Statistical Methods Certification

Coal Combustion Residuals (CCR)
Landfill and Surface Impoundments

R.D. Morrow, Sr. Generating Station
304 Old Okahola School Road
Purvis, Lamar County, Mississippi

Prepared For:

Cooperative Energy
7037 US Hwy 49
Hattiesburg, MS 39402
(601) 268-2083

Prepared By:

Environmental Management Services, Inc.
P. O. Box 15369
Hattiesburg, MS 39404-5369
(601) 544-3674

December 21, 2017

Statistical Methods Certification
Coal Combustion Residuals (CCR)
Landfill and Surface Impoundments

R.D. Morrow, Sr. Generating Station
304 Old Okahola School Road
Purvis, Lamar County, Mississippi

Table of Contents

REGULATORY REQUIREMENT

The U.S. Environmental Protection Agency's (EPA) final rule *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities* (Federal Register Vol. 80, No. 74, April 17, 2015) requires owners or operators of an existing coal combustion residual (CCR) unit to select one or more of the statistical methods specified in 40 CFR § 257.93(f)(1) through (f)(5) to evaluate groundwater monitoring data for each specified constituent in Appendix III to Part 257.

In accordance with § 257.93(f)(6), the owner or operator is required to obtain a certification from a qualified professional engineer stating the selected statistical methods are appropriate for evaluating the groundwater monitoring data for the CCR unit. This document provides the required certification for the CCR landfill and CCR surface impoundments at the R.D. Morrow, Sr. Generating Station, located in Purvis, Lamar County, Mississippi.

STATISTICAL METHOD NARRATIVE

The purpose of the statistical evaluation is to determine if there is statistically significant evidence that a regulated CCR unit has adversely affected groundwater quality downgradient of the unit. The goal is to detect an actual release to groundwater, while avoiding false positive determinations where wells are declared to be contaminated when in fact their concentration distribution is similar to background. Detection monitoring will consist of determining if there are any statistically significant increases (SSI) above background for the constituents listed in Appendix III of 40 CFR Part 257 that are attributable to a release from a regulated unit.

The statistical evaluation methods for groundwater monitoring data from the CCR landfill and CCR surface impoundments will be selected in accordance with 40 CFR § 257.93(f) and adhere to the performance criteria outlined in the applicable portions of 40 CFR §275.93(g) and the Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance (U.S. Environmental Protection Agency, March, 2009). No single statistical method is applicable in all situations. Any statistical methods allowed by the Unified Guidance and complying with the cited regulations may be used in future evaluations, as applicable. Different statistical methods may be applicable for evaluating baseline sample results versus subsequent detection or assessment monitoring results.

Prior to the selection of the appropriate method to determine if there is an SSI over background levels, the CCR rule provisions and Unified Guidance performance criteria require consideration of data patterns and usability, including the following:

- Handling of blind duplicate data collected as required by groundwater sampling protocol
- Distributional properties of data
- Identification of data that appear to be outside the range of expected values (outliers)
- Background stability (upward or downward trends)
- Data temporal independence (samples collected at sufficient intervals to provide independent values or samples exhibit any seasonal patterns)
- Spatial variation (no statistically significant variation between sampling points)

- Handling of non-detects or uncertain measurements.

In addition, the evaluation will determine whether interwell or intrawell statistical methods are appropriate:

- Traditional interwell tests compare upgradient background data with downgradient well measurements. An SSI is then assessed by whether the downgradient values exceed background. However, one or more of the monitored parameters may occur naturally in groundwater and vary substantially across the site due to natural geochemical factors (thus exhibiting natural spatial variability).
- Intrawell testing utilizes the contrast between past and present data within a given well or data set. Background levels are established at each well for future comparisons. Because the comparison is made at a single sampling point, concentration differences between wells due to natural spatial factors do not affect intrawell tests. Only changes over time (indicating a trend or shift in concentration level) cause an intrawell test to be statistically significant and to show a change in groundwater quality.

After the preceding evaluations are performed, suitable statistical methods will be selected to make SSI determinations. In accordance with 40 CFR § 257.93(f), four methods are acceptable for determining statistically significant increases: (analysis of variance (ANOVA), tolerance limits, prediction limits, and control charts. The appropriate method will be based upon the evaluation of data suitability as described above. Each method and the assumptions and conditions under which they may be utilized are described below:

<u>ANOVA</u>

ANOVA testing is typically used for comparing pooled compliance samples to pooled background samples. ANOVA testing has not been selected for initial Appendix III statistical analyses.

<u>Tolerance Limits</u>

Tolerance intervals are statistical ranges constructed from on-site background data, which define the range of data that fall within a specified percentage with a specified level of confidence. An upper tolerance limit (UTL) is designed to contain, but not exceed, a large fraction (that is, 95%, 99%) of the possible background concentrations, thus providing a reasonable upper limit on what is likely to be observed in background. Similarly, the lower tolerance limit (LTL) is designed to contain at most a certain percentage of the possible background concentrations, thus providing a reasonable lower limit on what is likely to be observed in background. The fraction to be contained or 'covered' by the limit is the coverage parameter, and must be specified along with a desired confidence level. Tolerance limits explicitly account for the degree of variation in the background population and the size of the sample of measurements used to construct the limit.

Once the limit is constructed on background, each compliance point observation (from each downgradient well) is compared to the upper tolerance limit. If any compliance point measurement exceeds the limit, the well from which it was drawn is flagged as showing a significant increase over background. Tolerance limits can be calculated under the following assumptions:

- Parametric tolerance limits assume the data follow a statistical distribution – typically normal (or can be normalized). If a transformation (logarithmic) is needed to normalize the measurements, the tolerance limit can be computed using the transformed values and then back-transforming the results to get the final limit.
- Nonparametric tolerance limits do not assume normality or any particular distributional form (but generally require larger samples sizes than parametric tolerance limits).
- Tolerance limits assume the population is stable (or stationary) over the period of time during which measurements are collected. No obvious trends or temporal patterns should exist in the background data.

Tolerance limits have been selected as the primary method for baseline statistical analyses of Appendix III parameters.

Prediction Limits

Prediction limits are used to predict the upper limit of possible future values based on a background or baseline data set, and then compare that limit to compliance point measurements or statistics. An upper prediction limit is constructed from upgradient or historical data and is designed to equal or exceed a specified number of future comparisons. If any of those values exceed the prediction limit, then the analysis suggests that groundwater concentrations have risen above the background levels. Prediction limits explicitly account for the degree of variation in the background population and the size of the sample of measurements used to construct the limit. Prediction limits can be calculated under the following assumptions:

- Parametric statistical model – assumes the data follow a known distribution or can be transformed to a known distribution. Based on the mean and standard deviation of the background data set.
- Nonparametric statistical model – does not assume normality or any particular distribution. Nonparametric prediction limits are based on ranking of the observations. This method will be used when a large percentage of the data are non-detect. A larger number of observations will produce results with higher statistical power; therefore, an attempt will be made to pool the downgradient well data. However, pooled data will only be used if there is no spatial variability.

Retesting consists of collecting and testing one or more new, independent groundwater samples after the initial test to confirm actual changes or eliminate false indications. Retests must be explicitly built into the statistical procedure as prediction limit calculations are dependent upon the resampling regime selected. If at least one sample in a series of two or three does not exceed the upper prediction limit then it can be concluded that an SSI has not occurred. The decision of whether to utilize a one-of-two or one-of-three procedure depends on factors including the number of downgradient wells, the number of background data points, and the number of physically independent samples able to be collected during the sampling period.

If an initial result indicates an increase, the resample should be collected prior to the next regularly scheduled sampling event for the exceeding parameter. Other geochemical parameters can also be analyzed to help identify the reason/source for the apparent increase. Where a statistically significant increase over background is identified, verification re-sampling may be used to confirm the increase. A potentially statistically significant increase will not be considered a verified exceedance until confirmatory re-sampling is performed and the annual comparative statistical analysis is conducted. Confirmatory sampling will occur during the next scheduled sampling event.

Control Charts

Control charts are a viable alternative to prediction limits in detection monitoring. One advantage of a control chart over a prediction limit is that control charts allow compliance point data to be viewed and assessed graphically over time. Trends and changes in concentration levels can be easily seen, because the compliance measurements are consecutively plotted on the chart as they are collected, presenting a historical overview of the concentration pattern. Standard prediction limits allow only point-in-time comparisons between the most recent data and background, making long-term trends more difficult to identify.

The guidance recommends use of the combined Shewhart-CUSUM control chart. The advantage is that two statistical quantities are assessed at every sampling event, both the new individual measurement and the cumulative sum (CUSUM) of past and current measurements. Prediction limits do not incorporate a CUSUM, and this can give control charts comparatively greater sensitivity to gradual (upward) trends and shifts in concentration levels. A disadvantage in applying control charts to groundwater monitoring data is that less is understood about their statistical performance, i.e., false positive rates and power. The control limit used to identify potential releases to groundwater is not based on a formula incorporating a desired false positive rate. Unlike prediction limits, the control limit cannot be precisely set to meet a pre-specified site-wide false positive rate. The same is true for assessing statistical power. Control charts usually provide less flexibility than prediction limits in designing a statistical monitoring program for a network. However, to enhance false positive error rate control and power, retesting can also be incorporated into the Shewhart-CUSUM control chart.

Shewhart-CUSUM control charts are a parametric procedure with no existing nonparametric counterpart. Non-parametric prediction limit tests are still generally needed when the background data on which the control chart is constructed cannot be normalized. Control charts are mostly appropriate for analytes with a reasonably high detection frequency in monitoring wells.

Retesting

Depending on the variables at hand should a SSI be determined, Cooperative Energy may opt to verify the result with a retest. If an initial result indicates an increase, the resample should be collected prior to the next regularly scheduled sampling event for the exceeding parameter. Other geochemical parameters can also be analyzed to help identify the reason/source for the apparent increase. Where a statistically significant increase over background is identified, verification re-sampling may be used to confirm the increase. A potentially statistically significant increase will not be considered a verified exceedance until confirmatory re-sampling is performed and the annual comparative statistical analysis is conducted, unless Cooperative Energy opts to begin the alternate source analysis. If the SSI is verified upon re-sampling, then alternate source analysis will be subsequently conducted with the verified results.

is performed and the annual comparative statistical analysis is conducted, unless Cooperative Energy opts to begin the alternate source analysis. If the SSI is verified upon re-sampling, then alternate source analysis will be subsequently conducted with the verified results.

ENGINEERING CERTIFICATION

The statistical analysis methods described herein will be used by Environmental Management Services, Inc. (EMS) to evaluate groundwater monitoring data for the CCR landfill and CCR surface impoundments at the Cooperative Energy, R.D. Morrow, Sr. Generating Station located in Purvis, Mississippi. This Statement of Professional Opinion is based on information available to EMS as of the date shown below and EMS's technical understanding of the United States Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments," published in the Federal Register on April 17, 2015 with an effective date of October 19, 2015 (CCR Rule).

It is my professional opinion based on my understanding of the technical requirements of the CCR Rule and good and accepted engineering practices that the applied statistical methods meet the technical requirements and/or intent of the CCR Rule (40 CFR 257.93) for groundwater sampling and analysis requirements. This Statement of Professional Opinion is not and shall not be interpreted or construed as a guarantee, warranty or legal opinion.

Environmental Management Services, Inc.

Christopher T. Johnson, P.E., P.S.
Engineering Manager/Vice President
Mississippi Professional Engineer No. #15761

Seal

Date: __December 21, 2017________________

Revision 1