Appendix A

Supplemental Groundwater Information

This page intentionally left blank

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

This page intentionally left blank

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
ODH	Ohio Department of Health
OEPA	Ohio Environmental Protection Agency
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
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
RW	recovery well
SCL	Shewhart control limit
SD	standard deviation
SER	*Fernald Preserve Site Environmental Report*

SSOD	Storm Sewer Outfall Ditch
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
µg/L	micrograms per liter
yd^3	cubic yards

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).

References

DOE (U.S. Department of Energy), 1993. *South Plume Groundwater Recovery System Design, Monitoring, and Evaluation Program Plan,* Fernald Environmental Management Project, Fernald Area Office, Cincinnati, Ohio, April.

DOE (U.S. Department of Energy), 1995. *Remedial Investigation Report for Operable Unit 5*, Final, Fernald Environmental Management Project, Fernald Area Office, Cincinnati, Ohio, March.

DOE (U.S. Department of Energy), 1996. *Record of Decision for Remedial Actions at Operable Unit 5*, 7478 U 007 501.4, Final, Fluor Fernald, Cincinnati, Ohio, January.

DOE (U.S. Department of Energy), 1997a. *Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration*, 2505-RP-0003, Revision 0, Final, Fernald Environmental Management Project, Fernald Area Office, Cincinnati, Ohio, June.

DOE (U.S. Department of Energy), 1997b. *Restoration Area Verification Sampling Program Project-Specific Plan*, Fernald Environmental Management Project, Fernald Area Office, Cincinnati, Ohio.

DOE (U.S. Department of Energy), 1997c. *On-site Disposal Facility Final Design Calculation Package*, Volume 2 of 4, Fernald Environmental Management Project, Fernald Area Office, Cincinnati, Ohio.

DOE (U.S. Department of Energy), 1998. *Restoration Area Verification Sampling Program Summary Report*, Final, Fernald Environmental Management Project, Fernald Area Office, Cincinnati, Ohio.

DOE (U.S. Department of Energy), 2001a. *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas*, Draft Final, Fernald Environmental Management Project, DOE, Fernald Area Office, Cincinnati, Ohio.

DOE (U.S. Department of Energy), 2001b. *2000 Integrated Site Environmental Report,* Final, Fernald Environmental Management Project, DOE, Fernald Area Office, Cincinnati, Ohio.

DOE (U.S. Department of Energy), 2004a. *Groundwater Remedy Evaluation and Field Verification*, 52460-PL-0001, Revision 0, Fluor Fernald, Fernald Area Office, Cincinnati, Ohio, October.

DOE (U.S. Department of Energy), 2004b. *2003 Site Environmental Report*, 51350-RP-0024, Fluor Fernald, Fernald Area Office, Cincinnati, Ohio, June.

DOE (U.S. Department of Energy), 2005a. *Waste Storage Area Phase II Design Report*, 52424-RP-0004, Revision A, Draft Final, Fluor Fernald, Fernald Area Office, Cincinnati, Ohio, June.

DOE (U.S. Department of Energy), 2005b. *Storm Sewer Outfall Ditch Infiltration Test Report,* 52460-RP-0001, Revision 0, Final, Fluor Fernald, Fernald Area Office, Cincinnati, Ohio, December.

DOE (U.S. Department of Energy), 2006. *Fernald Preserve 2005 Site Environmental Report*, DOE-LM/1607-2006, S.M. Stoller Corporation for DOE, Fernald Area Office, Cincinnati, Ohio, June.

DOE (U.S. Department of Energy), 2008. *Fernald Preserve 2007 Site Environmental Report*, DOE-LM/1607-2008, S.M. Stoller Corporation for DOE, Fernald Area Office, Cincinnati, Ohio, June.

DOE (U.S. Department of Energy), 2009b. *Fernald Preserve 2008 Site Environmental Report*, Fernald Area Office, Cincinnati, Ohio, May.

DOE (U.S. Department of Energy), 2010a. *Comprehensive Legacy Management and Institutional Controls Plan*, LMS/FER/S03496-3.0, Revision 3, prepared by S.M. Stoller Corporation for DOE, Fernald Area Office, Cincinnati, Ohio, March.

DOE (U.S. Department of Energy), 2010b. *Fernald Preserve 2009 Site Environmental Report*, Fernald Area Office, Cincinnati, Ohio, May.

DOE (U.S. Department of Energy), 2011. Five-Year Review Report, LMS/FER/S07045, Draft Final, prepared by S.M. Stoller Corporation for DOE, Fernald Area Office, Cincinnati, Ohio, April.

EPA (U.S. Environmental Protection Agency), 1992a. *General Methods for Remedial Operation Performance Evaluations*, Environmental Research Laboratory, Ada, Oklahoma, January.

EPA (U.S. Environmental Protection Agency), 1992b. "Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities – Addendum to Interim Final Guidance," July.

EPA (U.S. Environmental Protection Agency), 1996. *Report on the 1995 Workshop on Geosynthetic Clay Liners*, EPA/600/R-96/149, Washington, D.C., June.

EPA (U.S. Environmental Protection Agency), 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance*, EPA 530/R-09-007, March.

ERM Midwest, Inc., 1994. "Remedial Investigation and Risk Assessment, Paddys Run Road Site," Revision 1, Volumes 1 through 5, Crosby Township, Hamilton, Ohio.

Geosyntec Consultants, Inc., 2011. *Review of Video Survey for the Leachate Collection and Leak Detection System for Cells 1 through 8 at the Fernald Preserve*, Kennesaw, Georgia, February.

U.S. Navy, 1999. *Handbook for Statistical Analysis of Environmental Background Data*, prepared by SWDIB and EFA West of Naval Facilities Engineering Command, July.

This page intentionally left blank

Attachment A.1

This page intentionally left blank

A.1.0 Operational Assessment

This attachment presents operational data for each extraction well pumping in 2010, 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 2010, 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 2010 and for August 1993 through December 2010.

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 2010. 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 2010 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 2010. The footnotes explain individual extraction well outages of greater than 24 hours.

During 2010, 1,271.05 million gallons (M gal) of groundwater were pumped by the active extraction wells in the South Field Module, resulting in the removal of 350.85 pounds (lbs) of uranium from the Great Miami Aquifer (GMA). Since startup of the South Field Module in July 1998, the module has removed 13.58 billion gallons of water and 6,167.16 lbs of uranium from the GMA.

A.1.2 South Plume Module

Six extraction wells were operational in the South Plume Module in 2010. 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 2010 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 2010. 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 2010, 633.32 M gal of groundwater were pumped by the six wells in the South Plume Module, resulting in the removal of 109.5 lbs of uranium from the GMA. Since startup of the South Plume Module in August 1993, the module has removed 12.430 billion gallons of groundwater and 2,577.71 lbs of uranium from the GMA.

During 2010, 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 2010, 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 four different wells monitored for PRRS constituents of concern had “up, significant” trends:

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

Concentration versus time plots for these constituents and wells are provided in Figures A.1−2 through A.1−8. As reported in Attachment A.3, the groundwater flow direction at these wells was from the northeast to southwest and does not appear to be in the extent of capture from the South Plume wells. This indicates that the increasing concentrations at these locations were moving toward the PRRS plume, not away from it.

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 2009, there was an estimated detection for toluene in monitoring well 3898. There were no detects for toluene in monitoring well 3898 in 2010.

In 2010, toluene was detected in two different monitoring wells (well 3636 and well 3900). The detection in well 3636 of 0.46 µg/L and the detection in well 3900 of 0.38 µg/L were slightly above the laboratory method detection limit of 0.250 µg/L, but below the contract required detection limit of 10 µg/L. These results are similar to what was seen at monitoring well 3898

in 2009. Both 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 the practical quantitation limit of 1.00 µg/L. Given the low values and estimated qualifier of these detections continued monitoring is the only action recommended at this time.

A.1.3 Waste Storage Area Module

Four extraction wells were operational in the former Waste Storage Area in 2010. 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 2010 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 2010, 482.50 M gal of groundwater were pumped from extraction wells in the Waste Storage Area Module, resulting in the removal of 90.25 lbs of uranium from the GMA. Since startup of the Waste Storage Area Module in May 2002, 3.745 billion gallons of water and 1,592.58 lbs of uranium have been removed from the GMA.

A.1.4 Total Uranium Data

Water samples were collected monthly in 2010 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.1−9 provides a graph of the monthly gallons of groundwater extracted versus the monthly gallons of groundwater treated for 2010. Since 2005, the percentage of treatment needed to achieve uranium discharge limits has been decreasing. Data collected in 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.1−10 through A.1−32 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.1−10 through A.1−32 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 approximately 2025 (trend for the 95 percent UCL data).

Figures A.1−10 through A.1−32 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, 2010, are summarized in Table A.1−26.

At the end of December 2010, approximately 10,261 net lbs of uranium had been removed from the GMA by the pump-and-treat remedy. Model predictions indicate that through 2024 an additional 3,669 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 3,424 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 13,691 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**
Net pounds of uranium extracted through December 2010	10,261	10,261	10,261
Predicted pounds of U to be extracted between 2011 and the end of the pump and treat stage of the aquifer remedy	3,424	3,669	13,691
Total predicted pounds of uranium to be removed	**13,685**	**13,930**	**23,952**
Estimated Percent Complete (based on pounds of uranium to be removed)	**75%**	**74%**	**43%**

Table A.1−27 provides a yearly breakdown for the three predictions. Figure A.1−33 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 75 percent (based on the uranium concentration data set) or 74 percent (based on the model predictions). The pump and treat stage of the aquifer remedy is approximately 43 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.

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 2010 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 2010 through December 2010			August 1993 through December 2010		
	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	1,271.05	350.85	0.28	13,576.926	6,167.163	0.45
Waste Storage Area Module	482.50	90.25	0.19	3,744.818	1,592.576	0.43
South Plume Module	633.32	109.50	0.17	12,429.935	2,577.712	0.21
Re-injection Module[c]	0	0	NA	1,936.478	76.27	NA
Aquifer Restoration Systems Totals						
Extraction Wells	2,386.87	550.60	0.23	29,751.679	10,337.451	0.35
(Re-injection Wells)	0	0	NA	(1,936.478)	(76.27)	NA
Net	2,386.87	550.60	NA	27,815.201	10,261.181	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 2010

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 – 1,004

Hours pumped – 7,756
Operational percent – 88.54
Adjusted operational percent[a] – 96.76

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)**
1/10		107.8		4.814		33.6		0.28
2/10		104.2		4.203		37.3		0.31
3/10		100.3		4.479		39.1		0.33
4/10		96.6		4.172		38.5		0.32
5/10		2.5		0.112		32.6		0.27
6/10		93.5		4.037		38.0		0.32
7/10		105.9		4.729		33.2		0.28
8/10		91.7		4.095		39.3		0.33
9/10		103.6		4.476		38.8		0.32
10/10		105.8		4.723		37.8		0.32
11/10		98.7		4.263		33.5		0.28
12/10		109.5		4.888		35.3		0.29
	Average	93.4	Total	48.991	Average	36.4	Average	0.31

[a] Adjusted for planned annual well field shutdown.
[b] Well 18 was down from April 30 to May 31 for annual shutdown.
Well 18 was down from August 15 to August 18 for electric cable repair.
Well 18 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−3. Extraction Well 31560 (EW-19) Operational Summary Sheet For 2010

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 – 974

Hours pumped – 7,786
Operational percent – 88.89
Adjusted operational percent[a] – 97.14

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)**
1/10	113.0		5.043		19.3		0.16
2/10	108.8		4.388		19.0		0.16
3/10	92.6		4.136		20.6		0.17
4/10	93.1		4.024		21.2		0.18
5/10	2.6		0.118		13.2		0.11
6/10	96.8		4.182		21.3		0.18
7/10	106.5		4.753		23.0		0.19
8/10	111.6		4.981		24.5		0.20
9/10	103.5		4.473		22.6		0.19
10/10	108.3		4.836		19.0		0.16
11/10	96.7		4.178		17.2		0.14
12/10	108.6		4.847		16.9		0.14
Average	95.2	Total	49.959	Average	19.8	Average	0.17

[a] Adjusted for planned annual well field shutdown.
[b] Well 19 was down from April 15 to April 16 for chemical treatment.
Well 19 was down from April 30 to May 31 for annual shutdown.
Well 19 was down from November 9 to November 10 for electrical upgrade project tie–ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−4. Extraction Well 31561 (EW-20) Operational Summary Sheet For 2010

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 – 953

Hours pumped – 7,807
Operational percent – 89.12
Adjusted operational percent[a] – 97.39

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)
1/10	107.7	4.806	33.0	0.28
2/10	102.3	4.124	31.8	0.27
3/10	99.3	4.433	32.7	0.27
4/10	96.3	4.159	31.3	0.26
5/10	3.1	0.137	30.4	0.25
6/10	95.2	4.114	30.7	0.26
7/10	107.1	4.781	28.7	0.24
8/10	106.4	4.750	31.9	0.27
9/10	99.1	4.282	30.2	0.25
10/10	106.5	4.754	30.3	0.25
11/10	99.8	4.313	54.3	0.45
12/10	110.6	4.939	30.9	0.26
Average	94.5	Total 49.592	Average 33.0	Average 0.28

[a] Adjusted for planned annual well field shutdown.
[b] Well 20 was down from April 15 to April 16 for chemical treatment.
Well 20 was down from April 30 to May 31 for annual shutdown.
Well 20 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−5. Extraction Well 33326 (EW-17a) Operational Summary Sheet For 2010

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 – 1,266

Hours pumped – 7,494
Operational percent – 85.55
Adjusted operational percent[a] – 93.49

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)**
1/10	159.3		7.112		18.4		0.15
2/10	169.6		6.838		16.4		0.14
3/10	166.2		7.419		17.5		0.15
4/10	166.0		7.170		18.4		0.15
5/10	5.3		0.237		19.4		0.16
6/10	68.1		2.943		23.6		0.20
7/10	165.9		7.407		18.7		0.16
8/10	172.0		7.679		20.4		0.17
9/10	163.4		7.058		19.3		0.16
10/10	167.8		7.493		18.0		0.15
11/10	157.6		6.809		16.2		0.14
12/10	166.5		7.431		18.6		0.16
Average	144.0	Total	75.595	Average	18.7	Average	0.16

[a] Adjusted for planned annual well field shutdown.
[b] Well 17a was down from April 21 to April 22 for chemical treatment.
Well 17a was down from April 30 to May 31 for annual shutdown.
Well 17a was down from June 3 to June 15 for rehabilitation.
Well 17a was down June 16 and June 17 due to a blown fuse.
Well 17a was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−6. Extraction Well 32276 (EW-22) Operational Summary Sheet For 2010

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 – 1,022

Hours pumped – 7,738
Operational percent – 88.33
Adjusted operational percent[a] – 96.53

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)**
1/10		328.0		14.642		33.4		0.28
2/10		312.0		12.579		32.3		0.27
3/10		297.0		13.258		33.5		0.28
4/10		297.5		12.851		34.3		0.29
5/10		8.5		0.377		23.0		0.19
6/10		286.4		12.371		37.1		0.31
7/10		315.0		14.063		34.6		0.29
8/10		309.7		13.823		39.5		0.33
9/10		268.0		11.578		40.4		0.34
10/10		299.0		13.347		38.2		0.32
11/10		277.7		11.995		35.4		0.30
12/10		300.0		13.392		34.6		0.29
	Average	274.9	Total	144.277	Average	34.7	Average	0.29

[a] Adjusted for planned annual well field shutdown.
[b] Well 22 was down from April 30 to May 31 for annual shutdown.
Well 22 was down from September 27 to September 30 due to flow meter problems.
Well 22 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−7. Extraction Well 32446 (EW-24) Operational Summary Sheet For 2010

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 – 949

Hours pumped – 7,811
Operational percent – 89.17
Adjusted operational percent[a] – 97.44

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)**
1/10		326.4		14.572		43.9		0.37
2/10		307.7		12.406		32.3		0.27
3/10		289.5		12.922		44.1		0.37
4/10		290.7		12.560		43.3		0.36
5/10		8.6		0.383		27.7		0.23
6/10		307.9		13.300		41.6		0.35
7/10		318.6		14.220		43.0		0.36
8/10		322.0		14.374		42.8		0.36
9/10		312.6		13.504		44.5		0.37
10/10		310.0		13.839		43.1		0.36
11/10		303.4		13.107		40.8		0.34
12/10		318.4		14.213		43.5		0.36
	Average	284.6	Total	149.401	Average	40.9	Average	0.34

[a] Adjusted for planned annual well field shutdown.
[b] Well 24 was down from March 9 to March 10 for chemical treatment.
Well 24 was down from April 30 to May 31 for annual shutdown.
Well 24 was down from July 20 to July 21 for chemical treatment.
Well 24 was down from October 28 to October 29 for chemical treatment.
Well 24 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May and June.

Table A.1−8. Extraction Well 32447 (EW-23) Operational Summary Sheet For 2010

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 – 998

Hours pumped – 7,762
Operational percent – 88.61
Adjusted operational percent[a] – 96.83

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)**
1/10	325.1		14.514		57.8		0.48
2/10	292.7		11.800		55.7		0.46
3/10	291.0		12.992		56.7		0.47
4/10	277.5		11.990		57.3		0.48
5/10	8.5		0.378		25.6		0.21
6/10	270.7		11.694		49.2		0.41
7/10	299.2		13.355		62.2		0.52
8/10	324.5		14.487		58.1		0.48
9/10	288.4		12.460		58.2		0.49
10/10	274.0		12.232		54.6		0.46
11/10	303.4		13.108		50.6		0.42
12/10	314.4		14.033		52		0.43
Average	272.5	Total	143.043	Average	53.2	Average	0.44

[a] Adjusted for planned annual well field shutdown.
[b] Well 23 was down from March 9 to March 10 for chemical treatment.
Well 23 was down from April 15 to April 16 for chemical treatment.
Well 23 was down from April 30 to May 31 for annual shutdown.
Well 23 was down on June 17 to allow sampling of nearby monitoring well.
Well 23 was down from July 20 to July 21 for chemical treatment.
Well 23 was down from October 20 to October 21 for chemical treatment.
Well 23 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May and June.

Table A.1−9. Extraction Well 33061 (EW-25) Operational Summary Sheet For 2010

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 – 1,521

Hours pumped – 7,239
Operational percent – 82.64
Adjusted operational percent[a] – 90.31

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)**
1/10		144.0		6.430		25.9		0.22
2/10		143.3		5.777		23.3		0.19
3/10		34.4		1.534		28.1		0.23
4/10		195.5		8.446		25.7		0.21
5/10		0.1		0.007		21.0		0.18
6/10		143.3		6.191		33.7		0.28
7/10		149.5		6.676		37.0		0.31
8/10		143.1		6.389		34.1		0.28
9/10		139.1		6.011		26.0		0.22
10/9		143.2		6.394		23.1		0.19
11/10		140.2		6.056		24.3		0.20
12/10		194.5		8.682		24.9		0.21
	Average	131.9	Total	68.591	Average	27.3	Average	0.23

[a] Adjusted for planned annual well field shutdown.
[b] Well 25 was down from March 7 to March 31 for pump and motor maintenance.
Well 25 was down from April 30 to June 4 for annual shutdown and rehabilitation.
Well 25 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−10. Extraction Well 33262 (EW-15a) Operational Summary Sheet For 2010

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 – 877

Hours pumped – 7,883
Operational percent – 89.99
Adjusted operational percent[a] – 98.34

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)**
1/10		218.1		9.737		31.6		0.26
2/10		210.0		8.466		30.8		0.26
3/10		195.0		8.705		31.7		0.26
4/10		194.2		8.390		36.6		0.31
5/10		5.9		0.262		45.0		0.38
6/10		206.4		8.915		40.5		0.34
7/10		216.6		9.671		37.4		0.31
8/10		216.1		9.646		39.4		0.33
9/10		208.3		8.998		36.2		0.30
10/10		215.3		9.612		30.7		0.26
11/10		201.7		8.715		25.9		0.22
12/10		217.9		9.728		25.5		0.21
	Average	192.1	Total	100.845	Average	34.3	Average	0.29

[a] Adjusted for planned annual well field shutdown.
[b] Well 15a was down from April 30 to May 31 for annual shutdown.
Well 15a was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−11. Extraction Well 33264 (EW-30) Operational Summary Sheet For 2010

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 – 1,041
Hours pumped – 7,719
Operational percent – 88.12
Adjusted operational percent[a] – 96.30
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)**
1/10		220.0		9.821		47.2		0.39
2/10		207.3		8.358		43.1		0.36
3/10		197.0		8.794		47.2		0.39
4/10		191.8		8.288		45.8		0.38
5/10		5.5		0.245		21.7		0.18
6/10		187.4		8.094		45.8		0.38
7/10		210.4		9.392		45.4		0.38
8/10		208.6		9.311		49.6		0.41
9/10		204.6		8.838		47.4		0.40
10/10		212.7		9.496		45.3		0.38
11/10		199.0		8.599		38.5		0.32
12/10		214.2		9.563		41.4		0.35
	Average	188.2	Total	98.799	Average	43.2	Average	0.36

[a] Adjusted for planned annual well field shutdown.
[b] Well 30 was down from April 12 to April 13 for chemical treatment.
Well 30 was down from April 30 to May 31 for annual shutdown.
Well 30 was down on June 17 to allow sampling of nearby monitoring well.
Well 30 was down from July 21 to July 22 for chemical treatment.
Well 30 was down from October 26 to October 27 for chemical treatment.
Well 30 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−12. Extraction Well 33265 (EW-31) Operational Summary Sheet For 2010

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 – 1,152

Hours pumped – 7,608
Operational percent – 86.85
Adjusted operational percent[a] – 94.91

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)**
1/10		330.0		14.731		14.6		0.12
2/10		307.9		12.416		11.9		0.10
3/10		278.4		12.430		13.6		0.11
4/10		182.6		7.889		13.4		0.11
5/10		8.2		0.365		16.5		0.14
6/10		312.0		13.478		16.8		0.14
7/10		326.3		14.566		15.8		0.13
8/10		315.2		14.068		14.8		0.12
9/10		315.2		13.616		13.7		0.11
10/10		320.4		14.303		11.8		0.10
11/10		313.1		13.524		10.4		0.09
12/10		326.4		14.572		15.5		0.13
	Average	278.0	Total	145.960	Average	14.1	Average	0.12

[a] Adjusted for planned annual well field shutdown.
[b] Well 31 was down from April 12 to April 13 for chemical treatment.
Well 31 was down from April 21 to May 31 for rehabilitation and annual shutdown.
Well 31 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−13. Extraction Well 33266 (EW-32) Operational Summary Sheet For 2010

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 – 1,008.5
Hours pumped – 7,751.5
Operational percent – 88.49
Adjusted operational percent[a] – 96.70
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)**
1/10	220.0	9.821	7.1	0.06
2/10	204.9	8.262	6.6	0.06
3/10	189.9	8.477	7.4	0.06
4/10	195.1	8.429	6.2	0.05
5/10	5.4	0.240	8.0	0.07
6/10	198.7	8.583	10.2	0.09
7/10	208.4	9.301	6.2	0.05
8/10	212.5	9.485	5.8	0.05
9/10	209.1	9.033	6.6	0.06
10/10	203.3	9.077	5.5	0.05
11/10	199.0	8.596	5.8	0.05
12/10	215.6	9.623	6.6	0.06
Average	188.5	Total 98.927	Average 6.8	Average 0.06

[a] Adjusted for planned annual well field shutdown.
[b] Well 32 was down from April 30 to May 31 for annual shutdown.
Well 32 was down from July 21 to July 22 for chemical treatment.
Well 32 was down from October 26 to October 27 for chemical treatment.
Well 32 was down from October 28 to October 29 for chemical treatment.
Well 32 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May and June.

Table A.1−14. Extraction Well 33298 (EW-21a) Operational Summary Sheet For 2010

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 – 1,134
Hours pumped – 7,626
Operational percent – 87.06
Adjusted operational percent[a] – 95.14
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)**
1/10	216.7	9.673	40.1	0.33
2/10	210.9	8.505	40.6	0.34
3/10	196.7	8.783	37.1	0.31
4/10	134.7	5.817	44.0	0.37
5/10	5.3	0.235	63.5	0.53
6/10	191.7	8.283	59.9	0.50
7/10	213.2	9.517	48.9	0.41
8/10	213.6	9.536	49.1	0.41
9/10	206.7	8.929	42.2	0.35
10/10	210.1	9.380	40.3	0.34
11/10	201.7	8.714	40.4	0.34
12/10	217.4	9.703	41.2	0.34
Average	184.9	Total 97.075	Average 45.6	Average 0.38

[a] Adjusted for planned annual well field shutdown.
[b] Well 21a was down from April 21 to May 31 for rehabilitation and annual shutdown.
Well 21a was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−15. Extraction Well 3924 (RW-1) Operational Summary Sheet For 2010

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 – 8,246 Target pumping rate – 200 gpm
Hours not pumped – 514 Operational percent – 94.13

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)**
1/10		176.6		7.883		21.2		0.18
2/10		201.7		8.134		18.6		0.16
3/10		190.9		8.521		19.7		0.16
4/10		201.0		8.685		18.2		0.15
5/10		192.4		8.589		18.0		0.15
6/10		189.1		8.168		18.1		0.15
7/10		223.7		9.987		18.5		0.15
8/10		221.6		9.894		19.4		0.16
9/10		246.5		10.647		19.1		0.16
10/10		242.0		10.802		18.1		0.15
11/10		203.9		8.810		17.7		0.15
12/10		220.6		9.847		20.5		0.17
	Average	209.2	Total	109.965	Average	18.9	Average	0.16

[a] Well 1 was down from Jan 26 to Feb 1 due to a small leak in the body of the control valve.
Well 1 was down from May 3 to May 4 for piping system maintenance.
Well 1 was down from May 24 to May 26 for work on effluent line.
Well 1 was down from May 26 to May 27 due to a power outage.
Well 1 was down June 13 due to no control from process control system due to storm damage.
Well 1 was down from August 18 to August 19 for chemical treatment.
Well 1 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[b] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−16. Extraction Well 3925 (RW-2) Operational Summary Sheet For 2010

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 pumped – 8,349 Target pumping rate – 200 gpm
Hours not pumped – 411 Operational percent – 95.3

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)**
1/10	236.4	10.555	17.4	0.15
2/10	216.6	8.734	17.9	0.15
3/10	185.5	8.281	19.6	0.16
4/10	201.5	8.707	15.8	0.13
5/10	195.4	8.721	16.8	0.14
6/10	190.5	8.230	17.2	0.14
7/10	217.3	9.701	16.4	0.14
8/10	224.7	10.030	17.5	0.15
9/10	249.6	10.781	17.1	0.14
10/10	232.4	10.372	15.3	0.13
11/10	212.5	9.181	14.2	0.12
12/10	223.7	9.985	17.4	0.15
Average	215.5	Total 113.277	Average 16.9	Average 0.14

[a] Well 2 was down from March 17 to March 18 for chemical treatment.
Well 2 was down from May 3 to May 4 for piping system maintenance.
Well 2 was down from May 24 to May 26 for work on effluent line.
Well 2 was down from May 26 to May 27 due to a power outage.
Well 2 was down June 13 due to no control from process control system due to storm damage.
Well 2 was down from August 18 to August 19 for chemical treatment.
Well 2 was down from October 19 to October 21 for chemical treatment.
Well 2 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[b] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−17. Extraction Well 3926 (RW-3) Operational Summary Sheet For 2010

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 pumped – 8,354 Target pumping rate – 200 gpm
Hours not pumped – 406 Operational percent – 95.36

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)**
1/10		216.4		9.660		27.8		0.23
2/10		216.1		8.713		27.6		0.23
3/10		191.1		8.532		27.6		0.23
4/10		196.6		8.495		24.9		0.21
5/10		199.9		8.921		26.1		0.22
6/10		196.8		8.502		24.5		0.20
7/10		224.3		10.011		24.0		0.20
8/10		211.8		9.454		25.7		0.21
9/10		197.9		8.549		25.0		0.21
10/10		218.1		9.735		23.4		0.20
11/10		202.5		8.749		20.5		0.17
12/10		205.6		9.177		23.6		0.20
	Average	206.4	Total	108.497	Average	25.1	Average	0.21

[a] Well 3 was down from Jan 19 to Jan 20 for pump replacement.
Well 3 was down from April 20 to April 21 for chemical treatment.
Well 3 was down from May 3 to May 4 for piping system maintenance.
Well 3 was down from May 24 to May 26 for work on effluent line.
Well 3 was down from May 26 to May 27 due to a power outage.
Well 3 was down June 13 due to no control from process control system due to storm damage.
Well 3 was down from September 9 to September 10 for chemical treatment.
Well 3 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[b] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−18. Extraction Well 3927 (RW-4) Operational Summary Sheet For 2010

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 – 8,399 Target pumping rate – 200 gpm
Hours not pumped – 361 Operational percent – 95.88

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)**
1/10		219.6		9.802		2.7		0.02
2/10		211.5		8.528		2.1		0.02
3/10		189.7		8.466		3.1		0.03
4/10		192.3		8.308		2.8		0.02
5/10		197.2		8.803		2.8		0.02
6/10		187.5		8.102		2.9		0.02
7/10		231.1		10.318		2.8		0.02
8/10		215.9		9.638		2.6		0.02
9/10		202.1		8.730		2.7		0.02
10/10		218.0		9.732		2.3		0.02
11/10		200.0		8.641		2.2		0.02
12/10		218.3		9.745		3.2		0.03
	Average	206.9	Total	108.812	Average	2.7	Average	0.02

[a] Well 4 was down from April 20 to April 21 for chemical treatment.
Well 4 was down from May 3 to May 4 for piping system maintenance.
Well 4 was down from May 24 to May 26 for work on effluent line.
Well 4 was down from May 26 to May 27 due to a power outage.
Well 4 was down June 13 due to no control from process control system due to storm damage.
Well 4 was down from September 9 to September 10 for chemical treatment.
Well 4 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[b] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−19. Extraction Well 32308 (RW-6) Operational Summary Sheet For 2010

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 – 975.5

Hours pumped – 7,784.5
Operational percent – 88.86
Adjusted operational percent[a] – 97.11

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)**	
1/10		219.5		9.798		34.2		0.29
2/10		211.6		8.531		33.9		0.28
3/10		190.6		8.510		35.7		0.30
4/10		180.4		7.793		35.4		0.30
5/10		6.0		0.268		32.0		0.27
6/10		199.7		8.625		34.4		0.29
7/10		215.2		9.608		32.9		0.27
8/10		219.0		9.777		34.5		0.29
9/10		207.6		8.967		35.6		0.30
10/10		195.7		8.735		33.5		0.28
11/10		166.8		7.207		31.0		0.26
12/10		156.4		6.980		33.5		0.28
	Average	180.7	Total	94.800	Average	33.9	Average	0.28

[a] Adjusted for planned annual well field shutdown.
[b] Well 6 was down from April 27 to April 28 for chemical treatment.
Well 6 was down from April 30 to May 31 for annual shutdown.
Well 6 was down June 13 due to no control from process control system due to storm damage.
Well 6 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−20. Extraction Well 32309 (RW-7) Operational Summary Sheet For 2010

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 – 977.4
Hours re-injected – 7,782.6
Operational percent – 88.84
Adjusted operational percent[a] – 97.09
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)**
1/10	219.3	9.790	33.7	0.28
2/10	212.8	8.578	34.8	0.29
3/10	191.6	8.553	37.9	0.32
4/10	184.8	7.984	36.3	0.30
5/10	6.0	0.268	32.0	0.27
6/10	190.4	8.225	34.8	0.29
7/10	214.0	9.551	32.3	0.27
8/10	222.2	9.918	35.4	0.30
9/10	205.2	8.864	34.7	0.29
10/10	203.6	9.090	32.5	0.27
11/10	197.2	8.519	30.4	0.25
12/10	193.3	8.629	31.9	0.27
Average	186.7	Total 97.969	Average 33.9	Average 0.28

[a] Adjusted for planned annual well field shutdown.
[b] Well 7 was down from April 27 to April 28 for chemical treatment.
Well 7 was down from April 30 to May 31 for annual shutdown.
Well 7 was down June 13 due to no control from process control system due to storm damage.
Well 7 was down from November 9 to November 10 for electrical upgrade project tie-ins.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

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	236	0.000195	0.188	0.0114	0.0207	Down, Significant
	2625	209	0.00110	0.0706	0.0118	0.0096	Down, Significant
	2636	179	0.01	0.0939	0.0444	0.0186	Down, Significant
	2898	53	0.000147	0.082	0.0042	0.0119	**Up, Significant**
	2899	46	0.00032	0.0283	0.0022	0.0043	No Significant Trend
	2900	235	0.00032	0.0609	0.0050	0.0054	Down, Significant
	3128	56	0.0004	0.234	0.0076	0.0312	No Significant Trend
	3636	55	0.0005	0.0233	0.0027	0.0039	**Up, Significant**
	3898	53	0.0005	0.0434	0.0042	0.0069	**Up, Significant**
	3899	54	0.000147	0.0307	0.0025	0.0048	Up, Marginal
	3900	54	0.000375	0.0208	0.0028	0.0034	No Significant Trend
Phosphorus	2128	62	0.025	16.2	1.47	2.47	Down, Significant
	2625	33	0.307	12.3	3.04	2.82	No Significant Trend
	2636	31	9.6	170	89.2	44.9	No Significant Trend
	2898	54	0.005	9.95	0.282	1.37	Down, Marginal
	2899	45	0.005	0.831	0.059	0.124	No Significant Trend
	2900	52	0.05	4.74	0.507	0.691	Down, Significant
	3128	63	0.005	13	0.259	1.63	No Significant Trend
	3636	54	0.00955	1.1	0.075	0.15	No Significant Trend
	3898	52	0.00955	1.24	0.111	0.181	No Significant Trend
	3899	53	0.005	0.83	0.095	0.154	Down, Significant
	3900	54	0.005	1.38	0.096	0.248	Down, Marginal
Potassium	2128	54	0.83	18	3.5	3.47	No Significant Trend
	2625	34	0.64	9.49	3.21	1.94	No Significant Trend
	2636	31	5.31	218	70.0	53.0	Down, Significant
	2898	54	1.11	9.64	4.33	1.28	**Up, Significant**
	2899	46	1.36	8.85	4.01	1.02	**Up, Significant**
	2900	53	0.0095	6	2.04	1.09	Up, Marginal
	3128	56	1.09	3.7	1.99	0.66	Down, Significant
	3636	54	1.09	4.24	2.23	0.55	Down, Significant
	3898	53	0.61	3.93	2.42	0.57	**Up, Significant**
	3899	54	0.875	3.22	2.46	0.36	Up, Marginal
	3900	54	0.975	3.19	1.73	0.41	Down, Significant
Sodium	2128	54	12.3	75.2	34.3	11.4	Down, Significant
	2625	34	16.5	50.7	32.0	7.7	Down, Significant
	2636	31	23	148	55.2	27.4	No Significant Trend
	2898	54	4.95	29.2	18.4	4.1	No Significant Trend
	2899	46	11.2	22.9	16.8	2.6	No Significant Trend
	2900	53	0.0136	43.3	27.2	7.5	No Significant Trend
	3128	56	3.52	13.4	5.68	2.67	Down, Significant
	3636	54	3.14	13	6.0	2.9	Down, Significant
	3898	53	7.29	22.1	10.3	2.8	**Up, Significant**
	3899	54	6.24	13.3	8.89	1.35	Up, Marginal
	3900	54	3.13	10.8	4.93	1.86	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 2010 groundwater data (unfiltered and filtered for 2001 through 2010).
[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 either 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 2010

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 – 1045.5

Hours pumped – 7,714.5
Operational percent – 88.07
Adjusted operational percent[a] – 96.24

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)**
1/10	327.7	14.630	27.9	0.23
2/10	319.4	12.877	26.3	0.22
3/10	292.8	13.071	28.8	0.24
4/10	285.1	12.316	29.1	0.24
5/10	8.9	0.397	32.4	0.27
6/10	309.2	13.357	33.1	0.28
7/10	329.4	14.705	29.5	0.25
8/10	322.0	14.373	28.3	0.24
9/10	314.6	13.589	27.2	0.23
10/10	289.5	12.921	25.3	0.21
11/10	251.9	10.880	24.1	0.20
12/10	326.7	14.584	26.2	0.22
Average	281.4	Total 147.700	Average 28.2	Average 0.24

[a] Adjusted for planned annual well field shutdown.
[b] Well 26 was down from April 30 to May 31 for annual shutdown.
Well 26 was down from November 9 to November 10 for electrical upgrade project tie-ins.
Well 26 was down from November 17 to November 22 for electrical upgrades project.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−23. Extraction Well 33062 (EW-27) Operational Summary Sheet For 2010

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 – 1,424
Hours pumped – 7,336
Operational percent – 83.75
Adjusted operational percent[a] – 91.52
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)**	
1/10	216.2		9.650		31.8		0.27	
2/10	210.0		8.467		30.9		0.26	
3/10	194.4		8.679		33.7		0.28	
4/10	189.5		8.186		33.3		0.28	
5/10	6.7		0.297		32.5		0.27	
6/10	196.5		8.489		36.9		0.31	
7/10	119.9		5.352		23.6		0.20	
8/10	218.2		9.742		34.3		0.29	
9/10	209.1		9.031		34.3		0.29	
10/10	198.2		8.847		31.4		0.26	
11/10	157.3		6.797		30.4		0.25	
12/10	224.5		10.021		31.9		0.27	
Average	178.4	Total	93.559	Average	32.1	Average	0.27	

[a] Adjusted for planned annual well field shutdown.
[b] Well 27 was down from April 30 to May 31 for annual shutdown.
Well 27 was down from November 9 to November 10 for electrical upgrade project tie–ins.
Well 27 was down from November 17 to November 22 for electrical upgrades project.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−24. Extraction Well 33334 (EW-28a) Operational Summary Sheet For 2010

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 – 1,418

Hours pumped – 7,342
Operational percent – 83.81
Adjusted operational percent[a] – 91.59

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)**
1/10	216.2	9.652	12.0	0.10
2/10	214.0	8.630	11.1	0.09
3/10	198.0	8.840	12.8	0.11
4/10	209.0	9.030	11.8	0.10
5/10	6.7	0.297	11.2	0.09
6/10	152.6	6.592	11.1	0.09
7/10	222.4	9.929	11.5	0.10
8/10	214.2	9.563	12.3	0.10
9/10	208.1	8.991	13.3	0.11
10/10	211.0	9.418	11.7	0.10
11/10	109.5	4.732	10.5	0.09
12/10	216.6	9.667	11.4	0.10
Average	181.5	Total 95.340	Average 11.7	Average 0.10

[a] Adjusted for planned annual well field shutdown.
[b] Well 28a was down from April 30 to May 31 for annual shutdown.
Well 28a was down from June 16 to June 23 to troubleshoot and repair bad wires to well variable frequency drive.
Well 28a was down from November 9 to November 10 for electrical upgrade project tie-ins.
Well 28a was down from November 17 to November 30 for electrical upgrades project.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for March, May.

Table A.1−25. Extraction Well 33347 (EW-33a) Operational Summary Sheet For 2010

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 – 1,120
Hours pumped – 7,640
Operational percent – 87.21
Adjusted operational percent[a] – 95.30
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)**
1/10		329.1		14.690		14.5		0.12
2/10		318.3		12.835		15.4		0.13
3/10		282.1		12.594		17.7		0.15
4/10		288.3		12.455		18.6		0.16
5/10		10.0		0.446		11.9		0.10
6/10		285.0		12.313		16.3		0.14
7/10		324.4		14.483		22.1		0.18
8/10		325.8		14.544		20.9		0.17
9/10		304.2		13.141		19.2		0.16
10/10		268.5		11.986		15.5		0.13
11/10		274.5		11.858		14.7		0.12
12/10		326.0		14.552		16.1		0.13
	Average	278.0	Total	145.896	Average	16.9	Average	0.14

[a] Adjusted for planned annual well field shutdown.
[b] Well 33a was down from April 30 to May 31 for annual shutdown.
Well 33a was down on June 17 to allow sampling of nearby monitoring well.
Well 33a was down on September 1 to sample monitoring wells in the area.
Well 33a was down from October 11 to October 14 for electrical upgrades project construction.
Well 33a was down from October 24 to October 27 for construction.
Well 33a was down from November 9 to November 10 for electrical upgrade project tie-ins.
Well 33a was down from November 17 to November 19 for electrical upgrades project.
[c] Average is used if more than one concentration measurement is available for a particular month. In 2010, an average was used for May.

Table A.1−26. Regression Equations for Uranium Concentration Data Collected at Extraction Wells—Data Collected Through December 31, 2010

Well ID	Location ID	Data Trend	R^2	95% UCL	R^2	Function Type
RW-1	3924	$y=1.32E+05e^{-2.24E-04x}$	0.772	$y=5.18E+03e^{-1.19E-04x}$	0.717	Exponential Function
RW-2	3925	$y=1.140E-06x^2-.0914x+1.851E+03$	0.677	$y=1.14E-06x^2-0.0914x+1.871E+03$	0.671	Polynomial
RW-3	3926	$y=-2.18E-06x^2+1.66E-01x-3.15E+03$	0.772	$y=-2.18E-06x^2+1.66E-01x-3.13E+03$	0.772	Polynomial
RW-4	3927	$y=5.30E-3e^{1.62E-04x}$	0.305	$y=3.03E-01e^{7.29E-05x}$	0.248	Exponential Function
RW-6	32308	$y=1.04E+05e^{-2.01E-04x}$	0.826	$y=1.11E+04e^{-1.30E-04x}$	0.827	Exponential Function
RW-7	32309	$y=3.77E+05e^{-2.35E-04x}$	0.869	$y=1.85E+04e^{-1.41E-04x}$	0.847	Exponential Function
EW-15a	33262	$y=5.98E+59x^{-1.27E+01}$	0.745	$y=1.84E+39x^{-8.15E+00}$	0.740	Power Function
EW-17a	33326	$y=6.31E+03e^{-1.41E-04x}$	0.463	$y=1.56E+03e^{-9.25E-05x}$	0.454	Exponential Function
EW-18	31550	$y=5.99E+04e^{-1.88E-04x}$	0.501	$y=6.02E+03e^{-1.12E-04x}$	0.487	Exponential Function
EW-19	31560	$y=5.38E+08e^{-4.27E-04x}$	0.875	$y=1.54E+05e^{-1.87E-04x}$	0.791	Exponential Function
EW-20	31561	$y=4.80E+03e^{-1.26E-04x}$	0.438	$y=1.51E+03e^{-8.54E-05x}$	0.429	Exponential Function
EW-21a	33298	$y=3.34E+06e^{-2.84E-04x}$	0.773	$y=4.78E+04e^{-1.54E-04x}$	0.757	Exponential Function
EW-22	32276	$y=5.28E+09e^{-4.74E-04x}$	0.947	$y=5.17E+05e^{-2.05E-04x}$	0.901	Exponential Function
EW-23	32447	$y=5.51E+08e^{-4.06E-04x}$	0.891	$y=6.18E+05e^{-2.09E-04x}$	0.857	Exponential Function
EW-24	32446	$y=3.54E+05e^{-2.27E-04x}$	0.728	$y=2.12E+04e^{-1.40E-04x}$	0.686	Exponential Function
EW-25	33061	$y=8.65E+04e^{-1.97E-04x}$	0.397	$y=7.33E+03e^{-1.22E-04x}$	0.360	Exponential Function
EW-30	33264	$y=1.01E+10e^{-4.78E-04x}$	0.862	$y=4.05E+06e^{-2.62E-04x}$	0.838	Exponential Function
EW-31	33265	$y=2.60E+07e^{-3.60E-04x}$	0.723	$y=1.03E+05e^{-2.03E-04x}$	0.664	Exponential Function
EW-32	33266	$y=7.58E+11e^{-6.33E-04x}$	0.882	$y=3.47E+06e^{-2.97E-04x}$	0.789	Exponential Function
EW-26	32761	$y=1.85E+10e^{-5.07E-04x}$	0.881	$y=1.60E+6e^{-2.44E-04x}$	0.813	Exponential Function
EW-27	33062	$y=1.34E+11e^{-5.55E-04x}$	0.828	$y=2.20E+6e^{-2.46E-04x}$	0.727	Exponential Function
EW-28a	33334	$y=4.48E+14e^{-7.80E-04x}$	0.865	$y=1.18E+06e^{-2.33E-04x}$	0.666	Exponential Function
EW-33a	33347	$Y=1.84E+19e^{-1.04E-03x}$	0.588	$y=4.25E+8e^{-3.89E-04x}$	0.523	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
2011	474	450	1,479
2012	415	404	1,371
2013	365	366	1,271
2014	321	335	1,179
2015	265	307	1,094
2016	263	276	1,057
2017	234	247	984
2018	209	225	917
2019	187	208	854
2020	168	193	797
2021	151	180	743
2022	136	169	693
2023	123	159	647
2024	112	150	604
Total To Be Extracted	3,424	3,669	13,691
Pounds Already Extracted Through 12-31-2010	10,261	10,261	10,261
Total	13,685	13,930	23,952
% 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

This page intentionally left blank

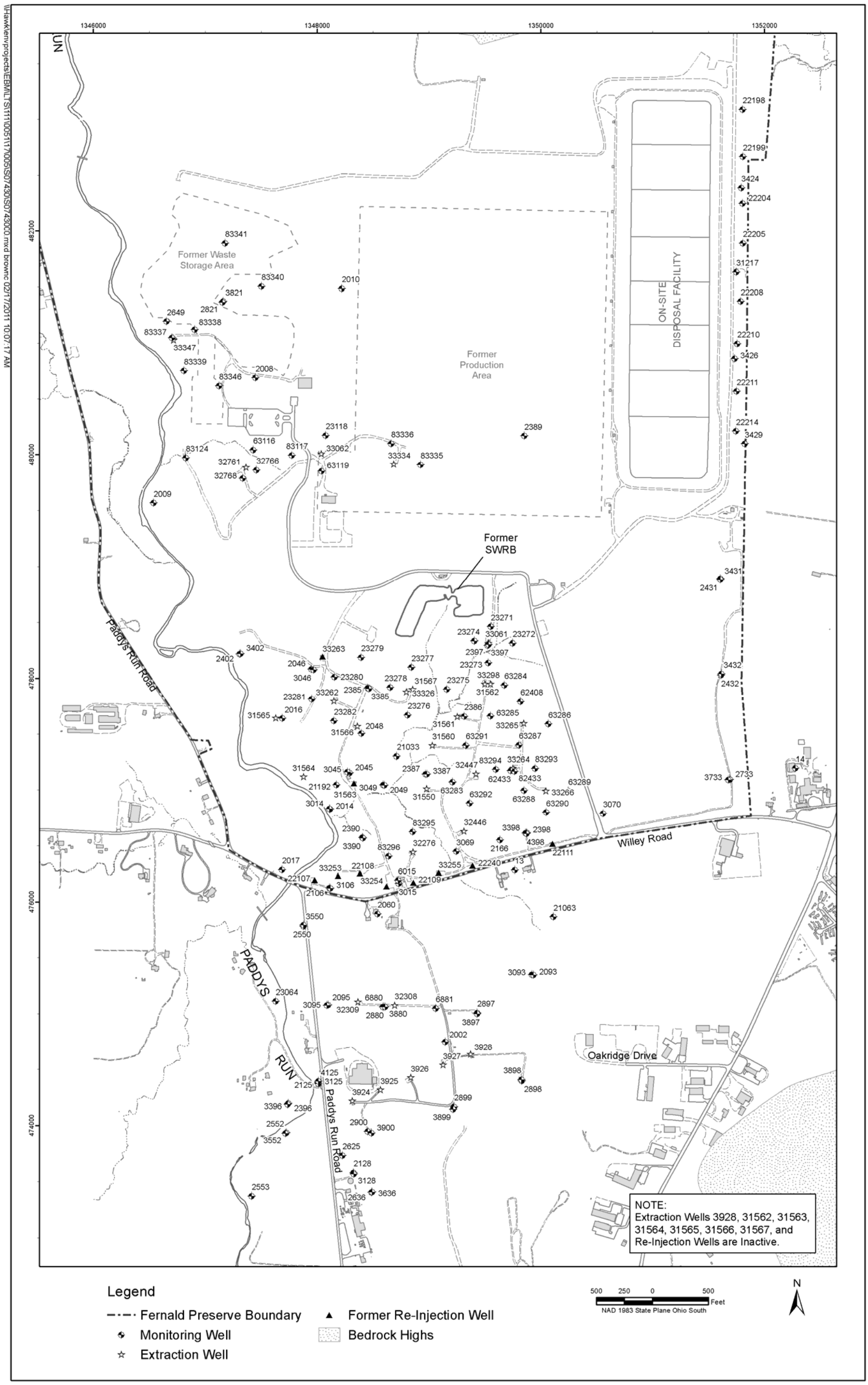


Figure A.1−1. Well Locations for South Plume, South Field, Waste Storage Area, and PRRS Monitoring Activities

This page intentionally left blank

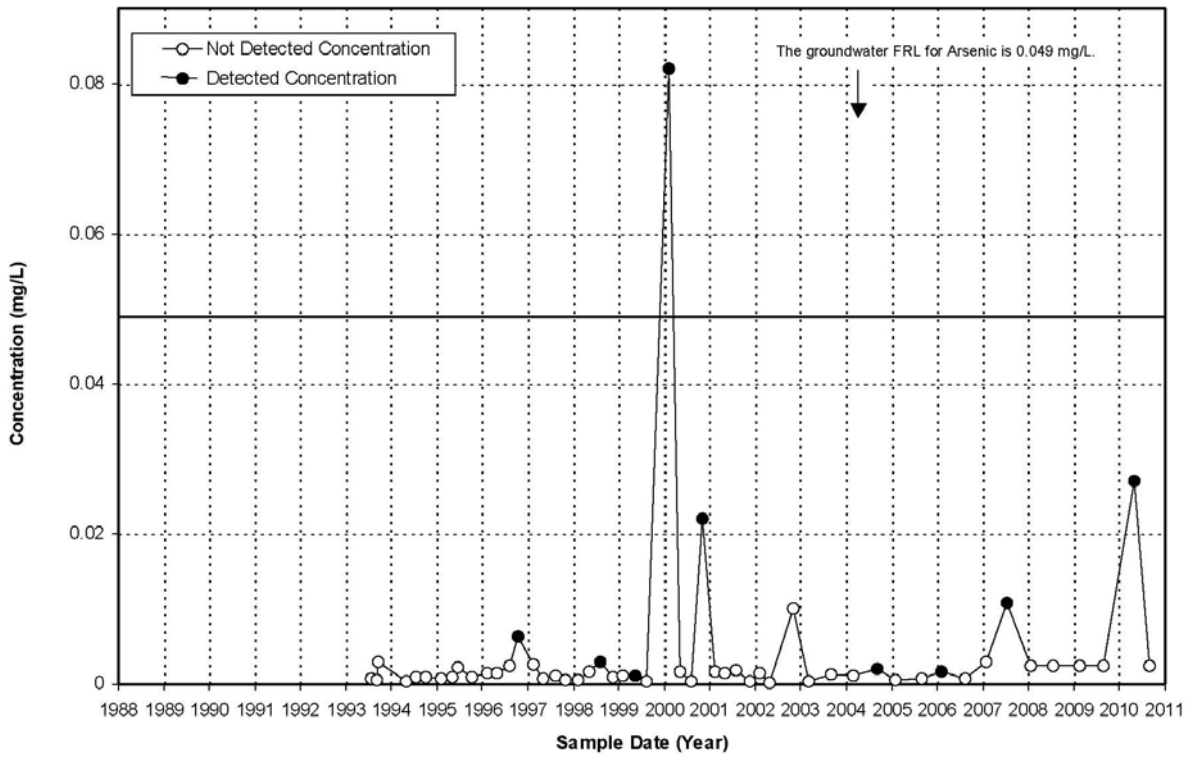


FIGURE A.1-2. ARSENIC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2898

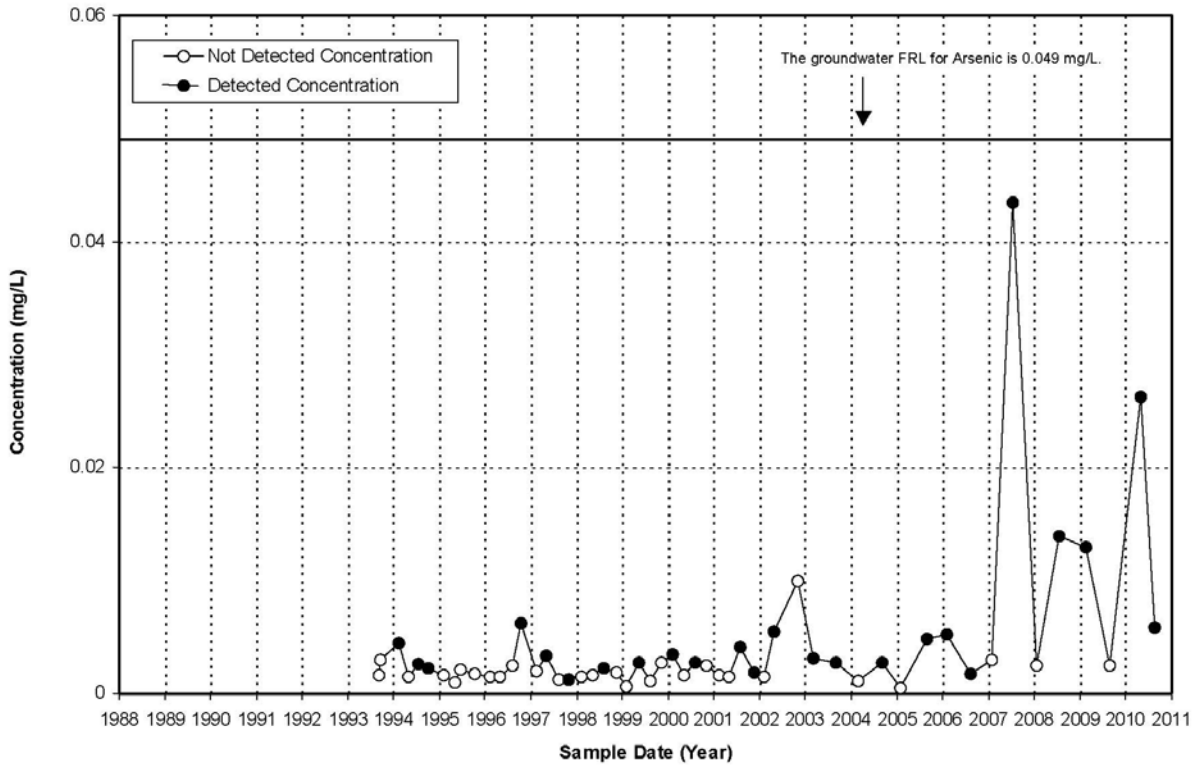


FIGURE A.1-3. ARSENIC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3898

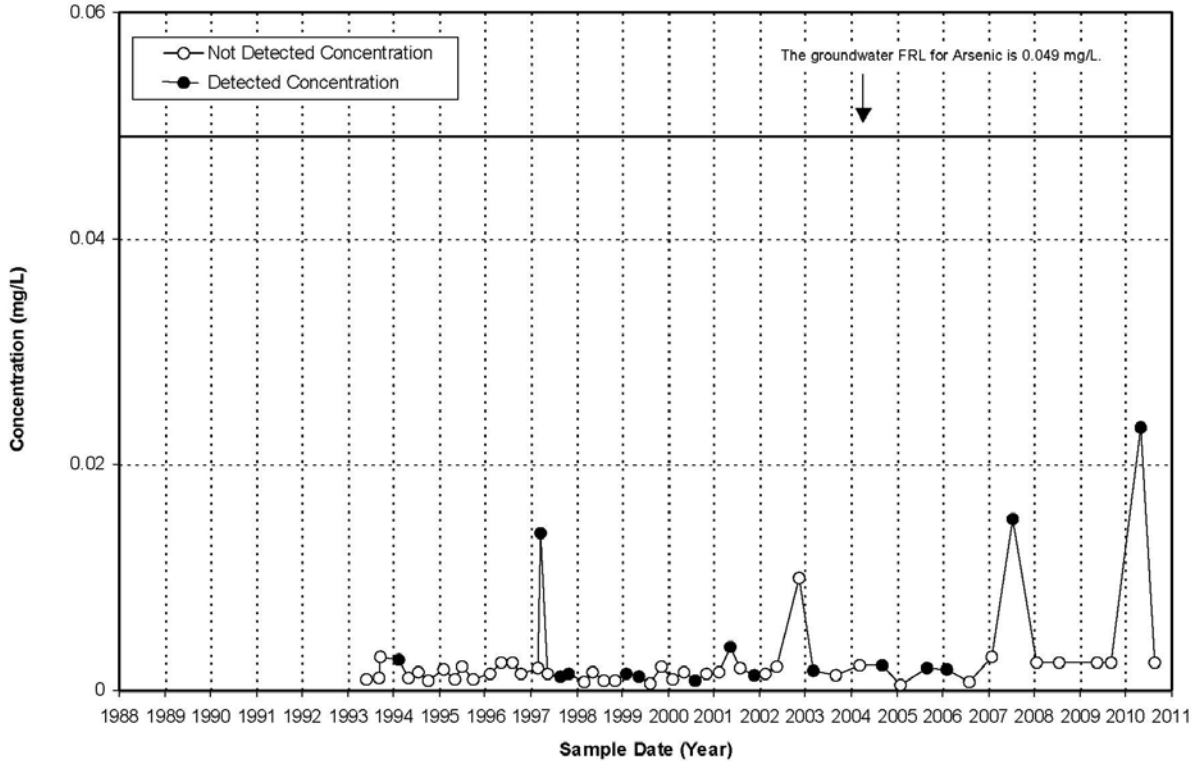


FIGURE A.1-4. ARSENIC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3636

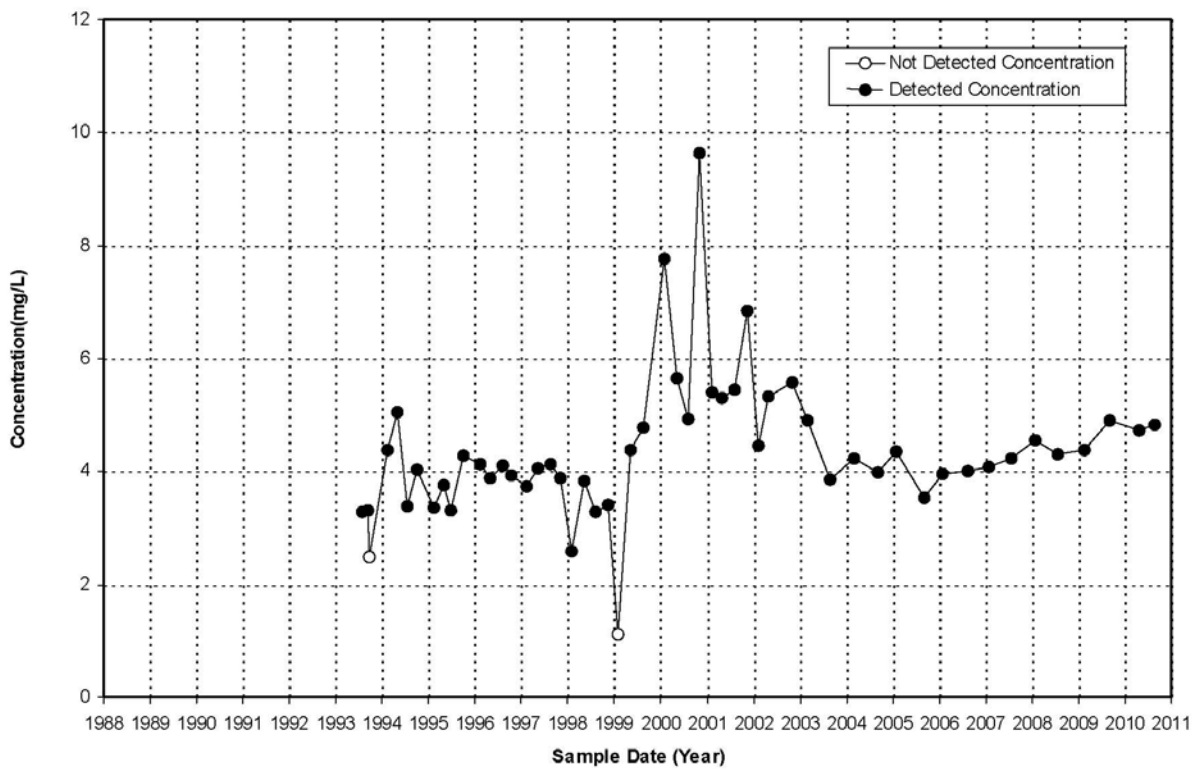


FIGURE A.1-5. POTASSIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2898

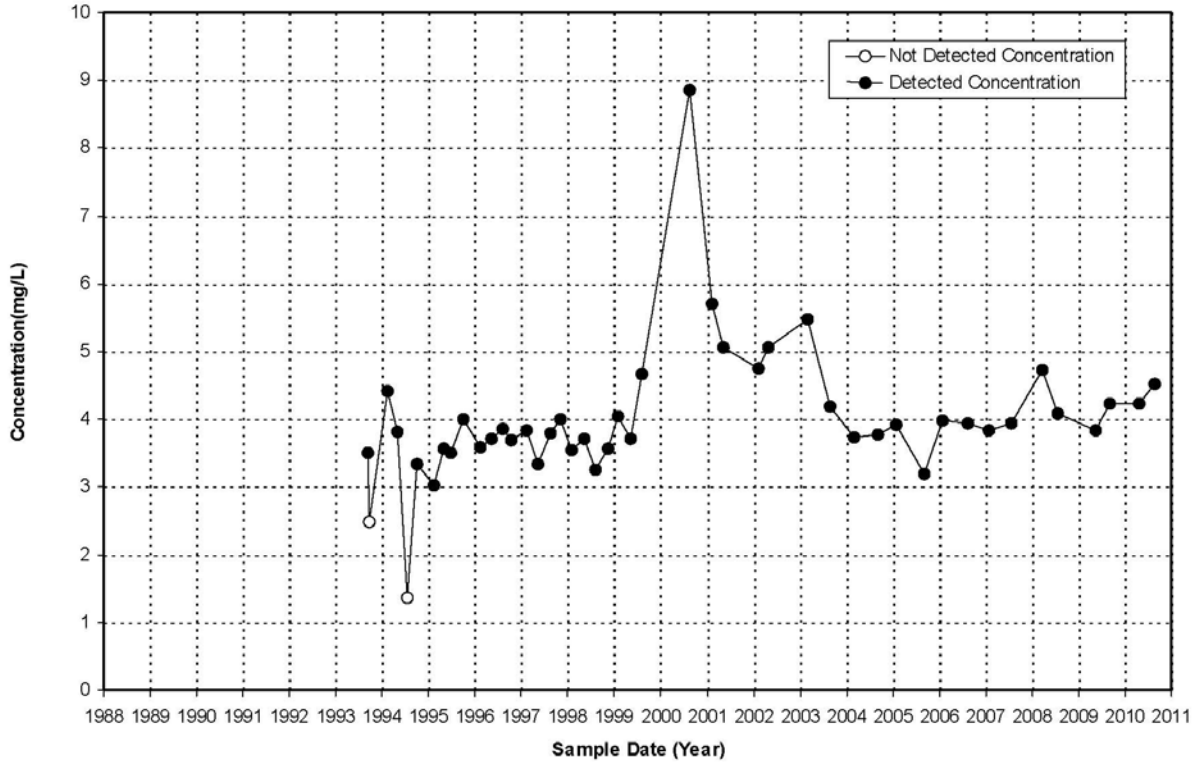


FIGURE A.1-6. POTASSIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2899

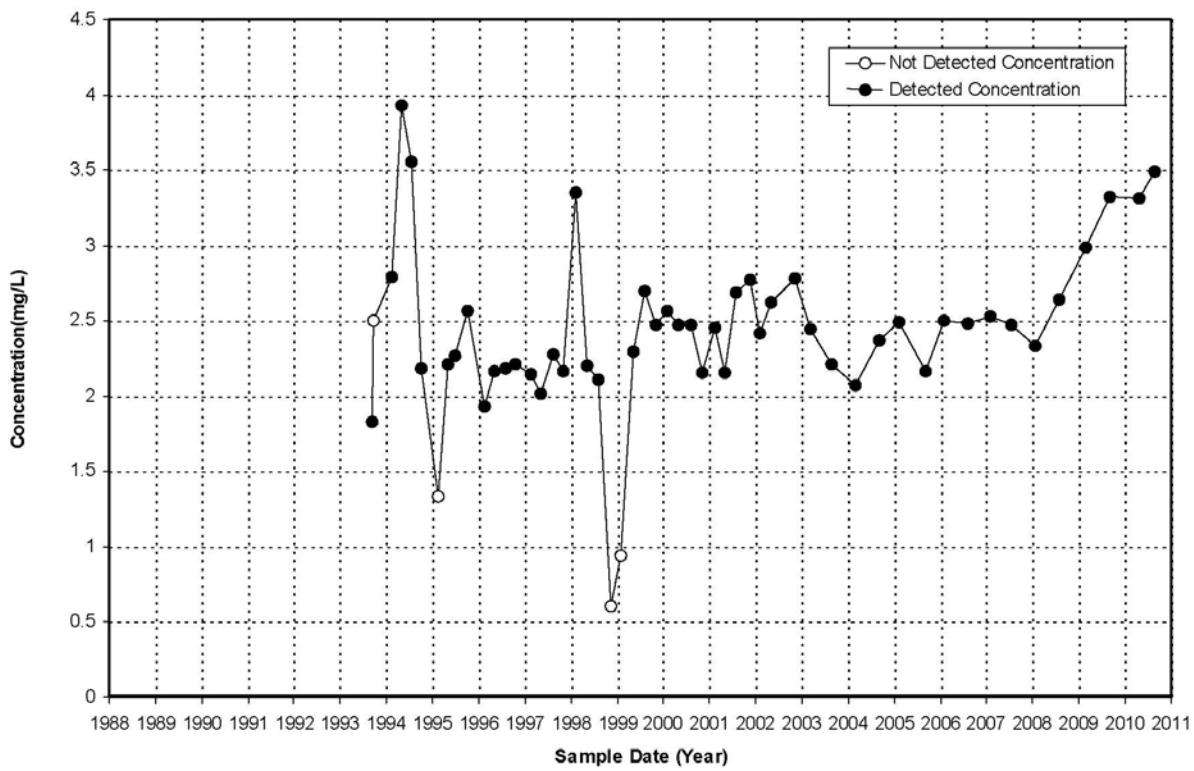


FIGURE A.1-7. POTASSIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3898

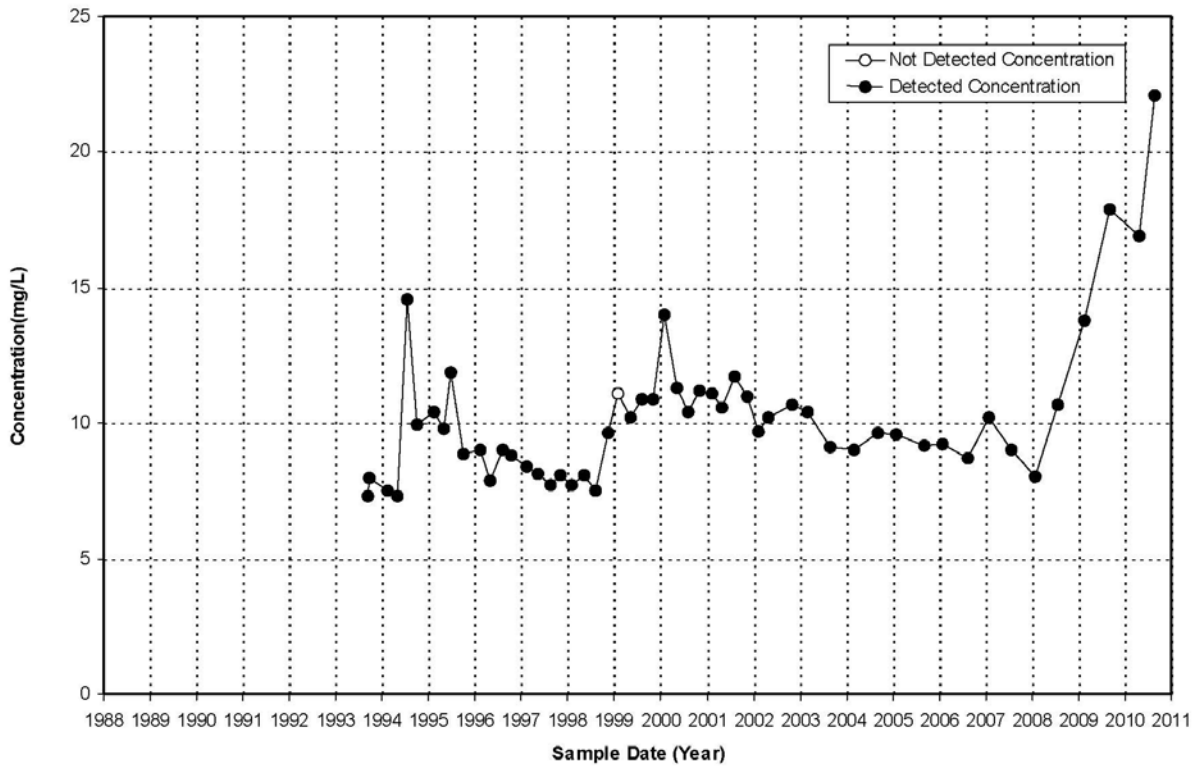


FIGURE A.1-8. SODIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3898

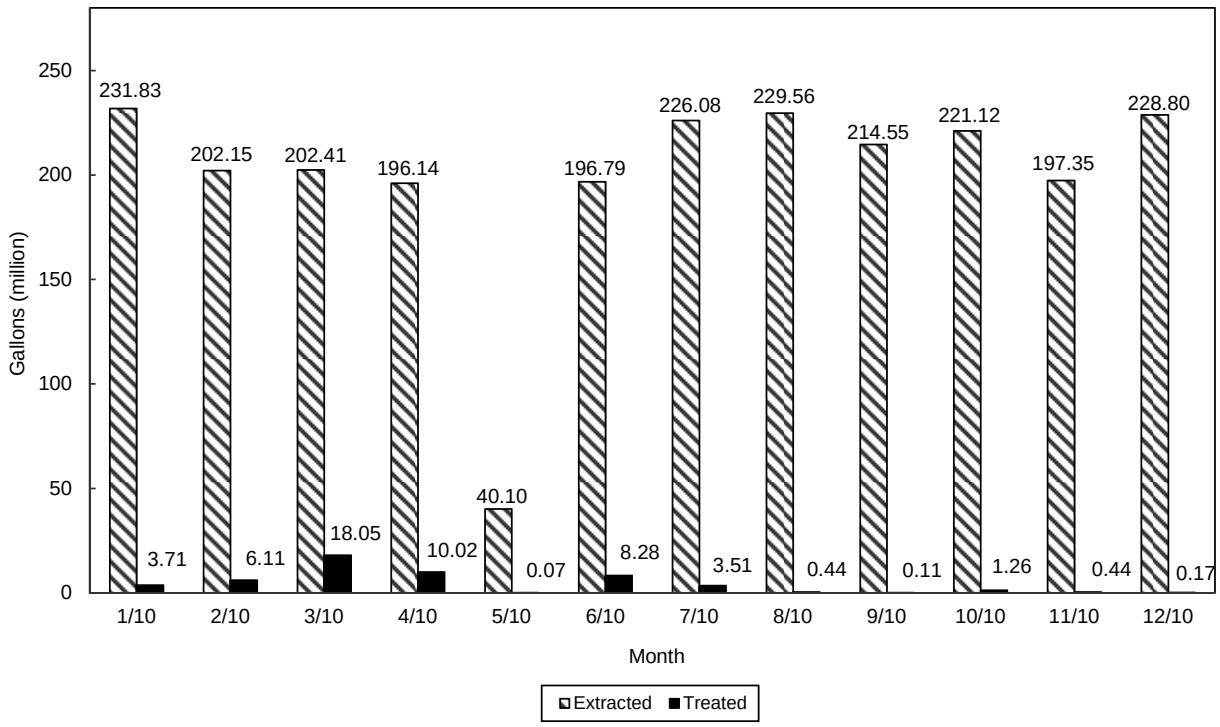


FIGURE A.1-9 TOTAL GROUNDWATER EXTRACTED VS. GROUNDWATER TREATED FOR 2010

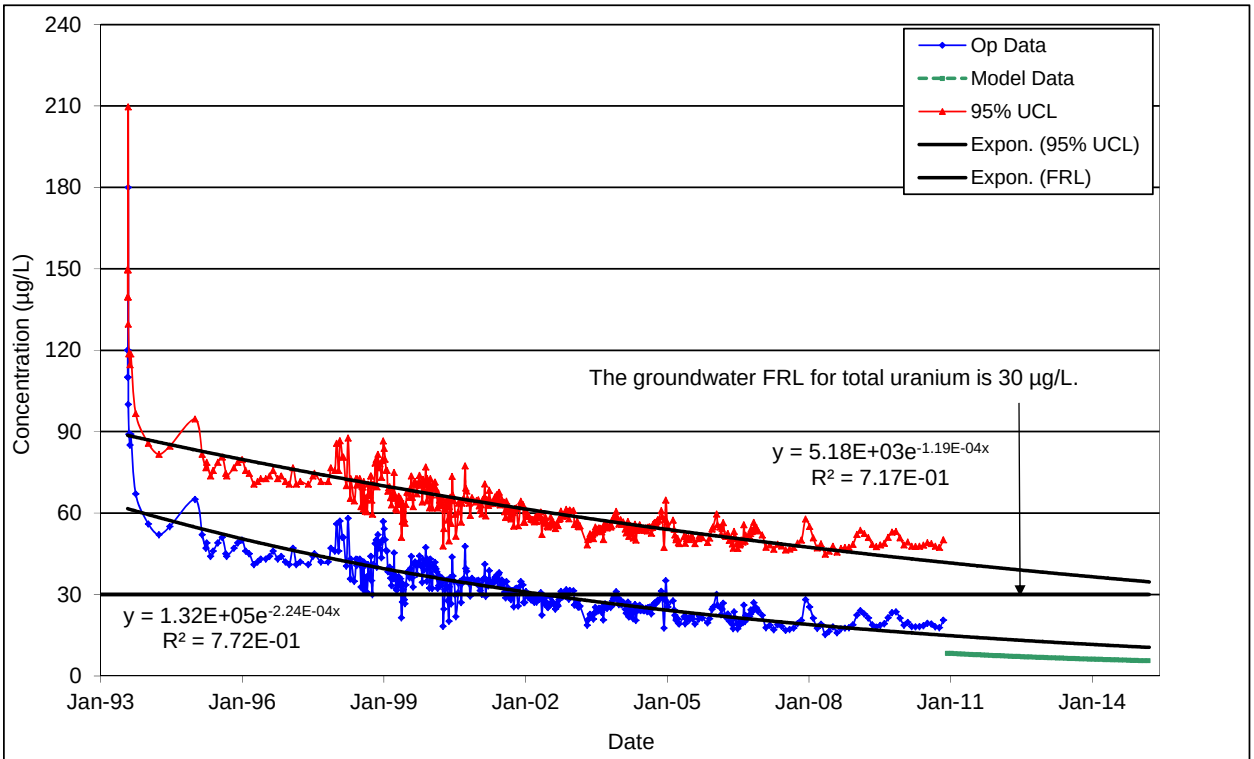


FIGURE A.1-10. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 3924 (RW-1) WITH REGRESSION ANALYSIS

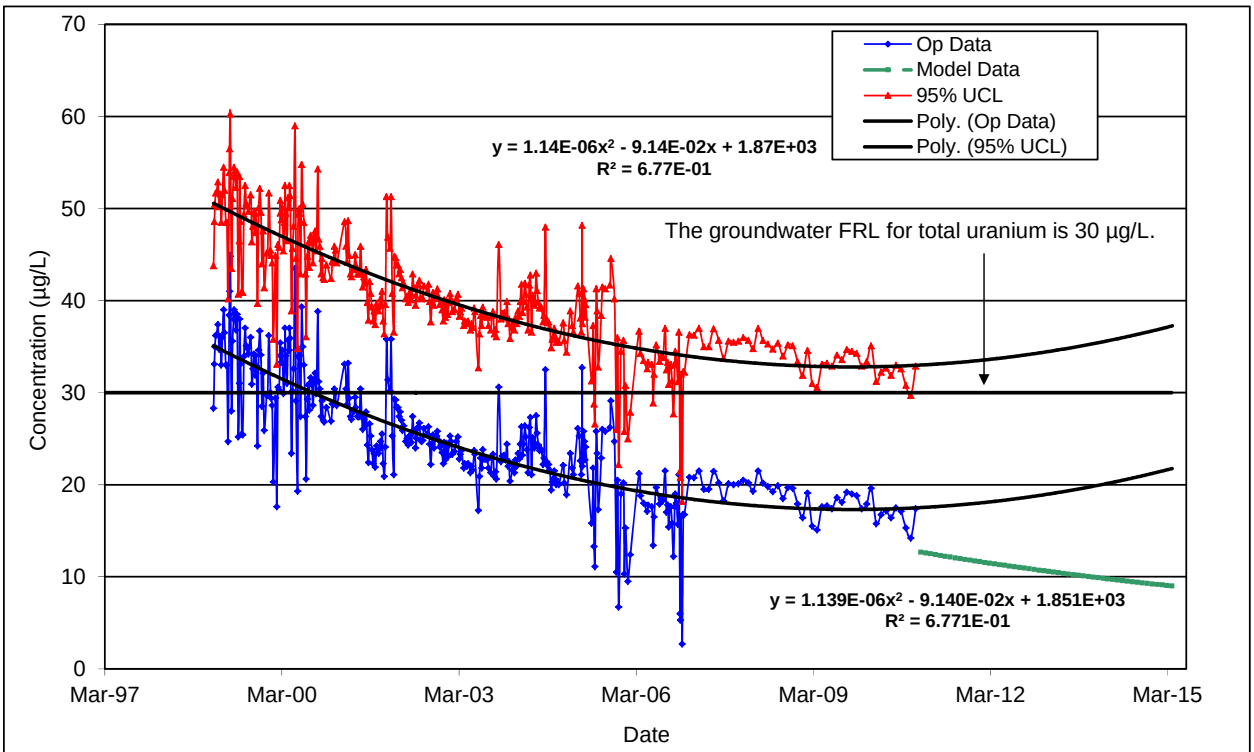


FIGURE A.1-11. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 3925 (RW-2) WITH REGRESSION ANALYSIS

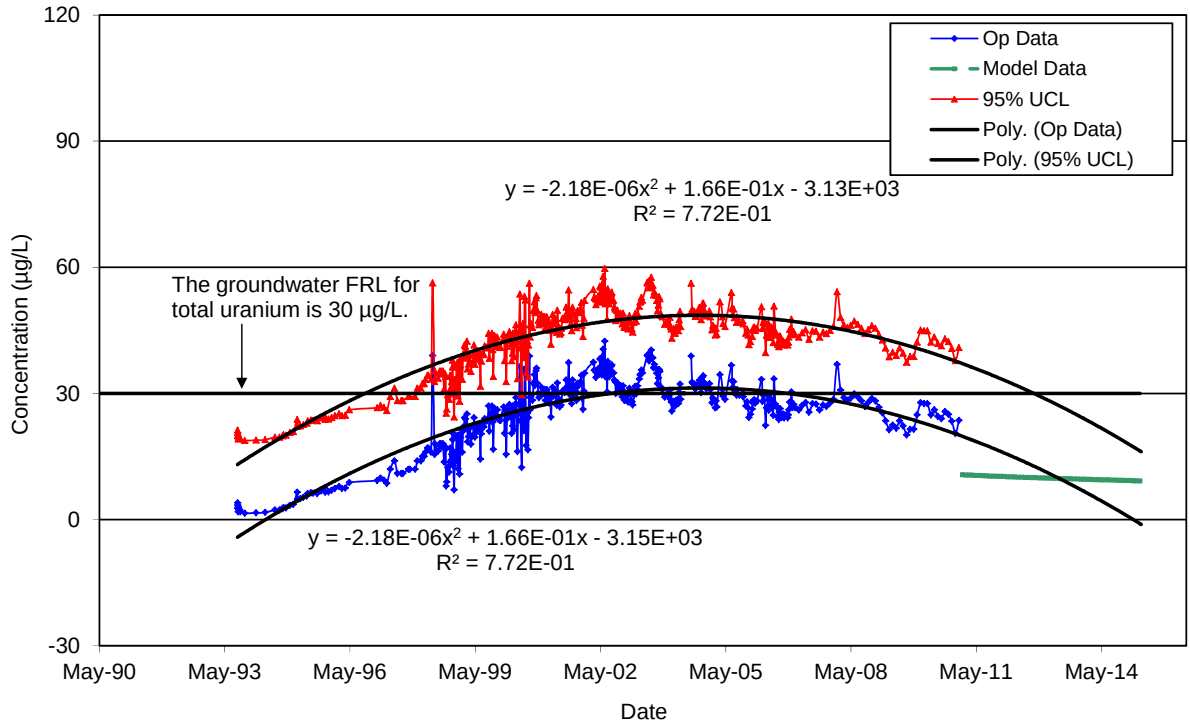


FIGURE A.1-12. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 3926 (RW-3) WITH REGRESSION ANALYSIS

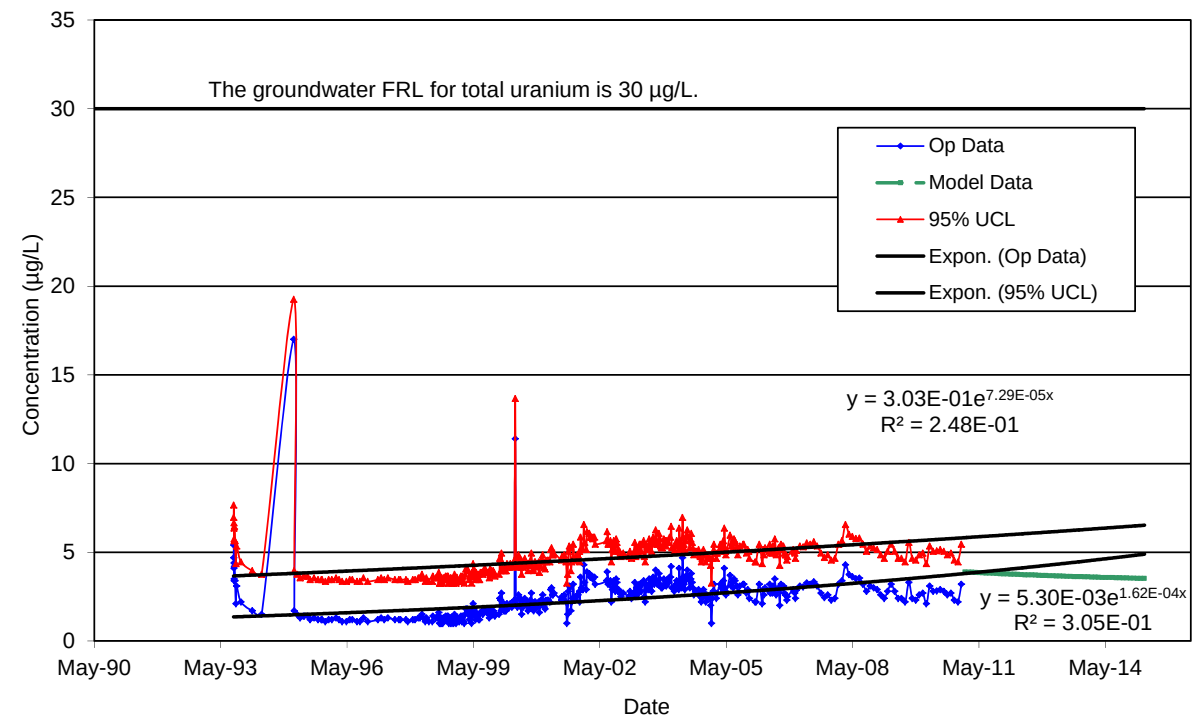


FIGURE A.1-13. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 3927 (RW-4) WITH REGRESSION ANALYSIS

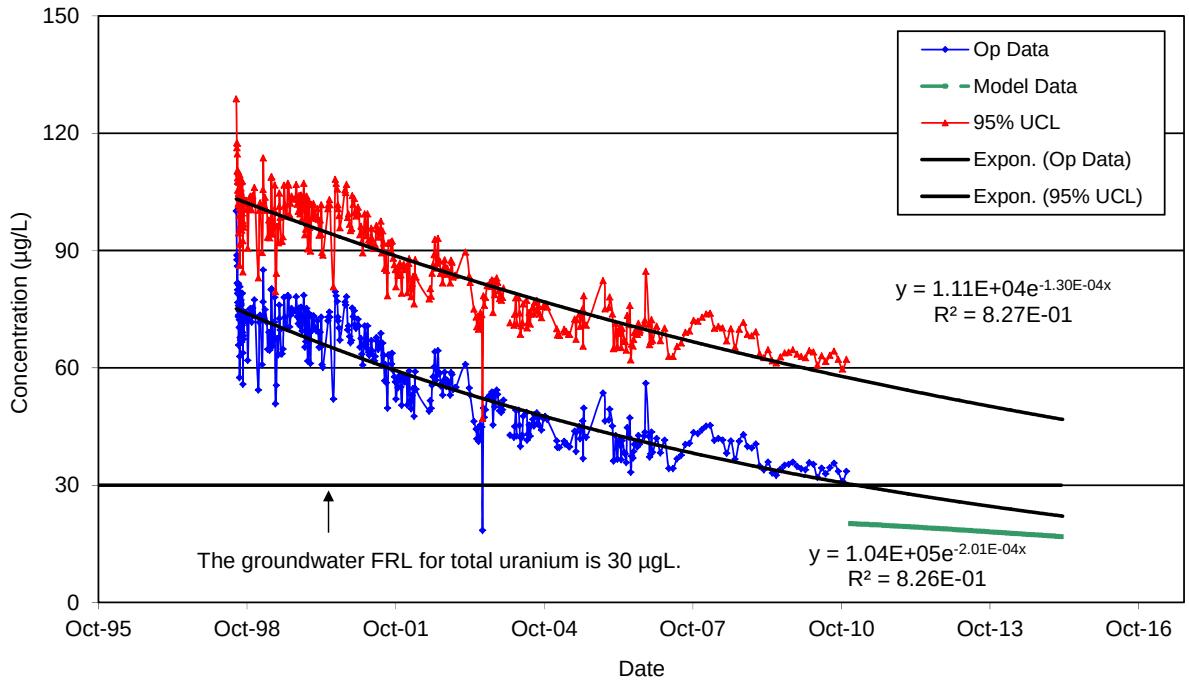


FIGURE A.1-14. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 32308 (RW-6) WITH REGRESSION ANALYSIS

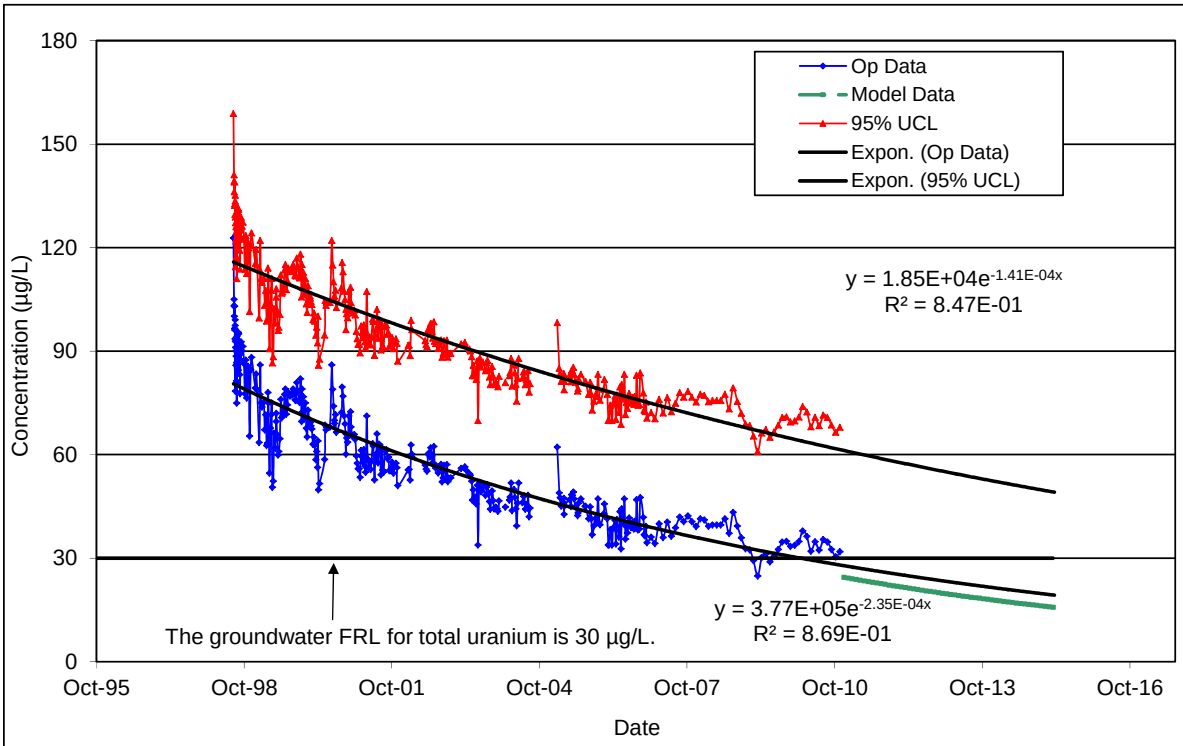


FIGURE A.1-15. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 32309 (RW-7) WITH REGRESSION ANALYSIS

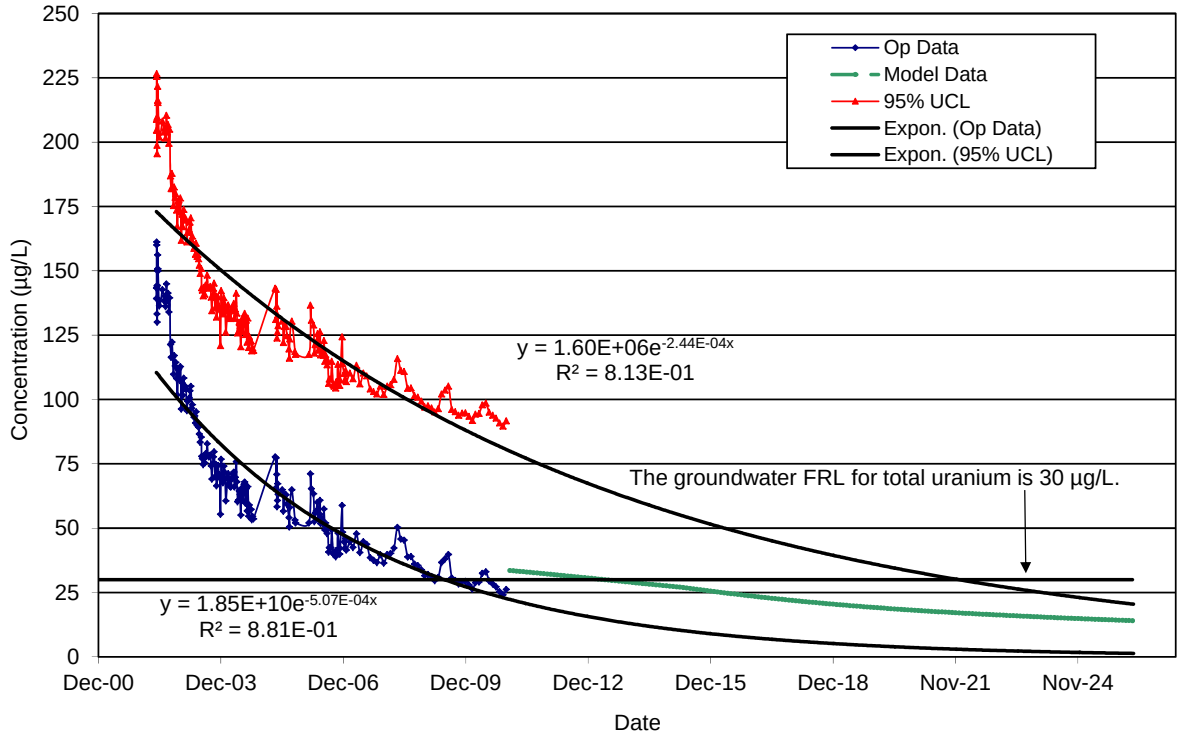


FIGURE A.1-16. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 32761 (EW-26) WITH REGRESSION ANALYSIS

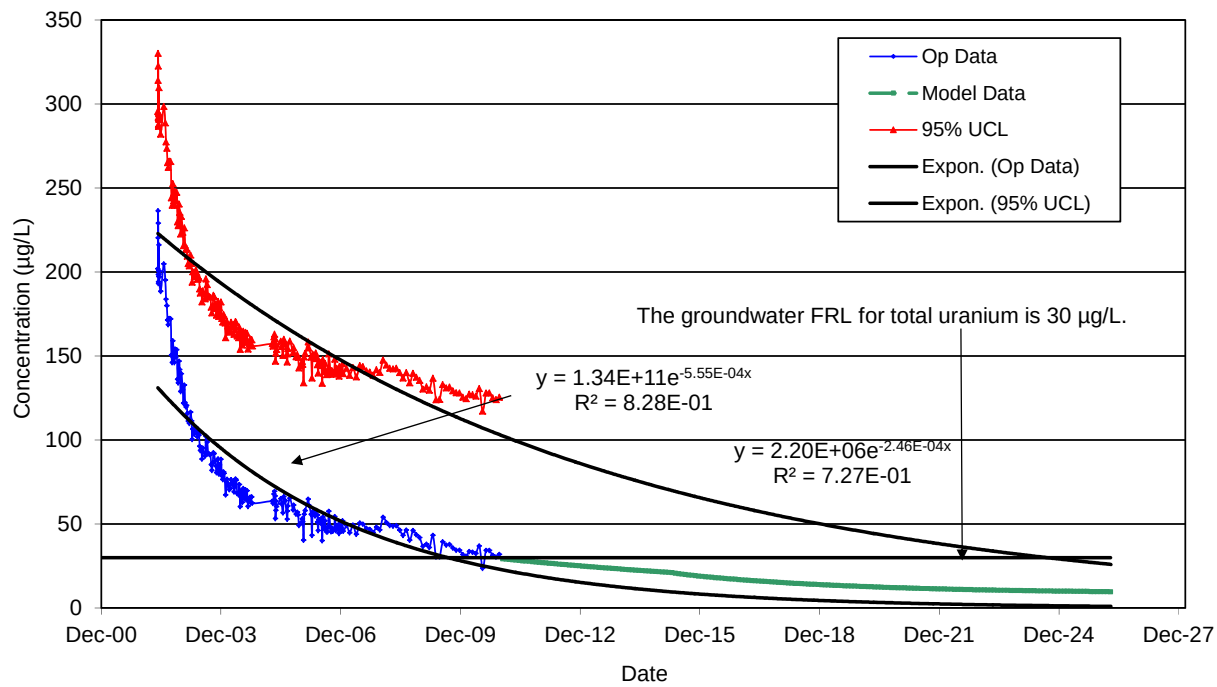


FIGURE A.1-17. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 33062 (EW-27) WITH REGRESSION ANALYSIS

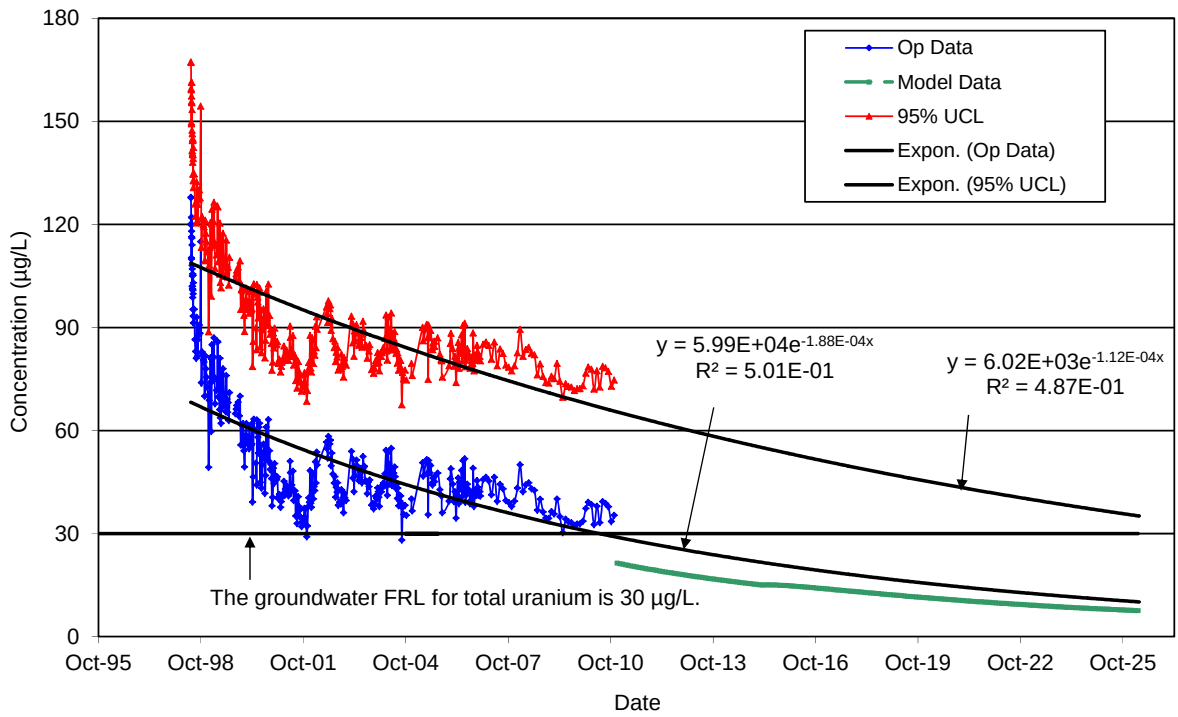


FIGURE A.1-18. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 31550 (EW-18) WITH REGRESSION ANALYSIS

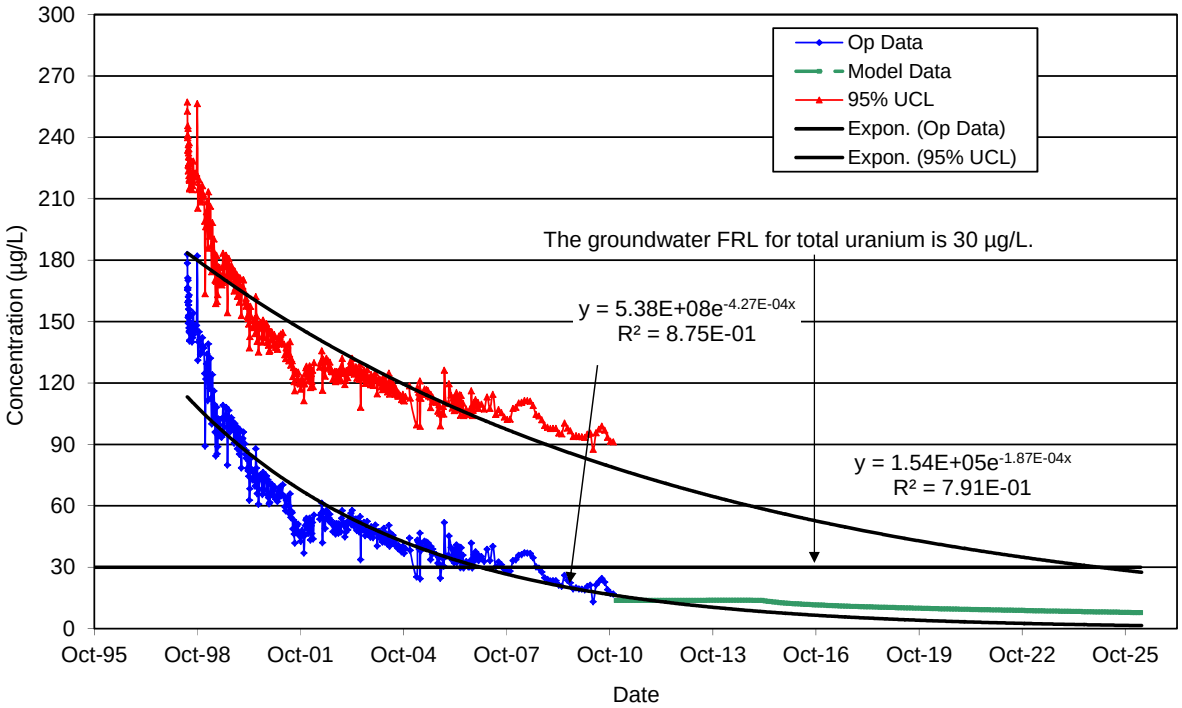


FIGURE A.1-19. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 31560 (EW-19) WITH REGRESSION ANALYSIS

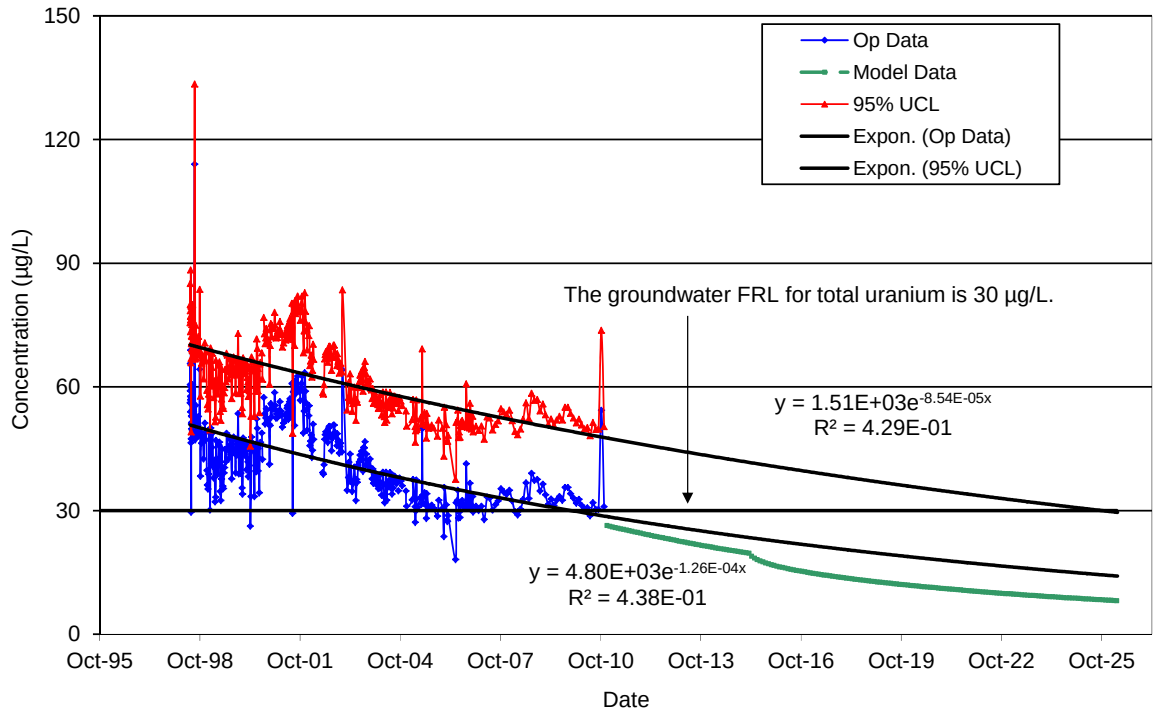


FIGURE A.1-20. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRATION WELL 31561 (EW-20) WITH REGRESSION ANALYSIS

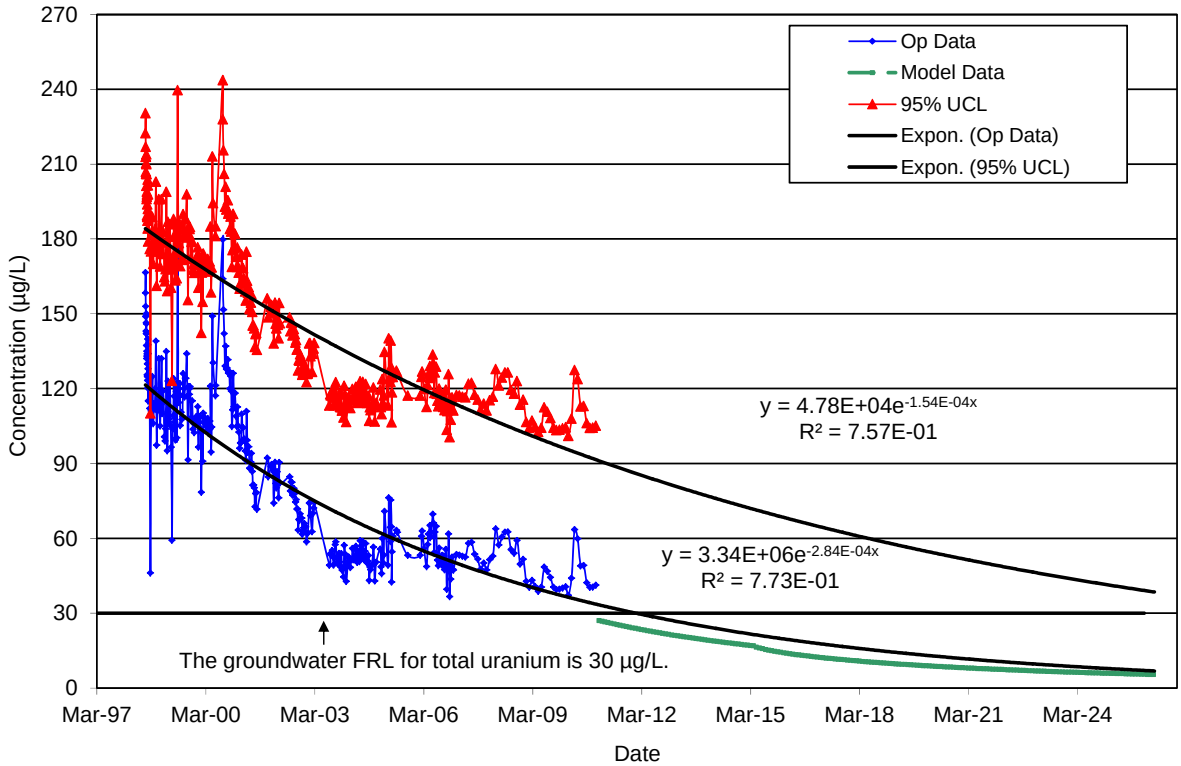


FIGURE A.1-21. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 31562 (EW-21) / 33298 (EW-21a) WITH REGRESSION ANALYSIS

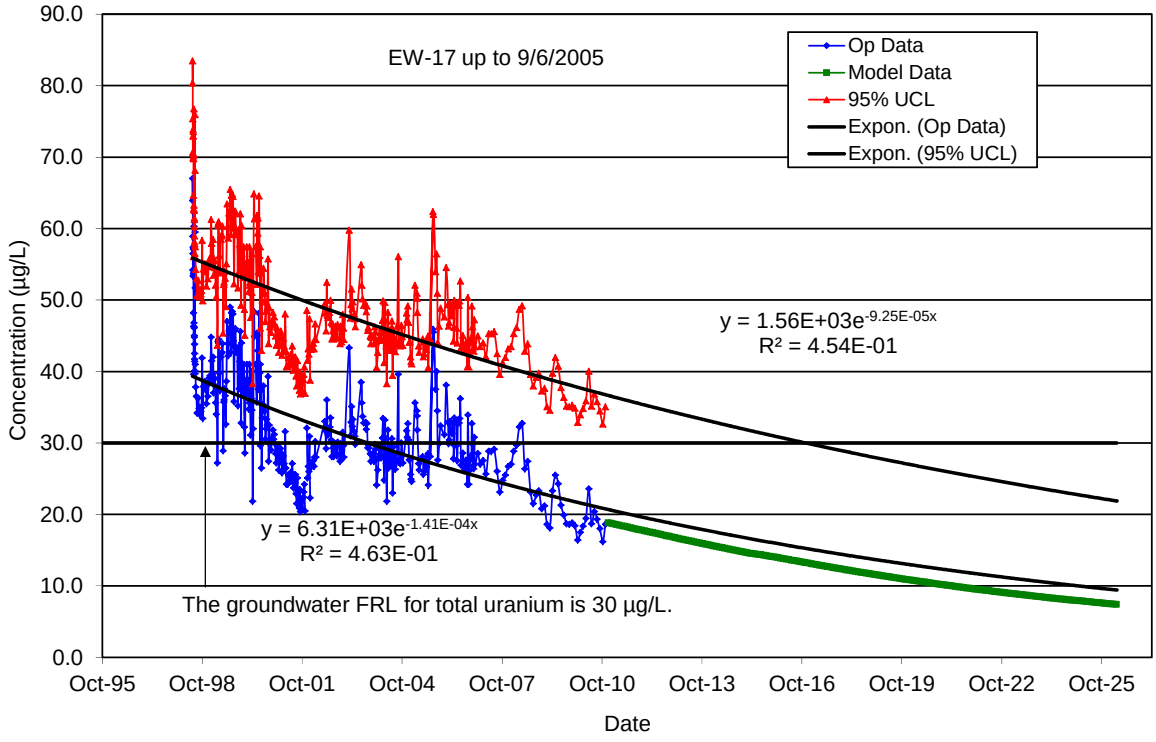


FIGURE A.1-22. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 31567 (EW-17)/ 33326 (EW-17a) WITH REGRESSION ANALYSIS

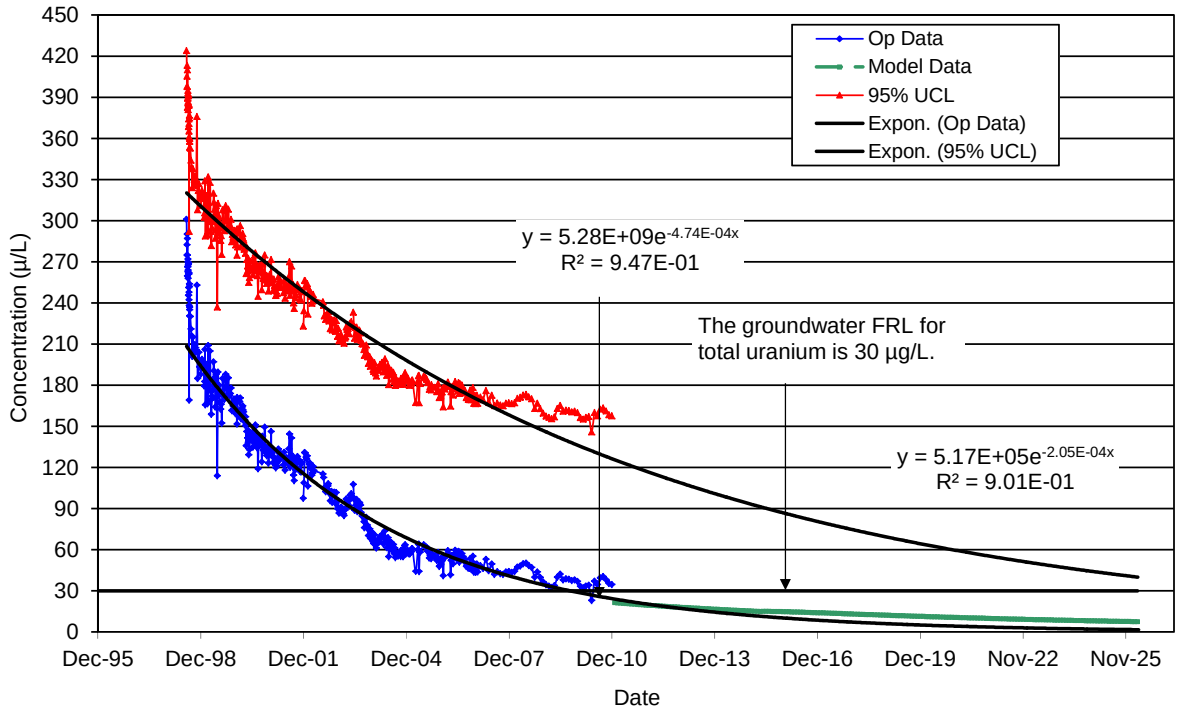


FIGURE A.1-23. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 32276 (EW-22) WITH REGRESSION ANALYSIS

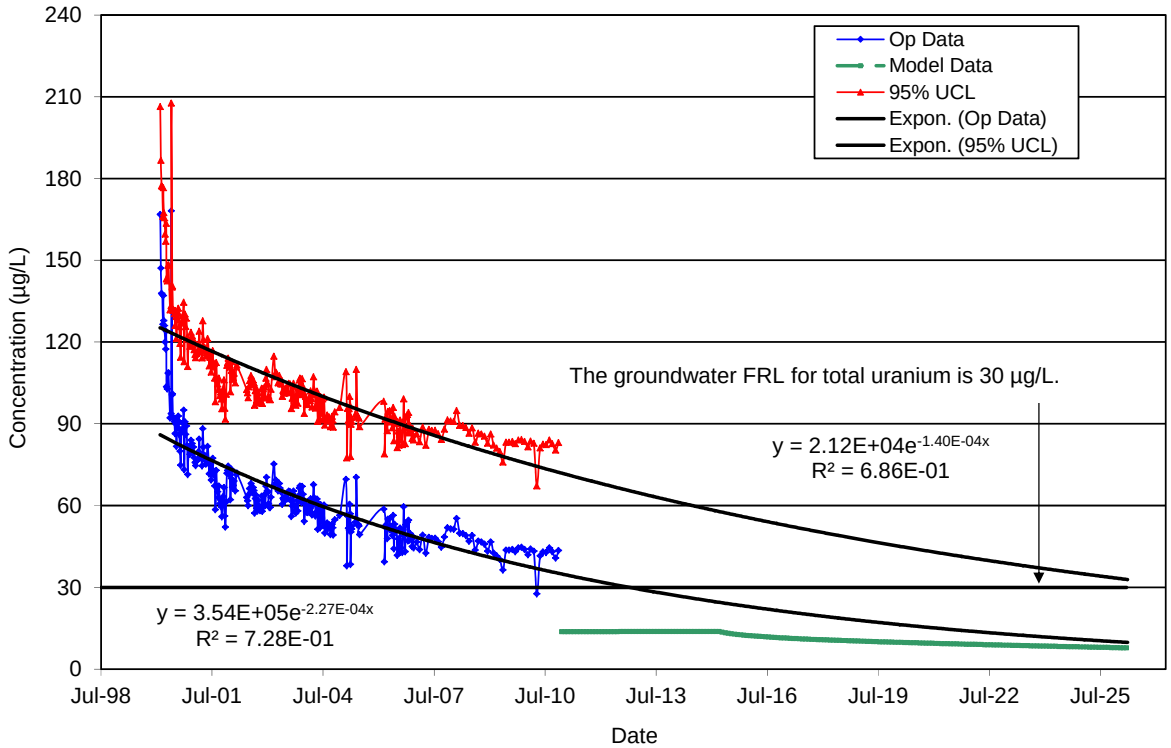


FIGURE A.1-24. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 32446 (EW-24) WITH REGRESSION ANALYSIS

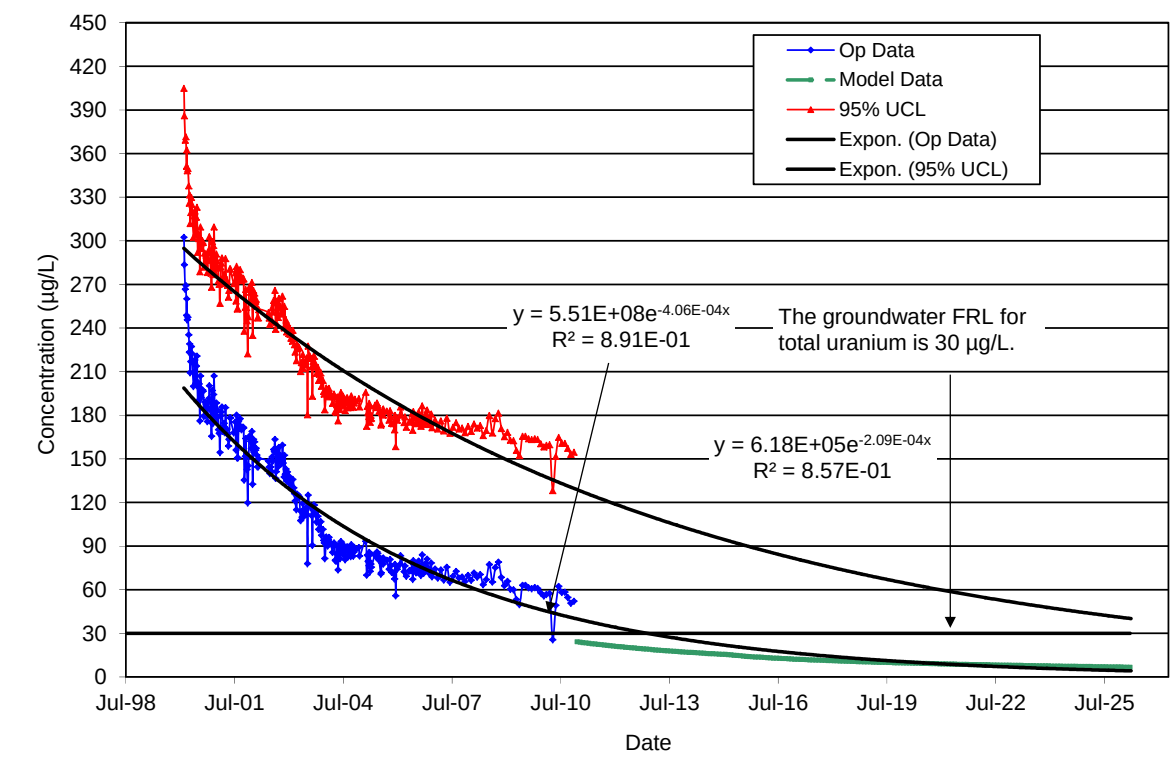


FIGURE A.1-25. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 32447 (EW-23) WITH REGRESSION ANALYSIS

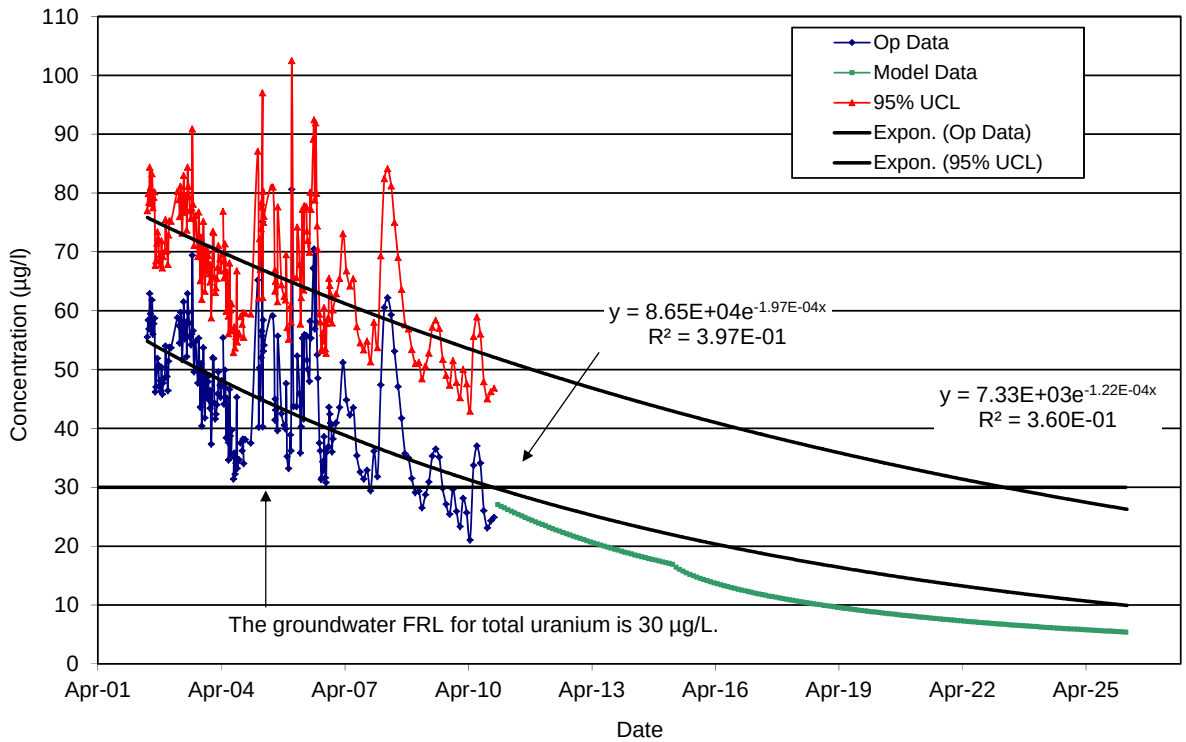


FIGURE A.1-26. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 33061 (EW-25) WITH REGRESSION ANALYSIS

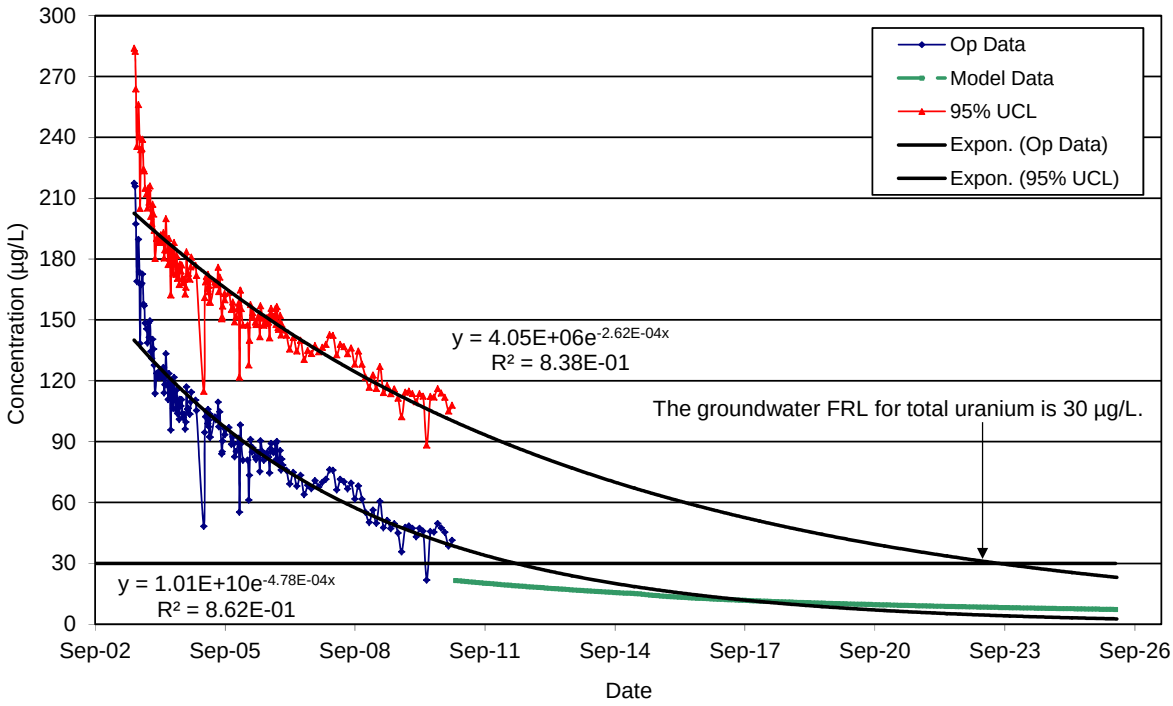


FIGURE A.1.27. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 33264 (EW-30) WITH REGRESSION ANALYSIS

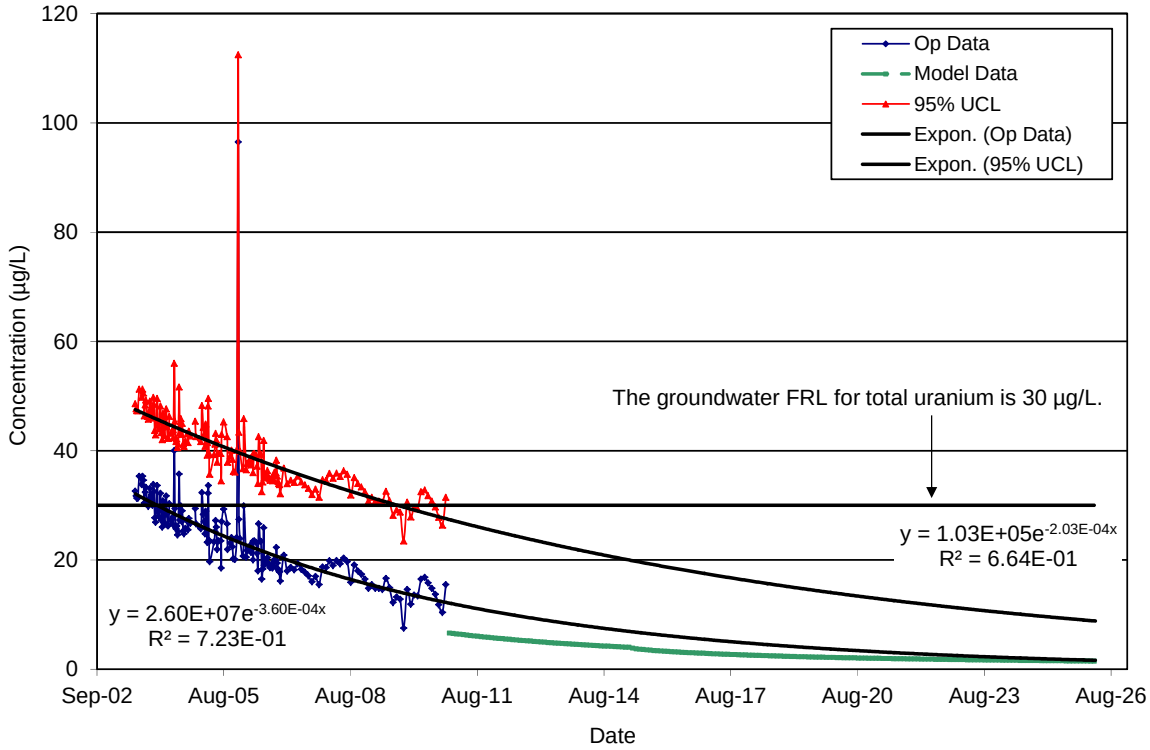


FIGURE A.1-28. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 33265 (EW-31) WITH REGRESSION ANALYSIS

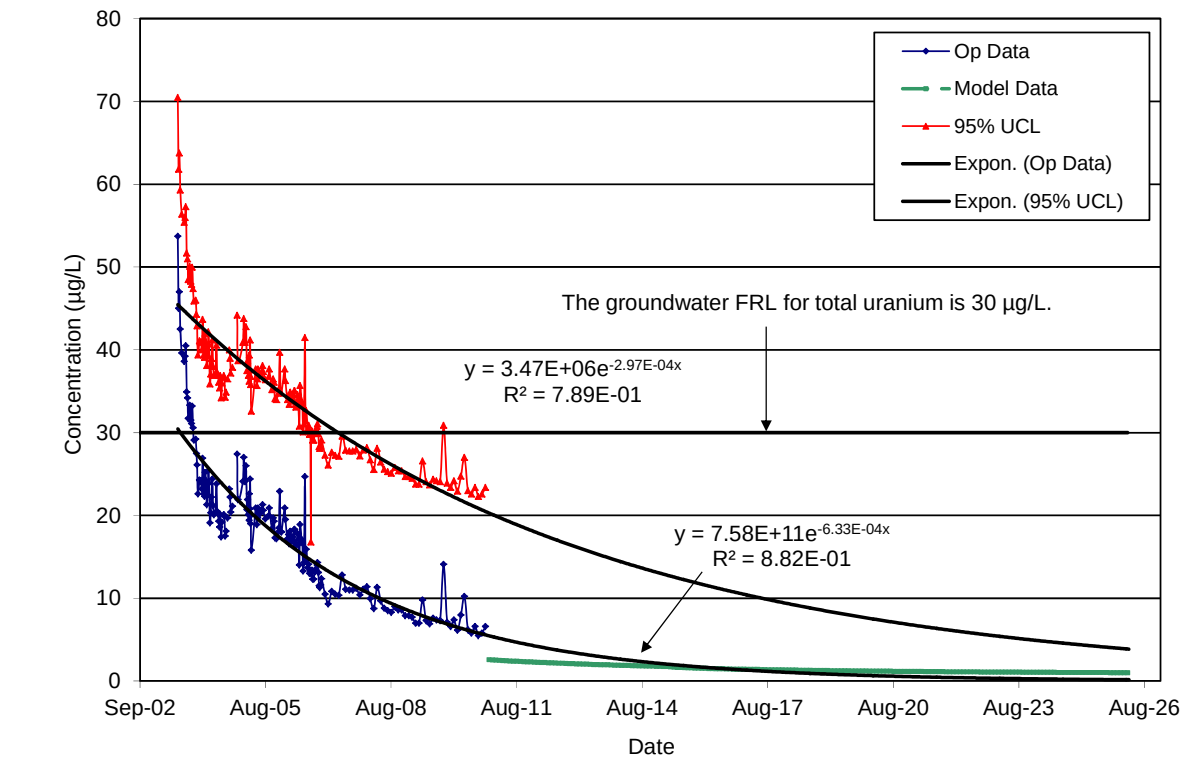


FIGURE A.1-29. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 33266 (EW-32) WITH REGRESSION ANALYSIS

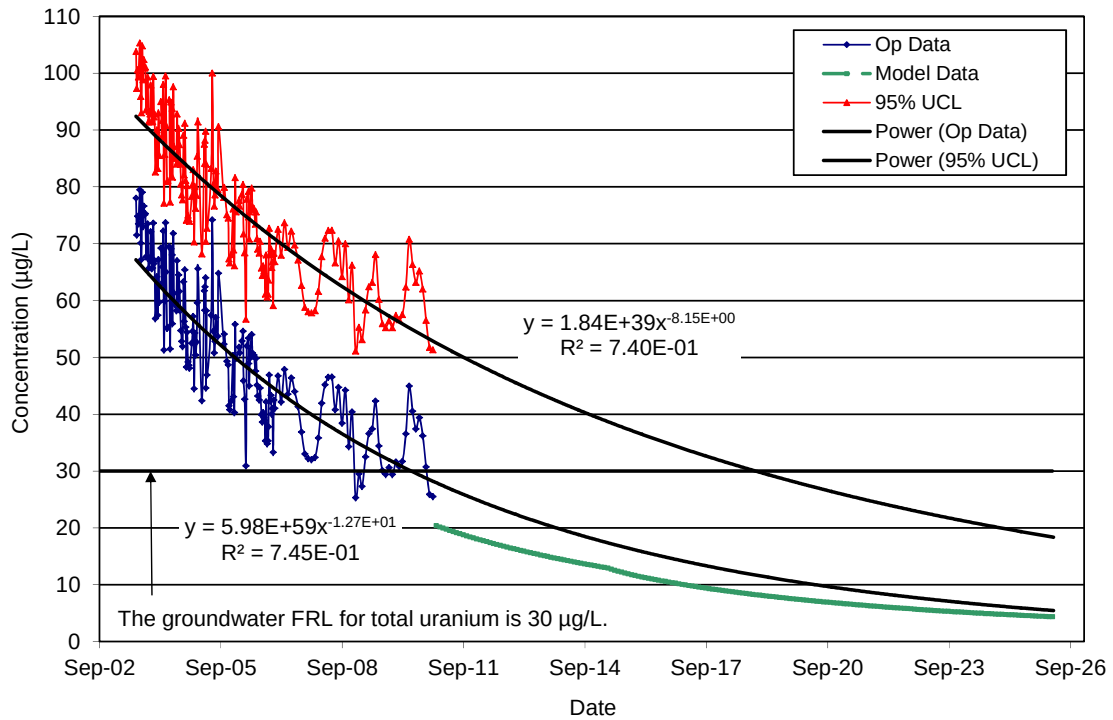


FIGURE A.1-30. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 33262 (EW-15a) WITH REGRESSION ANALYSIS

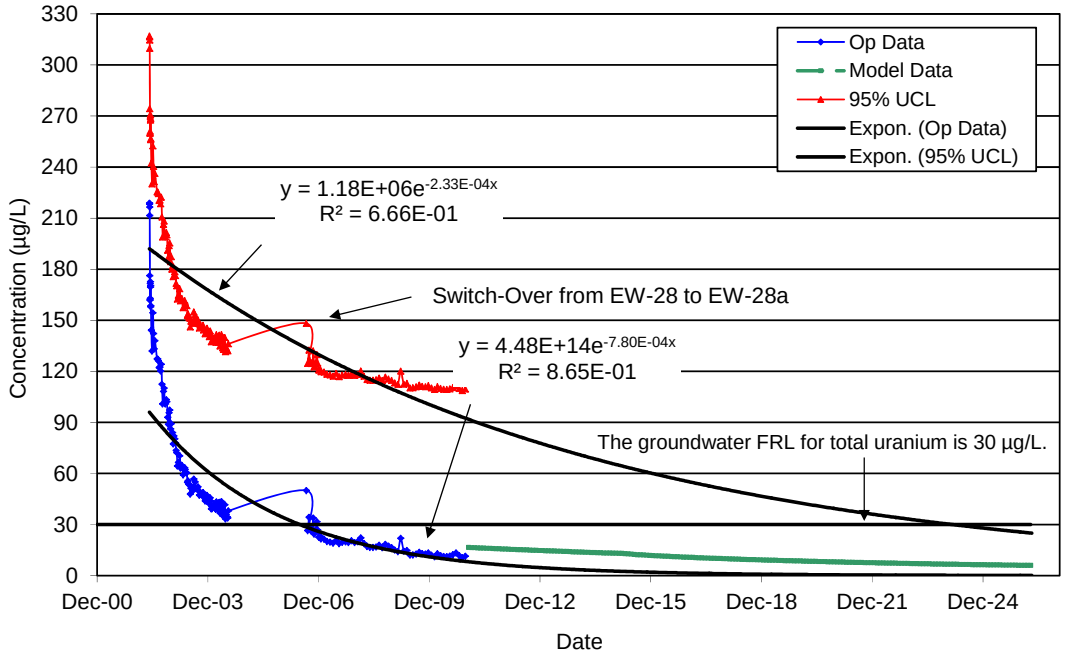


FIGURE A.1-31. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR EXTRACTION WELL 33063 (EW-28) / 33334 (EW-28a) WITH REGRESSION ANALYSIS

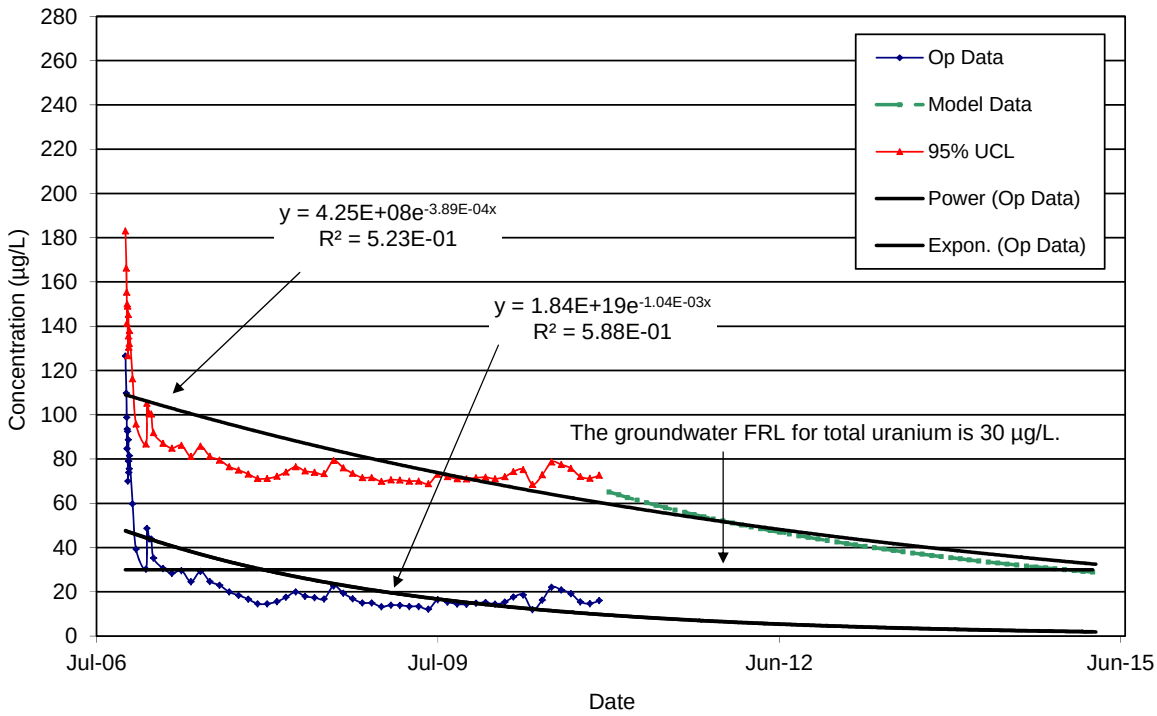


FIGURE A.1-32. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 33347 (EW-33a) WITH REGRESSION ANALYSIS

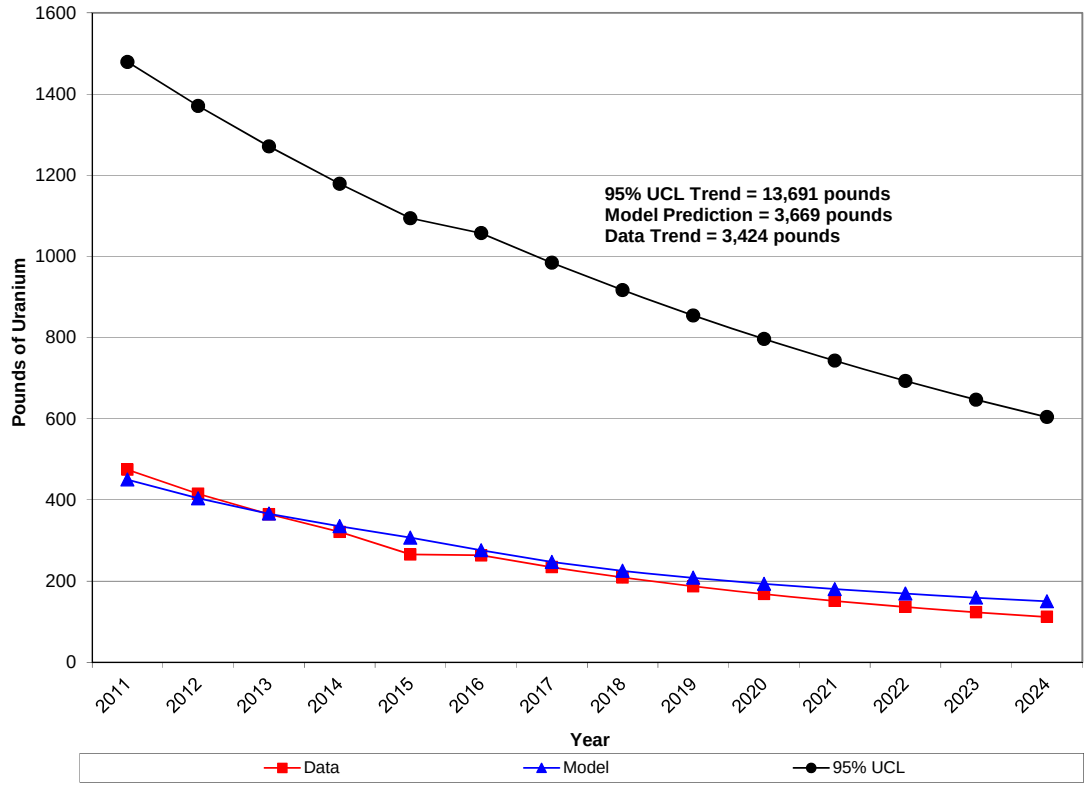


Figure A.1−33. Estimate of Yearly Pounds of Uranium to be Pumped from Aquifer (Model Predictions versus Measured Concentration Trends; Data Collected Through 2010)

Attachment A.2

This page intentionally left blank

A.2.0 Assessment of Total Uranium Results

This attachment discusses groundwater monitoring total uranium results through 2010. 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 2010a). 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, 10 locations were sampled using a direct-push sampling tool (Geoprobe®) in 2010. Direct-push sampling results are presented in Tables A.2–1 through A.2–10.

The number of locations sampled using direct-push equipment in 2010 is reduced from previous years. This reduction is due to a combination of equipment issues and low regional water levels. Probing in 2010 began using a new mill slot sampler. Water flowed into the new sampler much slower than it had in the old one. It was discovered that the slots of the new sampler were smaller than specified. The smaller slot size caused the sampler to clog frequently and made it difficult to get a representative sample from the aquifer. The sampler was replaced with one that has correct size slots (0.020 inch). By the time the sampler was replaced, regional water levels had fallen due to low amounts of precipitation. As a result, the decision was made not to collect additional samples until water levels rise again in 2011. The decision was also made not to use data obtained from the locations where the incorrect sampling tool was used. Only the direct push data that was obtained using the correct sampling tool are reported in this report. Data from the following locations were not used: 12717, 13412, 13413, 13418, and 13419. Those locations will be re-sampled in 2011.

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 2010, 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 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.2−11 lists the monitoring wells where total uranium concentrations exceeded the 30 µg/L FRL during 2010. Included in the table are total uranium statistical summaries for each well, which include Mann-Kendall trend analyses. Table A.2−12 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.2−11 (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.2.5 Residual Assessment of Groundwater Model Predictions
- A.2.6 Result of CERCLA 5-Year Review

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 at the end of 2010 remains unchanged from 2009 (22.429 acres). One direct-push sample was collected in the former Waste Storage Area in 2010 (location 13370B). The highest uranium concentration measured at this location was 3.7 µg/L, resulting in no change to the mapped plume.

Through 2009, uranium concentration data for monitoring wells 2821 and 3821 (Figures A.2−5 and A.2−6, respectively) indicated that the uranium concentration at monitoring well 3821 was increasing and the uranium concentration at monitoring well 2821 was decreasing. This data trend supported the possibility that that a partial penetration affect at pumping wells in the former Waste Storage Area was moving uranium deeper into the aquifer as it was being pulled toward the pumping wells. Data collected in 2010 at monitoring well 3821 indicates that uranium concentration decreased in 2010. This area will be targeted for direct-push sampling in 2011.

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 at the end of 2010 is slightly reduced from 2009 (25.733 acres in 2010 versus 26.24 acres in 2009). The reduction in size is due to direct push sampling results collected at location 13417. The highest uranium concentration measured at this location was 29.4 µg/L. The west end of the Pilot Plan Drainage Ditch Plume is being targeted for additional direct-push sampling in 2011.

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. As indicated in Figure A.2−7, sporadic uranium FRL exceedances were detected between 2002 and 2007 at monitoring well 2389. No uranium groundwater FRL exceedances have been measured at monitoring well 2389 since 2007.

Direct-push sampling in previous years indicates that the uranium FRL exceedances in this area are limited to a depth right at the water table. A small uranium plume is shown circling monitoring well 2389 on the maximum total uranium plume map (Figures A.2–2B and A.2–3B). A direct push sample was collected in this area in 2010 (location 13360B). Unfortunately as shown in the table below, the regional water table was too low for the result to be conclusive.

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

The former Plant 6 area will be targeted for additional direct-push sampling during the pump and treat stage of the aquifer remedy, when the water table elevation is at an elevation of 514.8 ft amsl or higher.

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 at the end of 2010 is slightly reduced from 2009 (135.513 acres in 2010 versus 137.057 acres in 2009). The reduction in size is due to a direct push sampling result in the former Southern Waste Unit Area (location 12816A) and a result on the east edge of the south plume (location 12835A).

As shown below, the maximum uranium concentration at location 12816 decreased from 112 µg/L down to 36.5 µg/L. The sample in 2010 was collected in May when water levels were within a foot of the elevation when the previous uranium high concentration was measured.

Year	Location	Maximum Uranium Concentration (µg/L)	Midpoint Screen Elevation (ft amsl)
2001	12816	112	511.9
2010	12816A	36.5	510.9

As shown below the maximum uranium concentration at location 12835 decreased from 64.0 µg/L down to 23.5 µg/L. The sample in 2010 was collected in May when water levels were close to the elevation previously recorded for the high uranium concentration. A decision was made to reduce the plume footprint. Additional sampling in the area will verify if the reduction holds.

Year	Location	Maximum Uranium Concentration (µg/L)	Midpoint Screen Elevation(ft amsl)
2001	12835	64.0	511.8
2010	12835A	23.5	510.2

As shown in Figure A.2−8, monitoring well 2900 had an FRL exceedance for uranium in the second half of 2009. No FRL exceedance for uranium was measured in 2010. This monitoring well is located south of the South Plume extraction wells, but appears to be just within capture of the South Plume wells. A small 30 µg/L uranium plume was drawn around this monitoring location on the second half 2009 maximum total uranium plume map. As shown in Figure A.2–9 monitoring well 2552 has two historical uranium FRL exceedances, but no exceedance has occurred since 2004. Based on water level interpretations, this location also appears to be just within capture of the South Plume Extraction Wells. A small 30 µg/L uranium plume is drawn around this monitoring location also. If monitoring results at either location in 2011 are below the FRL, DOE plans to remove the corresponding small mapped plume, and replacing it with a note on the maximum plume map identifying that historical sporadic uranium FRL exceedances have occurred at these two locations in the past. Monitoring will continue at these locations.

Stagnation zones exist within the uranium plume. These stagnation zones are created by the competition of extraction wells for water within the aquifer. A stagnation zone, between the off-property South Plume extraction wells and the on-property South Field extraction wells, appears to be impacting the remediation of an off-property lobe of contamination just south of Willey Road. Figure A.2–3A is a maximum uranium plume map for the second half of 2010. The subject lobe is identified by direct push location 13269. Additional direct-push sampling is being planned to provide an update of uranium concentrations within this lobe. Changes to the aquifer remedy may be needed to address this off-property lobe of contamination. Changes that could be considered include: changing the pumping rates of existing extraction wells; converting an out-of-service injection well just north of the lobe into an extraction well; and/or installing a new extraction well south of the lobe. Change to the aquifer remedy involving a new extraction well to address this lobe of contamination likely will be complicated by landowner concerns, due to its off-property location.

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, yearly sampling continued at five of the seven locations (12368, 12369, 12370, 12371, and 12372). The results are used to prepare two cross sections: Figures A.2–10 and A.2–11.

This area is subject to pumping stresses from both the South Field extraction wells to the north and the South Plume extraction wells to the south, creating a stagnation zone. Re-injection (when it was occurring) helped to break up this stagnation zone. As the remedy progressed, two of the locations (12367 and 12371) were dropped from the routine sampling because they are now located outside the 30 µg/L total uranium plume.

Collection of useful direct push sampling data is contingent upon regional water levels in the aquifer remaining high during the sampling period. In 2010, field crews did not reach two of the routine sampling locations along Willey Road in time to catch water levels at elevations high enough to match water levels seen in previous years. Therefore the decision was made not to sample at locations 12369O and 12370K in 2010. The results presented in Figures A.2–10 and A.2–11 mix 2009 and 2010 data. The 2009 data is identified on the figures. Data collected in 2010 indicate that the plume along Willey Road continues to dissipate.

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

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 1 year. A field study was conducted in 2005 to gauge seasonal flow of water in the 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.2−12, 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 Plan (OMMP), which 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 2010a). The wells are pumped as necessary to 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 southern most flume. It measures flow emptying out of the SSOD and into Paddys Run.

Pumping Operations

In 2010, 180,163,100 gallons of clean groundwater (average rate of 343 gpm) were pumped into the SSOD. Pumping of clean groundwater into the SSOD began on December 14, 2006. Since pumping began, flow metering indicates 579,058,650 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
Total	**579,058,650**	

In June, pumping of water into the SSOD was temporarily increased to maintain the water level of the Lodge Pond due to excessive drainage through or near the engineered outlet for the pond. Additional investigation to determine the cause of the excessive drainage is being planned for 2011.

Infiltration Assessment

Figure A.2−13 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 15, 2010 through December 6, 2010. Until March 15, 2010, 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 2010 was cut short due to a malfunctioning water level instrument in Flume 1 that failed on December 6, but was not discovered until December 20. Therefore, measurements of inflow versus outflow in the SSOD for 2010 extend from March 15 to December 6.

As illustrated in Figure A.2−13 from March until November 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 2010, operations were successful in achieving the target flow rate of 500 gpm in the SSOD. The average annual flow rate in Flume 6 in 2010 was 618 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.2−14 shows a monthly comparison of the flow rate into the SSOD from 2006 to 2010. Flow entering the SSOD in 2006 was natural until December of 2006, when supplemental pumping into the SSOD began. As shown in Figure A.2−14 supplemental pumping has helped to

keep flow rates higher in the summer months when natural flow is lower. In 2010 the average flow rate was less than 500 gpm in March and April, but the average flow rate for 2010 overall was 618 gpm.

A.2.5 Residual Assessment of Groundwater Model Predictions

A residual assessment of uranium concentrations (observed concentrations versus model predicted concentrations) evaluates how reasonable groundwater model concentration predictions remain over time. Two assessments have been conducted. The first assessment was conducted in 2005 and reported in the 2005 *Fernald Preserve Site Environmental Report* (SER, DOE 2006).

2010 data and model predictions used for the assessment are provided in Table A.2–13. A comparison of results from 2005 and 2010 is provided below. The total uranium concentration mean residual for 2010 was 29.4 µg/L. The maximum individual well residual for 2010 was 300 µg/L. As shown below, the mean residual calculated in 2010 is similar to the mean residual calculated in 2005 (29.4 µg/L vs. 30.5 µg/L).

Statistics	May 2005 Vs. Modeled Initial Conditions (µg/L)	2nd Half 2005 Vs. Model Predicted 4/1/2006 (µg/L)	1st Half 2010 Vs. Model Predicted 4/1/2010 (µg/L)
Mean Residual	19.1	30.5	29.4
Standard Deviation	78.8	87.9	75.6
Maximum Residual	273.7	330	300
Minimum Residual	-256.1	-131	-85.1
Residual Range	529.8	461	385

The small change in the mean residual of observed and modeled concentrations between 2005 and 2010 indicates that groundwater model predictions remain reasonable.

A.2.6 Results of Five-Year CERCLA Review

A five year review of the remedial action at the Fernald Preserve (conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA]) was recently submitted (DOE 2011). Three issues were identified in the review for the aquifer remediation that have the potential to extend the remediation completion time beyond that predicted by the groundwater model:

- Stagnation zones within the uranium plume
- Sorbed uranium contamination in the vadose zone of the aquifer
- Preferential flushing within the uranium plume.

The issue of stagnation zones was discussed in Section A.2.3. The other two issues are discussed below.

Sorbed Uranium Contamination in the Vadose Zone of the Aquifer

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 and saturate the contaminated sediments, allowing the bound contamination to dissolve into the groundwater. Early indicators include rising uranium concentrations in groundwater beneath former source areas when water levels are high.

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 normally not saturated in an attempt to alleviate this condition. To achieve the highest water level rise possible, the well field shutdowns are planned to coincide with seasonal high-water levels in the aquifer. Results for 2010 are reported in Attachment A.3. Based on review of data from monitoring wells located in or near the former source areas, the well field shutdowns and resultant aquifer water level rebound are providing some benefit and will therefore be continued. However, in general, recent aquifer water levels continue to be lower than the historic water levels that occurred when contamination was actively leaching from the source areas to the aquifer. This leaves a potential for additional leaching of contaminants from the vadose zone should the water levels return to the historic levels.

Preferential Flushing Pathways within the Uranium Plume

The GMA is both heterogeneous and anisotropic. Groundwater flowing through the aquifer matrix seeks the pathway of least resistance to the extraction wells. The result is that coarser grained aquifer material is flushed of contamination more effectively than the finer grained aquifer material because more water is moving through the coarser material. Contamination sorbed to the finer grained aquifer material slowly leaches out into the more active flow paths. Over time, this ineffective flushing of the finer grained material results in reduced cleanup efficiency and prolonged cleanup times. The constant pumping rate being maintained at each extraction well may be contributing to this possible condition. Indirect evidence that preferential flow paths may have been established is the increasingly asymptotic nature of the decreasing uranium concentration trends of the extraction wells and the relatively stable extent of the boundary of the maximum uranium plume. Operational changes to the aquifer remedy may be needed to address this issue. Operational changes could include changing the pumping rates of existing extraction wells, pulse-pumping the existing extraction wells, and/or installing additional extraction wells.

Table A.2−1. Geoprobe Location 13417

Easting '83: 1348237.76 feet
Northing '83: 479958.41 feet
Ground Elevation: 574.36 feet above mean sea level (AMSL)
Depth to Water Table: 62 feet below ground surface (BGS)
Water Table Elevation: 512.36 feet AMSL
Work Completed: 6/1/2010

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered (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	507	67	0 - 10	29.4	24.0	8.28	0.760	> 1000	> 1000	7.07
2	497.36	77	10 - 20	8.6	19.2	8.32	0.822	> 1000	154	5.76
3	497.36	77	10 - 20	9.2	19.2	8.32	0.822	> 1000	154	5.76
4	487.36	87	20 - 30	10.5	22.0	8.50	0.785	> 1000	273	6.78
5	477.36	97	30 - 40	2.3	23.4	9.71	0.717	> 1000	16	4.28

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

Table A.2−2. Geoprobe Location 13414

Easting '83: 1349256.63 feet
Northing '83: 477964.66 feet
Ground Elevation: 572.97 feet above mean sea level (AMSL)
Depth to Water Table: 57 feet below ground surface (BGS)
Water Table Elevation: 515.97 feet AMSL
Work Completed: 5/21/2010

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered (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	511	62	0 - 10	88.1	15.4	7.55	1.219	> 1000	9	6.58
2	500.97	72	10 - 20	59.3	17.4	7.75	1.027	> 1000	243	8.37
3	500.97	72	10 - 20	58.8	17.4	7.75	1.027	> 1000	243	8.37
4	490.97	82	20 - 30	15.0	16.2	8.02	0.870	> 1000	70	6.18
5	480.97	92	30 - 40	12.4	17.1	8.14	0.833	> 1000	893	7.24
6	470.97	102	40 - 50	4.0	13.7	9.82	0.657	> 1000	307	7.43
7	460.97	112	50 - 60	1.1	17.3	8.82	0.623	> 1000	83	8.83

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

Table A.2−3. Geoprobe Location 13370B

Easting '83: 1347193.71 feet
Northing '83: 481599.02 feet
Ground Elevation: 574.55 feet above mean sea level (AMSL)
Depth to Water Table: 57 feet below ground surface (BGS)
Water Table Elevation: 517.55 feet AMSL
Work Completed: 5/18/2010

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered (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	62	0 - 10	< 1.0	13.4	8.39	1.526	> 1000	2.22	6.00
2	502.55	72	10 - 20	3.5	13.5	8.78	1.489	> 1000	561	7.99
3	502.55	72	10 - 20	3.7	13.5	8.78	1.489	> 1000	561	7.99
4	492.55	82	20 - 30	< 1.0	14.9	9.28	1.429	> 1000	1.41	1.66

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

Table A.2−4. Geoprobe Location 12835A

Easting '83: 1349677 feet
Northing '83: 478284.8 feet
Ground Elevation: 570.209 feet above mean sea level (AMSL)
Depth to Water Table: 55 feet below ground surface (BGS)
Water Table Elevation: 515.209 feet AMSL
Work Completed: 5/5/2010

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered (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	510	60	0 - 10	23.5	16.1	9.56	1.380	> 1000	40	4.02
2	500.209	70	10 - 20	2.0	19.9	9.59	1.000	> 1000	> 1000	5.43
3	500.209	70	10 - 20	1.5	19.9	9.59	1.000	> 1000	> 1000	5.43
4	490.209	80	20 - 30	1.4	20.9	9.37	0.926	> 1000	931	6.66

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

Table A.2−5. Geoprobe Location 12816A

Easting '83: 1347938 feet
Northing '83: 477724.6 feet
Ground Elevation: 555.469 feet above mean sea level (AMSL)
Depth to Water Table: 39.5 feet below ground surface (BGS)
Water Table Elevation: 515.969 feet AMSL
Work Completed: 5/4/2010

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered (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	511	45	0 - 10	36.5	19.2	9.35	0.690	> 1000	> 1000	8.43
2	500.969	55	10 - 20	12.2	14.0	10.07	0.668	> 1000	335	6.81
3	500.969	55	10 - 20	12.2	14.0	10.07	0.668	> 1000	335	6.81
4	490.969	65	20 - 30	9.2	18.3	9.36	0.699	> 1000	> 1000	8.56

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

Table A.2−6. Geoprobe Location 12814B

Easting '83: 1347676 feet
Northing '83: 477889.4 feet
Ground Elevation: 538.622 feet above mean sea level (AMSL)
Depth to Water Table: 22 feet below ground surface (BGS)
Water Table Elevation: 516.622 feet AMSL
Work Completed: 5/3/2010

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered (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	27	0 - 10	103	12.9	7.83	0.700	> 1000	223	7.56
2	501.622	37	10 - 20	11	17.9	8.65	0.655	> 1000	351	7.14
3	501.622	37	10 - 20	9.3	17.9	8.65	0.655	> 1000	351	7.14
4	491.622	47	20 - 30	5.8	11.9	9.22	0.674	> 1000	> 1000	10.63

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

Table A.2−7. Geoprobe Location 13360B

Easting '83: 1349833 feet
Northing '83: 480171.1 feet
Ground Elevation: 574.316 feet above mean sea level (AMSL)
Depth to Water Table: 59 feet below ground surface (BGS)
Water Table Elevation: 515.316 feet AMSL
Work Completed: 4/29/2010

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered (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	510	64	0 - 10	4.4	11.4	9.60	1.086	> 1000	781	9.46
2	500.316	74	10 - 20	4.2	13.2	10.08	1.109	> 1000	> 1000	9.06
3	500.316	74	10 - 20	5.3	13.2	10.08	1.109	> 1000	> 1000	9.06
4	490.316	84	20 - 30	1.8	13.9	10.04	1.105	> 1000	320	6.10

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

Table A.2−8. Geoprobe Location 12368L

Easting '83: 1348469 feet
Northing '83: 476172 feet
Ground Elevation: 576.28 feet above mean sea level (AMSL)
Depth to Water Table: 63 feet below ground surface (BGS)
Water Table Elevation: 513.28 feet AMSL
Work Completed: 7/2/2010

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered (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	68	0 - 10	22.3	18.5	7.63	0.875	> 1000	> 1000	6.96
2	498.28	78	10 - 20	8.8	17.5	7.81	0.737	> 1000	266	7.50
3	498.28	78	10 - 20	8.4	17.5	7.81	0.737	> 1000	266	7.50

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

Table A.2−9. Geoprobe Location 12373P

Easting '83: 1349024 feet
Northing '83: 476239 feet
Ground Elevation: 564.23 feet above mean sea level (AMSL)
Depth to Water Table: 51 feet below ground surface (BGS)
Water Table Elevation: 513.23 feet AMSL
Work Completed: 9/2/2010

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered (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	56	0 - 10	10.8	17.1	7.90	0.778	> 1000	> 1000	7.61
2	498.23	66	10 - 20	6.3	18.0	6.54	0.689	> 1000	258	7.15
3	498.23	66	10 - 20	6.0	18.0	6.54	0.689	> 1000	258	7.15
4	488.23	76	20 - 30	5.7	17.0	7.22	0.714	> 1000	871	7.03

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

Table A.2−10. Geoprobe Location 12372P

Easting '83: 1348558 feet
Northing '83: 476216.78 feet
Ground Elevation: 576.07 feet above mean sea level (AMSL)
Depth to Water Table: 63 feet below ground surface (BGS)
Water Table Elevation: 513.07 feet AMSL
Work Completed: 9/1/2010

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered (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	68	0 - 10	34.8	16.8	8.63	0.889	> 1000	580	8.53
2	498.07	78	10 - 20	15.2	17.8	8.81	0.726	> 1000	> 1000	7.20
3	498.07	78	10 - 20	14.4	17.8	8.81	0.726	> 1000	> 1000	7.20

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

Table A.2–11. Summary Statistics and Trend Analysis of Monitoring Wells for Total Uranium with 2010 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	59	12.0	462	129	112	**Up, Significant**
2046	58	20	907	165	219	Down, Significant
2049	47	3	178	81.9	43.1	Down, Significant
2060	75	8.4	332	80.9	61.8	No Significant Trend
2095	60	27	208	107	46	Down, Significant
23271	18	34.6	144	78.2	32.4	Down, Significant
23273	18	169	421	273	74	No Significant Trend
23274	28	125	384	194	67	Down, Significant
23275	17	119	349	170	62	**Up, Significant**
23276	18	60.4	108	84.5	13.5	**Up, Significant**
23278	18	44.9	201	107.2	43.2	Down, Significant
23280	18	57.2	700	184	159	Down, Significant
23281	18	41.5	367	155	83	Down, Significant
2385	41	76.6	592	245	109	Down, Significant
2387	41	18.1	492	146	87	**Up, Significant**
2390	40	34.5	163	78.3	29.3	Down, Significant
2397	28	212	737	398	123	No Significant Trend
2550	51	3.3	120	61.9	19.6	Down, Significant
2649	36	6.01	634	97.1	174	**Up, Significant**
2880	41	0.4	62.9	13.6	19.9	**Up, Significant**
3069	67	0.5	398	131	97	Down, Significant
3095	61	2	94	24.9	17.5	No Significant Trend
62408	29	33.4	157	86.0	43.1	Down, Significant
62433	30	92.6	845	379	181	Down, Significant
63285	18	74.9	265	205	49	**Up, Significant**
63287	18	85.1	316	181	58	Down, Significant
63288	18	34.3	267	100	67	Down, Significant
63291	18	29.5	96.7	46.8	17.3	Down, Significant
6880	28	62.8	145	91.1	22.8	Down, Significant
82433_C3	21	92.4	506	241	131.	Down, Significant
83117_C1	20	646	1620	930	269	No Significant Trend
83117_C2	10	48.8	330	167	117	Down, Significant
83117_C3	10	40.6	128	89.0	30.4	Down, Significant
83117_C4	10	71.3	111	88.2	13.1	**Up, Significant**
83117_C6	10	0.5	43.9	5.34	13.6	**Up, Significant**
83124_C1	30	185	1070	473	204	No Significant Trend
83124_C2	14	27.8	103	55.8	21.5	Down, Significant
83124_C4	10	25.4	44.2	36.5	7.4	**Up, Significant**
83124_C5	10	24.4	61.4	50.9	10.3	No Significant Trend
83294_C1	15	98.5	198	170.0	31.1	**Up, Significant**
83294_C2	21	188	575	395	94	No Significant Trend
83294_C3	12	175	539	361	130	Down, Significant
83294_C4	10	30.2	299	148	102	Down, Significant
83295_C2	14	92.3	178	146	25	Up, Marginal

Table A.2–11 (continued). Summary Statistics and Trend Analysis of Monitoring Wells for Total Uranium with 2010 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	13	99.2	175	143	25	Down, Significant
83295_C4	11	47.8	199	118	57	Down, Significant
83295_C5	10	57.2	155	88.6	30.6	Down, Significant
83295_C6	10	3.4	55.1	26.5	21.0	**Up, Significant**
83296_C1	7	56.7	135	90.7	26.7	No Significant Trend
83296_C2	15	32.4	117	63.3	23.3	Down, Significant
83337_C1	12	877	243	1600	470	**Up, Significant**
83337_C2	18	2.67	835	169	230	Down, Significant
83338_C1	7	455	618	544	63	No Significant Trend
83338_C2	10	27.3	648	226	188	Down, Significant
83346_C1	6	39.7	70.7	48.2	11.5	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 2010 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 either 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 2010.

Table A.2–12. 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, 2010)						
3924	554	1.8	180	31.2	14.9	Down, Significant
3925	555	0.5	84	24.9	7.8	Down, Significant
3926	544	1.5	42.4	25.4	8.4	**Up, Significant**
3927	554	1	17	2.57	1.12	**Up, Significant**
South Plume Optimization Module (August 9, 1998, through December 31, 2010)						
32308	483	18.4	100	55.3	15.0	Down, Significant
32309	489	24.8	123	56.5	18.7	Down, Significant
South Field Module (July 13, 1998, through December 31, 2010)						
31550	505	16.2	128	51.9	19.0	Down, Significant
31560	528	12.1	183	62.1	37.4	Down, Significant
31561	502	18.1	114[d]	41.4	10.1	Down, Significant
32276	545	20.2	290	106	62	Down, Significant
32446	402	24.5	168	61.9	19.7	Down, Significant
32447	421	21.9	302	113	52	Down, Significant
33061	303	18.3	98.5	47.5	13.9	Down, Significant
33262	258	25.3	110	49.4	12.8	Down, Significant
33264	256	19.5	364	88.9	38.9	Down, Significant
33265	253	7.5	96.5	22.4	7.6	Down, Significant
33266	251	5.5	105.1	17.1	10.5	Down, Significant
33298	210	19.5	76.2	53.4	8.5	Down, Significant
33326	159	16.2	62.2	27.7	6.1	Down, Significant
Waste Storage Area Module (May 8, 2002, through December 31, 2010)						
32761	293	24.1	161	65.6	32.0	Down, Significant
33062	307	21.2	236	73.9	45.1	Down, Significant
33334	126	9.8	50	18.6	6.7	Down, Significant
33347	117	7	127	28.7	23.3	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 either 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.

Table A.2–13. Uranium Concentration Residuals Observed (1st Half 2010) Vs. Predicted (April 1, 2010)

Well ID	Observed Uranium Concentration, 1st Half 2010 (µg/L)	Predicted Uranium Concentration, April 1, 2010 (µg/L)	Uranium Concentration, Residuals (µg/L)
2002	3.01	6.29	-3.28
2008	17.3	17.5	-0.2
2016	3.34	10.08	-6.74
2017	2.47	4.32	-1.85
2045	63.0	45.9	17.1
2046	35.1	22.0	13.1
2048	9.43	29.54	-20.11
2049	58.0	39.0	19
2093	2.60	1.37	1.23
2106	7.32	8.54	-1.22
2385	166	52.2	114
2386	15.5	46.5	-31.2
2387	160	27	133
2402	3.19	3.72	-0.53
2821	7.71	13.24	-5.53
23118	1.68	18.76	-17.08
23271	50.0	11.5	38.5
23272	5.49	3.62	1.87
23273	248	75	173
23274	150	86	64
23275	260	82	178
23276	99.2	48.4	50.8
23277	3.83	8.04	-4.21
23278	44.9	23.7	21.2
23279	2.27	13.01	-10.74
23280	66.2	53.7	12.5
23281	138	62	76
23282	9.68	33.30	-23.62
63116	13.3	19.6	-6.3
82433_C2	20.0	23.9	-3.9
83117_C2	48.8	104.6	-55.8
83124_C2	49.5	134.6	-85.1
83293_C2	10.8	5.4	5.4
83294_C2	378	78	300
83295_C2	168	25	143
83296_C2	32.4	57.7	-25.3
Average	65.4	36.0	29.4
Std Dev	88.8	32.1	75.6
Max	378	134.6	300
Min	1.68	1.37	-85.1
Range	376	133.2	385

Note: Model Layer 12 was used in Residual Analyses.

This page intentionally left blank

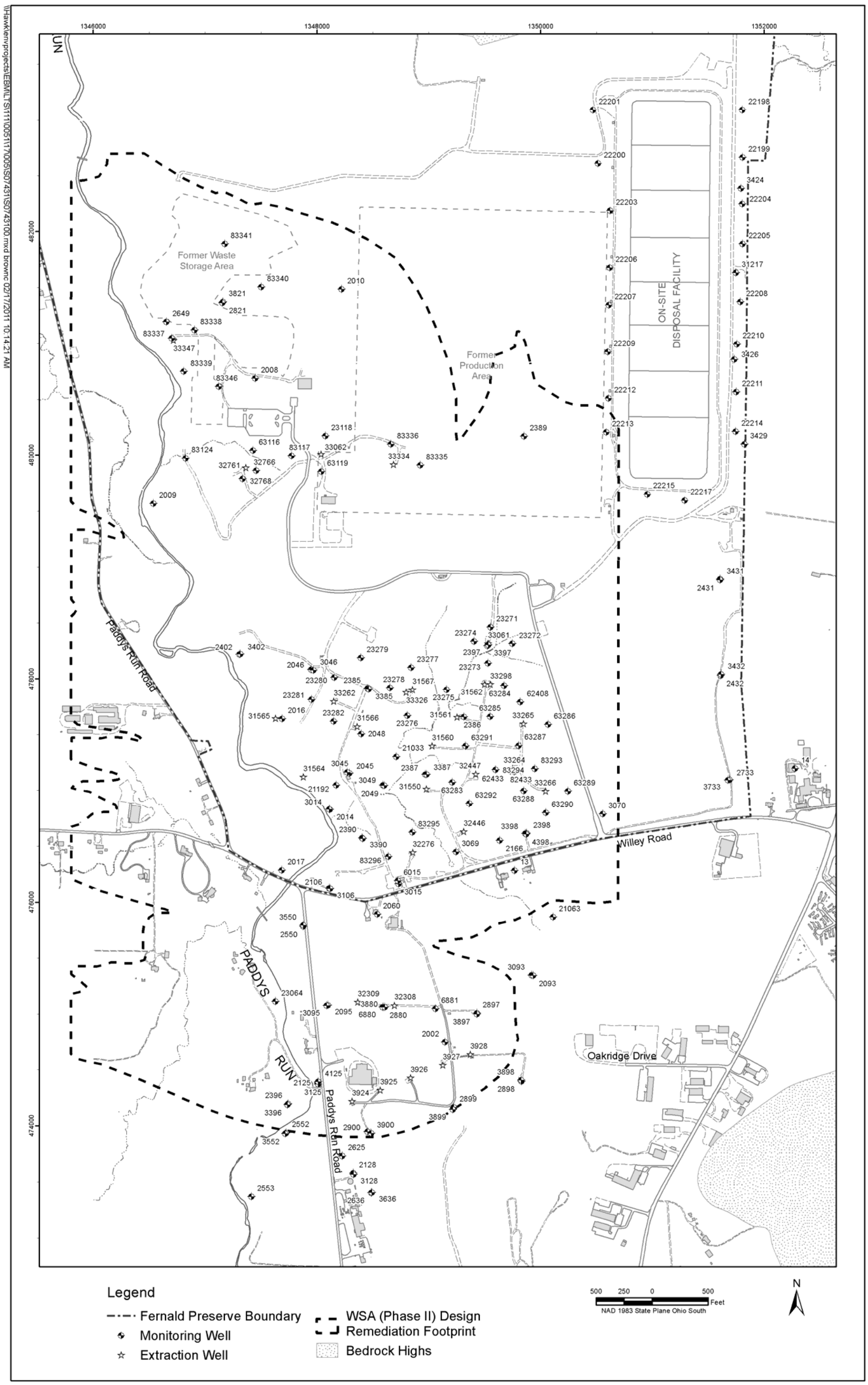


Figure A.2−1. IEMP Water Quality Monitoring Wells and Extraction Wells

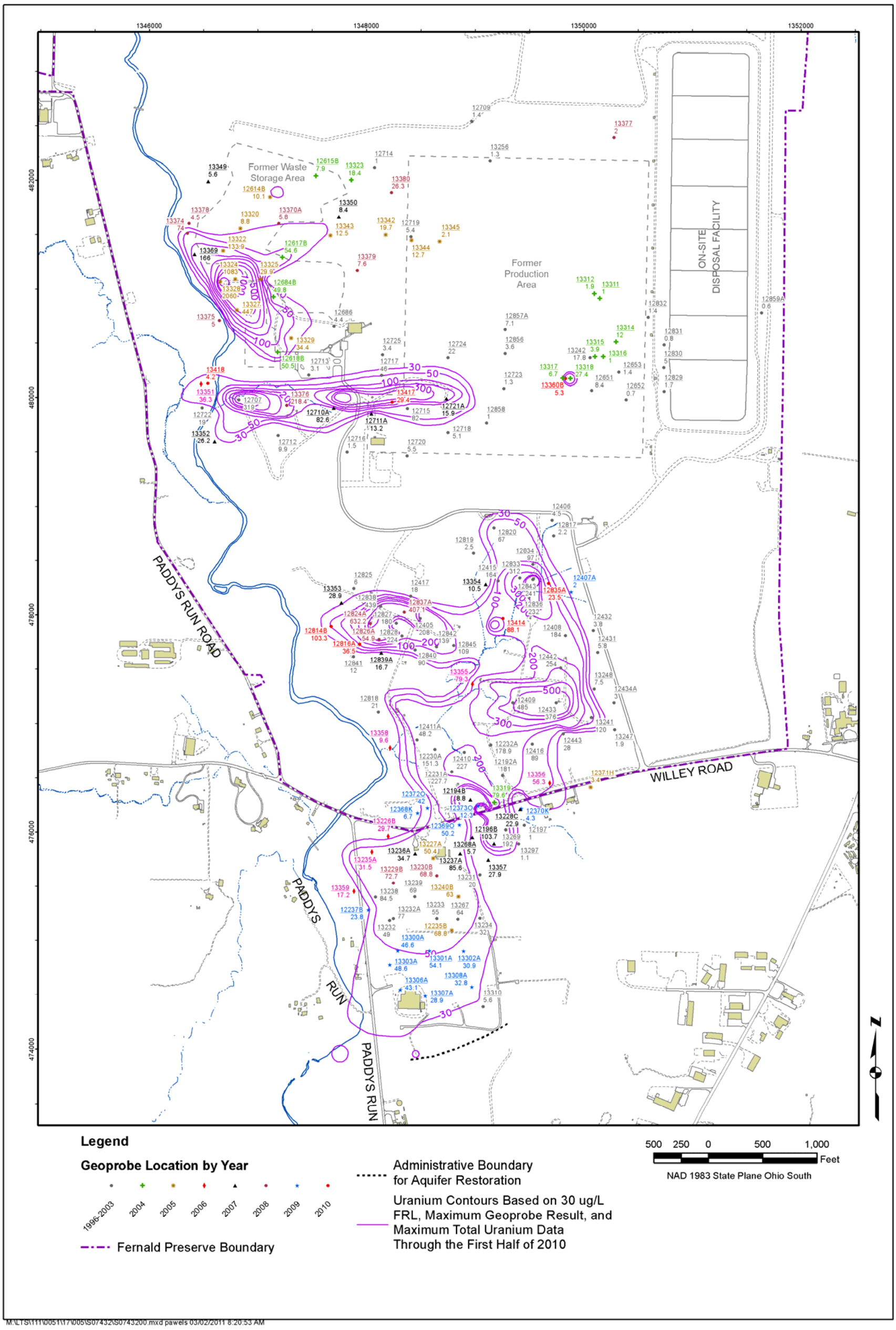


Figure A.2−2A. Direct-Push Data and Maximum Total Uranium Plume through the First Half of 2010

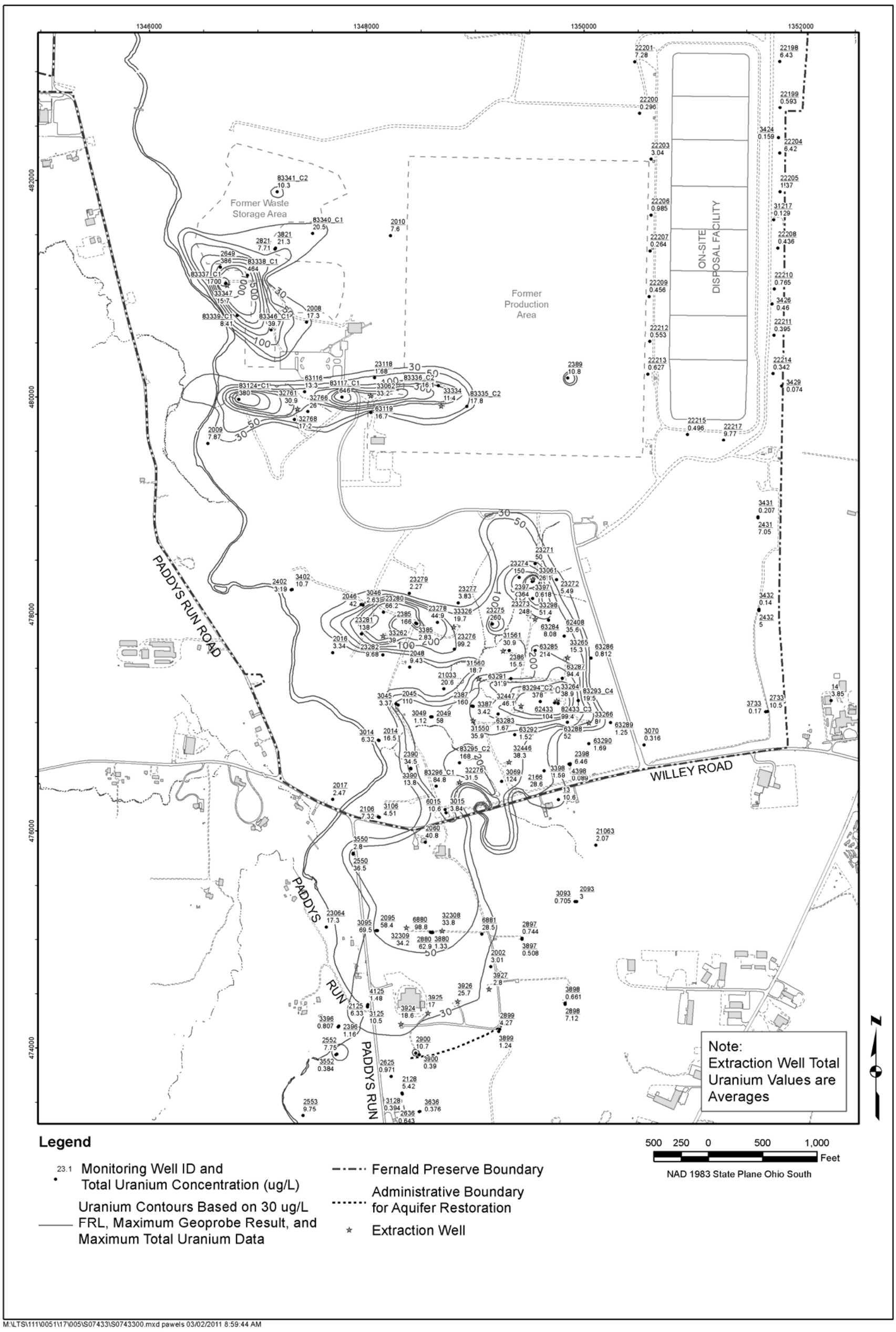


Figure A.2−2B. Monitoring Well Data and Maximum Total Uranium Plume through the First Half of 2010

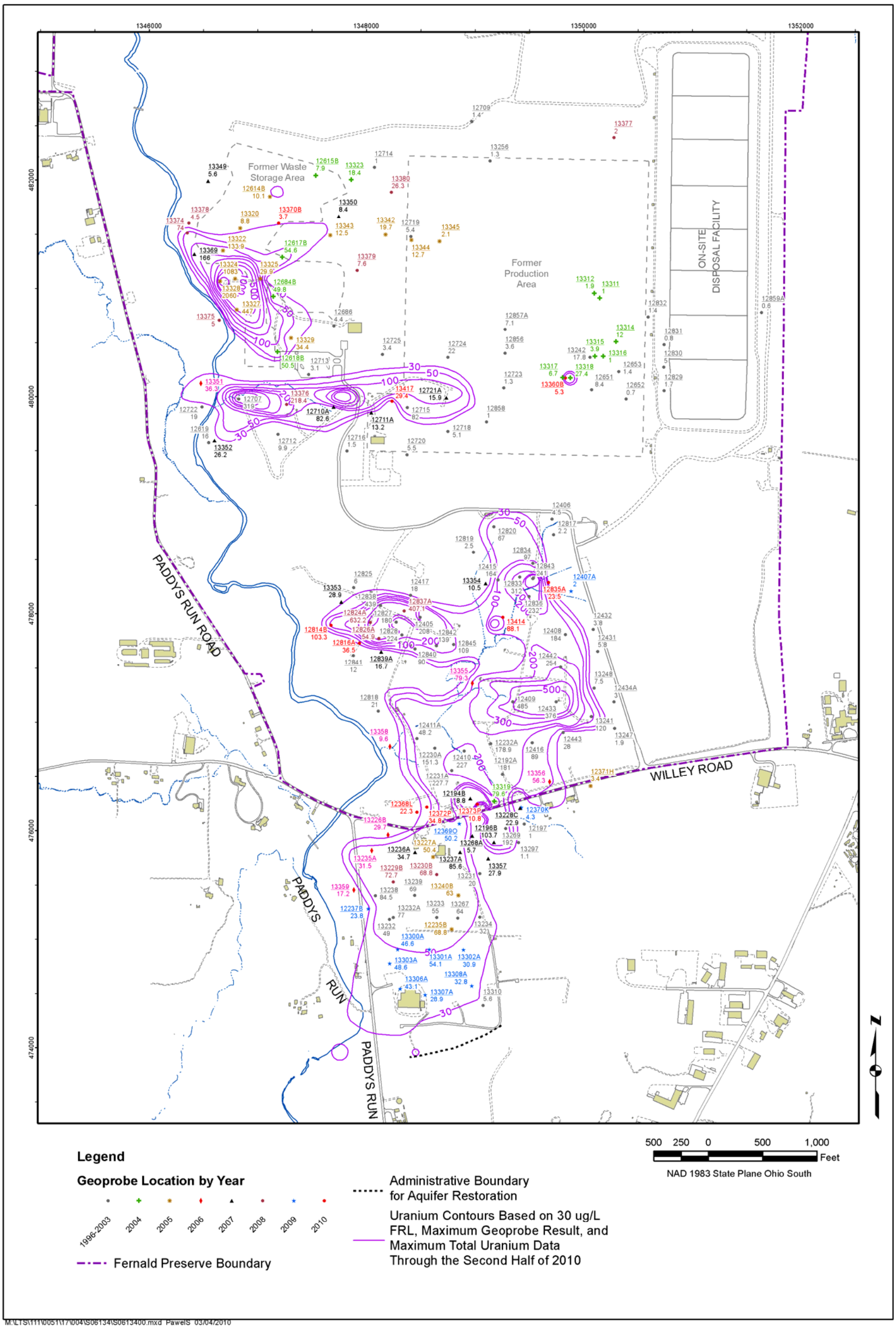


Figure A.2−3A. Direct-Push Data and Maximum Total Uranium Plume through the Second Half of 2010

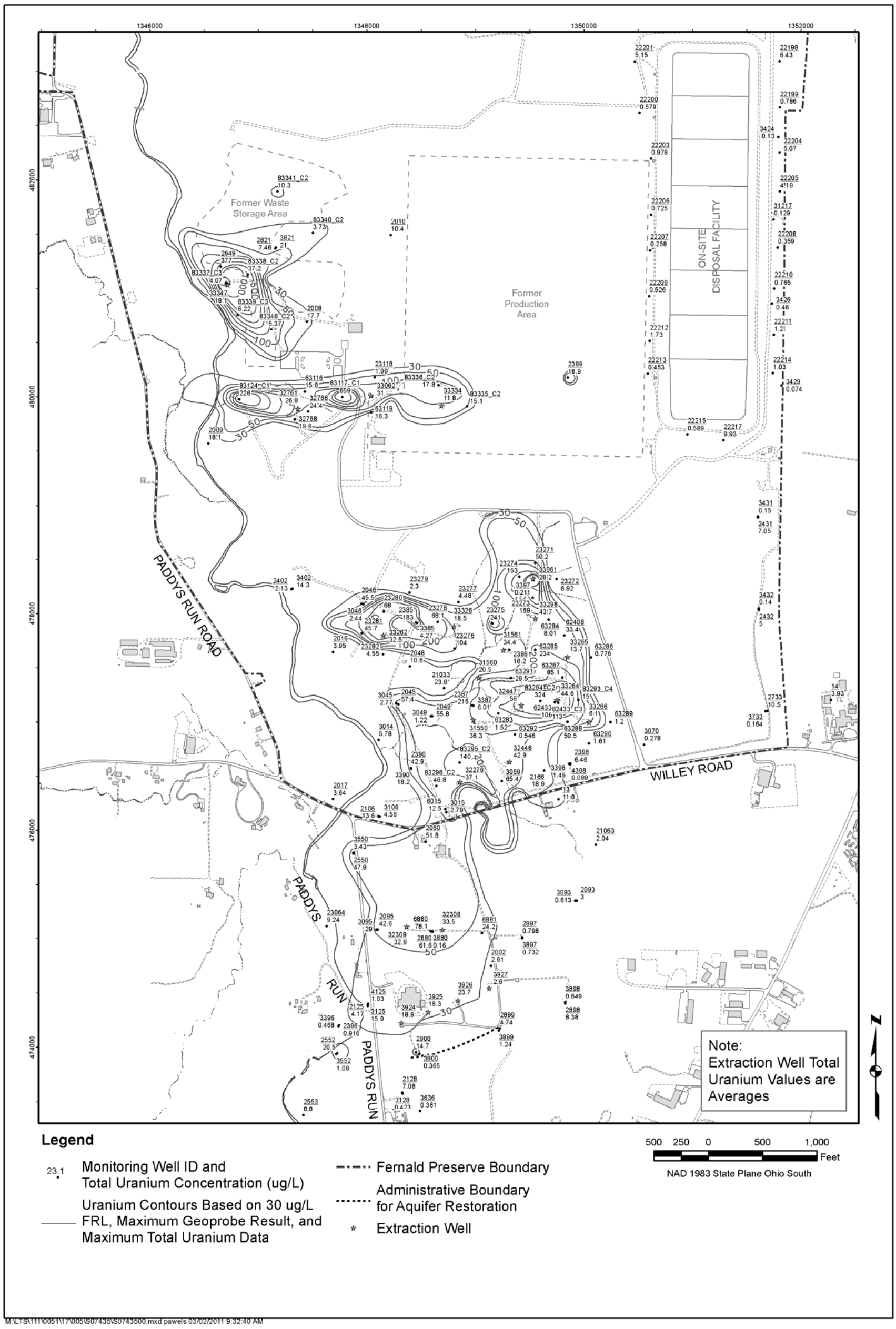


Figure A.2−3B. Monitoring Well Data and Maximum Total Uranium Plume through the Second Half of 2010

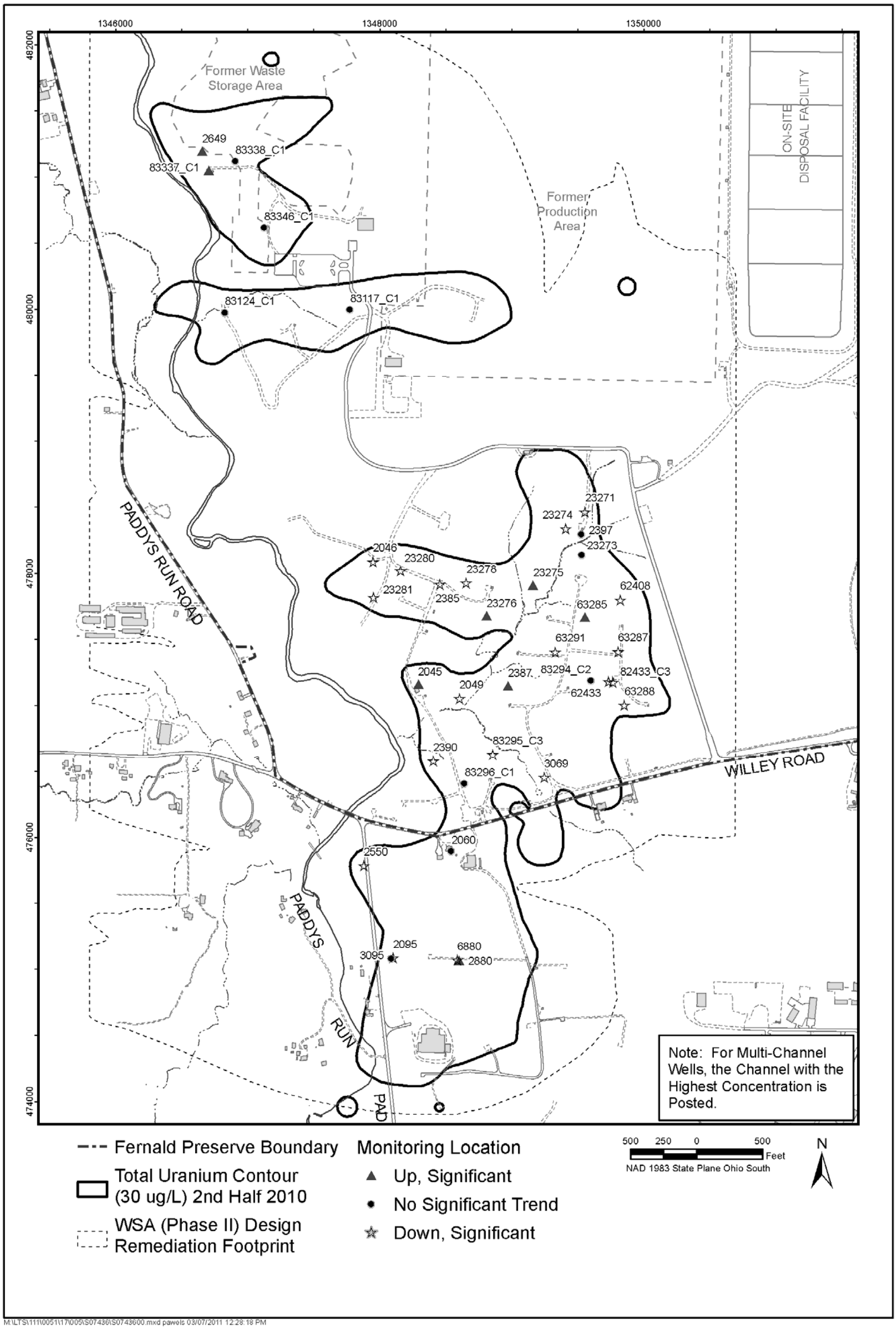


Figure A.2−4. Monitoring Wells with 2010 Exceedances for Total Uranium with Up, Down, or No Significant Trends

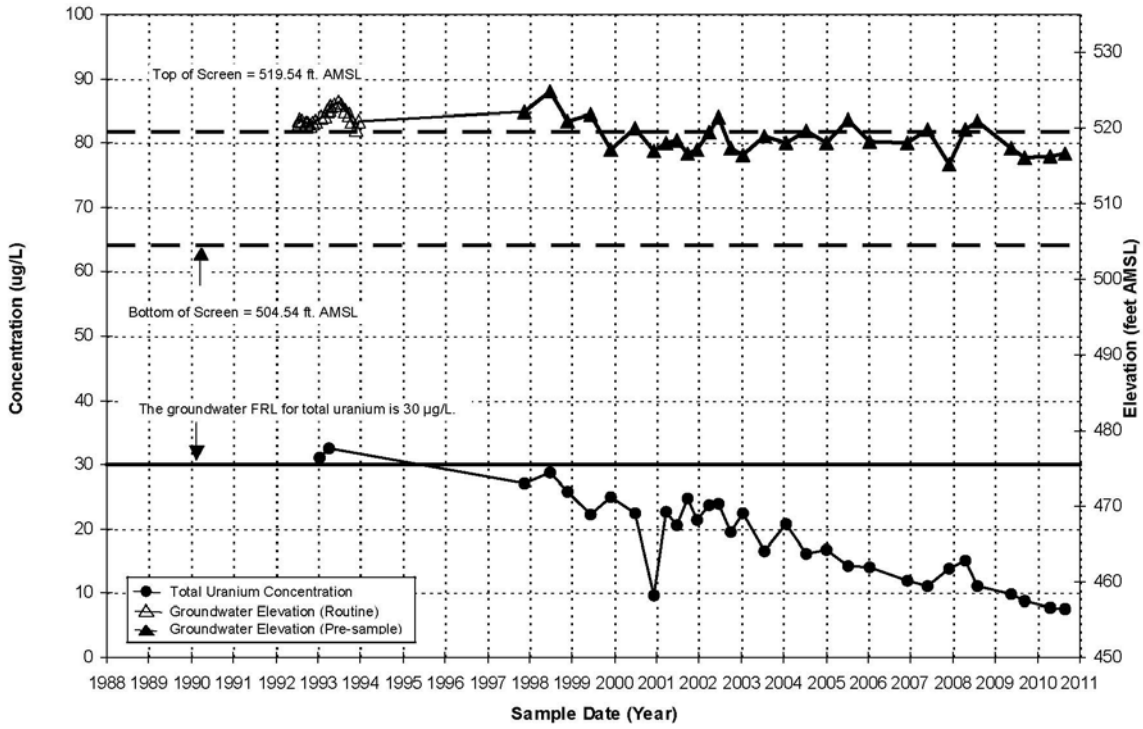


FIGURE A.2-5. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2821

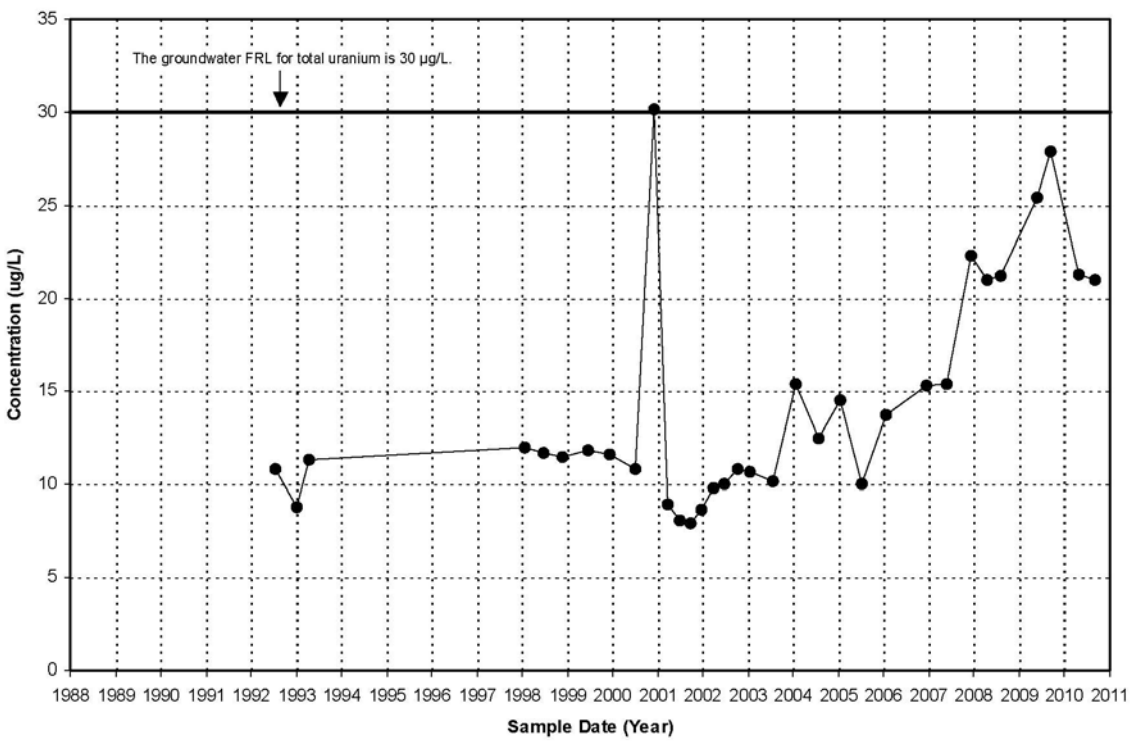


FIGURE A.2-6. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3821

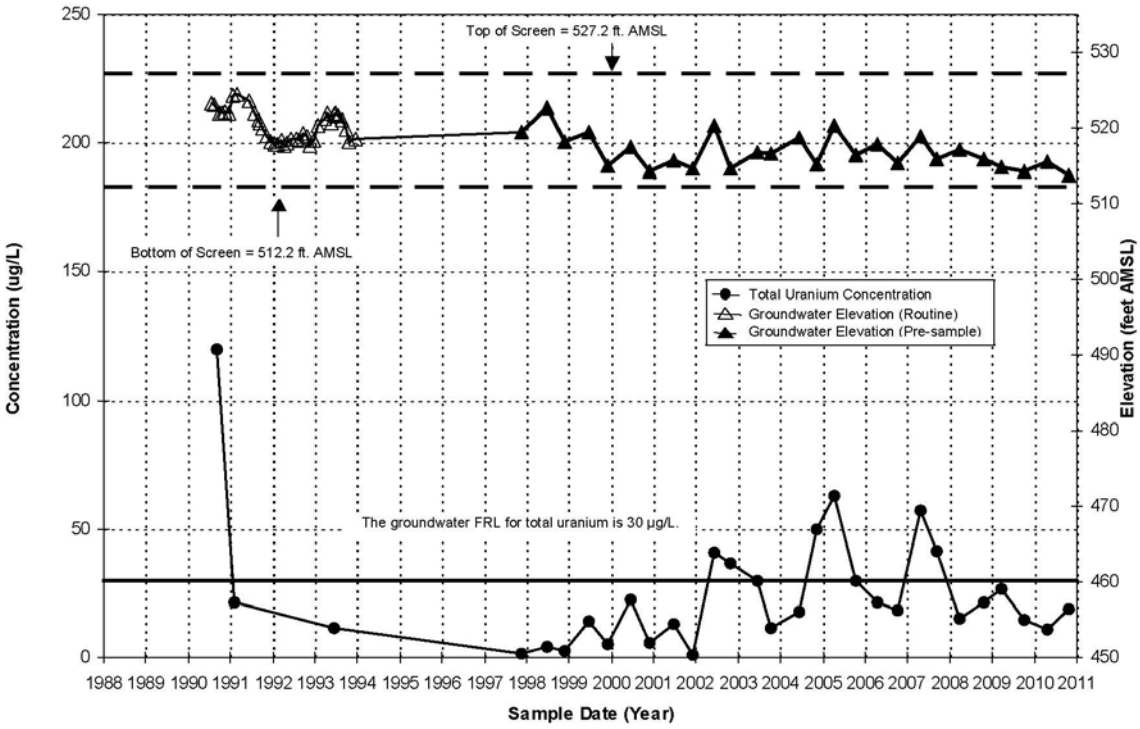


FIGURE A.2-7. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2389

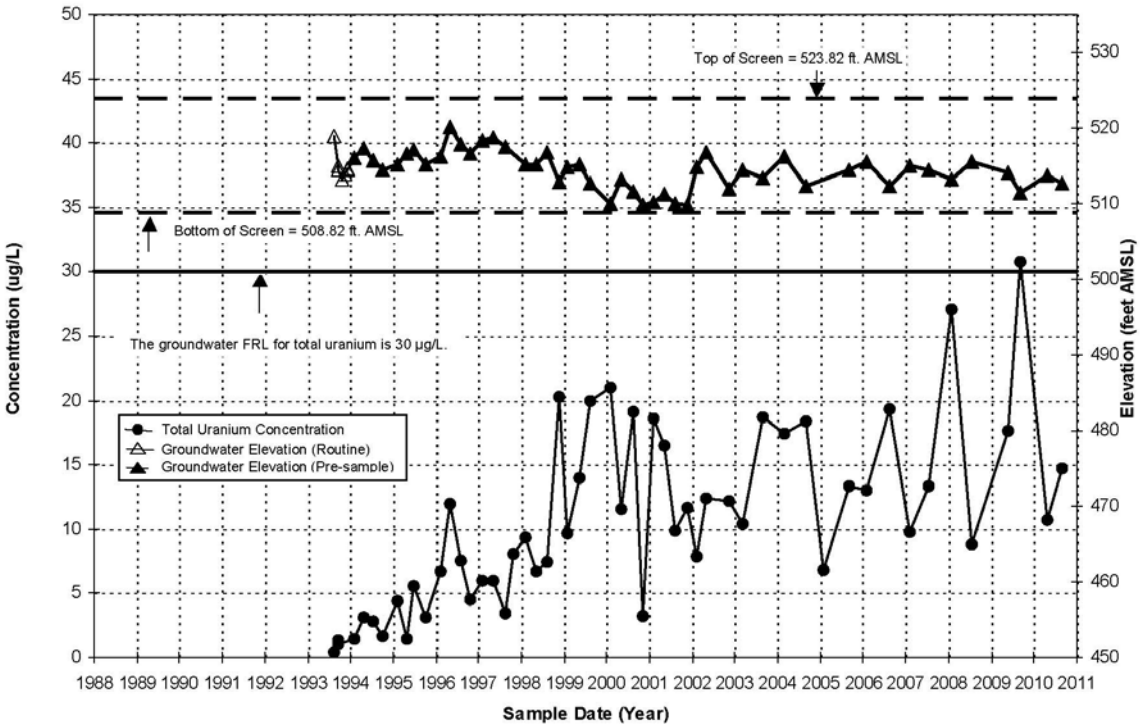


FIGURE A.2-8. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2900

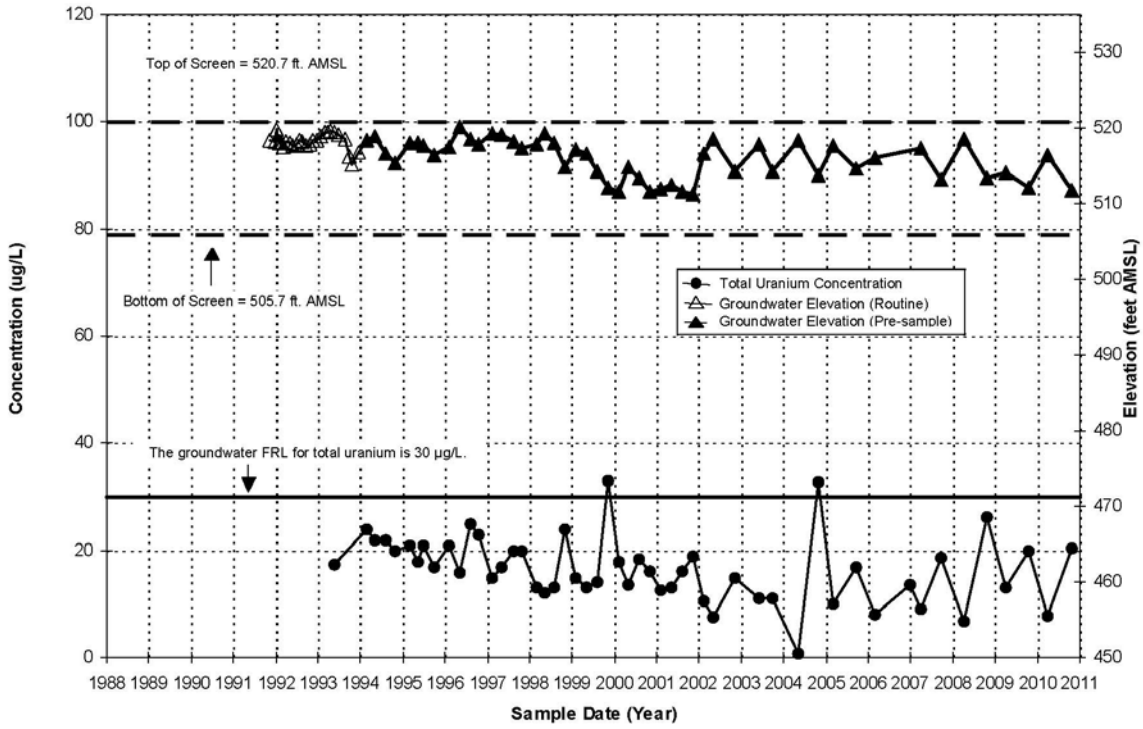


FIGURE A.2-9. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2552

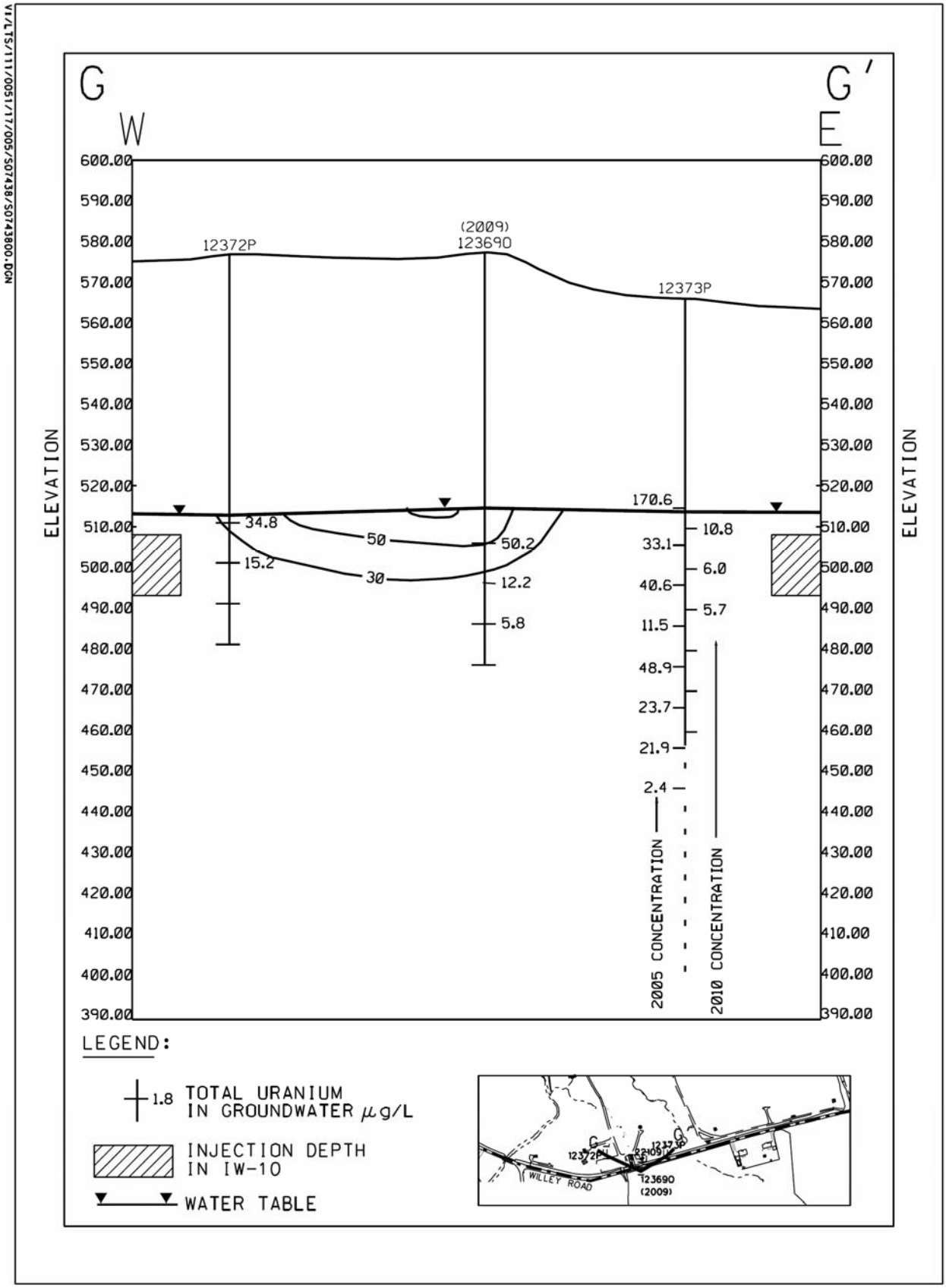


Figure A.2–10. Total Uranium in Groundwater (2010) Next to and South of IW-10

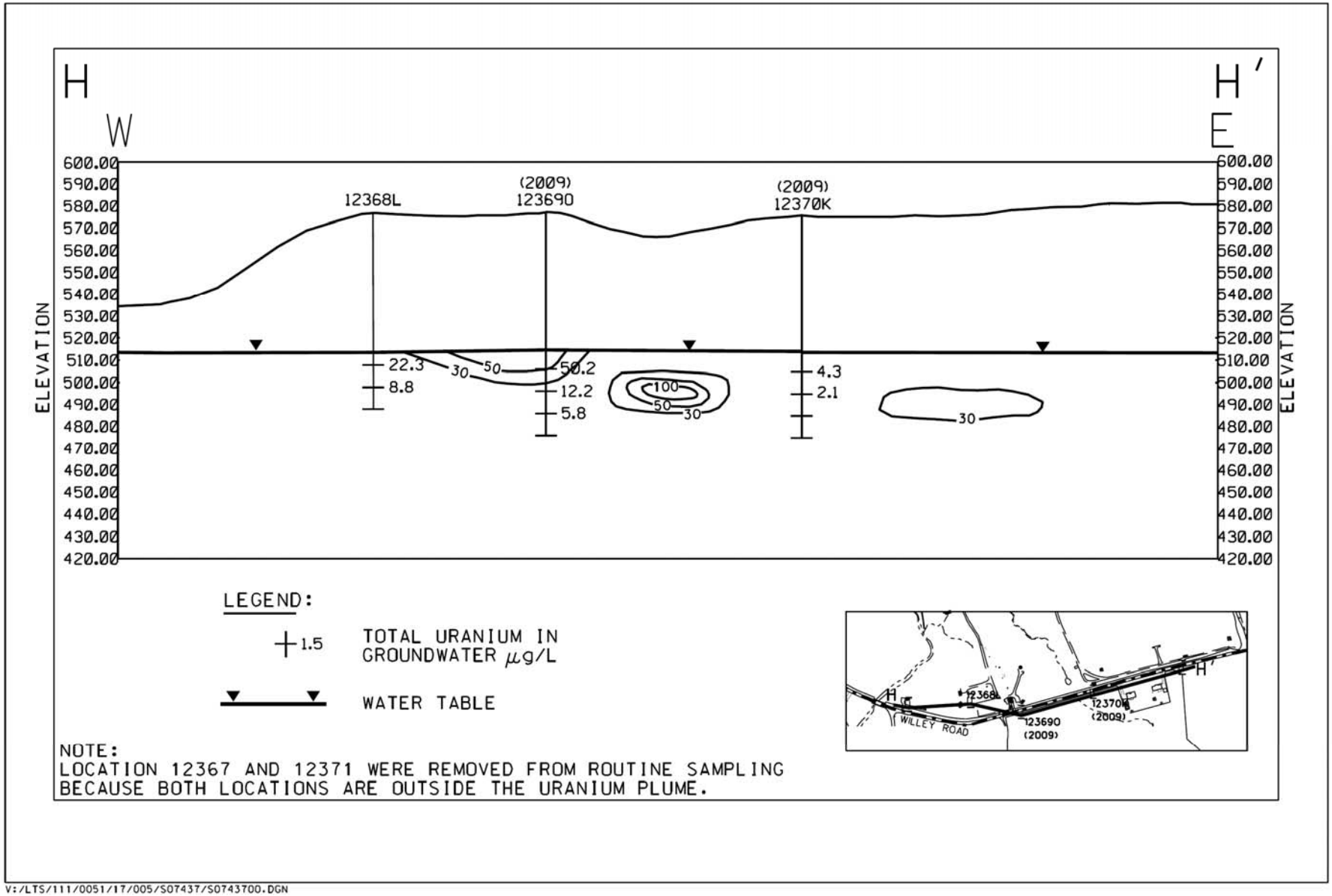


Figure A.2–11. Total Uranium in Groundwater (2010) South of Former Re-Injection Wells

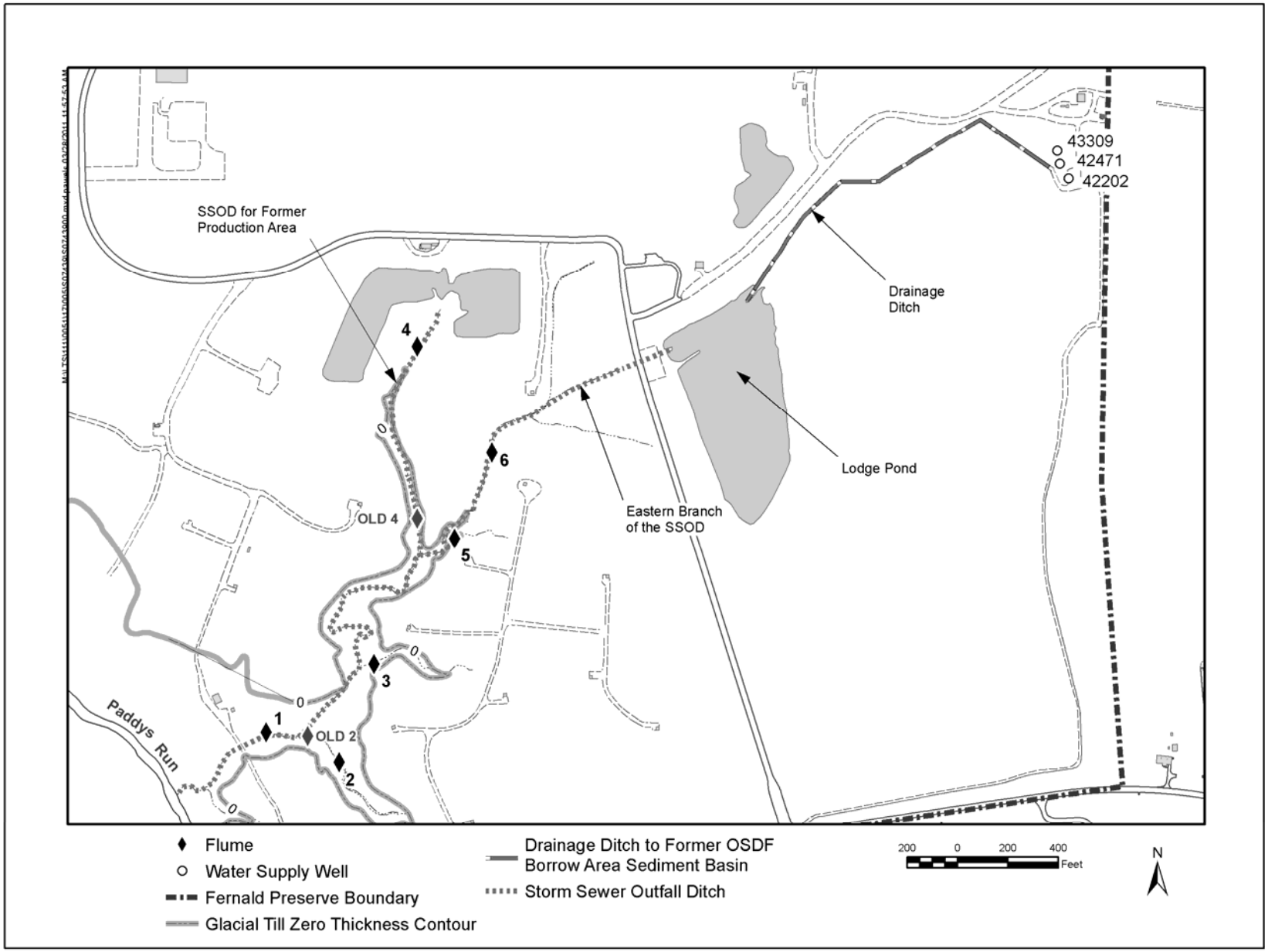


Figure A.2–12. SSOD Flumes and Water Supply Wells

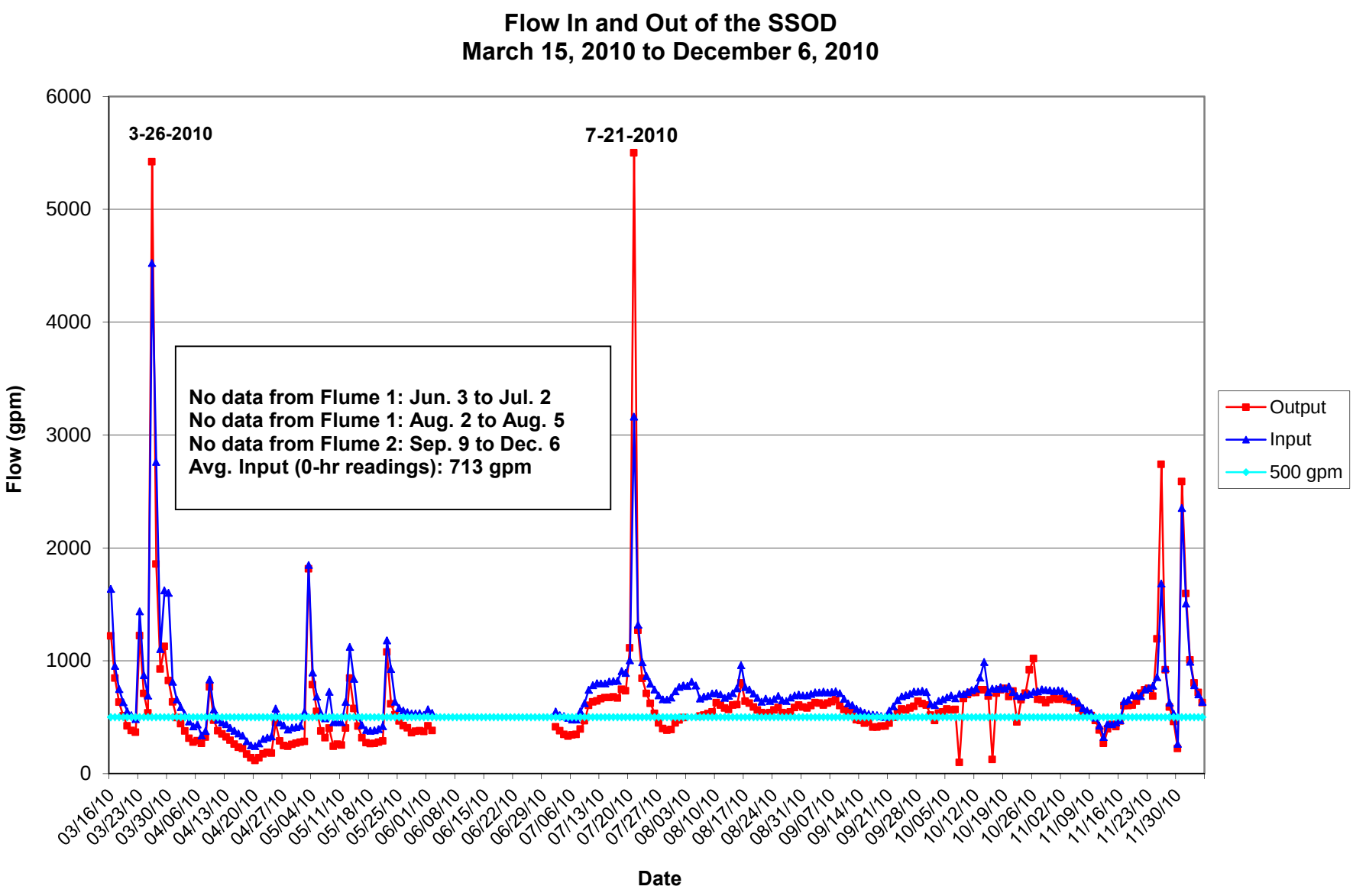


Figure A.2−13. Flow In and Out of the SSOD March 15, 2010, to December 6, 2010

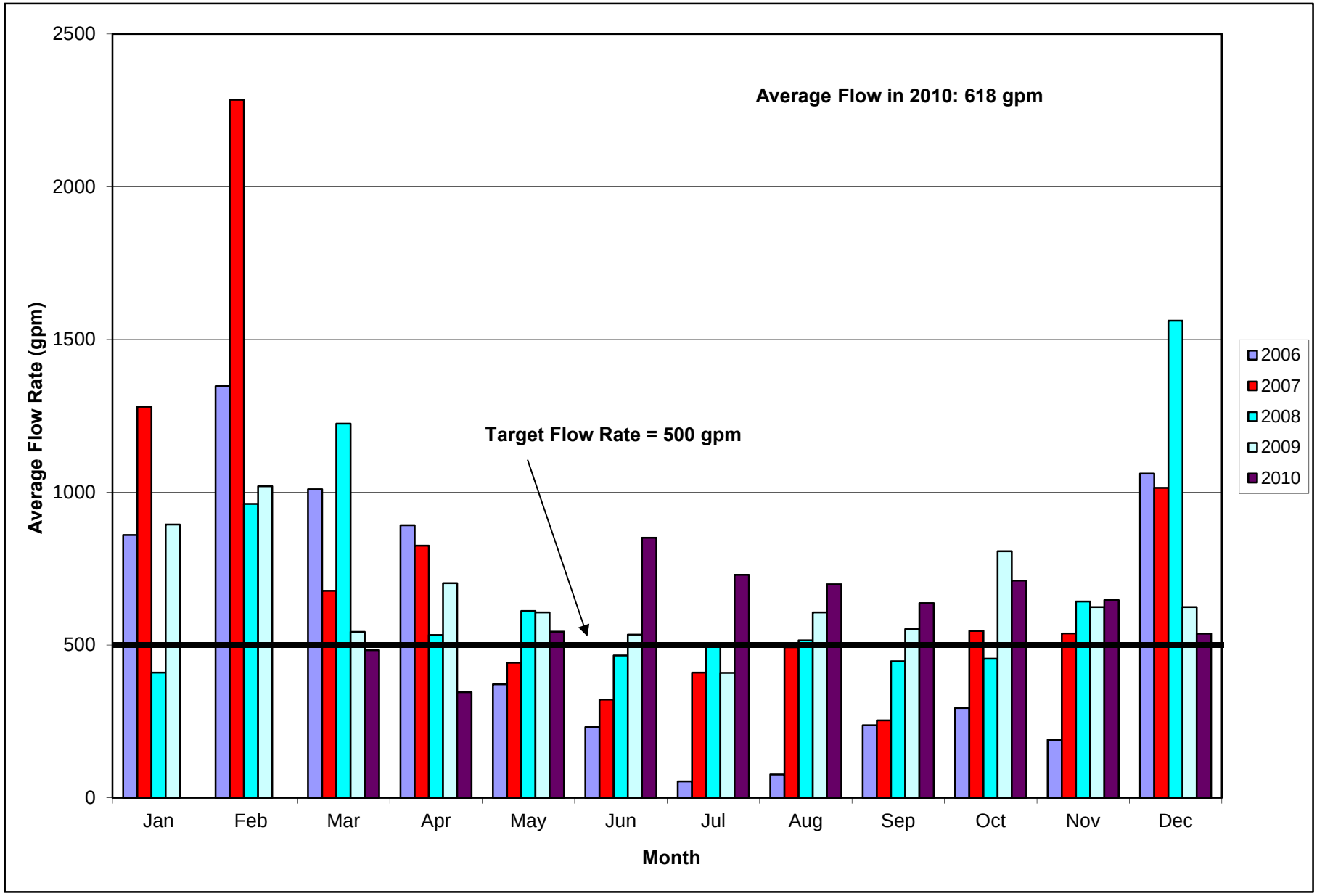


Figure A.2−14. Average Flow Rate into SSOD: 2006–2010 Flumes 2, 3, 4, 5 and 6

Attachment A.3

This page intentionally left blank

A.3.0 Groundwater Elevations and Capture Assessment

A.3.1 Groundwater Elevations and Capture Assessment

Quarterly groundwater elevation maps for 2010 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 2010 were measured at 178 locations, as specified in the IEMP (DOE 2010a).

Quarter	Measurement Dates	Number of Days	Average Water Level (ft amsl)
1	1/18/10 to 1/20/10	3	513.34
2	4/12/10 to 4/13/10	2	515.43
3	7/12/10 to 7/14/10	3	516.72
4	10/11/10 to 10/13/10	3	513.27

Seventeen monitoring wells were not measured at various times in 2010 because the wells were dry. A summary is provided below.

Well	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
2014	X	X	X	X
2544	X			X
2625	X			X
2636	X	X	X	X
21192	X	X	X	X
23118	X			
22303	X			X
82433_C1	X	X	X	X
83293_C1	X	X	X	X
83294_C1	X	X	X	X
83296_C1	X	X		X
83337_C1	X	X	X	X
83338_C1	X	X		X
83339_C1	X	X	X	X
83340_C1	X	X	X	X
83341_C1	X	X	X	X
83346_C1		X	X	X

Unplanned operational disruptions in 2010 were minimal. The entire well field (excluding the South Plume recovery wells) was shut down once in 2010 for a total of 31 days from April 30 to May 31 as planned to allow water levels to recover to nonpumping elevations.

The pumping rates on Figures A.3−1 through A.3−4 are averages of the actual pumping rates during the measurement period. Routine quarterly water level measurements were not collected in 2010 during the planned shutdowns.

The 2010 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 Waste Storage Area (Phase II) design remediation footprint used in this report was constructed using reverse, nonretarded, 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.

The groundwater flow divide between Paddys Run Outlet and the New Baltimore Outlet was not readily distinguishable for most of 2010. 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. The 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 2010.

Average annual water table fluctuations and yearly ranges for 2006 through 2010 are as follows:

Year	Average Fluctuation (ft)	Range (ft)
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

For 17 years DOE has been presenting well cluster hydrographs for a select group of Type 2 and Type 3 monitoring wells. The hydrographs were used to assess vertical groundwater gradients for the following well clusters 014, 017, 045, 046, 049, 065, 069 (434), 095, 106, 125, 385, 387, 390, 396, 398, 402, 550, 552, 821, 880, 881, and 900. (**Note:** The last three digits of the monitoring wells identify the well clusters, e.g., cluster 552 consists of monitoring wells 2552 and 3552). Figure A.3−6 identifies the well cluster locations.

The hydrographs consistently indicated that elevations in the Type 2 and Type 3 monitoring wells within the majority of the clusters were almost always identical for each measurement event. An occasional slight difference could be seen, but these differences did not appear to be

indicative of vertical hydraulic gradients. Rather, they were attributed to measurement and/or transcription errors during data collection and processing. The 17 years of data presented indicated that no vertical gradient has ever been detected through this monitoring effort. DOE therefore is no longer reporting cluster hydrographs.

A.3.2 Annual Planned Well Field Shutdown

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. The planned shutdown in 2010 was conducted from April 30 to May 31.

Figure A.3−7 shows cumulative annual precipitation levels for 2004 through 2010, as recorded at the Butler County Regional Airport. Cumulative precipitation in 2010 was approximately 33.20 inches. This is the lowest amount of annual precipitation recorded in the last 7 years. Low precipitation levels in 2010 impacted regional water levels. Regional water levels in 2010 were also lower than in previous 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.3−8). Water level measurements were recorded at the top of each hour.

The zero hour transducer readings (midnight) were used to illustrate water level changes in the transducer wells during the shutdown period. The maximum water level rise measured during the shutdown in 2010 at each transducer was as follows:

Location	Prior to Shutdown 4/30/2010	Just Prior to Restart 5/31/2010	Water Level Rise (ft)
2045	515.07	517.45	2.38
2046	515.77	517.88	2.11
2649	516.48	518.87	2.39
23274	514.94	517.30	2.36
63119	515.04	517.52	2.49
22302	514.10	516.71	2.61
23118	515.37	517.71	2.34
22301	514.49	516.06	2.57
22303	513.83	516.07	2.24
32763	515.20	518.64	3.44
62433	513.81	516.86	3.05

The water level rise calculations indicate that during the shutdown the water level rise at the transducer wells ranged from 2.11 ft to 3.44 ft.

Figure A.3−10 shows water levels verses precipitation from May 25, 2007, through March 15, 2011. 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 2010 resulted in a water level rise of approximately:

- 2.39 feet in the former Waste Storage Area (monitoring well 2649);
- 2.11 feet in the west side of the South Field (monitoring well 2046); and
- 3.05 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]). The results of the 2010 IEMP first-half uranium sampling are used to represent uranium concentrations in the well prior to the shutdown. Groundwater samples were collected on either May 27 or May 28, prior to the well field being restarted. The results of the 2010 IEMP second-half uranium sampling are used to represent uranium concentrations in the well after the shutdown exercises were completed. The two shallowest channels (Channels 1 and 2) of Type-8 monitoring wells were sampled. Uranium concentrations measured during the first half of 2010, prior to the shutdown, are used to represent pre-shutdown concentrations in the monitoring wells. Uranium concentrations measured during the second half of 2010, after the shutdown, are used to represent post-shutdown concentrations in the monitoring wells. Uranium concentration measurements collected at six monitoring wells before, during, and after the 2010 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, 2046, 83124_C1, and 83337_C2); in other monitoring wells the uranium concentrations during the shutdown decreased (i.e., 23274, 83124_C2, and 83294_C2). Note that during the shutdown, water levels rose high enough for a sample to be collected from 83294_C1 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 2010.

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 April at the extraction well. As the data indicate, the uranium concentration increased at most of the wells.

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]) are plotted in Figure A.3−10 along with precipitation data collected through March 15, 2011. The intent is to leave these transducers recording until several yearly water level cycles have been recorded. 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 2010 Well Field Shutdown

Well	Easting	Northing	First Half 2010 Pre-Shutdown Concentrations		Pre-Start-Up Concentrations		Second Half 2010 Post-Shutdown Concentrations	
			Date	Uranium (μg/L)	Date	Uranium (μg/L)	Date	Uranium (μg/L)
2045	1348291	477158.9	3/25/2010	63.0	5/28/2010	110.0	9/2/2010	57.4
2046	1347950	478087.8	3/9/2010	35.1	5/28/2010	42.0	10/19/2010	45.5
23274	1349406	478337	4/19/2010	150	5/28/2010	135	9/29/2010	153
83124_C1	1346826	479977.2	3/10/2010	231	5/28/2010	380.0	9/22/2010	226
83124_C2	1346826	479977.2	3/10/2010	49.5	5/28/2010	43.7	NA[a]	NA[a]
83294_C1	1349599	477189.5	DRY	DRY	5/28/2010	192	DRY	DRY
83294_C2	1349599	477189.5	4/5/2010	378	5/27/2010	327	9/21/2010	324
83337_C1	1346704	481051.9	DRY	DRY	5/27/2010	1700	DRY	DRY
83337_C2	1346704	481051.9	4/20/2010	4.84	5/27/2010	274	8/30/2010	2.7

[a]NA = not applicable

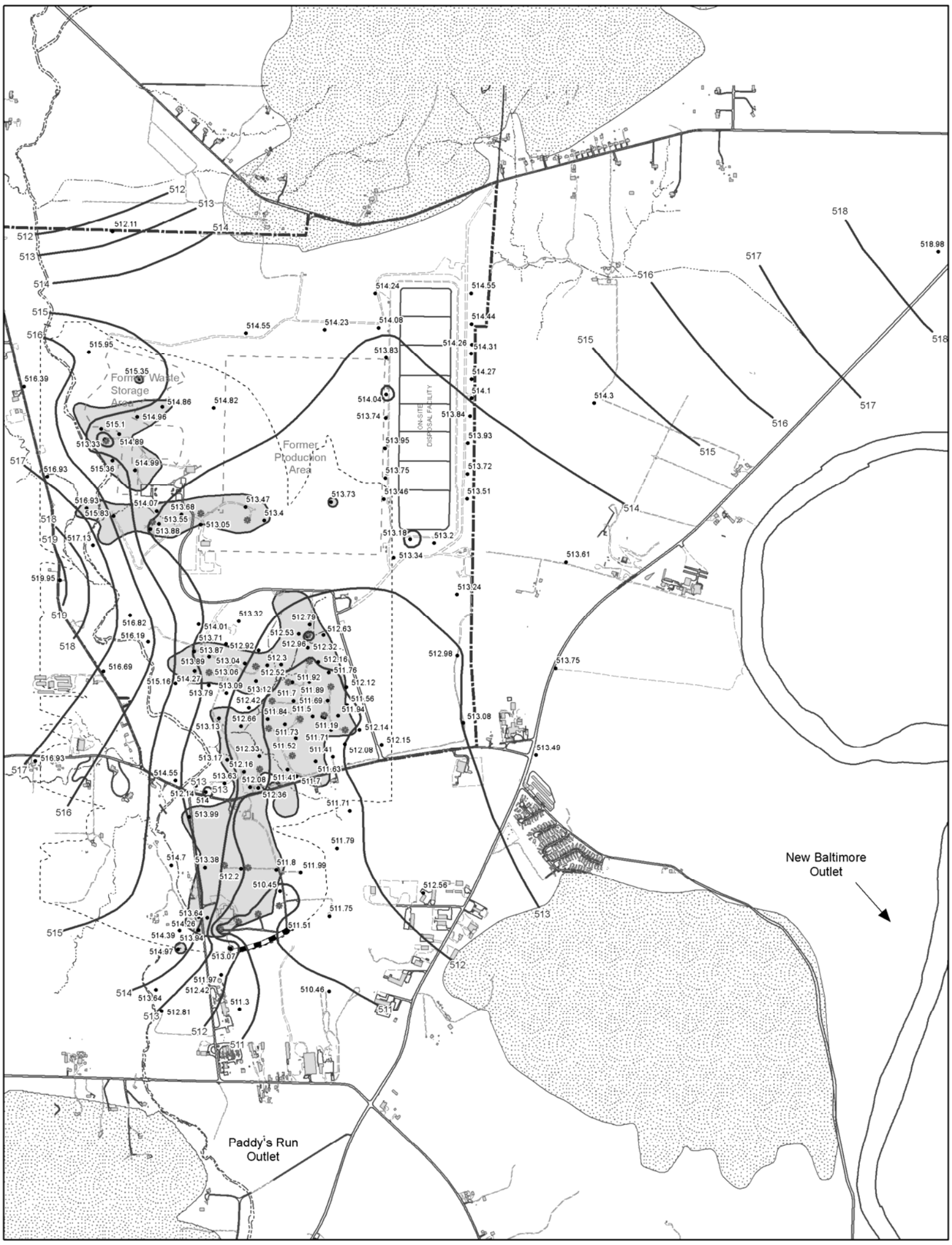
Table A.3–2. Uranium Concentrations at Extraction Wells Before and After the Well Field Shutdown

Ext. Well ID	April Avg. U Conc. (μg/L)	Uranium Concentration (μg/L) After Well Field Re-Start[a]							Max. after Re-Start minus April Avg.[a]
		6/1/2010	6/2/2010	6/3/2010	6/4/2010	Min.	Max.	Range	
RW-01	18.2	17.8	18.8	17.2	18.7	17.2	18.8	1.6	0.6
RW-02	15.8	17.3	17.3	17.0	17.1	17.0	17.3	0.3	1.5
RW-03	24.9	25.3	25.2	23.0	24.6	NA	NA	NA	NA
RW-04	2.8	2.8	2.9	3.1	2.8	2.8	3.1	0.3	0.3
RW-06	35.4	36.6	36.6	30.6	33.7	30.6	36.6	6.0	1.2
RW-07	36.3	36.3	36.0	33.0	33.7	33.0	36.3	3.3	0.0
EW-15a	36.6	44.9	42.3	37.1	37.8	37.1	44.9	7.8	8.3
EW-17a	18.4	25.5	24.2	21.0	NS	21.0	25.5	4.5	7.1
EW-18	38.5	39.2	40.0	35.3	37.4	35.3	40.0	4.7	1.5
EW-19	21.2	23.1	23.0	16.4	22.8	16.4	23.1	6.7	1.9
EW-20	31.3	31.7	31.6	29.4	30.0	29.4	31.7	2.3	0.4
EW-21a	44.0	64.7	62.1	53.4	59.2	53.4	64.7	11.3	20.7
EW-22	34.3	40.2	37.9	34.6	35.7	34.6	40.2	5.6	5.9
EW-23	57.3	53.4	54.8	35.8	52.7	35.8	54.8	19.0	-2.5
EW-24	43.3	42.8	42.4	39.9	41.3	39.9	42.8	2.9	-0.5
EW-25	25.7	NS	NS	NS	33.7	33.7	33.7	0.0	8.0
EW-26	29.1	36.2	34.9	30.5	30.6	NA	NA	NA	NA
EW-27	33.3	37.8	38.6	35.0	36.3	35.0	38.6	3.6	5.3
EW-28a	11.8	11.2	11.4	11.0	10.9	10.9	11.4	0.5	-0.4
EW-30	45.8	46.4	48.4	41.8	46.4	41.8	48.4	6.6	2.6
EW-31	13.4	16.1	18.1	15.8	17.3	15.8	18.1	2.3	4.7
EW-32	6.2	7.3	7.0	19.8	6.8	6.8	19.8	13.0	13.6
EW-33a	18.6	18.0	18.8	7.0	21.3	7.0	21.3	14.3	2.7

Shading identifies startup concentrations that are higher than or equal to the average concentration in the well prior to the shutdown exercise.

[a]NA = not applicable; NS = not sampled.

This page intentionally left blank



Extraction Well
Groundwater Elevation Contour
Bedrock Highs
Capture Zone
WSA (Phase II) Design Remediation Footprint (Defined in Attachment A.3)
Extent of the Maximum Total Uranium 30 ug/L Contour from BRSR, Modified as Needed through First Half 2010

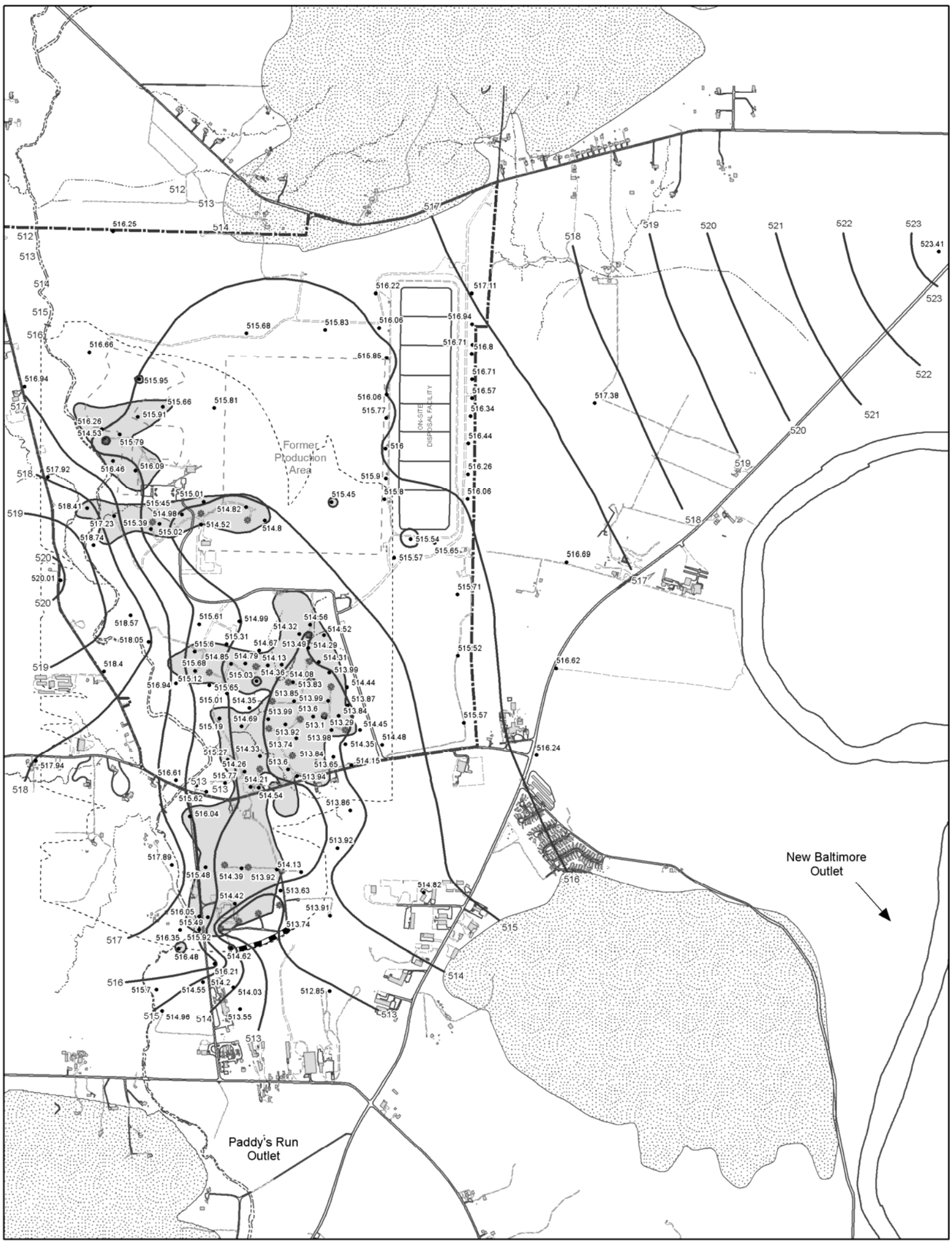
January 18 - January 25, 2010 Operational Status
Average Pumping Rates (gpm)

South Plume (6 wells): 1318 gpm
South Field Extraction (13 Wells): 2779 gpm
Waste Storage Area (4 Wells): 748 gpm

N

1000 0 1000
Feet

Figure A.3−1. Routine Groundwater Elevation Map, First Quarter 2010 (January 18 through January 25, 2010)



Extraction Well
Groundwater Elevation Contour
Bedrock Highs
Capture Zone
WSA (Phase II) Design Remediation Footprint (Defined in Attachment A.3)
Extent of the Maximum Total Uranium 30 ug/L Contour from BRSR, Modified as Needed through First Half 2010

April 12 - April 13, 2010 Operational Status
Average Pumping Rates (gpm)

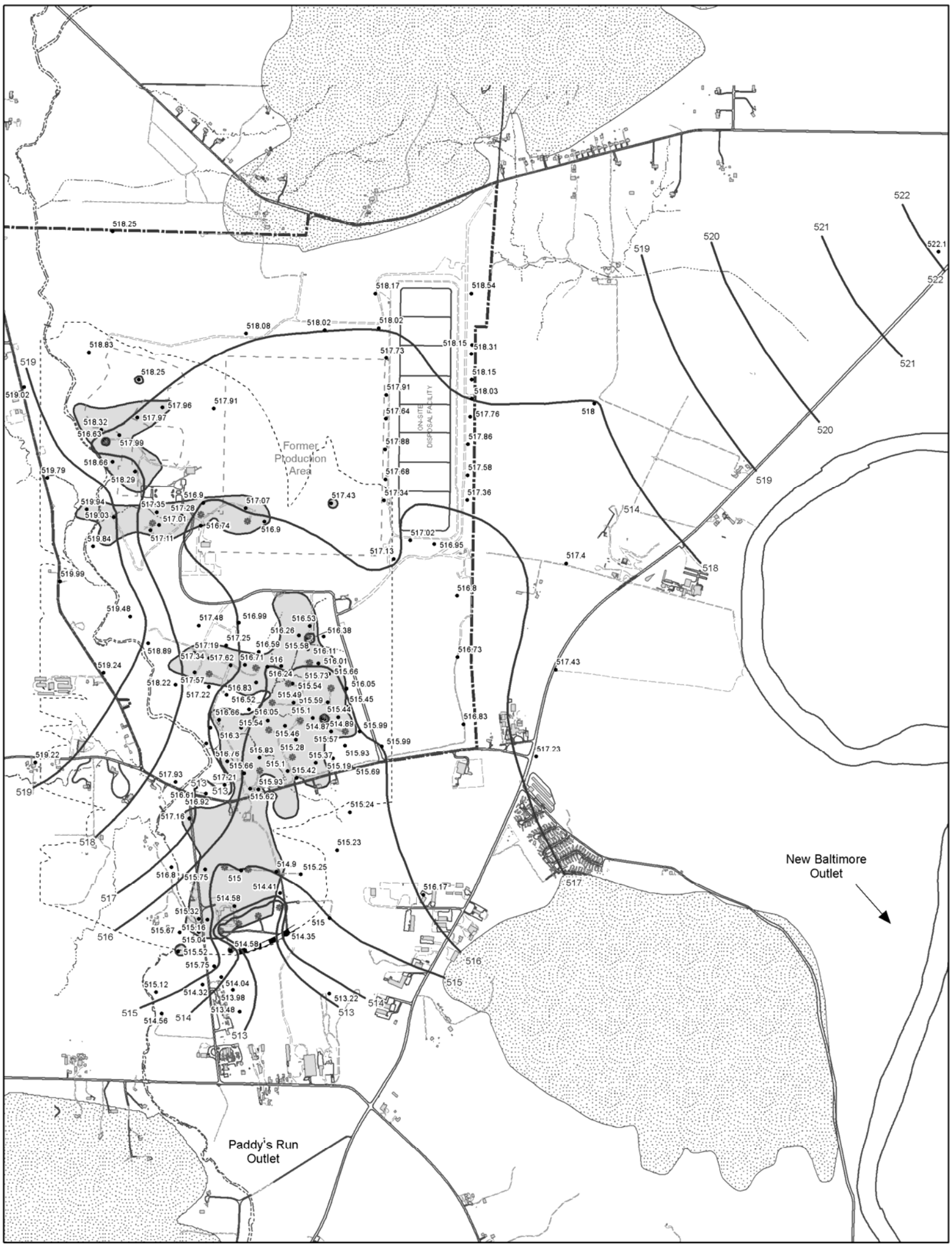
South Plume (6 wells): 1181 gpm
South Field Extraction (13 Wells): 2556 gpm
Waste Storage Area (4 Wells): 667 gpm

N

1000 0 1000
Feet

\\Hawk\envprojects\EBM\LTS\111\0051\17\005\S07441\S0744100.mxd brownc 03/02/2011 10:57:18 AM

Figure A.3−2. Routine Groundwater Elevation Map, Second Quarter 2010 (April 12 through April 13, 2010)



Extraction Well
Groundwater Elevation Contour
Bedrock Highs
Capture Zone
WSA (Phase II) Design Remediation Footprint (Defined in Attachment A.3)
Extent of the Maximum Total Uranium 30 ug/L Contour from BRSR, Modified as Needed through Second Half of 2010

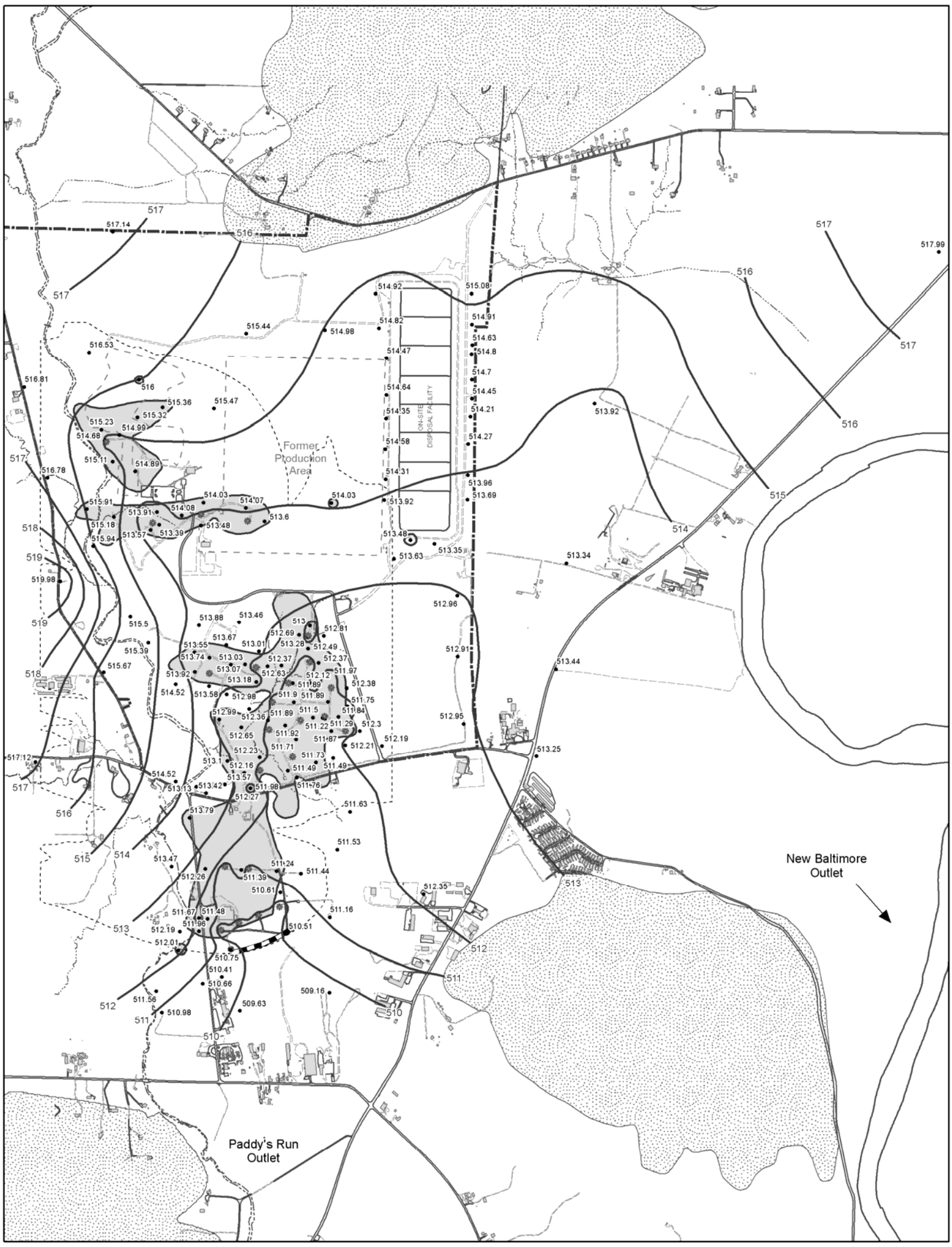
July 12 - July 14, 2010 Operational Status
Average Pumping Rates (gpm)

South Plume (6 wells): 1280 gpm
South Field Extraction (13 Wells): 2809 gpm
Waste Storage Area (4 Wells): 676 gpm

1000 0 1000
Feet

M:\LTS\111\0051\17\005\S07442\S0744200.mxd pawels 03/02/2011 10:53:51 AM

Figure A.3−3. Routine Groundwater Elevation Map, Third Quarter 2010 (July 12 through July 14, 2010)



Extraction Well
Groundwater Elevation Contour
Bedrock Highs
Capture Zone
WSA (Phase II) Design Remediation Footprint (Defined in Attachment A.3)
Extent of the Maximum Total Uranium 30 ug/L Contour from BRSR, Modified as Needed through Second Half 2010

October 11 - October 13, 2010 Operational Status
Average Pumping Rates (gpm)

South Plume (6 wells): 1362 gpm
South Field Extraction (13 Wells): 2728 gpm
Waste Storage Area (4 Wells): 750 gpm

N

1000 0 1000
Feet

M:\LTS\111\0051\17\005\S07443\S0744300.mxd pawels 03/02/2011 10:45:19 AM

Figure A.3−4. Routine Groundwater Elevation Map, Fourth Quarter 2010 (October 11 through October 13, 2010)

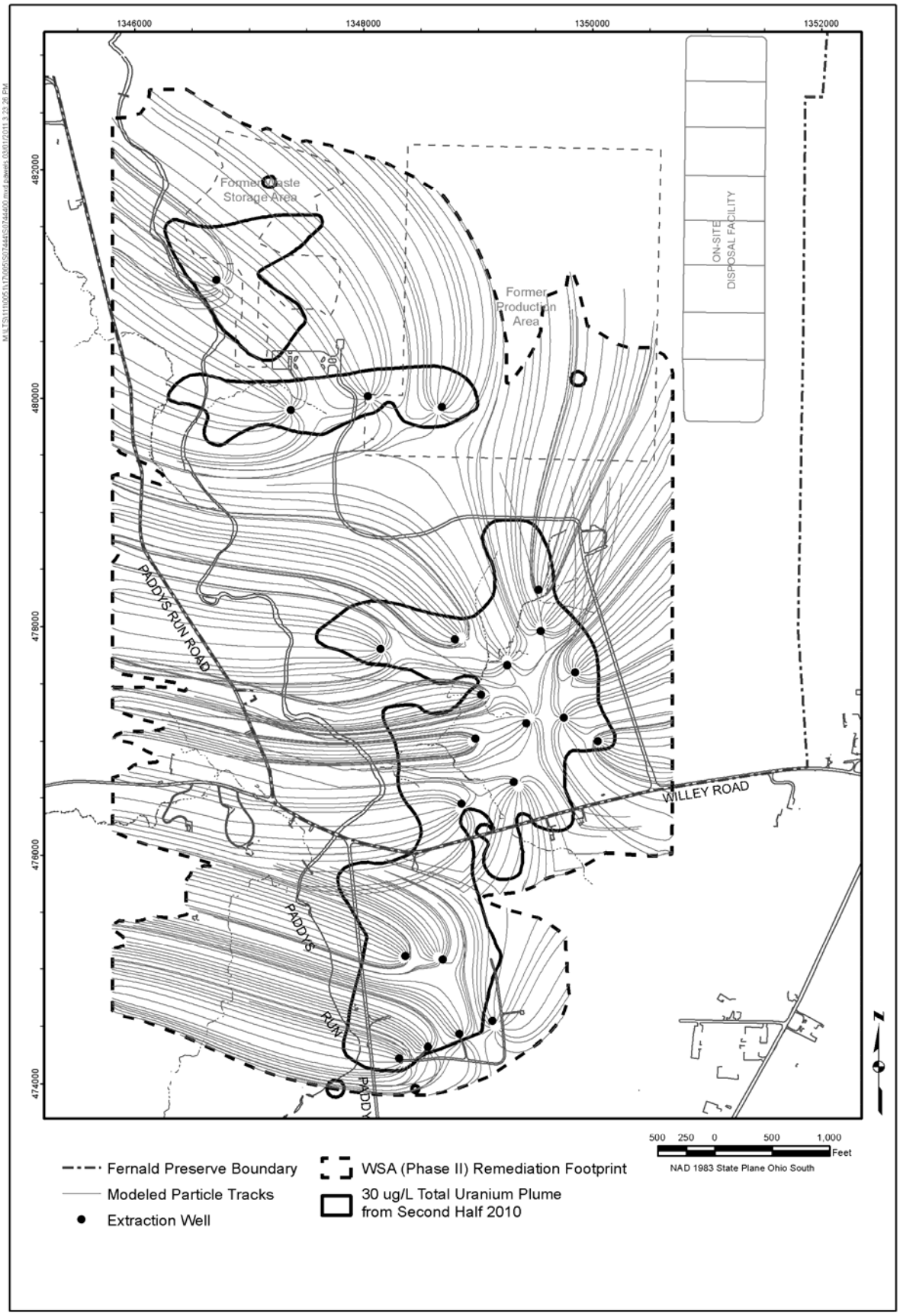


Figure A.3−5. WSA (Phase II) Design Remediation Footprint

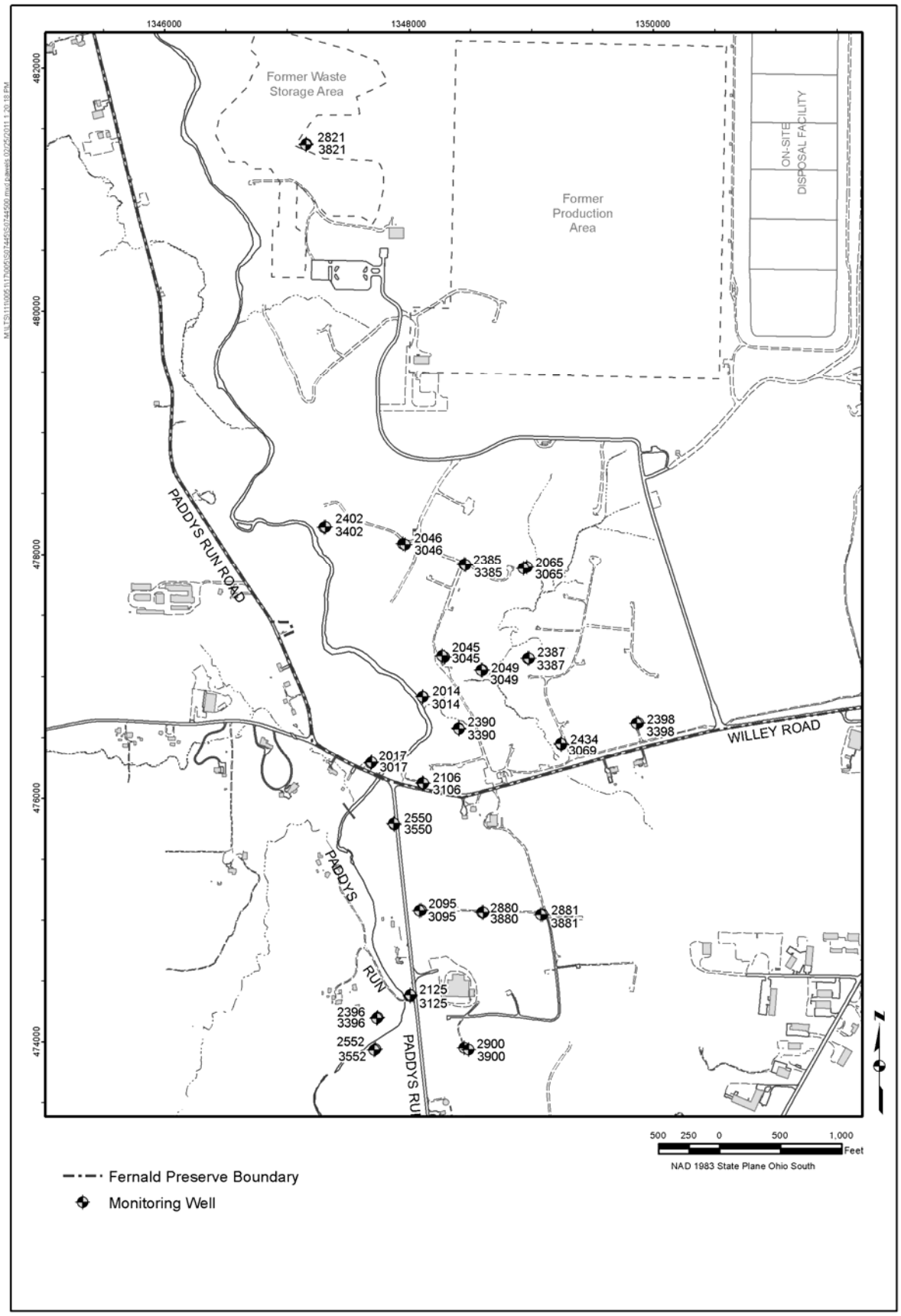


Figure A.3−6. Monitoring Well Locations for Well Cluster Hydrographs

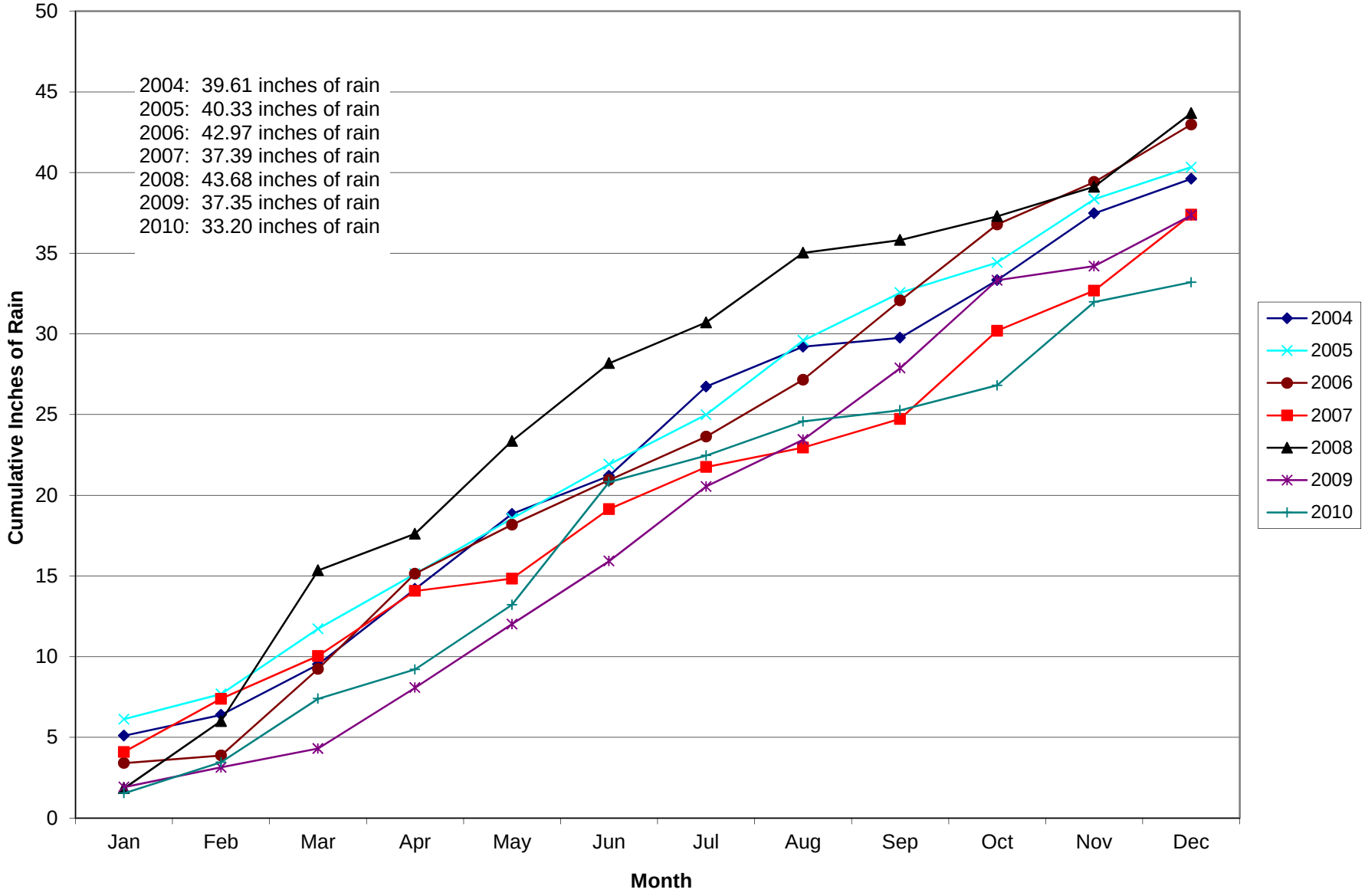


Figure A.3−7. Cumulative Annual Precipitation: 2004 through 2010 as Recorded at the Butler County Regional Airport

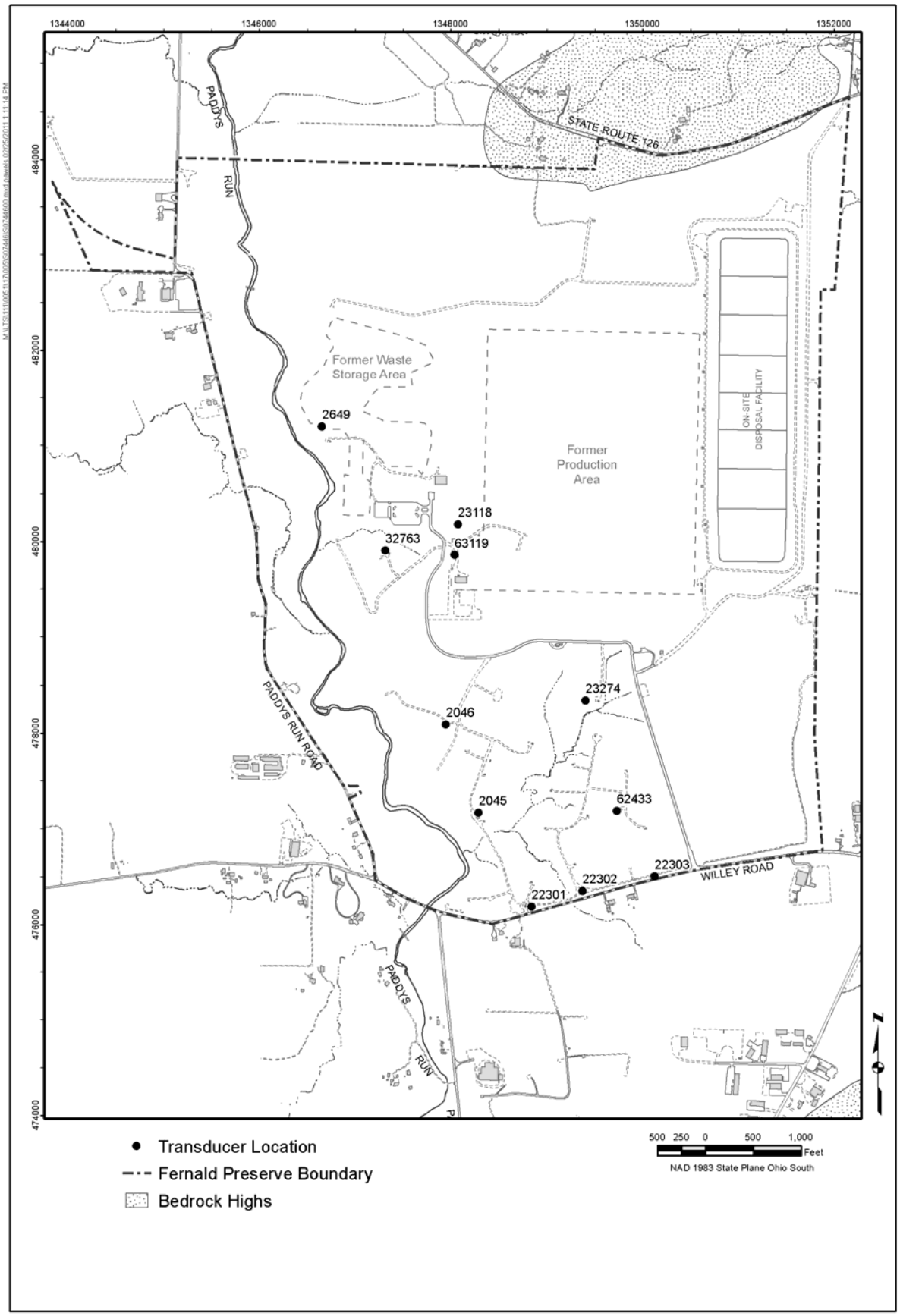


Figure A.3−8. Transducer Locations for the 2010 Operational Shutdown

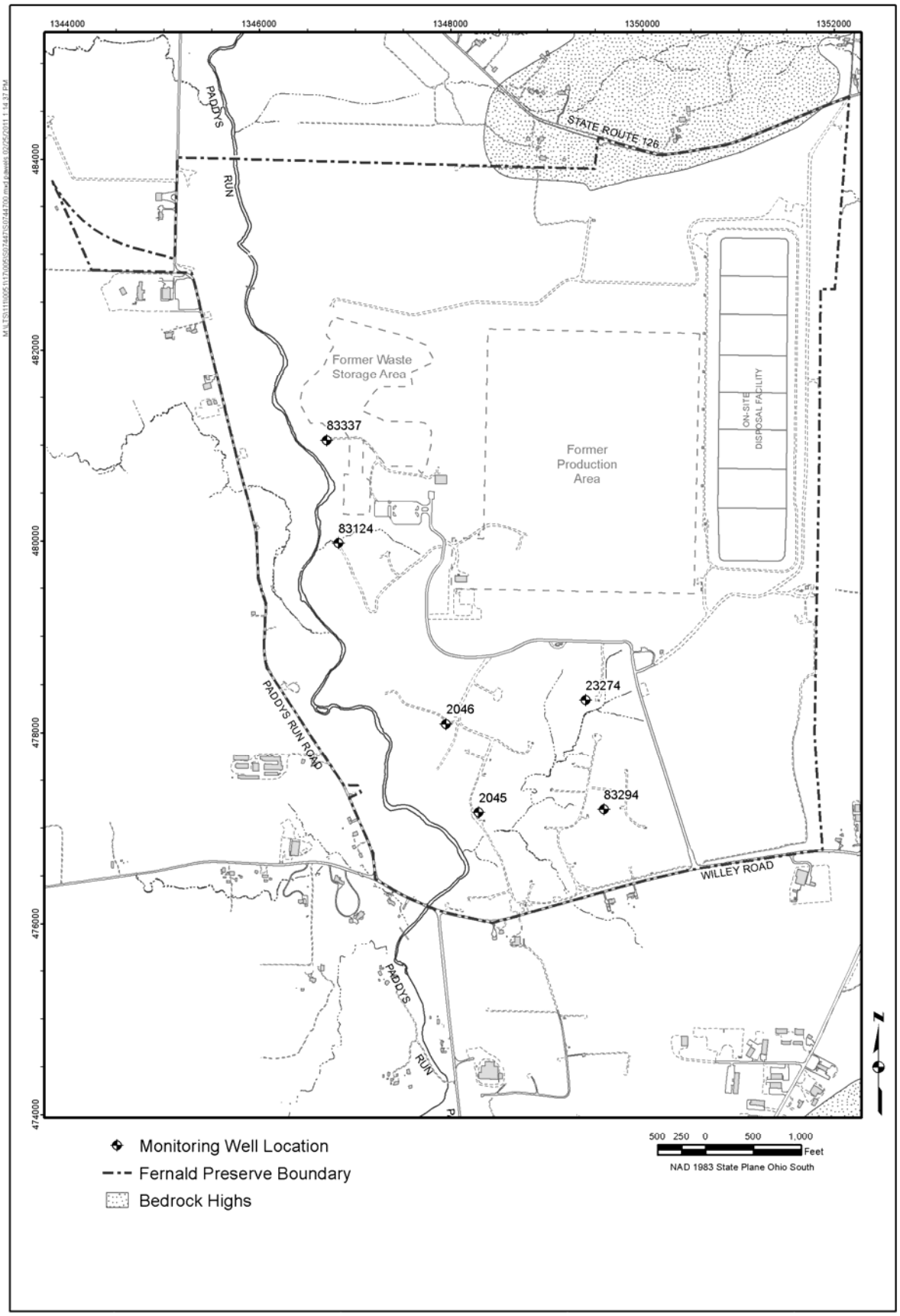


Figure A.3−9. Monitoring Well Locations for the 2010 Operational Shutdowns

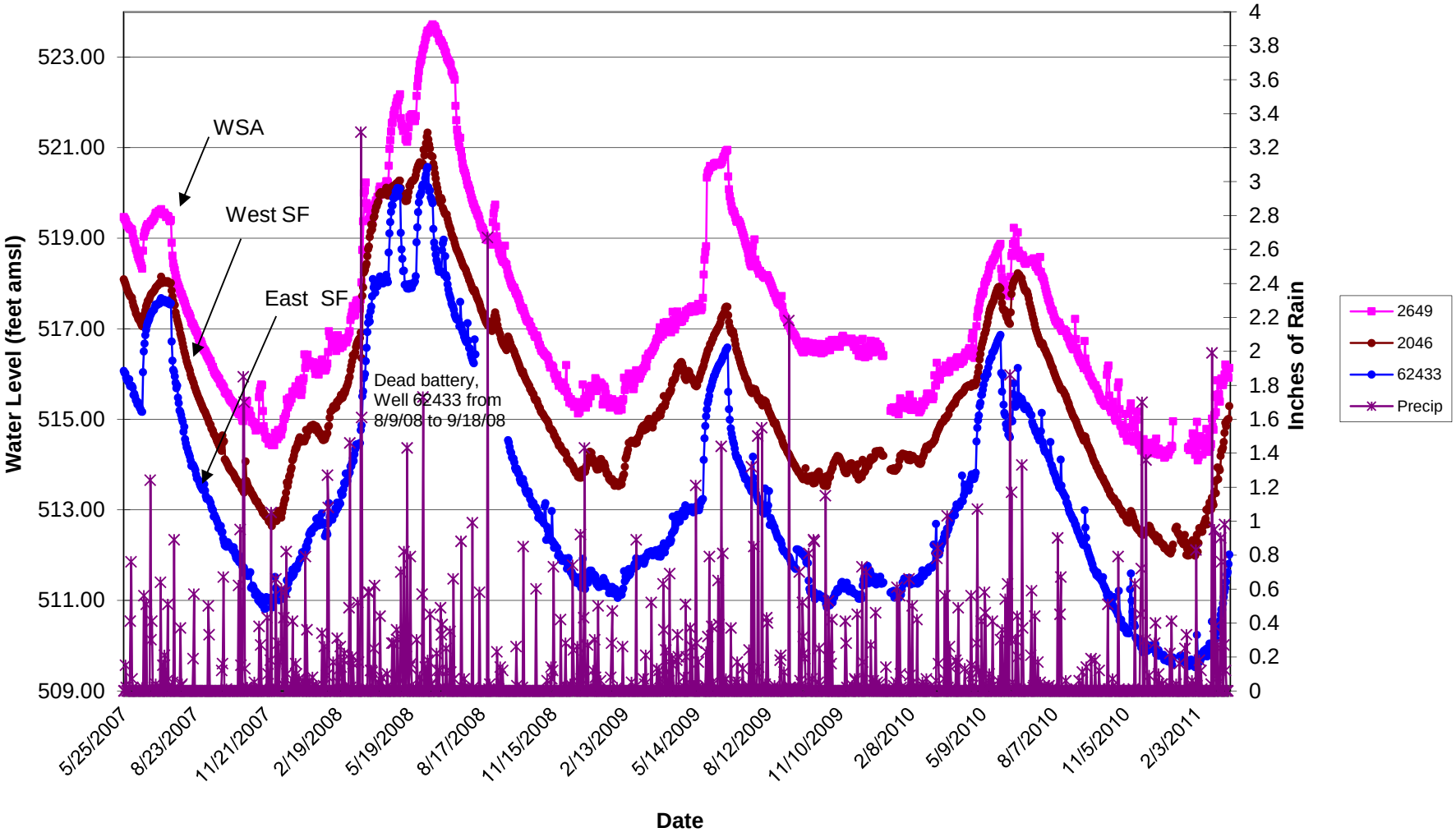


Figure A.3−10. Water Levels versus Precipitation May 25, 2007, through March 15, 2011

Attachment A.4

This page intentionally left blank

A.4.0 Non-Uranium FRL Results

This attachment evaluates non-uranium FRL results for 2010. The purpose of the evaluation is to:

- Identify 2010 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 2010

Table A.4−1 shows the summary statistics and trend analysis for the 2010 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, nine non-uranium FRL constituents had one or more FRL exceedances during 2010. Figure A.4−1 identifies the location of these FRL exceedances.

Figure A.4−1 shows that the non-uranium FRL exceedances in 2010 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 2010. The first column in Table A.4−2 lists the groundwater FRL constituents monitored in 2010. 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 2010; 9 had exceedances. The following table summarizes the 2010 non-uranium monitoring information:

Constituent	Monitoring Program	2010 Monitoring Summary
Antimony	Property/Plume Boundary for PRRS Constituents	Exceedance along the eastern site boundary, and in the PRRS area
Arsenic	Property/Plume Boundary for PRRS Constituents	Exceedance in PRRS area
Boron	South Field	No exceedances
Carbon Disulfide	Waste Storage Area	No exceedances
Fluoride	Property/Plume Boundary	No exceedances
Lead	Property/Plume Boundary	Exceedance along the eastern site boundary
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

A.4.2 Evaluation of 2010 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.

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

Seventeen (17) possible persistent FRL exceedances were identified in 2009 requiring additional data to be collected through routine monitoring in 2010. The exceedances were for antimony in wells 22198, 22199, 22204, 22205, 22208, 2431, 2432, 31217, 3424, 3431, and 3432, Manganese in wells 22201, 22217, and 3093, and zinc in monitoring wells 22210, 2625, and 2636. The non-uranium FRL exceedances for 2010 along with the possible persistent exceedances identified in 2009 are addressed below.

Figure A.4−1 and the shaded portion of Table A.4−1 identify the 2010 non-uranium FRL exceedances outside the Waste Storage Area (Phase II) design remediation footprint. In 2010, five constituents had one or more FRL exceedance at 7 wells located outside the Waste Storage Area (Phase II) design remediation footprint:

- Antimony at monitoring wells 22198 and 2636.
- Arsenic at monitoring well 2636.
- Lead at monitoring well 22198.
- Manganese at monitoring wells 22201, 22204, 22205, and 22217.
- Zinc at monitoring wells 22198, 22200, and 22204.

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 2010 listed in the bullets above, as well as those still being evaluated or deemed persistent from 2009. 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, FRL exceedances for manganese were identified as being persistent in 2010 at monitoring wells 22204 and 22217. In 2009, only manganese at monitoring well 22204 was identified as persistent.

The following is a summary of results presented in Table A.4−3:

- Additional data, to be collected through routine monitoring in 2011, are necessary to determine the persistence of the antimony exceedances at monitoring wells 2636 and 22198. All of the potential persistent exceedances for antimony identified in 2009 were identified as not persistent in 2010.
- Additional data, to be collected through routine monitoring in 2011, are necessary to determine the persistence of the arsenic exceedance at monitoring well 2636.
- Additional data, to be collected through routine monitoring in 2011, are necessary to determine the persistence of the lead exceedance at monitoring well 22198.

- The FRL exceedances recorded for manganese at monitoring wells 22204 and 22217 in 2010 are persistent. Figure A.4–7 shows that manganese FRL exceedances were persistent since 2004. The last sample collected at monitoring well 22204 in 2010 had a manganese concentration slightly below the FRL.
- Additional data, to be collected through routine monitoring in 2011, are necessary to determine the persistence of the manganese exceedances at monitoring wells 22201 and 22205. Note that monitoring well 22201 was sampled quarterly in 2010 for on-site disposal facility (OSDF) monitoring purposes.
- Additional data, to be collected through routine monitoring in 2011, are necessary to determine the persistence of the zinc exceedances at monitoring wells 2625, 2636, and 22198. Monitoring wells 2625 and 2636 were dry in the second half of 2010. Note that monitoring well 22200 was sampled quarterly in 2010 for OSDF monitoring purposes.

Figures A.4−2 through A.4−14 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.4–14.

The evaluation for persistence of non-uranium FRL exceedances in wells located outside the Waste Storage Area (Phase II) design remediation footprint in 2010 marks the fourteenth year that an evaluation has been conducted as part of the IEMP. In the past, many exceedances identified as persistent became nonpersistent in later years.

Prior to this year's report, persistent manganese exceedances outside the remediation footprint were isolated to monitoring well 22204. Unlike other persistent exceedances noted in past SERs that eventually went away, the manganese exceedance at monitoring well 22204 has been consistently identified as persistent since 2004, although the last sample collected in 2010 had a manganese concentration slightly below the groundwater FRL. This year, an additional persistent manganese exceedance was identified at monitoring well 22217.

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 2008 SER. 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 manganese exceedances at these two monitoring wells. The planned action is to continue monitoring to see if the exceedances continue.

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.
- Two persistent non-uranium FRL exceedances outside the Waste Storage Area (Phase II) design footprint were identified in 2010: manganese at monitoring wells 22204 and 22217. The exceedances are most likely a background definition issue. A change in the design of the aquifer remedy to address the exceedances is not being considered at this time. Additional monitoring will reveal if the exceedances continue.
- Additional data are needed to verify whether the 2 antimony, 1 arsenic, 1 lead, 1 manganese, and 3 zinc exceedances 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 2010 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]
Antimony (0.006 mg/L)	22198	35	2	1	0.000032	0.0334	0.00189	0.00567	No Significant Trend
	2636	6	4	1	0.0015	0.00741	0.00506	0.00278	Down, Significant
Arsenic (0.05 mg/L)	2636	23	8	1	0.0135	0.0887	0.0450	0.0196	No Significant Trend
Lead (0.015 mg/L)	22198	35	1	1	0.000007	0.026	0.00176	0.00477	**Up, Significant**
Manganese (0.90 mg/L)	22201	9	4	2	0.0322	2.06	0.87	0.82	No Significant Trend
	22204	23	20	5	0.418	3.01	1.29	0.50	No Significant Trend
	22205	23	2	1	0.184	1.10	0.64	0.21	Down, Significant
	22217	7	4	3	0.784	1.57	1.10	0.32	No Significant Trend
	3821	22	17	2	0.145	11.4	2.73	2.59	No Significant Trend
Molybdenum (0.10 mg/L)	2649	20	20	2	0.178	0.690	0.448	0.150	No Significant Trend
Nitrate + Nitrite as N (11 mg/L)[h]	2821	30	13	2	1.38	120	25.1	32.7	**Up, Significant**
	3821	30	7	2	0.01	171	16.9	38.8	**Up, Significant**
	83338_C1	6	1	1	0.404	42.4	9.3	16.3	**Up, Significant**
	83338_C2	9	4	2	1.98	109	28.9	35.9	**Up, Significant**
	83338_C3	9	5	2	2.42	105	37.0	38.0	**Up, Significant**
	83340_C1	5	5	1	30.6	58.2	44.9	10.5	No Significant Trend
	83340_C2	8	8	2	22.0	86.7	61.6	23.3	No Significant Trend
	83340_C3	8	8	2	23.4	133	73.0	40.3	Down, Significant

Table A.4–1 (continued). Summary Statistics and Trend Analysis for Non-Uranium Constituents with 2010 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)	22198	42	2	1	0.0005	0.0214	0.0041	0.0038	No Significant Trend
	22200	7	1	1	0.00525	0.0377	0.0164	0.0105	No Significant Trend
	22204	23	3	1	0.0010	0.0405	0.0113	0.0099	No Significant Trend
	22213	7	1	1	0.00165	0.0221	0.0079	0.0066	No Significant Trend
Technetium-99					(pCi/L)	(pCi/L)	(pCi/L)	(pCi/L)	
(94 pCi/L)	2649	28	28	2	101	1480	625	437	No Significant Trend
	2821	30	18	2	0.253	651	167	171	**Up, Significant**
	83338_C1	6	1	1	10.1	181	46	67	**Up, Significant**
	83338_C2	9	4	2	7.12	587	169	193	No Significant Trend
	83338_C3	9	5	2	0.059	313	131	125	**Up, Significant**
	83340_C1	5	5	1	186	817	364	263	No Significant Trend
					(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Trichloroethene (5.0 µg/L)	2821	22	7	2	0.125	11.5	3.6	4.2	**Up, Significant**

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 2010.
[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 2010.
[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 2010 Quarterly/Semiannually

Constituent	Well[a]	Aquifer Zone	Project[b]	1997	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010	
				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
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	
	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 2010 Quarterly/Semiannually

Constituent	Well[a]	Aquifer Zone	Project[b]	1997	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010	
				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
Lead																														
	22198	0	P/PB																										1	
	2431	0	PRRS						1																					
	3733	0	P/PB	1						1																				
Manganese																														
	2010	1	WSA							1		1			1	1	1	1		1	1	1	1	1	1	1		1		
	22198	0	OSDF											1																
	22201	0	OSDF																										1	1
	22204	0	OSDF												1			1	1	1	1	1	1	1	1	1	1	1	2	2
	22205	0	OSDF																	1										1
	22217	3	OSDF																								1		1	2
	2431	0	P/PB		2																									
	2432	0	P/PB							1		2	1		1															
	2648	1	WSA	1		1		1	1		1		1					1	1		1									
	2898	4	PRRS										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			
	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

Table A.4−2 (continued). Groundwater FRL Exceedances From 1997 Through 2010 Quarterly/Semiannually

Constituent	Well[a]	Aquifer Zone	Project[b]	1997	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010	
				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
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				
	2821	1	WSA					1							1				1		1	1	1	1	1	1	1	1	1	1
	3821	1	WSA							1		1								1				1			1	1	1	1
	83338_C1	1	WSA																										1	
	83338_C2	1	WSA																					1				1	1	1
	83338_C3	1	WSA																					1			1	1	1	1
	83340_C1	1	WSA																				1		1	1	1		1	
	83340_C2	1	WSA																				1	1	1	1	1	1	1	1
	83340_C3	1	WSA																				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
	2821	1	WSA					1						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	83338_C1	1	WSA																										1	
	83338_C2	1	WSA																					1				1	1	1
	83338_C3	1	WSA																					1			1	1	1	1
	83340_C1	1	WSA																				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		
Trichloroethene																														
	2649	1	WSA			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

Table A.4−2 (continued). Groundwater FRL Exceedances From 1997 Through 2010 Quarterly/Semiannually

Constituent	Well[a]	Aquifer Zone	Project[b]	1997	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010	
				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
Zinc																														
	22198	0	OSDF																										1	
	22199	0	OSDF												1															
	22200	0	OSDF																										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				
	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.

Note: 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.

[a]As defined in the IEMP all monitoring is semiannual (as of 2003). 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

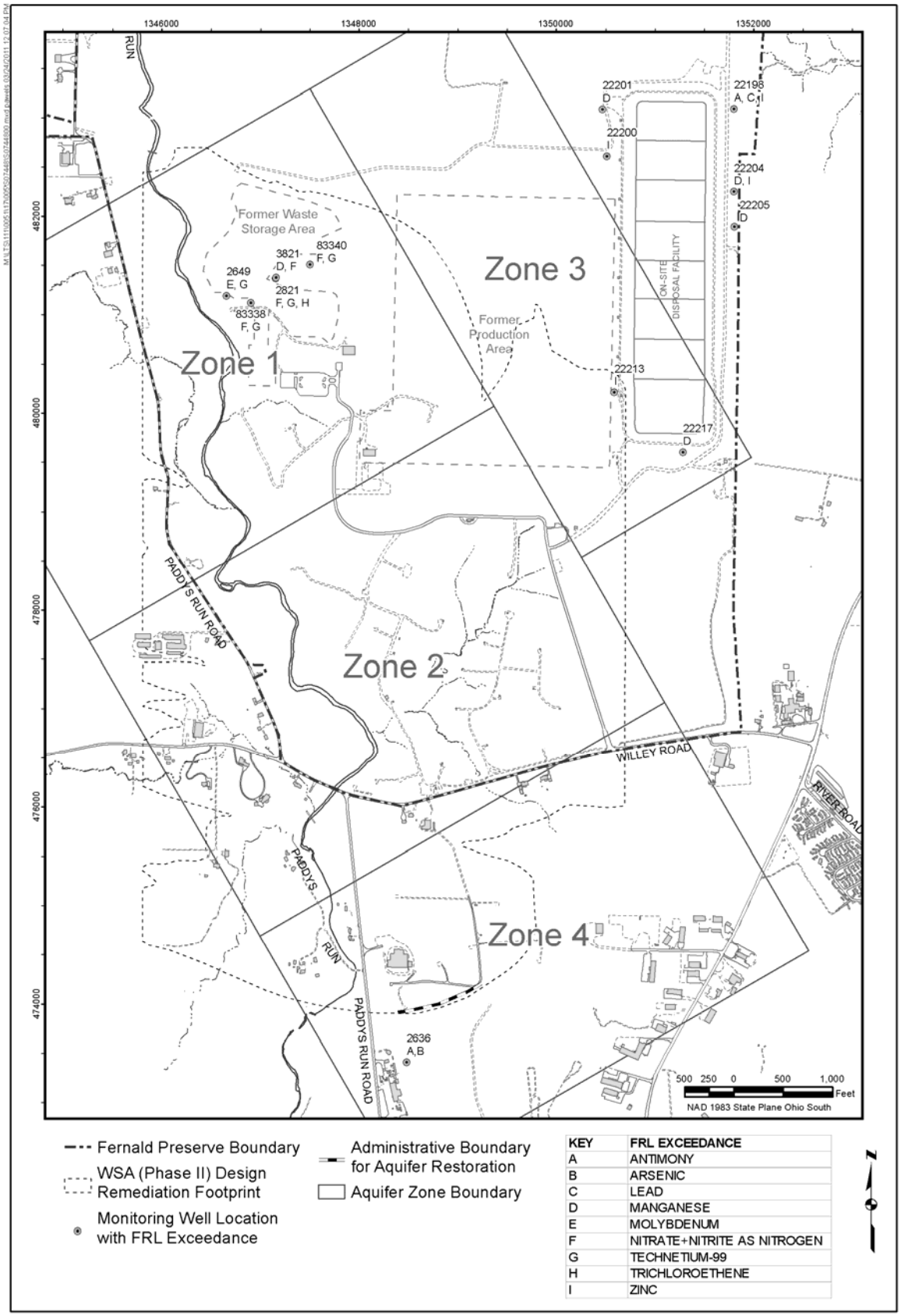
OSDF = Property/Plume Boundary for on-site disposal facility

[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 2009 Results[a]	2010 FRL Exceedance[a]		Evaluation Results for 2010	Figure Number[a]
			1st Half of 2010	2nd Half of 2010		
Antimony	22198	Additional Data Required	Yes	No	Additional Routine Data Required	A.4–2
	22199	Additional Data Required	No	No	Not Persistent	NA
	22204	Additional Data Required	No	No	Not Persistent	NA
	22205	Additional Data Required	No	No	Not Persistent	NA
	22208	Additional Data Required	No	No	Not Persistent	NA
	2431	Additional Data Required	No	No	Not Persistent	NA
	2432	Additional Data Required	No	No	Not Persistent	NA
	31217	Additional Data Required	No	No	Not Persistent	NA
	3424	Additional Data Required	No	No	Not Persistent	NA
	3431	Additional Data Required	No	No	Not Persistent	NA
	3432	Additional Data Required	No	No	Not Persistent	NA
	2636	NA	Yes	Dry	Additional Routine Data Required	A.4–3
Arsenic	2636	NA	Yes	Dry	Additional Routine Data Required	A.4–4
Lead	22198	NA	Yes	No	Additional Routine Data Required	A.4–5
Manganese	22201	Additional Data Required	Yes, No	No, Yes	Additional Routine Data Required	A.4–6
	22204	**Persistent**	Yes	Yes	**Persistent**	A.4–7
	22205	NA	No	Yes	Additional Routine Data Required	A.4–8
	22217	Additional Data Required	Yes	Yes	**Persistent**	A.4–9
	3093	Additional Data Required	No	No	Not Persistent	NA
Zinc	22210	Additional Data Required	No	No	Not Persistent	NA
	2625	Additional Data Required	No	Dry	Additional Routine Data Required	A.4–10
	2636	Additional Data Required	No	Dry	Additional Routine Data Required	A.4–11
	22198	NA	Yes	No	Additional Routine Data Required	A.4–12
	22200	NA	Yes, No	No, No	Not Persistent	A.4–13
	22204	NA	Yes	No	Additional Routine Data Required	A.4–14

[a] NA = not applicable



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

Figure A.4−1. Non-Uranium Constituents With 2010 Results Above FRLs

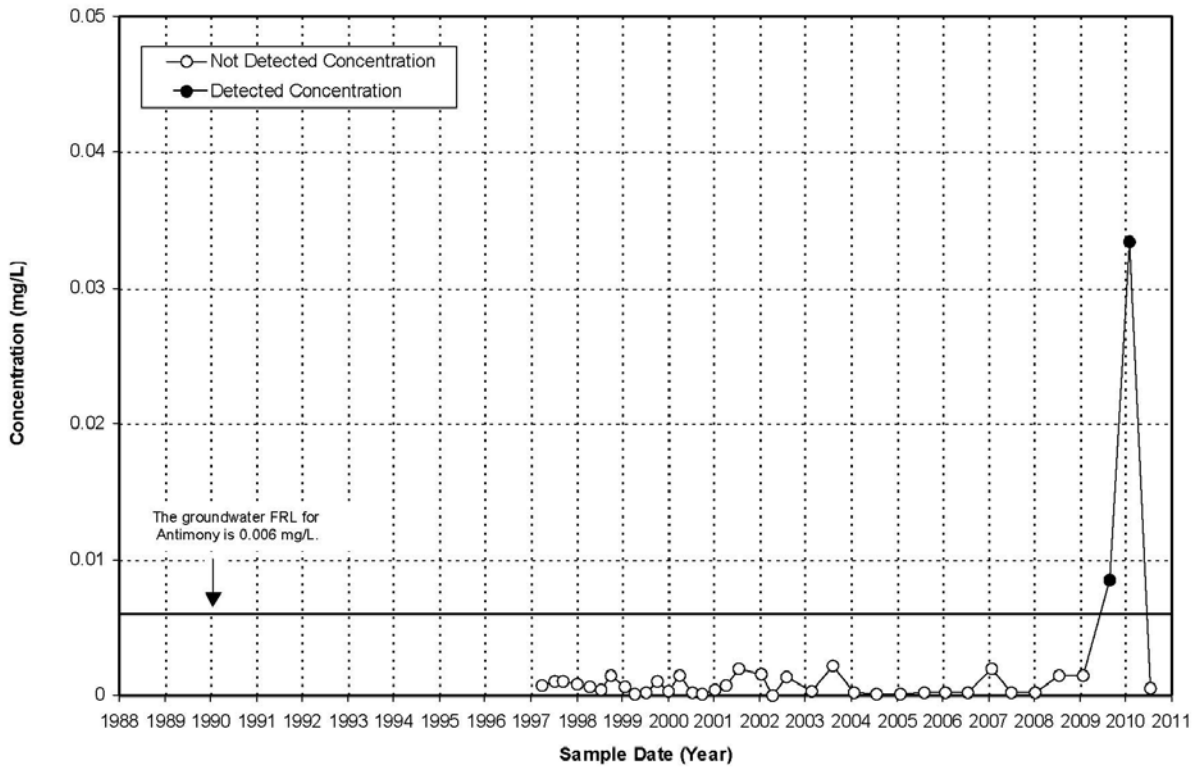


FIGURE A.4-2. ANTIMONY CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 22198

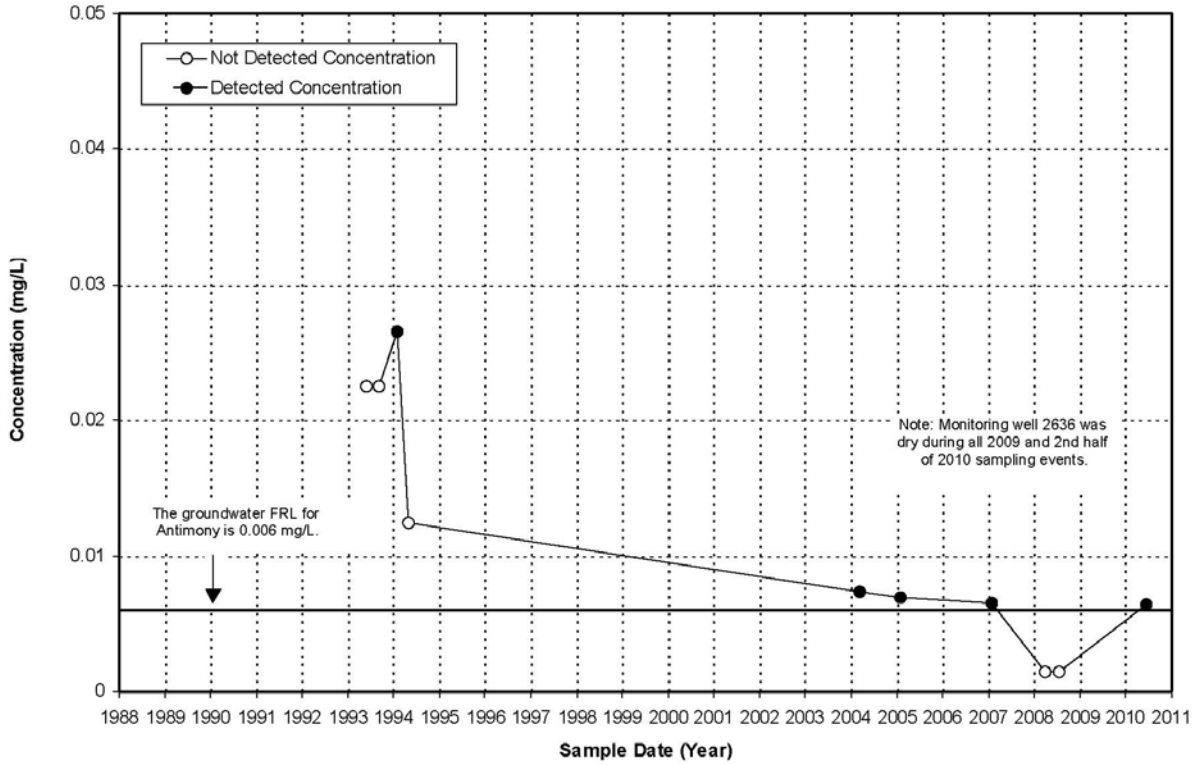


FIGURE A.4-3. ANTIMONY CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2636

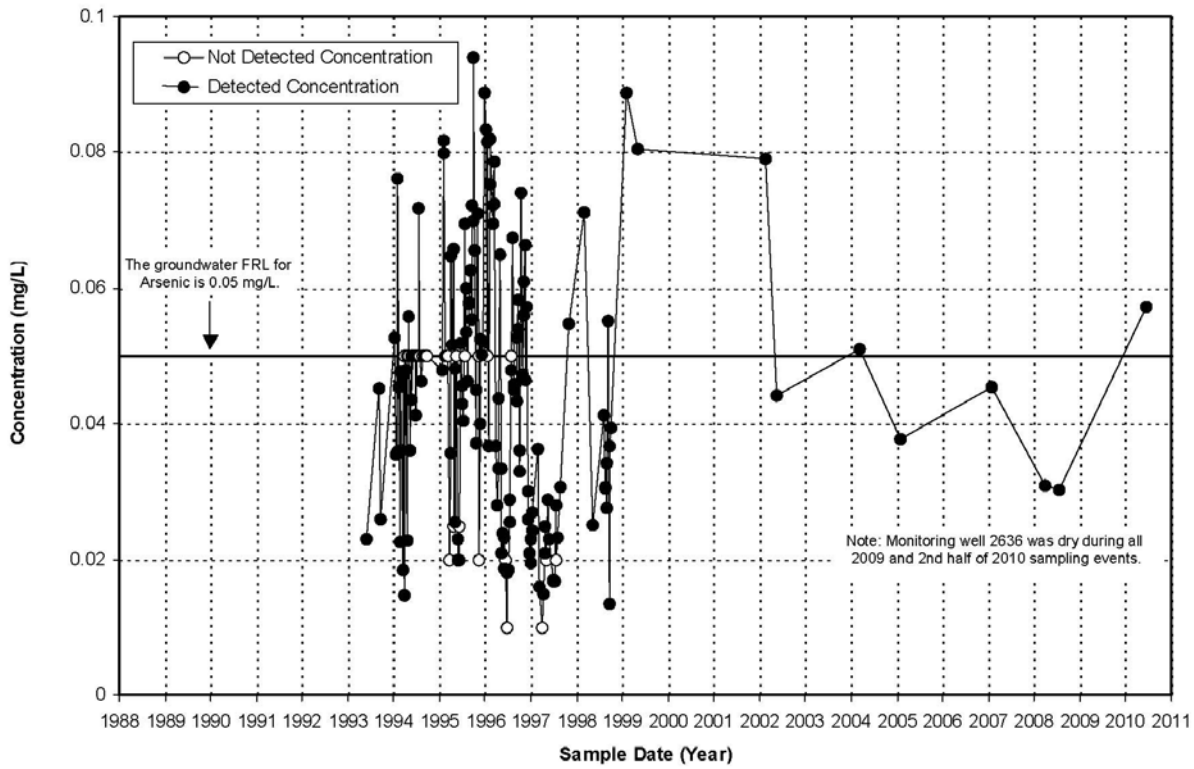


FIGURE A.4-4. ARSENIC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2636

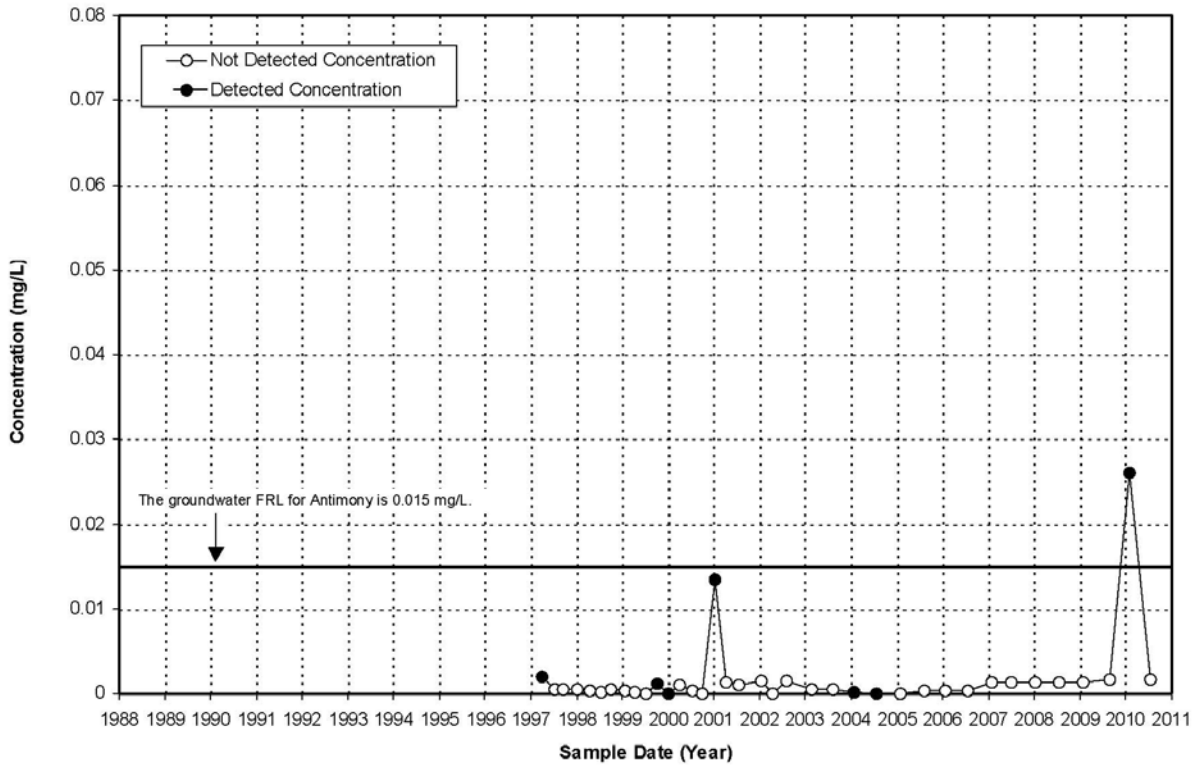


FIGURE A.4-5. LEAD CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 22198

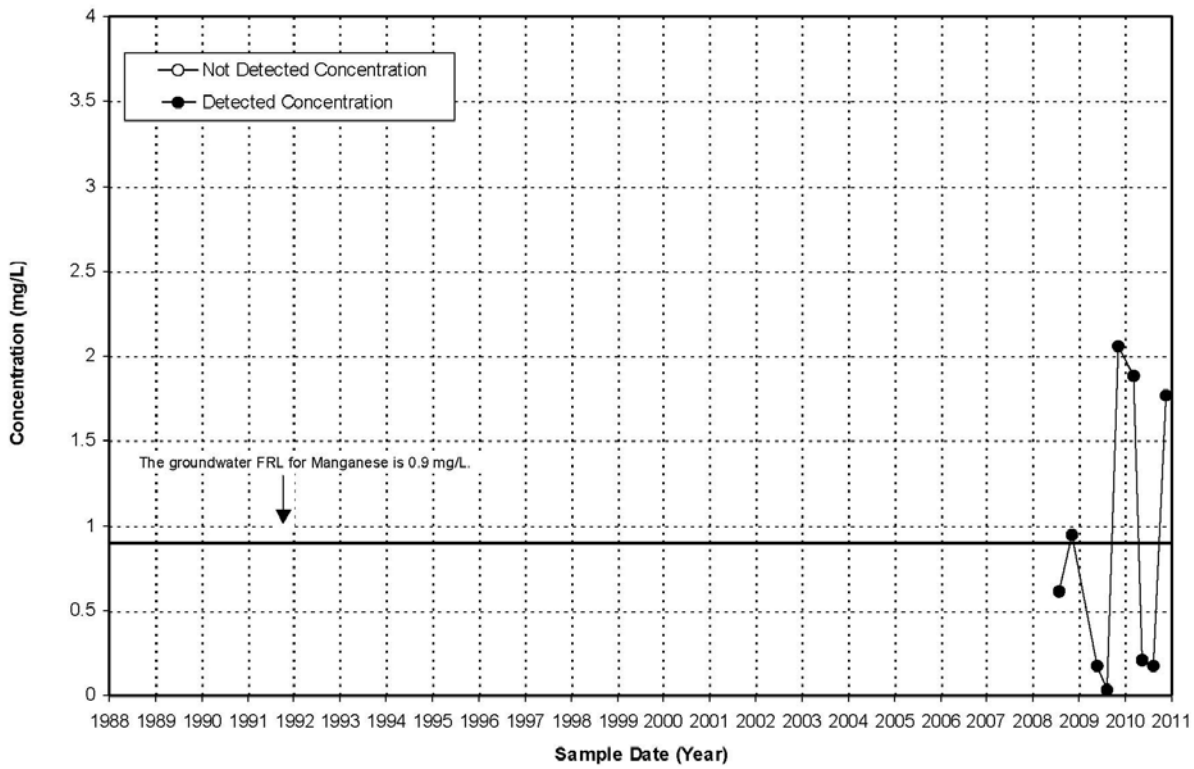


FIGURE A.4-6. MANGANESE CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 22201

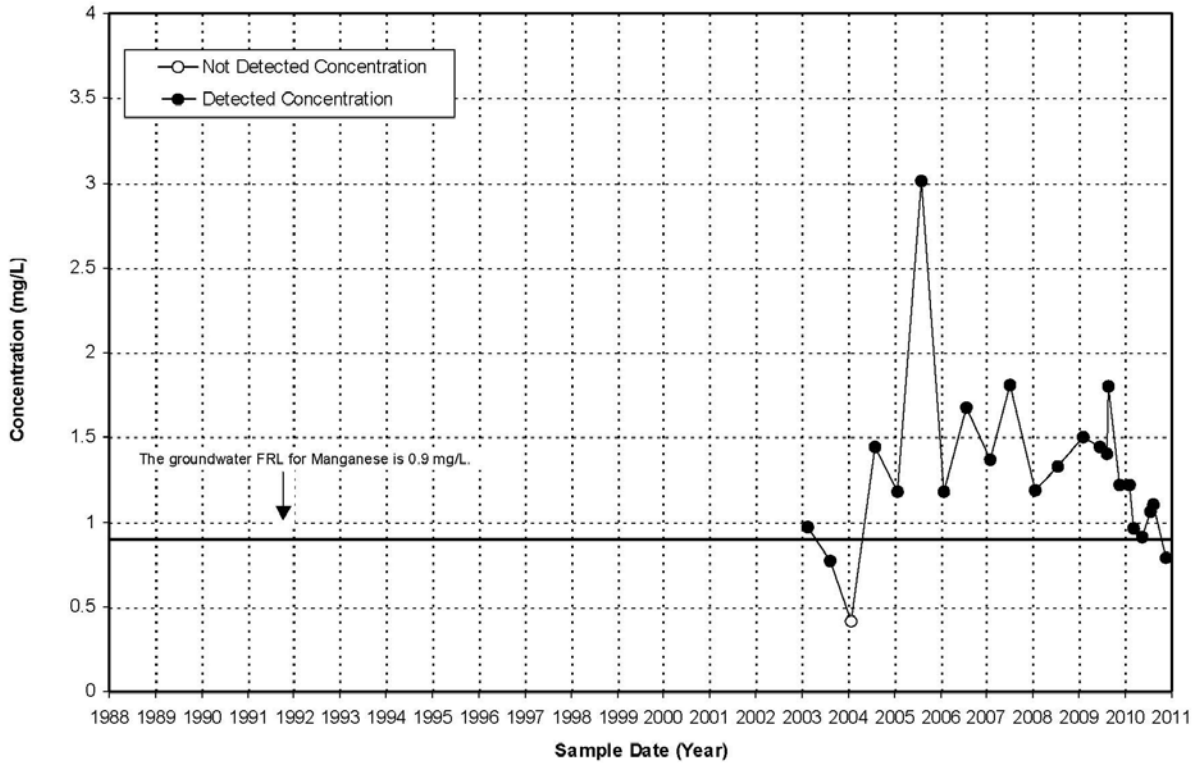


FIGURE A.4-7. MANGANESE CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 22204

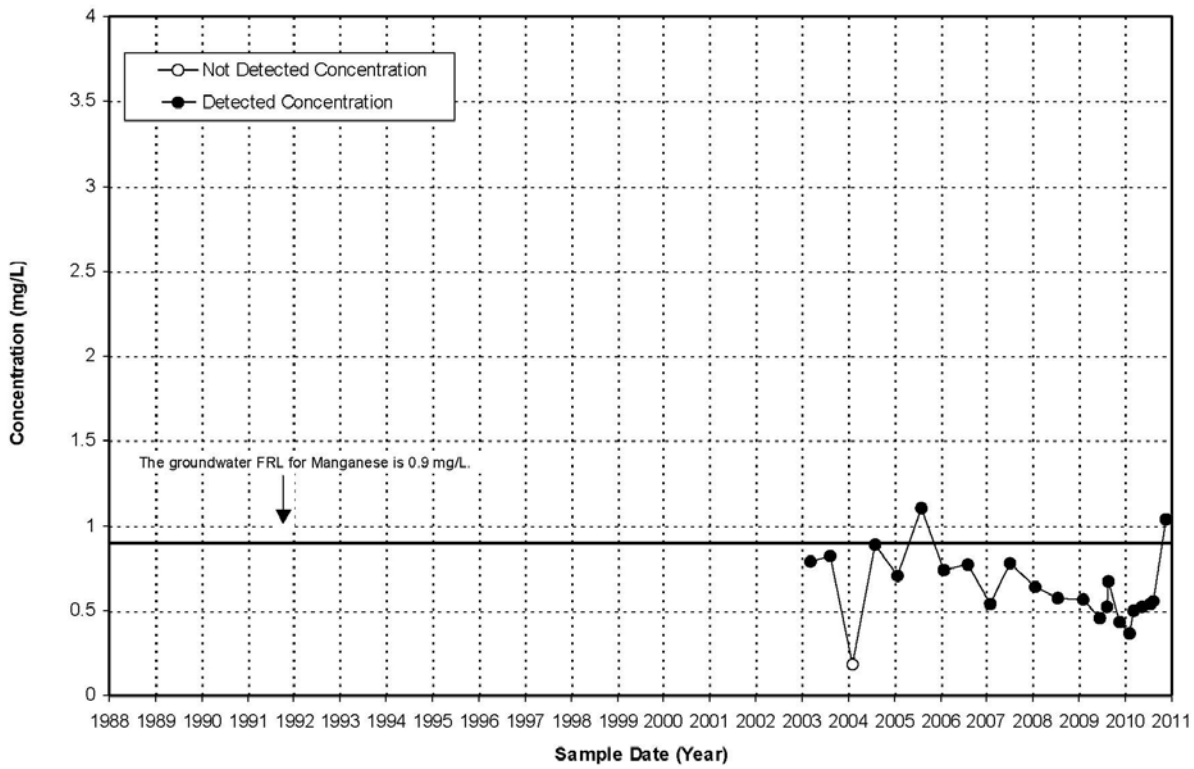


FIGURE A.4-8. MANGANESE CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 22205

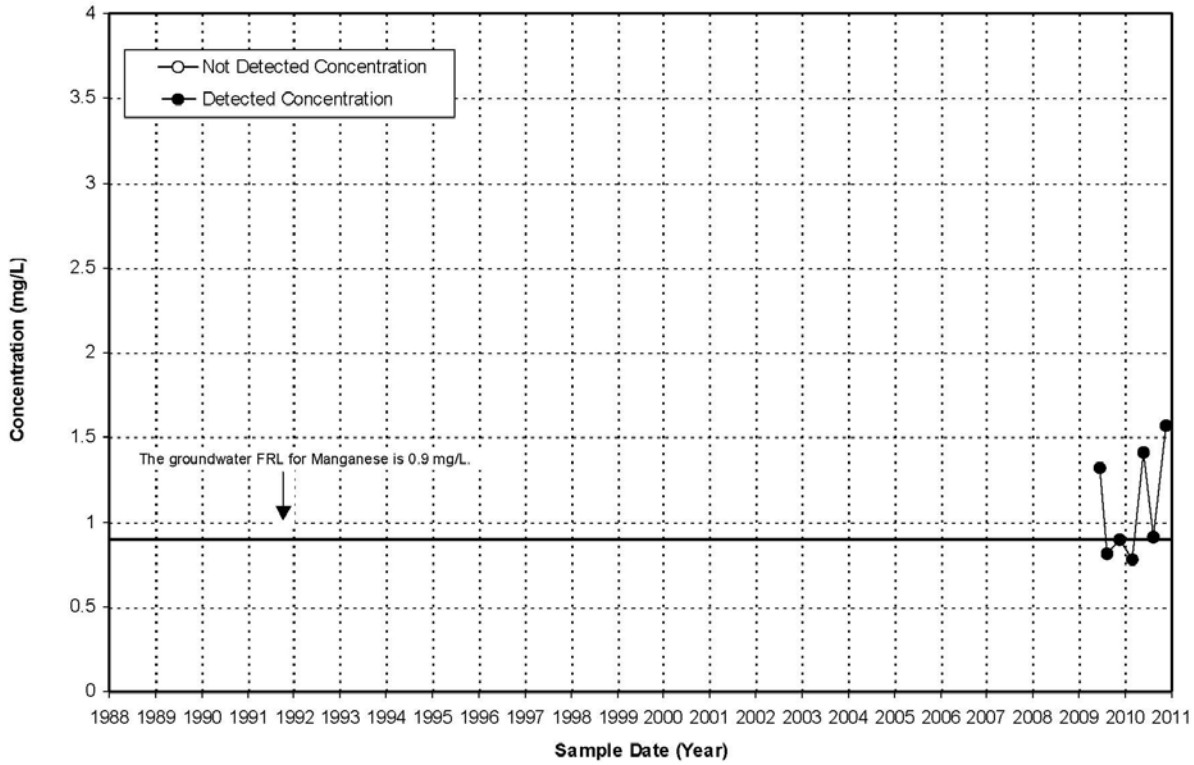


FIGURE A.4-9. MANGANESE CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 22217

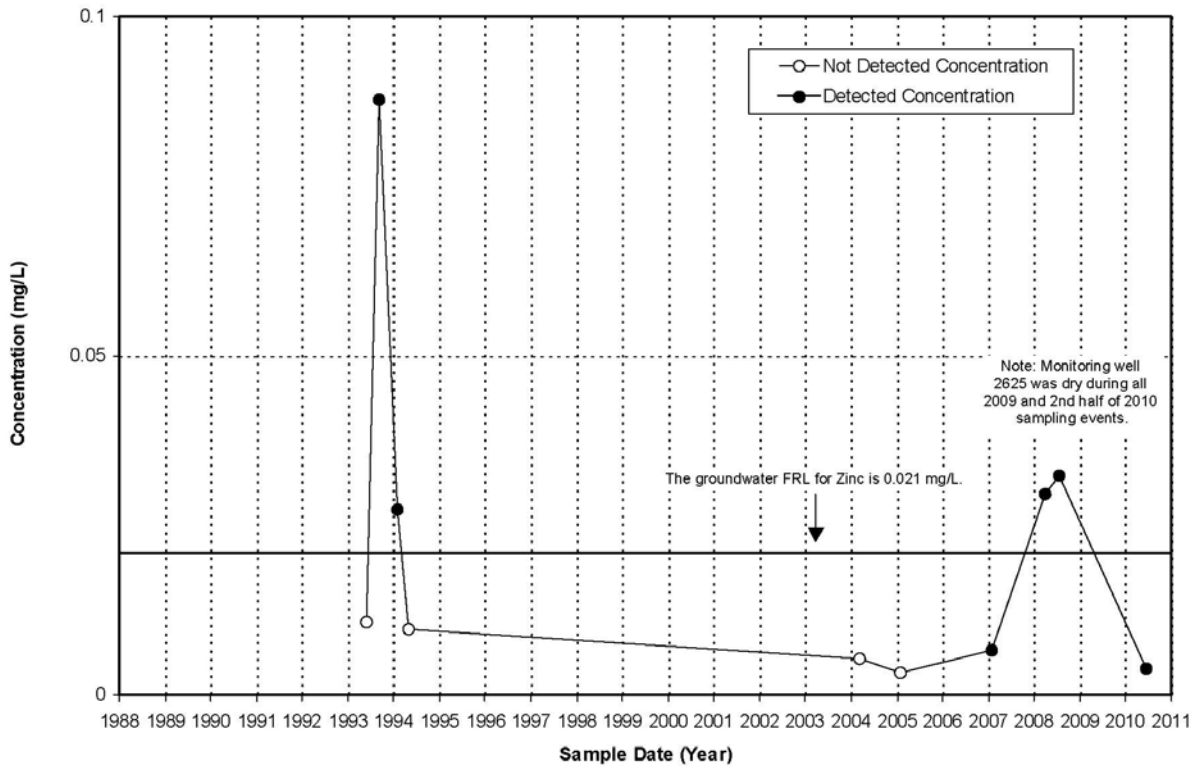


FIGURE A.4-10. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2625

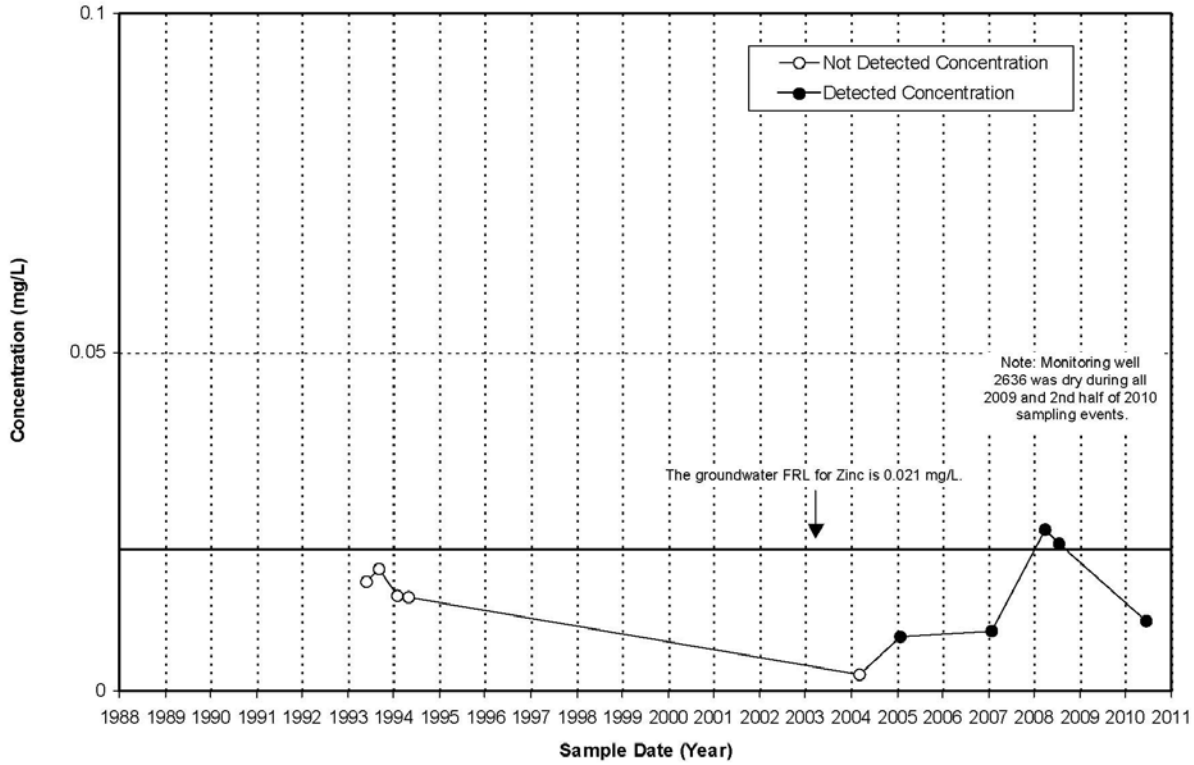


FIGURE A.4-11. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2636

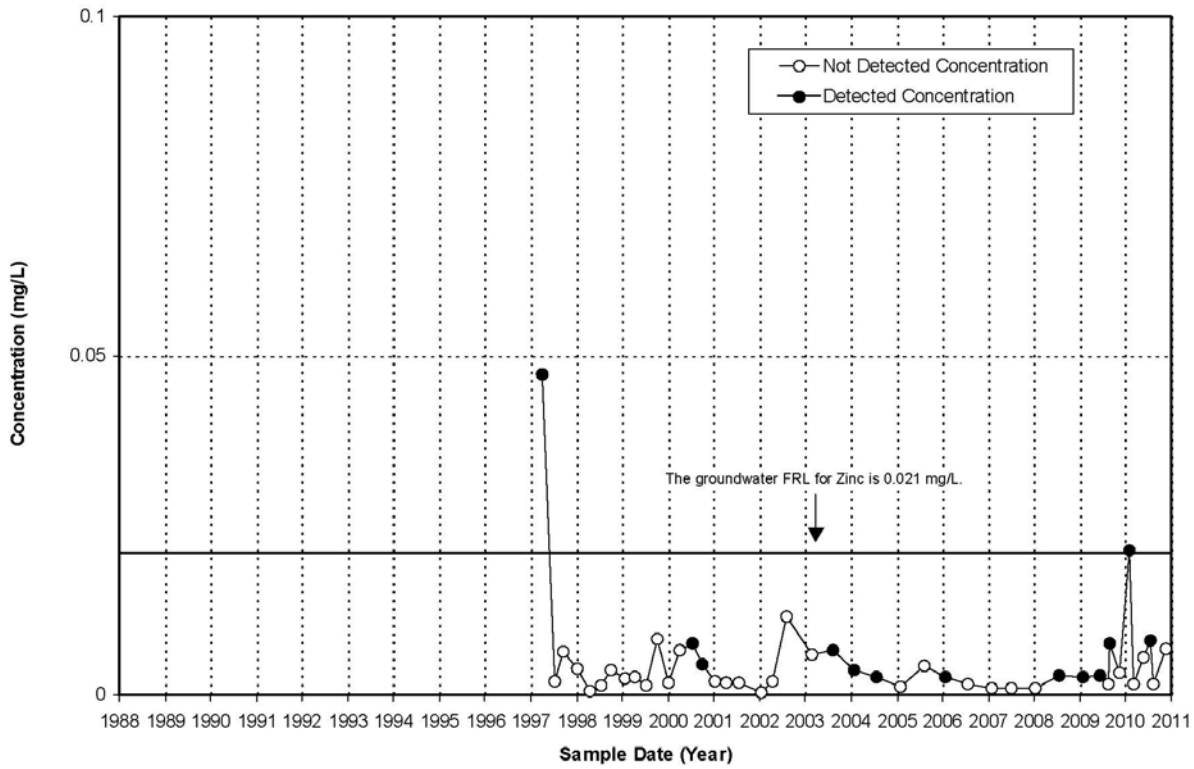


FIGURE A.4-12. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 22198

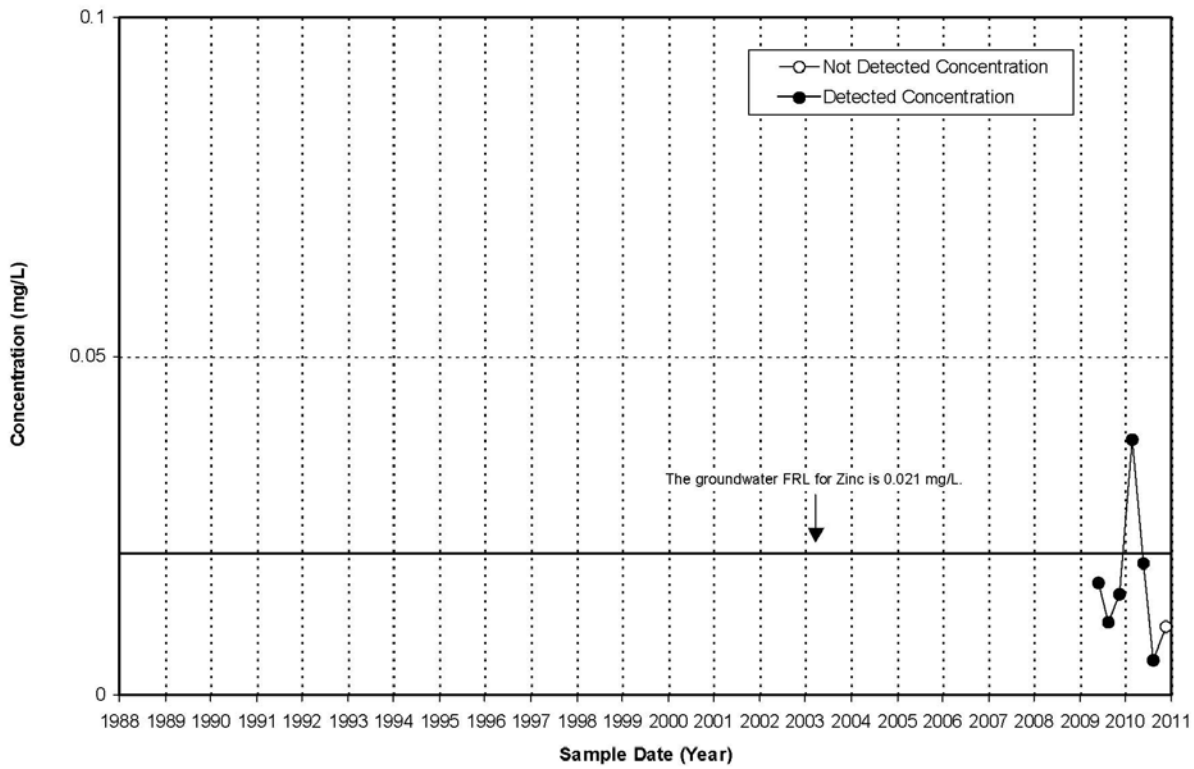


FIGURE A.4-13. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 22200

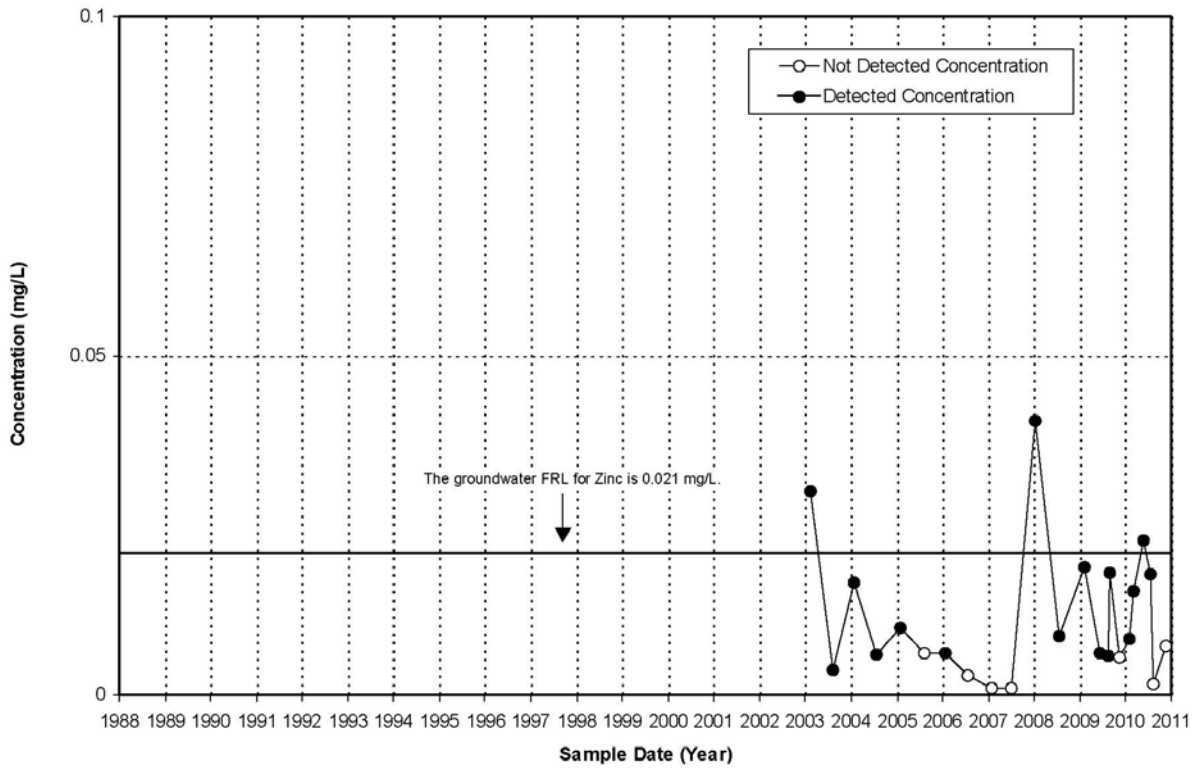


FIGURE A.4-14. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 22204

Attachment A.5

This page intentionally left blank

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 2010. 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 90 acres (36 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
- 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
- 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
- Residual soil contamination beneath the facility and its possible impact to HTW water quality results.

Information Organization

The 2010 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)
- Video Survey of LCS and LDS (Section A.5.4), and
- Summary of Overall Performance 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 2010, leachate volumes pumped from the LCS tanks were measured by recording readings from capacitance probes installed in each primary containment vessel and 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 LCS and LDS 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 2010. The data collected in 2010 indicate that 176,087 gallons of leachate were collected and pumped to the CAWWT Backwash Basin for subsequent treatment at the CAWWT. The total volume measured in 2010 represents a 14 percent decrease from the total volume measured in 2009 (204,937 gallons). The volume of precipitation that fell on the OSDF in 2010 was approximately 48.8 million gallons (33.2 inches of rain over 54.1 acres). The facility cap inhibits rainwater from permeating the OSDF. Collected leachate in 2010 represents approximately 0.4 percent of the precipitation that fell on the OSDF in 2010, 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 decline is decreasing. In 2010 the overall monthly facility leachate flow declined by 3,335 gallons or approximately 19.0 percent (17,147 gallons for January 2010 versus 13,812 gallons for December 2010).

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 2010 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)	Percent of Initial Response Leakage Rate
1	0.07	0.3
2	0.00	0.0
3	0.00	0.0
4	0.12	0.6
5	0.20	1.0
6	0.21	1.0
7	0.07	0.4
8	0.10	0.5

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
- Water from groundwater infiltration.

Quarterly apparent liner efficiencies were consistently greater than 98.66 percent for Cells 1 through 8 throughout 2010. Quarterly apparent liner efficiencies (in percentages) are provided for Cells 1 through 8 below.

Apparent Liner Efficiency (%), Quarterly for 2010

Quarter	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
First	99.96	100	100	99.47	98.91	99.43	99.51	98.88
Second	99.98	99.98	99.97	99.50	98.80	99.41	99.52	99.33
Third	99.98	100	100	99.54	98.66	99.48	99.82	99.37
Fourth	99.78	100	100	99.40	99.31	98.62	99.98	99.92

A.5.1.4 HTW Water Yields

HTW water yields are monitored at each cell to document trends in perched-water purge volumes. In 2010 the HTWs were purged four times (February, May, August, and December). Average purge water yields from the HTWs ranged from 0 gallons beneath Cell 8 to 1,081 gallons beneath Cell 5. The Cell 3 HTW water yield, which had been trending upward from 2001 through 2005, showed a fifth-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 Cell 6 based on annual LCS samples (Section A.5.2.5)
- Bivariate plots (uranium-sodium) 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 15 parameters monitored quarterly in the LCS, LDS, HTW, and GMA wells of each cell 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. A summary of data reported on the Tables A.5.1−2 to A.5.8−2 is provided in Table A.5−2. 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 10/30/1997 through 12/8/1997 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 15 parameters monitored quarterly in the LCS, LDS, and HTW of each cell 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 15 parameters monitored quarterly in the HTW and GMA wells of each cell. The plots are also constructed with a common *y*-scale based on the parameter.

A.5.2.3 Control Charts

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.

Eight samples are recommended for use in ChemStat® to define the baseline. For each control chart, (k) was defined as 1, the CUSUM control limit (h) was defined as 5, and the Shewart control limit (SCL) was defined as 4.5. An out-of-control condition is present if the CUSUM is greater than 5 or the standardized mean is greater than 4.5.

Fifty-nine Shewart-CUSUM control charts are presented in Sub-attachments A.5.1 through A.5.8 for those parameters monitored quarterly in the HTW and GMA wells that meet control chart criteria (i.e., eight samples, normal or lognormal distribution, no trend, and no serial correlation).

The Shewart-CUSUM test procedure found on ChemStat®, Version 6.3 was used to prepare the control charts. The control chart feature in ChemStat® uses the first eight samples of the data set for the baseline mean; therefore, control charts were only produced for data sets that had a minimum of eight samples.

The advantage of the Shewhart control chart over the CUSUM control chart is its immediate sensitivity to large releases. The advantage of the CUSUM control chart over the Shewhart control chart is its sensitivity to small gradual changes. A combined Shewart-CUSUM control chart combines the two approaches, so both immediate and gradual releases are rapidly detected.

A.5.2.4 Annual LCS Monitoring Results

Once each year, the LCS of each cell is sampled for Appendix I parameters and polychlorinated biphenols (PCBs). 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 reported last year, in 2009, four Appendix I and PCB parameters were detected for the first time in the LCS of Cells 3, 4, 5, 6, 7, and 8 as follows:

- Ammonia in Cell 3 and 8
- Acetone in Cells 4, 5, 6, 7, and 8
- 1,1-Dichloroethene in Cells 5, 7, and 8
- Toluene in Cell 6

The following parameters that were detected in 2009 were detected again in 2010:

- Ammonia in Cell 3
- 1,1-Dichloroethene in Cells 7 and 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." Therefore,

ammonia will be monitored for in the LDS of Cell 3 and 1,1-dichloroethene will be monitored for in the LDS of Cells 7 and 8 during the next scheduled sampling event.

In 2010, two Appendix I parameters were detected for the first time in the LCS of Cells 4 and 6 as follows:

- Lead in Cell 4
- Chromium in Cell 6

Detection of lead again in the LCS of Cell 4 or chromium in LCS of Cell 6 in 2011 will trigger monitoring for these two parameters in the applicable cell's LDS during the next scheduled sampling event.

A.5.2.5 Parameter Selection for Cell 6 based on Annual LCS Samples

A parameter selection process established in consultation with the OEPA in 2005 and 2006 is used to identify the Appendix I and PCB parameters detected in the LCS that will provide the most promise for detecting a leak from the facility and therefore warrant more frequent and robust monitoring. The process is presented in Figures A.5−5A and A.5−5B.

The parameter selection process was revised in 2010 by replacing the 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 2007 SER (DOE 2008). In the 2007 SER, 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 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 2009 SER (DOE 2010b). Eight new parameters were identified for quarterly monitoring in the LCS, LDS, HTW, and GMA wells of each cell beginning in 2011. These eight new parameters are alkalinity, chloride, nitrate/nitrite, barium, calcium, copper, magnesium, and potassium. Vanadium was also identified for quarterly sampling in the LCS, LDS, HTW, and GMA wells of Cell 5.

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. The data set for Cell 6 reached a minimum size of eight samples in 2010, and parameter selection results for Cell 6 are presented in Sub-attachment A.5.6. The data sets for Cells 7 and 8 will reach a minimum of eight samples in 2011. Once the parameter selection process has been completed for all eight cells, DOE plans on conducting a final comprehensive look at all cells to determine if the list of parameters can be further optimized.

As shown in Figure A.5–5B, statistical procedures were used to determine if the mean concentration of the Cell 6 LCS data set was statistically different from the mean concentration

of either the pre-design or background data set. The figure also establishes that the statistical method selection 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.

The Wilcoxon Rank Sum Test and Quantile Test are used in conjunction in that if either 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.

Specific details concerning the assessment for Cell 6 are provided in Table A.5.6−4 (contained in Sub-attachment A.5.6). Nine parameters were evaluated and the final evaluation is presented in the table below.

Parameter	Statistical Difference Detected
Alkalinity	YES
Ammonia	NO
Chloride	YES
Nitrate/nitrite	NO
Barium	YES
Calcium	YES
Copper	NO
Magnesium	YES
Potassium	YES

More 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.

Based on the results of the selection process shown in Table A.5.6−4, six of the nine parameters failed the null hypothesis and should be sampled quarterly in the LCS, LDS, HTW, and GMA wells of Cell 6. The six parameters are alkalinity, chloride, barium, calcium, magnesium, and potassium. Ammonia, nitrate/nitrite, and copper did not fail the null hypothesis.

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. These six parameters selected for quarterly monitoring from the Cell 6 parameter selection process described above, are already being sampled quarterly in all cells. Of the three parameters that did not fail the null hypothesis for Cell 6 (i.e., the mean LCS concentration for ammonia, nitrate/nitrite and copper was not statistically greater than the mean pre-design or background concentration), nitrate/nitrite and copper are already being sampled quarterly in all eight cells. Ammonia is not being sampled quarterly in any cell, because it has passed the null hypothesis in all cells to date (Cells 1 through 5, as well as the current Cell 6). After parameters have been selected for Cells 7 and 8 at the end of 2011, DOE plans to perform a comprehensive evaluation of the entire process to optimize the parameters.

Table A.5−3 provides an overview of the parameters that have been selected for quarterly sampling in the LCS, LDS, HTW, and GMA wells of each cell based on the evaluation for Cells 1 through 6. Also identified in the table are those parameters that were detected in 2010, but are not being sampled quarterly, and those parameters that were not detected in 2010, 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 2010 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 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. Additional parameters may be added to the quarterly monitoring activity pending the parameter selection process that will be conducted for Cells 7 and 8 at the end of 2011.

In regard to the 2010 data, several of the quarterly parameters were not detected in all of the cells in 2010. Also, technetium-99 was not detected in Cell 8 and vanadium was not detected in Cell 5.

A.5.2.6 Bivariate Plots (Uranium-Sodium) 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 OEPA comment on the 2009 SER (OEPA Comment Number 35) the closest points between monitoring horizons are dated.

A.5.2.7 Increasing Concentration Trends in the GMA Wells

Separate and distinct chemical signatures for uranium and sodium in the LCS, LDS, and HTW of all 8 cells, indicate that water is not mixing between the horizons. Therefore, concentration increases in the HTW and GMA wells are being attributed to fluctuating ambient concentrations beneath the cell, and not to cell performance.

As presented in subsections A.5.1 through A.5.8, several parameter concentrations are increasing in the GMA beneath specific cells. The average concentration in the LDS of a cell needs to be much larger than the average concentration in the GMA beneath the cell in order for a potential leak from the cell to be considered a possible cause for the increasing concentration trend in the GMA beneath the cell.

Additional evidence to support that several of the increasing concentrations in the GMA could not be related to cell performance was identified in 2010 by comparing the average concentration in the LDS of a cell to the average concentration in the GMA wells beneath the cell. The comparison shows that the average concentrations of manganese and arsenic are higher in some of the GMA wells than they are in the corresponding LDS of the same cell. Specifically:

- The average manganese concentration in the GMA beneath Cells 1, 3, 7, and 8 is higher than the average concentration in the LDS of those cells.
- The average arsenic concentration in the GMA beneath Cells 2, 4, 5, 6, 7, and 8 is higher than the average concentration in the LDS of those cells.

A.5.3 Cell Cap Inspections

OSDF cell cap inspections are conducted quarterly. The inspection team typically includes representatives from OEPA, 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 2010, inspections were conducted in March, June, September, and December. In 2010, there were no visual signs that the integrity of the cap had been compromised in any way.

A.5.4 Video Survey of LCS and LDS

The inner carrier pipes of both the LCS and LDS were video surveyed in September 2010. The survey revealed areas of standing leachate within the pipes, as well as areas of accumulated gravel. It was determined that the areas of standing leachate do not affect the operation of the leachate management system (Geosyntec 2011). Cleaning of the gravel from the pipes is planned for 2011.

A.5.5 Monitoring Changes

Beginning in the second quarter of 2011, DOE plans on implementing the following monitoring changes:

- For one year, tritium will be added to the quarterly sampling list for all four horizons of all eight cells.
- The quarterly sampling list for the HTW of each cell will only include tritium, uranium, arsenic, and sodium.

These changes stem from an informal proposal made to LM by OEPA in February 2011 via e-mail.

A.5.6 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 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 therefore

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 2010 was 14 percent less than in 2009 (approximately 176,087 gallons compared to 205,000 gallons).
- The largest LDS maximum accumulation rate recorded in 2010 was 0.21 gpad in Cell 6; approximately 1 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 98.6.6 percent for Cells 1 through 8 throughout 2010.
- Fifty-nine Shewart-CUSUM control charts were prepared in 2010. All but six Shewart-CUSUM control charts exhibit "in control" conditions. The "out of control" charts are:
  - Zinc in the GMA-D well of Cell 4
  - Arsenic, cobalt, and manganese in the HTW of Cell 5
  - Nickel in the HTW of Cell 7
  - TOC in the HTW of Cell 8

  Additional discussion on the "out of control" charts is provided in the respective sub-attachment.
- Two Appendix I parameters were identified for the first time at LCS monitoring locations.
  - Lead in Cell 4
  - Chromium in Cell 6
- The agreed-upon parameter selection process was applied to the LCS data set from Cell 6. Out of the nine parameters that were evaluated, six failed the null hypothesis and were identified for quarterly monitoring in the LCS, LDS, HTW, and GMA Wells (alkalinity, chloride, barium, calcium, magnesium, and potassium). As of January 1, 2011, all six of the identified parameters were already being sampled quarterly in the LCS, LDS, HTW, and GMA wells of all eight cells based on the outcome of parameter selections completed for Cells 1 through 5.
- In 2010, 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 distriburtion	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

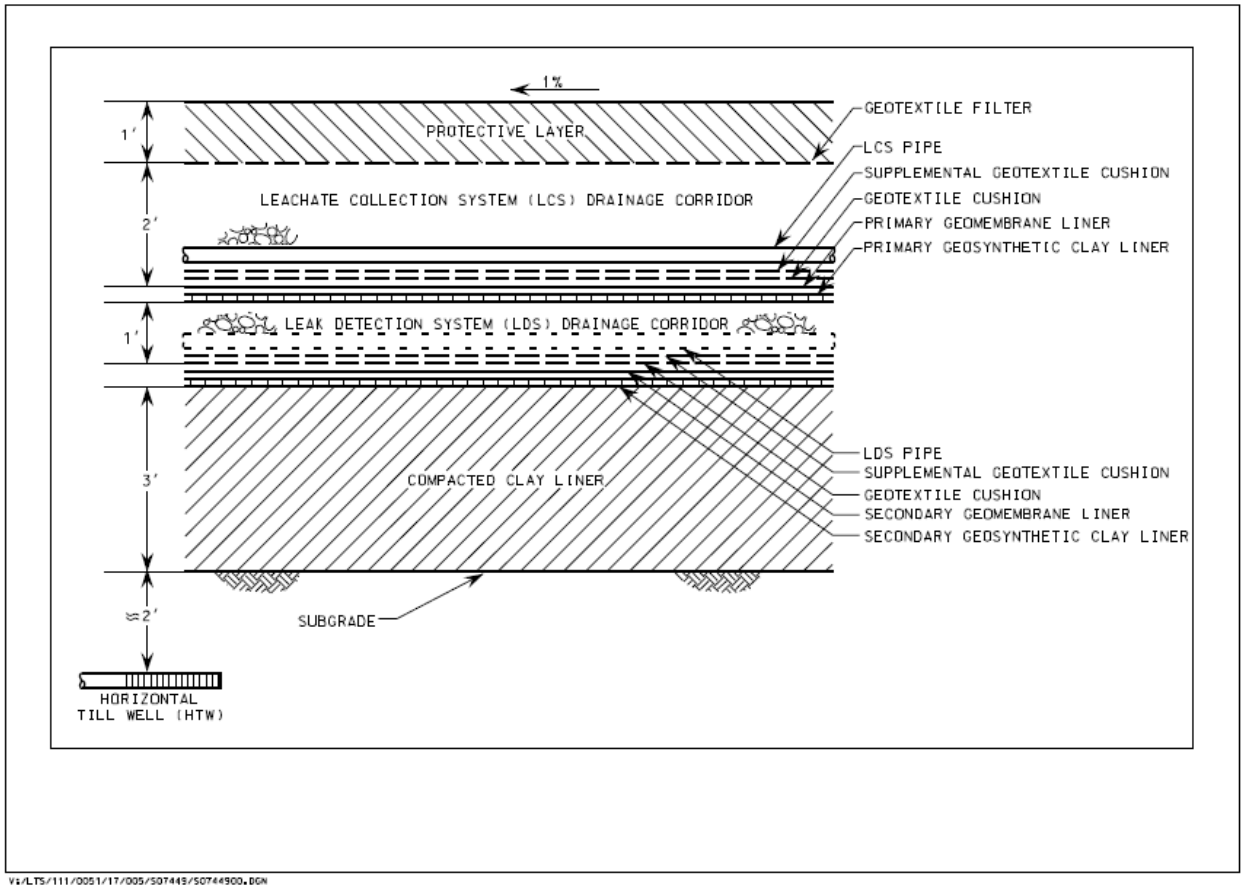
Parameters Selected for Quarterly Sampling in All Cells								
Constiuent	**Cell 1**	**Cell 2**	**Cell 3**	**Cell 4**	**Cell 5**	**Cell 6**	**Cell 7**	**Cell 8**
Alkalinity	X	X	X	X	X	X	X	X
Chloride	X	X	X	X	X	X	X	X
Nitrate/nitrite	X	X	X	X	X	X	X	X
TDS	X	X	X	X	X	X	X	X
TOC	X	X	X	X	X	X	X	X
TOX	X	X	X	X	X	X	X	X
Sulfate	X	X	X	X	X	X	X	X
Arsenic	X	X	X	X	X	X	X	X
Barium	X	X	X	X	X	X	X	X
Boron	X	X		X	X	X	X	X
Calcium	X	X	X	X	X	X	X	X
Cobalt		X	X					
Copper				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		X	X		X		X	
Nickel	X	X	X	X	X	X	X	X
Potassium	X	X	X	X	X	X	X	X
Selenium	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

Parameters Selcted 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%
Vanadium (Cell 5)								

Detected in 2010, 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	25%	
Chromium	25%	25%	25%	25%		1		25%
Lead	X	X	X	1				
Acetone								
1,1-dichloroethene							X	X
Toluene								
Tetrachloroethene								X

Not Detected in 2010, Detected at Least 25% of the time								
Constiuent	**Cell 1**	**Cell 2**	**Cell 3**	**Cell 4**	**Cell 5**	**Cell 6**	**Cell 7**	**Cell 8**
Beryllium							25%	
Cadmium		25%						
Thallium								
Carbon disulfide								
1,1-dichloroethane			25%					

X	Detected in 2010.
25%	Has been detected at least 25% of time, but not in 2010.
	Detected in 2010, has been detected at least 25% of time.
1	First time detect.



V:/LTS/111/0051/17/005/S07445/S0744900.DGN

Figure A.5−1. On-Site Disposal Facility Liner System with HTW at the Drainage Corridor

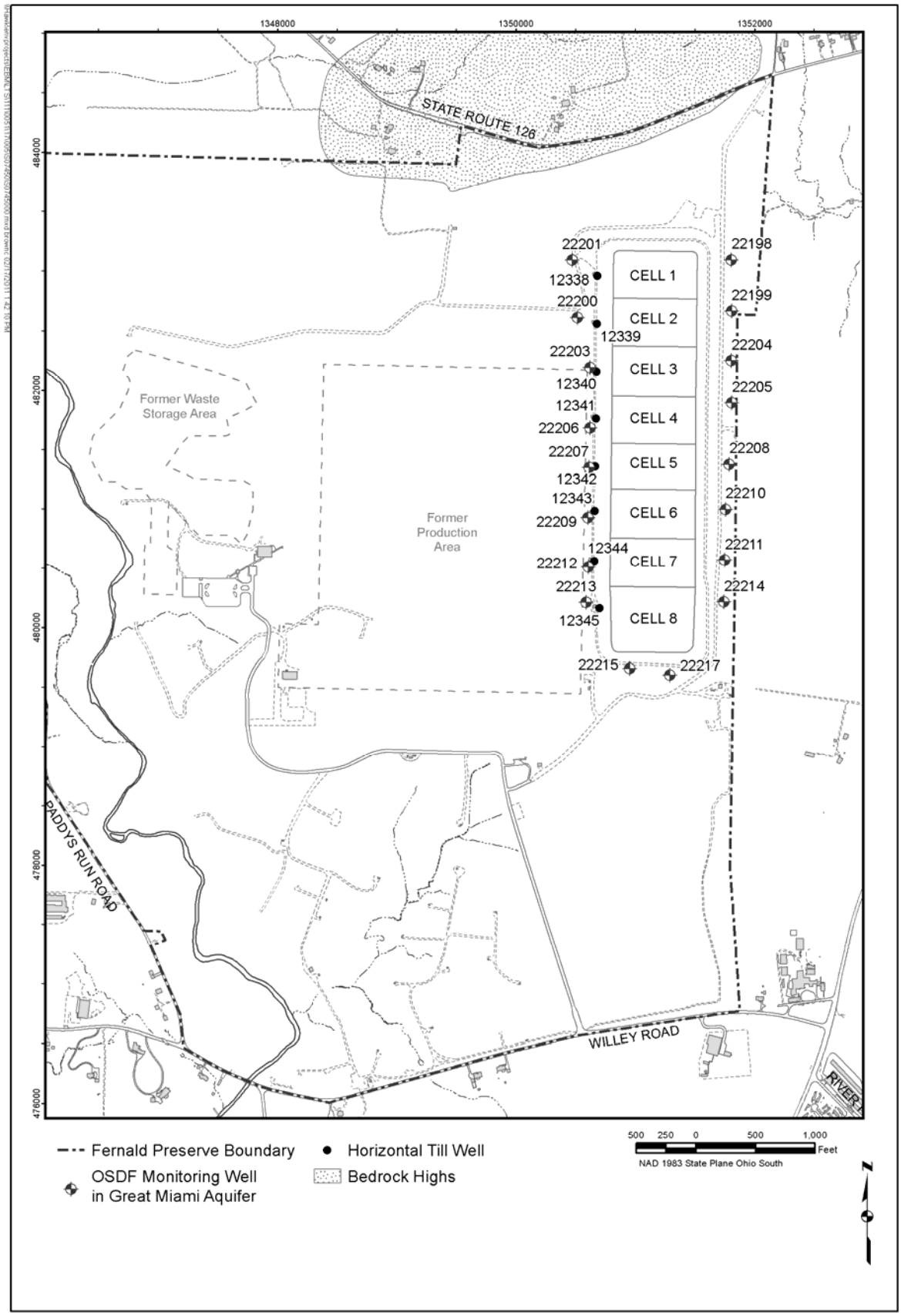


Figure A.5−2. On-Site Disposal Facility Footprint and Monitoring Well Locations

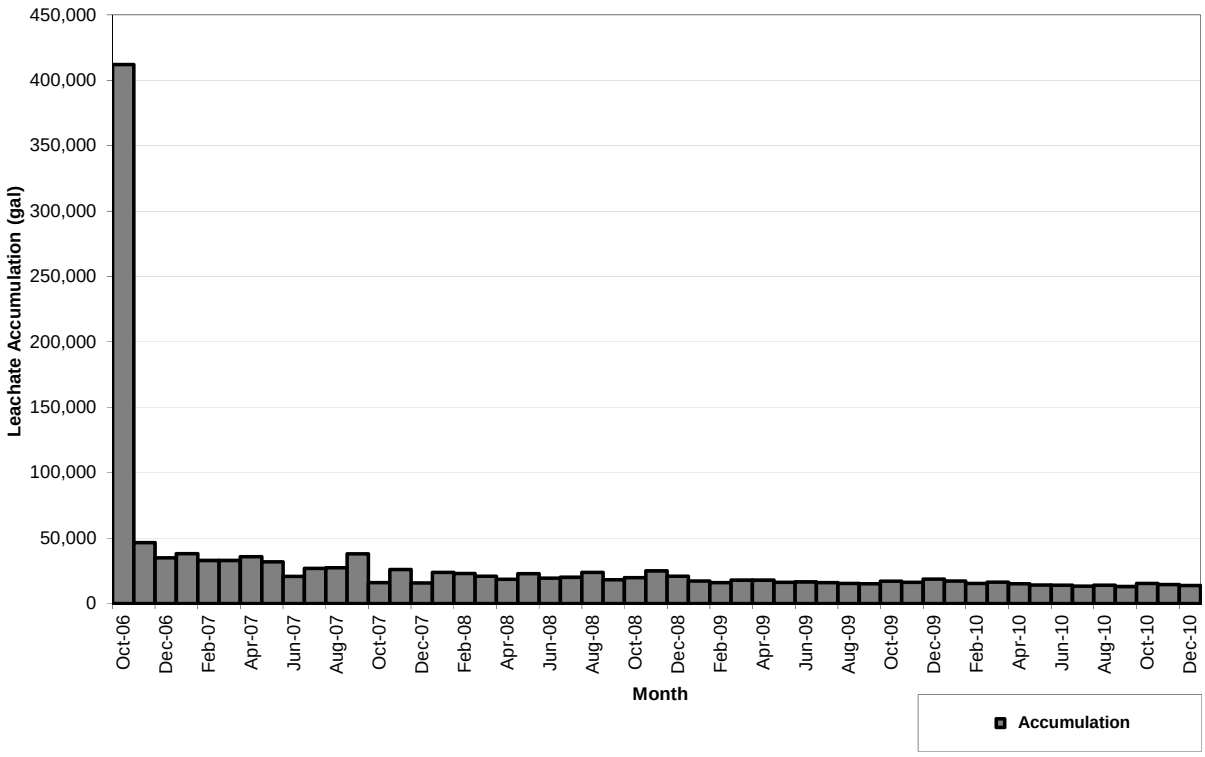


Figure A.5−3. OSDF Monthly LCS Flow (October 2006 through December 2010)

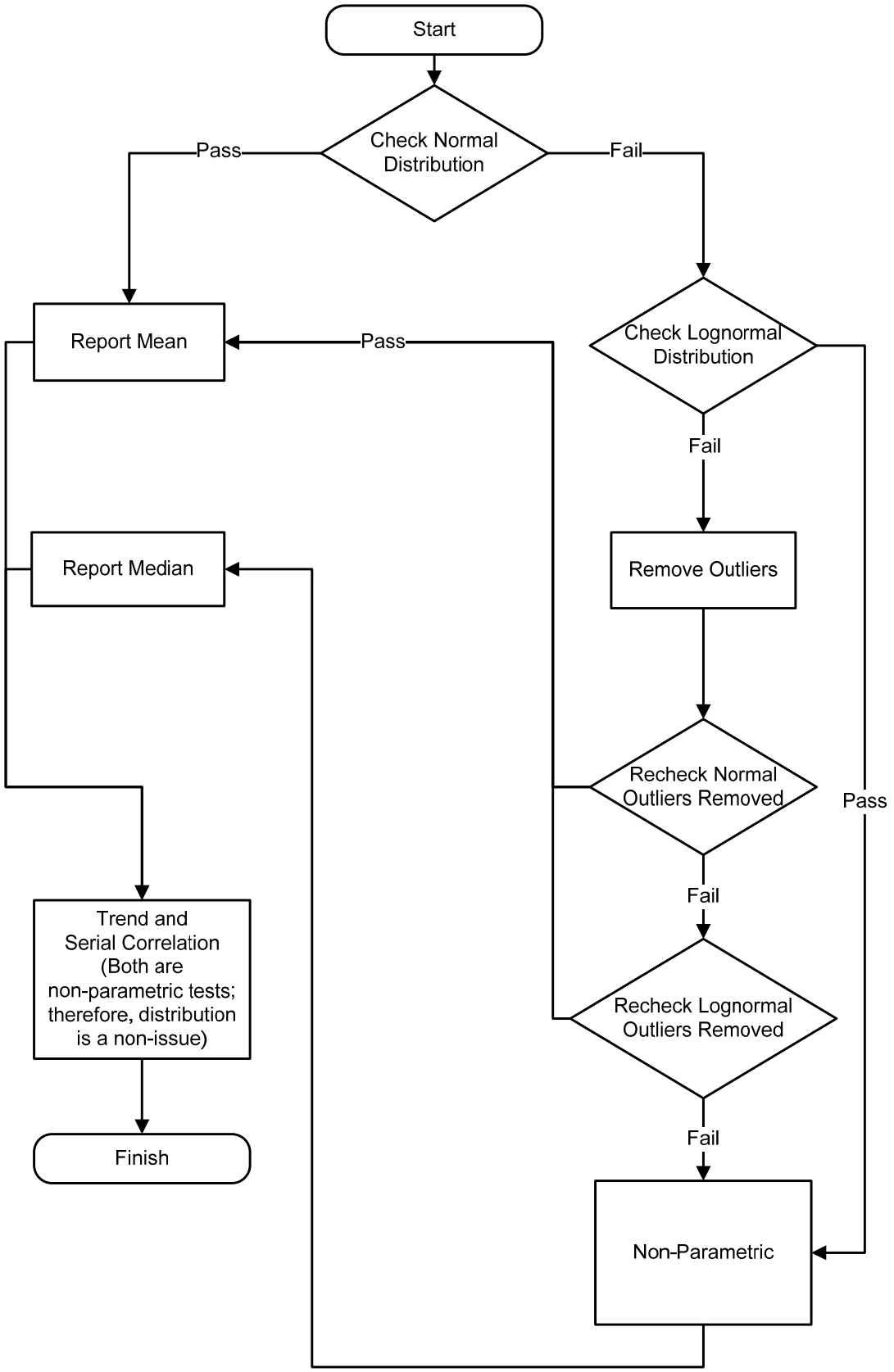


Figure A.5−4. OSDF Statistical Evaluation Process

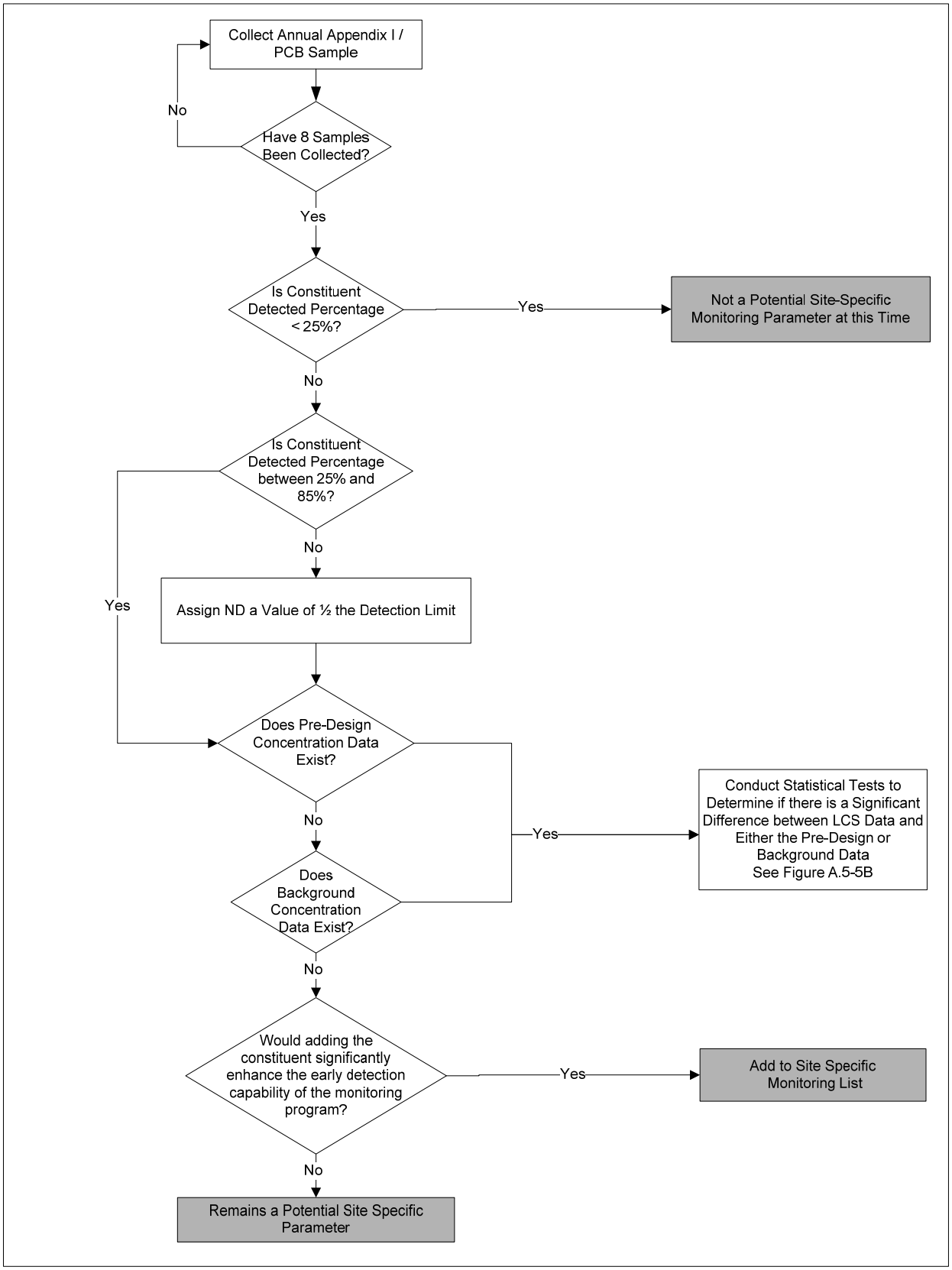


Figure A.5−5A. OSDF Site-Specific Leachate Monitoring Parameter Selection Approach

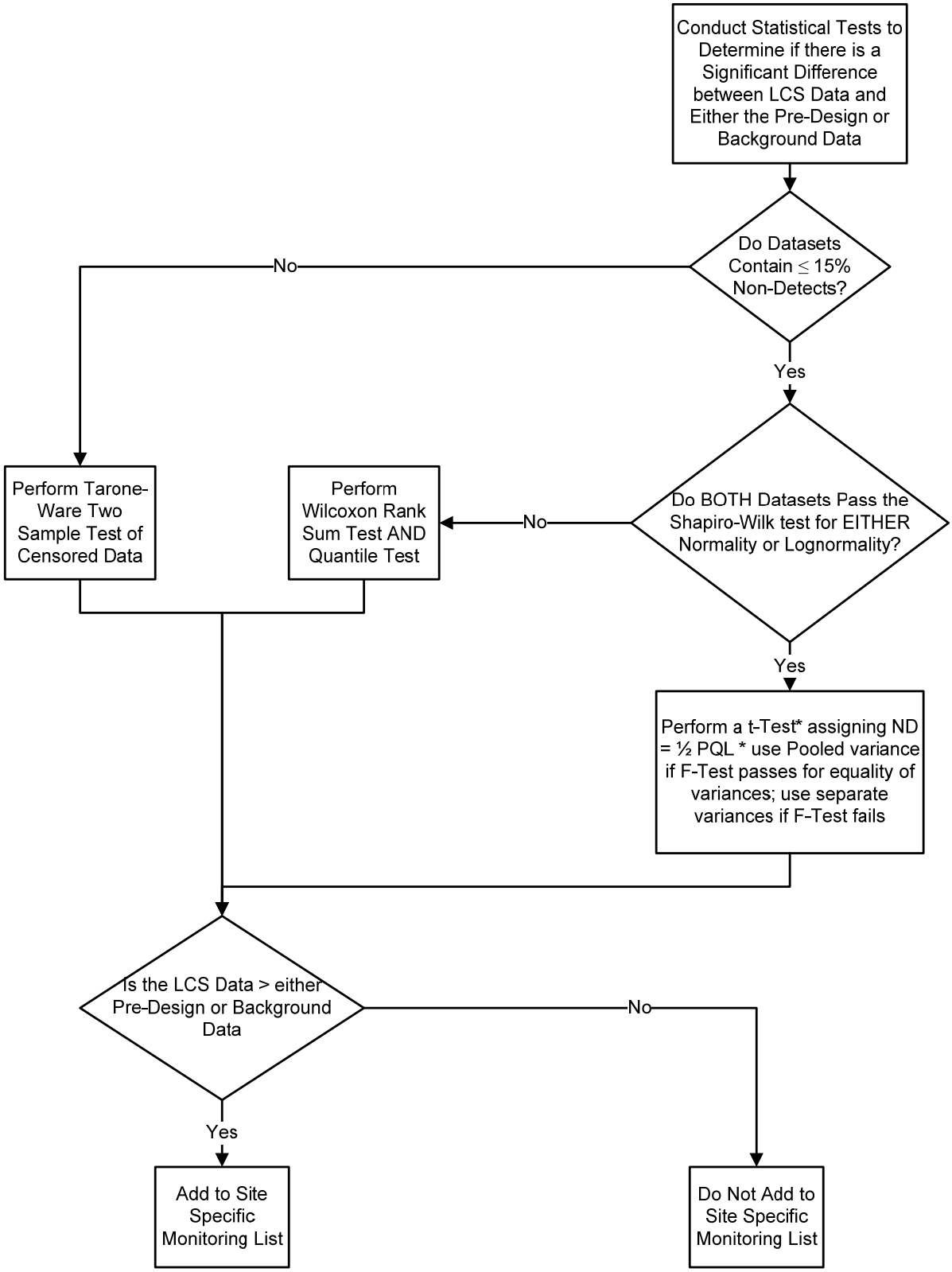


Figure A.5−5B. OSDF Site-Specific Leachate Monitoring Parameter Selection Approach

This page intentionally left blank