Department of Energy
Portsmouth/Paducah Project Office
1017 Majestic Drive, Suite 200
Lexington, Kentucky 40513
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May 27, 2020

Ms. Lauren Linehan
Division of Waste Management
Kentucky Department for Environmental Protection
625 Hospital Drive
Madisonville, Kentucky 42431

PPPO-02-10005980-20B

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

Dear Ms. Linehan and Ms. Webb:

C-404 HAZARDOUS WASTE LANDFILL MAY 2020 SEMIANNUAL GROUNDWATER REPORT (OCTOBER 2019–MARCH 2020), PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY, FRNP-RPT-0135/V1, HAZARDOUS WASTE MANAGEMENT FACILITY PERMIT NO. KY8-890-008-982, AGENCY INTEREST ID NO. 3059
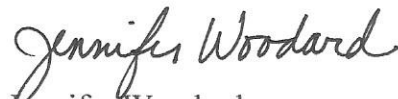
Enclosed is the subject report for the first reporting period 2020. This report is required in accordance with Part II, Specific Condition II.K.6.d, of Hazardous Waste Management Facility Permit No. KY8-890-008-982 (Permit).

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 trichloroethene (TCE) in monitoring well MW87A. This report presents a technical justification to apply the 2007 *C-404 Landfill Source Demonstration, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PRS-ENM-0031/R2 (ASD), demonstrating that the C-404 Landfill is not the source of the statistical exceedance for TCE observed in MW87A. This demonstration for TCE in MW87A fulfills Section II.K.8 of the Hazardous Waste Management Facility Permit, which allows for demonstrating that the exceedance is consistent with the findings in the 2007 ASD and also allows for the demonstration to be submitted within the semiannual report.

Notification of the statistically significant difference for TCE in MW87A was submitted, pursuant to Part II, Specific Condition II.K.6.a, to your department 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 May 2020 Semiannual Groundwater Report

cc w/enclosures:
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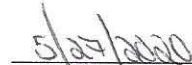weeks.victor@epa.gov, EPA

CERTIFICATION

Document Identification: *C-404 Hazardous Waste Landfill May 2020 Semiannual Groundwater Report (October 2019–March 2020), Paducah Gaseous Diffusion Plant, Paducah, Kentucky, FRNP-RPT-0135/V1, Permit No. KY8-890-008-982, Agency Interest ID No. 3059, dated May 2020*

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those 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, Program Manager   Date Signed
Four Rivers Nuclear Partnership, LLC
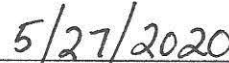
I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those 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

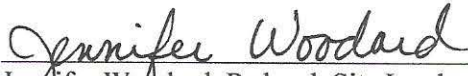_____   _____
Jennifer Woodard, Paducah Site Lead   Date Signed
Portsmouth/Paducah Project Office   5/27/2020
U.S. Department of Energy

C-404 Hazardous Waste Landfill
May 2020 Semiannual
Groundwater Report
(October 2019–March 2020),
Paducah Gaseous Diffusion Plant,
Paducah, Kentucky

FOUR RIVERS
NUCLEAR PARTNERSHIP, LLC

This document is approved for public release per review by:

David Hayden

FRNP Classification Support

5-20-2020

Date

C-404 Hazardous Waste Landfill
May 2020 Semiannual
Groundwater Report
(October 2019–March 2020),
Paducah Gaseous Diffusion Plant,
Paducah, Kentucky

Date Issued—May 2020

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
ASD	alternate source demonstration
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
KDWM	Kentucky Division of Waste Management
MW	monitoring well
RCRA	Resource Conservation and Recovery Act
RGA	Regional Gravel Aquifer
UCRS	Upper Continental Recharge System
URGA	Upper Regional Gravel Aquifer

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EXECUTIVE SUMMARY

This report, *C-404 Hazardous Waste Landfill May 2020 Semiannual Groundwater Report (October 2019– March 2020), Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* FRNP-RPT-0135/V1, is being submitted by the U.S. Department of Energy in accordance with requirements in Kentucky Division of Waste Management Hazardous Waste Management Facility Permit, KY8-890-008-982 (Permit). This first reporting period 2020 covers October 2019 through March 2020 and includes analytical data from the January 2020 sampling of monitoring wells located in the vicinity of the closed C-404 Hazardous Waste Landfill (C-404 Landfill).

The groundwater monitoring analytical data were subjected to statistical analyses. The analyses were conducted in accordance with the Hazardous Waste Management Facility Permit. Trichloroethene (TCE) concentrations in compliance monitoring well (MW) MW87A were statistically different from concentrations in the background wells. The statistical tests on all other parameters showed no statistical difference between concentrations in the compliance and background wells. The first quarter 2020 is the first occurrence of a statistical exceedance for TCE in MW87A.

TCE concentration trends have increased for both background and compliance well locations, indicating that the plume discussed in the 2007 *C-404 Landfill Source Demonstration, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PRS-ENM-0031/R2 (PRS 2007a) (ASD) appears to have continued to migrate northeastward impacting upgradient well MW420 and compliance well MW87A. Additionally, with one exception (July 2017—0.44 µg/L), none of the C-404 Landfill leachate samples collected over the past 10 years have had detectable concentrations of TCE; therefore, consistent with the findings in the 2007 ASD, the C-404 Landfill cannot be the source of the TCE found in the MWs. This determination for TCE in MW87A fulfills Section II.K.8 of the Hazardous Waste Management Facility Permit, which allows for demonstrating that the exceedance is consistent with the findings in the 2007 ASD and also allows for the demonstration to be submitted within the semiannual report.

The leachate in the C-404 Landfill leachate collection system is monitored, at least monthly and, at a minimum, is removed and sampled when the level exceeds 3 ft in depth. The volume of leachate removed from the sump during this reporting period, October 2019 through March 2020, was 2,775 gal. The leachate was sampled on January 8 and February 18, 2020. Analytical results for the January and February 2020 leachate samples 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 closed C-404 Hazardous Waste Landfill (C-404 Landfill) at the U.S. Department of Energy Paducah Site (Paducah Site), Paducah, Kentucky. This semiannual report is required by the Kentucky Division of Waste Management Hazardous Waste Management Facility Permit, KY8-890-008-982 (Permit) (KDWM 2020), Specific Condition II.K.6.d—Recordkeeping, Reporting, and Response. The period covered by this report is October 2019 through March 2020.

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.

1.1 BACKGROUND

The closed C-404 Landfill is located in the west-central portion of the Paducah Site 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 the 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 Management Facility Permit (KDWM 2020).

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 2007a) documented that the source of the TCE in compliance wells is not from the C-404 Landfill, but rather, the source is located upgradient/crossgradient of the C-404 Landfill.

Regional Gravel Aquifer (RGA) compliance monitoring well (MW) 90A was abandoned and replaced in 2001. RGA compliance well MW420 was installed in 2007 to assess groundwater quality at the C-404 Landfill better (PRS 2007b). The Burial Grounds Operable Unit evaluated the MW network at the C-404 Landfill relative to the prevailing groundwater flow direction and concluded that the additional RGA well was needed to assess upgradient groundwater quality.

Previous groundwater monitoring of RGA compliance well MW87 documented that concentrations in the compliance well were statistically different from background wells for lead and uranium (FRNP 2018). The *C-404 Hazardous Waste Landfill Alternate Source Demonstration—Source of Lead and Uranium in MW87 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, (FRNP 2019) concluded that the statistical differences were a result of infiltration of UCRS groundwater into the RGA well due to compromised integrity of the well. The integrity of the well had deteriorated to a point that it no longer was suitable for its intended purpose. RGA compliance wells MW84, MW87, and background well MW93 were abandoned and replaced with MW84A, MW87A, and MW93A in 2019. RGA wells MW84 and MW93 were abandoned and replaced because they were the same age (installed in 1988) as MW87. MW84A and

MW87A were placed 10 ft north of MW84 and MW87, respectively, and screened at the same depth intervals. MW93A was placed 6 ft west of MW91 and screened at the same depth interval.

1.2 MONITORING PERIOD ACTIVITIES

1.2.1 Groundwater Monitoring

There are nine MWs sampled under the Permit for the C-404 Landfill: four UCRS wells and five Upper Regional Gravel Aquifer (URGA) wells. A map of the MW locations is provided in Figure 1.

Table 1 presents the well number 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 the UCRS wells as being adjacent to an upgradient or downgradient URGA well location identified relative to these URGA groundwater flow direction. The conceptual model for the C-404 Landfill indicates that groundwater in the UCRS wells flows primarily vertically downward until it reaches the URGA; therefore, UCRS wells are not considered "upgradient" or "downgradient" of other wells in the area.

Table 1. Monitoring Well Locations

UCRS	
Located south of C-404 Landfill, adjacent to upgradient URGA background well MW93A	MW94
Located north of C-404 Landfill, adjacent to downgradient URGA compliance wells	MW85, MW88, MW91A*
URGA	
Upgradient background wells	MW93A*, MW420
Downgradient compliance wells	MW84A*, MW87A*, MW90A*

*MW90 was abandoned in 2001 and replaced with MW90A. MW91 was abandoned in 2017 and replaced with MW91A. MW84, MW87, and MW93 were abandoned in 2019 and replaced with MW84A, MW87A, and MW93A.
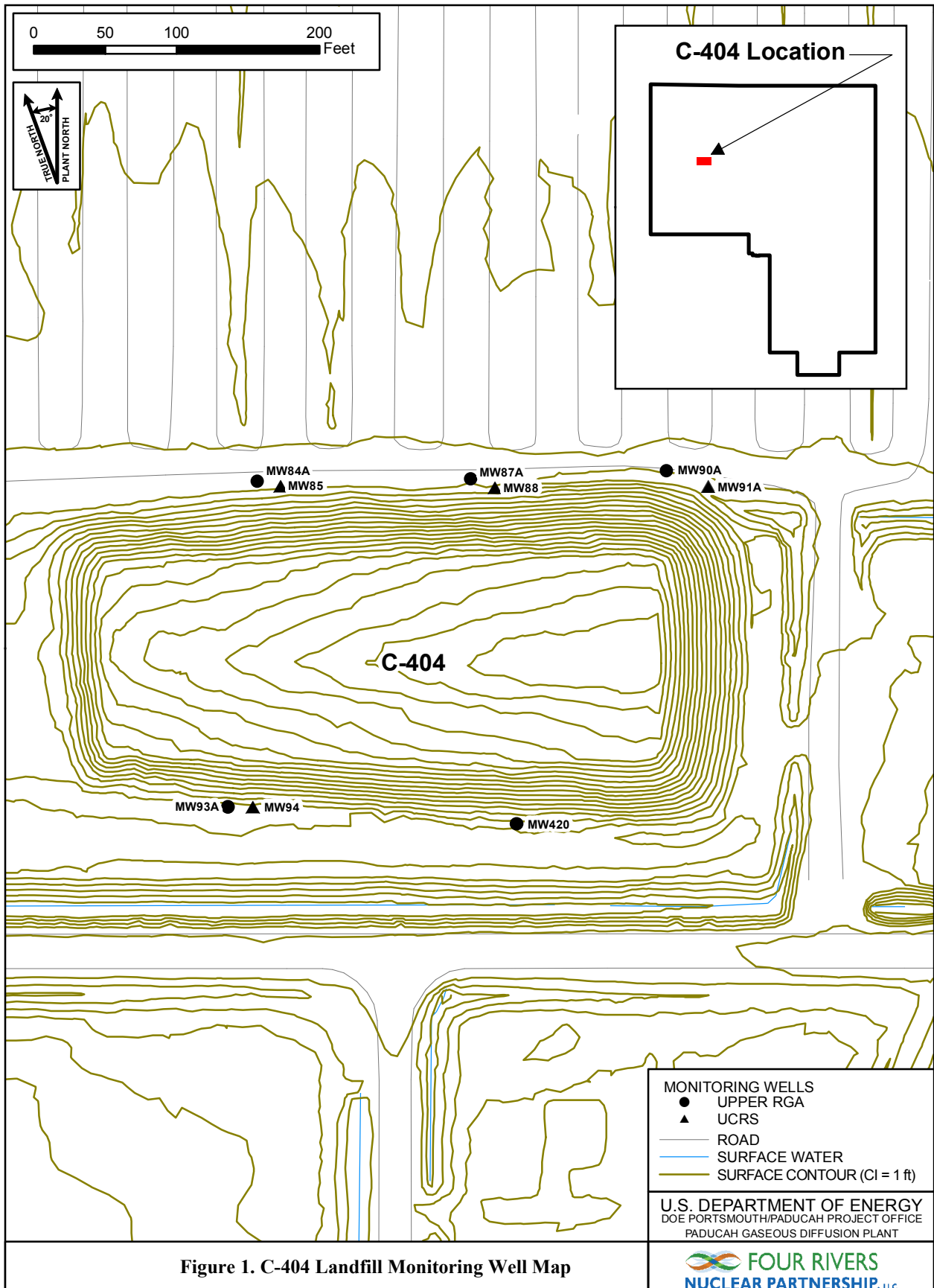
Figure 1. C-404 Landfill Monitoring Well Map

C-404 Location

0   50   100   200
Feet

TRUE NORTH / PLANT NORTH 20°

MW84A
MW85
MW87A
MW88
MW90A
MW91A

C-404

MW93A   MW94
MW420

MONITORING WELLS
● UPPER RGA
▲ UCRS
— ROAD
— SURFACE WATER
— SURFACE CONTOUR (CI = 1 ft)

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

FOUR RIVERS
NUCLEAR PARTNERSHIP, LLC

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5/8/2019

Table 2 presents the Assembled Kentucky Groundwater (AKGWA) numbers for each MW.

Table 2. Assembled Kentucky Groundwater Numbers

Paducah Site Well Number	AKGWA Number
MW84A	8007-4849
MW85	8000-5234
MW87A	8007-4850
MW88	8000-5237
MW90A	8004-0357
MW91A	8007-2917
MW93A	8007-4851
MW94	8000-5103
MW420	8005-3263

All nine MWs were sampled in January 2020 during this reporting period, and the samples were analyzed for parameters required by Part VIII.E of the Permit. Groundwater sampling was conducted using procedure CP4-ES-2101, *Groundwater Sampling*. Appropriate sample containers and preservatives were used. The laboratory that performed the analyses used U.S. Environmental Protection Agency-approved methods, as applicable. Appendix A of this report contains the analytical results. Appendix B of this report contains the statistical analyses.

1.2.2 Landfill Leachate

In accordance with Section 1.2 of the 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." Once the leachate depth reaches 3 ft, the leachate is pumped into a mobile tank. The leachate then is transferred to a permitted hazardous waste storage facility on-site prior to characterization and transferred off-site for treatment. The volume of leachate removed from the sump during this reporting period, October 2019 through March 2020, was 2,775 gal. The leachate was sampled on January 8 and February 18, 2020. Analytical results for the January and February 2020 leachate samples are included in Appendix C.

2. STATISTICAL SYNOPSIS

The statistical analyses conducted on the data collected from the C-404 Landfill were performed in accordance with procedures in the Permit, Part VIII.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, MW93A and MW420, and URGA compliance wells, MW84A, MW87A, and MW90A. For these statistical analyses, the reporting period data set includes data from January 2018, August 2018, January 2019, July 2019, and January 2020.

TCE concentrations in compliance well MW87A were statistically different from concentrations in the background wells. Appendix B provides a summary of the statistical analyses performed. The statistical tests on all other parameters showed no statistical difference between concentrations in the compliance and background wells. Notification of the statistically significant difference for TCE in MW87A was submitted, pursuant to Part II, Specific Condition II.K.6.a, to your department under separate correspondence.

STATISTICALLY SIGNIFICANT EXCEEDANCE OF TCE BACKGROUND IN MW87A

An alternate source demonstration previously was conducted for TCE in MW84. The 2007 *C-404 Landfill Source Demonstration, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PRS-ENM-0031/R2, (PRS 2007a) (ASD) demonstrated that the C-404 Landfill was not the source of the historical, statistically significant background exceedance of TCE in MW84. The 2007 demonstration found that the statistically significant increase of TCE in compliance well MW84 appeared to be due to an upgradient source whose TCE is migrating through the C-404 Landfill area.

The exceedance in TCE concentration in MW87A over background concentrations is consistent with the findings in the 2007 ASD (PRS 2007a). The trend of TCE concentrations in MW87A is similar to the historical TCE trends observed at MW84A as well as background wells MW93A and MW420, as demonstrated in Figures 2 and 3.
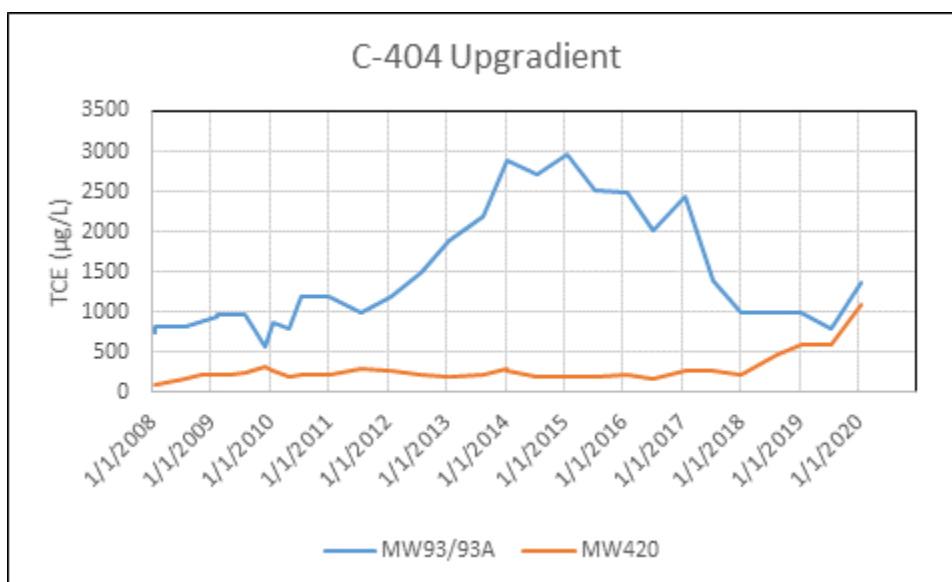
Figure 2. TCE Trend in C-404 Landfill Upgradient Wells
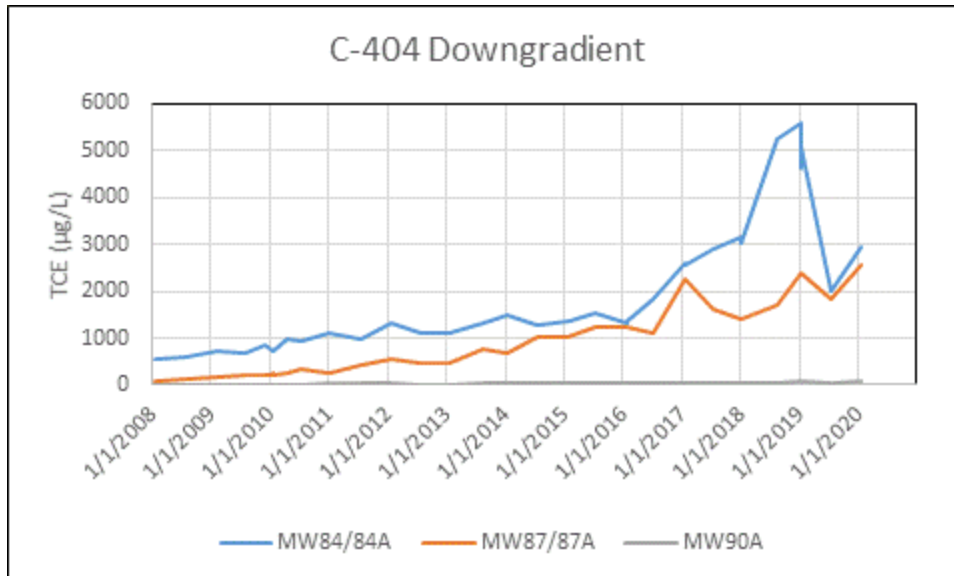
Figure 3. TCE Trend in C-404 Landfill Downgradient Wells

Secondly, groundwater flow directions are to the northeast—similarly indicating an upgradient, non-C-404 Landfill source of MW84A and MW87A impacts (Figure 4). This condition is consistent with flow patterns found in 2007 during the ASD. Recent increasing TCE concentration trends in both compliance and background wells at the C-404 Landfill further indicate that the source of the TCE is upgradient to the C-404 Landfill.

Finally, with one exception (July 2017—0.44 µg/L), none of the C-404 Landfill leachate samples collected over the past 10 years have had detectable concentrations of TCE; therefore, the C-404 Landfill cannot be the source of the TCE found in the MWs.

This demonstration fulfills Section II.K.8 of the Hazardous Waste Management Facility Permit, which allows for demonstrating that the exceedance is consistent with the findings in the 2007 ASD and allows for the demonstration to be submitted within the semiannual report.

Figure 4. Potentiometric Surface of the Upper Regional Gravel Aquifer at the C-404 Landfill, January 27 and 28, 2020
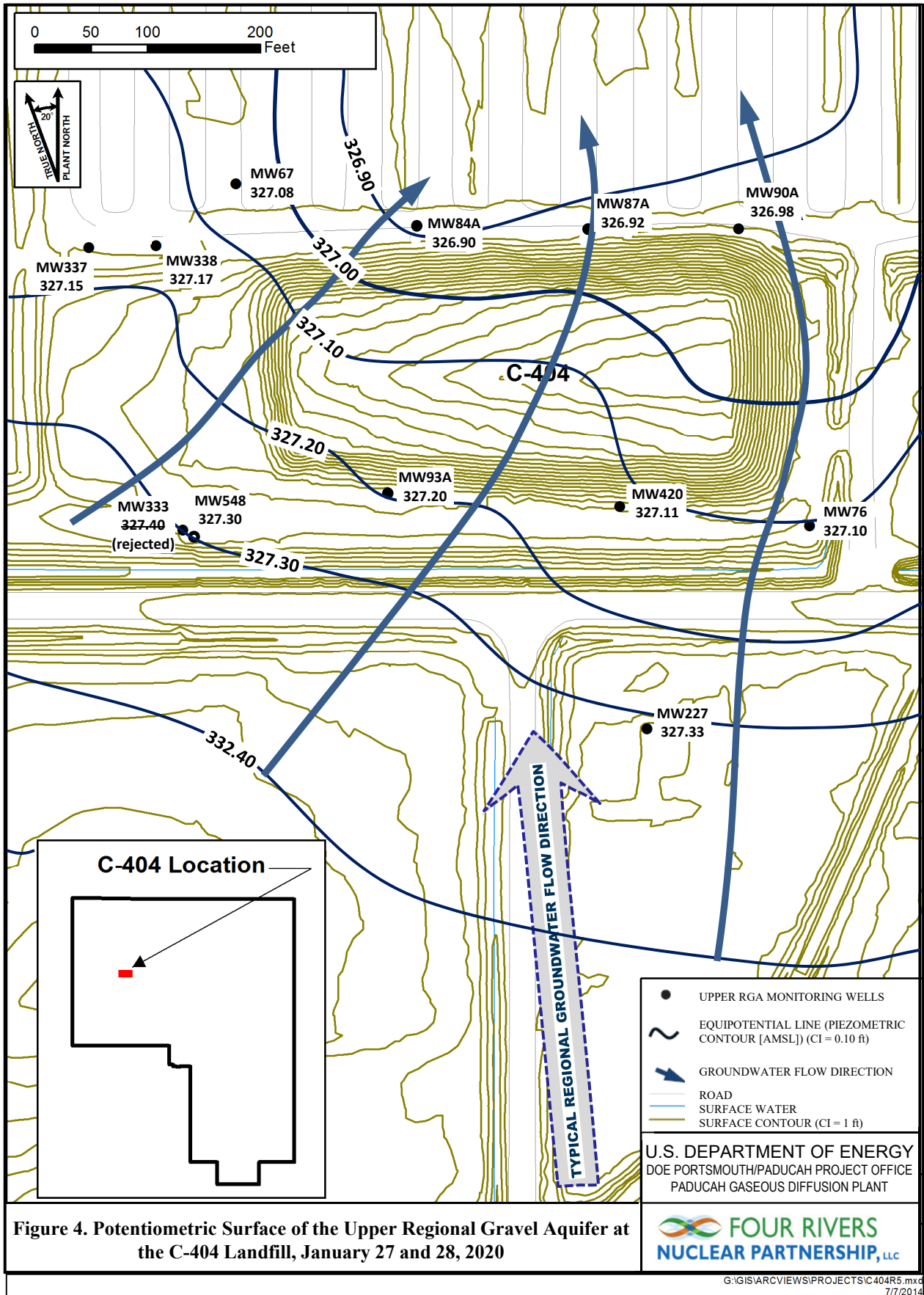
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3. DATA VALIDATION AND QA/QC SUMMARY

The data and the data validation qualifiers for the January 2020 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 during each semiannual sampling event. Equipment rinseate blanks, field blanks, field duplicates, and trip blanks are obtained to ensure quality control and are reported in the Analytical Results in Appendix A. 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.

FIELD DUPLICATE SAMPLE

During a May 23, 2018, teleconference, the U.S. Department of Energy discussed with Kentucky Division of Waste Management (KDWM) the method used to collect duplicate samples from MWs at the C-404 Landfill. The collection method being used is defined in SW-846 as a collocated duplicate and differs from a definition in the Permit Part VIII.E, Appendix E3. In the teleconference, KDWM agreed that the collocated duplicate collection method was appropriate for precision monitoring at the C-404 Landfill. Additionally, there was a discussion about how this collection method is an acceptable practice under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and it is the type of duplicate sampling utilized in CERCLA sampling events at the Paducah Site.

Permit Part VIII.E, Appendix E3, Monitoring Well Requirements, Section 1.4, Field Quality Control, states that field duplicates consist of two aliquots of a sample (i.e., the primary sample and its duplicate) that are aliquoted into two containers from a single sample collection container or sample mixing container. Additionally, the Permit defines a duplicate sample as two or more separate samples taken from the same source during the same sampling event.

Procedure CP4-ES-2704, *Trip, Equipment, and Field Blank Preparation*, describes a field duplicate sample (collocated duplicate) as being collected at the same time, using the same procedures, the same type of equipment, and in the same types of containers as the original sample. The samples are placed in separate, but identical sample containers as the original sample. This is consistent with the Permit's definition of a duplicate sample (i.e., separate samples taken from the same source during the same sampling event).

The Permit's description for collection of a field duplicate sample is similar to the field replicate sample identified in CP4-ES-2704. Field replicate samples also are referred to as split samples in the procedure. The field replicate sample is described as being collected by initially collecting twice as much volume as is normally collected, homogenizing the material by mixing, and distributing into two sets of sample containers. Additionally, the procedure states that samples for volatile organic compounds are not mixed prior to subsampling. A field replicate sample is not commonly used in groundwater sampling due to volatile organic compounds being a contaminant of concern at the Paducah Site.

In order to comply with the current Permit requirement until a Permit modification can be established, two field duplicates were collected during this reporting period. Both samples were collected from MW84A. A groundwater sample was collected from MW84A along with a field duplicate sample (MW84A REP) prescribed by the Permit. A separate groundwater sample was collected from MW84A along with a field duplicate sample (MW84A FR) prescribed by CP4-ES-2704. See Appendix A for data.

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4. PROFESSIONAL GEOLOGIST AUTHORIZATION

DOCUMENT IDENTIFICATION: *C–404 Hazardous Waste Landfill*
May 2020 Semiannual Groundwater Report
(October 2019–March 2020),
Paducah Gaseous Diffusion Plant, Paducah, Kentucky
(FRNP-RPT-0135/V1)

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

PG 113927
K. Davis
5-20-2020

_____   _____   _____
Kenneth R. Davis   PG113927   May 20, 2020
                                                                                           Date

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5. REFERENCES

FRNP 2018. *C-404 Hazardous Waste Landfill November 2018 Semiannual Groundwater Report (April 2018-September 2018), Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0026/V2, U.S. Department of Energy, Paducah, KY, November.

FRNP 2019. *C-404 Hazardous Waste Landfill Alternate Source Demonstration—Source of Lead and Uranium in MW87 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0078, Four Rivers Nuclear Partnership, LLC, Kevil, KY.

KDWM (Kentucky Division of Waste Management) 2020. Hazardous Waste Management Facility Permit for the U.S. Department of Energy, Paducah Gaseous Diffusion Plant, KY8-890-008-982, effective February 21.

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

PRS 2007b. *Well Plan for Addition of Wells for C-404 Monitoring Well Network, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PRS/PROJ/0028, Paducah Remediation Services, LLC, Kevil, KY, July.

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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: MW84A REG   Downgradient   URGA   **Period:** Semiannual Report

AKGWA Well Tag #: 8007-4849

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.0181	mg/L	0.005	1/14/2020			SW846-6020	=
Arsenic, Dissolved		0.0134	mg/L	0.005	1/14/2020			SW846-6020	=
Barometric Pressure Reading		30.2	Inches/Hg		1/14/2020				X
Cadmium	J	0.000371	mg/L	0.001	1/14/2020			SW846-6020	J
Cadmium, Dissolved	J	0.000355	mg/L	0.001	1/14/2020			SW846-6020	J
Chromium	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Conductivity		584	umho/cm		1/14/2020				X
Depth to Water		49.43	ft		1/14/2020				X
Dissolved Oxygen		0.43	mg/L		1/14/2020				X
Lead	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
pH		5.98	Std Unit		1/14/2020				X
Redox		366	mV		1/14/2020				X
Selenium	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Sulfate		77.7	mg/L	4	1/14/2020			SW846-9056	=
Technetium-99		297	pCi/L	22	1/14/2020	18.8	37.9	HASL 300, Tc-02-RC M	=
Temperature		59.2	deg F		1/14/2020				X
Trichloroethene	Y1	1950	ug/L	50	1/14/2020			SW846-8260B	=
Turbidity		0	NTU		1/14/2020				X
Uranium	B	0.000305	mg/L	0.0002	1/14/2020			SW846-6020	J
Uranium-234	U	0.634	pCi/L	1.55	1/14/2020	1.02	1.02	HASL 300, U-02-RC M	=
Uranium-235	U	0.429	pCi/L	1.56	1/14/2020	0.985	0.987	HASL 300, U-02-RC M	=
Uranium-238	U	0.52	pCi/L	1.39	1/14/2020	0.92	0.923	HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

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

Sampling Point: MW84A REG   Downgradient   URGA   **Period:** Semiannual Report

AKGWA Well Tag #: 8007-4849

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.02	mg/L	0.005	1/14/2020			SW846-6020	=
Arsenic, Dissolved		0.0153	mg/L	0.005	1/14/2020			SW846-6020	=
Barometric Pressure Reading		30.2	Inches/Hg		1/14/2020				X
Cadmium	J	0.000385	mg/L	0.001	1/14/2020			SW846-6020	J
Cadmium, Dissolved	J	0.000355	mg/L	0.001	1/14/2020			SW846-6020	J
Chromium	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Conductivity		517	umho/cm		1/14/2020				X
Depth to Water		49.44	ft		1/14/2020				X
Dissolved Oxygen		0.55	mg/L		1/14/2020				X
Lead	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
pH		5.97	Std Unit		1/14/2020				X
Redox		344	mV		1/14/2020				X
Selenium	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Sulfate		50	mg/L	2	1/14/2020			SW846-9056	=
Technetium-99		208	pCi/L	21.5	1/14/2020	16.9	28.6	HASL 300, Tc-02-RC M	=
Temperature		58.4	deg F		1/14/2020				X
Trichloroethene	Y1	2930	ug/L	50	1/14/2020			SW846-8260B	=
Turbidity		0	NTU		1/14/2020				X
Uranium	B	0.000252	mg/L	0.0002	1/14/2020			SW846-6020	J
Uranium-234	U	1.26	pCi/L	1.39	1/14/2020	1.12	1.14	HASL 300, U-02-RC M	=
Uranium-235	U	0.827	pCi/L	1.05	1/14/2020	0.974	0.981	HASL 300, U-02-RC M	=
Uranium-238	U	0.718	pCi/L	1.17	1/14/2020	0.874	0.88	HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

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

Sampling Point: MW84A FR   Downgradient   URGA   **Period:** Semiannual Report

AKGWA Well Tag #: 8007-4849

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.0184	mg/L	0.005	1/14/2020			SW846-6020	=
Arsenic, Dissolved		0.0126	mg/L	0.005	1/14/2020			SW846-6020	=
Cadmium	J	0.000313	mg/L	0.001	1/14/2020			SW846-6020	J
Cadmium, Dissolved	J	0.000329	mg/L	0.001	1/14/2020			SW846-6020	J
Chromium	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Lead	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
Selenium	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Sulfate		80	mg/L	4	1/14/2020			SW846-9056	=
Technetium-99		286	pCi/L	21.1	1/14/2020	18.1	36.5	HASL 300, Tc-02-RC M	=
Trichloroethene	Y1	2080	ug/L	50	1/14/2020			SW846-8260B	=
Uranium	B	0.000272	mg/L	0.0002	1/14/2020			SW846-6020	J
Uranium-234	U	0.72	pCi/L	1.63	1/14/2020	1.04	1.05	HASL 300, U-02-RC M	=
Uranium-235	U	0	pCi/L	0.723	1/14/2020	0.486	0.487	HASL 300, U-02-RC M	=
Uranium-238	U	0.452	pCi/L	1.51	1/14/2020	0.893	0.895	HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

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

Sampling Point: MW84A REP   Downgradient   URGA   **Period:** Semiannual Report

AKGWA Well Tag #: 8007-4849

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.0202	mg/L	0.005	1/14/2020			SW846-6020	=
Arsenic, Dissolved		0.0135	mg/L	0.005	1/14/2020			SW846-6020	=
Cadmium	J	0.000344	mg/L	0.001	1/14/2020			SW846-6020	J
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/14/2020			SW846-6020	=
Chromium	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Lead	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
Selenium	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Sulfate		50.1	mg/L	2	1/14/2020			SW846-9056	=
Technetium-99		200	pCi/L	23.9	1/14/2020	18.2	28.8	HASL 300, Tc-02-RC M	=
Trichloroethene	Y1	2910	ug/L	50	1/14/2020			SW846-8260B	=
Uranium	B	0.00021	mg/L	0.0002	1/14/2020			SW846-6020	J
Uranium-234	U	1.23	pCi/L	1.65	1/14/2020	1.21	1.22	HASL 300, U-02-RC M	=
Uranium-235	U	0.132	pCi/L	1.74	1/14/2020	0.852	0.852	HASL 300, U-02-RC M	=
Uranium-238	U	0.198	pCi/L	1.26	1/14/2020	0.677	0.678	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		0.00939	mg/L	0.005	1/15/2020			SW846-6020	=
Arsenic, Dissolved		0.00579	mg/L	0.005	1/15/2020			SW846-6020	=
Barometric Pressure Reading		30.04	Inches/Hg		1/15/2020				X
Cadmium	U	0.001	mg/L	0.001	1/15/2020			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/15/2020			SW846-6020	=
Chromium	J	0.00376	mg/L	0.01	1/15/2020			SW846-6020	=
Chromium, Dissolved	J	0.00439	mg/L	0.01	1/15/2020			SW846-6020	=
Conductivity		391	umho/cm		1/15/2020				X
Depth to Water		8.46	ft		1/15/2020				X
Dissolved Oxygen		2.2	mg/L		1/15/2020				X
Lead	U	0.002	mg/L	0.002	1/15/2020			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/15/2020			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	1/15/2020			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/15/2020			SW846-7470A	=
pH		6.22	Std Unit		1/15/2020				X
Redox		481	mV		1/15/2020				X
Selenium	U	0.005	mg/L	0.005	1/15/2020			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/15/2020			SW846-6020	=
Sulfate		11.4	mg/L	0.4	1/15/2020			SW846-9056	=
Technetium-99		54.5	pCi/L	22.4	1/15/2020	14.4	15.6	HASL 300, Tc-02-RC M	=
Temperature		59.1	deg F		1/15/2020				X
Trichloroethene		1.01	ug/L	1	1/15/2020			SW846-8260B	=
Turbidity		18.9	NTU		1/15/2020				X
Uranium	B	0.000244	mg/L	0.0002	1/15/2020			SW846-6020	J
Uranium-234	U	-0.808	pCi/L	4.29	1/15/2020	1.48	1.48	HASL 300, U-02-RC M	=
Uranium-235	U	0.469	pCi/L	2.9	1/15/2020	1.73	1.73	HASL 300, U-02-RC M	=
Uranium-238	U	0.0798	pCi/L	3.09	1/15/2020	1.42	1.43	HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

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

Sampling Point: MW87A REG   Downgradient   URGA   **Period:** Semiannual Report

AKGWA Well Tag #: 8007-4850

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.00928	mg/L	0.005	1/14/2020			SW846-6020	=
Arsenic, Dissolved		0.00548	mg/L	0.005	1/14/2020			SW846-6020	=
Barometric Pressure Reading		30.22	Inches/Hg		1/14/2020				X
Cadmium	J	0.000503	mg/L	0.001	1/14/2020			SW846-6020	J
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/14/2020			SW846-6020	=
Chromium	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Conductivity		348	umho/cm		1/14/2020				X
Depth to Water		49.53	ft		1/14/2020				X
Dissolved Oxygen		1.57	mg/L		1/14/2020				X
Lead	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
pH		5.93	Std Unit		1/14/2020				X
Redox		370	mV		1/14/2020				X
Selenium	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Sulfate		6.6	mg/L	0.4	1/14/2020			SW846-9056	=
Technetium-99	U	1.16	pCi/L	21	1/14/2020	12.2	12.2	HASL 300, Tc-02-RC M	=
Temperature		58.9	deg F		1/14/2020				X
Trichloroethene	Y1	2580	ug/L	50	1/14/2020			SW846-8260B	=
Turbidity		0	NTU		1/14/2020				X
Uranium	U	0.0002	mg/L	0.0002	1/14/2020			SW846-6020	=
Uranium-234	U	0.785	pCi/L	1.35	1/14/2020	0.932	0.941	HASL 300, U-02-RC M	=
Uranium-235	U	0	pCi/L	0.61	1/14/2020	0.41	0.411	HASL 300, U-02-RC M	=
Uranium-238	U	-0.0329	pCi/L	1.15	1/14/2020	0.494	0.495	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		0.00864	mg/L	0.005	1/15/2020			SW846-6020	=
Arsenic, Dissolved		0.00592	mg/L	0.005	1/15/2020			SW846-6020	=
Barometric Pressure Reading		30.04	Inches/Hg		1/15/2020				X
Cadmium	U	0.001	mg/L	0.001	1/15/2020			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/15/2020			SW846-6020	=
Chromium	U	0.01	mg/L	0.01	1/15/2020			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/15/2020			SW846-6020	=
Conductivity		645	umho/cm		1/15/2020				X
Depth to Water		7.93	ft		1/15/2020				X
Dissolved Oxygen		1.01	mg/L		1/15/2020				X
Lead	J	0.00086	mg/L	0.002	1/15/2020			SW846-6020	=
Lead, Dissolved	J	0.000507	mg/L	0.002	1/15/2020			SW846-6020	=
Mercury	J	0.000115	mg/L	0.0002	1/15/2020			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/15/2020			SW846-7470A	=
pH		5.81	Std Unit		1/15/2020				X
Redox		406	mV		1/15/2020				X
Selenium	U	0.005	mg/L	0.005	1/15/2020			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/15/2020			SW846-6020	=
Sulfate		124	mg/L	4	1/15/2020			SW846-9056	=
Technetium-99	U	17.6	pCi/L	20.6	1/15/2020	12.4	12.6	HASL 300, Tc-02-RC M	=
Temperature		59.4	deg F		1/15/2020				X
Trichloroethene		1.4	ug/L	1	1/15/2020			SW846-8260B	=
Turbidity		36	NTU		1/15/2020				X
Uranium	J	0.000165	mg/L	0.0002	1/15/2020			SW846-6020	=
Uranium-234	U	0.552	pCi/L	2.95	1/15/2020	1.6	1.61	HASL 300, U-02-RC M	=
Uranium-235	U	0.139	pCi/L	2.95	1/15/2020	1.41	1.41	HASL 300, U-02-RC M	=
Uranium-238	U	-0.272	pCi/L	3.01	1/15/2020	1.17	1.17	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	J	0.00211	mg/L	0.005	1/14/2020			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Barometric Pressure Reading		30.24	Inches/Hg		1/14/2020				X
Cadmium	U	0.001	mg/L	0.001	1/14/2020			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/14/2020			SW846-6020	=
Chromium	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Conductivity		214	umho/cm		1/14/2020				X
Depth to Water		48.65	ft		1/14/2020				X
Dissolved Oxygen		2.2	mg/L		1/14/2020				X
Lead	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
pH		5.94	Std Unit		1/14/2020				X
Redox		400	mV		1/14/2020				X
Selenium	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Sulfate		3.85	mg/L	0.4	1/14/2020			SW846-9056	=
Technetium-99	U	7.15	pCi/L	23.4	1/14/2020	13.8	13.8	HASL 300, Tc-02-RC M	=
Temperature		60	deg F		1/14/2020				X
Trichloroethene	Y1	92.9	ug/L	1	1/14/2020			SW846-8260B	=
Turbidity		0	NTU		1/14/2020				X
Uranium	U	0.0002	mg/L	0.0002	1/14/2020			SW846-6020	=
Uranium-234	U	0.86	pCi/L	1.31	1/14/2020	0.979	0.99	HASL 300, U-02-RC M	=
Uranium-235	U	0.812	pCi/L	1.28	1/14/2020	1.03	1.03	HASL 300, U-02-RC M	=
Uranium-238	U	0.328	pCi/L	0.894	1/14/2020	0.645	0.647	HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

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

Sampling Point: MW91A REG   Downgradient   UCRS   **Period:** Semiannual Report

AKGWA Well Tag #: 8007-2917

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.0178	mg/L	0.005	1/15/2020			SW846-6020	=
Arsenic, Dissolved		0.0139	mg/L	0.005	1/15/2020			SW846-6020	=
Barometric Pressure Reading		30.05	Inches/Hg		1/15/2020				X
Cadmium	U	0.001	mg/L	0.001	1/15/2020			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/15/2020			SW846-6020	=
Chromium	J	0.00423	mg/L	0.01	1/15/2020			SW846-6020	=
Chromium, Dissolved	J	0.00338	mg/L	0.01	1/15/2020			SW846-6020	=
Conductivity		1055	umho/cm		1/15/2020				X
Depth to Water		11.73	ft		1/15/2020				X
Dissolved Oxygen		0.62	mg/L		1/15/2020				X
Lead	U	0.002	mg/L	0.002	1/15/2020			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/15/2020			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	1/15/2020			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/15/2020			SW846-7470A	=
pH		6.25	Std Unit		1/15/2020				X
Redox		66	mV		1/15/2020				X
Selenium	U	0.005	mg/L	0.005	1/15/2020			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/15/2020			SW846-6020	=
Sulfate		134	mg/L	4	1/15/2020			SW846-9056	=
Technetium-99	U	17.6	pCi/L	21.1	1/15/2020	12.7	12.9	HASL 300, Tc-02-RC M	=
Temperature		61.5	deg F		1/15/2020				X
Trichloroethene		28.6	ug/L	1	1/15/2020			SW846-8260B	=
Turbidity		1	NTU		1/15/2020				X
Uranium	BJ	0.000077	mg/L	0.0002	1/15/2020			SW846-6020	U
Uranium-234	U	1.38	pCi/L	3.31	1/15/2020	2.18	2.2	HASL 300, U-02-RC M	=
Uranium-235	U	-0.219	pCi/L	3.09	1/15/2020	1.22	1.23	HASL 300, U-02-RC M	=
Uranium-238	U	-1.06	pCi/L	3.99	1/15/2020	1.09	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: MW93A REG   Upgradient   URGA   **Period:** Semiannual Report

AKGWA Well Tag #:   8007-4851

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-	TPU	Method	Validation
Arsenic		0.00817	mg/L	0.005	1/14/2020			SW846-6020	=
Arsenic, Dissolved		0.00572	mg/L	0.005	1/14/2020			SW846-6020	=
Barometric Pressure Reading		30.23	Inches/Hg		1/14/2020				X
Cadmium	U	0.001	mg/L	0.001	1/14/2020			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/14/2020			SW846-6020	=
Chromium	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Conductivity		358	umho/cm		1/14/2020				X
Depth to Water		52.47	ft		1/14/2020				X
Dissolved Oxygen		1.29	mg/L		1/14/2020				X
Lead	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
pH		6.03	Std Unit		1/14/2020				X
Redox		390	mV		1/14/2020				X
Selenium	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Sulfate		7.31	mg/L	0.4	1/14/2020			SW846-9056	=
Technetium-99	U	-1.5	pCi/L	20.5	1/14/2020	11.9	11.9	HASL 300, Tc-02-RC M	=
Temperature		61.4	deg F		1/14/2020				X
Trichloroethene	Y1	1360	ug/L	25	1/14/2020			SW846-8260B	=
Turbidity		5.4	NTU		1/14/2020				X
Uranium	BJ	0.000102	mg/L	0.0002	1/14/2020			SW846-6020	U
Uranium-234	U	1.13	pCi/L	1.51	1/14/2020	1.16	1.18	HASL 300, U-02-RC M	=
Uranium-235	U	0.195	pCi/L	1.23	1/14/2020	0.73	0.731	HASL 300, U-02-RC M	=
Uranium-238	U	0.265	pCi/L	1.27	1/14/2020	0.73	0.731	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	0.00265	mg/L	0.005	1/15/2020			SW846-6020	=
Arsenic, Dissolved	J	0.00206	mg/L	0.005	1/15/2020			SW846-6020	=
Barometric Pressure Reading		30.05	Inches/Hg		1/15/2020				X
Cadmium	U	0.001	mg/L	0.001	1/15/2020			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/15/2020			SW846-6020	=
Chromium	U	0.01	mg/L	0.01	1/15/2020			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/15/2020			SW846-6020	=
Conductivity		822	umho/cm		1/15/2020				X
Depth to Water		12.57	ft		1/15/2020				X
Dissolved Oxygen		0.7	mg/L		1/15/2020				X
Lead	J	0.0011	mg/L	0.002	1/15/2020			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/15/2020			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	1/15/2020			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/15/2020			SW846-7470A	=
pH		6.4	Std Unit		1/15/2020				X
Redox		187	mV		1/15/2020				X
Selenium	U	0.005	mg/L	0.005	1/15/2020			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/15/2020			SW846-6020	=
Sulfate		75.2	mg/L	4	1/15/2020			SW846-9056	=
Technetium-99		1410	pCi/L	20.5	1/15/2020	31.4	159	HASL 300, Tc-02-RC M	=
Temperature		61.5	deg F		1/15/2020				X
Trichloroethene		1.76	ug/L	1	1/15/2020			SW846-8260B	=
Turbidity		73.4	NTU		1/15/2020				X
Uranium	B	0.00178	mg/L	0.0002	1/15/2020			SW846-6020	=
Uranium-234	U	-0.147	pCi/L	3.86	1/15/2020	1.61	1.61	HASL 300, U-02-RC M	=
Uranium-235	U	1.22	pCi/L	3.27	1/15/2020	2.38	2.39	HASL 300, U-02-RC M	=
Uranium-238	U	0.517	pCi/L	3.72	1/15/2020	1.95	1.96	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		0.00518	mg/L	0.005	1/14/2020			SW846-6020	=
Arsenic, Dissolved	J	0.00395	mg/L	0.005	1/14/2020			SW846-6020	=
Barometric Pressure Reading		30.24	Inches/Hg		1/14/2020				X
Cadmium	U	0.001	mg/L	0.001	1/14/2020			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/14/2020			SW846-6020	=
Chromium	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Conductivity		337	umho/cm		1/14/2020				X
Depth to Water		51.42	ft		1/14/2020				X
Dissolved Oxygen		2.47	mg/L		1/14/2020				X
Lead	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
pH		5.97	Std Unit		1/14/2020				X
Redox		424	mV		1/14/2020				X
Selenium	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Sulfate		5.99	mg/L	0.4	1/14/2020			SW846-9056	=
Technetium-99	U	-3.61	pCi/L	21.2	1/14/2020	12.3	12.3	HASL 300, Tc-02-RC M	=
Temperature		60.1	deg F		1/14/2020				X
Trichloroethene	Y1	1090	ug/L	20	1/14/2020			SW846-8260B	=
Turbidity		0	NTU		1/14/2020				X
Uranium	U	0.0002	mg/L	0.0002	1/14/2020			SW846-6020	=
Uranium-234	U	0.0167	pCi/L	1.12	1/14/2020	0.512	0.513	HASL 300, U-02-RC M	=
Uranium-235	U	0.992	pCi/L	0.995	1/14/2020	0.943	0.952	HASL 300, U-02-RC M	=
Uranium-238	U	-0.0291	pCi/L	1.02	1/14/2020	0.436	0.437	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	1/14/2020			SW846-6020	=
Cadmium	U	0.001	mg/L	0.001	1/14/2020			SW846-6020	=
Chromium	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Lead	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
Selenium	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Technetium-99	U	-8.11	pCi/L	20.7	1/14/2020	11.8	11.8	HASL 300, Tc-02-RC M	=
Trichloroethene	UY1	1	ug/L	1	1/14/2020			SW846-8260B	=
Uranium	U	0.0002	mg/L	0.0002	1/14/2020			SW846-6020	=
Uranium-234	U	0.366	pCi/L	1.57	1/14/2020	0.87	0.873	HASL 300, U-02-RC M	=
Uranium-235	U	0.593	pCi/L	1.03	1/14/2020	0.854	0.858	HASL 300, U-02-RC M	=
Uranium-238	U	0.654	pCi/L	0.833	1/14/2020	0.771	0.776	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	1/14/2020			SW846-6020	=
Cadmium	U	0.001	mg/L	0.001	1/14/2020			SW846-6020	=
Chromium	U	0.01	mg/L	0.01	1/14/2020			SW846-6020	=
Lead	U	0.002	mg/L	0.002	1/14/2020			SW846-6020	=
Mercury	U	0.0002	mg/L	0.0002	1/14/2020			SW846-7470A	=
Selenium	U	0.005	mg/L	0.005	1/14/2020			SW846-6020	=
Technetium-99	U	-6.12	pCi/L	20.6	1/14/2020	11.8	11.8	HASL 300, Tc-02-RC M	=
Trichloroethene	UY1	1	ug/L	1	1/14/2020			SW846-8260B	=
Uranium	U	0.0002	mg/L	0.0002	1/14/2020			SW846-6020	=
Uranium-234	U	0.372	pCi/L	1.98	1/14/2020	1.08	1.08	HASL 300, U-02-RC M	=
Uranium-235	U	0.171	pCi/L	1.82	1/14/2020	0.949	0.95	HASL 300, U-02-RC M	=
Uranium-238	U	0.212	pCi/L	1.86	1/14/2020	0.952	0.953	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	UY1	1	ug/L	1	1/14/2020			SW846-8260B	=
Trichloroethene	U	1	ug/L	1	1/15/2020			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.
B   Analyte found in the asscociated blank.
Y1   MS/MSD recovery outside acceptance criteria.

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 Duplicate as defined in sampling procedure.
REP   Field Duplicate as defined in permit.
REG   Regular
RI   QC Equipment Rinseate/Decon
TB   Trip Blank

VALIDATION Codes

=   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.
U   The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
X   Not validated.

APPENDIX B

**C-404 HAZARDOUS WASTE LANDFILL
STATISTICAL ANALYSES**

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C-404 HAZARDOUS WASTE LANDFILL
May 2020 SEMIANNUAL
Facility: US DOE—Paducah Gaseous Diffusion Plant

Finds/Unit: KY8-980-008-982/1
LAB ID:
For Official Use Only

GROUNDWATER
STATISTICAL SUMMARY

INTRODUCTION

The statistical analyses conducted on the data collected from the C-404 Hazardous Waste Landfill (C-404 Landfill) were performed in accordance with procedures provided in Appendix E of the Hazardous Waste Management Facility 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 the first reporting period 2020 semiannual report, the reporting period data set includes data from January 2018, August 2018, January 2019, July 2019, and January 2020.

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. 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	MW93A*, MW420
Downgradient compliance wells	MW84A*, MW87A*, MW90A*

*MW90 was abandoned in 2001 and replaced with MW90A. MW84, MW87, and MW93 were
abandoned in 2019 and replaced with MW84A, MW87A, and MW93A, respectively.

For the first reporting period 2020 semiannual report, the reporting period data set from January 2018 through January 2020 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.

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	5	20
Cadmium	25	0	18	7
Chromium	25	0	15	10
Lead	25	0	15	10
Mercury	25	0	25	0
Selenium	25	0	24	1
Technetium-99	25	0	20	5
Trichloroethene	25	0	0	25
Uranium (Metals)	25	0	15	10
Uranium-234	25	0	21	4
Uranium-235	25	0	25	0
Uranium-238	25	0	23	2

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 required by Part VIII.E of the Permit.

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	20	5	20	3
Cadmium	25	7	18	72	2
Chromium	25	10	15	60	2
Lead	25	10	15	60	2
Mercury	25	0	25	100	1
Selenium	25	1	24	96	1
Technetium-99	25	5	20	80	2
Trichloroethene	25	25	0	0	4
Uranium (Metals)	25	10	15	60	2
Uranium-234	25	4	21	84	2
Uranium-235	25	0	25	100	1
Uranium-238	25	2	23	92	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.

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 C-404 Landfill statistical analyses for the first reporting period 2020, 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 B8. The statistician qualification statement is presented in Attachment B9.

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

Parameter	LOD Values	½ LOD Values
URGA		
Mercury (mg/L)	0.0002	0.0001
Selenium (mg/L)	0.005	0.0025
Uranium-235 (pCi/L)	1.74	0.87
Uranium-238 (pCi/L)	1.51	0.755

Table B.5. Summary of Conclusions from the C-404 Hazardous Waste Landfill Statistical Analyses for the First Reporting Period 2020

Attachment	RGA Well Type	Parameter	Applied Statistical Test	Results
B1	URGA	Arsenic	Statistical Test 3, Nonparametric ANOVA with 95% UTL, paired ANOVA (MW84A vs. MW93A), and Mann-Kendall	Because Nonparametric ANOVA indicated a statistically significant difference between concentrations in downgradient wells and concentrations in background wells for compliance well MW84A, a comparison to the 95% UTL, paired ANOVA, and Mann-Kendall was performed, as required by the Hazardous Waste Management Facility Permit. Results of the paired ANOVA have identified there is a significant difference between upgradient and downgradient wells. The Mann-Kendall identified no trend in MW84A.
B2	URGA	Cadmium	Statistical Test 2, Test of Proportions with Statistical Test 3, Nonparametric ANOVA, 95% UTL, Paired (parametric) ANOVA, Paired (nonparametric) ANNOVA, and Mann-Kendall	Because Test of Proportions indicated statistically significant evidence that the proportion of detects in one group of data exceeds the proportion of detects in the other group, Statistical Test 3, Nonparametric ANOVA, and a comparison to the 95% UTL, paired (parametric) ANOVA, paired (nonparametric) ANOVA, and Mann-Kendall were performed as required by the Hazardous Waste Management Facility Permit. Results of the paired (nonparametric) ANOVA identified a statistically significant difference between concentrations in downgradient well MW87A and concentrations in background wells. The Mann-Kendall identified no trend in MW87A.
B3	URGA	Chromium	Statistical Test 2, Test of Proportions	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.
B4	URGA	Lead	Statistical Test 2, Test of Proportions	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.
B5	URGA	Technetium-99	Statistical Test 2, Test of Proportions	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.
B6	URGA	Trichloroethene	Statistical Test 4, Parametric ANOVA, 95% UTL, Paired ANOVA (MW93A vs. MW84A and MW87A), Mann-Kendall	Because Parametric ANOVA indicated a statistically significant difference between concentrations in downgradient wells and concentrations in background wells for compliance wells MW84A and MW87A, a comparison to the 95% UTL and paired ANOVA were performed as required by the Hazardous Waste Management Facility Permit. Results of the paired ANOVA have identified there is a significant difference between upgradient and downgradient wells. The Mann-Kendall identified no trend in MW84A and an increasing trend in MW87A.

Table B.5. Summary of Conclusions from the C-404 Hazardous Waste Landfill Statistical Analyses for the First Reporting Period 2020 (Continued)

Attachment	RGA Well Type	Parameter	Applied Statistical Test	Results
B7	URGA	Uranium	Statistical Test 2, Test of Proportions	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.
B8	URGA	Uranium-234	Statistical Test 2, Test of Proportions	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.

In summary, Statistical Test 2, Test of Proportions, for chromium, lead, technetium-99, uranium, and uranium-234 in the URGA indicated no statistically significant difference between concentrations in downgradient wells and concentrations in background wells.

Statistical Test 2, Test of Proportions, for cadmium in the URGA indicated a statistically significant evidence that the proportion of detects in one group of data exceeds the proportion of detects in the other group. For cadmium, downgradient wells had a higher proportion of detects; therefore, the data were evaluated further using Nonparametric ANOVA. Nonparametric ANOVA identified a statistically significant difference between concentrations in downgradient well MW87A and concentrations in background wells; therefore, the data were compared to the 95% UTL. Comparison to the UTL indicated a statistically significant difference between upgradient wells and downgradient well MW87A. A paired (parametric) ANOVA then was performed. Because equality of variance could not be determined, a paired (nonparametric) ANOVA was performed that identified a statistically significant difference between upgradient well MW93A and downgradient well MW87A. A Mann-Kendall test was performed to evaluate further the data for MW87A, and no trend was identified for cadmium.

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 well MW84A 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., performed a comparison of downgradient well (MW84A) results to upgradient westernmost well (MW93A) results]. Results of the paired (parametric) ANOVA identified a significant difference between upgradient and downgradient wells. A Mann-Kendall test was performed to evaluate further the data, and no trend was identified for arsenic in MW84A.

Statistical Test 4, Parametric ANOVA, for trichloroethene in the URGA indicated 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 both downgradient wells MW84A and MW87A 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., performed a comparison of downgradient well (MW84A and MW87A) results to upgradient westernmost well MW93A]. Results of the paired (parametric) ANOVA identified a significant difference between upgradient and downgradient wells MW84A and MW87A. A Mann-Kendall test was performed to further evaluate the data, and no trend was identified for trichloroethene in MW84A while an increasing trend was identified for trichloroethene in MW87A.

ATTACHMENT B1

**ARSENIC
STATISTICAL TEST 3**

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Attachment B1: Arsenic URGA, Statistical Test 3, Nonparametric ANOVA, First Reporting Period 2020

	Arsenic (mg/L)				
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	**0.00807**	0.0025	**0.0185**	**0.0087**	0.0025
Aug-18	**0.00619**	**0.00304**	**0.0289**	**0.0105**	0.0025
Jan-19	**0.00462**	**0.00414**	**0.0275**	**0.0116**	0.0025
Jul-19	**0.00602**	**0.00359**	**0.0168**	**0.00723**	0.0025
Jan-20	**0.00817**	**0.00518**	**0.0202**	**0.00928**	**0.00211**
Sum	0.0515		0.11190	0.04731	0.0121
n_i	10		5	5	5
$(x_i)_{avg}$	0.00515		0.02238	0.00946	0.0024

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.. =   0.00891

N =   25   N = the total number of samples
p =   4   p = the number of n_i groups
x.. =   0.22   x.. = the sum of the total number of samples

Statistical Test 3, Nonparametric ANOVA

Ranking of Observations

Sequence	Arsenic (mg/L)	Adjusted Rank	Tie Number
1	0	3	
2	0	3	
3	0	3	Tie 1
4	0	3	
5	0	3	
6	**0.00211**	6	
7	**0.00304**	7	
8	**0.00359**	8	
9	**0.00414**	9	
10	**0.00462**	10	
11	**0.00518**	11	
12	**0.00602**	12	
13	**0.00619**	13	
14	**0.00723**	14	
15	**0.00807**	15	
16	**0.00817**	16	
17	**0.0087**	17	
18	**0.00928**	18	
19	**0.0105**	19	
20	**0.0116**	20	
21	**0.0168**	21	
22	**0.0185**	22	
23	**0.0202**	23	
24	**0.0275**	24	
25	**0.0289**	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}

5   Tie 1 =   120

          $\sum T_i$ =   120

Sums of Ranks and Averages

Arsenic (mg/L)				
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	**0.00807**	0	**0.0185**	**0.0087**	0
Aug-18	**0.00619**	**0.00304**	**0.0289**	**0.0105**	0
Jan-19	**0.00462**	**0.00414**	**0.0275**	**0.0116**	0
Jul-19	**0.00602**	**0.00359**	**0.0168**	**0.00723**	0
Jan-20	**0.00817**	**0.00518**	**0.0202**	**0.00928**	**0.00211**

Observation Ranks for Arsenic				
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	15	3	22	17	3
Aug-18	13	7	25	19	3
Jan-19	10	9	24	20	3
Jul-19	12	8	21	14	3
Jan-20	16	11	23	18	6
R_i	104		115	88	18
$(R_i)_{avg}$	10.4		23.0	17.6	3.6
R_i^2/n_i	1081.6		2645.0	1548.8	64.8

$\sum R_i^2/n_i =$ 5340.2

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

K = the number of n_i groups
N = the total number of samples

$K =$ 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

$H =$ 20.588 Kruskal-Wallis Statistic $H = [12/N(N+1)*\sum R_i^2/n_i] - 3(N+1)$

$H' =$ 20.748 Corrected Kruskal-Wallis $H' = H/[1-(\sum T_i/N^3-N)]$

$\chi^2_{crit}* =$ 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
$\alpha =$ 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).

Attachment B1: Arsenic URGA, Statistical Test 3, Nonparametric ANOVA, First Reporting Period 2020

Calculate Critical Values

<div align="center">Average Background Ranking =   10.4</div>

	Well No.	C_i	$(R_i)_{avg} - (R_b)_{avg}$	Conclusion
BG Well	MW93A			
BG Well	MW420			
	MW84A	8.578	12.6	**evidence of contamination**
	MW87A	8.578	7.2	not contaminated
	MW90A	8.578	-6.8	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 MW84A, there is a statistically significant difference between downgradient compliance test wells and background wells in MW84A from the C-404 Landfill.

Because nonparametric ANOVA indicated a statistically significant difference between compliance test wells and background wells at the C-404 Landfill in compliance well MW84A, the 95% UTL was performed.

Since $(R_i)_{avg} - (R_b)_{avg} < C_i$ for MW87A and MW90A, there is no statistically significant difference between background wells and these downgradient compliance test wells; however, the negative value indicates 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 B1: Arsenic URGA, Statistical Test 3, Nonparametric ANOVA,
First Reporting Period 2020

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.

January 2020 Data, First Reporting Period
Observations (mg/L)

Well No.						
MW93A	**0.00807**	**0.00619**	**0.00462**	**0.00602**	**0.00817**	Upgradient Well[!]
MW420	0.00250	**0.0030**	**0.00414**	**0.00359**	**0.00518**	Upgradient Well[!]

				Current Data
MW84A	X: Mean Value =	0.0052		**0.0202**
	S: Standard Deviation =	0.0020		
	K* factor =	2.911	(for n = 10)	
	CV = S/X	0.3811	<1, assume normal distribution	
	Upper Tolerance Interval: TL = X +(KxS) =	**0.0109**	(mg/L)	

    ! = Data from previous 5 sampling events.

CV = coefficient of variation

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

Result: **MW84A 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 MW84A, the paired ANOVA was performed.

Attachment B1: Arsenic URGA, Statistical Test 3, Nonparametric ANOVA, First Reporting Period 2020

Paired (Parametric) ANOVA

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.

Date	Arsenic (mg/L) Background MW93A	Compliance MW84A	n_i^2	
Jan-18	**0.00807**	**0.0185**	0.0000651	0.0003423
Aug-18	**0.00619**	**0.0289**	0.0000383	0.0008352
Jan-19	**0.00462**	**0.0275**	0.0000213	0.0007563
Jul-19	**0.00602**	**0.0168**	0.0000362	0.0002822
Jan-20	**0.00817**	**0.0202**	0.0000667	0.0004080
Sum (x_i)	0.0331	0.11190	0.1450	Total Sum ($x..$)
n_i	5	5		
$(x_i)_{avg}$	0.00661	0.02238		
$(x_i)^2$	0.00109	0.01252		

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

Overall mean $x.. =$	0.01450		
$N =$	10	$N =$ the total number of samples
$p =$	2	$p =$ the number of n_i groups
$X.. =$	0.1450	$x.. =$ the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test

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

Date	Background MW93A	Compliance MW84A
Jan-18	0.00146	-0.00388
Aug-18	-0.00042	0.00652
Jan-19	-0.00199	0.00512
Jul-19	-0.00059	-0.00558
Jan-20	0.00156	-0.00218

X: Mean Value =	1.13E-18	
S: Standard Deviation =	0.00378	
K* Factor =	2.911	(for n = 10)
CV = S/X =	3.35E+15	≥1, data are NOT normally distributed

Data are not normally distributed (i.e., ≥1).

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

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

Attachment B1: Arsenic URGA, Statistical Test 3, Nonparametric ANOVA, First Reporting Period 2020

Determine Equality of Variance of Dataset

p = number of wells	$x_{..}$ = 0.1450
n_i = number of data points per well	$(x_{avg})_{..}$ = 0.01450
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	$f_i S_i^2$	$f_i \ln(S_i^2)$
0.00150	0.00000226243	-12.999	5	0.0000090	-52.0
0.00547	0.00002991700	-10.417	5	0.0001197	-41.7

$\sum(S_i^2) =$ 0.00003 $\sum f_i \ln(S_i^2) =$ -93.66462

Equality of Variance: Bartlett's Test

f =	8
$Sp^2 =$	0.0000161
$\ln Sp^2 =$	-11.037
$\chi^2 =$	5.366
χ^2_{crit} * =	3.841

$\chi^2 =$ 5.366   (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 with   1   degrees of freedom (p-1)

NOTE: The variances are NOT equal.   **(i.e., calculated $\chi^2 > \chi^2_{crit}$)**

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).

Attachment B1: Arsenic URGA, Statistical Test 3, Nonparametric ANOVA, First Reporting Period 2020

Paired (Parametric) ANOVA—Lognormal Data

	ln[Arsenic (mg/L)]			
Date	Background	Compliance		
	MW93A	MW84A	n_i^2	
Jan-18	**-4.82**	**-3.99**	23.23	15.92
Aug-18	**-5.08**	**-3.54**	25.86	12.56
Jan-19	**-5.38**	**-3.59**	28.92	12.91
Jul-19	**-5.11**	**-4.09**	26.14	16.70
Jan-20	**-4.81**	**-3.90**	23.11	15.23
Sum (x_i)	-25.20	-19.12	-44.32	Total Sum (x..)
n_i	5	5		
$(x_i)_{avg}$	-5.04	-3.82		
$(x_i)^2$	635.13	365.42		

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

Overall mean x.. =	-4.43	
N =	10	N = the total number of samples
p =	2	p = the number of n_i groups
$x_{..} =$	-44.32	x.. = the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test—Lognormal Data

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

Date	Background	Compliance
	MW93A	MW84A
Jan-18	0.22	-0.17
Aug-18	-0.04	0.28
Jan-19	-0.34	0.23
Jul-19	-0.07	-0.26
Jan-20	0.23	-0.08

X: Mean Value =	2.66E-16	
S: Standard Deviation =	0.23	
K* Factor =	2.911	(for n = 10)
CV = S/X =	8.46E+14	≥1, data are NOT normally distributed

Data are not normally distributed (i.e., <1)

*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—Lognormal Data

p = number of wells $\qquad\qquad\qquad\qquad\qquad\qquad$ $x_{..}$ = -44.32

n_i = number of data points per well $\qquad\qquad\qquad$ $(x_{avg})_{..}$ = -4.43

N = total sample size $\qquad\qquad\qquad\qquad\qquad\qquad$ n_i = 5

S^2 = the square of the standard deviation $\qquad\qquad$ p = 2

$\ln(S_i^2)$ = natural logarithm of each variance $\qquad\qquad$ N = 10

f = total sample size minus the number of wells (groups) $\qquad$ 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	$f_i S_i^2$	$f_i \ln(S_i^2)$
0.24	0.06	-2.88	5	0.22	-11.5
0.24	0.06	-2.84	5	0.23	-11.4

$\sum(S_i^2) = \qquad$ 0.11 $\qquad\qquad\qquad$ $\sum f_i \ln(S_i^2) = \qquad$ -22.89

Equality of Variance: Bartlett's Test

f = $\qquad$ 8

Sp^2 = $\qquad$ 0.06

$\ln Sp^2$ = $\qquad$ -2.86

χ^2 = $\qquad$ 0.00 $\qquad$ (If calculated $\chi^2 \leq$ tabulated χ^2_{crit}, then variances are equal at the given significance level).

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

NOTE: The variances are equal. $\qquad$ **(i.e., calculated $\chi^2 \leq \chi^2_{crit}$)**

Since calculated $\chi^2 \leq \chi^2_{crit}$, then the analysis can proceed as normal.

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

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

Attachment B1: Arsenic URGA, Statistical Test 3, Nonparametric ANOVA, First Reporting Period 2020

Between Well Sum of Squares

Source of	Sums of Squares		Degrees of	Mean Squares	Calculated F	F Statistic**
Between Wells	$SS_{wells} =$	3.70372	1	3.70372	64.71	5.32
Error	$SS_{Error} =$	0.45786	8	0.057233		
Total	$SS_{Total} =$	4.16158	9			

If calculated F > F statistic, then reject the hypothesis of equal well means. If calculated F is less than or equal to F statistic, it can be concluded that there is no significant difference between concentrations; therefore, there is no evidence of well contamination.

CONCLUSION: **Calculated F > F statistic; therefore, ANOVA has identified a significant difference between background and downgradient wells.**

Because the paired ANOVA for the two wells indicated a statistically significant difference between compliance test wells and background wells at the C-404 Landfill in compliance well MW84A, a Mann-Kendall statistical analysis was performed.

**Table 2, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989). F statistic taken at the 5% significance level.

Mann-Kendall Statistical Analysis for Arsenic in MW84A

Input Data

Date Collected	Result (mg/L)
Jul-16	**0.0137**
Jan-17	**0.017**
Jul-17	**0.0191**
Jan-18	**0.0185**
Aug-18	**0.0289**
Jan-19	**0.0275**
Jul-19	**0.0168**
Jan-20	**0.0202**

Bolded values indicate a detected result.

Mann-Kendall Trend Test Analysis

User Selected Options	
Date/Time of Computation	ProUCL 5.14/1/2020 11:00:26 AM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

MW84A As

General Statistics

Number or Reported Events Not Used	0
Number of Generated Events	8
Number Values Reported (n)	8
Minimum	0.0137
Maximum	0.0289
Mean	0.0202
Geometric Mean	0.0196
Median	0.0188
Standard Deviation	0.00531
Coefficient of Variation	0.263

Mann-Kendall Test

M-K Test Value (S)	10
Tabulated p-value	0.138
Standard Deviation of S	8.083
Standardized Value of S	1.113
Approximate p-value	0.133

Insufficient evidence to identify a significant trend at the specified level of significance.

Mann-Kendall Statistical Analysis for Arsenic in MW84A

Mann-Kendall Trend Test

Mann-Kendall Trend Analysis	
n	8
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	8.0829
Standardized Value of S	1.1135
M-K Test Value (S)	10
Tabulated p-value	0.1380
Approximate p-value	0.1328

OLS Regression Line (Blue)	
OLS Regression Slope	0.0010
OLS Regression Intercept	0.0159

Insufficient statistical evidence of a significant trend at the specified level of significance.
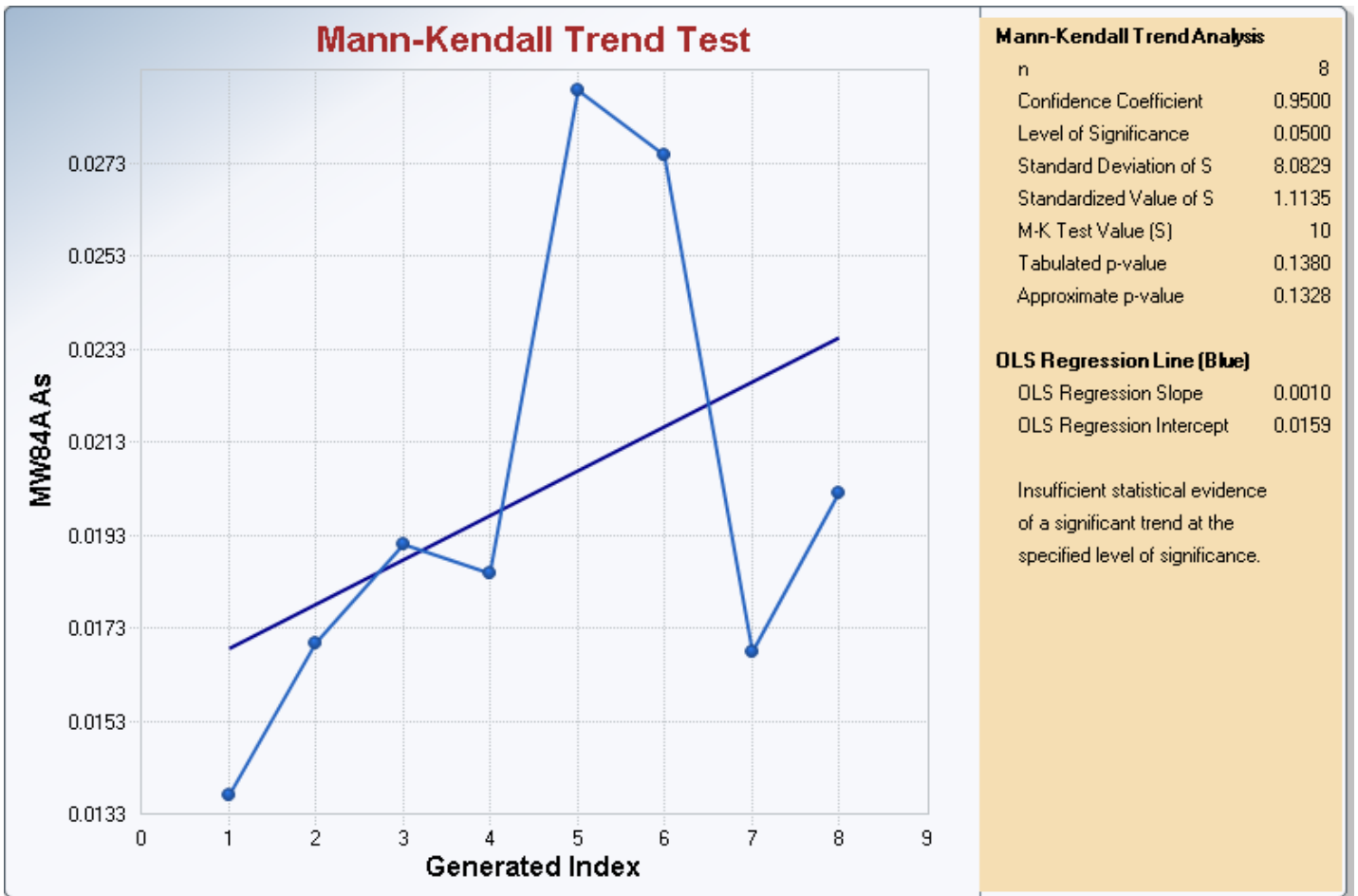
ATTACHMENT B2

**CADMIUM
STATISTICAL TEST 2**

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Attachment B2: Cadmium URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2020

Cadmium (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	0.0005	0.0005	0.0005	**0.000375**	0.0005
Aug-18	0.0005	0.0005	**0.000323**	**0.000372**	0.0005
Jan-19	0.0005	0.0005	**0.000415**	**0.000481**	0.0005
Jul-19	0.0005	0.0005	0.0005	0.0005	0.0005
Jan-20	0.0005	0.0005	**0.000385**	**0.000503**	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 =	0	X = number of samples above DL in background wells
Y =	7	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 =	0.280	P = (x+y)/n
nP =	7	$n = n_b + n_c$
n(1-P) =	18	

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

P_b =	0.000	P_b = proportion of detects in background wells
P_c =	0.467	P_c = proportion of detects in compliance wells
S_D =	0.183	S_D = standard error of difference in proportions
Z =	-2.546	$Z = (P_b - P_c)/S_D$
absolute value of Z =	2.546	

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 greater than 1.96, Nonparameteric ANOVA was performed.**

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

Attachment B2: Cadmium URGA, Statistical Test 3, Nonparametric ANOVA, First Reporting Period 2020

Date	Cadmium (mg/L) Background MW93A	Background MW420	Compliance MW84A	Compliance MW87A	Compliance MW90A
Jan-18	0.0005	0.0005	0.0005	**0.000375**	0.0005
Aug-18	0.0005	0.0005	**0.000323**	**0.000372**	0.0005
Jan-19	0.0005	0.0005	**0.000415**	**0.000481**	0.0005
Jul-19	0.0005	0.0005	0.0005	0.0005	0.0005
Jan-20	0.0005	0.0005	**0.000385**	**0.000503**	0.0005
Sum	0.0050		0.00212	0.00223	0.0025
n_i	10		5	5	5
$(x_i)_{avg}$	0.00050		0.00042	0.00045	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.

Overall mean x.. =   0.00047

N =   25 N = the total number of samples
p =   4 p = the number of n_i groups
x.. =   0.01   x.. = the sum of the total number of samples

Statistical Test 3, Nonparametric ANOVA

Ranking of Observations

Sequence	Cadmium (mg/L)	Adjusted Rank	Tie Number
1	0	9.5	
2	0	9.5	
3	0	9.5	
4	0	9.5	
5	0	9.5	
6	0	9.5	
7	0	9.5	
8	0	9.5	
9	0	9.5	Tie 1
10	0	9.5	
11	0	9.5	
12	0	9.5	
13	0	9.5	
14	0	9.5	
15	0	9.5	
16	0	9.5	
17	0	9.5	
18	0	9.5	
19	**0.000323**	19	
20	**0.000372**	20	
21	**0.000375**	21	
22	**0.000385**	22	
23	**0.000415**	23	
24	**0.000481**	24	
25	**0.000503**	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: $(n_{tie}^3 - n_{tie})$	
18	Tie 1 =	5814
	$\sum T_i =$	5814

Attachment B2: Cadmium URGA, Statistical Test 3, Nonparametric ANOVA, First Reporting Period 2020

Sums of Ranks and Averages

Cadmium (mg/L)				
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	0	0	0	**0.000375**	0
Aug-18	0	0	**0.000323**	**0.000372**	0
Jan-19	0	0	**0.000415**	**0.000481**	0
Jul-19	0	0	0	0	0
Jan-20	0	0	**0.000385**	**0.000503**	0

Observation Ranks for Cadmium				
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	9.5	9.5	9.5	21	9.5
Aug-18	9.5	9.5	19	20	9.5
Jan-19	9.5	9.5	23	24	9.5
Jul-19	9.5	9.5	9.5	9.5	9.5
Jan-20	9.5	9.5	22	25	9.5
R_i	95		83	99.5	47.5
$(R_i)_{avg}$	9.5		16.6	19.9	9.5
R_i^2/n_i	902.5		1377.8	1980.1	451.3

$\Sigma R_i^2/n_i =$ 4711.6

mg/L = milligrams per liter   K = the number of n_i groups

BG = background   N = the total number of samples

DL = detection limit

Bolded values indicate a detected result.

$K =$ 4   NOTE: For this method, observations below the detection limit

$N =$ 25   that are considered nondetects (i.e., U qualified data) are reported as a concentration of 0.

Calculation of Kruskal-Wallis Statistic

$H =$ 8.983   Kruskal-Wallis Statistic $H = [12/N(N+1) \ast \Sigma R_i^2/n_i] - 3(N+1)$

$H' =$ 14.321   Corrected Kruskal-Wallis $H' = H/[1-(\Sigma T_i/N^3-N)]$

$\chi^2_{crit} \ast =$ 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 $Z(\alpha/(K-1)) \ast\ast =$ 2.1280

$\alpha =$ 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 = 9.5

	Well No.	C_i	$(R_i)_{avg} - (R_b)_{avg}$	Conclusion
BG Well	MW93A			
BG Well	MW420			
	MW84A	8.578	7.10	not contaminated
	MW87A	8.578	10.40	**evidence of contamination**
	MW90A	8.578	0.00	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 MW87A, there is a statistically significant difference between downgradient compliance test wells and background wells in MW87A from the C-404 Landfill.

Because nonparametric ANOVA indicated a statistically significant difference between compliance test wells and background wells at the C-404 Landfill in compliance well MW87A, the 95% UTL was performed.

Since $(R_i)_{avg} - (R_b)_{avg} < C_i$ for MW84A and MW90A, there is no statistically significant difference between compliance test wells and background wells at the C-404 Landfill.

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

Attachment B2: Cadmium URGA, Statistical Test 3, Nonparametric ANOVA, First Reporting Period 2020

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.

January 2020 Data, First Reporting Period
Observations (mg/L)

Well No.						
MW93A	0.0005	0.0005	0.0005	0.0005	0.0005	Upgradient Well[!]
MW420	0.0005	0.0005	0.0005	0.0005	0.0005	Upgradient Well[!]
						Current Data
MW87A	X: Mean Value =	0.0005				0.000503
	S: Standard Deviation =	0.0000				
	K* factor =	2.911	(for n = 10)			
	CV = S/X	0.0000	<1, assume normal distribution			
	Upper Tolerance Interval: TL = X +(KxS) =	**0.0005**	(mg/L)			

    ! = Data from previous 5 sampling events.

CV = coefficient of variation

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

    **= The laboratory reported result of 0.000503 mg/L exceeds the UTL of 0.0005 mg/L; however, this mathematical result is assumed to not be a "true" exceedance, but is assumed to be an artifact of the statistical method used.

Result: **The Test Well has exceeded the UTL, which is statistically significant evidence that the well has elevated concentration with respect to background data.** **Paired (parametric) ANOVA is 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 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.

Cadmium (mg/L)					
Date	Background	Compliance			
	MW93A	MW87A	n_i^2		
Jan-18	0.0005	**0.000375**	0.0000003	0.0000001	
Aug-18	0.0005	**0.000372**	0.0000003	0.0000001	
Jan-19	0.0005	**0.000481**	0.0000003	0.0000002	
Jul-19	0.0005	0.0005	0.0000003	0.0000003	
Jan-20	0.0005	**0.000503**	0.0000003	0.0000003	
Sum (x_i)	0.0025	0.00223	0.0047	Total Sum ($x_{..}$)	
n_i	5	5			
$(x_i)_{avg}$	0.00050	0.00045			
$(x_i)^2$	0.00001	0.00000			

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

Overall mean $x_{..}$ = 0.00047
N = 10 N = the total number of samples
p = 2 p = the number of n_i groups
$x_{..}$ = 0.0047 $x_{..}$ = the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test

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

Date	Background	Compliance
	MW93A	MW87A
Jan-18	0.00000	-0.00007
Aug-18	0.00000	-0.00007
Jan-19	0.00000	0.00003
Jul-19	0.00000	0.00005
Jan-20	0.00000	0.00006

X: Mean Value = -5.42E-21
S: Standard Deviation = 0.00004
K* Factor = 2.911 (for n = 10)
CV = S/X = −8.23E+15 <1, data are normally distributed

Data are normally distributed (i.e., <1).

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

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

Determine Equality of Variance of Dataset

p = number of wells	$x_{..}$ = 0.0047
n_i = number of data points per well	$(x_{avg})_{..}$ = 0.00047
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	$f_i S_i^2$	$f_i \ln(S_i^2)$
0.00000	0.00000000000	#NUM!	5	0.0000000	#NUM!
0.00007	0.00000000448	-19.224	5	0.0000000	-76.9

$\sum(S_i^2) =$ 0.00000 $\sum f_i \ln(S_i^2) =$ #NUM!

Equality of Variance: Bartlett's Test

$f =$ 8

$Sp^2 =$ 0.0000000

$\ln Sp^2 =$ -19.918

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

$\chi^2_{crit} * =$ 3.841   at a 5% significance level with   1   degrees of freedom (p-1)

#NUM!   **(i.e., calculated $\chi^2 > \chi^2_{crit}$)**

Equality of variance can not be calculated, transform the original data to lognormal

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

Paired (Parametric) ANOVA—Lognormal Data

	ln[Cadmium (mg/L)]			
Date	Background	Compliance		
	MW93A	MW87A	n_i^2	
Jan-18	**-7.60**	**-7.89**	57.77	62.23
Aug-18	**-7.60**	**-7.90**	57.77	62.36
Jan-19	**-7.60**	**-7.64**	57.77	58.36
Jul-19	**-7.60**	**-7.60**	57.77	57.77
Jan-20	**-7.60**	**-7.59**	57.77	57.68
Sum (x_i)	-38.00	-38.62	-76.63	Total Sum $(x..)$
n_i	5	5		
$(x_i)_{avg}$	-7.60	-7.72		
$(x_i)^2$	1444.34	1491.56		

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

Overall mean x.. =	-7.66	
N =	10	N = the total number of samples
p =	2	p = the number of n_i groups
x.. =	-76.63	x.. = the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test—Lognormal Data

Table of Residuals (x_i-x_iavg) for Lognormal Data

Date	Background	Compliance
	MW93A	MW87A
Jan-18	0.00	-0.16
Aug-18	0.00	-0.17
Jan-19	0.00	0.08
Jul-19	0.00	0.12
Jan-20	0.00	0.13

X: Mean Value =	-3.55E-16	
S: Standard Deviation =	0.10	
K* Factor =	2.911	(for n = 10)
CV = S/X =	−2.90E+14	<1, data are normally distributed

Data are normally distributed (i.e., <1)

*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—Lognormal Data

p = number of wells	$x_{..} = -76.63$
n_i = number of data points per well	$(x_{avg})_{..} = -7.66$
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	$f_i S_i^2$	$f_i \ln(S_i^2)$
0.00	0.00	#NUM!	5	0.00	#NUM!
0.15	0.02	-3.73	5	0.10	-14.9

$\sum(S_i^2) = \quad 0.02$ $\qquad\qquad \sum f_i \ln(S_i^2) = \quad$ #NUM!

Equality of Variance: Bartlett's Test

f =	8
$Sp^2 =$	0.01
$\ln Sp^2 =$	-4.42
$\chi^2 =$	#NUM!

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

$\chi^2_{crit} * =$ 3.841 at a 5% significance level with 1 degrees of freedom (p-1)

#NUM! $\qquad\qquad\qquad$ **(i.e., calculated $\chi^2 \leq \chi^2_{crit}$)**

Because equality of variance could not be determined, a paired (nonparametric) ANOVA was performed.

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

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

Paired Nonparametric ANOVA

Cadmium (mg/L)		
Date	Background	Compliance
	MW93A	MW87A
Jan-18	0.0005	**0.000375**
Aug-18	0.0005	**0.000372**
Jan-19	0.0005	**0.000481**
Jul-19	0.0005	0.0005
Jan-20	0.0005	**0.000503**
Sum	0.0025	0.00223
n_i	5	5
$(x_i)_{avg}$	0.00050	0.00045

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.. = 0.00047
N = 10
p = 2
x.. = 0.00473

Ranking of Observations

Sequence	Cadmium	Adjusted	Tie Number
1	0	3.5	
2	0	3.5	
3	0	3.5	Tie-1
4	0	3.5	
5	0	3.5	
6	0	3.5	
7	**0.000372**	7	
8	**0.000375**	8	
9	**0.000481**	9	
10	**0.000503**	10	

mg/L = milligrams per liter

n_{tie}	Adjustment for Ties: $(n_{tie}^3 - n_{tie})$	
6	Tie 1 =	210
	$\sum T_i$ =	210

Bolded values indicate a detected result.

Note: for this method, observations below the detection that are considered non-detects (i.e., U qualified data) are reported as a concentration 0.

Sums of Ranks and Averages

Observation Ranks for Cadmium		
Date	Background	Compliance
	MW93A	MW87A
Jan-18	3.5	8
Aug-18	3.5	7
Jan-19	3.5	9
Jul-19	3.5	3.5
Jan-20	3.5	10
R_i	18	38
$(R_i)_{avg}$	4	8
R_i^2/n_i	61.3	281.3

$\sum R_i^2/n_i$ = 343
K = 2
N = 10

Calculation of Kruskal-Wallis Statistic

$H =$ 4.364 Kruskal-Wallis Statistic $H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$

$H' =$ 5.538 Corrected Kruskal-Wallis $H' = H/[1-(\sum T_i/N^3-N)]$

$\chi^2_{crit}* =$ 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 comes 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 $\alpha/(K-1) =$ 0.05000 $Z(\alpha/(K-1))** =$ 1.6449

$\alpha =$ 0.05 $1-(\alpha/K-1) =$ 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 = 3.500

	Well No.	C_i	$(R_i)_{avg} - (R_b)_{avg}$	Conclusion
BG Well	MW93A			
	MW87A	3.150	4.000	**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 (Ri)avg - (Rb)avg > Ci for MW87A, there is a statistically significant difference in this downgradient compliance test well.

Because the nonparametric ANOVA for the two wells indicated a statistically significant difference between compliance test wells and background wells at the C-404 Landfill in compliance well MW87A, a Mann Kendall statistical analysis was performed.

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

Mann-Kendall Analysis - MW87A - Cadmium

Mann-Kendall Trend Test Analysis

Input Data	
Date	Result (mg/L)
Jul-16	**0.000451**
Jan-17	0.001
Jul-17	**0.000304**
Jan-18	**0.000375**
Aug-18	**0.000372**
Jan-19	**0.000481**
Jul-19	0.0006
Jan-20	**0.000503**
Bolded values indicate a detected result	

User Selected Options

Date/Time of Computation	ProUCL 5.15/15/2020 2:47:33 PM
From File	WorkSheet_b.xls
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

MW87-87A_Cd_1-2020

General Statistics

Number or Reported Events Not Used	0
Number of Generated Events	8
Number Values Reported (n)	8
Minimum	3.0400E-4
Maximum	0.001
Mean	5.1075E-4
Geometric Mean	4.7911E-4
Median	4.6600E-4
Standard Deviation	2.1787E-4
Coefficient of Variation	0.427

Mann-Kendall Test

M-K Test Value (S)	6
Tabulated p-value	0.274
Standard Deviation of S	8.083
Standardized Value of S	0.619
Approximate p-value	0.268

**Insufficient evidence to identify a significant
trend at the specified level of significance.**

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Mann-Kendall Analysis - MW87A - Cadmium

Mann-Kendall Trend Test

Mann-Kendall Trend Analysis	
n	8
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	8.0829
Standardized Value of S	0.6186
M-K Test Value (S)	6
Tabulated p-value	0.2740
Approximate p-value	0.2681

OLS Regression Line (Blue)

OLS Regression Slope	0.0000
OLS Regression Intercept	0.0006

Insufficient statistical evidence of a significant trend at the specified level of significance.
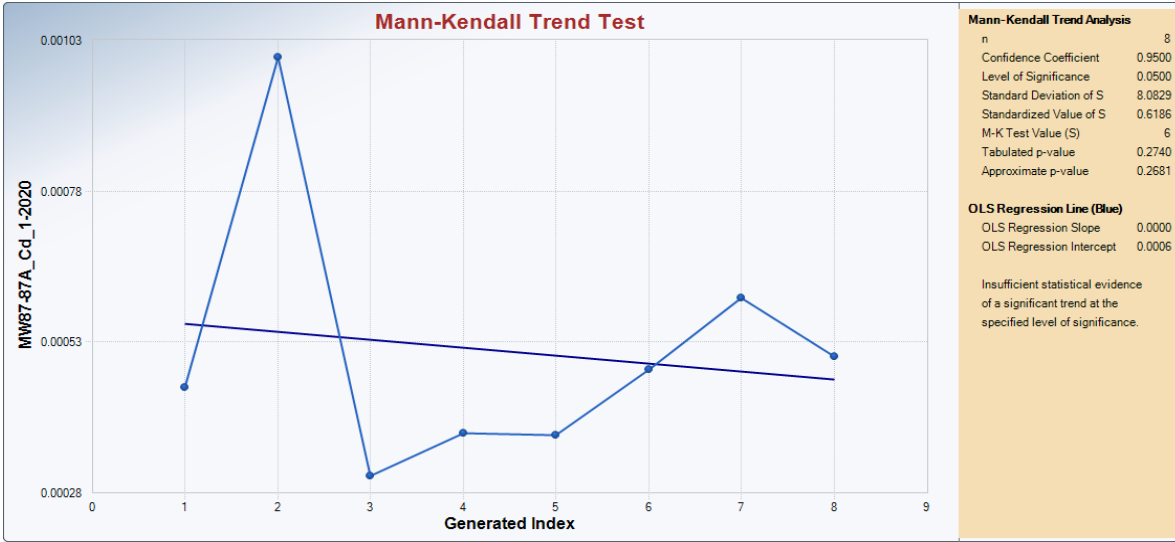
ATTACHMENT B3

**CHROMIUM
STATISTICAL TEST 2**

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Attachment B3: Chromium URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2020

Date	Uranium (mg/L)				
	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	**0.1510**	0.0050	**0.1430**	**1.1800**	**0.0038**
Aug-18	**0.1100**	0.0050	**0.0752**	**0.2750**	0.0050
Jan-19	**0.0561**	0.0050	**0.0251**	**0.0424**	0.0050
Jul-19	0.0050	0.0050	0.0050	0.0050	0.0050
Jan-20	0.0050	0.0050	0.0050	0.0050	0.0050

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

[1]**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
$Y =$	7	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.

$P_b =$	0.300	P_b = proportion of detects in background wells
$P_c =$	0.467	P_c = proportion of detects in compliance wells
$S_D =$	0.200	S_D = standard error of difference in proportions
$Z =$	-0.833	$Z = (P_b-P_c)/S_D$
absolute value of $Z =$	0.833	

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.**

[1]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

LEAD
STATISTICAL TEST 2

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Attachment B4: Lead URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2020

Date	Lead (mg/L)				
	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	**0.00186**	0.001	**0.00191**	**0.00579**	**0.000634**
Aug-18	**0.000802**	0.001	**0.00319**	**0.00682**	0.001
Jan-19	0.001	0.001	**0.00204**	**0.00502**	0.001
Jul-19	**0.00051**	0.001	0.001	0.001	0.001
Jan-20	0.001	0.001	0.001	0.001	0.001

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 =	7	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 =	0.300	P_b = proportion of detects in background wells
P_c =	0.467	P_c = proportion of detects in compliance wells
S_D =	0.200	S_D = standard error of difference in proportions
Z =	-0.833	$Z = (P_b - P_c)/S_D$
absolute value of Z =	0.833	

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 B5

**TECHNETIUM-99
STATISTICAL TEST 2**

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Attachment B5: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2020

	Technetium-99 (pCi/L)				
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	9.4	**21.5**	**34.4**	9.45	9.2
Aug-18	7.35	9.2	6.75	7.5	7.3
Jan-19	11.05	9.5	**28.8**	9.5	7.9
Jul-19	10.1	10.25	**126**	9.95	9.7
Jan-20	10.25	10.6	**297**	10.5	11.7

pCi/L = picocuries 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; 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
$P_c =$	0.267	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 B6

**TRICHLOROETHENE
STATISTICAL TESTS 4**

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Attachment B6: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2020

Date	Trichloroethene (TCE, µg/L)				
	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	**994**	**232**	**3160**	**1400**	**40.6**
Aug-18	**1000**	**476**	**5260**	**1690**	**53.3**
Jan-19	**1000**	**601**	**5580**	**2380**	**69.9**
Jul-19	**789**	**600**	**2000**	**1850**	**55.7**
Jan-20	**1360**	**1090**	**2930**	**2580**	**92.9**
n_i	10		5	5	5
Sum	8142		18930	9900	312.40
(x_i)avg	814.20		3786.00	1980.00	62.48

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

Overall mean x.. =   1491.38
N =   25   N = the total number of samples
p =   4   p = the number of n_i groups
x.. =   37284.40   x.. = the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test

Table of Residuals

Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	179.80	-582.20	-626.00	-580.00	-21.88
Aug-18	185.80	-338.20	1474.00	-290.00	-9.18
Jan-19	185.80	-213.20	1794.00	400.00	7.42
Jul-19	-25.20	-214.20	-1786.00	-130.00	-6.78
Jan-20	545.80	275.80	-856.00	600.00	30.42

X: Mean Value =   -1.17E-14
S: Standard Deviation =   697.8
K* Factor =   2.292   (for n = 25)
CV = S/X =   -5.99E+16   < 1, data are normally distributed

Data are normally distributed (i.e.,<1)
*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 B6: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2020

Determine Equality of Variance of Dataset

p = number of well groups

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.. = the sum of the total number of samples

$(x_{avg})_{..}$ = the mean of the total number of samples

$x_{..} = 37284.40$

$(x_{avg})_{..} = 1491.38$

p = 4

N = 25

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$	n_i	$f_iS_i^2$	$f_i\ln(S_i^2)$
336.756	113404.62	11.639	10	1020641.6	104.7
1557.684	2426380.00	14.702	5	9705520.000	58.8
489.234	239350.00	12.386	5	957400.000	49.5
19.934	397.35	5.985	5	1589.408	23.9

$\sum(S_i^2) =$ 2779531.97 $\qquad\qquad \sum f_i\ln(S_i^2) =$ 237.0

Equality of Variance: Bartlett's Test

$f =$ 21

$Sp^2 =$ 556435.762

$\ln Sp^2 =$ 13.229

$c^2 =$ 40.777 (If $c^2 \leq c^2_{crit}$, then variances are equal at the given significance level).

$c^2_{crit} * =$ 7.815 at a 5% significance level with 3 degrees of freedom

NOTE: The variances are NOT equal. $\qquad\qquad$ **(i.e., $c^2 > c^2_{crit}$)**

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

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

Attachment B6: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2020

Lognormal Data for TCE

	ln[TCE (µg/L)]				
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	6.90	5.45	8.06	7.24	3.70
Aug-18	6.91	6.17	8.57	7.43	3.98
Jan-19	6.91	6.40	8.63	7.77	4.25
Jul-19	6.67	6.40	7.60	7.52	4.02
Jan-20	7.22	6.99	7.98	7.86	4.53
Mean x_i	6.92	6.28	8.17	7.57	4.10
Background Mean	6.60		NA	NA	NA
Grand Mean	6.61				
x_i^2	47.63	29.67	64.94	52.48	13.72
	47.72	38.01	73.41	55.24	15.81
These values needed for ANOVA	47.72	40.94	74.42	60.45	18.04
	44.50	40.92	57.77	56.59	16.16
	52.06	48.92	63.72	61.71	20.53
Sum x_i^2	1143				

µg/L = micrograms per liter

Determine Normality of Dataset

Coefficient of Variability Test

Table of Residuals for Lognormal Data

Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	0.30	-1.16	-0.11	-0.32	-0.39
Aug-18	0.30	-0.44	0.40	-0.13	-0.12
Jan-19	0.30	-0.21	0.46	0.21	0.15
Jul-19	0.06	-0.21	-0.57	-0.04	-0.08
Jan-20	0.61	0.39	-0.18	0.29	0.44

$$X: \text{Mean Value} = -2.21\text{E-}03$$
$$S: \text{Standard Deviation} = 0.40$$
$$K^* \text{ Factor} = 2.292 \quad (\text{for } n = 25)$$
$$CV = S/X = -1.80\text{E+}02 \quad <1, \text{ data are normally distributed}$$

Data are normally distributed (i.e.,<1)

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

Attachment B6: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2020

Determine Equality of Variance of Dataset for Lognormal Data

p = number of wells (background wells considered as one group) $x_{..} = 165.15$

n_i = number of data points per well $(x_{avg})_{..} = 6.61$

N = total sample size $n_i = 5$

S^2 = the square of the standard deviation $p = 4$

$\ln(S_i^2)$ = natural logarithm of each variance $N = 25$

f = total sample size minus the number of wells (groups)

$f_i = n_i - 1$

x.. = the sum of the total lognormal dataset

$(x_{avg})_{..} =$ the mean of the lognormal dataset

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$	ni	$f_i S_i^2$	$f_i \ln(S_i^2)$
0.519	0.269	-1.314	10	2.420	-11.8
0.430	0.185	-1.689	5	0.738	-6.8
0.250	0.063	-2.770	5	0.251	-11.1
0.311	0.097	-2.337	5	0.387	-9.3

$\sum(S_i^2) =$ 0.61 $\sum f_i \ln(S_i^2) =$ -39.0

Equality of Variance: Bartlett's Test

$f =$ 21

$Sp^2 =$ 0.181

$\ln Sp^2 =$ -1.711

$c^2 =$ 3.082   (If $c^2 \leq c^2_{crit}$, then variances are equal at the given significance level).

$c^2_{crit} * =$ 7.815   at a 5% significance level with   3   degrees of freedom

NOTE: The variances are equal. $(i.e., c^2 \leq c^2_{crit})$

Because variances are equal, the Parametric ANOVA for the lognormal dataset will proceed.

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

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

Parametric ANOVA

Between Well Sum of Squares[1]

Source of Variation	Sums of Squares	df	Mean Squares	$F_{calculated}$
Between Wells (SS wells)	48.31	3	16.102	89.09
Error within wells (SS error)	3.80	21	0.181	
Total (SS total)	52.10	24		

If $F_{calculated} > F_{tabulated}$, then reject the hypothesis of equal well means. If $F_{calculated}$ is less than or equal to

$F_{tabulated}$, it can be concluded that there is no significant difference between concentrations, therefore,

there is no evidence of well contamination.

$F_{tabulated} = 3.07**$

CONCLUSION: $F_{calculated} > F_{tabulated}$; therefore, evidence of well contamination. Additional comparisons

must be made.

        NOTE: ** Table 2, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA*

Facilities, Interim Guidance , USEPA, 1989. $F_{tabulated}$ taken at the 5% significance level.

Comparison of Compliance Wells to Background Wells (Bonferroni Test)

$n_b =$	10	$N-p =$	21	$\alpha =$	0.05		
$(x_b)_{avg} =$	6.60	$m =$	3	$1-\alpha/m =$	0.9833		

    $n_b =$ total sample size of all background wells

$(x_b)_{avg} =$ average concentration from all background wells

Well No.	Well Mean	Differences of Avg.	Standard Error	Bonferroni's t^2	D_i	Conclusion
	$(x_b)_{avg}$	$(x_i)_{avg}-(x_b)_{avg}$	SE_i	$t_{(N-p),(\alpha/m)}$		
MW93A						
MW420						
MW84A	8.17	1.57	0.23	2.277	0.53	evidence of contamination
MW87A	7.57	0.97	0.23	2.277	0.53	evidence of contamination
MW90A	4.10	-2.50	0.23	2.277	0.53	not contaminated

CONCLUSION: If the "Differences of Averages" is greater than D_i, then the well is contaminated.

        After performing Bonferroni's t calculation, the following can be concluded:

        MW84A and MW87A show statistically significantly levels of contamination as compared

        background wells.

        MW90A does not show statistically significant levels of contamination.

[1]Section 5.2.1, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities,*

Interim Final Guidance , (EPA, 1989).

[2]Table 3 (EPA, 1989)

      A 95% UTL comparison is performed.

Attachment B6: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2020

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.

January 2020 Data, First Reporting Period
Observations (µg/L)

Well No.							
MW93A	994	1000	1000	789	1360	Upgradient Well[!]	
MW420	232	476	601	600	1090	Upgradient Well[!]	
						Current Data	
MW84A						2930	
MW87A	X: Mean Value =	814				2580	
	S: Standard Deviation =	337					
	K* factor =	2.911	(for n = 10)				
	CV = S/X	0.4136	<1, assume normal distribution				
	Upper Tolerance Interval: TL = X +(KxS) =	**1794**	(µg/L)				

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

Result:　　**Both MW84A and MW87A 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 wells MW84A and MW87A, the paired ANOVA was performed.

Paired (Parametric) ANOVA - MW93A and MW84A

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.

Date	TCE (µg/L) Background MW93A	TCE (µg/L) Compliance MW84A	n_i^2	
Jan-18	**994**	**3160**	988036	9985600
Aug-18	**1000**	**5260**	1000000	27667600
Jan-19	**1000**	**5580**	1000000	31136400
Jul-19	**789**	**2000**	622521	4000000
Jan-20	**1360**	**2930**	1849600	8584900
Sum (x_i)	5143	18930	24073	Total Sum (x..)
n_i	5	5		
$(x_i)_{avg}$	1029	3786		
$(x_i)^2$	26450449	358344900		

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

Overall mean x.. = 2407
N = 10   N = the total number of samples
p = 2   p = the number of n_i groups
x.. = 24073   x.. = the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test

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

Date	Background MW93A	Compliance MW84A
Jan-18	-35	-626
Aug-18	-29	1474
Jan-19	-29	1794
Jul-19	-240	-1786
Jan-20	331	-856

X: Mean Value = 0.00E+00
S: Standard Deviation = 1048
K* Factor = 2.911   (for n = 10)
CV = S/X = #ΔIς/0!   #DIV/0!

†The Coefficient of Variability Test was not performed due to mean = 0 (i.e., division by 0 not possible).

*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.

Attachment B6: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2020

Determine Equality of Variance of Dataset

p = number of wells	$x_{..} = 24073$
n_i = number of data points per well	$(x_{avg})_{..} = 2407$
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	$\ln(S_i^2)\dagger$	n_i	$f_i S_i^2$	$f_i\ln(S_i^2)\dagger$
206	42517	10.658	5	170067	42.6
1558	2426380	14.702	5	9705520	58.8

$\sum(S_i^2) =$ 2,468,897 $\sum f_i \ln(S_i^2) =$ 101

Equality of Variance: Bartlett's Test
$f =$ 8

$Sp^2 =$ 1234448

$\ln Sp^2 =$ 14.026

$\chi^2 =$ 10.771   (If calculated $\chi^2 \leq$ tabulated χ^2_{crit}, then variances are equal at the given significance level).

$\chi^2_{crit} * =$ 3.841   at a 5% significance level with   1   degrees of freedom (p-1)

NOTE: The variances are NOT equal.   (i.e., calculated $\chi^2 > \chi^2_{crit}$)

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).

Attachment B6: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2020

Paired (Parametric) ANOVA—Lognormal Data

Date	ln[TCE (µg/L)] Background MW93A	ln[TCE (µg/L)] Compliance MW84A	$n_i{}^2$	
Jul-17	**6.90**	**8.06**	47.63	64.94
Jan-18	**6.91**	**8.57**	47.72	73.41
Aug-18	**6.91**	**8.63**	47.72	74.42
Jan-19	**6.67**	**7.60**	44.50	57.77
Jul-19	**7.22**	**7.98**	52.06	63.72
Sum (x_i)	34.60	40.84	75.44	Total Sum (x..)
n_i	5	5		
$(x_i)_{avg}$	6.92	8.17		
$(x_i)^2$	1197.39	1667.65		

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

Overall mean x.. = 7.54

N = 10   N = the total number of samples

p = 2   p = the number of n_i groups

x.. = 75.44   x.. = the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test—Lognormal Data

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

Date	Background MW93A	Compliance MW84A
Jan-18	-0.02	-0.11
Aug-18	-0.01	0.40
Jan-19	-0.01	0.46
Jul-19	-0.25	-0.57
Jan-20	0.29	-0.18

X: Mean Value = -3.55E-16

S: Standard Deviation = 0.31

K* Factor = 2.911   (for n = 10)

CV = S/X = −8.84E+14   <1, data are normally distributed

Data are normally distributed (i.e., < or =1)

*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—Lognormal Data

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)

$f_i = n_i - 1$

$x_{..}$ = 75.44

$(x_{avg})_{..}$ = 7.54

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	$f_i S_i^2$	$f_i \ln(S_i^2)$
0.19	0.04	-3.28	5	0.15	-13.1
0.43	0.18	-1.69	5	0.74	-6.8

$\sum(S_i^2)$ =   0.22 $\sum f_i \ln(S_i^2)$ =   -19.89

Equality of Variance: Bartlett's Test

f =   8

Sp^2 =   0.11

$\ln Sp^2$ =   -2.20

χ^2 =   2.31   (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 with   1   degrees of freedom (p-1)

NOTE: The variances are equal.   **(i.e., calculated $\chi^2 \leq \chi^2_{crit}$)**

Since calculated $\chi^2 \leq \chi^2_{crit}$, then the analysis can proceed as normal.

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

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

Between Well Sum of Squares

Source of Variation	Sums of Squares		Degrees of Freedom	Mean Squares	Calculated F	F Statistic**
Between Wells	SS_{wells} =	3.89	1	3.89	34.99	5.32
Error	SS_{Error} =	0.89	8	0.11		
Total	SS_{Total} =	4.77	9			

If calculated F > F statistic, then reject the hypothesis of equal well means. If calculated F is less than or equal to F statistic, it can be concluded that there is no significant difference between concentrations; therefore, there is no evidence of well contamination.

CONCLUSION: **Calculated F > F statistic; therefore, ANOVA has identified a significant difference between background and downgradient wells.**

Because the paired ANOVA for the two wells indicated a statistically significant difference between compliance test wells and background wells at the C-404 Landfill in compliance well MW84A, a Mann-Kendall statistical analysis was performed.

**Table 2, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989). F statistic taken at the 5% significance level.

Attachment B6: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2020

Paired (Parametric) ANOVA - MW93A and MW87A

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.

TCE (µg/L)				
Date	Background	Compliance		
	MW93A	MW87A	n_i^2	
Jan-18	**994**	**1400**	988036	1960000
Aug-18	**1000**	**1690**	1000000	2856100
Jan-19	**1000**	**2380**	1000000	5664400
Jul-19	**789**	**1850**	622521	3422500
Jan-20	**1360**	**2580**	1849600	6656400
Sum (x_i)	5143	9900	15043	Total Sum (x..)
n_i	5	5		
$(x_i)_{avg}$	1029	1980		
$(x_i)^2$	26450449	98010000		

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

Overall mean x.. =	1504	
N =	10	N = the total number of samples
p =	2	p = the number of n_i groups
$x_{..} =$	15043	x.. = the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test

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

Date	Background	Compliance
	MW93A	MW87A
Jan-18	-35	-580
Aug-18	-29	-290
Jan-19	-29	400
Jul-19	-240	-130
Jan-20	331	600

X: Mean Value =	0.00E+00	
S: Standard Deviation =	354	
K* Factor =	2.911	(for n = 10)
CV = S/X =	#ΔIç/0!	#DIV/0!

†**The Coefficient of Variability Test was not performed due to mean = 0 (i.e., division by 0 not possible).**

*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 $x_{..}$ = 15043

n_i = number of data points per well $(x_{avg})_{..}$ = 1504

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	$f_iS_i^2$	$f_i\ln(S_i^2)$†
206	42517	10.658	5	170067	42.6
489	239350	12.386	5	957400	49.5

$\sum(S_i^2) =$ 281,867 $\sum f_i\ln(S_i^2) =$ 92

Equality of Variance: Bartlett's Test

$f =$ 8

$Sp^2 =$ 140933

$\ln Sp^2 =$ 11.856

$\chi^2 =$ 2.675   (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 with   1   degrees of freedom (p-1)

NOTE: The variances are equal.   **(i.e., calculated $\chi^2 \leq \chi^2_{crit}$)**

Since calculated $\chi^2 \leq \chi^2_{crit}$, then the analysis can proceed as normal.

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

Between Well Sum of Squares

Source of Variation	Sums of Squares		Degrees of Freedom	Mean Squares	Calculated F	F Statistic**
Between Wells	$SS_{wells} =$	2262904.90	1	2262904.90	16.06	5.32
Error	$SS_{Error} =$	1127467.20	8	140933.40		
Total	$SS_{Total} =$	3390372.10	9			

If calculated F > F statistic, then reject the hypothesis of equal well means. If calculated F is less than or equal to F statistic, it can be concluded that there is no significant difference between concentrations; therefore, there is no evidence of well contamination.

CONCLUSION: **Calculated F > F statistic; therefore, ANOVA has identified a significant
                     difference between upgradient and downgradient wells.**

                     **Because the paired ANOVA for the two wells indicated a statistically significant
                     difference between compliance test wells and background wells at the C-404 Landfill
                     in compliance well MW87A, a Mann-Kendall statistical analysis was performed.**

        **Table 2, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities,
        Interim Guidance* (EPA 1989). F statistic taken at the 5% significance level.

Attachment B6: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2020

Mann-Kendall Analysis MW84A - TCE

<p style="color:#8B0000">Mann-Kendall Trend Test Analysis</p>

Input Data	
Date	**Result (µg/L)**
Jul-16	**1820**
Jan-17	**2620**
Jul-17	**2910**
Jan-18	**3160**
Aug-18	**5260**
Jan-19	**5580**
Jul-19	**2000**
Jan-20	**2930**
Bolded results indicate a detected result	

User Selected Options

Date/Time of Computation	ProUCL 5.15/15/2020 1:17:10 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

MW84-84A_TCE_1-2020

General Statistics

Number or Reported Events Not Used	0
Number of Generated Events	8
Number Values Reported (n)	8
Minimum	1820
Maximum	5580
Mean	3285
Geometric Mean	3053
Median	2920
Standard Deviation	1398
Coefficient of Variation	0.426

Mann-Kendall Test

M-K Test Value (S)	12
Tabulated p-value	0.089
Standard Deviation of S	8.083
Standardized Value of S	1.361
Approximate p-value	0.0868

<p style="color:#8B0000">Insufficient evidence to identify a significant trend at the specified level of significance.</p>

Attachment B6: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2020

Mann-Kendall Analysis MW84A - TCE

Mann-Kendall Trend Test

Mann-Kendall Trend Analysis

n	8
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	8.0829
Standardized Value of S	1.3609
M-K Test Value (S)	12
Tabulated p-value	0.0890
Approximate p-value	0.0868

OLS Regression Line (Blue)

OLS Regression Slope	175.9524
OLS Regression Intercept	2,493.2143

Insufficient statistical evidence of a significant trend at the specified level of significance.
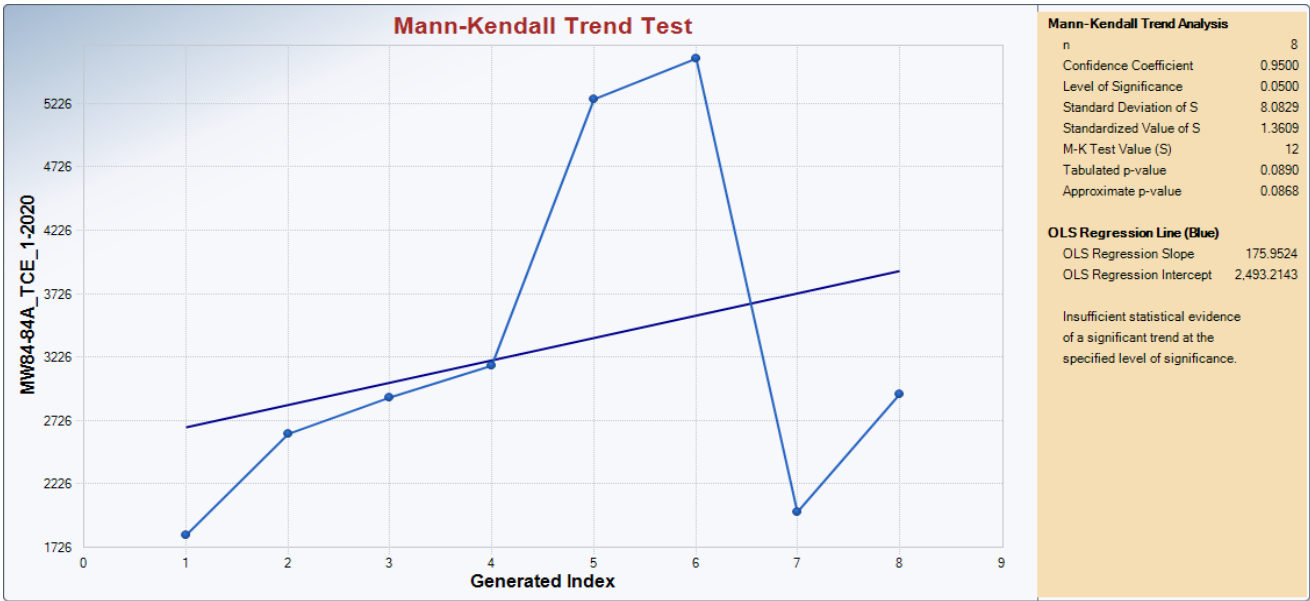
Mann-Kendall Analysis MW87A - TCE

Mann-Kendall Trend Test Analysis

Input Data	
Date	**Result (µg/L)**
Jul-16	**1090**
Jan-17	**2240**
Jul-17	**1620**
Jan-18	**1400**
Aug-18	**1690**
Jan-19	**2380**
Jul-19	**1850**
Jan-20	**2580**
Bolded results indicate a detected result	

User Selected Options

Date/Time of Computation	ProUCL 5.15/15/2020 1:24:13 PM
From File	WorkSheet_a.xls
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

MW87-87A_TCE_1-2020

General Statistics

Number or Reported Events Not Used	0
Number of Generated Events	8
Number Values Reported (n)	8
Minimum	1090
Maximum	2580
Mean	1856
Geometric Mean	1792
Median	1770
Standard Deviation	510.5
Coefficient of Variation	0.275

Mann-Kendall Test

M-K Test Value (S)	16
Tabulated p-value	0.031
Standard Deviation of S	8.083
Standardized Value of S	1.856
Approximate p-value	0.0317

Statistically significant evidence of an increasing trend at the specified level of significance.

Mann-Kendall Analysis MW87A - TCE

Mann-Kendall Trend Test

Mann-Kendall Trend Analysis	
n	8
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	8.0829
Standardized Value of S	1.8558
M-K Test Value (S)	16
Tabulated p-value	0.0310
Approximate p-value	0.0317

OLS Regression Line (Blue)

OLS Regression Slope	131.5476
OLS Regression Intercept	1,264.2857

Statistically significant evidence of an increasing trend at the specified level of significance.
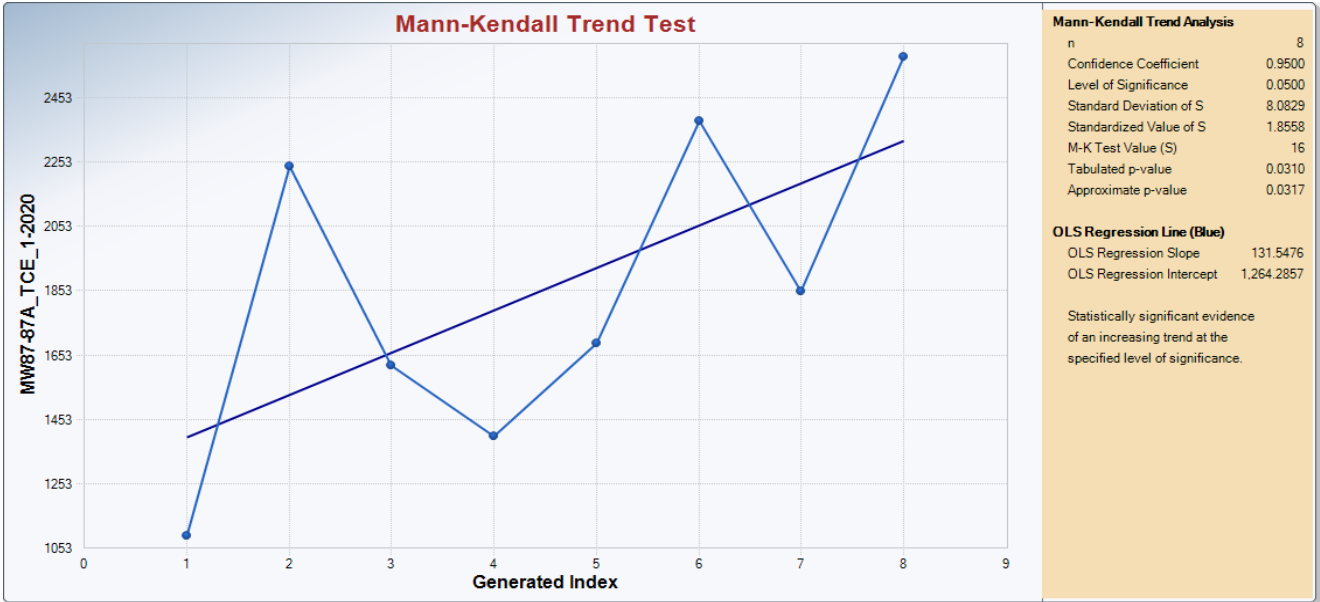
ATTACHMENT B7

**URANIUM
STATISTICAL TEST 2**

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Attachment B7: Uranium URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2020

Date	Uranium (mg/L)				
	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	0.000198	0.0001	**0.0002**	**0.000681**	0.0001
Aug-18	**0.000113**	0.0001	**0.000302**	**0.000722**	0.0001
Jan-19	0.000100	0.0001	**0.000193**	**0.00042**	0.0001
Jul-19	**0.000560**	0.0001	**0.00089**	0.0001	0.0001
Jan-20	0.000100	0.0001	**0.000305**	0.0001	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.

$X =$	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 B8

URANIUM-234
STATISTICAL TEST 2

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Attachment B8: Uranium-234 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2020

	Uranium-234 (pCi/L)				
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-18	1.1	0.73	0.58	0.955	1.035
Aug-18	0.78	0.78	0.525	0.865	1.305
Jan-19	0.685	1.115	0.715	1.19	**1.89**
Jul-19	**2.38**	0.71	**1.77**	1.01	**1.67**
Jan-20	0.755	0.56	0.695	0.675	0.655

pCi/L = picocuries 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

STATISTICIAN STATEMENT

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FOUR RIVERS
NUCLEAR PARTNERSHIP, LLC

April 20, 2020

Mr. Dennis Greene
Four Rivers Nuclear Partnership, LLC
5511 Hobbs Road
Kevil, KY 42053

Dear Mr. Greene:

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

As an Environmental Scientist, with a bachelor's degree in Earth Sciences/Geology, I have over 30 years of experience in reviewing and assessing laboratory analytical results associated with environmental sampling and investigation activities.

For this project, the statistical analyses on groundwater data from January 2018 through January 2020 were performed in accordance with the Hazardous Waste Management Facility Permit, Appendix E using Microsoft Excel 2016 and U.S. Environmental Protection Agency's (EPA's) ProUCL 5.1. The spreadsheets include the results for the following statistical tests:

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

The statistical analyses procedures were based on EPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Interim Final Guidance* (1989).

Sincerely,

Bryan Smith

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APPENDIX C

C-404 HAZARDOUS WASTE LANDFILL
LEACHATE ANALYTICAL RESULTS

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January 8, 2020
Leachate Analytical Results

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L1404L1-20	from: C404L	on 1/8/2020	Media: WW	SmpMethod: GR
Comments:				

Analysis	Results	Units	Result Qual	Foot Note	Reporting Limit	Counting Error	TPU	Method	LabCode	V/V/A*
ANION										
Fluoride	7.81	mg/L	W		0.2			SW846-9056	GEL	I / X /
FS										
Conductivity	540	umho/cm						FS	FS	/ /
Dissolved Oxygen	6.98	mg/L						FS	FS	/ /
pH	6.85	Std Unit						FS	FS	/ /
Redox	435	mV						FS	FS	/ /
Temperature	52.9	deg F						FS	FS	/ /
METAL										
Arsenic	0.00283	mg/L	J		0.005			SW846-6020	GEL	/ X /
Barium	0.0762	mg/L			0.004			SW846-6020	GEL	/ X /
Cadmium	0.001	mg/L	U		0.001			SW846-6020	GEL	/ X /
Chromium	0.01	mg/L	U		0.01			SW846-6020	GEL	/ X /
Copper	0.00991	mg/L			0.002			SW846-6020	GEL	/ X /
Iron	0.0389	mg/L	J		0.1			SW846-6020	GEL	S / X /
Lead	0.002	mg/L	U		0.002			SW846-6020	GEL	/ X /
Mercury	0.0002	mg/L	U		0.0002			SW846-7470A	GEL	/ X /
Nickel	0.00512	mg/L			0.002			SW846-6020	GEL	/ X /
Selenium	0.005	mg/L	U		0.005			SW846-6020	GEL	/ X /
Silver	0.001	mg/L	U		0.001			SW846-6020	GEL	/ X /
Uranium	59.8	mg/L			0.2			SW846-6020	GEL	I / X /
Zinc	0.02	mg/L	U		0.02			SW846-6020	GEL	/ X /
PPCB										
PCB-1016	0.1	ug/L	UY1		0.1			SW846-8082	GEL	/ X /
PCB-1221	0.1	ug/L	U		0.1			SW846-8082	GEL	/ X /
PCB-1232	0.1	ug/L	U		0.1			SW846-8082	GEL	/ X /
PCB-1242	0.1	ug/L	U		0.1			SW846-8082	GEL	/ X /
PCB-1248	0.778	ug/L			0.1			SW846-8082	GEL	/ X /
PCB-1254	0.1	ug/L	U		0.1			SW846-8082	GEL	/ X /
PCB-1260	0.1	ug/L	U		0.1			SW846-8082	GEL	/ X /
Polychlorinated biphenyl	0.778	ug/L			0.1			SW846-8082	GEL	I / X /
RADS										
Cesium-137	-3.43	pCi/L	U		9.99	5.73	5.95	EPA-901.1	GEL	/ X /
Neptunium-237	1.24	pCi/L	U		1.36	1.29	1.29	ASTM-1475-00M	GEL	/ X /
Plutonium-239/240	0.258	pCi/L	U		1.23	0.711	0.712	HASL 300, Pu-11-RC M	GEL	/ X /
Technetium-99	448	pCi/L			21.3	20.7	53.9	HASL 300, Tc-02-RC M	GEL	S / X /
Thorium-230	0.785	pCi/L	U		2.79	1.63	1.64	HASL 300, Th-01-RC M	GEL	/ X /
Uranium-234	1730	pCi/L			109	330	467	HASL 300, U-02-RC M	GEL	/ X /
Uranium-235	372	pCi/L			95.1	174	188	HASL 300, U-02-RC M	GEL	/ X /
Uranium-238	24200	pCi/L			88.9	1220	4760	HASL 300, U-02-RC M	GEL	/ X /
VOA										
Trichloroethene	1	ug/L	UY1		1			SW846-8260B	GEL	/ X /
WETCHEM										
Ammonia as Nitrogen	0.116	mg/L			0.05			EPA-350.1	GEL	/ X / FDUP-OUT

L1404LD1-20			from: C404L		on 1/8/2020	Media: WW		SmpMethod:	GR	

Comments:

Analysis	Results	Units	Result Qual	Foot Note	Reporting Limit	Counting Error	TPU	Method	LabCode	V/V/A*
ANION										
Fluoride	7.93	mg/L	W		0.2			SW846-9056	GEL	I / X /
METAL										
Arsenic	0.00268	mg/L	J		0.005			SW846-6020	GEL	/ X /
Barium	0.0743	mg/L			0.004			SW846-6020	GEL	/ X /
Cadmium	0.001	mg/L	U		0.001			SW846-6020	GEL	/ X /
Chromium	0.01	mg/L	U		0.01			SW846-6020	GEL	/ X /
Copper	0.00989	mg/L			0.002			SW846-6020	GEL	/ X /
Iron	0.0393	mg/L	J		0.1			SW846-6020	GEL	S / X /
Lead	0.002	mg/L	U		0.002			SW846-6020	GEL	/ X /
Mercury	0.0002	mg/L	U		0.0002			SW846-7470A	GEL	/ X /
Nickel	0.00509	mg/L			0.002			SW846-6020	GEL	/ X /
Selenium	0.005	mg/L	U		0.005			SW846-6020	GEL	/ X /
Silver	0.001	mg/L	U		0.001			SW846-6020	GEL	/ X /
Uranium	58.7	mg/L			0.2			SW846-6020	GEL	I / X /
Zinc	0.02	mg/L	U		0.02			SW846-6020	GEL	/ X /
PPCB										
PCB-1016	0.0943	ug/L	UY1		0.0943			SW846-8082	GEL	/ X /
PCB-1221	0.0943	ug/L	U		0.0943			SW846-8082	GEL	/ X /
PCB-1232	0.0943	ug/L	U		0.0943			SW846-8082	GEL	/ X /
PCB-1242	0.0943	ug/L	U		0.0943			SW846-8082	GEL	/ X /
PCB-1248	0.9	ug/L			0.0943			SW846-8082	GEL	/ X /
PCB-1254	0.0943	ug/L	U		0.0943			SW846-8082	GEL	/ X /
PCB-1260	0.0943	ug/L	U		0.0943			SW846-8082	GEL	/ X /
Polychlorinated biphenyl	0.9	ug/L			0.0943			SW846-8082	GEL	I / X /
RADS										
Cesium-137	-2.56	pCi/L	U		9.57	5.29	5.42	EPA-901.1	GEL	/ X /
Neptunium-237	0.497	pCi/L	U		3.18	1.67	1.67	ASTM-1475-00M	GEL	/ X /
Plutonium-239/240	0.409	pCi/L	U		1.32	0.814	0.816	HASL 300, Pu-11-RC M	GEL	/ X /
Technetium-99	407	pCi/L			20.7	19.7	49.3	HASL 300, Tc-02-RC M	GEL	S / X /
Thorium-230	0.594	pCi/L	U		1.58	0.979	0.987	HASL 300, Th-01-RC M	GEL	/ X /
Uranium-234	1950	pCi/L	T		173	416	597	HASL 300, U-02-RC M	GEL	/ X /
Uranium-235	311	pCi/L	T		168	197	208	HASL 300, U-02-RC M	GEL	/ X /
Uranium-238	21600	pCi/L	T		180	1360	4930	HASL 300, U-02-RC M	GEL	/ X /
VOA										
Trichloroethene	1	ug/L	UY1		1			SW846-8260B	GEL	/ X /
WETCHEM										
Ammonia as Nitrogen	0.476	mg/L			0.05			EPA-350.1	GEL	S / X / FDUP-OUT

Paducah OREIS Report for 404L20-01

FB404L1-20		from: QC	on 1/8/2020	Media: WQ	SmpMethod:

Comments:

Analysis	Results	Units	Result Qual	Foot Note	Reporting Limit	Counting Error	TPU	Method	LabCode	V/V/A*
ANION										
Fluoride	0.1	mg/L	UW		0.1			SW846-9056	GEL	/ X /
METAL										
Arsenic	0.005	mg/L	U		0.005			SW846-6020	GEL	/ X /
Barium	0.004	mg/L	U		0.004			SW846-6020	GEL	/ X /
Cadmium	0.001	mg/L	U		0.001			SW846-6020	GEL	/ X /
Chromium	0.01	mg/L	U		0.01			SW846-6020	GEL	/ X /
Copper	0.002	mg/L	U		0.002			SW846-6020	GEL	/ X /
Iron	0.1	mg/L	U		0.1			SW846-6020	GEL	/ X /
Lead	0.002	mg/L	U		0.002			SW846-6020	GEL	/ X /
Mercury	0.0002	mg/L	U		0.0002			SW846-7470A	GEL	/ X /
Nickel	0.002	mg/L	U		0.002			SW846-6020	GEL	/ X /
Selenium	0.005	mg/L	U		0.005			SW846-6020	GEL	/ X /
Silver	0.001	mg/L	U		0.001			SW846-6020	GEL	/ X /
Uranium	0.000093	mg/L	J		0.0002			SW846-6020	GEL	/ X /
Zinc	0.02	mg/L	U		0.02			SW846-6020	GEL	/ X /
PPCB										
PCB-1016	0.0952	ug/L	UY1		0.0952			SW846-8082	GEL	/ X /
PCB-1221	0.0952	ug/L	U		0.0952			SW846-8082	GEL	/ X /
PCB-1232	0.0952	ug/L	U		0.0952			SW846-8082	GEL	/ X /
PCB-1242	0.0952	ug/L	U		0.0952			SW846-8082	GEL	/ X /
PCB-1248	0.0952	ug/L	U		0.0952			SW846-8082	GEL	/ X /
PCB-1254	0.0952	ug/L	U		0.0952			SW846-8082	GEL	/ X /
PCB-1260	0.0952	ug/L	U		0.0952			SW846-8082	GEL	/ X /
Polychlorinated biphenyl	0.0952	ug/L	U		0.0952			SW846-8082	GEL	/ X /
RADS										
Cesium-137	6.42	pCi/L	U		10	10.9	10.9	EPA-901.1	GEL	/ X /
Neptunium-237	-1.53	pCi/L	U		4.11	1.2	1.21	ASTM-1475-00M	GEL	/ X /
Plutonium-239/240	0.193	pCi/L	U		0.921	0.531	0.532	HASL 300, Pu-11-RC M	GEL	/ X /
Technetium-99	4.33	pCi/L	U		19.3	11.4	11.4	HASL 300, Tc-02-RC M	GEL	/ X /
Thorium-230	0.421	pCi/L	U		1.35	0.812	0.818	HASL 300, Th-01-RC M	GEL	/ X /
Uranium-234	-0.151	pCi/L	U		2.04	0.85	0.85	HASL 300, U-02-RC M	GEL	/ X /
Uranium-235	0.217	pCi/L	U		1.37	0.814	0.816	HASL 300, U-02-RC M	GEL	/ X /
Uranium-238	0.176	pCi/L	U		1.11	0.659	0.66	HASL 300, U-02-RC M	GEL	/ X /
VOA										
Trichloroethene	1	ug/L	UY1		1			SW846-8260B	GEL	/ X /
WETCHEM										
Ammonia as Nitrogen	0.18	mg/L			0.05			EPA-350.1	GEL	/ X /

Paducah OREIS Report for 404L20-01

RI404L1-20   from: QC   on 1/8/2020   Media: WQ   SmpMethod:

Comments:

Analysis	Results	Units	Result Qual	Foot Note	Reporting Limit	Counting Error	TPU	Method	LabCode	V/V/A*
ANION										
Fluoride	0.1	mg/L	UW		0.1			SW846-9056	GEL	/ X /
METAL										
Arsenic	0.005	mg/L	U		0.005			SW846-6020	GEL	/ X /
Barium	0.004	mg/L	U		0.004			SW846-6020	GEL	/ X /
Cadmium	0.001	mg/L	U		0.001			SW846-6020	GEL	/ X /
Chromium	0.01	mg/L	U		0.01			SW846-6020	GEL	/ X /
Copper	0.002	mg/L	U		0.002			SW846-6020	GEL	/ X /
Iron	0.1	mg/L	U		0.1			SW846-6020	GEL	/ X /
Lead	0.002	mg/L	U		0.002			SW846-6020	GEL	/ X /
Mercury	0.0002	mg/L	U		0.0002			SW846-7470A	GEL	/ X /
Nickel	0.002	mg/L	U		0.002			SW846-6020	GEL	/ X /
Selenium	0.005	mg/L	U		0.005			SW846-6020	GEL	/ X /
Silver	0.001	mg/L	U		0.001			SW846-6020	GEL	/ X /
Uranium	0.0062	mg/L			0.0002			SW846-6020	GEL	/ X /
Zinc	0.02	mg/L	U		0.02			SW846-6020	GEL	/ X /
PPCB										
PCB-1016	0.1	ug/L	UY1		0.1			SW846-8082	GEL	/ X /
PCB-1221	0.1	ug/L	U		0.1			SW846-8082	GEL	/ X /
PCB-1232	0.1	ug/L	U		0.1			SW846-8082	GEL	/ X /
PCB-1242	0.1	ug/L	U		0.1			SW846-8082	GEL	/ X /
PCB-1248	0.1	ug/L	U		0.1			SW846-8082	GEL	/ X /
PCB-1254	0.1	ug/L	U		0.1			SW846-8082	GEL	/ X /
PCB-1260	0.1	ug/L	U		0.1			SW846-8082	GEL	/ X /
Polychlorinated biphenyl	0.1	ug/L	U		0.1			SW846-8082	GEL	/ X /
RADS										
Cesium-137	2.29	pCi/L	U		9.21	4.36	4.48	EPA-901.1	GEL	/ X /
Neptunium-237	-0.352	pCi/L	U		2.59	0.867	0.868	ASTM-1475-00M	GEL	/ X /
Plutonium-239/240	-0.817	pCi/L	U		2.01	0.537	0.537	HASL 300, Pu-11-RC M	GEL	/ X /
Technetium-99	-1.48	pCi/L	U		19.1	11.1	11.1	HASL 300, Tc-02-RC M	GEL	/ X /
Thorium-230	-0.256	pCi/L	U		1.71	0.618	0.618	HASL 300, Th-01-RC M	GEL	/ X /
Uranium-234	1.87	pCi/L			1.82	1.68	1.72	HASL 300, U-02-RC M	GEL	/ X /
Uranium-235	0.283	pCi/L	U		1.79	1.06	1.06	HASL 300, U-02-RC M	GEL	/ X /
Uranium-238	12.5	pCi/L			1.67	3.88	4.42	HASL 300, U-02-RC M	GEL	/ X /
VOA										
Trichloroethene	1	ug/L	UY1		1			SW846-8260B	GEL	/ X /
WETCHEM										
Ammonia as Nitrogen	0.205	mg/L			0.05			EPA-350.1	GEL	/ X /

TB404L1-20   from: QC   on 1/8/2020   Media: WQ   SmpMethod:

Comments:

Analysis	Results	Units	Result Qual	Foot Note	Reporting Limit	Counting Error	TPU	Method	LabCode	V/V/A*
VOA										
Trichloroethene	1	ug/L	UY1		1			SW846-8260B	GEL	/ X /

*Verification/Validation/Assessment

February 18, 2020
Leachate Analytical Results

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Paducah OREIS Report for 404L20-02

Analysis	Results	Units	Result Qual	Foot Note	Reporting Limit	Counting Error	TPU	Method	LabCode	V/V/A*
ANION										
Fluoride	6.56	mg/L			0.2			SW846-9056	GEL	I / X /
FS										
Conductivity	497	umho/cm						FS	FS	/ /
Dissolved Oxygen	8.67	mg/L						FS	FS	/ /
pH	7.8	Std Unit						FS	FS	/ /
Redox	411	mV						FS	FS	/ /
Temperature	51.9	deg F						FS	FS	/ /
METAL										
Arsenic	0.005	mg/L	U		0.005			SW846-6020	GEL	/ X /
Barium	0.104	mg/L			0.004			SW846-6020	GEL	/ X /
Cadmium	0.000313	mg/L	J		0.001			SW846-6020	GEL	S / X /
Chromium	0.0119	mg/L			0.01			SW846-6020	GEL	/ X /
Copper	0.0457	mg/L			0.002			SW846-6020	GEL	/ X /
Iron	2.04	mg/L			0.1			SW846-6020	GEL	/ X /
Lead	0.00907	mg/L			0.002			SW846-6020	GEL	/ X /
Mercury	0.0002	mg/L	U		0.0002			SW846-7470A	GEL	/ X /
Nickel	0.0506	mg/L			0.002			SW846-6020	GEL	/ X /
Selenium	0.00253	mg/L	J		0.005			SW846-6020	GEL	S / X /
Silver	0.001	mg/L	U		0.001			SW846-6020	GEL	/ X /
Uranium	60.7	mg/L			0.2			SW846-6020	GEL	I / X /
Zinc	0.0358	mg/L			0.02			SW846-6020	GEL	/ X /
PPCB										
PCB-1016	0.5	ug/L	U		0.5			SW846-8082	GEL	/ X /
PCB-1221	0.5	ug/L	U		0.5			SW846-8082	GEL	/ X /
PCB-1232	0.5	ug/L	U		0.5			SW846-8082	GEL	/ X /
PCB-1242	0.5	ug/L	U		0.5			SW846-8082	GEL	/ X /
PCB-1248	5.42	ug/L			0.5			SW846-8082	GEL	/ X /
PCB-1254	2.87	ug/L			0.5			SW846-8082	GEL	/ X /
PCB-1260	0.626	ug/L			0.5			SW846-8082	GEL	/ X /
Polychlorinated biphenyl	8.92	ug/L			0.5			SW846-8082	GEL	I / X /
RADS										
Cesium-137	4.4	pCi/L	U		16.2	7.42	7.69	EPA-901.1	GEL	/ X /
Neptunium-237	4.44	pCi/L			1.31	1.8	1.89	ASTM-1475-00M	GEL	/ X /
Plutonium-239/240	5.78	pCi/L			1.22	2.44	2.6	HASL 300, Pu-11-RC M	GEL	S / X /
Technetium-99	374	pCi/L			20.8	19.3	45.8	HASL 300, Tc-02-RC M	GEL	/ X /
Thorium-230	134	pCi/L			1.9	10.7	22	HASL 300, Th-01-RC M	GEL	S / X /
Uranium-234	1190	pCi/L			77.8	227	299	HASL 300, U-02-RC M	GEL	/ X /
Uranium-235	410	pCi/L			41	149	163	HASL 300, U-02-RC M	GEL	/ X /
Uranium-238	17200	pCi/L			67.5	854	2900	HASL 300, U-02-RC M	GEL	/ X /
VOA										
Trichloroethene	1	ug/L	U		1			SW846-8260B	GEL	/ X /
WETCHEM										
Ammonia as Nitrogen	0.122	mg/L			0.05			EPA-350.1	GEL	/ X /

TB404L2-20	from: QC	on 2/18/2020	Media: WQ	SmpMethod:
Comments:				

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

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*Verification/Validation/Assessment