Groundwater Detection Monitoring

Technical Memorandum

February 2022

Alaska Department of Environmental Conservation
Division of Environmental Health
Solid Waste Program

When groundwater monitoring is required at solid waste disposal facilities, the facility begins monitoring under a Detection Monitoring Program in accordance with Title 18, Chapter 60, sections 820 to 850 of the Alaska Administrative Code (18 AAC 60.820 to 850). Groundwater monitoring is conducted throughout the facility's active life and post-closure care period.

In detection monitoring, groundwater at the landfill is routinely monitored for the constituents listed in Appendix I of Title 40, Part 258 of the Code of Federal Regulations (40 CFR 258), or an alternate list approved by ADEC, to determine if evidence exists that a contaminant is being released from the facility into groundwater. This is accomplished by comparing the concentration of contaminants in upgradient (background) and downgradient (compliance) groundwater samples or in past and present samples from a single monitoring location. A possible contaminant release is indicated by a statistical analysis of the results that indicates a compliance well concentration is significantly different from the background concentration, or current concentrations in a well are significantly different than previous concentrations in the same well.

Groundwater Monitoring System

An effective detection monitoring program requires assessing many factors to ensure that monitoring will detect any contaminant release, but not falsely indicate that a landfill impact has occurred. A thorough understanding of site hydrogeology is necessary to develop a monitoring system that reflects the site-specific conditions and allows accurate assessment of a landfill's impact on groundwater quality. See the ADEC Hydrogeological Studies Fact Sheet for more information on how to characterize groundwater in preparation for a detection monitoring program as well as the ongoing assessment of groundwater conditions.

Once a hydrogeological study has identified groundwater depth and flow direction, at least one monitoring well must be installed upgradient of the landfill to establish background water quality for comparison. Additional upgradient wells are recommended for greater statistical power when determining background water quality. Several compliance wells must be installed downgradient of the landfill in locations likely to intercept any contaminant releases and should be no more than 500 feet from the waste management boundary. The size of the facility, the groundwater flow direction, and the complexity of the hydrogeology determine the number and placement of these wells [18 AAC 60.825]. All wells in the monitoring program must be screened in the uppermost aquifer.

Properly installed and maintained wells are essential for a monitoring system to operate effectively. Monitoring wells must be designed and installed according to the ADEC Contaminated Sites Program September 2013 Monitoring Well Guidance (http://dec.alaska.gov/spar/csp/guidance-forms/). Direct push wells may be used for short-term purposes, such as the hydrogeological study, but for long-term landfill monitoring, permanent monitoring wells must be installed. Maintenance of the monitoring wells is also essential to an effective monitoring system. Well components must be visually monitored for damage, and field and analytical results must be reviewed to determine if wells may be fouled and require redevelopment or replacement. See the Maintaining Monitoring Wells Technical Memorandum for details (http://dec.alaska.gov/eh/solid-waste/monitoring/).

Monitoring Schedule

In accordance with 18 AAC 60.825(g):

- At a new landfill, monitoring must be initiated at least one year before any waste is placed into the landfill and immediately after the installation of the groundwater monitoring system is complete. Initial sampling must include sampling in each of the four seasons in the year before waste is placed and the year after the first waste is placed. This means eight quarterly samples over two years are collected.
- At an existing facility, groundwater monitoring must be initiated after the installation of the groundwater wells is complete. Eight quarterly samples must be collected in the two years after the well installation is completed.

Detection monitoring *requires analytical detection limits be as low as technologically achievable to support the project specific data quality objective of detecting changes in groundwater quality as opposed to comparison to a regulatory standard.*

Quality Assurance Project Plan

In accordance with 18 AAC 60.830, a landfill owner/operator must establish monitoring procedures that result in a consistent and accurate representation of the groundwater quality at the upgradient and downgradient wells. The elements of a Quality Assurance Project Plan (QAPP) (a.k.a. Monitoring Plan) must provide the appropriate detail to:

- properly collect the groundwater samples;
- ensure program specific analytical sensitivity requirements are met;
- analyze the samples for the appropriate parameters;
- evaluate the data usability; and perform statistical analyses of the results.

Implementation of the QAPP, regardless of the individual performing the task(s), provides the necessary consistency to maintain an effective detection monitoring program. For additional assistance, ADEC has developed a QAPP Checklist for landfill groundwater monitoring (http://dec.alaska.gov/eh/solid-waste/monitoring/).

Statistical Analyses for Detection Monitoring

Statistical testing *methods should be reevaluated periodically as additional data are collected and/or as site conditions change.*

Once the site hydrogeology is clearly understood, the basic assumption in detection monitoring is that the facility is not impacting groundwater unless statistically demonstrated otherwise. Statistical comparisons of the analytical data are made between upgradient and downgradient wells (interwell comparison), or over time in a single well (intrawell comparison), to identify significant changes in groundwater quality that may be caused by the landfill. Intrawell comparisons might be required if no upgradient background can be determined, as an interim measure when there is not enough data to statistically calculate background, or when a significant change in groundwater flow occurs. 18 AAC 60.830(g) identifies five statistical procedures that can be used for detection monitoring, but not every test will be appropriate at a given site or for each constituent. The appropriate statistic requires consideration of the accumulated data for normality, independence, outliers, non-detects, spatial and temporal variability, etc. See Chapters 6 in EPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance* (Unified Guidance) for recommendations on choosing the proper statistical methods for detection monitoring. The Interstate Technology and Regulatory Council's (ITRC's) *Groundwater Statistics for Monitoring and Compliance* (ITRC 2013) provides guidance on the practical application of groundwater statistics to groundwater detection monitoring as well as other stages within the environmental project life cycle.

Analytical Laboratory Data Requirements

Analytical laboratory data collected for groundwater monitoring must include specific analytical limits. ADEC has adopted the following definitions from the Department of Defense Quality Systems Manual (DOD QSM) for Environmental Laboratories version 5.1 (January 2017) for classification of analytical limits:

Detection Limit (DL)

The smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration with 99% confidence. At the DL, the false positive rate (Type I error) is 1%. A DL may be used as the lowest concentration for reliably reporting a detection of a specific analyte in a specific matrix with a specific method with 99% confidence.

Limit of Detection (LOD)

The smallest concentration of a substance that must be present in a sample in order to be detected at the DL with 99% confidence. At the LOD, the false negative rate (Type II error) is 1%. A LOD may be used as the lowest concentration for reliably reporting a non-detect of a specific analyte in a specific matrix with a specific method at 99% confidence.

Limit of Quantitation (LOQ)

The smallest concentration that produces a quantitative result with known and recorded precision and bias.

Reporting Limit (RL)

A customer-specified lowest concentration value that meets project requirements for quantitative data with known precision and bias for a specific analyte in a specific matrix. This should not be used for statistical purposes.

In each laboratory or monitoring report, the **DL** must be recorded for each constituent, and the **LOD** and the **LOQ** must be recorded for each constituent in each sample.

Establishing Background Concentrations

The initial step in developing a detection monitoring program is establishing background concentrations for the required constituents. Background groundwater quality is represented by sampling groundwater that has not been affected by the landfill. Background concentrations are used as the baseline or the reference level for statistical comparisons. In the absence of background data challenges exist in differentiating between natural variability and landfill impacts

Generally, upgradient wells are used to determine background groundwater quality. In some instances, a suitable location to represent background groundwater quality may not be available upgradient of the landfill and an alternative well location can be approved by ADEC to represent background water quality. The Unified Guidance recommends a minimum of 8 to 10 independent background samples before performing most statistical tests, but as many background data points as possible are preferable to provide adequate statistical power to control false positive and negative errors.

The selection of the statistical tests for detection monitoring may dictate how much background data is necessary. Although prediction limits, control charts, or tolerance limit tests may be used and require very small future sample sizes per compliance well, they also require larger background sample sizes to demonstrate sufficient statistical power.

Assessment of temporal (over time) and spatial (across site) variability is fundamental to determining the appropriate statistical approach. Assessment of both requires collection of data from multiple monitoring events over several seasons.

Temporal effects, which can be seasonal or irregular, can be assessed by evaluating time series plots from multiple wells and by performing a one-way Analysis of Variance (ANOVA). Seasonal trends are readily identifiable as a regular pattern of changing concentrations noted at multiple wells (similar in direction and magnitude) and should not be confused with irregular temporal variability in which there is no identifiable pattern. Irregular temporal variability may result from precipitation or recharge events.

Spatial variability may be due to natural heterogeneity in the aquifer or to anthropogenic factors. Chapter 13 of the Unified Guidance recommends the use of box plots and ANOVA testing to evaluate for spatial variability. Side-by-side comparison of box plots from multiple wells provides a picture of variability between wells. ANOVA testing on the other hand compares pooled data from one well to that of another well and spatial variability is noted by differing mean concentrations in the two data sets.

Statistical Comparisons for Detection Monitoring

Once the type of background comparison has been determined, the appropriate statistical test should be used to check for a statistically

significant exceedance of background in downgradient wells. Prediction limits, tolerance limits, and control charts allow individual samples to be compared to pooled background samples. T-tests and ANOVA-type testing are only appropriate for comparing pooled compliance samples to pooled background samples. In order to use pooled data, statistical analyses must performed to demonstrate that the data can be pooled.

The Unified Guidance recommends using prediction limits instead of tolerance limits for detection monitoring because of their proven use with retesting strategies and their ability to define an exact false positive error rate.

If no detections exist in background data for comparison, Chapter 6 of the Unified Guidance recommends use of the Double Quantification Rule. ADEC allows for comparison to the highest background DL or LOD and a weight of evidence approach. The selection of the highest DL or LOD must be based on and consistent with the results obtained using current sample collection procedures and analytical methods. If using the LOD, the QAPP must outline how data between the DL and LOD will be handled for both background and compliance well detections. A compliance well detection above the highest background DL or LOD should be considered indicative of a possible landfill impact, but the weight of evidence should be carefully considered prior to transition to assessment monitoring (e.g. sufficient sample size to make comparisons, detection of multiple landfill constituents, possible offsite source, sampling or lab issue, etc.).

If during detection monitoring the concentration of any constituent statistically exceeds its background concentration, the landfill owner or operator must:

1. Within 14 days from receiving sample results indicating a statistical exceedance:
    a. Place a notice in the operating record
    b. Notify ADEC Solid Waste Program in writing

2. Within 90 days from receiving sample results indicating a statistical exceedances:
    a. Establish an assessment monitoring program in accordance with 18 AAC 860, OR
    b. Demonstrate that the exceedance is not a landfill impact (i.e. an offsite source is to blame), or that an error in sampling analysis, statistical evaluation, or natural variation occurred.

Statistical Methods Identified Under 18 AAC 60.830(g)

1. *Parametric analysis of variance (ANOVA)*
2. *ANOVA based on ranks*
3. *Tolerance interval or prediction interval*
4. *Control chart*
5. *Alternative approved method*

***For non-detect values**, you may record and use either the DL, LOD or the LOQ value in statistical analysis, but this should remain consistent, and satisfy the assumptions of the statistical methods. All estimated concentrations with an E or J flag must be reported and treated as valid for statistical purposes.*

Detection Monitoring Report

A detection monitoring report should include the minimum required content for a landfill groundwater monitoring report as outlined in our Landfill Groundwater Monitoring Checklist (http://dec.alaska.gov/eh/solid-waste/monitoring/).

References

- EPA. 40 CFR Part 258, Subpart E- Groundwater Monitoring and Corrective Action
- ADEC. 18 AAC 60.820 - 850. Groundwater Monitoring
- EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance (https://archive.epa.gov/epawaste/hazard/web/pdf/unified-guid.pdf).
- ITRC (Interstate Technology & Regulatory Council). 2013. Groundwater Statistics and Monitoring Compliance, Statistical Tools for the Project Life Cycle. GSMC-1. Washington, D.C.: Interstate Technology & Regulatory Council, Groundwater Statistics and Monitoring Compliance Team (http://www.itrcweb.org/gsmc-1/).
- DOD. January 2017. Department of Defense Quality Systems Manual (DOD QSM) for Environmental Laboratories version 5.1 (https://denix.osd.mil/edqw/documents/documents/qsm-version-5-1-final/).
- DOD. October 2017. QSM Version 5.1 FAQs (https://denix.osd.mil/edqw/documents/documents/qsm-version-5-1-faqs-october-2017/).