**MAY 29 2018**

PPPO-02-4813207-18A

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

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

Dear Ms. Linehan and Ms. Webb:

**TRANSMITTAL OF C-404 HAZARDOUS WASTE LANDFILL MAY 2018
SEMIANNUAL GROUNDWATER REPORT (OCTOBER 2017–MARCH 2018),
PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY,
FRNP-RPT-0026/V1, PERMIT NO. KY8-890-008-982**

Reference:     Letter from A. Webb to T. Duncan, "Approval of the C-404 Hazardous Waste
Landfill November 2017 Semiannual Groundwater Report (FPDP-RPT-0086/V2),
Notification of Statistical Exceedance (November 30, 2017), and Abandonment of
MW91 and Replacement of MW91A Report (December 19, 2017)," dated
January 8, 2018

This report is submitted to comply with Part II, Specific Condition II.K.6.d, of Hazardous Waste
Management Facility Permit No. KY8-890-008-982 (Permit). This report provides the
groundwater analytical results and statistical analysis of those results for the semiannual
sampling event conducted during January 2018 at the C-404 Hazardous Waste Landfill.

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 total arsenic
in monitoring well (MW), MW84. The MW84 total arsenic exceedance is consistent with
findings in the 2007 *C-404 Landfill Source Demonstration, Paducah Gaseous Diffusion Plant,
Paducah, Kentucky*, PRS-ENM-0031/R2, which demonstrated that the C-404 Hazardous Waste
Landfill was not the source of the historical, statistically significant background exceedance of
trichloroethene in MW84; therefore, there is no apparent exceedance (of total arsenic or any
other permit-required parameter) that is attributable to a release from the C-404 Hazardous
Waste Landfill. Notification of the statistically significant difference for total arsenic was

submitted, pursuant to Part II, Specific Condition II.K.6.a, to your department under separate correspondence.

In correspondence received for the November 2017 Semiannual Groundwater Report, the Kentucky Division of Waste Management (KDWM) included comments that are to be incorporated into future reports. The comments have been incorporated into this report. Please note that the requested trend for MW333 was included; however, this well has not been monitored routinely for total arsenic. (There is only one total arsenic data point for MW333. The sample collected July 20, 2004, had a detectable concentration of 2.90 µg/L.)
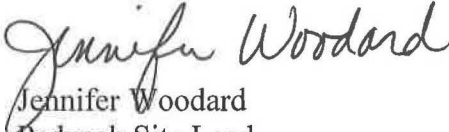
During a May 23, 2018, teleconference, the U.S. Department of Energy (DOE) discussed with KDWM the method used to collect duplicate samples from MWs at the C-404 Hazardous Waste Landfill. The collection method being used is defined in SW-846 as a co-located duplicate and differs from a definition in the Permit Application, Part E, Appendix E3. In the teleconference, KDWM agreed that the co-located duplicate collection method was appropriate for precision monitoring at the C-404 Landfill. Additionally discussed was 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. As a result, a Permit modification will be submitted to KDWM in the future to state that duplicate sampling shall be performed using the co-located duplicate sampling process.

Also during the May 23, 2018, teleconference, DOE discussed with KDWM the datum points and elevations used to generate annual groundwater flow rate and direction as described in the Permit Application Part E, Appendix E2. Other datum points historically have been used; however, the use of those datum points has not impacted the accuracy of groundwater flow directions depicted in the monitoring reports. When DOE submits the Permit modification to KDWM, the information on the data points will be updated.

As discussed with KDWM, DOE has not captured this information within the enclosed report and has inferred that modification of historical reports is not required. KDWM agreed that no further notifications of these events are required.

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

                                        Sincerely,

                                        *Jennifer Woodard*

                                        Jennifer Woodard
                                        Paducah Site Lead
                                        Portsmouth/Paducah Project Office

Enclosures:
  1. C-404 Hazardous Waste Landfill May 2018 Semiannual Groundwater Report
  2. Certification Page

e-copy w/enclosures:
april.webb@ky.gov, KDEP
brian.begley@ky.gov, KDEP
cheryl.baker@pad.pppo.gov, FRNP
christopher.jung@ky.gov, KDEP
corkran.julie@epa.gov, EPA
dave.dollins@lex.doe.gov, PPPO
dave.hutchison@pad.pppo.gov, FRNP
david.ashburn@pad.pppo.gov, FRNP
frnpcorrespondence@pad.pppo.gov, FRNP
gaye.brewer@ky.gov, KDEP
jennifer.blewett@pad.pppo.gov, FRNP
jennifer.watson@pad.pppo.gov, FRNP
jennifer.woodard@lex.doe.gov, PPPO
karen.walker@pad.pppo.gov, FRNP
kelly.layne@pad.pppo.gov, FRNP
ken.davis@pad.pppo.gov, FRNP
kim.knerr@lex.doe.gov, PPPO
lauren.linehan@ky.gov, KDEP
leo.williamson@ky.gov, KDEP
lisa.crabtree@pad.pppo.gov, FRNP
mike.guffey@ky.gov, KDEP
myrna.redfield@pad.pppo.gov, FRNP
richards.jon@epa.gov, EPA
stephaniec.brock@ky.gov, KYRHB
vicki.voisard@ky.gov, KDEP

# CERTIFICATION

**Document Identification:**   *C-404 Hazardous Waste Landfill May 2018*
*Semiannual Groundwater Report (October 2017–March 2018),*
*Paducah Gaseous Diffusion Plant, Paducah, Kentucky,*
**FRNP-18-0026/V1, Permit No. KY8-890-008-982**

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision 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.

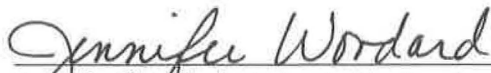Four Rivers Nuclear Partnership, LLC

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

5/29/18
_____
Date Signed

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
Portsmouth/Paducah Project Office

5/29/18
_____
Date Signed

# C-404 Hazardous Waste Landfill May 2018 Semiannual Groundwater Report (October 2017–March 2018), Paducah Gaseous Diffusion Plant, Paducah, Kentucky

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

# C-404 Hazardous Waste Landfill
# May 2018 Semiannual
# Groundwater Report
# (October 2017–March 2018),
# Paducah Gaseous Diffusion Plant,
# Paducah, Kentucky

Date Issued—May 2018

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

THIS PAGE INTENTIONALLY LEFT BLANK

# CONTENTS

# TABLES

# FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

# ACRONYMS

| | |
|---|---|
| AKGWA | Assembled Kentucky Groundwater |
| MW | monitoring well |
| RCRA | Resource Conservation and Recovery Act |
| RGA | Regional Gravel Aquifer |
| UCRS | Upper Continental Recharge System |
| URGA | Upper Regional Gravel Aquifer |
| UTL | upper tolerance limit |

THIS PAGE INTENTIONALLY LEFT BLANK

# EXECUTIVE SUMMARY

This report, *C-404 Hazardous Waste Landfill May 2018 Semiannual Groundwater Report (October 2017–March 2018), Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* FRNP-RPT-0026/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. The reporting period covers October 2017 through March 2018 and includes analytical data from the January 2018 sampling of monitoring wells (MWs) located in the vicinity of the closed C-404 Hazardous Waste Landfill (C-404 Landfill). In 1986, disposal of waste at C-404 Landfill was halted and a portion of the disposed-of waste was found to be Resource Conservation and Recovery Act (RCRA) hazardous. The landfill was covered with a RCRA multilayered cap and certified closed in 1987.

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

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

The leachate in the C-404 Landfill leachate collection system is monitored and, at a minimum, is removed and sampled when the level exceeds 3 ft in depth. On February 26, 2018, the leachate level in the C-404 Landfill leachate collection system was measured at 39 inches. On February 27, 2018, 1,000 gal was removed and sampled. Analytical data were not available for inclusion in this report by the regulatory deadline. The analytical data for the February 27, 2018, leachate sample will be included in the next semiannual report.

During this reporting period, MW91 was abandoned and replaced with MW91A (DOE 2017). Downhole camera inspections of MW91, as part of the site well maintenance program, revealed significant corrosion and some biofouling as well as a hole in the well riser. The integrity of the well riser had deteriorated to a point that it no longer was suitable for its intended purpose. MW91A was placed 10 ft north of MW91 and screened at the same depth interval. MW91A was sampled during this reporting period, and analytical data for this replacement well are included in this report.

THIS PAGE INTENTIONALLY LEFT BLANK

# 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 (the permit) (KDWM 2015), Specific Condition II.K.6.d—Recordkeeping, Reporting, and Response. The period covered by this report is October 2017 through March 2018.

Groundwater analytical results are provided in Appendix A. The statistical analyses and qualification statement are provided in Appendix B.

## 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 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 2015).

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

## 1.2 MONITORING PERIOD ACTIVITIES

### 1.2.1 Groundwater Monitoring

Groundwater sampling was conducted in January 2018 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. There are nine monitoring wells (MWs) sampled under this permit for the C-404 Landfill: four Upper Continental Recharge System (UCRS) wells and five Upper Regional Gravel Aquifer (URGA) wells.

During this reporting period, MW91 was abandoned and replaced with MW91A (DOE 2017). Downhole camera inspections of MW91, conducted in 2017 as part of the site well maintenance program, revealed significant corrosion and some biofouling as well as a hole in the well riser. The integrity of the well riser had deteriorated to a point that it no longer was suitable for its intended purpose. MW91 is a UCRS well

located in the northeast monitoring well cluster for the C-404 Landfill (Figure 1). MW91A was placed 10 ft north of MW91 and screened at the same depth interval. Downhole camera inspections of all other C-404 Landfill wells of the same age—MW84, MW85, MW87, MW88, MW93, and MW94 (installed in 1988)—did not reveal casing failures.

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

**Table 1. Monitoring Well Locations**

| UCRS | |
|---|---|
| Located south of C-404 Landfill, adjacent to upgradient URGA background well MW93 | MW94 |
| Located north of C-404 Landfill, adjacent to downgradient URGA compliance wells | MW85, MW88, MW91A* |
| **URGA** | |
| Upgradient background wells | MW93, MW420 |
| Downgradient compliance wells | MW84, MW87, MW90A* |

*MW90 was abandoned in 2001 and replaced with MW90A. MW91 was abandoned in 2017 and replaced with MW91A.

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

**Table 2. Assembled Kentucky Groundwater Numbers**

| Paducah Site Well Number | AKGWA Number |
|---|---|
| MW84 | 8000-5233 |
| MW85 | 8000-5234 |
| MW87 | 8000-5236 |
| MW88 | 8000-5237 |
| MW90A | 8004-0357 |
| MW91A | 8007-2917 |
| MW93 | 8000-5102 |
| MW94 | 8000-5103 |
| MW420 | 8005-3263 |

Appendix A of this report contains the analytical results from the wells that were sampled during the January 2018 semiannual sampling event. Appendix B of this report contains the statistical analyses.
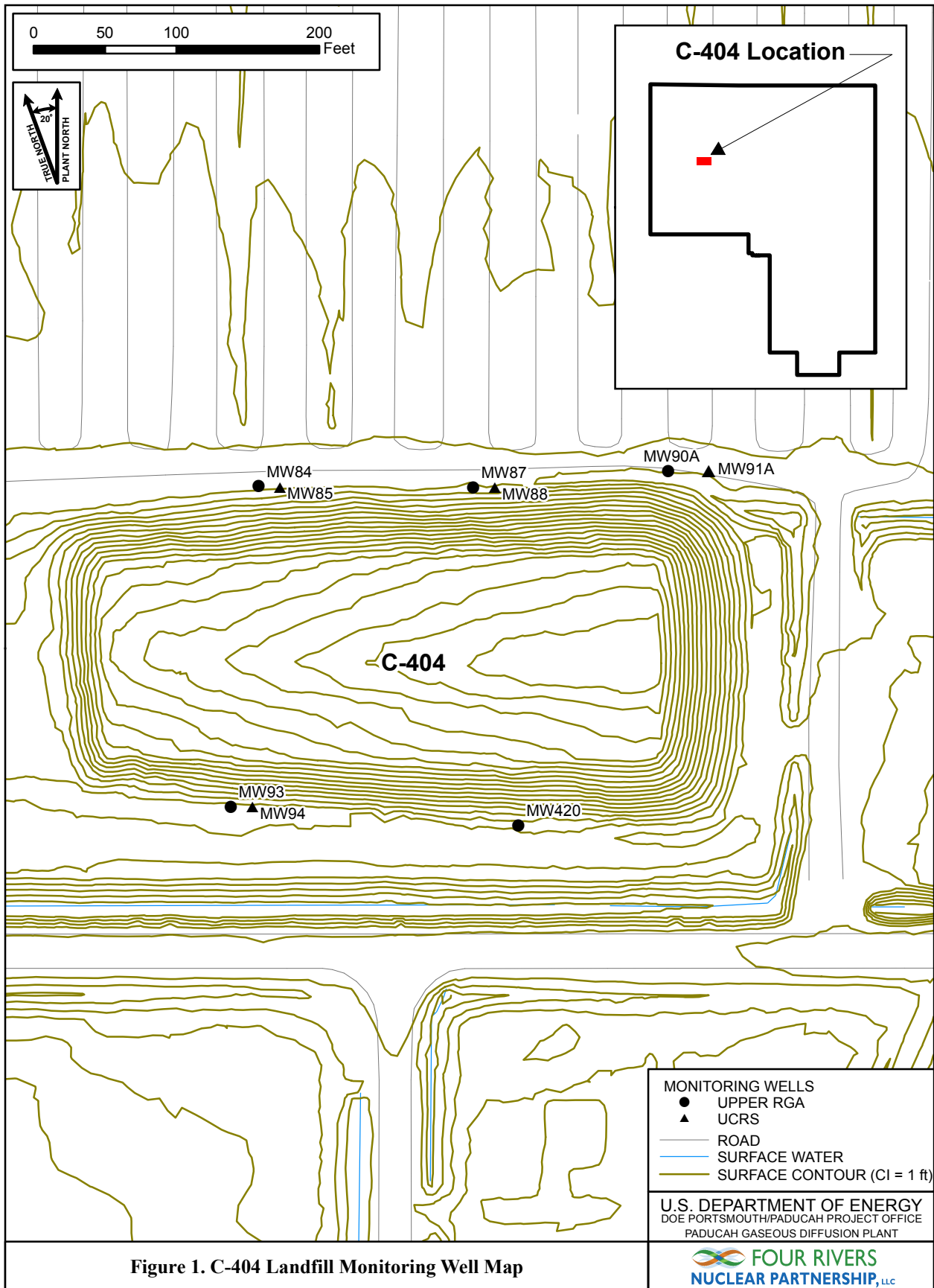
**Figure 1. C-404 Landfill Monitoring Well Map**

**1.2.2 Landfill Leachate**

In accordance with Section 1.2 of the Hazardous Waste Management Facility Permit, the quantity of liquid in the leachate collection system is monitored (at least monthly) and, at a minimum, will be "removed when the quantity exceeds 3 ft in depth." Once the leachate depth reached 3 ft, the leachate was pumped into a mobile tank. The leachate then was transferred to a permitted hazardous waste storage facility on-site prior to characterization and transferred off-site for treatment. The volume of leachate removed from the sump during this reporting period, October 2017 to March 2018, was 1,000 gal. The leachate was sampled on February 27, 2018. Analytical data were not available for inclusion in this report by the regulatory deadline. The analytical data for the February 27, 2018, leachate sample will be included in the next semiannual report.

# 2. STATISTICAL SYNOPSIS

The statistical analyses conducted on the data collected from C-404 Landfill were performed in accordance with procedures in the Hazardous Waste Management Facility Permit, Attachment Part E, reissued in July 2015. Appendix B of this report contains the statistical analyses performed for this reporting period. Data utilized for statistical analyses included data from the URGA background wells, MW93 and MW420, and URGA compliance wells, MW84, MW87, and MW90A. For these statistical analyses, the reporting period data set includes data from January 2016, July 2016, January 2017, July 2017, and January 2018.

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

Since the nonparametric ANOVA test for arsenic identified a statistically significant difference between concentrations in the compliance well, MW84, and concentrations in background wells, in accordance with the permit provisions, the data were evaluated further by comparing the most recent compliance analytical data to a 95% upper tolerance limit (UTL) using the five most recent sets of data for each background well. Results of the comparison showed concentrations in compliance well MW84 were higher than the UTL for the paired background concentrations. Analytical data were then evaluated using paired (parametric) ANOVA of wells in the same direction relative to the landfill (e.g., compare upgradient westernmost well MW93 analytical data to downgradient well MW84 analytical data). The paired ANOVA, could not be used for arsenic because there was no evidence of equality of variance. Thus, the paired ANOVA was abandoned, and the nonparametric ANOVA, was performed. Results of the nonparametric ANOVA identified there to be a significant difference between upgradient and downgradient wells. An additional intra-well evaluation of trend was then performed for arsenic in MW84 using the Mann-Kendall statistical test. The Mann-Kendall statistical test identified a positive trend in MW84 over the past eight semiannual events.

## STATISTICALLY SIGNIFICANT EXCEEDANCE OF BACKGROUND

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

Trending of groundwater data gathered in the vicinity and upgradient of the C-404 Landfill supports and supplements the finding in the 2007 Alternate Source Demonstration, as follows.
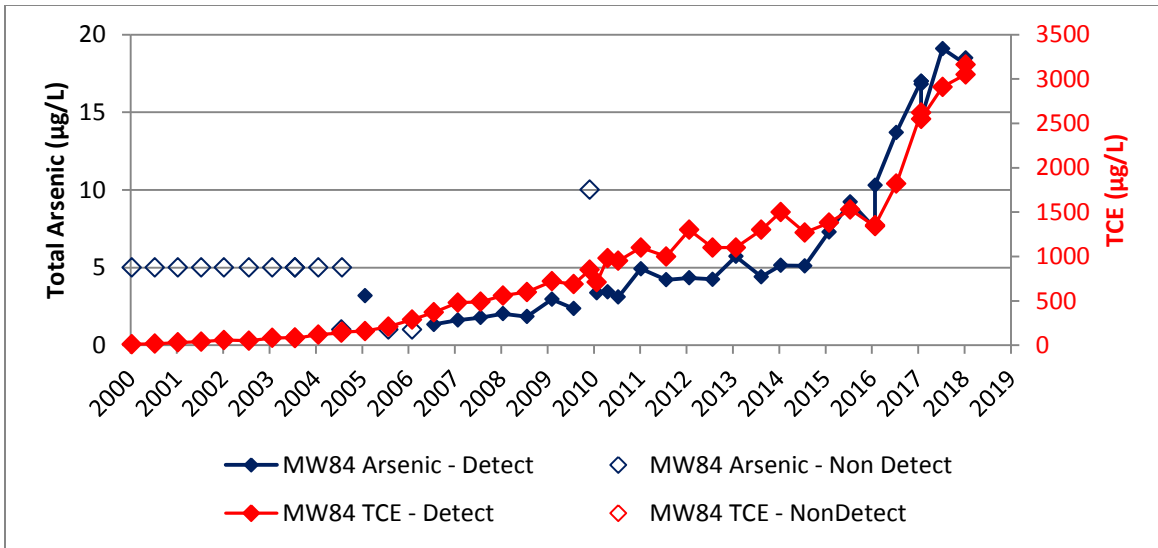
**Figure 2. Arsenic and TCE Trend in MW84**

First, until the January 2015 sampling event, the westernmost upgradient well (MW93) typically had higher arsenic concentrations than the downgradient well MW84 (see Figure 3). Since then, the MW84 arsenic concentrations have increased steadily, potentially reflecting increasing proximity to the core of the upgradient source. This condition is similar to the pattern of TCE concentrations historically seen in these same wells and is attributed to a source upgradient/crossgradient of the C-404 Landfill in the 2007 Alternate Source Demonstration. Similar, but slightly delayed, arsenic and TCE trends also are evident in neighboring (east) downgradient well MW87 (see Figure 4). The TCE detections[1] over time in MW333, located approximately 106 ft southwest of the C-404 Landfill, are depicted in Figure 5.
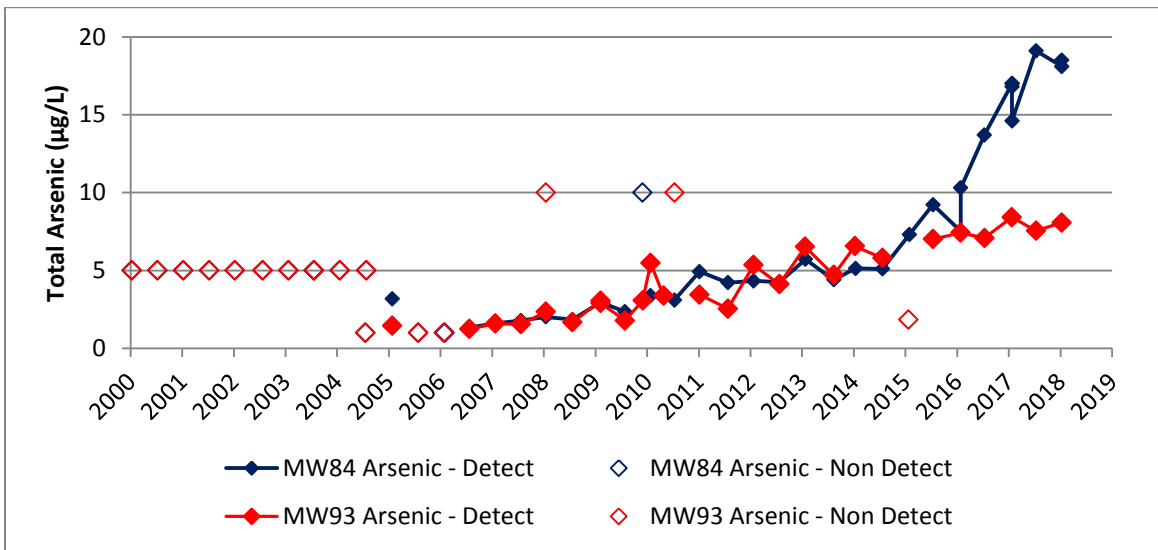


**Figure 3. Arsenic Trend in MW84 and MW93**

---

[1] There is only one arsenic data point for MW333. The sample collected July 20, 2004, had a detectable concentration of 2.90 μg/L.
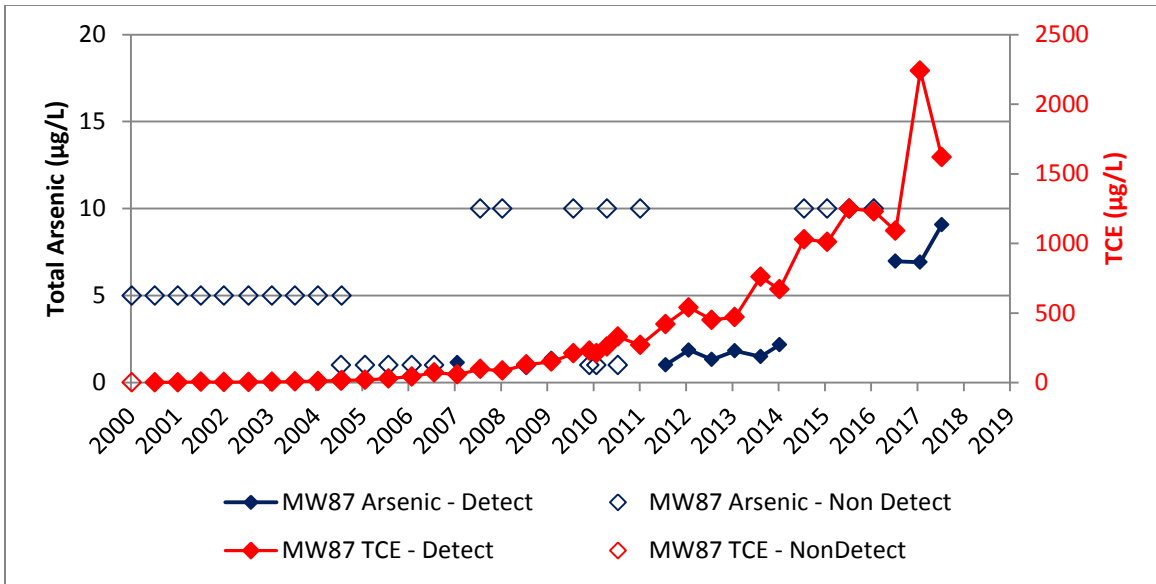
**Figure 4. Arsenic and TCE Trend in MW87**
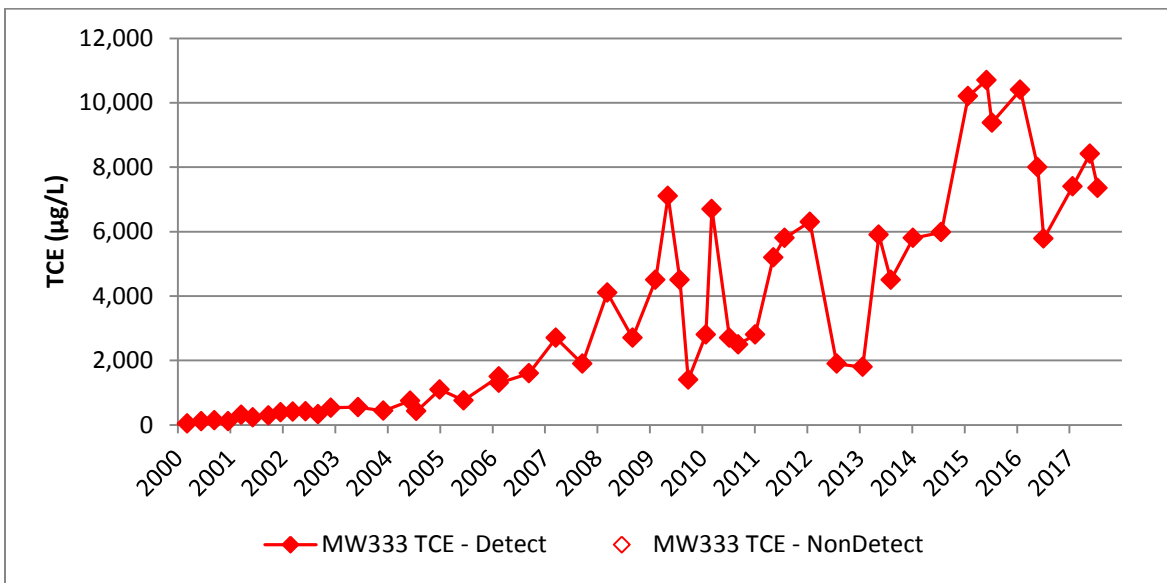


**Figure 5. TCE Trend in MW333**

Second, groundwater flow directions are to the northeast—similarly indicating an upgradient, non-C-404 Landfill source of MW84 impacts. This condition is consistent with flow patterns found in 2007 during the Alternate Source Demonstration.

Finally, most of the leachate samples collected over the years have had no detectable arsenic (dissolved arsenic is not required by the permit for leachate) and do not contain arsenic concentrations that could be the source of the concentrations recently detected in RGA groundwater at MW84. Of the 26% (14 of 54) of leachate samples that do contain arsenic, the maximum concentration of 6.32 μg/L in leachate is below the January 2018 arsenic concentration of 18.5 μg/L found in MW84; thus, the C-404 Landfill cannot be the source of the arsenic found in that well.

7

THIS PAGE INTENTIONALLY LEFT BLANK

# 3. DATA VALIDATION AND QA/QC SUMMARY

The data and the data validation qualifiers for the January 2018 data set are provided in Appendix A. All data for this data set were considered useable as reported.

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

Field quality control samples are collected semiannually during each sampling event. Equipment rinseate blanks, field blanks, 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.

THIS PAGE INTENTIONALLY LEFT BLANK

# 4. PROFESSIONAL GEOLOGIST AUTHORIZATION

**DOCUMENT IDENTIFICATION:**   *C-404 Hazardous Waste Landfill*
*May 2018 Semiannual Groundwater Report*
*(October 2017–March 2018),*
*Paducah Gaseous Diffusion Plant, Paducah, Kentucky*
*(FRNP-RPT-0026/V1)*

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

PG 113927
K. R. Davis
5-23-18

_____          _____          _____
Kenneth R. Davis                                          PG113927                    Date   May 23, 2018

THIS PAGE INTENTIONALLY LEFT BLANK

# 5. REFERENCES

DOE 2017. Letter from J. Woodard, U.S. Department of Energy, to A. Webb, Kentucky Department for Environmental Protection, "C-404 Landfill Report, Abandonment of MW91 and Replacement with MW91A, Per Hazardous Waste Management Facility Permit KY8-890-008-982, Conditions II.K.2.E and II.K.2.F; Hazardous Waste Permit Part E, 4.6.1; and 40 *CFR* § 264.97 (C); Agency Interest No. 3059," December 19.

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

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

THIS PAGE INTENTIONALLY LEFT BLANK

**APPENDIX A**

**C-404 HAZARDOUS WASTE LANDFILL GROUNDWATER ANALYTICAL RESULTS**

**Paducah OREIS**
**GROUNDWATER MONITORING REPORT**

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

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

**AKGWA Well Tag #:** 8000-5233

| Parameter | Qualifier | Result | Units | Reporting Limit | Date Collected | Counting Error (+/- | TPU | Method | Validation |
|---|---|---|---|---|---|---|---|---|---|
| Arsenic | | 0.0181 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Arsenic, Dissolved | U | 0.005 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Barometric Pressure Reading | | 30.07 | Inches/Hg | | 1/10/2018 | | | | X |
| Cadmium | U | 0.001 | mg/L | 0.001 | 1/10/2018 | | | SW846-6020 | = |
| Cadmium, Dissolved | U | 0.001 | mg/L | 0.001 | 1/10/2018 | | | SW846-6020 | = |
| Chromium | | 0.136 | mg/L | 0.01 | 1/10/2018 | | | SW846-6020 | = |
| Chromium, Dissolved | U | 0.01 | mg/L | 0.01 | 1/10/2018 | | | SW846-6020 | = |
| Conductivity | | 393 | umho/cm | | 1/10/2018 | | | | X |
| Depth to Water | | 53.32 | ft | | 1/10/2018 | | | | X |
| Dissolved Oxygen | | 3.19 | mg/L | | 1/10/2018 | | | | X |
| Lead | J | 0.00173 | mg/L | 0.002 | 1/10/2018 | | | SW846-6020 | = |
| Lead, Dissolved | U | 0.002 | mg/L | 0.002 | 1/10/2018 | | | SW846-6020 | = |
| Mercury | U | 0.0002 | mg/L | 0.0002 | 1/10/2018 | | | SW846-7470A | = |
| Mercury, Dissolved | U | 0.0002 | mg/L | 0.0002 | 1/10/2018 | | | SW846-7470A | = |
| pH | | 5.91 | Std Unit | | 1/10/2018 | | | | X |
| Redox | | 175 | mV | | 1/10/2018 | | | | X |
| Selenium | U | 0.005 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Selenium, Dissolved | J | 0.00204 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Technetium-99 | | 34.4 | pCi/L | 17.9 | 1/10/2018 | 11.5 | 12.1 | HASL 300, Tc-02-RC M | = |
| Temperature | | 57.9 | deg F | | 1/10/2018 | | | | X |
| Trichloroethene | | 3050 | ug/L | 50 | 1/10/2018 | | | SW846-8260B | = |
| Turbidity | | 117 | NTU | | 1/10/2018 | | | | X |
| Uranium | BJ | 0.000199 | mg/L | 0.0002 | 1/10/2018 | | | SW846-6020 | U |
| Uranium-234 | U | 0.404 | pCi/L | 1.16 | 1/10/2018 | 0.752 | 0.757 | HASL 300, U-02-RC M | = |
| Uranium-235 | U | 0.179 | pCi/L | 1.13 | 1/10/2018 | 0.671 | 0.672 | HASL 300, U-02-RC M | = |
| Uranium-238 | U | 0.0991 | pCi/L | 1.06 | 1/10/2018 | 0.55 | 0.551 | HASL 300, U-02-RC M | = |

# Paducah OREIS
## GROUNDWATER MONITORING REPORT

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

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

**AKGWA Well Tag #:** 8000-5233

| Parameter | Qualifier | Result | Units | Reporting Limit | Date Collected | Counting Error (+/- | TPU | Method | Validation |
|---|---|---|---|---|---|---|---|---|---|
| Arsenic | | 0.0185 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Arsenic, Dissolved | U | 0.005 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Barometric Pressure Reading | | 30.07 | Inches/Hg | | 1/10/2018 | | | | X |
| Cadmium | U | 0.001 | mg/L | 0.001 | 1/10/2018 | | | SW846-6020 | = |
| Cadmium, Dissolved | U | 0.001 | mg/L | 0.001 | 1/10/2018 | | | SW846-6020 | = |
| Chromium | | 0.143 | mg/L | 0.01 | 1/10/2018 | | | SW846-6020 | = |
| Chromium, Dissolved | U | 0.01 | mg/L | 0.01 | 1/10/2018 | | | SW846-6020 | = |
| Conductivity | | 393 | umho/cm | | 1/10/2018 | | | | X |
| Depth to Water | | 53.32 | ft | | 1/10/2018 | | | | X |
| Dissolved Oxygen | | 3.19 | mg/L | | 1/10/2018 | | | | X |
| Lead | J | 0.00191 | mg/L | 0.002 | 1/10/2018 | | | SW846-6020 | = |
| Lead, Dissolved | U | 0.002 | mg/L | 0.002 | 1/10/2018 | | | SW846-6020 | = |
| Mercury | U | 0.0002 | mg/L | 0.0002 | 1/10/2018 | | | SW846-7470A | = |
| Mercury, Dissolved | U | 0.0002 | mg/L | 0.0002 | 1/10/2018 | | | SW846-7470A | = |
| pH | | 5.91 | Std Unit | | 1/10/2018 | | | | X |
| Redox | | 175 | mV | | 1/10/2018 | | | | X |
| Selenium | U | 0.005 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Selenium, Dissolved | U | 0.005 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Technetium-99 | | 33.3 | pCi/L | 17.7 | 1/10/2018 | 11.4 | 12 | HASL 300, Tc-02-RC M | = |
| Temperature | | 57.9 | deg F | | 1/10/2018 | | | | X |
| Trichloroethene | | 3160 | ug/L | 50 | 1/10/2018 | | | SW846-8260B | = |
| Turbidity | | 117 | NTU | | 1/10/2018 | | | | X |
| Uranium | B | 0.0002 | mg/L | 0.0002 | 1/10/2018 | | | SW846-6020 | J |
| Uranium-234 | U | 0.283 | pCi/L | 1.32 | 1/10/2018 | 0.728 | 0.731 | HASL 300, U-02-RC M | = |
| Uranium-235 | U | 0.35 | pCi/L | 0.953 | 1/10/2018 | 0.687 | 0.689 | HASL 300, U-02-RC M | = |
| Uranium-238 | U | 0.244 | pCi/L | 0.89 | 1/10/2018 | 0.561 | 0.562 | 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 | | 0.0107 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Arsenic, Dissolved | U | 0.005 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Barometric Pressure Reading | | 30.08 | Inches/Hg | | 1/10/2018 | | | | X |
| Cadmium | U | 0.001 | mg/L | 0.001 | 1/10/2018 | | | SW846-6020 | = |
| Cadmium, Dissolved | U | 0.001 | mg/L | 0.001 | 1/10/2018 | | | SW846-6020 | = |
| Chromium | | 0.0116 | mg/L | 0.01 | 1/10/2018 | | | SW846-6020 | = |
| Chromium, Dissolved | J | 0.00538 | mg/L | 0.01 | 1/10/2018 | | | SW846-6020 | = |
| Conductivity | | 405 | umho/cm | | 1/10/2018 | | | | X |
| Depth to Water | | 12.36 | ft | | 1/10/2018 | | | | X |
| Dissolved Oxygen | | 2.44 | mg/L | | 1/10/2018 | | | | X |
| Lead | J | 0.00057 | mg/L | 0.002 | 1/10/2018 | | | SW846-6020 | = |
| Lead, Dissolved | U | 0.002 | mg/L | 0.002 | 1/10/2018 | | | SW846-6020 | = |
| Mercury | U | 0.0002 | mg/L | 0.0002 | 1/10/2018 | | | SW846-7470A | = |
| Mercury, Dissolved | U | 0.0002 | mg/L | 0.0002 | 1/10/2018 | | | SW846-7470A | = |
| pH | | 6.35 | Std Unit | | 1/10/2018 | | | | X |
| Redox | | 226 | mV | | 1/10/2018 | | | | X |
| Selenium | U | 0.005 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Selenium, Dissolved | U | 0.005 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Technetium-99 | | 73.6 | pCi/L | 20.6 | 1/10/2018 | 14.4 | 16.5 | HASL 300, Tc-02-RC M | = |
| Temperature | | 58.9 | deg F | | 1/10/2018 | | | | X |
| Trichloroethene | | 10.5 | ug/L | 1 | 1/10/2018 | | | SW846-8260B | = |
| Turbidity | | 31.6 | NTU | | 1/10/2018 | | | | X |
| Uranium | B | 0.000486 | mg/L | 0.0002 | 1/10/2018 | | | SW846-6020 | J |
| Uranium-234 | U | 0.0864 | pCi/L | 1.38 | 1/10/2018 | 0.669 | 0.669 | HASL 300, U-02-RC M | = |
| Uranium-235 | U | 0.104 | pCi/L | 1.11 | 1/10/2018 | 0.581 | 0.581 | HASL 300, U-02-RC M | = |
| Uranium-238 | U | 0.169 | pCi/L | 1.07 | 1/10/2018 | 0.578 | 0.578 | HASL 300, U-02-RC M | = |

**Paducah OREIS**
**GROUNDWATER MONITORING REPORT**

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

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

**AKGWA Well Tag #:** 8000-5236

| Parameter | Qualifier | Result | Units | Reporting Limit | Date Collected | Counting Error (+/- | TPU | Method | Validation |
|---|---|---|---|---|---|---|---|---|---|
| Arsenic | | 0.0087 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Arsenic, Dissolved | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Barometric Pressure Reading | | 30.25 | Inches/Hg | | 1/9/2018 | | | | X |
| Cadmium | J | 0.000375 | mg/L | 0.001 | 1/9/2018 | | | SW846-6020 | = |
| Cadmium, Dissolved | U | 0.001 | mg/L | 0.001 | 1/9/2018 | | | SW846-6020 | = |
| Chromium | | 1.18 | mg/L | 0.1 | 1/9/2018 | | | SW846-6020 | = |
| Chromium, Dissolved | J | 0.00331 | mg/L | 0.01 | 1/9/2018 | | | SW846-6020 | = |
| Conductivity | | 345 | umho/cm | | 1/9/2018 | | | | X |
| Depth to Water | | 53.42 | ft | | 1/9/2018 | | | | X |
| Dissolved Oxygen | | 2.93 | mg/L | | 1/9/2018 | | | | X |
| Lead | | 0.00579 | mg/L | 0.002 | 1/9/2018 | | | SW846-6020 | = |
| Lead, Dissolved | U | 0.002 | mg/L | 0.002 | 1/9/2018 | | | SW846-6020 | = |
| Mercury | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-7470A | = |
| Mercury, Dissolved | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-7470A | = |
| pH | | 6.3 | Std Unit | | 1/9/2018 | | | | X |
| Redox | | 394 | mV | | 1/9/2018 | | | | X |
| Selenium | J | 0.00219 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Selenium, Dissolved | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Technetium-99 | U | 4.48 | pCi/L | 18.9 | 1/9/2018 | 11.1 | 11.1 | HASL 300, Tc-02-RC M | = |
| Temperature | | 56.7 | deg F | | 1/9/2018 | | | | X |
| Trichloroethene | Y1 | 1400 | ug/L | 20 | 1/9/2018 | | | SW846-8260B | = |
| Turbidity | | 269 | NTU | | 1/9/2018 | | | | X |
| Uranium | B | 0.000681 | mg/L | 0.0002 | 1/9/2018 | | | SW846-6020 | J |
| Uranium-234 | U | 0.721 | pCi/L | 1.91 | 1/9/2018 | 1.21 | 1.22 | HASL 300, U-02-RC M | = |
| Uranium-235 | U | 0.0134 | pCi/L | 2.21 | 1/9/2018 | 0.992 | 0.994 | HASL 300, U-02-RC M | = |
| Uranium-238 | U | -0.119 | pCi/L | 2 | 1/9/2018 | 0.823 | 0.824 | 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 | | 0.0103 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Arsenic, Dissolved | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Barometric Pressure Reading | | 30.26 | Inches/Hg | | 1/9/2018 | | | | X |
| Cadmium | U | 0.001 | mg/L | 0.001 | 1/9/2018 | | | SW846-6020 | = |
| Cadmium, Dissolved | U | 0.001 | mg/L | 0.001 | 1/9/2018 | | | SW846-6020 | = |
| Chromium | | 0.0129 | mg/L | 0.01 | 1/9/2018 | | | SW846-6020 | = |
| Chromium, Dissolved | U | 0.01 | mg/L | 0.01 | 1/9/2018 | | | SW846-6020 | = |
| Conductivity | | 627 | umho/cm | | 1/9/2018 | | | | X |
| Depth to Water | | 11.36 | ft | | 1/9/2018 | | | | X |
| Dissolved Oxygen | | 2.13 | mg/L | | 1/9/2018 | | | | X |
| Lead | | 0.00369 | mg/L | 0.002 | 1/9/2018 | | | SW846-6020 | = |
| Lead, Dissolved | U | 0.002 | mg/L | 0.002 | 1/9/2018 | | | SW846-6020 | = |
| Mercury | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-7470A | = |
| Mercury, Dissolved | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-7470A | = |
| pH | | 6.38 | Std Unit | | 1/9/2018 | | | | X |
| Redox | | 345 | mV | | 1/9/2018 | | | | X |
| Selenium | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Selenium, Dissolved | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Technetium-99 | | 26.3 | pCi/L | 20.2 | 1/9/2018 | 12.6 | 12.9 | HASL 300, Tc-02-RC M | = |
| Temperature | | 57.7 | deg F | | 1/9/2018 | | | | X |
| Trichloroethene | Y1 | 7.17 | ug/L | 1 | 1/9/2018 | | | SW846-8260B | = |
| Turbidity | | 107 | NTU | | 1/9/2018 | | | | X |
| Uranium | B | 0.000519 | mg/L | 0.0002 | 1/9/2018 | | | SW846-6020 | J |
| Uranium-234 | U | 0.147 | pCi/L | 1.75 | 1/9/2018 | 0.864 | 0.866 | HASL 300, U-02-RC M | = |
| Uranium-235 | U | -0.0728 | pCi/L | 1.45 | 1/9/2018 | 0.628 | 0.629 | HASL 300, U-02-RC M | = |
| Uranium-238 | U | -0.236 | pCi/L | 1.62 | 1/9/2018 | 0.546 | 0.547 | HASL 300, U-02-RC M | = |

**Paducah OREIS**
**GROUNDWATER MONITORING REPORT**

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

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

**AKGWA Well Tag #:** 8004-0357

| Parameter | Qualifier | Result | Units | Reporting Limit | Date Collected | Counting Error (+/-) | TPU | Method | Validation |
|---|---|---|---|---|---|---|---|---|---|
| Arsenic | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Arsenic, Dissolved | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Barometric Pressure Reading | | 30.26 | Inches/Hg | | 1/9/2018 | | | | X |
| Cadmium | U | 0.001 | mg/L | 0.001 | 1/9/2018 | | | SW846-6020 | = |
| Cadmium, Dissolved | U | 0.001 | mg/L | 0.001 | 1/9/2018 | | | SW846-6020 | = |
| Chromium | J | 0.00381 | mg/L | 0.01 | 1/9/2018 | | | SW846-6020 | = |
| Chromium, Dissolved | U | 0.01 | mg/L | 0.01 | 1/9/2018 | | | SW846-6020 | = |
| Conductivity | | 221 | umho/cm | | 1/9/2018 | | | | X |
| Depth to Water | | 52.26 | ft | | 1/9/2018 | | | | X |
| Dissolved Oxygen | | 3.3 | mg/L | | 1/9/2018 | | | | X |
| Lead | J | 0.000634 | mg/L | 0.002 | 1/9/2018 | | | SW846-6020 | = |
| Lead, Dissolved | U | 0.002 | mg/L | 0.002 | 1/9/2018 | | | SW846-6020 | = |
| Mercury | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-7470A | = |
| Mercury, Dissolved | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-7470A | = |
| pH | | 6.45 | Std Unit | | 1/9/2018 | | | | X |
| Redox | | 360 | mV | | 1/9/2018 | | | | X |
| Selenium | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Selenium, Dissolved | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Technetium-99 | U | 4.69 | pCi/L | 18.4 | 1/9/2018 | 10.8 | 10.8 | HASL 300, Tc-02-RC M | = |
| Temperature | | 59.4 | deg F | | 1/9/2018 | | | | X |
| Trichloroethene | Y1 | 40.6 | ug/L | 1 | 1/9/2018 | | | SW846-8260B | = |
| Turbidity | | 32.8 | NTU | | 1/9/2018 | | | | X |
| Uranium | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-6020 | = |
| Uranium-234 | U | 1.1 | pCi/L | 2.07 | 1/9/2018 | 1.45 | 1.47 | HASL 300, U-02-RC M | = |
| Uranium-235 | U | 0.557 | pCi/L | 2.03 | 1/9/2018 | 1.28 | 1.28 | HASL 300, U-02-RC M | = |
| Uranium-238 | U | 0.083 | pCi/L | 1.81 | 1/9/2018 | 0.867 | 0.869 | 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 | | 0.00577 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Arsenic, Dissolved | J | 0.00203 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Barometric Pressure Reading | | 30.06 | Inches/Hg | | 1/10/2018 | | | | X |
| Cadmium | U | 0.001 | mg/L | 0.001 | 1/10/2018 | | | SW846-6020 | = |
| Cadmium, Dissolved | U | 0.001 | mg/L | 0.001 | 1/10/2018 | | | SW846-6020 | = |
| Chromium | | 0.129 | mg/L | 0.01 | 1/10/2018 | | | SW846-6020 | = |
| Chromium, Dissolved | U | 0.01 | mg/L | 0.01 | 1/10/2018 | | | SW846-6020 | = |
| Conductivity | | 1740 | umho/cm | | 1/10/2018 | | | | X |
| Depth to Water | | 13.53 | ft | | 1/10/2018 | | | | X |
| Dissolved Oxygen | | 1.52 | mg/L | | 1/10/2018 | | | | X |
| Lead | J | 0.00123 | mg/L | 0.002 | 1/10/2018 | | | SW846-6020 | = |
| Lead, Dissolved | U | 0.002 | mg/L | 0.002 | 1/10/2018 | | | SW846-6020 | = |
| Mercury | U | 0.0002 | mg/L | 0.0002 | 1/10/2018 | | | SW846-7470A | = |
| Mercury, Dissolved | U | 0.0002 | mg/L | 0.0002 | 1/10/2018 | | | SW846-7470A | = |
| pH | | 5.99 | Std Unit | | 1/10/2018 | | | | X |
| Redox | | -29 | mV | | 1/10/2018 | | | | X |
| Selenium | J | 0.00263 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Selenium, Dissolved | J | 0.00403 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Technetium-99 | | 60.5 | pCi/L | 19.5 | 1/10/2018 | 13.3 | 14.9 | HASL 300, Tc-02-RC M | = |
| Temperature | | 58.4 | deg F | | 1/10/2018 | | | | X |
| Trichloroethene | | 40.1 | ug/L | 1 | 1/10/2018 | | | SW846-8260B | = |
| Turbidity | | 33.3 | NTU | | 1/10/2018 | | | | X |
| Uranium | B | 0.000467 | mg/L | 0.0002 | 1/10/2018 | | | SW846-6020 | J |
| Uranium-234 | U | -0.303 | pCi/L | 1.72 | 1/10/2018 | 0.614 | 0.615 | HASL 300, U-02-RC M | = |
| Uranium-235 | U | 0.494 | pCi/L | 0.74 | 1/10/2018 | 0.846 | 0.849 | HASL 300, U-02-RC M | = |
| Uranium-238 | U | 1.01 | pCi/L | 1.32 | 1/10/2018 | 1.06 | 1.07 | HASL 300, U-02-RC M | = |

# Paducah OREIS
# GROUNDWATER MONITORING REPORT

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

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

**AKGWA Well Tag #:** 8000-5102

| Parameter | Qualifier | Result | Units | Reporting Limit | Date Collected | Counting Error (+/- | TPU | Method | Validation |
|---|---|---|---|---|---|---|---|---|---|
| Arsenic | | 0.00807 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Arsenic, Dissolved | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Barometric Pressure Reading | | 30.28 | Inches/Hg | | 1/9/2018 | | | | X |
| Cadmium | U | 0.001 | mg/L | 0.001 | 1/9/2018 | | | SW846-6020 | = |
| Cadmium, Dissolved | U | 0.001 | mg/L | 0.001 | 1/9/2018 | | | SW846-6020 | = |
| Chromium | | 0.151 | mg/L | 0.01 | 1/9/2018 | | | SW846-6020 | = |
| Chromium, Dissolved | U | 0.01 | mg/L | 0.01 | 1/9/2018 | | | SW846-6020 | = |
| Conductivity | | 377 | umho/cm | | 1/9/2018 | | | | X |
| Depth to Water | | 55.01 | ft | | 1/9/2018 | | | | X |
| Dissolved Oxygen | | 1.74 | mg/L | | 1/9/2018 | | | | X |
| Lead | J | 0.00186 | mg/L | 0.002 | 1/9/2018 | | | SW846-6020 | = |
| Lead, Dissolved | U | 0.002 | mg/L | 0.002 | 1/9/2018 | | | SW846-6020 | = |
| Mercury | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-7470A | = |
| Mercury, Dissolved | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-7470A | = |
| pH | | 6.55 | Std Unit | | 1/9/2018 | | | | X |
| Redox | | 352 | mV | | 1/9/2018 | | | | X |
| Selenium | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Selenium, Dissolved | J | 0.00201 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Technetium-99 | U | 5.18 | pCi/L | 18.8 | 1/9/2018 | 11 | 11 | HASL 300, Tc-02-RC M | = |
| Temperature | | 60.1 | deg F | | 1/9/2018 | | | | X |
| Trichloroethene | Y1 | 994 | ug/L | 20 | 1/9/2018 | | | SW846-8260B | = |
| Turbidity | | 103 | NTU | | 1/9/2018 | | | | X |
| Uranium | BJ | 0.000198 | mg/L | 0.0002 | 1/9/2018 | | | SW846-6020 | U |
| Uranium-234 | U | -0.0837 | pCi/L | 2.2 | 1/9/2018 | 0.951 | 0.952 | HASL 300, U-02-RC M | = |
| Uranium-235 | U | -0.0774 | pCi/L | 1.55 | 1/9/2018 | 0.668 | 0.669 | HASL 300, U-02-RC M | = |
| Uranium-238 | U | 0.522 | pCi/L | 0.783 | 1/9/2018 | 0.894 | 0.898 | 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 | 0.00425 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Arsenic, Dissolved | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Barometric Pressure Reading | | 30.28 | Inches/Hg | | 1/9/2018 | | | | X |
| Cadmium | U | 0.001 | mg/L | 0.001 | 1/9/2018 | | | SW846-6020 | = |
| Cadmium, Dissolved | U | 0.001 | mg/L | 0.001 | 1/9/2018 | | | SW846-6020 | = |
| Chromium | | 0.0301 | mg/L | 0.01 | 1/9/2018 | | | SW846-6020 | = |
| Chromium, Dissolved | U | 0.01 | mg/L | 0.01 | 1/9/2018 | | | SW846-6020 | = |
| Conductivity | | 805 | umho/cm | | 1/9/2018 | | | | X |
| Depth to Water | | 15.24 | ft | | 1/9/2018 | | | | X |
| Dissolved Oxygen | | 1.01 | mg/L | | 1/9/2018 | | | | X |
| Lead | | 0.00465 | mg/L | 0.002 | 1/9/2018 | | | SW846-6020 | = |
| Lead, Dissolved | U | 0.002 | mg/L | 0.002 | 1/9/2018 | | | SW846-6020 | = |
| Mercury | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-7470A | = |
| Mercury, Dissolved | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-7470A | = |
| pH | | 6.9 | Std Unit | | 1/9/2018 | | | | X |
| Redox | | 351 | mV | | 1/9/2018 | | | | X |
| Selenium | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Selenium, Dissolved | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Technetium-99 | | 1110 | pCi/L | 20.8 | 1/9/2018 | 33.8 | 127 | HASL 300, Tc-02-RC M | = |
| Temperature | | 61.7 | deg F | | 1/9/2018 | | | | X |
| Trichloroethene | Y1 | 2.66 | ug/L | 1 | 1/9/2018 | | | SW846-8260B | = |
| Turbidity | | 140 | NTU | | 1/9/2018 | | | | X |
| Uranium | B | 0.00228 | mg/L | 0.0002 | 1/9/2018 | | | SW846-6020 | J |
| Uranium-234 | U | 1.47 | pCi/L | 1.68 | 1/9/2018 | 1.41 | 1.43 | HASL 300, U-02-RC M | = |
| Uranium-235 | U | 0 | pCi/L | 0.932 | 1/9/2018 | 0.626 | 0.628 | HASL 300, U-02-RC M | = |
| Uranium-238 | U | 0.884 | pCi/L | 1.39 | 1/9/2018 | 1.12 | 1.13 | 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 | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Arsenic, Dissolved | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Barometric Pressure Reading | | 30.26 | Inches/Hg | | 1/9/2018 | | | | X |
| Cadmium | U | 0.001 | mg/L | 0.001 | 1/9/2018 | | | SW846-6020 | = |
| Cadmium, Dissolved | U | 0.001 | mg/L | 0.001 | 1/9/2018 | | | SW846-6020 | = |
| Chromium | U | 0.01 | mg/L | 0.01 | 1/9/2018 | | | SW846-6020 | = |
| Chromium, Dissolved | U | 0.01 | mg/L | 0.01 | 1/9/2018 | | | SW846-6020 | = |
| Conductivity | | 285 | umho/cm | | 1/9/2018 | | | | X |
| Depth to Water | | 55.1 | ft | | 1/9/2018 | | | | X |
| Dissolved Oxygen | | 2.51 | mg/L | | 1/9/2018 | | | | X |
| Lead | U | 0.002 | mg/L | 0.002 | 1/9/2018 | | | SW846-6020 | = |
| Lead, Dissolved | U | 0.002 | mg/L | 0.002 | 1/9/2018 | | | SW846-6020 | = |
| Mercury | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-7470A | = |
| Mercury, Dissolved | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-7470A | = |
| pH | | 6.51 | Std Unit | | 1/9/2018 | | | | X |
| Redox | | 372 | mV | | 1/9/2018 | | | | X |
| Selenium | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Selenium, Dissolved | U | 0.005 | mg/L | 0.005 | 1/9/2018 | | | SW846-6020 | = |
| Technetium-99 | | 21.5 | pCi/L | 18 | 1/9/2018 | 11.2 | 11.4 | HASL 300, Tc-02-RC M | J |
| Temperature | | 56.7 | deg F | | 1/9/2018 | | | | X |
| Trichloroethene | Y1 | 232 | ug/L | 5 | 1/9/2018 | | | SW846-8260B | J |
| Turbidity | | 15.8 | NTU | | 1/9/2018 | | | | X |
| Uranium | U | 0.0002 | mg/L | 0.0002 | 1/9/2018 | | | SW846-6020 | = |
| Uranium-234 | U | 1.05 | pCi/L | 1.46 | 1/9/2018 | 1.05 | 1.07 | HASL 300, U-02-RC M | = |
| Uranium-235 | U | 0.313 | pCi/L | 1.14 | 1/9/2018 | 0.718 | 0.719 | HASL 300, U-02-RC M | = |
| Uranium-238 | U | -0.2 | pCi/L | 1.17 | 1/9/2018 | 0.378 | 0.379 | 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 | 1/10/2018 | | | SW846-6020 | = |
| Cadmium | U | 0.001 | mg/L | 0.001 | 1/10/2018 | | | SW846-6020 | = |
| Chromium | U | 0.01 | mg/L | 0.01 | 1/10/2018 | | | SW846-6020 | = |
| Lead | U | 0.002 | mg/L | 0.002 | 1/10/2018 | | | SW846-6020 | = |
| Mercury | U | 0.0002 | mg/L | 0.0002 | 1/10/2018 | | | SW846-7470A | = |
| Selenium | U | 0.005 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Technetium-99 | U | 4.75 | pCi/L | 19.7 | 1/10/2018 | 11.5 | 11.5 | HASL 300, Tc-02-RC M | = |
| Trichloroethene | U | 1 | ug/L | 1 | 1/10/2018 | | | SW846-8260B | = |
| Uranium | U | 0.0002 | mg/L | 0.0002 | 1/10/2018 | | | SW846-6020 | = |
| Uranium-234 | U | 0.949 | pCi/L | 1.68 | 1/10/2018 | 1.17 | 1.18 | HASL 300, U-02-RC M | = |
| Uranium-235 | U | 0.482 | pCi/L | 1.31 | 1/10/2018 | 0.947 | 0.95 | HASL 300, U-02-RC M | = |
| Uranium-238 | U | 0.062 | pCi/L | 1.35 | 1/10/2018 | 0.648 | 0.649 | HASL 300, U-02-RC M | = |

**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 | 1/10/2018 | | | SW846-6020 | = |
| Cadmium | U | 0.001 | mg/L | 0.001 | 1/10/2018 | | | SW846-6020 | = |
| Chromium | U | 0.01 | mg/L | 0.01 | 1/10/2018 | | | SW846-6020 | = |
| Lead | U | 0.002 | mg/L | 0.002 | 1/10/2018 | | | SW846-6020 | = |
| Mercury | U | 0.0002 | mg/L | 0.0002 | 1/10/2018 | | | SW846-7470A | = |
| Selenium | U | 0.005 | mg/L | 0.005 | 1/10/2018 | | | SW846-6020 | = |
| Technetium-99 | U | -3.94 | pCi/L | 18.3 | 1/10/2018 | 10.4 | 10.4 | HASL 300, Tc-02-RC M | = |
| Trichloroethene | U | 1 | ug/L | 1 | 1/10/2018 | | | SW846-8260B | = |
| Uranium | U | 0.0002 | mg/L | 0.0002 | 1/10/2018 | | | SW846-6020 | = |
| Uranium-234 | U | 0.0744 | pCi/L | 1.75 | 1/10/2018 | 0.826 | 0.826 | HASL 300, U-02-RC M | = |
| Uranium-235 | U | 0.218 | pCi/L | 1.38 | 1/10/2018 | 0.819 | 0.82 | HASL 300, U-02-RC M | = |
| Uranium-238 | U | -0.167 | pCi/L | 1.42 | 1/10/2018 | 0.505 | 0.506 | 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 | 1/9/2018 | | | SW846-8260B | = |
| | U | 1 | ug/L | 1 | 1/10/2018 | | | 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   Compound found in blank as well as sample.
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 Replicate (Code used for Field Duplicate)
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**

THIS PAGE INTENTIONALLY LEFT BLANK

# GROUNDWATER
# STATISTICAL SUMMARY

## Introduction

The statistical analyses conducted on the data collected from C-404 Hazardous Waste Landfill (C-404 Landfill) were performed in accordance with procedures provided in Appendix E of the 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 this report, the reporting period data set includes data from January 2016, July 2016, January 2017, July 2017, and January 2018.

## Statistical Analysis Process

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

· Determine the percentage of the censored data using the reporting period data set.

· Group by percentage of censored data where the following apply:

   — If censored data are greater than or equal to 90%, determine the limit of detection (LOD) and half of the LOD (1/2 LOD). This is Statistical Test 1.

   — If censored data are between 50% and 90%, perform a Test of Proportions. If the analysis indicates a significant proportional difference in compliance wells, further analyze through nonparametric Analysis of Variance (ANOVA) Test. This is Statistical Test 2.

   — If censored data are between 15% and 50%, perform nonparametric ANOVA Test. If results exceed the critical value, compute the critical difference used to identify individual well concentrations, which are significantly elevated compared with background. This is Statistical Test 3.

   — If censored data are less than 15%, actual data values are analyzed using parametric ANOVA procedures. If the wells exhibit equal variances, then the data are used as presented. If the wells do not exhibit equal variances, then the log of the data is taken and then used in the calculations. Where statistical testing indicates elevated compliance well concentrations, Bonferroni's Test of

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

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

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

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

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

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

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

## Data Analysis

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

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

**Table B.1. Monitoring Well Locations**

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

*MW90 was abandoned in 2001 and replaced with MW90A.

For this report, the reporting period data set from January 2016 through January 2018 consists of five sets of data.

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

## Censoring Percentage and Statistical Analysis

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

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

| Parameters | Observations | Missing Observations* | Censored Observations (Nondetects) | Uncensored Observations (Detects) |
|---|---|---|---|---|
| **URGA** | | | | |
| Arsenic | 25 | 0 | 9 | 16 |
| Arsenic, Dissolved | 25 | 0 | 20 | 5 |
| Cadmium | 25 | 0 | 15 | 10 |
| Cadmium, Dissolved | 25 | 0 | 25 | 0 |
| Chromium | 25 | 0 | 9 | 16 |
| Chromium, Dissolved | 25 | 0 | 20 | 5 |
| Lead | 25 | 0 | 9 | 16 |
| Lead, Dissolved | 25 | 0 | 25 | 0 |
| Mercury | 25 | 0 | 25 | 0 |
| Mercury, Dissolved | 25 | 0 | 25 | 0 |
| Selenium | 25 | 0 | 19 | 6 |
| Selenium, Dissolved | 25 | 0 | 19 | 6 |
| Technetium-99 | 25 | 0 | 22 | 3 |
| Trichloroethene | 25 | 0 | 0 | 25 |
| Uranium (Metals) | 25 | 0 | 14 | 11 |
| Uranium-234 | 25 | 0 | 25 | 0 |
| Uranium-235 | 25 | 0 | 25 | 0 |
| Uranium-238 | 25 | 0 | 25 | 0 |

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

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

| Parameter | Total Samples (Nonmissing) | Uncensored (Detects) | Censored (Nondetects) | Percent Censored | Statistical Test Set* |
|---|---|---|---|---|---|
| **URGA** | | | | | |
| Arsenic | 25 | 16 | 9 | 36.00 | 3 |
| Arsenic, Dissolved | 25 | 5 | 20 | 80.00 | 2 |
| Cadmium | 25 | 10 | 15 | 60.00 | 2 |
| Cadmium, Dissolved | 25 | 0 | 25 | 100.00 | 1 |
| Chromium | 25 | 16 | 9 | 36.00 | 3 |
| Chromium, Dissolved | 25 | 5 | 20 | 80.00 | 2 |
| Lead | 25 | 16 | 9 | 36.00 | 3 |
| Lead, Dissolved | 25 | 0 | 25 | 100.00 | 1 |
| Mercury | 25 | 0 | 25 | 100.00 | 1 |
| Mercury, Dissolved | 25 | 0 | 25 | 100.00 | 1 |
| Selenium | 25 | 6 | 19 | 76.00 | 2 |
| Selenium, Dissolved | 25 | 6 | 19 | 76.00 | 2 |
| Technetium-99 | 25 | 3 | 22 | 88.00 | 2 |
| Trichloroethene | 25 | 25 | 0 | 0.00 | 4/3** |
| Uranium (Metals) | 25 | 11 | 14 | 56.00 | 2 |
| Uranium-234 | 25 | 0 | 25 | 100.00 | 1 |
| Uranium-235 | 25 | 0 | 25 | 100.00 | 1 |
| Uranium-238 | 25 | 0 | 25 | 100.00 | 1 |

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

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

## SUMMARY OF CONCLUSIONS

The results for Statistical Test 1, LOD, are summarized in Table B.4. Table B.5 provides the summary of conclusions for the statistical analyses for the C-404 Landfill, including the statistical tests performed, the attachment number, well type, parameter, and results of each statistical test. Results of Statistical Test 2, Statistical Test 3, and Statistical Test 4 are presented in Attachments B1 through B11. The statistician qualification statement is presented in Attachment B12.

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

| Parameter | LOD Values | ½ LOD Values |
|---|---|---|
| **URGA** | | |
| Cadmium, Dissolved (mg/L) | 0.001 | 0.0005 |
| Lead, Dissolved (mg/L) | 0.002 | 0.001 |
| Mercury (mg/L) | 0.0002 | 0.0001 |
| Mercury, Dissolved (mg/L) | 0.0002 | 0.0001 |
| Uranium-234 (pCi/L) | 2.2 | 1.1 |
| Uranium-235 (pCi/L) | 2.21 | 1.105 |
| Uranium-238 (pCi/L) | 2 | 1 |

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

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

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

Statistical Test 3, Nonparametric ANOVA, for lead in the URGA identified a statistically significant difference between concentrations in downgradient wells and concentrations in background wells; therefore, the data were evaluated further by comparing results to the UTL. The 95% UTL indicated a statistically significant difference between concentrations in downgradient wells and concentrations in

background wells. Based on these results, the data were evaluated using paired (parametric) ANOVA of wells in the same direction relative to the landfill [e.g., performed a comparison of downgradient well (MW87) results to upgradient westernmost well (MW93) results]. The paired ANOVA could not be used for lead because there was no evidence of equality of variance. Thus, Statistical Test 4 was abandoned, and Statistical Test 3, Nonparametric ANOVA, was performed. Results of the Nonparametric ANOVA identified there was no significant difference between upgradient and downgradient wells.

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

**Table B.5. Summary of Conclusions from the Statistical Analyses for the C-404 Hazardous Waste Landfill for the January 2018 Data Set**

| Attachment | RGA Well Type | Parameter | Applied Statistical Test | Results |
|---|---|---|---|---|
| B1 | URGA | Arsenic | Statistical Test 3, Nonparametric ANOVA with 95% UTL, paired ANOVA (MW84 vs. MW93), Mann-Kendall, and data review | Because Nonparametric ANOVA indicated a statistically significant difference between concentrations in downgradient wells and concentrations in background wells for compliance well MW84, a comparison to the 95% UTL, paired ANOVA, Mann-Kendall, and an attempt to review data was performed, as required by the Hazardous Waste Management Facility Permit. Because equality of variance could not be confirmed on the paired ANOVA, it was abandoned, and Statistical Test 3, Nonparametric ANOVA, was performed. Results of the Nonparametric ANOVA have identified there is a significant difference between upgradient and downgradient wells. The Mann-Kendall identified a positive trend in MW84. |
| B2 | URGA | Arsenic, Dissolved | Statistical Test 2, Test of Proportions | No statistically significant difference between concentrations in downgradient wells and concentrations in background wells. |
| B3 | URGA | Cadmium | Statistical Test 2, Test of Proportions | No statistically significant difference between concentrations in downgradient wells and concentrations in background wells. |
| B4 | URGA | Chromium | Statistical Test 3, Nonparametric ANOVA | No statistically significant difference between concentrations in downgradient wells and concentrations in background wells. |
| B5 | URGA | Chromium, Dissolved | Statistical Test 2, Test of Proportions | No statistically significant difference between concentrations in downgradient wells and concentrations in background wells. |
| B6 | URGA | Lead | Statistical Test 3, Nonparametric ANOVA with 95% UTL and paired ANOVA (MW87 vs. MW93) | Because Nonparametric ANOVA indicated a statistically significant difference between concentrations in downgradient wells and concentrations in background wells for compliance well MW87, a comparison to the 95% UTL and paired ANOVA was performed, as required by the Hazardous Waste Management Facility Permit. Because equality of variance could not be confirmed on the paired ANOVA, it was abandoned, and Statistical Test 3, Nonparametric ANOVA, was performed. Results of the Nonparametric ANOVA have identified there is no significant difference between upgradient and downgradient wells. |
| B7 | URGA | Selenium | Statistical Test 2, Test of Proportions | No statistically significant difference between concentrations in downgradient wells and concentrations in background wells. |
| B8 | URGA | Selenium, Dissolved | Statistical Test 2, Test of Proportions | No statistically significant difference between concentrations in downgradient wells and concentrations in background wells. |

**Table B.5. Summary of Conclusions from the Statistical Analyses for the C-404 Hazardous Waste Landfill for the January 2018 Data Set (Continued)**

| Attachment | RGA Well Type | Parameter | Applied Statistical Test | Results |
|---|---|---|---|---|
| B9 | URGA | Technetium-99 | Statistical Test 2, Test of Proportions | No statistically significant difference between concentrations in downgradient wells and concentrations in background wells. |
| B10 | URGA | Trichloroethene | Statistical Test 4, Parametric ANOVA/Statistical Test 3, Nonparametric ANOVA | Because equality of variance could not be confirmed, Statistical Test 4 was abandoned and Statistical Test 3, Nonparametric ANOVA, was performed. Results of the Nonparametric ANOVA showed no statistically significant difference between concentrations in downgradient wells and concentrations in background wells. |
| B11 | URGA | Uranium | Statistical Test 2, Test of Proportions | No statistically significant difference between concentrations in downgradient wells and concentrations in background wells. |

**ATTACHMENT B1**

**ARSENIC**
**STATISTICAL TEST 3**

THIS PAGE INTENTIONALLY LEFT BLANK

# Attachment B1: Statistical Test 3, Nonparametric ANOVA, January 2018 Arsenic URGA

| | Arsenic (mg/L) | | | | |
|---|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | **0.00743** | 0.0025 | **0.0103** | **0.00481** | 0.0025 |
| Jul-16 | **0.00709** | 0.0025 | **0.0137** | **0.00698** | 0.0025 |
| Jan-17 | **0.00842** | 0.0025 | **0.017** | **0.00692** | 0.0025 |
| Jul-17 | **0.00755** | **0.00207** | **0.0191** | **0.00907** | 0.0025 |
| Jan-18 | **0.00807** | 0.0025 | **0.0185** | **0.0087** | 0.0025 |
| Sum | 0.0506 | | 0.07860 | 0.03648 | 0.0125 |
| $n_i$ | 10 | | 5 | 5 | 5 |
| $(x_i)_{avg}$ | 0.00506 | | 0.01572 | 0.00730 | 0.0025 |

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

Overall mean $x.. =$      0.00713

| | | |
|---|---|---|
| $N =$ | 25 | $N$ = the total number of samples |
| $p =$ | 4 | $p$ = the number of $n_i$ groups |
| $x.. =$ | 0.18 | $x..$ = 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 | 5 | |
| 2 | 0 | 5 | |
| 3 | 0 | 5 | |
| 4 | 0 | 5 | |
| 5 | 0 | 5 | Tie 1 |
| 6 | 0 | 5 | |
| 7 | 0 | 5 | |
| 8 | 0 | 5 | |
| 9 | 0 | 5 | |
| 10 | **0.00207** | 10 | |
| 11 | **0.00481** | 11 | |
| 12 | **0.00692** | 12 | |
| 13 | **0.00698** | 13 | |
| 14 | **0.00709** | 14 | |
| 15 | **0.00743** | 15 | |
| 16 | **0.00755** | 16 | |
| 17 | **0.00807** | 17 | |
| 18 | 0.00842 | 18 | |
| 19 | **0.0087** | 19 | |
| 20 | **0.00907** | 20 | |
| 21 | **0.0103** | 21 | |
| 22 | **0.0137** | 22 | |
| 23 | **0.017** | 23 | |
| 24 | **0.0185** | 24 | |
| 25 | **0.0191** | 25 | |

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

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

**Attachment B1: Statistical Test 3, Nonparametric ANOVA, January 2018 Arsenic URGA**

**Sums of Ranks and Averages**

| Arsenic (mg/L) | | | | |
|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | **0.00743** | 0 | **0.0103** | **0.00481** | 0 |
| Jul-16 | **0.00709** | 0 | **0.0137** | **0.00698** | 0 |
| Jan-17 | **0.00842** | 0 | **0.017** | **0.00692** | 0 |
| Jul-17 | **0.00755** | **0.00207** | **0.0191** | **0.00907** | 0 |
| Jan-18 | **0.00807** | 0 | **0.0185** | **0.0087** | 0 |

| Observation Ranks for Arsenic | | | | |
|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | 15 | 5 | 21 | 11 | 5 |
| Jul-16 | 14 | 5 | 22 | 13 | 5 |
| Jan-17 | 18 | 5 | 23 | 12 | 5 |
| Jul-17 | 16 | 10 | 25 | 20 | 5 |
| Jan-18 | 17 | 5 | 24 | 19 | 5 |
| $R_i$ | 110 | | 115 | 75 | 25 |
| $(R_i)_{avg}$ | 11.0 | | 23.0 | 15.0 | 5.0 |
| $R_i^2/n_i$ | 1210.0 | | 2645.0 | 1125.0 | 125.0 |

$\Sigma R_i^2/n_i =$ 5105.0

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 = 16.246  Kruskal-Wallis Statistic  $H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$
H' = 17.032  Corrected Kruskal-Wallis  $H' = H/[1-(\Sigma T_i/N^3-N)]$
$\chi^2_{crit}* =$ 7.815  3  degrees of freedom at the 5% significance level

NOTE: $H' > \chi^2_{crit}$
If $H' \le \chi^2_{crit}$, 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).

B1-5

**Calculate Critical Values**

Average Background Ranking =　　11.0

|  | Well No. | $C_i$ | $(R_i)_{avg} - (R_b)_{avg}$ | Conclusion |
|---|---|---|---|---|
| BG Well | MW93 |  |  |  |
| BG Well | MW420 |  |  |  |
|  | MW84 | 8.578 | 12.0 | evidence of contamination |
|  | MW87 | 8.578 | 4.0 | not contaminated |
|  | MW90A | 8.578 | -6.0 | not contaminated |

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

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

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

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

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

**Since $(R_i)_{avg} - (R_b)_{avg} < C_i$ for MW87 and MW90A, there is no statistically significant difference from C-404 in these downgradient compliance test wells; however, the negative value indicates that background well has elevated concentrations.**

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

**95% Upper Tolerance Limit (UTL)**

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

### January 2018 Data, First Reporting Period
#### Observations (mg/L)

| Well No. | | | | | | |
|---|---|---|---|---|---|---|
| **MW93** | **0.00743** | **0.00709** | **0.00842** | **0.00755** | **0.00807** | **Upgradient Well**[!] |
| **MW420** | 0.0025 | 0.0025 | 0.0025 | **0.00207** | 0.0025 | **Upgradient Well**[!] |
| | | | | | | **Current Data** |
| **MW84** | X: Mean Value = | 0.0051 | | | | **0.0185** |
| MW87 | S: Standard Deviation = | 0.0028 | | | | 0.0087 |
| MW90A | K* factor = | 2.911 | (for n = 10) | | | 0.0025 |
| | CV = S/X | 0.5565 | <1, assume normal distribution | | | |
| | Upper Tolerance Interval: TL = X +(KxS) = | | **0.0133** | (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:** **MW84 exceeded the UTL, which is statistically significant evidence that this compliance well has elevated concentration with respect to background data.**

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

**Paired (Parametric) ANOVA**

Evaluate results using paired ANOVA of wells in the same direction relative to the landfill [e.g., compare upgradient westernmost well 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.

| | Arsenic (mg/L) | | | |
|---|---|---|---|---|
| Date | Background | Compliance | | |
| | MW93 | MW84 | $n_i^2$ | |
| Jan-16 | **0.00743** | **0.0103** | 0.0000552 | 0.0001061 |
| Jul-16 | **0.00709** | **0.0137** | 0.0000503 | 0.0001877 |
| Jan-17 | **0.00842** | **0.017** | 0.0000709 | 0.0002890 |
| Jul-17 | **0.00755** | **0.0191** | 0.0000570 | 0.0003648 |
| Jan-18 | **0.00807** | **0.0185** | 0.0000651 | 0.0003423 |
| Sum $(x_i)$ | 0.0386 | 0.07860 | 0.1172 | Total Sum (x..) |
| $n_i$ | 5 | 5 | | |
| $(x_i)_{avg}$ | 0.00771 | 0.01572 | | |
| $(x_i)^2$ | 0.00149 | 0.00618 | | |

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

| | | | |
|---|---|---|---|
| Overall mean x.. = | 0.01172 | | |
| N = | 10 | N = the total number of samples | |
| p = | 2 | p = the number of $n_i$ groups | |
| x.. = | 0.1172 | 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 |
|---|---|---|
| | MW93 | MW84 |
| Jan-16 | -0.00028 | -0.00542 |
| Jul-16 | -0.00062 | -0.00202 |
| Jan-17 | 0.00071 | 0.00128 |
| Jul-17 | -0.00016 | 0.00338 |
| Jan-18 | 0.00036 | 0.00278 |

| | | | |
|---|---|---|---|
| X: Mean Value = | -1.04E-18 | | |
| S: Standard Deviation = | 0.00248 | | |
| K* Factor = | 2.911 | (for n = 10) | |
| CV = S/X = | −2.38E+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 | $x_{..}$ = 0.1172 |
| $n_i$ = number of data points per well | $(x_{avg})_{..}$ = 0.01172 |
| N = total sample size | $n_i$ = 5 |
| $S^2$ = the square of the standard deviation | p = 2 |
| $\ln(S_i^2)$ = natural logarithm of each variance | N = 10 |
| f = total sample size minus the number of wells (groups) | $f_i$ = 4 |
| $f_i = n_i - 1$ | |

Calculations for Equality of Variance: Bartlett's Test

| $S_i$ | $S_i^2$ | $\ln(S_i^2)$ | $n_i$ | $f_iS_i^2$ | $f_i\ln(S_i^2)$ |
|---|---|---|---|---|---|
| 0.00053 | 0.00000028052 | -15.087 | 5 | 0.0000011 | -60.3 |
| 0.00368 | 0.00001356200 | -11.208 | 5 | 0.0000542 | -44.8 |

$\sum(S_i^2) =$ 0.00001          $\sum f_i\ln(S_i^2) =$ -105.17944

Equality of Variance: Bartlett's Test

| | |
|---|---|
| f = | 8 |
| $Sp^2 =$ | 0.0000069 |
| $\ln Sp^2 =$ | -11.881 |
| $\chi^2 =$ | 10.132 |

(If calculated $\chi^2 \leq$ tabulated $\chi^2_{crit}$, 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)

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

**Variances are not equal, transform the original data to lognormal (i.e., since calculated $\chi2 > \chi2_{crit}$).**

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

**Attachment B1: Statistical Test 3, Nonparametric ANOVA, January 2018 Arsenic URGA**

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

| | ln[Arsenic (mg/L)] | | | |
|---|---|---|---|---|
| Date | Background | Compliance | | |
| | MW93 | MW84 | $n_i^2$ | |
| Jan-16 | **-4.90** | **-4.58** | 24.03 | 20.94 |
| Jul-16 | **-4.95** | **-4.29** | 24.49 | 18.41 |
| Jan-17 | **-4.78** | **-4.07** | 22.82 | 16.60 |
| Jul-17 | **-4.89** | **-3.96** | 23.88 | 15.67 |
| Jan-18 | **-4.82** | **-3.99** | 23.23 | 15.92 |
| Sum ($x_i$) | -24.33 | -20.89 | -45.22 | Total Sum (x..) |
| $n_i$ | 5 | 5 | | |
| $(x_i)_{avg}$ | -4.87 | -4.18 | | |
| $(x_i)^2$ | 592.16 | 436.33 | | |

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

Overall mean x.. = -4.52
N = 10          N = the total number of samples
p = 2          p = the number of $n_i$ groups
x.. = -45.22          x.. = the sum of the total number of samples

**Determine Normality of Dataset**

**Coefficient of Variability Test—Lognormal Data for Arsenic in MW93 and MW84**

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

| Date | Background | Compliance |
|---|---|---|
| | MW93 | MW84 |
| Jan-16 | -0.04 | -0.40 |
| Jul-16 | -0.08 | -0.11 |
| Jan-17 | 0.09 | 0.10 |
| Jul-17 | -0.02 | 0.22 |
| Jan-18 | 0.05 | 0.19 |

X: Mean Value = 1.33E-16
S: Standard Deviation = 0.18
K* Factor = 2.911     (for n = 10)
CV = S/X = 1.33E+15     ≥1, data are NOT normally distributed

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

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

**Determine Equality of Variance—Lognormal Data for Arsenic in MW93 and MW84**

| | |
|---|---|
| p = number of wells | $x_{..} = -45.22$ |
| $n_i$ = number of data points per well | $(x_{avg})_{..} = -4.52$ |
| 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

| $S_i$ | $S_i^2$ | $\ln(S_i^2)$ | $n_i$ | $f_i S_i^2$ | $f_i \ln(S_i^2)$ |
|---|---|---|---|---|---|
| 0.07 | 0.00 | -5.37 | 5 | 0.02 | -21.5 |
| 0.26 | 0.07 | -2.71 | 5 | 0.27 | -10.9 |

$\sum(S_i^2) =$      0.07          $\sum f_i \ln(S_i^2) =$      -32.32

Equality of Variance: Bartlett's Test

| | |
|---|---|
| f = | 8 |
| $Sp^2 =$ | 0.04 |
| $\ln Sp^2 =$ | -3.34 |
| $\chi^2 =$ | 5.61 |
| $\chi^2_{crit} * =$ | 3.841 |

$\chi^2 = 5.61$    (If calculated $\chi^2 \leq$ tabulated $\chi^2_{crit}$, 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)

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

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

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

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

**Statistical Test 3, Nonparametric ANOVA**

| | Arsenic (mg/L) | |
|---|---|---|
| Date | Background | Compliance |
| | MW93 | MW84 |
| Jan-16 | **0.00743** | **0.0103** |
| Jul-16 | **0.00709** | **0.0137** |
| Jan-17 | **0.00842** | **0.017** |
| Jul-17 | **0.00755** | **0.0191** |
| Jan-18 | **0.00807** | **0.0185** |
| Sum | 0.0386 | 0.07860 |
| $n_i$ | 5 | 5 |
| $(x_i)_{avg}$ | 0.00771 | 0.01572 |

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.. =            0.01172

| | | |
|---|---|---|
| $N =$ | 10 | $N$ = the total number of samples |
| $p =$ | 2 | $p$ = the number of $n_i$ groups |
| $x.. =$ | 0.11716 | $x..$ = the sum of the total number of samples |

**Ranking of Observations**

| Sequence | Arsenic (mg/L) | Adjusted | Tie Number |
|---|---|---|---|
| 1 | **0.00709** | 1 | |
| 2 | **0.00743** | 2 | |
| 3 | **0.00755** | 3 | |
| 4 | **0.00807** | 4 | |
| 5 | **0.00842** | 5 | |
| 6 | **0.0103** | 6 | |
| 7 | **0.0137** | 7 | |
| 8 | **0.017** | 8 | |
| 9 | **0.0185** | 9 | |
| 10 | **0.0191** | 10 | |

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

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

**Sums of Ranks and Averages**

| | Observation Ranks for Arsenic | |
|---|---|---|
| Date | Background | Compliance |
| | MW93 | MW84 |
| Jan-16 | 2 | 6 |
| Jul-16 | 1 | 7 |
| Jan-17 | 5 | 8 |
| Jul-17 | 3 | 10 |
| Jan-18 | 4 | 9 |
| $R_i$ | 15 | 40 |
| $(R_i)_{avg}$ | 3 | 8 |
| $R_i^2/n_i$ | 45.0 | 320.0 |

| | |
|---|---|
| $\sum R_i^2/n_i =$ | 365 |
| $K =$ | 2 |
| $N =$ | 10 |

**Calculation of Kruskal-Wallis Statistic**

| | | | |
|---|---|---|---|
| $H =$ | 6.818 | Kruskal-Wallis Statistic | $H = [12/N(N+1) * \Sigma R_i^2/n_i] - 3(N+1)$ |
| $H' =$ | 6.818 | Corrected Kruskal-Wallis | $H' = H/[1-(\sum T_i/N^3-N)]$ |
| $\chi^2_{crit} * =$ | 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 = 3.000

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

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

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

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

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

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

**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 MW84, a Mann-Kendall statistical analysis was performed.**

**Mann-Kendall Statistical Analysis for Arsenic in MW84**

**Input Data**

| Date Collected | Result (mg/L) |
|---|---|
| Jul-14 | 0.00511 |
| Jan-15 | 0.0073 |
| Jul-15 | 0.00922 |
| Jan-16 | 0.0103 |
| Jul-16 | 0.0137 |
| Jan-17 | 0.017 |
| Jul-17 | 0.0191 |
| Jan-18 | 0.0185 |

**Mann-Kendall Trend Test Analysis**

**User Selected Options**

| | |
|---|---|
| Date/Time of Computation | ProUCL 5.13/28/2018 8:45:21 AM |
| From File | 404 Arsenic MW84 DataPROUCL.xls |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**RESULTS**

**General Statistics**

| | |
|---|---|
| Number or Reported Events Not Used | 0 |
| Number of Generated Events | 8 |
| Number Values Reported (n) | 8 |
| Minimum | 0.00511 |
| Maximum | 0.0191 |
| Mean | 0.0125 |
| Geometric Mean | 0.0114 |
| Median | 0.012 |
| Standard Deviation | 0.00533 |
| Coefficient of Variation | 0.425 |

**Mann-Kendall Test**

| | |
|---|---|
| M-K Test Value (S) | 26 |
| Tabulated p-value | 0 |
| Standard Deviation of S | 8.083 |
| Standardized Value of S | 3.093 |
| Approximate p-value | 9.9089E-4 |

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



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 | 3.0929 |
| M-K Test Value (S) | 26 |
| Tabulated p-value | 0.0000 |
| Approximate p-value | 0.0010 |

| OLS Regression Line (Blue) | |
|---|---|
| OLS Regression Slope | 0.0021 |
| OLS Regression Intercept | 0.0029 |

Statistically significant evidence of an increasing trend at the specified level of significance.
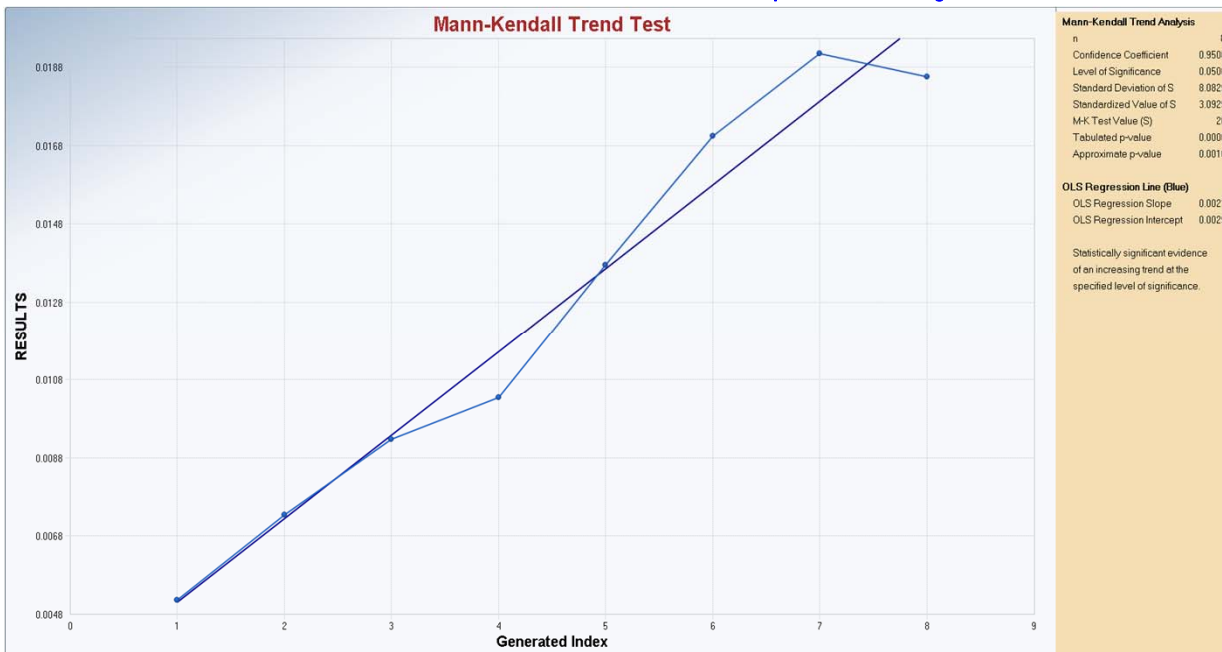
**ATTACHMENT B2**

**ARSENIC (DISSOLVED)**
**STATISTICAL TEST 2**

THIS PAGE INTENTIONALLY LEFT BLANK

## Attachment B2: Statistical Test 2, Test of Proportions, January 2018
## Arsenic, Dissolved URGA

| Date | Background MW93 | Background MW420 | Compliance MW84 | Compliance MW87 | Compliance MW90A |
|------|------|------|------|------|------|
| | Arsenic, Dissolved (mg/L) | | | | |
| Jan-16 | 0.0025 | 0.0025 | 0.0025 | 0.0025 | 0.0025 |
| Jul-16 | **0.00434** | 0.0025 | **0.00737** | **0.00282** | 0.0025 |
| Jan-17 | **0.00254** | 0.0025 | **0.011** | 0.0025 | 0.0025 |
| Jul-17 | 0.0025 | 0.0025 | 0.0025 | 0.0025 | 0.0025 |
| Jan-18 | 0.0025 | 0.0025 | 0.0025 | 0.0025 | 0.0025 |

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

[!]**Test of Proportions**

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

$X =$    2    $X$ = 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

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

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

$P_b =$    0.200      $P_b$ = proportion of detects in background wells
$P_c =$    0.200      $P_c$ = proportion of detects in compliance wells
$S_D =$    0.163      $S_D$ = standard error of difference in proportions
$Z =$    0.000      $Z = (P_b - P_c)/S_D$
absolute value of $Z =$    0.000

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).

THIS PAGE INTENTIONALLY LEFT BLANK

**ATTACHMENT B3**

**CADMIUM**
**STATISTICAL TEST 2**

THIS PAGE INTENTIONALLY LEFT BLANK

# Attachment B3: Statistical Test 2, Test of Proportions, January 2018
## Cadmium URGA

| Date | Cadmium (mg/L) Background | Background | Compliance | Compliance | Compliance |
|------|------------|------------|------------|------------|------------|
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | **0.000152** | 0.0005 | **0.000179** | **0.000121** | 0.0005 |
| Jul-16 | **0.000199** | 0.0005 | **0.000292** | **0.000451** | 0.0005 |
| Jan-17 | 0.0005 | 0.0005 | **0.000619** | 0.0005 | 0.0005 |
| Jul-17 | 0.0005 | 0.0005 | **0.000396** | **0.000304** | 0.0005 |
| Jan-18 | 0.0005 | 0.0005 | 0.0005 | **0.000375** | 0.0005 |

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

[!]**Test of Proportions**

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

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

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

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

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

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

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

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

THIS PAGE INTENTIONALLY LEFT BLANK

**ATTACHMENT B4**

**CHROMIUM**
**STATISTICAL TEST 3**

THIS PAGE INTENTIONALLY LEFT BLANK

| Chromium (mg/L) | | | | |
|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | **0.0401** | 0.005 | **0.0393** | **0.0266** | 0.005 |
| Jul-16 | **0.207** | 0.005 | **0.0206** | **0.165** | 0.005 |
| Jan-17 | **0.428** | 0.005 | **0.0309** | **0.262** | 0.005 |
| Jul-17 | **0.261** | 0.005 | **0.103** | **0.0557** | 0.005 |
| Jan-18 | **0.151** | 0.005 | **0.143** | **1.18** | **0.00381** |
| Sum | 1.1121 | | 0.33680 | 1.68930 | 0.0238 |
| $n_i$ | 10 | | 5 | 5 | 5 |
| $(x_i)_{avg}$ | 0.11121 | | 0.06736 | 0.33786 | 0.0048 |

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.. =     0.12648

| | | |
|---|---|---|
| N = | 25 | N = the total number of samples |
| p = | 4 | p = the number of $n_i$ groups |
| x.. = | 3.16 | x.. = the sum of the total number of samples |

**Statistical Test 3, Nonparametric ANOVA**

**Ranking of Observations**

| Sequence | Chromium (mg/L) | Adjusted Rank | Tie Number |
|---|---|---|---|
| 1 | 0 | 5 | |
| 2 | 0 | 5 | |
| 3 | 0 | 5 | |
| 4 | 0 | 5 | |
| 5 | 0 | 5 | Tie 1 |
| 6 | 0 | 5 | |
| 7 | 0 | 5 | |
| 8 | 0 | 5 | |
| 9 | 0 | 5 | |
| 10 | **0.00381** | 10 | |
| 11 | **0.0206** | 11 | |
| 12 | **0.0266** | 12 | |
| 13 | **0.0309** | 13 | |
| 14 | **0.0393** | 14 | |
| 15 | **0.0401** | 15 | |
| 16 | **0.0557** | 16 | |
| 17 | **0.103** | 17 | |
| 18 | **0.143** | 18 | |
| 19 | **0.151** | 19 | |
| 20 | **0.165** | 20 | |
| 21 | **0.207** | 21 | |
| 22 | **0.261** | 22 | |
| 23 | **0.262** | 23 | |
| 24 | **0.428** | 24 | |
| 25 | **1.18** | 25 | |

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

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

**Sums of Ranks and Averages**

| Chromium (mg/L) | | | | |
|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | **0.0401** | 0 | **0.0393** | **0.0266** | 0 |
| Jul-16 | **0.207** | 0 | **0.0206** | **0.165** | 0 |
| Jan-17 | **0.428** | 0 | **0.0309** | **0.262** | 0 |
| Jul-17 | **0.261** | 0 | **0.103** | **0.0557** | 0 |
| Jan-18 | **0.151** | 0 | **0.143** | **1.18** | **0.00381** |

| Observation Ranks for Chromium | | | | | |
|---|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | 15 | 5 | 14 | 12 | 5 |
| Jul-16 | 21 | 5 | 11 | 20 | 5 |
| Jan-17 | 24 | 5 | 13 | 23 | 5 |
| Jul-17 | 22 | 5 | 17 | 16 | 5 |
| Jan-18 | 19 | 5 | 18 | 25 | 10 |
| $R_i$ | 126 | | 73 | 96 | 30 |
| $(R_i)_{avg}$ | 12.6 | | 14.6 | 19.2 | 6.0 |
| $R_i^2/n_i$ | 1587.6 | | 1065.8 | 1843.2 | 180.0 |

$\Sigma R_i^2/n_i =$   4676.6

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 =   8.337   Kruskal-Wallis Statistic   $H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$

H' =   8.741   Corrected Kruskal-Wallis   $H' = H/[1-(\Sigma T_i/N^3-N)]$

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

**Calculate Critical Values**

Average Background Ranking =　　12.6

| | Well No. | $C_i$ | $(R_i)_{avg} - (R_b)_{avg}$ | Conclusion |
|---|---|---|---|---|
| BG Well | MW93 | | | |
| BG Well | MW420 | | | |
| | MW84 | 8.578 | 2.00 | not contaminated |
| | MW87 | 8.578 | 6.60 | not contaminated |
| | MW90A | 8.578 | -6.60 | not contaminated |

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

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

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

**Since $(R_i)_{avg} - (R_b)_{avg} < C_i$ for MW84, MW87, and MW90A, there is no statistically significant difference between compliance test wells and background wells at the C-404 Landfill; 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 B5**

**CHROMIUM, DISSOLVED
STATISTICAL TEST 2**

# Attachment B5: Statistical Test 2, Test of Proportions, January 2018
## Chromium, Dissolved URGA

| Date | Background MW93 | Background MW420 | Compliance MW84 | Compliance MW87 | Compliance MW90A |
|---|---|---|---|---|---|
| Chromium, Dissolved (mg/L) | | | | | |
| Jan-16 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 |
| Jul-16 | **0.0021** | 0.005 | 0.005 | **0.00438** | 0.005 |
| Jan-17 | **0.0116** | 0.005 | 0.005 | 0.005 | 0.005 |
| Jul-17 | **0.00474** | 0.005 | 0.005 | 0.005 | 0.005 |
| Jan-18 | 0.005 | 0.005 | 0.005 | **0.00331** | 0.005 |

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

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

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

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

$P_b =$    0.300      $P_b$ = proportion of detects in background wells
$P_c =$    0.133      $P_c$ = 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.

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

**ATTACHMENT B6**

**LEAD
STATISTICAL TEST 3**

THIS PAGE INTENTIONALLY LEFT BLANK

**Attachment B6: Statistical Test 3, Nonparametric ANOVA, January 2018 Lead URGA**

| Date | Lead (mg/L) | | | | |
|---|---|---|---|---|---|
| | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | **0.00144** | 0.001 | **0.00108** | **0.00107** | 0.001 |
| Jul-16 | **0.00181** | 0.001 | **0.00239** | **0.0056** | 0.001 |
| Jan-17 | **0.00155** | 0.001 | **0.00475** | **0.00439** | 0.001 |
| Jul-17 | **0.00213** | 0.001 | **0.00267** | **0.00533** | 0.001 |
| Jan-18 | **0.00186** | 0.001 | **0.00191** | **0.00579** | **0.000634** |
| Sum | 0.0138 | | 0.01280 | 0.02218 | 0.0046 |
| $n_i$ | 10 | | 5 | 5 | 5 |
| $(x_i)_{avg}$ | 0.00138 | | 0.00256 | 0.00444 | 0.0009 |

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.. =     0.00214

| | | |
|---|---|---|
| N = | 25 | N = the total number of samples |
| p = | 4 | p = the number of $n_i$ groups |
| x.. = | 0.05 | x.. = the sum of the total number of samples |

B6-3

**Statistical Test 3, Nonparametric ANOVA**

**Ranking of Observations**

| Sequence | Lead (mg/L) | Adjusted Rank | Tie Number |
|---|---|---|---|
| 1 | 0 | 5 | |
| 2 | 0 | 5 | |
| 3 | 0 | 5 | |
| 4 | 0 | 5 | |
| 5 | 0 | 5 | Tie 1 |
| 6 | 0 | 5 | |
| 7 | 0 | 5 | |
| 8 | 0 | 5 | |
| 9 | 0 | 5 | |
| 10 | **0.000634** | 10 | |
| 11 | **0.00107** | 11 | |
| 12 | **0.00108** | 12 | |
| 13 | **0.00144** | 13 | |
| 14 | **0.00155** | 14 | |
| 15 | **0.00181** | 15 | |
| 16 | **0.00186** | 16 | |
| 17 | **0.00191** | 17 | |
| 18 | **0.00213** | 18 | |
| 19 | **0.00239** | 19 | |
| 20 | **0.00267** | 20 | |
| 21 | **0.00439** | 21 | |
| 22 | **0.00475** | 22 | |
| 23 | **0.00533** | 23 | |
| 24 | **0.0056** | 24 | |
| 25 | **0.00579** | 25 | |

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

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

# Attachment B6: Statistical Test 3, Nonparametric ANOVA, January 2018 Lead URGA

**Sums of Ranks and Averages**

| Lead (mg/L) | | | | |
|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | **0.00144** | 0 | **0.00108** | **0.00107** | 0 |
| Jul-16 | **0.00181** | 0 | **0.00239** | **0.0056** | 0 |
| Jan-17 | **0.00155** | 0 | **0.00475** | **0.00439** | 0 |
| Jul-17 | **0.00213** | 0 | **0.00267** | **0.00533** | 0 |
| Jan-18 | **0.00186** | 0 | **0.00191** | **0.00579** | **0.000634** |

| Observation Ranks for Lead | | | | |
|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | 13 | 5 | 12 | 11 | 5 |
| Jul-16 | 15 | 5 | 19 | 24 | 5 |
| Jan-17 | 14 | 5 | 22 | 21 | 5 |
| Jul-17 | 18 | 5 | 20 | 23 | 5 |
| Jan-18 | 16 | 5 | 17 | 25 | 10 |
| $R_i$ | 101 | | 90 | 104 | 30 |
| $(R_i)_{avg}$ | 10.1 | | 18.0 | 20.8 | 6.0 |
| $R_i^2/n_i$ | 1020.1 | | 1620.0 | 2163.2 | 180.0 |

$\Sigma R_i^2/n_i =$    4983.3

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**

$H =$    13.999      Kruskal-Wallis Statistic      $H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$

$H' =$    14.677      Corrected Kruskal-Wallis      $H' = H/[1-(\Sigma T_i/N^3-N)]$

$\chi^2_{crit}* =$    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 B6: Statistical Test 3, Nonparametric ANOVA, January 2018 Lead URGA

**Calculate Critical Values**

Average Background Ranking = 10.1

|  | Well No. | $C_i$ | $(R_i)_{avg} - (R_b)_{avg}$ | Conclusion |
|---|---|---|---|---|
| BG Well | MW93 |  |  |  |
| BG Well | MW420 |  |  |  |
|  | MW84 | 8.578 | 7.90 | not contaminated |
|  | MW87 | 8.578 | 10.70 | evidence of contamination |
|  | MW90A | 8.578 | -4.10 | 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 MW87, there is a statistically significant difference between downgradient compliance test wells and background wells in MW87 from C-404.**

**Because nonparametric ANOVA indicated a statistically significant difference between compliance test wells and background wells at the C-404 Landfill in compliance well MW87, the 95% UTL was performed.**

**Since $(R_i)_{avg} - (R_b)_{avg} < C_i$ for MW84 and MW90A, there is no statistically significant difference from C-404 in these downgradient compliance test wells; however, the negative value indicates that the background wells have elevated concentrations.**

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

**95% Upper Tolerance Limit (UTL)**

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

**January 2018 Data, First Reporting Period**
**Observations (mg/L)**

| Well No. | | | | | | |
|---|---|---|---|---|---|---|
| **MW93** | 0.00144 | 0.00181 | 0.00155 | 0.00213 | 0.00186 | **Upgradient Well**[!] |
| **MW420** | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | **Upgradient Well**[!] |
| | | | | | | **Current Data** |
| MW84 | | X: Mean Value = | 0.0014 | | | 0.00191 |
| **MW87** | | S: Standard Deviati | 0.0004 | | | **0.00579** |
| MW90A | | K* factor = | 2.911 | (for n = 10) | | 0.000634 |
| | | CV = S/X | 0.3181 | <1, assume normal distribution | | |
| | | Upper Tolerance Interval: TL = X +(KxS) = | | **0.0027** | (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:** **MW87 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 MW87, the paired ANOVA was performed.**

**Paired (Parametric) ANOVA**

Evaluate results using paired ANOVA of wells in the same direction relative to the landfill [e.g., compare upgradient westernmost well 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 | Lead (mg/L) Background | Compliance | | |
|------|------------|------------|---|---|
| | MW93 | MW87 | $n_i^2$ | |
| Jan-16 | **0.00144** | **0.00107** | 0.0000021 | 0.0000011 |
| Jul-16 | **0.00181** | **0.0056** | 0.0000033 | 0.0000314 |
| Jan-17 | **0.00155** | **0.00439** | 0.0000024 | 0.0000193 |
| Jul-17 | **0.00213** | **0.00533** | 0.0000045 | 0.0000284 |
| Jan-18 | **0.00186** | **0.00579** | 0.0000035 | 0.0000335 |
| Sum $(x_i)$ | 0.009 | 0.02218 | 0.0310 | Total Sum (x..) |
| $n_i$ | 5 | 5 | | |
| $(x_i)_{avg}$ | 0.002 | 0.00444 | | |
| $(x_i)^2$ | 0.00008 | 0.00049 | | |

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

| | | |
|---|---|---|
| Overall mean x.. = | 0.00310 | |
| N = | 10 | N = the total number of samples |
| p = | 2 | p = the number of $n_i$ groups |
| X.. = | 0.0310 | 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 |
|------|-----------|-----------|
| | MW93 | MW87 |
| Jan-16 | -0.00032 | -0.00337 |
| Jul-16 | 0.00005 | 0.00116 |
| Jan-17 | -0.00021 | -0.00005 |
| Jul-17 | 0.00037 | 0.00089 |
| Jan-18 | 0.00010 | 0.00135 |

| | | |
|---|---|---|
| X: Mean Value = | -5.85E-19 | |
| S: Standard Deviation = | 0.00132 | |
| K* Factor = | 2.911 | (for n = 10) |
| CV = S/X = | −2.25E+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 is < 1, the data are normally distributed.
If the coefficient of variation is > or = 1, data are not normally distributed.

**Determine Equality of Variance of Dataset**

p = number of wells                                     $x_{..}$ = 0.0310

$n_i$ = number of data points per well                  $(x_{avg})_{..}$ = 0.00310

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

| $S_i$ | $S_i^2$ | $ln(S_i^2)$† | $n_i$ | $f_iS_i^2$ | $f_iln(S_i^2)$† |
|---|---|---|---|---|---|
| 0.000272 | 0.00000007397 | -16.420 | 5 | 0.0000003 | -65.7 |
| 0.00196 | 0.00000382988 | -12.473 | 5 | 0.0000153 | -49.9 |

$\sum(S_i^2)$ =    0.000003904          $\sum f_i ln(S_i^2)$ =   -115.56913

Equality of Variance: Bartlett's Test

f =          8

$Sp^2$ =    0.0000020

$ln Sp^2$ =    -13.147

$\chi^2$ =    10.396       (If calculated $\chi^2$ ≤ tabulated $\chi^2_{crit}$, then variances are equal at the given significance level).

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

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

**Variances are not equal, transform the original data to lognormal (i.e., since calculated $\chi2 > \chi2_{crit}$).**

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

# Attachment B6: Statistical Test 3, Nonparametric ANOVA, January 2018 Lead URGA

**Paired (Parametric) ANOVA─Lognormal Data for Lead in MW93 and MW87**

| Date | ln[Lead (mg/L)] Background | Compliance | | |
|---|---|---|---|---|
| | MW93 | MW87 | $n_i^2$ | |
| Jan-16 | **-6.54** | **-6.84** | 42.81 | 46.79 |
| Jul-16 | **-6.31** | **-5.18** | 39.87 | 26.88 |
| Jan-17 | **-6.47** | **-5.43** | 41.85 | 29.47 |
| Jul-17 | **-6.15** | **-5.23** | 37.84 | 27.40 |
| Jan-18 | **-6.29** | **-5.15** | 39.53 | 26.54 |
| Sum $(x_i)$ | -31.77 | -27.84 | -59.61 | Total Sum (x..) |
| $n_i$ | 5 | 5 | | |
| $(x_i)_{avg}$ | -6.35 | -5.57 | | |
| $(x_i)^2$ | 1009.07 | 775.04 | | |

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

Overall mean x.. =      -5.96
       N =      10      N = the total number of samples
       p =      2      p = the number of $n_i$ groups
       x.. =      -59.61      x.. = the sum of the total number of samples

**Determine Normality of Dataset**

**Coefficient of Variability Test—Lognormal Data for Lead in MW93 and MW87**

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

| Date | Background | Compliance |
|---|---|---|
| | MW93 | MW87 |
| Jan-16 | -0.19 | -1.27 |
| Jul-16 | 0.04 | 0.38 |
| Jan-17 | -0.12 | 0.14 |
| Jul-17 | 0.20 | 0.33 |
| Jan-18 | 0.07 | 0.42 |

X: Mean Value =    -6.22E-16
S: Standard Deviation =    0.49
K* Factor =    2.911      (for n = 10)
CV = S/X =    −7.89E+14    <1, data are normally distributed

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

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

**Determine Equality of Variance of Lognormal Dataset for Lead in MW93 and MW87**

p = number of wells                                                                     $x_{..} =$ -59.61

$n_i$ = number of data points per well                                    $(x_{avg})_{..} =$ -5.96

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

| $S_i$ | $S_i^2$ | $ln(S_i^2)$ | $n_i$ | $f_i S_i^2$ | $f_i ln(S_i^2)$ |
|-------|---------|-------------|-------|-------------|------------------|
| 0.15  | 0.02    | -3.73       | 5     | 0.10        | -14.9            |
| 0.72  | 0.52    | -0.66       | 5     | 2.07        | -2.6             |

$\sum(S_i^2) =$        0.54                    $\sum f_i ln(S_i^2) =$        -17.55

Equality of Variance: Bartlett's Test

f =              8

$Sp^2 =$        0.27

$ln\ Sp^2 =$    -1.31

$\chi^2 =$       7.10          (If calculated $\chi^2 \leq$ tabulated $\chi^2_{crit}$, 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)

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

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

**Because the variances were not equal, Statistical Test 3, Nonparametric ANOVA is performed.\*\***

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

# Attachment B6: Statistical Test 3, Nonparametric ANOVA, January 2018 Lead URGA

**Statistical Test 3, Nonparametric ANOVA**

| | Lead (mg/L) | |
|---|---|---|
| Date | Background | Compliance |
| | MW93 | MW87 |
| Jan-16 | **0.00144** | **0.00107** |
| Jul-16 | **0.00181** | **0.0056** |
| Jan-17 | **0.00155** | **0.00439** |
| Jul-17 | **0.00213** | **0.00533** |
| Jan-18 | **0.00186** | **0.00579** |
| Sum | 0.0088 | 0.02218 |
| $n_i$ | 5 | 5 |
| $(x_i)_{avg}$ | 0.00176 | 0.00444 |

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.. =    0.00310

| | | |
|---|---|---|
| N = | 10 | N = the total number of samples |
| p = | 2 | p = the number of $n_i$ groups |
| x.. = | 0.03097 | x.. = the sum of the total number of samples |

**Ranking of Observations**

| Sequence | Lead (mg/L) | Adjusted Rank | Tie Number |
|---|---|---|---|
| 1 | **0.00107** | 1 | |
| 2 | **0.00144** | 2 | |
| 3 | **0.00155** | 3 | |
| 4 | **0.00181** | 4 | |
| 5 | **0.00186** | 5 | |
| 6 | **0.00213** | 6 | |
| 7 | **0.00439** | 7 | |
| 8 | **0.00533** | 8 | |
| 9 | **0.0056** | 9 | |
| 10 | **0.00579** | 10 | |

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

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

**Sums of Ranks and Averages**

| | Observation Ranks for Lead | |
|---|---|---|
| Date | Background | Compliance |
| | MW93 | MW87 |
| Jan-16 | 2 | 1 |
| Jul-16 | 4 | 9 |
| Jan-17 | 3 | 7 |
| Jul-17 | 6 | 8 |
| Jan-18 | 5 | 10 |
| $R_i$ | 20 | 35 |
| $(R_i)_{avg}$ | 4 | 7 |
| $R_i^2/n_i$ | 80.0 | 245.0 |

$\sum R_i^2/n_i$ =    325
K =    2
N =    10

**Calculation of Kruskal-Wallis Statistic**

| | | | |
|---|---|---|---|
| H = | 2.455 | Kruskal-Wallis Statistic | $H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$ |
| H' = | 2.455 | 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' < χ2crit.

If H' ≤ $\chi^2_{crit}$, 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.

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

**Calculate Critical Values**

NOTE: Not required due to H' < $\chi^2_{crit}$.

**Since H' < χ2$_{crit}$, there is no statistically significfant evidence of a difference between background wells and compliance wells.**

**ATTACHMENT B7**

**SELENIUM
STATISTICAL TEST 2**

THIS PAGE INTENTIONALLY LEFT BLANK

| Selenium (mg/L) | | | | |
|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | **0.00165** | 0.0025 | 0.0025 | 0.0025 | **0.00231** |
| Jul-16 | 0.0025 | 0.0025 | 0.0025 | **0.00159** | **0.0017** |
| Jan-17 | 0.0025 | 0.0025 | **0.00294** | 0.0025 | 0.0025 |
| Jul-17 | 0.0025 | 0.0025 | 0.0025 | 0.0025 | 0.0025 |
| Jan-18 | 0.0025 | 0.0025 | 0.0025 | **0.00219** | 0.0025 |

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

[!]**Test of Proportions**

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

$X =$    1    $X$ = number of samples above DL in background wells
$Y =$    5    $Y$ = number of samples above DL in compliance wells
$n_b =$    10    $n_b$ = count of background well results/samples analyzed
$n_c =$    15    $n_c$ = count of compliance well results/samples analyzed
$n =$    25    $n$ = total number of samples

$P =$    0.240      $P=(x+y)/n$
$nP =$    6      $n=n_b+n_c$
$n(1-P) =$    19

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

$P_b =$    0.100      $P_b$ = proportion of detects in background wells
$P_c =$    0.333      $P_c$ = proportion of detects in compliance wells
$S_D =$    0.174      $S_D$ = standard error of difference in proportions
$Z =$    -1.338      $Z = (P_b-P_c)/S_D$
absolute value of $Z =$    1.338

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).

**ATTACHMENT B8**

**SELENIUM, DISSOLVED**
**STATISTICAL TEST 2**

THIS PAGE INTENTIONALLY LEFT BLANK

# Attachment B8: Statistical Test 2, Test of Proportions, January 2018
## Selenium, Dissolved URGA

| Selenium, Dissolved (mg/L) | | | | | |
|---|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | **0.00225** | 0.0025 | 0.0025 | **0.00199** | **0.00197** |
| Jul-16 | 0.0025 | 0.0025 | 0.0025 | 0.0025 | **0.00157** |
| Jan-17 | 0.0025 | 0.0025 | 0.0025 | 0.0025 | 0.0025 |
| Jul-17 | 0.0025 | 0.0025 | 0.0025 | 0.0025 | 0.0025 |
| Jan-18 | **0.00201** | 0.0025 | **0.00204** | 0.0025 | 0.0025 |

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

[!]**Test of Proportions**

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

$X =$     2     $X$ = 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

$P =$     0.240          $P = (x+y)/n$
$nP =$     6          $n = n_b + n_c$
$n(1-P) =$     19

**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
$P_c =$     0.267          $P_c$ = proportion of detects in compliance wells
$S_D =$     0.174          $S_D$ = standard error of difference in proportions
$Z =$     -0.382          $Z = (P_b - P_c)/S_D$
absolute value of $Z =$     0.382

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).

THIS PAGE INTENTIONALLY LEFT BLANK

**ATTACHMENT B9**

**TECHNETIUM-99**
**STATISTICAL TEST 2**

THIS PAGE INTENTIONALLY LEFT BLANK

## Attachment B9: Statistical Test 2, Test of Proportions, January 2018
## Technetium-99 URGA

| Technetium-99 (pCi/L) | | | | | |
|---|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | 10.45 | 9.3 | **170** | 10.55 | 10.3 |
| Jul-16 | 8.4 | 8.7 | 8.65 | 9 | 9.15 |
| Jan-17 | 6.75 | 6.8 | 6.75 | 6.9 | 7.2 |
| Jul-17 | 9.85 | 9.7 | 10.05 | 9.9 | 9.55 |
| Jan-18 | 9.4 | **21.5** | **34.4** | 9.45 | 9.2 |

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

[!]**Test of Proportions**

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

| | | |
|---|---|---|
| $X =$ | 1 | $X$ = number of samples above DL in background wells |
| $Y =$ | 2 | $Y$ = 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 |

| | | |
|---|---|---|
| $P =$ | 0.120 | $P = (x+y)/n$ |
| $nP =$ | 3 | $n = n_b + n_c$ |
| $n(1-P) =$ | 22 | |

**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 |
| $P_c =$ | 0.133 | $P_c$ = proportion of detects in compliance wells |
| $S_D =$ | 0.133 | $S_D$ = standard error of difference in proportions |
| $Z =$ | -0.251 | $Z = (P_b - P_c)/S_D$ |
| absolute value of $Z =$ | 0.251 | |

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).

THIS PAGE INTENTIONALLY LEFT BLANK

**ATTACHMENT B10**

**TRICHLOROETHENE**
**STATISTICAL TESTS 4/3**

THIS PAGE INTENTIONALLY LEFT BLANK

**Attachment B10: Statistical Test 4, Parametric ANOVA, January 2018 Trichloroethene URGA**

| Trichloroethene (TCE, µg/L) | | | | | |
|---|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | **2490** | **222** | **1350** | **1230** | **39.8** |
| Jul-16 | **2020** | **169** | **1820** | **1090** | **35.3** |
| Jan-17 | **2450** | **274** | **2620** | **2240** | **49.5** |
| Jul-17 | **1400** | **264** | **2910** | **1620** | **46.1** |
| Jan-18 | **994** | **232** | **3160** | **1400** | **40.6** |
| $n_i$ | 10 | | 5 | 5 | 5 |
| Sum | 10515 | | 11860 | 7580 | 211.30 |
| $(x_i)$avg | 1051.50 | | 2372.00 | 1516.00 | 42.26 |

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

Overall mean x.. = 1206.65

$N$ = 25     $N$ = the total number of samples

$p$ = 4     $p$ = the number of $n_i$ groups

x.. = 30166.30     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 |
|---|---|---|---|---|---|
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | 1438.50 | -829.50 | -1022.00 | -286.00 | -2.46 |
| Jul-16 | 968.50 | -882.50 | -552.00 | -426.00 | -6.96 |
| Jan-17 | 1398.50 | -777.50 | 248.00 | 724.00 | 7.24 |
| Jul-17 | 348.50 | -787.50 | 538.00 | 104.00 | 3.84 |
| Jan-18 | -57.50 | -819.50 | 788.00 | -116.00 | -1.66 |

X: Mean Value = -1.14E-15

S: Standard Deviation = 694.7

K* Factor = 2.292    (for n = 25)

CV = S/X = -6.11E+17   < 1, the data are normally distributed

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

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

# Attachment B10: Statistical Test 4, Parametric ANOVA, January 2018 Trichloroethene URGA

**Determine Equality of Variance of Dataset**

p = number of wells

$n_i$ = number of data points per well

N = total sample size

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

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

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

$f_i = n_i - 1$

$x_{..}$ = 30166.30

$(x_{avg})_{..}$ = 1206.65

p = 4

N = 25

Calculations for Equality of Variance: Bartlett's Test

| $S_i$ | $S_i^2$ | $\ln(S_i^2)$ | $n_i$ | $f_i S_i^2$ | $f_i \ln(S_i^2)$ |
|---|---|---|---|---|---|
| 969.018 | 938994.94 | 13.753 | 10 | 8450954.5 | 123.8 |
| 761.755 | 580270.00 | 13.271 | 5 | 2321080.000 | 53.1 |
| 450.478 | 202930.00 | 12.221 | 5 | 811720.000 | 48.9 |
| 5.577 | 31.10 | 3.437 | 5 | 124.412 | 13.7 |

$\sum(S_i^2) =$     1722226.05        $\sum f_i \ln(S_i^2) =$     239.5

Equality of Variance: Bartlett's Test

f = 21

$Sp^2$ = 551613.282

$\ln Sp^2$ = 13.221

$\chi^2$ = 38.143    (If $\chi^2 \leq \chi^2_{crit}$, then variances are equal at the given significance level).

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

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

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

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

# Attachment B10: Statistical Test 4, Parametric ANOVA, January 2018 Trichloroethene URGA

**Lognormal Data for TCE**

| | ln[TCE (µg/L)] | | | | |
|---|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | 7.82 | 5.40 | 7.21 | 7.11 | 3.68 |
| Jul-16 | 7.61 | 5.13 | 7.51 | 6.99 | 3.56 |
| Jan-17 | 7.80 | 5.61 | 7.87 | 7.71 | 3.90 |
| Jul-17 | 7.24 | 5.58 | 7.98 | 7.39 | 3.83 |
| Jan-18 | 6.90 | 5.45 | 8.06 | 7.24 | 3.70 |
| $x_i$ | 64.55 | | 38.62 | 36.46 | 18.68 |
| $(x_i)$avg | 6.45 | | 7.72 | 7.29 | 3.74 |

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 |
|---|---|---|---|---|---|
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | 1.37 | -1.05 | -0.52 | -0.18 | -0.05 |
| Jul-16 | 1.16 | -1.33 | -0.22 | -0.30 | -0.17 |
| Jan-17 | 1.35 | -0.84 | 0.15 | 0.42 | 0.17 |
| Jul-17 | 0.79 | -0.88 | 0.25 | 0.10 | 0.09 |
| Jan-18 | 0.45 | -1.01 | 0.33 | -0.05 | -0.03 |

$X$: Mean Value = 2.31E-16
$S$: Standard Deviation = 0.71
$K^*$ Factor = 2.292    (for n = 25)
CV = S/X = 3.07E+15   ≥1, data are NOT normally distributed

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

## Attachment B10: Statistical Test 4, Parametric ANOVA, January 2018 Trichloroethene URGA

**Determine Equality of Variance of Dataset for Lognormal Data**

p = number of wells (background wells considered as one group)          $x_{..} =$ 158.31

$n_i$ = number of data points per well          $(x_{avg})_{..} =$ 6.33

N = total sample size

$S^2$ = 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)

$f_i = n_i - 1$

Calculations for Equality of Variance: Bartlett's Test

| $S_i$ | $S_i^2$ | $\ln(S_i^2)$ | ni | $f_i S_i^2$ | $f_i \ln(S_i^2)$ |
|---|---|---|---|---|---|
| 1.116 | 1.245 | 0.219 | 10 | 11.203 | 2.0 |
| 0.357 | 0.128 | -2.059 | 5 | 0.510 | -8.2 |
| 0.279 | 0.078 | -2.556 | 5 | 0.310 | -10.2 |
| 0.132 | 0.017 | -4.047 | 5 | 0.070 | -16.2 |

$\sum(S_i^2) =$          1.47          $\sum f_i \ln(S_i^2) =$          -32.7

Equality of Variance: Bartlett's Test

f =          21

$Sp^2$ =          0.576

$\ln Sp^2$ =          -0.552

$\chi^2$ =          21.087          (If $\chi^2 \leq \chi^2_{crit}$, then variances are equal at the given significance level).

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

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

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

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

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

# Attachment B10: Statistical Test 3, Nonparametric ANOVA, January 2018 Trichloroethene URGA

**Statistical Test 3, Nonparametric ANOVA**

| Date | TCE (µg/L) Background MW93 | Background MW420 | Compliance MW84 | Compliance MW87 | Compliance MW90A |
|------|------------|------------|------------|------------|------------|
| Jan-16 | **2490** | **222** | **1350** | **1230** | **39.8** |
| Jul-16 | **2020** | **169** | **1820** | **1090** | **35.3** |
| Jan-17 | **2450** | **274** | **2620** | **2240** | **49.5** |
| Jul-17 | **1400** | **264** | **2910** | **1620** | **46.1** |
| Jan-18 | **994** | **232** | **3160** | **1400** | **40.6** |
| $n_i$ | 10 | | 5 | 5 | 5 |
| $x_i$ | 10515 | | 11860 | 7580 | 211.30 |
| $(x_i)$avg | 1051.50 | | 2372.00 | 1516.00 | 42.26 |

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

Overall mean $x.. =$    1206.65

| | | |
|---|---|---|
| $N =$ | 25 | $N$ = the total number of samples |
| $p =$ | 4 | $p$ = the number of $n_i$ groups |
| $x.. =$ | 30166.30 | $x..$ = the sum of the total number of samples |

**Statistical Test 3, Nonparametric ANOVA**

**Ranking of Observations**

| Sequence | TCE (µg/L) | Adjusted Rank | Tie Number |
|---|---|---|---|
| 1 | **35.3** | 1 | |
| 2 | **39.8** | 2 | |
| 3 | **40.6** | 3 | |
| 4 | **46.1** | 4 | |
| 5 | **49.5** | 5 | |
| 6 | **169** | 6 | |
| 7 | **222** | 7 | |
| 8 | **232** | 8 | |
| 9 | **264** | 9 | |
| 10 | **274** | 10 | |
| 11 | **994** | 11 | |
| 12 | **1090** | 12 | |
| 13 | **1230** | 13 | |
| 14 | **1350** | 14 | |
| 15 | **1400** | 15.5 | Tie 1 |
| 16 | **1400** | 15.5 | |
| 17 | **1620** | 17 | |
| 18 | **1820** | 18 | |
| 19 | **2020** | 19 | |
| 20 | **2240** | 20 | |
| 21 | **2450** | 21 | |
| 22 | **2490** | 22 | |
| 23 | **2620** | 23 | |
| 24 | **2910** | 24 | |
| 25 | **3160** | 25 | |

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

$n_{tie}$     Adjustment for Ties: $(ntie^3 - ntie)$

2          Tie 1 =       6

           $\sum T_i$ =       6

# Attachment B10: Statistical Test 3, Nonparametric ANOVA, January 2018 Trichloroethene URGA

**Sums of Ranks and Averages**

| | TCE (µg/L) | | | | |
|---|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | **2520** | **191** | **1530** | **1250** | **37.9** |
| Jul-16 | **2490** | **222** | **1350** | **1230** | **39.8** |
| Jan-17 | **2020** | **169** | **1820** | **1090** | **35.3** |
| Jul-17 | **2450** | **274** | **2620** | **2240** | **49.5** |
| Jan-18 | **1400** | **264** | **2910** | **1620** | **46.1** |

| | Observation Ranks for TCE | | | | |
|---|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | 22 | 7 | 14 | 13 | 2 |
| Jul-16 | 19 | 6 | 18 | 12 | 1 |
| Jan-17 | 21 | 10 | 23 | 20 | 5 |
| Jul-17 | 15.5 | 9 | 24 | 17 | 4 |
| Jan-18 | 11 | 8 | 25 | 15.5 | 3 |
| $R_{i.}$ | 128.5 | | 104 | 77.5 | 15 |
| $(R_i)_{avg}$ | 12.9 | | 20.8 | 15.5 | 3 |
| $R_i^2/n_i$ | 1651.2 | | 2163.2 | 1201.3 | 45 |

$\Sigma R_i^2/n_i =$   5060.7

µg/L = micrograms per liter     K = the number of $n_i$ groups
BG=background     N = the total number of samples
DL=detection limit

$K =$   4     **Bolded values indicate a detected result.**
$N =$   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**

$H =$   15.428    Kruskal-Wallis Statistic    $H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$

$H' =$   15.434    Corrected Kruskal-Wallis    $H' = H/[1-(\Sigma T_i/N^3-N)]$

$\chi^2_{crit} * =$   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     $Z(\alpha/(K-1))** =$   2.128
$\alpha =$   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* (USEPA 1989).
**Table 4, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (USEPA 1989).

# Attachment B10: Statistical Test 3, Nonparametric ANOVA, January 2018 Trichloroethene URGA

**Calculate Critical Values**

Average Background Ranking =    12.9

| | Well No. | $C_i$ | $(R_i)_{avg}$ - $(R_b)_{avg}$ | Conclusion |
|---|---|---|---|---|
| BG Well | MW93 | | | |
| BG Well | MW420 | | | |
| | MW84 | 8.578 | 7.95 | not contaminated |
| | MW87 | 8.578 | 2.65 | not contaminated |
| | MW90A | 8.578 | -9.85 | not contaminated |

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

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

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

**Since $(R_i)_{avg}$ - $(R_b)_{avg}$ < $C_i$ for MW84, MW87, and MW90A, there is no statistically significant difference between compliance test wells and background wells at the C-404 Landfill; 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 B11**

**URANIUM**
**STATISTICAL TEST 2**

THIS PAGE INTENTIONALLY LEFT BLANK

## Attachment B11: Statistical Test 2, Test of Proportions, January 2018 Uranium URGA

| | Uranium (mg/L) | | | | |
|---|---|---|---|---|---|
| Date | Background | Background | Compliance | Compliance | Compliance |
| | MW93 | MW420 | MW84 | MW87 | MW90A |
| Jan-16 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Jul-16 | **0.000165** | 0.0001 | **0.000345** | **0.000559** | 0.0001 |
| Jan-17 | **0.000223** | 0.0001 | **0.000618** | **0.000522** | 0.0001 |
| Jul-17 | **0.000224** | 0.0001 | **0.000355** | **0.000571** | 0.0001 |
| Jan-18 | 0.0001 | 0.0001 | **0.0002** | **0.000681** | 0.0001 |

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

[!]**Test of Proportions**

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

| | | |
|---|---|---|
| $X=$ | 3 | $X$=number of samples above DL in background wells |
| $Y=$ | 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 |

| | | |
|---|---|---|
| $P =$ | 0.440 | $P=(x+y)/n$ |
| $nP =$ | 11 | $n=n_b+n_c$ |
| $n(1-P) =$ | 14 | |

**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 |
| $P_c =$ | 0.533 | $P_c$ =proportion of detects in compliance wells |
| $S_D =$ | 0.203 | $S_D$=standard error of difference in proportions |
| $Z =$ | -1.151 | $Z = (P_b-P_c)/S_D$ |
| absolute value of $Z =$ | 1.151 | |

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).

**ATTACHMENT B12**

**STATISTICIAN STATEMENT**

THIS PAGE INTENTIONALLY LEFT BLANK

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

March 28, 2018

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

Dear Ms. Layne:

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

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

For this project, the statistical analyses on groundwater data from January 2016 through January 2018 were performed in accordance with the Hazardous Waste Management Facility Permit, Appendix E using Microsoft Excel 2010 and U.S. Environmental Protection Agency's (USEPA'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
· Mann-Kendall

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

Sincerely,

Jennifer R. Blewett

THIS PAGE INTENTIONALLY LEFT BLANK