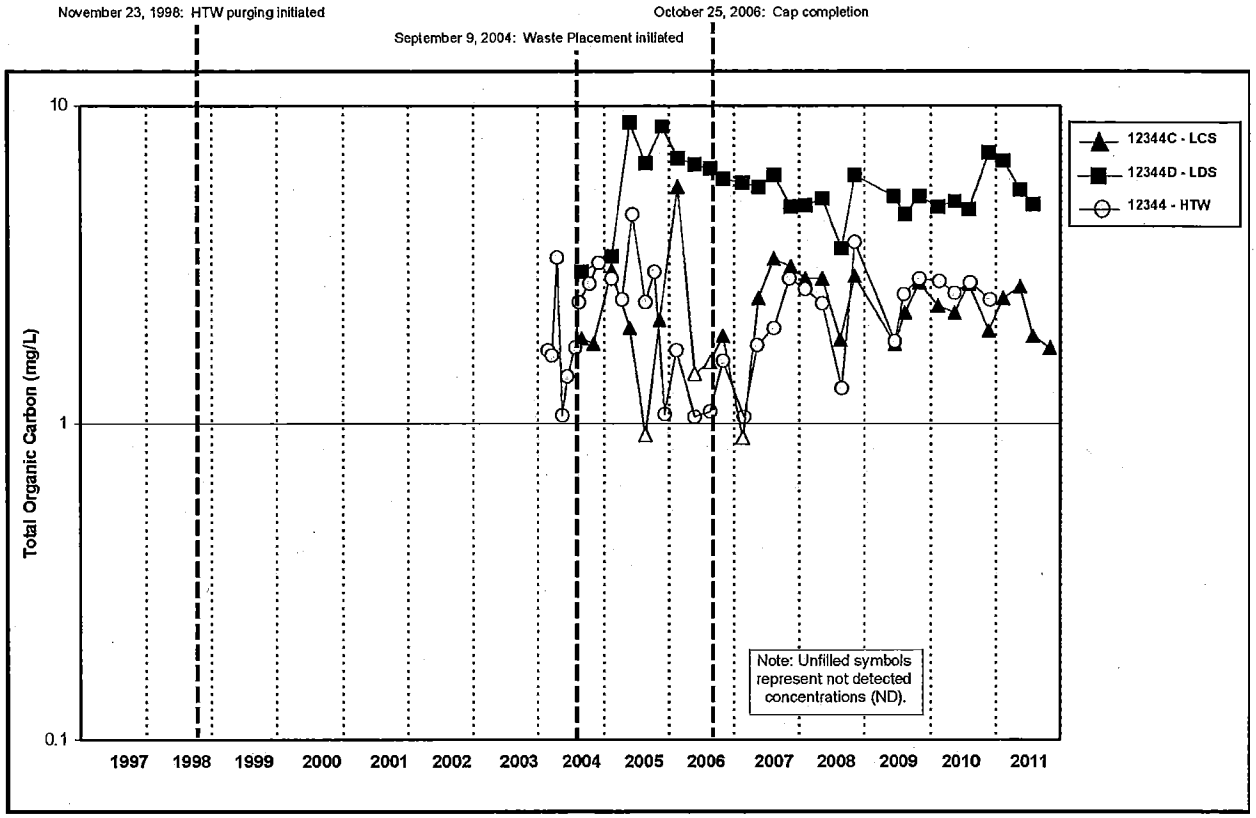


Figure A.5.7-13A. Cell 7 Total Organic Carbon Concentration vs. Time Plot for LCS, LDS, and HTW

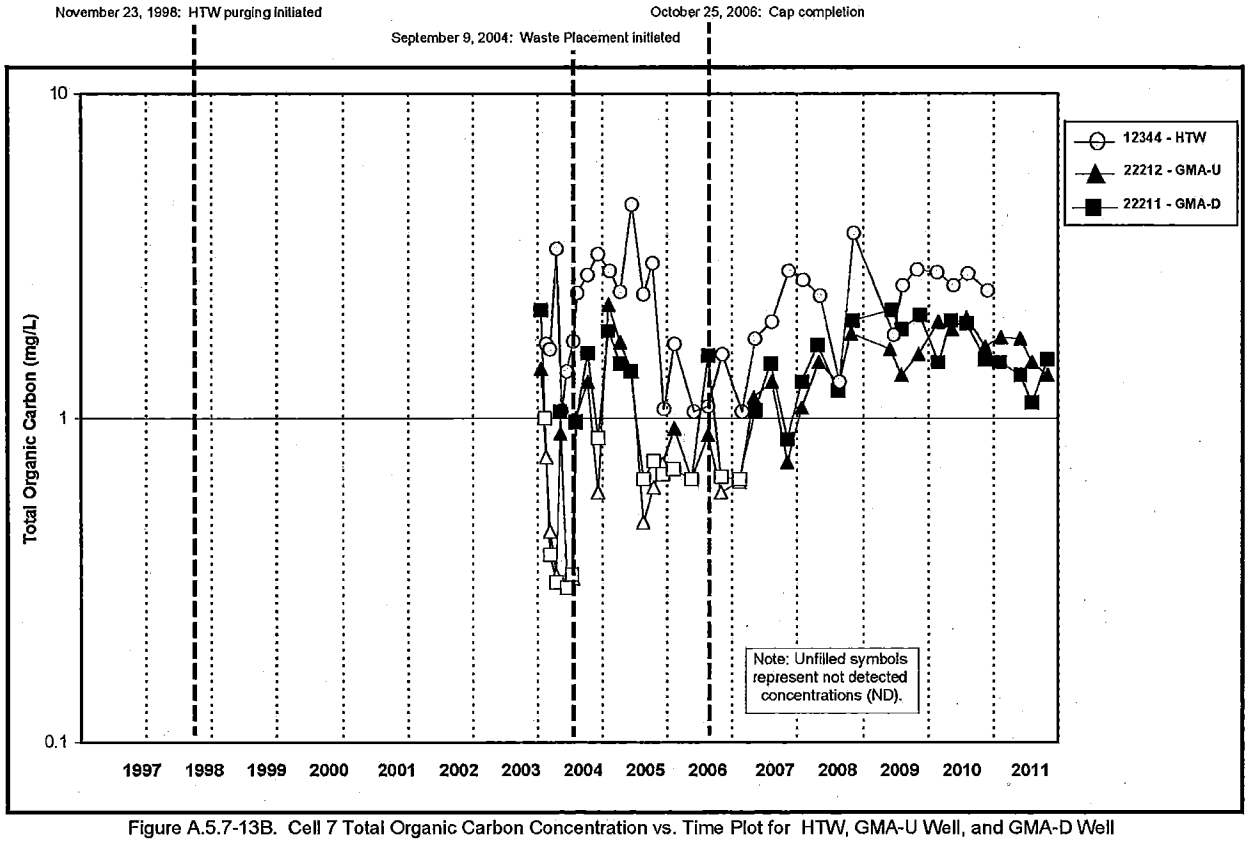


Figure A.5.7-13B. Cell 7 Total Organic Carbon Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

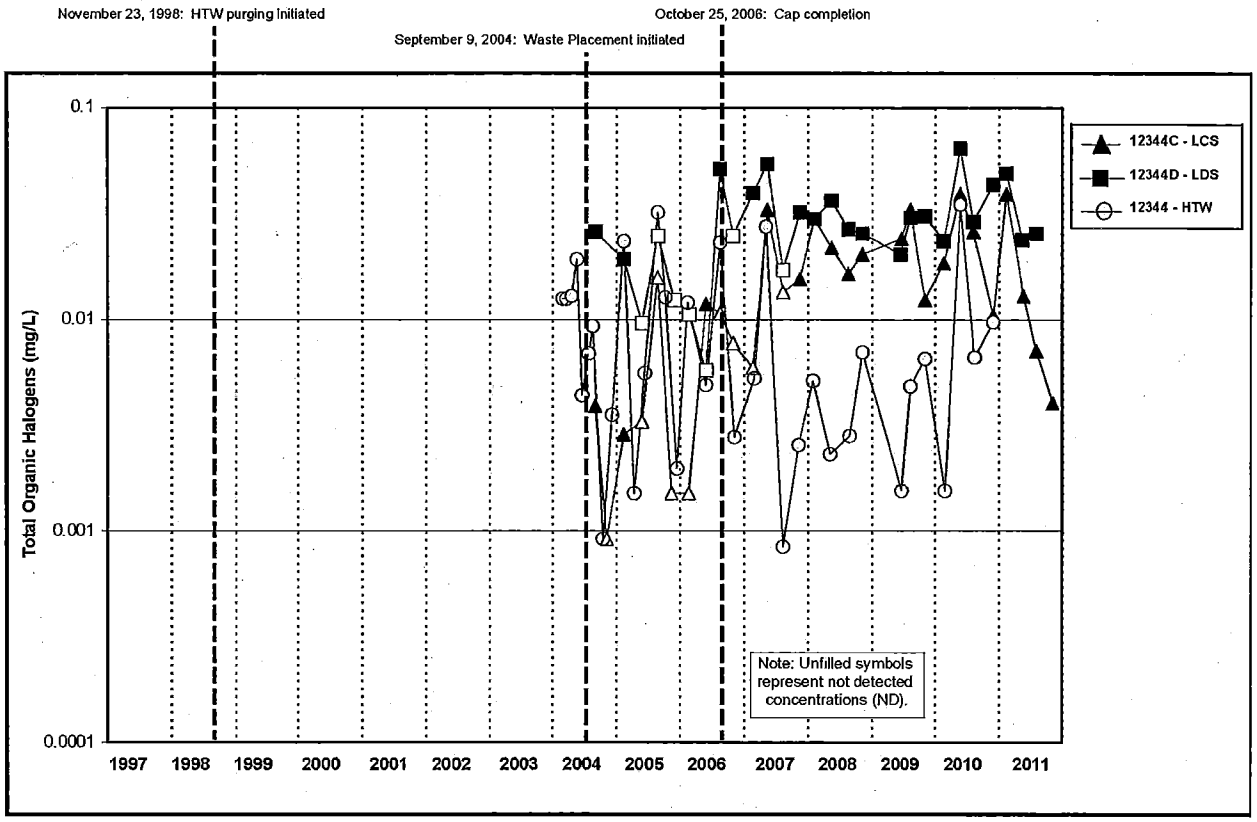


Figure A.5.7-14A. Cell 7 Total Organic Halogens Concentration vs. Time Plot for LCS, LDS, and HTW

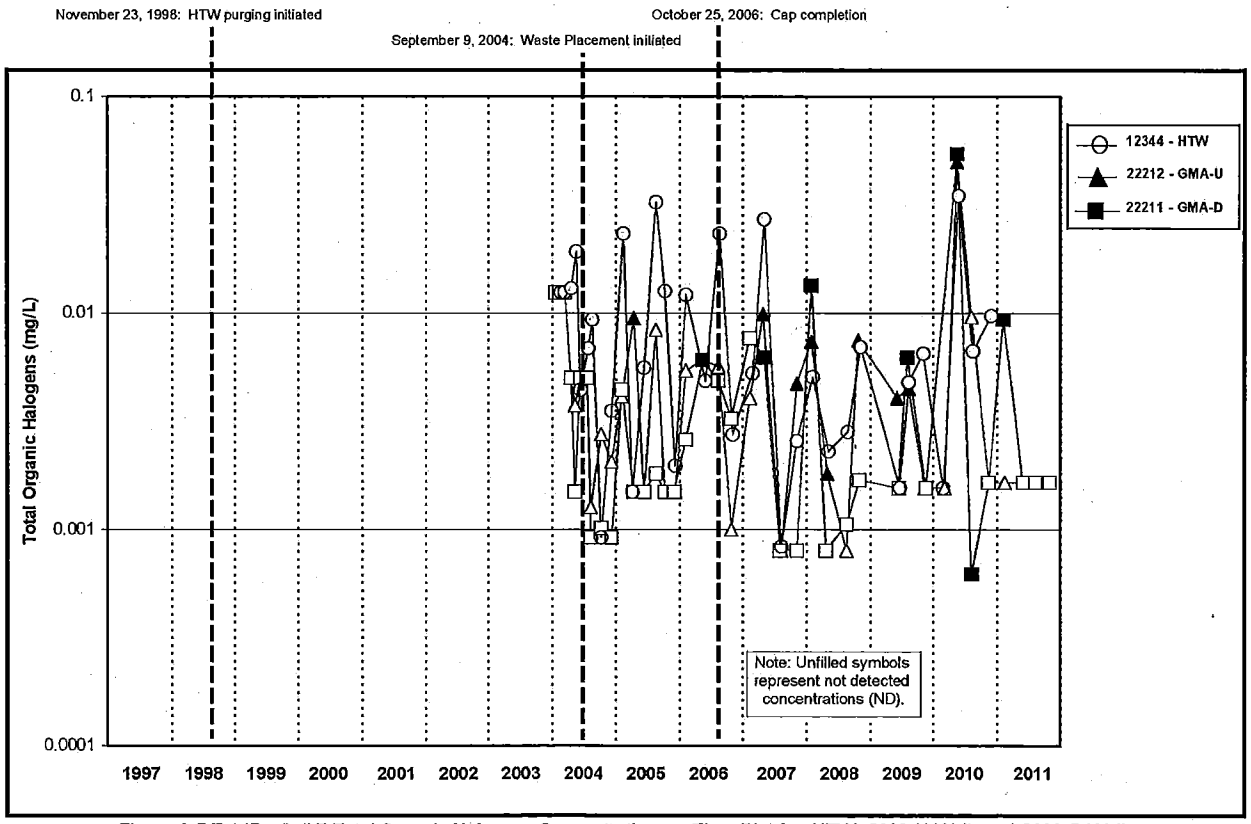


Figure A.5.7-14B. Cell 7 Total Organic Halogens Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

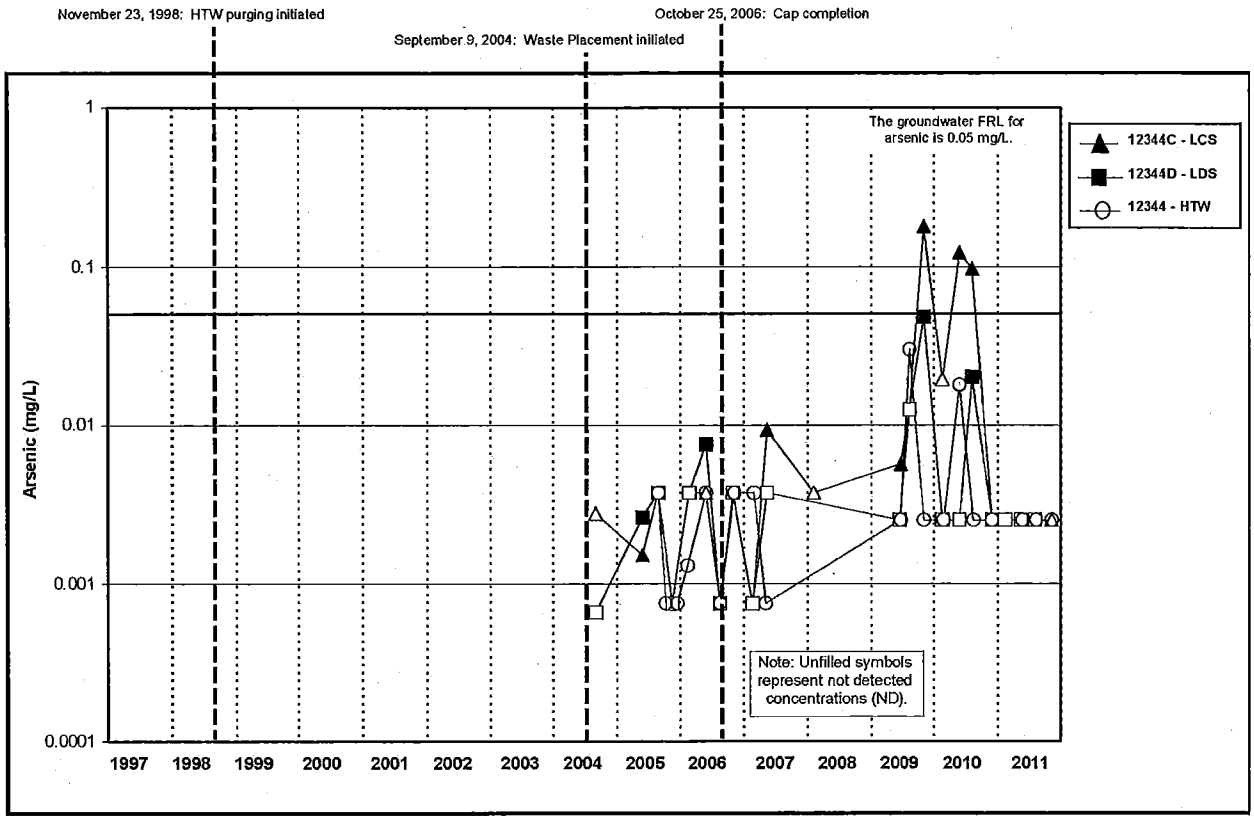


Figure A.5.7-15A. Cell 7 Arsenic Concentration vs. Time Plot for LCS, LDS, and HTW

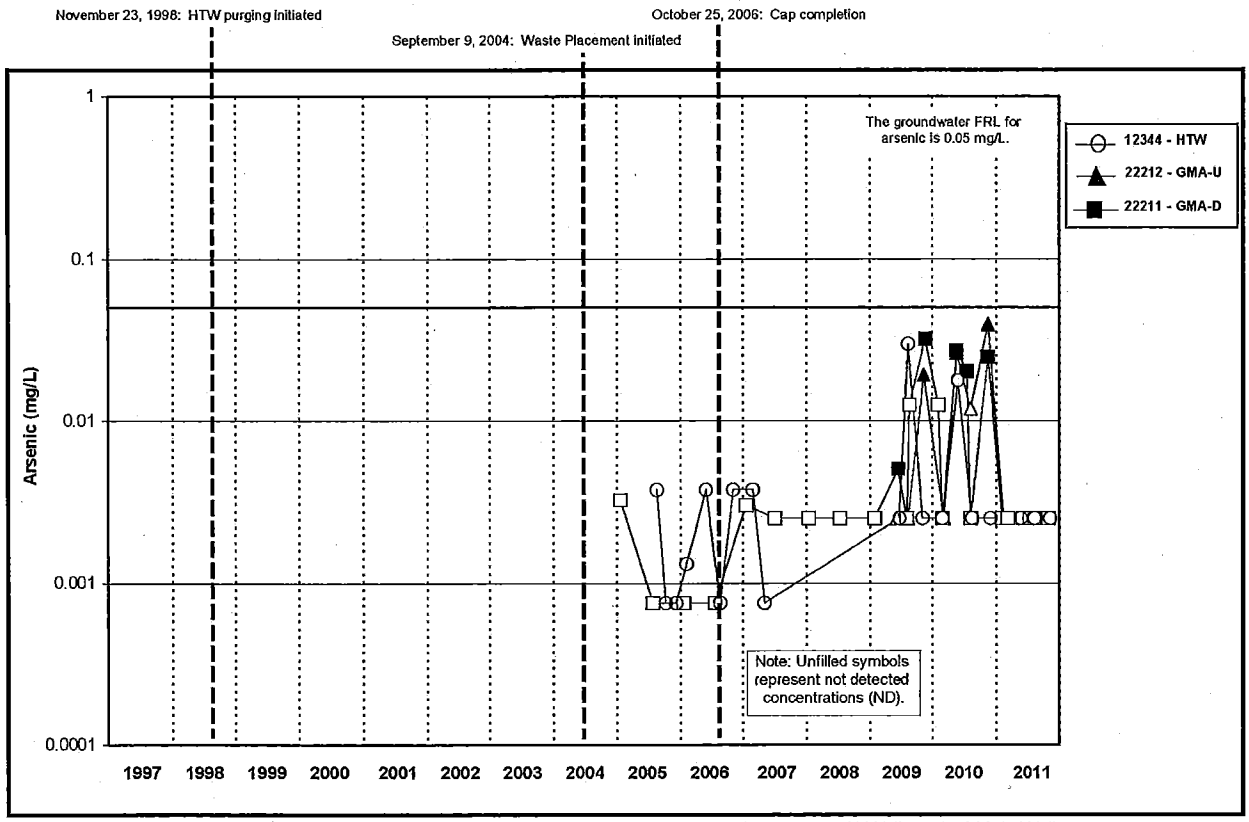


Figure A.5.7-15B. Cell 7 Arsenic Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

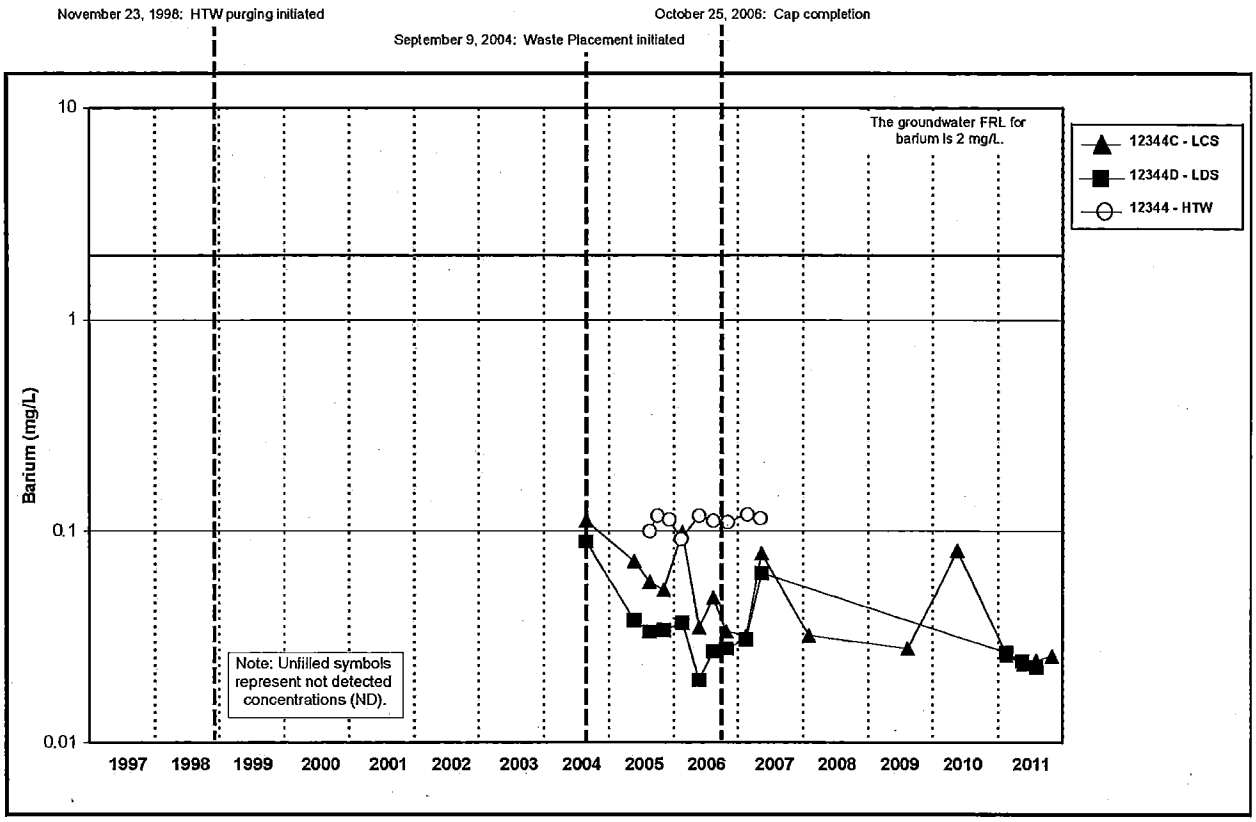


Figure A.5.7-16A. Cell 7 Barium Concentration vs. Time Plot for LCS, LDS, and HTW

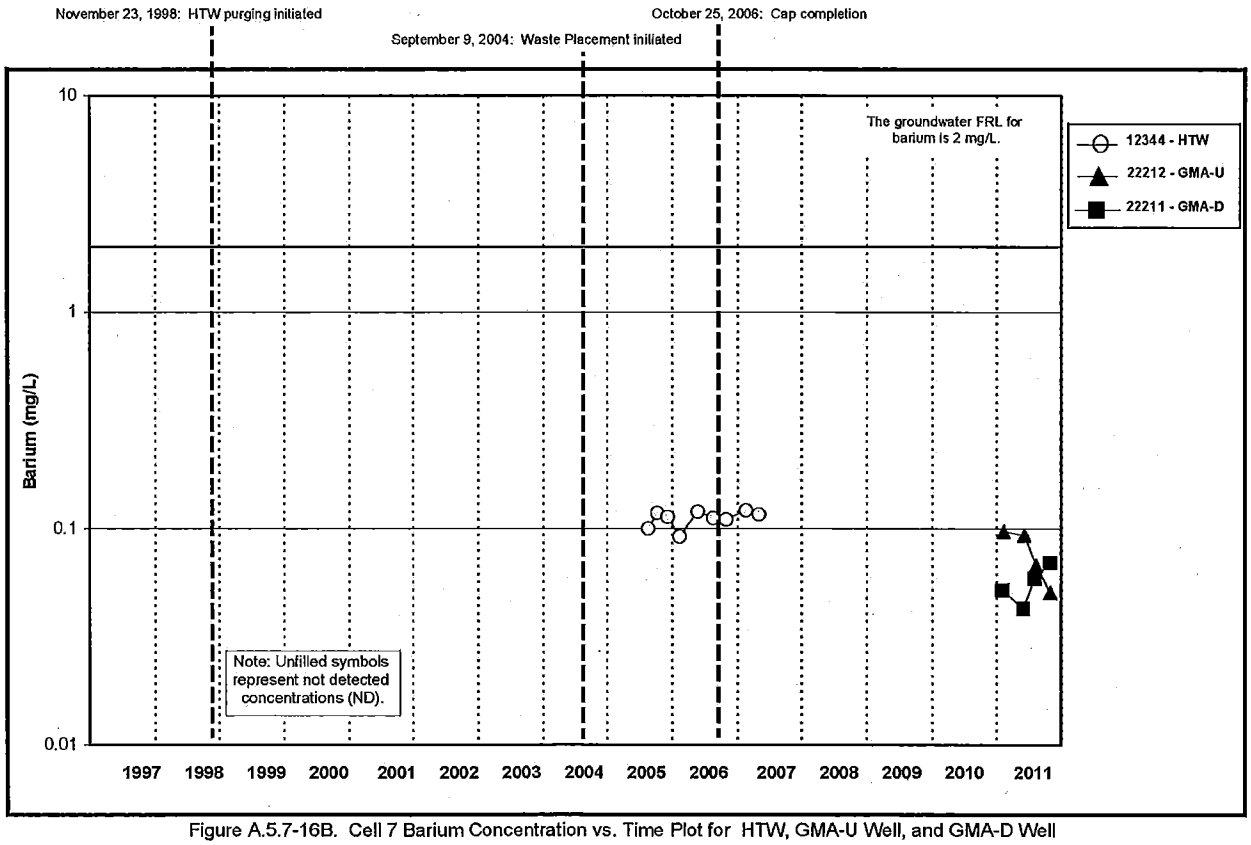


Figure A.5.7-16B. Cell 7 Barium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

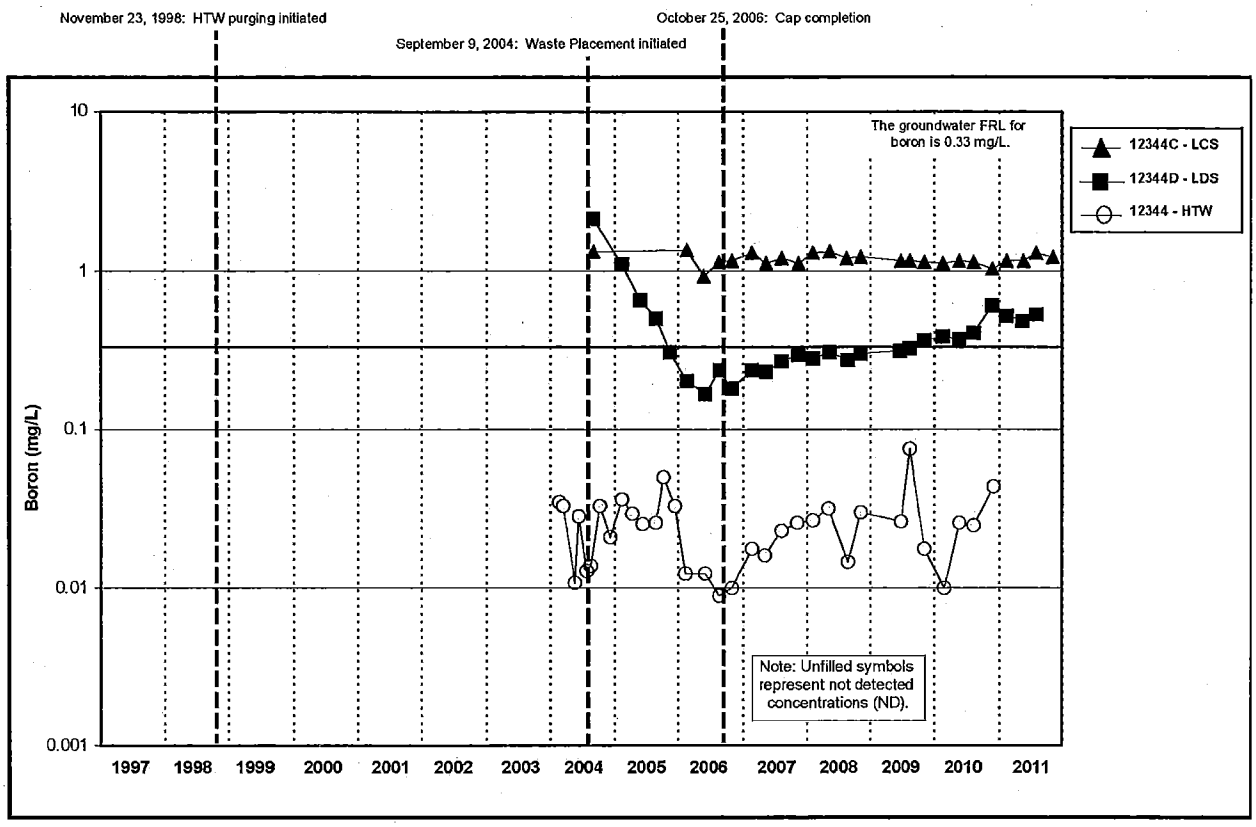


Figure A.5.7-17A. Cell 7 Boron Concentration vs. Time Plot for LCS, LDS, and HTW

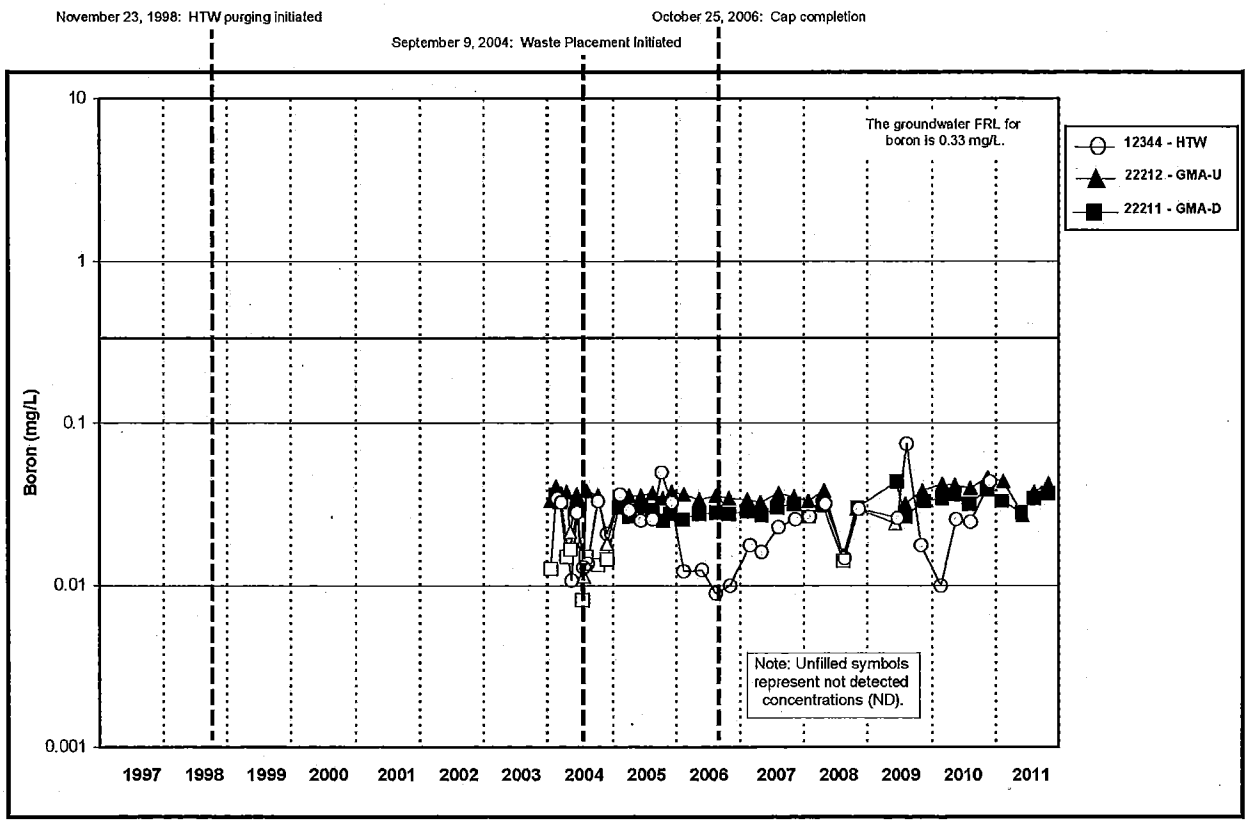


Figure A.5.7-17B. Cell 7 Boron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

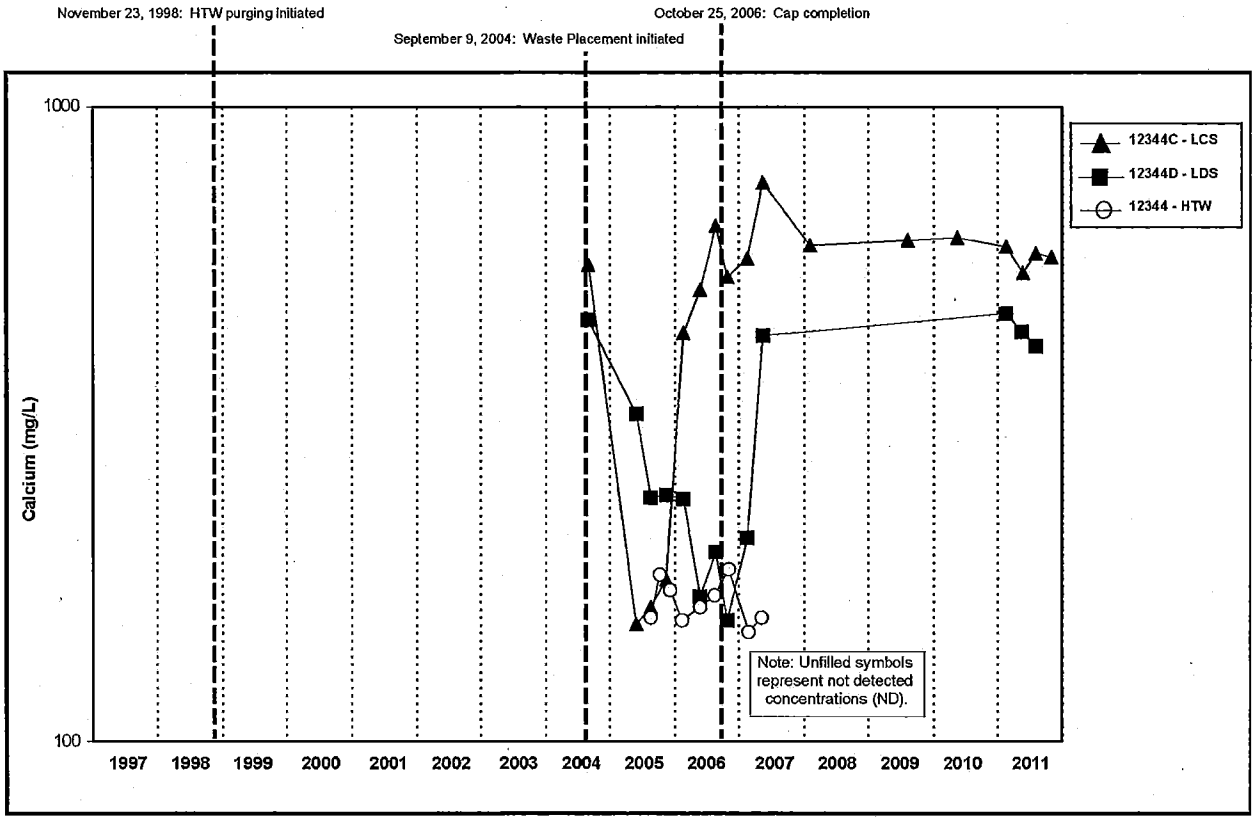


Figure A.5.7-18A. Cell 7 Calcium Concentration vs. Time Plot for LCS, LDS, and HTW

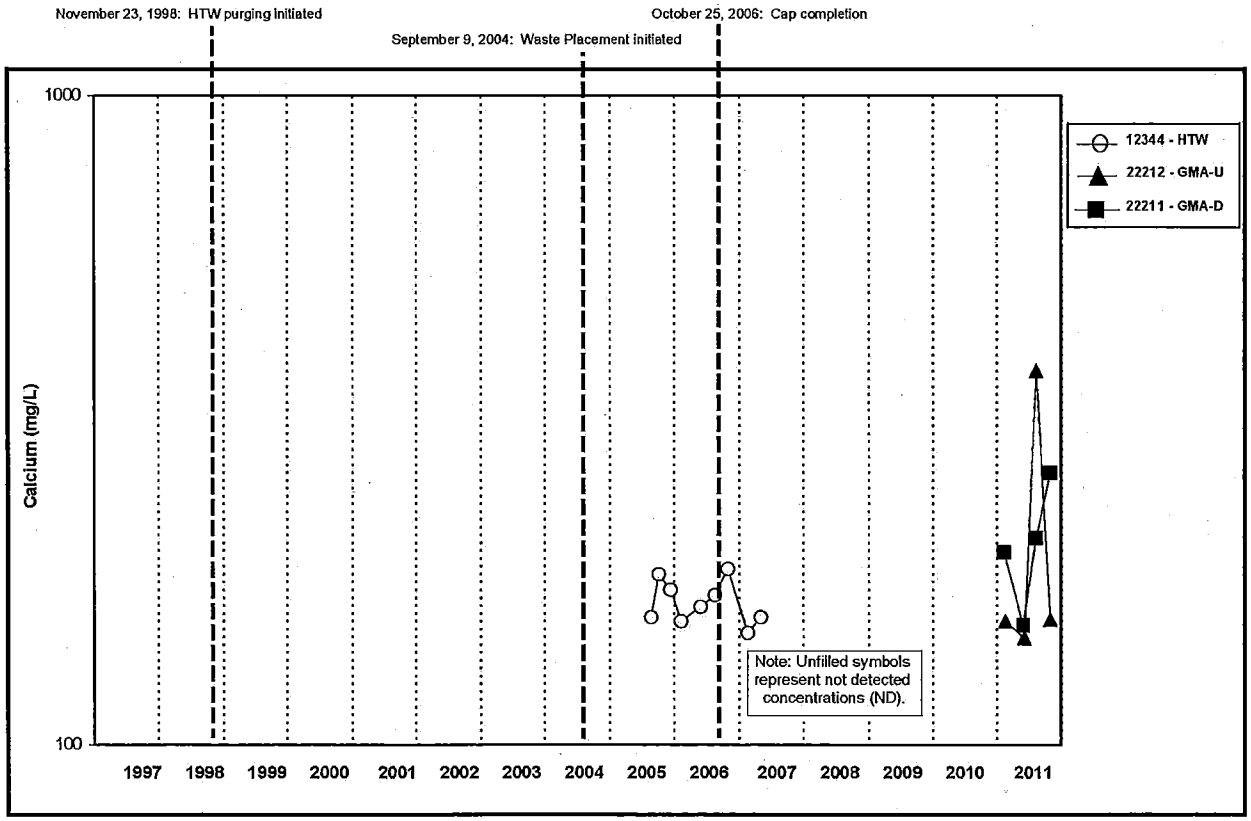


Figure A.5.7-18B. Cell 7 Calcium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

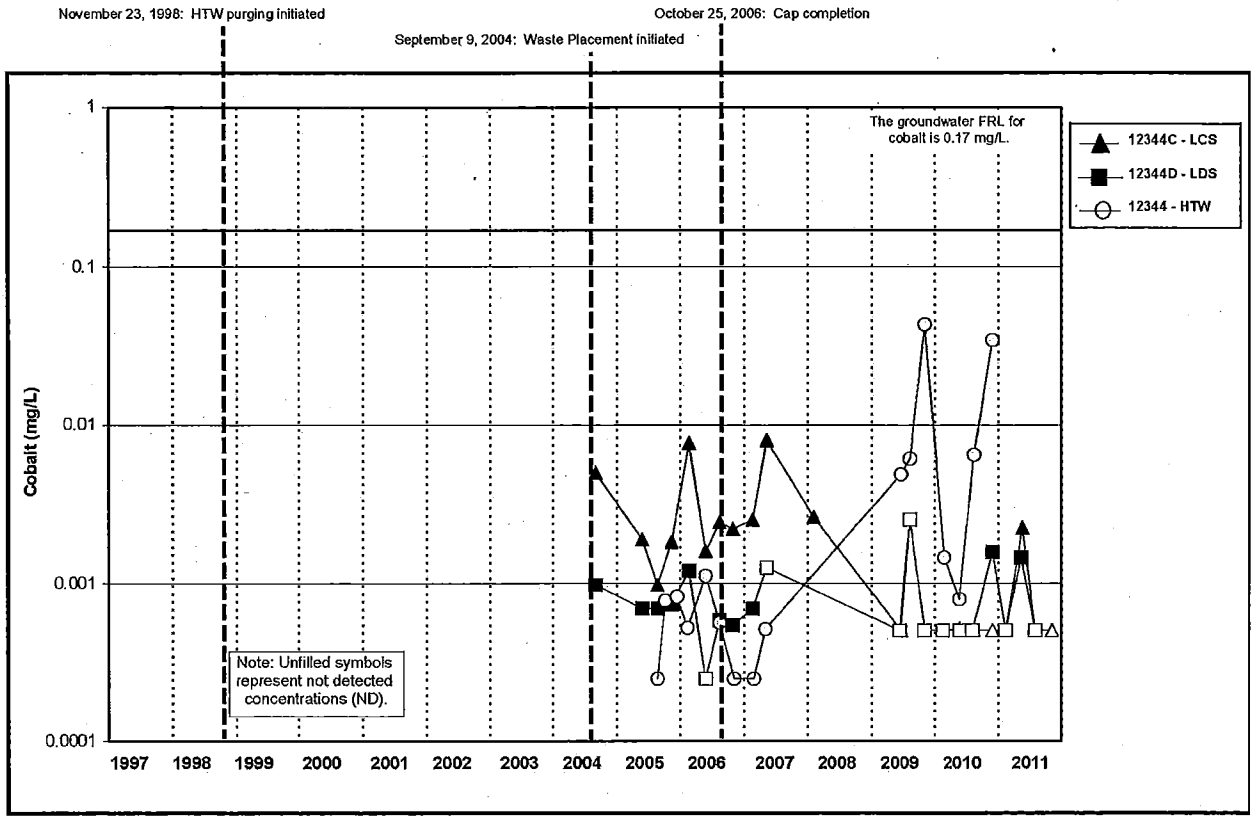


Figure A.5.7-19A. Cell 7 Cobalt Concentration vs. Time Plot for LCS, LDS, and HTW

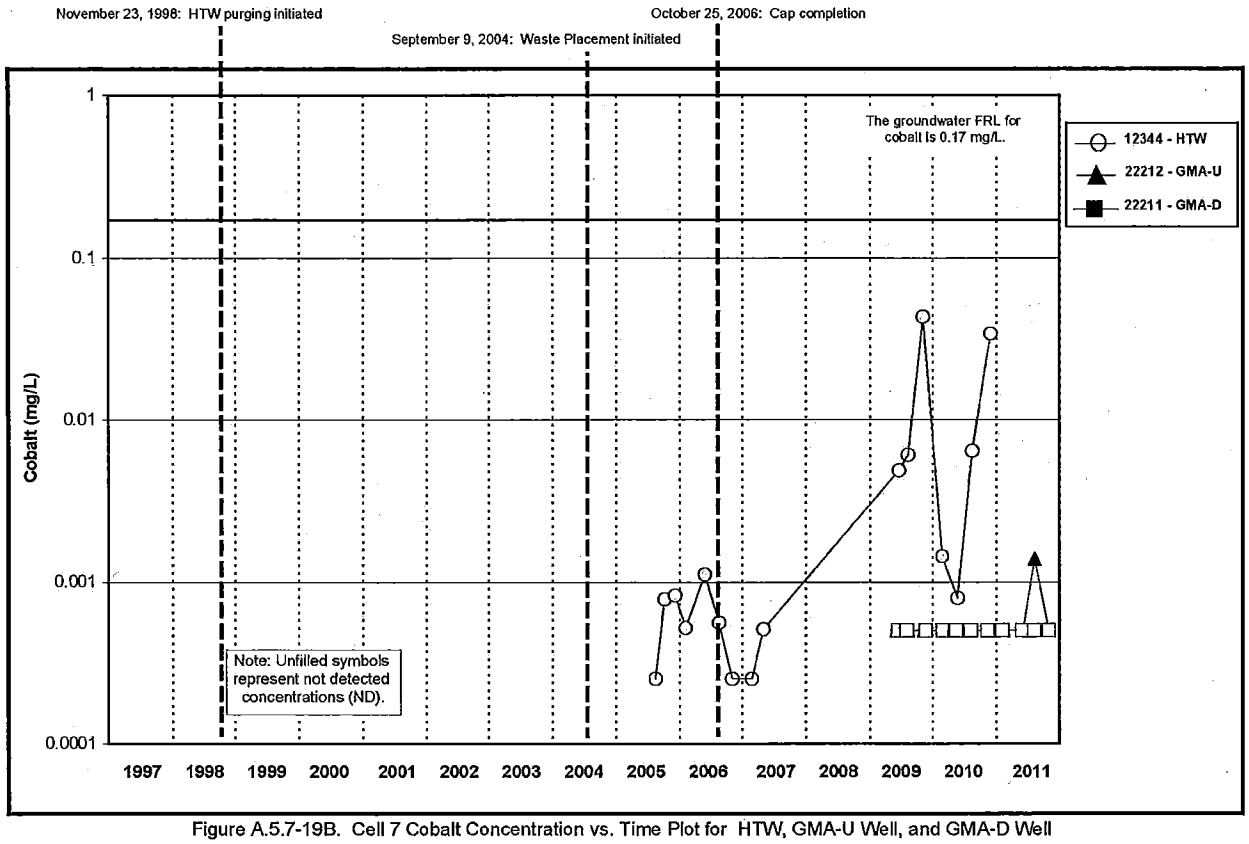


Figure A.5.7-19B. Cell 7 Cobalt Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

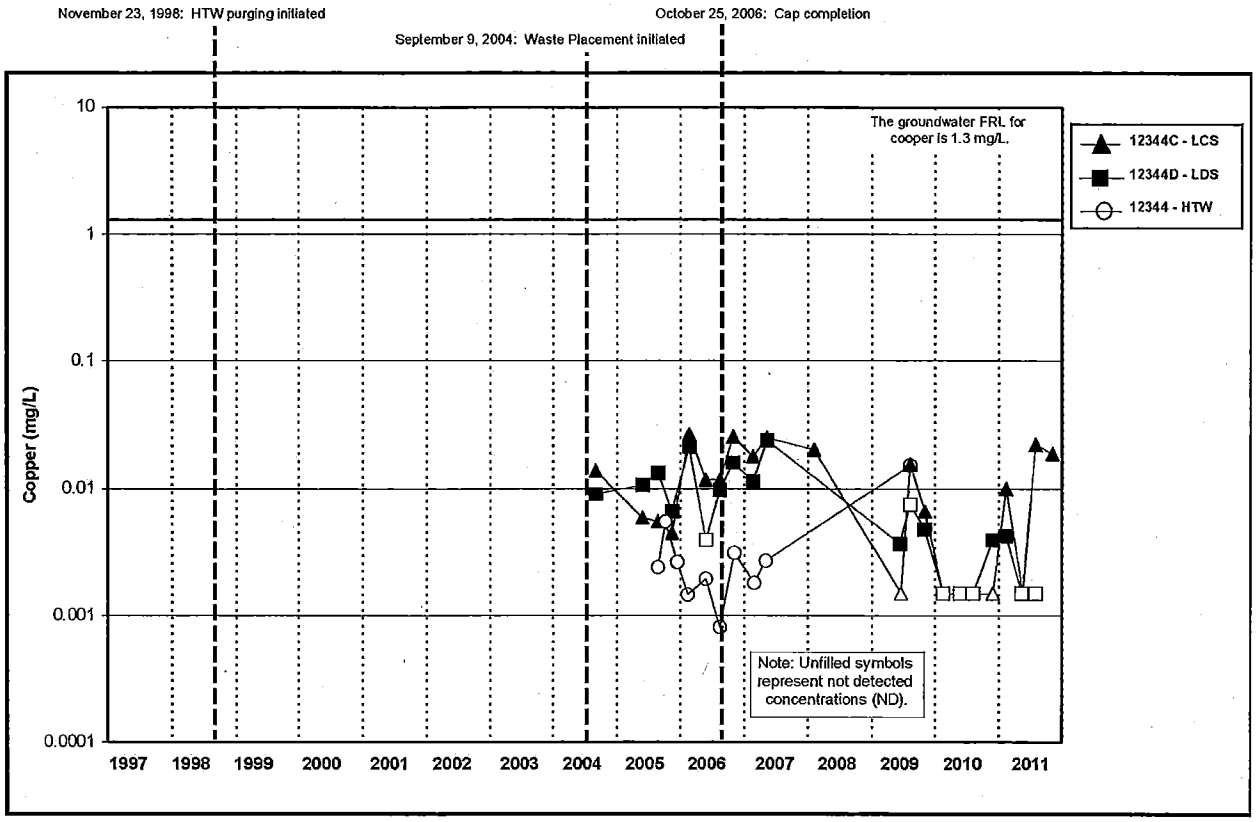


Figure A.5.7-20A. Cell 7 Copper Concentration vs. Time Plot for LCS, LDS, and HTW

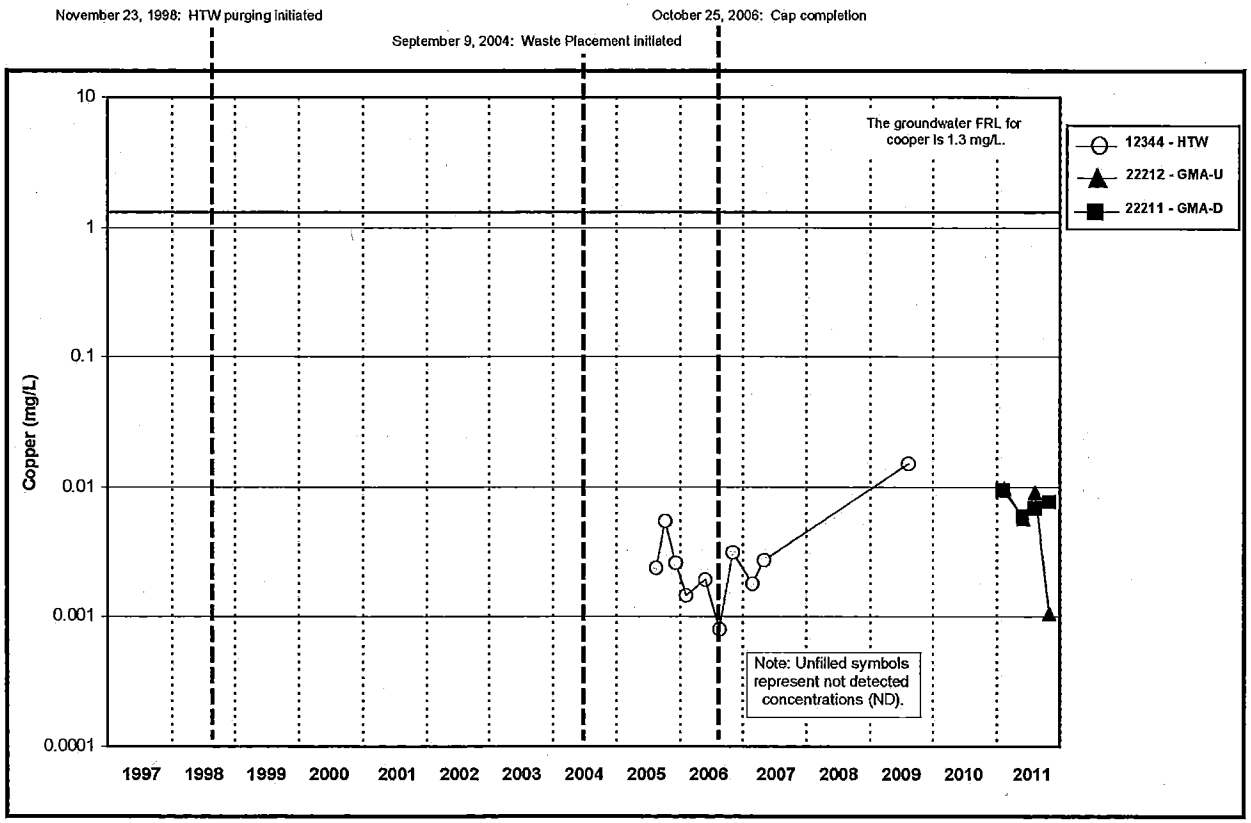


Figure A.5.7-20B. Cell 7 Copper Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

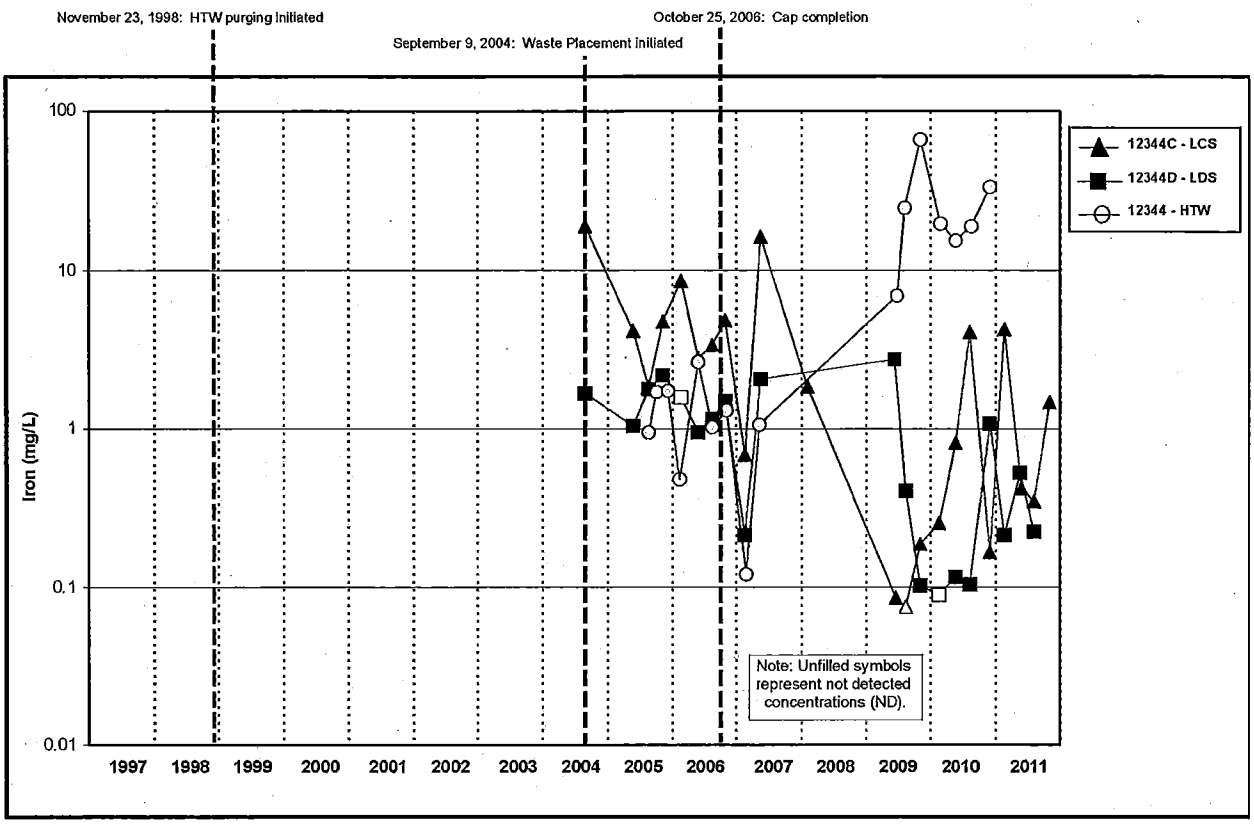


Figure A.5.7-21A. Cell 7 Iron Concentration vs. Time Plot for LCS, LDS, and HTW

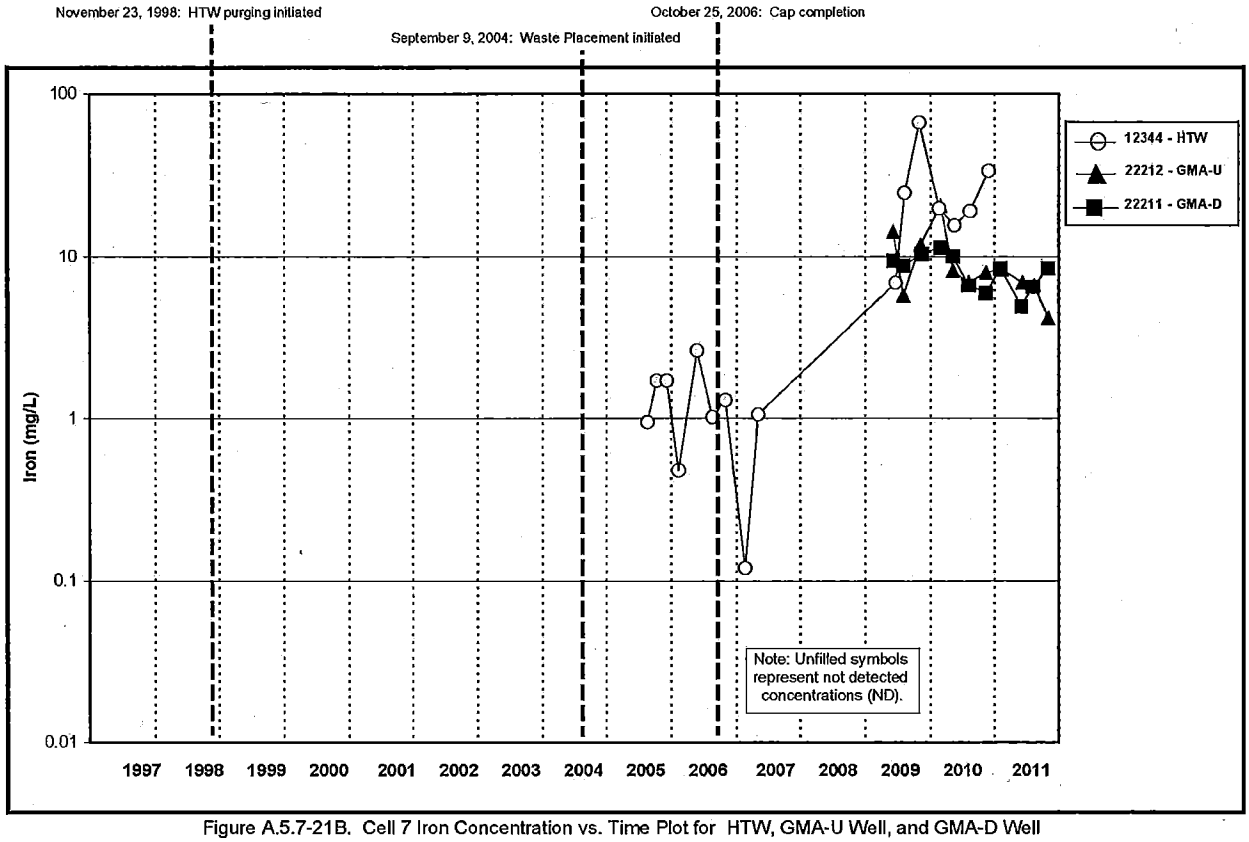


Figure A.5.7-21B. Cell 7 Iron Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

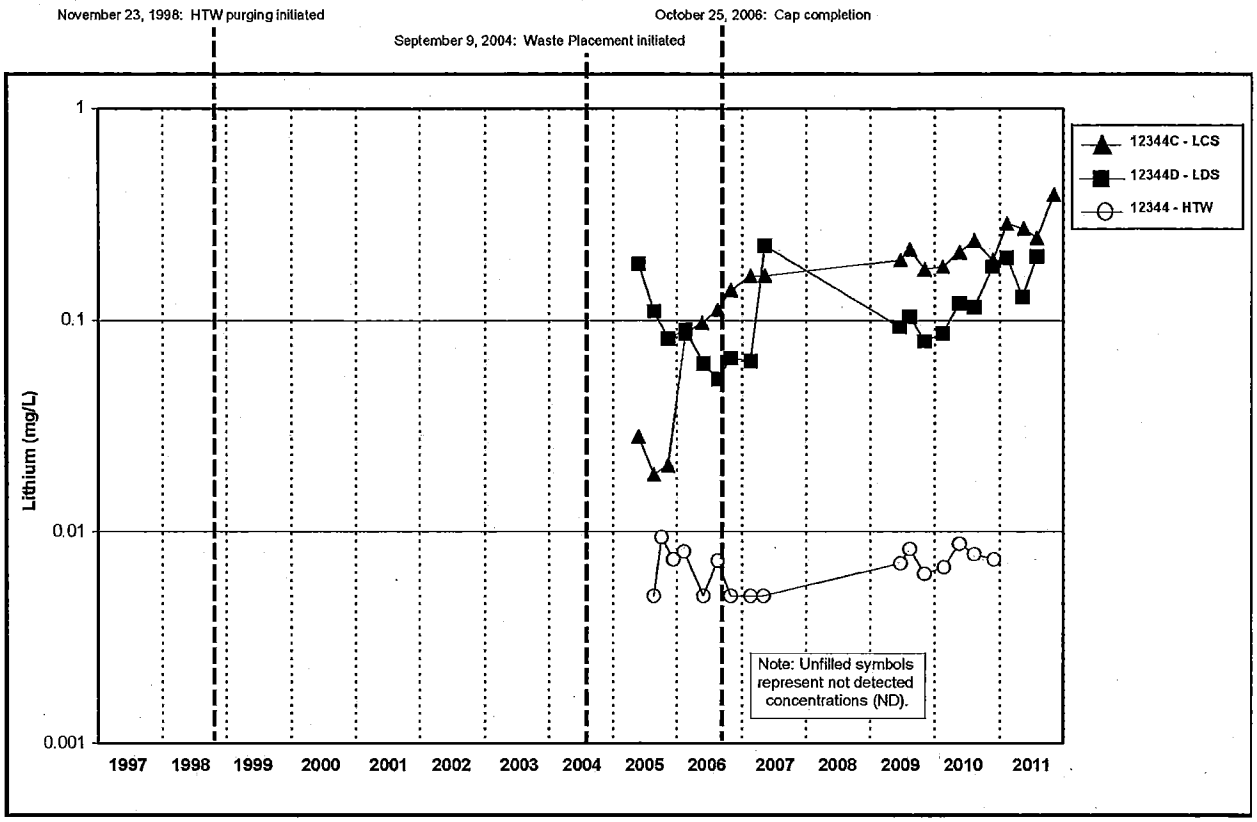


Figure A.5.7-22A. Cell 7 Lithium Concentration vs. Time Plot for LCS, LDS, and HTW

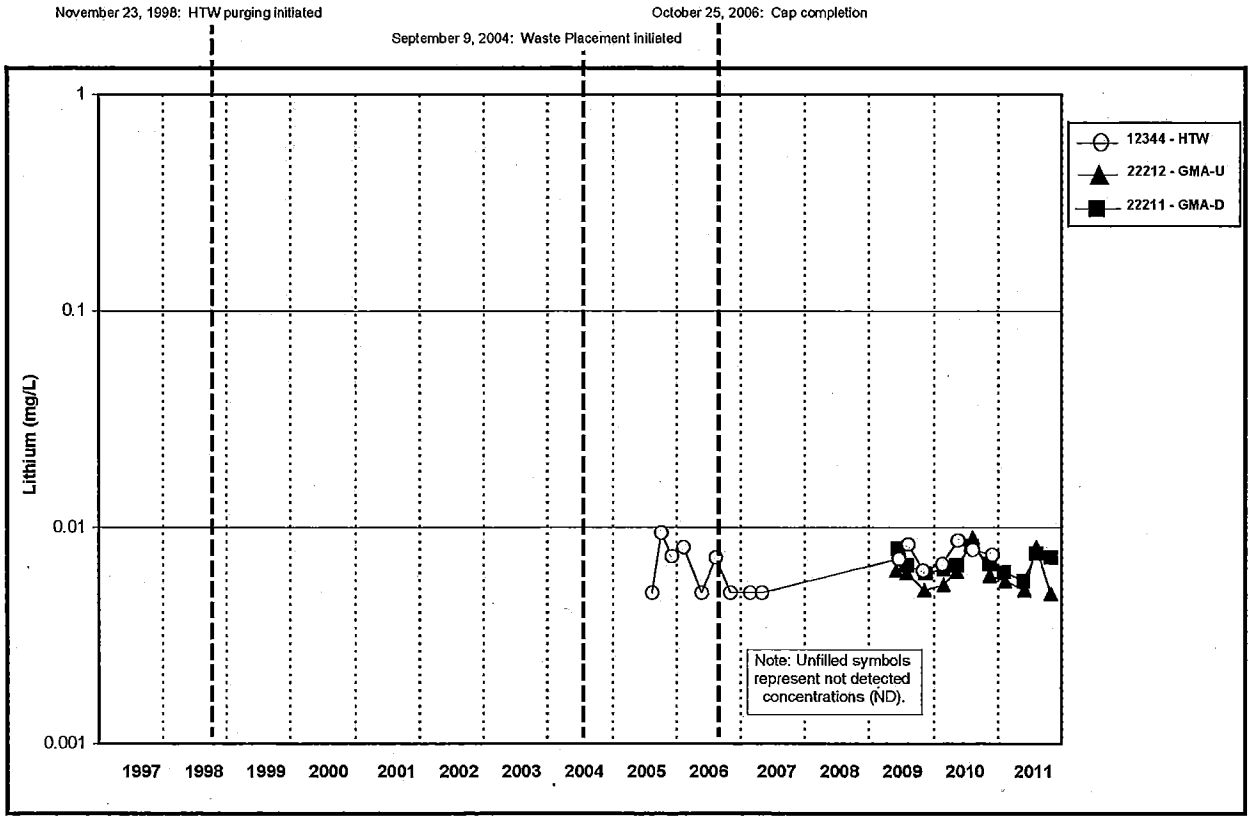


Figure A.5.7-22B. Cell 7 Lithium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

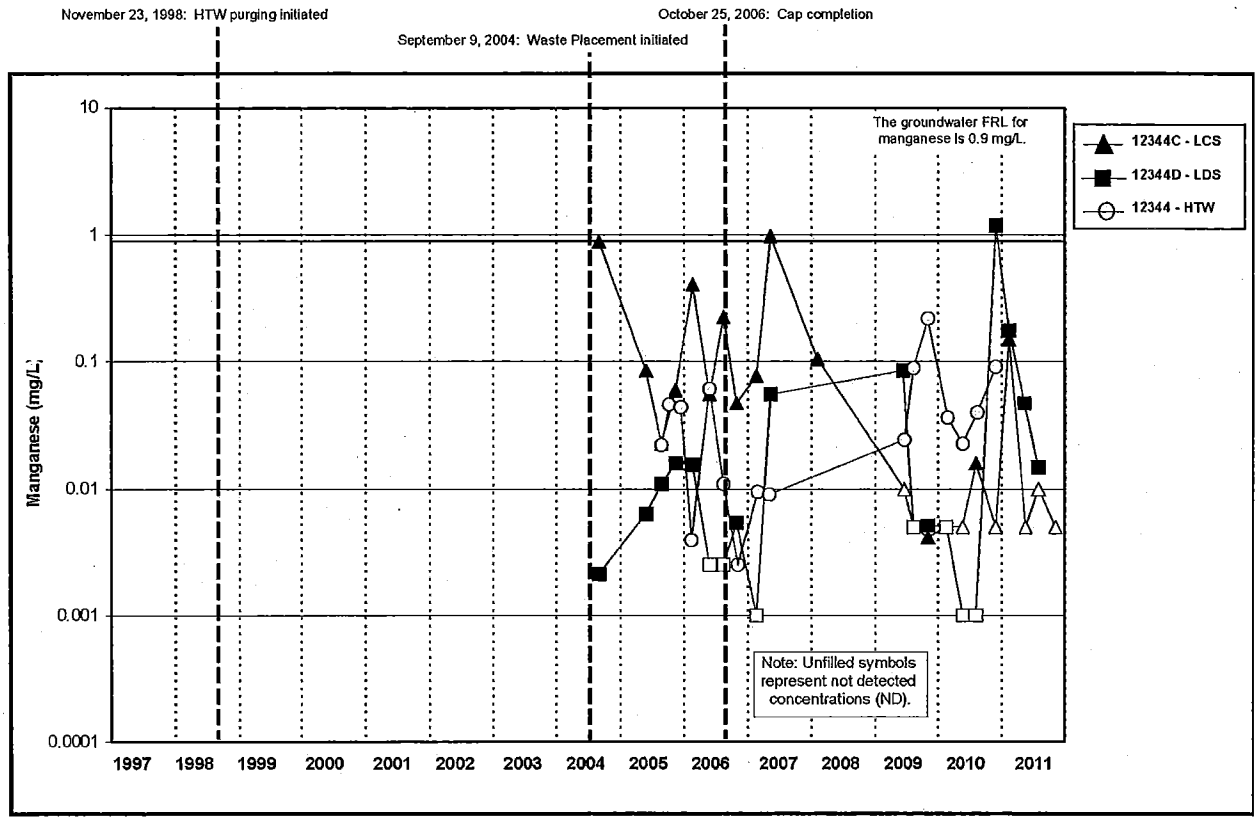


Figure A.5.7-23A. Cell 7 Manganese Concentration vs. Time Plot for LCS, LDS, and HTW

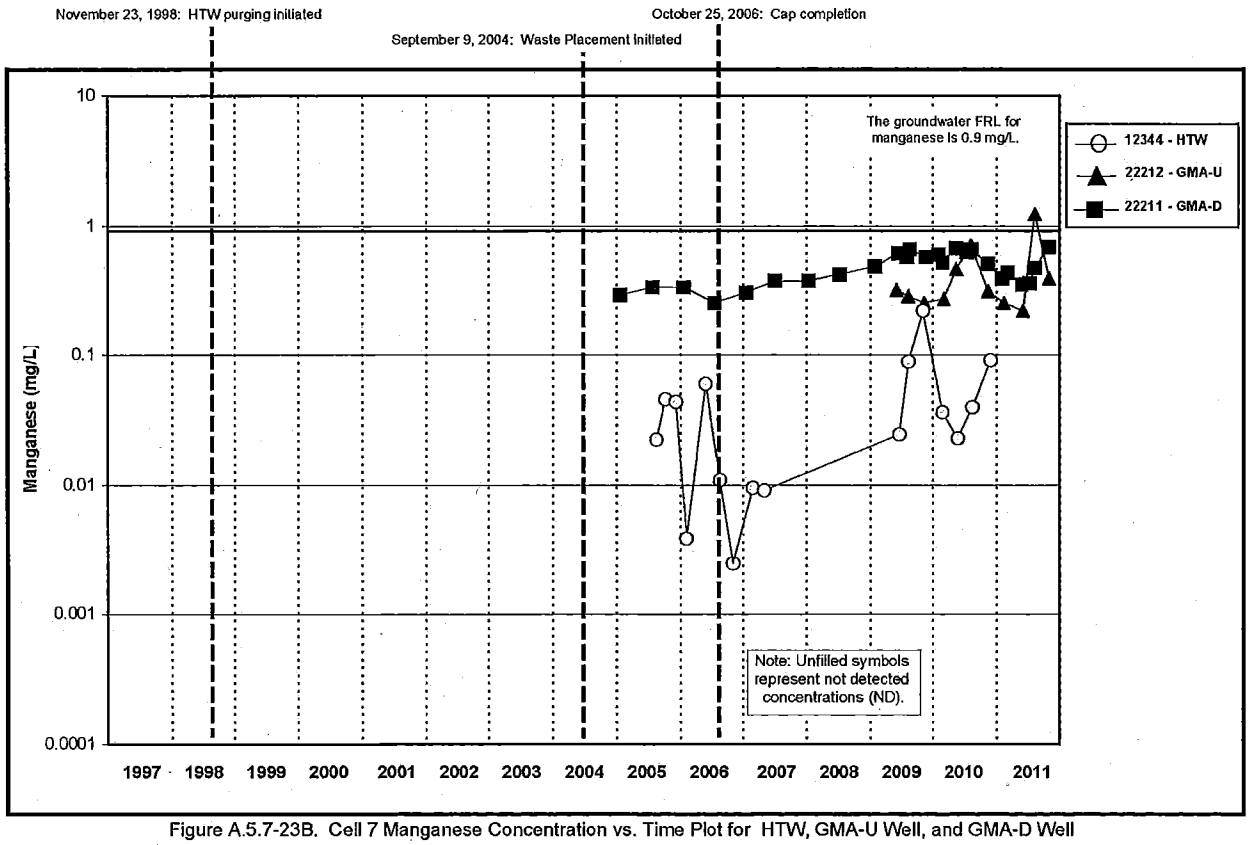


Figure A.5.7-23B. Cell 7 Manganese Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

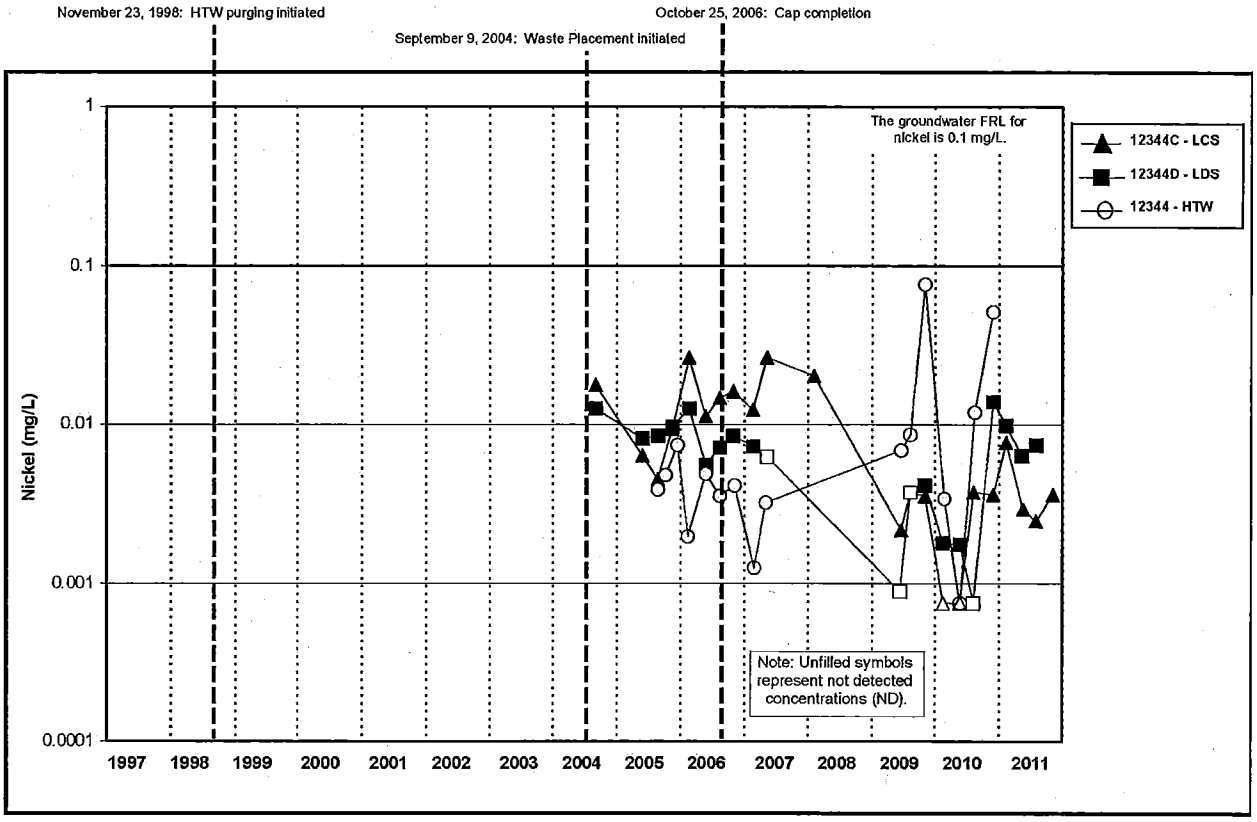


Figure A.5.7-24A. Cell 7 Nickel Concentration vs. Time Plot for LCS, LDS, and HTW

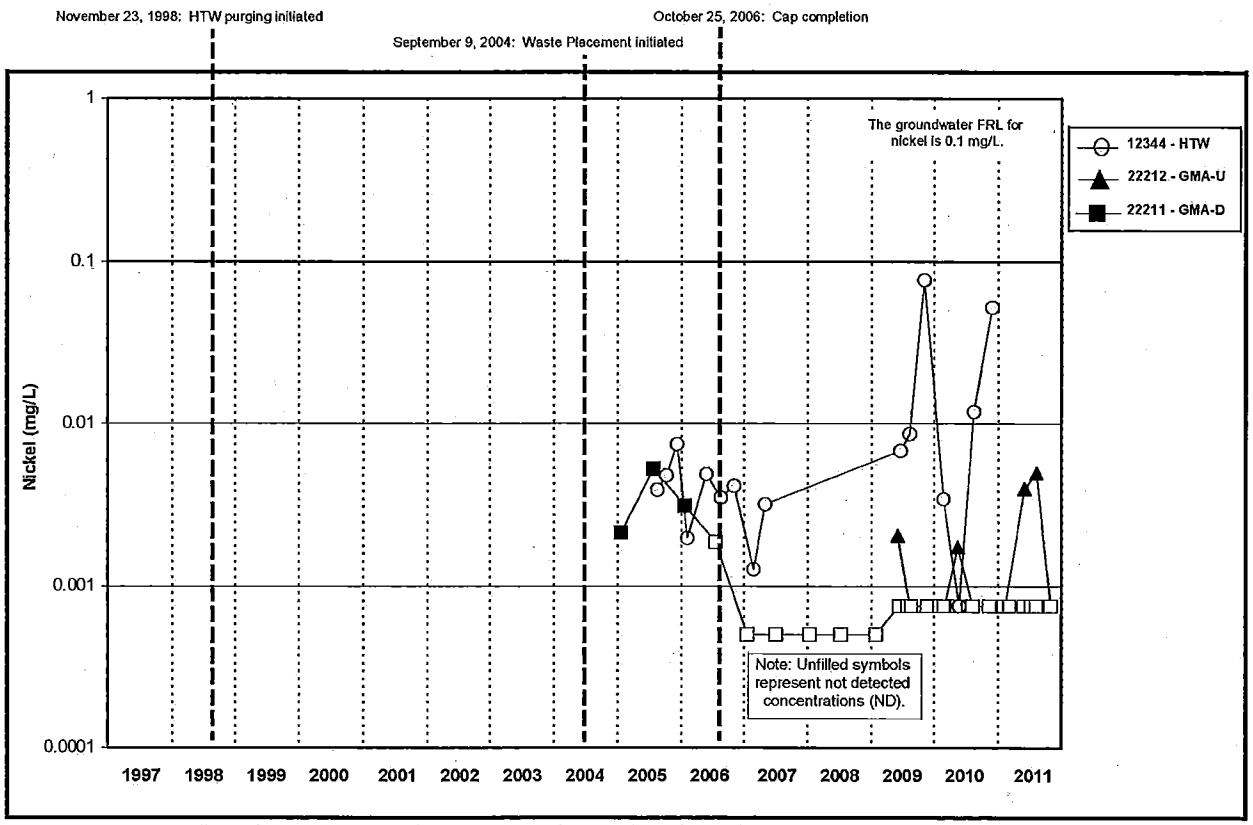


Figure A.5.7-24B. Cell 7 Nickel Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

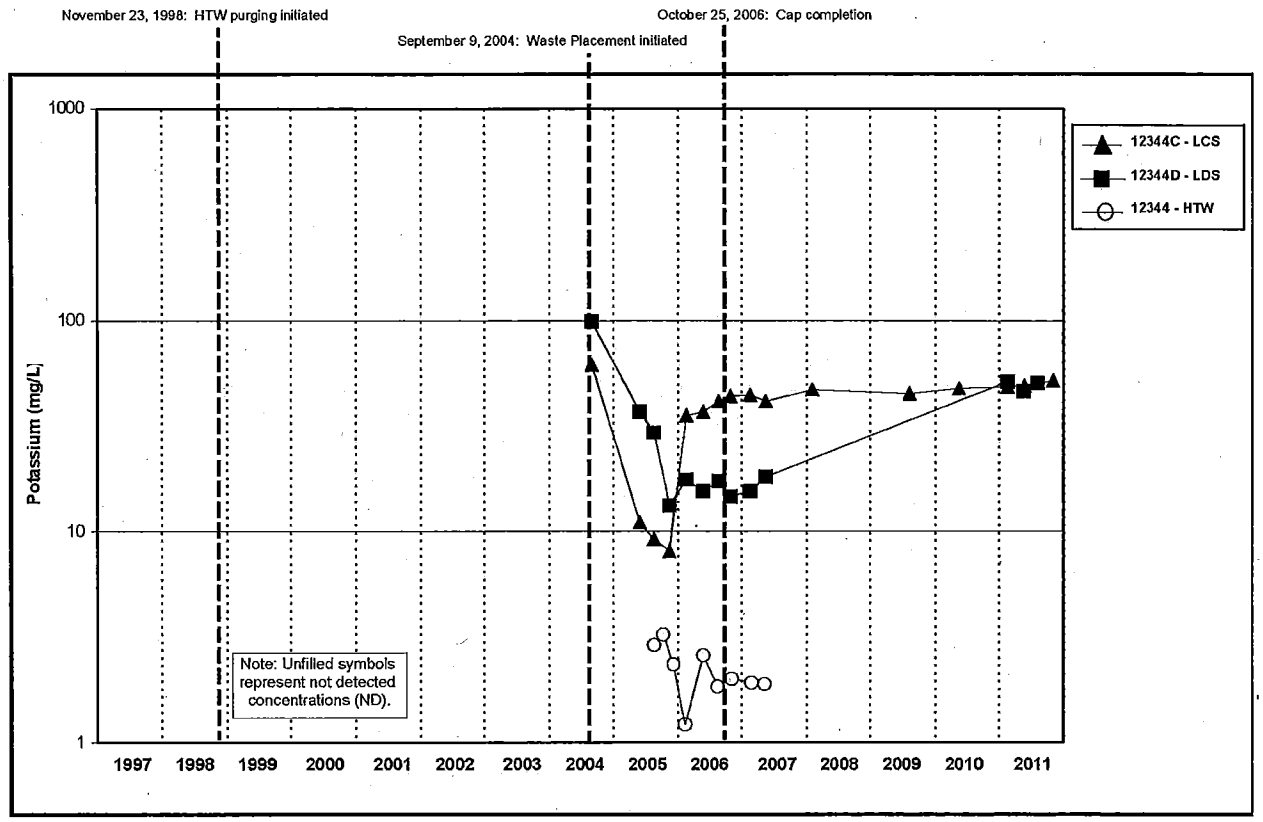


Figure A.5.7-25A. Cell 7 Potassium Concentration vs. Time Plot for LCS, LDS, and HTW

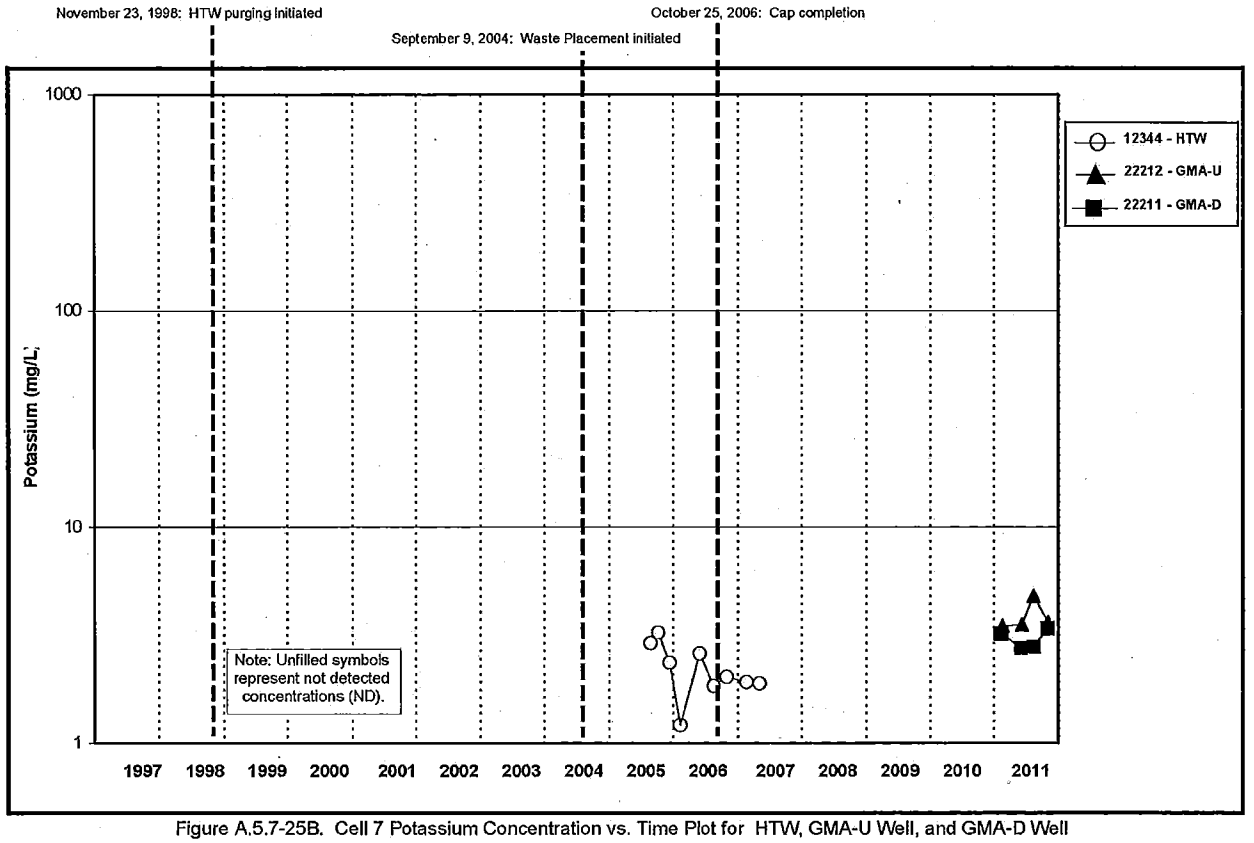


Figure A.5.7-25B. Cell 7 Potassium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

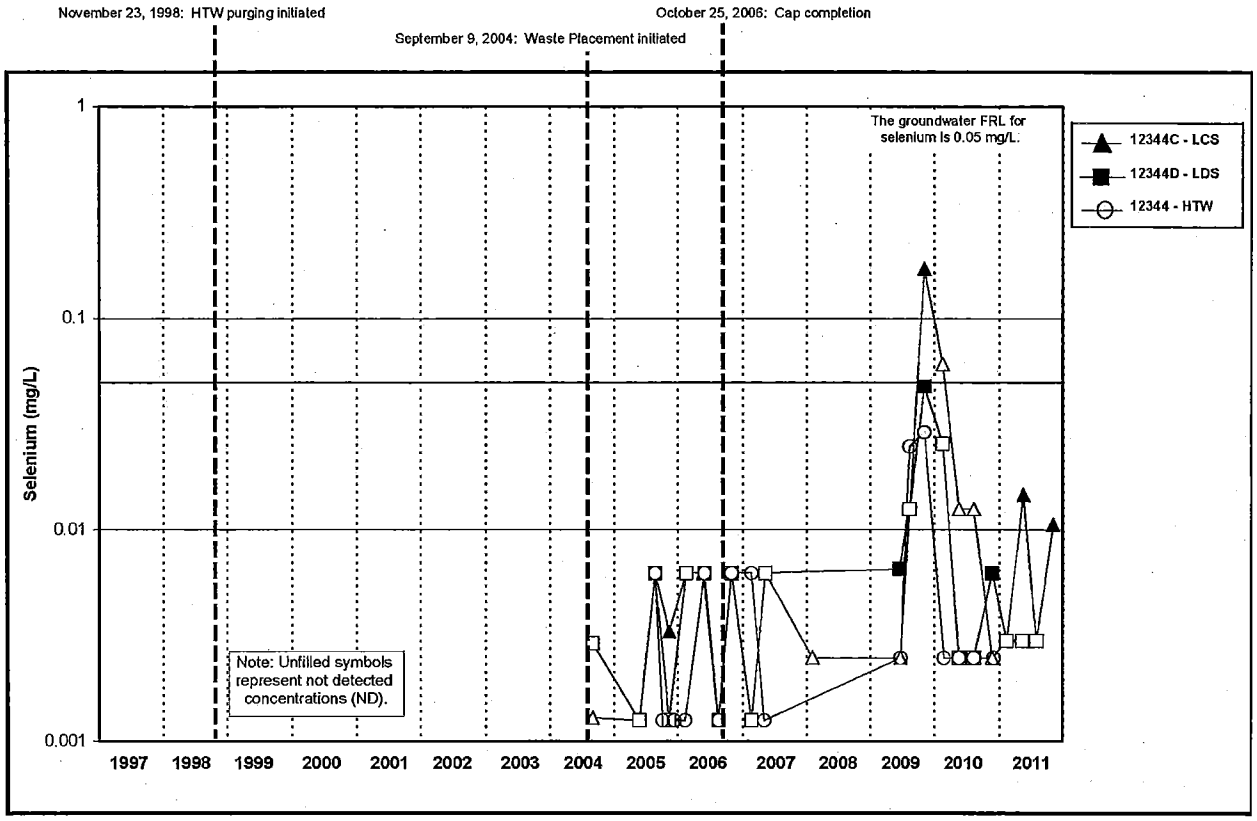


Figure A.5.7-26A. Cell 7 Selenium Concentration vs. Time Plot for LCS, LDS, and HTW

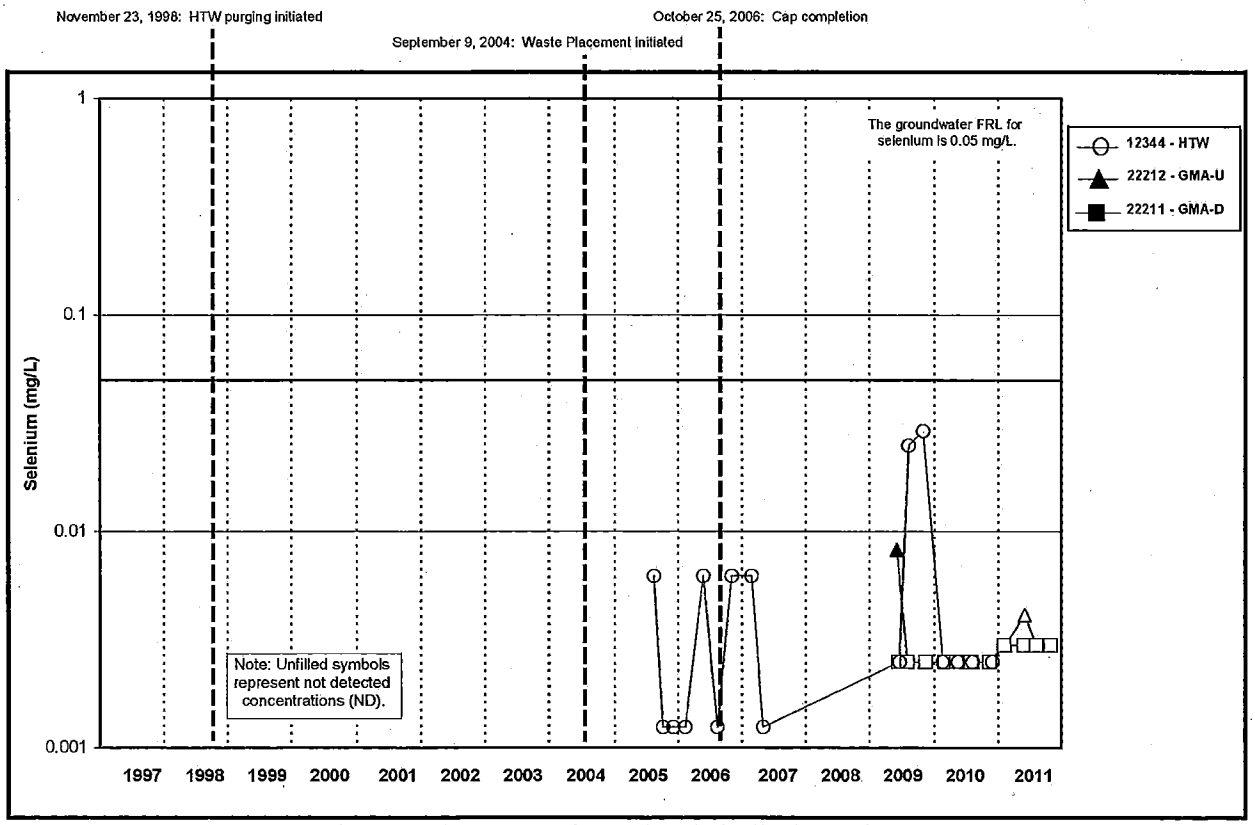


Figure A.5.7-26B. Cell 7 Selenium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

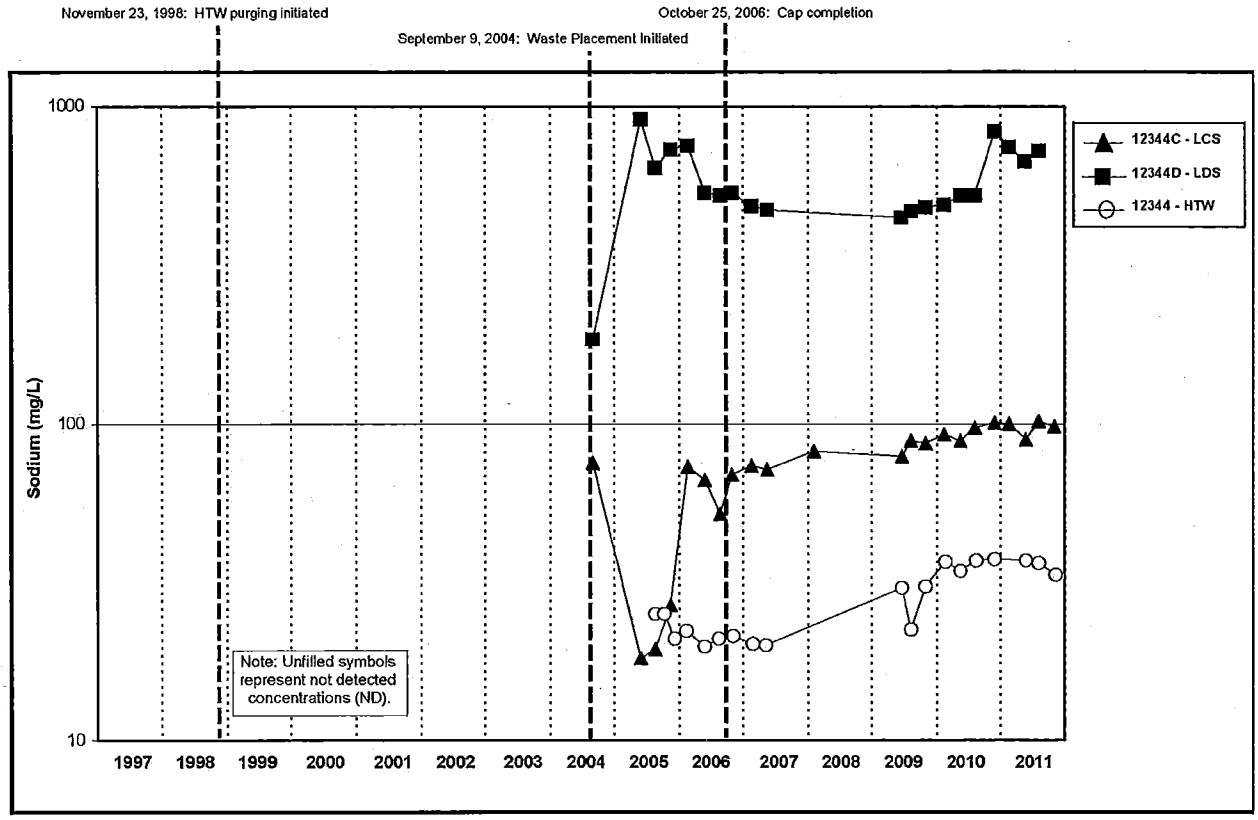


Figure A.5.7-27A. Cell 7 Sodium Concentration vs. Time Plot for LCS, LDS, and HTW

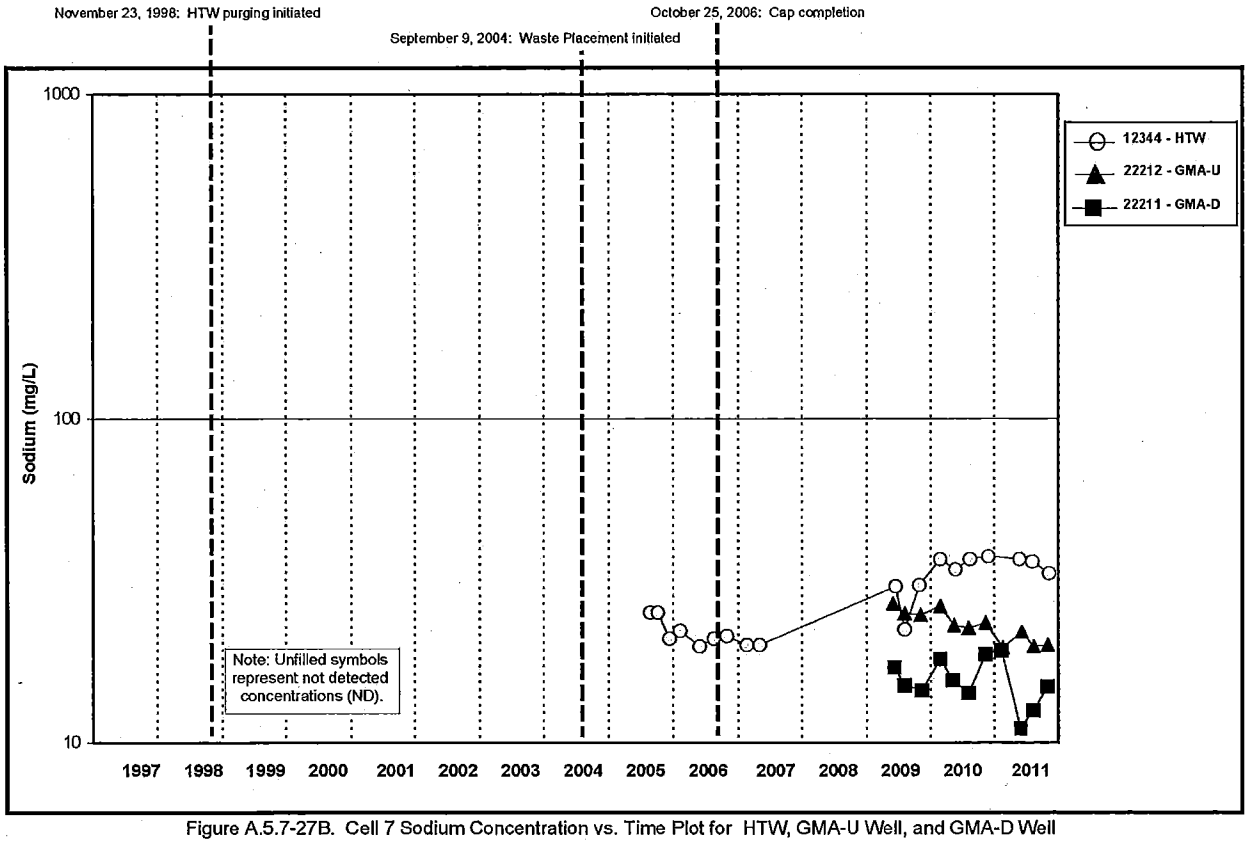


Figure A.5.7-27B. Cell 7 Sodium Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

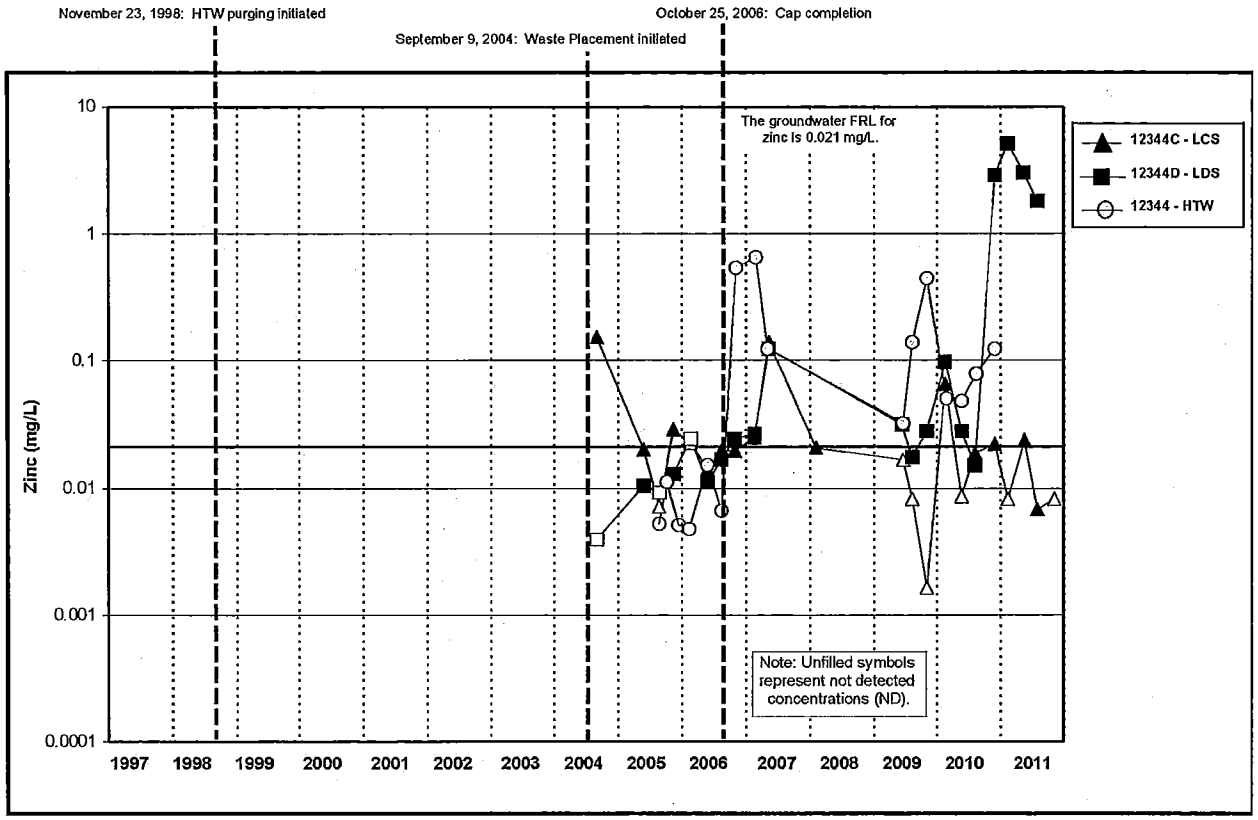


Figure A.5.7-28A. Cell 7 Zinc Concentration vs. Time Plot for LCS, LDS, and HTW

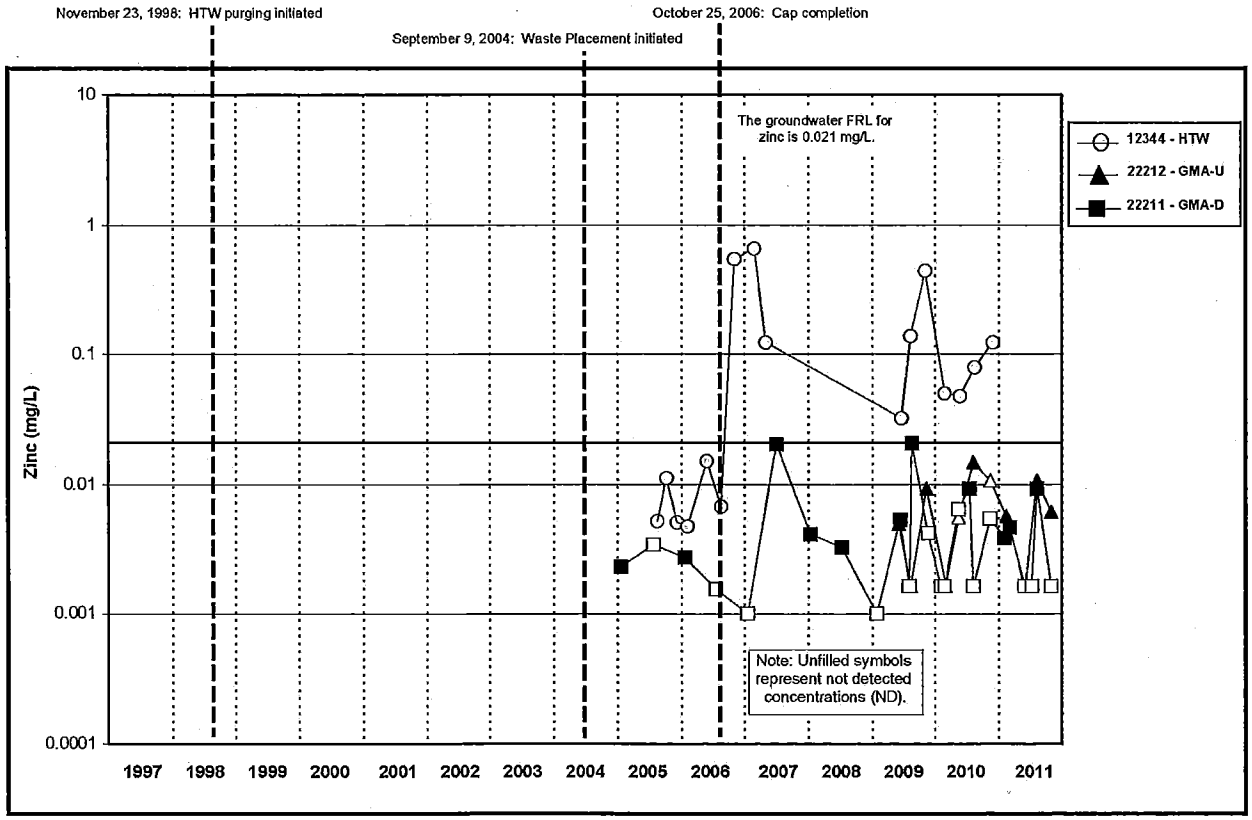


Figure A.5.7-28B. Cell 7 Zinc Concentration vs. Time Plot for HTW, GMA-U Well, and GMA-D Well

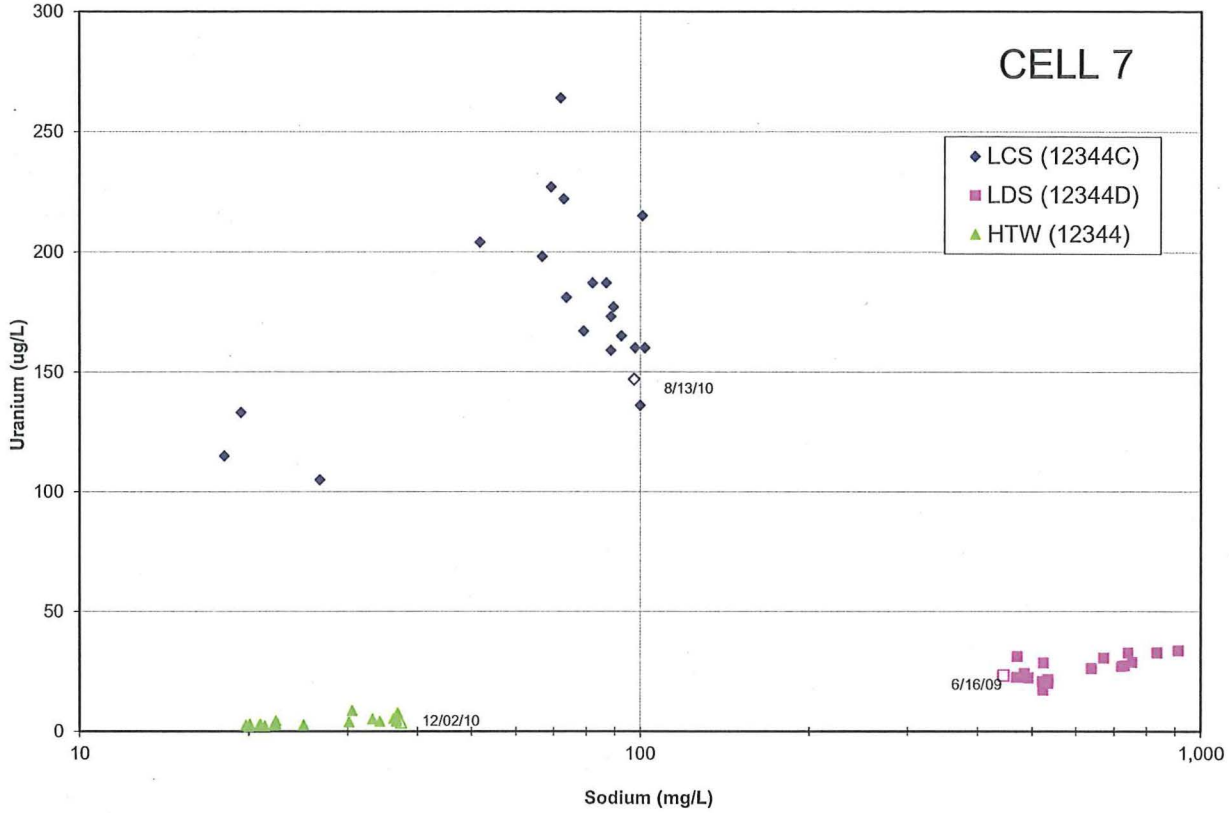


Figure A.5.7–29. Cell 7 Bivariate Plot for Uranium and Sodium

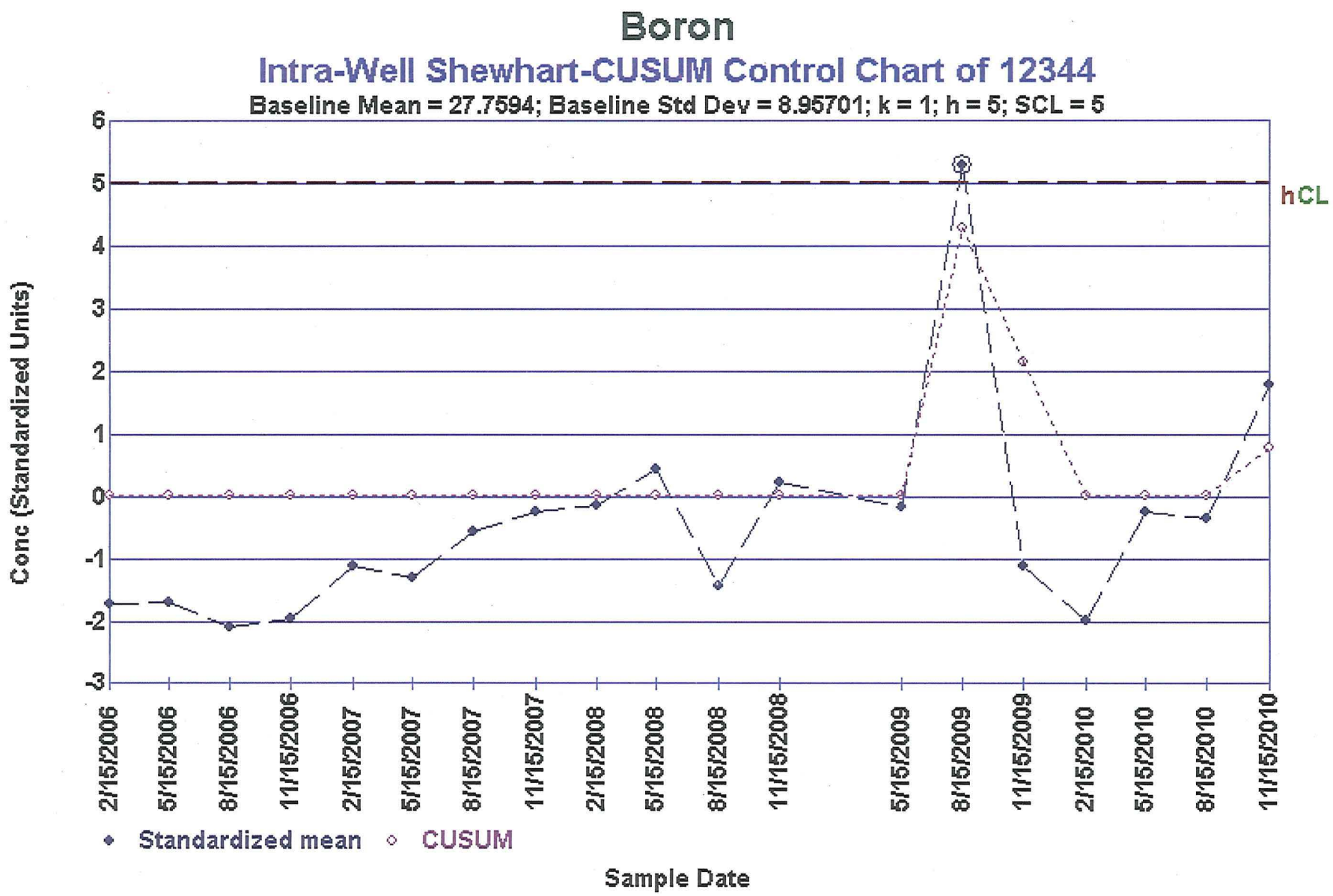


Figure A.5.7−30. Intra-Well Shewhart-CUSUM Control Chart (Boron 12344)

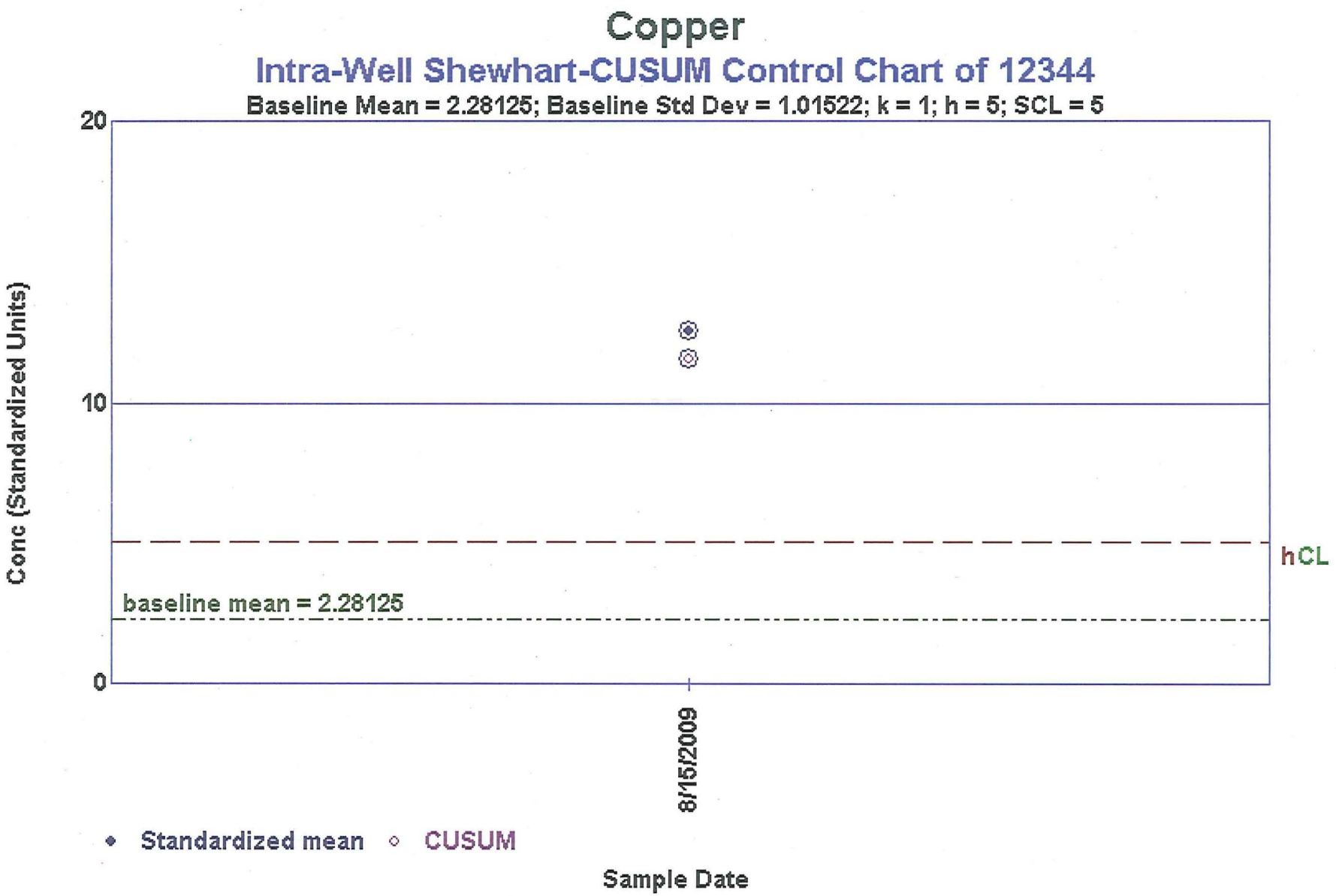


Figure A.5.7−31. Intra-Well Shewhart-CUSUM Control Chart (Copper 12344)

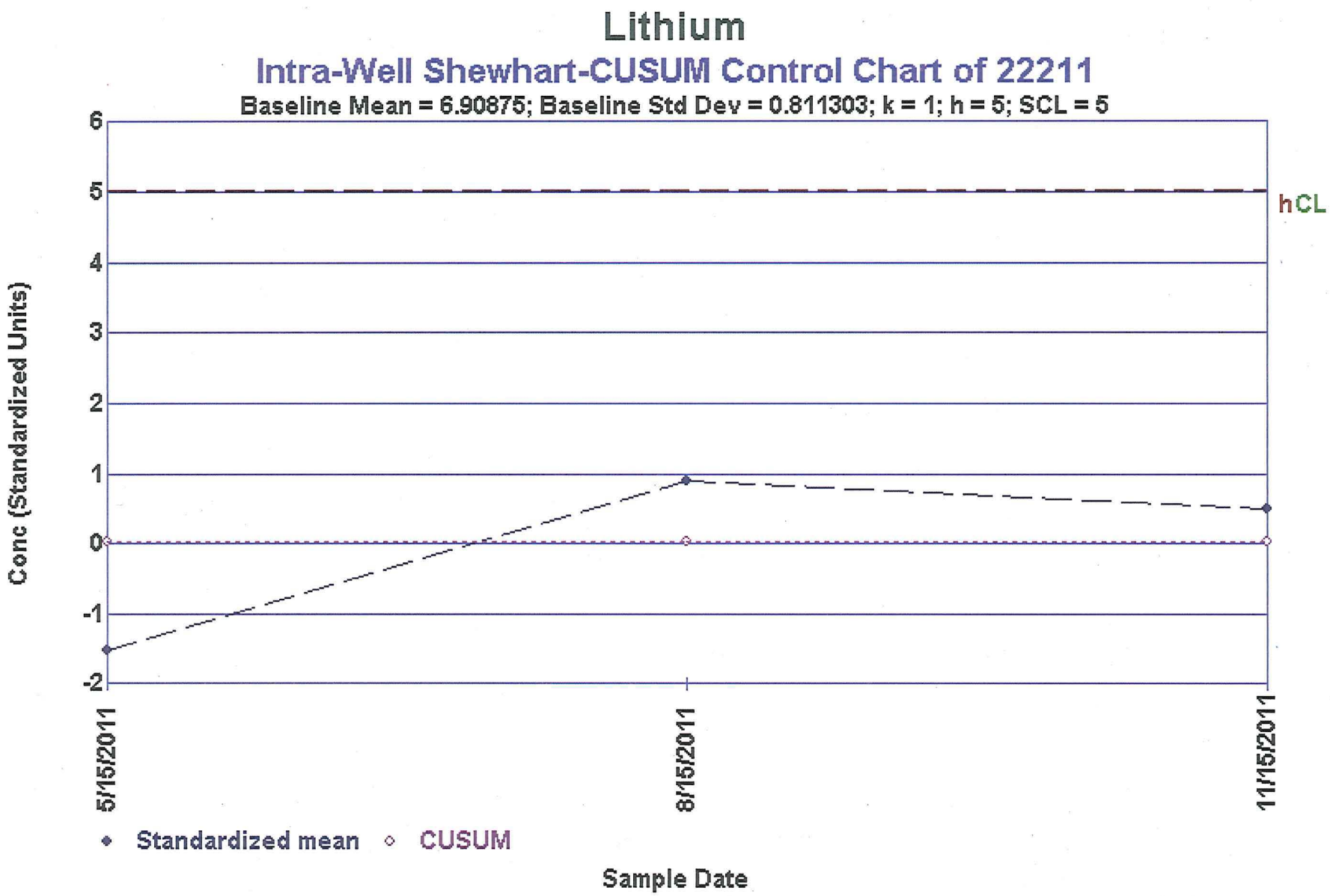


Figure A.5.7–32. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22211)

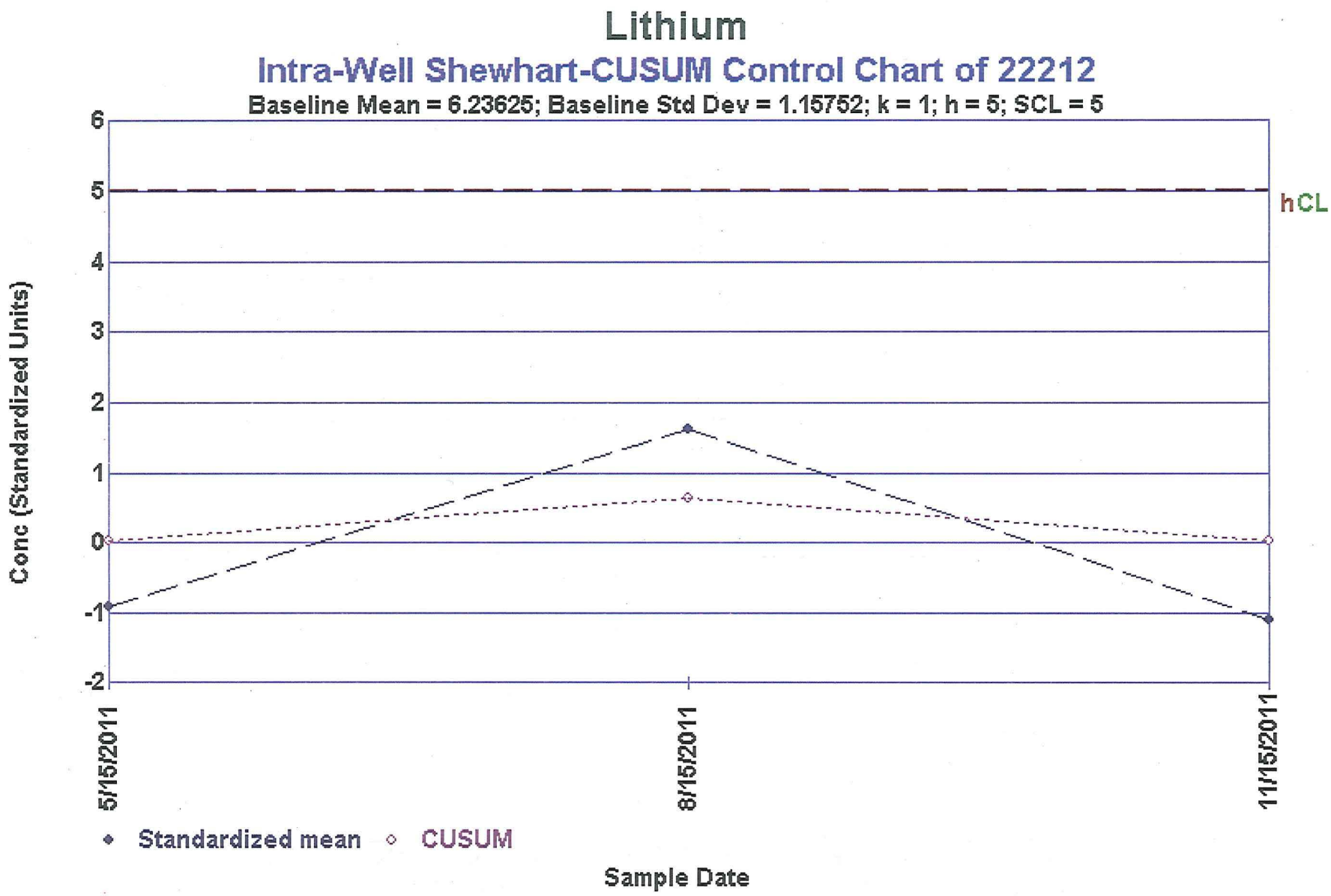


Figure A.5.7−33. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22212)

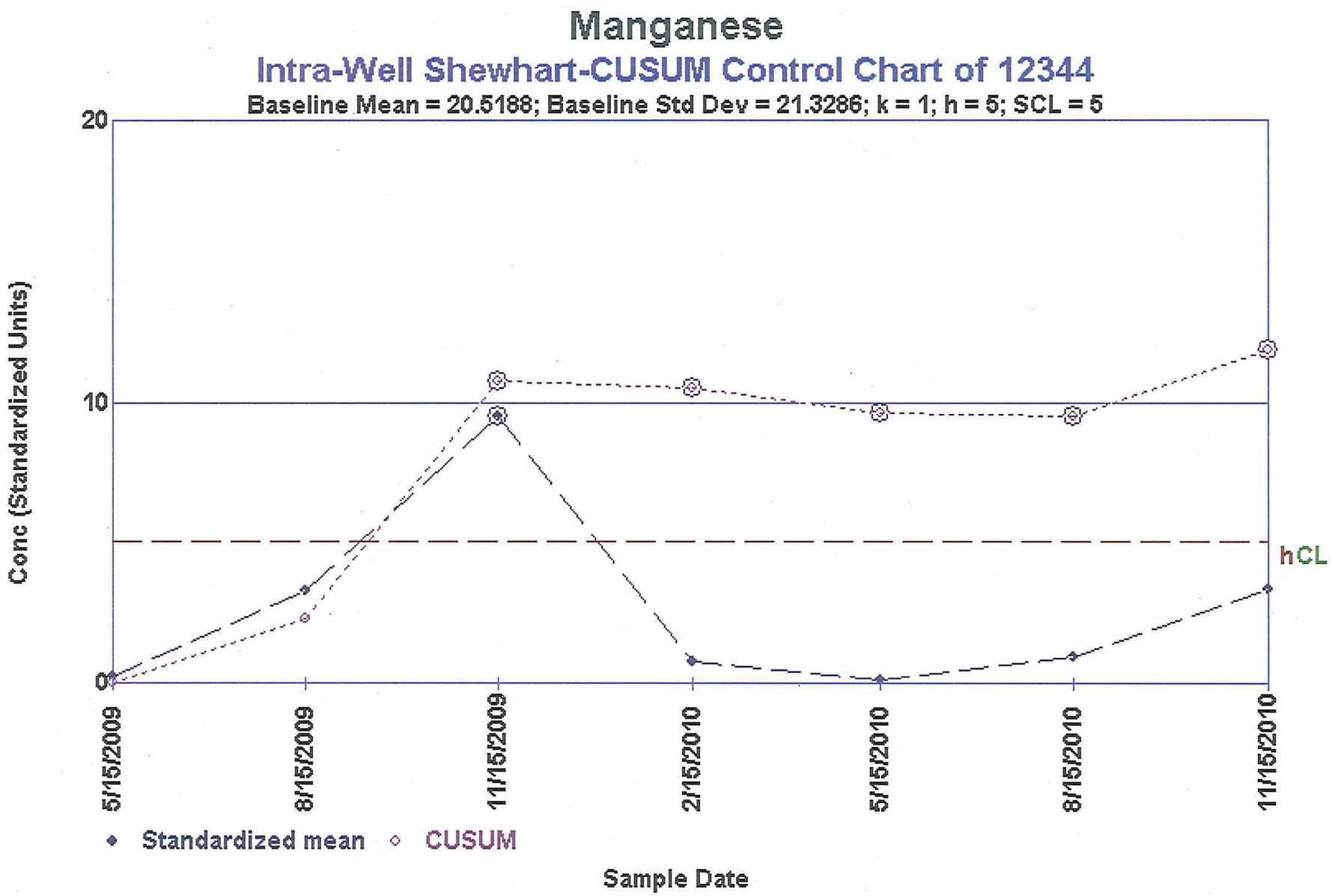


Figure A.5.7−34. Intra-Well Shewhart-CUSUM Control Chart (Manganese 12344)

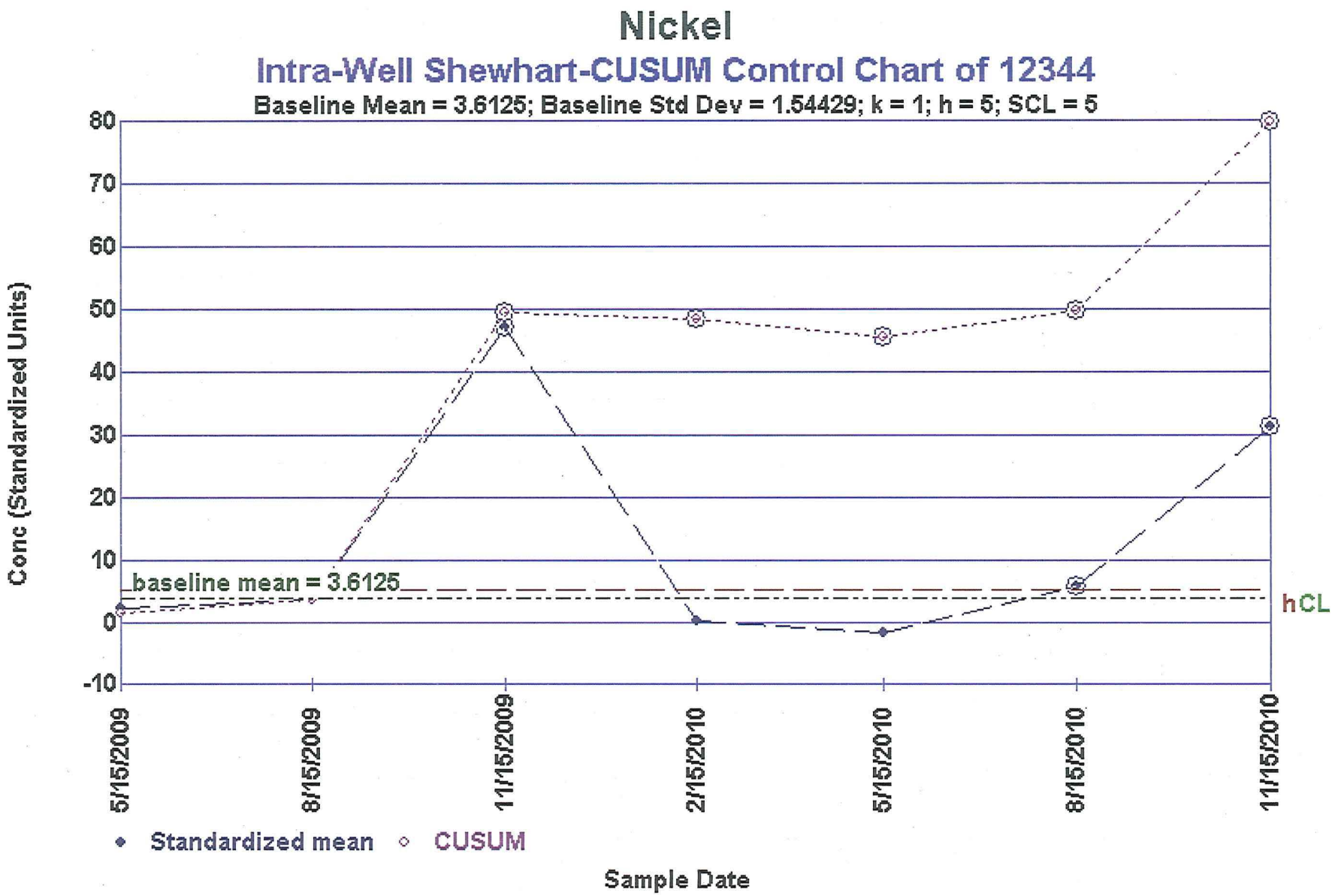


Figure A.5.7−35. Intra-Well Shewhart-CUSUM Control Chart (Nickel 12344)

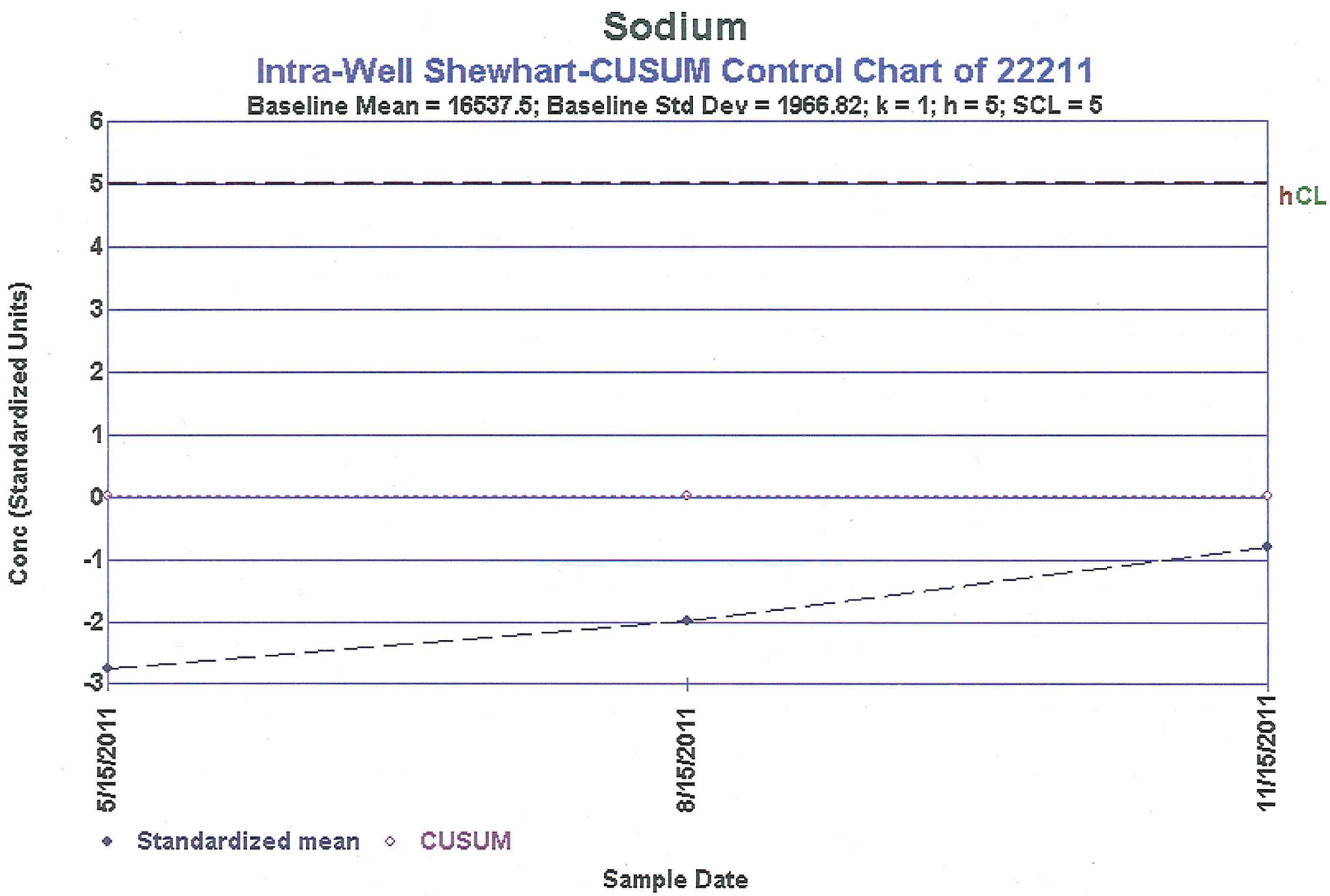


Figure A.5.7−36. Intra-Well Shewhart-CUSUM Control Chart (Sodium 22211)

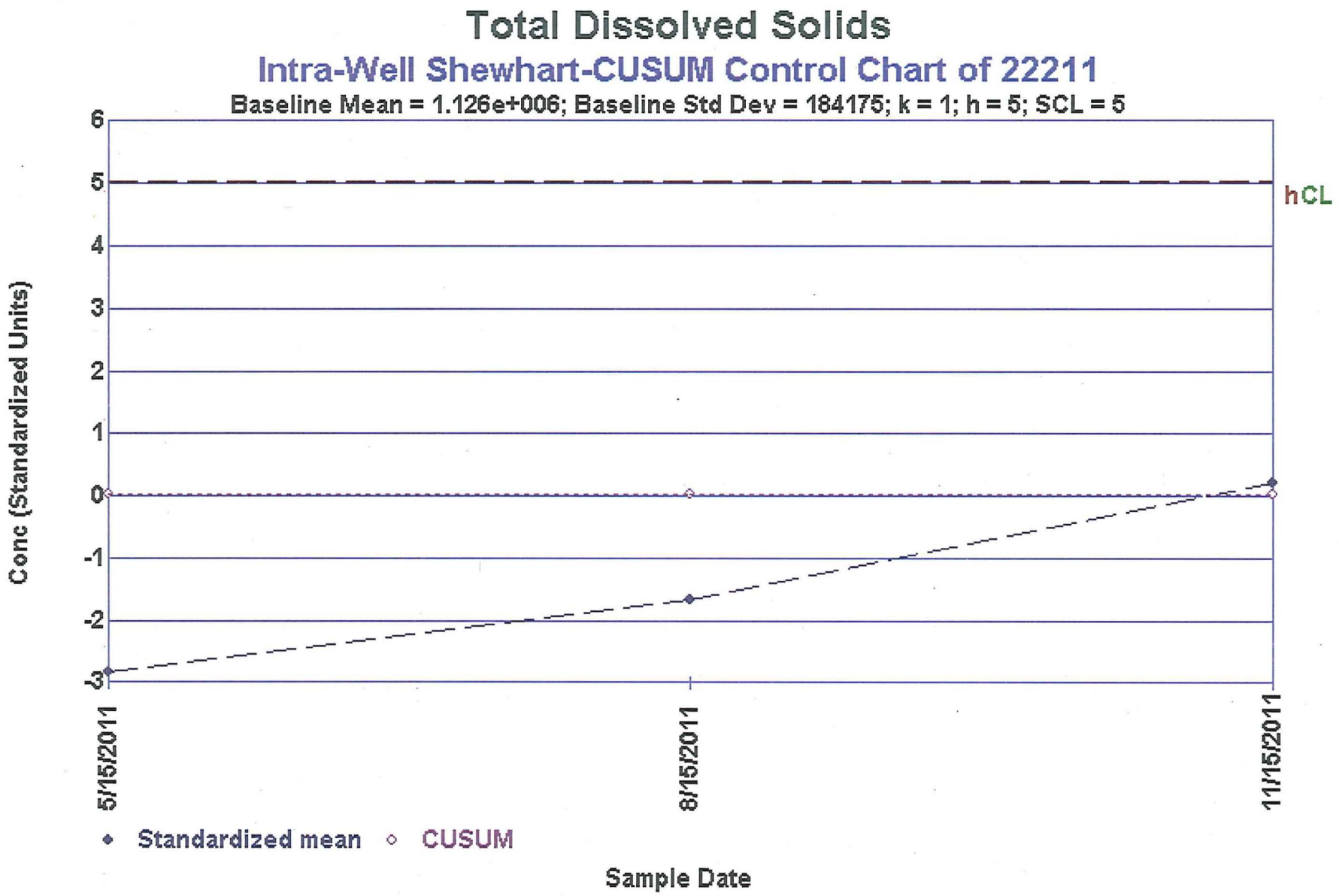


Figure A.5.7–37. Intra-Well Shewhart-CUSUM Control Chart (TDS 22211)

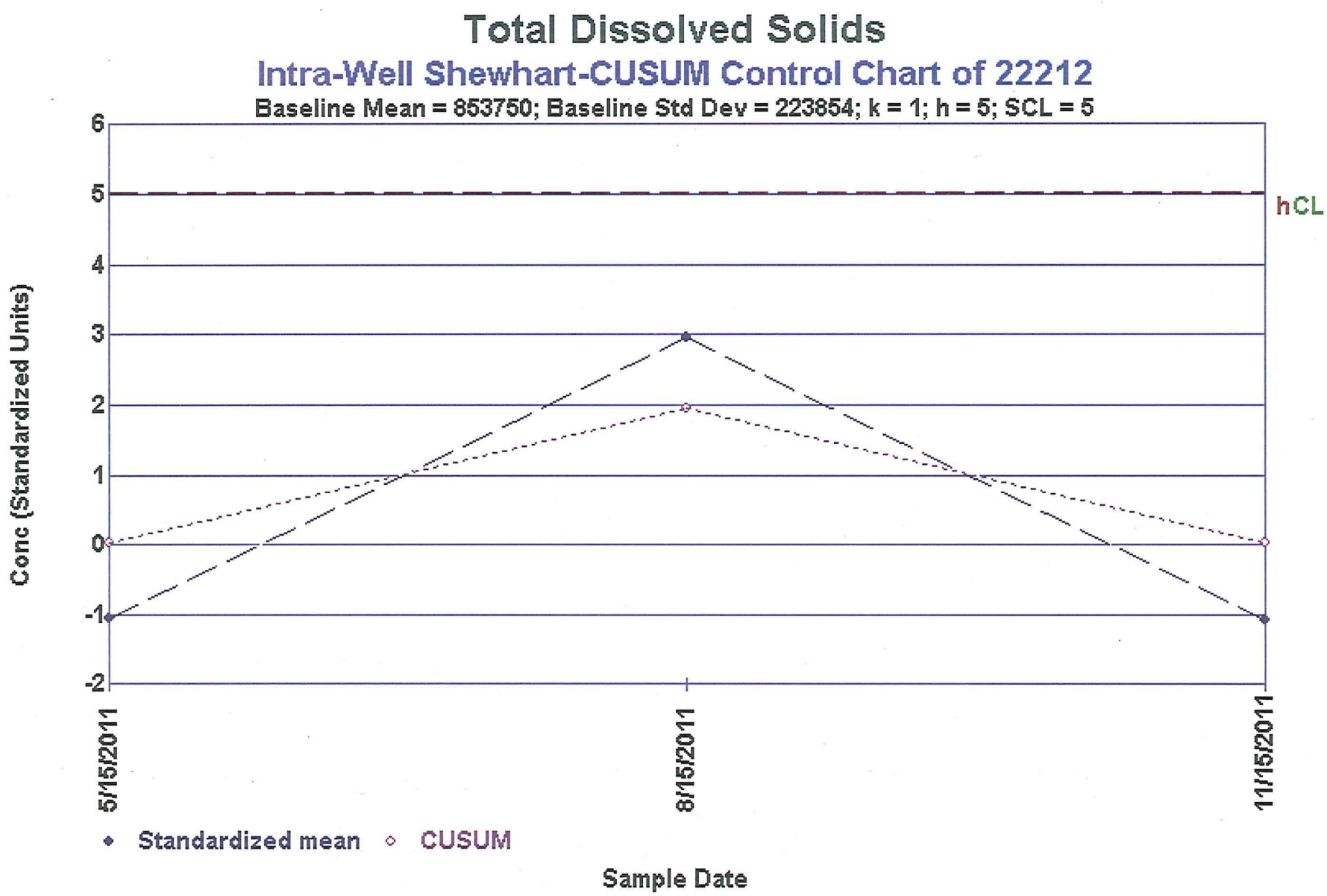


Figure A.5.7–38. Intra-Well Shewhart-CUSUM Control Chart (TDS 22212)

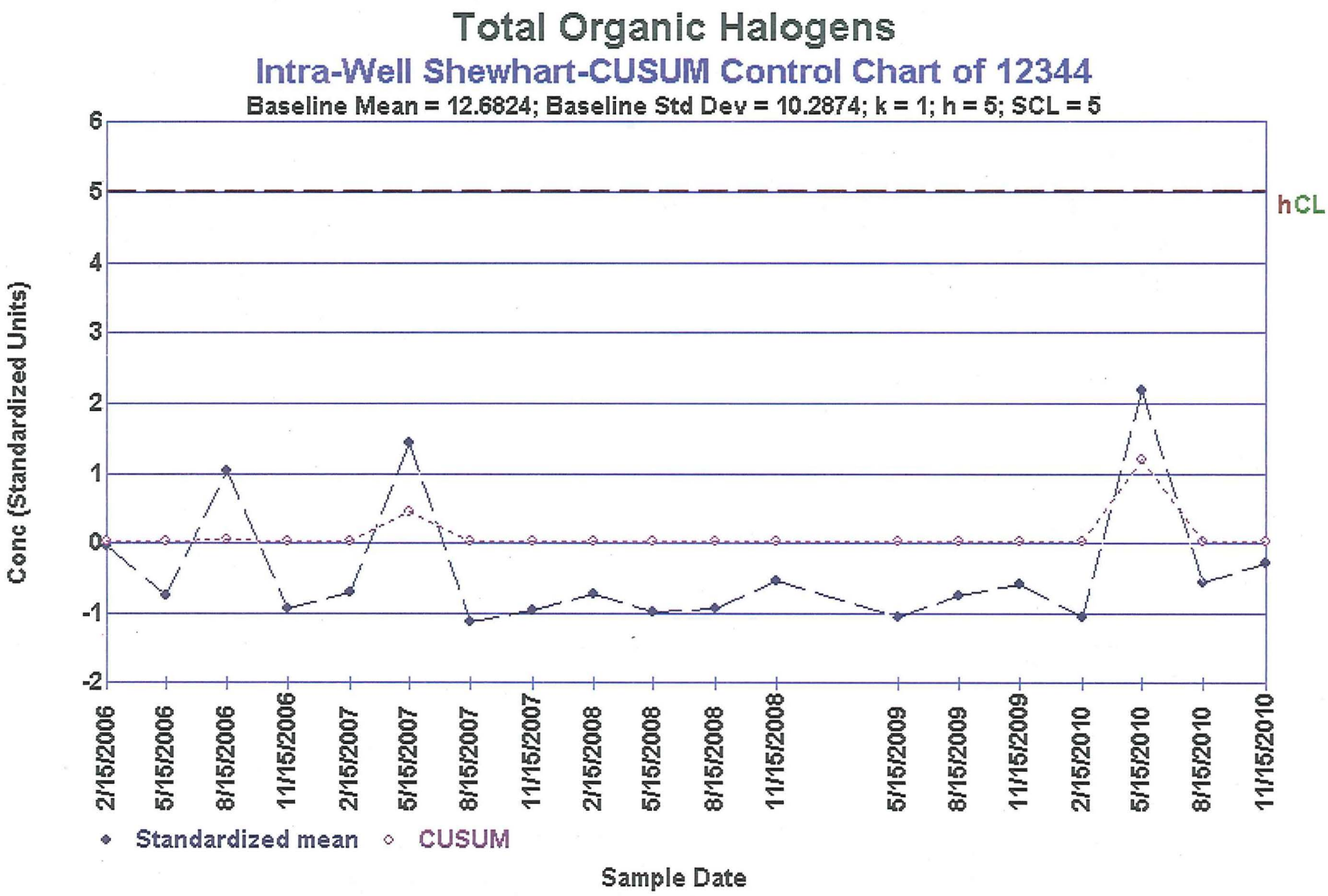


Figure A.5.7−39. Intra-Well Shewhart-CUSUM Control Chart (TOX 12344)

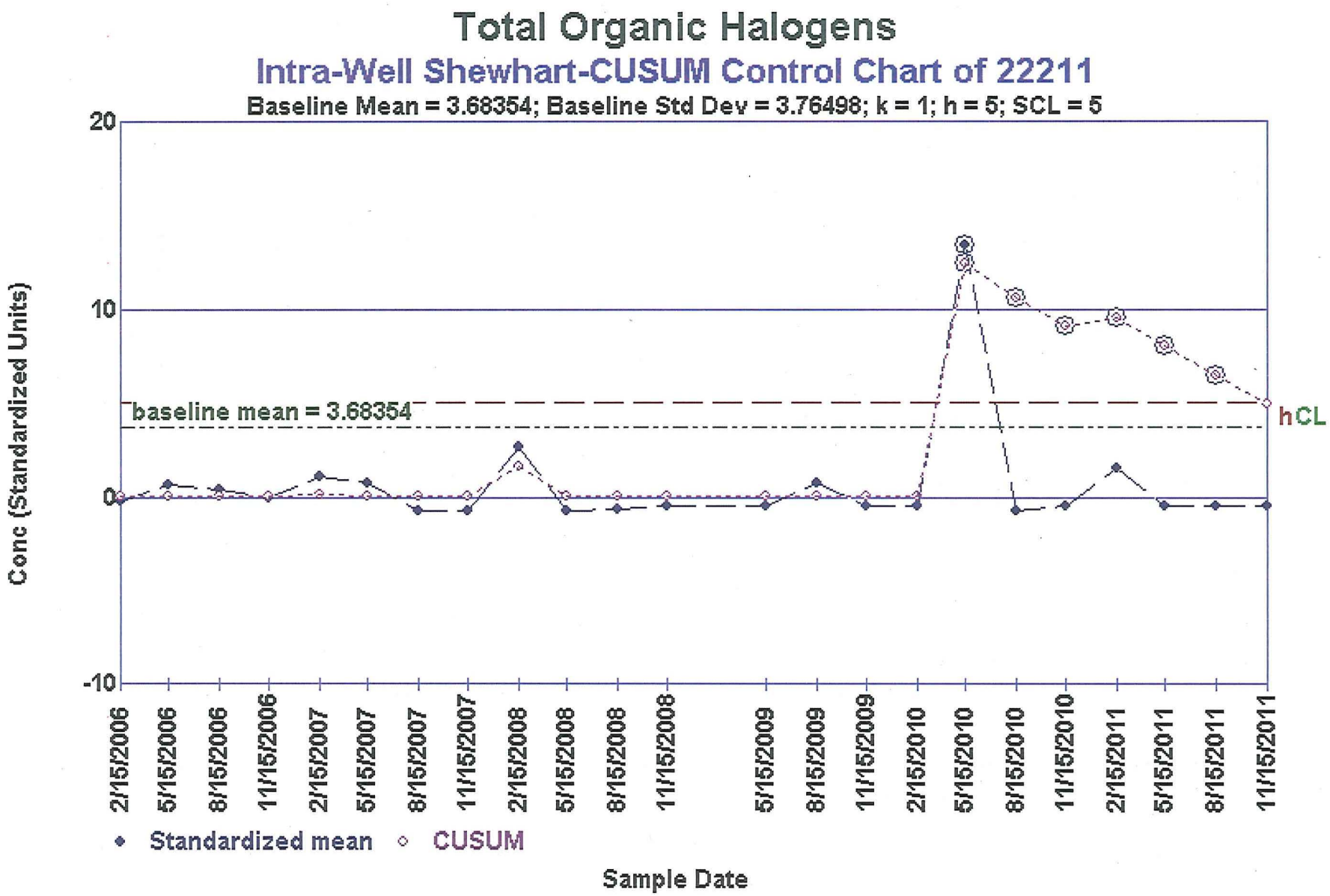


Figure A.5.7−40. Intra-Well Shewhart-CUSUM Control Chart (TOX 22211)

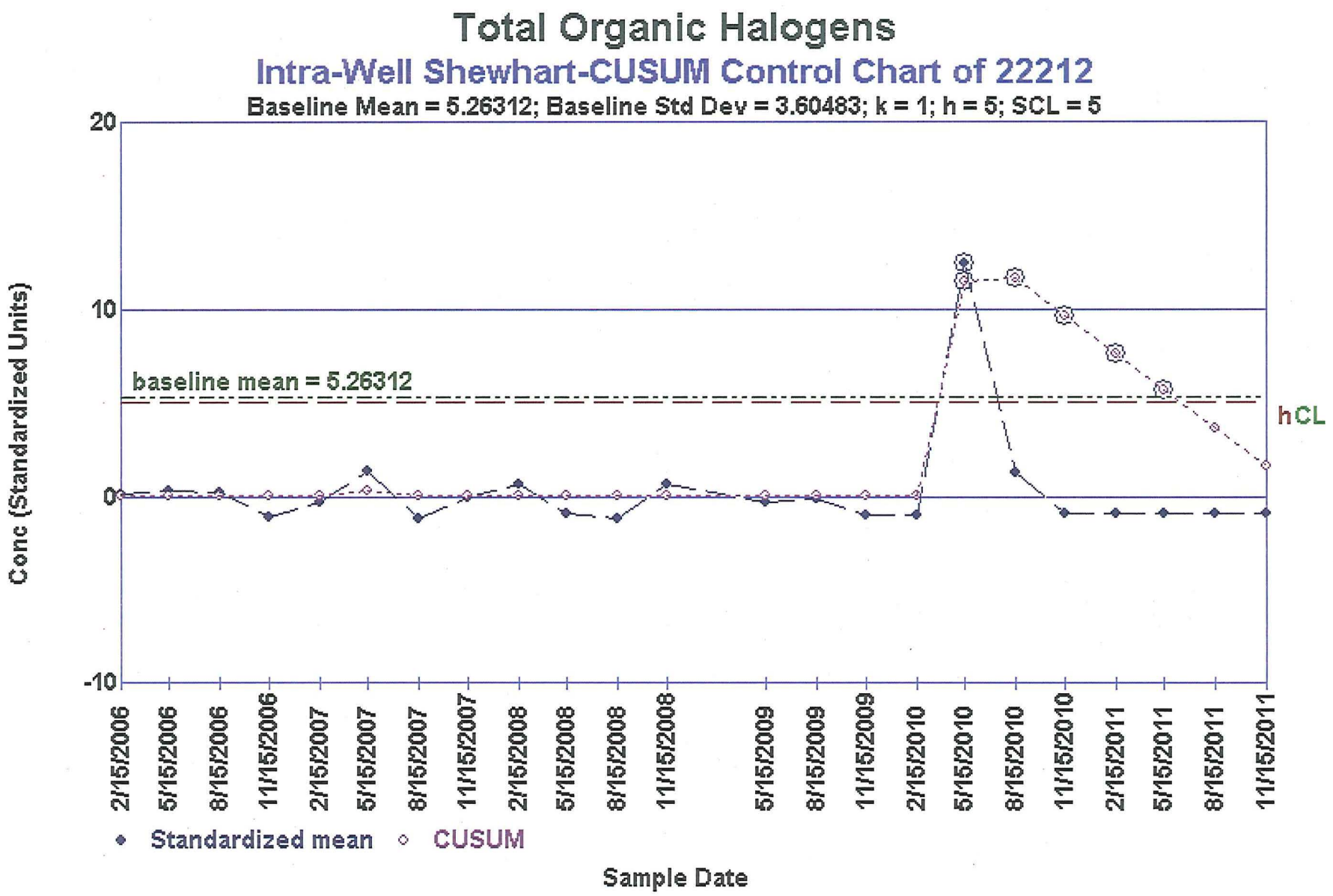


Figure A.5.7–41. Intra-Well Shewhart-CUSUM Control Chart (TOX 22212)

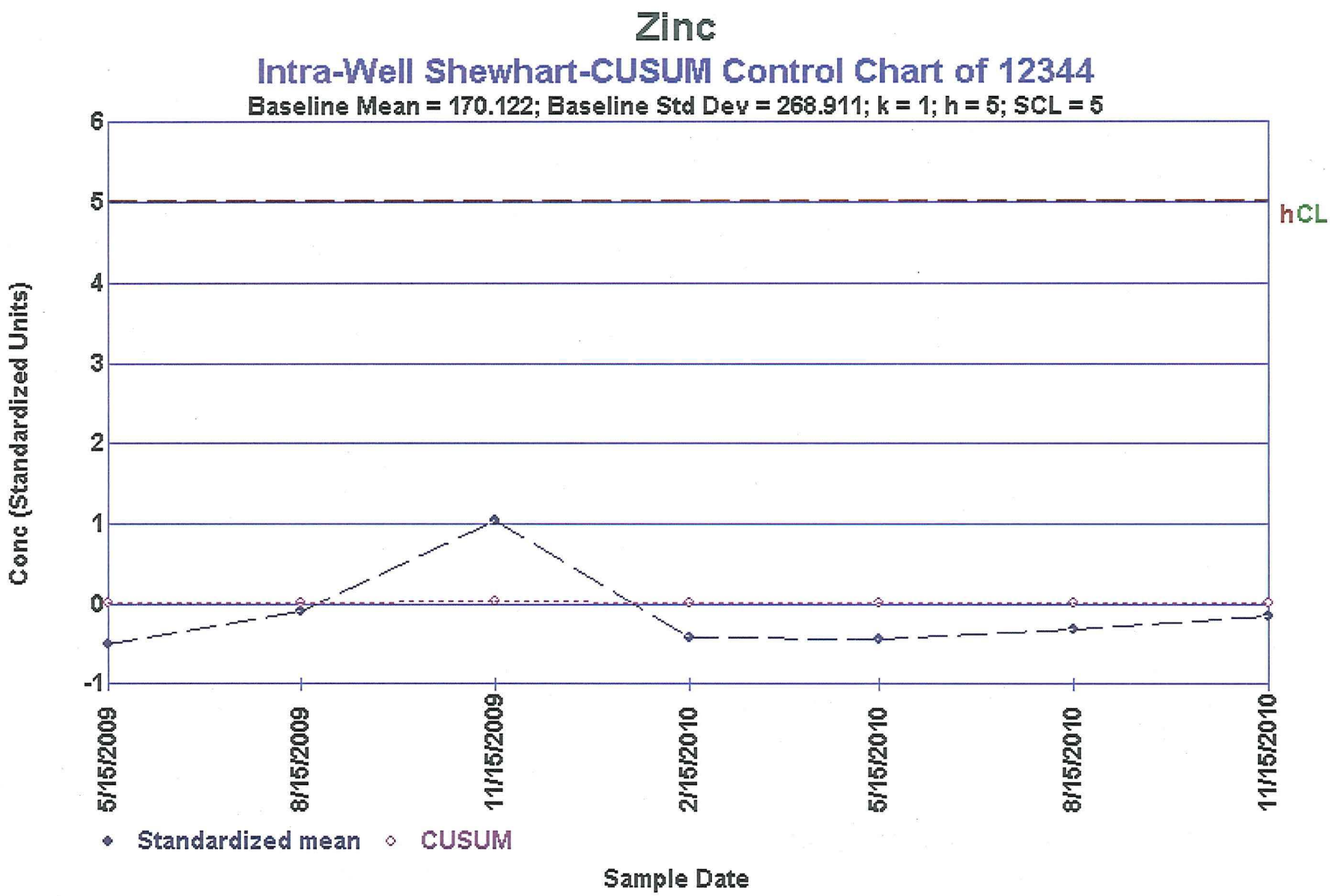


Figure A.5.7−42. Intra-Well Shewhart-CUSUM Control Chart (Zinc 12344)

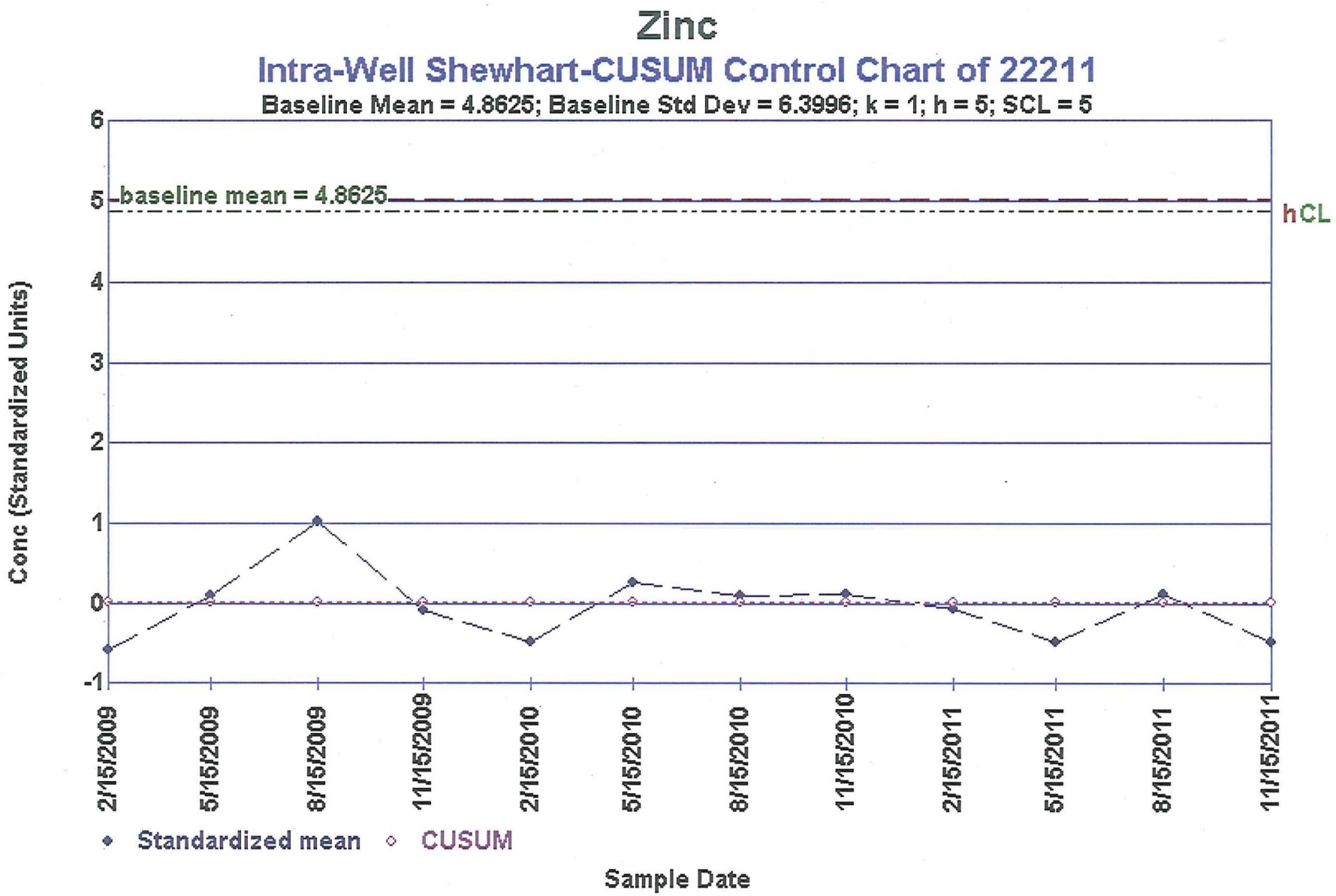


Figure A.5.7–43. Intra-Well Shewhart-CUSUM Control Chart (Zinc 22211)

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Sub-attachment A.5.8

Sub-attachment A.5.8

Cell 8

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The following information is provided in this sub-attachment:

- Quarterly monitoring summary statistics (refer to Table A.5.8–1)
- Annual LCS sample summary information for detected parameters (refer to Table A.5.8–2)
- Site-specific parameter selection results (refer to Table A.5.8–3)
- LCS monthly accumulation volumes (refer to Figure A.5.8–1)
- LDS monthly accumulation volumes (refer to Figure A.5.8–2)
- OSDF horizontal till well 12345 water yield (refer to Figure A.5.8–3)
- GMA water levels and uranium concentration versus time (refer to Figures A.5.8–4 and A.5.8–7)
- Plots of concentration versus time (refer to Figures A.5.8–8A to A.5.8–30B)
- A bivariate plots (refer to Figure A.5.8–31 and A.5.8–32)
- Control charts (refer to Figures A.5.8–33 to A.5.8–56)

A.5.8.1 Quarterly Monitoring Results

Quarterly water quality monitoring takes place in the LCS, LDS, HTW, and GMA wells of each cell for the purpose of determining if the OSDF is operating as designed. Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentrations versus time plots, bivariate plots, and control charts are used to help interpret and present the results.

In the first quarter of 2011, 23 parameters were sampled in the LCS, LDS, HTW, and GMA wells of each cell. In the second, third, and fourth quarters tritium was added to the analyte list for all horizons (LCS, LDS, HTW, and GMA wells), and the analyte list for the HTWs in all cells was changed to just four parameters: arsenic, uranium, tritium, and sodium. These changes were agreed to via the comment resolution process between Ohio EPA and DOE on LMICP (revision 4). Tritium results for all cells are reported in Section A.5.5.

The Cell 8 HTW was dry for all four quarters of 2011, and the LDS of Cell 8 was dry the fourth quarter of 2011. As shown in Table A.5.8–1, twelve of the 23 parameters monitored quarterly in the LCS, LDS, HTW, and GMA wells, (uranium, nitrate, sulfate, TDS, TOC, arsenic, boron, lithium, manganese, nickel, sodium, and zinc) have upward concentration trends in the HTW and/or GMA wells based on the Mann-Kendall test for trend. Cell 8 is unique in that it has four GMA wells (GMA-U, GMA-D, GMA-SW, and GMA-SE).

Horizontal Till Well

The HTW is located beneath the liner penetration box of each cell by design. This area of the liner penetration box is considered to be potentially the weakest point in the cell design. If a leak were to develop, it should be detected beneath the liner penetration box first. Therefore, the water quality in the HTW represents the first line of evidence that a potential leak from the cell might be occurring. A leak would be indicated by an increasing concentration in the HTW.

Of the 23 parameters monitored quarterly in the LCS, LDS, HTW, and GMA wells, only nitrate concentrations are increasing in the HTW of Cell 8 (as indicated in the table below). A bivariate plot for the Cell 8 LCS, LDS, and HTW (uranium-sodium) is provided in Figure A.5.8–31 and a bivariate plot for the Cell 8 LCS, LDS, and HTW (uranium-sulfate) is provided in Figure A.5.8–32. Both plots show that the chemical signature for uranium-sodium and uranium-sulfate in the LCS are separate and distinct from the signatures seen in the LDS and HTW. The uranium-sulfate plot does a better job than the uranium-sodium plot for showing that the chemical signatures in the LDS and HTW are also separate and distinct. Separate and distinct chemical signatures in the LCS, LDS, and HTW indicate that water is not mixing between the horizons. The increasing nitrate concentrations in the HTW of Cell 8 are therefore due to fluctuating ambient concentrations beneath the cell, and are not related to cell performance.

Parameter	HTW[a]	GMA-U[a]	GMA-D[a]	GMA-SW[a]	GMA-SE[a]
Uranium		Up		Up	
Nitrate	Up				
Sulfate		Up		Up	
TDS			Up	Up	
TOC		Up		Up	
Arsenic			Up		
Boron				Up	
Lithium			Up	Up	
Manganese				Up	
Nickel				Up	
Sodium				Up	
Zinc			Up		

[a]HTW = horizontal till well, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer; GMA-SW = southwest Great Miami Aquifer; GMA-SE = southeast Great Miami Aquifer; TDS = total dissolved solids; TOC = total organic carbon. No entry indicates that the trend was not up.

Great Miami Aquifer Wells

GMA monitoring wells are positioned for post-aquifer-remediation flow conditions, when flow directions will be from west to east. However, water levels measured in 2011 indicate that groundwater in the GMA in most of the area of the OSDF is moving in a general direction of northeast to south/southwest in response to the active groundwater remediation occurring to the west and southwest. This may be the reason nine parameters had increasing concentration trends in the GMA-SW well of Cell 8 in 2011. Pumping for the groundwater remediation is scheduled to last until 2023. Because bivariate plots (discussed above) indicate that LCS, LDS, and HTW monitoring horizons are not mixing, the increasing concentrations seen in the GMA wells are attributed to fluctuating ambient conditions that are not related to cell performance.

The following table provides a summary of the average concentration (as reported in Table A.5.8–1) measured in the LDS and GMA wells for parameters with increasing concentrations in the Cell 8 GMA wells.

Parameter	LDS[a]	GMA-U[a]	GMA-D[a]	GMA-SW[a]	GMA-SE[a]
Uranium (µg/L)	**22.0**	0.377	0.488	0.480	7.94
Sulfate (mg/L)	**3050**	199	253	138	445
TDS (mg/L)	**6070**	795	712	698	1080
TOC (mg/L)	**3.07**	1.28	1.35	1.32	1.60
Arsenic (mg/L)	**0.0118**	0.00250	0.00250	0.00250	0.00250
Boron (mg/L)	**0.899**	0.0344	0.0294	0.0335	0.0269
Lithium (mg/L)	**0.196**	0.00580	0.00542	0.00584	0.00671
Manganese (mg/L)	0.117	0.257	0.368	0.298	**0.982**
Nickel (mg/L)	**0.0116**	0.00176[b]	0.00075	0.00524[c]	0.00423
Sodium (mg/L)	**408**	27.3	11.1	15.9	14.0
Zinc (mg/L)	**0.130**	0.00703	0.00337	0.00668	0.00698

Note: The highest averages are shown in bold.

[a] HTW = horizontal till well, GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer; GMA-SW = southwest Great Miami Aquifer; GMA-SE = southeast Great Miami Aquifer; TDS = total dissolved solids; TOC = total organic carbon.

[b] Nickel has only been detected once in the GMA-U (third quarter 2010, 0.00176 mg/L).

[c] Nickel has only been detected once in the GMA-SW (second quarter 2011, 0.00524 mg/L and third quarter 2011, 0.0019 mg/L)

A.5.8.2 Control Charts

Intrawell control charts employ historical measurements from a compliance point as background The *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance* (EPA 2009), defines the process of creating a Shewart-CUSUM control chart. Appropriate background data are used to define a baseline for the well. The baseline parameters for the chart, estimates of the mean, and standard deviation are obtained from the background data. These baseline measurements characterize the expected background concentrations at the monitoring point. As future concentrations are collected, the baseline parameters are used to standardize the newly gathered data. After these measurements are standardized and plotted, a control chart is declared "out of control" if future concentrations exceed the baseline control limit. This is indicated on the control chart when either the Shewart or CUSUM plot traces begin to exceed a control limit. The limit is based on the rationale that if the monitoring point remains unchanged from the baseline condition, new standardized observations should not deviate substantially from the baseline mean. If a change occurs, the standardized values will deviate significantly from the baseline and tend to exceed the control limit.

A minimum of eight samples are recommended for use in ChemStat® software to define the baseline for a control chart. Therefore, only sample sets with greater than eight samples were selected for control charts. By default, the ChemStat® software plots both a CUSUM control limit (h) and a SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit (h) and a value of 4.5 for the SCL.

EPA Unified Guidance suggests that to simplify the interpretation of the control chart that an out of control condition be based on the CUSUM (h) limit alone. Plotting the SCL limit is not needed. The ChemStat® software though, by default, plots both the SCL and CUSUM (h) control limit on the charts. As a "work-a-round", the SCL limit was defined as 5 to match the recommended CUSUM limit. On the charts the combined limit is identified as hCL. For interpretation purposes, regard hCL as the CUSUM limit (h).

As shown in Table A.5.8–1 in gray shading, eleven parameters in the HTW and/or GMA wells of Cell 8 (uranium, sulfate, TDS, TOC, TOX, boron, iron, lithium, manganese, sodium, and zinc) meet the criteria for control charts (i.e., more than 8 samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in twenty four control charts.

Parameter and Monitoring Point[a]	Assessment
Uranium in the HTW	In Control
Uranium in the GMA-SE	In Control
Sulfate in the GMA-D	**Out of Control**
Sulfate in the GMA-SE	In Control
TDS in the GMA-SE	In Control
TOC in the HTW	**Out of Control**
TOC in the GMA-SE	In Control
TOX in the HTW	In Control
Boron in the HTW	In Control
Boron in the GMA-U	In Control
Boron in the GMA-SE	In Control
Iron in the GMA-U	In Control
Iron in the GMA-D	In Control
Iron in the GMA-SE	In Control
Lithium in the GMA-U	In Control
Lithium in the GMA-SE	In Control
Manganese in the GMA-U	In Control
Manganese in the GMA-SE	In Control
Sodium in the GMA-U	In Control
Sodium in the GMA-D	In Control
Sodium in the GMA-SE	In Control
Zinc in the GMA-U	In Control
Zinc in the GMA-SW	In Control
Zinc in the GMA-SE	In Control

[a]HTW = horizontal till well; GMA-D = downgradient Great Miami Aquifer; GMA-U = upgradient Great Miami Aquifer; GMA-SW = southwest Great Miami Aquifer; GMA-SE = southeast Great Miami Aquifer

The control charts are presented in Figures A.5.8–33 to A.5.8–56. With the exception of Sulfate in the GMA-D well and TOC in the HTW, the charts all exhibit "in control" conditions. As discussed above, separate and distinct signatures for uranium-sodium and uranium-sulfate in the LCS, LDS, and HTW of Cell 8 indicate that water is not mixing between the horizons, so the out of control conditions are attributed to fluctuating ambient conditions beneath the cell, and not to cell performance.

A.5.8.3 Annual LCS Sample Results

Annual LCS sampling results for Cell 8 are provided in Table A.5.8–2 for those parameters that were detected at least once, and are not being sampled quarterly. One new Appendix I parameter (cadmium) was detected in the LCS of Cell 8 in 2011. Detection of cadmium in the LCS of Cell 8 in 2012 will trigger sampling for cadmium in the LDS of Cell 8 during the subsequent next scheduled sampling event.

As reported last year, in 2009, 1,1-dichloroethene was detected for the first time in the LCS of Cell 8. In 2010, 1,1-dichloroethene was detected again in the LCS of Cell 8. As stated in Appendix B of the GWLMP (DOE 2010a) "two consecutive detects in a cell's LCS will trigger sampling in the cell's LDS during the next scheduled sampling round." Sampled for twice in the LDS of Cell 8 in 2011, 1,1-dichloroethene was not detected in the LDS of Cell 8. Since it continues to be detected in the LCS of Cell 8 sampling in the LDS will continue.

A.5.8.4 Site-Specific Parameter Selection for Cell 8

The sample size of the Cell 8 dataset reached a minimum of eight samples at the end of 2011; therefore, the site-specific leachate monitoring parameter selection approach presented in Figures A.5–5A and A.5–5B was followed to determine if any of the Appendix I and PCB parameters detected in Cell 8 should be selected as site-specific monitoring parameters.

As discussed in Attachment A.5, the objective of the selection process is to determine if the mean concentration of an Appendix I or PCB parameter (that has been sampled eight times and detected more than 25 percent of the time) is statistically greater than the mean of either the pre-design or background data for the parameter. If the mean is greater, then the parameter is selected for more quarterly monitoring in the LCS, LDS, HTW, and GMA wells of the cell.

The null hypothesis used for each statistical test is that the mean of the concentration of the LCS dataset is less than or equal to the mean of the pre-design or background dataset. Failure of the null hypothesis indicates that the mean of the LCS dataset is greater than the mean of the pre-design or background dataset.

As shown in Table A.5.8–2, three of the Appendix I parameters not already being sampled for quarterly have been detected at least 25 percent of the time (ammonia, chromium, and tetrachloroethene). Pre-design and/or background data does not exist for tetrachloroethene so parameter selection statistics could not be conducted. Since 2004, tetrachloroethene has been sampled 19 times and detected 6 times. Four of the six detects were at concentrations that were greater than the MDL but less than either the PQL or RDL. The two other detects were also very low (1.1 ug/L and 1.24 ug/L). Given the low concentrations, adding tetrachloroethene to the quarterly sampling list would not significantly enhance the early detection capability of the monitoring program.

Parameter selection statistics were conducted on ammonia and chromium for Cell 8. Results are presented in Table A.5.8–3. Both ammonia and chromium passed the null hypothesis for the Tarone-Ware test so they do not need to be added to the quarterly sampling list. As stated in Attachment A.5.7, chromium failed the null hypothesis for Cell 7 so has been added to the quarterly sampling list for the LCS, LDS, and GMA wells of each cell beginning in January of 2013.

A.5.8.4 Summary and Conclusions

- The concentrations of 12 parameters monitored quarterly are increasing in either the HTW and/or GMA wells of Cell 8 (uranium, nitrate, sulfate, TDS, TOC, arsenic, boron, lithium, manganese, nickel, sodium, and zinc).
- The chemical signature for uranium-sodium and uranium-sulfate in the LCS of Cell 8 is separate and distinct from the signatures seen in the LDS and HTW. The signature for

uranium-sodium the HTW is also separate and distinct from the LDS, but low uranium concentrations in both horizons have the clusters closer than what is seen in the other seven cells. The signature for uranium-sulfate in the HTW is separate and distinct from the LDS. Separate and distinct chemical signatures in the LCS, LDS, and HTW indicate that water is not mixing between the horizons. Concentration increases in the HTW and GMA wells of Cell 8 are attributed to fluctuating ambient concentrations beneath the cell, and not to cell performance. It should also be noted that the HTW of Cell 8 has been dry since the third quarter of 2008, providing additional evidence that the secondary liner is not leaking.

- Twenty-four control charts were constructed for Cell 8 parameters. Twenty-two of the charts exhibit "in control" conditions. The control chart for sulfate in the GMA-D and TOC in the HTW are not in control.
- One new Appendix I parameter (cadmium) was detected in the LCS of Cell 8 in 2011. Detection of cadmium in the LCS of Cell 8 in 2012 will trigger sampling for cadmium in the LDS of Cell 8 during the subsequent next scheduled sampling event.
- Chromium and ammonia have been sampled at least 8 times in the LCS of Cell 8 and detected at least 25 percent of the time. Both passed the null hypothesis of the Tarone-ware test. Because chromium failed for Cell 7 it is being added to the quarterly sampling list for the LCS, LDS, and GMA wells of each cell beginning in January 2013.
- Tetrachloroethene has been sampled at least 8 times in the LCS of Cell 8 and detected at least 25 percent of the time. Pre-design and/or background data does not exist for tetrachloroethene so parameter selection statistics could not be conducted. Given the low concentrations of the detections, adding tetrachloroethene to the quarterly sampling list would not significantly enhance the early detection capability of the monitoring program.

Table A.5.8–1. Summary Statistics for Cell 8

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12345C	28	28	100.0	1.51	335	178	71	Normal	Up	Detected	
	LDS	12345D	26	26	100.0	9.38	64.4	22.0	11.0	Lognormal	None	Detected	
	HTW	12345	16	16	100.0	3.67	7.30	5.02	0.99	Normal	None	Not Detected	
	GMA-U	22213	25	31	80.6	ND	0.627	0.377	0.135	Normal	Up	Detected	
	GMA-D	22214	31	32	96.9	ND	1.58	0.488	0.410	Undefined	None	Not Detected	
	GMA-SW	22215	22	25	88.0	ND	16.4	0.480	3.40	Undefined	Up	Not Detected	
	GMA-SE	22217	21	21	100.0	0.898	18.3	7.94	5.04	Normal	None	Not Detected	
Alkalinity as CaCO3 (mg/L)	LCS	12345C	17	17	100.0	64.9	466	281	143	Normal	Up	Detected	
	LDS	12345D	12	12	100.0	170	487	422	114	Undefined	None	Not Detected	
	HTW	12345	7	7	100.0	328	921	374	212	Undefined	None	Not Detected	
	GMA-U	22213	4	4	100.0	326	353	341	12	Normal	None	Insuff	
	GMA-D	22214	4	4	100.0	291	336	320	20	Normal	None	Insuff	
	GMA-SW	22215	4	4	100.0	330	338	334	3	Normal	None	Insuff	
	GMA-SE	22217	4	4	100.0	323	348	338	10	Normal	None	Insuff	
Chloride (mg/L)	LCS	12345C	17	17	100.0	18.9	339	185	115	Normal	Up	Detected	
	LDS	12345D	12	12	100.0	34.5	104	63.9	23.4	Normal	None	Detected	
	HTW	12345	7	7	100.0	743	1290	1020	200	Normal	Down	Detected	
	GMA-U	22213	4	4	100.0	29.7	52.0	39.2	10.1	Normal	None	Insuff	
	GMA-D	22214	4	4	100.0	22.8	28.4	25.9	2.8	Normal	None	Insuff	
	GMA-SW	22215	4	4	100.0	30.2	38.6	34.0	3.7	Normal	None	Insuff	
	GMA-SE	22217	4	4	100.0	23.1	32.5	27.4	3.9	Normal	None	Insuff	
Nitrate/Nitrite as N (mg/L)	LCS	12345C	16	17	94.1	ND	74.6	32.9	22.9	Normal	None	Detected	
	LDS	12345D	6	12	50.0	ND	3.62	0.0225	1.17	Undefined	Up	Detected	
	HTW	12345	2	7	28.6	ND	0.123	Insuff	Insuff	Normal	Up	Not Detected	
	GMA-U	22213	0	4	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22214	0	4	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-SW	22215	0	4	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-SE	22217	0	4	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Sulfate (mg/L)	LCS	12345C	28	28	100.0	146	3030	2340	950	Undefined	Up	Detected	
	LDS	12345D	26	26	100.0	1730	5020	3050	890	Normal	Up	Detected	
	HTW	12345	15	15	100.0	95.5	152	116	18	Normal	None	Detected	
	GMA-U	22213	31	31	100.0	90.3	284	199	67	Undefined	Up	Detected	
	GMA-D	22214	31	31	100.0	172	457	253	73	Lognormal	None	Not Detected	
	GMA-SW	22215	24	25	96.0	ND	911	138	214	Undefined	Up	Detected	
	GMA-SE	22217	21	21	100.0	163	1320	445	248	Lognormal	None	Not Detected	
Total Dissolved Solids (mg/L)	LCS	12345C	16	16	100.0	882	5300	5090	1500	Undefined	Up	Detected	
	LDS	12345D	11	11	100.0	3860	7990	6070	1170	Normal	Up	Detected	
	HTW	12345	0	0	0.0	NA	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-U	22213	11	11	100.0	672	843	795	54	Undefined	None	Not Detected	
	GMA-D	22214	11	11	100.0	531	872	712	122	Normal	Up	Not Detected	
	GMA-SW	22215	11	11	100.0	457	1800	698	459	Undefined	Up	Detected	
	GMA-SE	22217	11	11	100.0	842	1550	1080	250	Normal	None	Not Detected	
Total Organic Carbon (mg/L)	LCS	12345C	25	28	89.3	1.04	5.31	2.39	0.87	Lognormal	None	Not Detected	
	LDS	12345D	25	26	96.2	ND	5.45	3.07	1.04	Normal	None	Detected	
	HTW	12345	9	15	60.0	ND	3.12	1.63	0.62	Normal	None	Not Detected	
	GMA-U	22213	26	31	83.9	0.486	2.23	1.28	0.48	Normal	Up	Detected	
	GMA-D	22214	25	31	80.6	0.536	2.03	1.35	0.42	Undefined	None	Not Detected	
	GMA-SW	22215	20	25	80.0	ND	2.83	1.32	0.55	Normal	Up	Detected	
	GMA-SE	22217	20	21	95.2	ND	2.33	1.60	0.39	Normal	None	Not Detected	

Table A.5.8-1 (continued). Summary Statistics for Cell 8

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Total Organic Halogens (mg/L)	LCS	12345C	17	28	60.7	ND	0.080	0.0154	0.0221	Undefined	Up	Detected	
	LDS	12345D	17	26	65.4	0.00274	0.0794	0.0153	0.0156	Lognormal	None	Not Detected	
	HTW	12345	11	15	73.3	ND	0.0942	0.0484	0.0244	Normal	None	Not Detected	
	GMA-U	22213	5	31	16.1	ND	0.0231	0.00165	0.00458	Undefined	None	Not Detected	0.0560 (Q2-10)
	GMA-D	22214	6	31	19.4	ND	0.0590	0.00165	0.0107	Undefined	None	Not Detected	
	GMA-SW	22215	6	25	24.0	ND	0.0460	0.00220	0.00971	Undefined	None	Not Detected	
	GMA-SE	22217	7	21	33.3	ND	0.00658	0.00165	0.00150	Undefined	None	Not Detected	0.0140 (Q4-06) 0.0149 (Q2-07) 0.0730 (Q2-10)
Arsenic (mg/L)	LCS	12345C	4	20	20.0	ND	0.142	0.00375	0.0450	Undefined	None	Not Detected	
	LDS	12345D	3	17	17.6	ND	0.0912	0.0118	Insuff	Normal	None	Not Detected	
	HTW	12345	0	7	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-U	22213	4	11	36.4	ND	0.0406	0.00250	0.0128	Undefined	None	Not Detected	
	GMA-D	22214	5	20	25.0	ND	0.0457	0.00250	0.0132	Undefined	Up	Detected	
	GMA-SW	22215	4	11	36.4	ND	0.0430	0.00250	0.0146	Undefined	None	Not Detected	
	GMA-SE	22217	3	11	27.3	ND	0.0344	0.00250	Insuff	Undefined	None	Not Detected	
Barium (mg/L)	LCS	12345C	15	15	100.0	0.0236	0.103	0.0492	0.0234	Lognormal	Down	Not Detected	
	LDS	12345D	10	10	100.0	0.0146	0.0837	0.0380	0.0220	Normal	Down	Detected	
	HTW	12345	7	7	100.0	0.284	0.444	0.352	0.064	Normal	Down	Detected	
	GMA-U	22213	4	4	100.0	0.112	0.132	0.120	0.009	Normal	None	Insuff	
	GMA-D	22214	4	4	100.0	0.0582	0.105	0.0825	0.0231	Normal	None	Insuff	
	GMA-SW	22215	4	4	100.0	0.0409	0.122	0.0745	0.0349	Normal	None	Insuff	
	GMA-SE	22217	4	4	100.0	0.0294	0.0844	0.0551	0.0284	Normal	None	Insuff	
Boron (mg/L)	LCS	12345C	28	28	100.0	0.0681	0.776	0.660	0.215	Undefined	Up	Detected	
	LDS	12345D	26	26	100.0	0.582	2.40	0.889	0.468	Undefined	None	Detected	
	HTW	12345	15	15	100.0	0.0683	0.0978	0.0834	0.0078	Normal	None	Not Detected	
	GMA-U	22213	28	31	90.3	ND	0.0463	0.0344	0.0072	Normal	None	Not Detected	
	GMA-D	22214	29	31	93.6	ND	0.0393	0.0294	0.0064	Undefined	None	Not Detected	
	GMA-SW	22215	23	25	92.0	ND	0.0409	0.0335	0.0065	Undefined	Up	Not Detected	
	GMA-SE	22217	19	21	90.5	ND	0.0360	0.0269	0.0062	Normal	None	Not Detected	
Calcium (mg/L)	LCS	12345C	15	15	100.0	65.4	874	468	253	Normal	Up	Detected	
	LDS	12345D	10	10	100.0	279	678	490	119	Normal	None	Detected	
	HTW	12345	7	7	100.0	250	402	338	60	Normal	None	Detected	
	GMA-U	22213	4	4	100.0	167	186	174	9	Normal	None	Insuff	
	GMA-D	22214	4	4	100.0	174	230	198	27	Normal	None	Insuff	
	GMA-SW	22215	4	4	100.0	164	446	307	149	Normal	None	Insuff	
	GMA-SE	22217	4	4	100.0	204	334	208	64	Undefined	None	Insuff	
Cobalt (mg/L)	LCS	12345C	10	20	50.0	ND	0.00290	0.00077	0.00081	Undefined	None	Not Detected	
	LDS	12345D	7	17	41.2	ND	0.00250	0.00072	0.00081	Undefined	Down	Not Detected	
	HTW	12345	6	7	85.7	ND	0.00145	0.000949	0.000356	Normal	None	Not Detected	
	GMA-U	22213	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22214	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-SW	22215	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-SE	22217	7	11	63.6	ND	0.00216	0.00109	0.00057	Normal	None	Not Detected	
Copper (mg/L)	LCS	12345C	12	20	60.0	ND	0.0309	0.00455	0.00828	Undefined	None	Not Detected	
	LDS	12345D	9	17	52.9	ND	0.0427	0.00750	0.0127	Undefined	Down	Detected	
	HTW	12345	5	7	71.4	ND	0.0106	0.00379	0.00326	Lognormal	None	Not Detected	
	GMA-U	22213	4	4	100.0	0.0016	0.0111	0.00633	0.00391	Normal	None	Insuff	
	GMA-D	22214	4	4	100.0	0.00117	0.0105	0.00634	0.00392	Normal	None	Insuff	
	GMA-SW	22215	4	4	100.0	0.00332	0.0102	0.00799	0.00315	Normal	None	Insuff	
	GMA-SE	22217	4	4	100.0	0.00191	0.0127	0.00748	0.00456	Normal	None	Insuff	

Table A.5.8-1 (continued). Summary Statistics for Cell 8

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Iron (mg/L)	LCS	12345C	15	20	75.0	ND	3.91	1.20	1.07	Lognormal	Down	Not Detected	
	LDS	12345D	14	17	82.4	ND	6.20	2.37	2.03	Lognormal	Down	Detected	
	HTW	12345	6	7	85.7	0.696	2.68	1.62	0.74	Normal	None	Not Detected	
	GMA-U	22213	11	11	100.0	0.551	2.83	1.91	0.78	Normal	None	Not Detected	
	GMA-D	22214	11	11	100.0	2.87	6.69	4.12	1.13	Normal	None	Not Detected	
	GMA-SW	22215	11	11	100.0	5.25	17.4	6.00	3.63	Undefined	None	Not Detected	
	GMA-SE	22217	11	11	100.0	1.13	10.3	4.86	2.85	Normal	None	Not Detected	
Lithium (mg/L)	LCS	12345C	19	19	100.0	0.0073	0.150	0.106	0.042	Undefined	Up	Detected	
	LDS	12345D	16	16	100.0	0.0702	0.367	0.196	0.076	Normal	Up	Detected	
	HTW	12345	7	7	100.0	0.0145	0.0183	0.0164	0.0015	Normal	None	Not Detected	
	GMA-U	22213	11	11	100.0	0.00489	0.00728	0.00580	0.00067	Normal	None	Not Detected	
	GMA-D	22214	11	11	100.0	0.00431	0.00718	0.00542	0.00096	Normal	Up	Not Detected	
	GMA-SW	22215	11	11	100.0	0.00467	0.00828	0.00584	0.00115	Normal	Up	Not Detected	
	GMA-SE	22217	11	11	100.0	0.00546	0.00799	0.00671	0.00091	Normal	None	Not Detected	
Magnesium (mg/L)	LCS	12345C	15	15	100.0	21.9	583	351	221	Undefined	Up	Detected	
	LDS	12345D	10	10	100.0	148	787	359	221	Normal	None	Not Detected	
	HTW	12345	7	7	100.0	77.7	118	104	16	Normal	None	Not Detected	
	GMA-U	22213	4	4	100.0	37.4	42.0	39.1	2.0	Normal	None	Insuff	
	GMA-D	22214	4	4	100.0	39.6	48.4	43.8	4.5	Normal	None	Insuff	
	GMA-SW	22215	4	4	100.0	35.4	74.5	52.0	19.6	Normal	None	Insuff	
	GMA-SE	22217	4	4	100.0	41.6	55.2	46.2	6.1	Normal	None	Insuff	
Manganese (mg/L)	LCS	12345C	11	20	55.0	ND	0.328	0.0398	0.0795	Lognormal	None	Not Detected	
	LDS	12345D	11	17	64.7	ND	0.687	0.117	0.174	Lognormal	None	Not Detected	
	HTW	12345	7	7	100.0	0.0116	0.199	0.0528	0.0653	Lognormal	None	Not Detected	
	GMA-U	22213	11	11	100.0	0.222	0.281	0.257	0.020	Normal	None	Not Detected	
	GMA-D	22214	20	20	100.0	0.293	0.706	0.368	0.135	Undefined	None	Not Detected	
	GMA-SW	22215	11	11	100.0	0.24	1.94	0.298	0.595	Undefined	Up	Detected	
	GMA-SE	22217	11	11	100.0	0.537	1.57	0.982	0.349	Normal	None	Not Detected	
Nickel (mg/L)	LCS	12345C	16	20	80.0	ND	0.0180	0.00645	0.00458	Normal	None	Not Detected	
	LDS	12345D	15	17	88.2	0.00178	0.0220	0.0116	0.0068	Normal	None	Not Detected	
	HTW	12345	7	7	100.0	0.0057	0.0144	0.00903	0.00312	Normal	None	Not Detected	
	GMA-U	22213	1	11	9.1	ND	0.00176	Insuff	Insuff	Undefined	None	Detected	
	GMA-D	22214	4	20	20.0	ND	0.00630	0.00075	0.00134	Undefined	None	Detected	
	GMA-SW	22215	2	11	18.2	ND	0.00524	Insuff	Insuff	Undefined	Up	Detected	
	GMA-SE	22217	6	11	54.6	ND	0.0228	0.00423	0.00685	Undefined	None	Not Detected	
Potassium (mg/L)	LCS	12345C	15	15	100.0	4.86	27.6	25.1	7.9	Undefined	Up	Detected	
	LDS	12345D	10	10	100.0	38.0	99.4	66.7	21.8	Normal	None	Not Detected	
	HTW	12345	6	7	85.7	ND	2.90	2.43	0.50	Normal	None	Not Detected	
	GMA-U	22213	4	4	100.0	3.67	4.14	3.92	0.20	Normal	None	Insuff	
	GMA-D	22214	4	4	100.0	2.53	3.07	2.77	0.24	Normal	None	Insuff	
	GMA-SW	22215	4	4	100.0	3.18	5.01	4.10	0.90	Normal	None	Insuff	
	GMA-SE	22217	4	4	100.0	2.95	4.09	3.32	0.53	Lognormal	None	Insuff	

Table A.5.8-1 (continued). Summary Statistics for Cell 8

Note: The data used in this table has been standardized to quarterly.

Parameter	Horizon[a]	Monitoring Location	No. of Detected Samples	Total No. of Samples	Percent of Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[c,d]	Distribution Type[d,e]	Trend[d,f]	Serial Correlation[d,g]	Outliers[h,i]
Selenium (mg/L)	LCS	12345C	2	20	10.0	ND	0.151	Insuff	Insuff	Lognormal	None	Not Detected	
	LDS	12345D	1	17	5.9	ND	0.0750	Insuff	Insuff	Lognormal	None	Not Detected	
	HTW	12345	0	7	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-U	22213	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-D	22214	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
	GMA-SW	22215	1	11	9.1	ND	0.00648	Insuff	Insuff	Undefined	None	Detected	
	GMA-SE	22217	0	11	0.0	ND	NA	Insuff	Insuff	Insuff	Insuff	Insuff	
Sodium (mg/L)	LCS	12345C	20	20	100.0	16.8	118	97.0	37.0	Undefined	Up	Detected	
	LDS	12345D	17	17	100.0	76.6	762	408	192	Normal	Up	Not Detected	
	HTW	12345	7	7	100.0	277	385	334	45	Normal	None	Not Detected	
	GMA-U	22213	11	11	100.0	22.7	30.3	27.3	2.4	Normal	None	Not Detected	
	GMA-D	22214	11	11	100.0	9.83	13.6	11.1	1.1	Normal	None	Not Detected	
	GMA-SW	22215	11	11	100.0	13.5	18.8	15.9	1.5	Normal	Up	Detected	
	GMA-SE	22217	11	11	100.0	12.1	16.2	14.0	1.3	Normal	None	Not Detected	
Zinc (mg/L)	LCS	12345C	11	20	55.0	ND	0.0622	0.00463	0.0160	Lognormal	Up	Not Detected	
	LDS	12345D	13	17	76.5	ND	0.333	0.130	0.098	Lognormal	None	Detected	
	HTW	12345	5	7	71.4	0.0062	1.89	0.00855	0.704	Undefined	None	Not Detected	
	GMA-U	22213	6	11	54.6	ND	0.0221	0.00703	0.00589	Lognormal	None	Not Detected	
	GMA-D	22214	10	20	50.0	ND	0.00705	0.00337	0.00185	Normal	Up	Not Detected	
	GMA-SW	22215	6	11	54.6	ND	0.0158	0.00668	0.00458	Normal	None	Not Detected	
	GMA-SE	22217	6	11	54.6	ND	0.0184	0.00698	0.00536	Normal	None	Not Detected	

Note: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least 8 samples, normal or lognormal distribution, no trend, and no serial correlation. These wells achieve control chart criteria.

Note: For results where the concentrations are below the detection limit, the results used in the Average, Standard Deviation, Distribution Type, Trend, Serial Correlation, and Outliers are each set at half the detection limit.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption and requires $n \geq 3$. In addition, Standard Deviation requires $n \geq 4$.

[d]"Insuff" = Insufficient and is used for Average, Standard Deviation, Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic (where $3 \leq n \leq 50$) or Shapiro Francia (where $n > 50$).

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the lognormal assumption.

Lognormal: Lognormal assumption could not be rejected at the 5 percent level and has a higher probability value than the normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25% detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure. Trend testing requires a sample with $n \geq 4$.

[g]Serial correlation based on Rank Von Neumann test. Serial Correlation testing requires a sample with $n \geq 6$.

[h]Outliers determined by Rosner's (where $n > 25$) or Dixon procedure (where $4 \leq n \leq 25$).

[i]Q = quarterly

Table A.5.8-2. Cell 8 Annual LCS Sample Summary Information for Detected Parameters

PARAMETER(UNIT)	NUMBER OF SAMPLES[a,b]	NUMBER OF SAMPLES WITH DETECTIONS[a,b]	PERCENT OF DETECTIONS[a,b]	DETECTED IN 2011	MIN DETECTED CONCENTRATION[a,b,c]	MAX DETECTED CONCENTRATION[a,b,c]	AVG DETECTED CONCENTRATION[a,b,c]	GW FRL[d] (#OF SAMPLES>GWFRL)	GW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	PW BACKGROUND[a,b,e] (# OF SAMPLES>PW BACKGROUND)	MAX PW DETECTED CONCENTRATION [a,b,f] (# OF SAMPLES>MAX PW)
General Chemistry											
Ammonia (mg/L)	8	2	25.0	Yes	0.03	0.0451	0.0376	-	4.2 mg/L(0)	4.34 mg/L(0)	220 mg/L(0)
Inorganics											
Cadmium (mg/L)	8	1	12.5	Yes	0.000127	-	-	0.014 mg/L(0)	0.014 mg/L(0)	-	0.05 mg/L(0)
Chromium (mg/L)	8	3	37.5	Yes	0.0016	0.0269	0.0107	0.022 mg/L[g](1)	0.021 mg/L(1)	0.0046 mg/L(1)	0.818 mg/L(0)
Thallium (mg/L)	8	1	12.5	No	0.00057	-	-	-	-	-	0.0028 mg/L(0)
Vanadium (mg/L)	8	1	12.5	No	0.016	-	-	0.038 mg/L(0)	0.012 mg/L(1)	0.005 mg/L(1)	0.299 mg/L(0)
Radionuclides											
Technetium-99	22	15	68.2	Yes	8.39	101	40.4	94 pCi/L(1)	22 pCi/L(9)	30 pCi/L(8)	6,130 pCi/L(0)
Organics											
1,1-Dichloroethene	19	3	15.8	Yes	0.86	2.11	1.65	7 ug/L(0)	-	-	-
Acetone	8	1	12.5	No	2.31	-	-	-	-	-	-
Aroclor - 1260	8	1	12.5	No	0.058	-	-	-	-	-	-
Tetrachloroethene	19	6	31.6	Yes	0.38	1.24	0.784	-	-	-	-
Trichloroethene	19	3	15.8	No	0.246	1.11	0.587	5 ug/L(0)	-	-	-

Note: Shading indicates that at least one detected sample is greater than the FRL, groundwater background, PW background, or PW maximum.

[a]If more than one sample is collected per well per day (e.g., duplicates), then only one sample is counted for the total number of samples, and the sample with the maximum representative concentration is used for all the summary information

[b]Rejected data qualified with an R or Z were not included.

[c]If the number of detected samples is equal to two, then the minumun and maximumn are reported. If the number of detected is equal to one, then the data point is reported as the minimum. The "AVG DETECTED CONCENTRATION" is not reported for either of these cases.

[d]From Operable Unit 5 Record of Decision, Table 9-4.

[e]From the Characterization of Background Water Quality for Streams and Groundwater which was developed for Operable Unit 5 RI/FS documents.

[f]Max PW - maximum detected concentration in perched water as defined in the Remedial Investigation Report for Operable Unit 5.

[g]FRL based on hexavalent chromium from Operable Unit 5 Record of Decision, Table 9-4.

Table A.5.8–3. Site-Specific Parameter Selection Results

					t-Test												Wilcoxon + Quantile		Tarone-Ware Test
Parameter	Dataset	Samples	Detects	Detect %	Shapiro-Wilk (N)	Shapiro-Wilk (LN)	Min	Max	Mean (mg/L)	Median	Variance	Std. Dev.	Log Mean	Log SD	F-Test	t-Test Prob	Wilcoxen Group Comparison	Quantile Test	
Ammonia	LCS	8	2	25%			0.0050	0.0451	0.0184	0.0150	0.000196	0.0140							
	PreDesign**	9	7	78%			0.015	450	54.98	0.604	22100	149							Pass
	* before 2/10/95																		
	** after 2/10/95																		
Chromium	LCS	8	3	38%			0.0010	0.0269	0.0061	0.0031	0.000075	0.0086							
	PreDesign	40	19	48%			0.002	0.478	0.046	0.004	0.008	0.087							Pass
	PreDesign*	19	17	89%			0.004	0.478	0.093	0.051	0.012	0.110							Pass
	PreDesign**	21	2	10%			0.002	0.012	0.004	0.004	0.000	0.002							Pass
	* before 2/10/95																		
	** after 2/10/95																		

No significant difference (Pass)
LCS significantly GREATER than PreDesign (Fail)

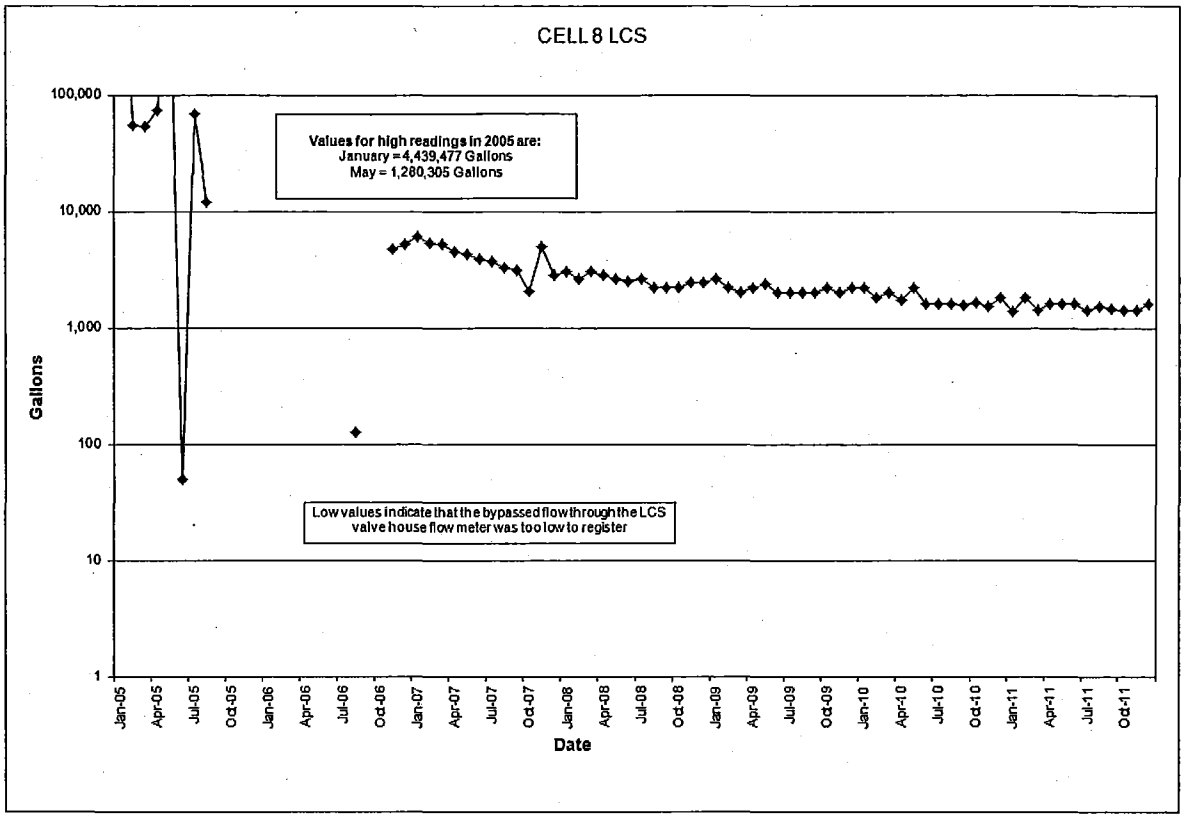


Figure A.5.8–1. Monthly Accumulation Volumes for Cell 8 LCS

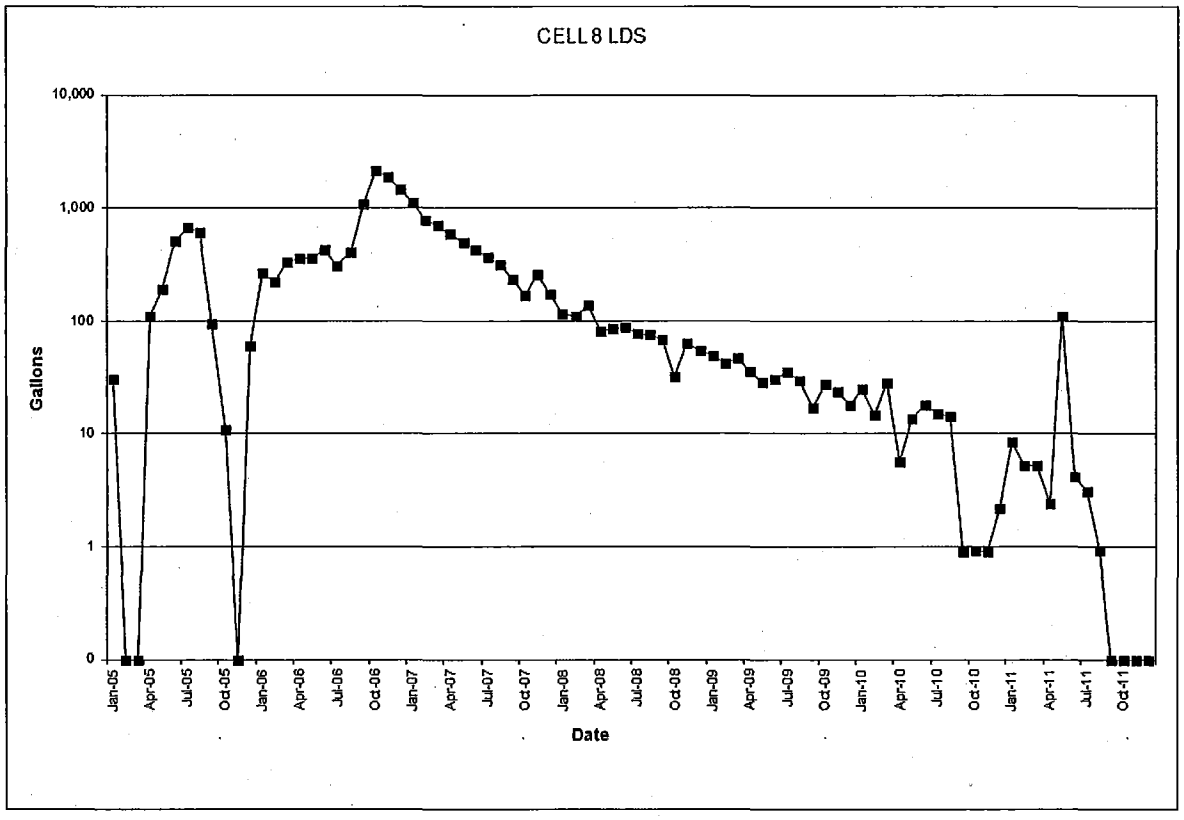
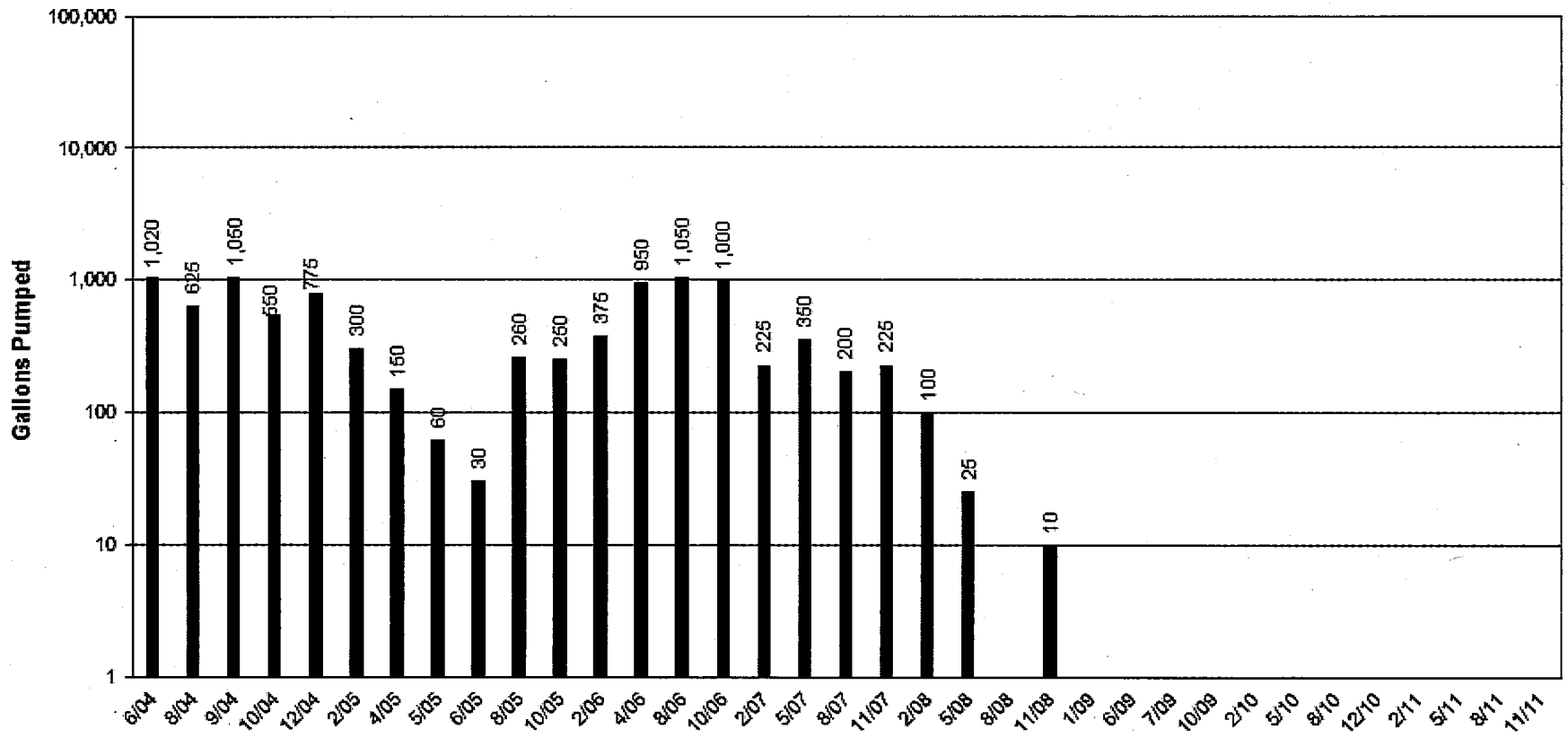


Figure A.5.8–2. Monthly Accumulation Volumes for Cell 8 LDS



12345 Purge Information

Year	Total Volumes (gal.)	Months Purged	Avg. Monthly Purge (gal.)
2004:	4020	n=5	804
2005:	1050	n=6	175
2006:	3375	n=4	844
2007:	1000	n=4	250
2008:	135	n=4	34
2009:	0	n=3	0
2010:	0	n=4	0
2011:	0	n=4	0
Overall:			282

Figure A.5.8–3. OSDF Horizontal Till Well 12343 (Cell 8) Water Yield

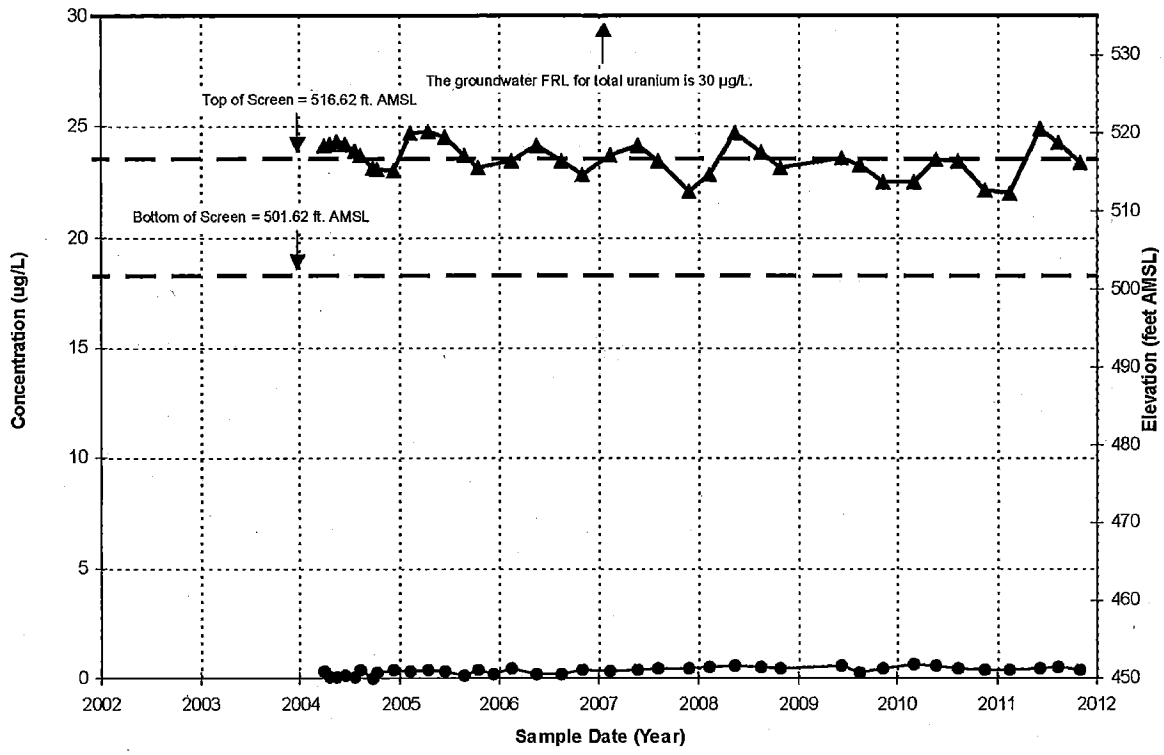


FIGURE A.5.8-4. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 8 Upgradient Monitoring Well 22213

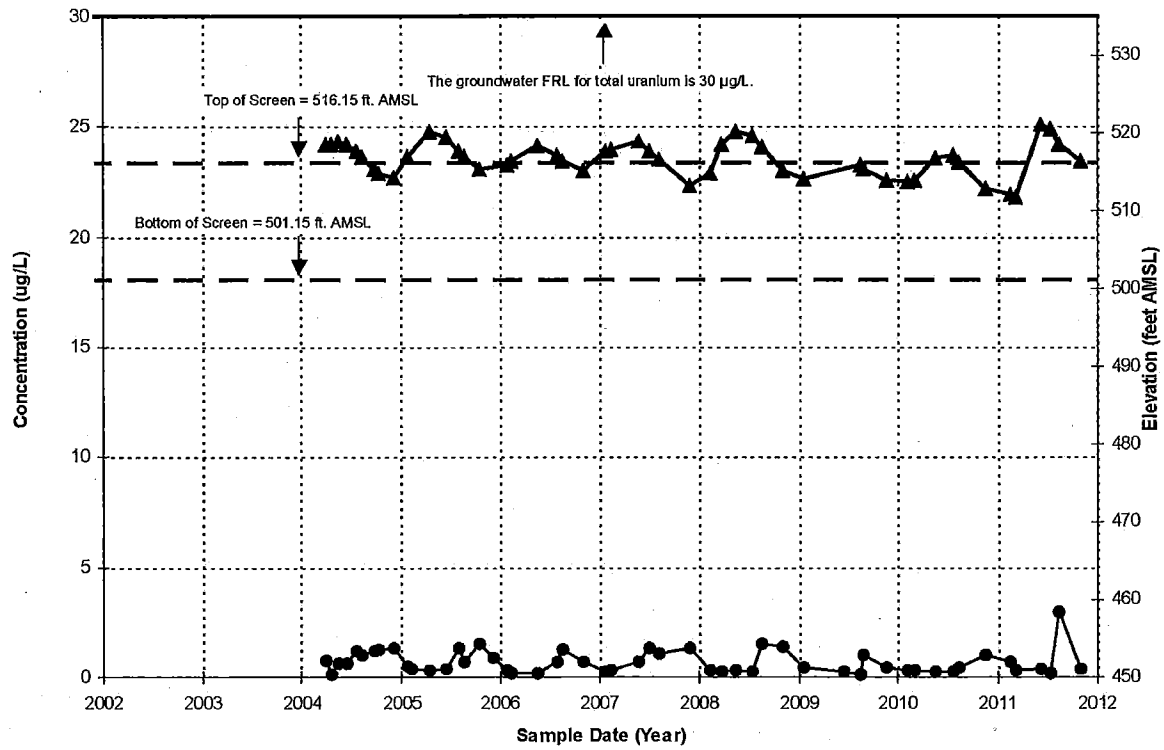


FIGURE A.5.8-5. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 8 Downgradient Monitoring Well 22214

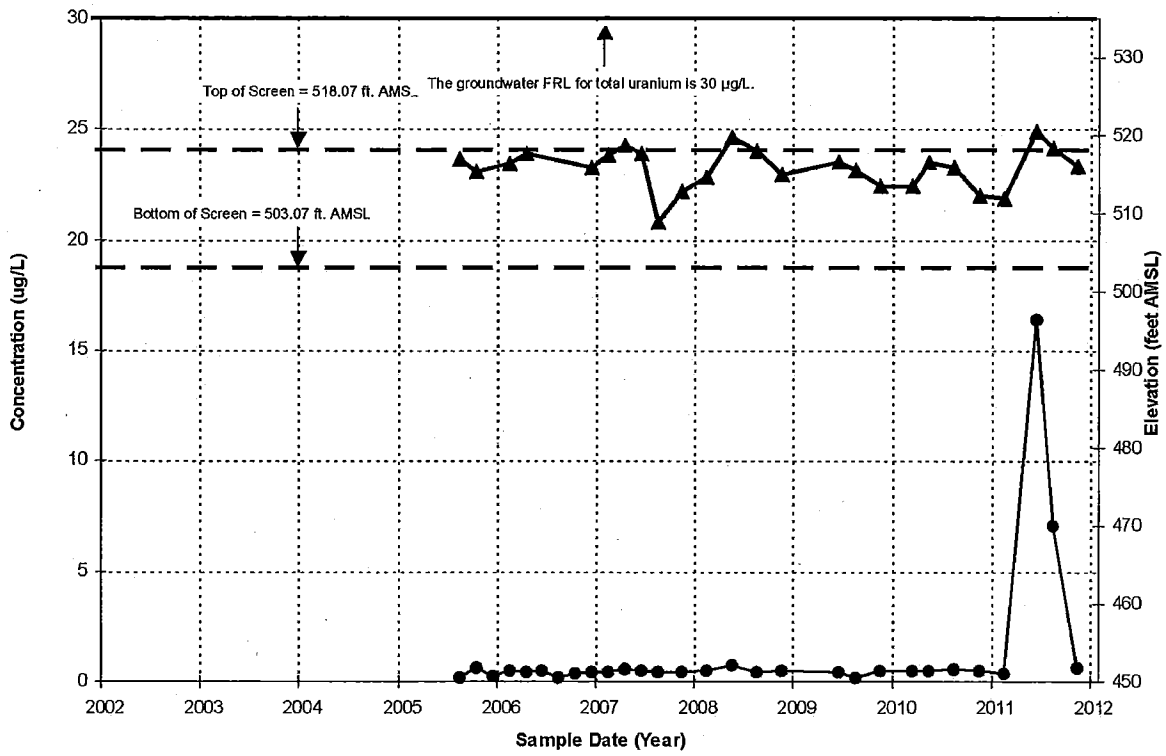


FIGURE A.5.8-6. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 8 Downgradient Monitoring Well 22215

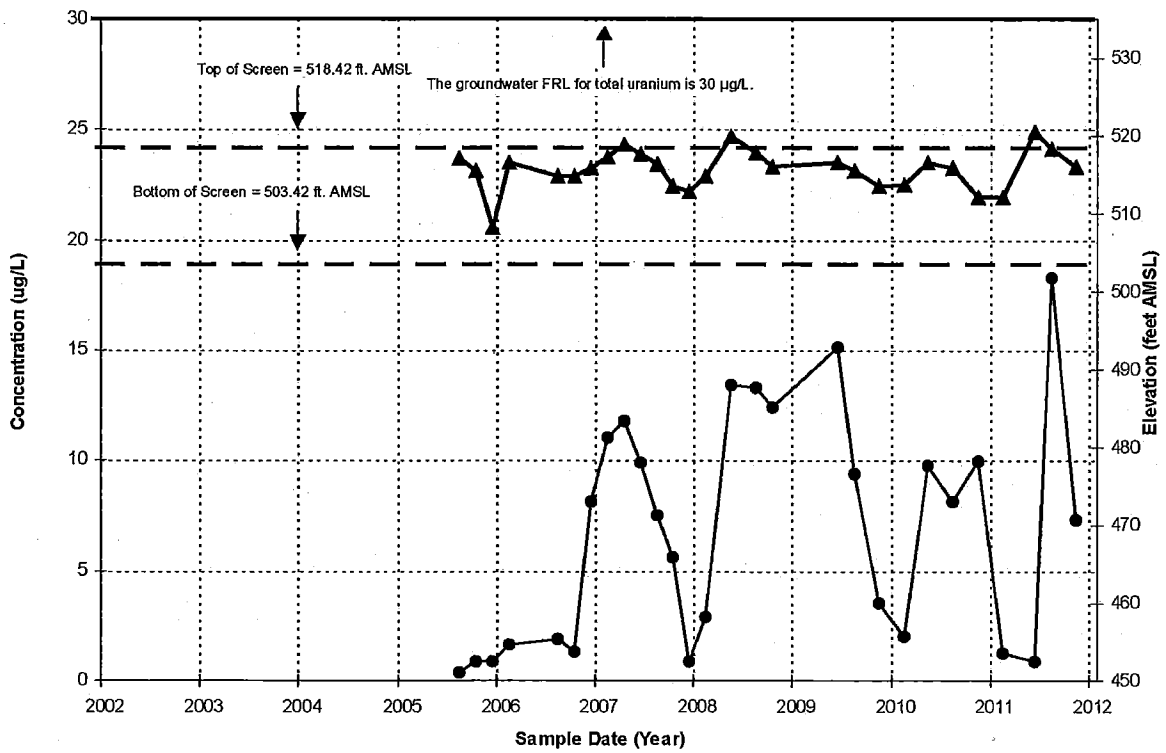


FIGURE A.5.8-7. Total Uranium Concentration and Groundwater Elevation vs. Time Plot for Cell 8 Downgradient Monitoring Well 22216/22217

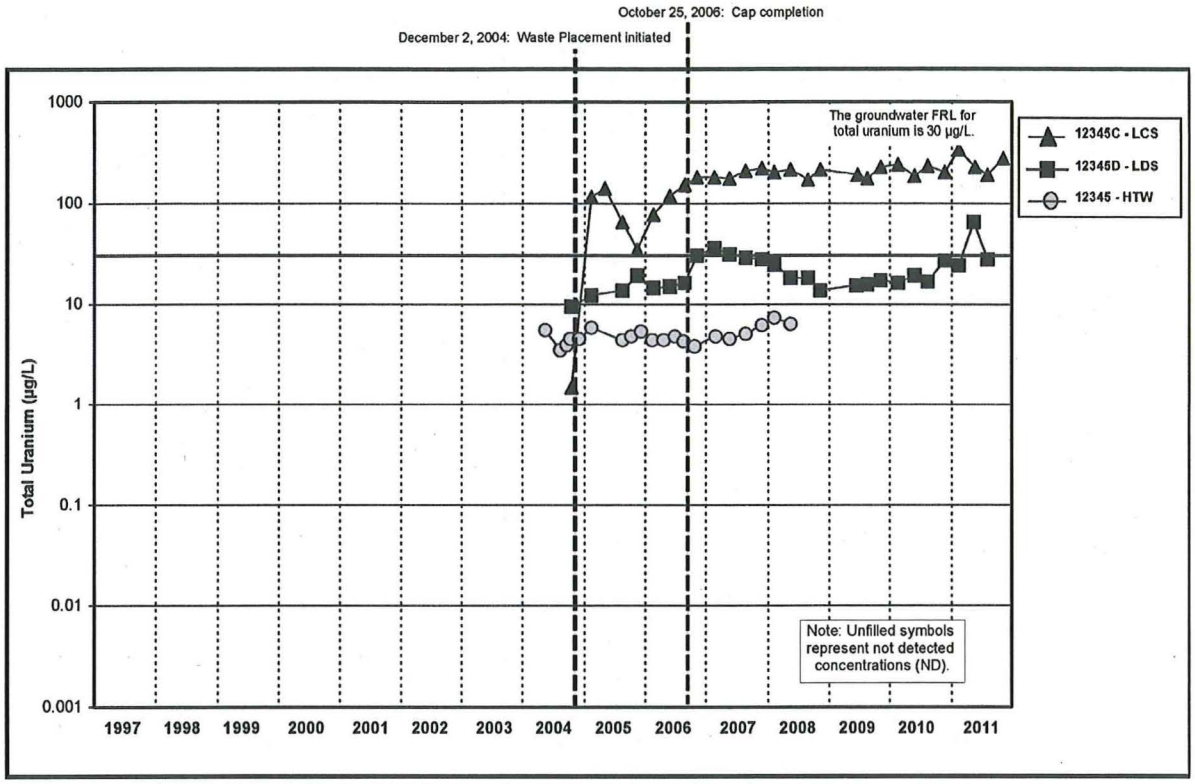


Figure A.5.8-8A. Cell 8 Uranium, Total Concentration vs. Time Plot for LCS, LDS, and HTW

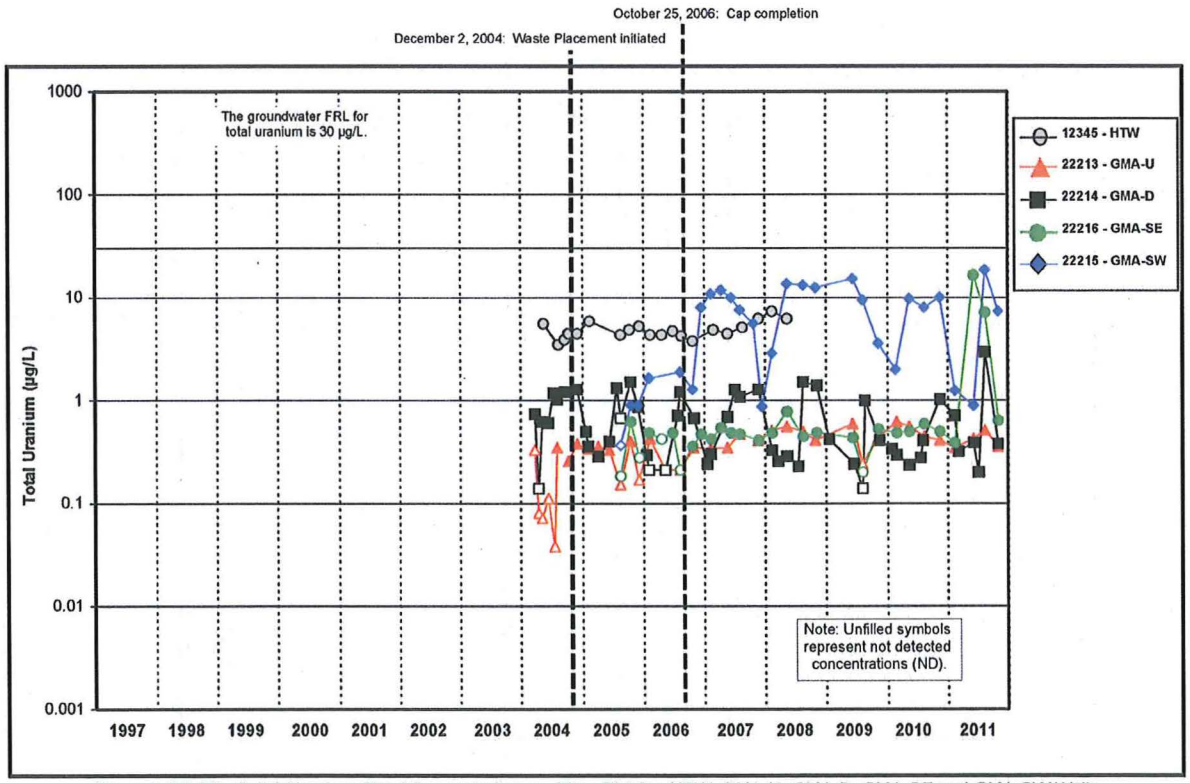


Figure A.5.8-8B. Cell 8 Uranium, Total Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

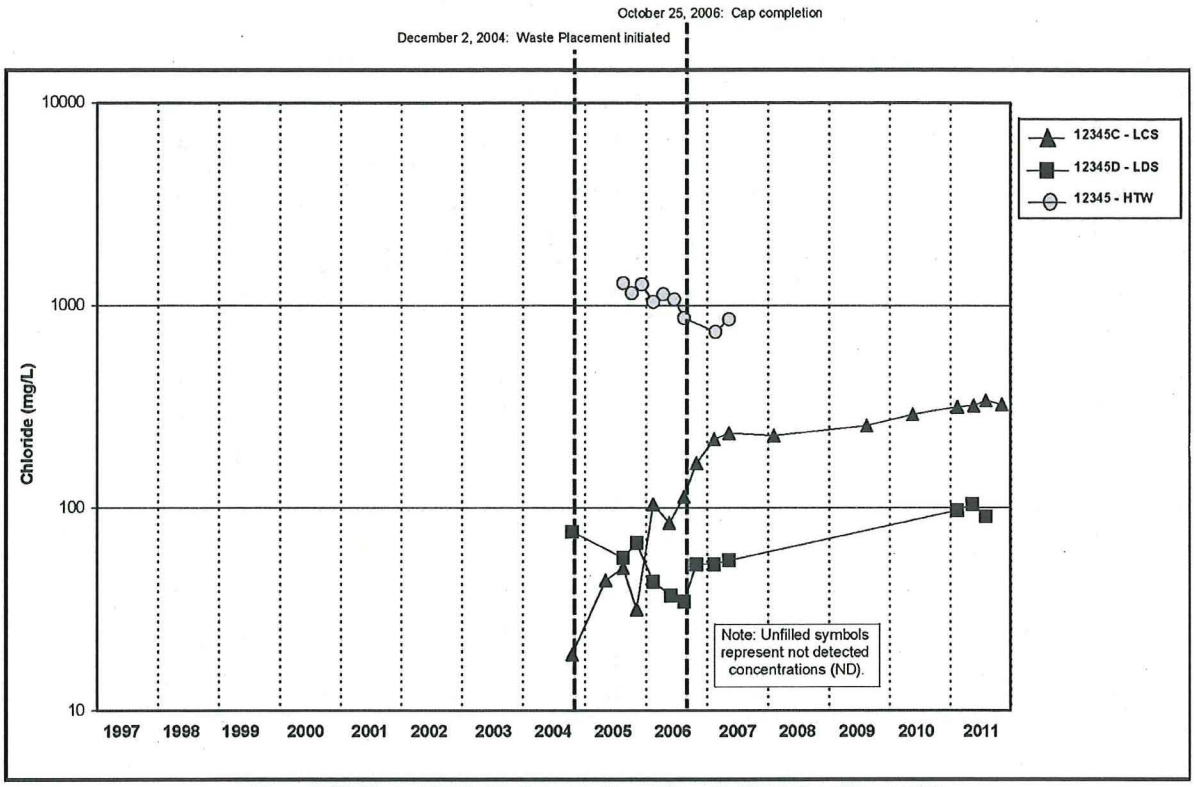


Figure A.5.8-9A. Cell 8 Chloride Concentration vs. Time Plot for LCS, LDS, and HTW

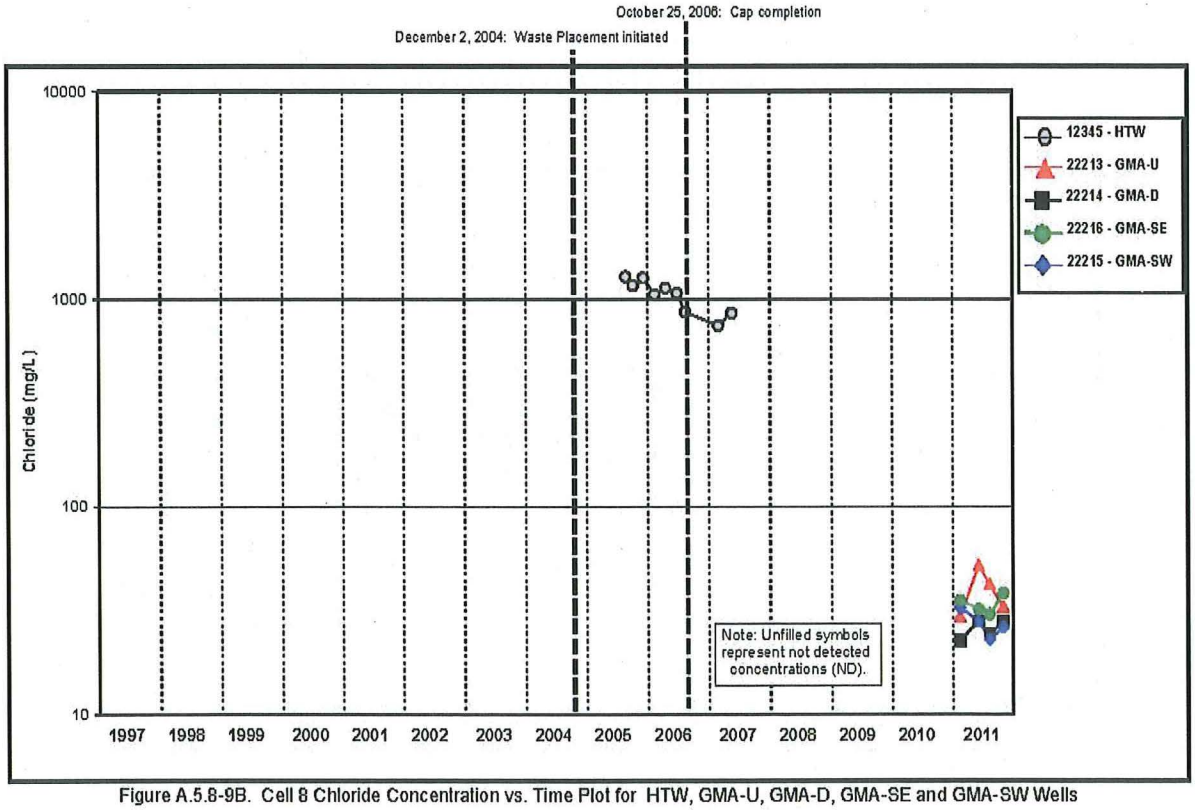


Figure A.5.8-9B. Cell 8 Chloride Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

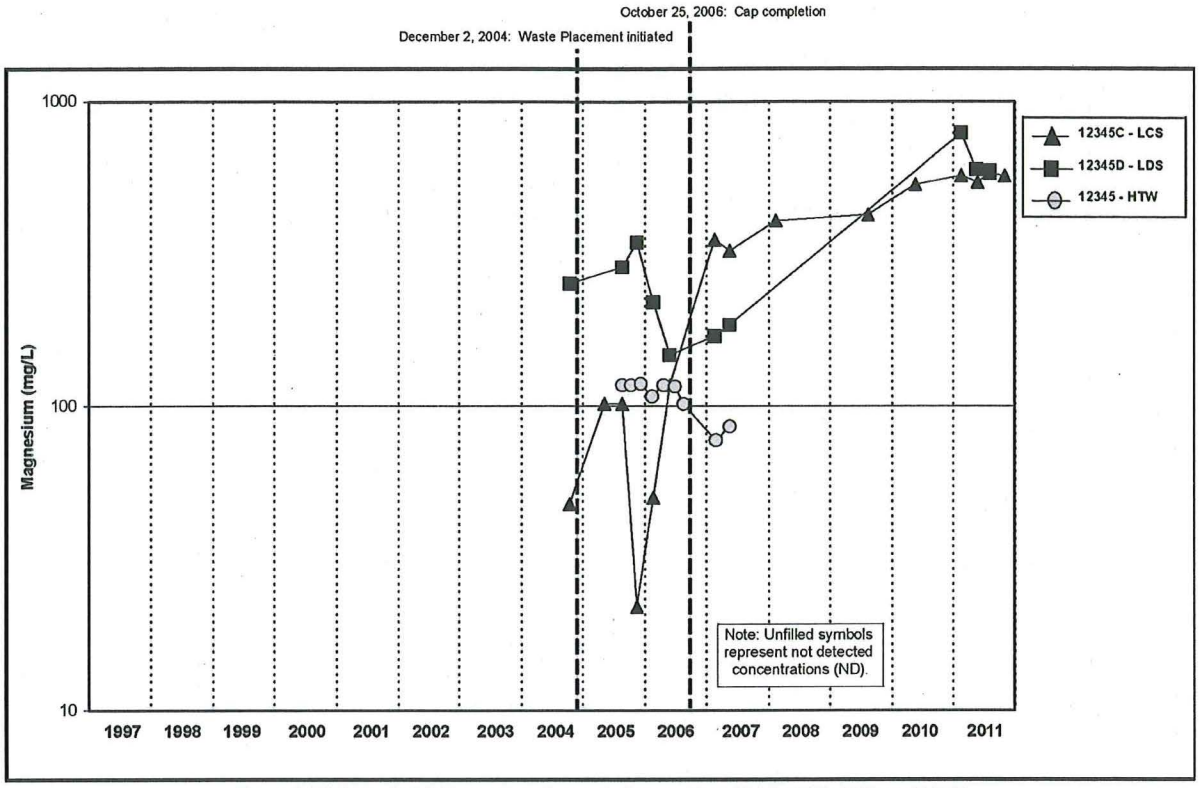


Figure A.5.8-10A. Cell 8 Magnesium Concentration vs. Time Plot for LCS, LDS, and HTW

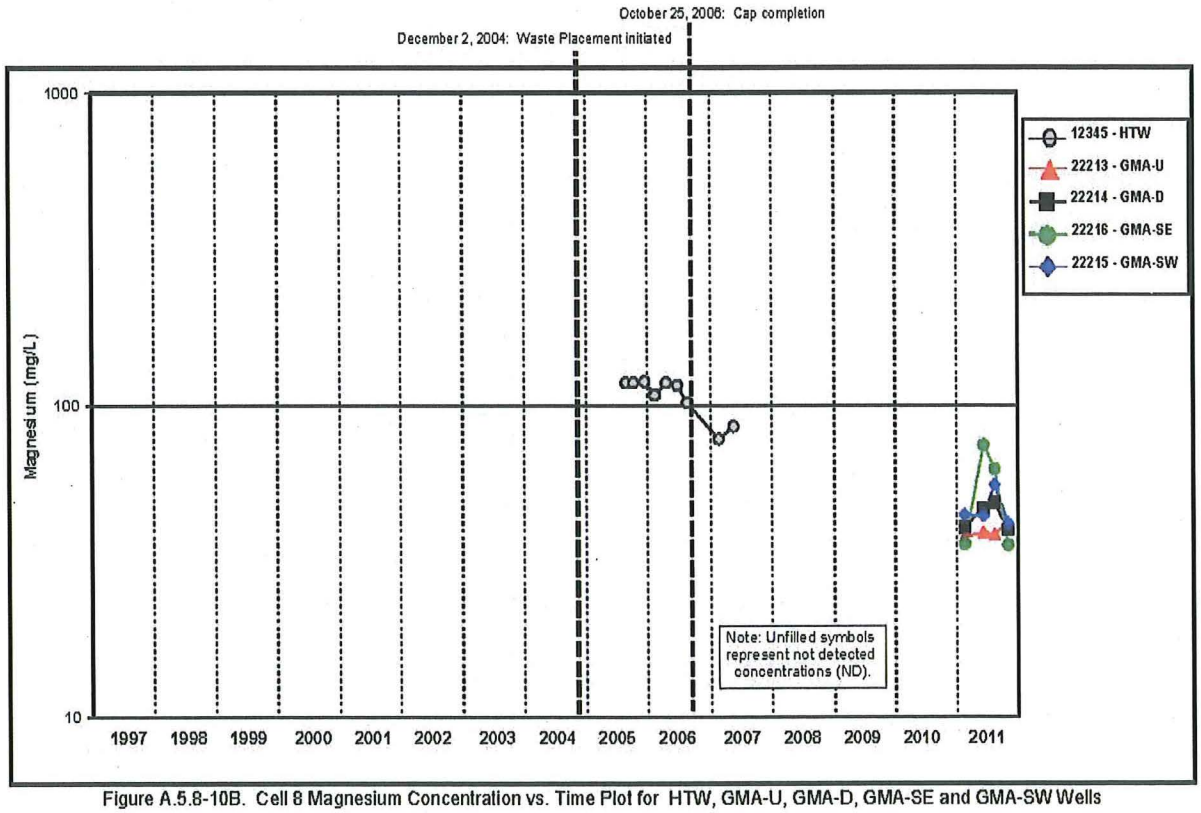


Figure A.5.8-10B. Cell 8 Magnesium Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

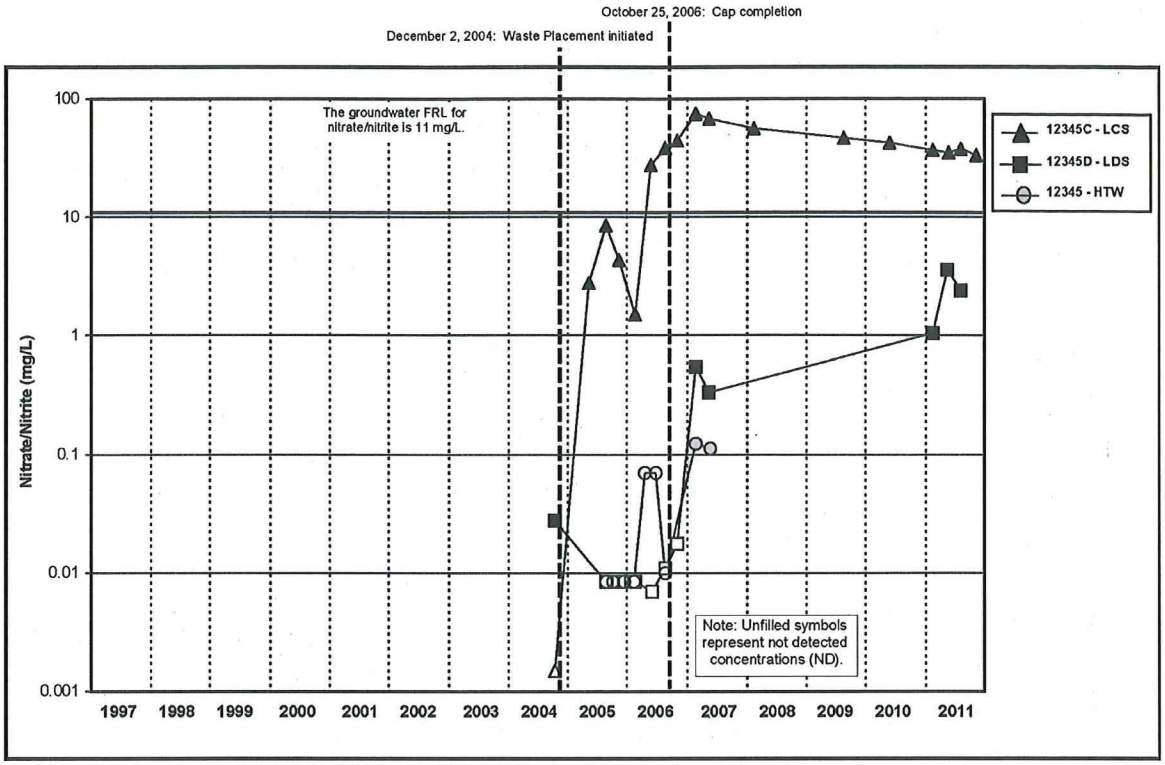


Figure A.5.8-11A. Cell 8 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for LCS, LDS, and HTW

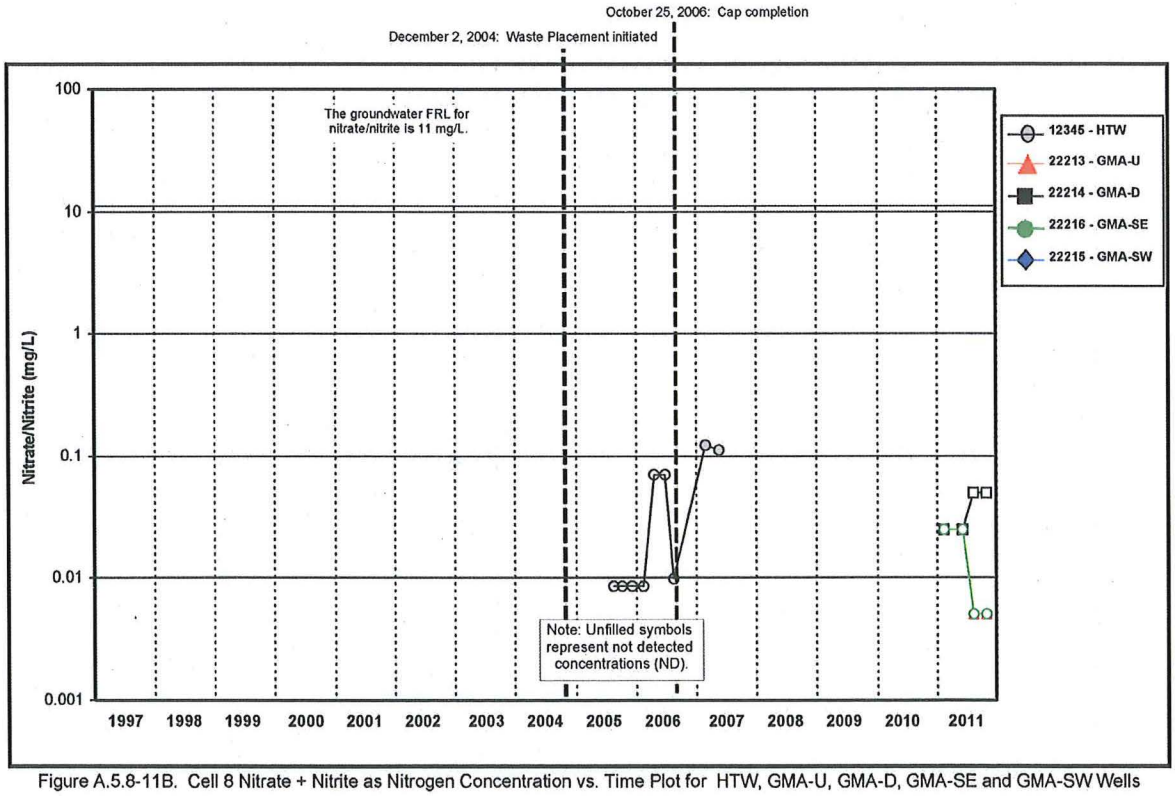


Figure A.5.8-11B. Cell 8 Nitrate + Nitrite as Nitrogen Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

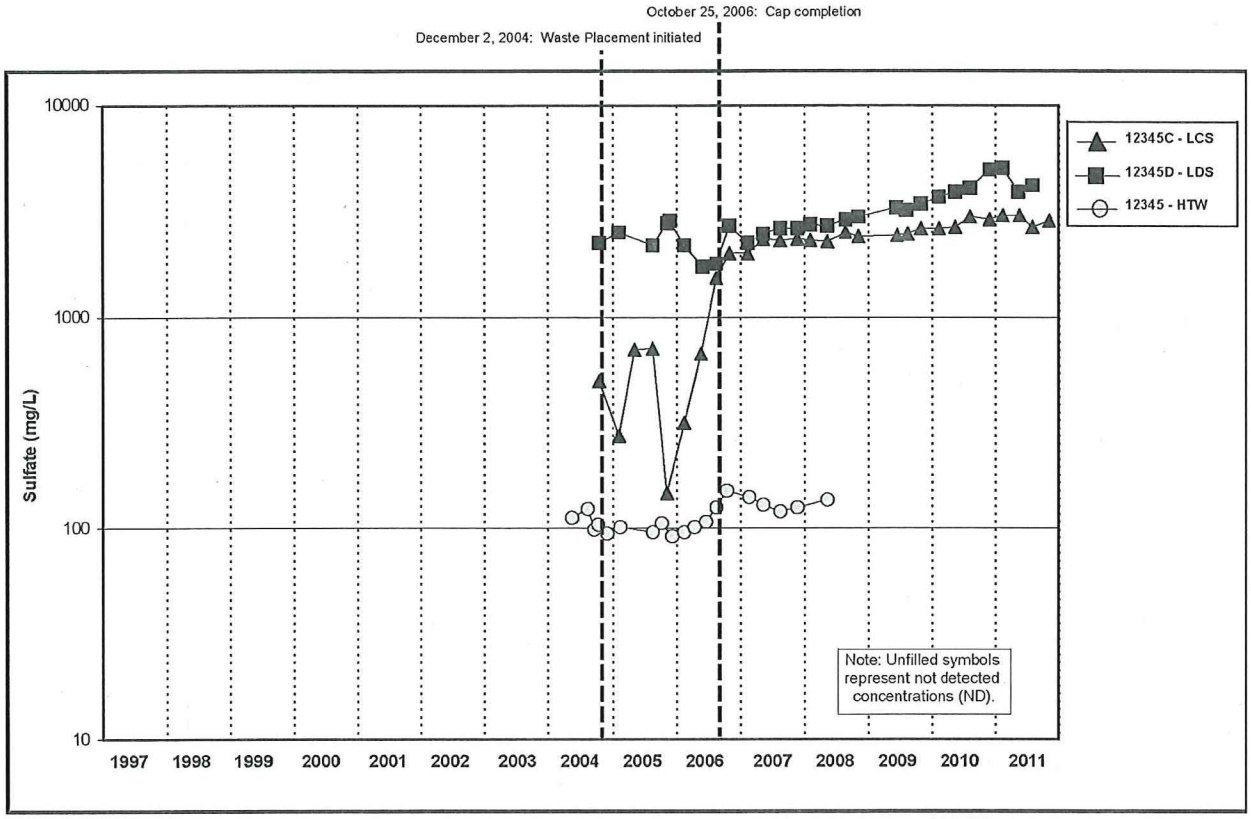


Figure A.5.8-12A. Cell 8 Sulfate Concentration vs. Time Plot for LCS, LDS, and HTW

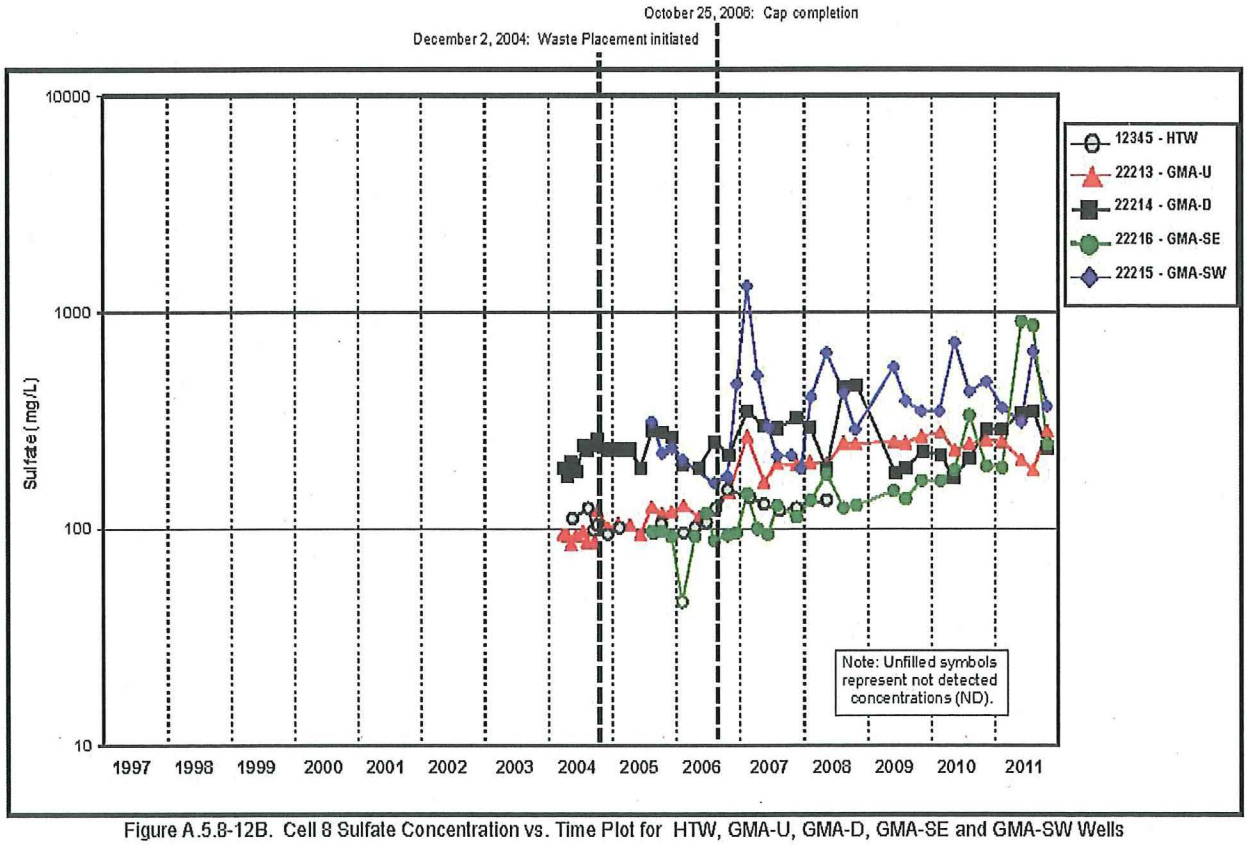


Figure A.5.8-12B. Cell 8 Sulfate Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

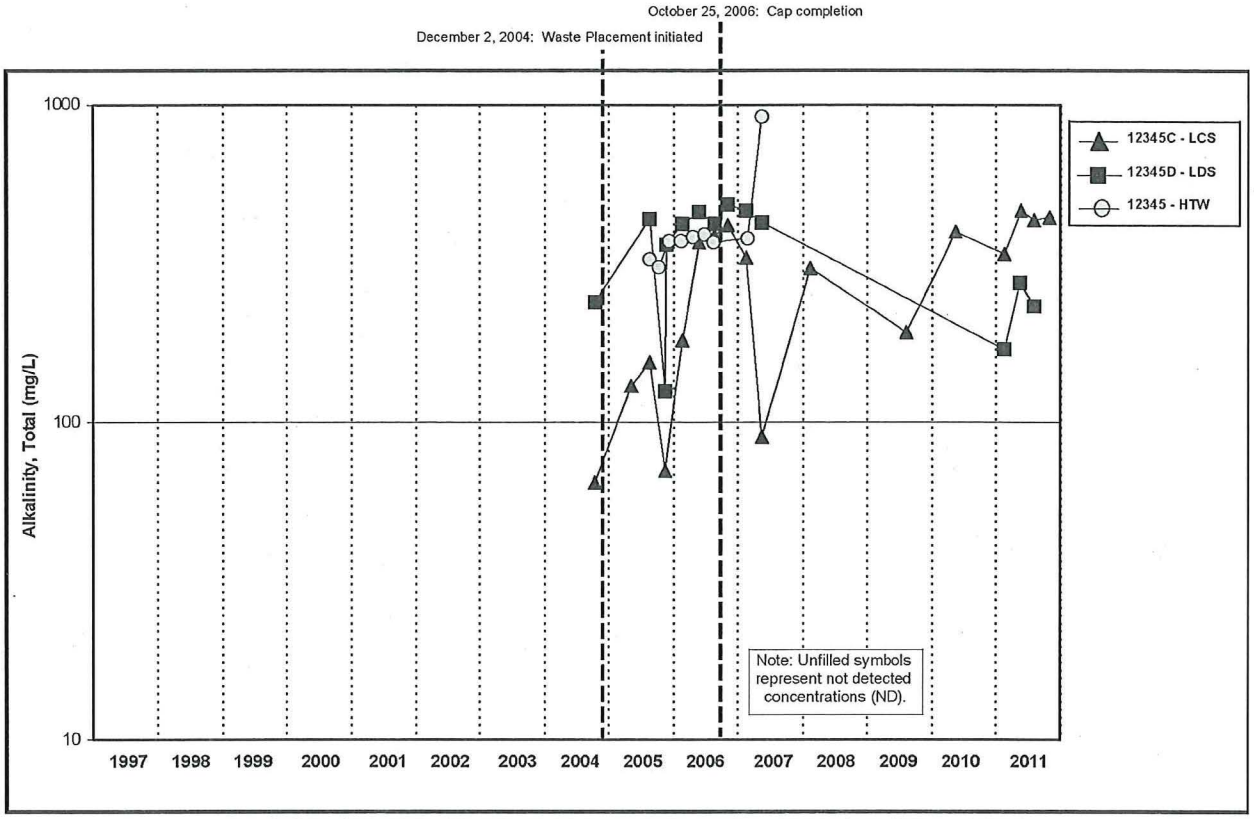


Figure A.5.8-13A. Cell 8 Alkalinity, Total Concentration vs. Time Plot for LCS, LDS, and HTW

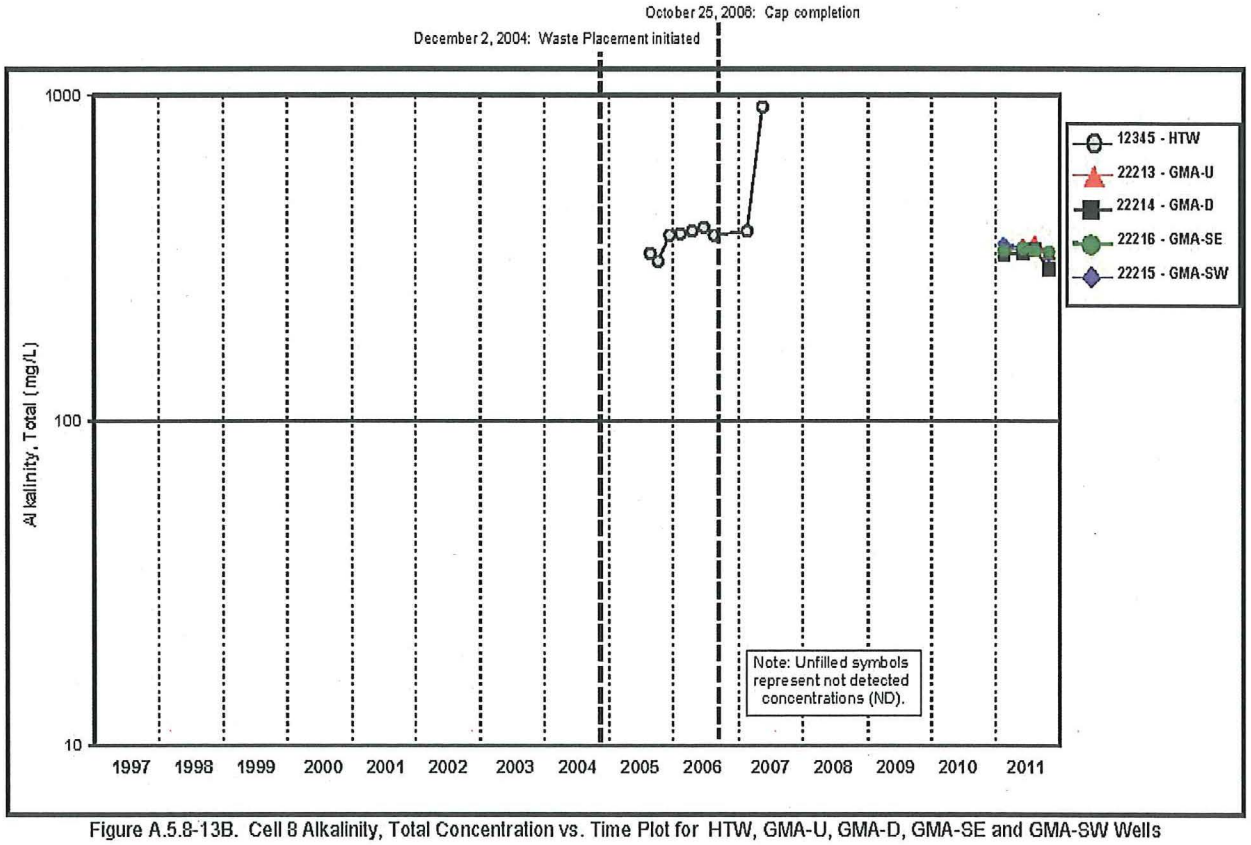


Figure A.5.8-13B. Cell 8 Alkalinity, Total Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

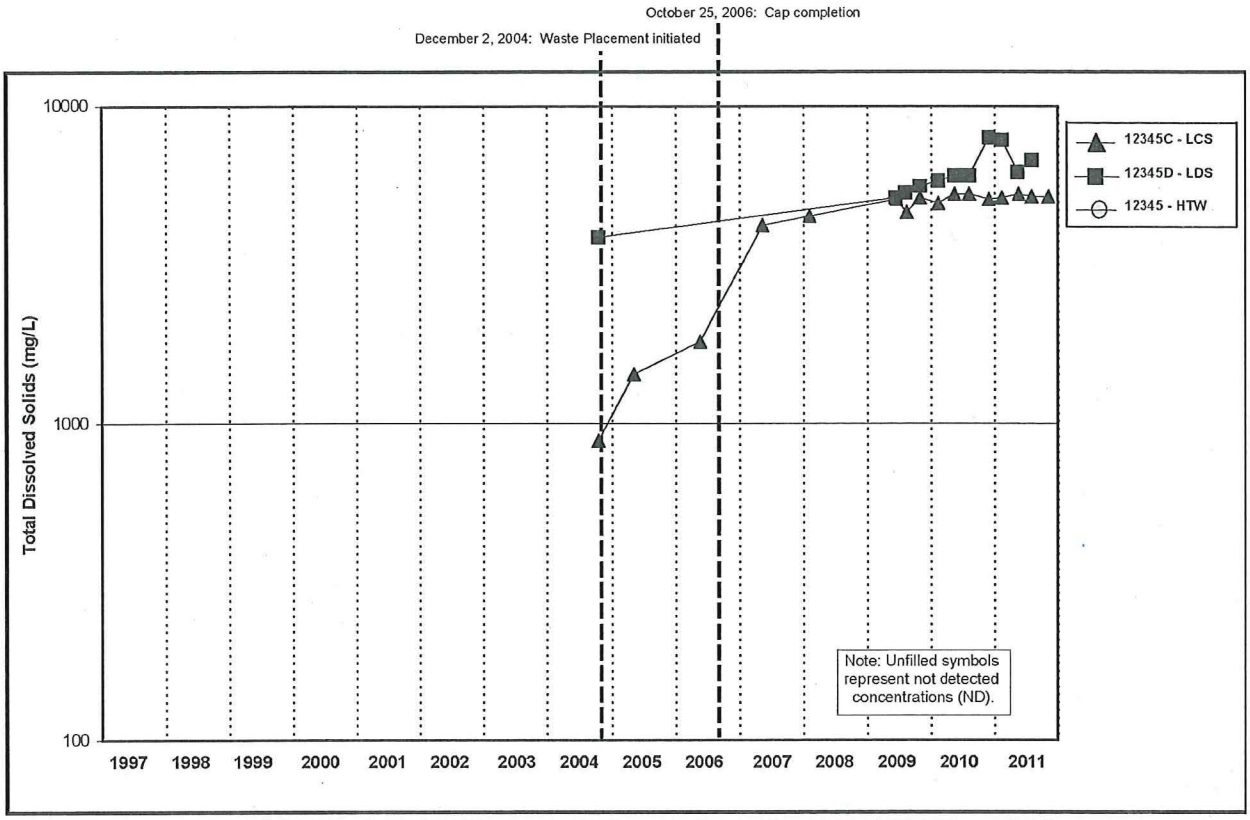


Figure A.5.8-14A. Cell 8 Total Dissolved Solids Concentration vs. Time Plot for LCS, LDS, and HTW

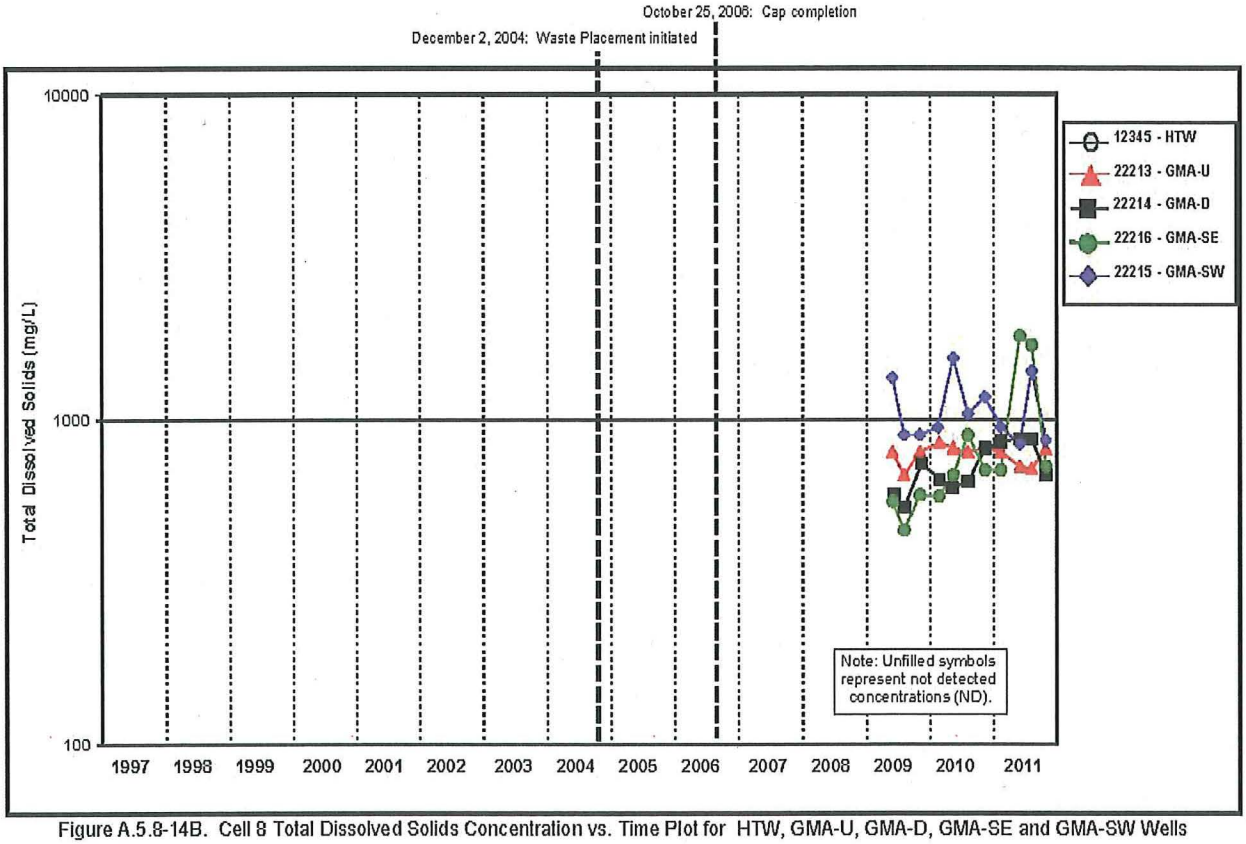


Figure A.5.8-14B. Cell 8 Total Dissolved Solids Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

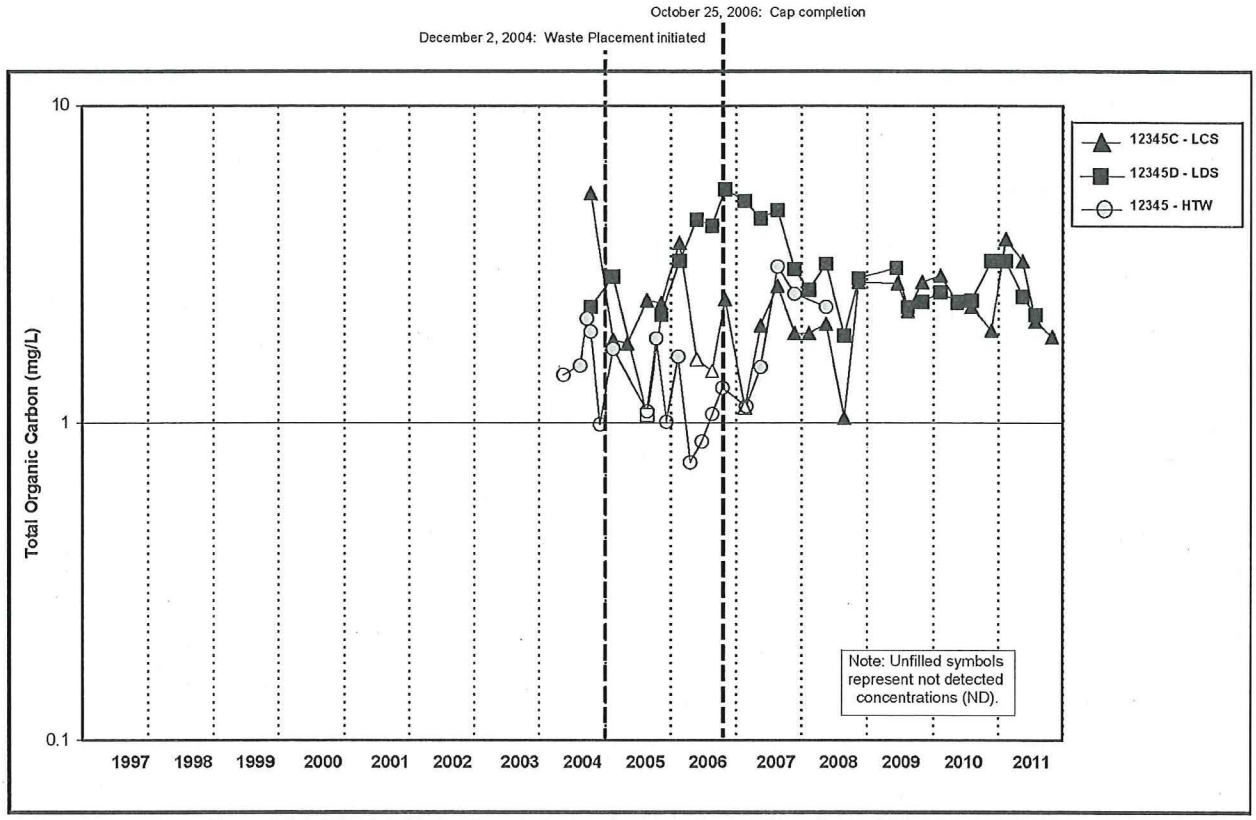


Figure A.5.8-15A. Cell 8 Total Organic Carbon Concentration vs. Time Plot for LCS, LDS, and HTW

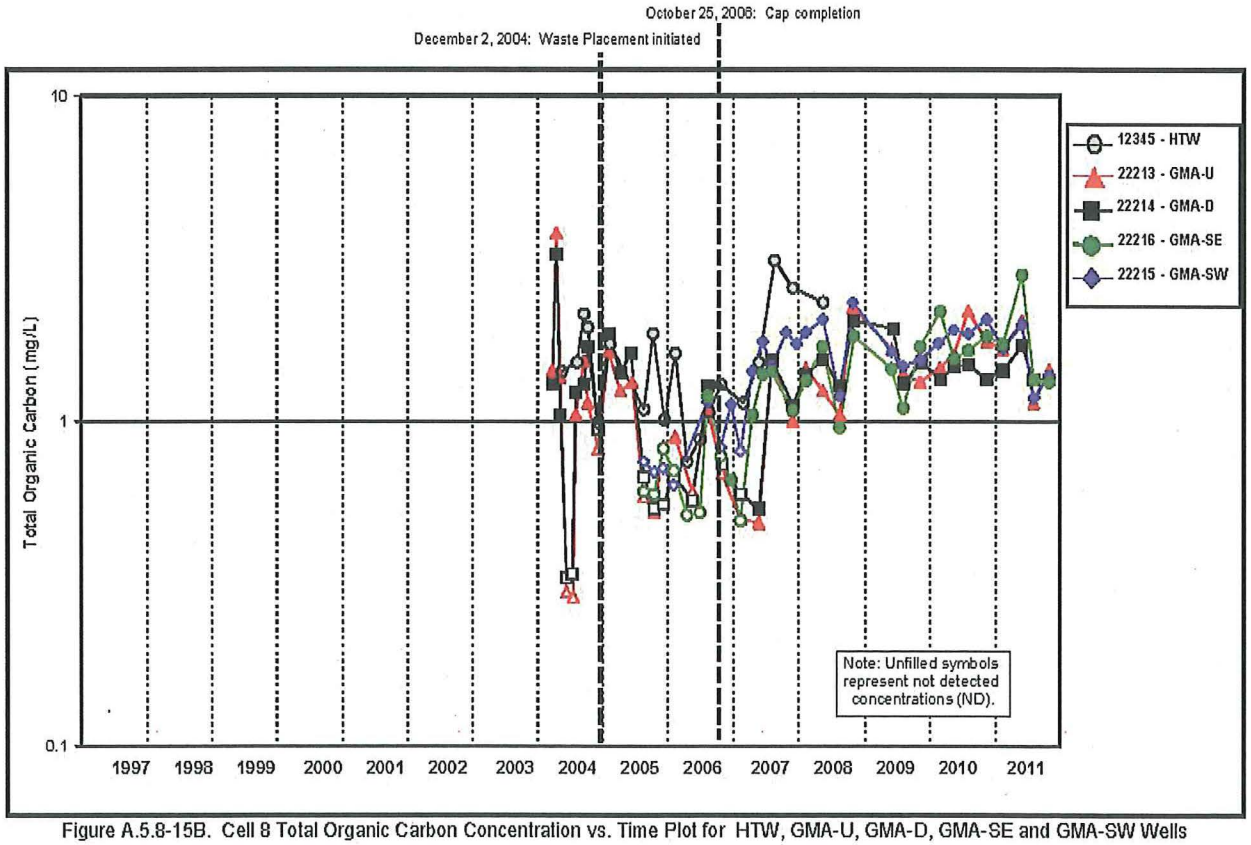


Figure A.5.8-15B. Cell 8 Total Organic Carbon Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

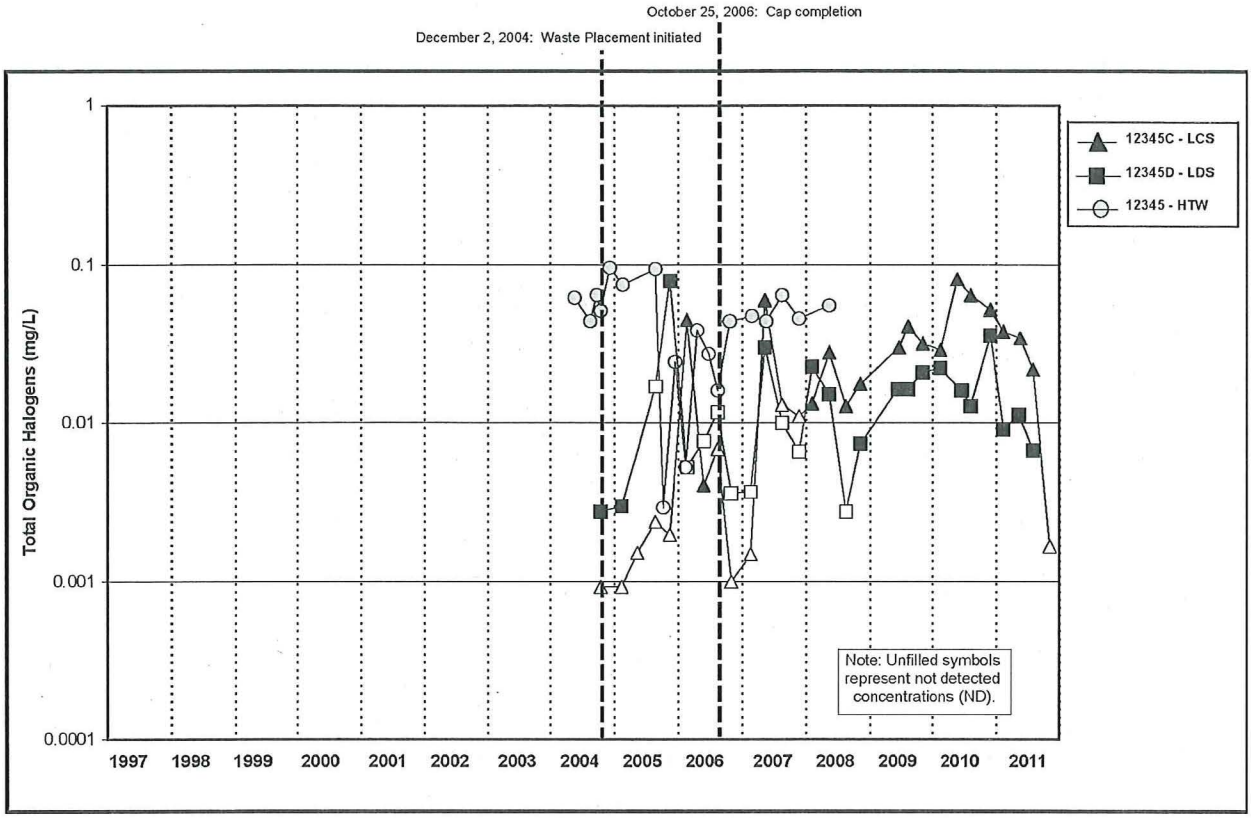


Figure A.5.8-16A. Cell 8 Total Organic Halogens Concentration vs. Time Plot for LCS, LDS, and HTW

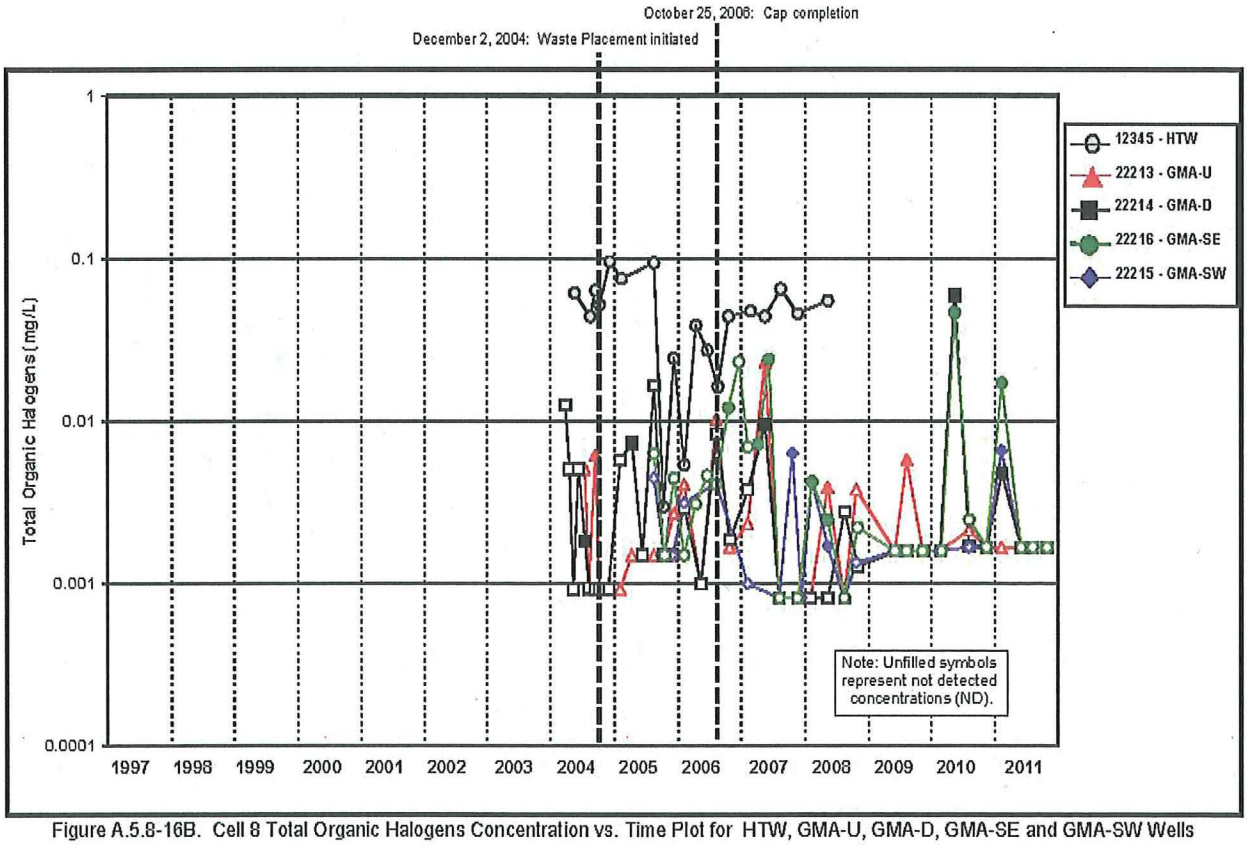


Figure A.5.8-16B. Cell 8 Total Organic Halogens Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

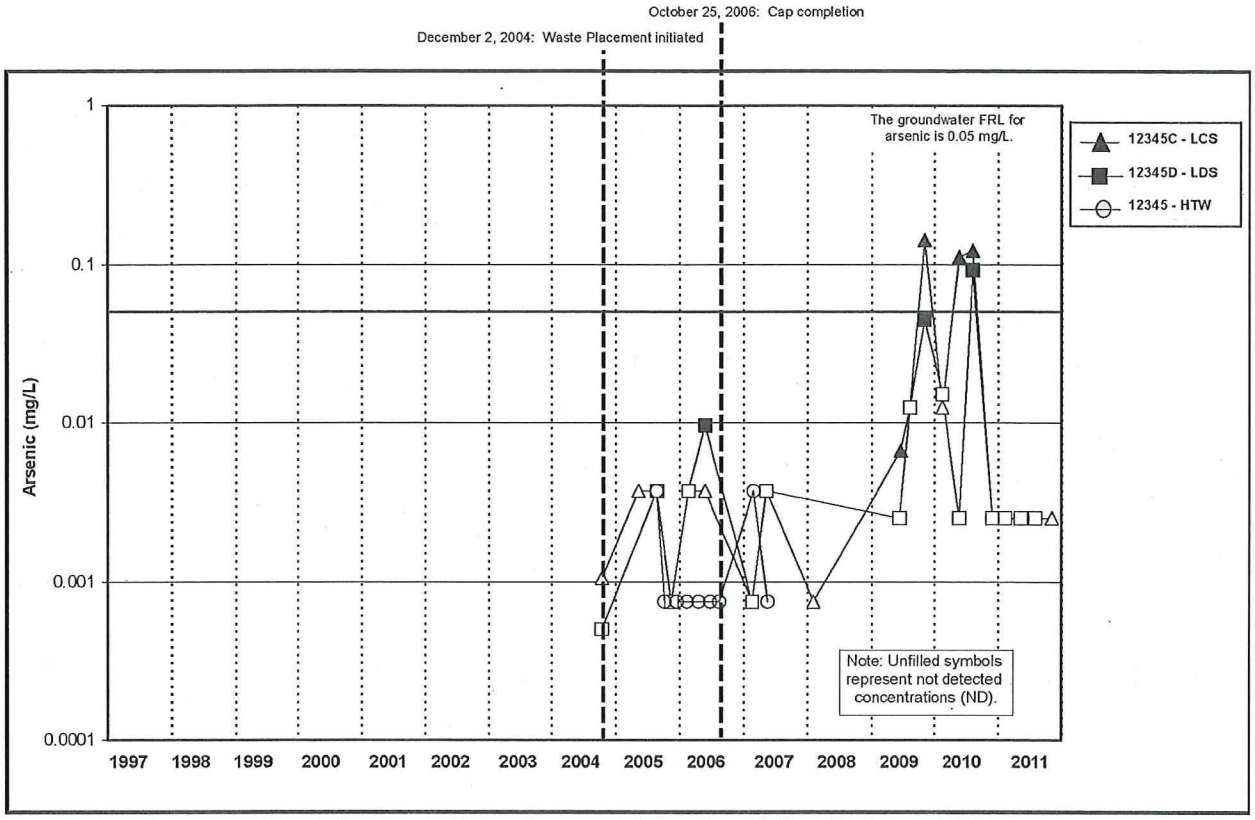


Figure A.5.8-17A. Cell 8 Arsenic Concentration vs. Time Plot for LCS, LDS, and HTW

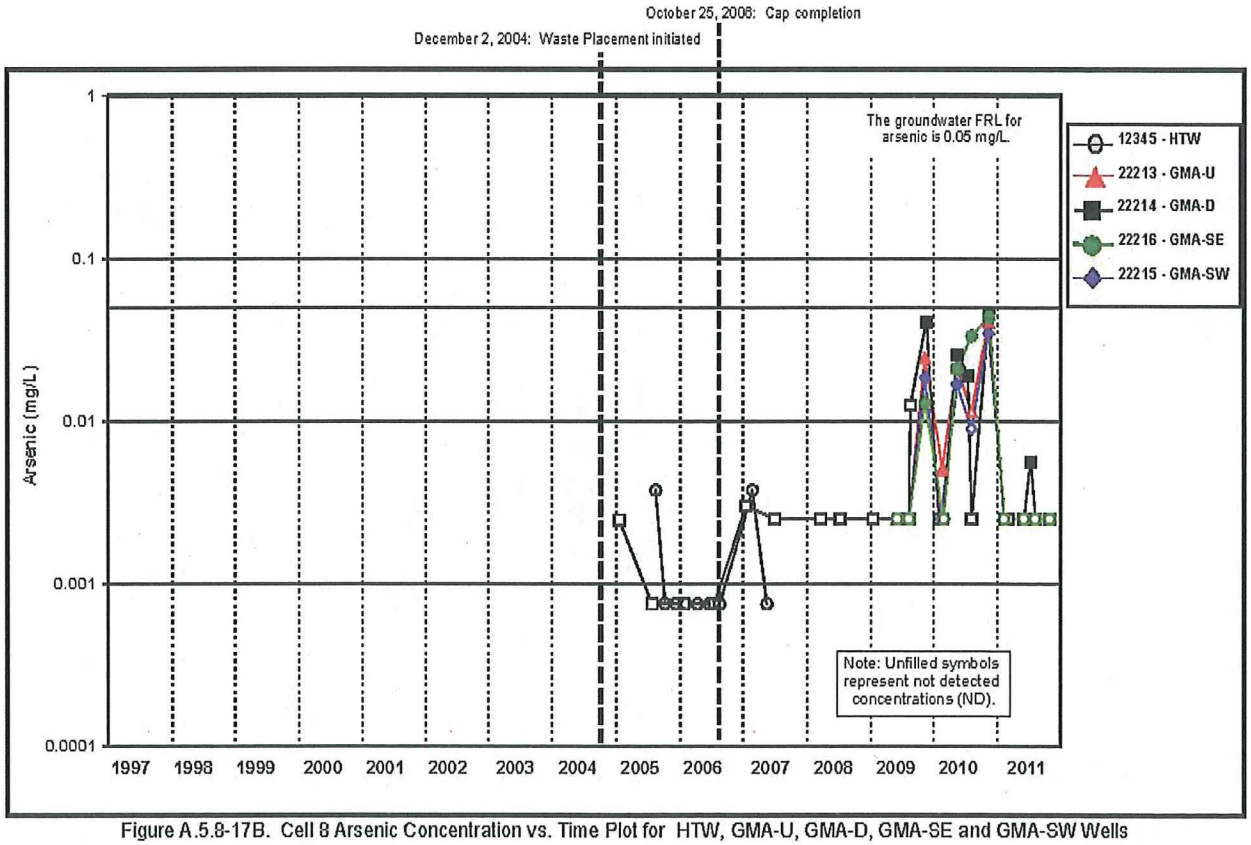


Figure A.5.8-17B. Cell 8 Arsenic Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

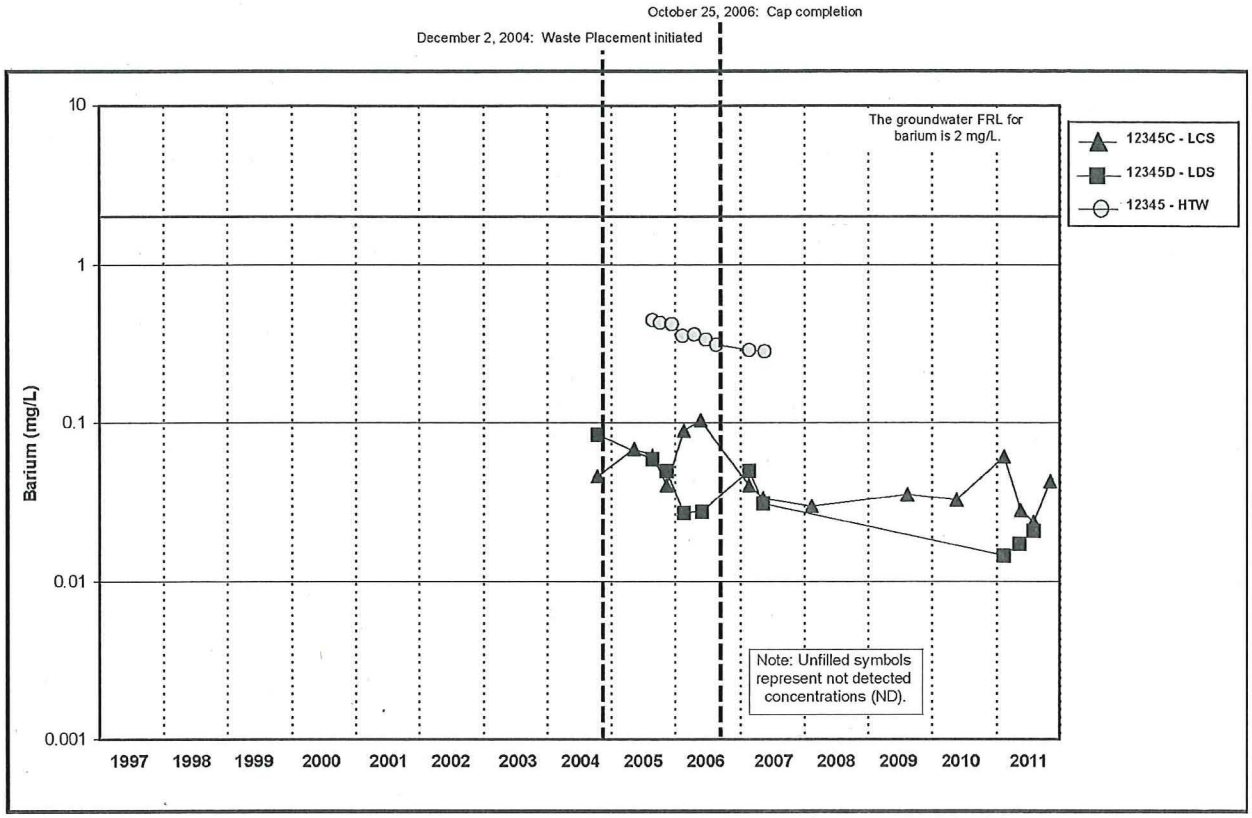


Figure A.5.8-18A. Cell 8 Barium Concentration vs. Time Plot for LCS, LDS, and HTW

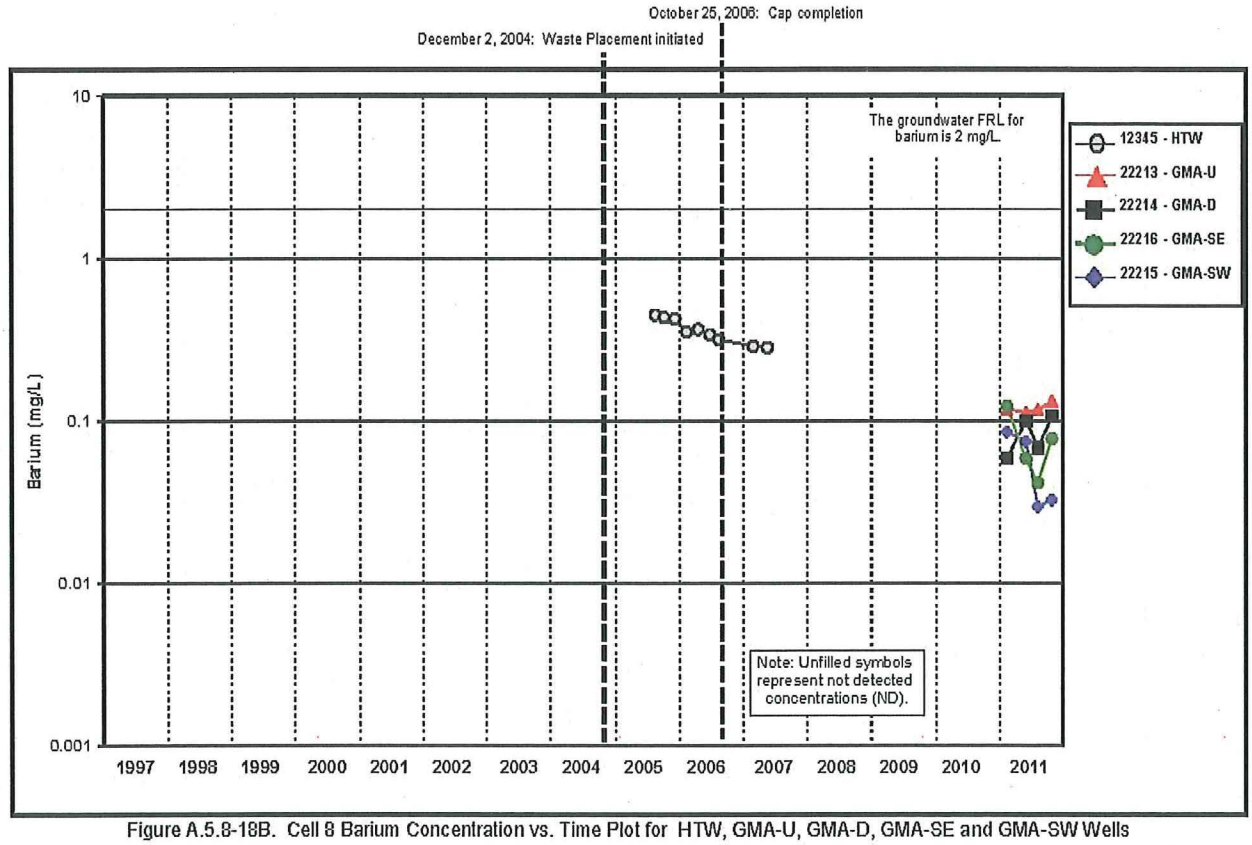


Figure A.5.8-18B. Cell 8 Barium Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

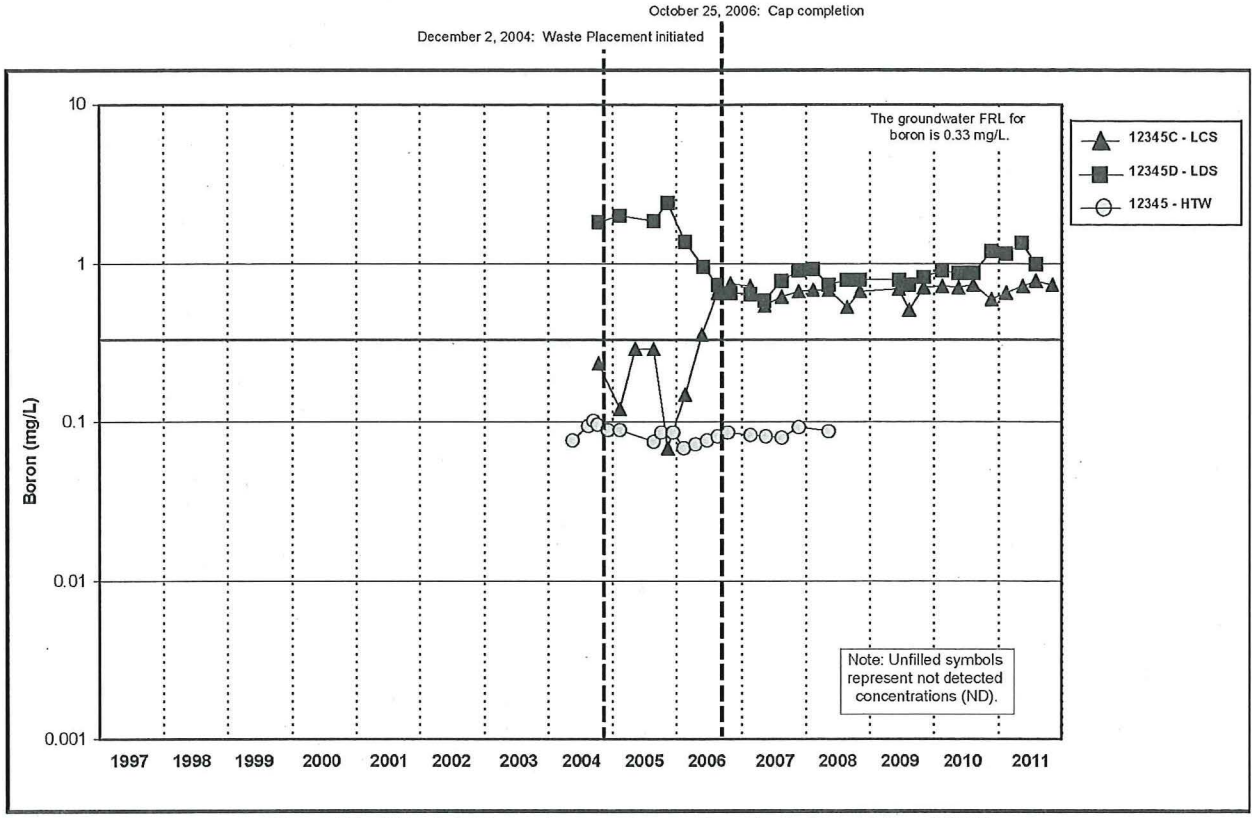


Figure A.5.8-19A. Cell 8 Boron Concentration vs. Time Plot for LCS, LDS, and HTW

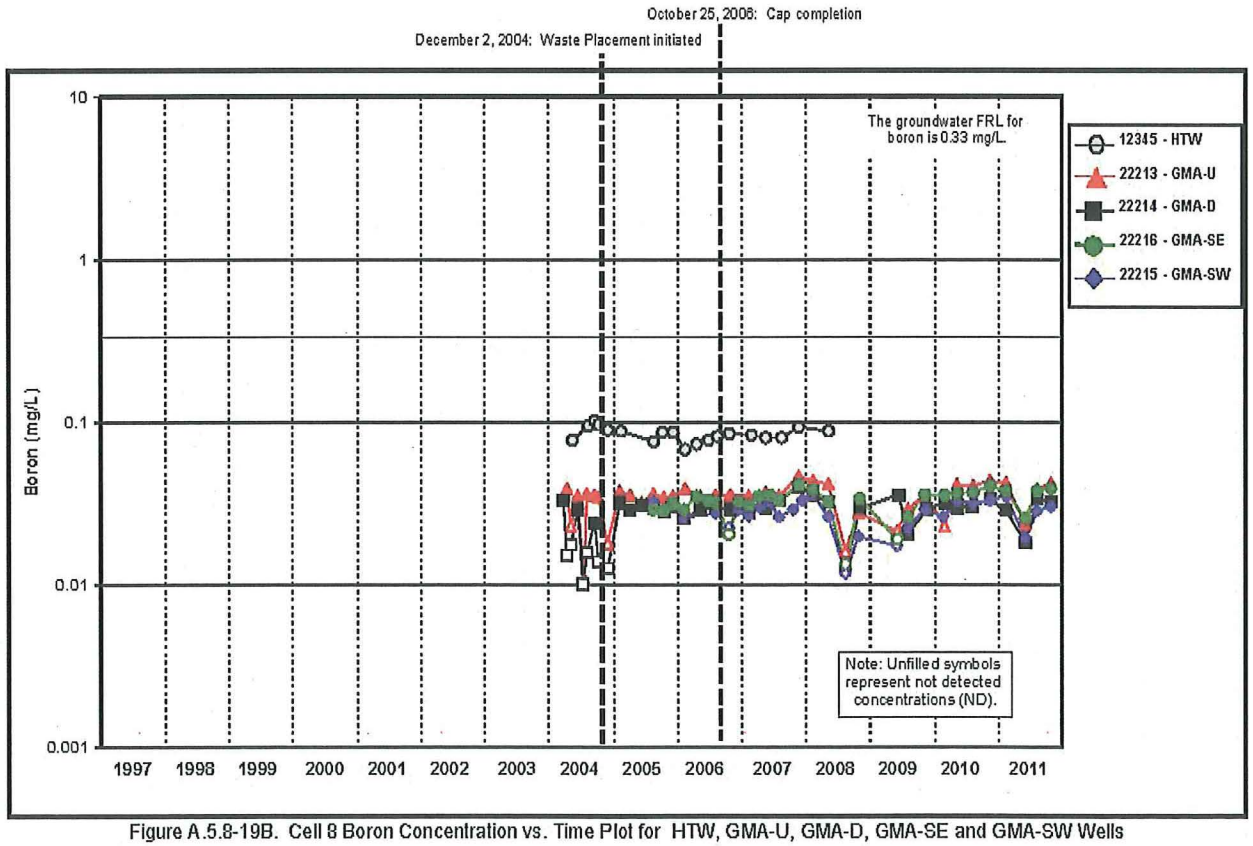


Figure A.5.8-19B. Cell 8 Boron Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

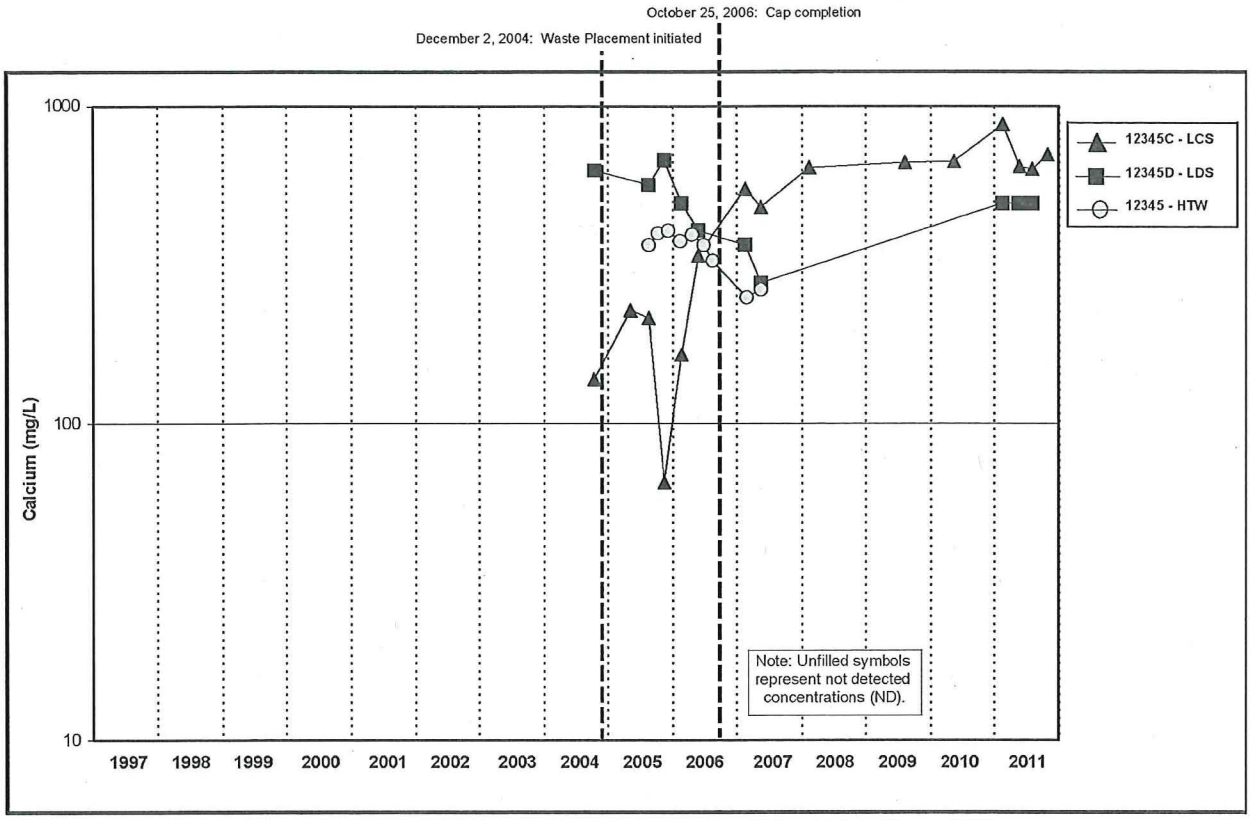


Figure A.5.8-20A. Cell 8 Calcium Concentration vs. Time Plot for LCS, LDS, and HTW

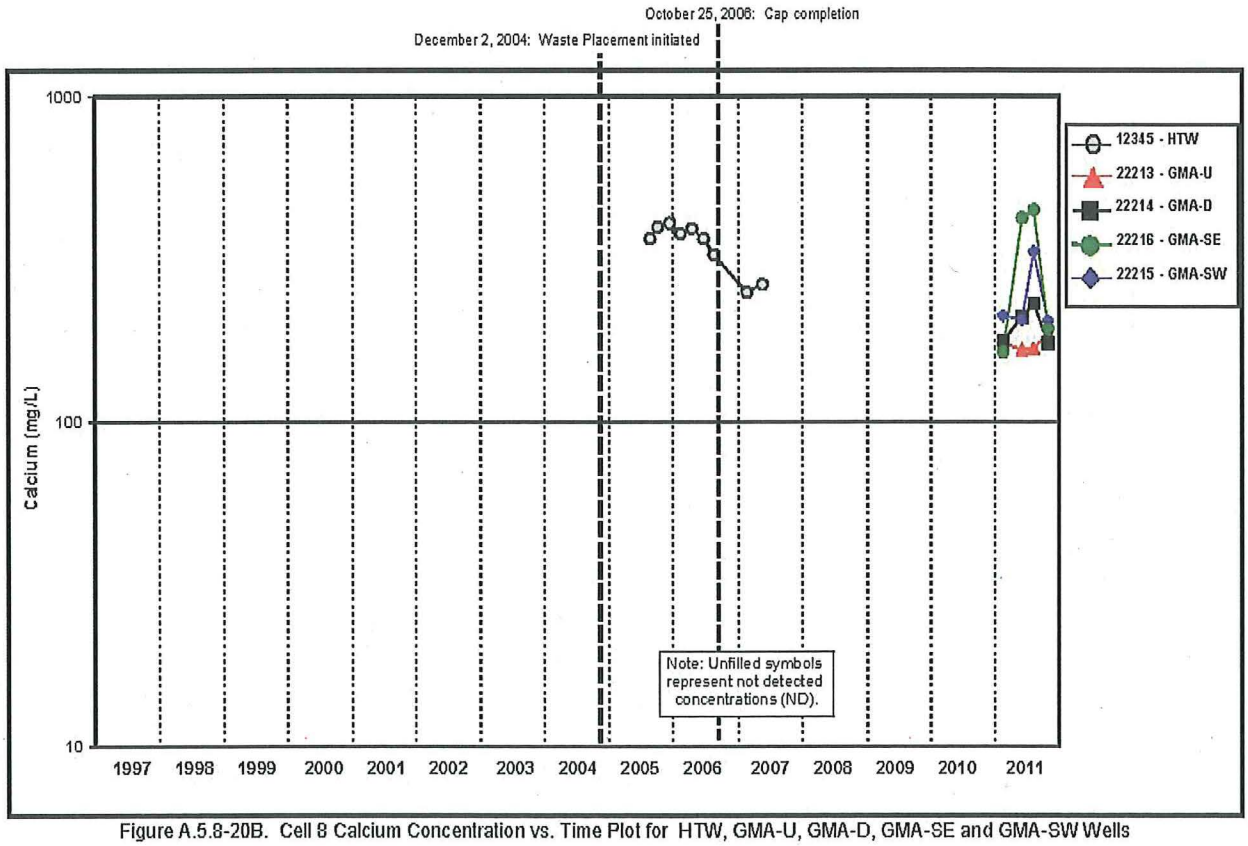


Figure A.5.8-20B. Cell 8 Calcium Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

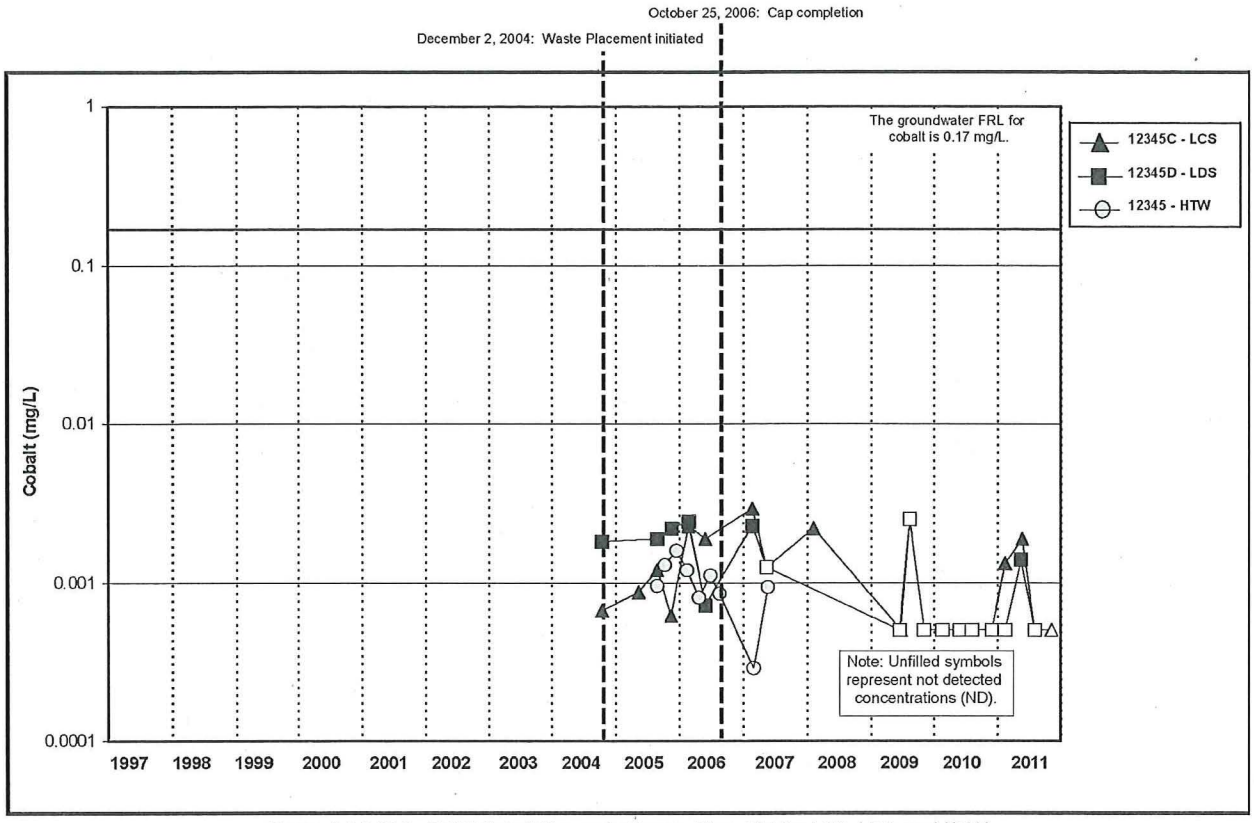


Figure A.5.8-21A. Cell 8 Cobalt Concentration vs. Time Plot for LCS, LDS, and HTW

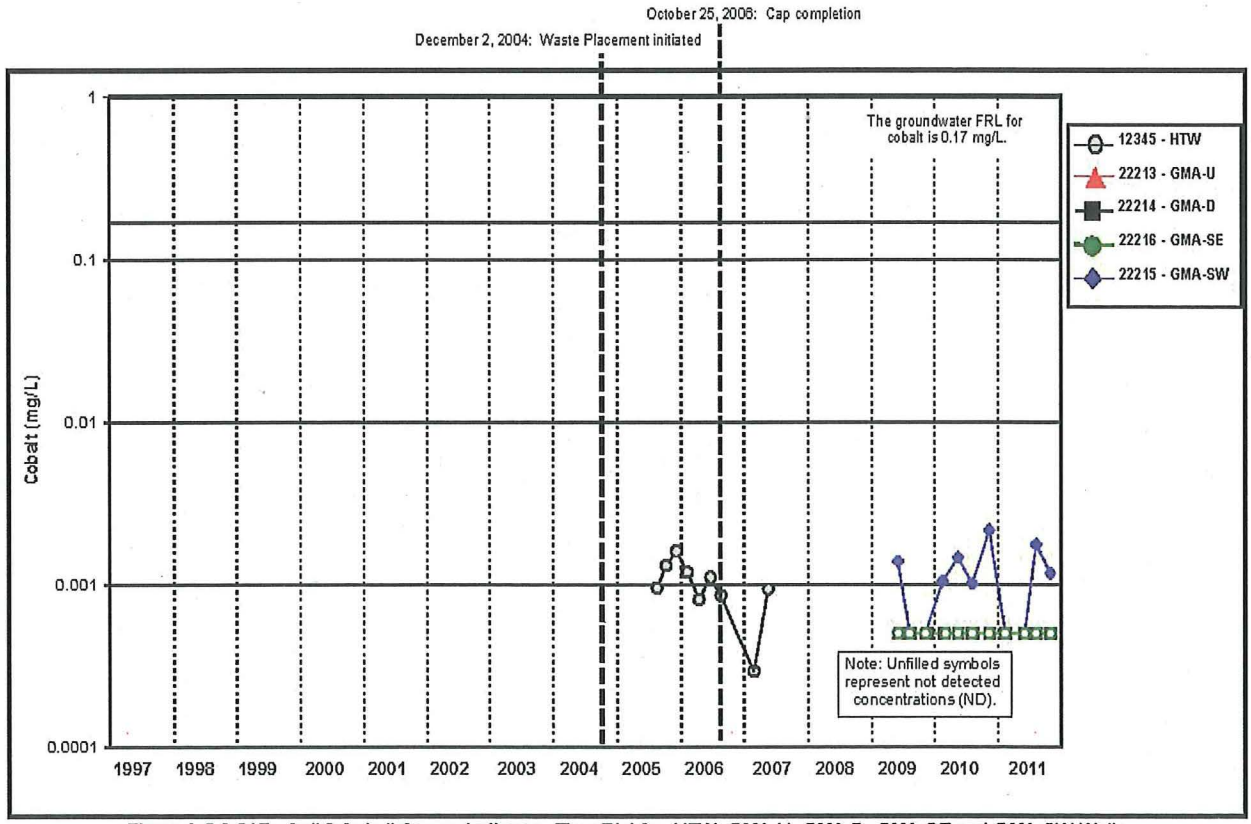


Figure A.5.8-21B. Cell 8 Cobalt Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

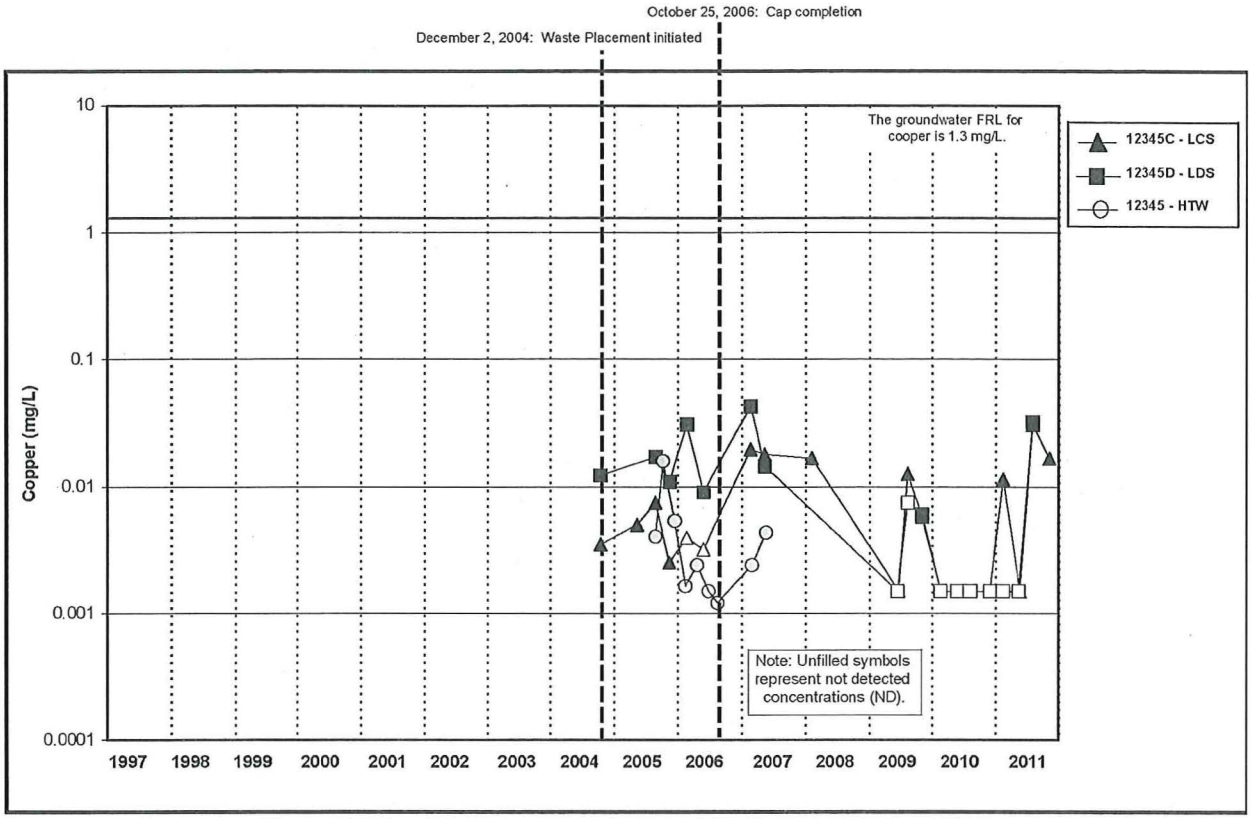


Figure A.5.8-22A. Cell 8 Copper Concentration vs. Time Plot for LCS, LDS, and HTW

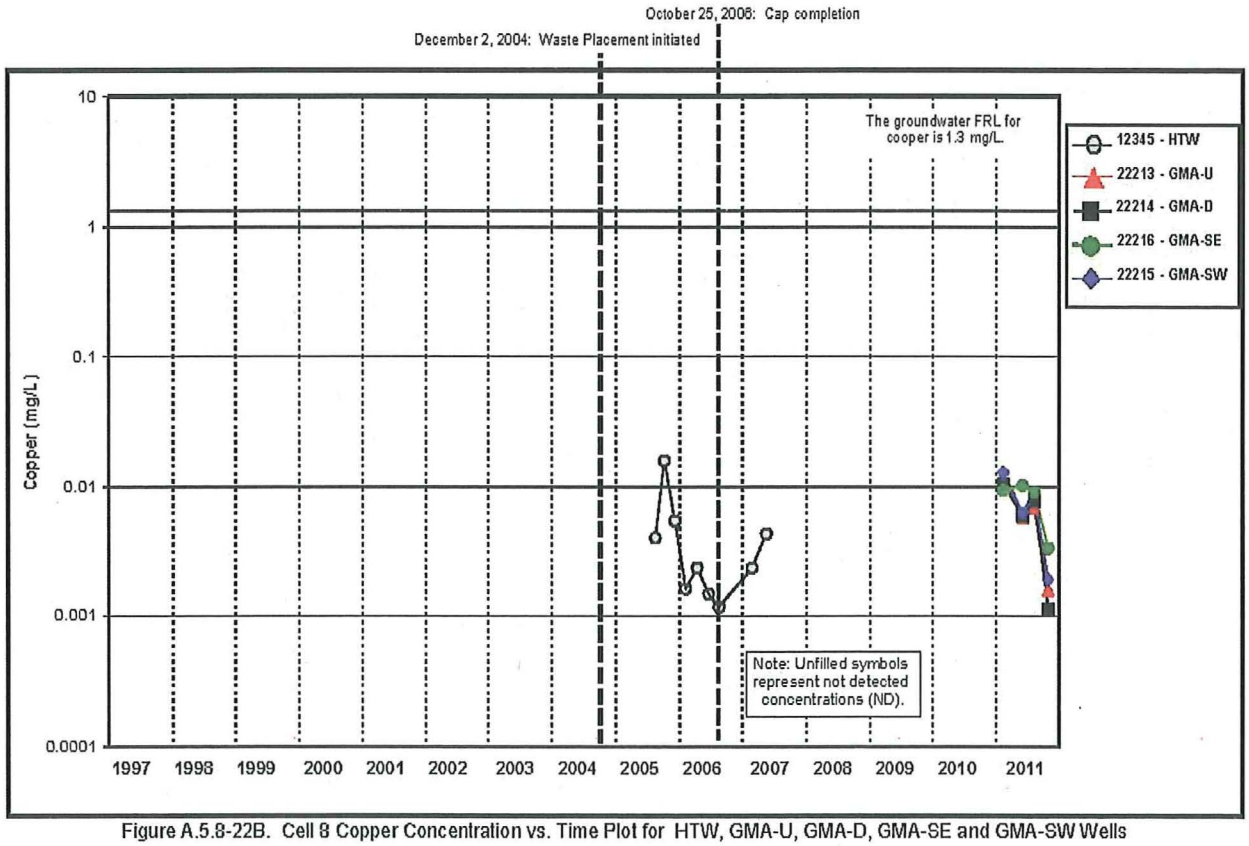


Figure A.5.8-22B. Cell 8 Copper Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

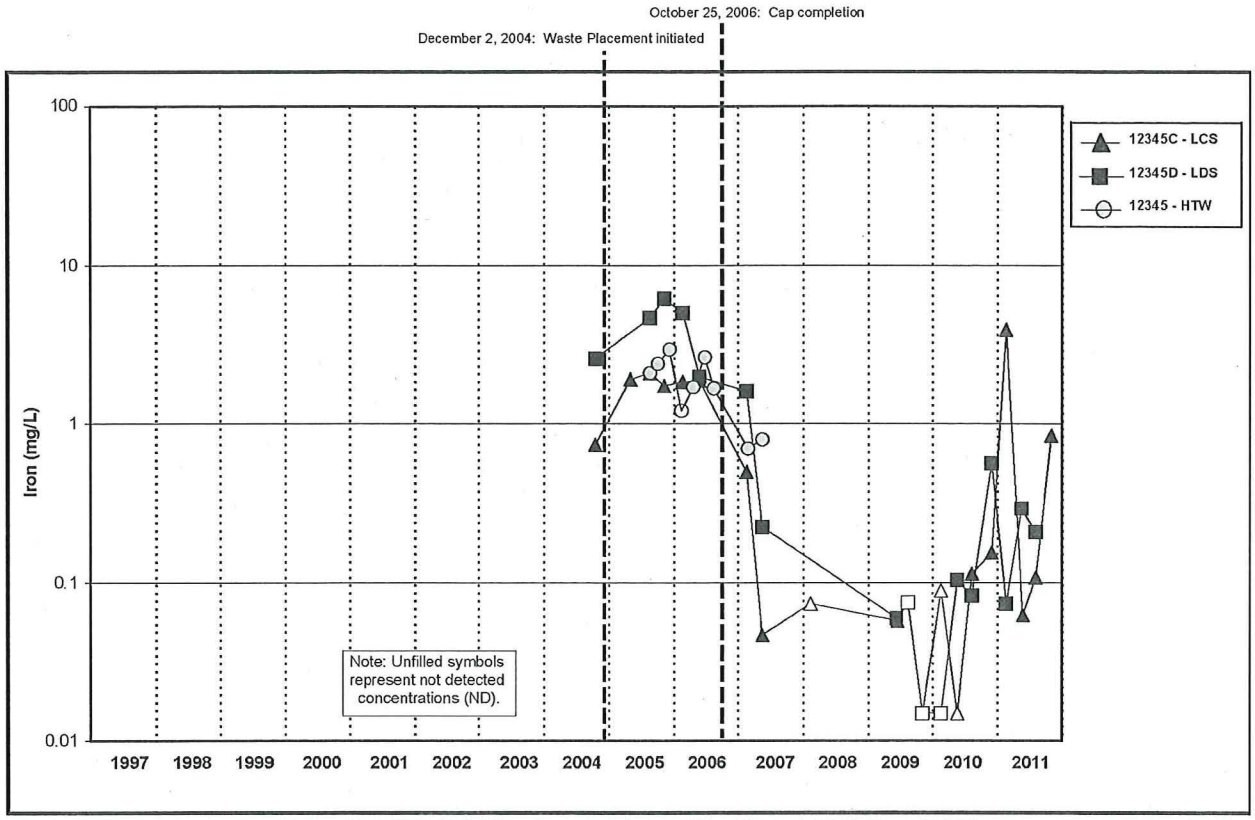


Figure A.5.8-23A. Cell 8 Iron Concentration vs. Time Plot for LCS, LDS, and HTW

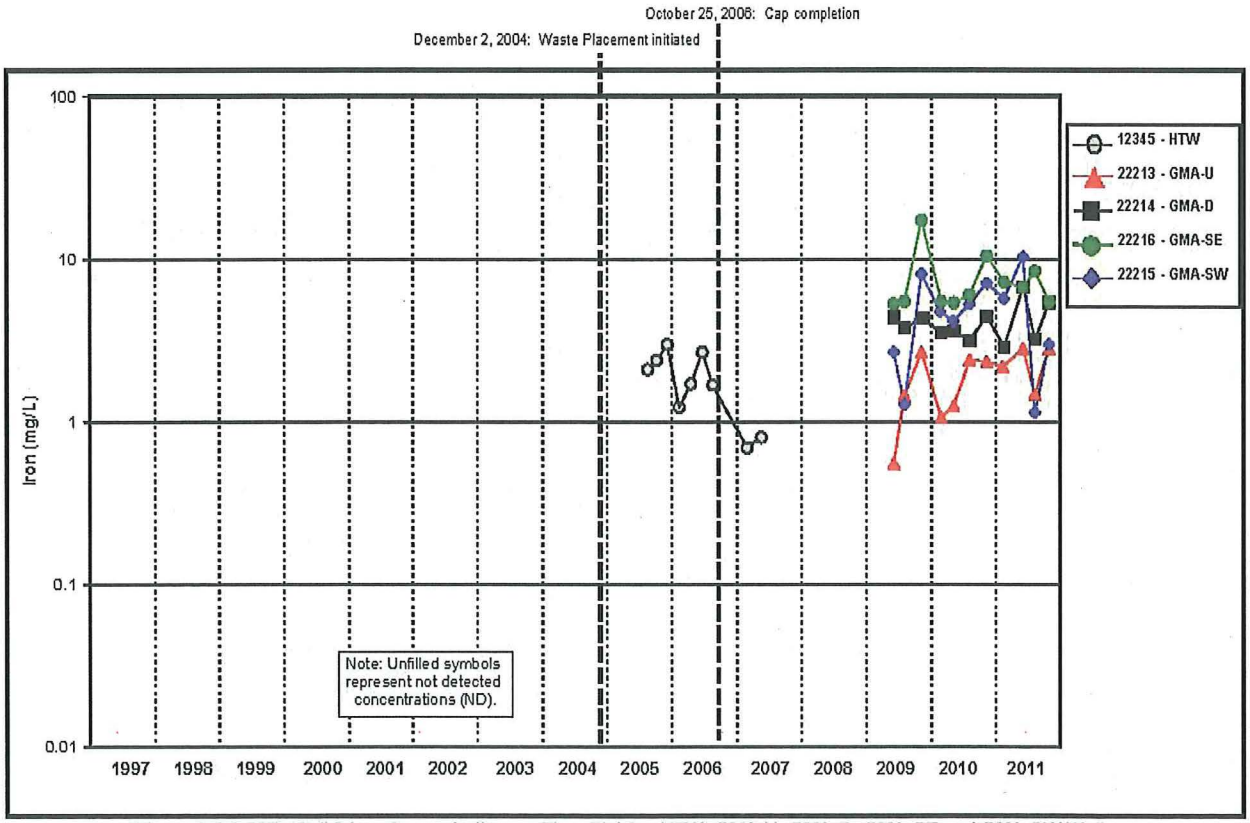


Figure A.5.8-23B. Cell 8 Iron Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

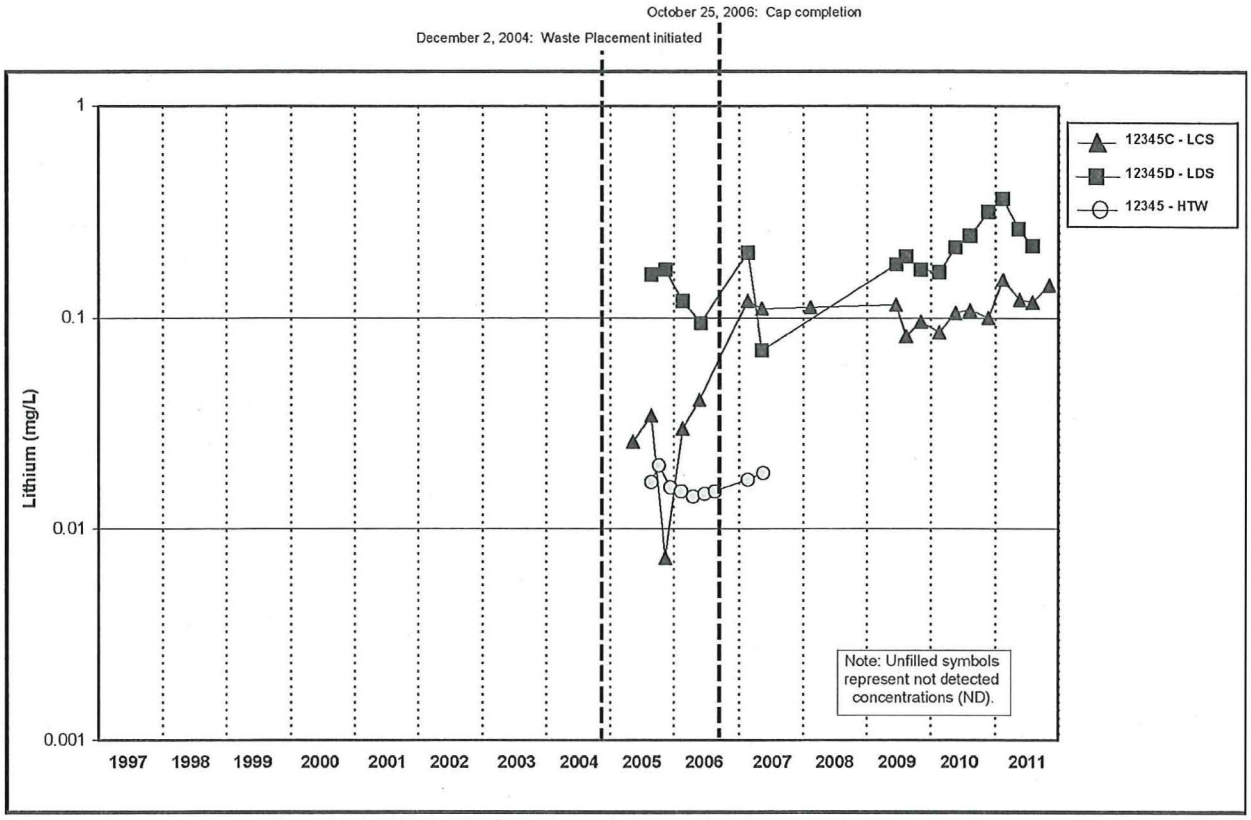


Figure A.5.8-24A. Cell 8 Lithium Concentration vs. Time Plot for LCS, LDS, and HTW

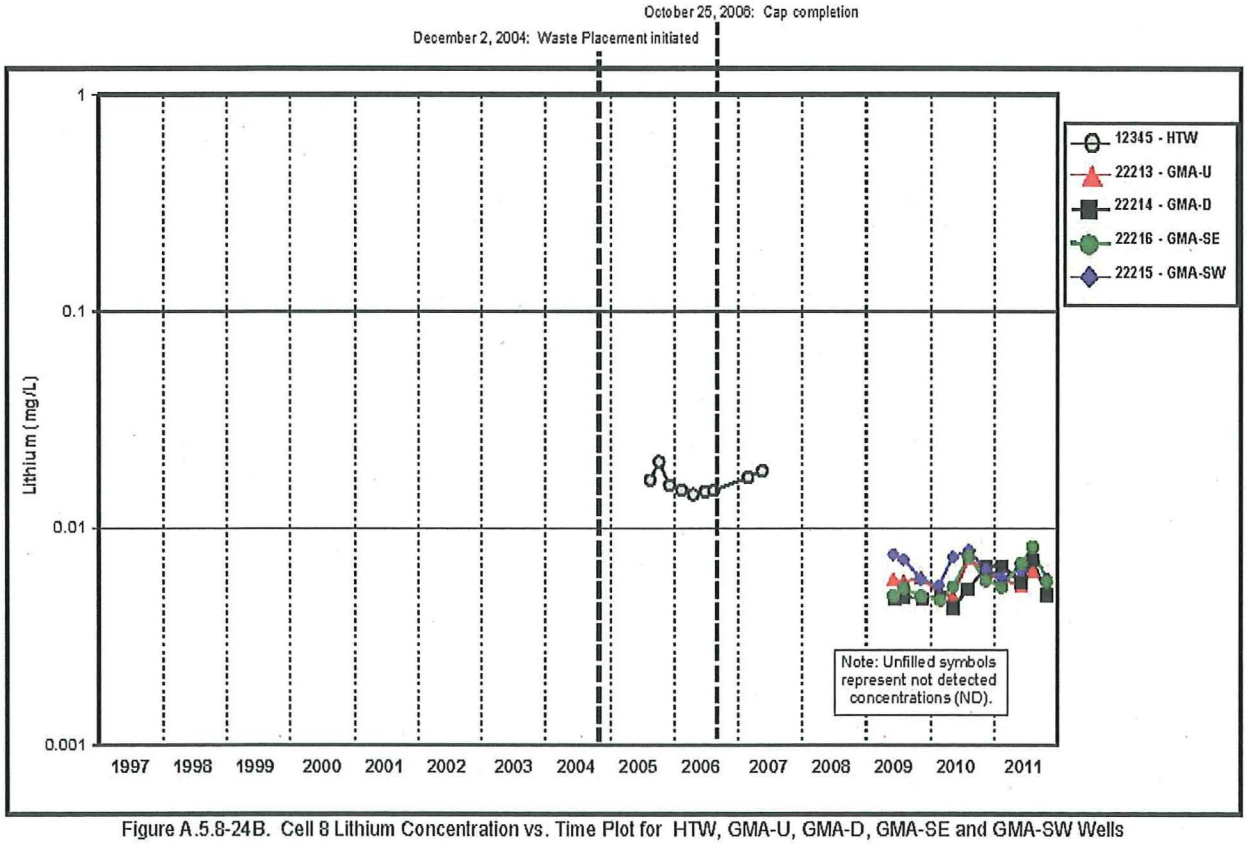


Figure A.5.8-24B. Cell 8 Lithium Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

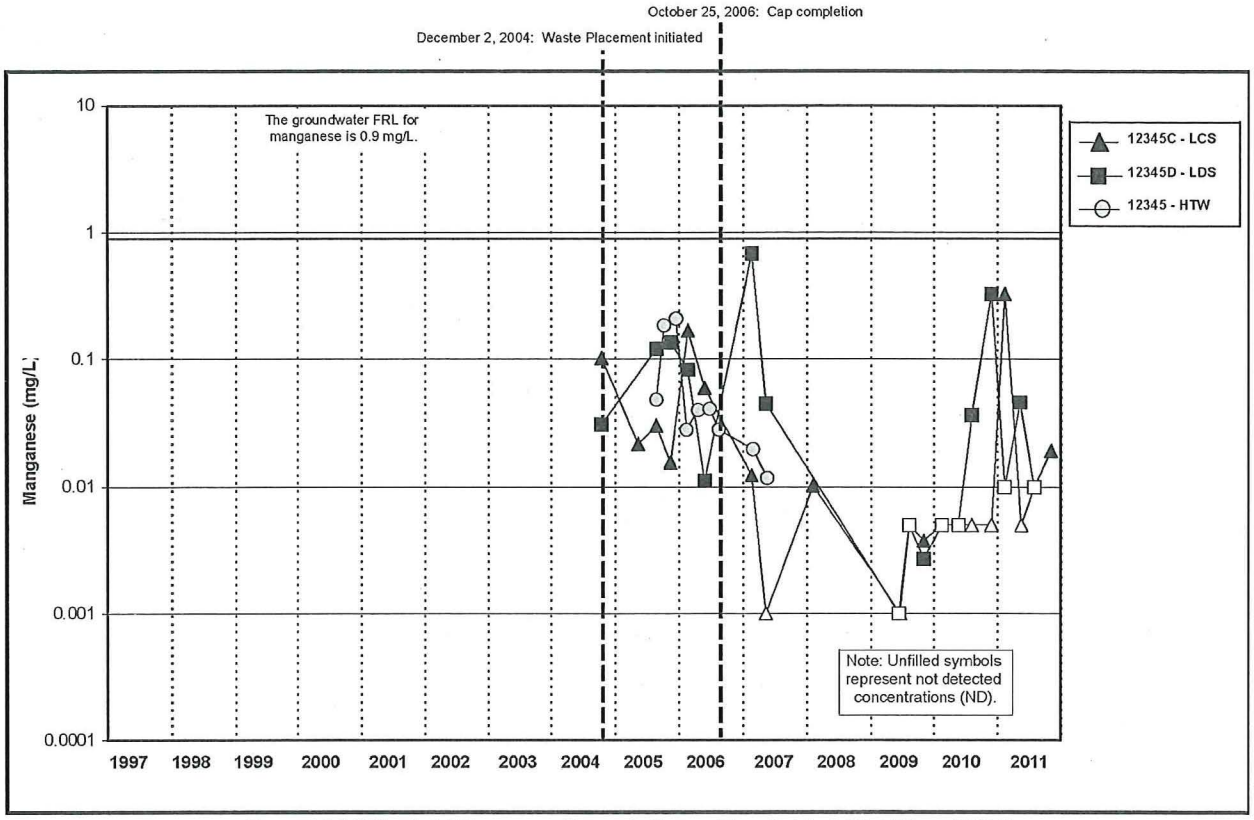


Figure A.5.8-25A. Cell 8 Manganese Concentration vs. Time Plot for LCS, LDS, and HTW

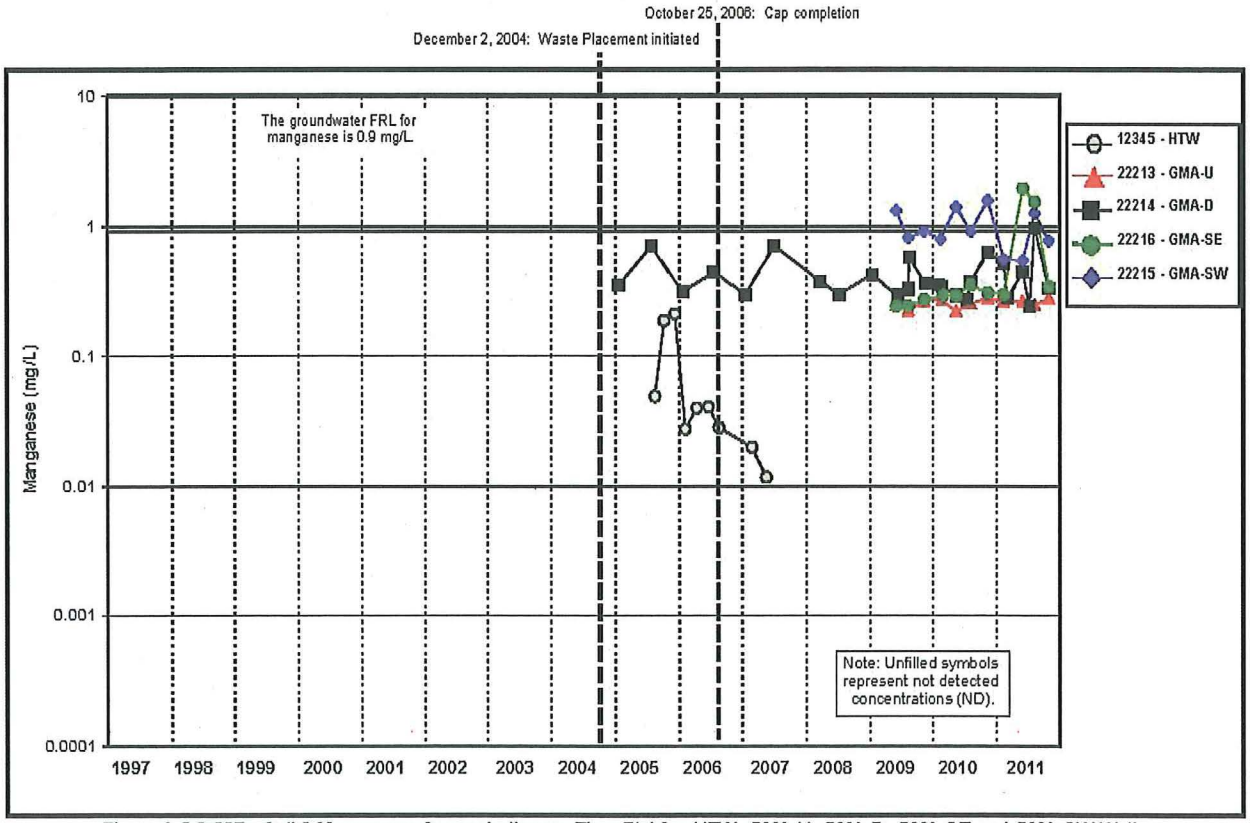


Figure A.5.8-25B. Cell 8 Manganese Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

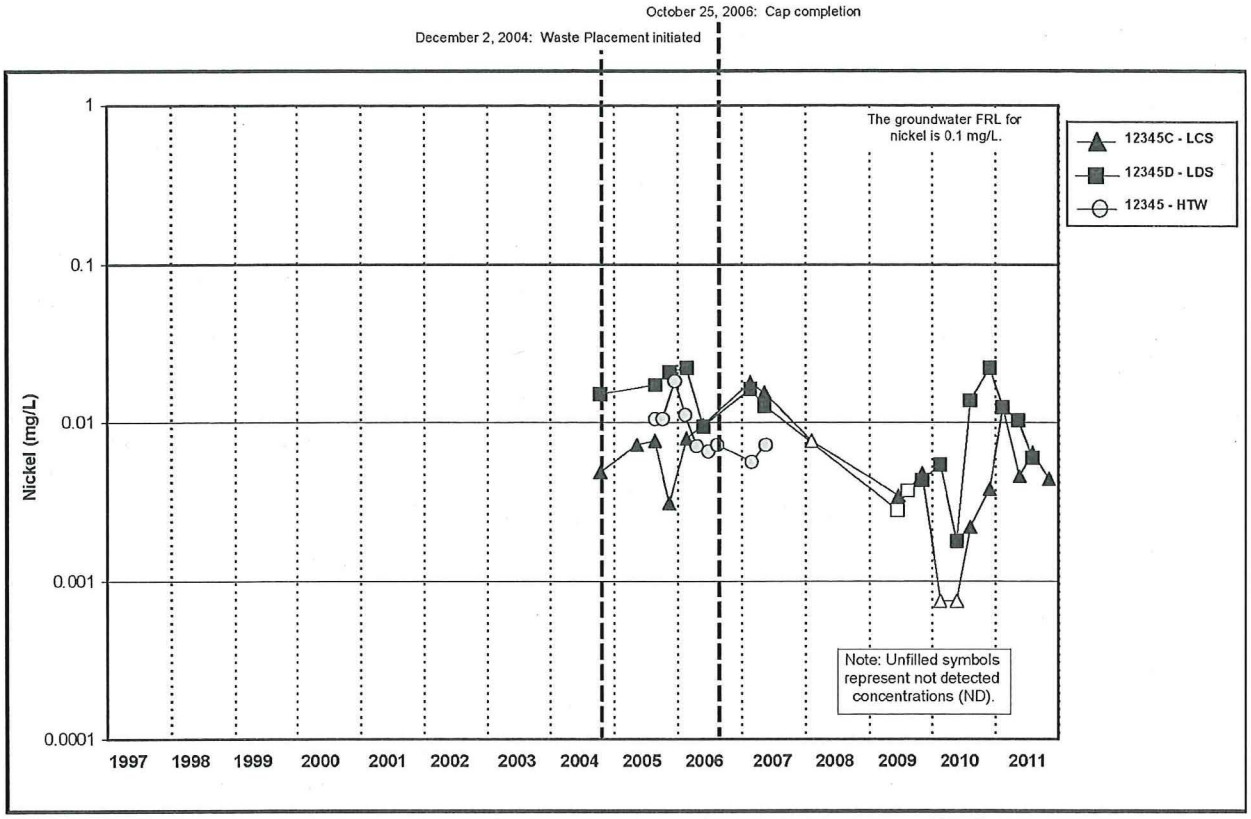


Figure A.5.8-26A. Cell 8 Nickel Concentration vs. Time Plot for LCS, LDS, and HTW

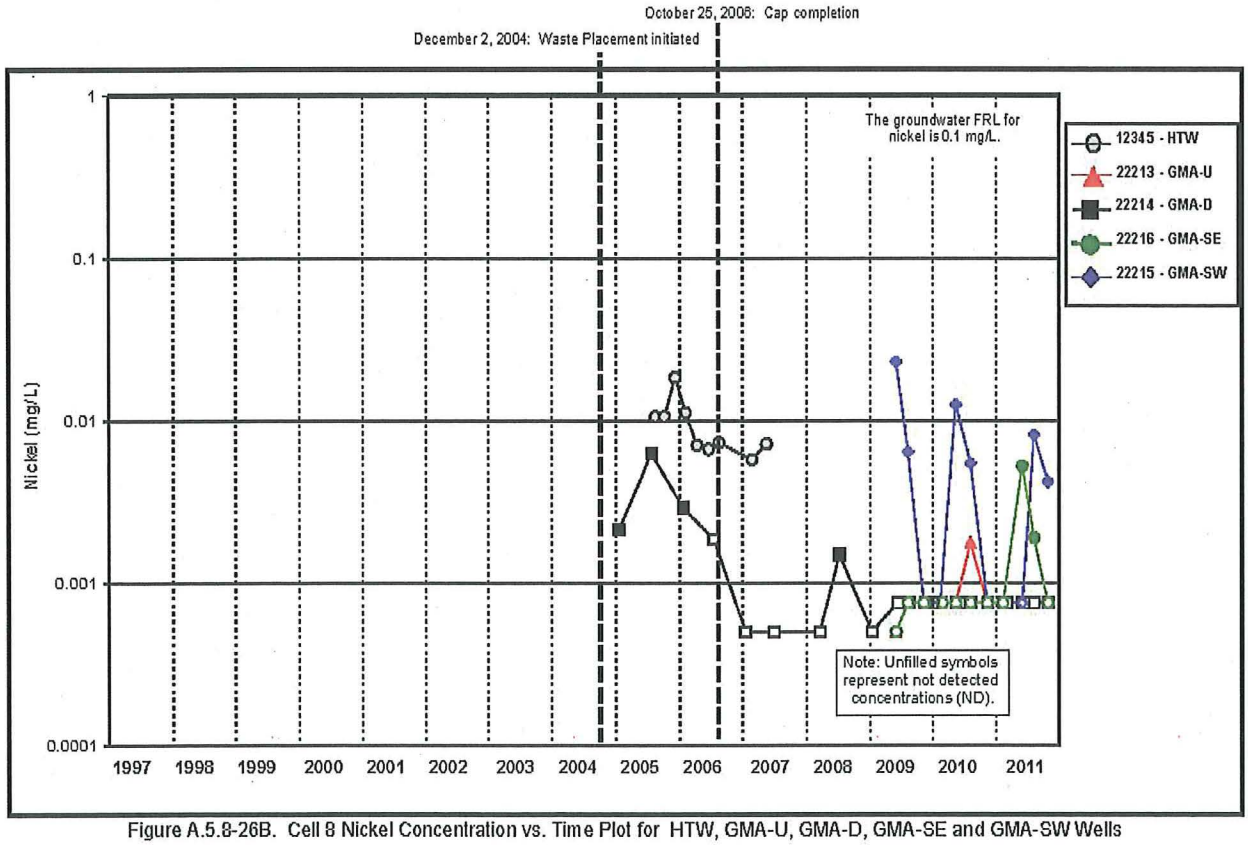


Figure A.5.8-26B. Cell 8 Nickel Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

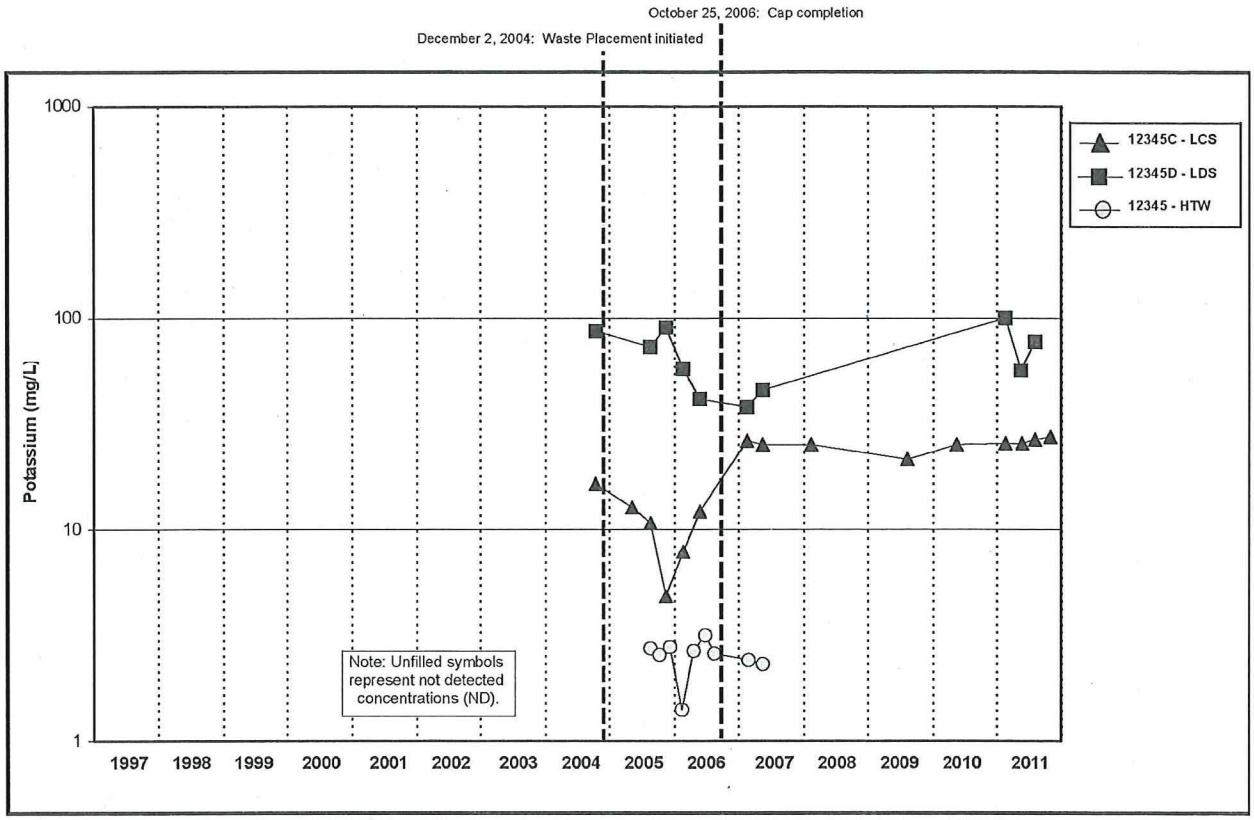


Figure A.5.8-27A. Cell 8 Potassium Concentration vs. Time Plot for LCS, LDS, and HTW

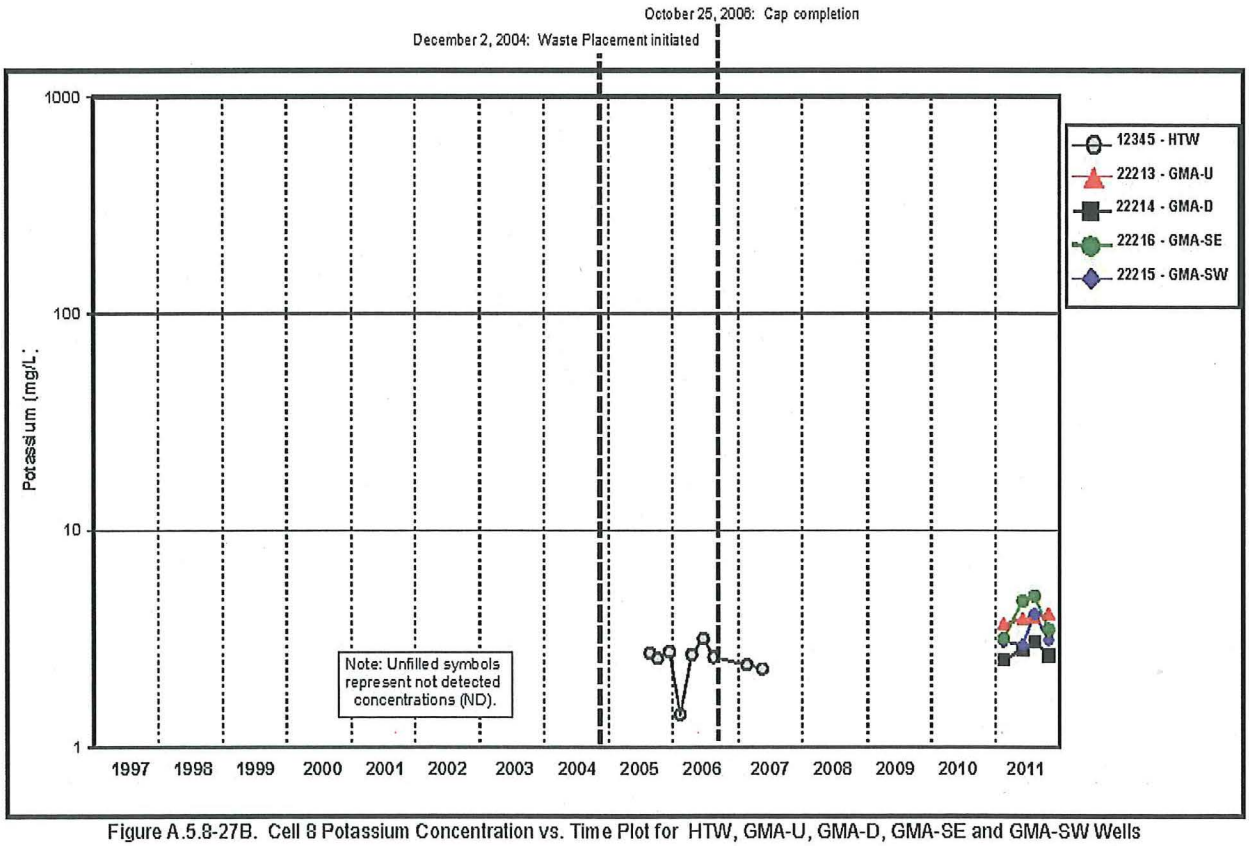


Figure A.5.8-27B. Cell 8 Potassium Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

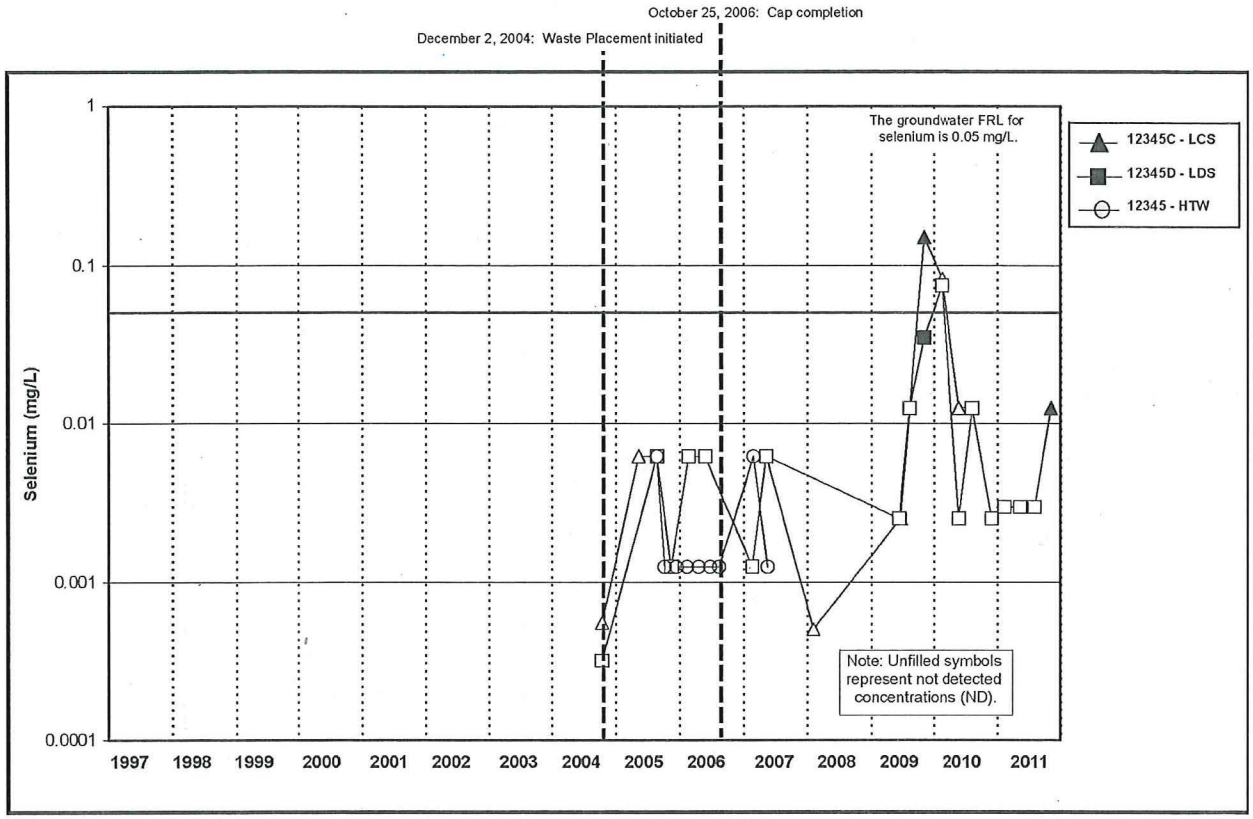


Figure A.5.8-28A. Cell 8 Selenium Concentration vs. Time Plot for LCS, LDS, and HTW

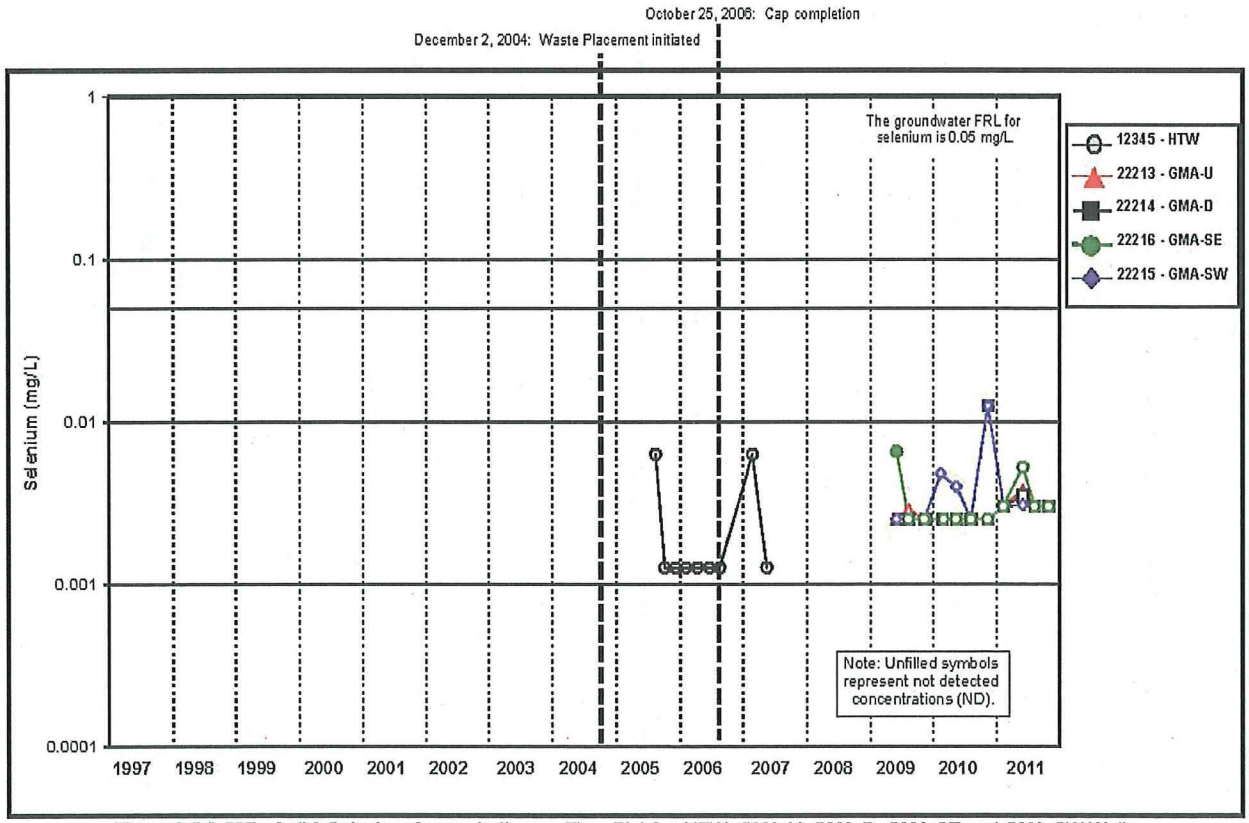


Figure A.5.8-28B. Cell 8 Selenium Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

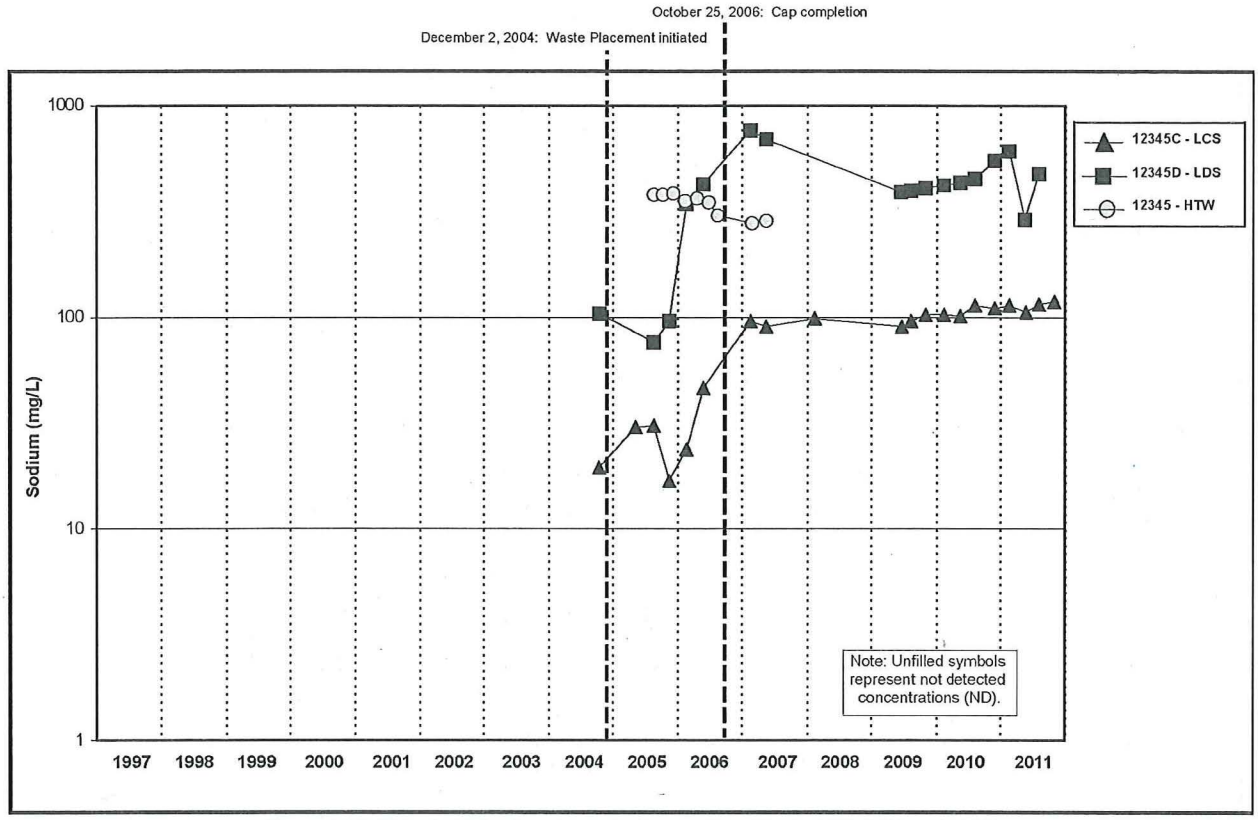


Figure A.5.8-29A. Cell 8 Sodium Concentration vs. Time Plot for LCS, LDS, and HTW

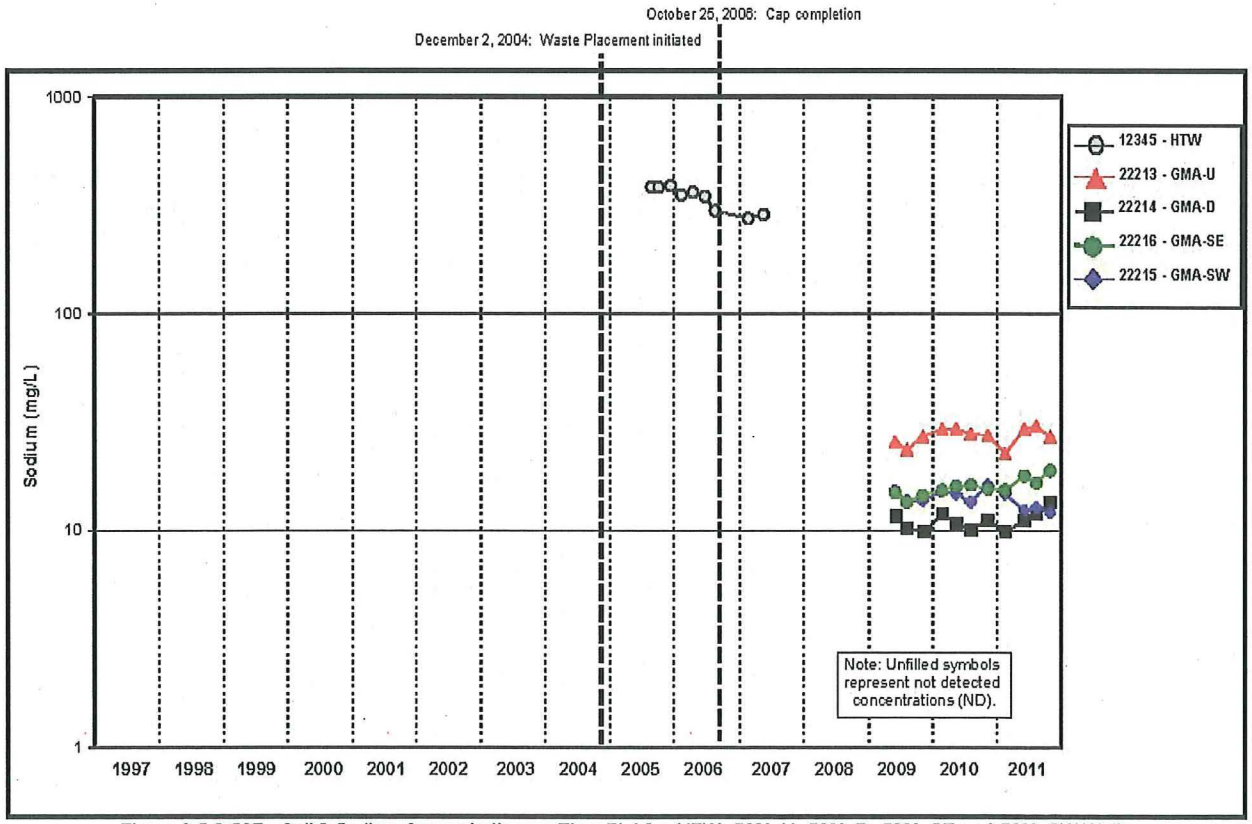


Figure A.5.8-29B. Cell 8 Sodium Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

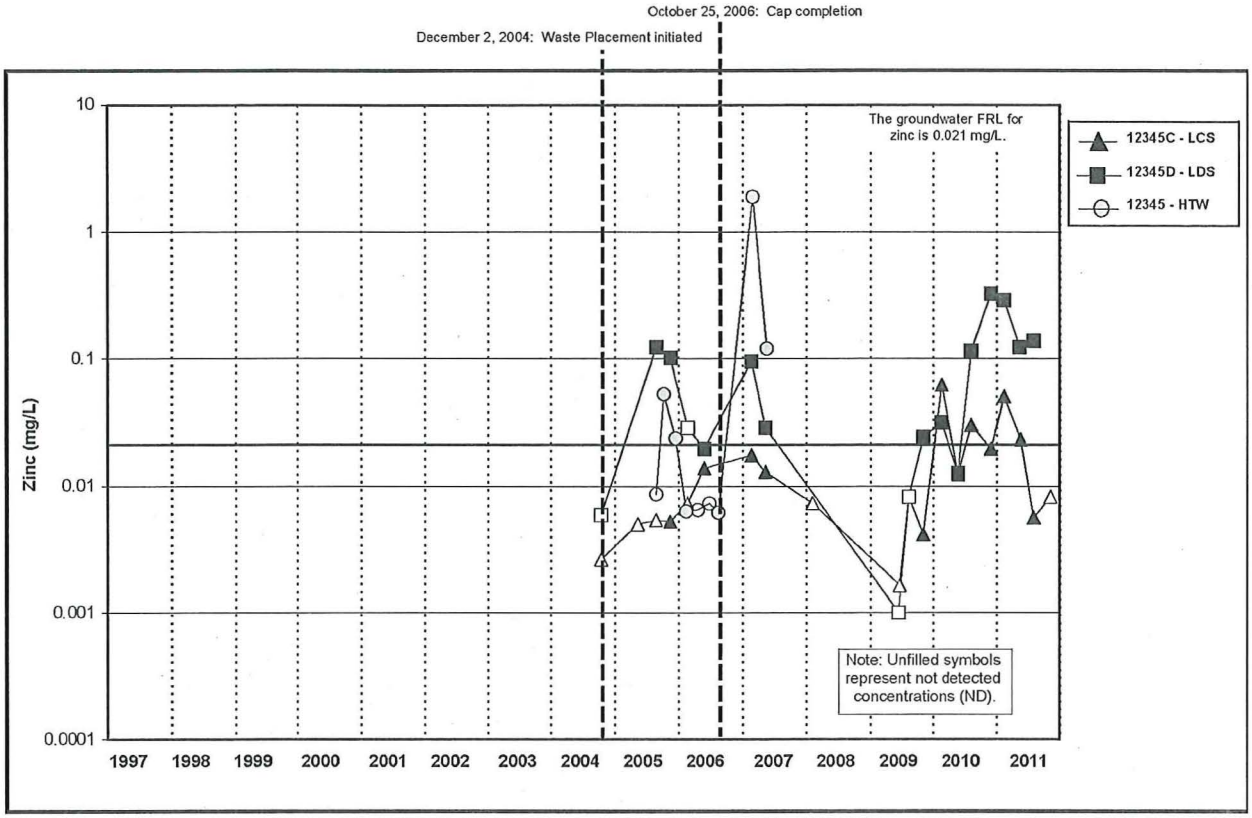


Figure A.5.8-30A. Cell 8 Zinc Concentration vs. Time Plot for LCS, LDS, and HTW

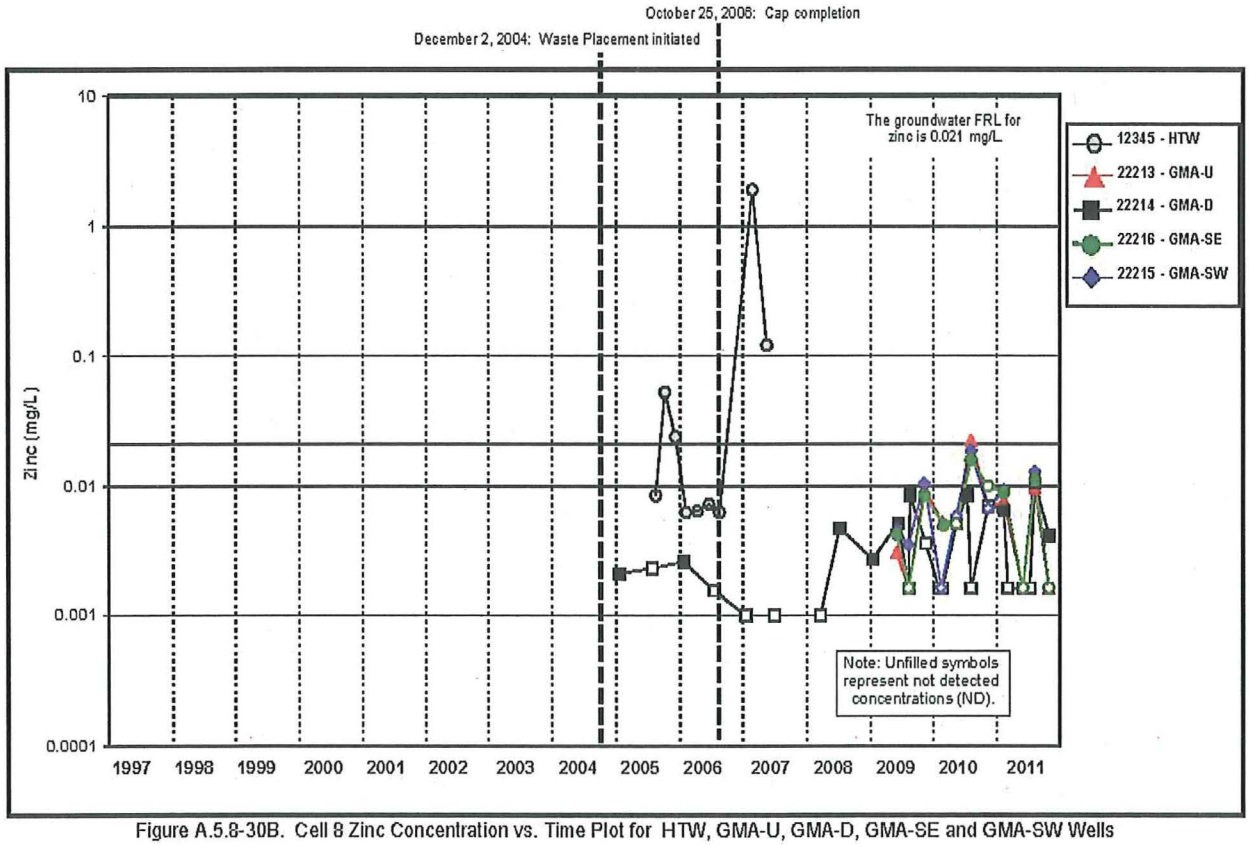


Figure A.5.8-30B. Cell 8 Zinc Concentration vs. Time Plot for HTW, GMA-U, GMA-D, GMA-SE and GMA-SW Wells

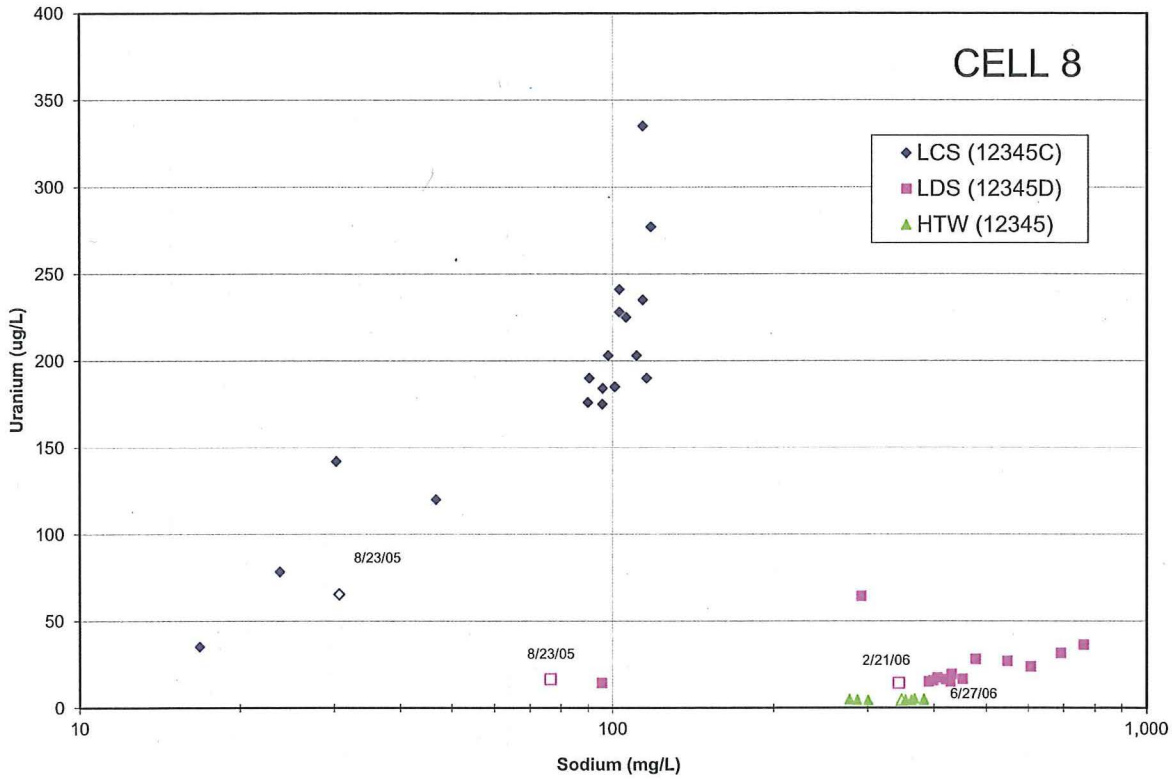


Figure A.5.8-31. Cell 8 Bivariate Plot for Uranium and Sodium

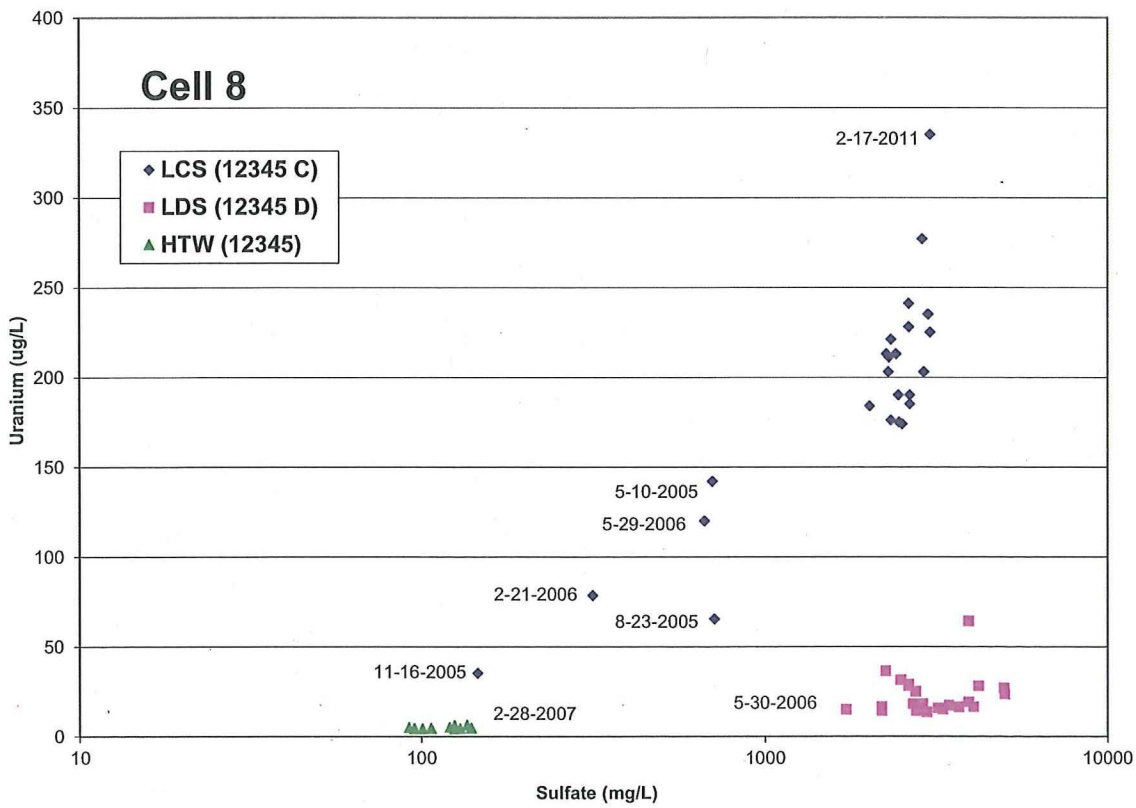


Figure A.5.8-32. Cell 8 Bivariate Plot for Uranium and Sulfate

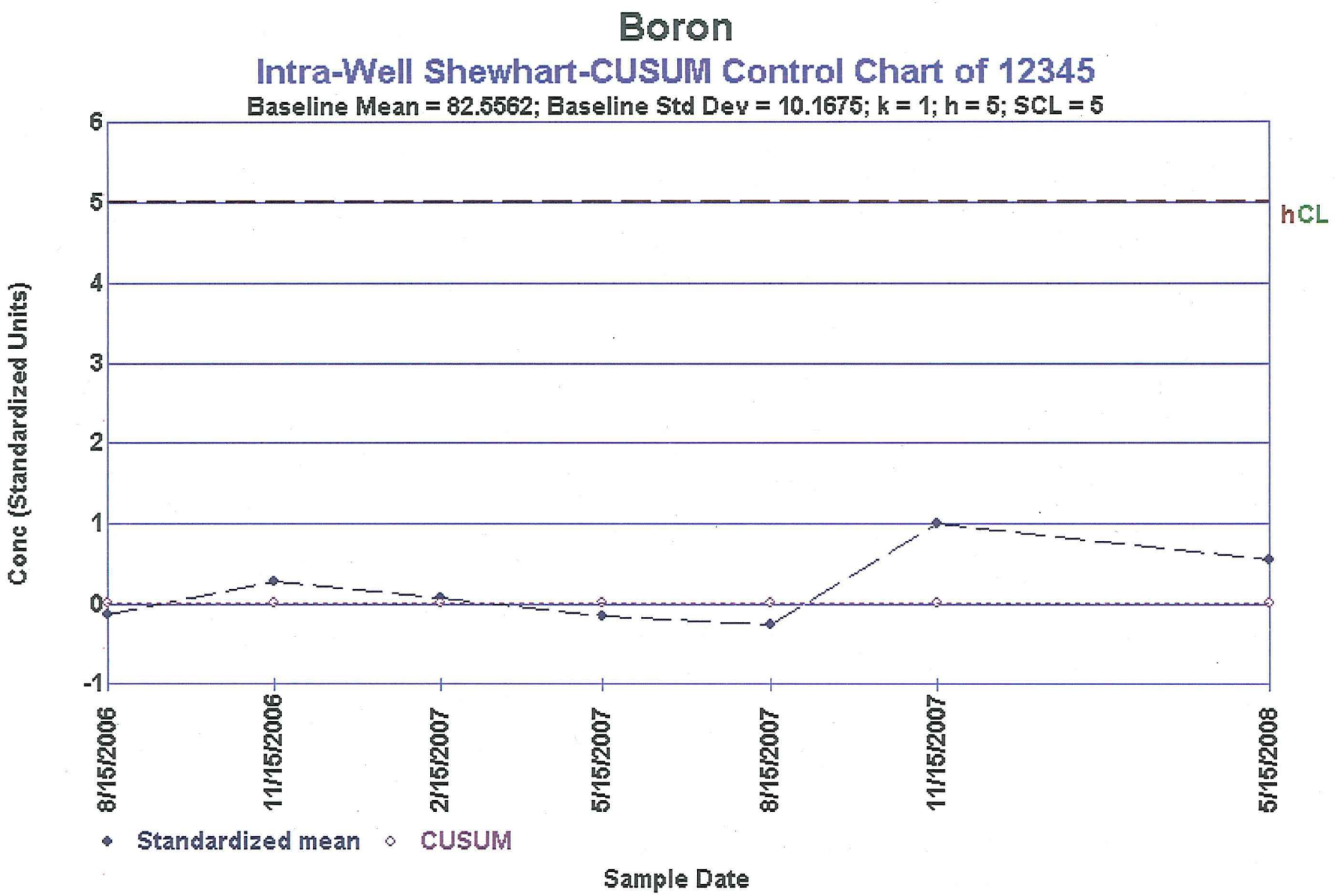


Figure A.5.8−33. Intra-Well Shewhart-CUSUM Control Chart (Boron 12345)

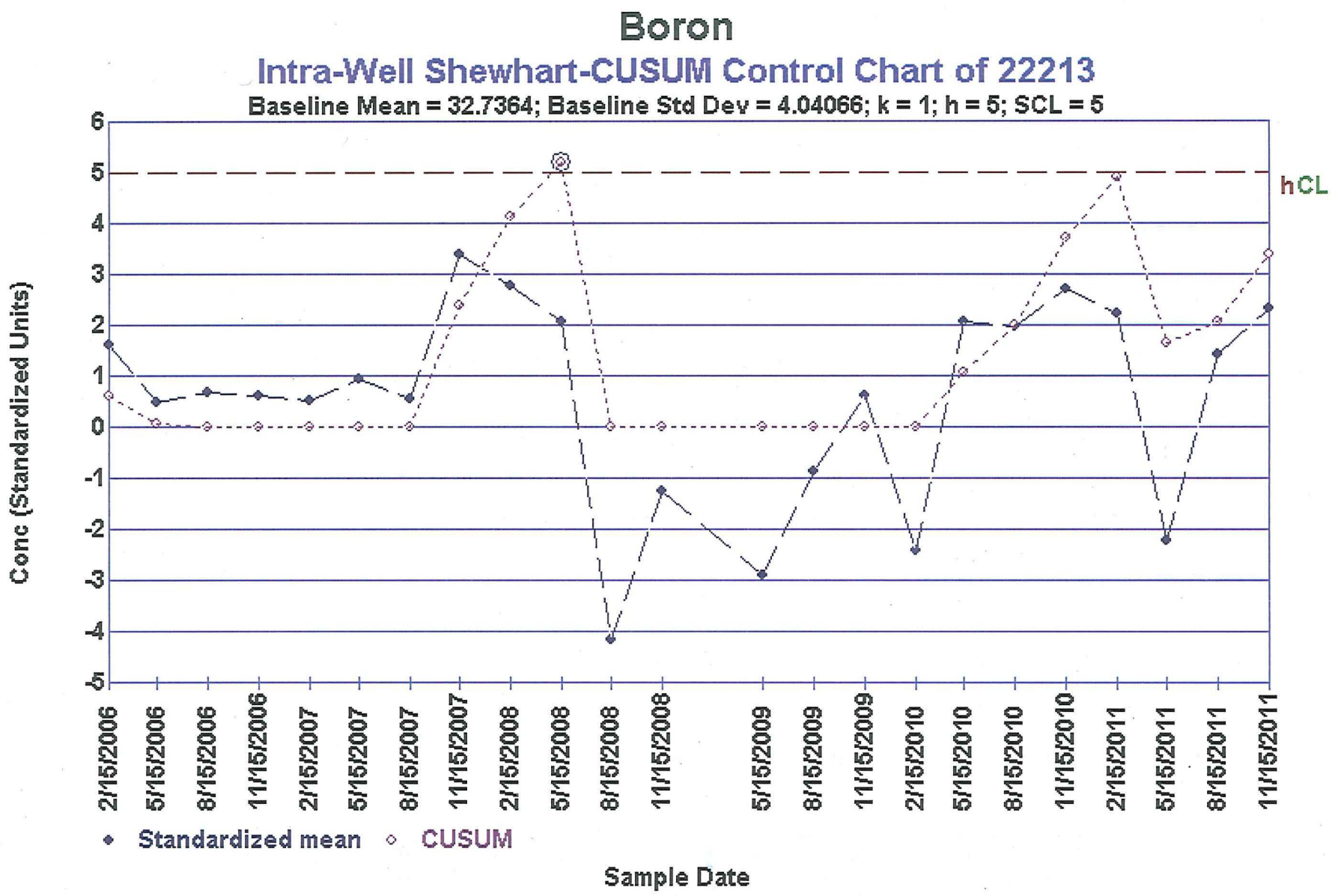


Figure A.5.8–34. Intra-Well Shewhart-CUSUM Control Chart (Boron 22213)

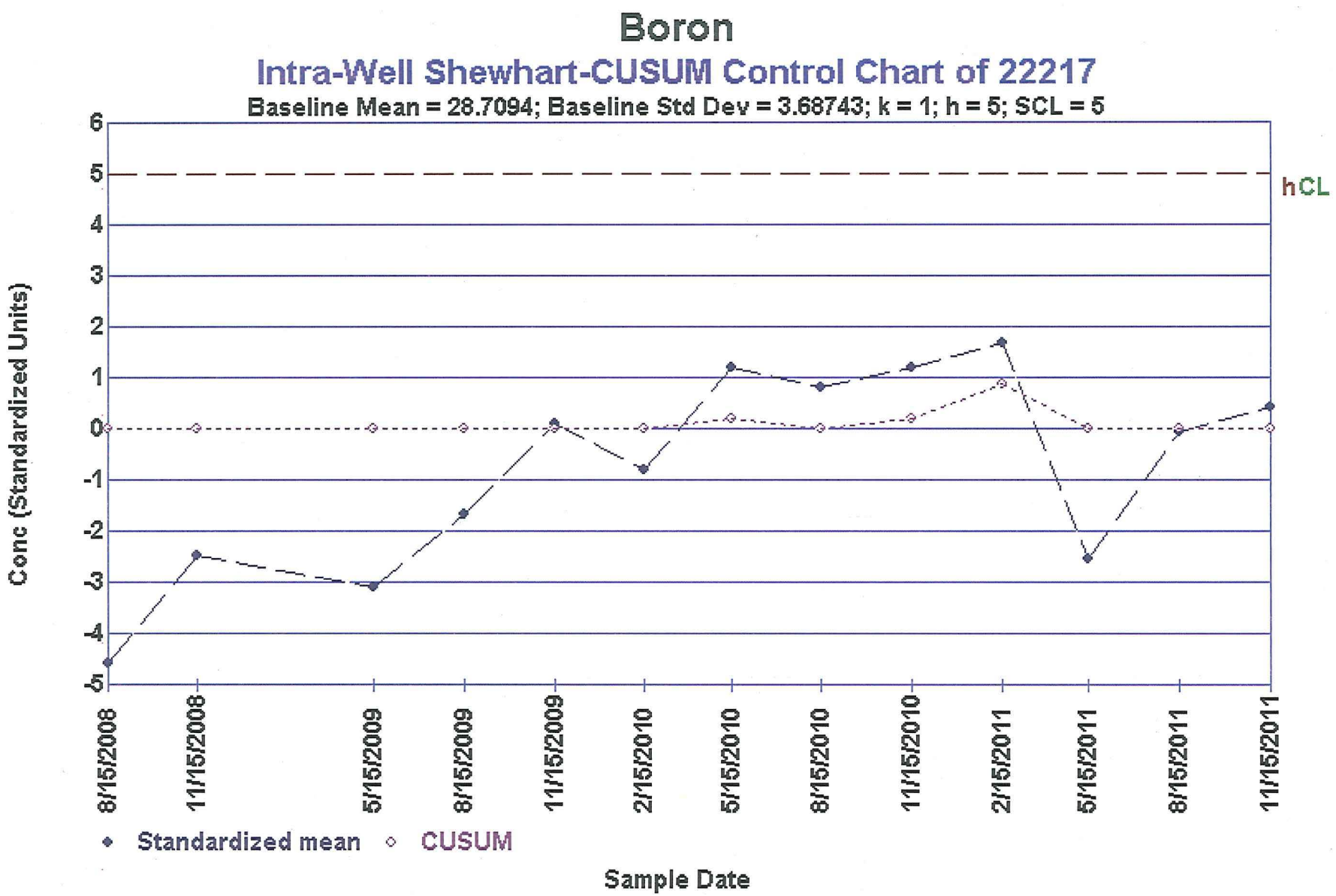


Figure A.5.8−35. Intra-Well Shewhart-CUSUM Control Chart (Boron 22217)

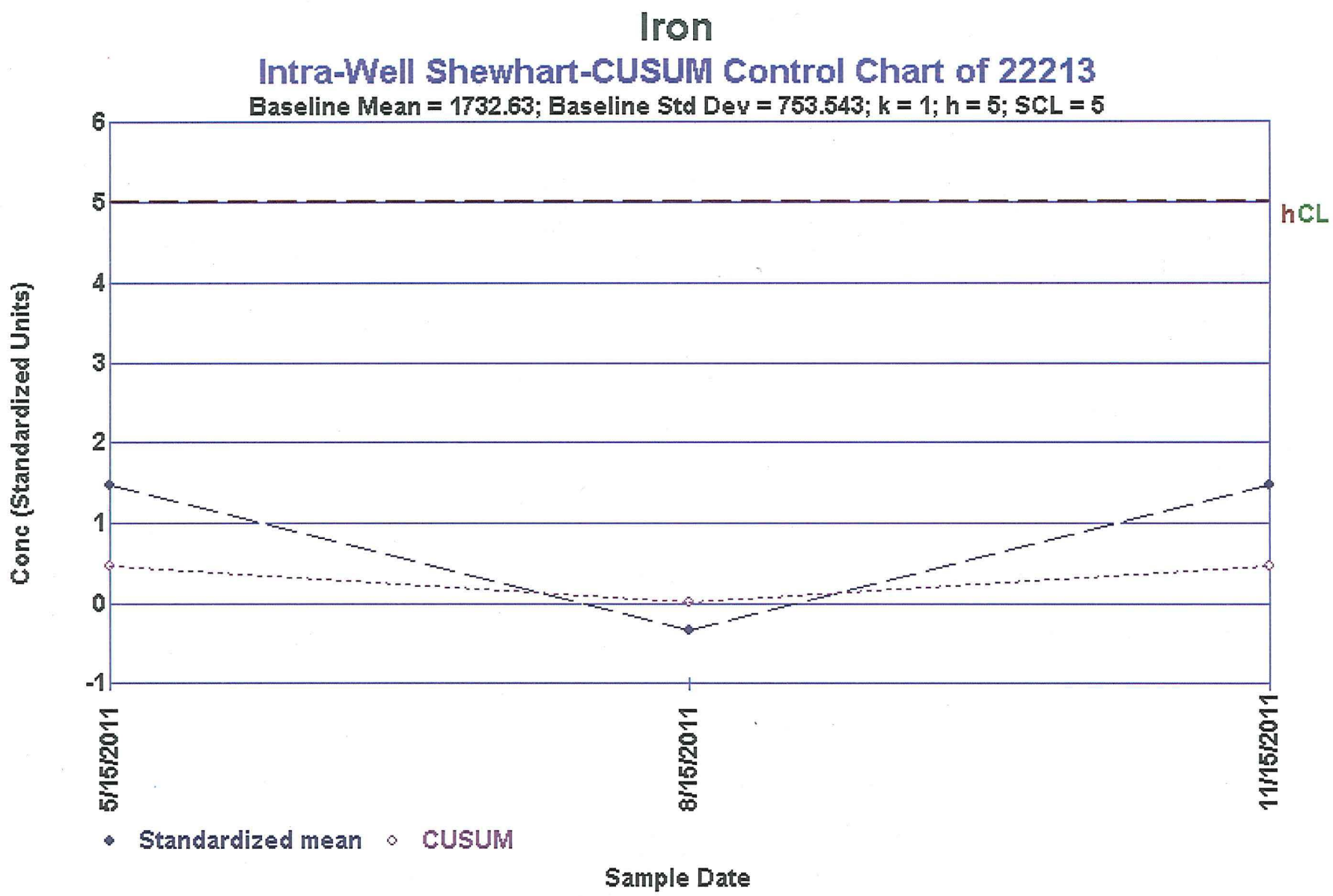


Figure A.5.8−36. Intra-Well Shewhart-CUSUM Control Chart (Iron 22213)

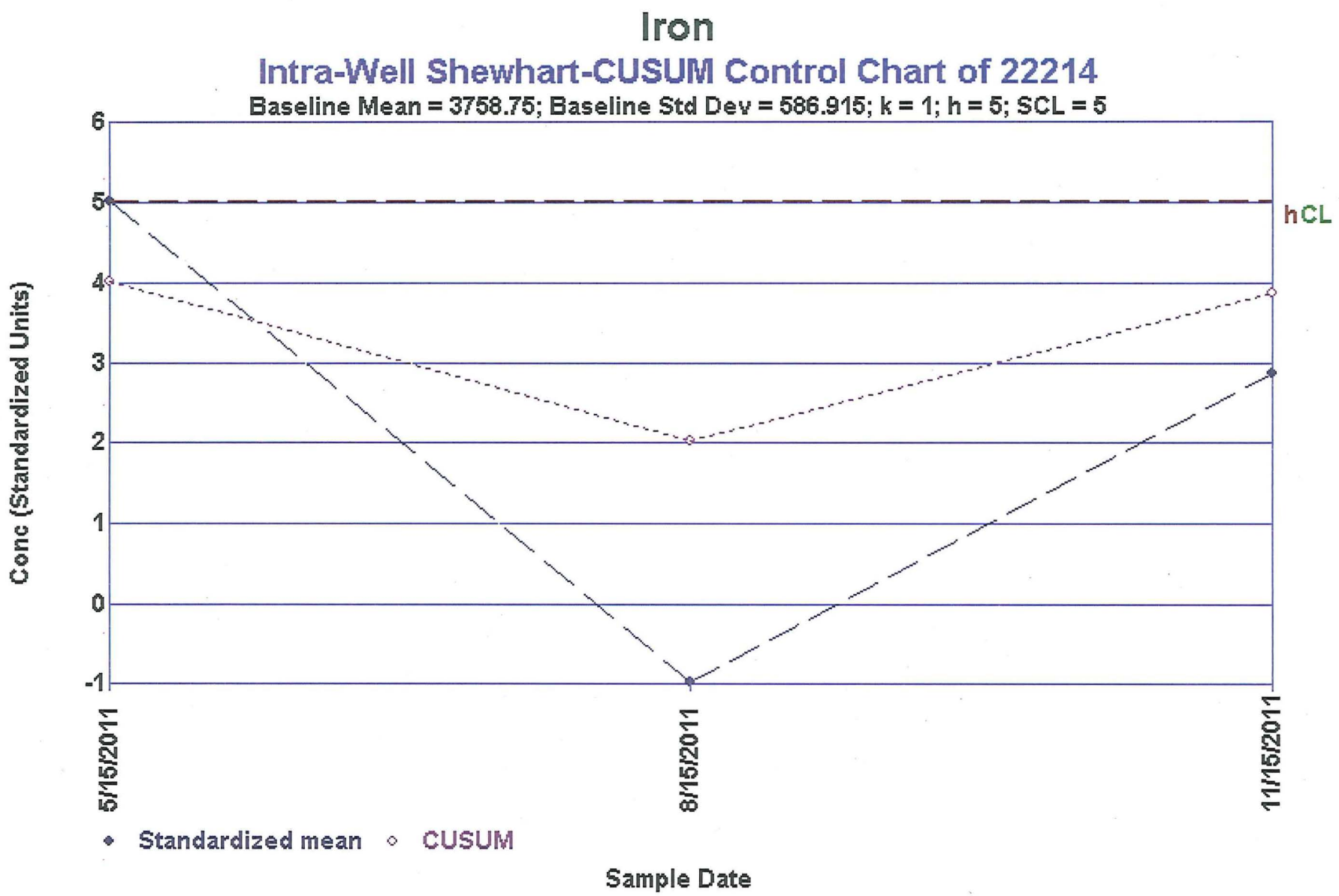


Figure A.5.8−37. Intra-Well Shewhart-CUSUM Control Chart (Iron 22214)

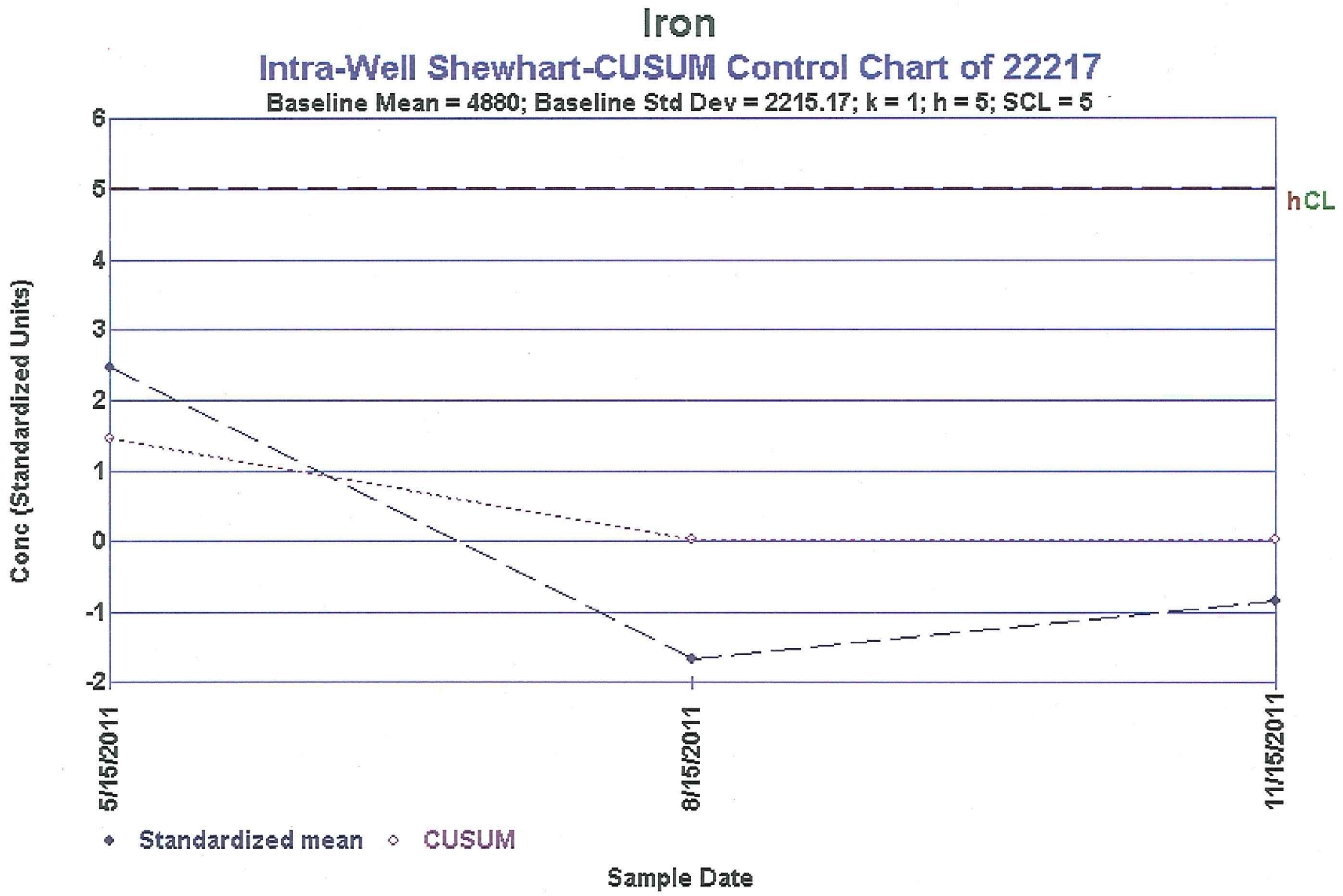


Figure A.5.8−38. Intra-Well Shewhart-CUSUM Control Chart (Iron 22217)

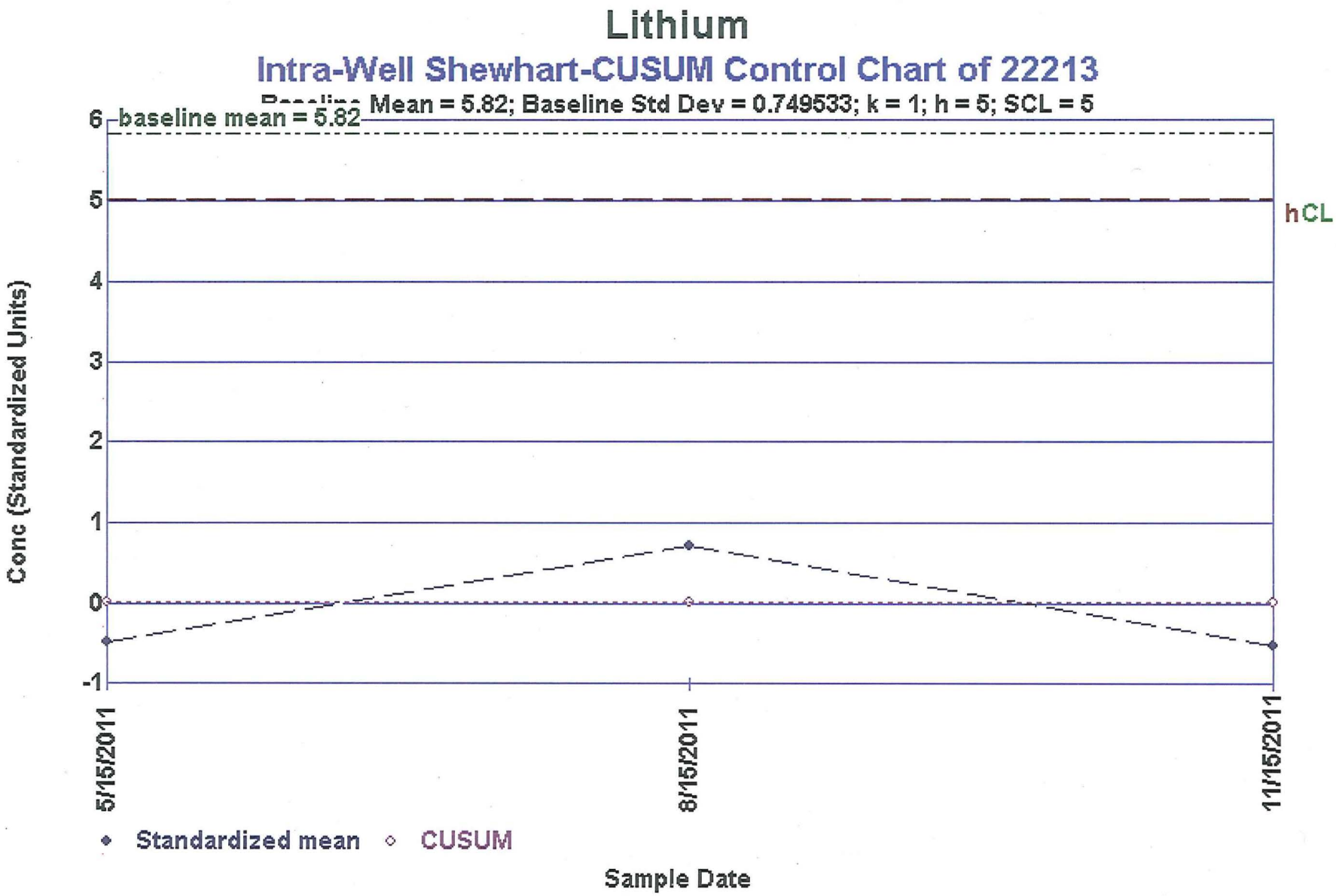


Figure A.5.8−39. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22213)

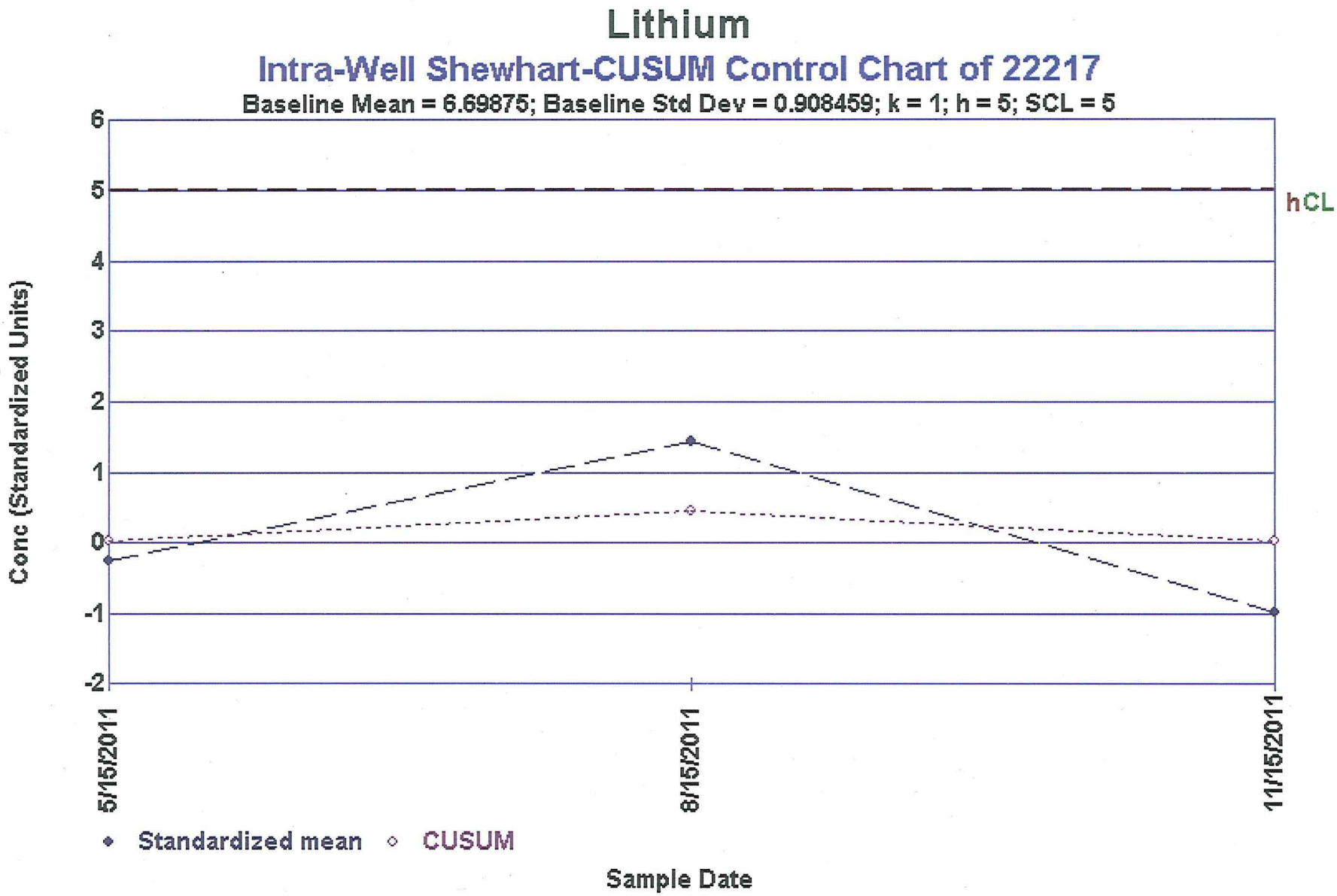


Figure A.5.8−40. Intra-Well Shewhart-CUSUM Control Chart (Lithium 22217)

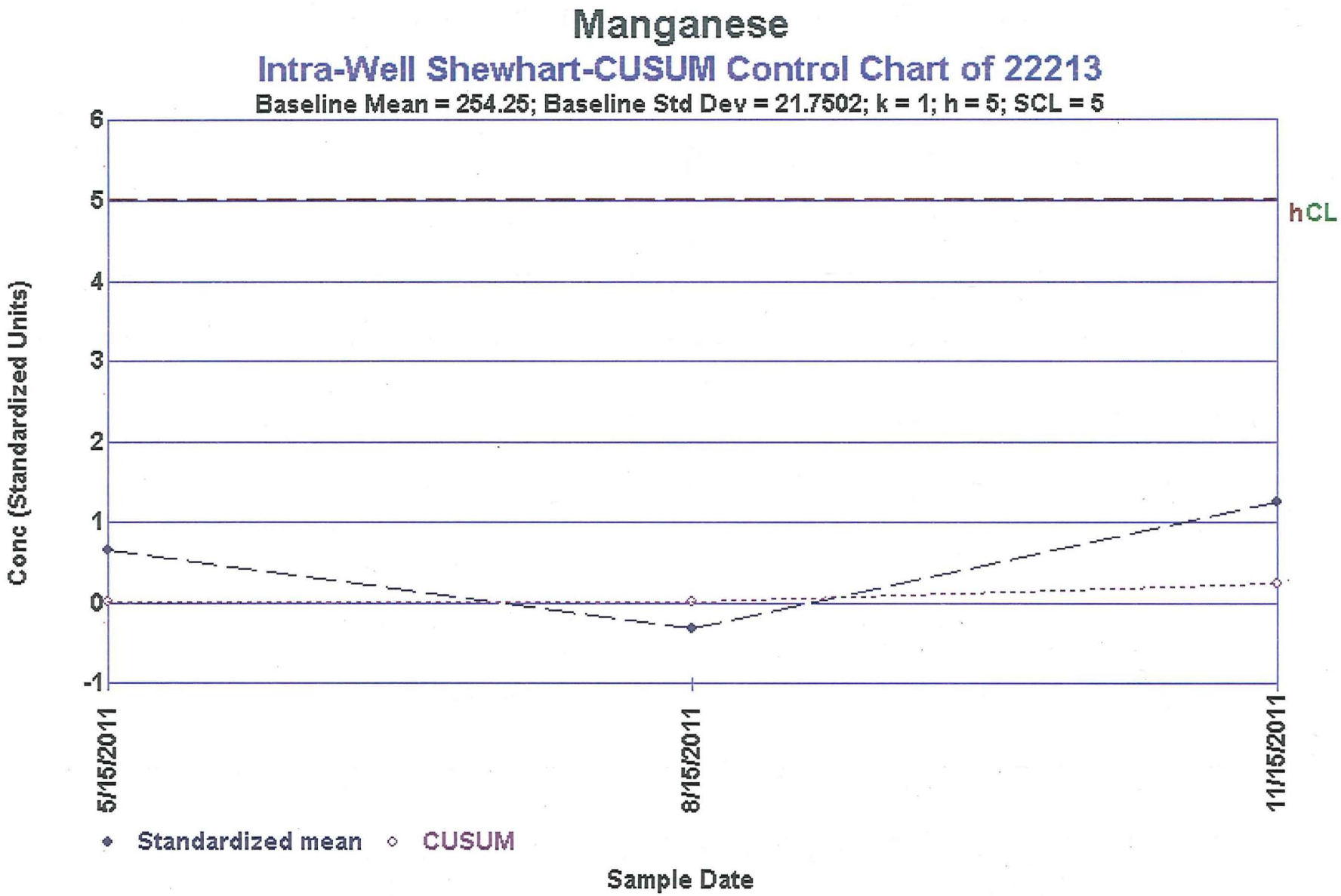


Figure A.5.8−41. Intra-Well Shewhart-CUSUM Control Chart (Manganese 22213)

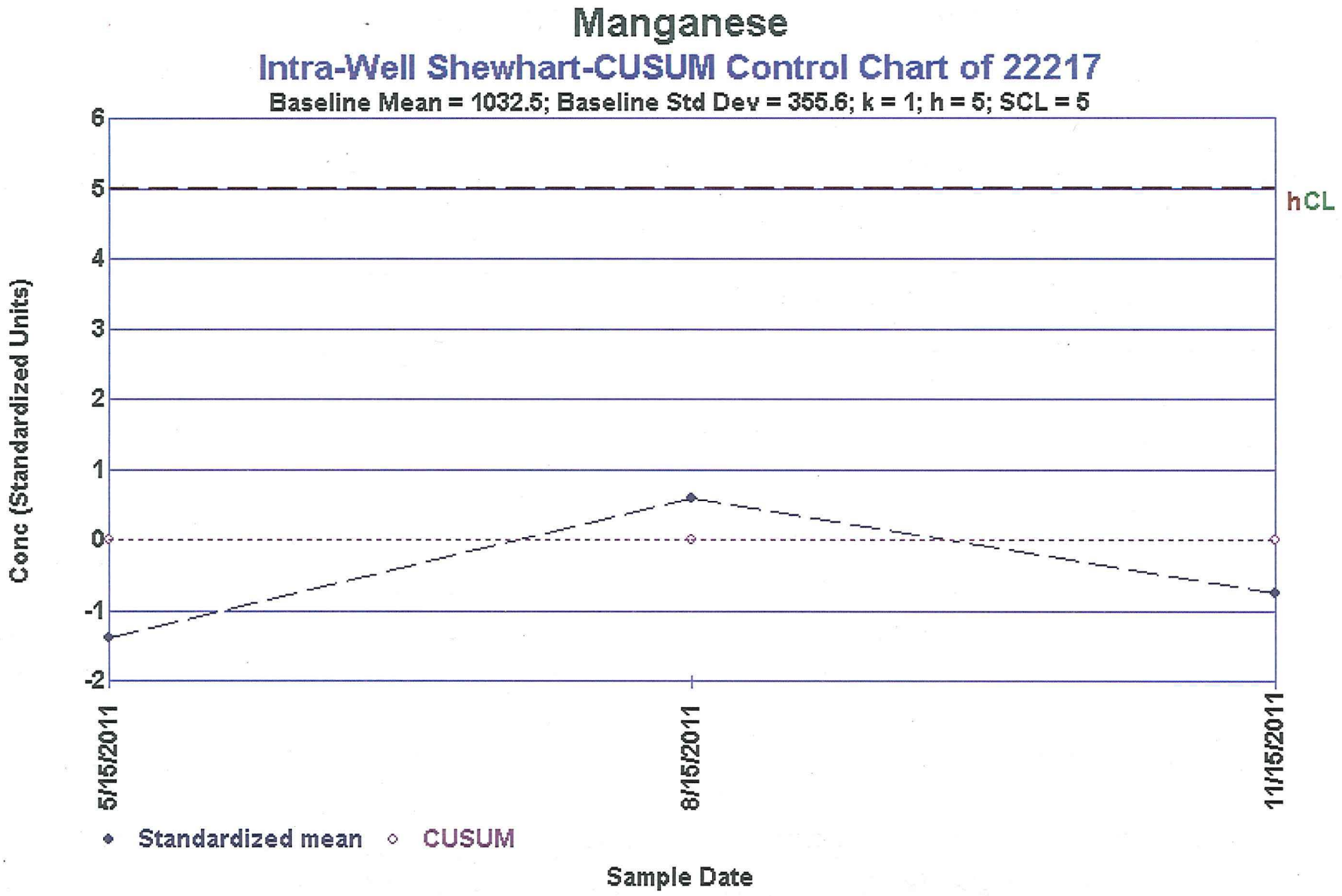


Figure A.5.8–42. Intra-Well Shewhart-CUSUM Control Chart (Manganese 22217)

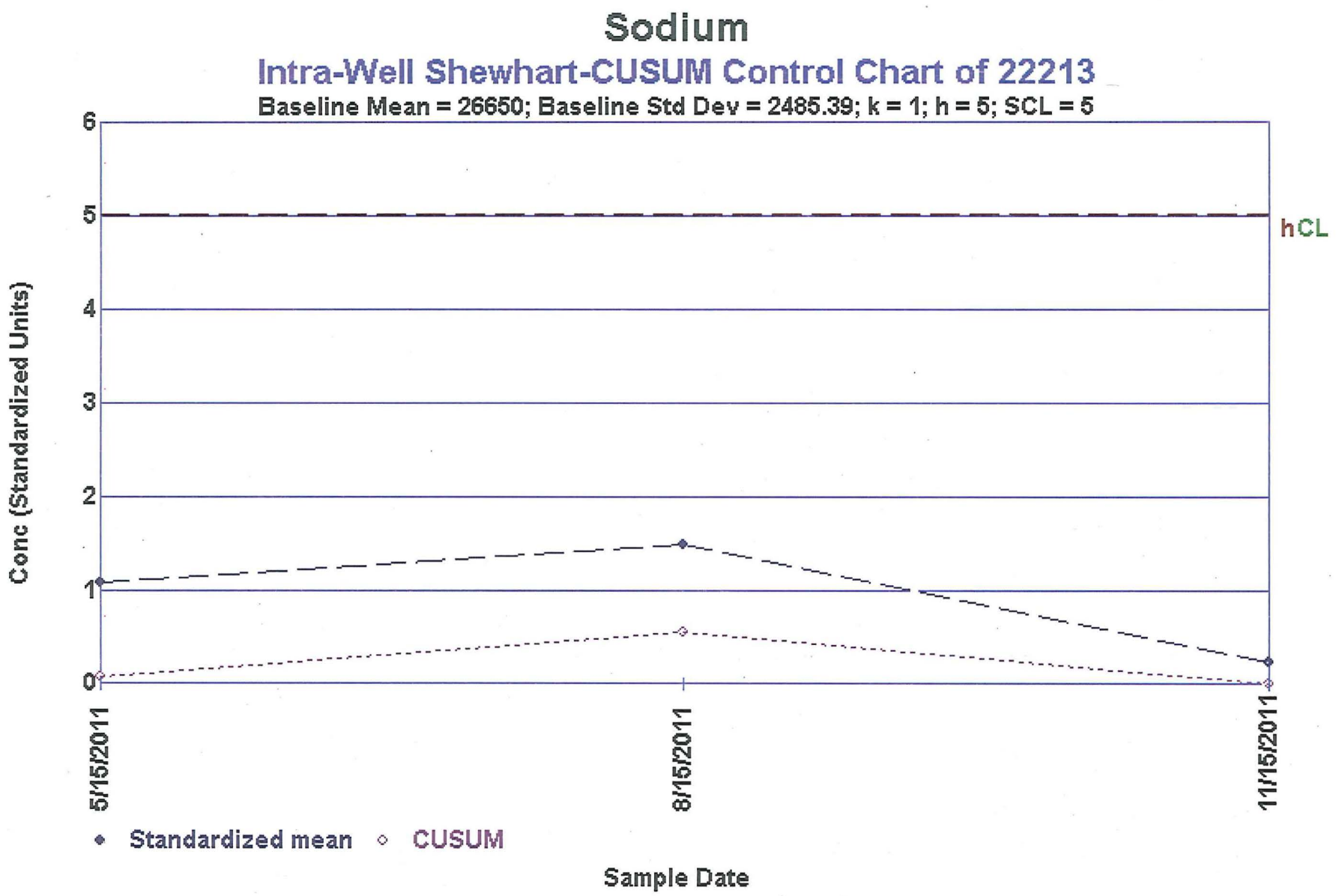


Figure A.5.8−43. Intra-Well Shewhart-CUSUM Control Chart (Sodium 22213)

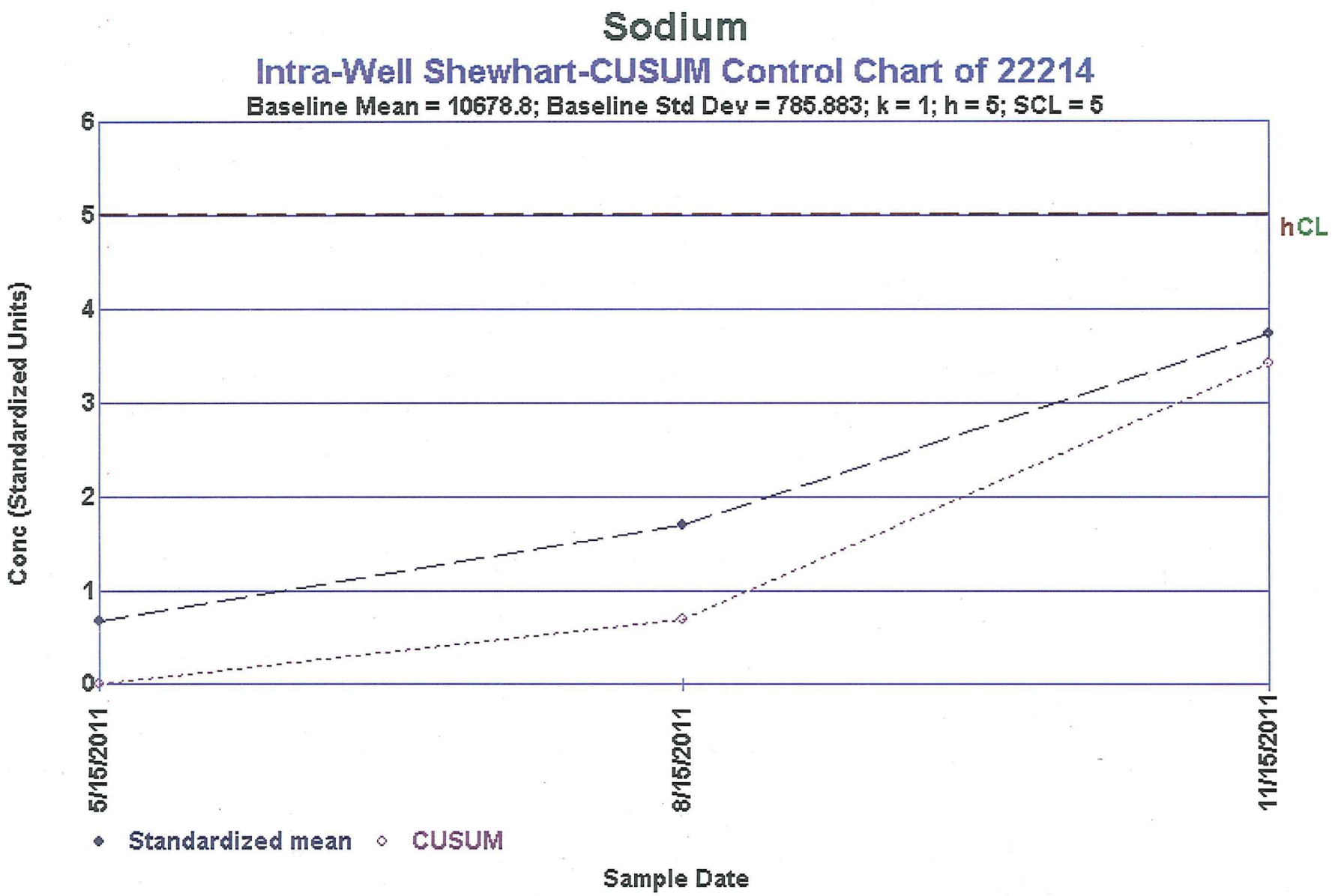


Figure A.5.8−44. Intra-Well Shewhart-CUSUM Control Chart (Sodium 22214)

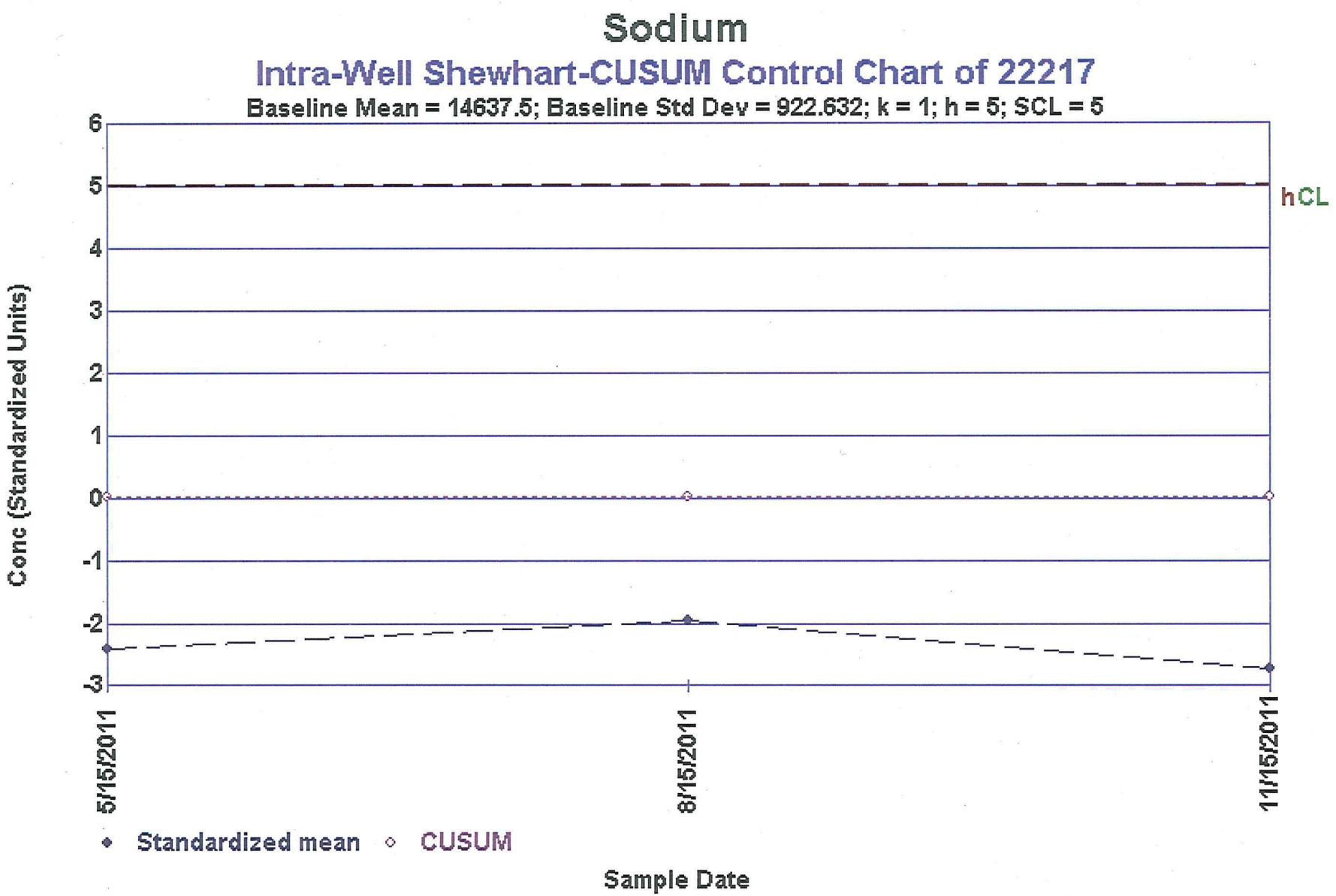


Figure A.5.8−45. Intra-Well Shewhart-CUSUM Control Chart (Sodium 22217)

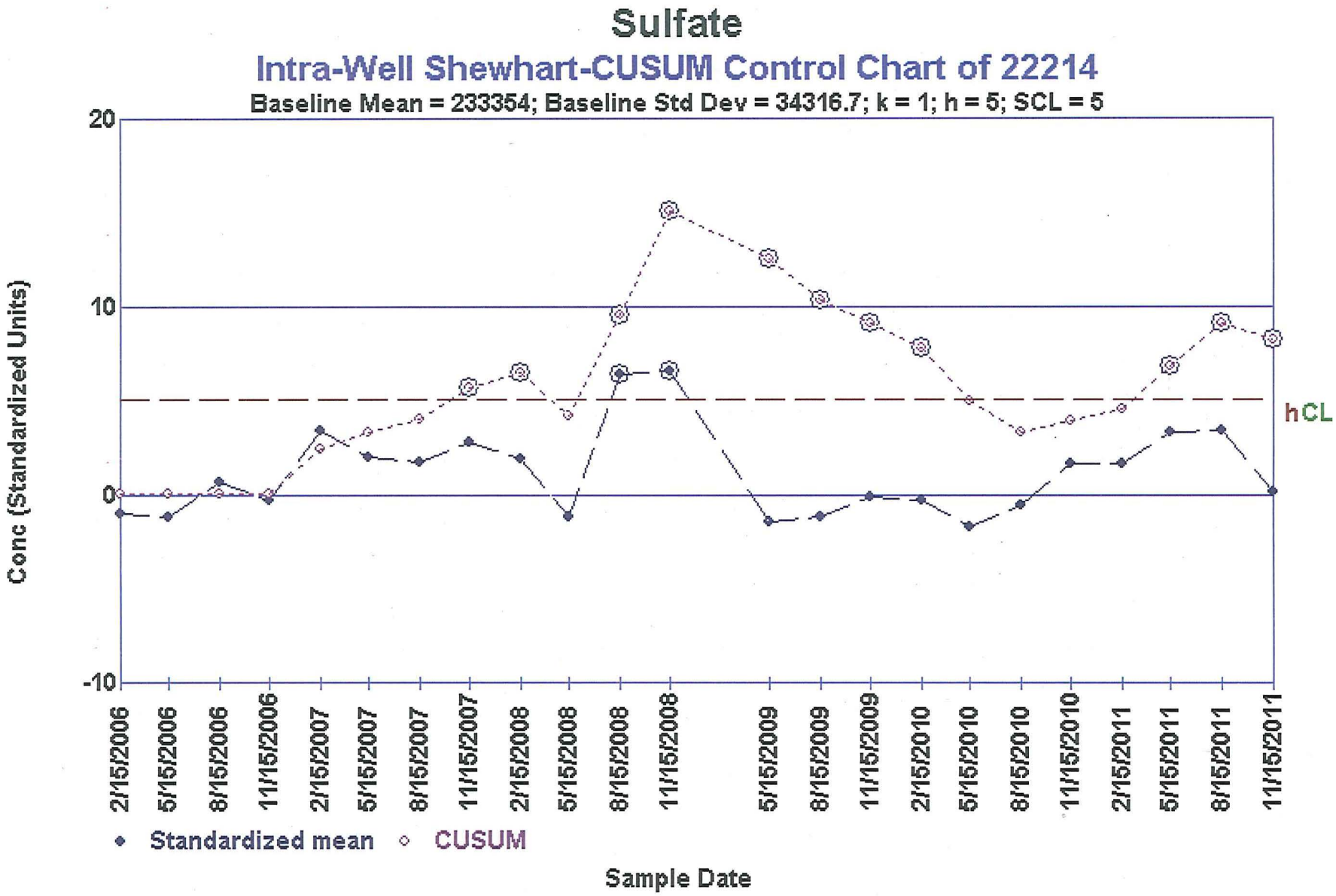


Figure A.5.8−46. Intra-Well Shewhart-CUSUM Control Chart (Sulfate 22214)

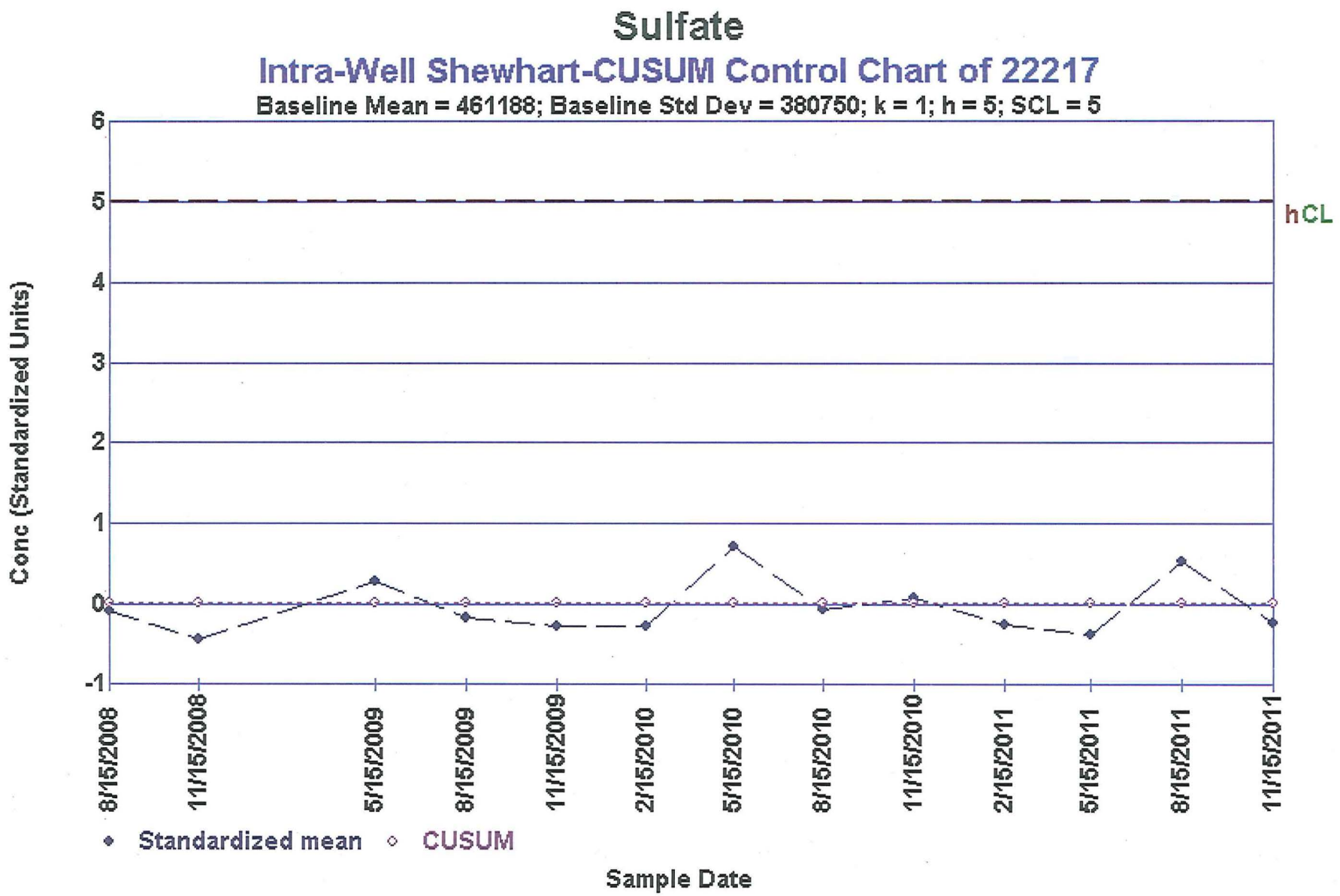


Figure A.5.8−47. Intra-Well Shewhart-CUSUM Control Chart (Sulfate 22217)

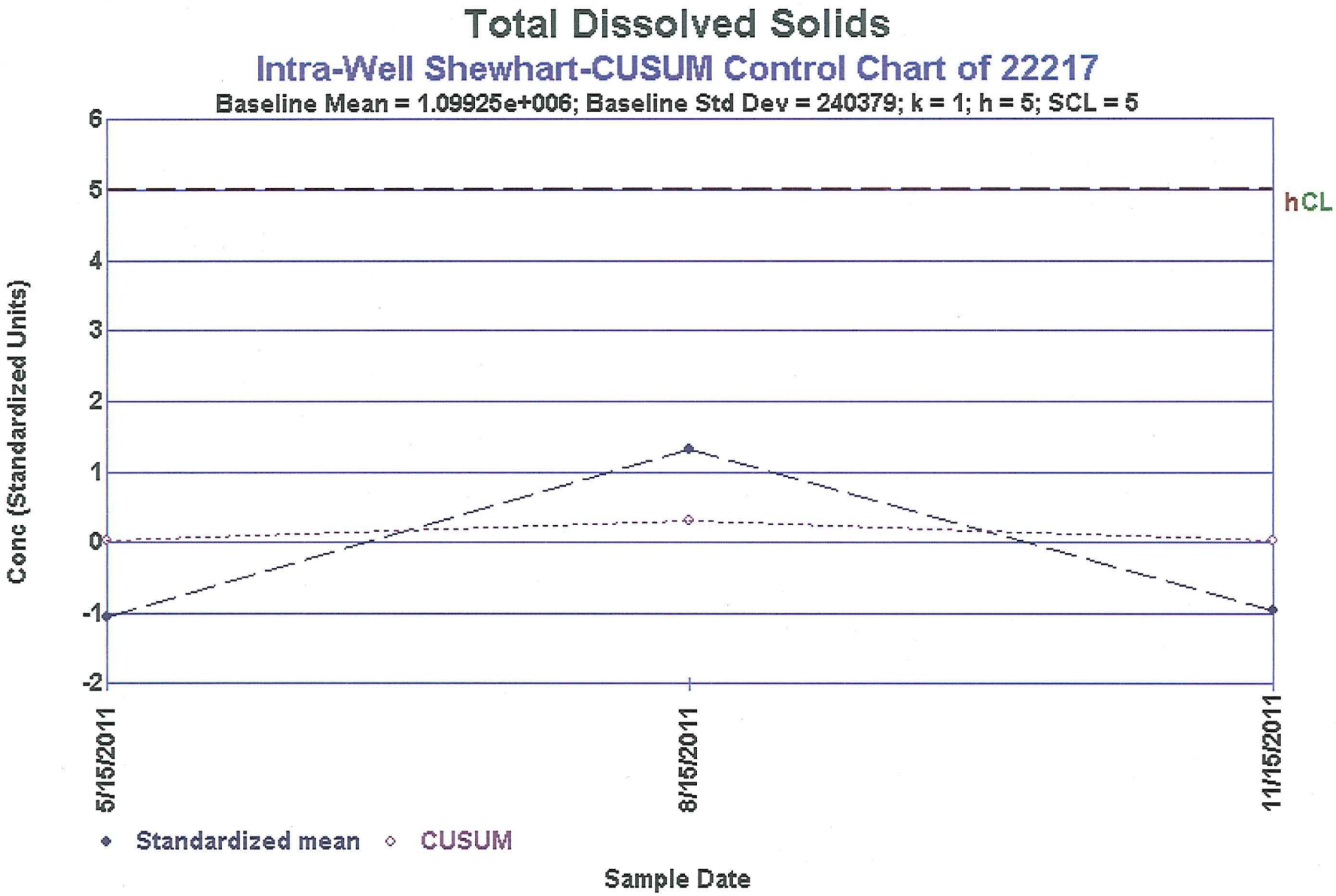


Figure A.5.8–48. Intra-Well Shewhart-CUSUM Control Chart (TDS 22217)

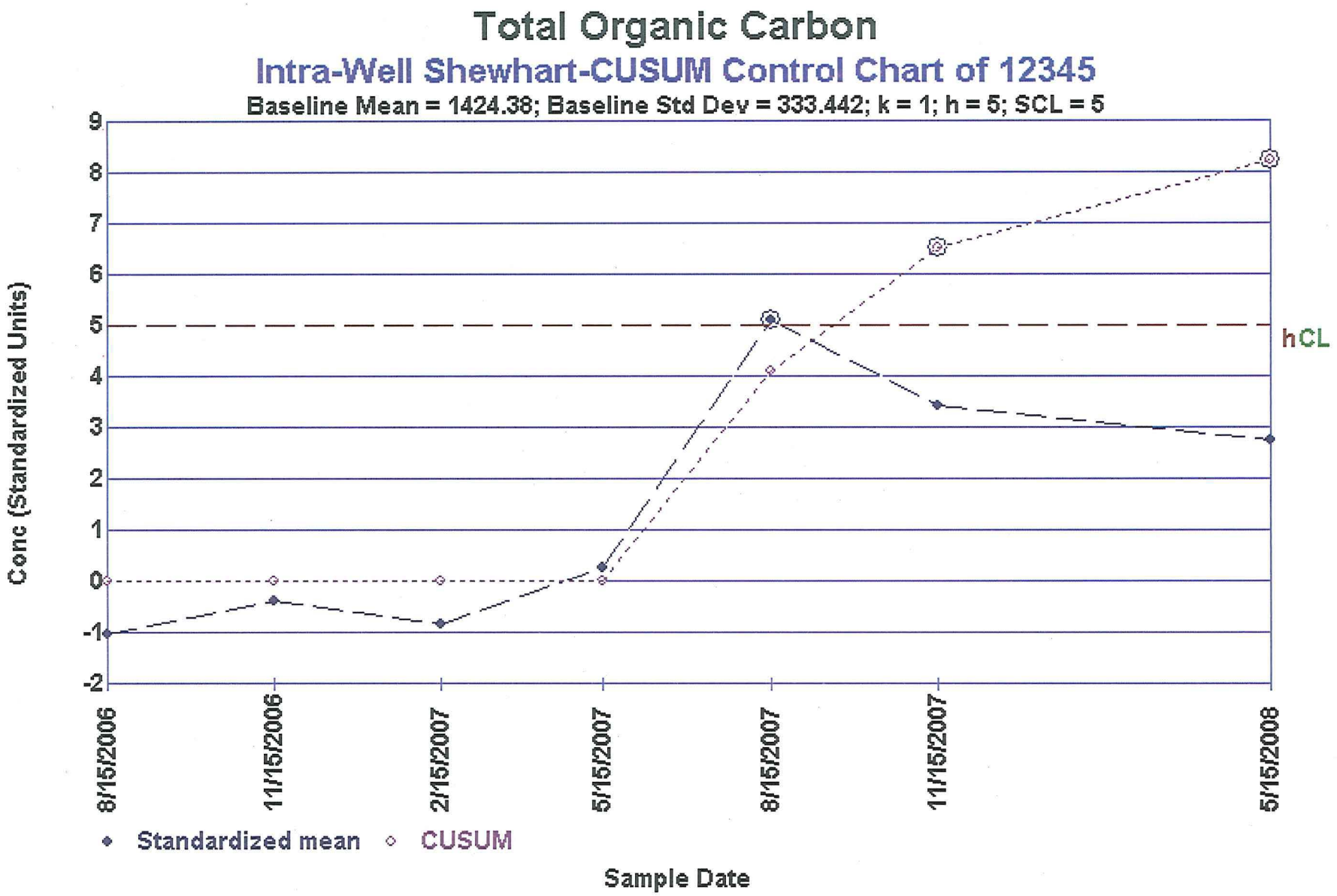


Figure A.5.8−49. Intra-Well Shewhart-CUSUM Control Chart (TOC 12345)

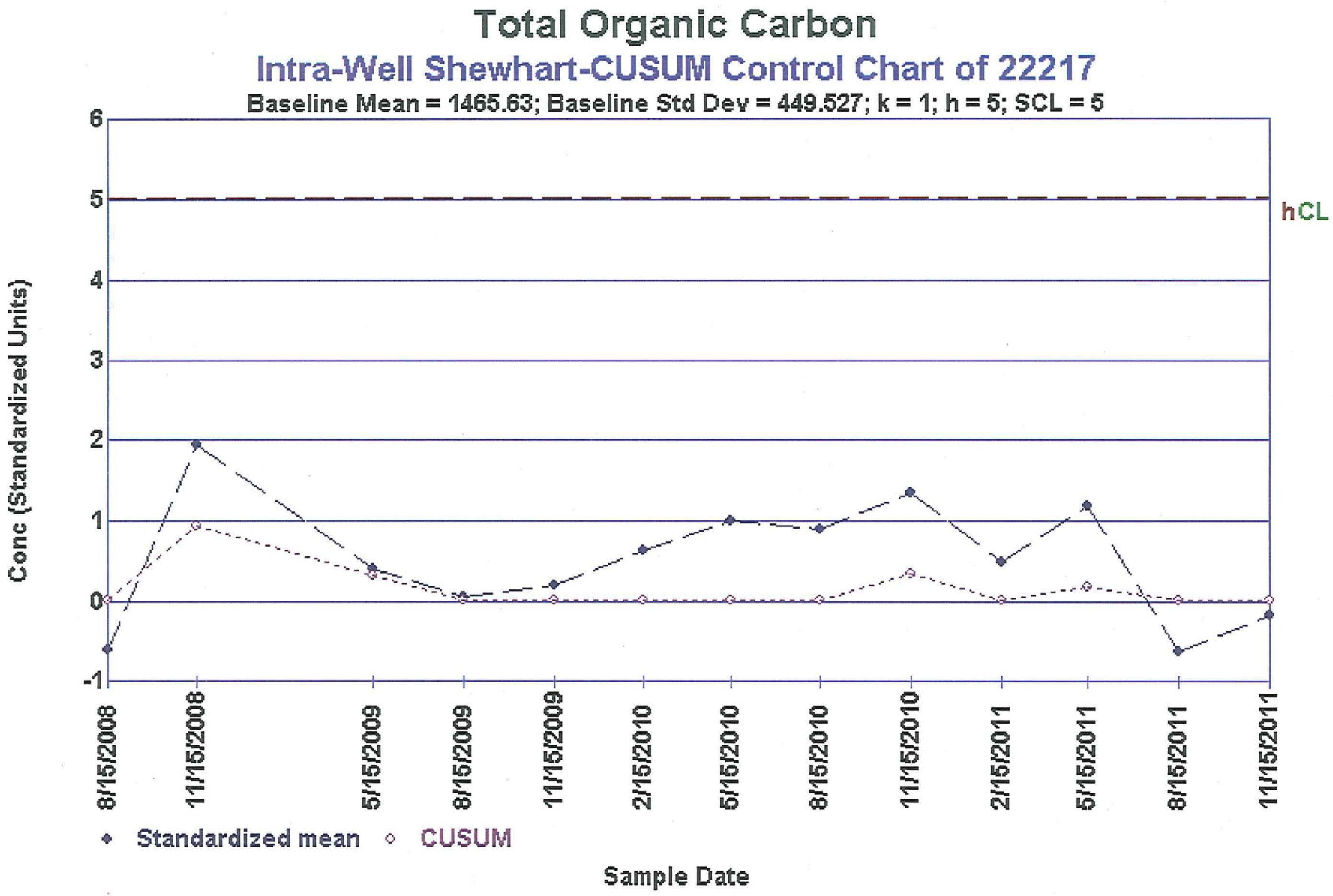


Figure A.5.8−50. Intra-Well Shewhart-CUSUM Control Chart (TOC 22217)

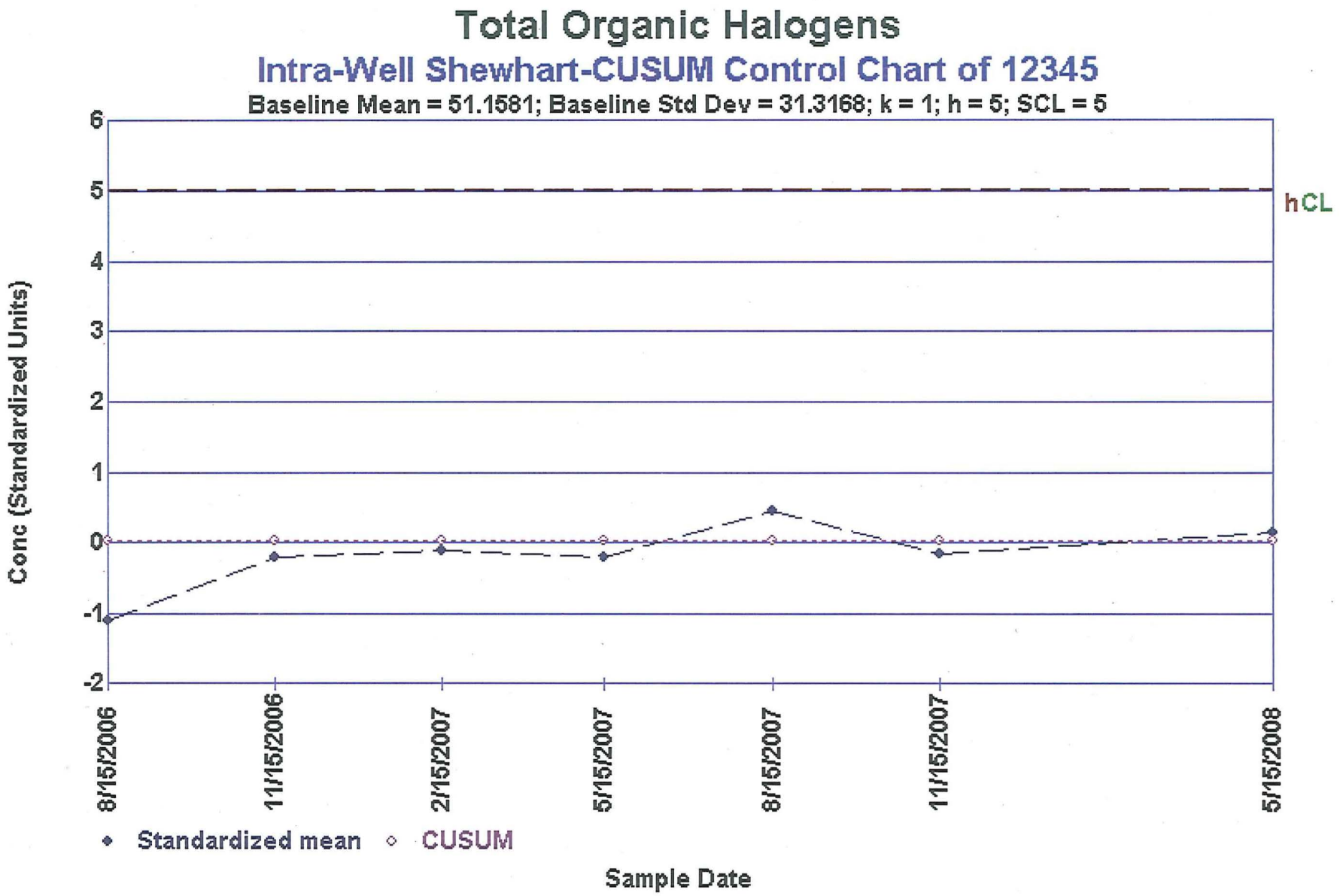


Figure A.5.8−51. Intra-Well Shewhart-CUSUM Control Chart (TOC 12345)

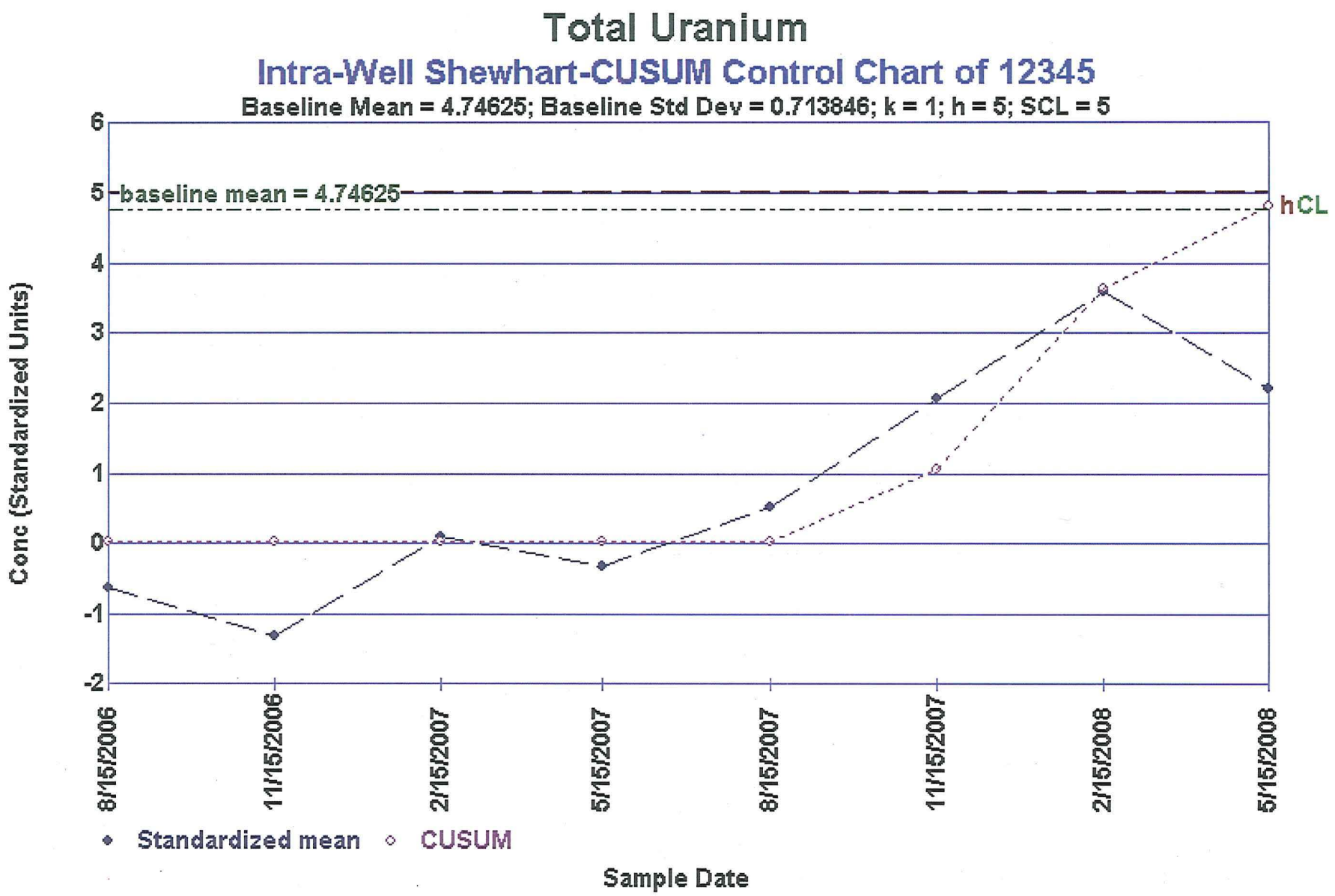


Figure A.5.8–52. Intra-Well Shewhart-CUSUM Control Chart (Uranium 12345)

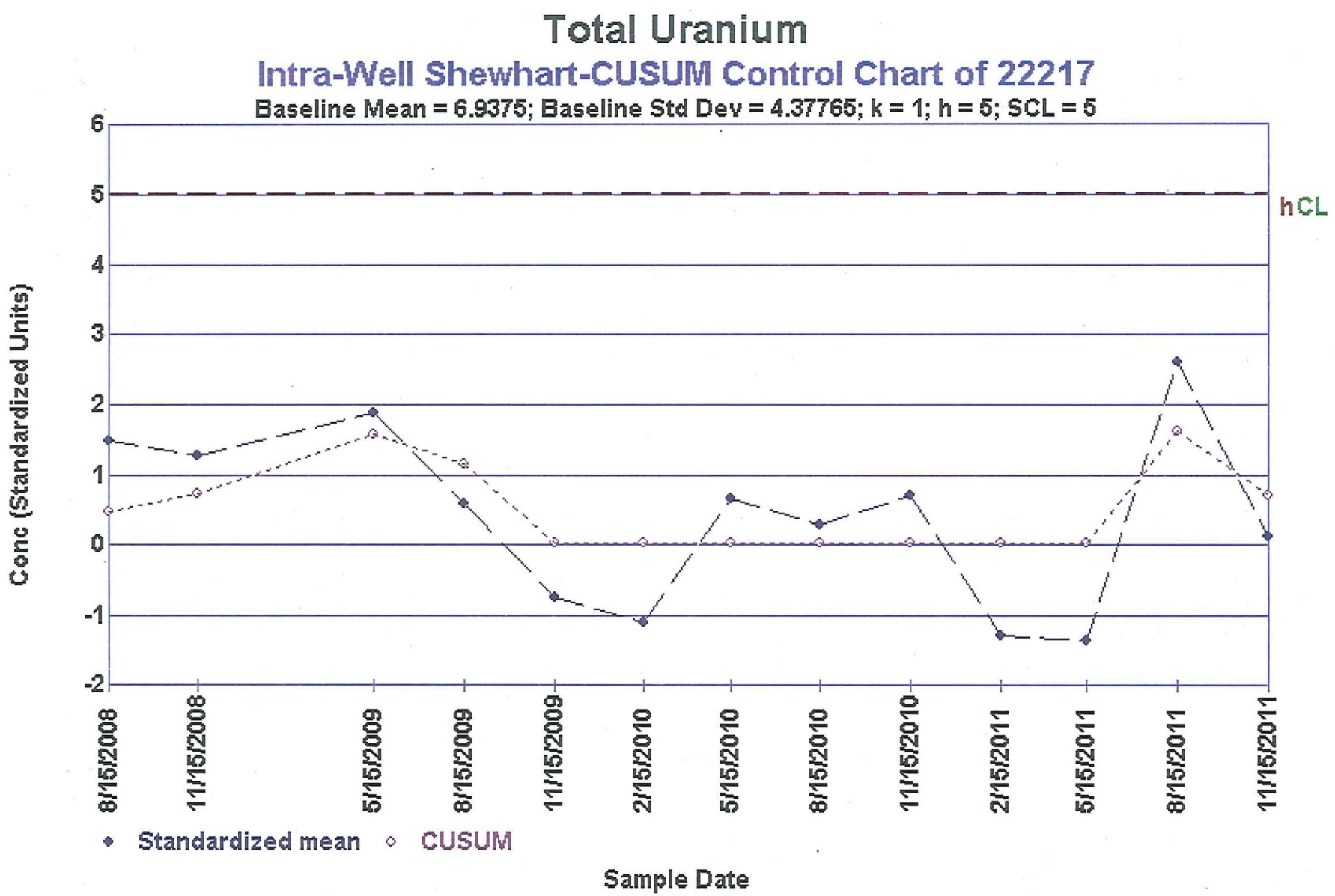


Figure A.5.8–53. Intra-Well Shewhart-CUSUM Control Chart (Uranium 22217)

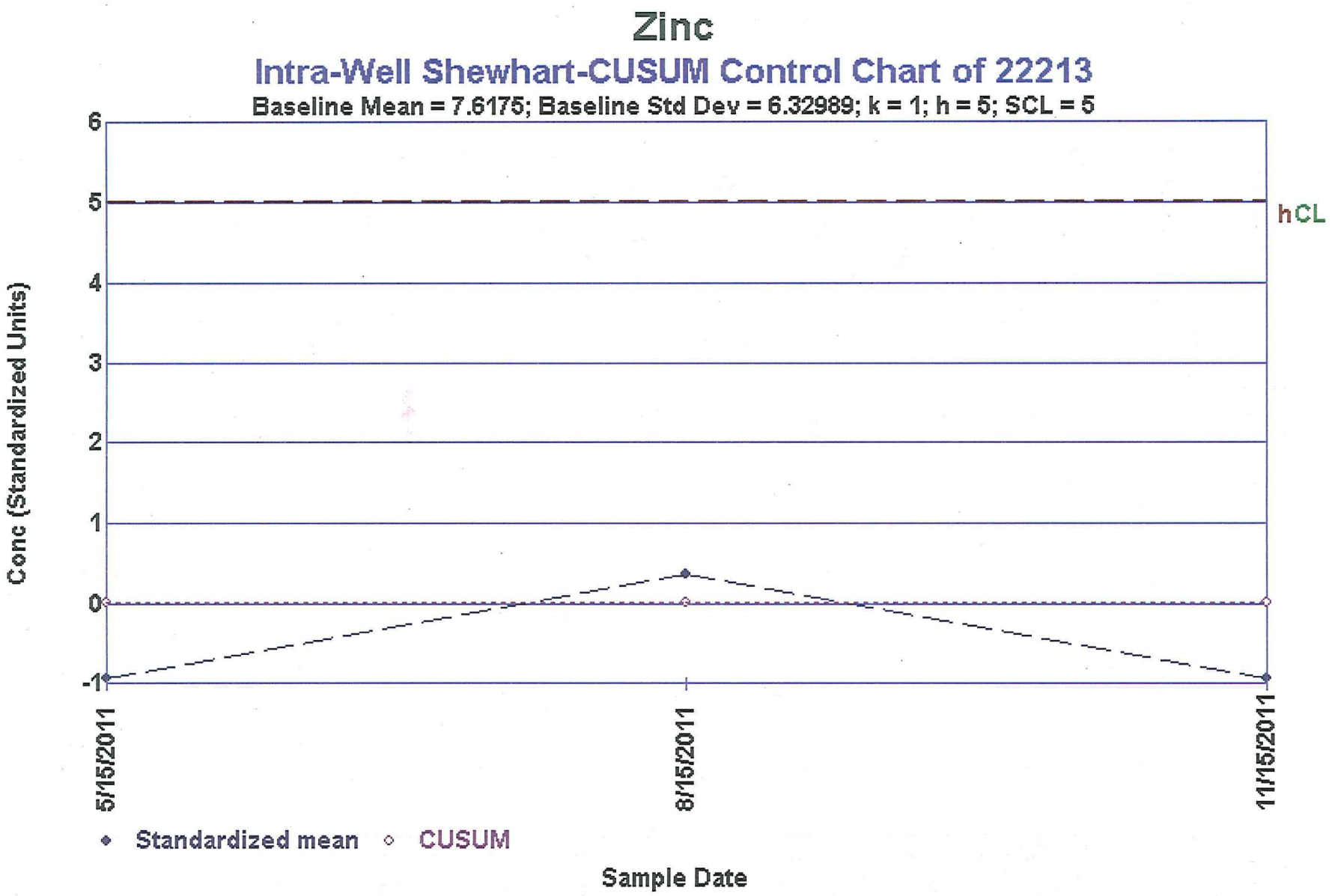


Figure A.5.8−54. Intra-Well Shewhart-CUSUM Control Chart (Zinc 22213)

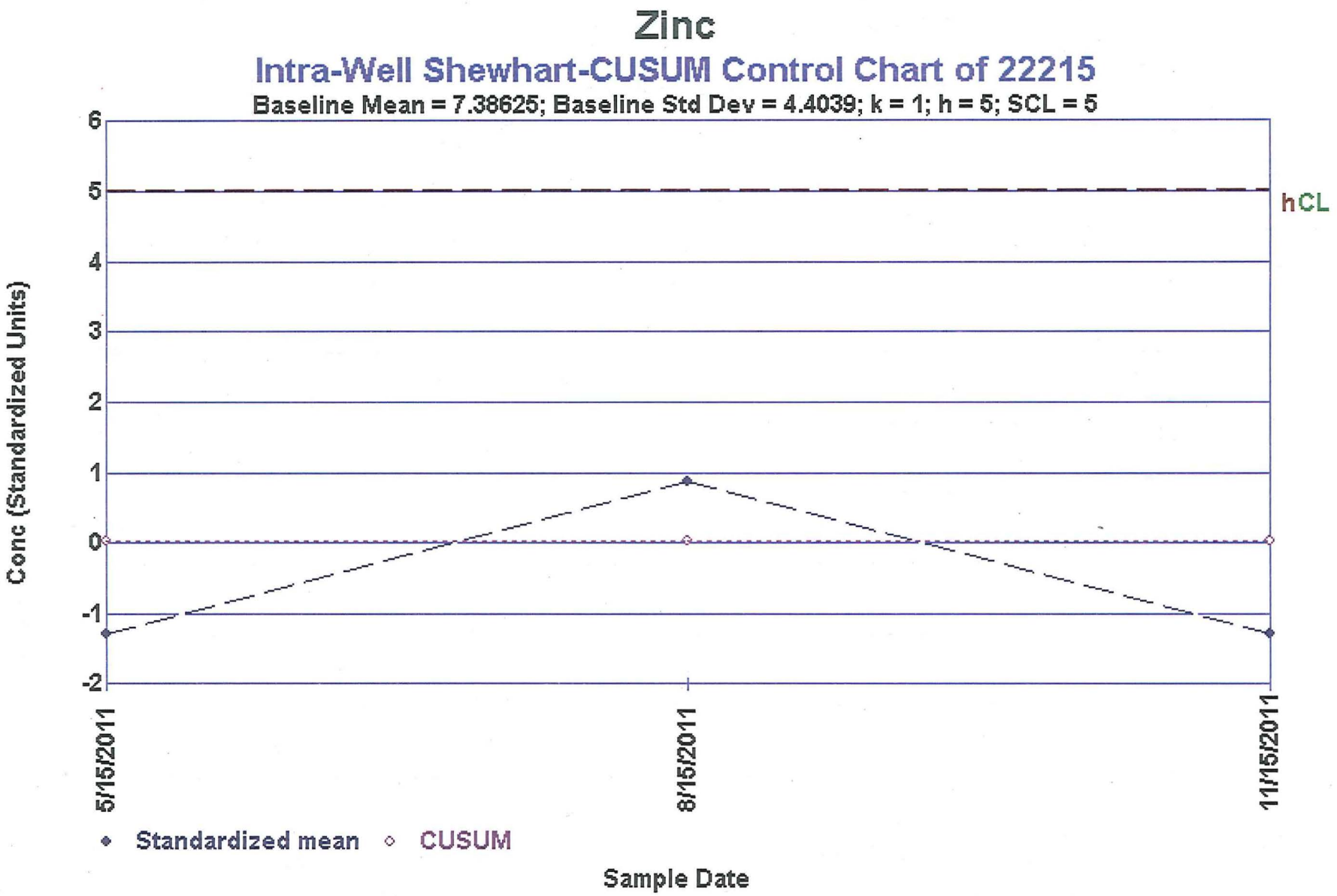


Figure A.5.8–55. Intra-Well Shewhart-CUSUM Control Chart (Zinc 22215)

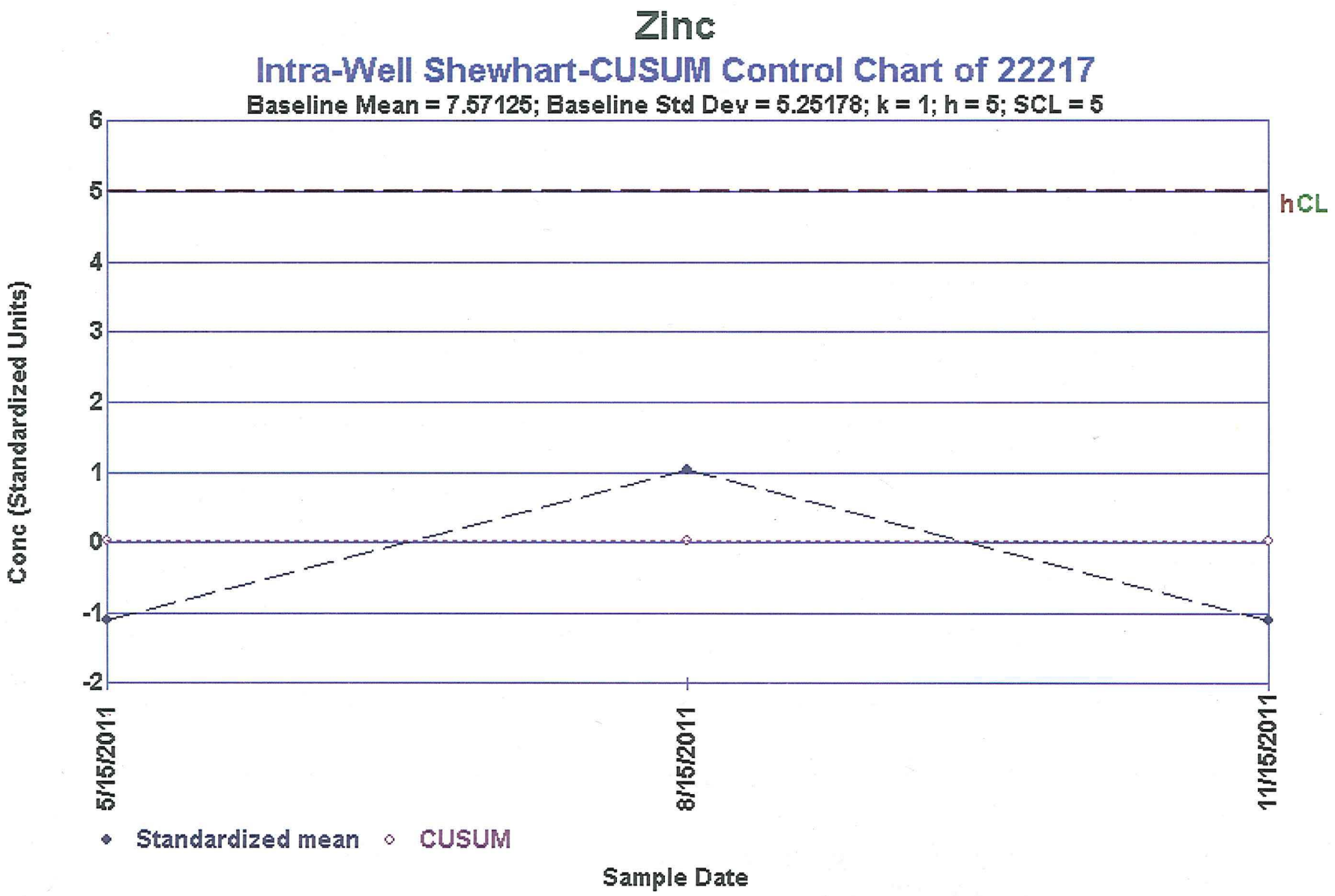


Figure A.5.8−56. Intra-Well Shewhart-CUSUM Control Chart (Zinc 22217)

Appendix B

Appendix B

Supplemental Surface Water and Treated Effluent Information

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Contents

Abbreviations iii
Measurement Abbreviations iii
References v
B.1.0 Surface Water and Treated Effluent 1
B.1.1 Surveillance Monitoring 1
B.1.1.1 Evaluation of Constituents above FRLs for 2011 2
B.1.1.2 Evaluation of Cross-Media Impacts for 2011 2
B.1.2 FFCA/OU5 ROD Compliance 6
B.1.3 Controlled and Uncontrolled Storm Water Runoff Areas 6

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Abbreviations

FFCA	Federal Facilities Compliance Agreement
FRL	final remediation level
GMA	Great Miami Aquifer
IEMP	Integrated Environmental Monitoring Plan
LMICP	*Comprehensive Legacy Management and Institutional Controls Plan*
NPDES	National Pollutant Discharge Elimination System
OU5 ROD	*Final Record of Decision for Remedial Actions at Operable Unit 5*

Measurement Abbreviations

cfs	cubic feet per second
mg/L	milligrams per liter
pCi/L	picocuries per liter
µg/L	micrograms per liter

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References

DOE (U.S. Department of Energy), 1996. *Final Record of Decision for Remedial Actions at Operable Unit 5*, 7478 U-007-501.4, Final, Fernald Environmental Management Project, DOE, Fernald Area Office, Cincinnati, Ohio, January.

DOE (U.S. Department of Energy), 2001. *Explanation of Significant Differences for Operable Unit 5*, Final, Fernald Environmental Management Project, DOE, Fernald Area Office, Cincinnati, Ohio, November.

DOE (U.S. Department of Energy), 2010. *Comprehensive Legacy Management and Institutional Controls Plan*, LMS/FER/S03496, Revision 4, prepared by S.M. Stoller Corporation for DOE, Fernald Area Office, Cincinnati, Ohio, April.

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B.1.0 Surface Water and Treated Effluent

This appendix presents additional surface water and treated effluent data in support of Section 4 of this *Fernald Preserve 2011 Site Environmental Report*. This appendix provides an evaluation of the final remediation level (FRL) exceedances for surface water and treated effluent, including an assessment of potential cross-media impacts to the groundwater pathway. Surface water data are available through the Department of Energy Office of Legacy Management's Geospatial Environmental Mapping System (http://www.lm.doe.gov/Fernald/Sites.aspx).

Surface water and treated effluent samples are collected as required by the Integrated Environmental Monitoring Plan (IEMP), which is Attachment D of the *Comprehensive Legacy Management and Institutional Controls Plan* (LMICP) (DOE 2010). Figures B.1–1 and B.1–2 show all surface water monitoring locations. The following information is discussed in this attachment:

- Surveillance monitoring (see Section B.1.1).
- Federal Facilities Compliance Agreement (FFCA)/*Final Record of Decision for Remedial Actions at Operable Unit 5* (OU5 ROD) (DOE 1996) compliance (see Section B.1.2).
- Controlled and uncontrolled areas (see Section B.1.3).

The National Pollutant Discharge Elimination System (NPDES) permit sampling is not discussed in this attachment because it is discussed in detail in Section 4, "Surface Water and Treated Effluent Pathway," of this report.

B.1.1 Surveillance Monitoring

Surveillance monitoring is the comparison of surface water and treated effluent analytical results to the surface water FRLs to determine effects of remediation activities on the surface water pathway. Surveillance monitoring also includes an assessment of the effects surface water may have on the groundwater pathway (referred to as cross-media impacts).

All 2011 data were compared to FRLs. Samples collected at the Parshall Flume (PF 4001) are used in the surveillance evaluation because this is the last point treated effluent is sampled prior to discharge to the Great Miami River.

Water discharges to the Great Miami River are required to be below the FRLs at the point where discharged water is completely mixed with water in the Great Miami River (i.e., outside the mixing zone). In cases where the Parshall Flume data are already below the FRLs, no further action is taken. When the Parshall Flume data are above the FRLs, to make a determination of each constituent's concentration at this point in the Great Miami River, the following calculation is applied:

$$C_{PF4001} = \frac{[Q_{10}][C_{GMR}]+[Q_{PF}][C_{PF}]}{[Q_{10}]+[Q_{PF}]}$$

where:

C_{PF4001} = Flow-weighted average concentration outside the mixing zone in the Great Miami River, picocuries per liter (pCi/L) micrograms per liter (µg/L), or milligrams per liter (mg/L)

Q_{10} = 7-day, 10-year low flow, 706 cubic feet per second (cfs)

C_{GMR} = Background concentration in Great Miami River from Table 4–2 in Attachment D of the 2010 LMICP, pCi/L, µg/L, or mg/L (zero was used when no background concentration was available)

Q_{PF} = Daily flow at PF 4001, cfs

C_{PF} = Daily concentration at PF 4001, pCi/L, µg/L, or mg/L

Note: Flow conditions at the Hamilton Dam gauge are periodically reviewed to determine if there is a lower flow than the 7-day, 10-year low flow of 706 cfs. The lowest daily flow measured at the Hamilton Dam gauge (if lower than 706 cfs) is used in the equation to see if an exceedance could potentially occur. The lowest daily flow recorded during 2011 was 662 cfs, which occurred on September 3. The low flow of 706 cfs went into effect during the 2003 NPDES permit renewal process.

B.1.1.1 Evaluation of Constituents above FRLs for 2011

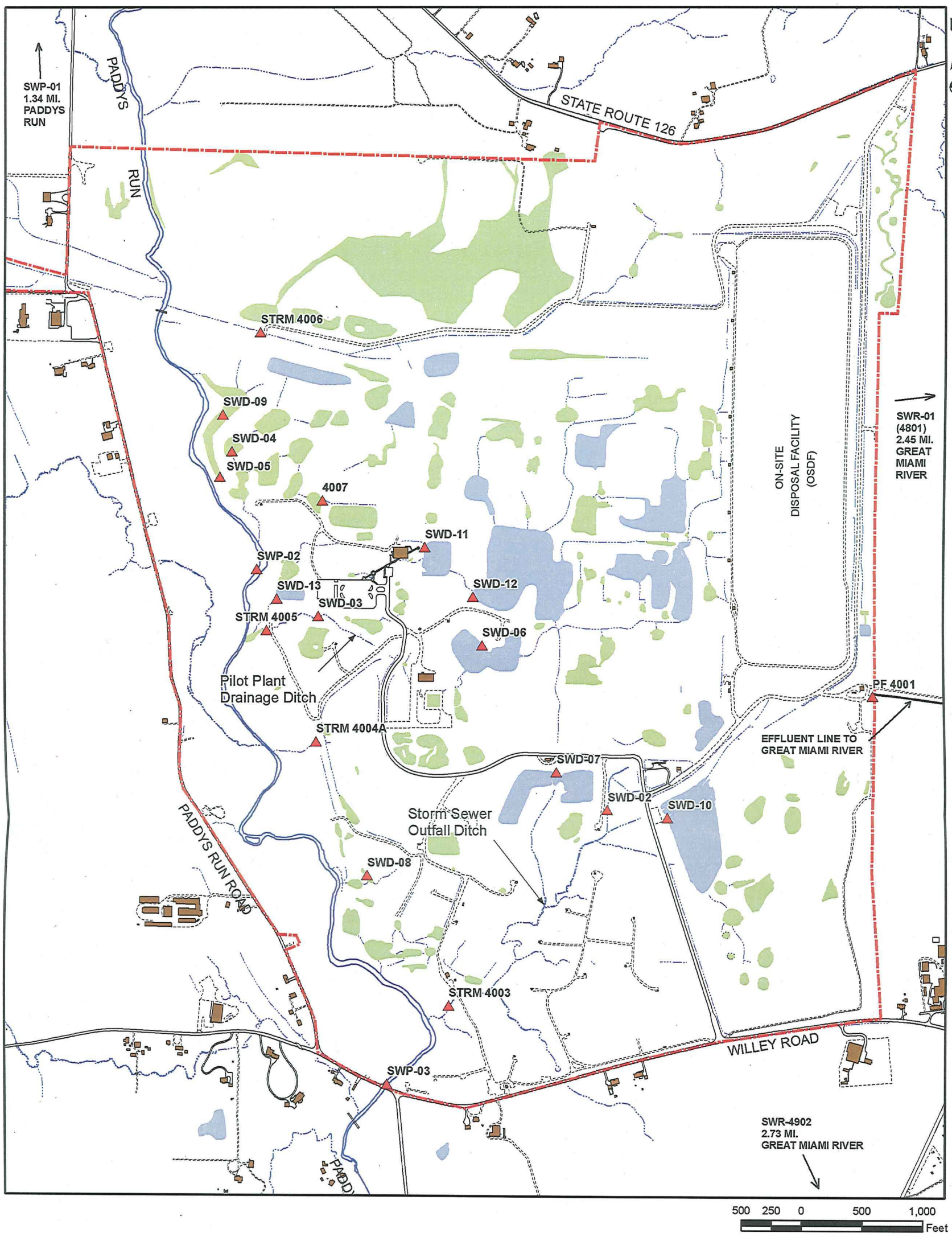
As shown in Table B.1–1, there were 27 exceedances in 2011 of surface water FRLs. The following are general observations:

- No FRL exceedances occurred at PF 4001, thus there was no need to run the mixing equation to determine the concentration in the Great Miami River.
- Twenty-seven results from sampling location SWD-09 exceeded the surface water FRL for total uranium (530 µg/L). Figure B.1–3 is a plot of the total uranium concentration versus time for sampling location SWD-09. Figures B.1–4 through B.1–22 are plots of the total uranium concentration versus time for all of the surface water sampling locations.

As discussed in Section 4, surface water monitoring currently conducted in a small area west of the former waste pits continues to show elevated but slowly diminishing uranium concentrations. After a limited maintenance activity was completed in the fall of 2007, DOE committed to continued monitoring of the area. Two monitoring points (SWD-05 and SWD-09) were added to the surface water program to fulfill this monitoring commitment. These two locations are sampled weekly, when water is present. As shown in Table B.1-1, SWD-09 has been sampled 131 times between January 2007 and December 2012. One-hundred and one of the 131 sampling events have exceeded the surface water FRL. SWD-05 has been sampled 90 times and SWD-09 has been sampled 131 times.

B.1.1.2 Evaluation of Cross-Media Impacts for 2011

Another objective of the IEMP surveillance monitoring program is to provide an ongoing assessment of the potential for cross-media impacts from surface water to the underlying Great Miami Aquifer (GMA). To conduct this assessment, sampling locations were selected to evaluate contaminant concentrations in surface water just upstream from those areas where site drainages have eroded through the protective glacial overburden (e.g., the Storm Sewer Outfall Ditch, Pilot Plant Drainage Ditch, and certain reaches of Paddys Run). In areas where the glacial overburden is absent, a direct pathway exists for contaminants to reach the aquifer. Key sampling locations associated with these areas of direct infiltration are SWD-02, SWD-03, SWD-04, SWD-05, SWD-07, SWD-08, STRM 4005, and SWP-02 (Figures B.1–4 through B.1–11).



Legend

- Sample Location
- Fernald Preserve Boundary
- Building
- Road-paved
- Road-gravel
- Open Water
- Wetland
- Creek
- Intermittent Stream

NOTE 1: STRM 4003, SWR-4902, SWR-01, AND PF 4001 ARE REGULATED UNDER THE NPDES PERMIT.

NOTE 2: DISTANCES TO OFFSITE SAMPLE LOCATIONS ARE MEASURED FROM THE CENTER OF THE FORMER PRODUCTION AREA

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Figure B.1–1. IEMP/NPDES Surface Water and Treated Effluent Sample Locations

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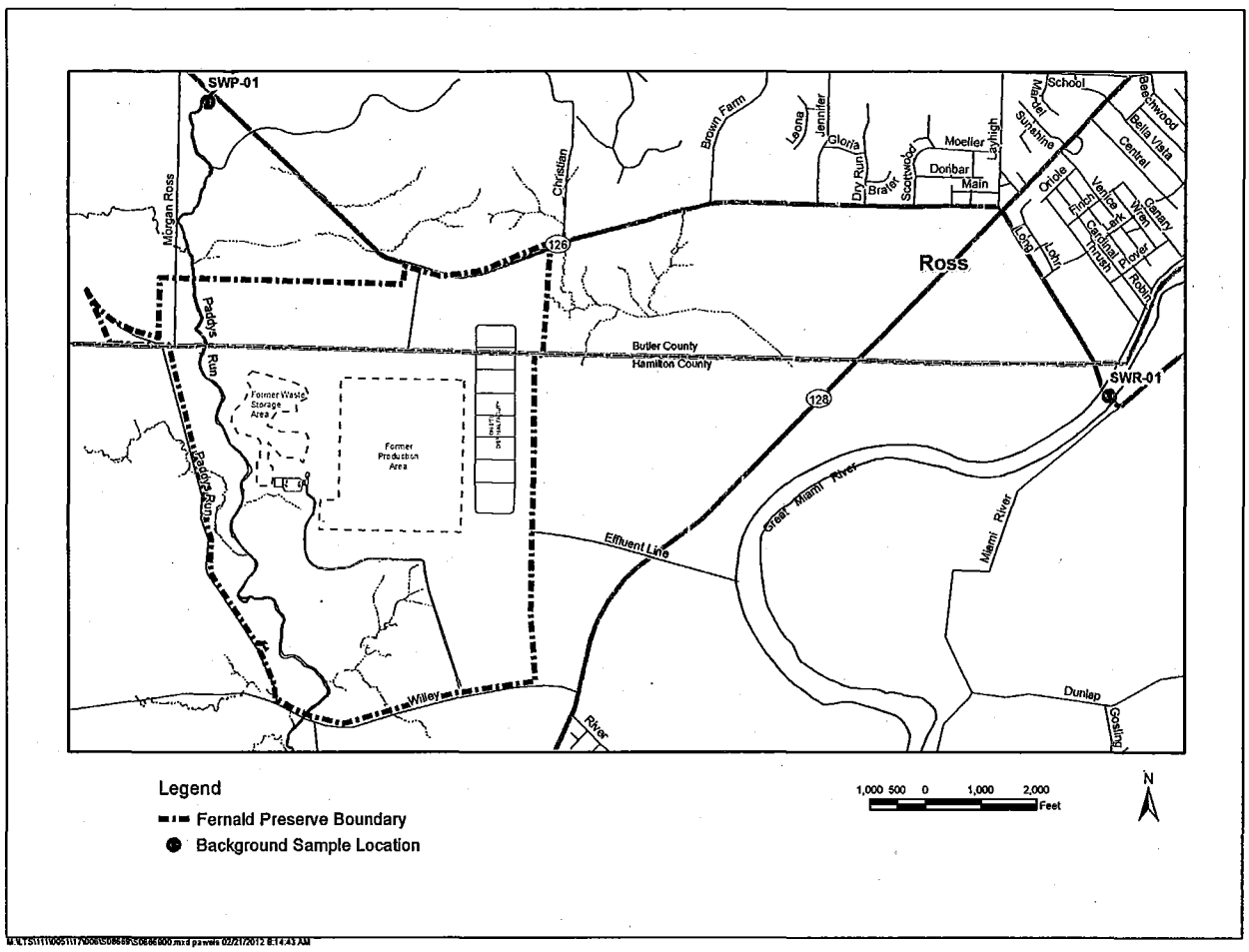

Figure B.1-2. IEMP Background Surface Water Sample Locations

Because it is the primary contaminant at the site, total uranium is used as an indicator to evaluate the impact of surface water on the GMA. A conservative assumption is used in this assessment, which considers the total uranium concentration (and all other constituent concentrations) in the surface water to be at the same concentration when the water reaches the GMA through infiltration. However, the more likely scenario is that the total uranium concentration (and all other constituent concentrations) would decrease through dilution and adsorption as the water infiltrates through the ground and mixes with the groundwater in the GMA.

The results of the cross-media impact assessment for 2011 indicate that three of the eight surface water locations (SWD-04 – Figure B.1-6, SWD-05 – Figure B.1-7, and STRM 4005 – Figure B.1-10) evaluated had results that exceeded the total uranium groundwater FRL of 30 µg/L.

Location SWD-05 is the point at which drainage from the swale area adjacent to former Waste Pit 3 collects and infiltrates into the underlying aquifer. As discussed in Attachment A.2, this may be contributing to increased uranium concentrations in adjacent groundwater monitoring wells. However, the area in question remains within the capture zone of Waste Storage Area Module extraction wells. The design of the groundwater restoration systems has

accounted for this potential contaminant pathway by installing extraction wells downgradient of these areas where direct infiltration can occur.

B.1.2 FFCA/OU5 ROD Compliance

The OU5 ROD and subsequent *Explanation of Significant Differences for Operable Unit 5* (DOE 2001) stipulate compliance with a monthly flow-weighted average total uranium concentration of 30 μg/L at the Great Miami River via PF 4001. In addition to the concentration limitation, the OU5 ROD stipulated that the total mass discharged during a year not exceed 600 pounds.

During 2011, the total uranium concentrations were monitored daily at PF 4001 to demonstrate compliance with these limitations. The Fernald Preserve was in compliance with the total mass limitation, as uranium discharges totaled 565 pounds, which is below the 600-pound limit. The Fernald Preserve was in compliance with the monthly flow-weighted concentration limit every month in 2011, as identified on Figure B.1–23.

B.1.3 Controlled and Uncontrolled Storm Water Runoff Areas

In 2011, there were no previously uncontrolled areas that were added to the Fernald Preserve controlled storm water system (refer to Figure B.1–24). At the conclusion of remediation in October 2006, control of storm water runoff is no longer required. The only storm water collected for treatment is that which falls on the controlled pad of the Converted Advanced Wastewater Treatment Facility.

Table B.1–1. Summary Statistics and Trend Analysis for Constituents with 2011 Results above Surface Water Final Remediation Levels

Location[a]	Constituent	No. of Samples[b,c,d]	No. of Samples Above FRL[b,c,d]	No. of Samples Above FRL for 2011[c,d]	FRL[e] (µg/L)	Min.[b,c,d,f,g] (µg/L)	Max.[b,c,d,f,g] (µg/L)	Avg.[b,c,d,f,g] (µg/L)	SD[b,c,d,f,g] (µg/L)	Trend[b,c,d,f,g] (µg/L)
SWD-09 (Waste Storage Area)	Uranium	131	101	27	530	40.8	1,710	810	350	Down, Significant

[a]Refer to Figure B.1–1.
[b]Based on samples collected from January 3, 2007, through December 31, 2011.
[c]If more than one sample is collected per surface water location per day (e.g., duplicate, grab, composite), then only one sample is counted for the number of samples, and the sample with the maximum concentration is used for determining the summary statistics (minimum, maximum, average, and standard deviation), Mann-Kendall test for trend, and in determining FRL exceedances.
[d]Rejected data qualified with either an R or Z were not included in the count, the summary statistics, or Mann-Kendall test for trend.
[e]From OU5 ROD, Table 9–5.
[f]For results where the concentrations are below the detection limit, the results used in the summary statistics and Mann-Kendall test for trend are each set at half the method detection limit.
[g]If the number of samples is greater than or equal to four, then all of the summary statistics and the Mann Kendall test for trend are reported. If the total number of samples is equal to three, then the minimum, maximum, and average are reported. If the total number of samples is equal to two, then the minimum and maximum are reported. If the total number of samples is equal to one, then the data point is reported as the minimum.

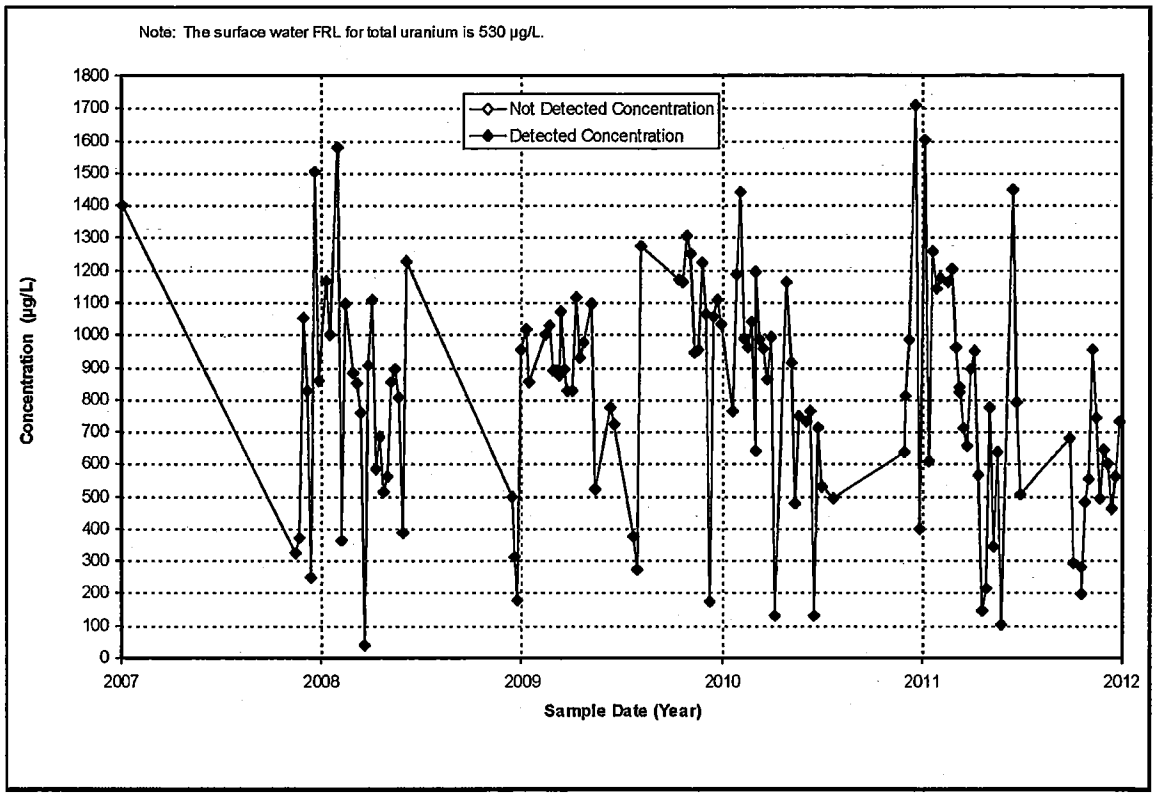

Figure B.1-3. Plot of Total Uranium Concentration versus Time for Location SWD-09 (Former Waste Storage Area)

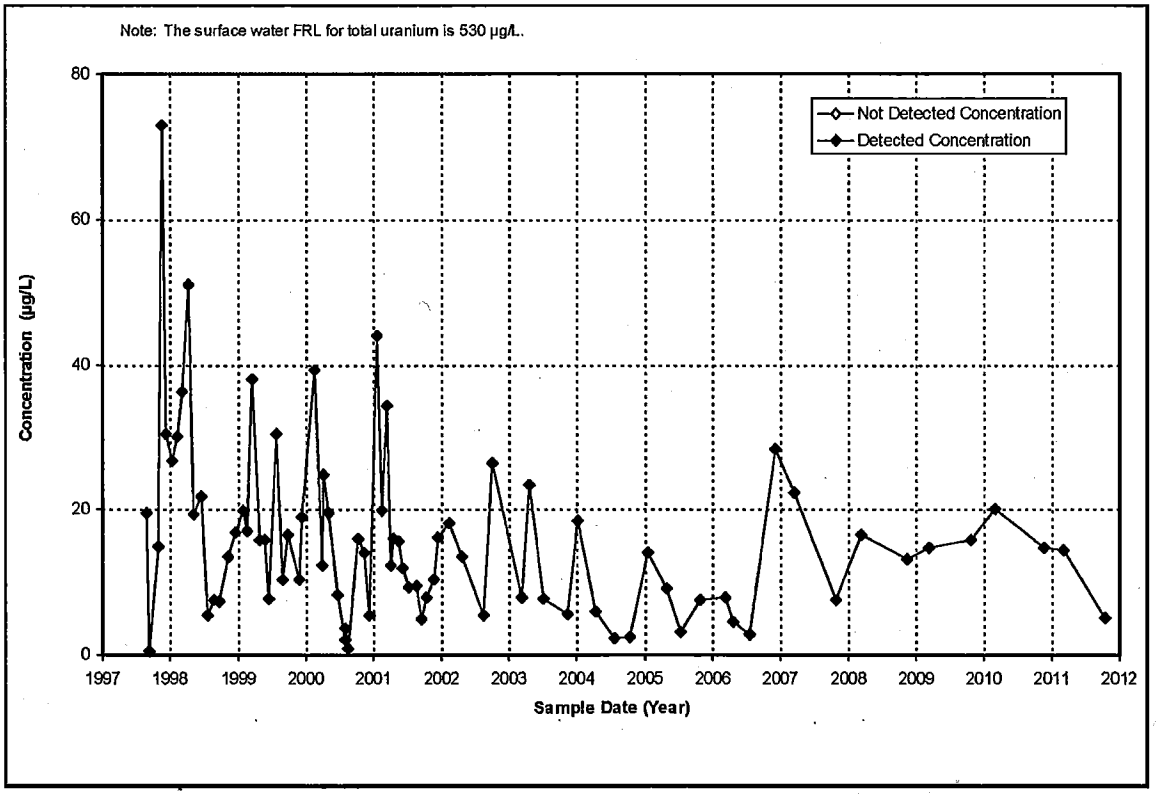

Figure B.1-4. Total Uranium Concentration vs. Time Plot for Location SWD-02 (Storm Sewer Outfall Ditch) for Cross-Media Impact Evaluation

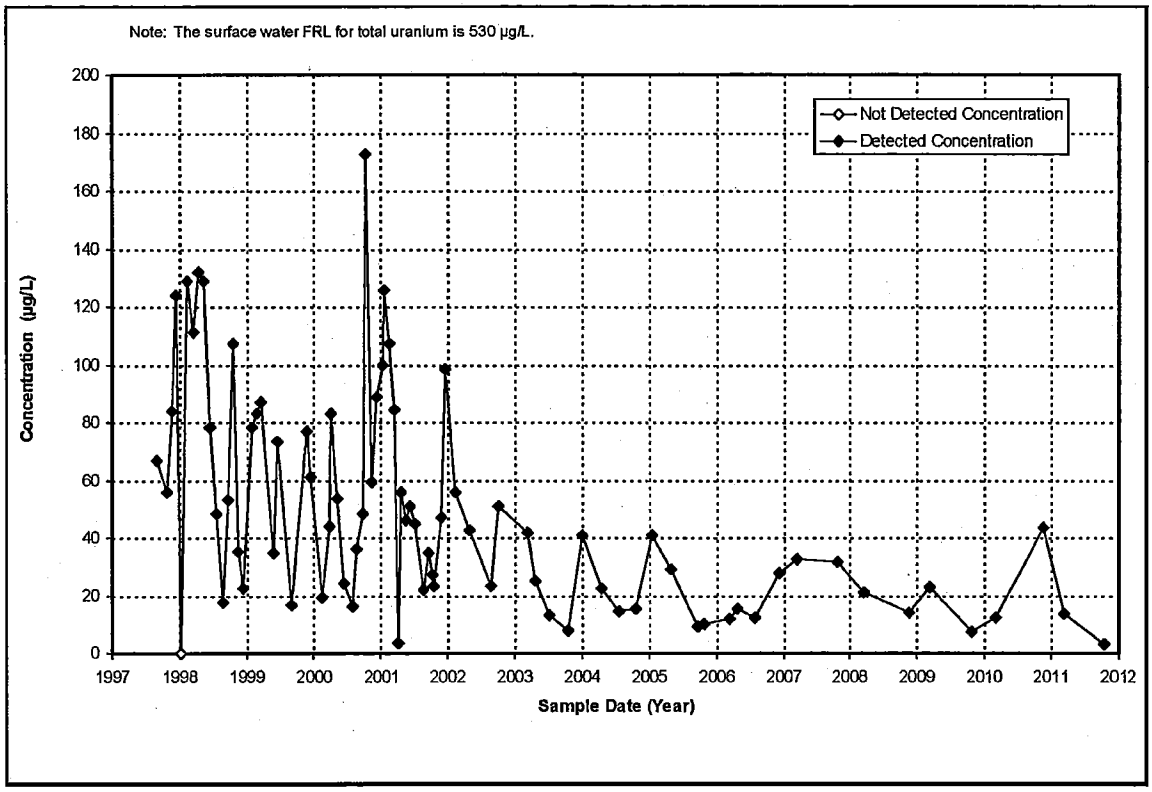

Figure B.1–5. Plot of Total Uranium Concentration versus Time for Location SWD-03 (Former Pilot Plant Drainage Ditch) for Cross-Media Impact Evaluation

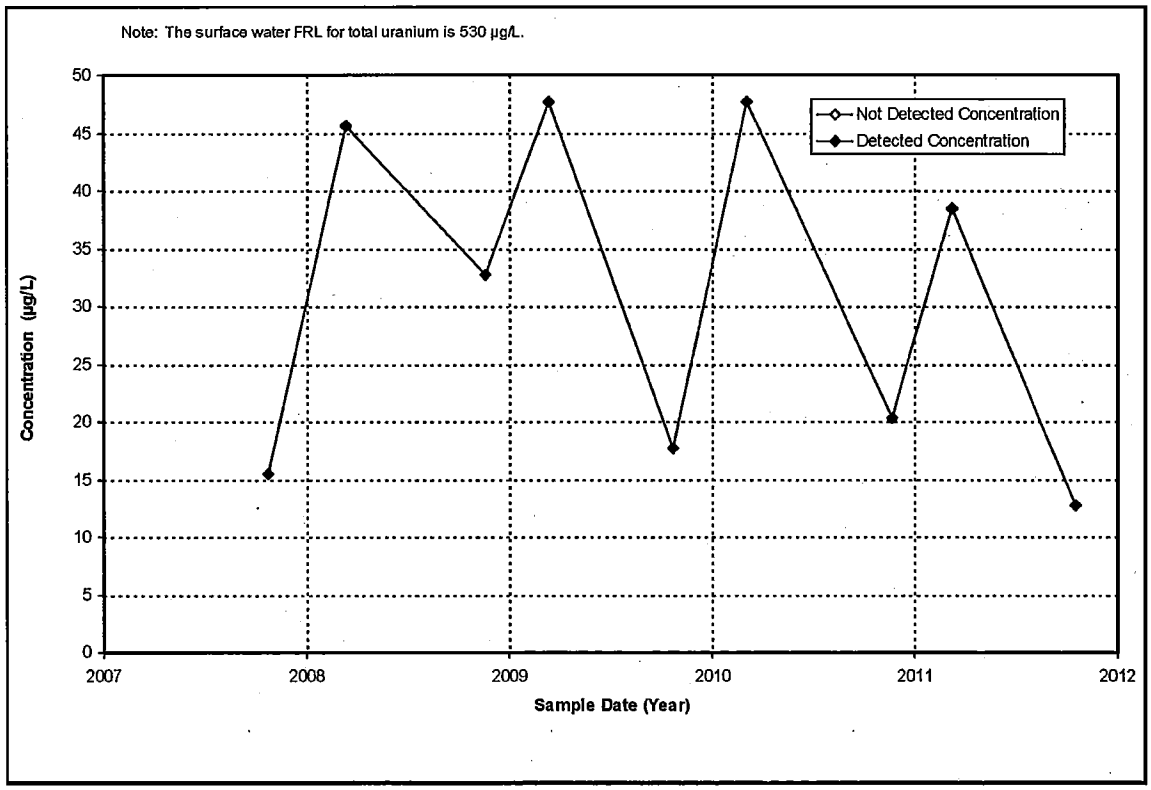

Figure B.1–6. Plot of Total Uranium Concentration versus Time for Location SWD-04 (Former Waste Pit 3) for Cross-Media Impact Evaluation

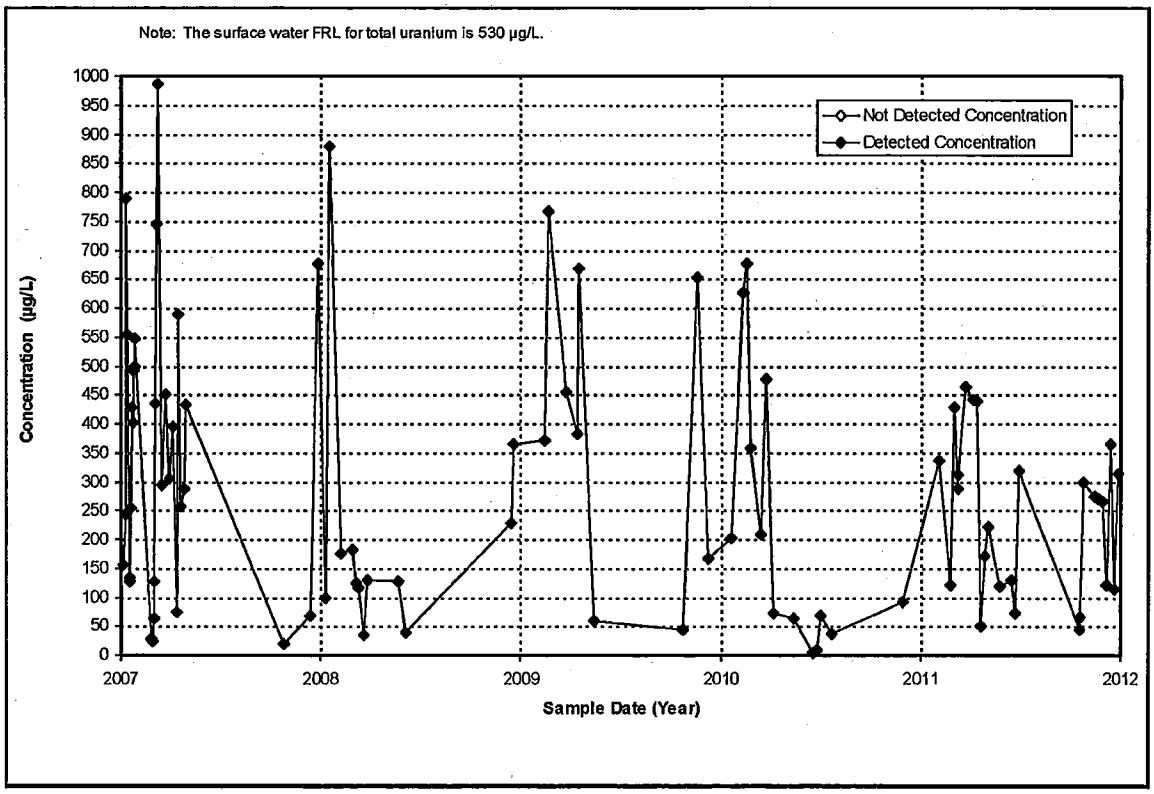

Figure B.1–7. Plot of Total Uranium Concentration versus Time for Location SWD-05 (Former Waste Storage Area) for Cross-Media Impact Evaluation

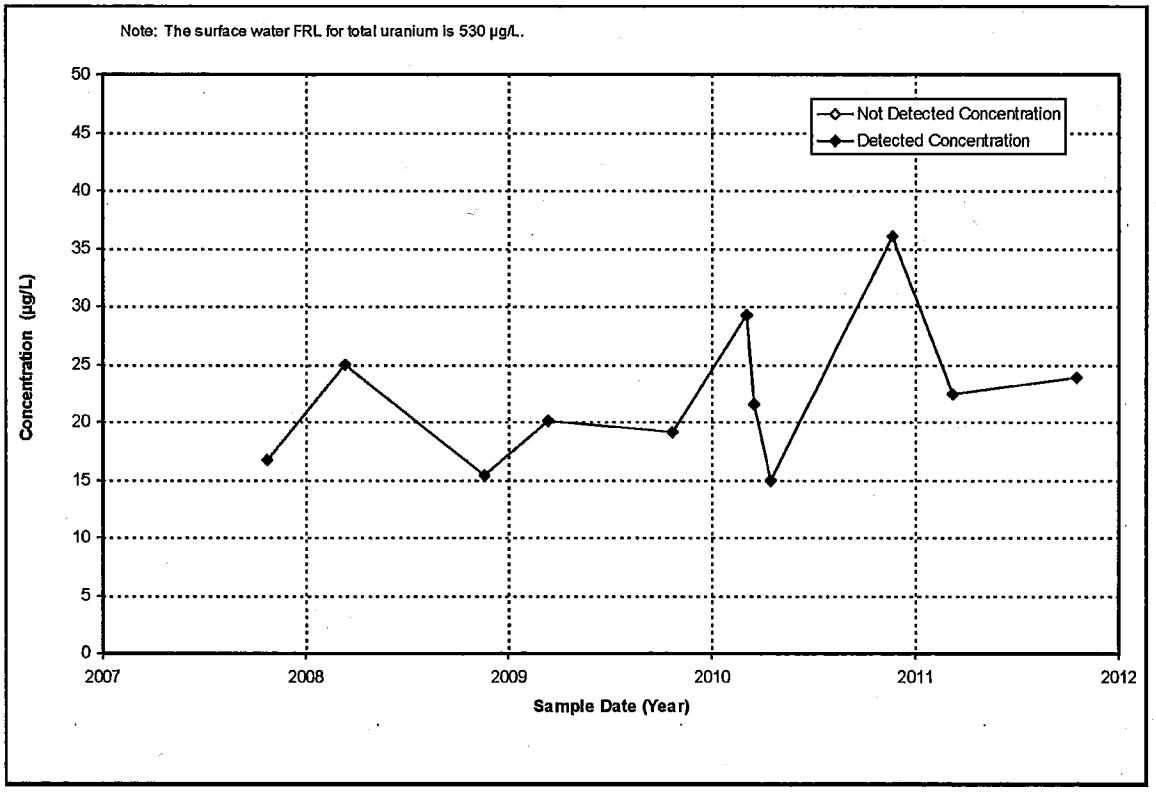

Figure B.1–8. Plot of Total Uranium Concentration versus Time for Location SWD-07 (Former Production Area Drainage) for Cross-Media Impact Evaluation

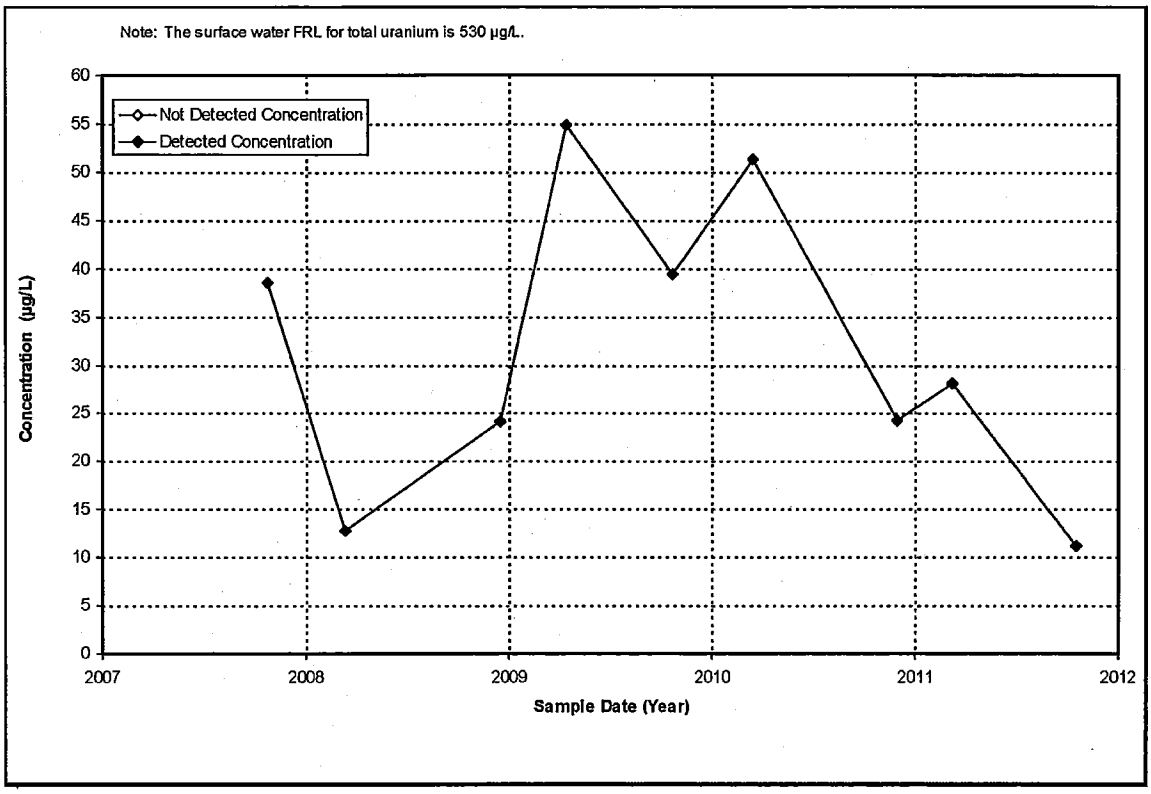

Figure B.1-9. Plot of Total Uranium Concentration versus Time for Location SWD-08 (Former Southern Waste Units) for Cross-Media Impact Evaluation

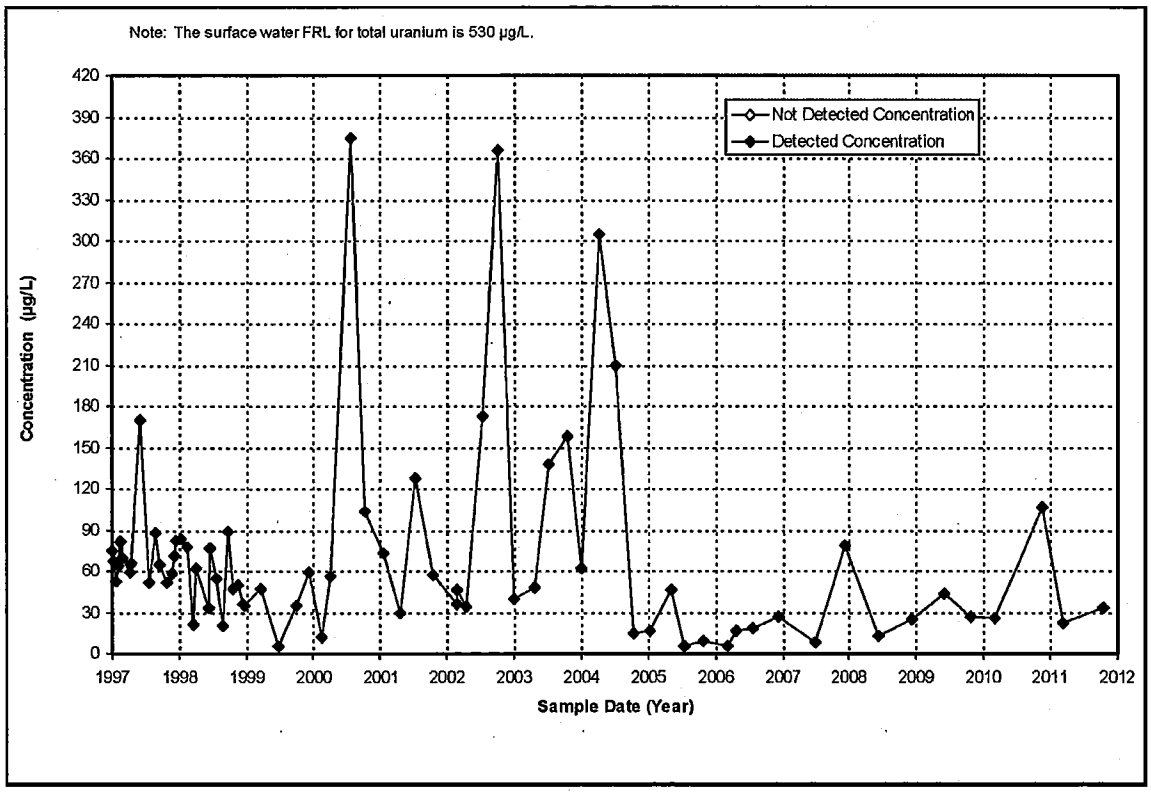

Figure B.1-10. Plot of Total Uranium Concentration versus Time for Location STRM 4005 (Drainage to Paddys Run) for Cross-Media Impact Evaluation

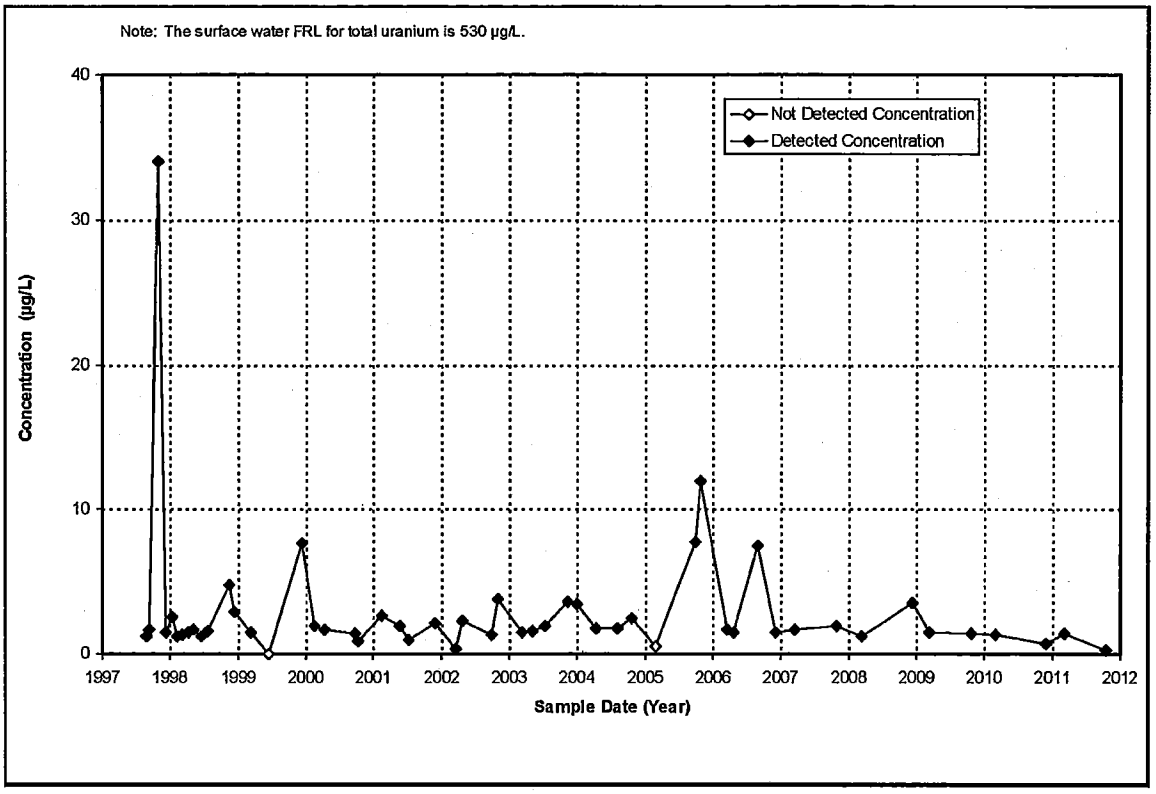

Figure B.1-11. Total Uranium Concentration vs. Time Plot for Location SWP-02 (Paddys Run) for Cross-Media Impact Evaluation

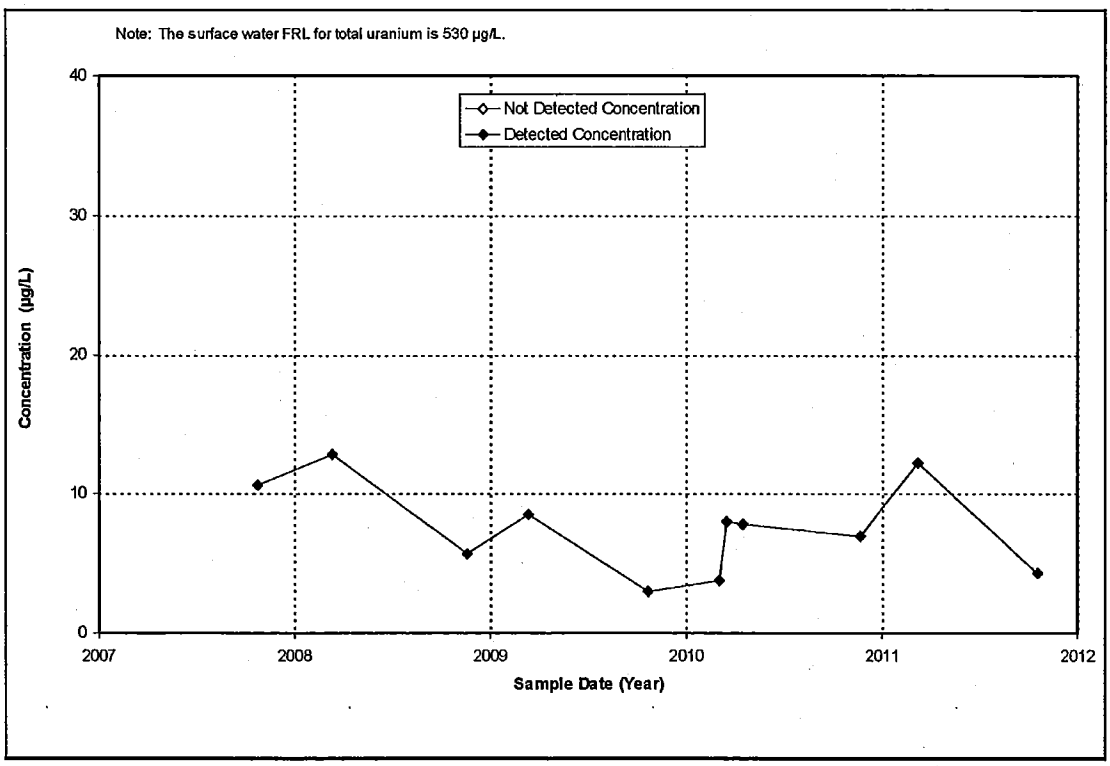

Figure B.1-12. Plot of Total Uranium Concentration versus Time for Location SWD-06 (Former Pilot Plant)

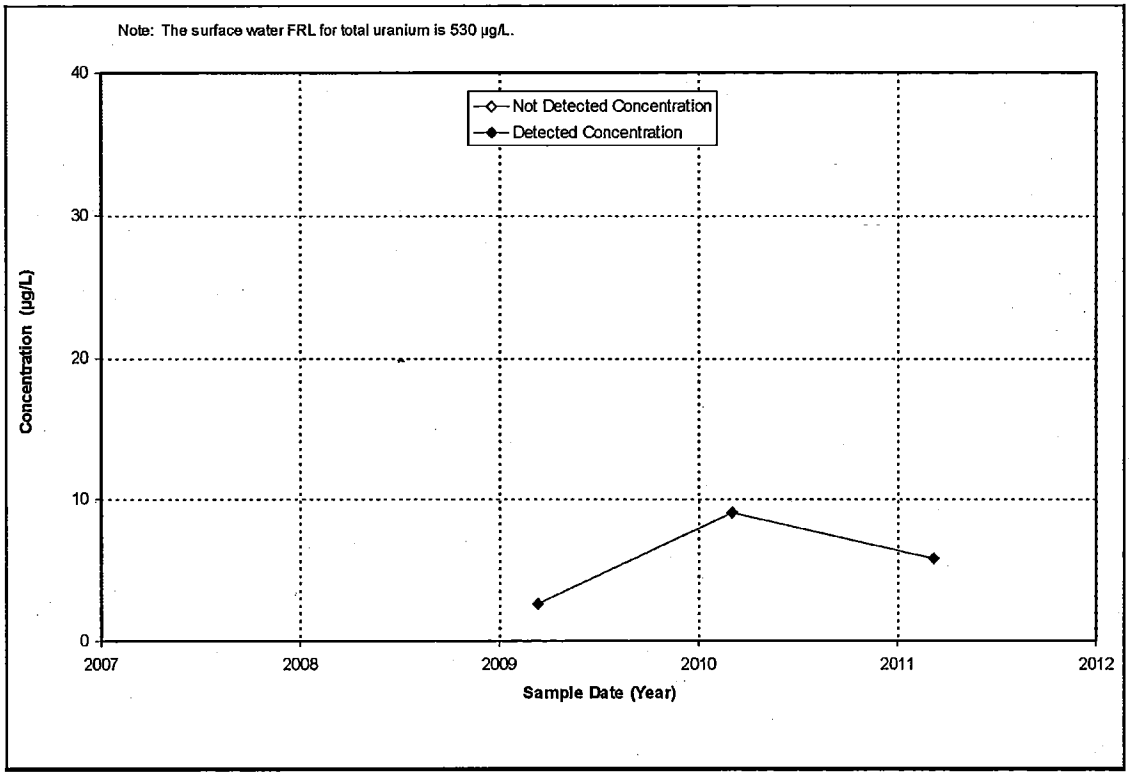

Figure B.1-13. Total Uranium Concentration vs. Time Plot for Location SWD-10 (Lodge Pond)

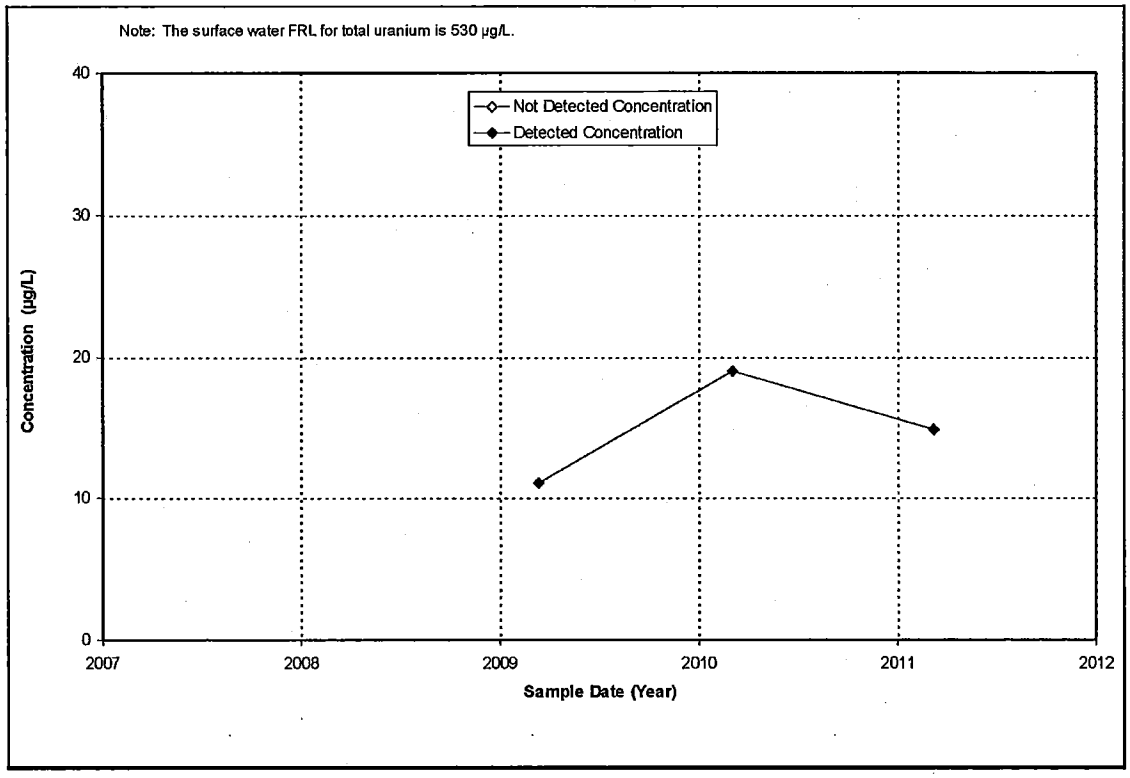

Figure B.1-14. Total Uranium Concentration vs. Time Plot for Location SWD-11 (Former Lime Sludge Pond)

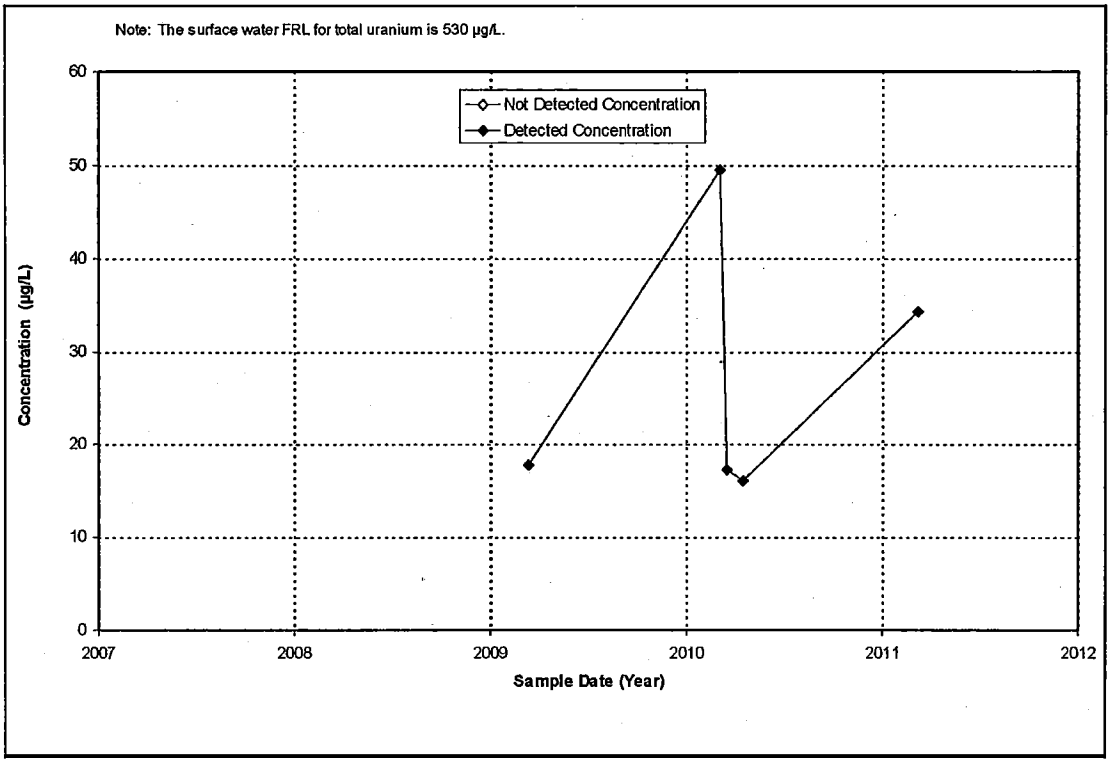

Figure B.1-15. Total Uranium Concentration vs. Time Plot for Location SWD-12 (Former Area 4B)

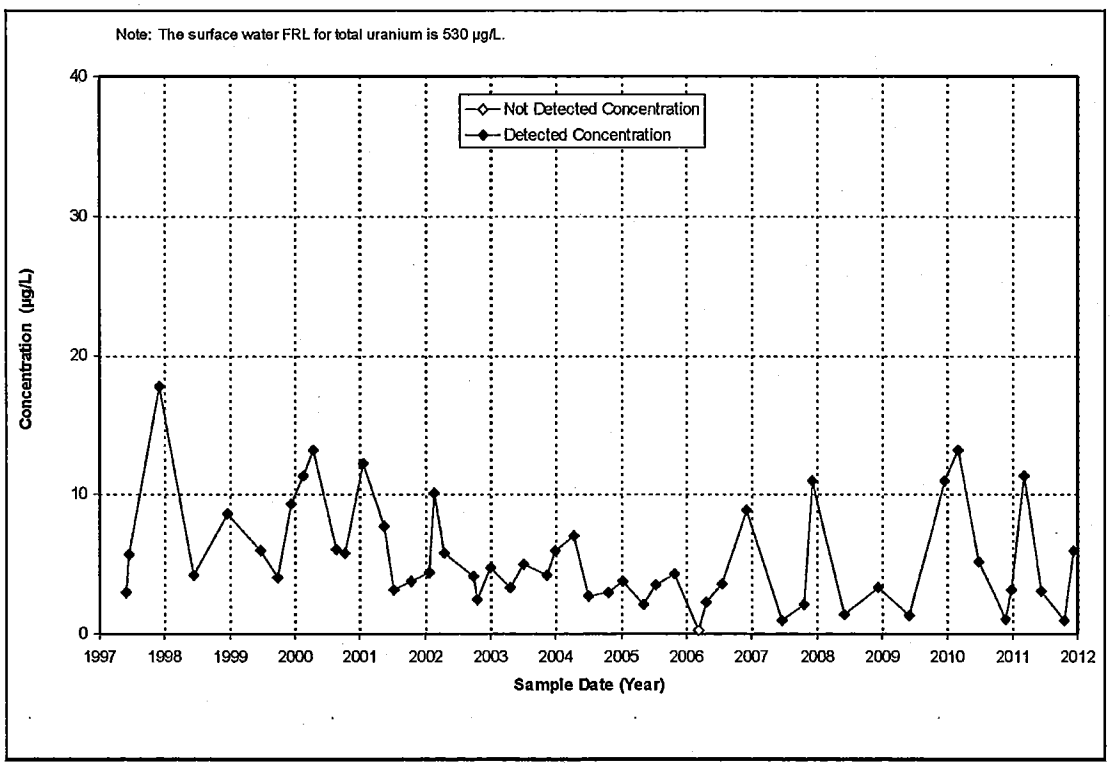

Figure B.1-16. Total Uranium Concentration vs. Time Plot for Location STRM 4004/4004A (Drainage to Paddys Run)

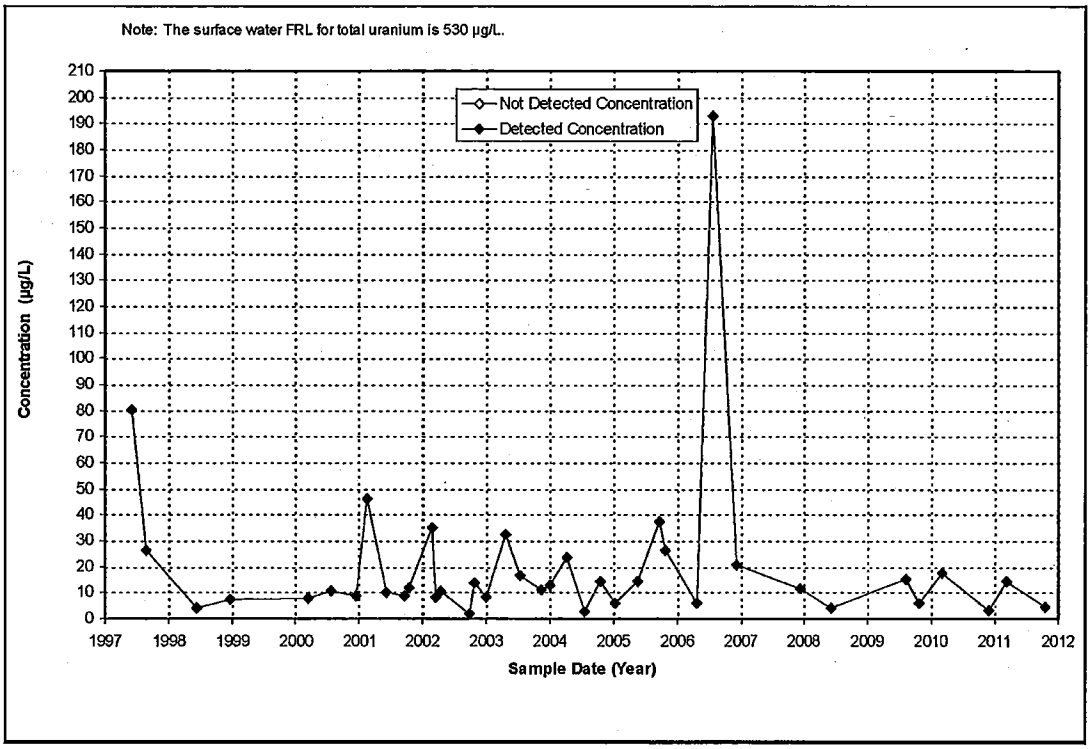

Figure B.1-17. Total Uranium Concentration vs. Time Plot for Location STRM 4006 (Drainage to Paddys Run)

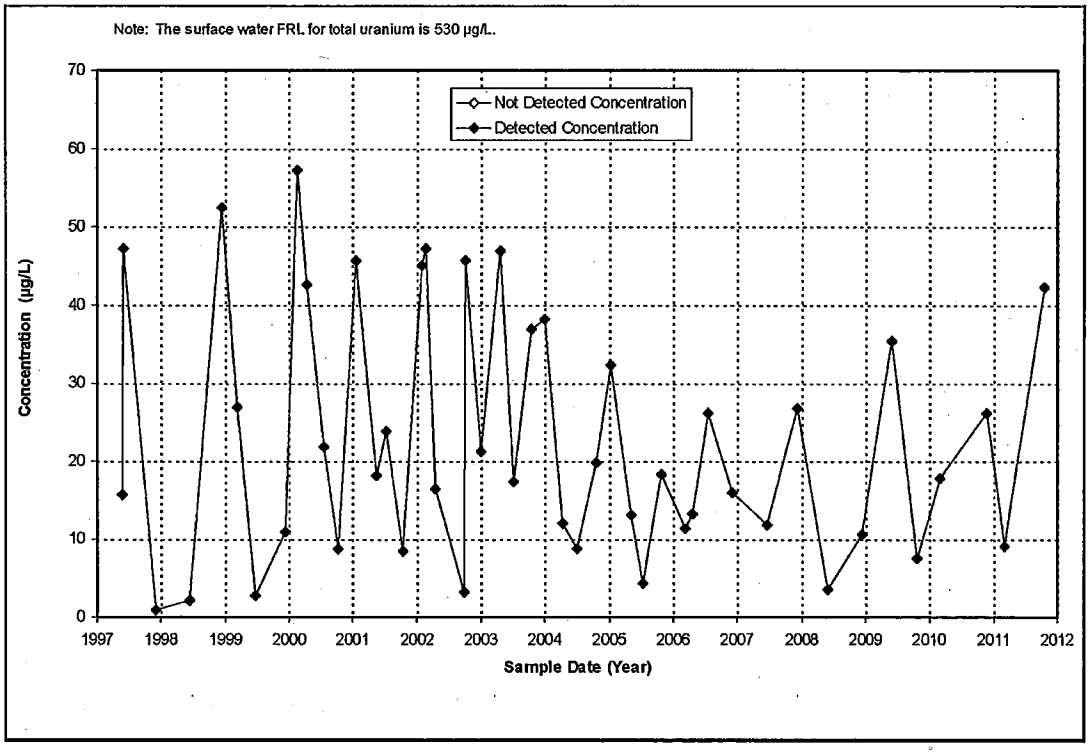

Figure B.1-18. Plot of Total Uranium Concentration versus Time for Location SWD-13 (Former Silos Area)

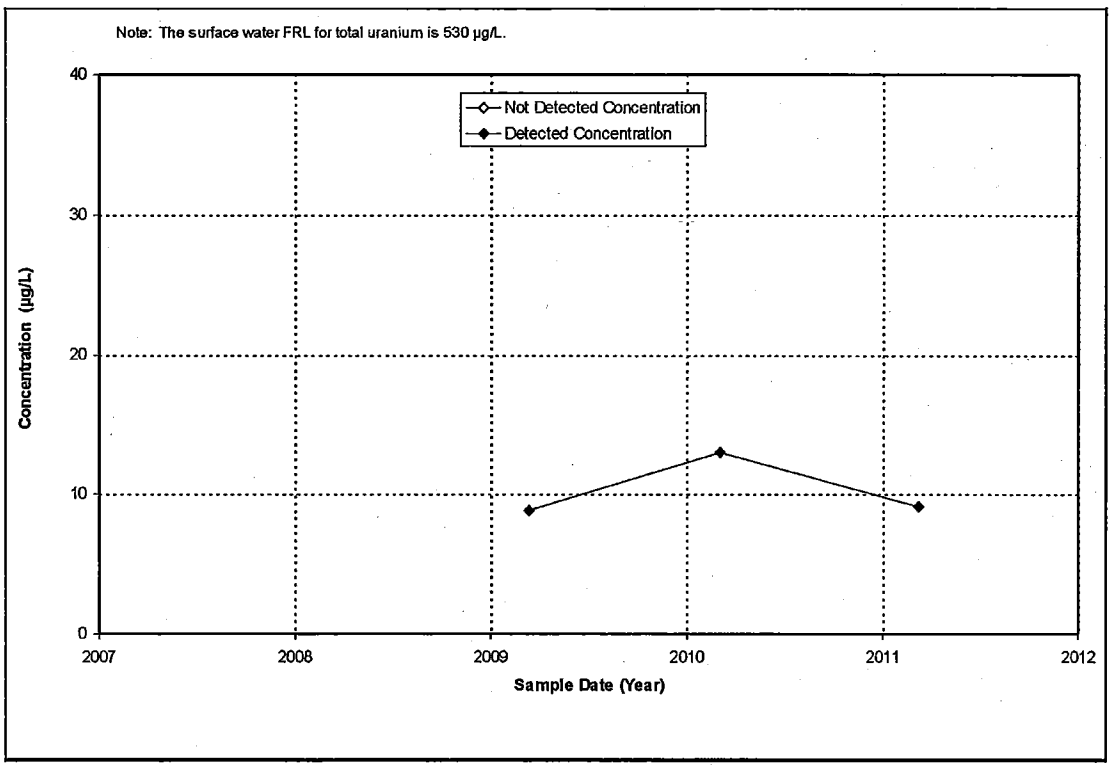

Figure B.1-19. Total Uranium Concentration vs. Time Plot for Location STRM 4003 (Drainage to Paddys Run)

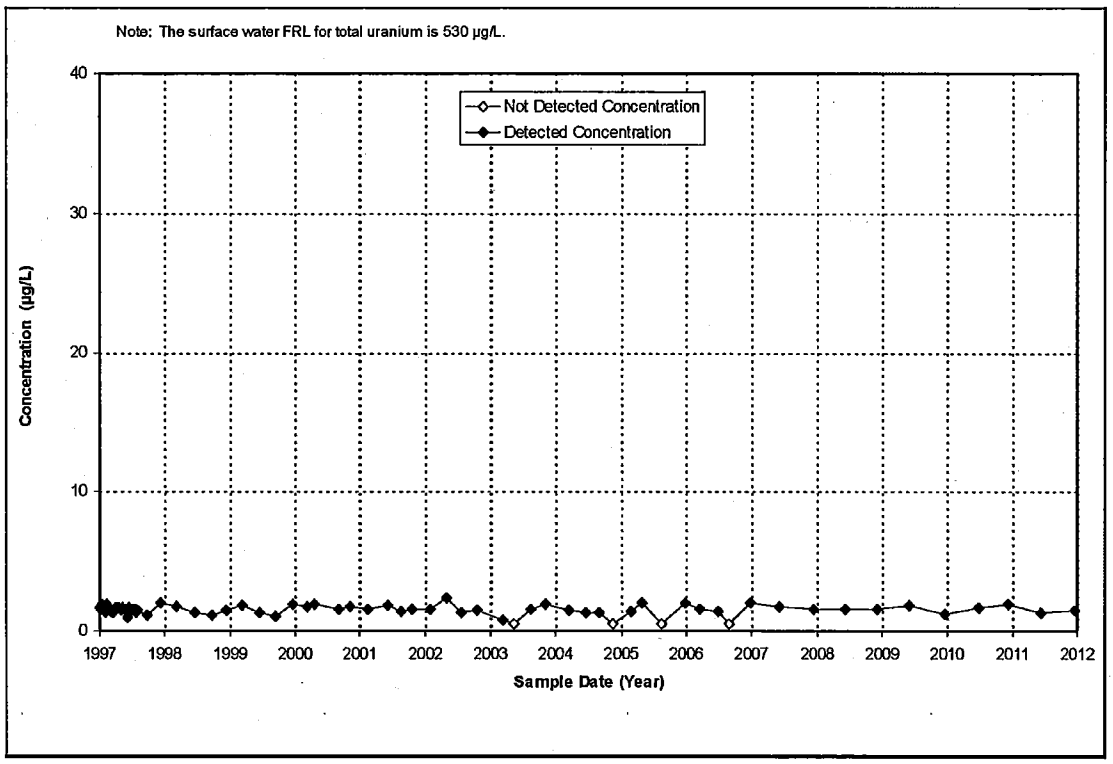

Figure B.1-20. Total Uranium Concentration vs. Time Plot for Location SWR-01 (Great Miami River Background)

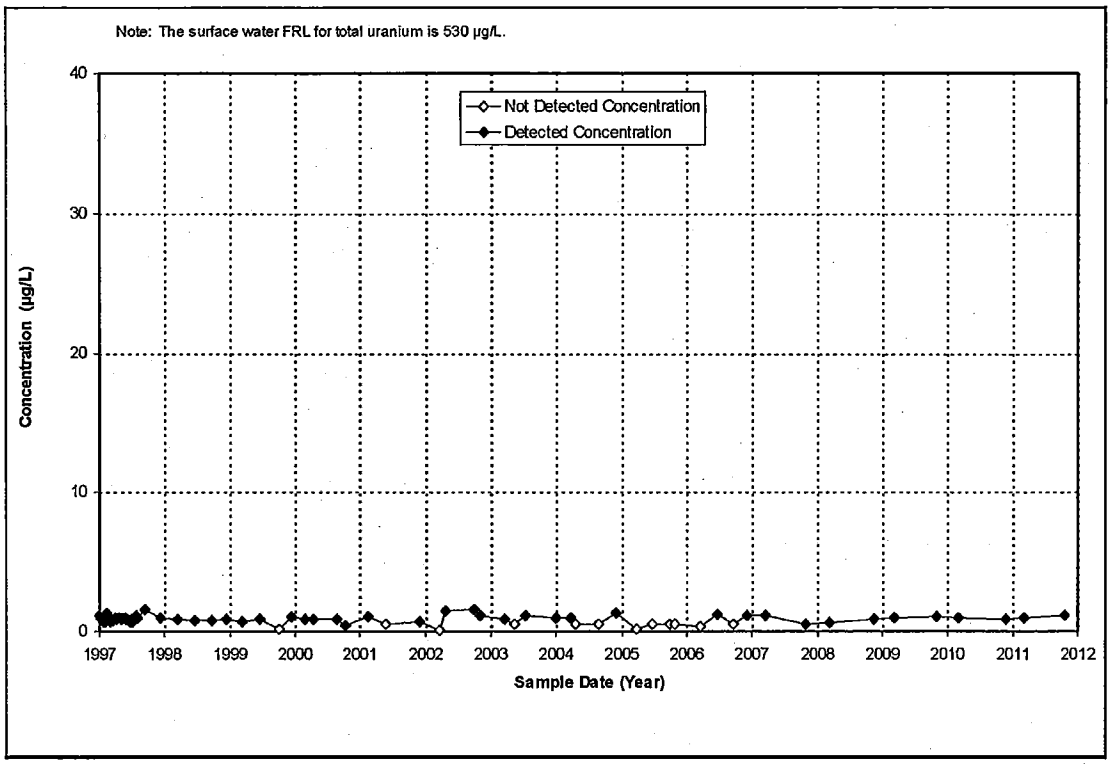

Figure B.1-21. Total Uranium Concentration vs. Time Plot for Location SWP-01 (Paddys Run Background)

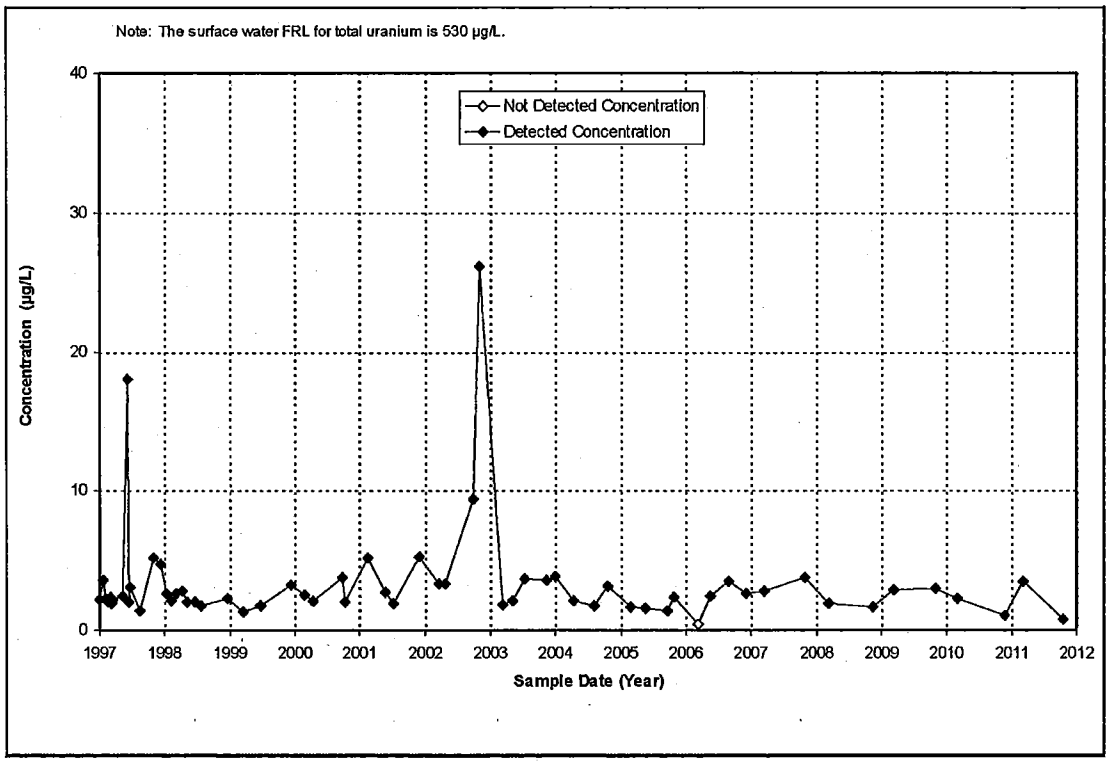

Figure B.1-22. Total Uranium Concentration vs. Time Plot for Location SWP-03 (Paddys Run at Downstream Property Boundary)

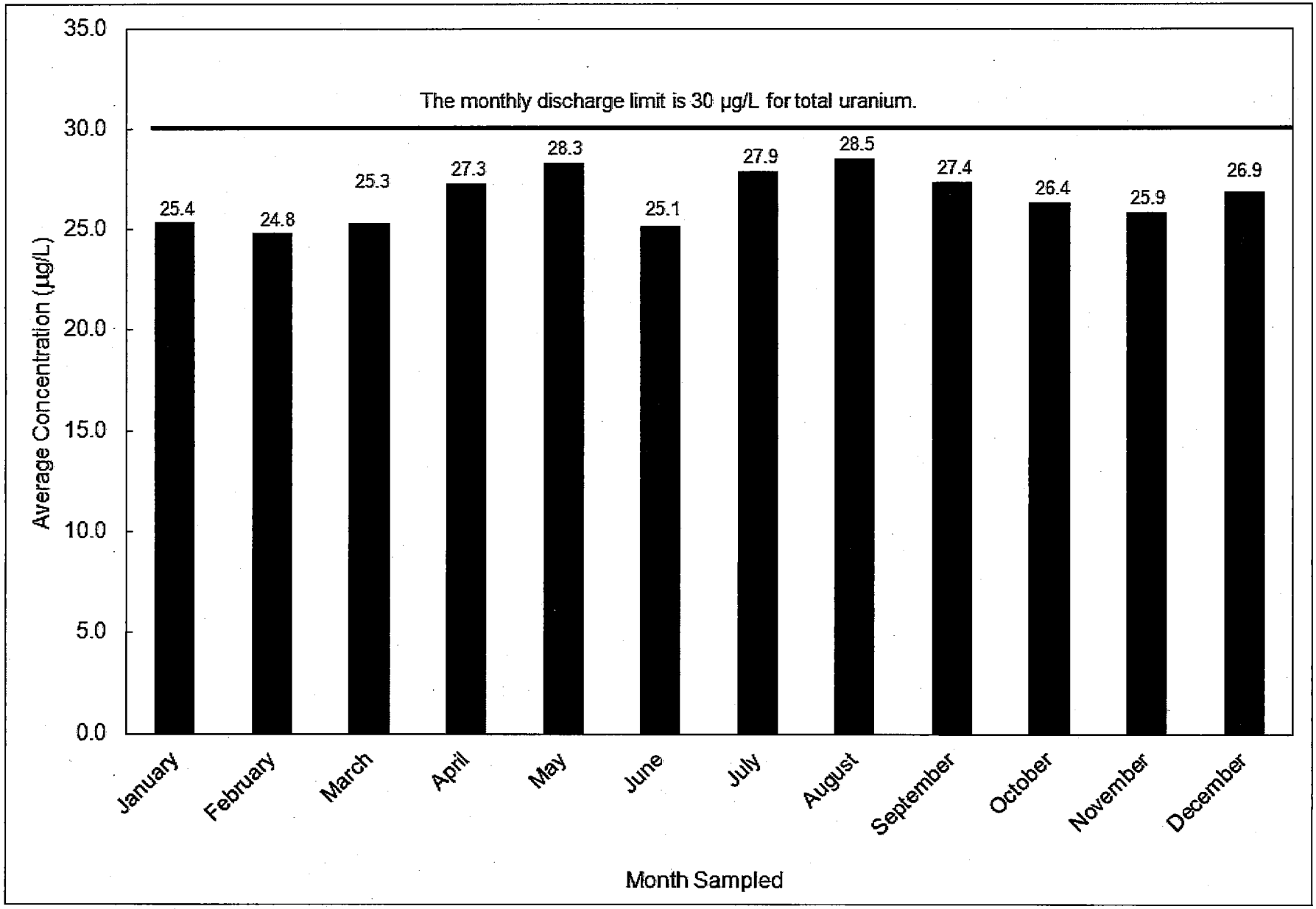

Figure B.1-23. 2011 Monthly Average Total Uranium Concentration in Water Discharged from PF 4001 to the Great Miami River

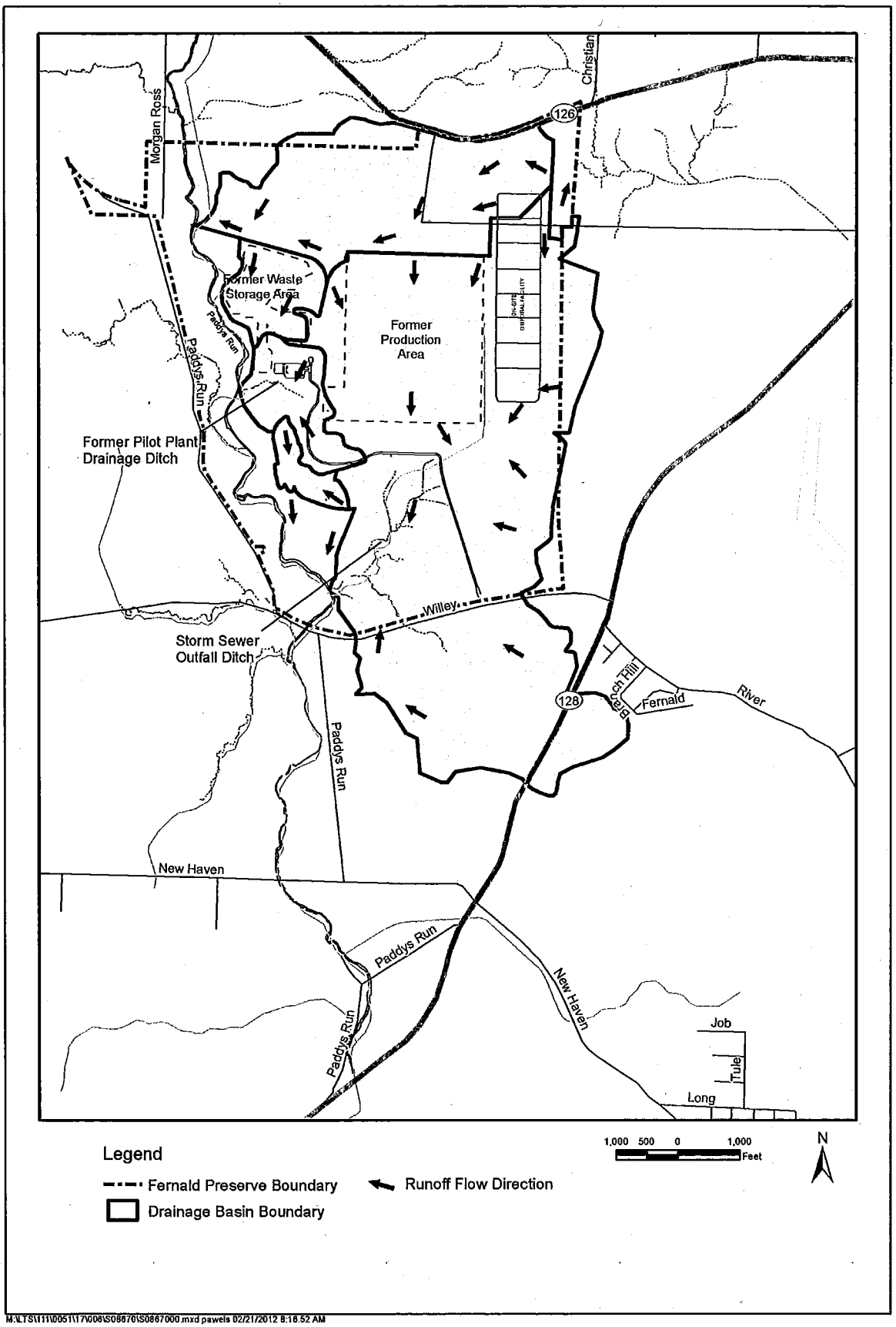

Figure B.1–24. Controlled Surface Water Areas and Uncontrolled Runoff Flow Directions

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Appendix C

Supplemental Air Information

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Contents

Abbreviations ..... C–ii
Measurement Abbreviations ..... C–ii
References ..... C–iii
Attachment C.1: Direct Radiation C.1–1
Attachment C.2: Supplemental Dose Assessments C.2–1

Abbreviations

BCG	Biota Concentration Guide
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FRL	final remediation level
IEMP	*Integrated Environmental Monitoring Plan*
LM	DOE Office of Legacy Management
OSL	optically stimulated luminescence
OU5 ROD	*Operable Unit 5 Record of Decision*

Measurement Abbreviations

cfs	cubic feet per second
pCi/L	picocuries per liter
rad	radiation absorbed dose
rem	roentgen equivalent man
yr	year

Appendix C presents additional dosimeter data and analysis in support of Section 5 of this *Fernald Preserve 2011 Site Environmental Report.* This appendix consists of two attachments:

- Attachment C.1 provides information on the direct radiation monitoring program, including an assessment of 2011 results with respect to historical data.
- Attachment C.2 provides the results of supplemental dose assessments that are part of the standards and requirements contained in DOE Order 5400.5. The methods and data sources used for the population and biota dose assessments are explained. In addition, an evaluation of trends observed in the dose assessments over the past 10 years is also provided.

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Attachment C.1

Attachment C.1: Direct Radiation

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C.1.0 Direct Radiation

The Fernald Preserve maintains 11 optically stimulated luminescence (OSL) dosimeters, which are used to collect direct radiation measurements as part of the Integrated Environmental Monitoring Plan Dose Assessment Program, which is Attachment D of the *Comprehensive Legacy Management and Institutional Controls Plan* (DOE 2010a). The OSL dosimeters are at one background, five boundary, and four trail locations, as well as a single location at the Visitors Center (Figure C.1–1). Three OSL dosimeters are deployed at each location to track and evaluate direct radiation, and each OSL dosimeter is collected and measured quarterly (approximately every 91 days). The three measurements are averaged to obtain a quarterly result for each location. Quarterly results are plotted on Figure 29 in Section 5. The OSL dosimeter data for each location are presented on the U.S. Department of Energy Office of Legacy Management's (LM) website under the Fernald Preserve (http://www.lm.doe.gov/fernald/Sites.aspx)

Table C.1–1 provides a summary of the annual dose for 2011 and 2010. Annual dose is calculated by summing the quarterly results at each location. Quantification of the direct radiation dose delivered to an individual at the Fernald Preserve boundary (Section 5) indicates there is no significant dose associated with direct radiation. These results are in agreement with Figure C.1–2, which shows that the 95 percent confidence interval of the mean values for the on-site dosimeters and background dosimeter overlap. One exception is the lower 95 percent confidence interval for OSL-2 is slightly above the upper 95 percent confidence interval for OSL-27. Note that OSL-54 is inside the Visitors Center, and direct radiation is lowest there due to the shielding effects of the building. Given the remediation of the Fernald Preserve to soil FRLs, and statistically similar boundary and background values in 2011, it is reasonable to expect future readings to be at or near background levels.

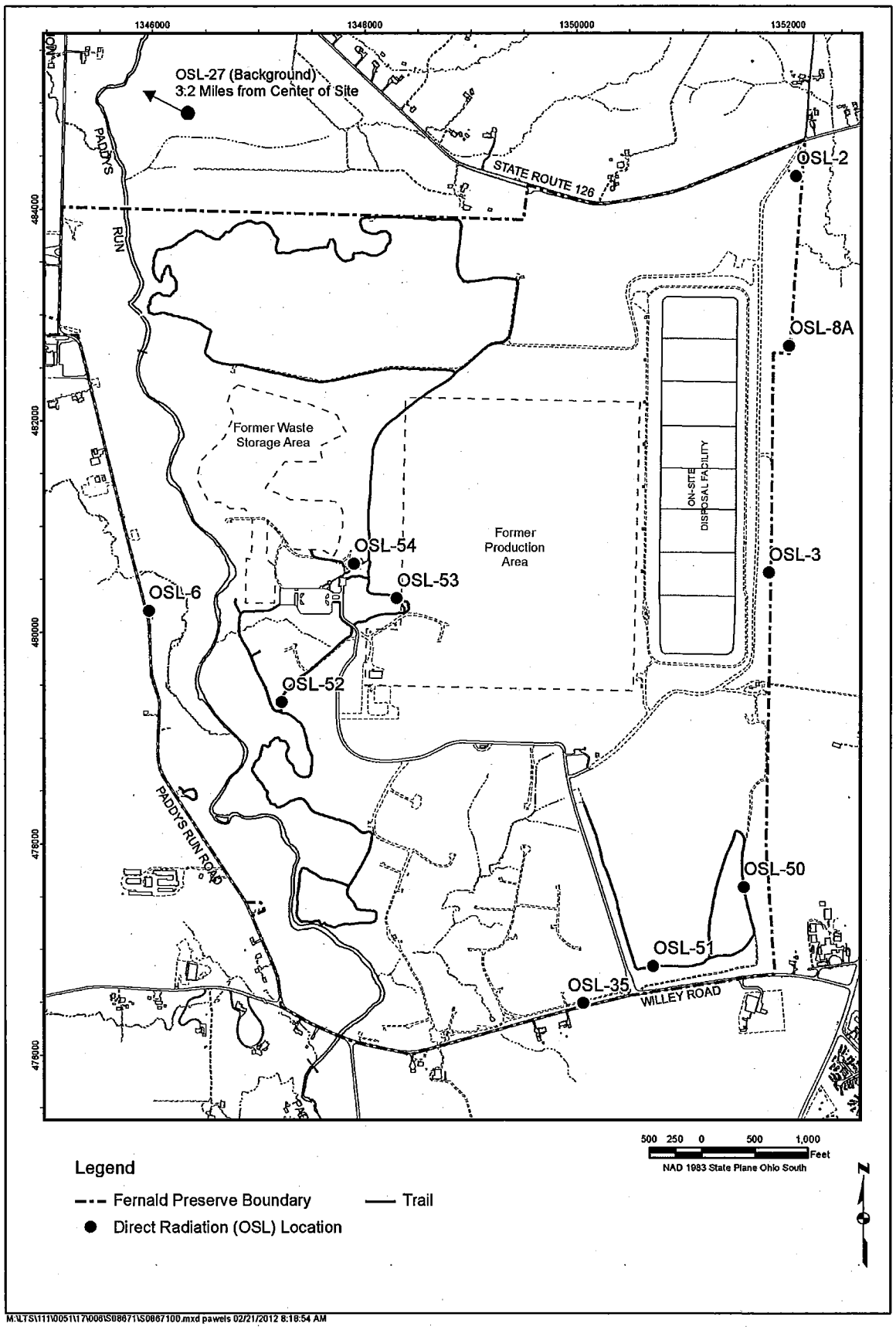

Figure C.1–1. Direct Radiation (OSL) Monitoring Locations

Table C.1-1. Dose Based on Direct Radiation (OSL) Measurements

	Direct Radiation (mrem)[a]	
Location	2011	2010
Boundary		
2	33	26
3	25	25
6	16	18
8A	33	26
35	28	20
50	25	21
51	30	28
52	23	20
53	21	18
54	6.0	5.2
Minimum	**6.0**	**5.2**
Maximum	**33**	**28**
Background		
27	21	18

[a]Annual dose is derived by summing the average quarterly result for each location.

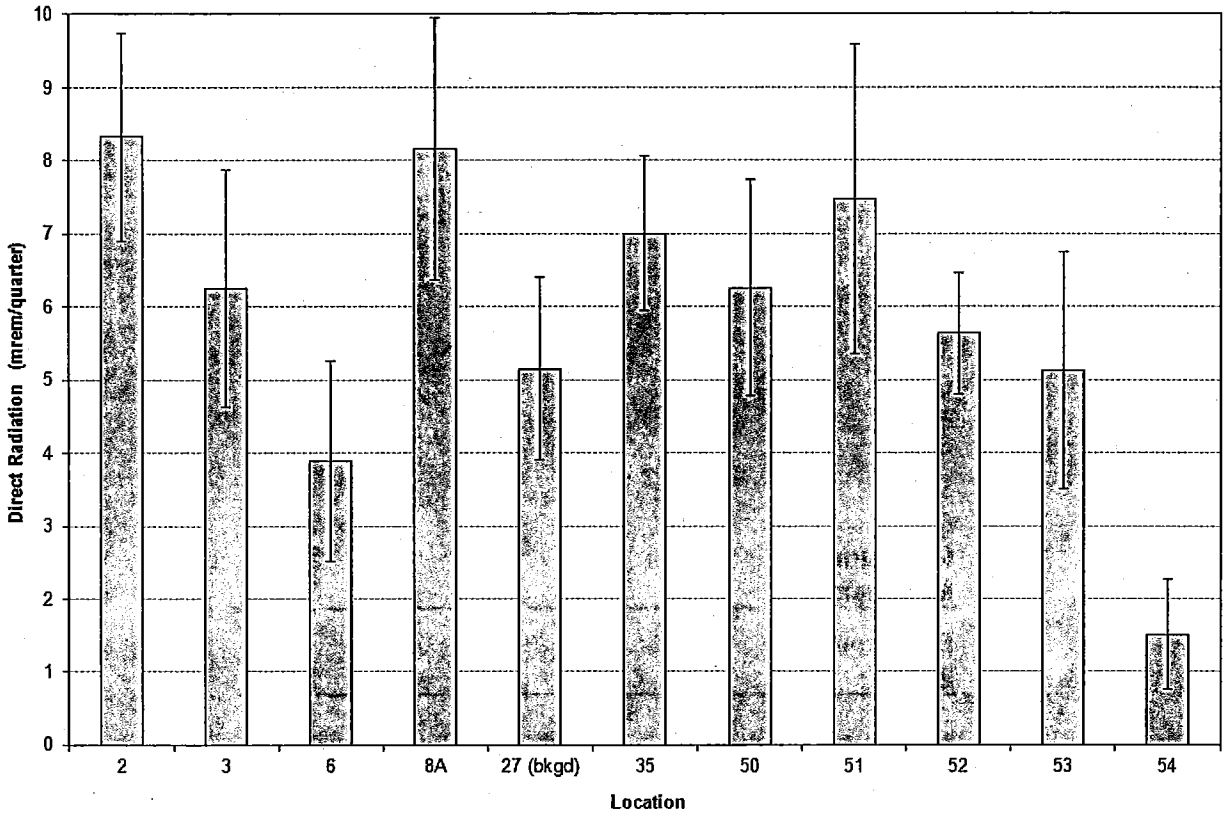

Figure C.1–2. 2011 Mean and 95 Percent Confidence Interval for Quarterly Dosimeter Measurements

Attachment C.2

Attachment C.2: Supplemental Dose Assessments

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C.2.0 Supplemental Dose Assessments

This attachment contains a detailed discussion of the supplemental dose assessments performed for calendar year 2011, and compares the 2011 results to those from 2000 through 2010. The supplemental dose assessment comprises the population and biota dose assessments, which provide required information for compliance with DOE Order 5400.5.

The 2011 population dose assessment provides an aggregate measure of the impact of direct radiation from sources at the Fernald Preserve to the population in the area. However, with the completion of soil remediation, removal of the silo and waste pit material, and capping of the final OSDF cells in 2006, the only remaining source for direct radiation is the soil. As the soil has been certified to contain contaminant levels below the OU5 FRLs, there is no significant remaining source to deliver a dose to the public in excess of the dose that corresponds to an incremental lifetime cancer risk of 1 in 10,000, which is acceptable for EPA superfund sites. The population dose assessment presented below supports this conclusion.

The groundwater remediation program continues to discharge large volumes of water to the Great Miami River, and the biota dose assessment provides information on the Fernald Preserve's compliance with dose limits to aquatic organisms in the Great Miami River. Groundwater is not considered as part of the population dose because contaminated groundwater is not consumed by the public.

C.2.1 Population Dose Assessment

Computation of a population dose is a requirement of DOE Order 5400.5, which defines population dose as the collective effective dose equivalent. Collective effective dose is the dose spread across the population within a 50-mile radius of the site. For 2011, the effective dose equivalent was 0.048 person-rem/yr from the direct radiation component (Table C.2–1). Monitoring of the air inhalation pathway was discontinued at the beginning of 2010 and there was no estimated biota dose to the population from consumption of produce, as the produce monitoring program was completed in 2003.

Table C.2–1. Estimated Population Doses (person-rem)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010[c]	2011
Air Inhalation	3.29	3.35	3.47	3.84	3.87	1.20	0.485	0.010	0.039	0.014	NA	NA
Direct radiation	0.108	0.159	0.23	0.155	0.47	0.35	0.030	0.015	0.019	0.028	0.019	0.048
Biota[a,b]	0.48	NA	NA	0.002	NA	NA	NA	NA	NA	NA	NA	NA
Total	**3.88**	**3.51**	**3.70**	**4.00**	**4.34**	**1.55**	**0.515**	**0.025**	**0.058**	**0.042**	**0.019**	**0.048**

[a]NA = not applicable.
[b]Produce for biota dose was sampled every three years, and program was completed in 2003.
[c]Particulate monitoring for the air inhalation pathway was discontinued in 2010.

The direct radiation dose component was estimated by using the population distribution within 50 miles of the site, as distributed between 16 equally spaced compass sectors (N, NNE, NE, ENE, etc.). In 2011, monitoring was performed at the 5 boundary locations approved by EPA (DOE 2006a and 2006b), resulting in direct radiation dose data that are not uniformily distributed between the 16 sectors. Therefore, an estimate of the direct radiation at the unmonitored 11 compass sectors is used to evaluate the direct radiation dose.

The 95 percent confidence interval of the mean for quarterly measurements at the on-site and background locations overlap (Attachment C.1). This implies that direct radiation at the site boundary is not significantly different from background; therefore, the background value was applied to the 11 compass sectors that had no collected data. A dose was estimated for each population sector based on the direct radiation level that exceeded background at the site boundary, and the distance between the location of the population and the site boundary. The following conservative assumptions were used in the calculations:

- Population lives 8,760 hours per year in area (DOE Order 5400.5).
- The number of people per household is estimated by total population per sector per mile divided by number of households per sector per mile.
- The net direct radiation levels are calculated from on-site OSL dosimeter results minus the background result, with no correction for analytical uncertainty.

The collective effective population dose was in 2011 was higher than 2010 due to a larger difference between the highest boundary and background dosimeter. The air inhalation pathway is no longer evaluated at the Fernald Preserve, per DOE and EPA agreement (DOE 2010b). As discussed in Attachment C.1, the direct radiation dose has been at or near background for the past several years.

The collective population dose attributed to direct radiation at the Fernald Preserve (Table C.2–1) is very low relative to background dose values from the sun and food products. The background radiation dose from the sun and naturally occurring radionuclides in food products and the earth is estimated to be 300,000 person-rem for the population within 50 miles of the Fernald Preserve. A review of the 2011 estimated dose in Table C.2–1 shows dose attributable to the Fernald Preserve is over 6 million times less than background dose, which implies it is an insignificant dose in terms of compliance with DOE Order 5400.5.

C.2.2 Biota Dose Assessment

DOE Order 5400.5 requires that populations of aquatic biota be protected at a dose limit of 1 rad/day. DOE has issued a technical standard entitled *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) and supporting software (RAD-BCG) for use in the evaluation and reporting of biota dose limits. A biota dose assessment divides the radionuclide concentrations in surface water and/or sediment samples by pre-established biota concentration guides (BCGs) for specific radionuclides and sums the fractions for each radionuclide. If the resulting sum of fractions is less than 1.0, compliance with the biota dose limit is assured. BCGs have been established for radionuclides that are relatively common constituents in past radionuclide releases to the environment from DOE facilities. For the isotopes at the Fernald Preserve, the radium isotopes have the lowest BCG values, hence they account for most of the weight in the sum of fractions presented here.

For 2000 through 2005, the Fernald site determined compliance with the biota dose limit to aquatic biota using RAD-BCG and the diluted (i.e., mixed) concentration for each applicable radionuclide discharged to the Great Miami River at the Parshall Flume. Although the Parshall Flume was the only discharge point evaluated through 2005, two discharge points (Paddys Run and the Parshall Flume) are delivering mass to the Great Miami River. Beginning in 2006, both discharge points were evaluated to calculate the dose to aquatic biota in the Great Miami River.

In 2003, Ohio EPA published a fact sheet that provided the harmonic mean flow of 0.19 cubic feet per second (cfs) for Paddys Run (Ohio EPA 2003), allowing this discharge point to be evaluated in addition to the Parshall Flume. Therefore, the biota assessments for 2003 through 2011 were performed using the mass delivered from both discharge points to determine the annual average mixing concentration in the Great Miami River. These assessments only evaluate the contaminant contribution from the Fernald Preserve, and contaminant concentrations in the Great Miami River may be higher due to other sources that discharge similar pollutants.

The maximum measured concentration for radium-226 and total uranium (note that radium-228 and technetium-99 were reported at detection limit values and one-half of the detection limit was used in the calculation) at the Parshall Flume (PF 4001) and total uranium (note that radium-226, radiium-228 and thorium-232 were reported at detection limit values and one-half of the detection limit was used in the calculation) at Paddys Run (SWP-03) monitoring locations (see Section 4.0 and Appendix B) was multiplied by the annual volume of water discharged to the Great Miami River at the Parshall Flume and Paddys Run to obtain an estimate of the maximum activity of each radionuclide delivered to the river at each discharge point (e.g., pCi/L × L = total pCi). For each radionuclide, the activity discharged at the Parshall Flume was added to the activity discharged at Paddys Run to obtain the annual total activity delivered to the river. The annual total activity delivered to the river was divided by the annual total volume of mixed water (Parshall Flume + Paddys Run + Great Miami River) to obtain the annual radionuclide activities used in RAD-BCG for the biota dose assessment (as noted above, this activity represents discharge from a single source, the Fernald Preserve).

Table C.2–2 contains a summary of the output from RAD-BCG for 2000 through 2011. Results for 2011 show that the sum-of-fractions result (0.006) is well below the compliance threshold value of 1.0.

Table C.2–2. Estimated Sum-of-Fractions[a] for Biota Dose

	2000[b]	2001[b]	2002[b]	2003	2004	2005	2006[b]	2007[b]	2008[b]	2009[b]	2010[b]	2011[b]
A	0.035	0.038	0.023	0.035	0.059	0.017	NA	NA	NA	NA	NA	NA
B	NA	NA	NA	0.035	0.059	0.005	0.062	0.009	0.010	0.005	0.007	0.006

Note: A = 2000 through 2005 calculated using one discharge point (Parshall Flume)
B = 2003 through 2011 calculated using two discharge points (Paddys Run and Parshall Flume)

[a]Sum-of-the-fractions calculated with the RAD-BCG code.
[b]NA = not applicable.

Recalculated results for 2003 and 2004, for two discharge points, are identical to the initial results calculated for one discharge point. This indicates that the mass delivered from Paddys Run is insignificant relative to the mass delivered at the Parshall Flume. When the contaminant concentration is similar at the two discharge points, the contaminant mass delivered to the Great Miami River from Paddys Run will be much less than the mass delivered to the river at the Parshall Flume because of the large difference in discharge volume. Based on the harmonic mean flow for Paddys Run (0.19 cfs; Ohio EPA 2003), the annual volume of water discharged in 2011 to the Great Miami River is 1.70×10^8 L, compared to 9.62×10^9 L for the Parshall Flume.

The 2005 sum-of-fractions result for Scenario A (one discharge point) is greater than that for Scenario B (two discharge points). This anomaly is due to an incorrect calculation of the mass of radium discharged to the Great Miami River for Scenario A. In 2005, the maximum radium concentration recorded for water discharged to Paddys Run was multiplied by the annual volume discharged at the Parshall Flume. As the maximum radium concentration at Paddys Run was much higher than radium values recorded at the Parshall Flume, changing the radium concentration to maximum observed at the Parshall Flume (lower than the maximum value for Paddys Run) lowers the mass of radium delivered to the Great Miami River and decreases the sum-of-fractions result for Scenario B to the proper value.

Appendix D

Appendix D

Ecological Restoration Monitoring

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Contents

Abbreviations iii
Measurement Abbreviations iv
References v
D.1.0 Ecological Restoration Monitoring 1
D.1.1 Wetland Mitigation Monitoring 1
D.1.1.1 Jurisdictional Wetland Delineation and Other Design Parameters 1
D.1.1.2 Hydrologic Regime Parameters 2
D.1.1.3 Vegetation Parameters and Vegetation Index of Biotic Integrity 3
D.1.1.4 Soil Biogeochemical Parameters and Water Chemistry 4
D.1.1.5 Amphibian Index of Biotic Integrity 5
D.1.2 Forest Functional Phase Monitoring 6
D.1.3 Implementation Monitoring 7
D.1.4 Species Inventory Activities 7
D.1.5 Activities in 2012 7

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Abbreviations

A/P	Area to Perimeter Ratio
AIBI	Amphibian Index of Biotic Integrity
BAP	Borrow Area Project
CC	Coefficient of Conservatism
DBH	Diameter at Breast Height
DOE	U.S. Department of Energy
FACW	Facultative Wet
FPA	Former Production Area
FQAI	Floristic Quality Assessment Index
GIS	Graphical Information System
NPP	Northern Pine Plantation
NRRP	Natural Resource Restoration Plan
NRT	Natural Resource Trustee
NWE	Northern Woodlot Enhancement
OBL	Obligate
Ohio EPA	Ohio Environmental Protection Agency
USACE	U.S. Army Corps of Engineers
VIBI	Vegetation Index of Biotic Integrity
WM1	Wetland Mitigation Phase I
WM2	Wetland Mitigation Phase II
WMMP	Fernald Preserve Wetland Mitigation Monitoring Plan
WMMR	Fernald Preserve Wetland Mitigation Monitoring Report

Measurement Abbreviations

cm	centimeters
m^2	meter squared

References

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D.1.0 Ecological Restoration Monitoring

Ecological restoration monitoring at the Fernald Preserve in 2011 involved completing the wetland mitigation monitoring program, as well as characterization of forest communities as part of functional monitoring. Implementation monitoring was conducted in 2011 as well, as a follow-up to the Natural Resource Trustee (NRT) "Resolution No. 3" projects. Species inventory activities also took place, including reptile and small mammal coverboards.

Wetland mitigation monitoring, functional phase monitoring and implementation monitoring are required as a result of the natural resource damage settlement between U. S. Department of Energy (DOE), Ohio Environmental Protection Agency (Ohio EPA) and U.S. Department of Interior. The *Fernald Preserve Natural Resource Restoration Plan* (NRRP) specifies ecological restoration monitoring requirements (State of Ohio 2008).

D.1.1 Wetland Mitigation Monitoring

Enhanced wetland mitigation monitoring was to take place from 2009 through 2011, as specified in the *Fernald Preserve Wetland Mitigation Monitoring Plan* (WMMP, DOE 2009). For 2011, activities included vegetation surveys, amphibian monitoring, hydrological monitoring and soil biogeochemical sampling. A jurisdictional wetland delineation was also conducted, in order to calculate the extent of mitigation wetland acreage created. Wetland perimeter to area ratios and basin morphometry were calculated as well, Figure D–1 shows the wetland areas that are included in the wetland mitigation monitoring program.

The discussion below summarizes 2011 activities only. The *Fernald Preserve Wetland Mitigation Monitoring Report* (WMMR, DOE 2012) presents detailed discussions of the three-year monitoring effort, as well as a comparison to mitigation performance standards that were established in the WMMP (DOE 2009).

D.1.1.1 Jurisdictional Wetland Delineation and Other Design Parameters

Mitigation wetland acreage was estimated via a jurisdictional wetland delineation. The 1987 U.S. Army Corp of Engineers (USACE) *Wetland Delineation Manual* (USACE 1987) and associated *Interim Regional Supplement to the Corps of Engineers Wetlands Delineation Manual: Midwest Region* (USACE 2008) were used to delineate wetland boundaries within all evaluated wetland basins. Fieldwork commenced in late May 2011 and continued through July 2011. Field personnel identified major landscape or vegetation units within each of the 23 wetland areas to be evaluated. One or more delineation sample points were selected from each basin. Two indicator tests were applied to determine the presence of hydrophytic vegetation and hydric soil in order to determine whether the delineation sample point fell within a wetland area, thus determining the wetland boundary. Landscape-level photographs and photographs of vegetation and soil, were taken at each sample point. Each sample point was documented with a *Midwest Region Wetland Determination Data Form* (USACE 2008). Pursuant to Ohio EPA monitoring protocols (Mack 2004), net wetland acreage was calculated by subtracting the area of unvegetated open water (above 10 percent) from the total acreage within the delineation boundary.

A total of 31.3 acres of jurisdictional wetlands was delineated across the wetland areas included in the monitoring program. Table D-1 provides wetland acreages by basin. Figures D–2A through D–2E show the wetland delineation boundary within each basin, along with delineation sample locations. The delineation acreage is well in excess of the 17.85 acres of mitigation wetlands specified in the WMMP.

Additional design parameter performance standards include a perimeter to area ratio of greater than 75 percent, and basin morphometry of greater than 15:1 ratio (i.e., less than 6.8 percent side slope). Basin morphometry and perimeter-to-area ratio were estimated using Graphical Information System (GIS) measurement and analytical tools. Delineation boundaries were used to calculate morphometry via slope histograms. Slope percentage was determined for all areas within the wetland boundary. Pursuant to the Ohio EPA monitoring protocols, the performance standard is met when greater than 50 percent of the wetland area has a slope of less than 6.8 percent.

Because impacted wetlands were lost during remediation, a "basin to basin" comparison for determining perimeter to area ratio was not possible. Instead, the ratio was calculated on a sitewide basis. The total length of mitigation wetlands is approximately 84 percent of the total impacted wetland length. Therefore, the 75 percent performance standard is met. Note that since this calculation is for all wetlands evaluated, basin-specific percentages are not presented in Table D–1.

For basin morphometry (percent side slopes), Table D–1 shows that this performance standard was met for all basins except FPAW7. This is most likely an artifact of the way that morphometry is calculated. The "open water" portions of the wetland areas are excluded from the area calculations by the GIS program. Most of FPAW7 consists of a level, emergent wetland community. Since the GIS shape considers this area "open water" it is not included in the calculation. If it were included, FPAW7 would certainly meet the greater than 50 percent performance standard.

D.1.1.2 Hydrologic Regime Parameters

Hydrological monitoring consists of daily water level readings from shallow wells (i.e., piezometers) that were installed in late 2009. The location of piezometers within site wetlands is shown on Figures D–2A to D–2E. Table D–2 summarizes the 2011 findings.

There are three performance standards associated with water levels: the average depth to water from ground surface should be less than 29.4 centimeters (cm), water should be present in the root zone (less than 30 cm from ground surface) more than 53 percent of the time, and the "flashiness index" of the basin should be less than 2.0. Flashiness index is determined by calculating the absolute value of daily water elevation differences and averaging them throughout the year.

Table D–2 shows that most wetlands met both the root zone standard and average depth standard. All basins met the standard for flashiness index. These findings are as expected for surface water-fed emergent wetlands such as those at Fernald. Hydrographs, which are included in Figures D–3A to D–3W showed a similar trend as in 2010, with variation dictated by precipitation. Over 60 inches of rain fell onsite in 2011, making it the wettest year on record.

Nevertheless, most basins experienced a drawdown of water in the fall. This pattern is consistent with other surface water-fed wetlands in Ohio (Mack 2004). Note that the results presented in the hydrographs and in Table D–2 are slightly different than what is reported in the WMMR (DOE 2012). These SER results represent the entire calendar year, while the values presented in the WMMR were through October 15, 2011. Notes are provided on the hydrograph charts indicating when the piezometer was dry, or when data was not collected due to transducer failure.

D.1.1.3 Vegetation Parameters and Vegetation Index of Biotic Integrity

Several vegetation parameters are used to compare on-site restored wetlands against performance criteria established by Ohio EPA (Mack 2004). Parameters include less than 10 percent of unvegetated open water, greater than 75 percent native perennial hydrophytes, and a Vegetation Index of Biotic Integrity (VIBI) of 48 to 63. All of these metrics are obtained via fixed plot vegetation survey, where ten 10-meter by 10-meter modules are established and surveyed for species richness. The 10 plots are arranged to be representative of the vegetation within a particular wetland area. Usually, the fixed plot grid is laid out in a 2-module by 5-module pattern. However, this configuration can be altered if conditions warrant. For instance, a 1-module by 10-module pattern may be used to survey a long, narrow stretch of wetland vegetation along a shoreline. Four of the 10 modules are intensively monitored, with cover and biomass data collected in addition to species richness. Field procedures are documented in the *Fernald Preserve Ecological Monitoring Methods Plan* (DOE 2010).

Unvegetated open water is determined from cover estimates taken during the fixed plot surveys. The percentage of native perennial hydrophytes is estimated via species richness values for each wetland basin. The Ohio Floristic Quality Assessment Index (FQAI) Database is used to determine nativity status (Andreas 2004).

The VIBI is calculated using 10 metrics. Collected vegetation data are used to assign a score (0, 3, 7, 10) for each of the 10 metrics, which results in a composite score for a given wetland between 0 and 100. The WMMP (DOE 2009) established that site wetland areas will be evaluated against the emergent wetland performance criteria. Therefore, the VIBI metrics calculated from the collected vegetation data include the following:

1. *Carex* Richness: The total number of species in the genus *Carex.*
2. Dicot Richness: The total number of native species that are dicotyledons.
3. Shrub Richness: The total number of native wetland shrubs.
4. Hydrophyte Richness: The total number of native species that have a facultative wetland (FACW) or obligate (OBL) wetland indicator status.
5. Annual/Perennial Ratio (A/P Ratio): The number of annual species divided by the number of perennial species.
6. FQAI: The sum of Coefficient of Conservatism (CC) values is divided by the square root of the total number of species.
7. Percent Sensitive Species: The sum of relative cover for all species with CC of 6 or higher.
8. Percent Tolerant Species: The sum of relative cover for all species with CC of 2 or less. This includes non-native species, which are assigned a CC of 0.

9. Percent Invasive Graminoids: The sum of the relative cover for reed canary grass (*Phalaris arundacea*), cattails (*Typha* spp.), and giant reed (*Phragmites australis*).
10. Biomass: Average grams per square meter (m^2) of standing biomass samples. Four biomass samples were collected in each wetland basin; one from each of the four intensive modules.

Figures D–2A to D–2E show the location of fixed plot grids within each wetland basin evaluated. Data summaries for each of the wetland basins are provided in Table D–3. Basin-specific species lists are included in Tables D–4 to D–26. As discussed in the WMMR, results of the vegetation surveys are mixed. Most basins met the unvegetated open water standard. Most of the basins that did not meet the standard were created adjacent to larger open water bodies. For the percent native perennial hydrophytes, many basins either met the standard or came close. As the basin-specific tables show, some basins are influenced by non-native species such as cattail (*Typha x glauca*).

There may be some benefit to wetlands that are located near existing forest communities. All of the wetlands in the Northern Pine Plantation (NPP) and Wetland Mitigation Phase II (WM2) met the VIBI performance standard. These wetland areas are both located in the northern part of the site, adjacent to undisturbed woodlots (Figure D–1). The basin-specific tables show that the WM2 basins benefit from establishment of volunteer woody vegetation. For other wetland areas, it is difficult to discern a pattern for vegetation. Additional monitoring in future years would help to establish trends.

D.1.1.4 Soil Biogeochemical Parameters and Water Chemistry

Soil and water samples were collected at each wetland basin. Pursuant to Ohio EPA monitoring protocols, six samples were collected: five in a "Y" shaped pattern that extended into the wetland basin and one at the center of vegetation monitoring fixed plots (Mack 2004). Samples were analyzed for total nitrogen, total organic carbon, and percent solids. Median values were calculated for all parameters in each basin. Additionally, a surface water grab sample was collected in each basin and analyzed for a number of water quality parameters. Sample locations are shown on Figures D–2A to D–2E.

Table D–27 provides the results of soil and water chemistry sampling. For soil sampling, the only performance standards that were obtained were for percent total organic carbon in three of the Former Production Area basins. These results are consistent with other wetland mitigation evaluations in Ohio (Fennessy 2004). The compacted clay that is needed to construct surface water-fed wetlands limits the establishment of a loose, organic soil column. Field observations showed that there was strong stratification in the soil samples, with a thin organic layer sitting on top of a dense clay horizon. It is expected that biogeochemistry will improve over time. Hydrologic and vegetation results show that basins are sufficiently inundated and that wetland vegetation is well established. These factors will lend to gradual buildup of the organic soils that are characteristic of natural wetlands.

There are no performance standards associated with water quality. All of the results appear to be within normal range of conditions.

D.1.1.5 Amphibian Index of Biotic Integrity

The use of the Amphibian Index of Biotic Integrity (AIBI) is an additional tool for evaluation of wetlands as detailed in the WMMP (DOE 2009). The purpose of the AIBI is to use amphibian communities in wetlands as indicators of overall wetland conditions. The data collected provides information on species richness and abundance per wetland basin. While there are no performance standards associated with AIBI calculations, the results do provide a good indication of mitigation wetland ecological services and functions.

Monitoring and data collection are conducted three times between late February and early July, with each event spaced approximately six weeks apart. Late winter to early spring sampling (late February to early April) allows for monitoring of adult salamanders, early breeding frogs and macroinvertebrates. Middle spring sampling (late April to mid May) is conducted to collect adult frog species, amphibian larvae, and macroinvertebrates. Late spring to early summer sampling (early June to early July) is conducted to collect well-developed amphibian larvae and macroinvertebrates.

Ten funnel traps are placed evenly around the perimeter of a wetland basin. The distance between each trap was determined by pacing around the wetland perimeter and dividing the total paces by 10. Traps are placed on the substrates of the wetland and partially submerged. The traps are left at the designated locations for 24 hours to ensure results for diurnal and nocturnal activity patterns. Traps are not baited. Funnel traps are similar in size and shape to a commercial minnow trap but constructed with a smaller mesh aluminum screen. Cylinders are 18 inches long and 8 inches in diameter with fiberglass cones on each end. The funnels are directed inward and contain a 1.75-inch-diameter circular opening in the middle. The monitoring methods described above are in accordance with *Integrated Wetland Assessment Program Part 7: Amphibian Index of Biotic Integrity for Ohio Wetlands* (Micacchion 2004).

The AIBI is calculated using five metrics. Amphibian data are used to assign a score (0, 3, 7, 10) for each of the 5 metrics resulting in a composite score for a given wetland between 0 and 50. The WMMP established that site wetland areas will be evaluated against the emergent wetland performance criteria (DOE 2009), therefore, the AIBI metrics calculated from the collected amphibian data include the following:

- Amphibian Quality Assessment Index: A weighted index that takes into account both the sensitivity of individual species and the number of individuals collected. The sum of each individual species is multiplied by its associated CC score. This total is then divided by the total number of amphibians collected in the wetland.
- Relative Abundance of Sensitive Species: The sum for all species with CC of six or higher divided by the total number of amphibians.
- Relative Abundance of Tolerant Species: The sum for all species with CC of three or less divided by the total number of amphibians.
- Number of Pond Breeding Salamanders Species: Adult pond breeding ambystomatid salamander species are primarily terrestrial; however, egg and larval life stages are aquatic.
- Presence of Spotted Salamanders or Wood Frogs: These two species are indicators of relatively undisturbed conditions. Neither occurs at sites that are severely degraded.

Fifteen wetland basins within five different restoration areas were surveyed in 2011. Figures D–2A to D–2E show the wetland areas that are included in the amphibian monitoring program.

Scoring metrics and results of the amphibian monitoring program are provided in Table D–28. Table D–29 lists the amphibian species observed in 2011. These tables show that several of the onsite mitigation wetlands are developing into good habitat for amphibians. It is interesting to note the importance of placement of created wetlands. As with the vegetation results discussed above, most of the basins that support ambystomatid salamanders are located adjacent to established forest communities. The NPP wetlands had two species observed, and all three WM2 wetlands included at least one salamander species. These findings are corroborated with previous species inventory and public outreach activities, where ambystomatid salamanders have been observed in the WM2 basins for several years. For the first time, a larval salamander (*Ambystoma sp.*) was also observed in the Wetland Mitigation Phase I (WM1) wetlands. This is an encouraging indication that ambystomatid salamanders may be expanding their range where habitat allows.

D.1.2 Forest Functional Phase Monitoring

Pursuant to the NRRP, functional phase monitoring in 2011 focused on restored and existing forest communities. Fifteen random 1 m^2 quadrats were surveyed across each of 23 forest areas during the growing season (June through September). Figures D–4A to D–4D show quadrat locations within each monitoring area. Surveys were divided into three rounds of five samples to ensure coverage throughout the growing season. Species richness data were collected and were used to calculate the percent native species, average CC and FQAI for each restoration area. Cover class estimates were also obtained in order to evaluate the extent of vegetation establishment across restored areas. Processes for calculating FQAI and cover are described in the *Ecological Monitoring Methods Plan* (DOE 2010).

A summary of forest functional monitoring findings is provided in Tables D–30 and D–31. Results are presented separately in these tables for the herbaceous layer and woody vegetation. As with previous functional monitoring efforts, the forest data sets are used to compare to both the baseline and reference sites. The baseline and reference site information was originally reported in the *2002 Consolidated Monitoring Report for Restored Areas* (DOE 2003). This information is now available as an appendix to the *Fernald Preserve Ecological Monitoring Methods Plan* (DOE 2010). A comparison of the three communities originally investigated in 2005 is provided in Table D–32. Area-specific data summaries for herbaceous vegetation are provided in Tables D–33 through D–55. For woody vegetation, area-specific results are included in Tables D–56 to D–78.

Results are mostly as expected across the site, with older forests containing quality herbaceous vegetation and larger trees. A number of restored forest communities have diverse native trees and shrubs, due to revegetation efforts during restoration. For the baseline and reference site comparison, results show improvement over baseline conditions in Area 8, Phase II, but relatively similar conditions in the Northern Woodlot Enhancement (NWE) and the Southern Waste Units. The NWE area benefits from restoration plantings, but this was offset by several new woody invasives that were not present in 2005. Callery pear (*Pyrus communis*) is establishing in restored areas, and this has affected the native species composition in NWERF1. There was also a higher density of multiflora rose (*Rosa multiflora*) and amur honeysuckle

(*Lonicera maackii*) when compared to 2005 (Table D-32). Continued control of invasive species is needed to reverse this trend.

D.1.3 Implementation Monitoring

The Natural Resource Trustee Resolution No. 3 projects were completed in late summer 2010. These projects involved erosion repair, addition of soil amendment and seeding to establish mesic tallgrass prairie within three areas in the Former Production Area. Figure D-1 shows the location of these projects, which are known as the Solid Waste Landfill, the Haul Road, and the Prairie Area. In 2011, herbaceous surveys were conducted as required in the NRRP. Five random quadrats were sampled from each of these areas to determine total cover and native species establishment. A summary of results is provided in Table D–79, with area-specific species lists included in Tables D–80 to D–82. Figures D–4A to D–4D show quadrat locations within each area.

The NRRP specifies a goal of 90 percent total cover and 50 percent native species establishment. Native species was met for two of the three areas, but total cover goals were not met. The Prairie Area appears to be impacted by the existing cool season grasses and forbs that dominated the area prior to seeding, with only two forbs from the seeding mix observed (gray-headed coneflower and black-eyed Susan, Table 82). Glysophate herbicide was applied to the area prior to seeding, but there still appeared to be competition from the soil seedbank. A large amount of ragweed (*Ambrosia artemisifolia*) became established, prompting the need to mow and bale the area. This may have led to additional impacts from Canada geese, which were observed grazing these mowed areas in the fall of 2011. All three of the Resolution No. 3 project areas will be surveyed in 2012, to determine if conditions have improved.

D.1.4 Species Inventory Activities

An effort was initiated in 2008 to inventory a variety of plant and animal species at the Fernald Preserve. This work assists with adaptive management of ecologically restored areas, adds to the local database of biological information, and provides opportunities for educational outreach.

Reptile and small mammal surveys were continued in 2011. Coverboards were placed around a number of site wetlands and monitored biweekly from April through October. The coverboards are simply 2-feet by 4-feet pieces of corrugated sheet metal placed directly on the ground. Animals are attracted to the cover and warmth the coverboards provide. Table D–83 lists the species observed and frequency of occurrence in 2011. Findings were roughly similar to those in previous years. No new species of reptiles or amphibians were observed in 2011.

D.1.5 Activities in 2012

The WMMR is the primary driver for future monitoring activities (DOE 2012). The report specifies that intensive annual monitoring of mitigation wetlands is no longer required. However, wetlands will continue to be evaluated on a three-year rotation, as part of a continued functional monitoring program. This process involves vegetation and amphibian surveys of mitigation wetlands in 2012. Hydrological monitoring will also continue. Implementation monitoring will continue as well, with a second year of herbaceous cover in the Resolution No. 3 project areas. Several restoration projects are planned for 2012, and these will be evaluated for herbaceous cover and woody vegetation survival. Project-specific species inventory activities will also continue.

Table D–1. Wetland Mitigation Design Parameters Summary

Restoration Project Area	Wetland Area	Delineation Acreage	Less Than 6.8% side slope (Percent of area)
Borrow Area (BAP)	BAPW2	NA[a]	NA[a]
	BAPW3	2.8	**84%**
	BAPW4	3.0	**86%**
	BAPW7	NA[a]	NA[a]
	BAPW9	7.3	**76%**
Former Production Area (FPA)	FPAW2	2.0	**84%**
	FPAW4	1.4	**76%**
	FPAW5	1.2	**85%**
	FPAW7	1.4	48%
	FPAW9	0.5	**68%**
	PREW6	2.8	**75%**
Northern Pine Plantation Enhancement (NPP)	NPPW4	0.7	**73%**
	NPPW5	0.2	**98%**
Wetland Mitigation Phase I (WM1)	WM1W1	0.9	**68%**
	WM1W2	1.1	**91%**
	WM1M3	0.8	**80%**
	WM1W4	0.8	**88%**
	WM1W5	0.2	**71%**
	WM1W6	1.5	**83%**
	WM1W7	0.5	**76%**
Wetland Mitigation Phase II (WM2)	WM2W1	1.2	**55%**
	WM2W2	0.6	**89%**
	WM2W3	0.5	**53%**
	All Basins	**31.3**	
Peformance Standard		**17.85 Acres**	**>50%**

Values in bold have met the performance standard

[a]NA = Not Applicable. BAPW2 and BAPW7 were combined during the delineation. The acreage for these three areas are included in the delineation acreage for BAPW9.

Table D–2. Wetland Mitigation Hydrological Monitoring Summary

Restoration Project Area	Wetland Area	Average Depth (cm)	Time in Root Zone (Percent)	Flashiness Index
Borrow Area (BAP)	BAPW2	**25**	**70%**	**0.6**
	BAPW3	**13**	**81%**	**0.8**
	BAPW4	**17**	**81%**	**0.8**
	BAPW7	**26**	**79%**	**0.4**
	BAPW9	**18**	**77%**	**0.9**
Former Production Area (FPA)	FPAW2	**27**	**78%**	**0.4**
	FPAW4	**16**	**85%**	**0.3**
	FPAW5	**23**	**81%**	**0.4**
	FPAW7	**20**	**80%**	**0.9**
	FPAW9	30	**76%**	**0.3**
	PREW6	**7**	**83%**	**0.5**
Northern Pine Plantation Enhancement (NPP)	NPPW4	**18**	**76%**	**0.7**
	NPPW5	**24**	**73%**	**0.6**
Wetland Mitigation Phase I (WM1)	WM1W1	41	**55%**	**0.7**
	WM1W2	32	**74%**	**0.4**
	WM1W3	38	**69%**	**0.7**
	WM1W4	**22**	**79%**	**0.4**
	WM1W5	**29**	**67%**	**1.3**
	WM1W6	52	46%	**0.6**
	WM1W7	**25**	**66%**	**0.6**
Wetland Mitigation Phase II (WM2)	WM2W1	**4**	**97%**	**0.9**
	WM2W2	**20**	**60%**	**0.7**
	WM2W3	**0**	**76%**	**0.6**
Performance Standard		<29.4	>53%	<2.0

Values in bold have met the performance standard

Table D–3. Wetland Mitigation Vegetation Monitoring Summary

Restoration Project Area	Wetland Area	Unvegetated Open Water (Percent)	Native Perennial Hydrophytes (Percent)	Total Species	Native Species	Non-Native Species	Native Species (Percent)	Average CC[a]	FQAI[b]	VIBI Score[c]
Borrow Area (BAP)	BAPW2	**1.3%**	**84.3%**	34	30	4	88%	2.78	15.73	**46**
	BAPW3	**2.0%**	67.2%	37	30	6	81%	2.08	12.5	42
	BAPW4	**1.3%**	61.8%	42	28	14	67%	1.71	10.93	23
	BAPW7	**1.8%**	55.5%	45	35	9	78%	1.83	11.88	**50**
	BAPW9	**3.0%**	70.2%	35	28	7	80%	1.91	11.15	29
Former Production Area (FPA)	FPAW2	40.0%	**96.1%**	22	19	3	86%	2.14	9.82	40
	FPAW4	26.0%	42.0%	33	27	4	82%	2.10	11.67	18
	FPAW5	11.5%	56.0%	58	42	13	72%	2.17	15.8	**54**
	FPAW7	**1.0%**	29.1%	12	10	2	83%	2.25	8.37	13
	FPAW9	**2.8%**	58.3%	35	30	4	86%	2.85	16.36	**56**
	PREW6	17.3%	46.2%	40	28	12	70%	1.64	10.25	25
Northern Pine Plantation Enhancement (NPP)	NPPW4	**5.3%**	72.1%	49	41	6	84%	2.34	16.05	**58**
	NPPW5	**3.8%**	**79.6%**	55	44	10	80%	2.04	14.97	**61**
Wetland Mitigation Phase I (WM1)	WM1W1	**1.3%**	47.2%	33	27	6	82%	2.18	12.53	39
	WM1W2	**2.1%**	60.6%	70	52	18	74%	1.94	16.01	**61**
	WM1M3	**3.8%**	**75.6%**	43	29	13	67%	1.75	11.07	46
	WM1W4	**8.0%**	60.2%	63	48	14	76%	1.72	13.44	**54**
	WM1W5	**0.0%**	71.0%	42	22	19	52%	1.30	8.22	32
	WM1W6	**1.3%**	43.3%	58	42	16	72%	1.96	14.7	**48**
	WM1W7	**2.9%**	64.0%	29	21	6	72%	2.00	10.39	42
Wetland Mitigation Phase II (WM2)	WM2W1	**1.0%**	63.8%	50	37	10	74%	1.73	11.63	**53**
	WM2W2	13.8%	**81.0%**	34	31	2	91%	2.29	12.75	**49**
	WM2W3	20.5%	55.6%	45	38	7	84%	2.20	14.76	**51**
Performance Standard		<10%	>75%	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	48-63

Values in bold have met the performance standard

[a]CC = Coefficent of Conservatism

[b]FQAI = Floristic Quality Assessment Index

[c]VIBI = Vegetative Index of Biotic Integrity

[d]NA = Not Applicable. No performance standard exists for this parameter

Table D–4. BAPW2 Wetland Vegetation Monitoring Data Summary

Total Species:	34
Native Species:	30
Non-Native Species:	4
Average CC[a]:	2.78

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	0.296%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	0.075%
Ammannia robusta	SESSILE TOOTH-CUP	forb	7	OBL	0.296%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	1.035%
Asclepias incarnata	SWAMP MILKWEED	forb	4	OBL	0.739%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	0.222%
Carex hystericina	PORCUPINE SEDGE	sedge	5	OBL	0.517%
Cephalanthus occidentalis	BUTTONBUSH	shrub	6	OBL	1.035%
Cyperus sp.	NDA[c]	sedge	NDA[c]	NDA[c]	0.001%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	10.420%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	0.443%
Elymus canadensis	CANADA WILD RYE	grass	6	FACU+	0.517%
Hamamelis virginiana	WITCH-HAZEL	sm tree	5	FAC-	0.074%
Juncus tenuis	PATH RUSH	forb	1	FAC-	0.443%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	10.790%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.001%
Ludwigia palustris	WATER-PURSLANE	forb	3	OBL	0.223%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	18.476%
Populus deltoides	EASTERN COTTONWOOD	tree	3	FAC	0.591%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	7.243%
Robinia pseudoacacia	BLACK LOCUST	tree	0	FACU-	5.617%
Sagittaria latifolia	COMMON ARROWHEAD	forb	1	OBL	0.074%
Salix nigra	BLACK WILLOW	tree	2	FACW+	2.143%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	5.912%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	0.222%
Sorghastrum nutans	INDIAN GRASS	grass	5	UPL	0.074%
Sparganium eurycarpum	GIANT BUR-REED	forb	4	OBL	1.330%
Spartina pectinata	PRAIRIE CORD GRASS	grass	5	OBL	22.171%
Ulmus rubra	SLIPPERY ELM	tree	3	FAC	1.109%
Vitis sp.	NDA[c]	vine	NDA[c]	NDA[c]	0.001%
Agrostis gigantea	**REDTOP**	grass	0	FACW	1.109%
Najas minor	**EURASIAN WATER-NYMPH**	forb	0	OBL	6.651%
Polygonum persicaria	**LADY'S THUMB**	forb	0	FACW	0.074%
Solanum carolinense	**HORSE NETTLE**	forb	0	UPL	0.075%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–5. BAPW3 Wetland Vegetation Monitoring Data Summary

Total Species:	37
Native Species:	30
Non-Native Species:	6
Average CC[a]:	2.08

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	1.568%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	0.224%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	0.224%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	FACW	0.672%
Carex comosa	BEARDED SEDGE	sedge	2	OBL	0.523%
Carex frankii	FRANK'S SEDGE	sedge	2	OBL	0.747%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	2.763%
Cephalanthus occidentalis	BUTTONBUSH	shrub	6	OBL	0.523%
Cornus amomum	SILKY DOGWOOD	shrub	2	FACW	1.120%
Cyperus strigosus	STRAW-COLORED UMBRELLA-S.	sedge	1	FACW	0.075%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	10.978%
Eupatorium altissimum	TALL BONESET	forb	0	UPL	0.224%
Iris versicolor	NORTHERN BLUE FLAG	forb	6	OBL	1.120%
Juncus effusus	SOFT RUSH	forb	1	FACW+	1.120%
Juncus tenuis	PATH RUSH	forb	1	FAC-	1.120%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	4.854%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.075%
Ludwigia palustris	WATER-PURSLANE	forb	3	OBL	3.659%
Mimulus ringens	COMMON MONKEY-FLOWER	forb	4	OBL	0.075%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	12.696%
Phyla lanceolata	FOG-FRUIT	forb	3	OBL	0.224%
Populus deltoides	EASTERN COTTONWOOD	tree	3	FAC	0.149%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	18.670%
Salix nigra	BLACK WILLOW	tree	2	FACW+	2.838%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	4.258%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	0.523%
Scirpus cyperinus	WOOL-GRASS	sedge	1	FACW+	0.523%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	0.224%
Sparganium eurycarpum	GIANT BUR-REED	forb	4	OBL	0.523%
Spartina pectinata	PRAIRIE CORD GRASS	grass	5	OBL	1.120%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	FACU	0.075%
Najas minor	**EURASIAN WATER-NYMPH**	forb	0	OBL	6.721%
Polygonum persicaria	**LADY'S THUMB**	forb	0	FACW	0.075%
Schoenoplectus mucronatus	**RICEFIELD BULRUSH**	sedge	0	OBL	0.672%
Trifolium pratense	**RED CLOVER**	forb	0	FACU-	0.075%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	18.969%
Euphorbia species	NDA[c]	forb	NDA[c]	NDA[c]	0.001%

[a] CC = Coefficient of Conservatism

[b] see http://plants.usda.gov/wetinfo.html

[c] NDA = No Determination Available

Species in bold are non-native.

Table D–6. BAPW4 Wetland Vegetation Monitoring Data Summary

Total Species:	42
Native Species:	28
Non-Native Species:	14
Average CC[a]:	1.71

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Acer negundo	BOX ELDER	tree	3	FAC+	0.173%
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	3.001%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	0.346%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	0.404%
Asclepias incarnata	SWAMP MILKWEED	forb	4	OBL	0.289%
Bidens connata	PURPLE-STEMMED BEGGAR'S-TICK	forb	3	FACW+	0.115%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	FACW	1.154%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	4.385%
Carex frankii	FRANK'S SEDGE	sedge	2	OBL	0.808%
Carex hystericina	PORCUPINE SEDGE	sedge	5	OBL	0.346%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	2.597%
Cephalanthus occidentalis	BUTTONBUSH	shrub	6	OBL	0.866%
Cyperus sp.	NDA[c]	sedge	NDA[c]	NDA[a]	0.173%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	5.078%
Juncus effusus	SOFT RUSH	forb	1	FACW+	0.808%
Juncus tenuis	PATH RUSH	forb	1	FAC-	1.673%
Juncus torreyi	TORREY'S RUSH	forb	3	FACW	1.731%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	5.366%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.173%
Ludwigia palustris	WATER-PURSLANE	forb	3	OBL	1.731%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	6.751%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	17.022%
Sagittaria latifolia	COMMON ARROWHEAD	forb	1	OBL	0.173%
Salix nigra	BLACK WILLOW	tree	2	FACW+	0.115%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	4.155%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	7.617%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	0.173%
Verbena hastata	BLUE VERVAIN	forb	4	FACW+	0.173%
Agrostis gigantea	**REDTOP**	grass	0	FACW	3.289%
Bromus japonicus	**JAPANESE BROME**	grass	0	FACU-	0.058%
Cichorium intybus	**CHICORY**	forb	0	UPL	0.001%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	FACU	0.058%
Festuca elatior	**TALL FESCUE**	grass	0	FACU	0.173%
Najas minor	**EURASIAN WATER-NYMPH**	forb	0	OBL	6.347%
Plantago lanceolata	**ENGLISH PLANTAIN**	forb	0	UPL	0.058%
Polygonum persicaria	**LADY'S THUMB**	forb	0	FACW	0.173%
Potamogeton crispus	**CURLY-LEAVED PONDWEED**	forb	0	OBL	1.731%
Rumex crispus	**CURLY DOCK**	forb	0	FACU	0.173%
Schoenoplectus mucronatus	**RICEFIELD BULRUSH**	sedge	0	OBL	0.058%
Trifolium repens	**WHITE CLOVER**	forb	0	FACU-	0.173%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	20.196%
Xanthium strumarium	**COMMON COCKLEBUR**	forb	0	FAC	0.115%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–7. BAPW7 Wetland Vegetation Monitoring Data Summary

Total Species:	45
Native Species:	35
Non-Native Species:	9
Average CC[a]:	1.83

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	1.448%
Alopecurus sp.	NDA[c]	grass	NDA[c]	NDA[c]	0.603%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	0.121%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	0.181%
Asclepias incamata	SWAMP MILKWEED	forb	4	OBL	0.060%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	FACW	0.784%
Carex annectens	YELLOW FOX SEDGE	sedge	3	FACW	0.181%
Carex comosa	BEARDED SEDGE	sedge	2	OBL	3.016%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	0.181%
Carex frankii	FRANK'S SEDGE	sedge	2	OBL	1.749%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	5.549%
Cephalanthus occidentalis	BUTTONBUSH	shrub	6	OBL	5.488%
Ceratophyllum demersum	COONTAIL	forb	2	OBL	0.181%
Cyperus sp.	NDA[c]	sedge	NDA[c]	NDA[c]	0.181%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	5.609%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	4.825%
Eupatorium altissimum	TALL BONESET	forb	0	UPL	1.267%
Eupatorium perfoliatum	COMMON BONESET	forb	3	FACW+	0.181%
Juncus effusus	SOFT RUSH	forb	1	FACW+	0.603%
Juncus tenuis	PATH RUSH	forb	1	FAC-	10.555%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	1.327%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.785%
Ludwigia palustris	WATER-PURSLANE	forb	3	OBL	0.603%
Mimulus ringens	COMMON MONKEY-FLOWER	forb	4	OBL	1.327%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	11.158%
Polygonum hydropiper	WATER-PEPPER	forb	1	OBL	0.181%
Populus deltoides	EASTERN COTTONWOOD	tree	3	FAC	3.016%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	0.965%
Salix nigra	BLACK WILLOW	tree	2	FACW+	1.809%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	0.724%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	4.644%
Scirpus cyperinus	WOOL-GRASS	sedge	1	FACW+	0.905%
Scirpus pendulus	DROOPING BULRUSH	sedge	2	OBL	0.422%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	0.060%
Sparganium eurycarpum	GIANT BUR-REED	forb	4	OBL	4.825%
Agrostis gigantea	**REDTOP**	grass	0	FACW	5.549%
Cirsium arvense	**CANADA THISTLE**	forb	0	FACU	0.181%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	FACU	0.362%
Festuca elatior	**TALL FESCUE**	grass	0	FACU	0.181%
Najas minor	**EURASIAN WATER-NYMPH**	forb	0	OBL	11.580%
Polygonum persicaria	**LADY'S THUMB**	forb	0	FACW	0.060%
Potamogeton crispus	**CURLY-LEAVED PONDWEED**	forb	0	OBL	4.222%
Rumex crispus	**CURLY DOCK**	forb	0	FACU	0.483%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	1.689%
Unknown forb	UNKNOWN	forb	NDA[c]	NDA[c]	0.181%

[a] CC = Coefficient of Conservatism

[b] see http://plants.usda.gov/wetinfo.html

[c] NDA = No Determination Available

Species in bold are non-native.

Table D–8. BAPW9 Wetland Vegetation Monitoring Data Summary

Total Species:	35
Native Species:	28
Non-Native Species:	7
Average CC[a]:	1.91

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	1.149%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	0.805%
Asclepias incarnata	SWAMP MILKWEED	forb	4	OBL	3.678%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	FACW	0.805%
Carex comosa	BEARDED SEDGE	sedge	2	OBL	12.643%
Carex lurida	BOTTLEBRUSH SEDGE	sedge	3	OBL	1.724%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	8.046%
Cornus amomum	SILKY DOGWOOD	shrub	2	FACW	0.805%
Cyperus sp.	NDA[a]	sedge	NDA[c]	NDA[c]	0.690%
Desmodium canescens	HOARY TICK-TREFOIL	forb	4	UPL	1.609%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	4.368%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	1.149%
Eupatorium altissimum	TALL BONESET	forb	0	UPL	0.345%
Fraxinus pennsylvanica	GREEN ASH	tree	3	FACW	0.345%
Juncus tenuis	PATH RUSH	forb	1	FAC-	5.747%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	4.253%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.692%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	3.333%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	FACU	0.345%
Polygonum hydropiper	WATER-PEPPER	forb	1	OBL	0.345%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	1.609%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	1.034%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	0.805%
Scirpus cyperinus	WOOL-GRASS	sedge	1	FACW+	5.747%
Senna hebecarpa	NORTHERN WILD SENNA	forb	4	FAC	0.345%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	1.724%
Spartina pectinata	PRAIRIE CORD GRASS	grass	5	OBL	19.539%
Ulmus rubra	SLIPPERY ELM	tree	3	FAC	0.002%
Agrostis gigantea	**REDTOP**	grass	0	FACW	3.448%
Cirsium arvense	**CANADA THISTLE**	forb	0	FACU	1.609%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	FACU	5.747%
Najas minor	**EURASIAN WATER-NYMPH**	forb	0	OBL	4.023%
Polygonum persicaria	**LADY'S THUMB**	forb	0	FACW	0.690%
Rumex crispus	**CURLY DOCK**	forb	0	FACU	0.690%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	0.115%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–9. FPAW2 Wetland Vegetation Monitoring Data Summary

Total Species:	22
Native Species:	19
Non-Native Species:	3
Average CC[a]:	2.14

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Acer sp.	NDA[a]	tree	NDA[c]	NDA[c]	0.002%
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	2.256%
Asclepias incarnata	SWAMP MILKWEED	forb	4	OBL	0.846%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	FACW	0.094%
Carex annectens	YELLOW FOX SEDGE	sedge	3	FACW	0.282%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	0.094%
Ceratophyllum demersum	COONTAIL	forb	2	OBL	7.049%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	5.639%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	1.974%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	16.541%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	1.128%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	0.282%
Populus deltoides	EASTERN COTTONWOOD	tree	3	FAC	4.041%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	51.221%
Sagittaria latifolia	COMMON ARROWHEAD	forb	1	OBL	0.094%
Salix nigra	BLACK WILLOW	tree	2	FACW+	6.579%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	0.846%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	0.094%
Sparganium eurycarpum	GIANT BUR-REED	forb	4	OBL	0.282%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	FACU	0.376%
Schoenoplectus mucronatus	**RICEFIELD BULRUSH**	sedge	0	OBL	0.188%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	0.094%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–10. FPAW4 Wetland Vegetation Monitoring Data Summary

Total Species:	33
Native Species:	27
Non-Native Species:	5
Average CC[a]:	2.10

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	0.251%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	0.497%
Apocynum cannabinum	INDIAN HEMP	forb	1	FACU	0.124%
Asclepias incarnata	SWAMP MILKWEED	forb	4	OBL	1.368%
Aster novae-angliae	NEW ENGLAND ASTER	forb	2	FACW-	0.002%
Bidens connata	PURPLE-STEMMED BEGGAR'S-TICK	forb	3	FACW+	0.124%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	FACW	0.622%
Carex hystericina	PORCUPINE SEDGE	sedge	5	OBL	2.736%
Carex lurida	BOTTLEBRUSH SEDGE	sedge	3	OBL	0.124%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	2.612%
Cyperus sp.	NDA[c]	sedge	NDA[c]	NDA[c]	1.244%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	2.985%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	1.865%
Erechtites hieracifolia	PILEWORT	forb	2	FACU	0.002%
Juncus tenuis	PATH RUSH	forb	1	FAC-	0.746%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	27.111%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	5.969%
Ludwigia palustris	WATER-PURSLANE	forb	3	OBL	10.944%
Monarda fistulosa	WILD BERGAMOT	forb	3	UPL	0.002%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	3.109%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	0.251%
Ratibida pinnata	GRAY-HEADED CONEFLOWER	forb	5	UPL	0.373%
Rudbeckia hirta	BLACK-EYED SUSAN	forb	1	FACU-	0.124%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	0.622%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	0.373%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	0.622%
Verbena hastata	BLUE VERVAIN	forb	4	FACW+	0.249%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	FACU	4.726%
Hydrocotyle ranunculoides	**BUTTERCUP-PENNYWORT**	forb	0	OBL	1.741%
Melilotus alba	**WHITE SWEET-CLOVER**	forb	0	FACU-	0.373%
Najas minor	**EURASIAN WATER-NYMPH**	forb	0	OBL	2.612%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	24.251%
Unknown forb	UNKNOWN	forb	NDA[c]	NDA[c]	1.244%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–11. FPAW5 Wetland Vegetation Monitoring Data Summary

Total Species:	58
Native Species:	42
Non-Native Species:	13
Average CC[a]:	2.17

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	0.163%
Ammannia robusta	SESSILE TOOTH-CUP	forb	7	OBL	0.003%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	5.373%
Apocynum cannabinum	INDIAN HEMP	forb	1	FACU	0.488%
Asclepias incarnata	SWAMP MILKWEED	forb	4	OBL	0.488%
Aster novae-angliae	NEW ENGLAND ASTER	forb	2	FACW-	0.166%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	FACW	0.814%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	0.163%
Carex frankii	FRANK'S SEDGE	sedge	2	OBL	0.488%
Carex hystericina	PORCUPINE SEDGE	sedge	5	OBL	11.886%
Carex sp.	NDA[c]	sedge	NDA[c]	NDA[c]	0.488%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	6.513%
Ceratophyllum demersum	COONTAIL	forb	2	OBL	3.256%
Chamaecrista fasciculata	PARTRIDGE-PEA	forb	3	FACU	0.488%
Conyza canadensis	HORSEWEED	forb	0	UPL	0.163%
Cyperus sp.	NDA[c]	sedge	NDA[c]	NDA[c]	2.280%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	1.628%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	1.628%
Elymus canadensis	CANADA WILD RYE	grass	6	FACU+	0.488%
Erigeron annuus	DAISY FLEABANE	forb	0	FACU	0.163%
Eupatorium serotinum	LATE-FLOWERING BONESET	forb	2	FAC-	0.003%
Euthamia graminifolia	FLAT-TOPPED GOLDENROD	forb	2	FAC	0.003%
Juncus tenuis	PATH RUSH	forb	1	FAC-	3.419%
Juncus torreyi	TORREY'S RUSH	forb	3	FACW	8.141%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	3.582%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	3.256%
Ludwigia palustris	WATER-PURSLANE	forb	3	OBL	0.163%
Monarda fistulosa	WILD BERGAMOT	forb	3	UPL	0.488%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	7.164%
Penstemon digitalis	FOXGLOVE BEARD-TONGUE	forb	2	FAC	0.163%
Platanus occidentalis	SYCAMORE	tree	7	FACW-	0.651%
Populus deltoides	EASTERN COTTONWOOD	tree	3	FAC	0.651%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	1.628%
Ratibida pinnata	GRAY-HEADED CONEFLOWER	forb	5	UPL	1.143%
Rudbeckia hirta	BLACK-EYED SUSAN	forb	1	FACU-	0.651%
Salix nigra	BLACK WILLOW	tree	2	FACW+	0.166%
Schizachyrium scoparium	LITTLE BLUESTEM	grass	5	FACU-	3.582%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	1.628%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	2.768%
Spartina pectinata	PRAIRIE CORD GRASS	grass	5	OBL	1.140%
Tradescantia ohiensis	OHIO SPIDERWORT	forb	5	FAC	0.488%
Verbena hastata	BLUE VERVAIN	forb	4	FACW+	0.651%
Bromus japonicus	**JAPANESE BROME**	grass	0	FACU-	0.003%
Cirsium arvense	**CANADA THISTLE**	forb	0	FACU	0.488%
Conium maculatum	**POISON-HEMLOCK**	forb	0	FACW	0.488%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	UPL	0.977%
Dipsacus fullonum	**WILD TEASEL**	forb	0	FACU-	3.582%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	FACU	0.163%
Melilotus officinalis	**YELLOW SWEET-CLOVER**	forb	0	FACU-	8.141%
Plantago lanceolata	**ENGLISH PLANTAIN**	forb	0	UPL	0.326%
Plantago major	**COMMON PLANTAIN**	forb	0	FACU	0.003%
Polygonum persicaria	**LADY'S THUMB**	forb	0	FACW	0.163%
Trifolium pratense	**RED CLOVER**	forb	0	FACU-	0.163%
Trifolium repens	**WHITE CLOVER**	forb	0	FACU-	0.488%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	5.048%
Unknown forb	UNKNOWN	forb	NDA[c]	NDA[c]	0.163%
Unknown grass	UNKNOWN	grass	NDA[c]	NDA[c]	0.651%
Unknown	UNKNOWN	NDA[c]	NDA[c]	NDA[c]	0.488%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–12. FPAW7 Wetland Vegetation Monitoring Data Summary

Total Species:	12
Native Species:	10
Non-Native Species:	2
Average CC[a]:	2.25

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	3.524%
Carex comosa	BEARDED SEDGE	sedge	2	UPL	1.542%
Carex hystericina	PORCUPINE SEDGE	sedge	5	OBL	1.542%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	6.608%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	24.228%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	3.304%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.225%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	0.000%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	3.304%
Sparganium eurycarpum	GIANT BUR-REED	forb	4	OBL	10.792%
Schoenoplectus mucronatus	**RICEFIELD BULRUSH**	sedge	0	OBL	1.982%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	42.950%

[a] CC = Coefficient of Conservatism

[b] see http://plants.usda.gov/wetinfo.html

[c] NDA = No Determination Available

Species in bold are non-native.

Table D–13. FPAW9 Wetland Vegetation Monitoring Data Summary

Total Species:	35
Native Species:	30
Non-Native Species:	4
Average CC[a]:	2.85

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Carex hystericina	PORCUPINE SEDGE	sedge	5	OBL	0.467%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	0.350%
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	4.433%
Ammannia robusta	SESSILE TOOTH-CUP	forb	7	OBL	0.117%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	0.233%
Apocynum cannabinum	INDIAN HEMP	forb	1	FACU	0.355%
Asclepias incarnata	SWAMP MILKWEED	forb	4	OBL	1.867%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	FACW	0.583%
Bouteloua curtipendula	SIDE-OATS GRAMA GRASS	grass	8	UPL	0.117%
Cephalanthus occidentalis	BUTTONBUSH	shrub	6	OBL	5.716%
Cornus amomum	SILKY DOGWOOD	shrub	2	FACW	0.117%
Cyperus sp.	NDA[c]	sedge	NDA[c]	NDA[c]	0.117%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	2.917%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	1.517%
Eupatorium serotinum	LATE-FLOWERING BONESET	forb	2	FAC-	3.267%
Ilex verticillata	WINTERBERRY	shrub	6	FACW+	0.117%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.236%
Ludwigia palustris	WATER-PURSLANE	forb	3	OBL	9.919%
Monarda fistulosa	WILD BERGAMOT	forb	3	UPL	0.350%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	16.333%
Populus deltoides	EASTERN COTTONWOOD	tree	3	FAC	3.267%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	3.733%
Salix discolor	PUSSY WILLOW	shrub	3	FACW	1.633%
Salix nigra	BLACK WILLOW	tree	2	FACW+	10.383%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	1.517%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	4.900%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	1.167%
Spiraea alba	MEADOW-SWEET	shrub	3	FACW+	0.350%
Verbena hastata	BLUE VERVAIN	forb	4	FACW+	0.002%
Vitis vulpina	FROST GRAPE	vine	3	FAC	0.002%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	FACU	0.119%
Rumex crispus	**CURLY DOCK**	forb	0	FACU	0.002%
Schoenoplectus mucronatus	**RICEFIELD BULRUSH**	sedge	0	OBL	0.467%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	23.332%
Unknown cress	UNKNOWN	forb	NDA[c]	NDA[c]	0.002%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–14. PREW6 Wetland Vegetation Monitoring Data Summary

Total Species:	40
Native Species:	28
Non-Native Species:	12
Average CC[a]:	1.64

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Acer negundo	BOX ELDER	tree	3	FAC+	0.107%
Acer saccharinum	SILVER MAPLE	tree	3	FACW	0.320%
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	1.814%
Apocynum cannabinum	INDIAN HEMP	forb	1	FACU	0.002%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	FACW	0.002%
Campsis radicans	TRUMPET-CREEPER	vine	1	FAC	0.107%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	0.747%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	8.003%
Cyperus strigosus	STRAW-COLORED UMBRELLA-S.	sedge	1	FACW	0.747%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	5.656%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	0.320%
Erechtites hieracifolia	PILEWORT	forb	2	FACU	0.320%
Eupatorium serotinum	LATE-FLOWERING BONESET	forb	2	FAC-	0.002%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	1.069%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	8.857%
Platanus occidentalis	SYCAMORE	tree	7	FACW-	0.747%
Polygonum hydropiper	WATER-PEPPER	forb	1	OBL	3.950%
Populus deltoides	EASTERN COTTONWOOD	tree	3	FAC	0.107%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	7.470%
Rosa palustris	SWAMP ROSE	shrub	5	OBL	0.747%
Salix nigra	BLACK WILLOW	tree	2	FACW+	8.003%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	6.936%
Scirpus pendulus	DROOPING BULRUSH	sedge	2	OBL	1.601%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	0.107%
Sparganium eurycarpum	GIANT BUR-REED	forb	4	OBL	0.322%
Toxicodendron radicans	POISON-IVY	vine	1	FAC	1.601%
Ulmus rubra	SLIPPERY ELM	tree	3	FAC	0.107%
Vitis sp.	NDA[c]	vine	NDA[c]	NDA[c]	0.107%
Agrostis gigantea	**REDTOP**	grass	0	FACW	1.707%
Convolvulus arvensis	**FIELD BINDWEED**	forb	0	UPL	0.107%
Dipsacus fullonum	**WILD TEASEL**	forb	0	FACU-	0.320%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	FACU	0.107%
Najas minor	**EURASIAN WATER-NYMPH**	forb	0	OBL	13.339%
Phalaris arundinacea	**REED CANARY GRASS**	grass	0	FACW+	9.711%
Phleum pratense	**TIMOTHY**	grass	0	FACU	0.107%
Rumex crispus	**CURLY DOCK**	forb	0	FACU	0.320%
Schoenoplectus mucronatus	**RICEFIELD BULRUSH**	sedge	0	OBL	0.640%
Sorghum halepense	**JOHNSON GRASS**	grass	0	FACU	0.320%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	13.339%
Xanthium strumarium	**COMMON COCKLEBUR**	forb	0	FAC	0.107%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–15. NPPW4 Wetland Vegetation Monitoring Data Summary

Total Species:	49
Native Species:	41
Non-Native Species:	6
Average CC[a]:	2.34

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Agrimonia gryposepala	TALL AGRIMONY	forb	3	FACU	1.875%
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	0.893%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	0.268%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	0.089%
Asclepias incamata	SWAMP MILKWEED	forb	4	OBL	0.091%
Carex annectens	YELLOW FOX SEDGE	sedge	3	FACW	0.268%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	0.270%
Carex frankii	FRANK'S SEDGE	sedge	2	OBL	1.160%
Carex hystericina	PORCUPINE SEDGE	sedge	5	OBL	6.427%
Carex lurida	BOTTLEBRUSH SEDGE	sedge	3	OBL	0.536%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	2.142%
Ceratophyllum demersum	COONTAIL	forb	2	OBL	0.268%
Desmodium canescens	HOARY TICK-TREFOIL	forb	4	UPL	0.268%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	1.428%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	0.089%
Epilobium coloratum	PURPLE-LEAVED WILLOW-HERB	forb	1	OBL	2.142%
Erechtites hieracifolia	PILEWORT	forb	2	FACU	0.089%
Eupatorium maculatum	SPOTTED JOE-PYE WEED	forb	6	FACW	0.625%
Eupatorium perfoliatum	COMMON BONESET	forb	3	FACW+	4.285%
Euthamia graminifolia	FLAT-TOPPED GOLDENROD	forb	2	FAC	2.053%
Fraxinus pennsylvanica	GREEN ASH	tree	3	FACW	0.268%
Juncus effusus	SOFT RUSH	forb	1	FACW+	4.642%
Juncus torreyi	TORREY'S RUSH	forb	3	FACW	0.536%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	20.531%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.896%
Ludwigia palustris	WATER-PURSLANE	forb	3	OBL	1.428%
Mimulus ringens	COMMON MONKEY-FLOWER	forb	4	OBL	5.088%
Monarda fistulosa	WILD BERGAMOT	forb	3	UPL	0.002%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	0.268%
Polygonum amphibium	WATER SMARTWEED	forb	4	OBL	0.002%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	0.089%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	UPL	0.268%
Sagittaria latifolia	COMMON ARROWHEAD	forb	1	OBL	0.002%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	1.607%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	11.069%
Scirpus cyperinus	WOOL-GRASS	sedge	1	FACW+	4.285%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	11.158%
Spartina pectinata	PRAIRIE CORD GRASS	grass	5	OBL	0.982%
Ulmus rubra	SLIPPERY ELM	tree	3	FAC	0.089%
Verbena hastata	BLUE VERVAIN	forb	4	FACW+	0.002%
Verbena urticifolia	WHITE VERVAIN	forb	3	FACU	0.714%
Agrostis gigantea	**REDTOP**	grass	0	FACW	1.250%
Convolvulus arvensis	**FIELD BINDWEED**	forb	0	UPL	0.002%
Dipsacus fullonum	**WILD TEASEL**	forb	0	FACU-	0.179%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	FACU	6.784%
Solanum carolinense	**HORSE NETTLE**	forb	0	UPL	0.004%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	1.875%
Unknown forb	UNKNOWN	forb	NDA[c]	NDA[c]	0.091%
Unknown grass	UNKNOWN	grass	NDA[c]	NDA[c]	0.625%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–16. NPPW5 Wetland Vegetation Monitoring Data Summary

Total Species:	55
Native Species:	44
Non-Native Species:	10
Average CC[a]:	2.04

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Agrimonia parviflora	SMALL-FLOWERED AGRIMONY	forb	2	FAC	0.820%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	0.546%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	7.558%
Aster pilosus	AWL ASTER	forb	1	UPL	0.273%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	0.637%
Carex frankii	FRANK'S SEDGE	sedge	2	OBL	5.828%
Carex granularis	MEADOW SEDGE	sedge	3	FACW+	0.911%
Carex hystericina	PORCUPINE SEDGE	sedge	5	OBL	1.366%
Carex shortiana	SHORT'S SEDGE	sedge	2	FAC	0.182%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	4.006%
Ceratophyllum demersum	COONTAIL	forb	2	OBL	2.823%
Cyperus strigosus	STRAW-COLORED UMBRELLA-S.	sedge	1	FACW	0.364%
Desmodium canescens	HOARY TICK-TREFOIL	forb	4	UPL	2.094%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	2.185%
Epilobium coloratum	PURPLE-LEAVED WILLOW-HERB	forb	1	OBL	0.002%
Erigeron annuus	DAISY FLEABANE	forb	0	FACU	0.004%
Eupatorium altissimum	TALL BONESET	forb	0	UPL	1.275%
Eupatorium perfoliatum	COMMON BONESET	forb	3	FACW+	0.273%
Euthamia graminifolia	FLAT-TOPPED GOLDENROD	forb	2	FAC	2.278%
Fraxinus pennsylvanica	GREEN ASH	tree	3	FACW	1.548%
Juncus effusus	SOFT RUSH	forb	1	FACW+	1.821%
Juncus tenuis	PATH RUSH	forb	1	FAC-	2.550%
Juncus torreyi	TORREY'S RUSH	forb	3	FACW	1.275%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	14.569%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.637%
Liatris spicata	SPIKED BLAZING-STAR	forb	7	FAC+	0.546%
Ludwigia palustris	WATER-PURSLANE	forb	3	OBL	1.275%
Monarda fistulosa	WILD BERGAMOT	forb	3	UPL	0.093%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	3.005%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	UPL	0.639%
Rudbeckia hirta	BLACK-EYED SUSAN	forb	1	FACU-	0.093%
Schizachyrium scoparium	LITTLE BLUESTEM	grass	5	FACU-	0.273%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	6.376%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	9.834%
Scirpus cyperinus	WOOL-GRASS	sedge	1	FACW+	1.366%
Scirpus pendulus	DROOPING BULRUSH	sedge	2	OBL	0.273%
Senna hebecarpa	NORTHERN WILD SENNA	forb	4	FAC	0.091%
Silphium laciniatum	COMPASS PLANT	forb	8	UPL	0.091%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	2.276%
Spartina pectinata	PRAIRIE CORD GRASS	grass	5	OBL	9.470%
Toxicodendron radicans	POISON-IVY	vine	1	FAC	0.091%
Ulmus rubra	SLIPPERY ELM	tree	3	FAC	0.091%
Verbena urticifolia	WHITE VERVAIN	forb	3	FACU	0.182%
Vernonia gigantea	TALL IRONWEED	forb	2	FAC	0.002%
Agrostis gigantea	**REDTOP**	grass	0	FACW	4.462%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	UPL	0.182%
Dipsacus fullonum	**WILD TEASEL**	forb	0	FACU-	1.184%
Melilotus officinalis	**YELLOW SWEET-CLOVER**	forb	0	FACU-	0.091%
Najas minor	**EURASIAN WATER-NYMPH**	forb	0	OBL	0.637%
Phleum pratense	**TIMOTHY**	grass	0	FACU	0.091%
Plantago major	**COMMON PLANTAIN**	forb	0	FACU	0.002%
Potamogeton crispus	**CURLY-LEAVED PONDWEED**	forb	0	OBL	0.637%
Rumex crispus	**CURLY DOCK**	forb	0	FACU	0.182%
Trifolium repens	**WHITE CLOVER**	forb	0	FACU-	0.637%
Unknown forb	UNKNOWN	forb	NDA[c]	NDA[c]	0.002%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–17. WM1W1 Wetland Vegetation Monitoring Data Summary

Total Species:	33
Native Species:	27
Non-Native Species:	6
Average CC[a]:	2.18

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	0.069%
Carex annectens	YELLOW FOX SEDGE	sedge	3	FACW	0.412%
Carex comosa	BEARDED SEDGE	sedge	2	OBL	3.569%
Carex lurida	BOTTLEBRUSH SEDGE	sedge	3	OBL	8.030%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	0.412%
Cephalanthus occidentalis	BUTTONBUSH	shrub	6	OBL	5.149%
Ceratophyllum demersum	COONTAIL	forb	2	OBL	1.235%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	2.608%
Epilobium coloratum	PURPLE-LEAVED WILLOW-HERB	forb	1	OBL	0.137%
Eupatorium perfoliatum	COMMON BONESET	forb	3	FACW+	3.638%
Fraxinus pennsylvanica	GREEN ASH	tree	3	FACW	0.069%
Juncus effusus	SOFT RUSH	forb	1	FACW+	1.167%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	1.579%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.892%
Ludwigia palustris	WATER-PURSLANE	forb	3	OBL	1.235%
Lycopus americanus	AMERICAN WATER-HOREHOUND	forb	3	OBL	0.480%
Mimulus ringens	COMMON MONKEY-FLOWER	forb	4	OBL	1.579%
Polygonum hydropiperoides	MILD WATER-PEPPER	forb	6	OBL	0.137%
Polygonum lapathifolium	DOCK-LEAVED SMARTWEED	forb	1	FACW+	0.069%
Sagittaria latifolia	COMMON ARROWHEAD	forb	1	OBL	0.206%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	13.383%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	0.206%
Scirpus cyperinus	WOOL-GRASS	sedge	1	FACW+	0.207%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	1.441%
Sparganium eurycarpum	GIANT BUR-REED	forb	4	OBL	1.167%
Utricularia vulgaris	COMMON BLADDERWORT	forb	6	OBL	0.755%
Verbena hastata	BLUE VERVAIN	forb	4	FACW+	1.029%
Agrostis gigantea	**REDTOP**	grass	0	FACW	3.363%
Cirsium arvense	**CANADA THISTLE**	forb	0	FACU	0.275%
Mentha x piperata	**PEPPERMINT**	forb	0	FACW+	3.569%
Phragmites australis subsp. australis	**GIANT REED**	grass	0	FACW	17.158%
Polygonum persicaria	**LADY'S THUMB**	forb	0	FACW	0.069%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	24.708%

[a] CC = Coefficient of Conservatism

[b] see http://plants.usda.gov/wetinfo.html

[c] NDA = No Determination Available

Species in bold are non-native.

Table D-18. WM1W2 Wetland Vegetation Monitoring Data Summary

Total Species:	**70**
Native Species:	**52**
Non-Native Species:	**18**
Average CC[a]:	**1.94**

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Acer rubrum	RED MAPLE	tree	2	FAC	0.001%
Agrimonia parviflora	SMALL-FLOWERED AGRIMONY	forb	2	FAC	0.069%
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	0.207%
Alopecurus sp.	NDA[c]	grass	NDA[c]	NDA[c]	0.069%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	1.105%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	11.256%
Asclepias incarnata	SWAMP MILKWEED	forb	4	OBL	0.760%
Asclepias syriaca	COMMON MILKWEED	forb	1	FACU-	0.069%
Aster novae-angliae	NEW ENGLAND ASTER	forb	2	FACW-	0.414%
Aster pilosus	AWL ASTER	forb	1	UPL	0.345%
Bidens connata	PURPLE-STEMMED BEGGAR'S-TICK	forb	3	FACW+	0.070%
Carex annectens	YELLOW FOX SEDGE	sedge	3	FACW	0.207%
Carex blanda	COMMON WOOD SEDGE	sedge	1	FAC	0.276%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	1.450%
Carex frankii	FRANK'S SEDGE	sedge	2	OBL	0.483%
Carex hystericina	PORCUPINE SEDGE	sedge	5	OBL	0.207%
Carex lupulina	HOP SEDGE	sedge	3	OBL	0.069%
Carex lurida	BOTTLEBRUSH SEDGE	sedge	3	OBL	0.276%
Carex scoparia	POINTED BROOM SEDGE	sedge	3	FACW	0.207%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	2.555%
Cephalanthus occidentalis	BUTTONBUSH	shrub	6	OBL	11.394%
Cyperus sp.	NDA[c]	sedge	NDA[c]	NDA[c]	0.898%
Decodon verticillatus	SWAMP LOOSESTRIFE	forb	6	OBL	0.483%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	0.691%
Elymus canadensis	CANADA WILD RYE	grass	6	FACU+	0.069%
Erigeron annuus	DAISY FLEABANE	forb	0	FACU	0.138%
Eupatorium altissimum	TALL BONESET	forb	0	UPL	0.070%
Eupatorium perfoliatum	COMMON BONESET	forb	3	FACW+	0.276%
Euthamia graminifolia	FLAT-TOPPED GOLDENROD	forb	2	FAC	0.414%
Galium aparine	CLEAVERS	forb	0	FACU	0.276%
Geum canadense	WHITE AVENS	forb	2	FACU	0.001%
Juncus effusus	SOFT RUSH	forb	1	FACW+	1.450%
Juncus tenuis	PATH RUSH	forb	1	FAC-	3.867%
Juniperus virginiana	EASTERN RED CEDAR	tree	3	FACU	0.207%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	2.072%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.001%
Ludwigia palustris	WATER-PURSLANE	forb	3	OBL	0.691%
Lycopus americanus	AMERICAN WATER-HOREHOUND	forb	3	OBL	1.243%
Monarda fistulosa	WILD BERGAMOT	forb	3	UPL	0.069%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	1.450%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	FACU	0.069%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	UPL	0.207%
Rudbeckia hirta	BLACK-EYED SUSAN	forb	1	FACU-	0.414%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	0.483%
Senna hebecarpa	NORTHERN WILD SENNA	forb	4	FAC	1.312%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	4.143%
Sorghastrum nutans	INDIAN GRASS	grass	5	UPL	0.207%
Sparganium eurycarpum	GIANT BUR-REED	forb	4	OBL	1.243%
Spartina pectinata	PRAIRIE CORD GRASS	grass	5	OBL	18.645%
Utricularia vulgaris	COMMON BLADDERWORT	forb	6	OBL	0.138%
Vernonia gigantea	TALL IRONWEED	forb	2	FAC	0.691%
Vitis riparia	RIVERBANK GRAPE	vine	3	FACW	0.207%
Agrostis gigantea	**REDTOP**	grass	0	FACW	8.287%
Bromus japonicus	**JAPANESE BROME**	grass	0	FACU-	0.276%
Cirsium arvense	**CANADA THISTLE**	forb	0	FACU	0.691%
Cirsium vulgare	**BULL THISTLE**	forb	0	FACU-	0.069%
Conium maculatum	**POISON-HEMLOCK**	forb	0	FACW	0.691%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	UPL	1.105%
Dipsacus fullonum	**WILD TEASEL**	forb	0	FACU-	3.038%
Festuca elatior	**TALL FESCUE**	grass	0	FACU	0.069%
Hordeum jubatum	**SQUIRREL-TAIL BARLEY**	grass	0	FAC	0.138%
Medicago lupulina	**BLACK MEDICK**	forb	0	UPL	0.001%
Mentha x piperata	**PEPPERMINT**	forb	0	FACW+	1.174%
Polygonum persicaria	**LADY'S THUMB**	forb	0	FACW	0.276%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	FACU	1.243%
Rumex crispus	**CURLY DOCK**	forb	0	FACU	0.069%
Solanum carolinense	**HORSE NETTLE**	forb	0	UPL	0.069%
Trifolium pratense	**RED CLOVER**	forb	0	FACU-	0.069%
Trifolium repens	**WHITE CLOVER**	forb	0	FACU-	0.483%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	8.632%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–19. WM1W3 Wetland Vegetation Monitoring Data Summary

Total Species:	43
Native Species:	29
Non-Native Species:	13
Average CC[a]:	1.75

Species	Common Name	Type	CC[a]	Nativity	Wetland Indicator[b]	Relative Cover
Acer saccharum	SUGAR MAPLE	tree	5	native	FACU-	0.230%
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	native	OBL	0.989%
Apocynum cannabinum	INDIAN HEMP	forb	1	native	FACU	0.304%
Asclepias incarnata	SWAMP MILKWEED	forb	4	native	OBL	0.533%
Carex cristatella	CRESTED SEDGE	sedge	3	native	FACW	0.228%
Carex hystericina	PORCUPINE SEDGE	sedge	5	native	OBL	0.076%
Carex lurida	BOTTLEBRUSH SEDGE	sedge	3	native	OBL	0.533%
Carex vulpinoidea	FOX SEDGE	sedge	1	native	OBL	2.663%
Carex sp.	NDA[c]	sedge	NDA[c]	native	NDA[c]	0.228%
Cephalanthus occidentalis	BUTTONBUSH	shrub	6	native	OBL	11.871%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	native	OBL	6.088%
Erechtites hieracifolia	PILEWORT	forb	2	native	FACU	3.044%
Eupatorium perfoliatum	COMMON BONESET	forb	3	native	FACW+	0.536%
Fraxinus pennsylvanica	GREEN ASH	tree	3	native	FACW	0.076%
Galium aparine	CLEAVERS	forb	0	native	FACU	0.457%
Juncus effusus	SOFT RUSH	forb	1	native	FACW+	4.033%
Leersia oryzoides	RICE CUT GRASS	grass	1	native	OBL	1.294%
Ludwigia palustris	WATER-PURSLANE	forb	3	native	OBL	0.989%
Lycopus americanus	AMERICAN WATER-HOREHOUND	forb	3	native	OBL	8.523%
Polygonum hydropiper	WATER-PEPPER	forb	1	native	OBL	0.304%
Polygonum lapathifolium	DOCK-LEAVED SMARTWEED	forb	1	native	FACW+	2.511%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	native	OBL	0.076%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	native	UPL	0.076%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	native	OBL	37.667%
Solidago canadensis	CANADA GOLDENROD	forb	1	native	FACU	6.544%
Sparganium eurycarpum	GIANT BUR-REED	forb	4	native	OBL	0.228%
Toxicodendron radicans	POISON-IVY	vine	1	native	FAC	0.078%
Utricularia vulgaris	COMMON BLADDERWORT	forb	6	native	OBL	0.152%
Vitis sp.	NDA[c]	vine	NDA[c]	native	NDA[c]	0.076%
Agrostis gigantea	**REDTOP**	grass	0	adventive	FACW	1.674%
Cirsium arvense	**CANADA THISTLE**	forb	0	adventive	FACU	1.902%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	adventive	UPL	0.304%
Dipsacus fullonum	**WILD TEASEL**	forb	0	adventive	FACU-	1.370%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	adventive	FACU	0.304%
Glechoma hederacea	**GROUND IVY**	forb	0	adventive	FACU	0.230%
Medicago lupulina	**BLACK MEDICK**	forb	0	adventive	UPL	0.076%
Mentha x piperata	**PEPPERMINT**	forb	0	adventive	FACW+	1.065%
Polygonum persicaria	**LADY'S THUMB**	forb	0	adventive	FACW	1.370%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	adventive	FACU	0.002%
Trifolium repens	**WHITE CLOVER**	forb	0	adventive	FACU-	0.078%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	adventive	OBL	0.913%
Xanthium strumarium	**COMMON COCKLEBUR**	forb	0	adventive	FAC	0.228%
Unknown forb	UNKNOWN	forb	NDA[c]	native	NDA[c]	0.076%

[a] CC = Coefficient of Conservatism

[b] see http://plants.usda.gov/wetinfo.html

[c] NDA = No Determination Available

Table D–20. WM1W4 Wetland Vegetation Monitoring Data Summary

Total Species:	63
Native Species:	48
Non-Native Species:	14
Average CC[a]:	1.72

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Agrimonia parviflora	SMALL-FLOWERED AGRIMONY	forb	2	FAC	0.087%
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	0.694%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	0.260%
Apocynum cannabinum	INDIAN HEMP	forb	1	FACU	0.087%
Asclepias incamata	SWAMP MILKWEED	forb	4	OBL	5.208%
Asclepias syriaca	COMMON MILKWEED	forb	1	FACU-	0.260%
Aster novae-angliae	NEW ENGLAND ASTER	forb	2	FACW-	0.260%
Aster pilosus	AWL ASTER	forb	1	UPL	0.087%
Bidens connata	PURPLE-STEMMED BEGGAR'S-TICK	forb	3	FACW+	0.087%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	FACW	0.260%
Calystegia sepium	HEDGE BINDWEED	forb	1	FAC-	0.521%
Carex annectens	YELLOW FOX SEDGE	sedge	3	FACW	0.608%
Carex blanda	COMMON WOOD SEDGE	sedge	1	FAC	0.260%
Carex comosa	BEARDED SEDGE	sedge	2	OBL	1.910%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	0.087%
Carex frankii	FRANK'S SEDGE	sedge	2	OBL	0.608%
Carex lurida	BOTTLEBRUSH SEDGE	sedge	3	OBL	6.250%
Carex tribuloides	BLUNT BROOM SEDGE	sedge	4	FACW+	0.868%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	2.083%
Ceratophyllum demersum	COONTAIL	forb	2	OBL	0.694%
Decodon verticillatus	SWAMP LOOSESTRIFE	forb	6	OBL	1.563%
Desmodium canescens	HOARY TICK-TREFOIL	forb	4	UPL	0.087%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	0.868%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	0.347%
Erigeron annuus	DAISY FLEABANE	forb	0	FACU	0.434%
Eupatorium perfoliatum	COMMON BONESET	forb	3	FACW+	1.476%
Fraxinus pennsylvanica	GREEN ASH	tree	3	FACW	0.694%
Galium aparine	CLEAVERS	forb	0	FACU	0.608%
Juncus effusus	SOFT RUSH	forb	1	FACW+	6.250%
Juniperus virginiana	EASTERN RED CEDAR	tree	3	FACU	1.128%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	3.993%
Ludwigia palustris	WATER-PURSLANE	forb	3	OBL	1.649%
Nymphaea odorata	FRAGRANT WATER-LILY	forb	6	OBL	13.021%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	0.868%
Polygonum lapathifolium	DOCK-LEAVED SMARTWEED	forb	1	FACW+	0.521%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	0.521%
Prunella vulgaris	SELF-HEAL	forb	0	FACU+	0.694%
Rosa palustris	SWAMP ROSE	shrub	5	OBL	0.260%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	UPL	0.260%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	3.646%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	1.563%
Scirpus cyperinus	WOOL-GRASS	sedge	1	FACW+	1.302%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	7.378%
Verbena hastata	BLUE VERVAIN	forb	4	FACW+	0.955%
Vemonia gigantea	TALL IRONWEED	forb	2	FAC	2.778%
Viburnum dentatum	ARROW-WOOD	shrub	2	FAC	0.521%
Vitis riparia	RIVERBANK GRAPE	vine	3	FACW	0.260%
Vitis sp.	NDA[c]	vine	NDA[c]	NDA[c]	0.087%
Agrostis gigantea	**REDTOP**	grass	0	FACW	5.903%
Cirsium arvense	**CANADA THISTLE**	forb	0	FACU	0.521%
Cirsium vulgare	**BULL THISTLE**	forb	0	FACU-	0.087%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	UPL	0.868%
Dipsacus fullonum	**WILD TEASEL**	forb	0	FACU-	2.257%
Lonicera japonica	**JAPANESE HONEYSUCKLE**	vine	0	FAC-	1.215%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	UPL	2.604%
Medicago lupulina	**BLACK MEDICK**	forb	0	UPL	0.087%
Melilotus officinalis	**YELLOW SWEET-CLOVER**	forb	0	FACU-	0.347%
Najas minor	**EURASIAN WATER-NYMPH**	forb	0	OBL	4.601%
Pyrus communis	**PEAR**	sm tree	0	UPL	1.910%
Rumex crispus	**CURLY DOCK**	forb	0	FACU	0.087%
Trifolium repens	**WHITE CLOVER**	forb	0	FACU-	1.389%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	2.604%
Unknown grass	UNKNOWN	grass	NDA[c]	NDA[c]	0.608%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–21. WM1W5 Wetland Vegetation Monitoring Data Summary

Total Species:	42
Native Species:	22
Non-Native Species:	19
Average CC[a]:	1.30

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	0.002%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	0.495%
Aster pilosus	AWL ASTER	forb	1	UPL	0.002%
Cornus amomum	SILKY DOGWOOD	shrub	2	FACW	0.124%
Cyperus sp.	NDA[c]	sedge	NDA[c]	NDA[c]	0.247%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	6.186%
Fraxinus pennsylvanica	GREEN ASH	tree	3	FACW	0.742%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	1.114%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	1.237%
Mimulus ringens	COMMON MONKEY-FLOWER	forb	4	OBL	0.371%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	1.237%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	FACU	0.124%
Phyla lanceolata	FOG-FRUIT	forb	3	OBL	0.371%
Populus deltoides	EASTERN COTTONWOOD	tree	3	FAC	0.002%
Salix exigua	SANDBAR WILLOW	shrub	1	OBL	18.312%
Salix nigra	BLACK WILLOW	tree	2	FACW+	0.124%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	39.593%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	0.124%
Scirpus cyperinus	WOOL-GRASS	sedge	1	FACW+	2.227%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	1.980%
Sorghastrum nutans	INDIAN GRASS	grass	5	UPL	0.742%
Vernonia gigantea	TALL IRONWEED	forb	2	FAC	0.002%
Agrostis gigantea	**REDTOP**	grass	0	FACW	0.742%
Bromus japonicus	**JAPANESE BROME**	grass	0	FACU-	0.002%
Cirsium arvense	**CANADA THISTLE**	forb	0	FACU	0.371%
Convolvulus arvensis	**FIELD BINDWEED**	forb	0	UPL	0.002%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	UPL	0.250%
Dipsacus fullonum	**WILD TEASEL**	forb	0	FACU-	0.374%
Festuca elatior	**TALL FESCUE**	grass	0	FACU	0.742%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	UPL	0.371%
Morus alba	**WHITE MULBERRY**	tree	0	UPL	0.124%
Plantago lanceolata	**ENGLISH PLANTAIN**	forb	0	UPL	0.495%
Polygonum persicaria	**LADY'S THUMB**	forb	0	FACW	1.237%
Pyrus communis	**PEAR**	sm tree	0	UPL	0.371%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	FACU	0.124%
Rumex crispus	**CURLY DOCK**	forb	0	FACU	0.742%
Solanum carolinense	**HORSE NETTLE**	forb	0	UPL	0.002%
Sonchus arvensis	**FIELD SOW-THISTLE**	forb	0	UPL	0.124%
Trifolium repens	**WHITE CLOVER**	forb	0	FACU-	0.002%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	18.188%
Xanthium strumarium	**COMMON COCKLEBUR**	forb	0	FAC	0.371%
Regreen	REGREEN	grass	NDA[c]	NDA[c]	0.002%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D-22. WM1W6 Wetland Vegetation Monitoring Data Summary

Total Species:	58
Native Species:	42
Non-Native Species:	16
Average CC[a]:	1.96

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Acer saccharum	SUGAR MAPLE	tree	5	FACU-	0.003%
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	0.296%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	0.151%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	0.592%
Asclepias incarnata	SWAMP MILKWEED	forb	4	OBL	0.148%
Aster novae-angliae	NEW ENGLAND ASTER	forb	2	FACW-	0.148%
Aster sp.	NDA[c]	forb	NDA[c]	NDA[c]	0.003%
Carex annectens	YELLOW FOX SEDGE	sedge	3	FACW	4.442%
Carex comosa	BEARDED SEDGE	sedge	2	OBL	0.444%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	2.517%
Carex frankii	FRANK'S SEDGE	sedge	2	OBL	2.369%
Carex hystericina	PORCUPINE SEDGE	sedge	5	OBL	0.444%
Carex lunda	BOTTLEBRUSH SEDGE	sedge	3	OBL	0.296%
Carex normalis	LARGE STRAW SEDGE	sedge	4	FACU	0.148%
Carex stricta	TUSSOCK SEDGE	sedge	5	OBL	0.148%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	3.258%
Cephalanthus occidentalis	BUTTONBUSH	shrub	6	OBL	2.221%
Cyperus sp.	NDA[c]	sedge	NDA[c]	NDA[c]	0.003%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	0.444%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	0.148%
Erigeron annuus	DAISY FLEABANE	forb	0	FACU	2.665%
Euthamia graminifolia	FLAT-TOPPED GOLDENROD	forb	2	FAC	0.447%
Fraxinus pennsylvanica	GREEN ASH	tree	3	FACW	0.148%
Juglans nigra	BLACK WALNUT	tree	5	FACU	0.148%
Juncus effusus	SOFT RUSH	forb	1	FACW+	1.037%
Juncus tenuis	PATH RUSH	forb	1	FAC-	7.256%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.003%
Ludwigia palustris	WATER-PURSLANE	forb	3	OBL	1.481%
Lycopus americanus	AMERICAN WATER-HOREHOUND	forb	3	OBL	0.296%
Panicum clandestinum	DEER'S-TONGUE PANIC GRASS	grass	2	FAC+	0.595%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	9.625%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	FACU	0.148%
Polygonum amphibium	WATER SMARTWEED	forb	4	OBL	0.003%
Prunella vulgaris	SELF-HEAL	forb	0	FACU+	0.003%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	1.481%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	0.740%
Scirpus cyperinus	WOOL-GRASS	sedge	1	FACW+	0.148%
Senna hebecarpa	NORTHERN WILD SENNA	forb	4	FAC	1.037%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	12.142%
Spartina pectinata	PRAIRIE CORD GRASS	grass	5	OBL	9.625%
Toxicodendron radicans	POISON-IVY	vine	1	FAC	0.148%
Verbesina alternifolia	WINGSTEM	forb	5	FAC	0.154%
Agrostis gigantea	**REDTOP**	grass	0	FACW	3.702%
Bromus japonicus	**JAPANESE BROME**	grass	0	FACU-	11.109%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	UPL	0.891%
Dipsacus fullonum	**WILD TEASEL**	forb	0	FACU-	4.442%
Festuca elatior	**TALL FESCUE**	grass	0	FACU	0.296%
Hordeum jubatum	**SQUIRREL-TAIL BARLEY**	grass	0	FAC	0.003%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	UPL	0.148%
Lotus corniculatus	**BIRD'S-FOOT TREFOIL**	forb	0	FACU-	3.258%
Medicago lupulina	**BLACK MEDICK**	forb	0	UPL	0.003%
Melilotus officinalis	**YELLOW SWEET-CLOVER**	forb	0	FACU-	0.592%
Phleum pratense	**TIMOTHY**	grass	0	FACU	0.444%
Pyrus communis	**PEAR**	sm tree	0	UPL	1.333%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	FACU	1.481%
Rumex crispus	**CURLY DOCK**	forb	0	FACU	0.003%
Solanum carolinense	**HORSE NETTLE**	forb	0	UPL	0.296%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	4.442%

[a] CC = Coefficient of Conservatism

[b] see http://plants.usda.gov/wetinfo.html

[c] NDA = No Determination Available

Table D–23. WM1W7 Wetland Vegetation Monitoring Data Summary

Total Species:	29
Native Species:	21
Non-Native Species:	6
Average CC[a]:	2.00

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	3.786%
Amorpha fruticosa	FALSE INDIGO	forb	3	FACW	1.136%
Carex comosa	BEARDED SEDGE	sedge	2	OBL	1.515%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	7.573%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	3.786%
Glyceria striata	FOWL MANNA GRASS	grass	2	OBL	0.379%
Iris versicolor	NORTHERN BLUE FLAG	forb	6	OBL	0.379%
Juncus effusus	SOFT RUSH	forb	1	FACW+	12.495%
Juncus tenuis	PATH RUSH	forb	1	FAC-	15.903%
Juncus torreyi	TORREY'S RUSH	forb	3	FACW	3.786%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	3.786%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.386%
Polygonum amphibium	WATER SMARTWEED	forb	4	OBL	1.893%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	1.515%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	1.136%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	1.515%
Senecio aureus	GOLDEN RAGWORT	forb	4	FACW	0.008%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	1.522%
Sparganium eurycarpum	GIANT BUR-REED	forb	4	OBL	9.466%
Spartina pectinata	PRAIRIE CORD GRASS	grass	5	OBL	13.253%
Verbena hastata	BLUE VERVAIN	forb	4	FACW+	0.379%
Agrostis gigantea	**REDTOP**	grass	0	FACW	9.466%
Cirsium arvense	**CANADA THISTLE**	forb	0	FACU	0.394%
Dipsacus fullonum	**WILD TEASEL**	forb	0	FACU-	0.379%
Festuca elatior	**TALL FESCUE**	grass	0	FACU	1.515%
Rumex crispus	**CURLY DOCK**	forb	0	FACU	0.379%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	1.136%
Unknown forb	UNKNOWN	forb	NDA[c]	NDA[c]	0.758%
Unknown	UNKNOWN	NDA[c]	NDA[c]	NDA[c]	0.379%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–24. WM2W1 Wetland Vegetation Monitoring Data Summary

Total Species:	50
Native Species:	37
Non-Native Species:	10
Average CC[a]:	1.73

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Acer rubrum	RED MAPLE	tree	2	FAC	0.082%
Achillea millefolium	YARROW	forb	1	FACU	0.242%
Agrimonia parviflora	SMALL-FLOWERED AGRIMONY	forb	2	FAC	0.081%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	0.161%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	FACW	0.081%
Calystegia sepium	HEDGE BINDWEED	forb	1	FAC-	0.081%
Campsis radicans	TRUMPET-CREEPER	vine	1	FAC	0.081%
Carex sp.	NDA[c]	sedge	NDA[c]	NDA[c]	0.081%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	0.161%
Carex frankii	FRANK'S SEDGE	sedge	2	OBL	0.403%
Carex granularis	MEADOW SEDGE	sedge	3	FACW+	0.645%
Carex hystericina	PORCUPINE SEDGE	sedge	5	OBL	0.081%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	0.886%
Cephalanthus occidentalis	BUTTONBUSH	shrub	6	OBL	0.242%
Ceratophyllum demersum	COONTAIL	forb	2	OBL	18.933%
Desmodium canescens	HOARY TICK-TREFOIL	forb	4	UPL	0.081%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	1.208%
Equisetum arvense	FIELD HORSETAIL	fern	0	FAC	2.338%
Erigeron sp.	NDA[c]	forb	NDA[c]	NDA[c]	0.081%
Euthamia graminifolia	FLAT-TOPPED GOLDENROD	forb	2	FAC	0.081%
Geum canadense	WHITE AVENS	forb	2	FACU	0.081%
Hamamelis virginiana	WITCH-HAZEL	sm tree	5	FAC-	7.251%
Juncus tenuis	PATH RUSH	forb	1	FAC-	0.806%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	0.725%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.002%
Monarda fistulosa	WILD BERGAMOT	forb	3	UPL	0.002%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	UPL	0.002%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	1.128%
Populus deltoides	EASTERN COTTONWOOD	tree	3	FAC	0.483%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	22.156%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	0.242%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	0.483%
Scirpus cyperinus	WOOL-GRASS	sedge	1	FACW+	0.242%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	0.324%
Sparganium eurycarpum	GIANT BUR-REED	forb	4	OBL	12.891%
Toxicodendron radicans	POISON-IVY	vine	1	FAC	0.242%
Vernonia gigantea	TALL IRONWEED	forb	2	FAC	0.002%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	UPL	0.081%
Dipsacus fullonum	**WILD TEASEL**	forb	0	FACU-	0.483%
Lysimachia nummularia	**MONEYWORT**	forb	0	OBL	0.242%
Medicago lupulina	**BLACK MEDICK**	forb	0	UPL	0.002%
Plantago lanceolata	**ENGLISH PLANTAIN**	forb	0	UPL	0.002%
Plantago major	**COMMON PLANTAIN**	forb	0	FACU	0.081%
Potamogeton crispus	**CURLY-LEAVED PONDWEED**	forb	0	OBL	15.469%
Solanum carolinense	**HORSE NETTLE**	forb	0	UPL	0.081%
Trifolium repens	**WHITE CLOVER**	forb	0	FACU-	0.322%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	10.071%
Unknown Cress	UNKNOWN	forb	NDA[c]	NDA[c]	0.081%
Unknown Grass	UNKNOWN	grass	NDA[c]	NDA[c]	0.002%
Unknown	UNKNOWN	NDA[c]	NDA[c]	NDA[c]	0.002%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–25. WM2W2 Wetland Vegetation Monitoring Data Summary

Total Species:	34
Native Species:	31
Non-Native Species:	2
Average CC[a]:	2.29

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Acer rubrum	RED MAPLE	tree	2	FAC	0.148%
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	0.148%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	0.148%
Asclepias incarnata	SWAMP MILKWEED	forb	4	OBL	1.038%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	FACW	0.445%
Campsis radicans	TRUMPET-CREEPER	vine	1	FAC	0.151%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	0.445%
Carex frankii	FRANK'S SEDGE	sedge	2	OBL	0.593%
Carex granularis	MEADOW SEDGE	sedge	3	FACW+	0.297%
Carex hystericina	PORCUPINE SEDGE	sedge	5	OBL	0.448%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	1.187%
Cephalanthus occidentalis	BUTTONBUSH	shrub	6	OBL	2.077%
Ceratophyllum demersum	COONTAIL	forb	2	OBL	5.192%
Cyperus sp.	NDA[c]	sedge	NDA[c]	NDA[c]	0.003%
Desmodium canescens	HOARY TICK-TREFOIL	forb	4	UPL	0.445%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	54.885%
Eleocharis obtusa	BLUNT SPIKE-RUSH	sedge	1	OBL	0.148%
Eupatorium sp.	NDA[a]	forb	NDA[c]	NDA[c]	0.148%
Fraxinus pennsylvanica	GREEN ASH	tree	3	FACW	1.038%
Juncus tenuis	PATH RUSH	forb	1	FAC-	0.593%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	0.593%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	6.675%
Penstemon digitalis	FOXGLOVE BEARD-TONGUE	forb	2	FAC	0.003%
Populus deltoides	EASTERN COTTONWOOD	tree	3	FAC	0.148%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	0.448%
Salix nigra	BLACK WILLOW	tree	2	FACW+	2.670%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	2.670%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	0.148%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	0.148%
Strophostyles helvula	WILD BEAN	forb	3	FACU-	0.297%
Verbena urticifolia	WHITE VERVAIN	forb	3	FACU	0.148%
Schoenoplectus mucronatus	**RICEFIELD BULRUSH**	sedge	0	OBL	0.148%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	16.317%
Unknown forb	UNKNOWN	forb	NDA[c]	NDA[c]	0.006%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–26. WM2W3 Wetland Vegetation Monitoring Data Summary

Total Species:	45
Native Species:	38
Non-Native Species:	7
Average CC[a]:	2.20

Species	Common Name	Type	CC[a]	Wetland Indicator[b]	Relative Cover
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	forb	2	OBL	0.608%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	FACU	0.004%
Andropogon gerardii	BIG BLUESTEM	grass	5	FAC	1.419%
Asclepias incarnata	SWAMP MILKWEED	forb	4	OBL	0.608%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	FACW	0.203%
Calystegia sepium	HEDGE BINDWEED	forb	1	FAC-	0.004%
Carex cristatella	CRESTED SEDGE	sedge	3	FACW	1.018%
Carex frankii	FRANK'S SEDGE	sedge	2	OBL	0.203%
Carex granularis	MEADOW SEDGE	sedge	3	FACW+	1.014%
Carex hirsutella	HIRSUTE SEDGE	sedge	2	FACU	0.004%
Carex hystericina	PORCUPINE SEDGE	sedge	5	OBL	0.203%
Carex shortiana	SHORT'S SEDGE	sedge	2	FAC	0.203%
Carex vulpinoidea	FOX SEDGE	sedge	1	OBL	1.825%
Cephalanthus occidentalis	BUTTONBUSH	shrub	6	OBL	0.811%
Ceratophyllum demersum	COONTAIL	forb	2	OBL	15.207%
Eleocharis erythropoda	RED-FOOTED SPIKE-RUSH	sedge	4	OBL	0.000%
Eupatorium serotinum	LATE-FLOWERING BONESET	forb	2	FAC-	0.811%
Euthamia graminifolia	FLAT-TOPPED GOLDENROD	forb	2	FAC	0.008%
Fraxinus pennsylvanica	GREEN ASH	tree	3	FACW	0.608%
Juncus tenuis	PATH RUSH	forb	1	FAC-	1.622%
Juncus torreyi	TORREY'S RUSH	forb	3	FACW	0.811%
Leersia oryzoides	RICE CUT GRASS	grass	1	OBL	0.811%
Lemna minor	COMMON DUCKWEED	forb	3	OBL	0.203%
Lycopus americanus	AMERICAN WATER-HOREHOUND	forb	3	OBL	0.203%
Panicum virgatum	SWITCH GRASS	grass	4	FAC	5.069%
Penstemon digitalis	FOXGLOVE BEARD-TONGUE	forb	2	FAC	0.004%
Platanus occidentalis	SYCAMORE	tree	7	FACW-	0.203%
Populus deltoides	EASTERN COTTONWOOD	tree	3	FAC	0.203%
Potamogeton nodosus	LONG-LEAVED PONDWEED	forb	3	OBL	15.207%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	1	FACU-	0.004%
Salix exigua	SANDBAR WILLOW	shrub	1	OBL	0.406%
Salix nigra	BLACK WILLOW	tree	2	FACW+	0.608%
Schoenoplectus tabernaemontani	SOFT-STEMMED BULRUSH	sedge	2	OBL	7.097%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	OBL	1.217%
Sisyrinchium angustifolium	STOUT BLUE-EYED-GRASS	forb	2	FACW-	0.004%
Solidago canadensis	CANADA GOLDENROD	forb	1	FACU	0.203%
Sorghastrum nutans	INDIAN GRASS	grass	5	UPL	0.203%
Verbena urticifolia	WHITE VERVAIN	forb	3	FACU	0.203%
Dipsacus fullonum	**WILD TEASEL**	forb	0	FACU-	0.203%
Lysimachia nummularia	**MONEYWORT**	forb	0	OBL	2.636%
Melilotus alba	**WHITE SWEET-CLOVER**	forb	0	FACU-	0.203%
Plantago lanceolata	**ENGLISH PLANTAIN**	forb	0	UPL	0.203%
Poa annual	**ANNUAL BLUEGRASS**	grass	0	FACU	0.004%
Schoenoplectus mucronatus	**RICEFIELD BULRUSH**	sedge	0	OBL	0.203%
Typha x glauca	**HYBRID CAT-TAIL**	forb	0	OBL	37.510%

[a] CC = Coefficient of Conservatism
[b] see http://plants.usda.gov/wetinfo.html
[c] NDA = No Determination Available
Species in bold are non-native.

Table D–27. Wetland Mitigation Soil Biogeochemistry and Water Chemistry Analytical Summary

Soil					Water																
Restoration Project Area	Wetland Area	Total Nitrogen (Median Percent)	Total Organic Carbon (Median Percent)	Solids (Median Percent)	Ammonia Total as Nitrogen (mg/L)	Chloride (mg/L)	Dissolved Oxygen (mg/L)	Iron (mg/L)	Magnesium (mg/L)	Nitrate + Nitrate as Nitrogen (mg/L)	Oxidation Reduction Potential (mV)	pH (S. U.)	Phophorous (mg/L)	Potassium (mg/L)	Specific Conductance (umhos/cm)	Temperature (C)	Total Kjeidahl Nitrogen (mg/L)	Total Organic Carbon (mg/L)	Total Solids (mg/L)	Total Suspended Solids (mg/L)	Turbidity (NTU)
Borrow Area (BAP)	BAPW2	0.2	1.2	75.4	0.228	0.534	11.54	0.872	14.7	1.25	5.5	7.66	0.3	3.37	294	26.67	1.78	16.6	438	184	2.65
	BAPW3	0.1	0.5	74.3	0.278	0.624	3.35	19.1	17.6	0.127	-67	7.06	0.3	3.47	407	27.62	1.07	22.1	463	217	4.25
	BAPW4	0.1	0.9	74.6	0.212	1.21	10.04	1.17	17.9	0.01	24	7.79	0.1	0.745	502	29.22	1.27	16.9	223	18.8	6.99
	BAPW7	0.2	1.6	67.3	0.193	0.353	7.5	2.25	11.8	0.05	-104	6.95	0.3	1.4	392	23.73	1.19	15.7	297	96	6.16
	BAPW9	0.4	1.5	85.7	0.226	0.405	10.59	0.768	6.99	1.99	2	8.09	0.6	2.05	160	27.52	2.76	13.7	350	222	2.65
Former Production Area (FPA)	FPAW2	0.2	**6.0**	75.0	1.2	8.35	3.57	7.04	43.9	<0.01	-86.7	7.03	0.4	12.1	578	21.37	10.3	62.2	783	198	96
	FPAW4	0.1	**4.5**	60.0	0.295	0.955	3.23	1.36	15.4	<0.01	-15	7.87	0.111	6.27	330	21.11	2.16	24.6	241	18.4	10.3
	FPAW5	0.2	3.3	55.3	0.513	12.8	1.24	2.53	57.3	0.01	-159	7.2	0.4	37.8	1024	20.66	9.61	37.5	928	198	9.35
	FPAW7	0.2	**5.7**	79.6	0.641	0.367	5.84	8.03	36.4	1.83	-115	6.93	0.8	6.57	874	18.35	6.77	50.6	968	352	22.7
	FPAW9	0.1	4.3	85.9	0.31	1.49	4.83	0.995	11.5	0.178	-31.5	7.55	0.1	7.87	321	22.82	2.05	19.9	269	75	6.24
	PREW6	0.1	0.4	74.9	0.263	0.456	5.3	3.43	8.62	2.59	185	7.6	0.7	5.15	162	22.11	2.05	16.5	229	63	8.08
Northern Pine Plantation Enhancement (NPP)	NPPW4	0.1	0.8	78.4	0.236	21.7	4.26	18.1	17.6	1.04	-30	6.87	0.1	2.64	255	28	2.29	16.3	532	189	9.48
	NPPW5	0.1	0.6	71.2	0.174	19.8	9.9	1.14	24.3	0.286	56	7.66	0.2	1.92	606	25.22	0.312	9.47	452	50.8	13.6
Wetland Mitigation Phase I (WM1)	WM1W1	0.1	1.7	78.2	0.153	2.68	9.61	3.52	16.3	<0.01	11.2	7.07	<0.1	3.08	453	19.67	0.237	13.4	400	91.2	50.9
	WM1W2	0.3	1.1	77.8	0.156	1.01	5.01	3.69	16.6	<0.01	116.4	7.26	<0.1	4.22	450	20.24	0.988	15.7	352	73	23.8
	WM1W3	0.2	1.3	83.8	0.148	0.674	4.75	2	20.4	0.311	103	7.28	<0.1	4.36	494	20.41	0.253	15.6	314	5.6	13
	WM1W4	0.1	0.6	76.3	0.113	0.908	6.06	2.01	6.49	2.03	57.9	7.53	0.2	4.19	190	20.53	1.7	9.64	369	215	29.9
	WM1W5	0.1	1.5	79.5	0.36	19.4	6.22	2.67	19.6	<0.01	63.3	7.05	0.5	22.8	540	18.58	2.1	28.6	508	108	179
	WM1W6	0.1	1.1	85.5	0.136	78.6	3.91	1.24	19.8	0.166	-25.6	6.97	0.2	1.56	763	19.21	0.36	10.6	615	150.8	24.5
	WM1W7	0.1	1.9	84.3	0.183	140	7.62	1.37	21.7	0.396	83.5	7.23	0.4	2.18	900	19.61	0.359	17.4	698	35.6	22.2
Wetland Mitigation Phase II (WM2)	WM2W1	0.0	0.5	73.9	0.146	12.9	6.75	3.62	22.7	0.095	-21.1	7.08	<0.2	1.48	384	27.08	1.69	8.83	310	17.2	7.23
	WM2W2	0.1	0.5	85.0	0.129	11.5	7.28	2	12.2	<0.01	125	7.73	<0.1	2.28	295	26.86	0.991	12.2	266	31.2	34.2
	WM2W3	0.0	0.3	78.6	0.132	26.8	8.04	1.88	18.5	<0.01	113	7.61	0.3	2.94	482	28.68	0.783	14.3	507	171	22.5
Performance Standard		>0.5	>3.9	<46.6	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]

Values in bold have met the performance standard

[a] *No performance standard exists for this parameter*

Table D–28. Wetland Mitigation Amphibian Monitoring Scoring Metrics and Results Summary

Restoration Area	Wetland Area	Amphibian Quality Assessment Index	Score	Percent Relative Abundance Sensitive Species	Score	Percent Relative Abundance Tolerant Species	Score	Number of Pond-Breeding Salamanders	Score	Spotted Salamanders or Wood Frogs	Score	Amphibian Index of Biotic Integrity Score
Borrow Area (BAP)	BAPW2	1.60	0	0%	0	100%	0	0	0	0	0	0
	BAPW4	1.00	0	0%	0	100%	0	0	0	0	0	0
	BAPW7	3.20	3	20%	7	60%	3	0	0	0	0	13
Former Production Area (FPA)	FPAW2	3.50	3	25%	7	75%	3	0	0	0	0	13
	FPAW7	1.90	0	0%	0	100%	0	0	0	0	0	0
	FPAW9	2.28	0	29%	7	71%	3	0	0	0	0	10
	PREW6	4.18	3	45%	7	55%	3	0	0	0	0	13
Northern Pine Plantation Enhancement (NPP)	NPPW4	6.26	10	85%	10	15%	10	1	3	0	0	33
	NPPW5	2.82	0	0%	0	100%	0	0	0	0	0	0
Wetland Mitigation Phase I (WM1)	WM1W1	2.00	0	0%	0	80%	0	1	3	0	0	3
	WM1W4	1.51	0	2%	3	98%	0	0	0	0	0	3
	WM1W7	3.00	0	0%	0	100%	0	0	0	0	0	0
Wetland Mitigation Phase II (WM2)	WM2W1	2.31	0	7%	3	91%	0	1	3	0	0	6
	WM2W2	1.66	0	1%	3	99%	0	2	3	0	0	6
	WM2W3	3.61	3	2%	3	65%	3	1	3	0	0	12

Table D–29. Wetland Mitigation Amphibian Species Monitoring Summary

Restoration Project Area	Wetland Area	AIBI[a]	Species and Number of Individuals												
			Cricket Frog (*Acris crepitans*)	Streamside Salamander (*Ambystoma barbouri*)	Marbled Salamander (*Ambystoma opacum*)	Salamander Species (*Ambystoma sp*)	Tiger Salamander (*Ambystoma tigrinum*)	American Toad (*Anaxyrus americanus*)	Fowlers Toad (*Anaxyrus fowleri*)	Toad Species (*Anaxyrus sp*)	American Bull Frog (*Lithobates catesbeiana*)	Green Frog (*Lithobates clamitans*)	Northern Leopard Frog (*Lithobates pipiens*)	Frog Species (*Lithobates sp*)	Spring Peeper (*Pseudacris crucifer*)
Borrow Area (BAP)	BAPW2	0	0	0	0	0	0	0	0	0	3	0	0	2	0
	BAPW4	0	0	0	0	0	0	0	0	0	0	1	0	19	0
	BAPW7	13	1	0	0	0	0	0	0	0	0	1	1	1	1
Former Production Area (FPA)	FPAW2	13	1	0	0	0	0	0	0	0	2	0	0	0	1
	FPAW7	0	0	0	0	0	0	0	0	0	1	0	0	10	0
	FPAW9	10	12	0	0	0	0	0	0	1	0	0	0	28	0
	PREW6	13	10	0	0	0	0	0	0	0	10	2	0	0	0
Northern Pine Plantation Enhancement (NPP)	NPPW4	33	40	0	0	1	1	0	0	0	4	2	1	0	0
	NPPW5	0	0	0	0	0	0	0	0	0	3	0	0	0	14
Wetland Mitigation Phase I (WM1)	WM1W1	3	0	0	1	0	0	0	0	0	1	3	0	0	0
	WM1W4	3	1	0	0	0	0	0	0	0	15	7	0	19	0
	WM1W7	0	0	0	0	0	0	0	0	0	0	0	0	0	40
Wetland Mitigation Phase II (WM2)	WM2W1	6	0	2	0	7	0	0	0	10	98	2	2	0	0
	WM2W2	6	0	1	1	0	0	0	0	213	2	0	1	134	2
	WM2W3	12	1	0	0	16	0	0	0	0	2	0	0	2	28

[a]*AIBI = Amphibian Index of Biotic Integrity Score*

Table D–30. Forest Functional Monitoring Herbaceous Vegetation Summary

Forest Community Type	Functional Monitoring Area	Total Species	Native Species	Native Species (Percent)	Relative Frequency of Native Species (Percent)	CC[a] (Median)	FQAI[b]
Mature Forest	NWEFO1	44	35	80%	72%	2.18	14.43
	PREFO1	36	27	75%	67%	1.67	10.00
	PREFO2	53	39	74%	65%	2.35	17.14
	PRWFO1	22	12	55%	33%	1.40	6.57
	PRWFO2	50	41	82%	67%	2.32	16.40
	PRWFO3	38	25	66%	85%	3.32	20.44
Pine Plantation	NPPPP1	35	22	63%	55%	1.33	7.89
	PREPP1	49	37	76%	72%	2.04	14.30
Restored Forest	A82RF1	45	31	69%	68%	1.86	12.48
	A82RF2	46	29	63%	55%	1.53	10.41
	ERPRF1	42	25	60%	47%	1.83	11.83
	FWPRF1	46	27	59%	56%	1.17	7.91
	NPPRF1	43	30	70%	68%	1.76	11.52
	NWERF1	54	38	70%	63%	1.47	10.81
	PRERF1	49	33	67%	64%	1.50	10.50
	PRERF2	36	23	64%	54%	1.41	8.47
	PRWRF1	41	28	68%	58%	1.85	11.82
	PRWRF2	50	34	68%	57%	1.53	10.84
	SWURF1	42	23	55%	52%	1.55	10.05
	SWURF2	38	26	68%	68%	2.09	12.86
Successional Forest	NPPSF1	32	23	72%	58%	1.30	7.35
	NWESF1	44	32	73%	68%	1.74	9.83
	PRESF1	60	42	70%	69%	1.61	12.45

[a] *CC = Coefficent of Conservatism*

[b] *FQAI = Floristic Quality Assessment Index*

Table D–31. Forest Functional Monitoring Woody Vegetation Summary

Forest Community Type	Functional Monitoring Area	Total Species	Native Species	Native Species (Percent)	Relative Density of Native Species (Percent)	CC[a] (Mean)	FQAI[b]	DBH[c] (Mean cm)
Mature Forest	NWEFO1	9	9	100%	100%	4.78	14.33	32.4
	PREFO1	17	15	88%	35%	4.00	16.49	17.8
	PREFO2	18	16	89%	35%	4.17	17.68	19.3
	PRWFO1	17	16	94%	20%	4.88	20.10	24.2
	PRWFO2	17	15	88%	46%	3.00	12.37	19.6
	PRWFO3	16	14	88%	13%	3.71	14.82	19.2
Pine Plantation	NPPPP1	12	9	75%	54%	3.25	11.26	8.3
	PREPP1	17	13	76%	81%	3.24	13.34	11.9
Restored Forest	A82RF1	33	29	88%	92%	3.39	19.46	6.9
	A82RF2	14	12	86%	77%	3.31	12.38	13.3
	ERPRF1	19	15	79%	80%	3.65	15.91	1.8
	FWPRF1	35	33	94%	89%	3.60	21.30	1.4
	NPPRF1	37	33	89%	95%	3.62	22.03	2.3
	NWERF1	26	21	81%	77%	2.80	14.28	5.6
	PRERF1	29	24	83%	98%	3.24	17.46	2.1
	PRERF2	40	36	90%	94%	4.00	25.30	1.4
	PRWRF1	32	27	84%	96%	3.45	19.53	2.1
	PRWRF2	24	20	83%	81%	3.33	16.33	1.7
	SWURF1	13	11	85%	87%	4.00	14.42	1.1
	SWURF2	19	16	84%	40%	4.58	19.96	2.1
Successional Forest	NPPSF1	15	14	93%	25%	4.07	15.75	16.6
	NWESF1	13	11	85%	32%	3.38	12.20	22.6
	PRESF1	23	21	91%	50%	4.18	20.06	11.8

[a] *CC = Coefficent of Conservatism*
[b] *FQAI = Floristic Quality Assessment Index*
[c] *DBH = Diameter at Breast Height*

Table D–32. Forest Functional Monitoring Comparison

	Southern Waste Units Restoration				Area 8, Phase II Revegetation				Northern Woodlot Enhancement			
Parameter	2005	2011	Reference (Upland Forest Complex)	Baseline (Developed)	2005	2011	Reference (Riparian)	Baseline (Grazed Pasture)	2005	2011	Reference (Upland Forest Complex)	Baseline (Woodlot)
Total Species	82	82	62	NA[c]	66	74	95	38	82	68	62	56
Total Native Species	61	55	58	NA[c]	44	55	85	15	58	50	58	42
Percent Native Species	74%	67%	94%	NA[c]	67%	74%	91%	39%	71%	74%	94%	75%
Average CC[a]	3.0	2.6	3.9	NA[c]	2.2	2.5	3.3	0.4	1.8	2.0	3.9	2.4
FQAI[b]	26.70	23.13	30.50	NA[c]	17.50	21.38	31.80	2.60	16.70	16.89	30.50	18.00

[a] *CC = Coefficent of Conservatism*
[b] *FQAI = Floristic Quality Assessment Index*
[c] *NA = Not Applicable (Developed areas were not characterized. Baseline conditions are assumed to be zero for all parameters.)*

Table D–33. NWEFO1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	44	**Mean CC[a]:**	2.18
Native Species:	35	**Average Cover:**	53.2%
Non-Native Species:	9	**FQAI[b]:**	14.43
Percent Native:	80%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.20	3%
Acer saccharinum	SILVER MAPLE	tree	3	0.13	2%
Aesculus glabra	OHIO BUCKEYE	tree	6	0.07	1%
Aster pilosus	AWL ASTER	forb	1	0.07	1%
Camassia scilloides	WILD HYACINTH	forb	6	0.07	1%
Cardamine concatenata	CUT-LEAVED TOOTHWORT	forb	3	0.27	4%
Carya sp.	NDA[c]	tree	NDA[c]	0.20	3%
Celtis occidentalis	HACKBERRY	tree	4	0.07	1%
Claytonia virginica	SPRING-BEAUTY	forb	2	0.20	3%
Echinocystis lobata	WILD CUCUMBER	vine	2	0.07	1%
Elymus canadensis	CANADA WILD RYE	grass	6	0.13	2%
Elymus sp.	NDA[c]	grass	NDA[c]	0.13	2%
Eupatorium perfoliatum	COMMON BONESET	forb	3	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.20	3%
Fragaria virginiana	WILD STRAWBERRY	forb	1	0.07	1%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.27	4%
Galium aparine	CLEAVERS	forb	0	0.13	2%
Geranium maculatum	WILD GERANIUM	forb	4	0.07	1%
Geum canadense	WHITE AVENS	forb	2	0.07	1%
Geum laciniatum	ROUGH AVENS	forb	2	0.13	2%
Impatiens capensis	SPOTTED TOUCH-ME-NOT	forb	2	0.20	3%
Impatiens sp.	NDA[c]	forb	NDA[c]	0.13	2%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	0.07	1%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.40	6%
Pilea pumila	CLEARWEED	forb	2	0.20	3%
Polygonum virginianum	JUMPSEED	forb	3	0.20	3%
Prunus serotina	BLACK CHERRY	tree	3	0.13	2%
Smilax rotundifolia	COMMON GREENBRIER	vine	4	0.07	1%
Toxicodendron radicans	POISON-IVY	vine	1	0.13	2%
Trillium sessile	TOAD-SHADE	forb	5	0.20	3%
Ulmus americana	AMERICAN ELM	tree	2	0.13	2%
Verbesina alternifolia	WINGSTEM	forb	5	0.13	2%
Viola sororia	COMMON BLUE VIOLET	forb	1	0.13	2%
Viola sp.	NDA[c]	forb	NDA[c]	0.13	2%
Vitis vulpina	FROST GRAPE	vine	3	0.20	3%
Agrostis gigantea	**REDTOP**	grass	0	0.13	2%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.67	9%
Cardamine hirsuta	**HOARY BITTER CRESS**	forb	0	0.07	1%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.20	3%
Glechoma hederacea	**GROUND IVY**	forb	0	0.20	3%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.47	7%
Lysimachia nummularia	**MONEYWORT**	forb	0	0.07	1%
Plantago major	**COMMON PLANTAIN**	forb	0	0.07	1%
Polygonum persicaria	**LADY'S THUMB**	forb	0	0.13	2%
			Native Species:	5.07	72%
			Non-Native Species:	2.00	28%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–34. PREFO1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	36	**Mean CC[a]:**	1.67
Native Species:	27	**Average Cover:**	56.3%
Non-Native Species:	9	**FQAI[b]:**	10.00
Percent Native:	75%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.27	5%
Acer saccharinum	SILVER MAPLE	tree	3	0.07	1%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	0.07	1%
Amphicarpaea bracteata	HOG-PEANUT	forb	4	0.07	1%
Aster pilosus	AWL ASTER	forb	1	0.20	4%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	0.07	1%
Carex sp.	NDA[c]	sedge	NDA[c]	0.07	1%
Carya sp.	NDA[c]	tree	ND	0.07	1%
Claytonia virginica	SPRING-BEAUTY	forb	2	0.07	1%
Corydalis flavula	YELLOW HARLEQUIN	forb	4	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.53	10%
Fragaria virginiana	WILD STRAWBERRY	forb	1	0.13	2%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.07	1%
Galium aparine	CLEAVERS	forb	0	0.07	1%
Geranium maculatum	WILD GERANIUM	forb	4	0.13	2%
Geum canadense	WHITE AVENS	forb	2	0.47	9%
Heliopsis helianthoides	SMOOTH OXEYE	forb	5	0.07	1%
Impatiens capensis	SPOTTED TOUCH-ME-NOT	forb	2	0.07	1%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.20	4%
Polygonum virginianum	JUMPSEED	forb	3	0.07	1%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	0.07	1%
Sanicula gregaria	CLUSTERED SNAKEROOT	forb	3	0.20	4%
Smilax rotundifolia	COMMON GREENBRIER	vine	4	0.07	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.07	1%
Toxicodendron radicans	POISON-IVY	vine	1	0.20	4%
Viola sororia	COMMON BLUE VIOLET	forb	1	0.07	1%
Viola sp.	NDA[c]	forb	NDA[c]	0.13	2%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.53	10%
Glechoma hederacea	**GROUND IVY**	forb	0	0.07	1%
Ipomoea hederacea	**IVY-LEAVED MORNING-GLORY**	forb	0	0.07	1%
Lamium purpuream	**PURPLE DEAD-NETTLE**	forb	0	0.07	1%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.60	11%
Maclura pomifera	**OSAGE-ORANGE**	tree	0	0.07	1%
Polygonum persicaria	**LADY'S THUMB**	forb	0	0.20	4%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	0.13	2%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.07	1%
		Native Species:		3.60	67%
		Non-Native Species:		1.80	33%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–35. PREFO2 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	53	**Mean CC[a]:**	2.35
Native Species:	39	**Average Cover:**	56.4%
Non-Native Species:	14	**FQAI[b]:**	17.14
Percent Native:	74%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.20	3%
Acer rubrum	RED MAPLE	tree	2	0.07	1%
Amelanchier arborea	DOWNY SERVICEBERRY	sm tree	5	0.13	2%
Aster pilosus	AWL ASTER	forb	1	0.13	2%
Carex laxiflora	TWO-EDGED WOOD SEDGE	sedge	3	0.13	2%
Carex stipata	CROWDED SEDGE	sedge	2	0.07	1%
Celtis occidentalis	HACKBERRY	tree	4	0.07	1%
Claytonia virginica	SPRING-BEAUTY	forb	2	0.07	1%
Cornus florida	FLOWERING DOGWOOD	sm tree	5	0.07	1%
Corydalis flavula	YELLOW HARLEQUIN	forb	4	0.07	1%
Elymus canadensis	CANADA WILD RYE	grass	6	0.13	2%
Elymus sp.	NDA[c]	grass	NDA[c]	0.07	1%
Elymus villosus	HAIRY WILD RYE	grass	4	0.13	2%
Elymus virginicus	VIRGINIA WILD RYE	grass	3	0.07	1%
Erythronium albidum	WHITE TROUT-LILY	forb	5	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.27	4%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.13	2%
Fraxinus quadrangulata	BLUE ASH	tree	7	0.07	1%
Galium aparine	CLEAVERS	forb	0	0.27	4%
Geum canadense	WHITE AVENS	forb	2	0.13	2%
Hackelia virginiana	VIRGINIA STICKSEED	forb	2	0.07	1%
Impatiens capensis	SPOTTED TOUCH-ME-NOT	forb	2	0.13	2%
Isopyrum biternatum	FALSE RUE-ANEMONE	forb	7	0.07	1%
Juniperus virginiana	EASTERN RED CEDAR	tree	3	0.07	1%
Maianthemum racemosum	FALSE SOLOMON'S-SEAL	forb	4	0.07	1%
Monarda fistulosa	WILD BERGAMOT	forb	3	0.07	1%
Ostrya virginiana	HOP-HORNBEAM	tree	5	0.07	1%
Panicum virgatum	SWITCH GRASS	grass	4	0.07	1%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.47	6%
Phryma leptostachya	LOPSEED	forb	5	0.07	1%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	0.07	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.27	4%
Solidago rugosa	ROUGH GOLDENROD	forb	2	0.13	2%
Toxicodendron radicans	POISON-IVY	vine	1	0.27	4%
Ulmus americana	AMERICAN ELM	tree	2	0.13	2%
Vernonia gigantea	TALL IRONWEED	forb	2	0.07	1%
Viola sp.	NDA[c]	forb	NDA[c]	0.13	2%
Vitis sp.	NDA[c]	vine	NDA[c]	0.13	2%
Vitis vulpina	FROST GRAPE	vine	3	0.13	2%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.53	7%
Allium vineale	**FIELD GARLIC**	forb	NDA[c]	0.20	3%
Bromus japonicus	**JAPANESE BROME**	grass	0	0.07	1%
Cardamine hirsuta	**HOARY BITTER CRESS**	forb	0	0.07	1%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.13	2%
Dipsacus fullonum	**WILD TEASEL**	forb	0	0.13	2%
Festuca sp.	**NDA[c]**	grass	0	0.07	1%
Glechoma hederacea	**GROUND IVY**	forb	0	0.27	4%
Lonicera japonica	**JAPANESE HONEYSUCKLE**	vine	0	0.13	2%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.53	7%
Melilotus officinalis	**YELLOW SWEET-CLOVER**	forb	0	0.07	1%
Saponaria officinalis	**SOAPWORT**	forb	0	0.07	1%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.27	4%
Trifolium sp.	**NDA[c]**	forb	0	0.07	1%
		Native Species:		4.80	65%
		Non-Native Species:		2.53	35%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–36. PRWFO1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	22	**Mean CC[a]:**	1.40
Native Species:	12	**Average Cover:**	38.5%
Non-Native Species:	10	**FQAI[b]:**	6.57
Percent Native:	55%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.07	2%
Asarum canadense	WILD GINGER	forb	6	0.07	2%
Cyperus sp.	NDA[c]	sedge	NDA[c]	0.07	2%
Elymus villosus	HAIRY WILD RYE	grass	4	0.13	4%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	0.07	2%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.20	6%
Prunus serotina	BLACK CHERRY	tree	3	0.07	2%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	0.07	2%
Toxicodendron radicans	POISON-IVY	vine	1	0.20	6%
Verbesina alternifolia	WINGSTEM	forb	5	0.07	2%
Viola sp.	NDA[c]	forb	NDA[c]	0.07	2%
Vitis vulpina	FROST GRAPE	vine	3	0.07	2%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.60	18%
Allium vineale	**FIELD GARLIC**	forb	0	0.13	4%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.07	2%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	0.07	2%
Festuca elatior	**TALL FESCUE**	grass	0	0.07	2%
Glechoma hederacea	**GROUND IVY**	forb	0	0.07	2%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.93	27%
Ranunculus ficaria	**LESSER CELANDINE**	forb	0	0.20	6%
Rumex crispus	**CURLY DOCK**	forb	0	0.07	2%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.07	2%
		Native Species:		1.13	33%
		Non-Native Species:		2.27	67%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–37. PRWFO2 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	50	**Mean CC[a]:**	2.32
Native Species:	41	**Average Cover:**	53.2%
Non-Native Species:	9	**FQAI[b]:**	16.40
Percent Native:	82%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.27	4%
Acer rubrum	RED MAPLE	tree	2	0.07	1%
Acer saccharinum	SILVER MAPLE	tree	3	0.07	1%
Amphicarpaea bracteata	HOG-PEANUT	forb	4	0.07	1%
Bidens connata	PURPLE-STEMMED BEGGAR'S-TICK	forb	3	0.07	1%
Carex sp.	NDA[c]	sedge	NDA[c]	0.07	1%
Carex stipata	CROWDED SEDGE	sedge	2	0.07	1%
Carya sp.	NDA[c]	tree	NDA[c]	0.07	1%
Claytonia virginica	SPRING-BEAUTY	forb	2	0.07	1%
Corydalis flavula	YELLOW HARLEQUIN	forb	4	0.07	1%
Elymus sp.	NDA[c]	grass	NDA[c]	0.20	3%
Elymus villosus	HAIRY WILD RYE	grass	4	0.07	1%
Elymus virginicus	VIRGINIA WILD RYE	grass	3	0.13	2%
Elymus virginicus	VIRGINIA WILD RYE	grass	3	0.00	0%
Erythronium albidum	WHITE TROUT-LILY	forb	5	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.33	5%
Fragaria virginiana	WILD STRAWBERRY	forb	1	0.07	1%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.13	2%
Fraxinus quadrangulata	BLUE ASH	tree	7	0.07	1%
Galium aparine	CLEAVERS	forb	0	0.13	2%
Geranium maculatum	WILD GERANIUM	forb	4	0.13	2%
Geum canadense	WHITE AVENS	forb	2	0.13	2%
Geum laciniatum	ROUGH AVENS	forb	2	0.13	2%
Gleditsia triacanthos	HONEY LOCUST	tree	4	0.07	1%
Impatiens capensis	SPOTTED TOUCH-ME-NOT	forb	2	0.07	1%
Isopyrum biternatum	FALSE RUE-ANEMONE	forb	7	0.07	1%
Maianthemum racemosum	FALSE SOLOMON'S-SEAL	forb	4	0.07	1%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	0.07	1%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.20	3%
Pilea pumila	CLEARWEED	forb	2	0.20	3%
Polygonum amphibium	WATER SMARTWEED	forb	4	0.07	1%
Polygonum virginianum	JUMPSEED	forb	3	0.07	1%
Prunus serotina	BLACK CHERRY	tree	3	0.07	1%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	0.07	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.07	1%
Solidago juncea	PLUME GOLDENROD	forb	2	0.07	1%
Toxicodendron radicans	POISON-IVY	vine	1	0.13	2%
Ulmus americana	AMERICAN ELM	tree	2	0.20	3%
Verbesina alternifolia	WINGSTEM	forb	5	0.20	3%
Vitis riparia	RIVERBANK GRAPE	vine	3	0.07	1%
Vitis vulpina	FROST GRAPE	vine	3	0.07	1%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.73	12%
Allium vineale	**FIELD GARLIC**	forb	0	0.07	1%
Festuca sp.	**NDA[c]**	grass	0	0.13	2%
Glechoma hederacea	**GROUND IVY**	forb	0	0.27	4%
Lonicera japonica	**JAPANESE HONEYSUCKLE**	vine	0	0.07	1%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.47	7%
Polygonum persicaria	**LADY'S THUMB**	forb	0	0.07	1%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.20	3%
Xanthium sp.	**NDA[c]**	forb	0	0.07	1%
		Native Species:		4.27	67%
		Non-Native Species:		2.07	33%

[a] CC = Coefficent of Conservatism

[b] FQAI = Florist Quality Assessment Index

[c] NDA= No Determination Available

Species in bold are non-native.

Table D–38. PRWFO3 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	38	**Mean CC[a]:**	3.32
Native Species:	25	**Average Cover:**	49.2%
Non-Native Species:	13	**FQAI[b]:**	20.44
Percent Native:	66%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.13	3%
Actaea alba	WHITE BANEBERRY	forb	7	0.13	3%
Agrimonia sp.	NDA[c]	forb	ND	0.06	1%
Cardamine concatenata	CUT-LEAVED TOOTHWORT	forb	3	0.06	1%
Carex sp.	NDA[c]	sedge	NDA[c]	0.06	1%
Celtis occidentalis	HACKBERRY	tree	4	0.06	1%
Elymus sp.	NDA[c]	grass	NDA[c]	0.13	3%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.13	3%
Fragaria virginiana	WILD STRAWBERRY	forb	1	0.06	1%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.13	3%
Galium aparine	CLEAVERS	forb	0	0.13	3%
Impatiens sp.	NDA[c]	forb	NDA[c]	0.13	3%
Juglans nigra	BLACK WALNUT	tree	5	0.06	1%
Juniperus virginiana	EASTERN RED CEDAR	tree	3	0.13	3%
Leersia sp.	NDA[c]	grass	NDA[c]	0.06	1%
Mertensia virginica	BLUEBELLS	forb	6	0.06	1%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	0.06	1%
Prunus serotina	BLACK CHERRY	tree	3	0.06	1%
Sanguinaria canadensis	BLOODROOT	forb	5	0.06	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.13	3%
Solidago rigida	STIFF GOLDENROD	forb	8	0.06	1%
Toxicodendron radicans	POISON-IVY	vine	1	0.06	1%
Ulmus americana	AMERICAN ELM	tree	2	0.06	1%
Verbesina alternifolia	WINGSTEM	forb	5	0.19	4%
Viola sp.	NDA[c]	forb	NDA[c]	0.25	5%
Agrostis gigantea	**REDTOP**	grass	0	0.06	1%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.69	15%
Allium vineale	**FIELD GARLIC**	forb	0	0.13	3%
Conium maculatum	**POISON-HEMLOCK**	forb	0	0.06	1%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	0.06	1%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.56	12%
Lysimachia nummularia	**MONEYWORT**	forb	0	0.13	3%
Melilotus alba	**WHITE SWEET-CLOVER**	forb	0	0.13	3%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	0.06	1%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.13	3%
Taraxacum officinale	**COMMON DANDELION**	forb	0	0.06	1%
Trifolium repens	**WHITE CLOVER**	forb	0	0.06	1%
Urtica dioica var. dioica	**EUROPEAN STINGING NETTLE**	forb	0	0.13	3%
		Native Species:		4.00	85%
		Non-Native Species:		0.69	15%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–39. NPPPP1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	35	**Mean CC[a]:**	1.33
Native Species:	22	**Average Cover:**	84.7%
Non-Native Species:	13	**FQAI[b]:**	7.89
Percent Native:	63%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.13	2%
Acer rubrum	RED MAPLE	tree	2	0.07	1%
Agrimonia parviflora	SMALL-FLOWERED AGRIMONY	forb	2	0.07	1%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	0.20	3%
Carex laxiflora	TWO-EDGED WOOD SEDGE	sedge	3	0.07	1%
Celtis occidentalis	HACKBERRY	tree	4	0.07	1%
Elymus villosus	HAIRY WILD RYE	grass	4	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.47	8%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.13	2%
Galium aparine	CLEAVERS	forb	0	0.13	2%
Humulus lupulus	COMMON HOPS	vine	2	0.07	1%
Impatiens capensis	SPOTTED TOUCH-ME-NOT	forb	2	0.07	1%
Leersia oryzoides	RICE CUT GRASS	grass	1	0.20	3%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.27	5%
Phytolacca americana	POKEWEED	forb	1	0.13	2%
Polygonum hydropiperoides	MILD WATER-PEPPER	forb	6	0.13	2%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	0.13	2%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	1	0.13	2%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.20	3%
Toxicodendron radicans	POISON-IVY	vine	1	0.20	3%
Viola sp.	NDA[c]	forb	NDA[c]	0.07	1%
Vitis sp.	NDA[c]	vine	NDA[c]	0.13	2%
Agrostis gigantea	**REDTOP**	grass	0	0.07	1%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.53	9%
Cirsium arvense	**CANADA THISTLE**	forb	0	0.20	3%
Conium maculatum	**POISON-HEMLOCK**	forb	0	0.07	1%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.07	1%
Glechoma hederacea	**GROUND IVY**	forb	0	0.27	5%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.47	8%
Polygonum cespitosum	**LONG-BRISTLED SMARTWEED**	forb	0	0.20	3%
Polygonum persicaria	**LADY'S THUMB**	forb	0	0.27	5%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	0.07	1%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.20	3%
Taraxacum officinale	**COMMON DANDELION**	forb	0	0.07	1%
Urtica dioica var. dioica	**EUROPEAN STINGING NETTLE**	forb	0	0.13	2%
		Native Species:		3.13	55%
		Non-Native Species:		2.60	45%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–40. PREPP1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	49	**Mean CC[a]:**	2.04
Native Species:	37	**Average Cover:**	59.1%
Non-Native Species:	12	**FQAI[b]:**	14.30
Percent Native:	76%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.43	5%
Acer saccharinum	SILVER MAPLE	tree	3	0.07	1%
Agrimonia parviflora	SMALL-FLOWERED AGRIMONY	forb	2	0.07	1%
Asimina triloba	PAWPAW	sm tree	6	0.14	2%
Aster pilosus	AWL ASTER	forb	1	0.07	1%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	0.29	3%
Boehmeria cylindrica	FALSE NETTLE	forb	4	0.07	1%
Calystegia sepium	HEDGE BINDWEED	forb	1	0.07	1%
Campsis radicans	TRUMPET-CREEPER	vine	1	0.07	1%
Cardamine pensylvanica	PENNSYLVANIA BITTER CRESS	forb	3	0.21	3%
Celtis occidentalis	HACKBERRY	tree	4	0.07	1%
Epilobium angustifolium	FIREWEED	forb	7	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.43	5%
Euthamia graminifolia	FLAT-TOPPED GOLDENROD	forb	2	0.07	1%
Fraxinus americana	WHITE ASH	tree	6	0.07	1%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.14	2%
Galium aparine	CLEAVERS	forb	0	0.29	3%
Geranium maculatum	WILD GERANIUM	forb	4	0.07	1%
Geum canadense	WHITE AVENS	forb	2	0.14	2%
Impatiens capensis	SPOTTED TOUCH-ME-NOT	forb	2	0.21	3%
Oxalis stricta	COMMON YELLOW WOOD SORREL	forb	0	0.07	1%
Panicum virgatum	SWITCH GRASS	grass	4	0.07	1%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.71	9%
Phacelia purshii	MIAMI-MIST	forb	4	0.07	1%
Phytolacca americana	POKEWEED	forb	1	0.07	1%
Polygonum amphibium	WATER SMARTWEED	forb	4	0.07	1%
Polygonum hydropiper	WATER-PEPPER	forb	1	0.07	1%
Polygonum punctatum	DOTTED SMARTWEED	forb	6	0.21	3%
Polygonum virginianum	JUMPSEED	forb	3	0.07	1%
Prunus serotina	BLACK CHERRY	tree	3	0.14	2%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	0.07	1%
Sanicula gregaria	CLUSTERED SNAKEROOT	forb	3	0.21	3%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.14	2%
Toxicodendron radicans	POISON-IVY	vine	1	0.64	8%
Verbena urticifolia	WHITE VERVAIN	forb	3	0.07	1%
Viola sp.	NDA[c]	forb	NDA[c]	0.07	1%
Vitis sp.	NDA[c]	vine	NDA[c]	0.14	2%
Agrostis gigantea	**REDTOP**	grass	0	0.07	1%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.43	5%
Dipsacus fullonum	**WILD TEASEL**	forb	0	0.07	1%
Festuca sp.	**ND**	grass	0	0.14	2%
Glechoma hederacea	**GROUND IVY**	forb	0	0.50	6%
Ipomoea hederacea	**IVY-LEAVED MORNING-GLORY**	forb	0	0.07	1%
Lonicera japonica	**JAPANESE HONEYSUCKLE**	vine	0	0.07	1%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.36	4%
Phalaris arundinacea	**REED CANARY GRASS**	grass	0	0.21	3%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	0.29	3%
Saponaria officinalis	**SOAPWORT**	forb	0	0.07	1%
Taraxacum officinale	**COMMON DANDELION**	forb	0	0.07	1%
		Native Species:		6.00	72%
		Non-Native Species:		2.36	28%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–41. A82RF1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	45	**Mean CC[a]:**	1.86
Native Species:	31	**Average Cover:**	87.0%
Non-Native Species:	14	**FQAI[b]:**	12.48
Percent Native:	69%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.40	6%
Acer saccharinum	SILVER MAPLE	tree	3	0.07	1%
Achillea millefolium	YARROW	forb	1	0.07	1%
Agrimonia parviflora	SMALL-FLOWERED AGRIMONY	forb	2	0.07	1%
Andropogon gerardii	BIG BLUESTEM	grass	5	0.20	3%
Asclepias incarnata	SWAMP MILKWEED	forb	4	0.07	1%
Aster pilosus	AWL ASTER	forb	1	0.07	1%
Calystegia sepium	HEDGE BINDWEED	forb	1	0.07	1%
Carex laxiflora	TWO-EDGED WOOD SEDGE	sedge	3	0.13	2%
Desmodium canadense	CANADA TICK-TREFOIL	forb	4	0.07	1%
Elymus canadensis	CANADA WILD RYE	grass	6	0.07	1%
Erigeron philadelphicus	PHILADELPHIA FLEABANE	forb	2	0.07	1%
Eryngium yuccifolium	RATTLESNAKE-MASTER	forb	7	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.07	1%
Geum canadense	WHITE AVENS	forb	2	0.07	1%
Ipomoea pandurata	POTATO-VINE	forb	2	0.07	1%
Juglans nigra	BLACK WALNUT	tree	5	0.07	1%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	0.07	1%
Panicum virgatum	SWITCH GRASS	grass	4	0.13	2%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.40	6%
Physalis heterophylla	CLAMMY GROUND-CHERRY	forb	1	0.07	1%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	0.07	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.47	7%
Sorghastrum nutans	INDIAN GRASS	grass	5	0.13	2%
Toxicodendron radicans	POISON-IVY	vine	1	0.53	8%
Tridens flavus	GREASE GRASS	grass	1	0.07	1%
Verbesina alternifolia	WINGSTEM	forb	5	0.27	4%
Vernonia gigantea	TALL IRONWEED	forb	2	0.13	2%
Viola sp.	NDA[c]	forb	NDA[c]	0.07	1%
Vitis labrusca	FOX GRAPE	vine	3	0.13	2%
Vitis sp.	NDA[c]	vine	NDA[c]	0.27	4%
Agrostis gigantea	**REDTOP**	grass	0	0.33	5%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.07	1%
Allium vineale	**FIELD GARLIC**	forb	0	0.07	1%
Bromus japonicus	**JAPANESE BROME**	grass	0	0.07	1%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.27	4%
Festuca sp.	**NDA[c]**	grass	0	0.40	6%
Glechoma hederacea	**GROUND IVY**	forb	0	0.13	2%
Lonicera japonica	**JAPANESE HONEYSUCKLE**	vine	0	0.07	1%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.07	1%
Lysimachia nummularia	**MONEYWORT**	forb	0	0.27	4%
Polygonum persicaria	**LADY'S THUMB**	forb	0	0.07	1%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	0.20	3%
Taraxacum officinale	**COMMON DANDELION**	forb	0	0.07	1%
Vicia sativa	**COMMON VETCH**	forb	0	0.07	1%
		Native Species:		4.47	68%
		Non-Native Species:		2.13	32%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–42. A82RF2 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	46	**Mean CC[a]:**	1.53
Native Species:	29	**Average Cover:**	78.3%
Non-Native Species:	17	**FQAI[b]:**	10.41
Percent Native:	63%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.47	6%
Agrimonia parviflora	SMALL-FLOWERED AGRIMONY	forb	2	0.07	1%
Aster sp.	NDA[c]	forb	NDA[c]	0.07	1%
Cardamine pensylvanica	PENNSYLVANIA BITTER CRESS	forb	3	0.07	1%
Carex laxiflora	TWO-EDGED WOOD SEDGE	sedge	3	0.33	4%
Claytonia virginica	SPRING-BEAUTY	forb	2	0.07	1%
Cornus racemosa	GRAY DOGWOOD	shrub	1	0.07	1%
Desmodium canadense	CANADA TICK-TREFOIL	forb	4	0.07	1%
Elymus canadensis	CANADA WILD RYE	grass	6	0.07	1%
Elymus villosus	HAIRY WILD RYE	grass	4	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.20	3%
Galium aparine	CLEAVERS	forb	0	0.27	3%
Geum canadense	WHITE AVENS	forb	2	0.13	2%
Gleditsia triacanthos	HONEY LOCUST	tree	4	0.07	1%
Ipomoea pandurata	POTATO-VINE	forb	2	0.07	1%
Juglans nigra	BLACK WALNUT	tree	5	0.07	1%
Maianthemum racemosum	FALSE SOLOMON'S-SEAL	forb	4	0.07	1%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	0.20	3%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.33	4%
Pilea pumila	CLEARWEED	forb	2	0.07	1%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	0.13	2%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.27	3%
Solidago sp.	NDA[c]	forb	NDA[c]	0.13	2%
Toxicodendron radicans	POISON-IVY	vine	1	0.27	3%
Verbesina alternifolia	WINGSTEM	forb	5	0.33	4%
Vernonia gigantea	TALL IRONWEED	forb	2	0.07	1%
Viola sororia	COMMON BLUE VIOLET	forb	1	0.13	2%
Vitis riparia	RIVERBANK GRAPE	vine	3	0.07	1%
Vitis sp.	NDA[c]	vine	NDA[c]	0.07	1%
Agrostis gigantea	**REDTOP**	grass	0	0.20	3%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.13	2%
Allium vineale	**FIELD GARLIC**	forb	0	0.20	3%
Cirsium arvense	**CANADA THISTLE**	forb	0	0.13	2%
Dactylis glomerata	**ORCHARD GRASS**	grass	0	0.07	1%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.60	8%
Festuca elatior	**TALL FESCUE**	grass	0	0.20	3%
Festuca sp.	**NDA[c]**	grass	0	0.47	6%
Glechoma hederacea	**GROUND IVY**	forb	0	0.40	5%
Lonicera japonica	**JAPANESE HONEYSUCKLE**	vine	0	0.07	1%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.40	5%
Lysimachia nummularia	**MONEYWORT**	forb	0	0.07	1%
Medicago lupulina	**BLACK MEDICK**	forb	0	0.13	2%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	0.07	1%
Solanum carolinense	**HORSE NETTLE**	forb	0	0.13	2%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.13	2%
Trifolium repens	**WHITE CLOVER**	forb	0	0.07	1%
			Native Species:	4.27	55%
			Non-Native Species:	3.47	45%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–43. ERPRF1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	42	**Mean CC[a]:**	1.83
Native Species:	25	**Average Cover:**	95.4%
Non-Native Species:	17	**FQAI[b]:**	11.83
Percent Native:	60%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.20	3%
Amphicarpaea bracteata	HOG-PEANUT	forb	4	0.07	1%
Asarum canadense	WILD GINGER	forb	6	0.07	1%
Aster pilosus	AWL ASTER	forb	1	0.13	2%
Cardamine concatenata	CUT-LEAVED TOOTHWORT	forb	3	0.07	1%
Cardamine pensylvanica	PENNSYLVANIA BITTER CRESS	forb	3	0.13	2%
Carex laxiflora	TWO-EDGED WOOD SEDGE	sedge	3	0.07	1%
Desmodium canadense	CANADA TICK-TREFOIL	forb	4	0.07	1%
Elymus canadensis	CANADA WILD RYE	grass	6	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.13	2%
Galium aparine	CLEAVERS	forb	0	0.13	2%
Gleditsia triacanthos	HONEY LOCUST	tree	4	0.07	1%
Humulus lupulus	COMMON HOPS	vine	2	0.07	1%
Ipomoea pandurata	POTATO-VINE	forb	2	0.13	2%
Panicum virgatum	SWITCH GRASS	grass	4	0.07	1%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.13	2%
Phacelia purshii	MIAMI-MIST	forb	4	0.07	1%
Ruellia strepens	SMOOTH RUELLIA	forb	5	0.07	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.40	6%
Solidago sp.	NDA[c]	forb	NDA[c]	0.07	1%
Sorghastrum nutans	INDIAN GRASS	grass	5	0.13	2%
Toxicodendron radicans	POISON-IVY	vine	1	0.13	2%
Verbesina alternifolia	WINGSTEM	forb	5	0.27	4%
Vernonia gigantea	TALL IRONWEED	forb	2	0.20	3%
Vitis sp.	NDA[c]	vine	NDA[c]	0.07	1%
Agrostis gigantea	**REDTOP**	grass	0	0.47	7%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.13	2%
Allium vineale	**FIELD GARLIC**	forb	0	0.07	1%
Bromus inermis	**HUNGARIAN BROME**	grass	0	0.07	1%
Cirsium arvense	**CANADA THISTLE**	forb	0	0.20	3%
Convolvulus arvensis	**FIELD BINDWEED**	forb	0	0.20	3%
Datura stramonium	**JIMSONWEED**	forb	0	0.13	2%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.20	3%
Festuca sp.	**NDA[c]**	grass	0	0.80	13%
Glechoma hederacea	**GROUND IVY**	forb	0	0.33	5%
Lonicera japonica	**JAPANESE HONEYSUCKLE**	vine	0	0.07	1%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.07	1%
Lysimachia nummularia	**MONEYWORT**	forb	0	0.20	3%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	0.07	1%
Sorghum halepense	**JOHNSON GRASS**	grass	0	0.07	1%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.13	2%
Taraxacum officinale	**COMMON DANDELION**	forb	0	0.13	2%
		Native Species:		3.00	47%
		Non-Native Species:		3.33	53%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D44.FWPRF1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	46	**Mean CC[a]:**	1.17
Native Species:	27	**Average Cover:**	66.2%
Non-Native Species:	19	**FQAI[b]:**	7.91
Percent Native:	59%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.13	2%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	0.13	2%
Asclepias incarnata	SWAMP MILKWEED	forb	4	0.07	1%
Aster pilosus	AWL ASTER	forb	1	0.13	2%
Carex sp.	NDA[c]	sedge	NDA[c]	0.07	1%
Chamaecrista fasciculata	PARTRIDGE-PEA	forb	3	0.07	1%
Cornus racemosa	GRAY DOGWOOD	shrub	1	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.33	5%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.07	1%
Galium aparine	CLEAVERS	forb	0	0.20	3%
Geum canadense	WHITE AVENS	forb	2	0.33	5%
Geum laciniatum	ROUGH AVENS	forb	2	0.07	1%
Impatiens sp.	NDA[c]	forb	NDA[c]	0.07	1%
Juglans nigra	BLACK WALNUT	tree	5	0.07	1%
Monarda fistulosa	WILD BERGAMOT	forb	3	0.07	1%
Muhlenbergia schreberi	NIMBLEWILL	grass	0	0.07	1%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	0.07	1%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.47	7%
Robinia pseudoacacia	BLACK LOCUST	tree	0	0.07	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.20	3%
Toxicodendron radicans	POISON-IVY	vine	1	0.27	4%
Trichophorum planifolium	FLAT-LEAVED BULRUSH	sedge	7	0.07	1%
Verbesina alternifolia	WINGSTEM	forb	5	0.20	3%
Vernonia gigantea	TALL IRONWEED	forb	2	0.07	1%
Viola sororia	COMMON BLUE VIOLET	forb	1	0.07	1%
Viola sp.	NDA[c]	forb	NDA[c]	0.07	1%
Vitis sp.	NDA[c]	vine	NDA[c]	0.07	1%
Agrostis gigantea	**REDTOP**	grass	0	0.20	3%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.40	6%
Bromus japonicus	**JAPANESE BROME**	grass	0	0.07	1%
Cirsium arvense	**CANADA THISTLE**	forb	0	0.07	1%
Convolvulus arvensis	**FIELD BINDWEED**	forb	0	0.07	1%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.27	4%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	0.07	1%
Festuca sp.	**NDA[c]**	grass	0	0.07	1%
Glechoma hederacea	**GROUND IVY**	forb	0	0.33	5%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.33	5%
Lysimachia nummularia	**MONEYWORT**	forb	0	0.07	1%
Medicago lupulina	**BLACK MEDICK**	forb	0	0.07	1%
Melilotus officinalis	**YELLOW SWEET-CLOVER**	forb	0	0.20	3%
Plantago major	**COMMON PLANTAIN**	forb	0	0.13	2%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	0.07	1%
Setaria sp.	**NDA[c]**	grass	0	0.07	1%
Sonchus arvensis	**FIELD SOW-THISTLE**	forb	0	0.07	1%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.13	2%
Trifolium pratense	**RED CLOVER**	forb	0	0.07	1%
Trifolium sp.	**NDA[c]**	forb	0	0.07	1%
		Native Species:		3.53	56%
		Non-Native Species:		2.80	44%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–45. NPPRF1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	43	**Mean CC[a]:**	1.76
Native Species:	30	**Average Cover:**	97.0%
Non-Native Species:	13	**FQAI[b]:**	11.52
Percent Native:	70%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Agrimonia parviflora	SMALL-FLOWERED AGRIMONY	forb	2	0.07	1%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	0.20	3%
Andropogon gerardii	BIG BLUESTEM	grass	5	0.33	6%
Apocynum cannabinum	INDIAN HEMP	forb	1	0.07	1%
Aster pilosus	AWL ASTER	forb	1	0.13	2%
Cardamine pensylvanica	PENNSYLVANIA BITTER CRESS	forb	3	0.07	1%
Carex hystericina	PORCUPINE SEDGE	sedge	5	0.07	1%
Cyperus sp.	NDA[c]	sedge	NDA[c]	0.07	1%
Elymus villosus	HAIRY WILD RYE	grass	4	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.13	2%
Euthamia graminifolia	FLAT-TOPPED GOLDENROD	forb	2	0.07	1%
Galium aparine	CLEAVERS	forb	0	0.07	1%
Juncus effusus	SOFT RUSH	forb	1	0.13	2%
Monarda fistulosa	WILD BERGAMOT	forb	3	0.07	1%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	0.13	2%
Panicum virgatum	SWITCH GRASS	grass	4	0.20	3%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.07	1%
Polygonum hydropiperoides	MILD WATER-PEPPER	forb	6	0.07	1%
Ratibida pinnata	GRAY-HEADED CONEFLOWER	forb	5	0.07	1%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	1	0.27	4%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	0.27	4%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	0.07	1%
Silphium perfoliatum	CUP-PLANT	forb	6	0.07	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.73	12%
Sorghastrum nutans	INDIAN GRASS	grass	5	0.07	1%
Spartina pectinata	PRAIRIE CORD GRASS	grass	5	0.07	1%
Toxicodendron radicans	POISON-IVY	vine	1	0.07	1%
Ulmus americana	AMERICAN ELM	tree	2	0.20	3%
Vernonia gigantea	TALL IRONWEED	forb	2	0.13	2%
Vitis sp.	NDA[c]	vine	NDA[c]	0.07	1%
Agrostis gigantea	**REDTOP**	grass	0	0.27	4%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.13	2%
Bromus japonicus	**JAPANESE BROME**	grass	0	0.07	1%
Cirsium arvense	**CANADA THISTLE**	forb	0	0.13	2%
Conium maculatum	**POISON-HEMLOCK**	forb	0	0.13	2%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.13	2%
Dipsacus fullonum	**WILD TEASEL**	forb	0	0.40	7%
Epilobium parviflorum	**SMALL-FLOWERED WILLOW-HERB**	forb	0	0.07	1%
Glechoma hederacea	**GROUND IVY**	forb	0	0.27	4%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.07	1%
Medicago lupulina	**BLACK MEDICK**	forb	0	0.07	1%
Polygonum persicaria	**LADY'S THUMB**	forb	0	0.13	2%
Solanum tuberosum	**POTATO**	forb	0	0.07	1%
		Native Species:		4.07	68%
		Non-Native Species:		1.93	32%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–46. NWERF1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	54	**Mean CC[a]:**	1.47
Native Species:	38	**Average Cover:**	85.5%
Non-Native Species:	16	**FQAI[b]:**	10.81
Percent Native:	70%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.20	2%
Agrimonia parviflora	SMALL-FLOWERED AGRIMONY	forb	2	0.07	1%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	0.13	2%
Asclepias syriaca	COMMON MILKWEED	forb	1	0.07	1%
Aster pilosus	AWL ASTER	forb	1	0.27	3%
Campsis radicans	TRUMPET-CREEPER	vine	1	0.07	1%
Cardamine pensylvanica	PENNSYLVANIA BITTER CRESS	forb	3	0.07	1%
Carex frankii	FRANK'S SEDGE	sedge	2	0.07	1%
Cornus amomum	SILKY DOGWOOD	shrub	2	0.07	1%
Echinocystis lobata	WILD CUCUMBER	vine	2	0.07	1%
Elymus villosus	HAIRY WILD RYE	grass	4	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.20	2%
Euthamia graminifolia	FLAT-TOPPED GOLDENROD	forb	2	0.07	1%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.20	2%
Fraxinus sp.	NDA[c]	tree	NDA[c]	0.07	1%
Geum canadense	WHITE AVENS	forb	2	0.20	2%
Geum laciniatum	ROUGH AVENS	forb	2	0.07	1%
Impatiens capensis	SPOTTED TOUCH-ME-NOT	forb	2	0.07	1%
Ipomoea pandurata	POTATO-VINE	forb	2	0.13	2%
Juncus tenuis	PATH RUSH	forb	1	0.07	1%
Muhlenbergia schreberi	NIMBLEWILL	grass	0	0.13	2%
Oxalis stricta.	COMMON YELLOW WOOD SORREL	forb	0	0.07	1%
Panicum clandestinum	DEER'S-TONGUE PANIC GRASS	grass	2	0.20	2%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.33	4%
Penstemon digitalis	FOXGLOVE BEARD-TONGUE	forb	2	0.07	1%
Phacelia purshii	MIAMI-MIST	forb	4	0.20	2%
Polygonum hydropiperoides	MILD WATER-PEPPER	forb	6	0.07	1%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	1	0.07	1%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	0.27	3%
Rudbeckia hirta	BLACK-EYED SUSAN	forb	1	0.07	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.67	8%
Solidago sp.	NDA[c]	forb	NDA[c]	0.07	1%
Toxicodendron radicans	POISON-IVY	vine	1	0.53	6%
Verbena urticifolia	WHITE VERVAIN	forb	3	0.07	1%
Verbesina alternifolia	WINGSTEM	forb	5	0.07	1%
Vernonia gigantea	TALL IRONWEED	forb	2	0.07	1%
Vitis sp.	NDA[c]	vine	NDA[c]	0.33	4%
Zizia aurea	GOLDEN ALEXANDERS	forb	6	0.07	1%
Agrostis gigantea	**REDTOP**	grass	0	0.40	5%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.27	3%
Allium vineale	**FIELD GARLIC**	forb	0	0.07	1%
Bromus japonicus	**JAPANESE BROME**	grass	0	0.07	1%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.13	2%
Dipsacus fullonum	**WILD TEASEL**	forb	0	0.07	1%
Festuca sp.	**ND**	grass	0	0.07	1%
Glechoma hederacea	**GROUND IVY**	forb	0	0.20	2%
Lonicera japonica	**JAPANESE HONEYSUCKLE**	vine	0	0.27	3%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.53	6%
Lysimachia nummularia	**MONEYWORT**	forb	0	0.33	4%
Polygonum persicaria	**LADY'S THUMB**	forb	0	0.07	1%
Rhamnus cathartica	**EUROPEAN BUCKTHORN**	sm tree	0	0.07	1%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	0.47	5%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.07	1%
Trifolium repens	**WHITE CLOVER**	forb	0	0.13	2%
			Native Species:	5.53	63%
			Non-Native Species:	3.20	37%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–47. PRERF1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	49	**Mean CC[a]:**	1.50
Native Species:	33	**Average Cover:**	74.8%
Non-Native Species:	16	**FQAI[b]:**	10.50
Percent Native:	67%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.13	2%
Aesculus flava	YELLOW BUCKEYE	tree	7	0.07	1%
Alopecurus carolinianus	CAROLINA FOXTAIL	grass	1	0.07	1%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	0.20	3%
Andropogon gerardii	BIG BLUESTEM	grass	5	0.27	4%
Aster novae-angliae	NEW ENGLAND ASTER	forb	2	0.07	1%
Aster pilosus	AWL ASTER	forb	1	0.20	3%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	0.07	1%
Cardamine pensylvanica	PENNSYLVANIA BITTER CRESS	forb	3	0.20	3%
Conyza canadensis	HORSEWEED	forb	0	0.07	1%
Carex granularis	MEADOW SEDGE	sedge	3	0.07	1%
Carex vulpinoidea	FOX SEDGE	sedge	1	0.13	2%
Cyperus sp.	NDA[c]	sedge	NDA[c]	0.07	1%
Desmodium canescens	HOARY TICK-TREFOIL	forb	4	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.07	1%
Eupatorium serotinum	LATE-FLOWERING BONESET	forb	2	0.07	1%
Galium aparine	CLEAVERS	forb	0	0.13	2%
Juncus tenuis	PATH RUSH	forb	1	0.13	2%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	0.13	2%
Panicum virgatum	SWITCH GRASS	grass	4	0.20	3%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.13	2%
Populus deltoides	EASTERN COTTONWOOD	tree	3	0.07	1%
Rhus glabra	SMOOTH SUMAC	shrub	2	0.13	2%
Rhus typhina	STAGHORN SUMAC	shrub	2	0.07	1%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	1	0.33	5%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	0.20	3%
Schizachyrium scoparium	LITTLE BLUESTEM	grass	5	0.07	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.27	4%
Solidago sp.	NDA[c]	forb	NDA[c]	0.33	5%
Sorghastrum nutans	INDIAN GRASS	grass	5	0.20	3%
Toxicodendron radicans	POISON-IVY	vine	1	0.07	1%
Verbena hastata	BLUE VERVAIN	forb	4	0.07	1%
Vitis sp.	NDA[c]	vine	NDA[c]	0.13	2%
Agrostis gigantea	**REDTOP**	grass	0	0.07	1%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.40	6%
Bromus japonicus	**JAPANESE BROME**	grass	0	0.13	2%
Dactylis glomerata	**ORCHARD GRASS**	grass	0	0.07	1%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.40	6%
Dipsacus fullonum	**WILD TEASEL**	forb	0	0.13	2%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	0.13	2%
Festuca elatior	**TALL FESCUE**	grass	0	0.07	1%
Festuca sp.	**NDA[c]**	grass	0	0.20	3%
Glechoma hederacea	**GROUND IVY**	forb	0	0.20	3%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.27	4%
Medicago lupulina	**BLACK MEDICK**	forb	0	0.07	1%
Phalaris arundinacea	**REED CANARY GRASS**	grass	0	0.07	1%
Plantago major	**COMMON PLANTAIN**	forb	0	0.07	1%
Polygonum persicaria	**LADY'S THUMB**	forb	0	0.20	3%
Sorghum halepense	**JOHNSON GRASS**	grass	0	0.07	1%
		Native Species:		4.47	64%
		Non-Native Species:		2.53	36%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–48. PRERF2 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	36	**Mean CC[a]:**	1.41
Native Species:	23	**Average Cover:**	96.2%
Non-Native Species:	13	**FQAI[b]:**	8.47
Percent Native:	64%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Achillea millefolium	YARROW	forb	1	0.20	3%
Asclepias syriaca	COMMON MILKWEED	forb	1	0.07	1%
Aster pilosus	AWL ASTER	forb	1	0.13	2%
Cardamine pensylvanica	PENNSYLVANIA BITTER CRESS	forb	3	0.07	1%
Cercis canadensis	REDBUD	sm tree	3	0.07	1%
Desmodium canadense	CANADA TICK-TREFOIL	forb	4	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.07	1%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.07	1%
Geum canadense	WHITE AVENS	forb	2	0.07	1%
Hypericum sphaerocarpum	ROUND-FRUITED ST. JOHN'S-WORT	forb	6	0.07	1%
Juglans nigra	BLACK WALNUT	tree	5	0.13	2%
Leersia virginica	WHITE GRASS	grass	4	0.07	1%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	0.13	2%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.47	8%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	1	0.07	1%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	0.07	1%
Rudbeckia hirta	BLACK-EYED SUSAN	forb	1	0.07	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.40	6%
Solidago sp.	NDA[c]	forb	NDA[c]	0.13	2%
Toxicodendron radicans	POISON-IVY	vine	1	0.47	8%
Verbena urticifolia	WHITE VERVAIN	forb	3	0.07	1%
Vernonia gigantea	TALL IRONWEED	forb	2	0.20	3%
Vitis sp.	NDA[c]	vine	NDA[c]	0.20	3%
Agrostis gigantea	**REDTOP**	grass	0	0.47	8%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.07	1%
Cirsium vulgare	**BULL THISTLE**	forb	0	0.07	1%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.47	8%
Dipsacus fullonum	**WILD TEASEL**	forb	0	0.13	2%
Festuca sp.	**NDA[c]**	grass	0	0.87	14%
Glechoma hederacea	**GROUND IVY**	forb	0	0.13	2%
Lonicera japonica	**JAPANESE HONEYSUCKLE**	vine	0	0.07	1%
Medicago lupulina	**BLACK MEDICK**	forb	0	0.13	2%
Setaria glauca	**YELLOW FOXTAIL GRASS**	grass	0	0.13	2%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.07	1%
Taraxacum officinale	**COMMON DANDELION**	forb	0	0.13	2%
Trifolium sp.	**NDA[c]**	forb	0	0.13	2%
		Native Species:		3.33	54%
		Non-Native Species:		2.87	46%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–49. PRWRF1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	41	**Mean CC[a]:**	1.85
Native Species:	28	**Average Cover:**	91.4%
Non-Native Species:	13	**FQAI[b]:**	11.82
Percent Native:	68%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer saccharinum	SILVER MAPLE	tree	3	0.33	5%
Achillea millefolium	YARROW	forb	1	0.13	2%
Andropogon gerardii	BIG BLUESTEM	grass	5	0.07	1%
Asclepias syriaca	COMMON MILKWEED	forb	1	0.07	1%
Aster pilosus	AWL ASTER	forb	1	0.20	3%
Bouteloua curtipendula	SIDE-OATS GRAMA GRASS	grass	8	0.07	1%
Cardamine pensylvanica	PENNSYLVANIA BITTER CRESS	forb	3	0.07	1%
Carex cristatella	CRESTED SEDGE	sedge	3	0.07	1%
Carex laxiflora	TWO-EDGED WOOD SEDGE	sedge	3	0.13	2%
Cornus amomum	SILKY DOGWOOD	shrub	2	0.07	1%
Desmodium canadense	CANADA TICK-TREFOIL	forb	4	0.07	1%
Galium aparine	CLEAVERS	forb	0	0.20	3%
Geum canadense	WHITE AVENS	forb	2	0.07	1%
Juglans nigra	BLACK WALNUT	tree	5	0.07	1%
Juncus tenuis	PATH RUSH	forb	1	0.07	1%
Panicum virgatum	SWITCH GRASS	grass	4	0.07	1%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.27	4%
Physalis heterophylla	CLAMMY GROUND-CHERRY	forb	1	0.07	1%
Platanus occidentalis	SYCAMORE	tree	7	0.07	1%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	0.07	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.27	4%
Sorghastrum nutans	INDIAN GRASS	grass	5	0.07	1%
Toxicodendron radicans	POISON-IVY	vine	1	0.20	3%
Verbesina alternifolia	WINGSTEM	forb	5	0.13	2%
Vernonia gigantea	TALL IRONWEED	forb	2	0.33	5%
Viola sororia	COMMON BLUE VIOLET	forb	1	0.13	2%
Viola sp.	NDA[c]	forb	NDA[c]	0.07	1%
Vitis sp.	NDA[c]	vine	NDA[c]	0.33	5%
Agrostis gigantea	**REDTOP**	grass	0	0.67	10%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.07	1%
Allium vineale	**FIELD GARLIC**	forb	0	0.27	4%
Bromus japonicus	**JAPANESE BROME**	grass	0	0.07	1%
Cirsium arvense	**CANADA THISTLE**	forb	0	0.20	3%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.07	1%
Festuca sp.	**NDA[c]**	grass	0	0.20	3%
Glechoma hederacea	**GROUND IVY**	forb	0	0.60	9%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.07	1%
Medicago lupulina	**BLACK MEDICK**	forb	0	0.07	1%
Phleum pratense	**TIMOTHY**	grass	0	0.27	4%
Sorghum halepense	**JOHNSON GRASS**	grass	0	0.07	1%
Taraxacum officinale	**COMMON DANDELION**	forb	0	0.13	2%
			Native Species:	3.73	58%
			Non-Native Species:	2.73	42%

[a] CC = Coefficent of Conservatism

[b] FQAI = Florist Quality Assessment Index

[c] NDA= No Determination Available

Species in bold are non-native.

Table D–50. PRWRF2 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	50	**Mean CC[a]:**	1.53
Native Species:	34	**Average Cover:**	95.4%
Non-Native Species:	16	**FQAI[b]:**	10.84
Percent Native:	68%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Achillea millefolium	YARROW	forb	1	0.07	1%
Aesculus glabra	OHIO BUCKEYE	tree	6	0.07	1%
Allium canadense	WILD GARLIC	forb	2	0.07	1%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	0.13	2%
Calystegia sepium	HEDGE BINDWEED	forb	1	0.07	1%
Campsis radicans	TRUMPET-CREEPER	vine	1	0.07	1%
Cardamine pensylvanica	PENNSYLVANIA BITTER CRESS	forb	3	0.07	1%
Carex sp.	NDA[c]	sedge	NDA[c]	0.07	1%
Celtis occidentalis	HACKBERRY	tree	4	0.07	1%
Cercis canadensis	REDBUD	sm tree	3	0.07	1%
Erigeron annuus	DAISY FLEABANE	forb	0	0.07	1%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.13	2%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.07	1%
Galium aparine	CLEAVERS	forb	0	0.07	1%
Ipomoea pandurata	POTATO-VINE	forb	2	0.07	1%
Juglans nigra	BLACK WALNUT	tree	5	0.07	1%
Juniperus virginiana	EASTERN RED CEDAR	tree	3	0.07	1%
Monarda fistulosa	WILD BERGAMOT	forb	3	0.07	1%
Oxalis sp.	NDA[c]	forb	NDA[c]	0.07	1%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	0.07	1%
Panicum virgatum	SWITCH GRASS	grass	4	0.07	1%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.07	1%
Rhus aromatica var. aromatica	FRAGRANT SUMAC	shrub	3	0.07	1%
Rhus glabra	SMOOTH SUMAC	shrub	2	0.07	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.47	8%
Solidago sp.	NDA[c]	forb	NDA[c]	0.20	3%
Sorghastrum nutans	INDIAN GRASS	grass	5	0.07	1%
Toxicodendron radicans	POISON-IVY	vine	1	0.20	3%
Verbena urticifolia	WHITE VERVAIN	forb	3	0.07	1%
Verbesina alternifolia	WINGSTEM	forb	5	0.33	5%
Vernonia gigantea	TALL IRONWEED	forb	2	0.07	1%
Viola sororia	COMMON BLUE VIOLET	forb	1	0.07	1%
Viola sp.	NDA[c]	forb	NDA[c]	0.13	2%
Vitis sp.	NDA[c]	vine	NDA[c]	0.20	3%
Agrostis gigantea	**REDTOP**	grass	0	0.47	8%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.27	4%
Allium vineale	**FIELD GARLIC**	forb	0	0.33	5%
Bromus japonicus	**JAPANESE BROME**	grass	0	0.07	1%
Convolvulus arvensis	**FIELD BINDWEED**	forb	0	0.07	1%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.13	2%
Festuca elatior	**TALL FESCUE**	grass	0	0.13	2%
Festuca sp.	**NDA[c]**	grass	0	0.07	1%
Glechoma hederacea	**GROUND IVY**	forb	0	0.33	5%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.13	2%
Lysimachia nummularia	**MONEYWORT**	forb	0	0.07	1%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	0.07	1%
Solanum carolinense	**HORSE NETTLE**	forb	0	0.07	1%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.07	1%
Taraxacum officinale	**COMMON DANDELION**	forb	0	0.27	4%
Trifolium pratense	**RED CLOVER**	forb	0	0.13	2%
		Native Species:		3.53	57%
		Non-Native Species:		2.67	43%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–51. SWURF1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	42	**Mean CC[a]:**	1.55
Native Species:	23	**Average Cover:**	83.9%
Non-Native Species:	19	**FQAI[b]:**	10.05
Percent Native:	55%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Achillea millefolium	YARROW	forb	1	0.07	1%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	0.33	5%
Andropogon gerardii	BIG BLUESTEM	grass	5	0.33	5%
Aster novae-angliae	NEW ENGLAND ASTER	forb	2	0.13	2%
Aster pilosus	AWL ASTER	forb	1	0.47	7%
Bouteloua curtipendula	SIDE-OATS GRAMA GRASS	grass	8	0.13	2%
Cardamine pensylvanica	PENNSYLVANIA BITTER CRESS	forb	3	0.07	1%
Carex vulpinoidea	FOX SEDGE	sedge	1	0.07	1%
Conyza canadensis	HORSEWEED	forb	0	0.07	1%
Cyperus sp.	NDA[c]	sedge	NDA[c]	0.13	2%
Echinacea purpurea	PURPLE CONEFLOWER	forb	6	0.13	2%
Elymus canadensis	CANADA WILD RYE	grass	6	0.13	2%
Eupatorium maculatum	SPOTTED JOE-PYE WEED	forb	6	0.07	1%
Juncus tenuis	PATH RUSH	forb	1	0.07	1%
Monarda fistulosa	WILD BERGAMOT	forb	3	0.27	4%
Panicum virgatum	SWITCH GRASS	grass	4	0.27	4%
Physalis heterophylla	CLAMMY GROUND-CHERRY	forb	1	0.07	1%
Rudbeckia hirta	BLACK-EYED SUSAN	forb	1	0.07	1%
Schizachyrium scoparium	LITTLE BLUESTEM	grass	5	0.13	2%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.33	5%
Solidago rugosa	ROUGH GOLDENROD	forb	2	0.07	1%
Solidago sp.	NDA[c]	forb	NDA[c]	0.13	2%
Sorghastrum nutans	INDIAN GRASS	grass	5	0.07	1%
Agrostis gigantea	**REDTOP**	grass	0	0.27	4%
Bromus japonicus	**JAPANESE BROME**	grass	0	0.27	4%
Cichorium intybus	**CHICORY**	forb	0	0.07	1%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.60	9%
Dipsacus fullonum	**WILD TEASEL**	forb	0	0.27	4%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	0.07	1%
Festuca elatior	**TALL FESCUE**	grass	0	0.07	1%
Festuca sp.	**NDA[c]**	grass	0	0.13	2%
Leonurus cardiaca	**MOTHERWORT**	forb	0	0.13	2%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.07	1%
Medicago lupulina	**BLACK MEDICK**	forb	0	0.07	1%
Melilotus officinalis	**YELLOW SWEET-CLOVER**	forb	0	0.47	7%
Plantago lanceolata	**ENGLISH PLANTAIN**	forb	0	0.07	1%
Plantago major	**COMMON PLANTAIN**	forb	0	0.07	1%
Polygonum aviculare	**COMMON KNOTWEED**	forb	0	0.07	1%
Polygonum persicaria	**LADY'S THUMB**	forb	0	0.07	1%
Setaria sp.	**NDA[c]**	grass	0	0.13	2%
Taraxacum officinale	**COMMON DANDELION**	forb	0	0.27	4%
Trifolium repens	**WHITE CLOVER**	forb	0	0.13	2%
		Native Species:		3.60	52%
		Non-Native Species:		3.27	48%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–52. SWURF2 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	38	**Mean CC[a]:**	2.09
Native Species:	26	**Average Cover:**	80.5%
Non-Native Species:	12	**FQAI[b]:**	12.86
Percent Native:	68%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	0.07	1%
Andropogon gerardii	BIG BLUESTEM	grass	5	0.40	8%
Aster pilosus	AWL ASTER	forb	1	0.07	1%
Bouteloua curtipendula	SIDE-OATS GRAMA GRASS	grass	8	0.13	3%
Cardamine pensylvanica	PENNSYLVANIA BITTER CRESS	forb	3	0.20	4%
Carex frankii	FRANK'S SEDGE	sedge	2	0.07	1%
Echinacea purpurea	PURPLE CONEFLOWER	forb	6	0.07	1%
Galium aparine	CLEAVERS	forb	0	0.07	1%
Juniperus virginiana	EASTERN RED CEDAR	tree	3	0.07	1%
Monarda fistulosa	WILD BERGAMOT	forb	3	0.13	3%
Panicum virgatum	SWITCH GRASS	grass	4	0.40	8%
Populus deltoides	EASTERN COTTONWOOD	tree	3	0.07	1%
Oxalis stricta	COMMON YELLOW WOOD SORREL	forb	0	0.07	1%
Ratibida pinnata	GRAY-HEADED CONEFLOWER	forb	5	0.07	1%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	1	0.07	1%
Rudbeckia hirta	BLACK-EYED SUSAN	forb	1	0.13	3%
Schizachyrium scoparium	LITTLE BLUESTEM	grass	5	0.13	3%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.40	8%
Solidago rigida	STIFF GOLDENROD	forb	8	0.07	1%
Solidago sp.	NDA[c]	forb	NDA[c]	0.27	5%
Sorghastrum nutans	INDIAN GRASS	grass	5	0.27	5%
Tridens flavus	GREASE GRASS	grass	1	0.07	1%
Ulmus americana	AMERICAN ELM	tree	2	0.13	3%
Ulmus rubra	SLIPPERY ELM	tree	3	0.07	1%
Verbena urticifolia	WHITE VERVAIN	forb	3	0.07	1%
Vitis sp.	NDA[c]	vine	NDA[c]	0.07	1%
Agrostis gigantea	**REDTOP**	grass	0	0.13	3%
Bromus japonicus	**JAPANESE BROME**	grass	0	0.20	4%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.20	4%
Dipsacus fullonum	**WILD TEASEL**	forb	0	0.40	8%
Dipsacus laciniatus	**CUT-LEAVED TEASEL**	forb	0	0.07	1%
Festuca sp.	**NDA[c]**	grass	0	0.13	3%
Glechoma hederacea	**GROUND IVY**	forb	0	0.13	3%
Melilotus officinalis	**YELLOW SWEET-CLOVER**	forb	0	0.13	3%
Melilotus sp.	**NDA[c]**	forb	0	0.07	1%
Plantago lanceolata	**ENGLISH PLANTAIN**	forb	0	0.07	1%
Trifolium sp.	**NDA[c]**	forb	NDA[c]	0.07	1%
Valerianella locusta	**EUROPEAN CORN-SALAD**	forb	0	0.07	1%
		Native Species:		3.60	68%
		Non-Native Species:		1.67	32%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–53. NPPSF1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	32	**Mean CC[a]:**	1.30
Native Species:	23	**Average Cover:**	41.7%
Non-Native Species:	9	**FQAI[b]:**	7.35
Percent Native:	72%		

Species	Common Name	Type	CC	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.07	2%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	0.07	2%
Asplenium platyneuron	EBONY SPLEENWORT	fern	3	0.07	2%
Aster pilosus	AWL ASTER	forb	1	0.07	2%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	0.13	3%
Carex laxiflora	TWO-EDGED WOOD SEDGE	sedge	3	0.07	2%
Celtis occidentalis	HACKBERRY	tree	4	0.07	2%
Conyza canadensis	HORSEWEED	forb	0	0.07	2%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.27	6%
Euthamia graminifolia	FLAT-TOPPED GOLDENROD	forb	2	0.07	2%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.07	2%
Geum canadense	WHITE AVENS	forb	2	0.13	3%
Geum laciniatum	ROUGH AVENS	forb	2	0.07	2%
Impatiens capensis	SPOTTED TOUCH-ME-NOT	forb	2	0.27	6%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	0.07	2%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.13	3%
Prunus serotina	BLACK CHERRY	tree	3	0.07	2%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	0.13	3%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	0.07	2%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.20	5%
Solidago sp.	NDA[c]	forb	NDA[c]	0.07	2%
Toxicodendron radicans	POISON-IVY	vine	1	0.07	2%
Vitis sp.	NDA[c]	vine	NDA[c]	0.13	3%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.53	13%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.07	2%
Festuca sp.	**NDA[c]**	grass	0	0.07	2%
Lonicera japonica	**JAPANESE HONEYSUCKLE**	vine	0	0.20	5%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.53	13%
Polygonum persicaria	**LADY'S THUMB**	forb	0	0.07	2%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	0.13	3%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.07	2%
Urtica dioica var. dioica	**EUROPEAN STINGING NETTLE**	forb	0	0.07	2%
		Native Species:		2.40	58%
		Non-Native Species:		1.73	42%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–54. NWESF1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	44	**Mean CC[a]:**	1.74
Native Species:	32	**Average Cover:**	59.9%
Non-Native Species:	12	**FQAI[b]:**	11.53
Percent Native:	73%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.07	1%
Acer saccharinum	SILVER MAPLE	tree	3	0.07	1%
Agrimonia parviflora	SMALL-FLOWERED AGRIMONY	forb	2	0.20	3%
Aster pilosus	AWL ASTER	forb	1	0.20	3%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	0.07	1%
Cardamine concatenata	CUT-LEAVED TOOTHWORT	forb	3	0.07	1%
Carex davisii	DAVIS' SEDGE	sedge	5	0.13	2%
Carex laxiflora	TWO-EDGED WOOD SEDGE	sedge	3	0.20	3%
Claytonia virginica	SPRING-BEAUTY	forb	2	0.13	2%
Elymus hystrix	BOTTLEBRUSH GRASS	grass	4	0.13	2%
Eupatorium rugosum	WHITE SNAKEROOT	forb	3	0.20	3%
Euthamia graminifolia	FLAT-TOPPED GOLDENROD	forb	2	0.07	1%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.33	4%
Galium aparine	CLEAVERS	forb	0	0.07	1%
Galium triflorum	SWEET-SCENTED BEDSTRAW	forb	4	0.07	1%
Geum canadense	WHITE AVENS	forb	2	0.60	8%
Hypericum sphaerocarpum	ROUND-FRUITED ST. JOHN'S-WORT	forb	6	0.07	1%
Impatiens capensis	SPOTTED TOUCH-ME-NOT	forb	2	0.40	5%
Impatiens sp.	NDA[c]	forb	NDA[c]	0.13	2%
Juncus tenuis	PATH RUSH	forb	1	0.07	1%
Leersia virginica	WHITE GRASS	grass	4	0.27	3%
Panicum clandestinum	DEER'S-TONGUE PANIC GRASS	grass	2	0.07	1%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.40	5%
Pilea pumila	CLEARWEED	forb	2	0.07	1%
Polygonum lapathifolium	DOCK-LEAVED SMARTWEED	forb	1	0.27	3%
Rubus occidentalis	BLACK RASPBERRY	shrub	1	0.07	1%
Scirpus atrovirens	GREEN BULRUSH	sedge	1	0.27	3%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.20	3%
Solidago rugosa	ROUGH GOLDENROD	forb	2	0.07	1%
Toxicodendron radicans	POISON-IVY	vine	1	0.27	3%
Verbesina alternifolia	WINGSTEM	forb	5	0.07	1%
Viola sp.	NDA[c]	forb	NDA[c]	0.13	2%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.13	2%
Allium vineale	**FIELD GARLIC**	forb	0	0.27	3%
Elaeagnus umbellata	**AUTUMN-OLIVE**	sm tree	0	0.07	1%
Glechoma hederacea	**GROUND IVY**	forb	0	0.27	3%
Lonicera japonica	**JAPANESE HONEYSUCKLE**	vine	0	0.07	1%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.53	7%
Lysimachia nummularia	**MONEYWORT**	forb	0	0.27	3%
Polygonum persicaria	**LADY'S THUMB**	forb	0	0.13	2%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	0.47	6%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.27	3%
Taraxacum officinale	**COMMON DANDELION**	forb	0	0.07	1%
Trifolium repens	**WHITE CLOVER**	forb	0	0.07	1%
			Native Species:	5.40	68%
			Non-Native Species:	2.60	33%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–55. PRESF1 Forest Functional Monitoring Herbaceous Cover Data Summary

Total Species:	60	**Mean CC[a]:**	1.61
Native Species:	42	**Average Cover:**	81.2%
Non-Native Species:	18	**FQAI[b]:**	12.45
Percent Native:	70%		

Species	Common Name	Type	CC[a]	Frequency (species/quadrat)	Relative Frequency
Acer negundo	BOX ELDER	tree	3	0.20	2%
Acer saccharinum	SILVER MAPLE	tree	3	0.07	1%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	0.13	1%
Aster divaricatus	WHITE WOOD ASTER	forb	5	0.07	1%
Aster lateriflorus	CALICO ASTER	forb	2	0.07	1%
Aster sp.	NDA[c]	forb	NDA[c]	0.07	1%
Cardamine pensylvanica	PENNSYLVANIA BITTER CRESS	forb	3	0.13	1%
Carex blanda	COMMON WOOD SEDGE	sedge	1	0.20	2%
Carex laxiflora	TWO-EDGED WOOD SEDGE	sedge	3	0.07	1%
Carex sp.	NDA[c]	sedge	NDA[c]	0.13	1%
Celtis occidentalis	HACKBERRY	tree	4	0.07	1%
Cercis canadensis	REDBUD	sm tree	3	0.13	1%
Conyza canadensis	HORSEWEED	forb	0	0.07	1%
Elymus canadensis	CANADA WILD RYE	grass	6	0.07	1%
Elymus villosus	HAIRY WILD RYE	grass	4	0.27	3%
Elymus virginicus	VIRGINIA WILD RYE	grass	3	0.07	1%
Eupatorium perfoliatum	COMMON BONESET	forb	3	0.07	1%
Eupatorium serotinum	LATE-FLOWERING BONESET	forb	2	0.80	8%
Fraxinus americana	WHITE ASH	tree	6	0.07	1%
Fraxinus pennsylvanica	GREEN ASH	tree	3	0.13	1%
Galium aparine	CLEAVERS	forb	0	0.20	2%
Geum canadense	WHITE AVENS	forb	2	0.40	4%
Geum laciniatum	ROUGH AVENS	forb	2	0.60	6%
Impatiens capensis	SPOTTED TOUCH-ME-NOT	forb	2	0.07	1%
Ipomoea pandurata	POTATO-VINE	forb	2	0.07	1%
Oxalis stricta	COMMON YELLOW WOOD-SORREL	forb	0	0.13	1%
Panicum capillare	WITCH GRASS	grass	1	0.07	1%
Panicum virgatum	SWITCH GRASS	grass	4	0.07	1%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	2	0.47	4%
Pilea pumila	CLEARWEED	forb	2	0.07	1%
Plantago rugelii	RUGEL'S PLANTAIN	forb	0	0.07	1%
Polygonatum biflorum	SMOOTH SOLOMON'S-SEAL	forb	4	0.07	1%
Polygonum lapathifolium	DOCK-LEAVED SMARTWEED	forb	1	0.07	1%
Polygonum virginianum	JUMPSEED	forb	3	0.13	1%
Ranunculus abortivus	KIDNEY-LEAVED BUTTERCUP	forb	1	0.13	1%
Sanicula gregaria	CLUSTERED SNAKEROOT	forb	3	0.40	4%
Senecio aureus	GOLDEN RAGWORT	forb	4	0.07	1%
Smilax sp.	NDA[c]	ND	NDA[c]	0.07	1%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.33	3%
Toxicodendron radicans	POISON-IVY	vine	1	0.40	4%
Viola sororia	COMMON BLUE VIOLET	forb	1	0.07	1%
Viola sp.	NDA[c]	forb	NDA[c]	0.20	2%
Vitis sp.	NDA[c]	vine	NDA[c]	0.27	3%
Agrostis gigantea	**REDTOP**	grass	0	0.07	1%
Alliaria petiolata	**GARLIC MUSTARD**	forb	0	0.40	4%
Allium vineale	**FIELD GARLIC**	forb	0	0.13	1%
Bromus sp.	**NDA[c]**	grass	0	0.13	1%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.27	3%
Festuca sp.	**NDA[c]**	grass	0	0.07	1%
Glechoma hederacea	**GROUND IVY**	forb	0	0.40	4%
Lonicera japonica	**JAPANESE HONEYSUCKLE**	vine	0	0.27	3%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0	0.33	3%
Medicago lupulina	**BLACK MEDICK**	forb	0	0.13	1%
Melilotus alba	**WHITE SWEET-CLOVER**	forb	0	0.07	1%
Plantago major	**COMMON PLANTAIN**	forb	0	0.07	1%
Polygonum persicaria	**LADY'S THUMB**	forb	0	0.20	2%
Pyrus callieryana	**CALLIERY PEAR**	sm tree	0	0.07	1%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	0	0.27	3%
Stellaria media	**COMMON CHICKWEED**	forb	0	0.13	1%
Taraxacum officinale	**COMMON DANDELION**	forb	0	0.07	1%
Trifolium repens	**WHITE CLOVER**	forb	0	0.13	1%
		Native Species:		7.27	69%
		Non-Native Species:		3.20	31%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–56. NWEFO1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	4.78	**Native Species:**	9
Total Species:	9	**Non-Native Species.:**	0
FQAI[b]:	14.33	**Percent Native:**	100%
Total Abundance:	87	**Average DBH[c] (cm):**	32.4

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Aesculus glabra	OHIO BUCKEYE	tree	4.5	6	32	3.2	36.8%
Acer saccharum	SUGAR MAPLE	tree	8.6	5	3	0.3	3.4%
Acer saccharinum	SILVER MAPLE	tree	17.1	3	39	3.9	44.8%
Celtis occidentalis	HACKBERRY	tree	29.3	4	2	0.2	2.3%
Fraxinus pennsylvanica	GREEN ASH	tree	31.2	3	1	0.1	1.1%
Gymnocladus dioicus	KENTUCKY COFFEE-TREE	tree	39.6	3	6	0.6	6.9%
Quercus shumardii	SHUMARD OAK	tree	42.4	7	1	0.1	1.1%
Carya tomentosa	MOCKERNUT HICKORY	tree	48.8	6	2	0.2	2.3%
Quercus rubra	RED OAK	tree	70.1	6	1	0.1	1.1%
			Native Species:		87	8.7	100.0%
			Non-Native Species:		0	0.0	0.0%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH = Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–57. PREFO1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	4.00	**Native Species:**	15
Total Species:	17	**Non-Native Species.:**	2
FQAI[b]:	16.49	**Percent Native:**	88%
Total Abundance:	529	**Average DBH[c] (cm):**	17.8

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	13.6	3	21	2.1	4.0%
Acer saccharum	SUGAR MAPLE	tree	0.6	5	104	10.4	19.6%
Aesculus glabra	OHIO BUCKEYE	tree	7.4	6	2	0.2	0.4%
Carya cordiformis	BITTERNUT HICKORY	tree	25.3	5	2	0.2	0.4%
Celtis occidentalis	HACKBERRY	tree	7.5	4	7	0.7	1.3%
Cercis canadensis	REDBUD	sm tree	12.1	3	4	0.4	0.8%
Cornus florida	FLOWERING DOGWOOD	sm tree	6.0	5	3	0.3	0.6%
Fraxinus pennsylvanica	GREEN ASH	tree	25.0	3	8	0.8	1.5%
Juglans nigra	BLACK WALNUT	tree	30.9	5	2	0.2	0.4%
Prunus serotina	BLACK CHERRY	tree	19.2	3	7	0.7	1.3%
Quercus coccinea	SCARLET OAK	tree	17.5	6	2	0.2	0.4%
Quercus muehlenbergii	CHINQUAPIN OAK	tree	26.5	7	6	0.6	1.1%
Quercus velutina	BLACK OAK	tree	44.2	7	1	0.1	0.2%
Ulmus americana	AMERICAN ELM	tree	13.4	2	10	1.0	1.9%
Vitis sp.	NDA[d]	vine	N/A[e]	NDA[d]	7	0.7	1.3%
Lonicera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	339	33.9	64.0%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	4	0.4	0.8%
			Native Species:		186	18.6	35.2%
			Non-Native Species:		343	34.3	64.8%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH = Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–58. PREFO2 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	4.17	**Native Species:**	16
Total Species:	18	**Non-Native Species.:**	2
FQAI[b]:	17.68	**Percent Native:**	89%
Total Abundance:	308	**Average DBH[c] (cm):**	19.3

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	11.0	3	6	0.6	1.9%
Acer saccharinum	SILVER MAPLE	tree	6.6	3	1	0.1	0.3%
Acer saccharum	SUGAR MAPLE	tree	11.0	5	34	3.4	11.0%
Aesculus glabra	OHIO BUCKEYE	tree	6.0	6	7	0.7	2.3%
Asimina triloba	PAWPAW	sm tree	0.6	6	7	0.7	2.3%
Carya tomentosa	MOCKERNUT HICKORY	tree	0.6	6	3	0.3	1.0%
Celtis occidentalis	HACKBERRY	tree	13.5	4	3	0.3	1.0%
Fraxinus americana	WHITE ASH	tree	4.2	6	7	0.7	2.3%
Fraxinus pennsylvanica	GREEN ASH	tree	0.6	3	4	0.4	1.3%
Juglans cinerea	BUTTERNUT	tree	27.4	7	3	0.3	1.0%
Juglans nigra	BLACK WALNUT	tree	32.4	5	8	0.8	2.6%
Juniperus virginiana	EASTERN RED CEDAR	tree	16.0	3	11	1.1	3.6%
Liriodendron tulipifera	TULIP TREE	tree	84.8	6	1	0.1	0.3%
Platanus occidentalis	SYCAMORE	tree	71.4	7	2	0.2	0.6%
Sassafras albidum	SASSAFRAS	tree	0.6	3	1	0.1	0.3%
Ulmus americana	AMERICAN ELM	tree	22.3	2	10	1.0	3.2%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	199	19.9	64.6%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	1	0.1	0.3%
			Native Species:		108	10.8	35.1%
			Non-Native Species:		200	20.0	64.9%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–59. PRWFO1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	4.88	**Native Species:**	16
Total Species:	17	**Non-Native Species.:**	1
FQAI[b]:	20.10	**Percent Native:**	94%
Total Abundance:	83	**Average DBH[c] (cm):**	24.2

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Asimina triloba	PAWPAW	sm tree	1.1	6	13	1.3	3.1%
Aesculus glabra	OHIO BUCKEYE	tree	4.2	6	2	0.2	0.5%
Acer saccharinum	SILVER MAPLE	tree	6.2	3	5	0.5	1.2%
Acer negundo	BOX ELDER	tree	9.2	3	4	0.4	1.0%
Celtis occidentalis	HACKBERRY	tree	12.9	4	32	3.2	7.6%
Carya cordiformis	BITTERNUT HICKORY	tree	14.0	5	1	0.1	0.2%
Prunus serotina	BLACK CHERRY	tree	15.2	3	2	0.2	0.5%
Fraxinus pennsylvanica	GREEN ASH	tree	22.8	3	2	0.2	0.5%
Quercus rubra	RED OAK	tree	24.1	6	1	0.1	0.2%
Carya laciniosa	SHELLBARK HICKORY	tree	25.7	7	1	0.1	0.2%
Carya tomentosa	MOCKERNUT HICKORY	tree	26.4	6	8	0.8	1.9%
Ulmus americana	AMERICAN ELM	tree	29.2	2	6	0.6	1.4%
Juglans nigra	BLACK WALNUT	tree	34.3	5	2	0.2	0.5%
Quercus velutina	BLACK OAK	tree	45.0	7	2	0.2	0.5%
Platanus occidentalis	SYCAMORE	tree	53.1	7	1	0.1	0.2%
Quercus imbricaria	SHINGLE OAK	tree	64.3	5	1	0.1	0.2%
Lonicfera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	336	33.6	80.2%
			Native Species:		83	8.3	19.8%
			Non-Native Species:		336	33.6	80.2%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–60. PRWFO2 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	3.00	**Native Species:**	15
Total Species:	17	**Non-Native Species.:**	2
FQAI[b]:	12.37	**Percent Native:**	88%
Total Abundance:	238	**Average DBH[c] (cm):**	19.6

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	12.4	3	31	3.1	13.0%
Acer saccharum	SUGAR MAPLE	tree	13.0	5	2	0.2	0.8%
Aesculus flava	YELLOW BUCKEYE	tree	14.0	7	6	0.6	2.5%
Aesculus glabra	OHIO BUCKEYE	tree	3.6	6	29	2.9	12.2%
Campsis radicans	TRUMPET-CREEPER	vine	N/A[e]	1	1	0.1	0.4%
Carya cordiformis	BITTERNUT HICKORY	tree	69.9	5	1	0.1	0.4%
Celtis occidentalis	HACKBERRY	tree	4.3	4	3	0.3	1.3%
Crataegus pruinosa	FROSTED HAWTHORN	sm tree	7.9	2	2	0.2	0.8%
Gleditsia triacanthos	HONEY LOCUST	tree	27.3	4	3	0.3	1.3%
Juglans nigra	BLACK WALNUT	tree	23.7	5	3	0.3	1.3%
Maclura pomifera	OSAGE-ORANGE	tree	9.7	0	1	0.1	0.4%
Platanus occidentalis	SYCAMORE	tree	33.3	7	12	1.2	5.0%
Robinia pseudoacacia	BLACK LOCUST	tree	20.4	0	9	0.9	3.8%
Ulmus americana	AMERICAN ELM	tree	16.0	2	6	0.6	2.5%
Vitis sp.	NDA[d]	vine	N/A[e]	0	1	0.1	0.4%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	125	12.5	52.5%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	3	0.3	1.3%
			Native Species:		109	10.9	45.8%
			Non-Native Species:		128	12.8	53.8%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–61. PRWFO3 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	3.71	**Native Species:**	14
Total Species:	16	**Non-Native Species.:**	3
FQAI[b]:	14.82	**Percent Native:**	88%
Total Abundance:	333	**Average DBH[c] (cm):**	19.2

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	15.5448	3	2	0.2	0.6%
Acer saccharinum	SILVER MAPLE	tree	20.828	3	1	0.1	0.3%
Aesculus glabra	OHIO BUCKEYE	tree	15.748	6	3	0.3	0.9%
Carya cordiformis	BITTERNUT HICKORY	tree	18.9992	5	2	0.2	0.6%
Carya tomentosa	MOCKERNUT HICKORY	tree	32.004	6	2	0.2	0.6%
Celtis occidentalis	HACKBERRY	tree	21.463	4	2	0.2	0.6%
Fraxinus pennsylvanica	GREEN ASH	tree	42.7482	3	6	0.6	1.8%
Juglans nigra	BLACK WALNUT	tree	0.635	5	1	0.1	0.3%
Juniperus virginiana	EASTERN RED CEDAR	tree	0.635	3	5	0.5	1.5%
Platanus occidentalis	SYCAMORE	tree	62.738	7	1	0.1	0.3%
Quercus imbricaria	SHINGLE OAK	tree	21.59	5	2	0.2	0.6%
Quercus macrocarpa	BUR OAK	tree	26.543	6	12	1.2	3.6%
Quercus velutina	BLACK OAK	tree	24.6888	7	2	0.2	0.6%
Robinia pseudoacacia	BLACK LOCUST	tree	1.524	0	1	0.1	0.3%
Ailanthus altissima	**TREE-OF-HEAVEN**	tree	0.635	0	1	0.1	0.3%
Catalpa speciosa	**NORTHERN CATALPA**	tree	0.635	0	1	0.1	0.3%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	289	28.9	86.8%
			Native Species:		42	4.20	12.6%
			Non-Native Species:		291	29.10	87.4%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–62. NPPPP1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	3.25	**Native Species:**	9
Total Species:	12	**Non-Native Species.:**	3
FQAI[b]:	11.26	**Percent Native:**	75%
Total Abundance:	213	**Average DBH[c] (cm):**	8.3

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	1.3	3	48	4.8	22.5%
Celtis occidentalis	HACKBERRY	tree	13.5	4	1	0.1	0.5%
Fraxinus americana	WHITE ASH	tree	3.4	6	2	0.2	0.9%
Fraxinus pennsylvanica	GREEN ASH	tree	2.5	3	5	0.5	2.3%
Juglans nigra	BLACK WALNUT	tree	0.6	5	1	0.1	0.5%
Morus rubra	RED MULBERRY	tree	0.6	7	1	0.1	0.5%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	3.8	2	1	0.1	0.5%
Pinus strobus	WHITE PINE	tree	28.2	6	48	4.8	22.5%
Prunus serotina	BLACK CHERRY	tree	6.0	3	7	0.7	3.3%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	84	8.4	39.4%
Pinus nigra	**AUSTRIAN PINE**	tree	23.5	0	14	1.4	6.6%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	1	0.1	0.5%
				Native Species:	114	11.4	53.5%
				Non-Native Species:	99	9.9	46.5%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–63. PREPP1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	3.24	**Native Species:**	13
Total Species:	17	**Non-Native Species.:**	4
FQAI[b]:	13.34	**Percent Native:**	76%
Total Abundance:	257	**Average DBH[c] (cm):**	11.9

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	1.4	3	139	13.9	54.1%
Acer saccharum	SUGAR MAPLE	tree	2.8	5	1	0.1	0.4%
Cornus florida	FLOWERING DOGWOOD	sm tree	3.2	5	7	0.7	2.7%
Euonymus atropurpureus	BURNING-BUSH	shrub	2.5	3	1	0.1	0.4%
Fagus grandifolia	AMERICAN BEECH	tree	0.6	7	1	0.1	0.4%
Nyssa sylvatica	BLACK-GUM	tree	2.5	7	1	0.1	0.4%
Pinus strobus	WHITE PINE	tree	31.2	6	44	4.4	17.1%
Prunus serotina	BLACK CHERRY	tree	3.8	3	4	0.4	1.6%
Quercus imbricaria	SHINGLE OAK	tree	89.7	5	1	0.1	0.4%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	N/A[e]	1	1	0.1	0.4%
Tilia americana	AMERICAN BASSWOOD	tree	2.0	6	1	0.1	0.4%
Ulmus americana	AMERICAN ELM	tree	0.6	2	1	0.1	0.4%
Viburnum dentatum	ARROW-WOOD	shrub	1.0	2	5	0.5	1.9%
Celastrus orbiculatus	**ORIENTAL BITTERSWEET**	vine	0.6	0	1	0.1	0.4%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	37	3.7	14.4%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	2	0.2	0.8%
Pinus nigra	**AUSTRIAN PINE**	tree	25.2	0	10	1.0	3.9%
			Native Species:		207	20.7	80.5%
			Non-Native Species:		50	5.0	19.5%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–64. A82RF1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	3.39	**Native Species:**	29
Total Species:	33	**Non-Native Species.:**	4
FQAI[b]:	19.46	**Percent Native:**	88%
Total Abundance:	318	**Average DBH[c] (cm):**	6.9

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	1.0	3	83	8.3	26.1%
Acer saccharum	SUGAR MAPLE	tree	11.0	5	8	0.8	2.5%
Aesculus glabra	OHIO BUCKEYE	tree	5.6	6	4	0.4	1.3%
Campsis radicans	TRUMPET-CREEPER	vine	N/A[e]	1	1	0.1	0.3%
Carya cordiformis	BITTERNUT HICKORY	tree	17.3	5	1	0.1	0.3%
Carya ovata	SHAGBARK HICKORY	tree	0.6	6	2	0.2	0.6%
Celtis occidentalis	HACKBERRY	tree	16.3	4	1	0.1	0.3%
Cercis canadensis	REDBUD	sm tree	3.2	3	5	0.5	1.6%
Cornus amomum	SILKY DOGWOOD	shrub	0.7	2	11	1.1	3.5%
Cornus florida	FLOWERING DOGWOOD	sm tree	1.2	5	2	0.2	0.6%
Cornus racemosa	GRAY DOGWOOD	shrub	1.1	1	12	1.2	3.8%
Crataegus crus-galli	COCKSPUR	sm tree	2.9	3	4	0.4	1.3%
Fagus grandifolia	AMERICAN BEECH	tree	5.2	7	2	0.2	0.6%
Fraxinus americana	WHITE ASH	tree	8.0	6	9	0.9	2.8%
Fraxinus pennsylvanica	GREEN ASH	tree	7.6	3	1	0.1	0.3%
Gymnocladus dioicus	KENTUCKY COFFEE-TREE	tree	9.1	3	1	0.1	0.3%
Hypericum prolificum	SHRUBBY ST. JOHN'S-WORT	shrub	N/A[e]	3	12	1.2	3.8%
Juglans nigra	BLACK WALNUT	tree	2.0	5	51	5.1	16.0%
Juniperus virginiana	EASTERN RED CEDAR	tree	10.9	3	1	0.1	0.3%
Lindera benzoin	SPICEBUSH	shrub	N/A[e]	5	3	0.3	0.9%
Liriodendron tulipifera	TULIP TREE	tree	1.7	6	11	1.1	3.5%
Prunus serotina	BLACK CHERRY	tree	31.1	3	2	0.2	0.6%
Quercus macrocarpa	BUR OAK	tree	15.2	6	1	0.1	0.3%
Quercus velutina	BLACK OAK	tree	17.3	7	3	0.3	0.9%
Robinia pseudoacacia	BLACK LOCUST	tree	0.8	0	3	0.3	0.9%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	N/A[e]	1	54	5.4	17.0%
Sambucus canadensis	COMMON ELDERBERRY	shrub	N/A[e]	3	2	0.2	0.6%
Ulmus sp.	NDA[d]	NDA[d]	1.3	NDA[d]	1	0.1	0.3%
Vitis sp.	NDA[d]	vine	N/A[e]	NDA[d]	2	0.2	0.6%
Elaeagnus umbellata	**AUTUMN-OLIVE**	sm tree	0.9	0	4	0.4	1.3%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	14	1.4	4.4%
Maclura pomifera	**OSAGE-ORANGE**	tree	1.4	0	2	0.2	0.6%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	5	0.5	1.6%
				Native Species:	293	29.3	92.1%
				Non-Native Species:	25	2.5	7.9%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–65. A82RF2 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	3.31	**Native Species:**	12
Total Species:	14	**Non-Native Species.:**	2
FQAI[b]:	12.38	**Percent Native:**	86%
Total Abundance:	128	**Average DBH[c] (cm):**	13.3

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	2.4	3	53	5.3	41.4%
Acer saccharum	SUGAR MAPLE	tree	9.7	5	1	0.1	0.8%
Aesculus glabra	OHIO BUCKEYE	tree	10.4	6	3	0.3	2.3%
Fagus grandifolia	AMERICAN BEECH	tree	9.7	7	6	0.6	4.7%
Fraxinus americana	WHITE ASH	tree	9.7	6	3	0.3	2.3%
Fraxinus pennsylvanica	GREEN ASH	tree	6.4	3	6	0.6	4.7%
Juglans nigra	BLACK WALNUT	tree	6.3	5	15	1.5	11.7%
Juniperus virginiana	EASTERN RED CEDAR	tree	34.8	3	1	0.1	0.8%
Prunus serotina	BLACK CHERRY	tree	30.2	3	1	0.1	0.8%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	N/A[e]	1	6	0.6	4.7%
Rubus occidentalis	BLACK RASPBERRY	shrub	N/A[e]	1	2	0.2	1.6%
Vitis sp.	NDA[d]	vine	N/A[e]	NDA[d]	1	0.1	0.8%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	18	1.8	14.1%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	12	1.2	9.4%
			Native Species:		98	9.8	76.6%
			Non-Native Species:		30	3.0	23.4%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–66. ERPRF1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	3.65	**Native Species:**	15
Total Species:	19	**Non-Native Species.:**	4
FQAI[b]:	15.91	**Percent Native:**	79%
Total Abundance:	151	**Average DBH[c] (cm):**	1.8

Species	Common Name	Type	avg dbh (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	2.1	3	24	2.4	15.9%
Acer saccharum	SUGAR MAPLE	tree	0.8	5	5	0.5	3.3%
Aesculus flava	YELLOW BUCKEYE	tree	2.3	7	1	0.1	.7%
Aesculus glabra	OHIO BUCKEYE	tree	4.8	6	1	0.1	.7%
Carya cordiformis	BITTERNUT HICKORY	tree	0.6	5	1	0.1	.7%
Castanea dentata	AMERICAN CHESTNUT	tree	5.6	6	2	0.2	1.3%
Celtis occidentalis	HACKBERRY	tree	0.6	4	1	0.1	.7%
Cercis canadensis	REDBUD	sm tree	1.5	3	1	0.1	.7%
Cornus florida	FLOWERING DOGWOOD	sm tree	0.6	5	1	0.1	.7%
Fagus grandifolia	AMERICAN BEECH	tree	0.6	7	1	0.1	.7%
Juglans nigra	BLACK WALNUT	tree	2.2	5	17	1.7	11.3%
Quercus muehlenbergii	CHINQUAPIN OAK	tree	0.6	7	2	0.2	1.3%
Robinia pseudoacacia	BLACK LOCUST	tree	3.4	0	53	5.3	35.1%
Rubus occidentalis	BLACK RASPBERRY	shrub	0.6	1	1	0.1	.7%
Ulmus americana	AMERICAN ELM	tree	0.6	2	2	0.2	1.3%
Ulmus thomasii	ROCK ELM	sm tree	1.4	7	8	0.8	5.3%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	3	0.3	2%
Pyrus communis	**PEAR**	sm tree	2.3	0	1	0.1	.7%
Quercus acutissima	**SAWTOOTH OAK**	tree	1.2	0	19	1.9	12.6%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	7	0.7	4.6%
				Native Species:	121	12.10	80.1%
				Non-Native Species:	30	3	0.198675

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–67. FWPRF1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	3.60	**Native Species:**	33
Total Species:	35	**Non-Native Species.:**	2
FQAI[b]:	21.30	**Percent Native:**	94%
Total Abundance:	446	**Average DBH[c] (cm):**	1.4

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	1.6	3	46	4.6	10.3%
Acer rubrum	RED MAPLE	tree	1.0	2	9	0.9	2.0%
Acer saccharinum	SILVER MAPLE	tree	0.6	3	1	0.1	0.2%
Acer saccharum	SUGAR MAPLE	tree	1.2	5	2	0.2	0.4%
Asimina triloba	PAWPAW	sm tree	3.0	6	14	1.4	3.1%
Celastrus scandens	BITTERSWEET	vine	0.6	2	4	0.4	0.9%
Celtis occidentalis	HACKBERRY	tree	6.2	4	2	0.2	0.4%
Cephalanthus occidentalis	BUTTONBUSH	shrub	0.6	6	2	0.2	0.4%
Cercis canadensis	REDBUD	sm tree	0.6	3	1	0.1	0.2%
Cornus racemosa	GRAY DOGWOOD	shrub	0.6	1	17	1.7	3.8%
Crataegus crus-galli	COCKSPUR	sm tree	0.6	3	5	0.5	1.1%
Fraxinus americana	WHITE ASH	tree	2.5	6	2	0.2	0.4%
Fraxinus pennsylvanica	GREEN ASH	tree	2.8	3	13	1.3	2.9%
Hamamelis virginiana	WITCH-HAZEL	sm tree	0.6	5	1	0.1	0.2%
Ilex verticillata	WINTERBERRY	shrub	0.6	6	1	0.1	0.2%
Juglans nigra	BLACK WALNUT	tree	2.0	5	5	0.5	1.1%
Juniperus virginiana	EASTERN RED CEDAR	tree	2.3	3	4	0.4	0.9%
Lindera benzoin	SPICEBUSH	shrub	0.6	5	4	0.4	0.9%
Liriodendron tulipifera	TULIP TREE	tree	0.6	6	1	0.1	0.2%
Physocarpus opulifolius	NINEBARK	shrub	0.6	4	14	1.4	3.1%
Platanus occidentalis	SYCAMORE	tree	0.9	7	72	7.2	16.1%
Populus deltoides	EASTERN COTTONWOOD	tree	3.6	3	123	12.3	27.6%
Prunus serotina	BLACK CHERRY	tree	1.0	3	2	0.2	0.4%
Quercus alba	WHITE OAK	tree	1.5	6	3	0.3	0.7%
Quercus rubra	RED OAK	tree	0.6	6	2	0.2	0.4%
Rhus aromatica var. aromatica	FRAGRANT SUMAC	shrub	0.6	3	12	1.2	2.7%
Robinia pseudoacacia	BLACK LOCUST	tree	2.2	0	2	0.2	0.4%
Rubus occidentalis	BLACK RASPBERRY	shrub	0.6	1	7	0.7	1.6%
Salix nigra	BLACK WILLOW	tree	3.0	2	15	1.5	3.4%
Symphoricarpos orbiculatus	CORALBERRY	shrub	0.6	3	3	0.3	0.7%
Ulmus americana	AMERICAN ELM	tree	0.6	2	1	0.1	0.2%
Ulmus thomasii	ROCK ELM	sm tree	2.1	7	5	0.5	1.1%
Viburnum dentatum	ARROW-WOOD	shrub	0.6	2	1	0.1	0.2%
Lonicera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	47	4.7	10.5%
Morus alba	**WHITE MULBERRY**	tree	0.6	0	3	0.3	0.7%
			Native Species:		396	39.6	88.8%
			Non-Native Species:		50	5.0	11.2%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–68. NPPRF1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	3.62	**Native Species:**	33
Total Species:	37	**Non-Native Species.:**	4
FQAI[b]:	22.03	**Percent Native:**	89%
Total Abundance:	573	**Average DBH[c] (cm):**	2.3

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	3.0	3	5	0.5	0.9%
Acer rubrum	RED MAPLE	tree	2.1	2	4	0.4	0.7%
Acer saccharinum	SILVER MAPLE	tree	3.3	3	13	1.3	2.3%
Acer saccharum	SUGAR MAPLE	tree	5.7	5	10	1	1.7%
Asimina triloba	PAWPAW	sm tree	1.1	6	4	0.4	0.7%
Carya cordiformis	BITTERNUT HICKORY	tree	0.6	5	2	0.2	0.3%
Carya tomentosa	MOCKERNUT HICKORY	tree	1.0	6	4	0.4	0.7%
Ceanothus americanus	NEW JERSEY TEA	shrub	1.0	5	2	0.2	0.3%
Cercis canadensis	REDBUD	sm tree	3.2	3	4	0.4	0.7%
Cornus florida	FLOWERING DOGWOOD	sm tree	1.3	5	16	1.6	2.8%
Cornus racemosa	GRAY DOGWOOD	shrub	1.1	1	7	0.7	1.2%
Fagus grandifolia	AMERICAN BEECH	tree	2.2	7	4	0.4	0.7%
Fraxinus americana	WHITE ASH	tree	1.4	6	12	1.2	2.1%
Fraxinus pennsylvanica	GREEN ASH	tree	1.7	3	10	1	1.7%
Juglans nigra	BLACK WALNUT	tree	2.5	5	7	0.7	1.2%
Liriodendron tulipifera	TULIP TREE	tree	2.0	6	1	0.1	0.2%
Ostrya virginiana	HOP-HORNBEAM	tree	1.3	5	1	0.1	0.2%
Physocarpus opulifolius	NINEBARK	shrub	0.6	4	9	0.9	1.6%
Populus deltoides	EASTERN COTTONWOOD	tree	3.7	3	75	7.5	13.1%
Prunus serotina	BLACK CHERRY	tree	0.6	3	2	0.2	0.3%
Quercus alba	WHITE OAK	tree	2.7	6	7	0.7	1.2%
Quercus macrocarpa	BUR OAK	tree	1.1	6	3	0.3	0.5%
Quercus prinus	ROCK CHESTNUT OAK	tree	1.0	7	3	0.3	0.5%
Quercus rubra	RED OAK	tree	2.4	6	4	0.4	0.7%
Quercus shumardii	SHUMARD OAK	tree	8.9	7	1	0.1	0.2%
Rhus glabra	SMOOTH SUMAC	shrub	N/A[e]	2	8	0.8	1.4%
Rhus typhina	STAGHORN SUMAC	shrub	1.6	2	3	0.3	0.5%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	N/A[e]	1	247	24.7	43.0%
Rubus occidentalis	BLACK RASPBERRY	shrub	0.1	1	17	1.7	3.0%
Symphoricarpos orbiculatus	CORALBERRY	shrub	1.0	3	44	4.4	7.7%
Ulmus americana	AMERICAN ELM	tree	3.8	2	3	0.3	0.5%
Ulmus rubra	SLIPPERY ELM	tree	3.3	3	8	0.8	1.4%
Vibumum dentatum	ARROW-WOOD	shrub	0.8	2	4	0.4	0.7%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	24	2.4	4.2%
Morus alba	**WHITE MULBERRY**	tree	3.0	0	2	0.2	0.3%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	2	0.2	0.3%
Pyrus communis	**PEAR**	sm tree	7.9	0	1	0.1	0.2%
				Native Species:	544	54.4	94.9%
				Non-Native Species:	29	2.9	5.1%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–69. NWERF1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	2.80	**Native Species:**	21
Total Species:	26	**Non-Native Species.:**	5
FQAI[b]:	14.28	**Percent Native:**	81%
Total Abundance:	819	**Average DBH[c] (cm):**	5.6

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	5.0	3	8	0.8	1.0%
Acer saccharum	SUGAR MAPLE	tree	23.6	5	2	0.2	0.2%
Campsis radicans	TRUMPET-CREEPER	vine	0.6	1	1	0.1	0.1%
Celtis occidentalis	HACKBERRY	tree	3.2	4	3	0.3	0.4%
Cornus florida	FLOWERING DOGWOOD	sm tree	0.9	5	54	5.4	6.6%
Cornus racemosa	GRAY DOGWOOD	shrub	0.8	1	149	14.9	18.2%
Fagus grandifolia	AMERICAN BEECH	tree	0.6	7	7	0.7	0.9%
Fraxinus americana	WHITE ASH	tree	29.9	6	11	1.1	1.3%
Fraxinus pennsylvanica	GREEN ASH	tree	1.8	3	281	28.1	34.3%
Juniperus virginiana	EASTERN RED CEDAR	tree	2.2	3	25	2.5	3.1%
Ostrya virginiana	HOP-HORNBEAM	tree	1.0	5	2	0.2	0.2%
Parthenocissus quinquefolia	VIRGINIA CREEPER	vine	0.6	2	1	0.1	0.1%
Platanus occidentalis	SYCAMORE	tree	24.8	7	7	0.7	0.9%
Prunus serotina	BLACK CHERRY	tree	6.7	3	2	0.2	0.2%
Quercus imbricaria	SHINGLE OAK	tree	0.6	5	1	0.1	0.1%
Quercus rubra	RED OAK	tree	1.5	6	1	0.1	0.1%
Robinia pseudoacacia	BLACK LOCUST	tree	4.3	0	1	0.1	0.1%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	0.6	1	45	4.5	5.5%
Rubus occidentalis	BLACK RASPBERRY	shrub	0.6	1	7	0.7	0.9%
Ulmus americana	AMERICAN ELM	tree	10.6	2	18	1.8	2.2%
Vitis sp.	ND[c]	vine	N/A[e]	NDA[d]	2	0.2	0.2%
Elaeagnus umbellata	**AUTUMN-OLIVE**	sm tree	2.4	0	6	0.6	0.7%
Lonicera japonica	**JAPANESE HONEYSUCKLE**	vine	N/A[e]	0	1	0.1	0.1%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	100	10	12.2%
Pyrus communis	**PEAR**	sm tree	0.6	0	1	0.1	0.1%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	83	8.3	10.1%
			Native Species:		628	62.8	76.7%
			Non-Native Species:		191	19.1	23.3%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–70. PRERF1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	3.24	**Native Species:**	24
Total Species:	29	**Non-Native Species.:**	5
FQAI[b]:	17.46	**Percent Native:**	83%
Total Abundance:	390	**Average DBH[c] (cm):**	2.1

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	0.9	3	29	2.9	7.4%
Acer saccharinum	SILVER MAPLE	tree	1.3	3	2	0.2	0.5%
Acer saccharum	SUGAR MAPLE	tree	0.6	5	3	0.3	0.8%
Cornus amomum	SILKY DOGWOOD	shrub	0.8	2	21	2.1	5.4%
Fagus grandifolia	AMERICAN BEECH	tree	2.8	7	2	0.2	0.5%
Fraxinus pennsylvanica	GREEN ASH	tree	0.6	3	7	0.7	1.8%
Fraxinus quadrangulata	BLUE ASH	tree	1.5	7	1	0.1	0.3%
Juglans nigra	BLACK WALNUT	tree	1.6	5	2	0.2	0.5%
Liriodendron tulipifera	TULIP TREE	tree	0.6	6	1	0.1	0.3%
Platanus occidentalis	SYCAMORE	tree	1.3	7	9	0.9	2.3%
Populus deltoides	EASTERN COTTONWOOD	tree	3.8	3	24	2.4	6.2%
Prunus serotina	BLACK CHERRY	tree	0.6	3	1	0.1	0.3%
Quercus alba	WHITE OAK	tree	2.0	6	8	0.8	2.1%
Quercus muehlenbergii	CHINQUAPIN OAK	tree	0.6	7	5	0.5	1.3%
Quercus rubra	RED OAK	tree	3.2	6	2	0.2	0.5%
Quercus velutina	BLACK OAK	tree	0.6	7	1	0.1	0.3%
Rhus copallinum	WINGED SUMAC	shrub	1.5	4	2	0.2	0.5%
Rhus glabra	SMOOTH SUMAC	shrub	0.6	2	2	0.2	0.5%
Robinia pseudoacacia	BLACK LOCUST	tree	4.3	0	35	3.5	9.0%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	N/A[e]	1	168	16.8	43.1%
Rubus occidentalis	BLACK RASPBERRY	shrub	N/A[e]	1	6	0.6	1.5%
Salix nigra	BLACK WILLOW	tree	4.8	2	1	0.1	0.3%
Ulmus americana	AMERICAN ELM	tree	0.6	2	8	0.8	2.1%
Viburnum dentatum	ARROW-WOOD	shrub	N/A[e]	2	41	4.1	10.5%
Catalpa speciosa	**NORTHERN CATALPA**	tree	9.1	0	1	0.1	0.3%
Lonicera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	2	0.2	0.5%
Pyrus communis	**PEAR**	sm tree	0.6	0	1	0.1	0.3%
Quercus acutissima	**SAWTOOTH OAK**	tree	4.7	0	4	0.4	1.0%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	1	0.1	0.3%
			Native Species:		381	38.1	97.7%
			Non-Native Species:		9	0.9	2.3%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–71. PRERF2 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	4.00	**Native Species:**	36
Total Species:	40	**Non-Native Species.:**	4
FQAI[b]:	25.30	**Percent Native:**	90%
Total Abundance:	396	**Average DBH[c] (cm):**	1.4

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	1.4	3	3	0.3	0.8%
Acer rubrum	RED MAPLE	tree	1.5	2	1	0.1	0.3%
Acer saccharum	SUGAR MAPLE	tree	0.9	5	12	1.2	3.0%
Asimina triloba	PAWPAW	sm tree	0.6	6	4	0.4	1.0%
Carya cordiformis	BITTERNUT HICKORY	tree	1.6	5	38	3.8	9.6%
Carya laciniosa	SHELLBARK HICKORY	tree	0.6	7	1	0.1	0.3%
Carya tomentosa	MOCKERNUT HICKORY	tree	0.6	6	2	0.2	0.5%
Cercis canadensis	REDBUD	sm tree	0.6	3	3	0.3	0.8%
Cornus amomum	SILKY DOGWOOD	shrub	0.8	2	139	13.9	35.1%
Cornus florida	FLOWERING DOGWOOD	sm tree	0.6	5	1	0.1	0.3%
Corylus americana	AMERICAN HAZEL	shrub	0.6	4	18	1.8	4.5%
Crataegus mollis	DOWNY HAWTHORN	sm tree	0.6	3	1	0.1	0.3%
Fraxinus americana	WHITE ASH	tree	0.9	6	7	0.7	1.8%
Fraxinus pennsylvanica	GREEN ASH	tree	1.2	3	5	0.5	1.3%
Hamamelis virginiana	WITCH-HAZEL	sm tree	0.6	5	4	0.4	1.0%
Ilex verticillata	WINTERBERRY	shrub	0.6	6	4	0.4	1.0%
Juglans nigra	BLACK WALNUT	tree	2.0	5	21	2.1	5.3%
Morus rubra	RED MULBERRY	tree	1.1	7	4	0.4	1.0%
Ostrya virginiana	HOP-HORNBEAM	tree	1.0	5	6	0.6	1.5%
Populus deltoides	EASTERN COTTONWOOD	tree	1.2	3	2	0.2	0.5%
Prunus serotina	BLACK CHERRY	tree	3.3	3	1	0.1	0.3%
Quercus alba	WHITE OAK	tree	1.0	6	2	0.2	0.5%
Quercus bicolor	SWAMP WHITE OAK	tree	1.1	7	2	0.2	0.5%
Quercus imbricaria	SHINGLE OAK	tree	1.4	5	4	0.4	1.0%
Quercus macrocarpa	BUR OAK	tree	1.6	6	6	0.6	1.5%
Quercus rubra	RED OAK	tree	1.8	6	1	0.1	0.3%
Quercus shumardii	SHUMARD OAK	tree	3.0	7	1	0.1	0.3%
Quercus velutina	BLACK OAK	tree	0.6	7	2	0.2	0.5%
Rhus glabra	SMOOTH SUMAC	shrub	0.6	2	1	0.1	0.3%
Rhus typhina	STAGHORN SUMAC	shrub	2.5	2	1	0.1	0.3%
Robinia pseudoacacia	BLACK LOCUST	tree	4.0	0	7	0.7	1.8%
Rosa carolina	PASTURE ROSE	shrub	N/A[e]	4	2	0.2	0.5%
Rubus allegheniensis	COMMON BLACKBERRY	shrub	N/A[e]	1	1	0.1	0.3%
Rubus occidentalis	BLACK RASPBERRY	shrub	N/A[e]	1	56	5.6	14.1%
Tilia americana	AMERICAN BASSWOOD	tree	2.3	6	8	0.8	2.0%
Tilia heterophylla	WHITE BASSWOOD	tree	0.6	6	1	0.1	0.3%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	4.1	0	10	1	2.5%
Morus alba	**WHITE MULBERRY**	tree	0.6	0	2	0.2	0.5%
Pyrus communis	**PEAR**	sm tree	1.3	0	1	0.1	0.3%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	11	1.1	2.8%
				Native Species:	372	37.2	93.9%
				Non-Native Species:	24	2.4	6.1%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–72. PRWRF1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	3.45	**Native Species:**	27
Total Species:	32	**Non-Native Species.:**	5
FQAI[b]:	19.53	**Percent Native:**	84%
Total Abundance:	592	**Average DBH[c] (cm):**	2.1

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	1.4	3	98	9.8	16.6%
Acer saccharinum	SILVER MAPLE	tree	1.7	3	20	2	3.4%
Acer saccharum	SUGAR MAPLE	tree	0.8	5	24	2.4	4.1%
Asimina triloba	PAWPAW	sm tree	1.3	6	1	0.1	0.2%
Cercis canadensis	REDBUD	sm tree	2.4	3	7	0.7	1.2%
Cornus florida	FLOWERING	sm tree	1.0	5	4	0.4	0.7%
Cornus racemosa	GRAY DOGWOOD	shrub	0.6	1	3	0.3	0.5%
Fagus grandifolia	AMERICAN BEECH	tree	2.1	7	6	0.6	1.0%
Fraxinus americana	WHITE ASH	tree	4.6	6	1	0.1	0.2%
Fraxinus pennsylvanica	GREEN ASH	tree	1.1	3	6	0.6	1.0%
Hydrangea arborescens	WILD HYDRANGEA	shrub	N/A[e]	7	1	0.1	0.2%
Juglans nigra	BLACK WALNUT	tree	1.3	5	10	1	1.7%
Liriodendron tulipifera	TULIP TREE	tree	0.6	6	2	0.2	0.3%
Ostrya virginiana	HOP-HORNBEAM	tree	1.1	5	3	0.3	0.5%
Platanus occidentalis	SYCAMORE	tree	2.3	7	112	11.2	18.9%
Populus deltoides	EASTERN	tree	2.3	3	185	18.5	31.2%
Prunus serotina	BLACK CHERRY	tree	0.6	3	2	0.2	0.3%
Quercus alba	WHITE OAK	tree	2.0	6	2	0.2	0.3%
Quercus imbricaria	SHINGLE OAK	tree	0.6	5	1	0.1	0.2%
Quercus macrocarpa	BUR OAK	tree	3.7	6	2	0.2	0.3%
Quercus rubra	RED OAK	tree	4.1	6	1	0.1	0.2%
Rhus glabra	SMOOTH SUMAC	shrub	1.3	2	4	0.4	0.7%
Robinia pseudoacacia	BLACK LOCUST	tree	7.2	0	3	0.3	0.5%
Rubus allegheniensis	COMMON	shrub	N/A[e]	1	54	5.4	9.1%
Rubus occidentalis	BLACK RASPBERRY	shrub	N/A[e]	1	8	0.8	1.4%
Ulmus americana	AMERICAN ELM	tree	0.6	2	1	0.1	0.2%
Vitis sp.	NDA[d]	vine	N/A[e]	NDA[d]	8	0.8	1.4%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0.3	0	6	0.6	1.0%
Maclura pomifera	**OSAGE-ORANGE**	tree	0.6	0	1	0.1	0.2%
Morus alba	**WHITE MULBERRY**	tree	2.0	0	3	0.3	0.5%
Quercus acutissima	**SAWTOOTH OAK**	tree	8.0	0	2	0.2	0.4%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	11	1.1	1.9%
			Native Species:		569	56.9	96.1%
			Non-Native Species:		23	2.3	3.9%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–73. PRWRF2 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	3.33	**Native Species:**	20
Total Species:	24	**Non-Native Species.:**	4
FQAI[b]:	16.33	**Percent Native:**	83%
Total Abundance:	421	**Average DBH[c] (cm):**	1.7

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	1.5	3	74	7.4	17.5%
Acer saccharinum	SILVER MAPLE	tree	0.9	3	8	0.8	1.9%
Acer saccharum	SUGAR MAPLE	tree	1.9	5	9	0.9	2.1%
Carya laciniosa	SHELLBARK HICKORY	tree	0.6	7	3	0.3	0.7%
Cercis canadensis	REDBUD	sm tree	0.8	3	3	0.3	0.7%
Cornus amomum	SILKY DOGWOOD	shrub	1.3	2	3	0.3	0.7%
Crataegus crus-galli	COCKSPUR	sm tree	2.0	3	1	0.1	0.2%
Fraxinus americana	WHITE ASH	tree	1.4	6	6	0.6	1.4%
Fraxinus pennsylvanica	GREEN ASH	tree	3.8	3	1	0.1	0.2%
Hamamelis virginiana	WITCH-HAZEL	sm tree	0.6	5	5	0.5	1.2%
Juglans nigra	BLACK WALNUT	tree	2.3	5	27	2.7	6.4%
Prunus serotina	BLACK CHERRY	tree	2.3	3	5	0.5	1.2%
Quercus alba	WHITE OAK	tree	2.3	6	10	1	2.4%
Quercus macrocarpa	BUR OAK	tree	0.6	6	1	0.1	0.2%
Quercus muehlenbergii	CHINQUAPIN OAK	tree	2.3	7	4	0.4	0.9%
Quercus rubra	RED OAK	tree	3.3	6	1	0.1	0.2%
Rhus glabra	SMOOTH SUMAC	shrub	N/A[e]	2	125	12.5	29.6%
Rhus typhina	STAGHORN SUMAC	shrub	0.6	2	27	2.7	6.4%
Robinia pseudoacacia	BLACK LOCUST	tree	3.1	0	16	1.6	3.8%
Symphoricarpos orbiculatus	CORALBERRY	shrub	N/A[e]	3	11	1.1	2.6%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0.1	0	68	6.8	16.1%
Maclura pomifera	**OSAGE-ORANGE**	tree	1.7	0	2	0.2	0.5%
Pyrus communis	**PEAR**	sm tree	2.2	0	8	0.8	1.9%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	3	0.3	0.7%
			Native Species:		340	34.0	80.8%
			Non-Native Species:		81	8.1	19.2%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–74. SWURF1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	4.00	**Native Species:**	11
Total Species:	13	**Non-Native Species.:**	2
FQAI[b]:	14.42	**Percent Native:**	85%
Total Abundance:	82	**Average DBH[c] (cm):**	1.1

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Fraxinus americana	WHITE ASH	tree	1.8	6	9	0.9	11.0%
Fraxinus pennsylvanica	GREEN ASH	tree	0.6	3	2	0.2	2.4%
Fraxinus sp.	NDA[d]	tree	3.0	NDA[d]	1	0.1	1.2%
Platanus occidentalis	SYCAMORE	tree	1.9	7	6	0.6	7.3%
Populus deltoides	EASTERN COTTONWOOD	tree	1.4	3	24	2.4	29.3%
Quercus coccinea	SCARLET OAK	tree	0.6	6	1	0.1	1.2%
Quercus rubra	RED OAK	tree	0.6	6	2	0.2	2.4%
Quercus shumardii	SHUMARD OAK	tree	1.2	7	2	0.2	2.4%
Quercus velutina	BLACK OAK	tree	1.1	7	3	0.3	3.7%
Rhus glabra	SMOOTH SUMAC	shrub	0.6	2	4	0.4	4.9%
Salix exigua	SANDBAR WILLOW	shrub	0.7	1	17	1.7	20.7%
Pyrus communis	**PEAR**	sm tree	0.6	0	1	0.1	1.2%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	0.1	0	10	1	12.2%
			Native Species:		71	7.1	86.6%
			Non-Native Species:		11	1.1	13.4%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–75. SWURF2 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	4.58	**Native Species:**	16
Total Species:	19	**Non-Native Species.:**	3
FQAI[b]:	19.96	**Percent Native:**	84%
Total Abundance:	122	**Average DBH[c] (cm):**	2.1

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Carya cordiformis	BITTERNUT HICKORY	tree	1.4	5	3	0.3	2.5%
Carya tomentosa	MOCKERNUT HICKORY	tree	2.1	6	5	0.5	4.1%
Fagus grandifolia	AMERICAN BEECH	tree	1.4	7	5	0.5	4.1%
Fraxinus americana	WHITE ASH	tree	0.6	6	1	0.1	0.8%
Fraxinus pennsylvanica	GREEN ASH	tree	0.6	3	1	0.1	0.8%
Hamamelis virginiana	WITCH-HAZEL	sm tree	1.3	5	1	0.1	0.8%
Juniperus virginiana	EASTERN RED CEDAR	tree	2.0	3	9	0.9	7.4%
Liquidambar styraciflua	SWEETGUM	tree	0.6	6	1	0.1	0.8%
Physocarpus opulifolius	NINEBARK	shrub	0.6	4	5	0.5	4.1%
Platanus occidentalis	SYCAMORE	tree	17.5	7	6	0.6	4.9%
Populus deltoides	EASTERN COTTONWOOD	tree	0.6	3	6	0.6	4.9%
Quercus bicolor	SWAMP WHITE OAK	tree	2.4	7	2	0.2	1.6%
Quercus coccinea	SCARLET OAK	tree	0.6	6	1	0.1	0.8%
Quercus macrocarpa	BUR OAK	tree	0.6	6	1	0.1	0.8%
Quercus velutina	BLACK OAK	tree	0.6	7	1	0.1	0.8%
Tilia americana	AMERICAN BASSWOOD	tree	1.5	6	1	0.1	0.8%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	70	7	57.4%
Pyrus communis	**PEAR**	sm tree	0.6	0	1	0.1	0.8%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	2	0.2	1.6%
			Native Species:		49	4.9	40.2%
			Non-Native Species:		73	7.3	59.8%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–76. NPPSF1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	4.07	Native Species:	14
Total Species:	15	Non-Native Species.:	1
FQAI[b]:	15.75	Percent Native:	93%
Total Abundance:	365	Average DBH[c] (cm):	16.6

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Celtis occidentalis	HACKBERRY	tree	12.4	4	11	1.1	3.0%
Cercis canadensis	REDBUD	sm tree	15.7	3	1	0.1	0.3%
Cornus florida	FLOWERING DOGWOOD	sm tree	4.6	5	2	0.2	0.5%
Cornus racemosa	GRAY DOGWOOD	shrub	3.3	1	5	0.5	1.4%
Fraxinus americana	WHITE ASH	tree	15.3	6	4	0.4	1.1%
Fraxinus pennsylvanica	GREEN ASH	tree	23.5	3	9	0.9	2.5%
Juglans nigra	BLACK WALNUT	tree	23.6	5	12	1.2	3.3%
Quercus imbricaria	SHINGLE OAK	tree	23.1	5	4	0.4	1.1%
Quercus muehlenbergii	CHINQUAPIN OAK	tree	9.7	7	2	0.2	0.5%
Quercus rubra	RED OAK	tree	35.2	6	5	0.5	1.4%
Quercus shumardii	SHUMARD OAK	tree	28.1	7	2	0.2	0.5%
Quercus velutina	BLACK OAK	tree	16.8	7	2	0.2	0.5%
Robinia pseudoacacia	BLACK LOCUST	tree	9.0	0	29	2.9	7.9%
Ulmus americana	AMERICAN ELM	tree	11.6	2	4	0.4	1.1%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	273	27.3	74.8%
			Native Species:		92	9.2	25.2%
			Non-Native Species:		273	27.3	74.8%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–77. NWESF1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	3.38	Native Species:	11
Total Species:	13	Non-Native Species.:	2
FQAI[b]:	12.20	Percent Native:	85%
Total Abundance:	280	Average DBH[c] (cm):	22.6

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOXELDER	tree	24.7	3	8	0.8	2.9%
Acer saccharinum	SILVER MAPLE	tree	30.2	3	1	0.1	0.4%
Carya laciniosa	SHELLBARK HICKORY	tree	14.7	7	46	4.6	16.4%
Celtis occidentalis	HACKBERRY	tree	9.9	4	2	0.2	0.7%
Cornus racemosa	GRAY DOGWOOD	shrub	0.6	1	1	0.1	0.4%
Fraxinus pennsylvanica	GREEN ASH	tree	28.2	3	6	0.6	2.1%
Platanus occidentalis	SYCAMORE	tree	50.5	7	1	0.1	0.4%
Quercus shumardii	SHUMARD OAK	tree	22.4	7	1	0.1	0.4%
Quercus velutina	BLACK OAK	tree	30.7	7	1	0.1	0.4%
Ulmus americana	AMERICAN ELM	tree	14.4	2	14	1.4	5.0%
Vitis sp.	ND[c]	vine	N/A[e]	0	8	0.8	2.9%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	143	14.3	51.1%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	48	4.8	17.1%
			Native Species:		89	8.9	31.8%
			Non-Native Species:		191	19.1	68.2%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–78. PRESF1 Forest Functional Monitoring Woody Stem Data Summary

Mean CC[a]:	4.18	**Native Species:**	21
Total Species:	23	**Non-Native Species.:**	2
FQAI[b]:	20.06	**Percent Native:**	91%
Total Abundance:	600	**Average DBH[c] (cm):**	11.8

Species	Common Name	Type	Avg DBH (cm)	CC	Abundance	Density (ind./100m^2)	Relative Density
Acer negundo	BOX ELDER	tree	11.4	3	19	1.9	3.2%
Acer saccharum	SUGAR MAPLE	tree	15.4	5	4	0.4	0.7%
Aesculus glabra	OHIO BUCKEYE	tree	5.2	6	2	0.2	0.3%
Asimina triloba	PAWPAW	sm tree	1.9	6	191	19.1	31.8%
Carya cordiformis	BITTERNUT HICKORY	tree	5.2	5	2	0.2	0.3%
Celastrus scandens	BITTERSWEET	vine	0.6	2	1	0.1	0.2%
Celtis occidentalis	HACKBERRY	tree	22.1	4	2	0.2	0.3%
Cercis canadensis	REDBUD	sm tree	10.1	3	6	0.6	1.0%
Cornus florida	FLOWERING DOGWOOD	sm tree	2.2	5	27	2.7	4.5%
Fraxinus pennsylvanica	GREEN ASH	tree	0.6	3	2	0.2	0.3%
Fraxinus quadrangulata	BLUE ASH	tree	7.2	7	3	0.3	0.5%
Gleditsia triacanthos	HONEY LOCUST	tree	27.4	4	1	0.1	0.2%
Juglans nigra	BLACK WALNUT	tree	35.3	5	6	0.6	1.0%
Juniperus virginiana	EASTERN RED CEDAR	tree	19.8	3	4	0.4	0.7%
Platanus occidentalis	SYCAMORE	tree	19.3	7	1	0.1	0.2%
Prunus serotina	BLACK CHERRY	tree	13.8	3	3	0.3	0.5%
Quercus imbricaria	SHINGLE OAK	tree	11.0	5	4	0.4	0.7%
Quercus muehlenbergii	CHINQUAPIN OAK	tree	13.8	7	2	0.2	0.3%
Quercus shumardii	SHUMARD OAK	tree	0.6	7	1	0.1	0.2%
Ulmus americana	AMERICAN ELM	tree	12.4	2	4	0.4	0.7%
Vitis sp.	NDA[d]	vine	N/A[e]	NDA[d]	13	1.3	2.2%
Loniciera maackii	**AMUR HONEYSUCKLE**	shrub	N/A[e]	0	298	29.8	49.7%
Rosa multiflora	**MULTIFLORA ROSE**	shrub	N/A[e]	0	4	0.4	0.7%
			Native Species:		298	29.8	49.7%
			Non-Native Species:		302	30.2	50.3%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] DBH- Diameter at Breast Height
[d] NDA= No Determination Available
[e] N/A= Not Applicable
Species in bold are non-native.

Table D–79. Implementation Monitoring Summary

Area	Total Species	Native Species	Native Species (Percent)	Relative Frequency of Native Species (Percent)	Cover (Percent)
FPA-Haul Road	19	11	58%	49%	85%
FPA - Solid Waste Landfill	24	14	58%	51%	85%
FPA-Prairie Area	15	5	33%	40%	73%

Table D–80. FPA-Haul Road Implementation Monitoring Herbaceous Cover Data Summary

Total Species:	19	**Mean CC[a]:**	1.26
Native Species:	11	**Average Cover:**	85.3%
Non-Native Species:	8	**FQAI[b]:**	5.51
Percent Native:	58%		

Species	Common Name	Type	CC	Frequency (species/quadrat)	Relative Frequency
Amaranthus albus	TUMBLEWEED	forb	0	0.20	2%
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	0.60	7%
Conyza canadensis	HORSEWEED	forb	0	0.40	5%
Elymus canadensis	CANADA WILD RYE	grass	6	0.60	7%
Heliopsis helianthoides	SMOOTH OXEYE	forb	5	0.20	2%
Lactuca biennis	TALL BLUE LETTUCE	forb	1	0.20	2%
Panicum capillare	WITCH GRASS	grass	1	0.20	2%
Panicum virgatum	SWITCH GRASS	grass	4	0.20	2%
Ratibida pinnata	GRAY-HEADED CONEFLOWER	forb	5	0.20	2%
Rudbeckia hirta	BLACK-EYED SUSAN	forb	1	0.80	10%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.40	5%
Bromus japonicus	**JAPANESE BROME**	grass	0	0.20	2%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.60	7%
Echinochloa crusgalli	**BARNYARD GRASS**	grass	0	0.40	5%
Lolium multiflorum	**ITALIAN RYEGRASS**	grass	0	0.40	5%
Melilotus officinalis	**YELLOW SWEET-CLOVER**	forb	0	0.80	10%
Plantago lanceolata	**ENGLISH PLANTAIN**	forb	0	1.00	12%
Polygonum aviculare	**COMMON KNOTWEED**	forb	0	0.60	7%
Trifolium pratense	**RED CLOVER**	forb	0	0.20	2%
		Native Species:		4.00	49%
		Non-Native Species:		4.20	51%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination
Species in bold are non-native.

Table D–81. FPA - Solid Waste Landfill Implementation Monitoring Herbaceous Cover Data Summary

Total Species:	24	**Mean CC[a]:**	1.79
Native Species:	14	**Average Cover:**	85.3%
Non-Native Species:	10	**FQAI[b]:**	8.78
Percent Native:	58%		

Species	Common Name	Type	CC	Frequency (species/quadrat)	Relative Frequency
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	0.80	9%
Andropogon gerardii	BIG BLUESTEM	grass	5	0.20	2%
Bidens frondosa	DEVIL'S BEGGAR'S-TICK	forb	2	0.20	2%
Chamaecrista fasciculata	PARTRIDGE-PEA	forb	3	0.20	2%
Conyza canadensis	HORSEWEED	forb	0	0.40	4%
Echinacea purpurea	PURPLE CONEFLOWER	forb	6	0.40	4%
Elymus canadensis	CANADA WILD RYE	grass	6	0.40	4%
Eupatorium altissimum	TALL BONESET	forb	0	0.40	4%
Heliopsis helianthoides	SMOOTH OXEYE	forb	5	0.20	2%
Panicum virgatum	SWITCH GRASS	grass	4	0.40	4%
Ratibida pinnata	GRAY-HEADED CONEFLOWER	forb	5	0.20	2%
Rudbeckia hirta	BLACK-EYED SUSAN	forb	1	0.20	2%
Solidago canadensis	CANADA GOLDENROD	forb	1	0.60	6%
Sorghastrum nutans	INDIAN GRASS	grass	5	0.20	2%
Allium vineale	**FIELD GARLIC**	forb	0	0.40	4%
Bromus japonicus	**JAPANESE BROME**	grass	0	0.60	6%
Cichorium intybus	**CHICORY**	forb	0	0.20	2%
Cirsium vulgare	**BULL THISTLE**	forb	0	0.20	2%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	1.00	11%
Dipsacus fullonum	**WILD TEASEL**	forb	0	0.20	2%
Melilotus officinalis	**YELLOW SWEET-CLOVER**	forb	0	0.80	9%
Plantago lanceolata	**ENGLISH PLANTAIN**	forb	0	0.40	4%
Setaria sp.	**NDA[c]**	grass	0	0.60	6%
Trifolium repens	**WHITE CLOVER**	forb	0	0.20	2%
			Native Species:	4.80	51%
			Non-Native Species:	4.60	49%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] ND= No Determination Available
Species in bold are non-native.

Table D–82. FPA -Prairie Area Implementation Monitoring Herbaceous Cover Data Summary

Total Species:	15	**Mean CC[a]:**	0.47
Native Species:	5	**Average Cover:**	73.4%
Non-Native Species:	10	**FQAI[b]:**	1.81
Percent Native:	33%		

Species	Common Name	Type	CC	Frequency (species/quadrat)	Relative Frequency
Ambrosia artemisiifolia	COMMON RAGWEED	forb	0	1.00	17%
Aster pilosus	AWL ASTER	forb	1	0.20	3%
Erigeron annuus	DAISY FLEABANE	forb	0	0.20	3%
Ratibida pinnata	GRAY-HEADED CONEFLOWER	forb	5	0.60	10%
Rudbeckia hirta	BLACK-EYED SUSAN	forb	1	0.40	7%
Agrostis gigantea	**REDTOP**	grass	0	0.20	3%
Cichorium intybus	**CHICORY**	forb	0	0.20	3%
Daucus carota	**QUEEN-ANNE'S-LACE**	forb	0	0.80	13%
Lolium multiflorum	**ITALIAN RYEGRASS**	grass	0	0.60	10%
Melilotus officinalis	**YELLOW SWEET-CLOVER**	forb	0	0.20	3%
Plantago lanceolata	**ENGLISH PLANTAIN**	forb	0	0.60	10%
Polygonum aviculare	**COMMON KNOTWEED**	forb	0	0.20	3%
Taraxacum officinale	**COMMON DANDELION**	forb	0	0.20	3%
Trifolium pratense	**RED CLOVER**	forb	0	0.20	3%
Trifolium repens	**WHITE CLOVER**	forb	0	0.40	7%
			Native Species:	2.40	40%
			Non-Native Species:	3.60	60%

[a] CC = Coefficent of Conservatism
[b] FQAI = Florist Quality Assessment Index
[c] NDA= No Determination Available
Species in bold are non-native.

Table D–83. Reptile Coverboard Observations

Species	Common Name	BAPW3	BAPW4	BAPW5	BAPW7	BAPW8	BAPW9	NPPW1	NPPW2	NPPW3	NPPW4	NPPW5	PREW6	WM1W1	WM1W2	WM1W3	WM1W4	WM1W5	WM1W6	WM1W7	WM2M1	WM2W2	WM2W3	Frequency	Relative Frequency
Blarina brevicauda	short-tailed shrew	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	1	4	3%
Elaphe obsoleta obsoleta	black rat snake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	1%
Microtus pennsylvanicus	meadow vole	0	2	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	1	1	6	14	9%
Peromyscus leucopis	field mouse	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	1%
Peromyscus maniculatus	deer mouse	5	6	10	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	1	29	18%
Nerodia sipedon	northern water snake	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	4	1	2	10	6%
Rana clamitans	American green frog	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	3	2%
Rana pipiens	leopard frog	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1%
Thamnophis sirtalis sirtalis	eastern garter snake	2	15	4	6	6	11	3	2	0	2	3	2	4	2	0	5	3	2	0	4	1	16	93	59%

Total Frequency: 158

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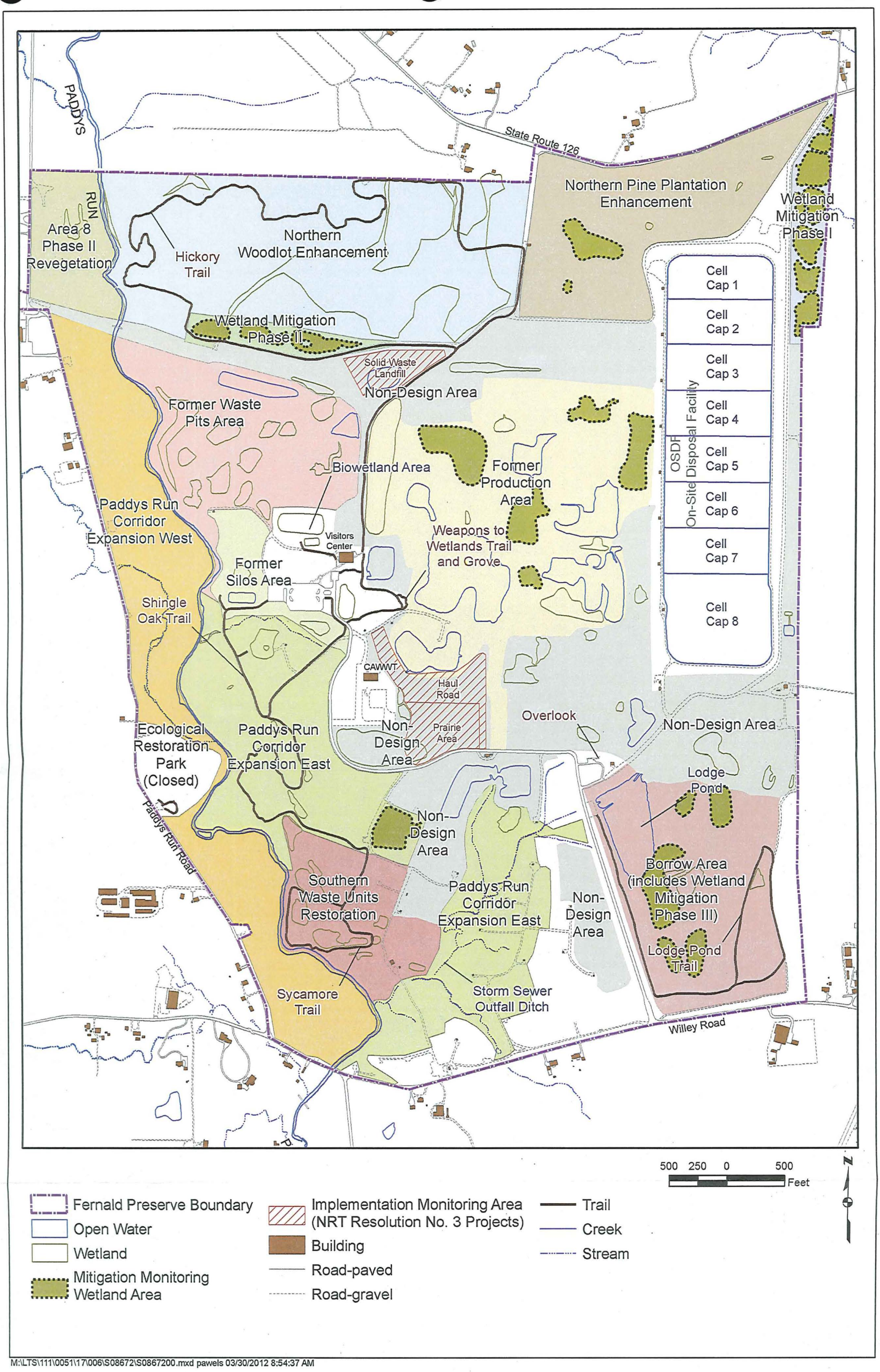

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Figure D–1. Ecological Monitoring Areas

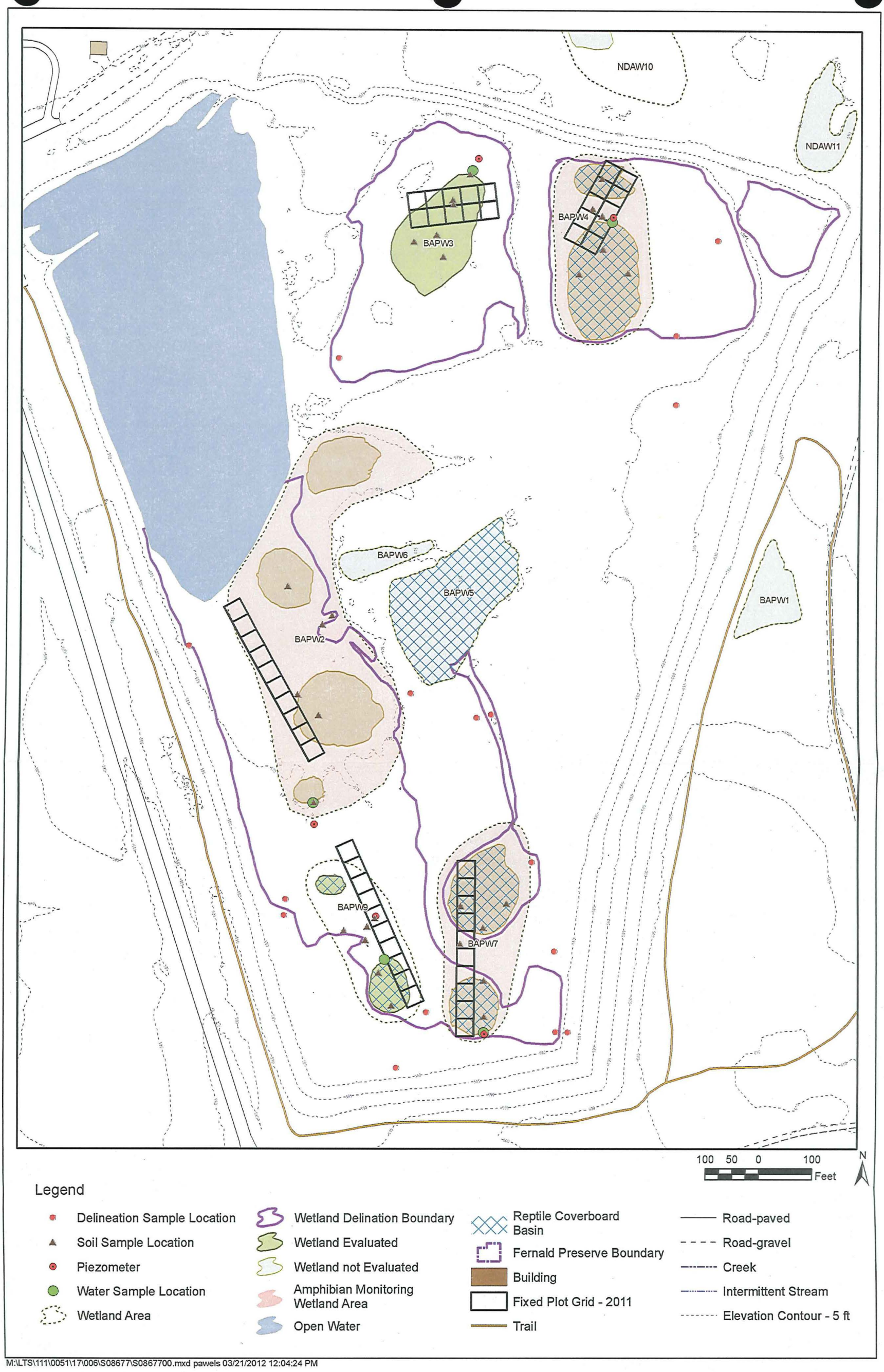

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Figure D–2A. Wetland Mitigation – Borrow Area Project Wetlands

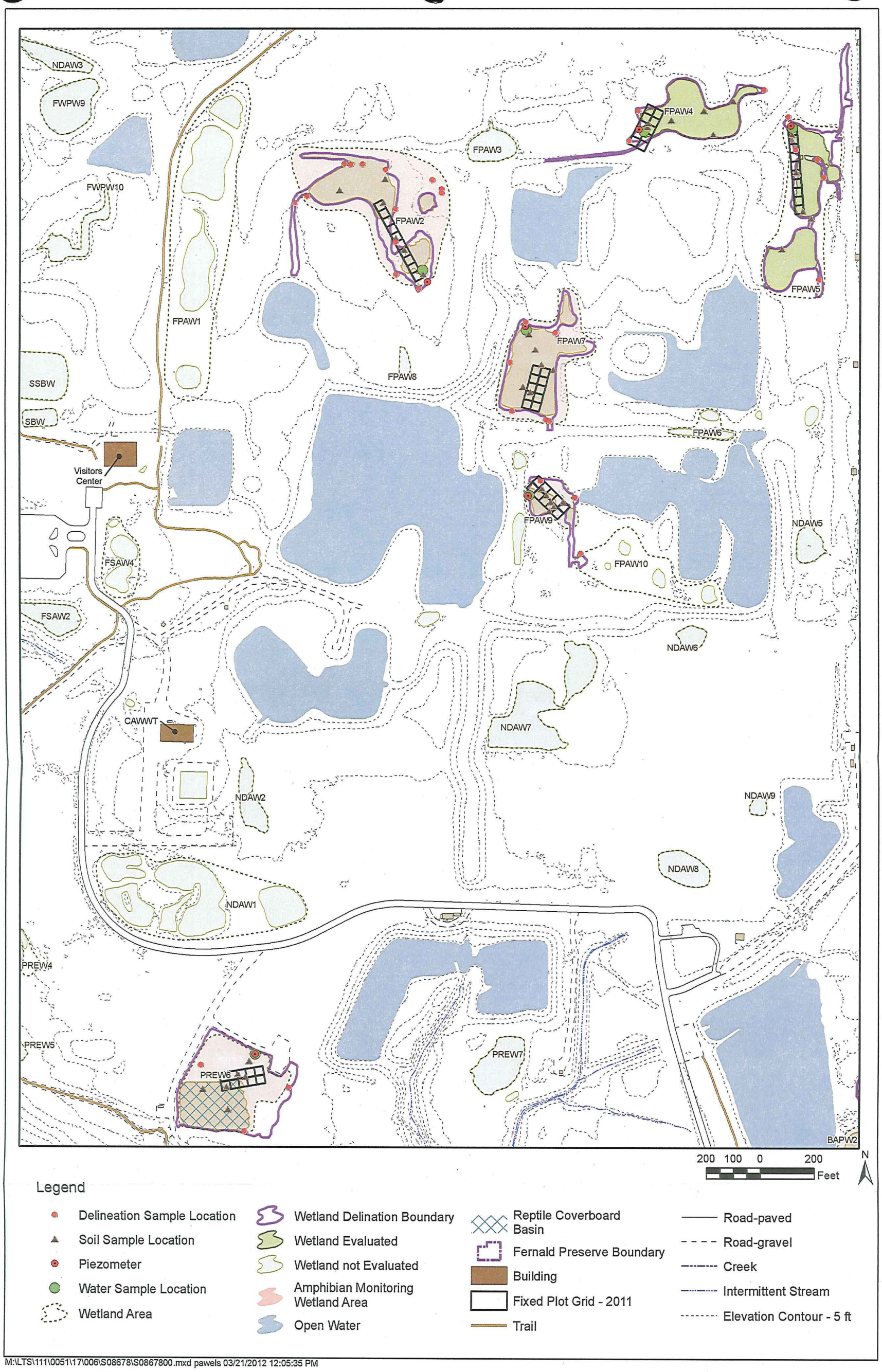

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Figure D–2B. Wetland Mitigation – Former Production Area Wetlands

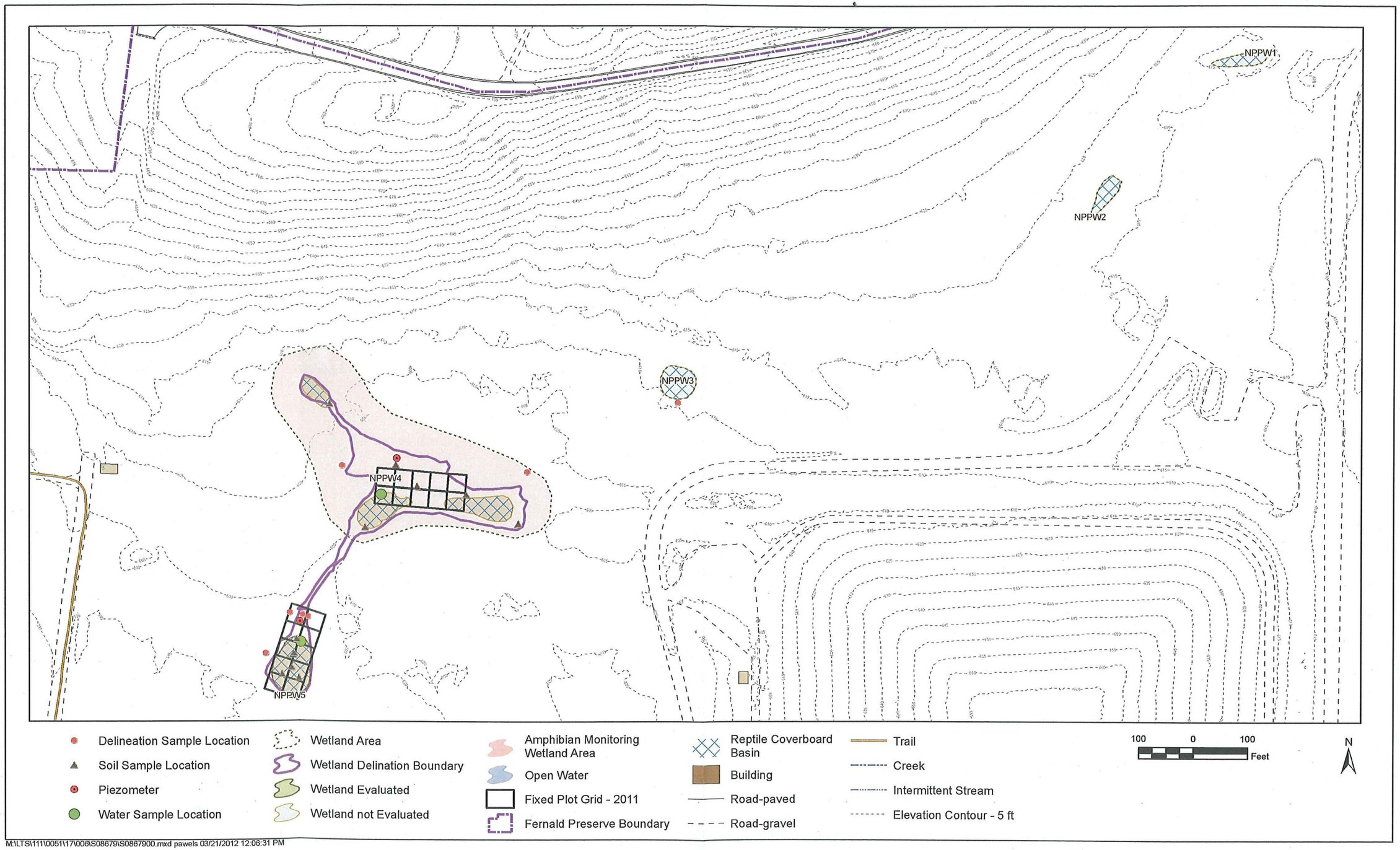

Figure D–2C. Wetland Mitigation – Northern Pine Plantation Wetlands

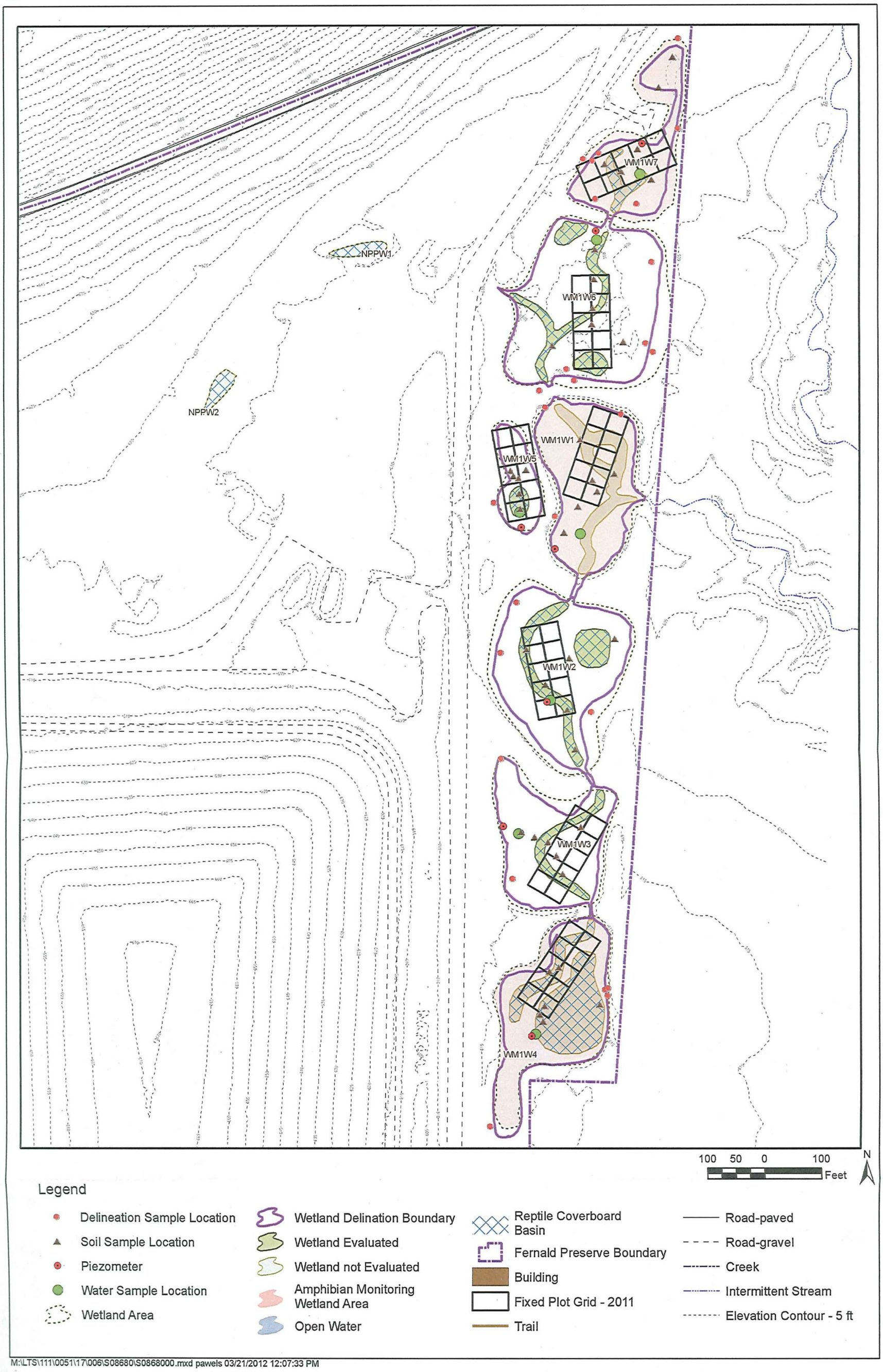

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Figure D–2D. Wetland Mitigation – Phase I Wetlands

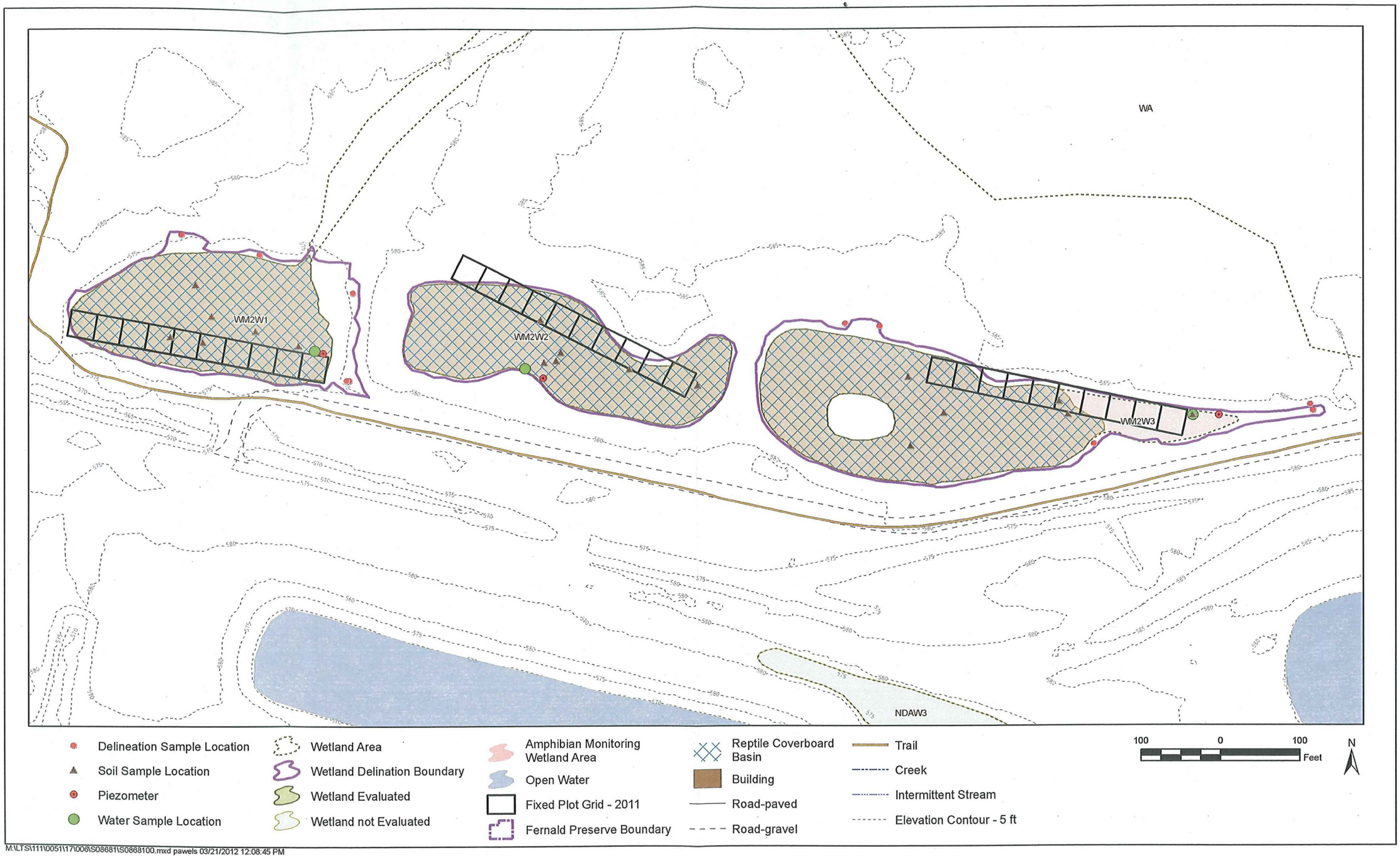

Figure D–2E. Wetland Mitigation – Phase II Wetlands

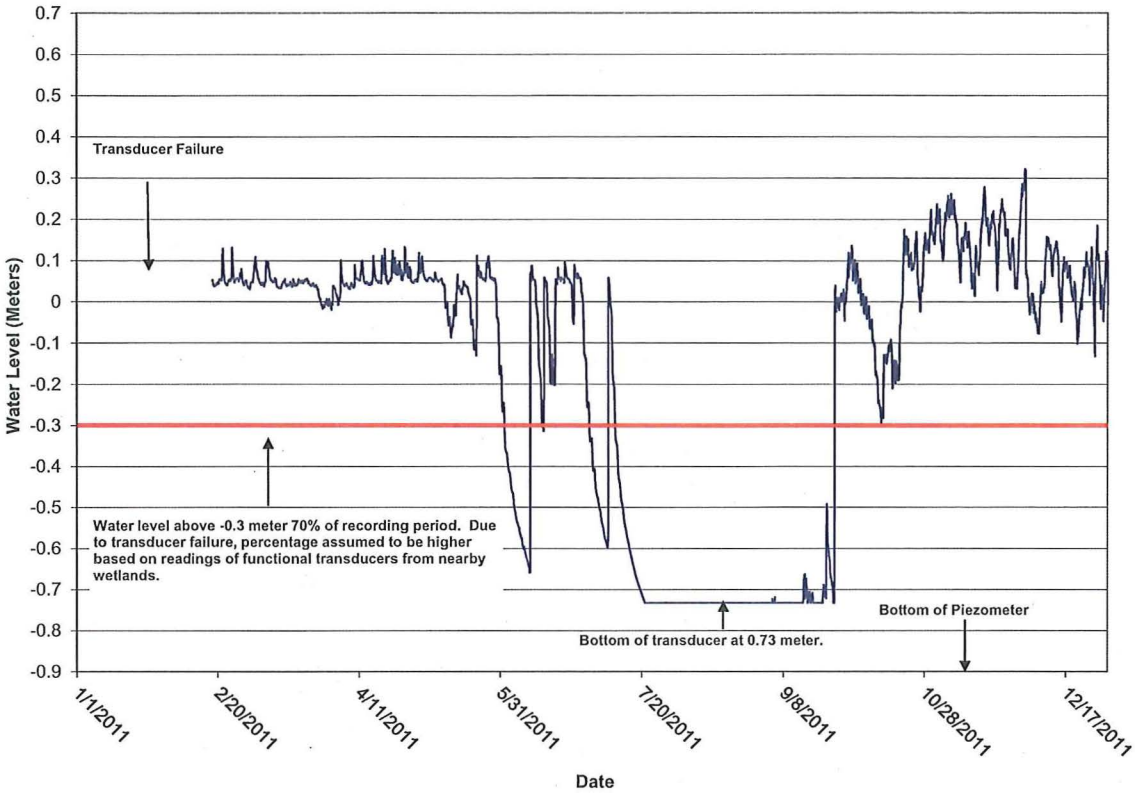

Figure D–3A. Wetland Area BAPW2 Hydrograph

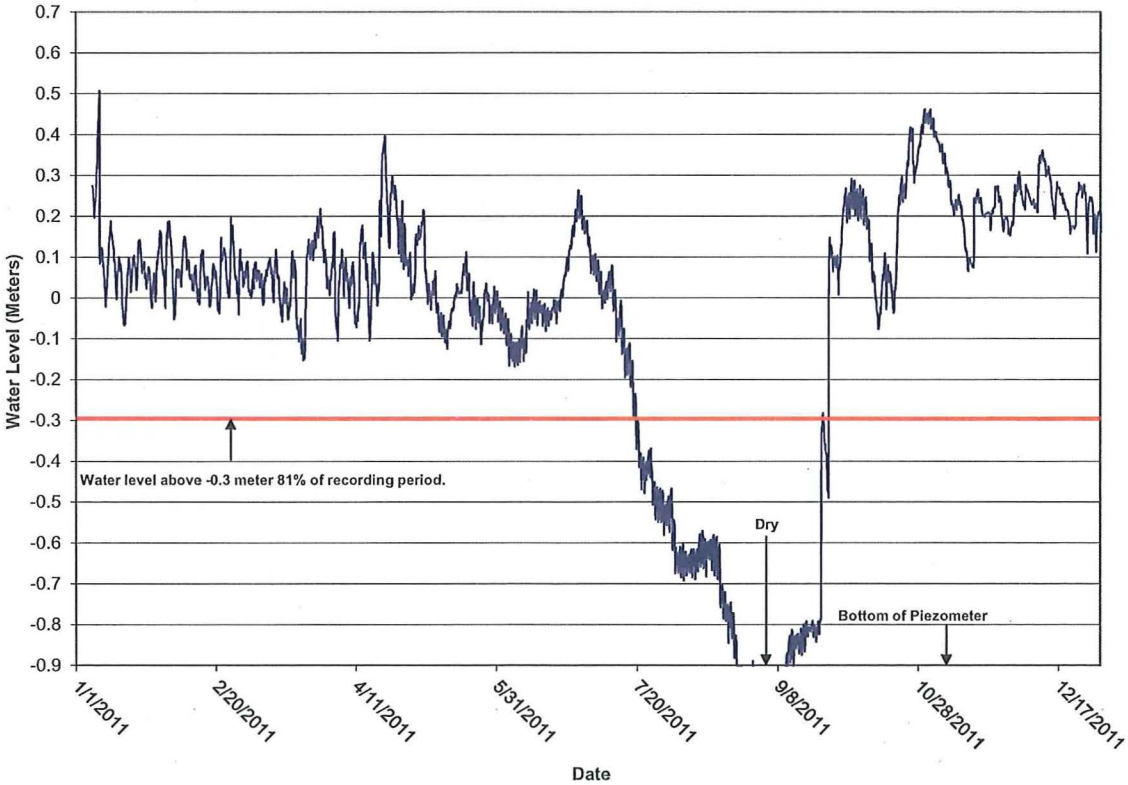

Figure D–3B. Wetland Area BAPW3 Hydrograph

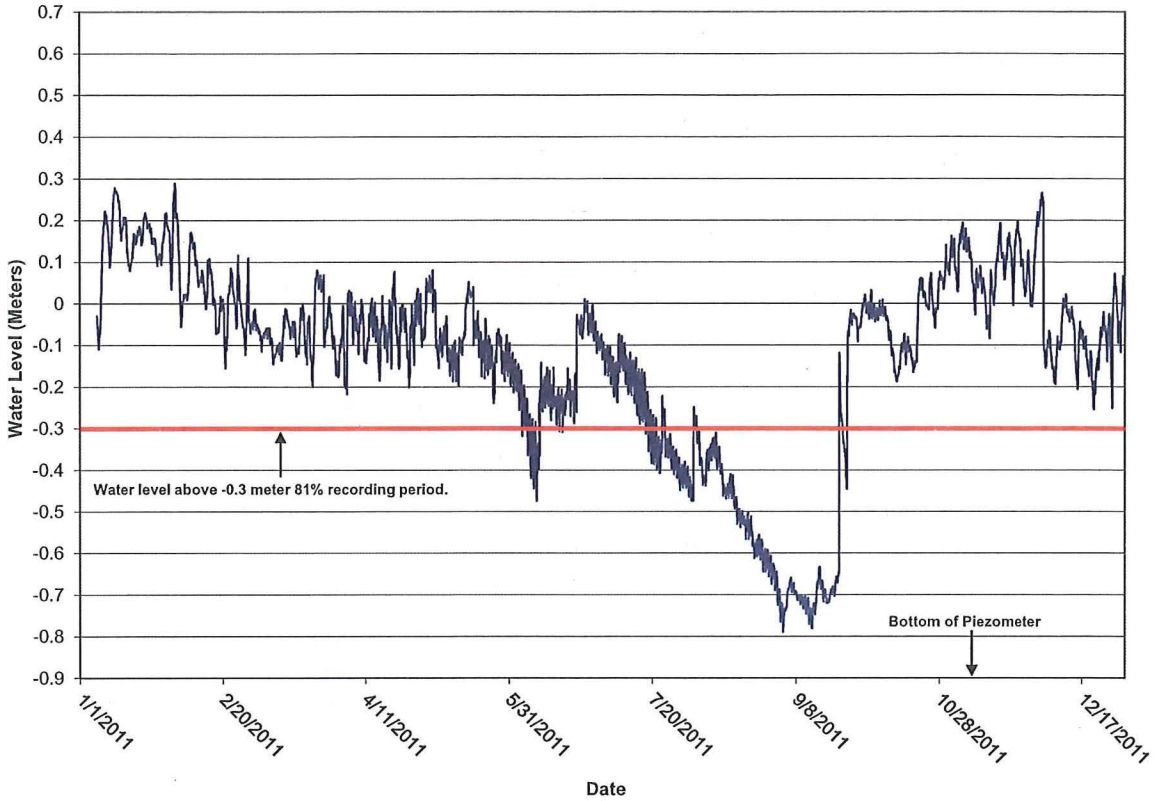

Figure D–3C. Wetland Area BAPW4 Hydrograph

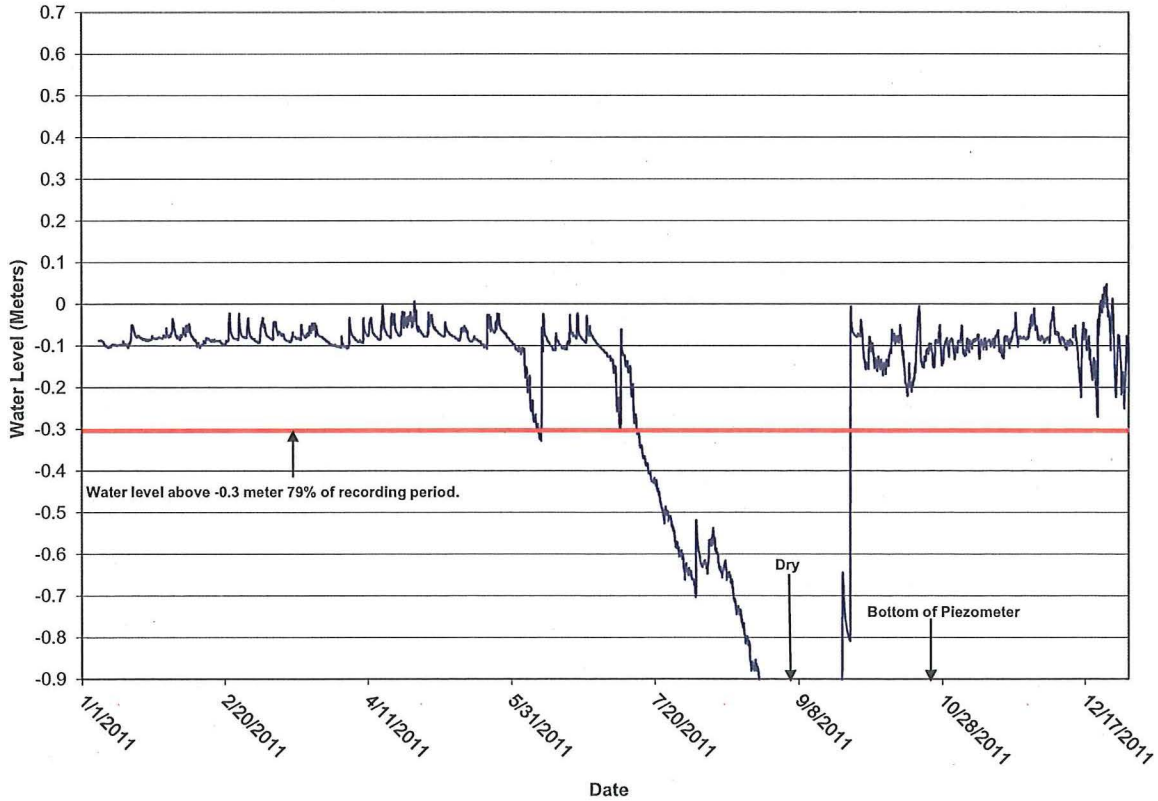

Figure D–3D. Wetland Area BAPW7 Hydrograph

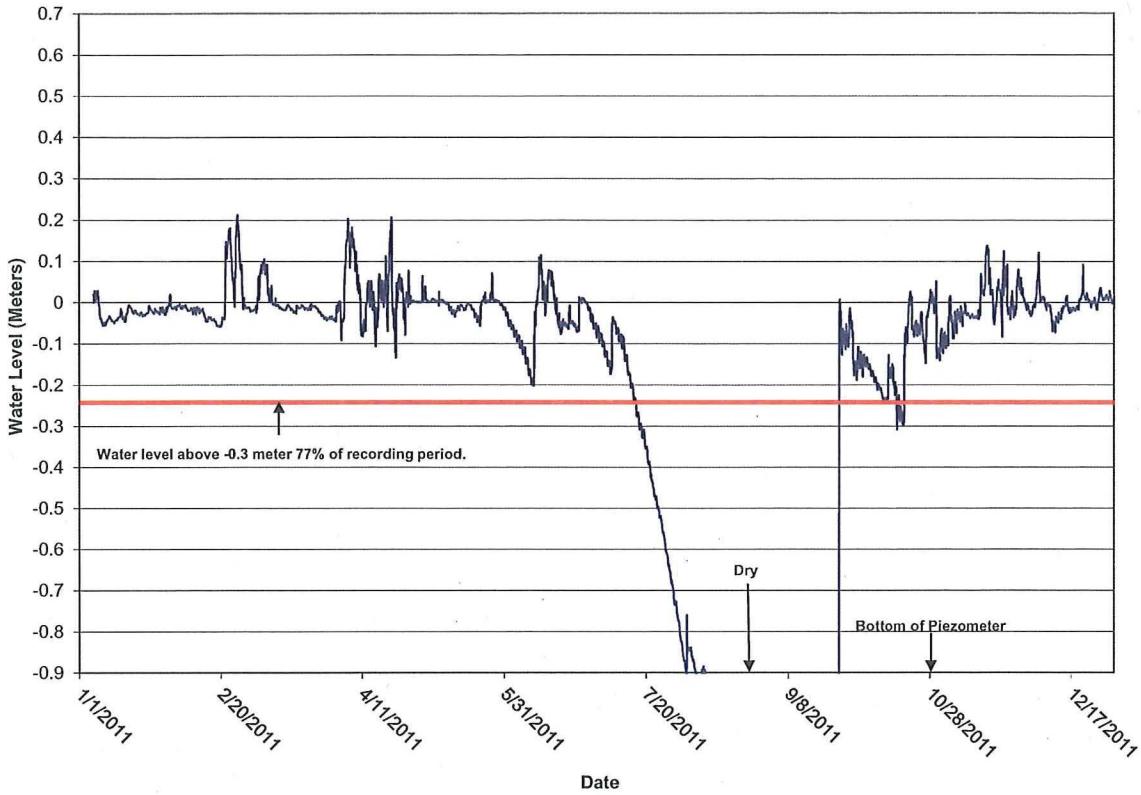

Figure D–3E. Wetland Area BAPW9 Hydrograph

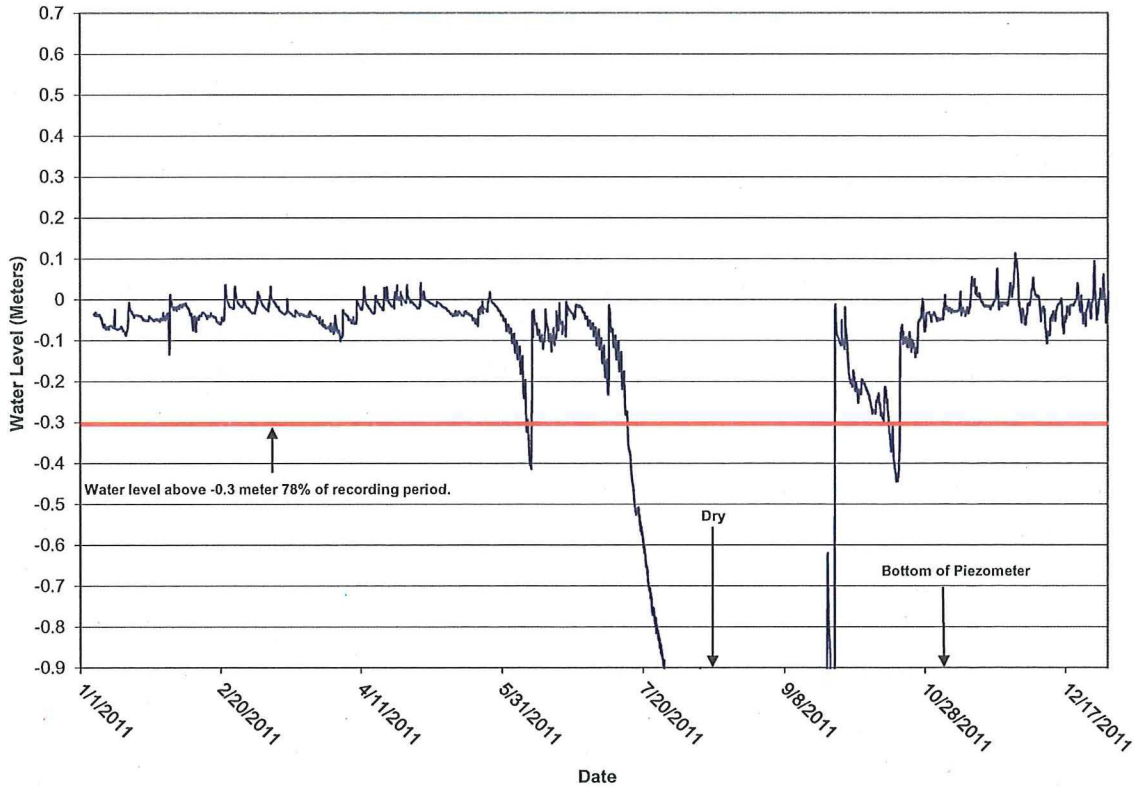

Figure D–3F. Wetland Area FPAW2 Hydrograph

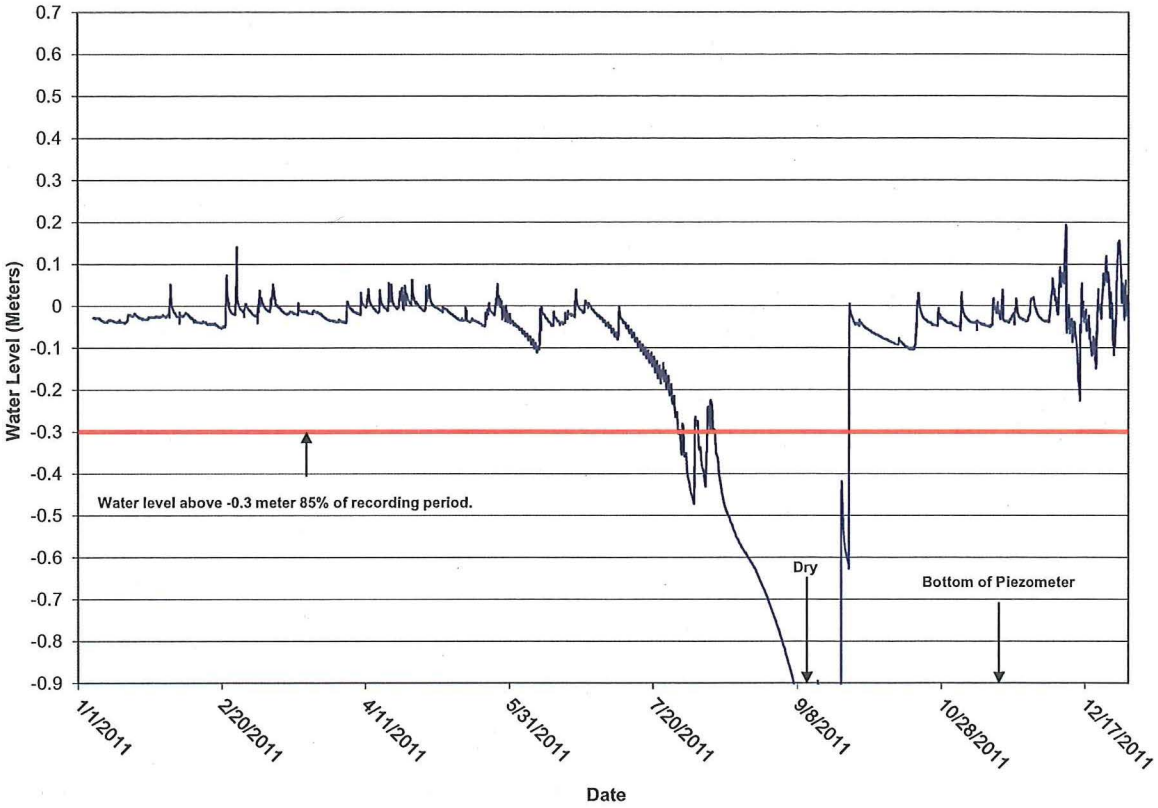

Figure D–3G. Wetland Area FPAW4 Hydrograph

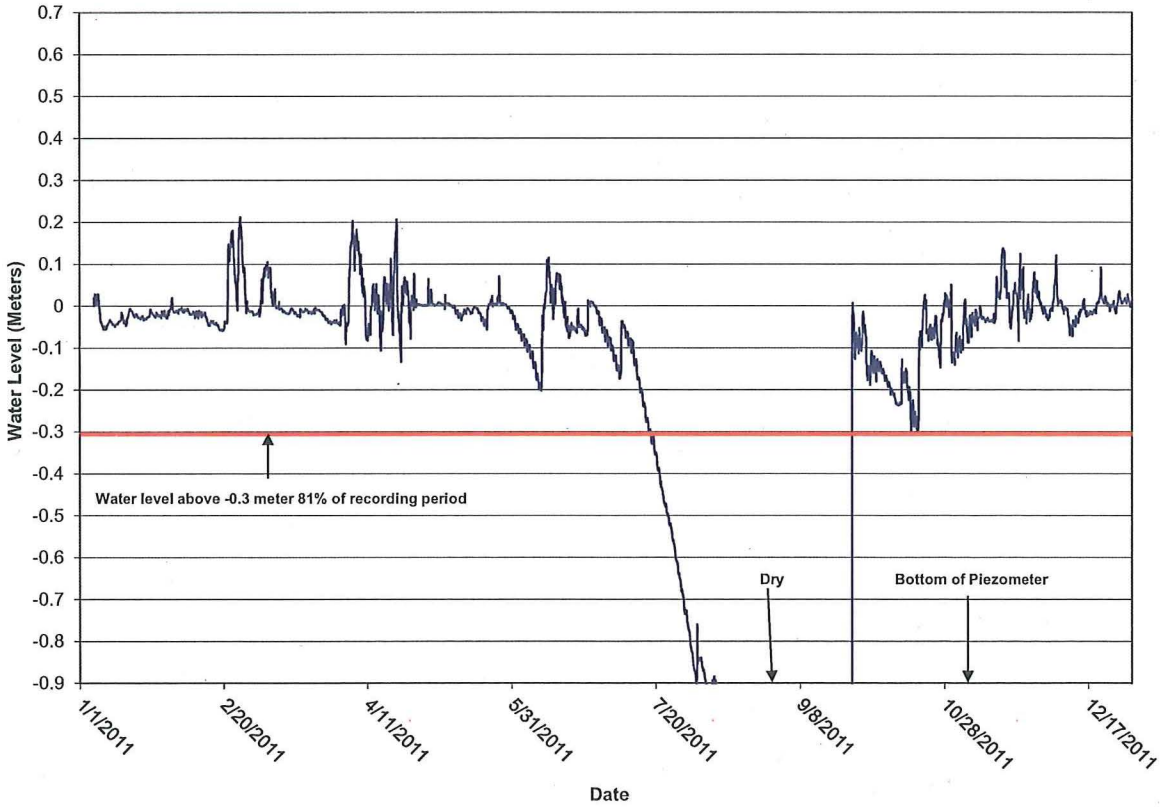

Figure D–3H. Wetland Area FPAW5 Hydrograph

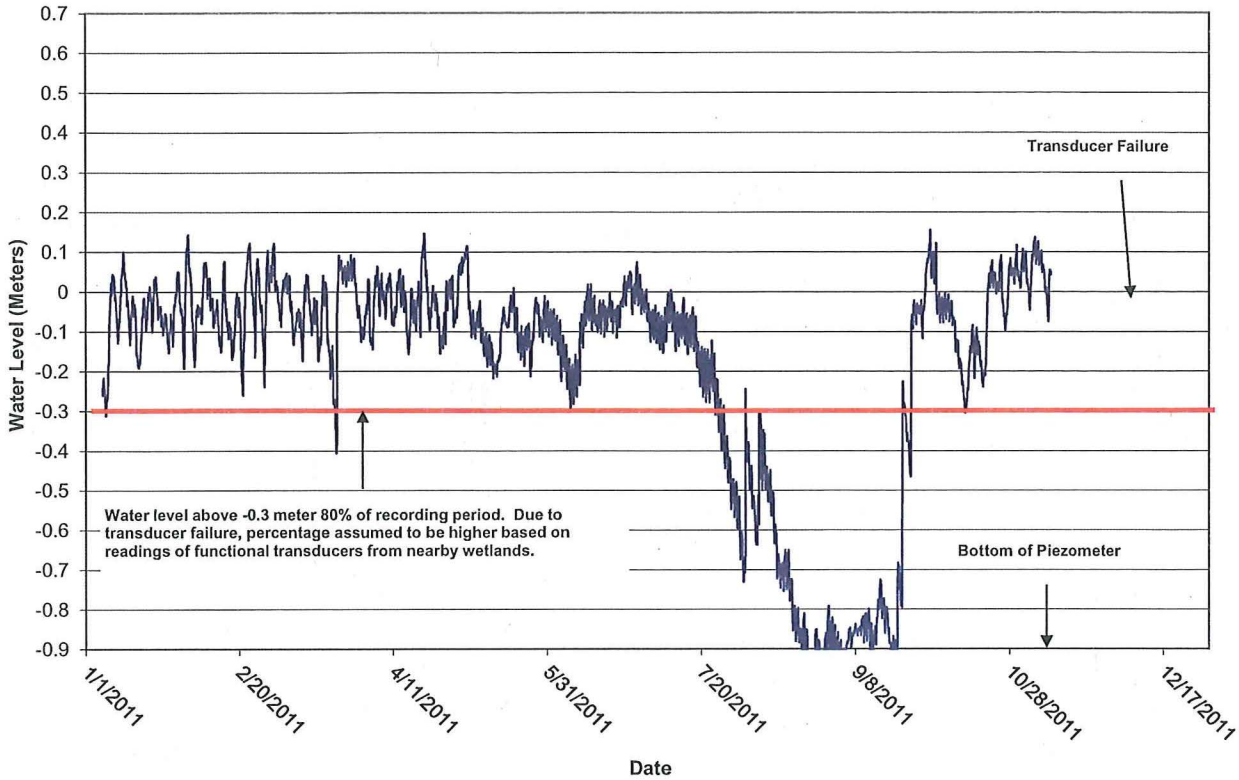

Figure D–3I. Wetland Area FPAW7 Hydrograph

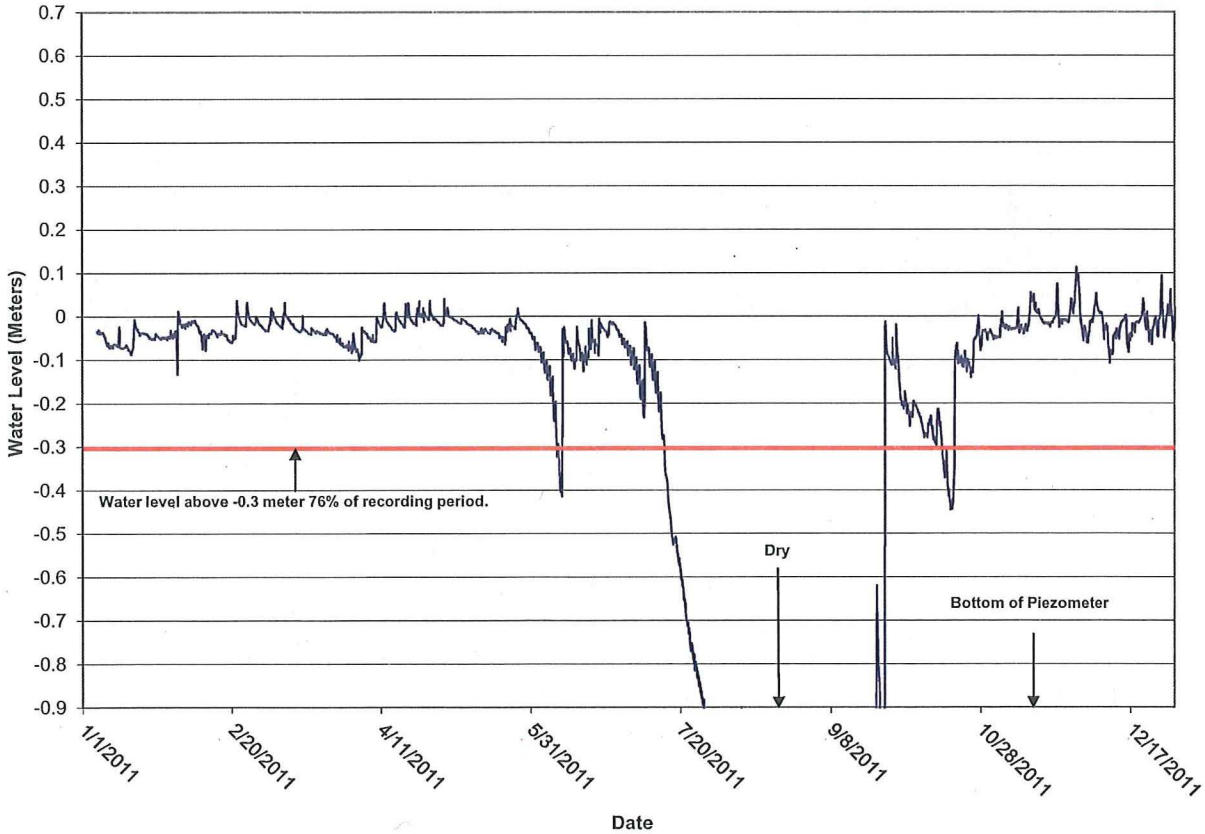

Figure D–3J. Wetland Area FPAW9 Hydrograph

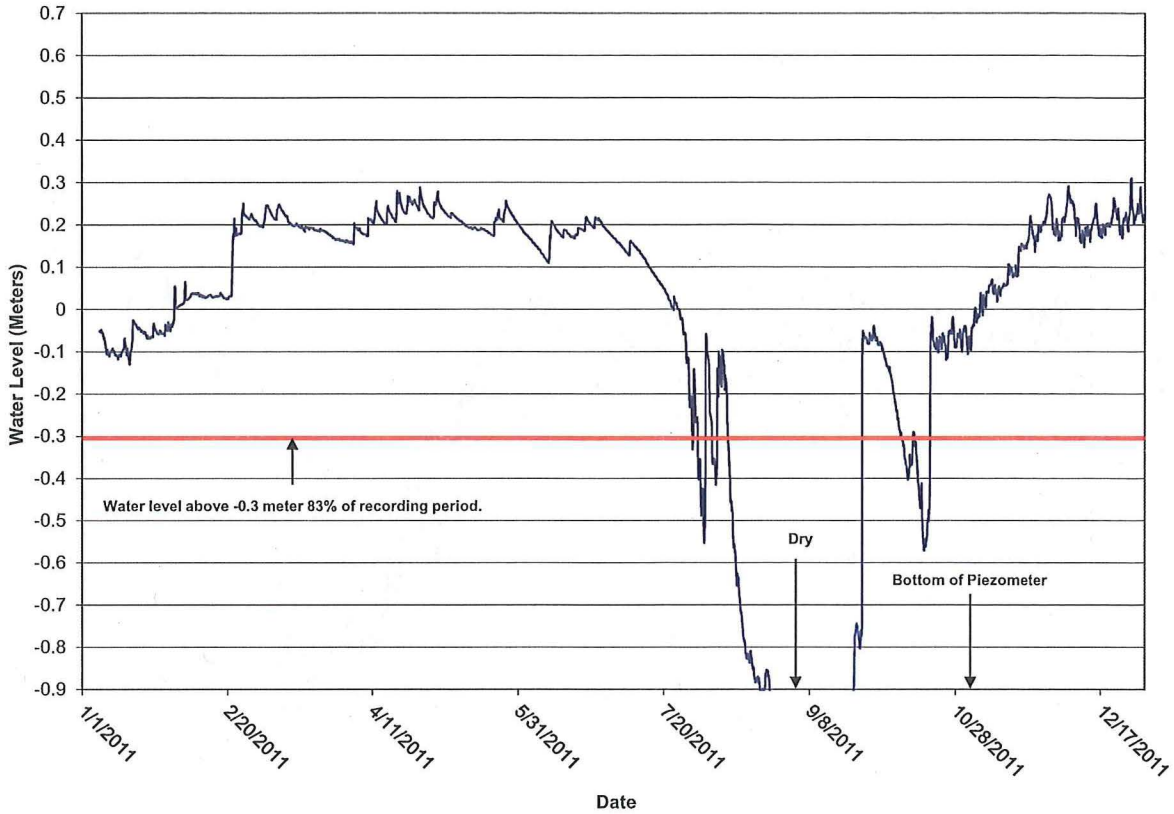

Figure D–3K. Wetland Area PREW6 Hydrograph

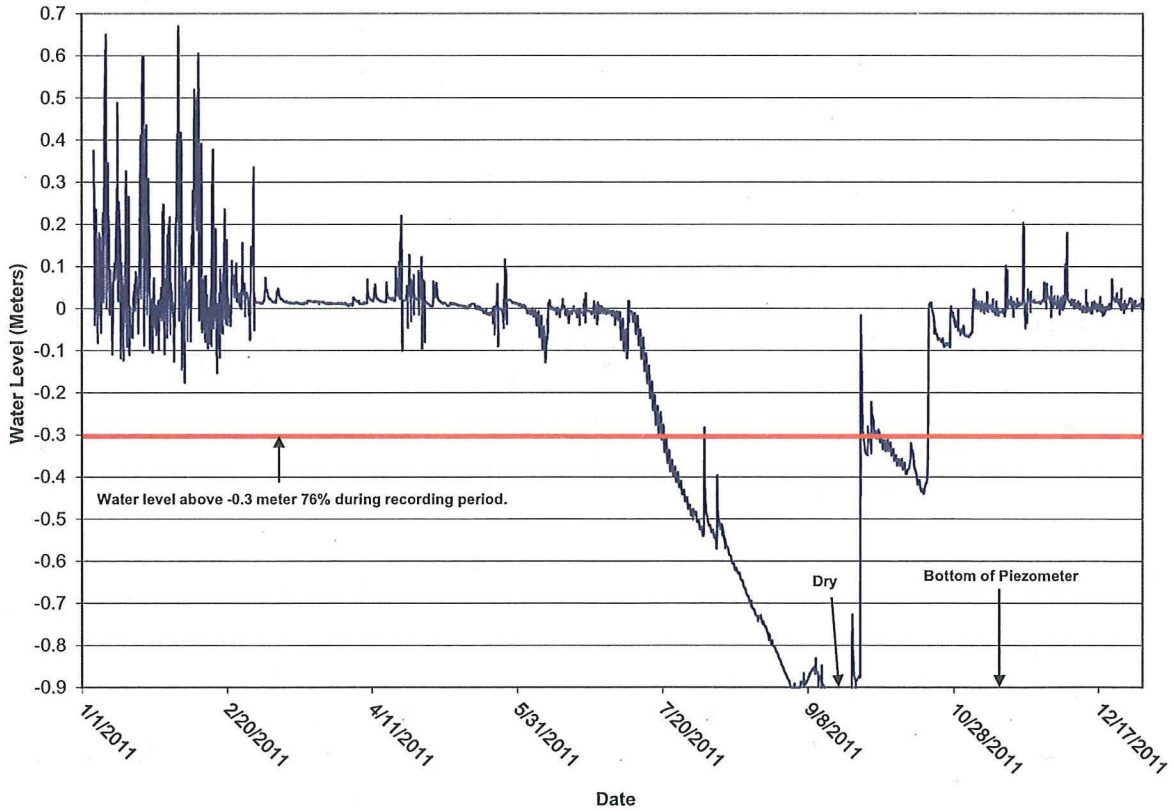

Figure D–3L. Wetland Area NPPW4 Hydrograph

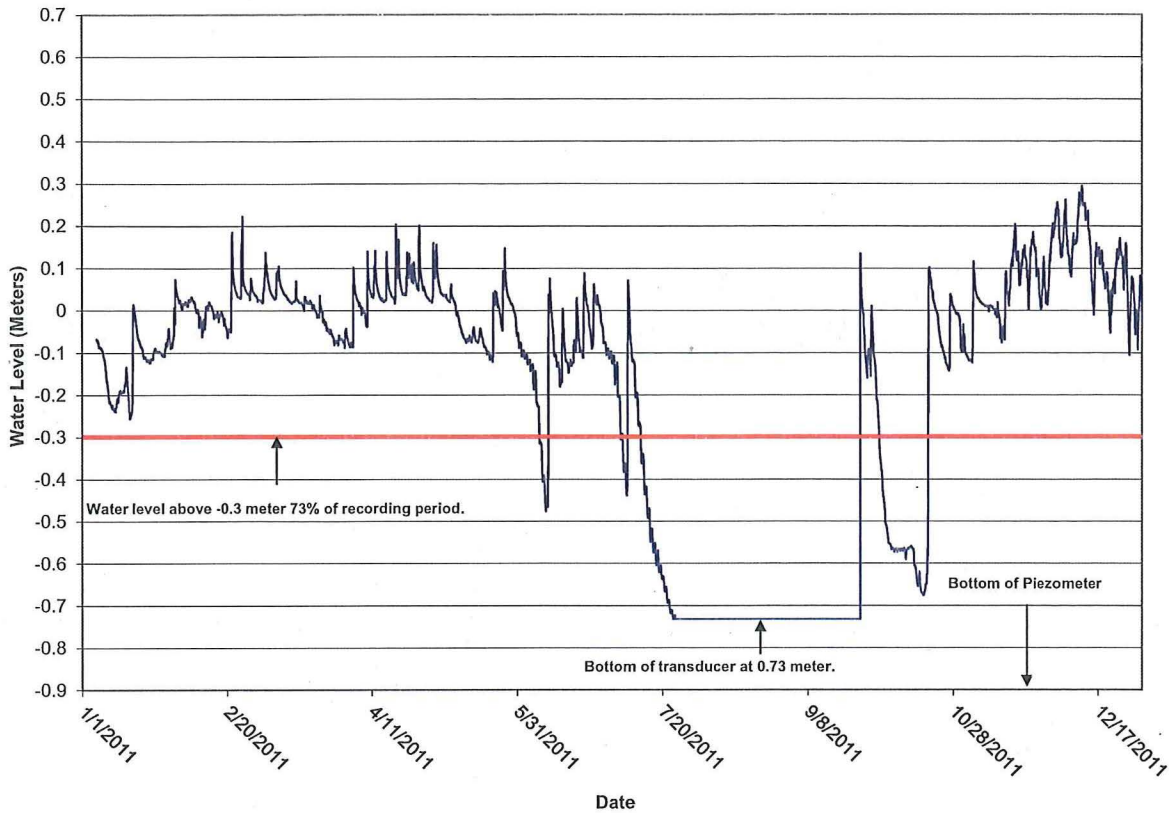

Figure D–3M. Wetland Area NPPW5 Hydrograph

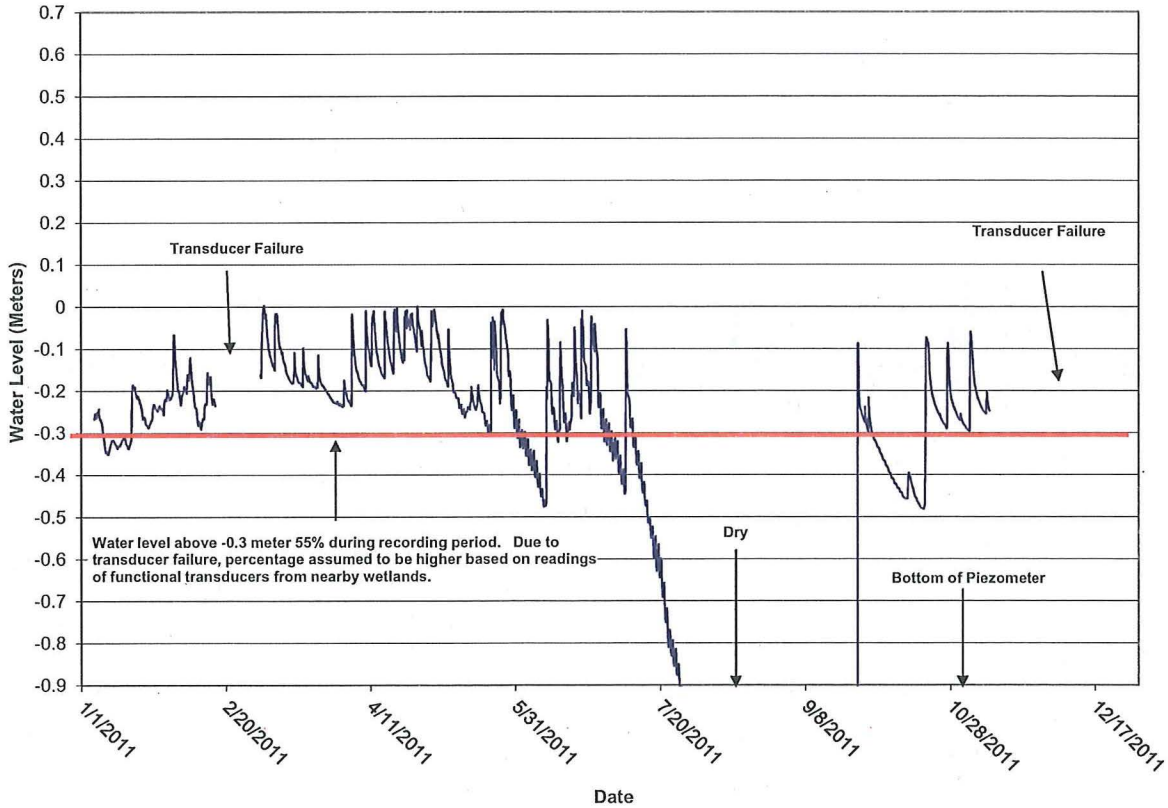

Figure D–3N. Wetland Area WM1W1 Hydrograph

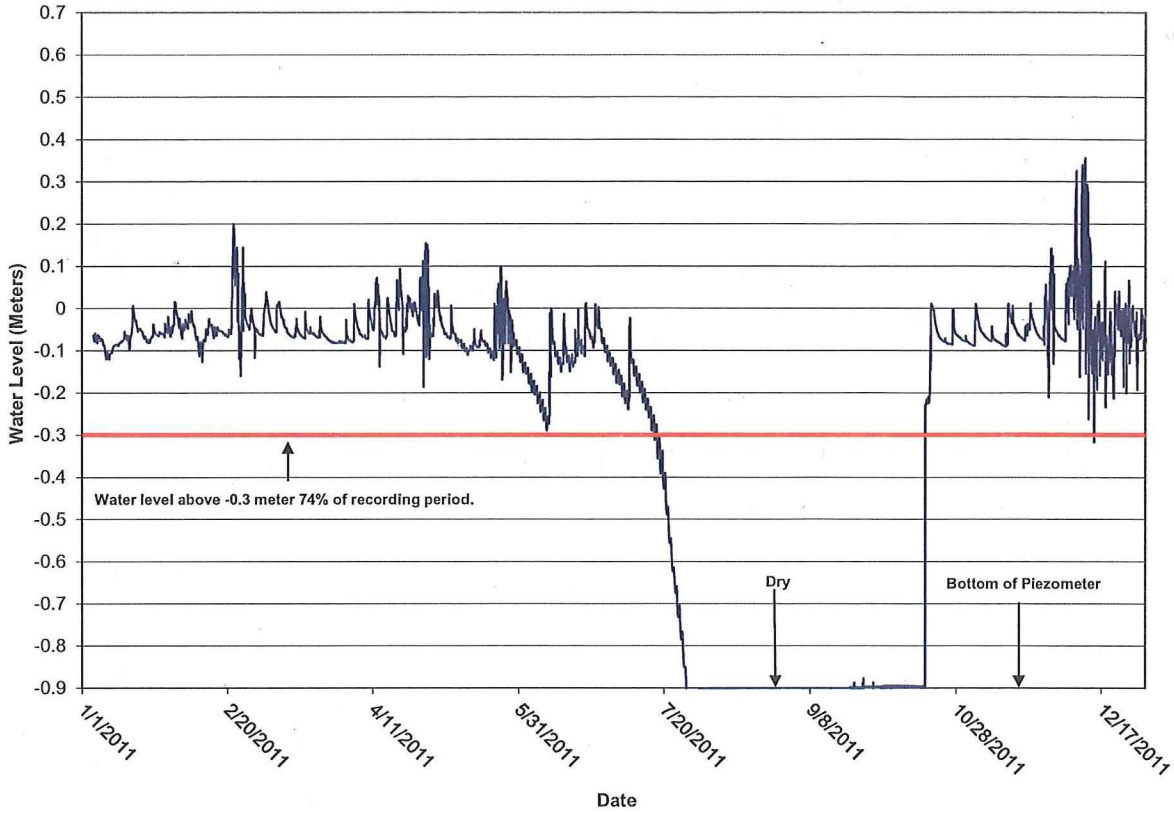

Figure D–3O. Wetland Area WM1W2 Hydrograph

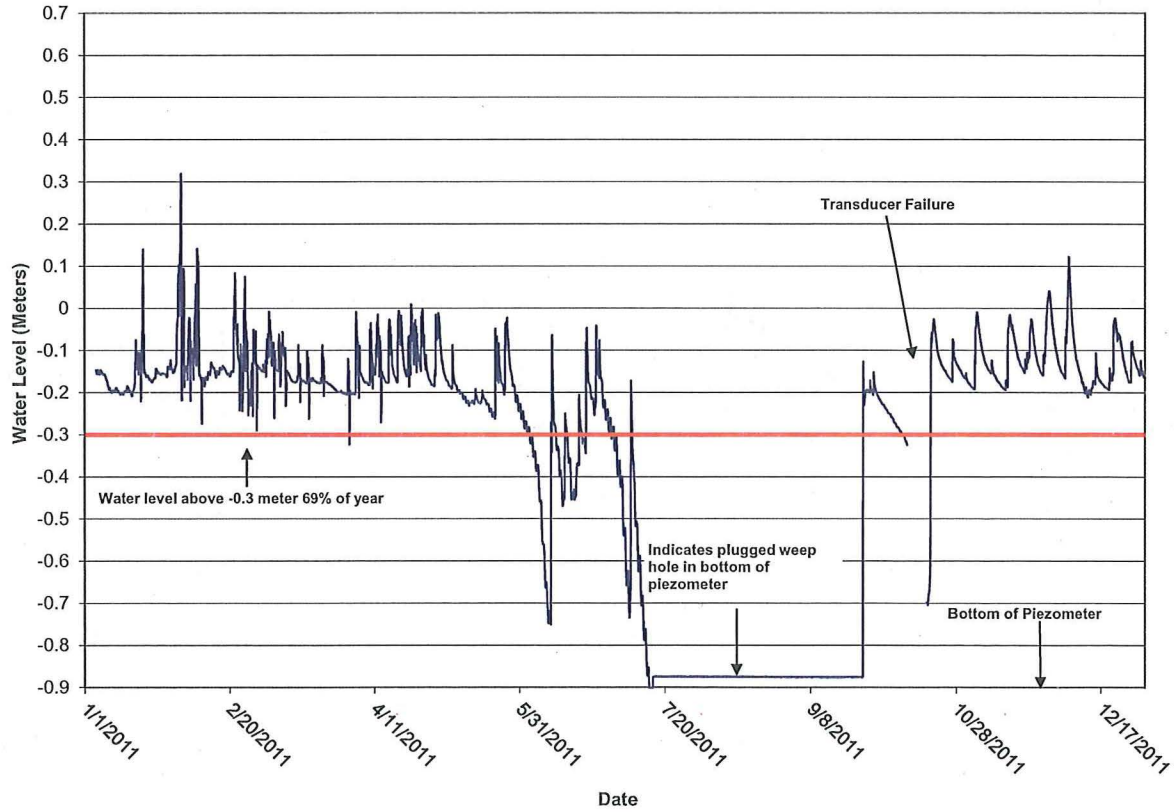

Figure D–3P. Wetland Area WM1W3 Hydrograph

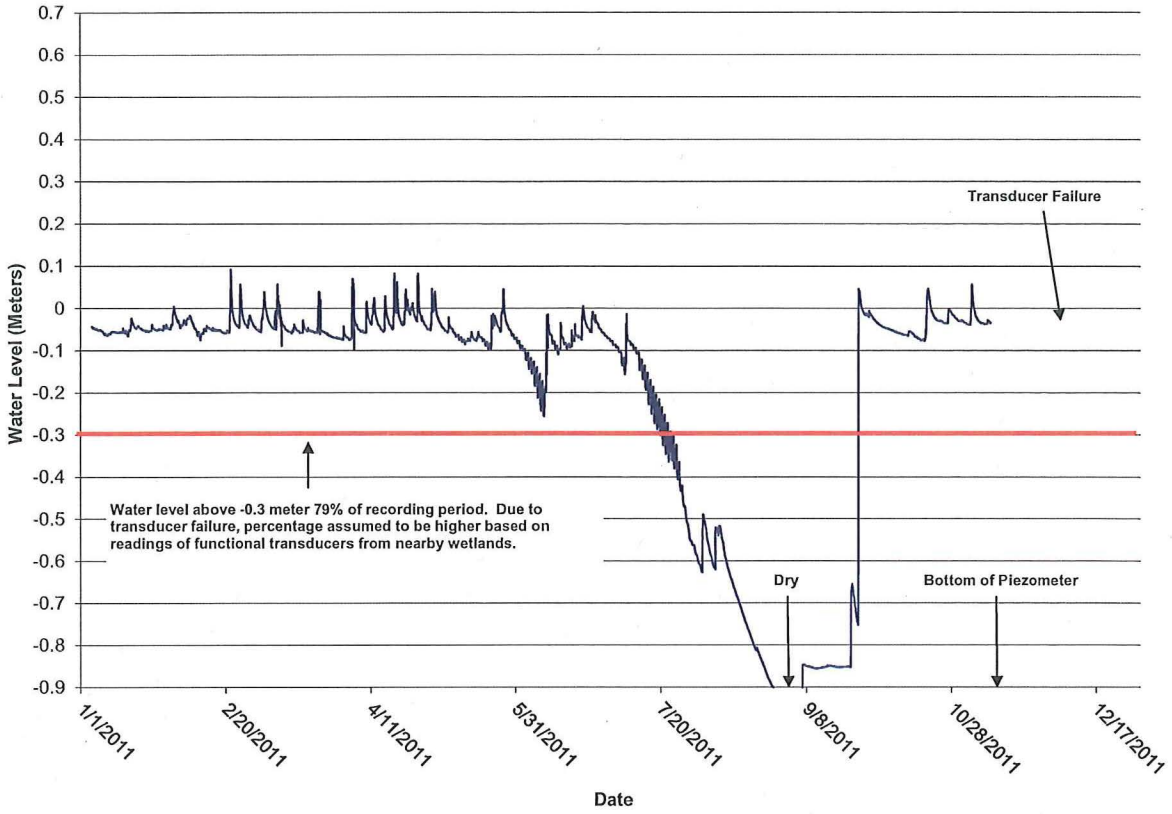

Figure D–3Q. Wetland Area WM1W4 Hydrograph

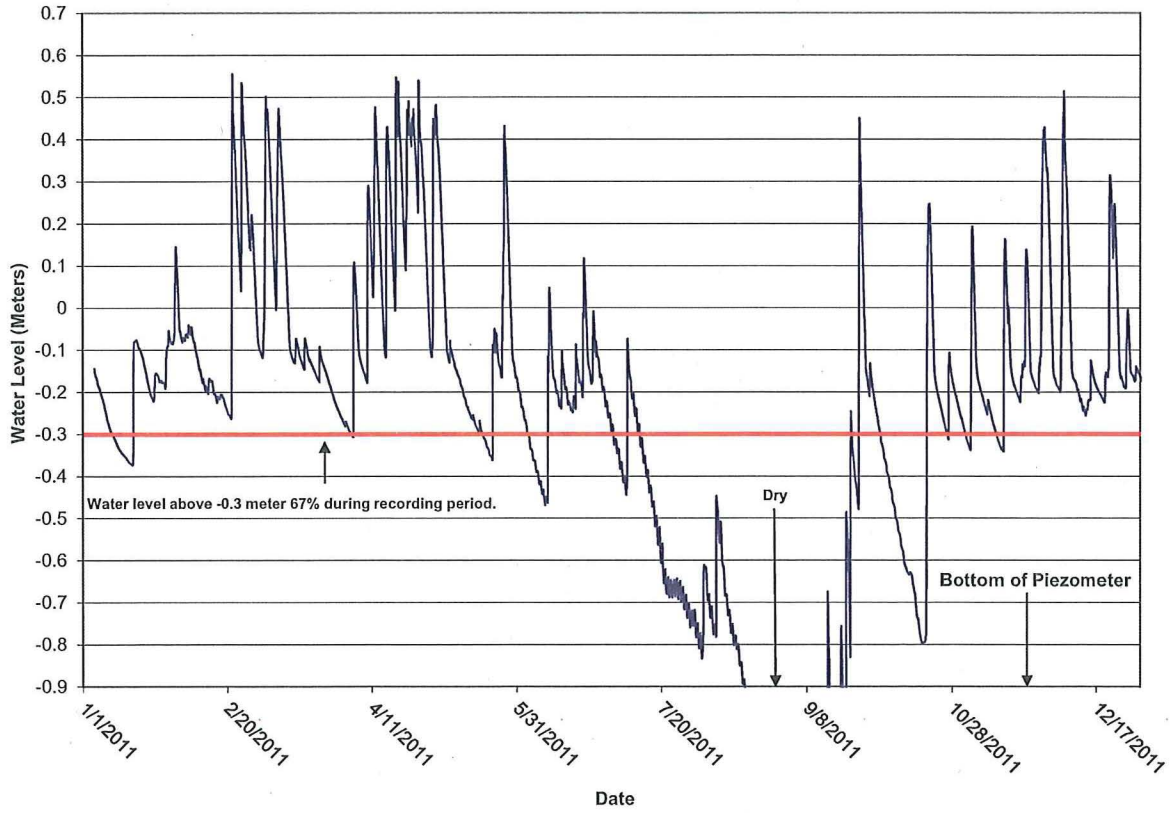

Figure D–3R. Wetland Area WM1W5 Hydrograph

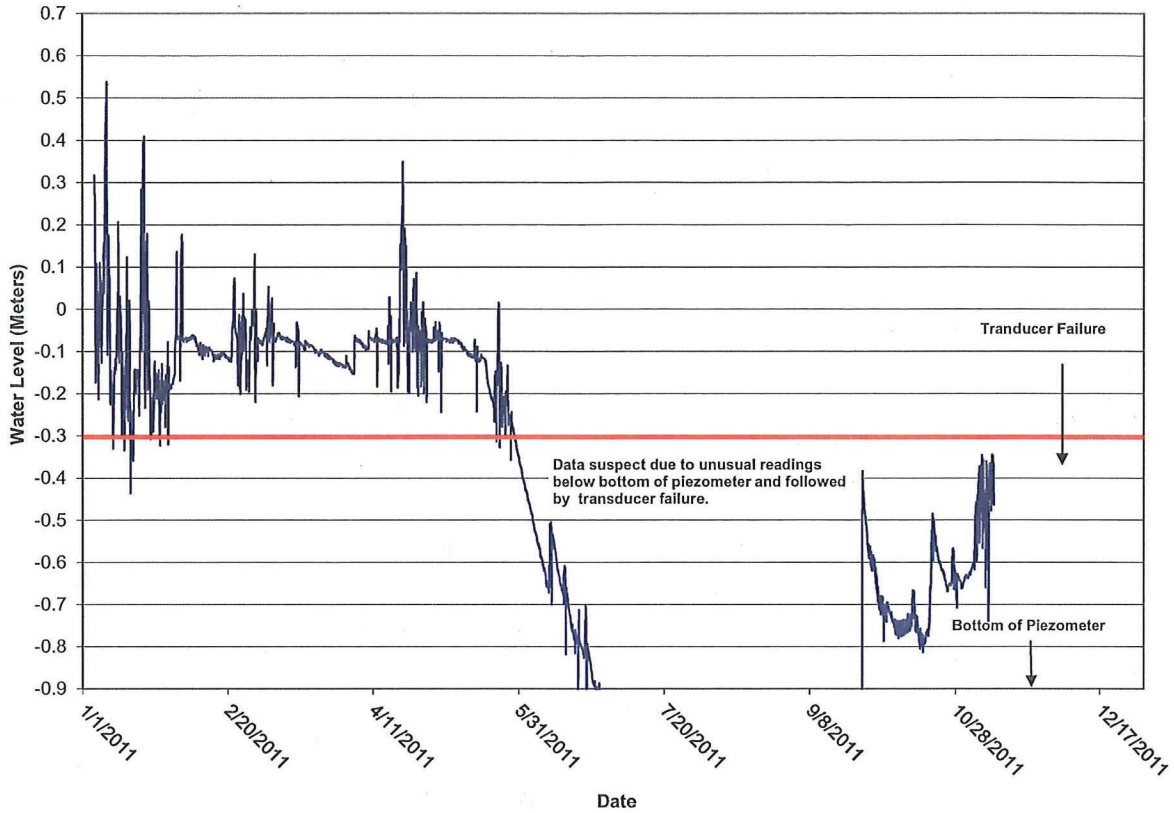

Figure D–3S. Wetland Area WM1W6 Hydrograph

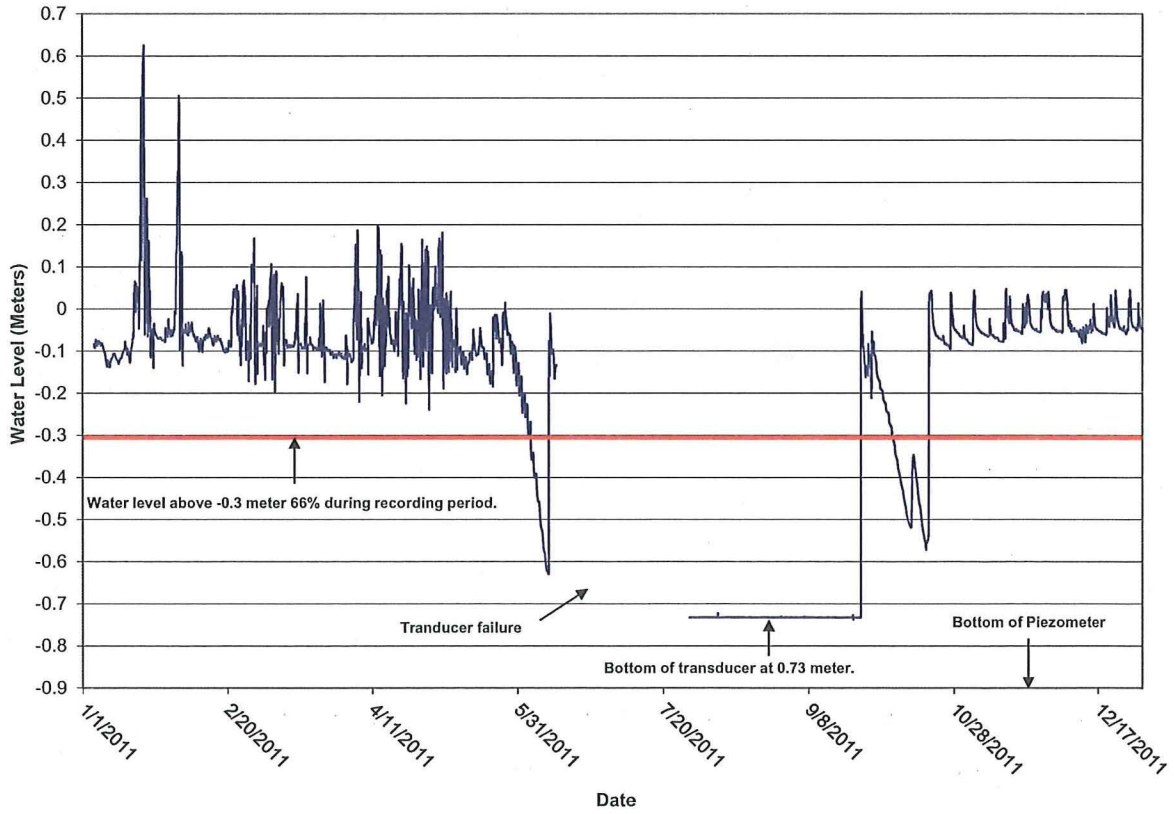

Figure D–3T. Wetland Area WM1W7 Hydrograph

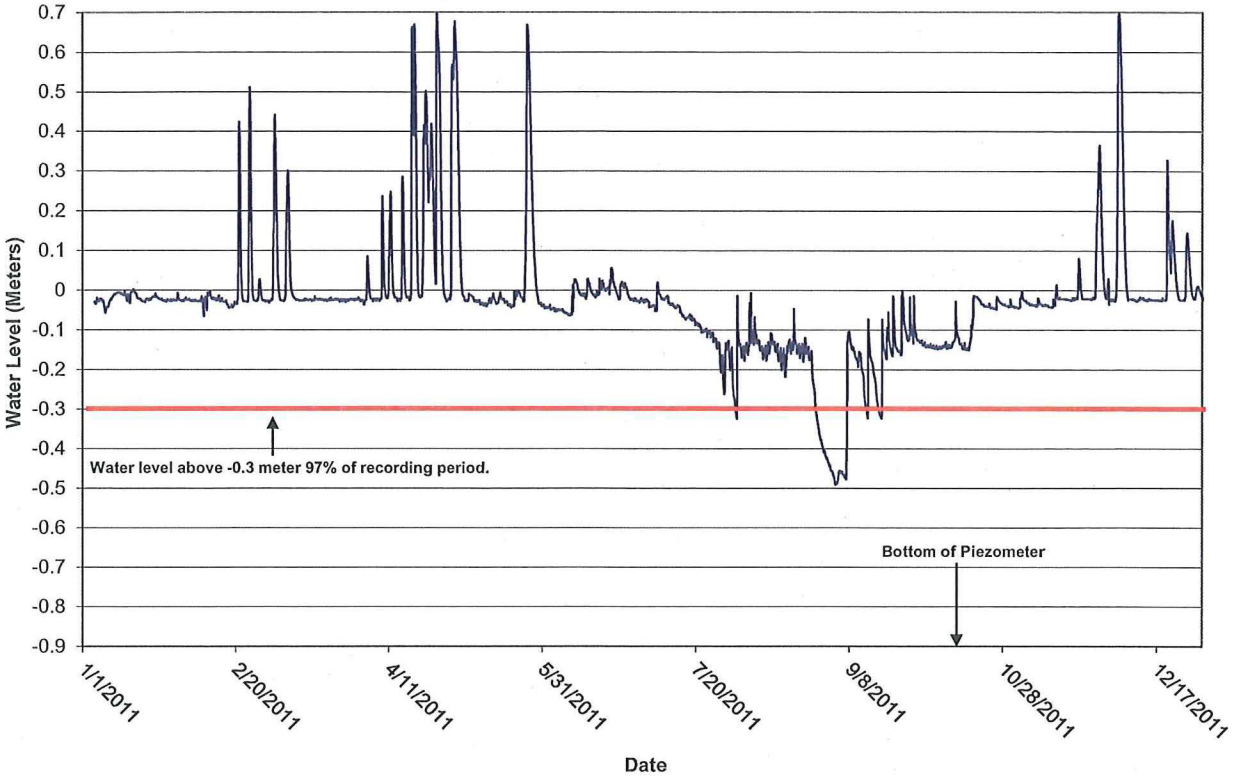

Figure D–3U. Wetland Area WM2W1 Hydrograph

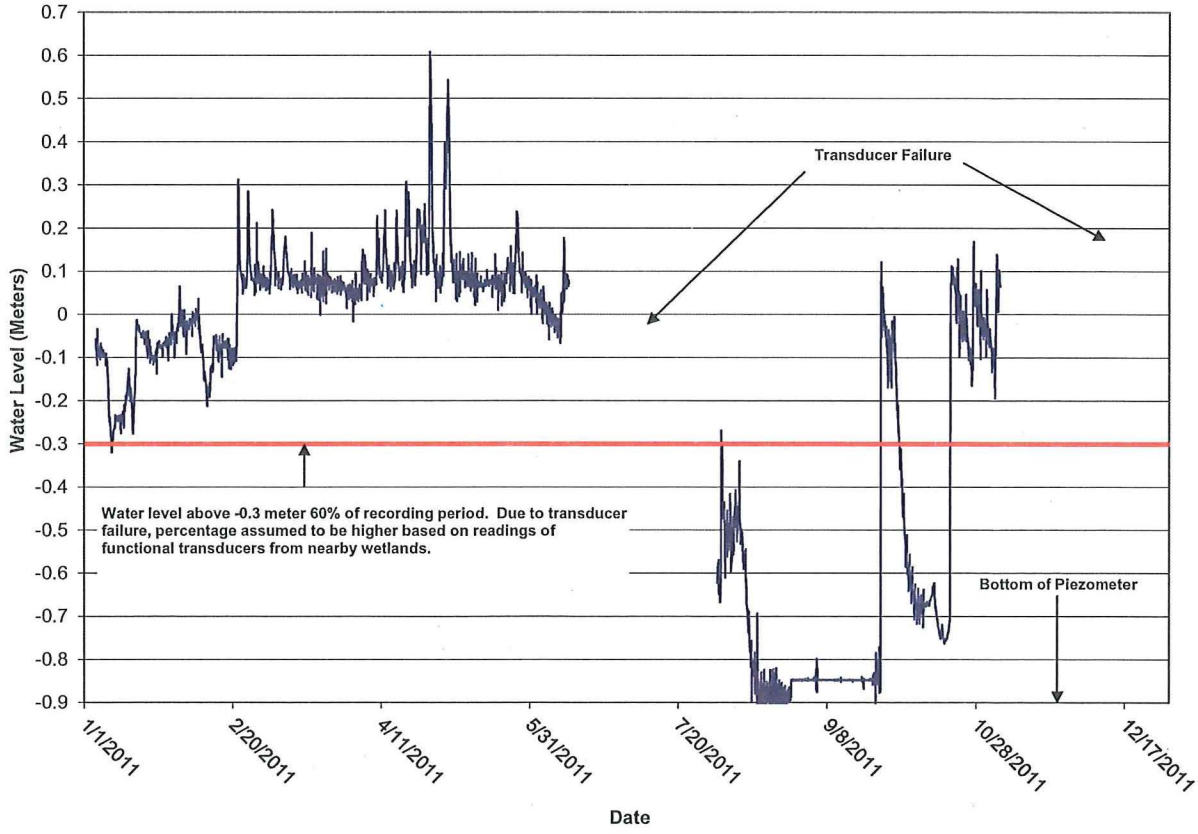

Figure D–3V. Wetland Area WM2W2 Hydrograph

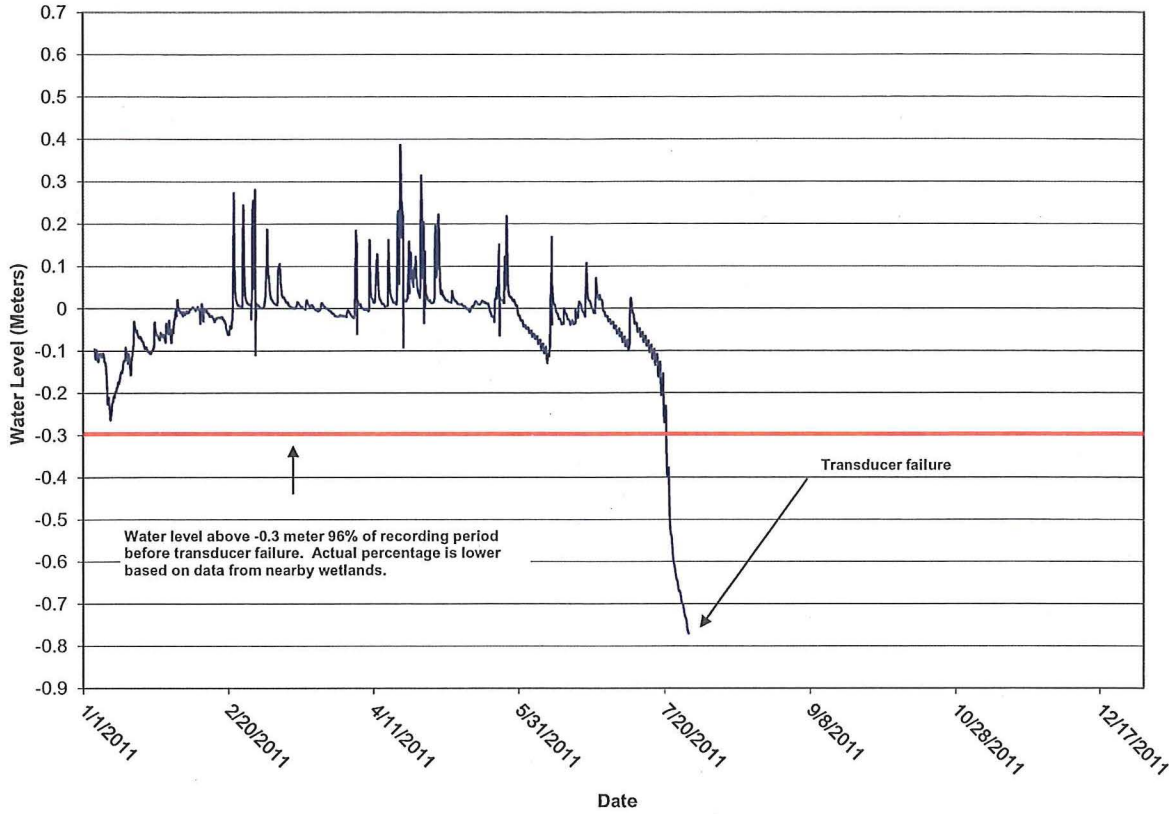

Figure D–3W. Wetland Area WM2W3 Hydrograph

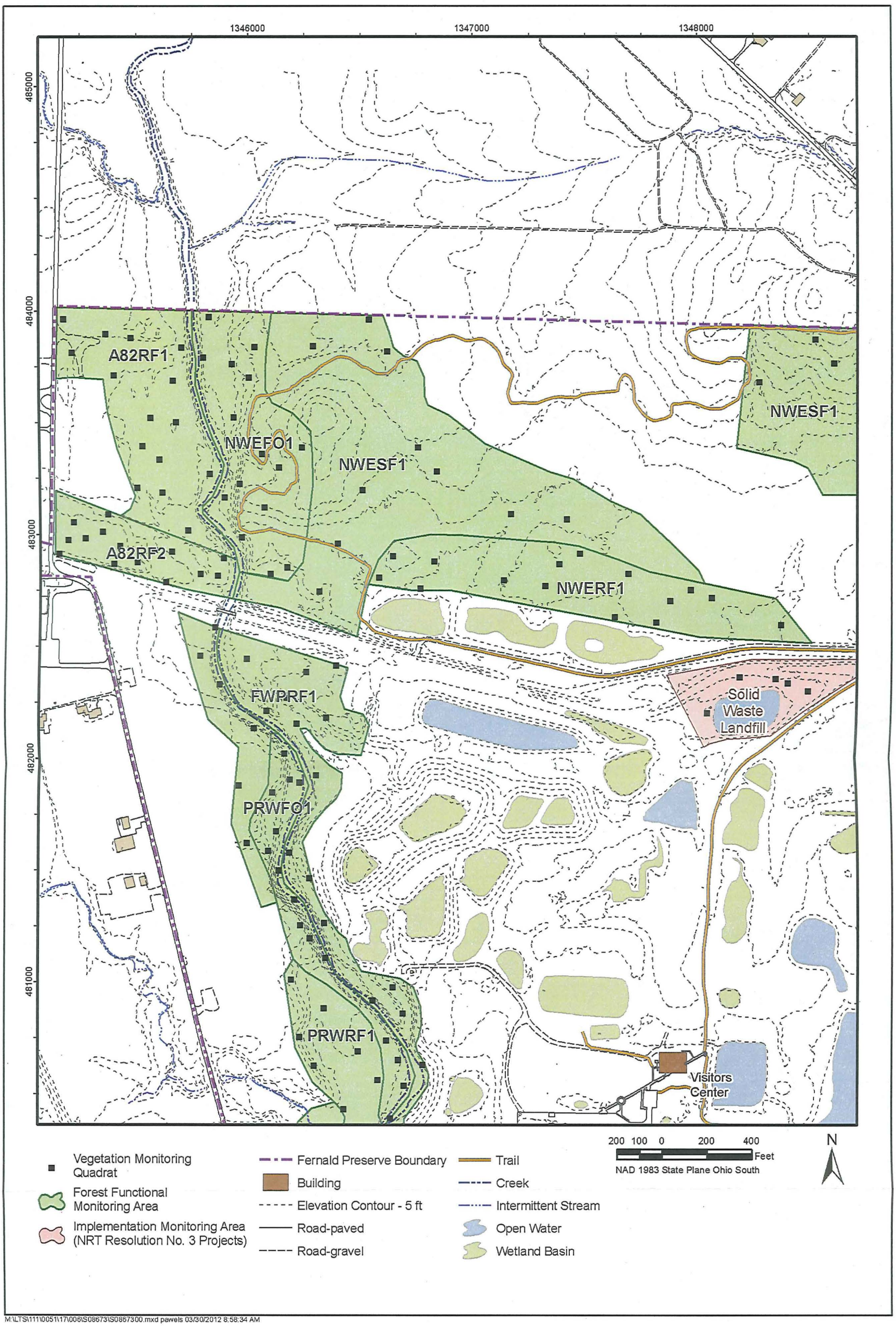

Figure D–4A. Vegetation Monitoring Survey Areas – Northwest Site Quadrant

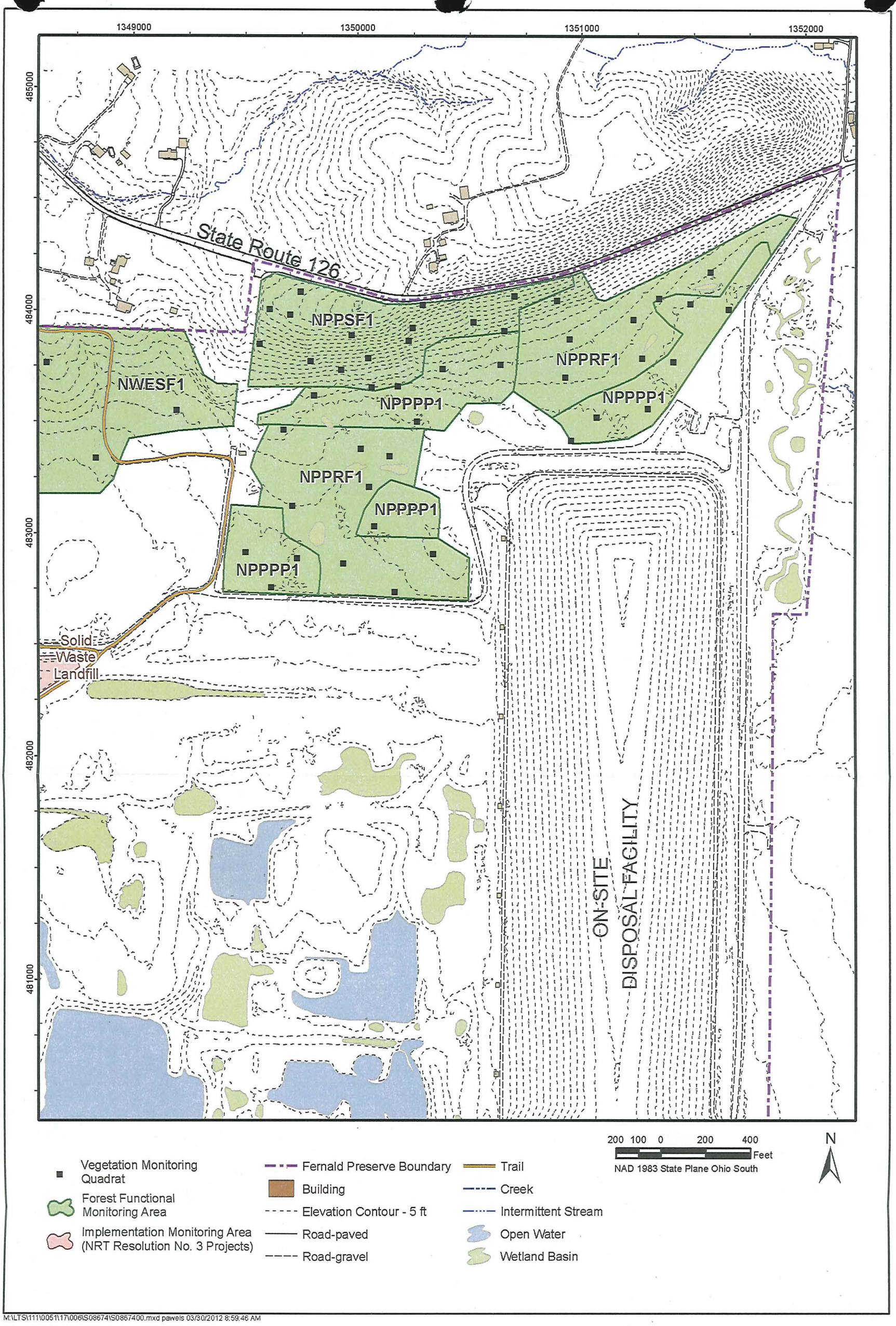

Figure D–4B. Vegetation Monitoring Survey Areas – Northeast Site Quadrant

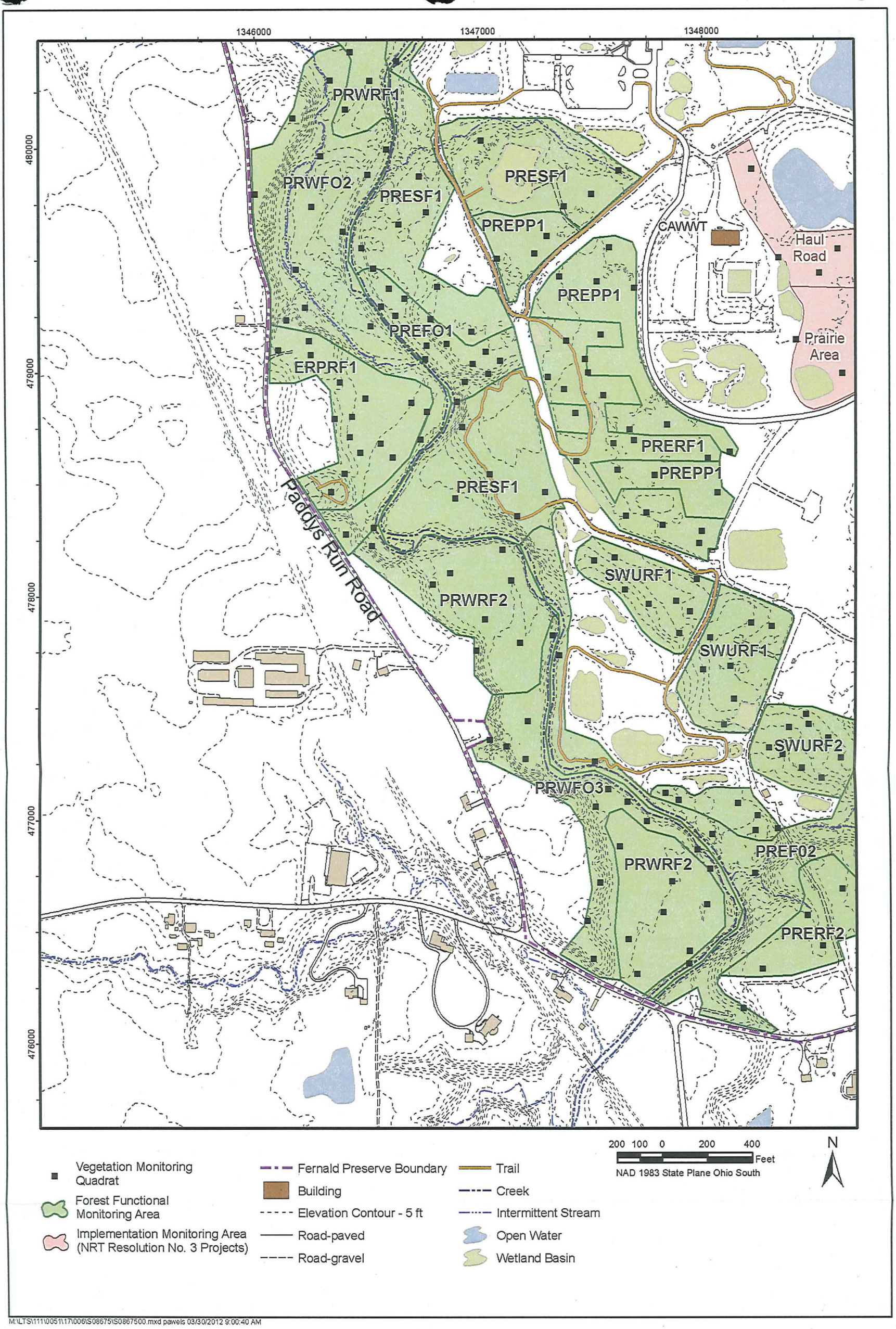

Figure D–4C. Vegetation Monitoring Survey Areas – Southwest Site Quadrant

7316

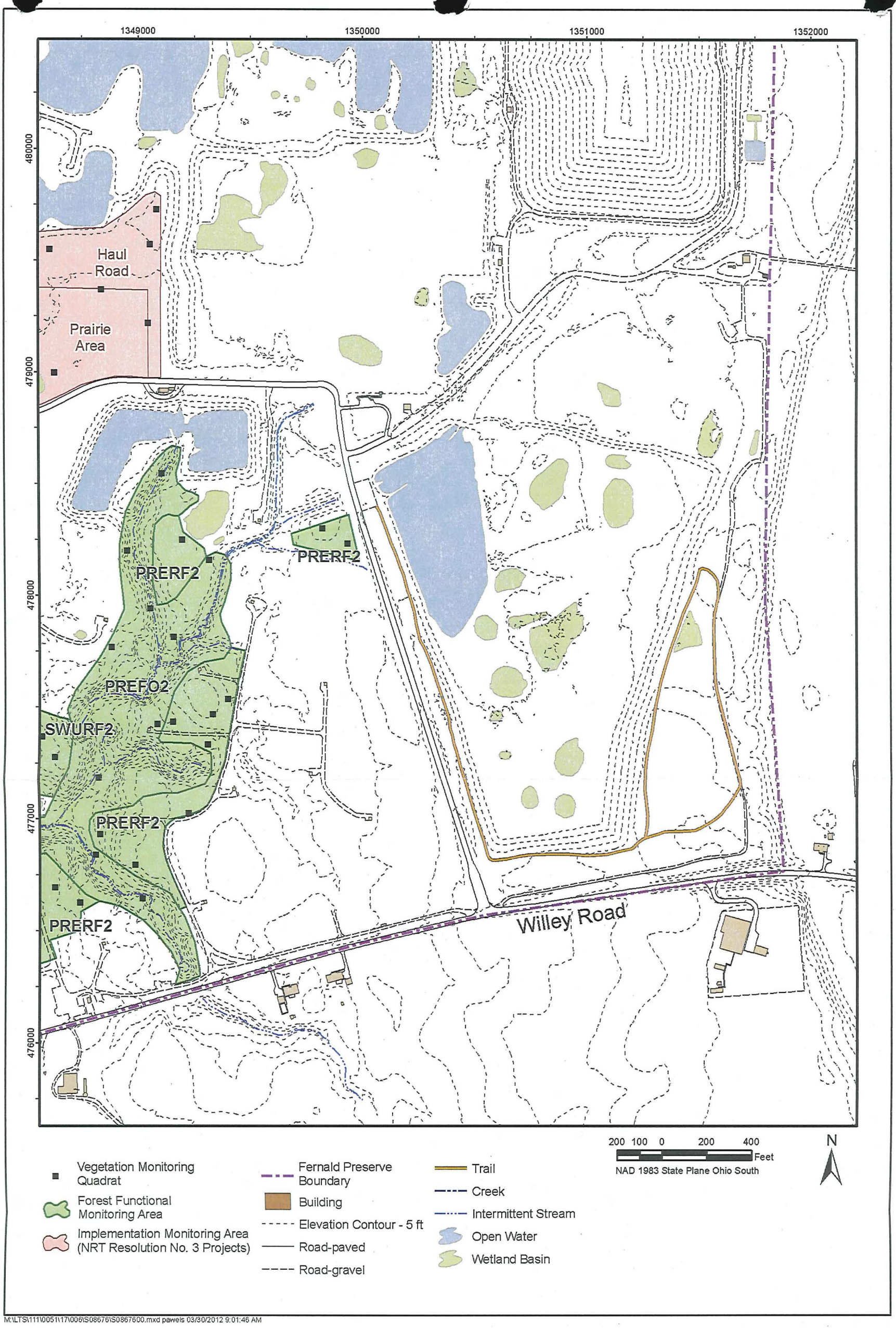

Figure D–4D. Vegetation Monitoring Survey Areas – Southeast Site Quadrant

Ohio | Environmental Protection Agency

John R. Kasich, Governor
Mary Taylor, Lt. Governor
Scott J. Nally, Director

September 17, 2012

Ms. Jane Powell
Fernald Site Manager
DOE-LM-20.1
10995 Hamilton-Cleves Hwy
Harrison, OH 45030

RE: Ohio EPA Comments on the Fernald Preserve 2011 Site Environmental Report, May 2012

Dear Ms. Powell:

Ohio EPA has reviewed the, "Fernald Preserve 2011 Site Environmental Report," received May 25, 2012. Ohio EPA comments are attached.

Sincerely,

Donna Bohannon for

Thomas A. Schneider
Fernald Project Manager
Ohio Environmental Protection Agency

Southwest District Office
401 East Fifth Street
Dayton, OH 45402-2911

937 | 285 6357
937 | 285 6249 (fax)
www.epa.ohio.gov

Ohio EPA Comments on the Fernald Preserve
2011 Site Environmental Report
May 2012

General Comments:

1. Commenting Organization: Ohio EPA
   Section #: na Pg #:na
   Comment: Ohio EPA notes that DOE continues to use sodium and uranium in construction of bivariate plots to show no mixing of waters between monitored zones. Ohio EPA is interested in what criteria led DOE to select only these two parameters? Were other parameter combinations considered? Ohio EPA requests DOE discuss the intended use of bivariate plots to support alternate source demonstrations (ASD's) in future Site Environmental Reports; specifically, what parameters will be paired and the rational for selecting them.

2. Commenting Organization: Ohio EPA
   Section #: na Pg #:na
   Comment: In prior Site Environmental Report reviews, Ohio EPA requested DOE consider using Trilinear (Piper diagrams) and Stiff plots to represent differences and/or mixing of various water types. DOE indicated that Trilinear and Stiff plots would be considered on an as needed basis. Ohio EPA does not understand DOE's reluctance to prepare these plots and requests further explanation.

3. Commenting Organization: Ohio EPA
   Section #: na Pg #:na
   Comment: Ohio EPA is concerned with DOE statements in response to Ohio EPA comments on previous Site Environmental Reports that "different bivariate plot combinations will be considered should the uranium/sodium combination no longer provide a conclusive interpretation." In preparation of ASD's, it is Ohio EPA's experience that a "multiple line of evidence" approach is typically undertaken to justify statistically significant increases. If mixing is identified in uranium/sodium bivariate plots, what assurance(s) can DOE make that another parameter combination will work better than the uranium/sodium bivariate plot?

4. Commenting Organization: Ohio EPA
   Section #: na Pg #:na
   Comment: It may be beneficial for DOE to provide a written narrative that explains the criteria that will be used in preparation of future ASD's. Ohio EPA suggests DOE consider incorporating a standalone section in future Site Environmental Reports describing how ASD's will be prepared.

5. Commenting Organization: Ohio EPA
   Section #: na Pg #:na
   Comment: Review of Leachate Collection system data suggests an upward trend for many inorganic constituents in all cells. Ohio EPA suggests that DOE continue evaluating these trends as they may prove useful in making future alternate source demonstrations.

Specific Comments:

6. Commenting Organization: Ohio EPA
   Section #: Executive Summary Pg #: vii
   Comment: Last paragraph of first sentence, "Environmental monitoring programs were developed to ensure continued protection of the remediation." Change "remediation" to "remedy".

7. Commenting Organization: Ohio EPA
   Section #: 2.3 Pg #: 30
   Comment: End of first paragraph. Insert the word 'occasionally' to read "Ohio EPA occasionally performs independent..."

8. Commenting Organization: Ohio EPA
   Section #: 3.5, Table 6 Pg #: 57
   Comment: An explanation for the "new highs" detected in numerous cells should be discussed.

9. Commenting Organization: Ohio EPA
   Section #: 5.1 Pg #: 73
   Comment: A brief discussion as to why Fernald contributes 12 mrem/yr direct radiation is warranted. This is due to the fact that Fernald was not remediated to background and contains residual radionuclides > background.

10. Commenting Organization: Ohio EPA
    Section #: General Comment Pg #: na
    Comment: The use of the uranium-sodium bivariate plot is used exclusively to indicate that w aters f rom t he d ifferent ho rizons are no t m ixing. What w ould bivariate plots, using different analytes, show?

Department of Energy
Washington, DC 20585

September 25, 2012

Mr. Timothy Fischer
U.S. Environmental Protection Agency
Region V-SRF-6J
77 W. Jackson Blvd.
Chicago, IL 60604-3590

Mr. Thomas A. Schneider
Ohio Environmental Protection Agency
401 East 5th Street
Dayton, Ohio 45402

Dear Mr. Fischer and Mr. Schneider:

SUBJECT: **Transmittal of Responses to Ohio Environmental Protection Agency Comments on the 2011 Site Environmental Report**

Reference: Letter, T. Schneider to J. Powell, "Ohio EPA Comments on the Fernald Preserve 2011 Site Environmental Report, May 2012," dated September 17, 2012

Enclosed for your review are responses to Ohio Environmental Protection Agency (Ohio EPA) comments on the 2011 Fernald Preserve Site Environmental Report (Reference). Consistent with past practice, the 2011 Fernald Preserve Site Environmental Report and appendices will not be revised. Comments will be considered during preparation of the 2012 Fernald Preserve Site Environmental Report.

If you have any questions regarding this report, please call me at (513) 648-3148. Please send any correspondence to:

U.S. Department of Energy
Office of Legacy Management
10995 Hamilton-Cleves Highway
Harrison, OH 45030

Sincerely,

Jane Powell

Jane Powell
Fernald Preserve Manager
DOE-LM-20.2

Printed with soy ink on recycled paper

Enclosure

cc w/enclosure:
S. Helmer, ODH
G. Hooten, DOE
T. Schneider, OEPA (3 copies of enclosure)
T. Tucker, OEPA-Columbus
Project Record File FER030.1(A) (thru W. Sumner)

cc w/o enclosure:
(electronic)
B. Hertel, Stoller
J. Homer, Stoller
G. Lupton, Stoller
T. Pauling, DOE
K. Reed, DOE
K. Voisard, Stoller
C. White, Stoller

Responses to Ohio EPA Comments on the Fernald Preserve
2011 Site Environmental Report
May 2012

General Comments:

1. Commenting Organization: Ohio EPA
   Section #: na Pg #: na
   Comment: Ohio EPA notes that DOE continues to use sodium and uranium in construction of bivariate plots to show no mixing of waters between monitored zones. Ohio EPA is interested in what criteria led DOE to select only these two parameters? Were other parameter combinations considered? Ohio EPA requests DOE discuss the intended use of bivariate plots to support alternate source demonstrations (ASD's) in future Site Environmental Reports. Specifically, what parameters will be paired and the rational for selecting them.

   Response: Sodium and uranium were selected because this combination provides a good distinction between the LCS, LDS and HTW for all 8 cells. The combination was discovered during the Common Ion Study. A report of the study was issued in 2008, titled: "Evaluation of Aqueous Ions in the Monitoring Systems of the OSDF". Although the sodium-uranium bivariate plot for Cell 8 provides a distinction between the LDS and HTW, the separation shown between the LDS and HTW of Cell 8 is not as distinct as for the other seven cells. Therefore, beginning with this report a sulfate-uranium bivariate plot was added for Cell 8. DOE will continue the above mentioned combinations for bivariate plots in future Site Environmental Reports. Other combinations may be added on an as needed basis if deemed appropriate. A discussion of bivariate plot use and ASDs will be added to future SER reports as requested.

   Action: As stated in the response.

2. Commenting Organization: Ohio EPA
   Section #: na Pg #: na
   Comment: In prior Site Environmental Report reviews, Ohio EPA requested DOE consider using Trilinear (Piper diagrams) and Stiff plots to represent differences and/or mixing of various water types. DOE indicated that Trilinear and Stiff plots would be considered on an as needed basis. Ohio EPA does not understand DOE's reluctance to prepare these plots and requests further explanation.

   Response: Trilinear and Stiff plots are not needed at this time. The large amount of data interpretation already provided does a good job of showing the distinct chemical separation between monitoring horizons. DOE does agree though that on an "as needed basis" the future use of Trilinear and Stiff plots could be beneficial for providing additional information to decision makers.

   Action: As stated in the response.

3. Commenting Organization: Ohio EPA
Section #: na Pg #: na
Comment: Ohio EPA is concerned with DOE statements in response to OEPA comments on previous Site Environmental Reports that "different bivariate plot combinations will be considered should the uranium/sodium combination no longer provide a conclusive interpretation." In preparation of ASD's, it is Ohio EPA's experience that a "multiple line of evidence" approach is typically undertaken to justify statistically significant increases. If mixing is identified in uranium/sodium bivariate plots, what assurance(s) can DOE make that another parameter combination will work better than the uranium/sodium bivariate plot?

Response: DOE also strongly supports the "multiple line of evidence" approach. The reference to "different bivariate plot combinations" was meant with this in mind. As was done with Cell 8, two bivariate plots are now used. The sulfate-uranium plot is provided with the sodium-uranium plot to provide additional clarification between the chemistry of leachate in the LDS and HTW. The sulfate-uranium chemical signature is more distinct than the sodium-uranium signature between the LDS and HTW of Cell 8. The intent is to use additional bivariate plots as needed to provide clarification if warranted, not to serve as replacements. If the situation ever occurs that the bivariate plots indicate potential mixing between monitoring horizons, other interpretation techniques will be considered (e.g., Piper Plots, Stiff Diagrams) to see if additional insight into the data interpretation can be provided. The objective is to avoid the situation where a decision is based on a false positive interpretation of the data.

Action: As stated in the response.

4. Commenting Organization: Ohio EPA
Section #: na Pg #: na
Comment: It may be beneficial for DOE to provide a written narrative that explains the criteria that will be used in preparation of future ASD's. Ohio EPA suggests DOE consider incorporating a standalone section in future Site Environmental Reports describing how ASD's will be prepared.

Response: DOE will review the ASD information provided by the State and consider how best to incorporate the information into future SERs.

Action: As stated in the response.

5. Commenting Organization: Ohio EPA
Section #: na Pg #: na
Comment: Review of Leachate Collection system data suggests an upward trend for many inorganic constituents in all cells. Ohio EPA suggests that DOE continue evaluating these trends as they may prove useful in making future alternate source demonstrations.

Response: Agreed. DOE will continue evaluating upward trends of inorganic constituents in all cells.

Action: As stated in the response.

Specific Comments:

6. Commenting Organization: Ohio EPA
Section #: Executive Summary Pg #: vii
Comment: Last paragraph of first sentence, "Environmental monitoring programs were developed to ensure continued protection of the remediation." Change "remediation" to "remedy".

Response: Agree.
Action: The text will be revised in future SERs.

7. Commenting Organization: Ohio EPA
Section #: 2.3 Pg #: 30
Comment: End of first paragraph. Insert the word 'occasionally' to read "Ohio EPA occasionally performs independent..."

Response: Agree

Action: The text will be revised in future SERs.

8. Commenting Organization: Ohio EPA
Section #: 3.5, Table 6 Pg #: 57
Comment: An explanation for the "new highs" detected in numerous cells should be discussed.

Response: Agree. In future SERs DOE will discuss any "new high" uranium concentrations detected in the cell monitoring network. The "new highs" detected in 2011 occurred in GMA wells and the LDS. The new highs in the GMA wells are all below the cleanup level of 30 μg/L. They pose no unacceptable risk to human health and the environment. The new highs in the LDS occurred in Cells 1, 6, and 8. The new highs are probably the result of fluctuations in concentrations due to changing low flow conditions in the LDS. For example, the Cell 1 LDS is usually dry for three quarters of the year. For the past five years a sample could only be collected during the first quarter of the year. The once a year sample could be fairly concentrated with uranium due to being held in the system for so long. The samples immediately following the new highs in Cells 6 and 8 in 2011 were both lower, again perhaps reflecting concentration changes in the LDS due to flow volumes.

Action: As stated in the response.

9. Commenting Organization: Ohio EPA
Section #: 5.1 Pg #: 73
Comment: A brief discussion as to why Fernald contributes 12 mrem/yr direct radiation is warranted. This is due to the fact that Fernald was not remediated to background and contains residual radionuclides > background.

Response: The text in future SERs will be revised to state that "Slightly higher results are not unexpected, as the Fernald site was remediated to reduce the radionuclide levels to values that were near or somewhat higher than background. However, this slight increase is not a significant source of risk because, as noted in Appendix C, Attachment C.1, the mean of the quarterly boundary measurements is similar to background when statistical variability is evaluated, which is in agreement with removal of the last direct radiation waste sources in 2006."

Action: As stated in the response.

10. Commenting Organization: Ohio EPA
Section #: General Comment Pg #: na
Comment: The use of the uranium-sodium bivariate plot is used exclusively to indicate that waters from the different horizons are not mixing. What would bivariate plots, using different analytes, show?

Response: Bivariate plots for many different analyte combinations are provided in the report titled, "Evaluation of Aqueous Ions in the Monitoring Systems of the OSDF" (2008), routinely referred to as the Common Ion report. The different types reported include: Sodium-Chloride, Sodium-Potassium, Sodium-Silica, Strontium-Boron, TOC-Iron, Lithium-uranium, Barium-Sulfate, Copper-Fluoride, and Cobalt-Molybdenum. In many cases analyte concentrations in the LCS, LDS, and HTW are similar so the combination of analytes would not be useful for tracking the potential of future mixing.

Action: No action required.

Ohio | Environmental Protection Agency

John R. Kasich, Governor
Mary Taylor, Lt. Governor
Scott J. Nally, Director

September 28, 2012

Ms. Jane Powell
Fernald Site Manager
DOE-LM-20.1
10995 Hamilton Cleves Highway
Harrison, Ohio 45030

RE: APPROVAL – ON THE RESPONSE TO COMMENTS AND THE FERNALD PRESERVE 2011 SITE ENVIRONMENTAL REPORT AND SUMMARY (APPENDICES A through D), MAY 2012

Dear Ms. Powell:

Ohio EPA has received and reviewed Fernald Preserve's "Response to Comments and the 2011 Site Environmental Report and Summary (Appendices A through D)", dated May 2012. Ohio EPA approves of the responses and the document.

If you have any questions, please contact me at (937) 285-6466.

Sincerely,

Thomas A. Schneider
Fernald Project Manager
Division of Environmental Response and Revitalization
Federal Facilities Section

TS/tf

ec: Tim Fischer, U.S. EPA
Bill Hertel, Stoller Corporation

Q: Temp/FernaldPreserve/SER/ApprovalSept28-12.doc

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