DETECTION MONITORING STATISTICAL METHODS CERTIFICATION

U.S. EPA COAL COMBUSTION RESIDUAL RULE

COAL ASH PONDS
ELMER SMITH STATION
DAVIESS COUNTY
OWENSBORO, KENTUCKY

Prepared For:

OWENSBORO MUNICIPAL UTILITIES
OWENSBORO, KENTUCKY

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1.0 INTRODUCTION

The United States Environmental Protection Agency (USEPA) issued 40 Code of Federal Regulations (CFR) 257, Subpart D, *Disposal of Coal Combustion Residuals from Electric Utilities* (CCR Rule or the Rule) on April 17, 2015. The CCR Rule regulates disposal of coal combustion residuals (CCR) in new and active landfills and impoundments. Civil & Environmental Consultants, Inc. (CEC) has been engaged by Owensboro Municipal Utilities (OMU) to select the statistical method for evaluating groundwater monitoring data at the Elmer Smith Station (ESS) coal ash ponds as required by the CCR Rule. This document summarizes the statistical methods that will be used to evaluate ESS groundwater quality data to meet the requirements of the CCR Rule. As specified in 40 CFR 257.93(f)(6), the owner or operator must obtain certification from a qualified Professional Engineer (P.E.) stating that the selected statistical method is appropriate for evaluating the groundwater monitoring data for the CCR management area. It is intended that this document will be placed in the facility operating record as required by 40 CFR 257.105(h)(4).

2.0 CCR RULE STATISTICAL METHOD REGULATORY BACKGROUND

The CCR Rule requires that background water quality be determined in hydraulically upgradient or background wells for each of the constituents listed in Appendix III of Part 257 of the Rule. The design of the groundwater monitoring program includes sampling and analysis procedures to provide for collected monitoring results to be representative of groundwater quality at the upgradient and downgradient wells. The sampling and analysis plan is designed to limit spatial and temporal variability in groundwater monitoring results. The plan as implemented is designed to produce data that accurately represent the quality of groundwater passing the waste boundary of the CCR unit and provide for monitoring of potential contaminant pathways.

The Groundwater Monitoring System for the ESS ash ponds is described in the *Groundwater Monitoring System Certification* Report (CEC, 2017). The ESS ash pond Groundwater Monitoring System consists of two background monitoring wells (MW-2 and MW-7) and three downgradient compliance monitoring wells (MW-4, MW-5, and MW-6). Additional details regarding the monitoring network are provided in the Report.

For an existing facility, the Rule specifies that the statistical procedures used to evaluate groundwater quality must be developed by October 17, 2017, at the conclusion of the baseline groundwater monitoring phase. The available statistical methods that may be used in evaluating groundwater monitoring data are specified in § 257.93(f)(1-5) of the Rule. The goal of the statistical evaluation is to identify statistically significant evidence of CCR impacts for each constituent at each downgradient monitoring location by comparing it to background concentrations (interwell) or to its own data trend (intrawell).

The statistical test chosen shall be conducted separately for each constituent at each monitoring well location. Many statistical tests, including those specified in the Rule, such as those used to compare downgradient results to background or to a fixed criterion such as the groundwater protection standard (GWPS), require knowledge of the data distribution. The initial phase of the sampling and analysis plan consists of eight rounds of groundwater samples collected from upgradient (background) and background (monitoring) wells to establish baseline or background

concentrations at each location. CEC has developed this plan based upon the statistical distributions determined from the results after the eight rounds of sampling.

The Rule requires that the selected statistical test be chosen from the five identified in § 257.93(f) as follows:

1) *Method 1*: A parametric analysis of variance followed by multiple comparison procedures to identify statistically significant evidence of groundwater impacts. The method must include estimation and testing of the contrasts between each compliance well's mean and the background mean levels for each constituent.
2) *Method 2*: An analysis of variance based on ranks followed by multiple comparison procedures to identify statistically significant evidence of groundwater impacts. The method must include estimation and testing of the contrasts between each compliance well's median and the background median levels for each constituent.
3) *Method 3*: A tolerance or prediction interval procedure, in which an interval for each constituent is established from the distribution of the background data and the level of each constituent in each compliance well is compared to the upper tolerance or prediction limit.
4) *Method 4*: A control chart approach that gives control limits for each constituent.
5) *Method 5*: Another statistical test method that meets the performance standards of 40 C.F.R. § 257.93(g).

Additionally, the statistical approach for Detection Monitoring is required to be based upon a comparison test that has adequate statistical power to be capable of limiting the Site-Wide False Positive rate (SWFPR), as appropriate based on the method chosen. The statistical power is measured as the ability of a statistical test to detect a true statistically significant increase (SSI). The test must also be appropriate for the distribution and detection frequency of the background dataset.

3.0 ASSESSMENT NARRATIVE

Pursuant to 40 CFR 257.93(f)(6), the owner or operator of the CCR unit must obtain a certification from a qualified P.E. stating that the selected statistical method is appropriate for evaluating the groundwater monitoring data for the CCR management area. The certification must include a narrative description of the statistical method selected to evaluate the groundwater monitoring data.

In support of this requirement, CEC conducted an evaluation of the statistical method selected for evaluating the groundwater monitoring data associated with the above-referenced CCR unit and determined that sufficient information is available to make the certification required under 40 CFR 257.93(f)(6).

4.0 GROUNDWATER QUALITY DATA

To meet the requirement of § 257.94 of the Rule, eight rounds of groundwater samples were collected at each designated background and downgradient Site monitoring well to establish baseline concentrations of Appendix III and IV CCR constituents. The eight rounds of samples were collected between February 2017 and September 2017. Low-flow sampling techniques were used to collect the baseline samples at each monitoring well.

Based upon a review of the analytical results, CEC concluded the following:

The statistical method set out in 40 CFR 257.93(f) (3) (*Method 3)* was selected to evaluate the data collected during the Baseline Monitoring phase. The prediction interval or tolerance procedure approach of M*ethod 3* was selected based on a review of the EPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance* (2009), as well as preliminary analysis of the data from the eight baseline sampling events. It is expected that the prediction interval approach will be applicable during the subsequent Detection Monitoring phase. In the event that Assessment Monitoring is triggered, the tolerance procedure approach will be implemented. If the review of future data indicates that this method is unsuitable for evaluating the groundwater monitoring data for this Site, an appropriate method will be selected from the alternative methods listed in § 257.93(f) and the Certification Statement will be updated accordingly. See Section 2.0 for a summary of these methods.

Regardless of which statistical test is chosen for each constituent, the Rule specifies that the performance criteria of § 257.96(g) be met. A key component of the performance criteria is that the statistical method chosen to evaluate groundwater monitoring data shall be appropriate for the observed distribution of constituents. In general, normally distributed datasets (or datasets that may be transformed into normal distributions) are evaluated using parametric statistics while datasets that do not follow a normal distribution (including those with high numbers of non-detects) are evaluated using non-parametric means.

Data collected from the background and downgradient wells at the ESS ash ponds will be statistically evaluated using methodology consistent with guidance in the EPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance (*USEPA, 2009*)* that provides the equations and other details needed for the statistical calculations discussed in this document. A statistical software package consistent with the Unified Guidance will be used to perform the mathematical portion of the statistical evaluation. One such tool, developed with EPA funding, is ProUCL, a statistical software package that can support the statistical methods described in various USEPA documents including the Unified Guidance. Even if not ultimately selected to be used for the statistical determinations for the ESS, the accompanying documentation for ProUCL provides clarifying guidance that may prove useful in the implementation of the statistical evaluation at the ESS.

In general, the following approach will be implemented for the OMU statistical evaluation:

a) Potential outliers in the baseline dataset for each constituent will be evaluated using Dixon's Outlier test, at a 99% level of significance. Outliers identified by the test will be considered for removal from the dataset. However, as cautioned in the Unified Guidance, care should be exercised prior to removing outliers from the dataset. A multiple lines of evidence approach will be used to evaluate whether it is truly an outlier concentration not representative of background groundwater quality.

b) The dataset for each well will be screened for normality (or ability to be transformed into a normal distribution) using the Shapiro-Wilk (S-W) normality test at the 95% significance level. If not normally distributed, the data will first be transformed to a natural logarithm distribution and tested for a lognormal distribution at a 95% significance level. If the data set is determined to be normal or lognormal then a parametric evaluation will be used to generate upper prediction limits (UPL) for the monitored constituent. If the dataset is not normal or log normal, then a non-parametric statistical evaluation will be used.

c) Each dataset will be subject to a Theil-Sen trend analysis.

d) The datasets from the two background wells will be evaluated to determine if they represent a single population using either a Wilcoxon test (non-parametric) or student t-test prior to combining them.

e) For normally distributed datasets a one-sided parametric UPL will be generated. For non-normal distributed datasets, non-parametric UPLs will be used. Per the Unified Guidance, the non-parametric UPL will be the maximum concentration detected in the dataset.

f) Because a CCR release has the potential to lower or raise groundwater pH, a two-sided parametric prediction limit function will be used to calculate a UPL and LPL for pH.

When a tolerance interval or a prediction interval is used to evaluate groundwater monitoring data, the levels of confidence and, for tolerance intervals, the percentage of the population that the interval must contain, shall be such that this approach is at least as effective as any other approach in this section for evaluating groundwater data. These parameters shall be determined after considering the number of samples in the background database, the data distribution, and the range of the concentration values for each constituent of concern.

The statistical method chosen will account for data below the limit of detection with one or more statistical procedures that shall be at least as effective as any other approach in the Rule for evaluating groundwater data. Based upon guidance in the ProUCL software, nondetects will not be handled by a straight substitution of a numerical value (often one half the reporting limit [RL]) or practical quantitation limit (PQL). According to the guidance provided in the ProUCL software:

> "*Until recently, the substitution method has been the most commonly used method for computing various statistics of interest for data sets which include NDs. The main reason for this has been the lack of the availability of the other rigorous methods and associated software programs that can be used to estimate the various environmental parameters of interest. Today, several methods (e.g., using KM estimates) with better performance, including the Chebyshev inequality and bootstrap methods, are available for computing the upper limits of interest.*"

The statistical approach used by OMU will therefore be based upon a non-parametric approach for handling datasets with non-detects. It is believed that this will produce a more representative evaluation of the groundwater data quality at each monitoring location. RL or PQL values that are used in the statistical method represent the lowest concentration level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions that are available to the facility. The use of defensible RLs or PQLs reduces the possibility of false positives in the dataset.

5.0 SUMMARY OF PLAN

The Baseline Groundwater Monitoring phase will consist of collecting eight rounds of data from upgradient and downgradient locations. The chosen statistical method will be used to establish background levels at each location as well as determine whether interwell or intrawell comparisons are appropriate for the Detection Monitoring phase.

Following the eight rounds of baseline sampling, if the data set from the background locations is determined to be both unimpacted by the CCR facility and off-site activities and has groundwater quality statistically similar to the dataset for the downgradient locations (assuming no CCR impacts in the downgradient wells), then an interwell statistical evaluation can be performed. Subsequent sampling events will compare the results of the downgradient wells to the upgradient wells.

If the eight rounds of baseline sampling indicate that the background groundwater is impacted by the CCR facility, or by offsite impacts (up or crossgradient activities) and therefore statistically dissimilar to the downgradient groundwater, then an intrawell statistical evaluation will be used in Detection Monitoring moving forward. In such a case, the initial eight samples from each downgradient well will be used as background (assuming there are no CCR impacts determined at the downgradient well).

The intent of this statistical plan is to establish background concentrations for each constituent and to evaluate results from subsequent semiannual Detection Monitoring sampling events for the presence of a SSI based on the established background concentrations. Periodically updating background through addition of recent results to the existing background dataset improves the statistical power and accuracy, especially for non-parametric prediction intervals. It is recommended that statistical limits be updated when at least four to eight datasets are available to compare as a group to the historical data and test for equal means (normal data distribution) or medians (non-normal data distribution) between the historical and new datasets.

It is the intent of OMU to periodically update the established background levels every 2 to 4 years, when a minimum of four new observations are available. More frequent updating is not recommended because there will be insufficient samples for a statistical comparison between the historical dataset and the new dataset, and therefore it will not be possible to evaluate if the mean (or median) is stationary over time. New data will continue to be collected semiannually during detection monitoring; however, it will not be added to the background dataset automatically. Once at least four additional data points are available, an evaluation will be made to verify that the existing data set and new data are statistically similar and therefore may be combined. This approach reduces the potential for background creep.

6.0 LIMITATIONS

If following the evaluation of the future rounds of Detection Monitoring results, the subsequent data set does not lend itself to the method selected above, an appropriate method from the remaining methods listed in § 257.93(f) will be chosen and this Certification Statement will be updated.

7.0 REFERENCES

CEC, 2017. Groundwater Monitoring System Certification, Coal Ash Ponds, Elmer Smith Station, Daviess County, Owensboro, Kentucky, Prepared by Civil & Environmental Consultants, Inc., Pittsburgh, Pennsylvania, CEC Project 164-014, October 2017.

USEPA, 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance, EPA 530/R-09-007, March, 2009.

USEPA, 2015. Disposal of Coal Combustion Residuals from Electric Utilities (CCR Rule) 40 CFR § 257, Subpart D, April 17, 2015.

USEPA, 2015. ProUCL Version 5.1, Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations, EPA 600/R-07-041, October 2015.

8.0 PROFESSIONAL ENGINEER CERTIFICATION

CCR Impoundment Information

Name: Elmer Smith Station Ash Ponds

Operator: Owensboro Municipal Utilities

Address: 4301 E 4th Street Owensboro, Kentucky 42303

Qualified Professional Engineer (P.E.):

Name: James E. Zentmeyer

Company: Civil & Environmental Consultants, Inc.

I, **James E. Zentmeyer** being a Registered P.E., in accordance with the laws of Kentucky, do hereby certify to the best of my knowledge, information, and belief, that, pursuant to 40 C.F.R. § 257.93, the selected statistical method is appropriate for evaluating the groundwater monitoring data for the ESS ash ponds, and this document is true and correct and has been prepared in accordance with generally accepted good engineering practices.

Signature: _____ Date: 10/17/2017

License Number: 18953
My license renewal date is: 6/30/2018