Voluntary Remediation Program (VRP) | (307) 777-7752 | http://deq.state.wy.us/volremedi/index.asp

Establishing Site-Specific Background Metals Concentrations in Soil

In its 2000 session, the Wyoming Legislature created new opportunities, procedures, and standards for voluntary remediation of contaminated sites. These provisions, enacted as Articles 16, 17, and 18 of the Wyoming Environmental Quality Act and implemented by the Wyoming Department of Environmental Quality (DEQ), will govern future environmental cleanups in Wyoming.

This Fact Sheet provides guidelines for soil sampling and data evaluation to establish site-specific background metals concentrations in soil.

1. What are background concentrations of metals and how are they used?

Naturally-occurring background concentrations are the concentrations of metals in the environment that existed before any human activities (e.g., waste management, mining, industrial activities) may have affected those concentrations. Naturally-occurring background concentrations of metals may vary regionally and locally based on the soil and bedrock present.

Under Wyoming law, cleanup levels are not to be set lower than naturally-occurring background levels. Therefore, if a risk-based concentration calculated for a potential analyte (chemical with the potential to have impacted soil based on historical usage, operator knowledge, or other information and identified in the Preliminary Remediation Agreement) is below that contaminant's natural background level, the cleanup level is adjusted upward to the background level. Background concentrations are also used at different stages of ecological and human health risk assessments to screen out from further consideration those contaminants that do not exist at a site above background levels. These are the most common uses for background concentrations at Voluntary Remediation Program (VRP) sites. For further information regarding risk assessments, see Fact Sheets #11 (*Risk Assessment)*, #14 (*Ecological Risk Assessment*), and #20 (*Human Health Risk Assessment*).

2. Do I have to establish background concentrations?

No. Potential analytes at your site should be identified using the process described in Fact Sheet #8 (*Site Characterization*). If one or more metals are potential analytes at your site, DEQ recommends that a stepwise approach be used to develop cleanup levels. The recommended steps are described below.

- **Step 1.** The easiest way to determine soil cleanup levels is use of the risk-based soil cleanup levels listed in the soil cleanup levels table available in a spreadsheet at: http://deq.state.wy.us/volremedi/factsheets.asp. The lower of the concentrations shown for residential contact and migration to groundwater must be used. If concentrations of metals at your site do not exceed these values, or if a Volunteer chooses to use these values, there is no reason to establish cleanup levels based on background concentrations. If concentrations of some metals exceed the cleanup level for migration to groundwater, but do not exceed the cleanup level for residential contact, a Volunteer may wish to determine a site-specific cleanup level for migration to groundwater for those metals as described in Step 2. If the concentration of some metals exceeds both the cleanup level for residential contact and the cleanup level for migration to groundwater, a Volunteer may wish to establish a site-specific soil cleanup level based on background concentration for those metals, as described in Step 3. If ecological receptors are a concern at the site, then the Volunteer should also consider medium specific Ecological Risk Based Screening Concentrations (ERBSCs). The Volunteer should use the lower of the 3 cleanup levels: ERBSCs, residential contact, and migration to groundwater.
- **Step 2.** Site-specific soil cleanup levels for migration to groundwater may be calculated using a fate and transport model as described in Fact Sheet #25 (*Fate and Transport Modeling to Evaluate Cleanup Levels*). If concentrations of metals at your site do not exceed these values or if a Volunteer chooses to use these values, there is no reason to establish cleanup levels based on background concentrations. If the concentration of some metals exceeds the cleanup level calculated in this way, a Volunteer may wish to establish a soil cleanup level based on background concentration for those metals, as described in Steps 3 and/or 4.
- **Step 3.** Soil cleanup levels for naturally-occurring metals may be established based on background concentrations. The purpose of establishing background concentration-based cleanup levels for metals with risk-based cleanup levels or migration to groundwater levels lower than background concentrations is to avoid spending money and effort cleaning up naturally-occurring metals. The VRP has established statewide background values for Arsenic, Selenium and Lead. For more information please refer to *Fact Sheet #12 Technical Memorandum #2*. In order to use statewide background values you will need approval from the DEQ. Consideration will be given to whether or not the metal(s) may have been related to site contamination, analytical methods, and the potential contribution to groundwater contamination. If DEQ determines that statewide background values are not appropriate for a particular site, or if metals other than Arsenic, Selenium, and Lead are an issue, the Volunteer may wish to establish site-specific background concentrations of metals as described in Step 4 and in Sections 3 through 6 of this Fact Sheet.
- **Step 4.** The Volunteer may establish soil cleanup levels for naturally occurring metals based on site-specific background concentrations. This step requires Volunteers to conduct their own site-specific background metals investigation. The Volunteer should refer to Sections 3 through 6 of this Fact Sheet when conducting this investigation and establishing site-specific background concentrations for metals at their site.

Volunteers who plan to conduct an investigation at their site to establish site-specific background concentrations in soil should submit a work plan to the DEQ for approval prior to initiating the background investigation. After the work plan is approved and implemented, a report will need to be submitted. DEQ approval of the report will be required prior to the establishment of background concentration-based cleanup levels.

3. How are background levels determined?

The VRP prefers that levels of background metals are determined by collecting an appropriate number of site-specific background samples at locations near the site, and that are not influenced by the site (i.e. topographically uphill and upwind) or other anthropogenic sources and should be collected at depths matching the soil weathering and geologic strata of the site samples. Analysis procedures should be consistent with those used for site characterization. Once adequate background samples are collected and analyzed, the levels of background metals can be determined statistically by following the ProUCL guidance in section 5 below and compared to the site characterization data to determine if the on-site levels exceed the background level.

The use of state-wide or regional background data for site-specific cleanups is not acceptable without approval from the DEQ. However, in some situations, such as in urban industrial areas, it may be difficult to identify appropriate locations for collection of background samples. In such situations, a lines of evidence approach may be appropriate. The lines of evidence may include a general idea of naturally-occurring concentrations of metals in the general region of a site by referring to published literature or an expansion of the background data set using data from previous studies and/or data from potentially contaminated areas of the site. In any case, the VRP project manager should be contacted for assistance in determining an alternative approach for establishing background cleanup levels.

4. How do I collect background samples?

Background samples should be collected using the same sampling and sample-handling protocols as those used to collect the site characterization samples. The work plan for establishing background concentrations in soil should outline specific methods for collecting background soil samples. In a data set (background or site), collected samples should be either all discrete or all composite. In general, both discrete and composite site samples may be used for comparing site-specific data with background concentrations or background data sets. Soil samples should be collected at specific locations over small (typically 2 to 6 inch) depth intervals. The location of each background sample should be identified by using global positioning system (GPS), surveying, or other means and provided to DEQ along with the sample results.

The analytical methods used for background samples should also be similar to those used for the site characterization samples. A Volunteer should ensure the proposed analytical method detection limits are low enough to determine background concentrations. An analyte detection

limit must be no greater than the corresponding risk-based or migration to groundwater cleanup level for the data to be useful in calculating background concentration-based cleanup levels. The work plan for establishing background concentrations in soil should include a discussion of applicable data quality objectives (DQOs). For additional information regarding site characterization sampling and analyses, see Fact Sheet #8. For additional information on sampling and analysis plans, see Fact Sheet #29.

5. How do I calculate background concentration-based cleanup levels and compare background data sets to site-specific data?

An appropriate number of natural background samples for a site investigation is typically based on a number of factors, both strategic (i.e., factors related to the size of the site, knowledge of site conditions and past practices, etc.) and technical (i.e., factors related to the accuracy of the statistical evaluation). A larger number of samples will result in a more accurate estimate of the background concentration. A more accurate estimate will in turn result in lower error rates associated with comparisons involving natural background sample estimates (i.e. less frequently concluding incorrectly that site concentrations exceed natural background concentrations). As a general rule, it is appropriate to increase the background sample size for larger and more complex sites. The DEQ recommends using the EPA's ProUCL statistical program to evaluate background data sets and calculate background concentration-based cleanup levels. The ProUCL 4.1 User Guide recommends a minimum sample size of 8 to 10 background observations from each geologic strata/depth of interest (more are desirable), or a higher number as determined by a DQO process and the statistical methods provided in into ProUCL 4.1.

ProUCL has the capacity to calculate upper confidence limits (UCLs), upper tolerance limits (UTLs), and upper prediction limits (UPLs), perform goodness of fit statistics for normal, lognormal and gamma distributions, perform parametric and nonparametric hypothesis tests, test for outliers, handle non-detects in the data set, perform ANOVA, and calculate trend statistics. ProUCL Version 4.1 User Guide and ProUCL Version 4.1.00 Technical Guide present guidance on the use of statistical methods incorporated in ProUCL 4.1.

The DEQ requests that Volunteers use the statistical methods recommended in the ProUCL user and technical guides when characterizing background and site-specific data sets, calculating background concentration-based cleanup levels, and comparing site-specifc and background data sets. The Interstate Technology and Regulatory Council (ITRC) web-based document Groundwater Statistics and Monitoring Compliance provides summary information about a number of statistical software packages including ProUCL (ITRC 2013), where it identifies that ProUCL has capabilities of UPL and other statistical calculations for conducting a background concentration evaluation. Links to ProUCL Version 4.1 and the associated user and technical guides are provided in the references section of this fact sheet.

5.1 Calculating Background Threshold Values (BTVs) with ProUCL

With a data set that meets the requirements specified above and established DQO's background data set (a minimum of 8-10 observations), the DEQ prefers that Volunteers calculate a BTV and

compare this value to site-specific data on a point-by-point basis. ProUCL recommends calculating a 95% upper prediction limit (UPL) for use as a BTV. When using this method, the background evaluation should include the following data analyses and associated documentation:

a) Outliers – Volunteers should test for the presence of outliers in the background data set. Examples of outlier tests include the Dixon and Rosner tests. The DEQ recommends accepting or denying outliers in the background data set based on a 5% significance level. Volunteers should submit the applicable box plots, probability plots and summary statistics to the DEQ in support of the outlier evaluation in the final background evaluation report.

b) Data Distribution – Volunteers should perform goodness of fit (GOF) tests to determine the distribution of background data sets. Depending on the data distribution (e.g., normal, log-normal, gamma, etc.), Volunteers should select an appropriate parametric or non-parametric method for calculating a BTV. Volunteers should submit the appropriate graphical outputs and summary statistics in support of the data distribution analysis.

c) Non-detect Data – Non-detected data are those analytes that have a concentration below its analytical method detection limit. Volunteers should evaluate background data sets for the presence of non-detected data. If non-detects are present in the background data set, the Volunteer should propose an approach to the DEQ for addressing non-detect data during the statistical analyses in a background evaluation work plan. In general, for left censored background data sets including non-detects, ProUCL recommends using a non-parametric method (e.g., Kaplan-Meier) to calculate a BTV. In addition, ProUCL discourages the use of the DL/2 Substitution Method to compute summary statistics and to perform GOF tests.

5.2 Alternative approaches for background evaluations

Hypothesis testing may also be used through ProUCL for background evaluations. 8-10 site-specific observations per exposure area are required to use the hypothesis testing approach. With this method, the 95UCL of site data within each exposure area is compared to the background data set. Volunteers should work with their DEQ project manager to establish an adequate approach for using hypothesis testing to compare background and site-specific data sets. The alternative approach should be described in an appropriate background evaluation work plan.

Volunteers may also propose alternative approaches for evaluating background data sets (e.g., the graphical method modeled after California EPA (1997)). Volunteers should obtain DEQ approval of any proposed alternative method not referenced in this fact sheet prior to conducting the background investigation/evaluation. A work plan for an alternative approach should be submitted to DEQ for approval prior to conducting the background evaluation.

6. Reporting

The background evaluation report should, at a minimum, include the following:

a) Discussion of outlier test results and data distribution analyses, with supporting statistical outputs (outputs include but are not limited to box plots, probability plots, outlier tests results, goodness of fit analyses and summary statistics);
b) If applicable, a discussion of the approach used for addressing non-detect data in the background data set with supporting graphical documentation and summary statistics;
c) Analytical data report(s) and any other information as specified in the work plan that will be included in the report; and
d) Background evaluation conclusions.

7. How can I get more information about the VRP?

To learn about VRP sites that may exist in your community, obtain copies of other VRP Fact Sheets/guidance documents, get answers to your questions, or volunteer for the program, contact DEQ at (307) 777-7752 or through the VRP website at: http://deq.state.wy.us/volremedi/index.asp.

The VRP website includes all of the Fact Sheets and other guidance documents for the VRP. This website is updated frequently and includes the latest information about DEQ's progress in developing guidance, policy, and other supporting documents for the VRP.

8. References

For additional information regarding statistical analysis of environmental data, the Volunteer is referred to the following documents.

California EPA - Department of Toxic Substances Control. 1997. Selecting Inorganic Constituents as Chemicals of Potential Concern at Risk Assessments at Hazardous Waste Sites and Permitted Facilities – Final Policy. February. Available at: http://www.dtsc.ca.gov/AssessingRisk/upload/backgrnd.pdf

EPA. ProUCL Version 4.1.00 Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations. *Software may be downloaded at* http://www.epa.gov/osp/hstl/tsc/software.htm.

EPA. 2002. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. EPA 540-R-01-003, OSWER 9285.7-41. September. Available at: http://www.epa.gov/oswer/riskassessment/pdf/background.pdf

EPA. 2000. *Guidance for Data Quality Assessment: Practical Methods for Data Analysis, EPA QA/G-9, QA00 Version*. Quality Assurance Management Staff, Washington, DC, EPA 600-R-96-084. July. Available at: http://www.epa.gov/quality/qs-docs/g9-final.pdf

EPA. 1992. *Supplemental Guidance to RAGS: Calculating the Concentration Term,* Publication 9285.7-08I, Office of Solid Waste and Emergency Response, Washington, DC. Available at: http://www.deq.state.or.us/lq/pubs/forms/tanks/UCLsEPASupGuidance.pdf

EPA. 2010. *ProUCL Version 4.1.00 Technical Guide (Draft)*. EPA 600-R-07-041. May. Available at: http://www.epa.gov/osp/hstl/tsc/software.htm.

EPA. 2010. *ProUCL Version 4.1User Guide (Draft)*. EPA 600-R-07-041. May. Available at: http://www.epa.gov/osp/hstl/tsc/software.htm.

Gilbert, Richard. 1987. *Statistical Methods for Environmental Pollution Monitoring.* Van Nostrand Reinhold Company, New York, NY. 320 pp.

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/.

Sinclair, Alastair. 1976. *Applications of Probability Graphs in Mineral Exploration*. The Association of Exploration Geochemists - Special Volume No. 4. Reprinted October 1989.