Department of Energy

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NOV 30 2017

Ms. April Webb
Division of Waste Management
Kentucky Department for Environmental Protection
300 Sower Boulevard, 2nd Floor
Frankfort, Kentucky 40601

PPPO-02-4511598-18A

Dear Ms. Webb:

TRANSMITTAL OF C-404 HAZARDOUS WASTE LANDFILL NOVEMBER 2017 SEMIANNUAL GROUNDWATER REPORT (APRIL–SEPTEMBER 2017), PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY, FPDP-RPT-0086/V2, PERMIT NO. KY8-890-008-982

This report is submitted to comply with Part II, Specific Condition II.K.6.d, of Hazardous Waste Management Facility Permit Number KY8-890-008-982. This report provides the groundwater analytical results and statistical analyses of those results for the semiannual sampling event conducted during July 2017 at the C-404 Hazardous Waste Landfill. This report also includes the permit required annual flow rate and direction.

Results of the statistical analyses indicate that compliance well concentrations of permit required parameters are not statistically different from those in background wells, except for arsenic in monitoring well (MW) 84. The MW84 arsenic exceedance is consistent with findings in the 2007 *C-404 Landfill Source Demonstration, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PRS-ENM-0031/R2, which demonstrates that the C-404 Landfill was not the source of the historical, statistically significant, background exceedance of trichloroethene in MW84; therefore, there is no apparent exceedance (of arsenic or any other permit required parameter) that is attributable to a release from the C-404 Landfill. Notification of the statistically significant difference for arsenic was submitted, pursuant to Part II Specific Condition II.K.6.a, to the Kentucky Department for Environmental Protection, under separate correspondence.

If you have any questions or require additional information, please contact David Dollins at (270) 441-6819.

Sincerely,

Jennifer Woodard

Jennifer Woodard
Paducah Site Lead
Portsmouth/Paducah Project Office

Enclosures:
1. Certification Page
2. C-404 Hazardous Waste Landfill November 2017 Semiannual Groundwater Report

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CERTIFICATION

Document Identification: ***C-404 Hazardous Waste Landfill November 2017 Semiannual Groundwater Report (April–September 2017), Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FPDP-RPT-0086/V2, Permit No. KY8-890-008-982**

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Four Rivers Nuclear Partnership, LLC

Myrna E. Redfield, Deputy Program Manager
Four Rivers Nuclear Partnership, LLC

11/29/17
Date Signed

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

U.S. Department of Energy

Jennifer Woodard, Paducah Site Lead
Portsmouth/Paducah Project Office

11/29/2017
Date Signed

FPDP-RPT-0086/V2

C-404 Hazardous Waste Landfill November 2017 Semiannual Groundwater Report (April–September 2017), Paducah Gaseous Diffusion Plant, Paducah, Kentucky

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

This document is approved for public release per review by:

David Hayden — 11-29-17

FRNP Classification Support — Date

FPDP-RPT-0086/V2

C-404 Hazardous Waste Landfill November 2017 Semiannual Groundwater Report (April–September 2017), Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—November 2017

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC,
managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under Contract DE-EM0004895

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CONTENTS

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TABLES

FIGURES

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ACRONYMS

AKGWA	Assembled Kentucky Groundwater
MW	monitoring well
PGDP	Paducah Gaseous Diffusion Plant
RCRA	Resource Conservation and Recovery Act
RGA	Regional Gravel Aquifer
UCRS	Upper Continental Recharge System
URGA	Upper Regional Gravel Aquifer
UTL	upper tolerance limit

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EXECUTIVE SUMMARY

This report, *C-404 Hazardous Waste Landfill November 2017 Semiannual Groundwater Report (April–September 2017), Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FPDP-RPT-0086/V2, is being submitted by the U.S. Department of Energy in accordance with requirements in Kentucky Division of Waste Management Hazardous Waste Facility Permit, KY8-890-008-982. The reporting period covers April through September 2017 and includes analytical data from the July 2017 sampling of monitoring wells (MWs) located in the vicinity of the closed C-404 Hazardous Waste Landfill (C-404 Landfill). In 1986, disposal of waste at C-404 Landfill was halted and a portion of the disposed-of waste was found to be Resource Conservation and Recovery Act (RCRA) hazardous. The landfill was covered with a RCRA multilayered cap and certified closed in 1987.

The groundwater monitoring analytical data were subjected to statistical analyses. The analyses were conducted in accordance with the Hazardous Waste Facility Permit. Only the arsenic concentration in compliance well MW84 was statistically different from concentrations in the background wells. The MW84 arsenic exceedance is consistent with the 2007 Alternate Source Demonstration (PRS 2007), which demonstrates that the C-404 Landfill was not the source of the historical, statistically significant background exceedance of trichloroethene in MW84. This determination fulfills Section II.K.8 of the Hazardous Waste Facility Permit, which allows for demonstrating that the exceedance is consistent with the findings in the 2007 Alternate Source Demonstration and also allows for the demonstration to be submitted within the semiannual report.

For the remaining parameters, concentrations in the downgradient (compliance) wells are not statistically different from the concentrations in upgradient (background) wells.

On May 1, 2017, the leachate level in the C-404 Landfill leachate collection system was measured at 41 inches and 1,000 gal was removed and sampled. On July 5, 2017, the leachate level was measured at 24 inches and 750 gal was removed and sampled on July 13, 2017. Analytical data are provided in this report.

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1. INTRODUCTION

This report contains the statistical evaluation of data from groundwater sampling and analysis for the C-404 Hazardous Waste Landfill (C-404 Landfill) at the Paducah Gaseous Diffusion Plant (PGDP), Paducah, Kentucky. This semiannual report is required by the Kentucky Division of Waste Management Hazardous Waste Facility Permit, KY8-890-008-982 (the permit) (KDWM 2015), Specific Condition II.K.6.d—Recordkeeping, Reporting, and Response. The period covered by this report is April through September 2017.

Groundwater analytical results are provided in Appendix A. The statistical analyses and qualification statement are provided in Appendix B. Landfill leachate analytical results are provided in Appendix C. The groundwater flow direction determination is provided in Appendix D.

1.1 BACKGROUND

The C-404 Landfill is located in the west-central portion of the PGDP secured area. The 1.2-acre facility operated as a surface impoundment from approximately 1952 until early 1957. During this time, influents to the impoundment originated from the C-400 Cleaning Building. In 1957, the impoundment was converted to a solid waste disposal facility for uranium-contaminated solid waste. When the impoundment was converted into a disposal facility, a sump was installed at the former weir to collect the leachate from the facility. Leachate is pumped from the sump, as needed, into a mobile tank. Then the leachate is transferred to a permitted hazardous waste storage facility on-site prior to characterization and transferred off-site for treatment.

In 1986, the disposal of waste at C-404 Landfill was halted, and a portion of the disposed-of waste was found to be Resource Conservation and Recovery Act (RCRA)-hazardous. The landfill was covered with a RCRA multilayered cap and certified closed in 1987. It currently is regulated under RCRA as a land disposal unit and compliance is monitored under the current Hazardous Waste Facility Permit (KDWM 2015).

Previous groundwater monitoring documented that concentrations in compliance wells were statistically different from background wells for trichloroethene (TCE). The *C-404 Landfill Source Demonstration, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (PRS 2007) documented that the source of the differences from background concentrations in compliance wells is not from the C-404 Landfill, but rather, the source is located upgradient/crossgradient of the C-404 Landfill.

1.2 MONITORING PERIOD ACTIVITIES

1.2.1 Groundwater Monitoring

Groundwater sampling was conducted in July 2017 using Fluor Federal Services, Inc., procedure CP4-ES-2101, *Groundwater Sampling*. Appropriate sample containers and preservatives were used. The laboratory that performed analyses used U.S. Environmental Protection Agency-approved methods, as applicable. There are nine MWs sampled under this permit for the C-404 Landfill: four Upper Continental Recharge System (UCRS) wells and five Upper Regional Gravel Aquifer (URGA) wells. Table 1 presents the well numbers for URGA wells located upgradient and downgradient of the C-404 Landfill. Table 1 also presents the well numbers for the UCRS wells located in proximity to the URGA wells. This table refers to these UCRS wells as being adjacent to an "upgradient" or "downgradient" URGA well location, identified relative to the URGA groundwater flow direction (see Figure 1).

Table 1. Monitoring Well Locations

UCRS	
Located south of C-404 Landfill, adjacent to upgradient URGA background well MW93	MW94
Located north of C-404 Landfill, adjacent to downgradient URGA compliance wells	MW85, MW88, MW91
URGA	
Upgradient background wells	MW93, MW420
Downgradient compliance wells	MW84, MW87, MW90A*

*MW90 was abandoned in 2001 and replaced with MW90A.

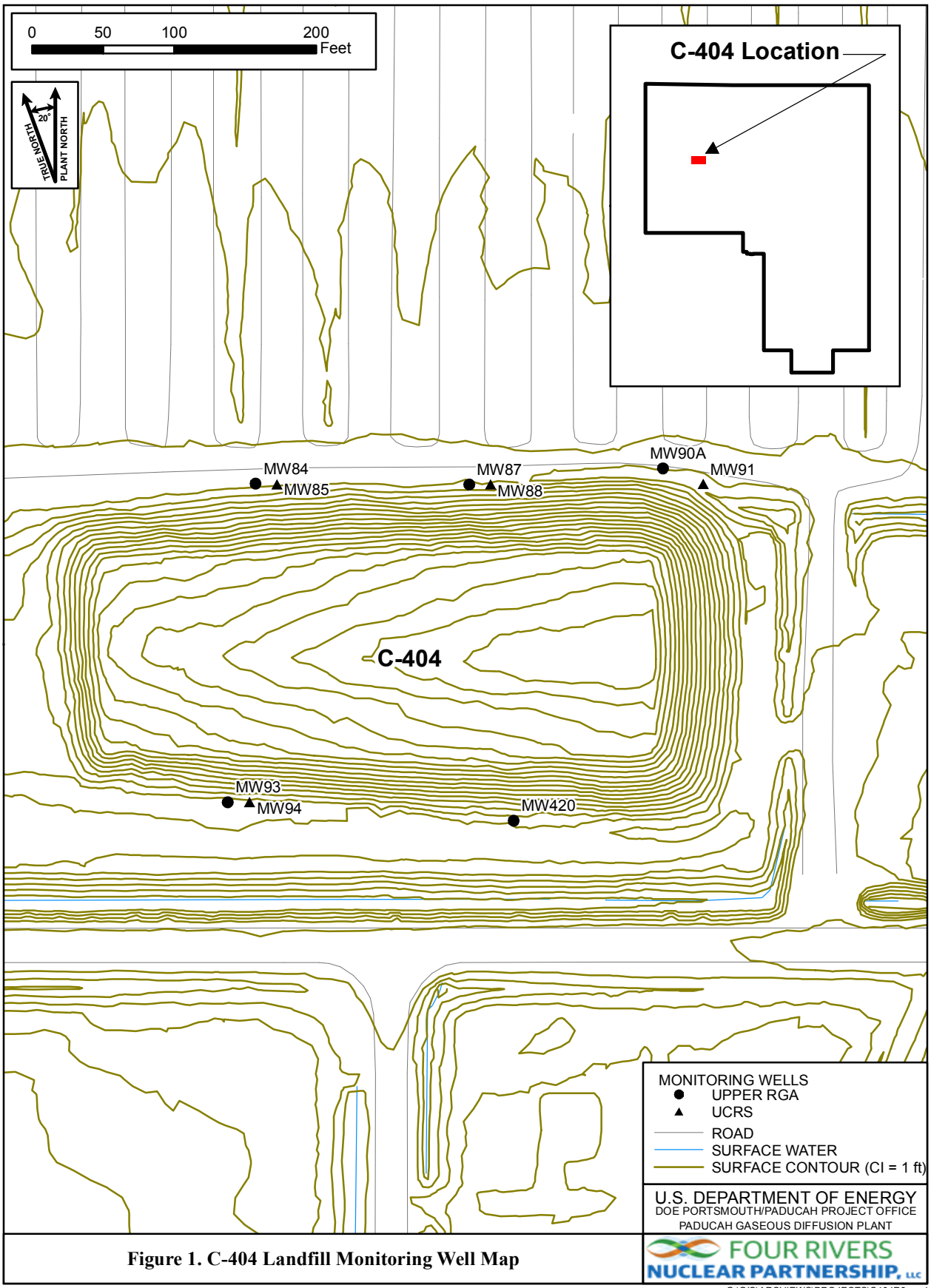

Figure 1. C-404 Landfill Monitoring Well Map

The conceptual model for the site indicates that groundwater in the UCRS wells flows primarily vertically until it reaches the URGA; therefore, UCRS wells are not considered "upgradient" or "downgradient" of other wells in the area.

Table 2 presents the Assembled Kentucky Groundwater (AKGWA) numbers for each MW. A map of the MW locations is provided in Figure 1. All of the MWs listed in Tables 1 and 2 were sampled during this reporting period, and the samples were analyzed for parameters required by Attachment E of the Hazardous Waste Facility Permit.

Table 2. Assembled Kentucky Groundwater Numbers

PGDP Well Number	AKGWA Number
MW84	8000-5233
MW85	8000-5234
MW87	8000-5236
MW88	8000-5237
MW90A	8004-0357
MW91	8000-5240
MW93	8000-5102
MW94	8000-5103
MW420	8005-3263

Appendix A of this report contains the analytical results from the wells that were sampled during the July 2017 semiannual sampling event. Appendix B of this report contains the statistical analyses.

Per Permit Specific Condition II.K.4.a, the groundwater flow rate and direction are evaluated annually and reported in each November report. For this report, a potentiometric map has been included in Appendix D using data from sampling performed in January and July 2017. Depth-to-water was measured on January 24, 2017, and July 26, 2017, from several wells at the perimeter of the C-404 Landfill. Water level measurements in 11 vicinity well locations define the potentiometric surface for the URGA (see Tables D.3 and D.4). Groundwater flow direction beneath the C-404 Landfill generally trends northward, but commonly varies from northeast to northwest. On January 24, 2017, and July 26, 2017, groundwater flow was toward the north-northeast (see Figures D.1 and D.2).

1.2.2 Landfill Leachate

In accordance with Section 1.2 of the Hazardous Waste Facility Permit, the quantity of liquid in the leachate collection system is monitored (at least monthly) and, at a minimum, will be "removed when the quantity exceeds 3 ft in depth." The volume of leachate removed from the sump during this reporting period, April to September 2017, was 1,750 gal. Once the leachate depth reached 3 ft, the leachate was pumped into a mobile tank. The leachate then was transferred to a permitted hazardous waste storage facility on-site prior to characterization and transfer off-site for treatment. Analytical results from leachate sampling on May 1, 2017, and July 13, 2017, are included in Appendix C.

2. STATISTICAL SYNOPSIS

The statistical analyses conducted on the data collected from C-404 Landfill were performed in accordance with procedures in the Hazardous Waste Facility Permit, Attachment Part E, reissued in July 2015. Appendix B of this report contains the statistical analyses performed for this reporting period. Data utilized for statistical analyses included data from the URGA background wells, MW93 and MW420, and URGA compliance wells, MW84, MW87, and MW90A. For these statistical analyses, the reporting period data set includes data from July 2015, January 2016, July 2016, January 2017, and July 2017.

Only the arsenic concentration in compliance well MW84 was statistically different from concentrations in the background wells (see Appendix B). The statistical tests on all other parameters, including dissolved arsenic, showed no statistical difference between concentrations in the compliance (downgradient) and background (upgradient) wells.

Since the nonparametric ANOVA test for arsenic identified a statistically significant difference between concentrations in the compliance well, MW84, and concentrations in background wells, in accordance with the permit provisions, the data were evaluated further by comparing the most recent compliance analytical data to a 95% upper tolerance limit (UTL) using the five most recent sets of data for each background well. Results of the comparison showed concentrations in compliance MW84 were higher than the UTL for the paired background concentrations. Analytical data were then evaluated using parametric ANOVA of wells in the same direction relative to the landfill (e.g., compare upgradient westernmost well MW93 analytical data to downgradient westernmost well MW84 analytical data). Results show the compliance (downgradient) well, MW84, does have statistically significant higher concentrations than the background (upgradient) well, MW93. Additional intra-well evaluation of trend was then performed for arsenic in MW84 using the Mann-Kendall statistical test. The Mann-Kendall statistical test identified a positive trend in MW84 over the past eight semiannual events.

STATISTICALLY SIGNIFICANT EXCEEDANCE OF BACKGROUND

The exceedance in arsenic concentration over background concentrations is consistent with the findings in the 2007 Alternate Source Demonstration (PRS 2007). The 2007 demonstration found that the statistically significant increase of TCE in the downgradient well, MW84, appeared to be due to an upgradient source whose TCE is migrating through the C-404 Landfill area. The trend of arsenic concentrations in MW84 is similar to the historical TCE trend in the same well, as demonstrated in Figure 2. This determination fulfills Section II.K.8 of the Hazardous Waste Facility Permit, which allows for demonstrating that the exceedance is consistent with the findings in the 2007 Alternate Source Demonstration and allows for the demonstration to be submitted within the semiannual report.

Trending of groundwater data gathered in the vicinity and upgradient of the C-404 Landfill supports and supplements the finding in the 2007 Alternate Source Demonstration, as follows. First, until the January 2015 sampling event, the westernmost upgradient well (MW93) typically had higher arsenic concentrations than the downgradient well MW84. Since then, the MW84 arsenic concentrations have increased steadily. This condition is similar to the pattern of TCE concentrations historically seen in these same wells and are attributed to a source upgradient/crossgradient of the C-404 Landfill in the 2007 Alternate Source Demonstration. Second, groundwater flow directions are to the northeast (see Figure D.1)—similarly indicating an upgradient, non-C-404 Landfill source of MW84 impacts. This condition is consistent with flow patterns found in 2007 during the Alternate Source Demonstration.

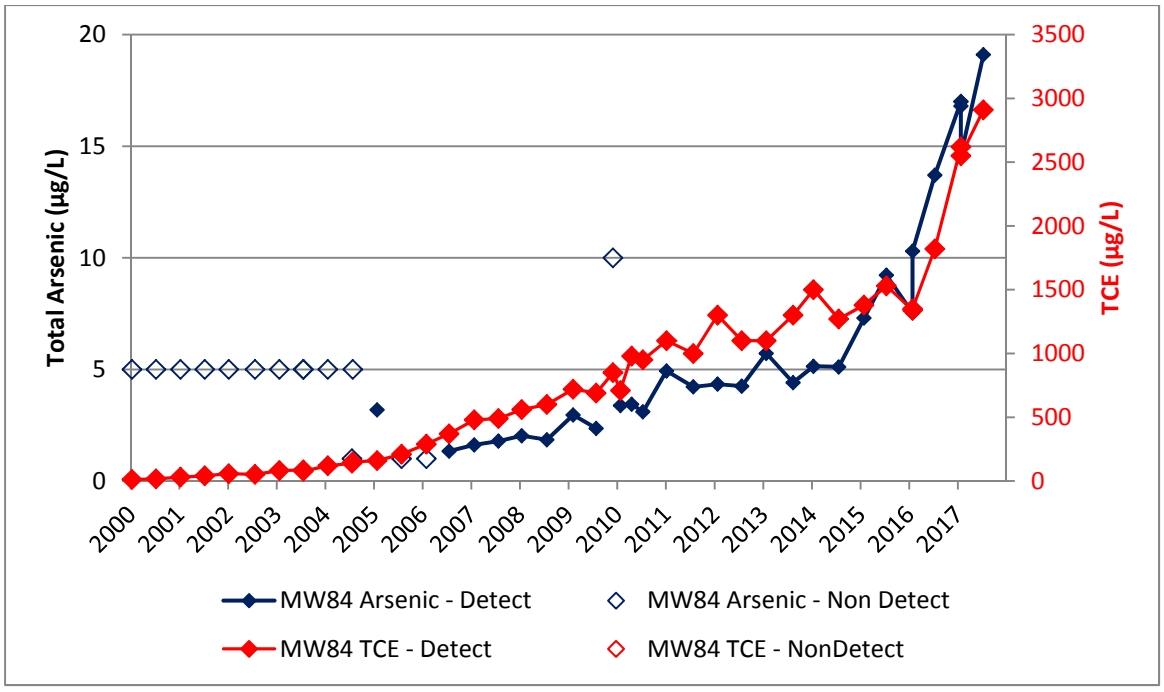

Figure 2. Arsenic and TCE Trend in MW84

Third, although there are significant differences in arsenic concentrations, there is no significant difference in dissolved arsenic concentrations between compliance well MW84 and background wells (see Appendix B, Attachment B2). Both arsenic and dissolved arsenic are permit-required analyses for groundwater. The mechanism of transport for arsenic from the landfill would have to be via a groundwater/dissolved pathway, because particulate-associated arsenic would not migrate through the subsurface.

Finally, most of the leachate samples collected over the years have had no detectable arsenic (dissolved arsenic is not required by the permit for leachate) and do not contain arsenic concentrations that could be the source of the concentrations recently detected in RGA groundwater at MW84. Of the 26% (14 of 54) of leachate samples that do contain arsenic, the maximum concentration of 0.00632 mg/L in leachate is below the arsenic concentration of 0.0191 mg/L found in MW84; thus, the C-404 Landfill cannot be the source of the arsenic found in that well. Similarly, the analysis of the leachate volume removed on May 1, 2017, contained no arsenic detected at a detection limit of 0.005 mg/L, also indicating that the C-404 Landfill is not the source of the arsenic exceedance in MW84 (see Appendix C). Of note, the field blank collected on May 1, 2017, contained arsenic detected at 0.00225 mg/L. The leachate removed from the sump on July 13, 2017, contained detectable arsenic at 0.00632 mg/L, substantially less than concentrations found in MW84 reinforcing the determination that the exceedances in MW84 are not related to the C-404 Landfill.

3. DATA VALIDATION AND QA/QC SUMMARY

The data and the data validation qualifiers for the July 2017 data set are provided in Appendix A. All data for this data set were considered useable as reported.

Data validation was performed on the analytical data by an independent, third-party validator.

Field quality control samples are collected semiannually during each sampling event. Equipment rinseate blanks, field blanks, and trip blanks are obtained to ensure quality control and are reported in the Analytical Results in Appendix A. No contamination was detected in the equipment rinseate blank or the trip blank. Low concentrations of arsenic, selenium, and uranium were detected in the field blank. Laboratory quality control samples, such as matrix spikes, matrix spike duplicates, and method blanks, are performed by the laboratory and reported in the laboratory report. Both field and laboratory quality control sample results are reviewed as part of the data validation process.

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4. PROFESSIONAL GEOLOGIST AUTHORIZATION

DOCUMENT IDENTIFICATION: *C-404 Hazardous Waste Landfill*
November 2017 Semiannual Groundwater Report
(April–September 2017),
Paducah Gaseous Diffusion Plant, Paducah, Kentucky
(FPDP-RPT-0086/V2)

Stamped and signed pursuant to my authority as a duly registered geologist under the provisions of *KRS* Chapter 322A.

PG 113927
Kenneth Davis 11-28-17

Kenneth R. Davis
Kenneth R. Davis

PG113927

November 28, 2017
Date

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5. REFERENCES

KDWM (Kentucky Division of Waste Management) 2015. Hazardous Waste Facility Permit for the U.S. Department of Energy, Paducah Gaseous Diffusion Plant, KY8-890-008-982, effective July 26.

PRS (Paducah Remediation Services, LLC) 2007. *C-404 Landfill Source Demonstration, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PRS-ENM-0031/R2, Paducah Remediation Services, LLC, Kevil, KY.

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APPENDIX A

C-404 HAZARDOUS WASTE LANDFILL GROUNDWATER ANALYTICAL RESULTS

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Paducah OREIS
GROUNDWATER MONITORING REPORT

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW84 REG Downgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5233

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.0191	mg/L	0.005	7/12/2017			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Barometric Pressure Reading		30.07	Inches/Hg		7/12/2017				X
Cadmium	J	0.000396	mg/L	0.001	7/12/2017			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Chromium		0.103	mg/L	0.01	7/12/2017			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	7/12/2017			SW846-6020	=
Conductivity		374	umho/cm		7/12/2017				X
Depth to Water		48.12	ft		7/12/2017				X
Dissolved Oxygen		3.69	mg/L		7/12/2017				X
Lead		0.00267	mg/L	0.002	7/12/2017			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
pH		5.99	Std Unit		7/12/2017				X
Redox		325	mV		7/12/2017				X
Selenium	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Technetium-99	U	9.98	pCi/L	20.1	7/12/2017	12		HASL 300, Tc-02-RC M	=
Temperature		73.1	deg F		7/12/2017				X
Trichloroethene		2910	ug/L	50	7/12/2017			SW846-8260B	=
Turbidity		134	NTU		7/12/2017				X
Uranium		0.000355	mg/L	0.0002	7/12/2017			SW846-6020	=
Uranium-234	U	0.153	pCi/L	0.967	7/12/2017	0.575		HASL 300, U-02-RC M	=
Uranium-235	U	0	pCi/L	0.748	7/12/2017	0.502		HASL 300, U-02-RC M	=
Uranium-238	U	-0.0403	pCi/L	1.41	7/12/2017	0.605		HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW85 REG Downgradient UCRS **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5234

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.0102	mg/L	0.005	7/12/2017			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Barometric Pressure Reading		30.07	Inches/Hg		7/12/2017				X
Cadmium	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Chromium	J	0.00545	mg/L	0.01	7/12/2017			SW846-6020	=
Chromium, Dissolved	J	0.00338	mg/L	0.01	7/12/2017			SW846-6020	=
Conductivity		366	umho/cm		7/12/2017				X
Depth to Water		9.93	ft		7/12/2017				X
Dissolved Oxygen		3.23	mg/L		7/12/2017				X
Lead	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
pH		6.34	Std Unit		7/12/2017				X
Redox		327	mV		7/12/2017				X
Selenium	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Technetium-99		67.3	pCi/L	20.3	7/12/2017	13.9		HASL 300, Tc-02-RC M	=
Temperature		73	deg F		7/12/2017				X
Trichloroethene		4.98	ug/L	1	7/12/2017			SW846-8260B	J
Turbidity		27.5	NTU		7/12/2017				X
Uranium		0.000343	mg/L	0.0002	7/12/2017			SW846-6020	=
Uranium-234	U	0.237	pCi/L	1.49	7/12/2017	0.889		HASL 300, U-02-RC M	=
Uranium-235	U	-0.0925	pCi/L	1.85	7/12/2017	0.798		HASL 300, U-02-RC M	=
Uranium-238	U	-0.0748	pCi/L	1.49	7/12/2017	0.645		HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW85 FR Downgradient UCRS **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5234

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.0102	mg/L	0.005	7/12/2017			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Barometric Pressure Reading		30.07	Inches/Hg		7/12/2017				X
Cadmium	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Chromium	J	0.00689	mg/L	0.01	7/12/2017			SW846-6020	=
Chromium, Dissolved	J	0.00363	mg/L	0.01	7/12/2017			SW846-6020	=
Conductivity		366	umho/cm		7/12/2017				X
Depth to Water		9.93	ft		7/12/2017				X
Dissolved Oxygen		3.23	mg/L		7/12/2017				X
Lead	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
pH		6.34	Std Unit		7/12/2017				X
Redox		327	mV		7/12/2017				X
Selenium	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Technetium-99		61.2	pCi/L	20.8	7/12/2017	14.1		HASL 300, Tc-02-RC M	=
Temperature		73	deg F		7/12/2017				X
Trichloroethene		6.71	ug/L	1	7/12/2017			SW846-8260B	J
Turbidity		27.5	NTU		7/12/2017				X
Uranium		0.000342	mg/L	0.0002	7/12/2017			SW846-6020	=
Uranium-234	U	-0.0392	pCi/L	2.05	7/12/2017	0.908		HASL 300, U-02-RC M	=
Uranium-235	U	0.23	pCi/L	1.45	7/12/2017	0.863		HASL 300, U-02-RC M	=
Uranium-238	U	0.313	pCi/L	1.5	7/12/2017	0.863		HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW87 REG Downgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5236

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.00907	mg/L	0.005	7/12/2017			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Barometric Pressure Reading		30.05	Inches/Hg		7/12/2017				X
Cadmium	J	0.000304	mg/L	0.001	7/12/2017			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Chromium		0.0557	mg/L	0.01	7/12/2017			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	7/12/2017			SW846-6020	=
Conductivity		352	umho/cm		7/12/2017				X
Depth to Water		48.07	ft		7/12/2017				X
Dissolved Oxygen		3.92	mg/L		7/12/2017				X
Lead		0.00533	mg/L	0.002	7/12/2017			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
pH		6.05	Std Unit		7/12/2017				X
Redox		403	mV		7/12/2017				X
Selenium	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Technetium-99	U	0.964	pCi/L	19.8	7/12/2017	11.4		HASL 300, Tc-02-RC M	=
Temperature		66.8	deg F		7/12/2017				X
Trichloroethene		1620	ug/L	50	7/12/2017			SW846-8260B	=
Turbidity		138	NTU		7/12/2017				X
Uranium		0.000571	mg/L	0.0002	7/12/2017			SW846-6020	=
Uranium-234	U	0.59	pCi/L	1.58	7/12/2017	1.04		HASL 300, U-02-RC M	=
Uranium-235	U	0.32	pCi/L	0.959	7/12/2017	0.899		HASL 300, U-02-RC M	=
Uranium-238	U	0.0724	pCi/L	1.58	7/12/2017	0.757		HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW88 REG Downgradient UCRS **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5237

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.00739	mg/L	0.005	7/12/2017			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Barometric Pressure Reading		30.06	Inches/Hg		7/12/2017				X
Cadmium	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Chromium	J	0.00662	mg/L	0.01	7/12/2017			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	7/12/2017			SW846-6020	=
Conductivity		621	umho/cm		7/12/2017				X
Depth to Water		9.45	ft		7/12/2017				X
Dissolved Oxygen		1.14	mg/L		7/12/2017				X
Lead	J	0.001	mg/L	0.002	7/12/2017			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
pH		5.88	Std Unit		7/12/2017				X
Redox		376	mV		7/12/2017				X
Selenium	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Technetium-99		20.4	pCi/L	19.8	7/12/2017	12.1		HASL 300, Tc-02-RC M	=
Temperature		71.4	deg F		7/12/2017				X
Trichloroethene		2.02	ug/L	1	7/12/2017			SW846-8260B	=
Turbidity		63.9	NTU		7/12/2017				X
Uranium		0.000238	mg/L	0.0002	7/12/2017			SW846-6020	=
Uranium-234	U	-0.0498	pCi/L	1.75	7/12/2017	0.748		HASL 300, U-02-RC M	=
Uranium-235	U	0.0862	pCi/L	1.88	7/12/2017	0.901		HASL 300, U-02-RC M	=
Uranium-238	U	-0.299	pCi/L	1.75	7/12/2017	0.566		HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW90A REG Downgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8004-0357

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Barometric Pressure Reading		30.07	Inches/Hg		7/12/2017				X
Cadmium	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Chromium	U	0.01	mg/L	0.01	7/12/2017			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	7/12/2017			SW846-6020	=
Conductivity		203	umho/cm		7/12/2017				X
Depth to Water		46.62	ft		7/12/2017				X
Dissolved Oxygen		3.83	mg/L		7/12/2017				X
Lead	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
pH		5.99	Std Unit		7/12/2017				X
Redox		354	mV		7/12/2017				X
Selenium	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Technetium-99	U	9.9	pCi/L	19.1	7/12/2017	11.4		HASL 300, Tc-02-RC M	=
Temperature		71.5	deg F		7/12/2017				X
Trichloroethene		46.1	ug/L	1	7/12/2017			SW846-8260B	=
Turbidity		10	NTU		7/12/2017				X
Uranium	U	0.0002	mg/L	0.0002	7/12/2017			SW846-6020	=
Uranium-234	U	-0.109	pCi/L	1.26	7/12/2017	0.481		HASL 300, U-02-RC M	=
Uranium-235	U	0	pCi/L	0.841	7/12/2017	0.565		HASL 300, U-02-RC M	=
Uranium-238	U	-0.0544	pCi/L	1.09	7/12/2017	0.469		HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW91 REG Downgradient UCRS **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5240

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.00704	mg/L	0.005	7/12/2017			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Barometric Pressure Reading		30.07	Inches/Hg		7/12/2017				X
Cadmium	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Chromium		0.985	mg/L	0.1	7/12/2017			SW846-6020	=
Chromium, Dissolved		0.0254	mg/L	0.01	7/12/2017			SW846-6020	=
Conductivity		519	umho/cm		7/12/2017				X
Depth to Water		10.69	ft		7/12/2017				X
Dissolved Oxygen		2.37	mg/L		7/12/2017				X
Lead		0.00562	mg/L	0.002	7/12/2017			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
pH		5.76	Std Unit		7/12/2017				X
Redox		345	mV		7/12/2017				X
Selenium	J	0.0029	mg/L	0.005	7/12/2017			SW846-6020	=
Selenium, Dissolved	J	0.0028	mg/L	0.005	7/12/2017			SW846-6020	=
Technetium-99		2620	pCi/L	23.5	7/12/2017	54		HASL 300, Tc-02-RC M	=
Temperature		74.9	deg F		7/12/2017				X
Trichloroethene		75.3	ug/L	2	7/12/2017			SW846-8260B	=
Turbidity		428	NTU		7/12/2017				X
Uranium		0.00115	mg/L	0.0002	7/12/2017			SW846-6020	=
Uranium-234	U	0.716	pCi/L	1.33	7/12/2017	0.978		HASL 300, U-02-RC M	=
Uranium-235	U	-0.129	pCi/L	1.49	7/12/2017	0.572		HASL 300, U-02-RC M	=
Uranium-238	U	0.279	pCi/L	1.33	7/12/2017	0.769		HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW93 REG Upgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5102

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.00755	mg/L	0.005	7/12/2017			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Barometric Pressure Reading		30.06	Inches/Hg		7/12/2017				X
Cadmium	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Chromium		0.261	mg/L	0.01	7/12/2017			SW846-6020	=
Chromium, Dissolved	J	0.00474	mg/L	0.01	7/12/2017			SW846-6020	=
Conductivity		351	umho/cm		7/12/2017				X
Depth to Water		49.55	ft		7/12/2017				X
Dissolved Oxygen		2.54	mg/L		7/12/2017				X
Lead		0.00213	mg/L	0.002	7/12/2017			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
pH		6.02	Std Unit		7/12/2017				X
Redox		314	mV		7/12/2017				X
Selenium	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Technetium-99	U	1.09	pCi/L	19.7	7/12/2017	11.4		HASL 300, Tc-02-RC M	=
Temperature		70.6	deg F		7/12/2017				X
Trichloroethene		1400	ug/L	50	7/12/2017			SW846-8260B	=
Turbidity		109	NTU		7/12/2017				X
Uranium		0.000224	mg/L	0.0002	7/12/2017			SW846-6020	=
Uranium-234	U	-0.149	pCi/L	1.27	7/12/2017	0.451		HASL 300, U-02-RC M	=
Uranium-235	U	0	pCi/L	0.769	7/12/2017	0.517		HASL 300, U-02-RC M	=
Uranium-238	U	0.523	pCi/L	1.15	7/12/2017	0.83		HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW94 REG Upgradient UCRS **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5103

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic	J	0.00356	mg/L	0.005	7/12/2017			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Barometric Pressure Reading		30.06	Inches/Hg		7/12/2017				X
Cadmium	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Chromium		0.0129	mg/L	0.01	7/12/2017			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	7/12/2017			SW846-6020	=
Conductivity		962	umho/cm		7/12/2017				X
Depth to Water		13.39	ft		7/12/2017				X
Dissolved Oxygen		1.18	mg/L		7/12/2017				X
Lead		0.00267	mg/L	0.002	7/12/2017			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
pH		6.46	Std Unit		7/12/2017				X
Redox		330	mV		7/12/2017				X
Selenium	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Technetium-99		604	pCi/L	20.7	7/12/2017	25.9		HASL 300, Tc-02-RC M	=
Temperature		71.8	deg F		7/12/2017				X
Trichloroethene		2.73	ug/L	1	7/12/2017			SW846-8260B	=
Turbidity		91	NTU		7/12/2017				X
Uranium		0.0029	mg/L	0.0002	7/12/2017			SW846-6020	=
Uranium-234	U	0.218	pCi/L	1.28	7/12/2017	0.683		HASL 300, U-02-RC M	=
Uranium-235	U	-0.139	pCi/L	1.58	7/12/2017	0.627		HASL 300, U-02-RC M	=
Uranium-238		1.41	pCi/L	1.22	7/12/2017	1.09		HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW420 REG Upgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8005-3263

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic	J	0.00207	mg/L	0.005	7/12/2017			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Barometric Pressure Reading		30.07	Inches/Hg		7/12/2017				X
Cadmium	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Chromium	U	0.01	mg/L	0.01	7/12/2017			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	7/12/2017			SW846-6020	=
Conductivity		315	umho/cm		7/12/2017				X
Depth to Water		49.69	ft		7/12/2017				X
Dissolved Oxygen		1.34	mg/L		7/12/2017				X
Lead	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
pH		5.99	Std Unit		7/12/2017				X
Redox		342	mV		7/12/2017				X
Selenium	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Technetium-99	U	-5.59	pCi/L	19.4	7/12/2017	11		HASL 300, Tc-02-RC M	=
Temperature		72.2	deg F		7/12/2017				X
Trichloroethene		264	ug/L	4	7/12/2017			SW846-8260B	=
Turbidity		8	NTU		7/12/2017				X
Uranium	U	0.0002	mg/L	0.0002	7/12/2017			SW846-6020	=
Uranium-234	U	-0.181	pCi/L	1.53	7/12/2017	0.546		HASL 300, U-02-RC M	=
Uranium-235	U	0	pCi/L	0.931	7/12/2017	0.625		HASL 300, U-02-RC M	=
Uranium-238	U	0.442	pCi/L	1.2	7/12/2017	0.868		HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Type of Sample: FB **Period:** Semiannual Report QC Samples

AKGWA Well Tag #: 0000-0000

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Cadmium	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Chromium	U	0.01	mg/L	0.01	7/12/2017			SW846-6020	=
Lead	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
Selenium	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Technetium-99	U	-2.04	pCi/L	21.1	7/12/2017	12.1		HASL 300, Tc-02-RC M	=
Trichloroethene	U	1	ug/L	1	7/12/2017			SW846-8260B	=
Uranium		0.0013	mg/L	0.0002	7/12/2017			SW846-6020	=
Uranium-234	U	0.289	pCi/L	1.82	7/12/2017	1.08		HASL 300, U-02-RC M	=
Uranium-235	U	0.939	pCi/L	1.41	7/12/2017	1.61		HASL 300, U-02-RC M	=
Uranium-238	U	-0.091	pCi/L	1.82	7/12/2017	0.786		HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Type of Sample: RI **Period:** Semiannual Report QC Samples

AKGWA Well Tag #: 0000-0000

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Cadmium	U	0.001	mg/L	0.001	7/12/2017			SW846-6020	=
Chromium	U	0.01	mg/L	0.01	7/12/2017			SW846-6020	=
Lead	U	0.002	mg/L	0.002	7/12/2017			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	7/12/2017			SW846-7470A	=
Selenium	U	0.005	mg/L	0.005	7/12/2017			SW846-6020	=
Technetium-99	U	-1.7	pCi/L	18.8	7/12/2017	10.8		HASL 300, Tc-02-RC M	=
Trichloroethene	U	1	ug/L	1	7/12/2017			SW846-8260B	=
Uranium	U	0.0002	mg/L	0.0002	7/12/2017			SW846-6020	=
Uranium-234	U	-0.243	pCi/L	2.07	7/12/2017	0.735		HASL 300, U-02-RC M	=
Uranium-235	U	0.217	pCi/L	2.31	7/12/2017	1.21		HASL 300, U-02-RC M	=
Uranium-238	U	-0.162	pCi/L	1.87	7/12/2017	0.718		HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Type of Sample: TB **Period:** Semiannual Report QC Samples

AKGWA Well Tag #: 0000-0000

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Trichloroethene	U	1	ug/L	1	7/12/2017			SW846-8260B	=

MEDIA Codes

WG Groundwater

QUALIFIER Codes

U Analyte analyzed for, but not detected at or below the lowest concentration reported.
J Estimated quantitation.

SAMPLE METHOD Codes

GR Grab

SAMPLING POINT Codes

UCRS Upper Continental Recharge System
URGA Upper Regional Gravel Aquifer

SAMPLE TYPE Codes

FB Field Blank
FR Field Replicate (Code used for Field Duplicate)
REG Regular
RI QC Equipment Rinseate/Decon
TB Trip Blank

VALIDATION Code

= Validated result, no qualifier is necessary.
J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
X Not validated.

APPENDIX B

C-404 HAZARDOUS WASTE LANDFILL STATISTICAL ANALYSES

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GROUNDWATER STATISTICAL SUMMARY

Introduction

The statistical analyses conducted on the data collected from C-404 Hazardous Waste Landfill (C-404 Landfill) were performed in accordance with procedures provided in Appendix E of the C-404 Hazardous Waste Management Permit, reissued by the Kentucky Division of Waste Management (KDWM) in July 2015. The percent of censored (nondetected) data points for individual parameters was calculated for the combined analytical data from the most recent five sampling events. The percent of censored data was used to select the types of statistical analyses to determine whether compliance well concentrations differed from background well concentrations. Data points were used in the statistical analysis for analyte results close to the sample quantitation limit that were judged to be below that limit by the data validator. For this report, the reporting period data set includes data from July 2015, January 2016, July 2016, January 2017, and July 2017.

Statistical Analysis Process

Utilizing the current data set and four previous data sets, the type of statistical test conducted for each chemical data set is a function of the number of samples and proportion of censored data (nondetects) to uncensored data (detects) in each group. The percent of censored (nondetected) data points for individual parameters was calculated for the combined analytical data. The statistical procedures applied to the data are summarized below.

- Determine the percentage of the censored data using the reporting period data set.
- Group by percentage of censored data where the following apply:
  - — If censored data are greater than or equal to 90%, determine the limit of detection (LOD) and half of the LOD (1/2 LOD). This is Statistical Test 1.
  - — If censored data are between 50% and 90%, perform a Test of Proportions. If the analysis indicates a significant proportional difference in compliance wells, further analyze through nonparametric Analysis of Variance (ANOVA) Test. This is Statistical Test 2.
  - — If censored data are between 15% and 50%, perform nonparametric ANOVA Test. If results exceed the critical value, compute the critical difference used to identify individual well concentrations, which are significantly elevated compared with background. This is Statistical Test 3.
  - — If censored data are less than 15%, actual data values are analyzed using parametric ANOVA procedures. If the wells exhibit equal variances, then the data are used as presented. If the wells do not exhibit equal variances, then the log of the data is taken and then used in the calculations. Where statistical testing indicates elevated compliance well concentrations, Bonferroni's Test of

Contrasts is performed. This is Statistical Test 4. If variances are found to be unequal even for log-transformed concentrations, Statistical Test 4 is abandoned and Statistical Test 3 is used to compare compliance wells with background wells. Statistical Test 4 is found in Section 5.2.1 of EPA guidance document, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (April 1989).

If the statistical method above indicates no statistical difference between concentrations in downgradient wells and concentrations in background wells, then there are no indications of statistically significant impacts on the groundwater from the C-404 Landfill. If the tiered statistical method above identifies a statistically significant difference between concentrations in downgradient wells and concentrations in background wells, then the data will be evaluated further to determine if the concentrations in downgradient wells are within statistically developed upper tolerance limit (UTL) for background concentrations or are consistent with the findings of the 2007 Alternate Source Demonstration (ASD), as follows:

(1) Compare the most recent downgradient sample results to a 95% UTL using the five most recent sets of data for each upgradient well as described below. If downgradient concentrations are lower than the UTL for the paired upgradient concentrations, then there is no confirmed exceedance.

(2) Evaluate results using paired ANOVA of wells in the same direction relative to the landfill (e.g., compare upgradient westernmost well results to downgradient westernmost well results). If ANOVA does not identify a statistically significant difference between upgradient and downgradient wells, then the results are consistent with the historical ASD.

(3) If results show downgradient wells have statistically significant higher concentrations than upgradient wells, even when evaluated with respect to the ASD, additional intra-well evaluation of trend will be performed using the Mann-Kendall test for trend. If concentrations do not show an increasing trend, then there is no confirmed exceedance attributable to C-404.

(4) Review other Regional Gravel Aquifer (RGA) well results in vicinity to determine if they are consistent with ASD.

If the statistical analysis identifies downgradient well concentrations that are increasing, are higher than UTL, are higher than the upgradient well concentrations even when the ASD results are taken into account, this evaluation will identify a confirmed, statistically significant exceedance (in a compliance well) over background.

Data Analysis

Data from the upgradient background wells in the Upper Regional Gravel Aquifer (URGA) are included for comparison with three downgradient URGA wells. Figure 1 of this C-404 Landfill Groundwater Report provides a map of the well locations associated with the C-404 Landfill. Upper Continental Recharge System (UCRS) wells in Figure 1 are provided for reference only. Data from wells that are in the UCRS are not included in the statistical analyses.

Table B.1 presents the C-404 Landfill upgradient or background wells and downgradient or compliance wells from the URGA. Data from the URGA compliance wells were compared with data from the URGA background wells.

Table B.1. Monitoring Well Locations

URGA	
Upgradient background wells	MW93, MW420
Downgradient compliance wells	MW84, MW87, MW90A*

*MW90 was abandoned in 2001 and replaced with MW90A.

For this report, the reporting period data set from July 2015 through July 2017 consists of five sets of data.

Table B.2 lists the number of analyses (observations), nondetects (censored observations), detects (uncensored observations), and missing observations by parameter. When field duplicate data are available from a well, the higher of the two readings was retained for further evaluation.

Censoring Percentage and Statistical Analysis

The type of statistical test set applied to the data is a function of the number of nondetects (censored) versus detects (uncensored) in each of the parameter groups and among the wells. Table B.3 presents the percentage of censored data and type of statistical test chosen for each of the parameters.

Table B.2. Summary of Missing, Censored, and Uncensored Data Collected

Parameters	Observations	Missing Observations*	Censored Observations (Nondetects)	Uncensored Observations (Detects)
URGA				
Arsenic	25	0	9	16
Arsenic, Dissolved	25	0	17	8
Cadmium	25	0	15	10
Cadmium, Dissolved	25	0	25	0
Chromium	25	0	10	15
Chromium, Dissolved	25	0	21	4
Lead	25	0	12	13
Lead, Dissolved	25	0	25	0
Mercury	25	0	25	0
Mercury, Dissolved	25	0	25	0
Selenium	25	0	20	5
Selenium, Dissolved	25	0	21	4
Technetium-99	25	0	24	1
Trichloroethene	25	0	0	25
Uranium (Metals)	25	0	16	9
Uranium-234	25	0	25	0
Uranium-235	25	0	25	0
Uranium-238	25	0	25	0

*Missing parameters that were dissolved metals were not analyzed when the parent total metals were not detected in prior sampling events.

Table B.3. Percent Censored Report and Statistical Test Set Selected

Parameter	Total Samples (Nonmissing)	Uncensored (Detects)	Censored (Nondetects)	Percent Censored	Statistical Test Set*
URGA					
Arsenic	25	16	9	36.00	3**
Arsenic, Dissolved	25	8	17	68.00	2
Cadmium	25	10	15	60.00	2
Cadmium, Dissolved	25	0	25	100.00	1
Chromium	25	15	10	40.00	3
Chromium, Dissolved	25	4	21	84.00	2
Lead	25	13	12	48.00	3
Lead, Dissolved	25	0	25	100.00	1
Mercury	25	0	25	100.00	1
Mercury, Dissolved	25	0	25	100.00	1
Selenium	25	5	20	80.00	2
Selenium, Dissolved	25	4	21	84.00	2
Technetium-99	25	1	24	96.00	1
Trichloroethene	25	25	0	0.00	4/3**
Uranium (Metals)	25	9	16	64.00	2
Uranium-234	25	0	25	100.00	1
Uranium-235	25	0	25	100.00	1
Uranium-238	25	0	25	100.00	1

*A list of the constituents with greater than or equal to 90% censored data is included in Table B.4, which summarizes the results of Statistical Test 1.

**Because equality of variance could not be confirmed, Statistical Test 4, Parametric ANOVA, was abandoned, and Statistical Test 3, Nonparametric ANOVA, was performed.

SUMMARY OF CONCLUSIONS

The results for Statistical Test 1, LOD, are summarized in Table B.4. Table B.5 provides the summary of conclusions for the statistical analyses for the C-404 Landfill, including the statistical tests performed, the attachment number, well type, parameter, and results of each statistical test. Results of Statistical Test 2, Statistical Test 3, and Statistical Test 4 are presented in Attachments B1 through B10. The statistician qualification statement is presented in Attachment B11.

Table B.4. Statistical Test 1: Limit of Detection

Parameter	LOD Values	½ LOD Values
URGA		
Cadmium, Dissolved (mg/L)	0.001	0.0005
Lead, Dissolved (mg/L)	0.002	0.001
Mercury (mg/L)	0.0002	0.0001
Mercury, Dissolved (mg/L)	0.0002	0.0001
Technetium-99 (pCi/L)	20.1	10.05
Uranium-234 (pCi/L)	1.58	0.79
Uranium-235 (pCi/L)	0.959	0.4795
Uranium-238 (pCi/L)	1.58	0.79

In summary, Statistical Test 2, Test of Proportions, for dissolved arsenic, cadmium, dissolved chromium, selenium, dissolved selenium, and uranium in the URGA indicated no statistically significant difference between concentrations in downgradient wells and concentrations in background wells.

Statistical Test 3, Nonparametric ANOVA, for arsenic in the URGA identified a statistically significant difference between concentrations in downgradient wells and concentrations in background wells; therefore, the data were evaluated further by comparing results to the UTL. The 95% UTL indicated a statistically significant difference between concentrations in downgradient wells and concentrations in background wells. Based on these results, the data were evaluated using paired (parametric) ANOVA of wells in the same direction relative to the landfill [e.g., a comparison was performed of downgradient westernmost well results (MW84) to upgradient westernmost well (MW93) results]. The paired ANOVA, could not be used for arsenic because there was no evidence of equality of variance. Thus, Statistical Test 4 was abandoned, and Statistical Test 3, Nonparametric ANOVA, was performed. Results of the ANOVA identified there to be a significant difference between upgradient and downgradient wells. A Mann-Kendall test was performed to further evaluate the data, and it identified a positive trend in MW84.

Statistical Test 3, Nonparametric ANOVA, for chromium and lead in the URGA indicated no statistically significant difference between concentrations in downgradient wells and concentrations in background wells.

Statistical Test 4, Parametric ANOVA, could not be used for trichloroethene in the URGA because there was no evidence of equality of variance. Thus, Statistical Test 4 was abandoned and Statistical Test 3, Nonparametric ANOVA, was performed. Statistical Test 3 showed there was no statistically significant difference between concentrations in downgradient wells and concentrations in background wells for trichloroethene.

Table B.5. Summary of Conclusions from the Statistical Analyses for the C-404 Hazardous Waste Landfill for the July 2017 Data Set

Attachment	RGA Well Type	Parameter	Applied Statistical Test	Results
B1	URGA	Arsenic	Statistical Test 3, Nonparametric ANOVA with 95% UTL, paired ANOVA (MW84 vs. MW93), Mann-Kendall, and data review	Because Nonparametric ANOVA indicated a statistically significant difference between concentrations in downgradient wells and concentrations in background wells for compliance well MW84, a comparison to the 95% UTL, paired ANOVA, Mann-Kendall, and an attempt to review data were performed, as required by the Hazardous Waste Facility Permit. Because equality of variance could not be confirmed on the paired ANOVA, it was abandoned, and Statistical Test 3, Nonparametric ANOVA, was performed. Results of the ANOVA have identified there to be a significant difference between upgradient and downgradient wells. The Mann-Kendall identified a positive trend in MW84.
B2	URGA	Arsenic, Dissolved	Statistical Test 2, Test of Proportions	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.
B3	URGA	Cadmium	Statistical Test 2, Test of Proportions	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.
B4	URGA	Chromium	Statistical Test 3, Nonparametric ANOVA	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.
B5	URGA	Chromium, Dissolved	Statistical Test 2, Test of Proportions	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.
B6	URGA	Lead	Statistical Test 3, Nonparametric ANOVA	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.
B7	URGA	Selenium	Statistical Test 2, Test of Proportions	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.
B8	URGA	Selenium, Dissolved	Statistical Test 2, Test of Proportions	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.
B9	URGA	Trichloroethene	Statistical Test 4, Parametric ANOVA/ Statistical Test 3, Nonparametric ANOVA	Because equality of variance could not be confirmed, Statistical Test 4 was abandoned and Statistical Test 3, Nonparametric ANOVA, was performed. Results of this analysis showed no statistically significant difference between concentrations in downgradient wells and concentrations in background wells.
B10	URGA	Uranium	Statistical Test 2, Test of Proportions	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.

ATTACHMENT B1

ARSENIC
STATISTICAL TEST 3

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Attachment B1: Statistical Test 3, Nonparametric ANOVA, July 2017 Arsenic URGA

Arsenic (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	**0.00702**	0.0025	**0.00922**	**0.00447**	0.0025
Jan-16	**0.00743**	0.0025	**0.0103**	**0.00481**	0.0025
Jul-16	**0.00709**	0.0025	**0.0137**	**0.00698**	0.0025
Jan-17	**0.00842**	0.0025	**0.017**	**0.00692**	0.0025
Jul-17	**0.00755**	**0.00207**	**0.0191**	**0.00907**	0.0025
Sum	0.0496		0.06932	0.03225	0.0125
n_i	10		5	5	5
$(x_i)_{avg}$	0.00496		0.01386	0.00645	0.0025

mg/L = milligrams per liter
BG = background
DL = detection limit
All data sets represent 1/2 DL values for nondetects.
Bolded values indicate a detected result.

Overall mean x.. =	0.00655
N =	25
p =	4
x.. =	0.16

Statistical Test 3, Nonparametric ANOVA

Ranking of Observations

Sequence	Arsenic (mg/L)	Adjusted Rank	Tie Number
1	0	5	
2	0	5	
3	0	5	
4	0	5	
5	0	5	Tie 1
6	0	5	
7	0	5	
8	0	5	
9	0	5	
10	**0.00207**	10	
11	**0.00447**	11	
12	**0.00481**	12	
13	**0.00692**	13	
14	**0.00698**	14	
15	**0.00702**	15	
16	**0.00709**	16	
17	**0.00743**	17	
18	**0.00755**	18	
19	**0.00842**	19	
20	**0.00907**	20	
21	**0.00922**	21	
22	**0.0103**	22	
23	**0.0137**	23	
24	**0.017**	24	
25	**0.0191**	25	

mg/L = milligrams per liter
BG = background
DL = detection limit
Bolded values indicate a detected result.
NOTE: For this method, observations below the detection limit that are considered nondetects (i.e., U qualified data) are reported as a concentration of 0.

n_{tie}	Adjustment for Ties: $(n_{tie}^3 - n_{tie})$	
9	Tie 1 =	720
	$\sum T_i$ =	720

Sums of Ranks and Averages

Arsenic (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	**0.00702**	0	**0.00922**	**0.00447**	0
Jan-16	**0.00743**	0	**0.0103**	**0.00481**	0
Jul-16	**0.00709**	0	**0.0137**	**0.00698**	0
Jan-17	**0.00842**	0	**0.017**	**0.00692**	0
Jul-17	**0.00755**	**0.00207**	**0.0191**	**0.00907**	0

Observation Ranks for Arsenic					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	15	5	21	11	5
Jan-16	17	5	22	12	5
Jul-16	16	5	23	14	5
Jan-17	19	5	24	13	5
Jul-17	18	10	25	20	5
R_i	115		115	70	25
$(R_i)_{avg}$	11.5		23.0	14.0	5.0
R_i^2/n_i	1322.5		2645.0	980.0	125.0

$\Sigma R_i^2/n_i$ = 5072.5

K = 4

N = 25

mg/L = milligrams per liter
BG = background
DL = detection limit
Bolded values indicate a detected result.
NOTE: For this method, observations below the detection limit that are considered nondetects (i.e., U qualified data) are reported as a concentration of 0.

Calculation of Kruskal-Wallis Statistic

H = 15.646 Kruskal-Wallis Statistic $H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$

H' = 16.403 Corrected Kruskal-Wallis $H' = H/[1-(\sum T_i/N^3-N)]$

χ^2_{crit}* = 7.815 3 degrees of freedom at the 5% significance level

NOTE: $H' > \chi^2_{crit}$

If $H' \leq \chi^2_{crit}$, the data from each well come from the same continuous distribution and hence have the same median concentrations of a specific constituent.

If $H' > \chi^2_{crit}$, reject the null hypothesis and calculate the critical difference for well comparisons to the background.

K-1 = 3 $\alpha/(K-1)$ = 0.01667 $Z(\alpha/(K-1))$** = 2.1280

α = 0.05 $1-(\alpha/K-1)$ = 0.983

NOTE *Table 1, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).
**Table 4, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

Calculate Critical Values

Average Background Ranking = 11.500

	Well No.	C_i	$(R_i)_{avg} - (R_b)_{avg}$	Conclusion
BG Well	MW93			
BG Well	MW420			
	MW84	8.578	11.50	evidence of contamination
	MW87	8.578	2.50	not contaminated
	MW90A	8.578	-6.50	not contaminated

mg/L = milligrams per liter
BG = background
DL = detection limit

CONCLUSION:

If $(R_i)_{avg} - (R_b)_{avg} > C_i$, then there is evidence that the compliance well is contaminated.

If $(R_i)_{avg} - (R_b)_{avg} < C_i$ for wells, there is no evidence of a statistically significant difference between concentrations in downgradient compliance test wells and background wells.

Since $(R_i)_{avg} - (R_b)_{avg} > C_i$ for MW84, there is a statistically significant difference between downgradient compliance test wells and background wells in MW84 from C-404.

Because nonparametric ANOVA indicated a statistically significant difference between compliance test wells and background wells at the C-404 Landfill in compliance well MW84, the 95% UTL was performed.

Since $(R_i)_{avg} - (R_b)_{avg} < C_i$ for MW87 and MW90A, there is no statistically significant difference from C-404 in these downgradient compliance test wells.

Section 5.2.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

95% Upper Tolerance Limit (UTL)

Compare the most recent downgradient sample results to a calculated 95% UTL using the five most recent sets of data for each upgradient well, as described below. If downgradient concentration is less than the UTL for the paired upgradient concentrations, then there is no confirmed exceedance.

July 2017 Data, First Reporting Period
Observations (mg/L)

Well No.						
MW93	**0.00702**	**0.00743**	**0.00709**	**0.00842**	**0.00755**	**Upgradient Well**[!]
MW420	0.0025	0.0025	0.0025	0.0025	**0.00207**	**Upgradient Well**[!]
MW84		X: Mean Value =	0.0050			**0.0191**
MW87		S: Standard Deviation =	0.0027			0.00907
MW90A		K* factor =	2.911	(for n = 10)		0.0025
		CV = S/X	0.5467	<1, assume normal distribution		
		Upper Tolerance Interval: TL = X +(KxS) =		**0.0128**	(mg/L)	

! = Data from previous 5 sampling events.
* = Table 5, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

Result: **MW84 exceeded the UTL, which is statistically significant evidence that this compliance well has elevated concentration with respect to background data.**

Because the 95% UTL indicated a statistically significant difference between compliance test wells and background wells at the C-404 Landfill in compliance well MW84, the paired ANOVA was performed.

Paired (Parametric) ANOVA

Evaluate results using paired ANOVA of wells in the same direction relative to the landfill [e.g., compare upgradient westernmost well (i.e., MW93) results to downgradient westernmost well (i.e., MW84) results]. If ANOVA does not identify a statistically significant difference between upgradient and downgradient wells, then the results are consistent with the historical ASD.

Arsenic (mg/L)				
Date	Background	Compliance		
	MW93	MW84	n_i^2	
Jul-15	**0.00702**	**0.00922**	0.0000493	0.0000850
Jan-16	**0.00743**	**0.0103**	0.0000552	0.0001061
Jul-16	**0.00709**	**0.0137**	0.0000503	0.0001877
Jan-17	**0.00842**	**0.017**	0.0000709	0.0002890
Jul-17	**0.00755**	**0.0191**	0.0000570	0.0003648
Sum (x_i)	0.0375	0.06932	0.1068	Total Sum (x..)
n_i	5	5		
$(x_i)_{avg}$	0.00750	0.01386		
$(x_i)^2$	0.00141	0.00481		

mg/L = milligrams per liter
Bolded values indicate a detected result.

Overall mean x.. = 0.01068
N = 10
p = 2
$x_{..}$ = 0.1068

Determine Normality of Dataset

Coefficient of Variability Test

Table of Residuals ($x_i - x_{iavg}$)

Date	Background	Compliance
	MW93	MW84
Jul-15	-0.00048	-0.00464
Jan-16	-0.00007	-0.00356
Jul-16	-0.00041	-0.00016
Jan-17	0.00092	0.00314
Jul-17	0.00005	0.00524

X: Mean Value = 1.30E-18
S: Standard Deviation = 0.00284
K* Factor = 2.911 (for n = 10)
CV = S/X = 2.19E+15 > or = 1, data are not normally distributed

Data are not normally distributed.

*Table 5, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

If the coefficient of variation is < 1, the data are normally distributed.
If the coefficient of variation is > or = 1, data are not normally distributed.

Determine Equality of Variance of Dataset

p = number of wells	$x_{..} =$ 0.1068
n_i = number of data points per well	$(x_{avg})_{..} =$ 0.01068
N = total sample size	$n_i =$ 5
S^2 = the square of the standard deviation	p = 2
$\ln(S_i^2)$ = natural logarithm of each variance	N = 10
f = total sample size minus the number of wells (groups)	f_i = 4
$f_i = n_i - 1$	

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$	n_i	$f_iS_i^2$	$f_i\ln(S_i^2)$
0.00056	0.00000031307	-14.977	5	0.0000013	-59.9
0.00423	0.00001788648	-10.931	5	0.0000715	-43.7

$\sum(S_i^2) =$ 0.00002 $\sum f_i\ln(S_i^2) =$ -103.63322

Equality of Variance: Bartlett's Test

f =	8	
Sp^2 =	0.0000091	
ln Sp^2 =	-11.607	
χ^2 =	10.775	(If calculated $\chi^2 \leq$ tabulated χ^2_{crit}, then variances are equal at the given significance level).
χ^2_{crit} * =	3.841	at a 5% significance level witl 1 degrees of freedom (p-1)

Variances are not equal, transform the original data to lognormal (i.e., since calculated $\chi 2 > \chi 2_{crit}$).

*Table 1, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

Paired (Parametric) ANOVA—Lognormal Data for Arsenic in MW93 and MW84

ln[Arsenic (mg/L)]				
Date	Background	Compliance		
	MW93	MW84	n_i^2	
Jul-15	**-4.96**	**-4.69**	24.59	21.96
Jan-16	**-4.90**	**-4.58**	24.03	20.94
Jul-16	**-4.95**	**-4.29**	24.49	18.41
Jan-17	**-4.78**	**-4.07**	22.82	16.60
Jul-17	**-4.89**	**-3.96**	23.88	15.67
Sum (x_i)	-24.47	-21.58	-46.06	Total Sum (x..)
n_i	5	5		
$(x_i)_{avg}$	-4.89	-4.32		
$(x_i)^2$	598.96	465.91		

mg/L = milligrams per liter **Bolded values indicate a detected result.**

Overall mean $x_{..}$ = -4.61
N = 10
p = 2
$x_{..}$ = -46.06

Determine Normality of Dataset

Coefficient of Variability Test

Table of Residuals (x_i-$x_i$avg) for Lognormal Data

Date	Background	Compliance
	MW93	MW84
Jul-15	-0.06	-0.37
Jan-16	-0.01	-0.26
Jul-16	-0.05	0.03
Jan-17	0.12	0.24
Jul-17	0.01	0.36

X: Mean Value = -3.55E-16
S: Standard Deviation = 0.21
K* Factor = 2.911 (for n = 10)
CV = S/X = –6.03E+14 < 1, the data are normally distributed

*Table 5, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

If the coefficient of variation is < 1, the residuals are normally distributed.
If the coefficient of variation is > or = 1, the residuals are not normally distributed.

Determine Equality of Variance of Dataset

p = number of wells
n_i = number of data points per well
N = total sample size
S^2 = the square of the standard deviation
$\ln(S_i^2)$ = natural logarithm of each variance
f = total sample size minus the number of wells (groups)
$f_i = n_i - 1$

$x_{..}$ = -46.06
$(x_{avg})_{..}$ = -4.61
n_i = 5
p = 2
N = 10
f_i = 4

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$	n_i	$f_iS_i^2$	$f_i\ln(S_i^2)$
0.07	0.01	-5.25	5	0.02	-21.0
0.31	0.10	-2.32	5	0.39	-9.3

$\sum(S_i^2)$ = 0.10 $\sum f_i\ln(S_i^2)$ = -30.29

Equality of Variance: Bartlett's Test

f = 8

Sp^2 = 0.05

ln Sp^2 = -2.96

χ^2 = 6.57 (If calculated $\chi^2 \leq$ tabulated χ^2_{crit}, then variances are equal at the given significance level).

χ^2_{crit} * = 3.841 at a 5% significance level witl 1 degrees of freedom (p-1)

Variances are not equal (i.e., calculated $\chi^2 \geq \chi^2_{crit}$).

*Table 1, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

Because variances are not equal, Statistical Test 3, Nonparametric ANOVA is performed.**

**Section 5.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989)].

Statistical Test 3, Nonparametric ANOVA

Arsenic (mg/L)		
Date	Background	Compliance
	MW93	MW84
Jul-15	**0.00702**	**0.00922**
Jan-16	**0.00743**	**0.0103**
Jul-16	**0.00709**	**0.0137**
Jan-17	**0.00842**	**0.017**
Jul-17	**0.00755**	**0.0191**
Sum	0.0375	0.06932
n_i	5	5
$(x_i)_{avg}$	0.00750	0.01386

mg/L = milligrams per liter
BG = background
DL = detection limit
All data sets represent 1/2 DL values for nondetects.
Bolded values indicate a detected result.

Overall mean x.. = 0.01068
N = 10
p = 2
x.. = 0.10683

Ranking of Observations

Sequence	Arsenic (mg/L)	Adjusted Rank	Tie Number
1	**0.00702**	1	
2	**0.00709**	2	
3	**0.00743**	3	
4	**0.00755**	4	
5	**0.00842**	5	
6	**0.00922**	6	
7	**0.0103**	7	
8	**0.0137**	8	
9	**0.017**	9	
10	**0.0191**	10	

mg/L = milligrams per liter
Bolded values indicate a detected result.

n_{tie}	Adjustment for Ties: $(n_{tie}^3 - n_{tie})$	
0	Tie 1 =	0
	$\sum T_i$ =	0

Sums of Ranks and Averages

Observation Ranks for Arsenic		
Date	Background	Compliance
	MW93	MW84
Jul-15	1	6
Jan-16	3	7
Jul-16	2	8
Jan-17	5	9
Jul-17	4	10
R_i	15	40
$(R_i)_{avg}$	3	8
R_i^2/n_i	45.0	320.0

$\Sigma R_i^2/n_i$ = 365
K = 2
N = 10

Calculation of Kruskal-Wallis Statistic

H =	6.818	Kruskal-Wallis Statistic	$H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$
H' =	6.818	Corrected Kruskal-Wallis	$H' = H/[1-(\sum T_i/N^3-N)]$
χ^2_{crit} * =	3.841	1	degrees of freedom at the 5% significance level

NOTE: $H' > \chi^2_{crit}$

If $H' \leq \chi^2_{crit}$, the data from each well come from the same continuous distribution and hence have the same median concentrations of a specific constituent.
If $H' > \chi^2_{crit}$, reject the null hypothesis and calculate the critical difference for well comparisons to the background.

K-1 =	1	α/(K-1) =	0.05000	Z(α/(K-1))** =	1.6449
α =	0.05	1-(α/K-1) =	0.950		

*Table 1, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).
**Table 4, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

Calculate Critical Values

Average Background Ranking = 3.000

	Well No.	C_i	$(R_i)_{avg} - (R_b)_{avg}$	Conclusion
BG Well	MW93			
	MW84	3.150	5.000	evidence of contamination

mg/L = milligrams per liter
BG = background
DL = detection limit

CONCLUSION:

If $(R_i)_{avg} - (R_b)_{avg} > C_i$, then there is evidence that the compliance well is contaminated.

If $(R_i)_{avg} - (R_b)_{avg} < C_i$ for wells, there is no evidence of a statistically significant difference between concentrations in downgradient compliance test wells and background wells.

Since $(R_i)_{avg} - (R_b)_{avg} > C_i$ for MW84, there is a statistically significant difference in this downgradient compliance test well.

Section 5.2.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

Attachment B1: Statistical Test 3, Nonparametric ANOVA, July 2017 Arsenic URGA

Location	Well ID	Parameter	Sample Size	Alpha[1]	p-Value [2]	S[3]	Var(S)[4]	Sen's Slope[5]	Kendall Correlation[6]	Decision[7]
C-404	MW84	Arsenic	8	0.05	0.001	26.00	65.33	0.002	0.929	**Positive Trend**

Footnotes:

[1]An alpha of 0.05 represents a 95% confidence interval.

[2]The p-value represents the risk of acceptance the H_a hypothesis of a trend, in terms of a percentage.

[3]The initial value of the Mann-Kendall statistic, S, is assumed to be 0 (e.g., no trend). If a data value from a later time period is higher than a data value from an earlier time period, S is incremented by 1. On the other hand, if the data value from a later time period is lower than a data value sampled earlier, S is decremented by 1. The net result of all such increments and decrements yields the final value of S. A very high positive value of S is an indicator of an increasing trend, and a very low negative value indicates a decreasing trend.

[4]VAR(S) represents the varience of S in the sample set and takes into account statistical ties.

[5]The magnitude of trend is predicted by the Sen's Slope. Here, the slope is described as the median of all $(x_j - x_k)/(j-k)$, where x is a data point and j and k are values of time.

[6]Kendall's correlation is described as the difference of concordant pairs and discordant pairs, also taking sample size and statistical ties into account. When the Kendall's correlation is postive, it indicates an increasing trend and when it is negative, it indicates a decreasing trend.

[7]The Mann-Kendall decision operates on two hypothesis, the H_0 and H_a. H_0 assumes there is no trend in the data, whereas H_a assumes either a positve or negative trend. Two different tests were ran to test for positive or negative trends. This table reports the test with the lowest p-value.

Note: Statistics generated using XLSTAT

ATTACHMENT B2

ARSENIC (DISSOLVED)
STATISTICAL TEST 2

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Attachment B2: Statistical Test 2, Test of Proportions, July 2017
Arsenic, Dissolved URGA

Arsenic, Dissolved (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	**0.00478**	0.0025	**0.00544**	**0.00273**	0.0025
Jan-16	0.0025	0.0025	0.0025	0.0025	0.0025
Jul-16	**0.00434**	0.0025	**0.00737**	**0.00282**	0.0025
Jan-17	**0.00254**	0.0025	**0.011**	0.0025	0.0025
Jul-17	0.0025	0.0025	0.0025	0.0025	0.0025

mg/L = milligrams per liter
BG = background
DL = detection limit
All data sets represent 1/2 DL values for nondetects.
Bolded values indicate a detected result.

[!]Test of Proportions

Calculate the number of detections in background wells vs. compliance wells.

X =	3	X = number of samples above DL in background wells
Y =	5	Y = number of samples above DL in compliance wells
n_b =	10	n_b = count of background well results/samples analyzed
n_c =	15	n_c = count of compliance well results/samples analyzed
n =	25	n = total number of samples

P =	0.320	P = (x+y)/n
nP =	8	$n = n_b+n_c$
n(1-P) =	17	

NOTE: If nP and n(1-P) are both >= 5, then the normal approximation may be used.

P_b =	0.300	P_b = proportion of detects in background wells
P_c =	0.333	P_c = proportion of detects in compliance wells
S_D =	0.190	S_D = standard error of difference in proportions
Z =	-0.175	$Z = (P_b-P_c)/S_D$
absolute value of Z =	0.175	

If the absolute value of Z exceeds the 97.5th percentile value of 1.96 from the standard normal distribution, this provides statistically significant evidence at the 5% significance level that the proportion of detects in one group of data exceeds the proportion of detects in the other group.

CONCLUSION: Because the absolute value of Z is less than 1.96, there is no statistical evidence that the proportion of samples with detected results differs between the background well and compliance well samples.

[!] Section 8.1.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (EPA 1989).

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ATTACHMENT B3

CADMIUM
STATISTICAL TEST 2

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Attachment B3: Statistical Test 2, Test of Proportions, July 2017
Cadmium URGA

Cadmium (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	0.0005	0.0005	**0.00012**	0.0005	0.0005
Jan-16	**0.000152**	0.0005	**0.000179**	**0.000121**	0.0005
Jul-16	**0.000199**	0.0005	**0.000292**	**0.000451**	0.0005
Jan-17	0.0005	0.0005	**0.000619**	0.0005	0.0005
Jul-17	0.0005	0.0005	**0.000396**	**0.000304**	0.0005

mg/L = milligrams per liter
BG = background
DL = detection limit
All data sets represent 1/2 DL values for nondetects.
Bolded values indicate a detected result.

[!] **Test of Proportions**

Calculate the number of detections in background wells vs. compliance wells.

X =	2	X = number of samples above DL in background wells
Y =	8	Y = number of samples above DL in compliance wells
n_b =	10	n_b = count of background well results/samples analyzed
n_c =	15	n_c = count of compliance well results/samples analyzed
n =	25	n = total number of samples

P =	0.400	P = (x+y)/n
nP =	10	$n = n_b+n_c$
n(1-P) =	15	

NOTE: If nP and n(1-P) are both >= 5, then the normal approximation may be used.

P_b =	0.200	P_b = proportion of detects in background wells
P_c =	0.533	P_c = proportion of detects in compliance wells
S_D =	0.200	S_D = standard error of difference in proportions
Z =	-1.667	$Z = (P_b-P_c)/S_D$
absolute value of Z =	1.667	

If the absolute value of Z exceeds the 97.5th percentile value of 1.96 from the standard normal distribution, this provides statistically significant evidence at the 5% significance level that the proportion of detects in one group of data exceeds the proportion of detects in the other group.

CONCLUSION: Because the absolute value of Z is less than 1.96, there is no statistical evidence that the proportion of samples with detected results differs between the background well and compliance well samples.

[!] Section 8.1.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (EPA 1989).

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ATTACHMENT B4

CHROMIUM
STATISTICAL TEST 3

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Attachment B4: Statistical Test 3, Nonparametric ANOVA, July 2017 Chromium URGA

Chromium (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	**0.00473**	0.005	**0.0347**	**0.00809**	0.005
Jan-16	**0.0401**	0.005	**0.0393**	**0.0266**	0.005
Jul-16	**0.207**	0.005	**0.0206**	**0.165**	0.005
Jan-17	**0.428**	0.005	**0.0309**	**0.262**	0.005
Jul-17	**0.261**	0.005	**0.103**	**0.0557**	0.005
Sum	0.9658		0.22850	0.51739	0.0250
n_i	10		5	5	5
$(x_i)_{avg}$	0.09658		0.04570	0.10348	0.0050

mg/L = milligrams per liter
BG = background
DL = detection limit
All data sets represent 1/2 DL values for nondetects.
Bolded values indicate a detected result.

Overall mean x.. = 0.06947

N = 25
p = 4
x.. = 1.74

Statistical Test 3, Nonparametric ANOVA

Ranking of Observations

Sequence	Chromium (mg/L)	Adjusted Rank	Tie Number
1	0	5.5	Tie 1
2	0	5.5	
3	0	5.5	
4	0	5.5	
5	0	5.5	
6	0	5.5	
7	0	5.5	
8	0	5.5	
9	0	5.5	
10	0	5.5	
11	**0.00473**	11	
12	**0.00809**	12	
13	**0.0206**	13	
14	**0.0266**	14	
15	**0.0309**	15	
16	**0.0347**	16	
17	**0.0393**	17	
18	**0.0401**	18	
19	**0.0557**	19	
20	**0.103**	20	
21	**0.165**	21	
22	**0.207**	22	
23	**0.261**	23	
24	**0.262**	24	
25	**0.428**	25	

mg/L = milligrams per liter
BG = background
DL = detection limit
Bolded values indicate a detected result.
NOTE: For this method, observations below the detection limit that are considered nondetects (i.e., U qualified data) are reported as a concentration of 0.

n_{tie}	Adjustment for Ties: $(n_{tie}^3-n_{tie})$	
10	Tie 1 =	990
	$\sum T_i$ =	990

Attachment B4: Statistical Test 3, Nonparametric ANOVA, July 2017 Chromium URGA

Sums of Ranks and Averages

Chromium (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	**0.00473**	0	**0.0347**	**0.00809**	0
Jan-16	**0.0401**	0	**0.0393**	**0.0266**	0
Jul-16	**0.207**	0	**0.0206**	**0.165**	0
Jan-17	**0.428**	0	**0.0309**	**0.262**	0
Jul-17	**0.261**	0	**0.103**	**0.0557**	0

Observation Ranks for Chromium					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	11	5.5	16	12	5.5
Jan-16	18	5.5	17	14	5.5
Jul-16	22	5.5	13	21	5.5
Jan-17	25	5.5	15	24	5.5
Jul-17	23	5.5	20	19	5.5
R_i	126.5		81	90	27.5
$(R_i)_{avg}$	12.7		16.2	18.0	5.5
R_i^2/n_i	1600.2		1312.2	1620.0	151.3

$\Sigma R_i^2/n_i$ = 4683.7

mg/L = milligrams per liter
BG = background
DL = detection limit
Bolded values indicate a detected result.

K = 4
N = 25

NOTE: For this method, observations below the detection limit that are considered nondetects (i.e., U qualified data) are reported as a concentration of 0.

Calculation of Kruskal-Wallis Statistic

H =	8.468	Kruskal-Wallis Statistic	$H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$
H' =	9.042	Corrected Kruskal-Wallis	$H' = H/[1-(\sum T_i/N^3-N)]$
χ^2_{crit}* =	7.815	3	degrees of freedom at the 5% significance level

NOTE: $H' > \chi^2_{crit}$

If $H' \leq \chi^2_{crit}$, the data from each well come from the same continuous distribution and hence have the same median concentrations of a specific constituent.

If $H' > \chi^2_{crit}$, reject the null hypothesis and calculate the critical difference for well comparisons to the background.

K-1 =	3	α/(K-1) =	0.01667	Z(α/(K-1))** =	2.1280
α =	0.05	1-(α/K-1) =	0.983		

NOTE *Table 1, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).
**Table 4, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

Calculate Critical Values

Average Background Ranking = 12.650

	Well No.	C_i	$(R_i)_{avg} - (R_b)_{avg}$	Conclusion
BG Well	MW93			
BG Well	MW420			
	MW84	8.578	3.55	not contaminated
	MW87	8.578	5.35	not contaminated
	MW90A	8.578	-7.15	not contaminated

mg/L = milligrams per liter
BG = background
DL = detection limit

CONCLUSION: If $(R_i)_{avg} - (R_b)_{avg} > C_i$, then there is evidence that the compliance well is contaminated.

If $(R_i)_{avg} - (R_b)_{avg} < C_i$ for wells, there is no evidence of a statistically significant difference between concentrations in downgradient compliance test wells and background wells.

Since $(R_i)_{avg} - (R_b)_{avg} < C_i$ for MW84, MW87, and MW90A, there is no statistically significant difference compliance test wells and background wells at the C-404 Landfill; however, the negative values indicate that background wells have elevated concentrations.

Section 5.2.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

ATTACHMENT B5

CHROMIUM, DISSOLVED
STATISTICAL TEST 2

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Attachment B5: Statistical Test 2, Test of Proportions, July 2017
Chromium, Dissolved URGA

Chromium, Dissolved (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	0.005	0.005	0.005	0.005	0.005
Jan-16	0.005	0.005	0.005	0.005	0.005
Jul-16	**0.0021**	0.005	0.005	**0.00438**	0.005
Jan-17	**0.0116**	0.005	0.005	0.005	0.005
Jul-17	**0.00474**	0.005	0.005	0.005	0.005

mg/L = milligrams per liter
BG = background
DL = detection limit
All data sets represent 1/2 DL values for nondetects.
Bolded values indicate a detected result.

[!] Test of Proportions

Calculate the number of detections in background wells vs. compliance wells.

X =	3	X = number of samples above DL in background wells
Y =	1	Y = number of samples above DL in compliance wells
n_b =	10	n_b = count of background well results/samples analyzed
n_c =	15	n_c = count of compliance well results/samples analyzed
n =	25	n = total number of samples

P =	0.160	P = (x+y)/n
nP =	4	n = n_b+n_c
n(1-P) =	21	

NOTE: If nP and n(1-P) are both >= 5, then the normal approximation may be used.

P_b =	0.300	P_b = proportion of detects in background wells
P_c =	0.067	P_c = proportion of detects in compliance wells
S_D =	0.150	S_D = standard error of difference in proportions
Z =	1.559	Z = (P_b-P_c)/S_D
absolute value of Z =	1.559	

If the absolute value of Z exceeds the 97.5th percentile value of 1.96 from the standard normal distribution, this provides statistically significant evidence at the 5% significance level that the proportion of detects in one group of data exceeds the proportion of detects in the other group.

CONCLUSION: Because the absolute value of Z is less than 1.96, there is no statistical evidence that the proportion of samples with detected results differs between the background well and compliance well samples.

[!] Section 8.1.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (EPA 1989).

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ATTACHMENT B6

LEAD
STATISTICAL TEST 3

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Attachment B6: Statistical Test 3, Nonparametric ANOVA, July 2017 Lead URGA

Lead (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	0.001	0.001	**0.00088**	0.001	0.001
Jan-16	**0.00144**	0.001	**0.00108**	**0.00107**	0.001
Jul-16	**0.00181**	0.001	**0.00239**	**0.0056**	0.001
Jan-17	**0.00155**	0.001	**0.00475**	**0.00439**	0.001
Jul-17	**0.00213**	0.001	**0.00267**	**0.00533**	0.001
Sum	0.0129		0.01177	0.01739	0.0050
n_i	10		5	5	5
$(x_i)_{avg}$	0.00129		0.00235	0.00348	0.0010

mg/L = milligrams per liter
BG = background
DL = detection limit
All data sets represent 1/2 DL values for nondetects.
Bolded values indicate a detected result.

Overall mean x.. = 0.00188

N = 25
p = 4
x.. = 0.05

Statistical Test 3, Nonparametric ANOVA

Ranking of Observations

Sequence	Lead (mg/L)	Adjusted Rank	Tie Number
1	0	6.5	Tie 1
2	0	6.5	
3	0	6.5	
4	0	6.5	
5	0	6.5	
6	0	6.5	
7	0	6.5	
8	0	6.5	
9	0	6.5	
10	0	6.5	
11	0	6.5	
12	0	6.5	
13	**0.00088**	13	
14	**0.00107**	14	
15	**0.00108**	15	
16	**0.00144**	16	
17	**0.00155**	17	
18	**0.00181**	18	
19	**0.00213**	19	
20	**0.00239**	20	
21	**0.00267**	21	
22	**0.00439**	22	
23	**0.00475**	23	
24	**0.00533**	24	
25	**0.0056**	25	

mg/L = milligrams per liter
BG = background
DL = detection limit
Bolded values indicate a detected result.
NOTE: For this method, observations below the detection limit that are considered nondetects (i.e., U qualified data) are reported as concentration of 0.

n_{tie}	Adjustment for Ties: $(n_{tie}^3 - n_{tie})$
12	Tie 1 = 1716
	$\sum T_i$ = 1716

Attachment B6: Statistical Test 3, Nonparametric ANOVA, July 2017 Lead URGA

Sums of Ranks and Averages

Lead (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	0	0	**0.00088**	0	0
Jan-16	**0.00144**	0	**0.00108**	**0.00107**	0
Jul-16	**0.00181**	0	**0.00239**	**0.0056**	0
Jan-17	**0.00155**	0	**0.00475**	**0.00439**	0
Jul-17	**0.00213**	0	**0.00267**	**0.00533**	0

Observation Ranks for Lead					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	6.5	6.5	13	6.5	6.5
Jan-16	16	6.5	15	14	6.5
Jul-16	18	6.5	20	25	6.5
Jan-17	17	6.5	23	22	6.5
Jul-17	19	6.5	21	24	6.5
R_i	109		92	91.5	32.5
$(R_i)_{avg}$	10.9		18.4	18.3	6.5
R_i^2/n_i	1188.1		1692.8	1674.5	211.3

$\Sigma R_i^2/n_i$ = 4766.6

mg/L = milligrams per liter
BG = background
DL = detection limit
Bolded values indicate a detected result.

K = 4
N = 25

NOTE: For this method, observations below the detection limit that are considered nondetects (i.e., U qualified data) are reported as a concentration of 0.

Calculation of Kruskal-Wallis Statistic

H =	9.999	Kruskal-Wallis Statistic	$H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$
H' =	11.235	Corrected Kruskal-Wallis	$H' = H/[1-(\sum T_i/N^3-N)]$
χ^2_{crit}* =	7.815	3	degrees of freedom at the 5% significance level

NOTE: $H' > \chi^2_{crit}$

If $H' \leq \chi^2_{crit}$, the data from each well come from the same continuous distribution and hence have the same median concentrations of a specific constituent.

If $H' > \chi^2_{crit}$, reject the null hypothesis and calculate the critical difference for well comparisons to the background.

K-1 =	3	α/(K-1) =	0.01667	Z(α/(K-1))** =	2.1280
α =	0.05	1-(α/K-1) =	0.983		

NOTE *Table 1, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).
**Table 4, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

Calculate Critical Values

Average Background Ranking = 10.900

	Well No.	C_i	$(R_i)_{avg} - (R_b)_{avg}$	Conclusion
BG Well	MW93			
BG Well	MW420			
	MW84	8.578	7.50	not contaminated
	MW87	8.578	7.40	not contaminated
	MW90A	8.578	-4.40	not contaminated

mg/L = milligrams per liter
BG = background
DL = detection limit

CONCLUSION: If $(R_i)_{avg} - (R_b)_{avg} > C_i$, then there is evidence that the compliance well is contaminated.

If $(R_i)_{avg} - (R_b)_{avg} < C_i$ for wells, there is no evidence of a statistically significant difference between downgradient compliance test wells and background wells.

Since $(R_i)_{avg} - (R_b)_{avg} < C_i$ for MW84, MW87, and MW90A, there is no statistically significant difference between compliance test wells and background wells at the C-404 Landfill; however, the negative values indicate that background wells have elevated concentrations.

Section 5.2.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

ATTACHMENT B7

SELENIUM
STATISTICAL TEST 2

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Attachment B7: Statistical Test 2, Test of Proportions, July 2017
Selenium URGA

Selenium (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	0.0025	0.0025	0.0025	0.0025	0.0025
Jan-16	**0.00165**	0.0025	0.0025	0.0025	**0.00231**
Jul-16	0.0025	0.0025	0.0025	**0.00159**	**0.0017**
Jan-17	0.0025	0.0025	**0.00294**	0.0025	0.0025
Jul-17	0.0025	0.0025	0.0025	0.0025	0.0025

mg/L = milligrams per liter
BG = background
DL = detection limit
Nondetect values are 1/2 DL.
Bolded values indicate a detected result.

[!]Test of Proportions

Calculate the number of detections in background wells vs. compliance wells.

X =	1	X = number of samples above DL in background wells
Y =	4	Y = number of samples above DL in compliance wells
n_b =	10	n_b = count of background well results/samples analyzed
n_c =	15	n_c = count of compliance well results/samples analyzed
n =	25	n = total number of samples

P =	0.200	P=(x+y)/n
nP =	5	$n=n_b+n_c$
n(1-P) =	20	

NOTE: If nP and n(1-P) are both >= 5, then the normal approximation may be used.

P_b =	0.100	P_b = proportion of detects in background wells
P_c =	0.267	P_c = proportion of detects in compliance wells
S_D =	0.163	S_D = standard error of difference in proportions
Z =	-1.021	$Z = (P_b-P_c)/S_D$
absolute value of Z =	1.021	

If the absolute value of Z exceeds the 97.5th percentile value of 1.96 from the standard normal distribution, this provides statistically significant evidence at the 5% significance level that the proportion of detects in one group of data exceeds the proportion of detects in the other group.

CONCLUSION: Because the absolute value of Z is less than 1.96, there is no statistical evidence that the proportion of samples with detected results differs between the background well and compliance well samples.

[!]Section 8.1.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (EPA 1989).

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ATTACHMENT B8

SELENIUM, DISSOLVED
STATISTICAL TEST 2

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Attachment B8: Statistical Test 2, Test of Proportions, July 2017
Selenium, Dissolved URGA

Selenium, Dissolved (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	0.0025	0.0025	0.0025	0.0025	0.0025
Jan-16	**0.00225**	0.0025	0.0025	**0.00199**	**0.00197**
Jul-16	0.0025	0.0025	0.0025	0.0025	**0.00157**
Jan-17	0.0025	0.0025	0.0025	0.0025	0.0025
Jul-17	0.0025	0.0025	0.0025	0.0025	0.0025

mg/L = milligrams per liter
BG = background
DL = detection limit
Nondetect values are 1/2 DL.
Bolded values indicate a detected result.

[!] **Test of Proportions**

Calculate the number of detections in background wells vs. compliance wells.

X =	1	X = number of samples above DL in background wells
Y =	3	Y = number of samples above DL in compliance wells
n_b =	10	n_b = count of background well results/samples analyzed
n_c =	15	n_c = count of compliance well results/samples analyzed
n =	25	n = total number of samples

P =	0.160	P = (x+y)/n
nP =	4	$n = n_b+n_c$
n(1-P) =	21	

NOTE: If nP and n(1-P) are both >= 5, then the normal approximation may be used; however, because nP < 5 and/or n(1-P) < 5, the test was continued to determine if the conclusion, along with a simple evaluation of the data would be similar.

P_b =	0.100	P_b = proportion of detects in background wells
P_c =	0.200	P_c = proportion of detects in compliance wells
S_D =	0.150	S_D = standard error of difference in proportions
Z =	-0.668	$Z = (P_b-P_c)/S_D$
absolute value of Z =	0.668	

If the absolute value of Z exceeds the 97.5th percentile value of 1.96 from the standard normal distribution, this provides statistically significant evidence at the 5% significance level that the proportion of detects in one group of data exceeds the proportion of detects in the other group.

CONCLUSION: Because the absolute value of Z is less than 1.96, there is no statistical evidence that the proportion of samples with detected results differs between the background well and compliance well samples.

[!] Section 8.1.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (EPA 1989).

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ATTACHMENT B9

TRICHLOROETHENE
STATISTICAL TESTS 4/3

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Attachment B9: Statistical Test 4, Parametric ANOVA, July 2017 Trichloroethene URGA

Trichloroethene (TCE, µg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	**2520**	**191**	**1530**	**1250**	**37.9**
Jan-16	**2490**	**222**	**1350**	**1230**	**39.8**
Jul-16	**2020**	**169**	**1820**	**1090**	**35.3**
Jan-17	**2450**	**274**	**2620**	**2240**	**49.5**
Jul-17	**1400**	**264**	**2910**	**1620**	**46.1**
n_i	10		5	5	5
Sum	12000		10230	7430	208.60
(x_i)avg	1200.00		2046.00	1486.00	41.72

µg/L = micrograms per liter
Bolded values indicate a detected result.

Overall mean x.. = 1194.74
N = 25
p = 4
x.. = 29868.60

Determine Normality of Dataset

Coefficient of Variability Test

Table of Residuals

Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	1320.00	-1009.00	-516.00	-236.00	-3.82
Jan-16	1290.00	-978.00	-696.00	-256.00	-1.92
Jul-16	820.00	-1031.00	-226.00	-396.00	-6.42
Jan-17	1250.00	-926.00	574.00	754.00	7.78
Jul-17	200.00	-936.00	864.00	134.00	4.38

X: Mean Value = -4.26E-15
S: Standard Deviation = 741.5
K* Factor = 2.292 (for n = 25)
CV = S/X = -1.74E+17 < 1, the data are normally distributed

*K factor [from Table 5, Appendix B of *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989)].

If the coefficient of variation is < 1, the data are normally distributed.
If the coefficient of variation is > or = 1, data are not normally distributed.

Attachment B9: Statistical Test 4, Parametric ANOVA, July 2017 Trichloroethene URGA

Determine Equality of Variance of Dataset

p = number of wells
n_i = number of data points per well
N = total sample size
S^2 = the square of the standard deviation
$\ln(S_i^2)$ = natural logarithm of each variance
f = total sample size minus the number of wells (groups)
$f_i = n_i - 1$

$x_{..} =$ 29868.60
$(x_{avg})_{..} =$ 1194.74

p = 4
N = 25

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$	n_i	$f_i S_i^2$	$f_i \ln(S_i^2)$
1077.677	1161388.67	13.965	10	10452498.0	125.7
685.150	469430.00	13.059	5	1877720.000	52.2
464.898	216130.00	12.284	5	864520.000	49.1
5.899	34.80	3.550	5	139.208	14.2

$\sum(S_i^2) =$ 1846983.47 $\sum f_i \ln(S_i^2) =$ 241.3

Equality of Variance: Bartlett's Test

f = 21
$Sp^2 =$ 628327.486
$\ln Sp^2 =$ 13.351
$\chi^2 =$ 39.111 (If $\chi^2 \leq \chi^2_{crit}$, then variances are equal at the given significance level).
χ^2_{crit} * = 7.815 at a 5% significance level with 3 degrees of freedom

Variances are not equal, transform the original data to lognormal (i.e., since $\chi^2 > \chi^2_{crit}$).

*Table 1, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

Lognormal Data for TCE

ln[TCE (µg/L)]					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	7.83	5.25	7.33	7.13	3.63
Jan-16	7.82	5.40	7.21	7.11	3.68
Jul-16	7.61	5.13	7.51	6.99	3.56
Jan-17	7.80	5.61	7.87	7.71	3.90
Jul-17	7.24	5.58	7.98	7.39	3.83
x_i	65.28		37.89	36.34	18.62
(x_i)avg	6.53		7.58	7.27	3.72

µg/L = micrograms per liter

Determine Normality of Dataset

Coefficient of Variability Test

Table of Residuals

Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	1.30	-1.28	-0.25	-0.14	-0.09
Jan-16	1.29	-1.13	-0.37	-0.15	-0.04
Jul-16	1.08	-1.40	-0.07	-0.27	-0.16
Jan-17	1.28	-0.92	0.29	0.45	0.18
Jul-17	0.72	-0.95	0.40	0.12	0.11

X: Mean Value = 1.60E-16
S: Standard Deviation = 0.77
K* Factor = 2.292 (for n = 25)
CV = S/X = 4.80E+15 > or = 1, log-transformed data are not normally distributed

*K factor [from Table 5, Appendix B of *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989)].

Determine Equality of Variance of Dataset

p = number of wells (background wells considered as one group)
n_i = number of data points per well
N = total sample size
S^2 = the square of the standard deviation
$\ln(S_i^2)$ = natural logarithm of each variance
f = total sample size minus the number of wells (groups)
$f_i = n_i - 1$

$x_{..} =$ 158.14
$(x_{avg})_{..} =$ 6.33
p = 4
N = 25

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$	ni	$f_i S_i^2$	$f_i \ln(S_i^2)$
1.214	1.475	0.389	10	13.275	3.5
0.334	0.112	-2.193	5	0.446	-8.8
0.288	0.083	-2.491	5	0.331	-10.0
0.140	0.020	-3.934	5	0.078	-15.7

$\sum(S_i^2) =$ 1.69 $\sum f_i \ln(S_i^2) =$ -31.0

Equality of Variance: Bartlett's Test

f = 21
$Sp^2 =$ 0.673
$\ln Sp^2 =$ -0.396
$\chi^2 =$ 22.654 (If $\chi^2 \leq \chi^2_{crit}$, then variances are equal at the given significance level).
χ^2_{crit} * = 7.815 at a 5% significance level with 3 degrees of freedom

Variances are not equal (i.e., $\chi^2 \geq \chi^2_{crit}$).

*Table 1, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989)].

Because variances are not equal, Statistical Test 3, Nonparametric ANOVA is performed.**

**Section 5.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989)].

Attachment B9: Statistical Test 3, Nonparametric ANOVA, July 2017 Trichloroethene URGA

Statistical Test 3, Nonparametric ANOVA

TCE (µg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	**2520**	**191**	**1530**	**1250**	**37.9**
Jan-16	**2490**	**222**	**1350**	**1230**	**39.8**
Jul-16	**2020**	**169**	**1820**	**1090**	**35.3**
Jan-17	**2450**	**274**	**2620**	**2240**	**49.5**
Jul-17	**1400**	**264**	**2910**	**1620**	**46.1**
n_i	10		5	5	5
x_i	12000		10230	7430	208.60
(x_i)avg	1200.00		2046.00	1486.00	41.72

µg/L = micrograms per liter
BG=background
DL=detection limit
All data sets represent 1/2 DL values for nondetects.
Bolded values indicate a detected result.

Overall mean x.. = 1194.74

N = 25
p = 4
x.. = 29868.60

Statistical Test 3, Nonparametric ANOVA

Ranking of Observations

Sequence	TCE (µg/L)	Adjusted Rank	Tie Number
1	**35.3**	1	
2	**37.9**	2	
3	**39.8**	3	
4	**46.1**	4	
5	**49.5**	5	
6	**169**	6	
7	**191**	7	
8	**222**	8	
9	**264**	9	
10	**274**	10	
11	**1090**	11	
12	**1230**	12	
13	**1250**	13	
14	**1350**	14	
15	**1400**	15	
16	**1530**	16	
17	**1620**	17	
18	**1820**	18	
19	**2020**	19	
20	**2240**	20	
21	**2450**	21	
22	**2490**	22	
23	**2520**	23	
24	**2620**	24	
25	**2910**	25	

µg/L = micrograms per liter
BG = background
DL = detection limit
Bolded values indicate a detected result.
NOTE: For this method, observations below the detection limit that are considered nondetects (i.e., U qualified data) are reported as a concentration of 0.

Adjustment for Ties: $(ntie^3 - ntie)$

n_{tie} Tie 1 = 0

0

$\sum T_i$ = 0

Attachment B9: Statistical Test 3, Nonparametric ANOVA, July 2017 Trichloroethene URGA

Sums of Ranks and Averages

TCE (µg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	**2520**	**191**	**1530**	**1250**	**37.9**
Jan-16	**2490**	**222**	**1350**	**1230**	**39.8**
Jul-16	**2020**	**169**	**1820**	**1090**	**35.3**
Jan-17	**2450**	**274**	**2620**	**2240**	**49.5**
Jul-17	**1400**	**264**	**2910**	**1620**	**46.1**

Observation Ranks for TCE					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	23	7	16	13	2
Jan-16	22	8	14	12	3
Jul-16	19	6	18	11	1
Jan-17	21	10	24	20	5
Jul-17	15	9	25	17	4
$R_{i.}$	140		97	73	15
$(R_i)_{avg}$	14.0		19.4	14.6	3
R_i^2/n_i	1960.0		1881.8	1065.8	45

$\Sigma R_i^2/n_i$ = 4952.6

K = 4

N = 25

µg/L = micrograms per liter
BG=background
DL=detection limit
Bolded values indicate a detected result.
NOTE: For this method, observations below the detection limit that are considered nondetects (i.e., U qualified data) are reported as a concentration of 0.

Calculation of Kruskal-Wallis Statistic

H = 13.433 Kruskal-Wallis Statistic $H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$

H' = 13.433 Corrected Kruskal-Wallis $H' = H/[1-(\sum T_i/N^3-N)]$

χ^2_{crit} * = 7.815 3 degrees of freedom at the 5% significance level

NOTE: $H' > \chi^2_{crit}$

If $H' \leq \chi^2_{crit}$, the data from each well come from the same continuous distribution and hence have the same median concentrations of a specific constituent.

If $H' > \chi^2_{crit}$, reject the null hypothesis and calculate the critical difference for well comparisons to the background.

K-1 = 3 $\alpha/(K-1)$ = 0.01667 $Z(\alpha/(K-1))$** = 2.128

α = 0.05 $1-(\alpha/K-1)$ = 0.983

NOTE *Table 1, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (USEPA 1989).
**Table 4, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (USEPA 1989).

Attachment B9: Statistical Test 3, Nonparametric ANOVA, July 2017 Trichloroethene URGA

Calculate Critical Values

Average Background Ranking = 14.0

	Well No.	C_i	$(R_i)_{avg} - (R_b)_{avg}$	Conclusion
BG Well	MW93			
BG Well	MW420			
	MW84	8.578	5.40	not contaminated
	MW87	8.578	0.60	not contaminated
	MW90A	8.578	-11.00	not contaminated

µg/L = micrograms per liter
BG = background
DL = detection limit

CONCLUSION: If $(R_i)_{avg} - (R_b)_{avg} > C_i$, then there is evidence that the compliance well is contaminated.

If $(R_i)_{avg} - (R_b)_{avg} < C_i$ for wells, there is no evidence of a statistically significant difference between downgradient compliance test wells and background wells.

Since $(R_i)_{avg} - (R_b)_{avg} < C_i$ for MW84, MW87, and MW90A, there is no statistically significant difference between compliance test wells and background wells at the C-404 Landfill; however, the negative values indicate that background wells have elevated concentrations.

Section 5.2.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

ATTACHMENT B10

URANIUM
STATISTICAL TEST 2

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Attachment B10: Statistical Test 2, Test of Proportions, July 2017 Uranium URGA

Uranium (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-15	0.0001	0.0001	0.0001	0.0001	0.0001
Jan-16	0.0001	0.0001	0.0001	0.0001	0.0001
Jul-16	**0.000165**	0.0001	**0.000345**	**0.000559**	0.0001
Jan-17	**0.000223**	0.0001	**0.000618**	**0.000522**	0.0001
Jul-17	**0.000224**	0.0001	**0.000355**	**0.000571**	0.0001

mg/L = milligrams per liter
BG=background
DL=detection limit
Nondetect values are 1/2 DL.
Bolded values indicate a detected result.

[!] Test of Proportions

Calculate the number of detections in background wells vs. compliance wells.

X=	3	X=number of samples above DL in background wells
Y=	6	Y=number of samples above DL in compliance wells
n_b=	10	n_b=count of background well results/samples analyzed
n_c=	15	n_c=count of compliance well results/samples analyzed
n=	25	n=total number of samples

P =	0.360	P=(x+y)/n
nP =	9	$n=n_b+n_c$
n(1-P) =	16	

NOTE: If nP and n(1-P) are both >= 5, then the normal approximation may be used.

P_b =	0.300	P_b =proportion of detects in background wells
P_c =	0.400	P_c =proportion of detects in compliance wells
S_D =	0.196	S_D=standard error of difference in proportions
Z =	-0.510	$Z = (P_b-P_c)/S_D$
absolute value of Z =	0.510	

If the absolute value of Z exceeds the 97.5th percentile value of 1.96 from the standard normal distribution, this provides statistically significant evidence at the 5% significance level that the proportion of detects in one group of data exceeds the proportion of detects in the other group.

CONCLUSION: Because the absolute value of Z is less than 1.96, there is no statistical evidence that the proportion of samples with detected results differs between the background well and compliance well samples.

[!] Section 8.1.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (EPA, 1989).

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ATTACHMENT B11

STATISTICIAN STATEMENT

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Four Rivers Nuclear Partnership, LLC
5511 Hobbs Road
Kevil, KY 42053
www.fourriversnuclearpartnership.com

November 20, 2017

Ms. Kelly Layne
Four Rivers Nuclear Partnership, LLC
5511 Hobbs Road
Kevil, KY 42053

Dear Ms. Layne:

I am submitting this statement as a supplementary document to the completed statistical analysis I performed on the groundwater data for the C-404 Landfill at the Paducah Gaseous Diffusion Plant.

As a Chemist, with a Bachelor of Science degree in chemistry and a minor in biology, I have over 20 years of experience in reviewing and assessing laboratory analytical results associated with environmental sampling and investigation activities. For the generation of these statistical analyses, my work was observed and reviewed by a senior chemist and geologist with Four Rivers Nuclear Partnership, LLC.

For this project, the statistical analyses on groundwater data from July 2015 through July 2017 were performed in accordance with the C-404 Hazardous Waste Landfill Permit, Appendix E using Microsoft Excel 2010. The spreadsheets include the results for the following statistical tests:

- Test of Proportions
- Parametric Analysis of Variance (ANOVA)
- Nonparametric ANOVA
- 95% Upper Tolerance Limit

The statistical analyses procedures were based on the U.S. Environmental Protection Agency (USEPA) *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Interim Final Guidance* (1989).

Sincerely,

Jennifer R. Blewett

Geosyntec consultants

180A Market Place Boulevard
Knoxville, TN 37922
PH 865.330.0037
www.geosyntec.com

28 November 2017

Ms. Kelly Layne
Four Rivers Nuclear Partnership, LLC
551 Hobbs Road
Kevil, KY 42053

Subject: Mann-Kendall Statistical Analysis

Dear Ms. Layne:

This statement is submitted in response to your request that it be included with the completed Mann-Kendall statistical analysis I performed on the groundwater data for the C-404 Landfill at the Paducah Gaseous Diffusion Plant.

As an environmental microbiologist, with a Ph.D. in Engineering Science, I have over 10 years of experience reviewing and analyzing geochemical results associated with environmental sampling and investigation activities. For the generation of the Mann-Kendall statistical analyses, my work was observed and reviewed by a Senior Principal with Geosyntec Consultants.

For this project, the Mann-Kendall statistical analyses conducted on the well data collected from July 2015 through July 2017 were performed using the XLSTAT statistical software program. This work was conducted in accordance with guidance provided in the U.S. Environmental Protection Agency guidance document, *EPA Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Interim Final Guidance* (1989).

Sincerely,

Andrea Rocha, Ph.D., Senior
Staff Scientist

Geosyntec consultants

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PH 865.330.0037
www.geosyntec.com

29 November 2017

Ms. Kelly Layne
Four Rivers Nuclear Partnership, LLC
551 Hobbs Road
Kevil, KY 42053

Subject: Mann-Kendall Statistical Analysis

Dear Ms. Layne:

This statement is submitted in response to your request that it be included with the completed Mann-Kendall statistical analysis that I checked and on the groundwater data for the C-404 Landfill at the Paducah Gaseous Diffusion Plant.

As an environmental scientist, with a Ph.D. in Life Sciences, I have over 35 years of experience reviewing and analyzing environmental chemistry data associated with environmental sampling, investigation, and remediation activities. For the generation of the Mann-Kendall statistical analyses, I have experience with the method and other parametric and nonparametric statistical methods to a level of expertise that allows me to provide peer and senior review of the analysis.

For this project, the Mann-Kendall statistical analyses conducted on the well data collected from July 2015 through July 2017 were performed using the XLSTAT statistical software program. This work was conducted in accordance with guidance provided in the U.S. Environmental Protection Agency guidance document, *EPA Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Interim Final Guidance* (1989).

Sincerely,

Duane Graves, Ph.D., BCES
Senior Principal

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APPENDIX C

C-404 HAZARDOUS WASTE LANDFILL LEACHATE ANALYTICAL RESULTS

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Paducah OREIS Report for 404L17-01

L1404L1-17 from: C404L on 5/1/2017 Media: WW SmpMethod: GR

Comments: Water level is 04.52' from the top of the manhole. CB 5-1-17

Analysis	Results	Counting Error	Units	Result Qual	Foot Note	Reporting Limit	TPU	Method	V/V/A*
ANION									
Fluoride	8.1		mg/L			0.5		SW846-9056	I / X /
FS									
Conductivity	468		umho/cm					FS	/ /
Dissolved Oxygen	7.84		mg/L					FS	/ /
pH	6.43		Std Unit					FS	/ /
Redox	380		mV					FS	/ /
Temperature	62.9		deg F					FS	/ /
METAL									
Arsenic	0.005		mg/L	U		0.005		SW846-6020	/ X /
Barium	0.0777		mg/L			0.002		SW846-6020	/ X /
Cadmium	0.001		mg/L	U		0.001		SW846-6020	/ X /
Chromium	0.01		mg/L	U		0.01		SW846-6020	/ X /
Copper	0.00901		mg/L			0.001		SW846-6020	/ X /
Iron	0.21		mg/L			0.1		SW846-6020	/ X /
Lead	0.002		mg/L	U		0.002		SW846-6020	/ X /
Mercury	0.0002		mg/L	U		0.0002		SW846-7470A	/ X /
Nickel	0.00415		mg/L			0.002		SW846-6020	/ X /
Selenium	0.0036		mg/L	BJ		0.005		SW846-6020	S / X /
Silver	0.001		mg/L	U		0.001		SW846-6020	/ X /
Uranium	109		mg/L			0.5		SW846-6020	I / X /
Zinc	0.01		mg/L	U		0.01		SW846-6020	/ X /
PPCB									
PCB-1016	0.0971		ug/L	U		0.0971		SW846-8082	/ X /
PCB-1221	0.0971		ug/L	U		0.0971		SW846-8082	/ X /
PCB-1232	0.0971		ug/L	U		0.0971		SW846-8082	/ X /
PCB-1242	0.0971		ug/L	U		0.0971		SW846-8082	/ X /

*Verification/Validation/Assessment

PCB-1248	0.808		ug/L		0.0971		SW846-8082	/ X /
PCB-1254	0.0971		ug/L	U	0.0971		SW846-8082	/ X /
PCB-1260	0.0576		ug/L	J	0.0971		SW846-8082	/ X /
PCB-1268	0.0971		ug/L	U	0.0971		SW846-8082	/ X /
Polychlorinated biphenyl	0.865		ug/L		0.0971		SW846-8082	I / X /
RADS								
Cesium-137	-0.557	5.54	pCi/L	U	9.14	5.54	EPA-901.1	/ X /
Neptunium-237	1.33	1.38	pCi/L	U	1.46	1.39	Alpha Spectroscopy	/ X /
Plutonium-239/240	0.0423	0.442	pCi/L	U	0.922	0.442	HASl 300, Pu-11-RC M	/ X /
Technetium-99	374	19.3	pCi/L		19	45.7	HASL 300, Tc-02-RC M	S / X /
Thorium-230	0.0183	0.762	pCi/L	U	1.65	0.764	HASL 300, Th-01-RC M	/ X /
Uranium-234	3680	478	pCi/L		88.9	846	HASL 300, U-02-RC M	S / X /
Uranium-235	744	243	pCi/L		110	281	HASL 300, U-02-RC M	S / X /
Uranium-238	40200	1580	pCi/L		106	7790	HASL 300, U-02-RC M	/ X /
VOA								
Trichloroethene	1		ug/L	U	1		SW846-8260B	/ X /
WETCHEM								
Ammonia as Nitrogen	0.0894		mg/L		0.05		EPA-350.1	/ X /

Paducah OREIS Report for 404L17-01

L1404LD1-17 from: C404L on 5/1/2017 Media: WW SmpMethod: GR

Comments: Water level is 04.52' from the top of the manhole. CB 5-1-17

Analysis	Results	Counting Error	Units	Result Qual	Foot Note	Reporting Limit	TPU	Method	V/V/A*
ANION									
Fluoride	8.17		mg/L			0.5		SW846-9056	I / X /
FS									
Conductivity	468		umho/cm					FS	/ /
Dissolved Oxygen	7.84		mg/L					FS	/ /
pH	6.43		Std Unit					FS	/ /
Redox	380		mV					FS	/ /
Temperature	62.9		deg F					FS	/ /
METAL									
Arsenic	0.005		mg/L	U		0.005		SW846-6020	/ X /
Barium	0.0792		mg/L			0.002		SW846-6020	/ X /
Cadmium	0.001		mg/L	U		0.001		SW846-6020	/ X /
Chromium	0.01		mg/L	U		0.01		SW846-6020	/ X /
Copper	0.00909		mg/L			0.001		SW846-6020	/ X /
Iron	0.207		mg/L			0.1		SW846-6020	/ X /
Lead	0.002		mg/L	U		0.002		SW846-6020	/ X /
Mercury	0.0002		mg/L	U		0.0002		SW846-7470A	/ X /
Nickel	0.00418		mg/L			0.002		SW846-6020	/ X /
Selenium	0.00461		mg/L	BJ		0.005		SW846-6020	S / X /
Silver	0.000399		mg/L	J		0.001		SW846-6020	S / X /
Uranium	116		mg/L			0.5		SW846-6020	I / X /
Zinc	0.01		mg/L	U		0.01		SW846-6020	/ X /
PPCB									
PCB-1016	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1221	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1232	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1242	0.098		ug/L	U		0.098		SW846-8082	/ X /

*Verification/Validation/Assessment

PCB-1248	0.935		ug/L		0.098		SW846-8082	/ X /
PCB-1254	0.098		ug/L	U	0.098		SW846-8082	/ X /
PCB-1260	0.0479		ug/L	JP	0.098		SW846-8082	S / X /
PCB-1268	0.098		ug/L	U	0.098		SW846-8082	/ X /
Polychlorinated biphenyl	0.983		ug/L		0.098		SW846-8082	I / X /
RADS								
Cesium-137	-3.69	8.3	pCi/L	U	14	8.47	EPA-901.1	/ X /
Neptunium-237	1.9	1.69	pCi/L	U	1.99	1.7	Alpha Spectroscopy	/ X /
Plutonium-239/240	0.0848	0.548	pCi/L	U	1.12	0.548	HASl 300, Pu-11-RC M	/ X /
Technetium-99	354	19.7	pCi/L		20.2	43.8	HASL 300, Tc-02-RC M	/ X /
Thorium-230	1.08	1.1	pCi/L	U	1.49	1.13	HASL 300, Th-01-RC M	/ X /
Uranium-234	4090	529	pCi/L		97.9	967	HASL 300, U-02-RC M	S / X /
Uranium-235	558	223	pCi/L		121	249	HASL 300, U-02-RC M	/ X /
Uranium-238	42500	1700	pCi/L		116	8570	HASL 300, U-02-RC M	/ X /
VOA								
Trichloroethene	1		ug/L	U	1		SW846-8260B	/ X /
WETCHEM								
Ammonia as Nitrogen	0.0957		mg/L		0.05		EPA-350.1	/ X /

FB404L1-17 from: QC on 5/1/2017 Media: WQ SmpMethod:

Comments:

Analysis	Results	Counting Error	Units	Result Qual	Foot Note	Reporting Limit	TPU	Method	V/V/A*
ANION									
Fluoride	0.1		mg/L	U		0.1		SW846-9056	/ X /
METAL									
Arsenic	0.00225		mg/L	J		0.005		SW846-6020	/ X /
Barium	0.002		mg/L	U		0.002		SW846-6020	/ X /
Cadmium	0.001		mg/L	U		0.001		SW846-6020	/ X /
Chromium	0.01		mg/L	U		0.01		SW846-6020	/ X /
Copper	0.001		mg/L	U		0.001		SW846-6020	/ X /
Iron	0.1		mg/L	U		0.1		SW846-6020	/ X /
Lead	0.002		mg/L	U		0.002		SW846-6020	/ X /
Mercury	0.0002		mg/L	U		0.0002		SW846-7470A	/ X /
Nickel	0.002		mg/L	U		0.002		SW846-6020	/ X /
Selenium	0.00314		mg/L	BJ		0.005		SW846-6020	/ X /
Silver	0.001		mg/L	U		0.001		SW846-6020	/ X /
Uranium	0.000437		mg/L			0.0002		SW846-6020	/ X /
Zinc	0.01		mg/L	U		0.01		SW846-6020	/ X /
PPCB									
PCB-1016	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1221	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1232	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1242	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1248	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1254	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1260	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1268	0.098		ug/L	U		0.098		SW846-8082	/ X /
Polychlorinated biphenyl	0.098		ug/L	U		0.098		SW846-8082	/ X /
RADS									

*Verification/Validation/Assessment

Cesium-137	5.62	6.12	pCi/L	U	13.3	6.64	EPA-901.1	/ X /
Neptunium-237	-0.242	0.526	pCi/L	U	1.62	0.527	Alpha Spectroscopy	/ X /
Plutonium-239/240	0.164	0.559	pCi/L	U	1.04	0.56	HASl 300, Pu-11-RC M	/ X /
Technetium-99	-14.2	11.4	pCi/L	U	20.4	11.4	HASL 300, Tc-02-RC M	/ X /
Thorium-230	0.509	0.891	pCi/L	U	1.47	0.903	HASL 300, Th-01-RC M	/ X /
Uranium-234	0.523	1.12	pCi/L	U	1.99	1.13	HASL 300, U-02-RC M	/ X /
Uranium-235	0.143	0.792	pCi/L	U	1.52	0.793	HASL 300, U-02-RC M	/ X /
Uranium-238	0.621	1.01	pCi/L	U	1.56	1.01	HASL 300, U-02-RC M	/ X /
VOA								
Trichloroethene	1		ug/L	U	1		SW846-8260B	/ X /
WETCHEM								
Ammonia as Nitrogen	0.0277		mg/L	J	0.05		EPA-350.1	/ X /

Paducah OREIS Report for 404L17-01

RI404L1-17 from: QC on 5/1/2017 Media: WQ SmpMethod:

Comments:

Analysis	Results	Counting Error	Units	Result Qual	Foot Note	Reporting Limit	TPU	Method	V/V/A*
ANION									
Fluoride	0.1		mg/L	U		0.1		SW846-9056	/ X /
METAL									
Arsenic	0.005		mg/L	U		0.005		SW846-6020	/ X /
Barium	0.002		mg/L	U		0.002		SW846-6020	/ X /
Cadmium	0.001		mg/L	U		0.001		SW846-6020	/ X /
Chromium	0.01		mg/L	U		0.01		SW846-6020	/ X /
Copper	0.001		mg/L	U		0.001		SW846-6020	/ X /
Iron	0.1		mg/L	U		0.1		SW846-6020	/ X /
Lead	0.002		mg/L	U		0.002		SW846-6020	/ X /
Mercury	0.0002		mg/L	U		0.0002		SW846-7470A	/ X /
Nickel	0.002		mg/L	U		0.002		SW846-6020	/ X /
Selenium	0.005		mg/L	U		0.005		SW846-6020	/ X /
Silver	0.000376		mg/L	J		0.001		SW846-6020	/ X /
Uranium	0.0002		mg/L	U		0.0002		SW846-6020	/ X /
Zinc	0.01		mg/L	U		0.01		SW846-6020	/ X /
PPCB									
PCB-1016	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1221	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1232	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1242	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1248	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1254	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1260	0.098		ug/L	U		0.098		SW846-8082	/ X /
PCB-1268	0.098		ug/L	U		0.098		SW846-8082	/ X /
Polychlorinated biphenyl	0.098		ug/L	U		0.098		SW846-8082	/ X /
RADS									

*Verification/Validation/Assessment

Cesium-137	-2.59	3.94	pCi/L	U	6.82	4.11	EPA-901.1	/ X /
Neptunium-237	-0.319	0.62	pCi/L	U	1.96	0.621	Alpha Spectroscopy	/ X /
Plutonium-239/240	0.0548	0.624	pCi/L	U	1.33	0.625	HASl 300, Pu-11-RC M	/ X /
Technetium-99	-3.9	11.5	pCi/L	U	20	11.5	HASL 300, Tc-02-RC M	/ X /
Thorium-230	-0.0979	0.648	pCi/L	U	1.6	0.65	HASL 300, Th-01-RC M	/ X /
Uranium-234	0.0103	0.763	pCi/L	U	1.7	0.764	HASL 300, U-02-RC M	/ X /
Uranium-235	-0.0763	0.658	pCi/L	U	1.53	0.66	HASL 300, U-02-RC M	/ X /
Uranium-238	0.0103	0.763	pCi/L	U	1.7	0.764	HASL 300, U-02-RC M	/ X /
VOA								
Trichloroethene	1		ug/L	U	1		SW846-8260B	/ X /
WETCHEM								
Ammonia as Nitrogen	0.0696		mg/L		0.05		EPA-350.1	/ X /

TB404L1-17 from: QC on 5/1/2017 Media: WQ SmpMethod:

Comments:

Analysis	Results	Counting Error	Units	Result Qual	Foot Note	Reporting Limit	TPU	Method	V/V/A*
VOA									
Trichloroethene	1		ug/L	U		1		SW846-8260B	/ X /

*Verification/Validation/Assessment

Paducah OREIS Report for 404L17-02

L1404L2-17 from: C404L on 7/13/2017 Media: WW SmpMethod: GR

Comments: Water level is 5.50 from the top of the manhole. In order to retrieve a vertical profile, samplers lowered & raised the Teflon tubing. There was a slight buildup of sediment in the bottom. Used a peristaltic pump to retrieve samples. CB 7-13-17

Analysis	Results	Counting Error	Units	Result Qual	Foot Note	Reporting Limit	TPU	Method	V/V/A*
ANION									
Fluoride	8.19		mg/L			0.2		SW846-9056	I / X /
FS									
Conductivity	485		umho/cm					FS	/ /
Dissolved Oxygen	6.51		mg/L					FS	/ /
pH	6.87		Std Unit					FS	/ /
Redox	376		mV					FS	/ /
Temperature	71.3		deg F					FS	/ /
METAL									
Arsenic	0.00632		mg/L			0.005		SW846-6020	S / X /
Barium	0.224		mg/L			0.002		SW846-6020	S / X /
Cadmium	0.00124		mg/L			0.001		SW846-6020	/ X /
Chromium	0.0897		mg/L			0.01		SW846-6020	/ X /
Copper	0.0857		mg/L	N		0.001		SW846-6020	/ X /
Iron	20.9		mg/L			0.1		SW846-6020	S / X /
Lead	0.028		mg/L			0.002		SW846-6020	/ X /
Mercury	0.00138		mg/L	*		0.0002		SW846-7470A	/ X /
Nickel	0.435		mg/L			0.002		SW846-6020	S / X /
Selenium	0.005		mg/L	U		0.005		SW846-6020	/ X /
Silver	0.00231		mg/L			0.001		SW846-6020	/ X /
Uranium	122		mg/L			0.2		SW846-6020	I / X /
Zinc	0.144		mg/L			0.01		SW846-6020	/ X /
PPCB									
PCB-1016	10		ug/L	UY1		10		SW846-8082	/ X / BL-QC
PCB-1221	10		ug/L	U		10		SW846-8082	/ X /
PCB-1232	10		ug/L	U		10		SW846-8082	/ X /
PCB-1242	10		ug/L	U		10		SW846-8082	/ X /

*Verification/Validation/Assessment

PCB-1248	81.3		ug/L		10	SW846-8082	S / X /
PCB-1254	30.7		ug/L		10	SW846-8082	S / X /
PCB-1260	5.21		ug/L	J	10	SW846-8082	/ X /
PCB-1268	10		ug/L	U	10	SW846-8082	/ X /
Polychlorinated biphenyl	117		ug/L		10	SW846-8082	I / X /
RADS							
Cesium-137	-5.14	8.98	pCi/L	U	15.4	EPA-901.1	/ X /
Neptunium-237	1.69	1.83	pCi/L	U	2.61	Alpha Spectroscopy	/ X /
Plutonium-239/240	0.179	0.613	pCi/L	U	1.14	HASL 300, Pu-11-RC M	/ X /
Technetium-99	305	19.4	pCi/L		19.4	HASL 300, Tc-02-RC M	/ X /
Thorium-230	10.8	3.1	pCi/L		1.76	HASL 300, Th-01-RC M	/ X /
Uranium-234	3700	511	pCi/L		101	HASL 300, U-02-RC M	S / X /
Uranium-235	469	208	pCi/L		108	HASL 300, U-02-RC M	/ X /
Uranium-238	32000	1500	pCi/L		54.8	HASL 300, U-02-RC M	/ X /
VOA							
Trichloroethene	0.44		ug/L	J	1	SW846-8260B	S / X /
WETCHEM							
Ammonia as Nitrogen	0.162		mg/L		0.05	EPA-350.1	/ X /

TB404L2-17 from: QC on 7/13/2017 Media: WQ SmpMethod:

Comments:

Analysis	Results	Counting Error	Units	Result Qual	Foot Note	Reporting Limit	TPU	Method	V/V/A*
VOA									
Trichloroethene	1		ug/L	U		1		SW846-8260B	/ X /

*Verification/Validation/Assessment

APPENDIX D

C-404 HAZARDOUS WASTE LANDFILL GROUNDWATER FLOW RATE AND DIRECTION

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2017 ANNUAL REPORT OF THE C-404 LANDFILL HYDRAULIC FLOW RATE AND DIRECTION

The C-404 Hazardous Waste Landfill (C-404 Landfill) Permit requires annual determination of average hydraulic flow rate and direction of flow in the uppermost aquifer. The uppermost aquifer below C-404 Landfill is the Regional Gravel Aquifer (RGA). Water level measurements currently are taken from several wells at the perimeter of the C-404 Landfill on a semiannual basis. The water levels used for this analysis (taken on January 24 and July 26, 2017) were measured as closely as possible and within a 24-hour period to ensure the comparability of the data. These measurements were used to plot the potentiometric surface of the upper RGA for the January and July 2017 sampling events.

Contours for each potentiometric surface were drawn after water-level data were corrected for barometric pressure; groundwater hydraulic gradients then are calculated from the contours. The average of the gradients measured during this reporting period is the annual average groundwater hydraulic gradient for the upper RGA and is calculated at 1.28×10^{-3} ft/ft.

The hydraulic conductivity (K) values reported in the *Resource Conservation and Recovery Act (RCRA) Part B Permit Modification for Inclusion of C-404 Low-Level Radioactive/Hazardous Waste Landfill* (Clausen et al., 1992) were determined by multi-well testing and range from 21 to 140 ft/day (7.41×10^{-3} to 4.94×10^{-2} cm/s).

Multiplication of the hydraulic gradient (i) and the hydraulic conductivity (K) yields the specific discharge (q) for a unit area of the RGA. Annual average linear-flow velocity (v) is calculated by multiplying the hydraulic conductivity by the gradient and dividing by the porosity (n). It is assumed that (n) equals 25 percent in the RGA beneath the C-404 Landfill.

Table D.1 summarizes the annual average results of the calculations. Table D.2 presents the calculation information for the annual groundwater flow rate. The January and July potentiometric surface data of the upper RGA are presented in Tables D.3 and D.4, and potentiometric surface maps are presented in Figures D.1 and D.2.

Table D.1. C-404 Landfill Annual Average Groundwater Flow Rate for 2017

Hydraulic Conductivity (K) Range	Annual Average Specific Discharge (q) ft/day (cm/s)	Annual Average Linear Flow Velocity (v) ft/day cm/s)
High K	0.18 (6.3×10^{-5})	0.72 (2.5×10^{-4})
Low K	0.03 (9.5×10^{-6})	0.11 (3.8×10^{-5})

The potentiometric contours depict the directions of hydraulic flow during each sampling event. Hydraulic flow direction beneath the C-404 Landfill generally trends northeastward, but commonly varies from northeast to north.

Table D.2. Calculation Information for the C-404 Landfill Annual Groundwater Flow Rate 2017

Upper RGA K = 21 ft/d					
	i (ft/ft)	q (ft/d)	q (cm/s)	v (ft/d)	v (cm/s)
January 2017	-1.14E-03	0.02	8.4E-06	0.10	3.4E-05
July 2017	-1.42E-03	0.03	1.1E-05	0.12	4.2E-05
Annual Average	**-1.28E-03**	**0.03**	**9.5E-06**	**0.11**	**3.8E-05**
Upper RGA K = 140 ft/d					
	i (ft/ft)	q (ft/d)	q (cm/s)	v (ft/d)	v (cm/s)
January 2017	-1.14E-03	0.16	5.6E-05	0.64	2.3E-04
July 2017	-1.42E-03	0.20	7.0E-05	0.80	2.8E-04
Annual Average	**-1.28E-03**	**0.18**	**6.3E-05**	**0.72**	**2.5E-04**

q = K*i

where:
q = specific discharge (per unit area)
K = hydraulic conductivity
i = hydraulic gradient (from potentiometric map)

v = q/n

where:
v = average linear velocity
q = specific discharge
n_e = porosity (assumed to be 25%)

ft/ft = foot per foot
ft/d = foot per day
cm/s = centimeter/second

Table D.3. Barometric Pressure Corrections

C-404 Landfill (January 2017) Water Levels									
						Raw Data		Corrected Data*	
Date	Time	Well	Datum Elev (ft amsl)	BP (in Hg)	Delta BP (ft H_20)	DTW (ft)	Elev (ft amsl)	DTW (ft)	Elev (ft amsl)
1/24/2017	7:55	MW67	374.95	29.92	0.00	50.82	324.13	50.82	324.13
1/24/2017	8:06	MW76	376.77	29.92	0.00	52.54	324.23	52.54	324.23
1/24/2017	14:13	MW86[1]	375.97	29.84	0.09	51.68	324.29	51.77	324.20
1/24/2017	7:52	MW87	375.79	29.92	0.00	51.72	324.07	51.72	324.07
1/24/2017	7:49	MW90A	374.20	29.92	0.00	50.28	323.92	50.28	323.92
1/24/2017	8:02	MW93	377.67	29.92	0.00	53.25	324.42	53.25	324.42
1/24/2017	10:25	MW227	378.81	29.92	0.00	54.29	324.52	54.29	324.52
1/24/2017	8:03	MW333	377.35	29.92	0.00	52.85	324.50	52.85	324.50
1/24/2017	8:15	MW337	374.67	29.92	0.00	50.35	324.32	50.35	324.32
1/24/2017	8:17	MW338	374.86	29.92	0.00	50.60	324.26	50.60	324.26
1/24/2017	7:58	MW420	377.70	29.92	0.00	53.36	324.34	53.36	324.34

[1]Measurement for MW86 (lower RGA) used in place of measurement for MW84 (upper RGA)
Initial Barometric Pressure 29.92
Elev = elevation
amsl = above mean sea level
BP = barometric pressure
DTW = depth to water in feet below datum
*Assumes a barometric efficiency of 1.0

Table D.4. Barometric Pressure Corrections

C-404 Landfill (July 2017) Water Levels									
						Raw Data		Corrected Data*	
Date	Time	Well	Datum Elev (ft amsl)	BP (in Hg)	Delta BP (ft H20)	DTW (ft)	Elev (ft amsl)	DTW (ft)	Elev (ft amsl)
7/26/2017	7:59	MW67	374.95	30.07	0.00	47.37	327.58	47.37	327.58
7/26/2017	7:43	MW76	376.77	30.07	0.00	49.06	327.71	49.06	327.71
7/26/2017	8:07	MW84	376.01	30.07	0.00	48.45	327.56	48.45	327.56
7/26/2017	7:59	MW87	375.79	30.07	0.00	48.27	327.52	48.27	327.52
7/26/2017	7:53	MW90A	374.20	30.07	0.00	46.81	327.39	46.81	327.39
7/26/2017	7:49	MW93	377.67	30.07	0.00	49.74	327.93	49.74	327.93
7/26/2017	7:41	MW227	378.81	30.07	0.00	50.82	327.99	50.82	327.99
7/26/2017	7:51	MW333	377.35	30.07	0.00	49.33	328.02	49.33	328.02
7/26/2017	8:00	MW337	374.67	30.07	0.00	46.81	327.86	46.81	327.86
7/26/2017	8:05	MW338	374.86	30.07	0.00	47.10	327.76	47.10	327.76
7/26/2017	7:15	MW420	377.70	30.07	0.00	49.88	327.82	49.88	327.82

Initial Barometric Pressure 30.07
Elev = elevation
amsl = above mean sea level
BP = barometric pressure
DTW = depth to water in feet below datum
*Assumes a barometric efficiency of 1.0

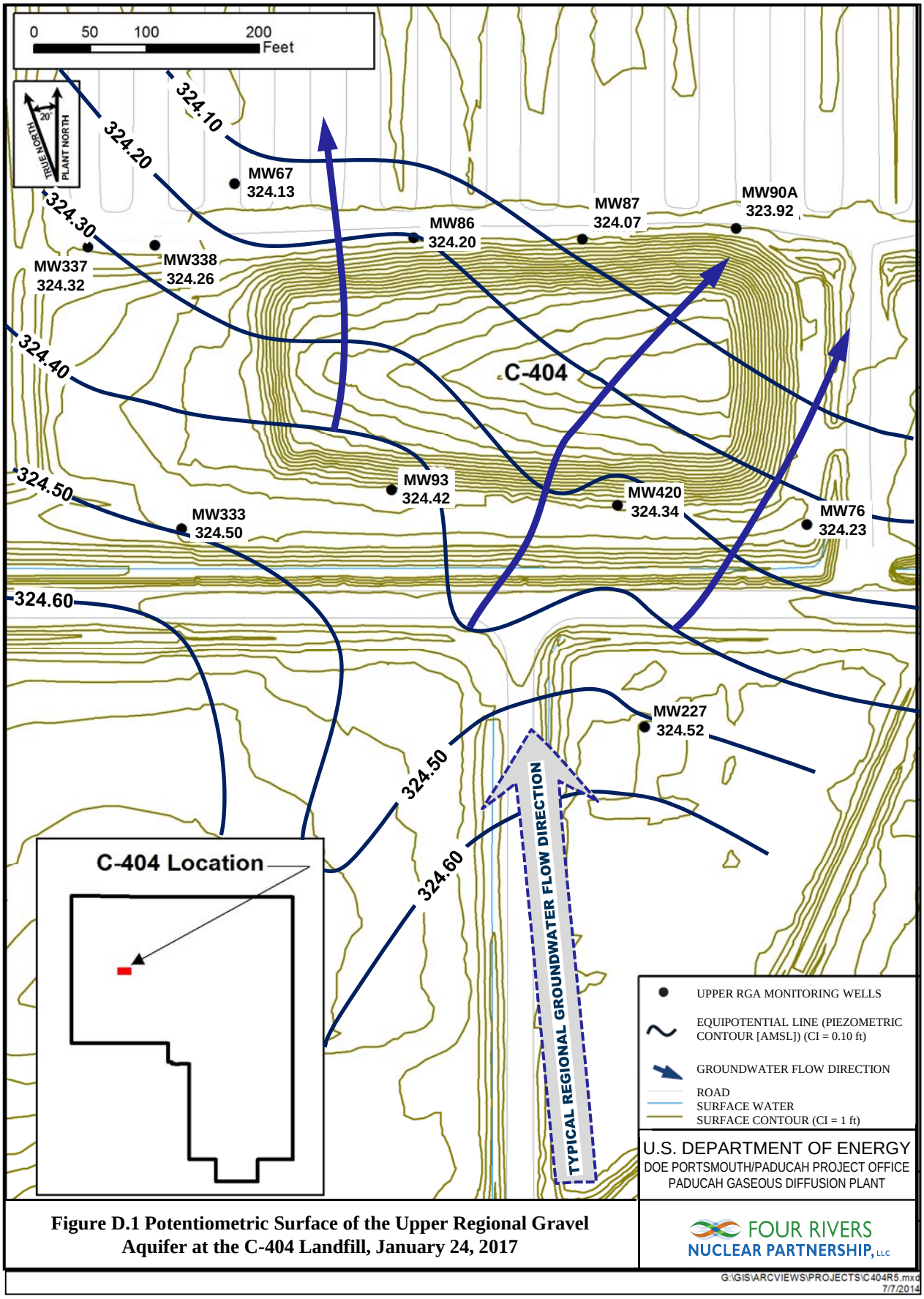

Figure D.1 Potentiometric Surface of the Upper Regional Gravel Aquifer at the C-404 Landfill, January 24, 2017

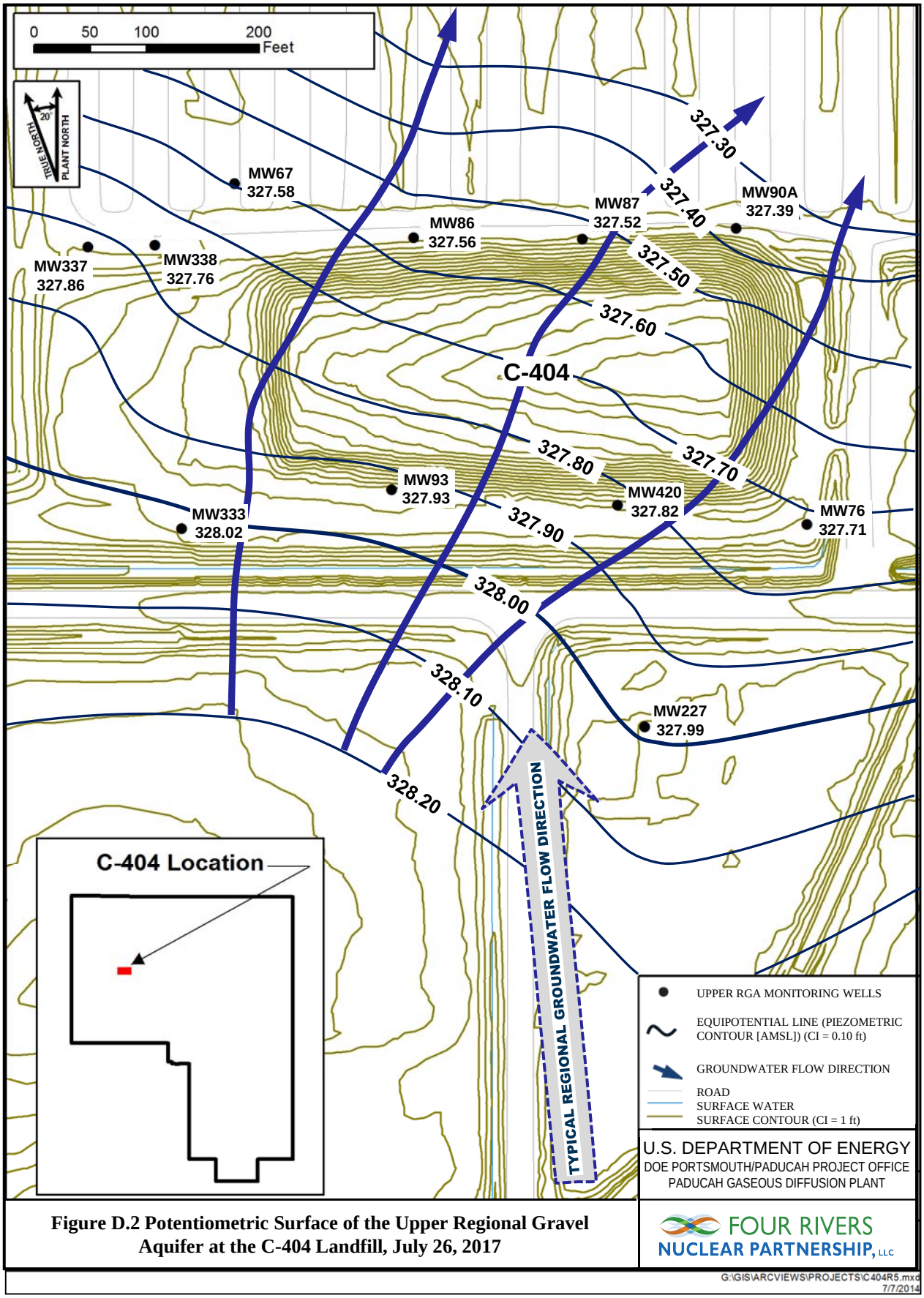

Figure D.2 Potentiometric Surface of the Upper Regional Gravel Aquifer at the C-404 Landfill, July 26, 2017