

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:)
) R 2020-019
STANDARDS FOR THE DISPOSAL OF)
COAL COMBUSTION RESIDUALS IN) (Rulemaking – Water)
SURFACE IMPOUNDMENTS:)
PROPOSED NEW 35 ILL. ADM.)
CODE 845)

NOTICE OF FILING

To: Service List

PLEASE TAKE NOTICE that I have today electronically filed with the Office of the Clerk of the Pollution Control Board Pre-Filed Testimony of Richard Gnat on Behalf of Midwest Generation, LLC, a copy of which is herewith served upon you.

Dated: August 27, 2020

MIDWEST GENERATION, LLC

By: /s/Kristen L. Gale

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CERTIFICATE OF SERVICE

The undersigned, an attorney, certifies that a true copy of the foregoing Notice of Filing, and Pre-Filed Testimony of Richard Gnat on Behalf of Midwest Generation, LLC was electronically filed on August 27, 2020 with the following:

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and that copies were sent via e-mail on August 27, 2020 to the parties on the service list.

Dated: August 27, 2020

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BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:)
)
STANDARDS FOR THE DISPOSAL OF)
COAL COMBUSTION RESIDUALS IN) R20-019
SURFACE IMPOUNDMENTS:) (Rulemaking - Water)
PROPOSED NEW TO 35 Ill. Adm. Code Parts 845)

**PRE-FILED TESTIMONY OF RICHARD GNAT
ON BEHALF OF MIDWEST GENERATION, LLC**

My name is Richard Gnat. I am a Principal of the environmental consulting firm KPRG and Associates, Inc. (KPRG), of which I am also part owner. I have been employed by KPRG since January 2002. Prior to KPRG, I worked with several other environmental consulting firms and have been working in this industry since 1984. I have a Bachelor of Science (B.S.) degree in Earth Science from Northeastern Illinois University, a Master of Science (M.S.) degree in Geosciences from the University of Illinois at Chicago and had subsequent additional course work in hydrogeology from Eastern Michigan University. My primary expertise is with subsurface soil and groundwater investigations and subsequent remediation. I am a registered Professional Geologist (P.G.) with the State of Illinois. My curriculum vitae is attached as Attachment 1.

Since 2005, KPRG has assisted Midwest Generation, LLC (Midwest Generation) with the investigation, remediation and/or management of various coal combustion residual (CCR) and coal combustion by-product (CCB) issues. I have been retained by Midwest Generation to provide this testimony with regard to the Illinois Environmental Protection Agency (Illinois EPA) proposed Part 845 Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments (Draft Rule) dated March 30, 2020.

Altogether, I believe the Illinois EPA has done a good and thorough job in preparing the Draft Rule and believe the Draft Rule effectively regulates CCR surface impoundments. My comments are limited to provisions of the Draft Rule relating to groundwater monitoring and assessment of corrective measures requirements in Sections 845.600 through 845.660. I also concur with the Agency's interpretation of the term "free liquids" as used in the Draft Rule and am providing further support for its interpretation.

I. Subpart F: Groundwater Monitoring and Corrective Action – Sections 845.600 through 845.660

Generally, I agree with Illinois EPA's overall approach in the groundwater monitoring program to statistically evaluate and assess the groundwater data generated at power generating stations (Stations), including those Stations with multiple CCR impoundments in close proximity to each other. I also agree with the Illinois EPA that the intent of the proposed groundwater monitoring program within Subpart F of the Draft Rule is to develop a monitoring approach to evaluate the groundwater that is passing the boundary of a regulated CCR surface impoundment. Accordingly, the Illinois EPA correctly defines a "landfill containing CCR" as a "CCR landfill" defined in the Federal Coal Combustion Residual Rule (Federal CCR Rule) in 40 CFR 257.53.

However, the groundwater monitoring program should be modified to both add clarity and time to collect representative data that reflects the unique circumstances at each Station. In various sections of the Draft Rule, the language is unclear concerning when a timeline starts, or the information required for submission of documents. Additionally, the Draft Rule provides only a "one-size fits all" approach to groundwater monitoring that does not take into account the site-specific characteristics of the CCR stored in the impoundment. The final rule should allow regulated entities to make a demonstration on a case-by-case basis for a targeted, site-specific groundwater monitoring program.

The Draft Rule's groundwater monitoring program has serious flaws that will not ensure development of accurate and representative data. Limiting the initial groundwater quality background groundwater sampling to 180 days for existing CCR surface impoundments will not result in the most representative groundwater data to establish the accurate background groundwater before the groundwater passes the boundary of the CCR surface impoundment. Instead, the Rule should have the same two-year timeline for establishing background groundwater as does the Federal Rule.

Also, the Draft Rule eliminates the initial detection monitoring tier of the Federal CCR Rule two-tiered approach outlined in 40 CFR 257.90 through 257.95, resulting in only a one-tier approach with groundwater protection standards (GWPSs) for all parameters. Eliminating the initial detection monitoring tier significantly reduced the timeframe from the initial detection of a "statistically significant increase" (SSI) to the start of an assessment of corrective measures from about 360 days, as allowed under the Federal CCR Rule, to just 90 days. Because deadlines relating to potential corrective measures in the Draft Rule are so tight, revising the Draft Rule to allow some additional time to complete further detection monitoring investigations and, where applicable, to potentially conduct a technically sound Alternate Source Demonstration (ASD), can be afforded while still maintaining consistency with but more stringent requirements than provided in the Federal CCR Rule. Allowing some additional time to complete these investigations will still result in a substantial reduction of the timeframe for initiation of potential corrective measures while providing a more robust and accurate basis on which to determine what corrective measures may need to be implemented. It is not prudent to "rush to judgment" on potential corrective measures when the end result may be that the measures selected are not appropriate or effective.

A. Section 845.610 – General Requirements

Overall, I agree with the Illinois EPA's proposed approach to the development of a groundwater monitoring program. However, the requirement in Section 845.610(b)(3)(D) to submit all groundwater monitoring data and any analysis performed within 60 days after "completion of sampling" may create confusion as to the required date for submission of the data to the Agency. The phrase "completion of sampling" is unclear. It is susceptible to various interpretations. It may be interpreted to mean the date the sample of groundwater is collected or alternatively, the date the laboratory analysis of the sample is received. If "completion of sampling" means the date of sample collection, then the 60-day clock for analysis of the data starts running even before any actual "sampling data" to be analyzed has been received from the laboratory. Such an interpretation would afford a very limited time to review and analyze the data upon receipt as it can typically take 14 to 21 days to receive the laboratory analytical results, depending upon the type of analytical work being performed (receipt of radium data generally takes on the order of 30 days or more). A 60-day deadline for both obtaining the sampling data and performing an analysis of that data is simply too short.

In response to MWG's questions, the Agency stated that "Part 845 requires, consistent with Part 257, that the assessment of corrective measures begin within 90 days of an exceedance of a GWPS." (Ex. 3, p. 22, Answer to Question 60.a). I am assuming the Agency means Section 257.95 of the Federal Rule, which is the section regarding Assessment Monitoring that triggers corrective action depending on the results. Section 257.95 uses language such as "after obtaining the results from the initial and subsequent sampling events..." and "within 90 days of finding that any of the constituents..." 40 CFR 257.95(d)(1), (f)(3). This language makes it clear that the trigger for a data and analytical submission deadline is the receipt of the sample results, not the completion of sample collection. I believe based upon the Agency's Answer to MWG Question 60.a, in addition

to its Answer to MWG Question 71.e., that the Agency intended the phrase “completion of sampling” to mean “upon receipt of all analytical results”. The language of the Draft Rule should be clarified so that the activity (*i.e.*, the receipt of all sample analytical results) which triggers the start of the 60-day submission deadline is clear.

B. Section 845.620 Hydrogeologic Site Characterization

The requirements in Section 845.620 provide the basis for a good hydrogeologic assessment. However, there are several clarifications I suggest making to ensure a clearer understanding of what needs to be included in the assessment. Specifically, Subsections (b)(3) and (4) state that “nearby” surface bodies, drinking water intakes, and pumping wells must be identified. The term “nearby” is vague. Instead, the rule should include a definite distance or actual radius from the CCR surface impoundment. For example, Section 1600.210 of the Board rules defines a search radius for Community Water Systems (CWS) of 2,500 feet. Subsections 845.620(b)(3) and (4) should include a similar distance.

Also, it is unclear in Section 845.620(b)(13) whether the requirement to determine the vertical and horizontal extent of the geologic layers to a minimum depth of 100 feet can be fulfilled using available data and information without necessarily drilling to 100 feet as part of the study. Illinois EPA’s answer in Exhibit 3 suggests that the Agency may accept information from other site specific or regional data sources. (Ex. 3, p. 23, Answer to Question no. 64). To avoid confusion, Section 845.620(b)(13) should specifically state that the vertical and horizontal extent of the geologic layers may be determined by using other available site-specific and local stratigraphy information.

Similarly, the requirement to describe the chemical and physical properties of the geologic layers to a minimum depth of 100 feet in Section 845.620(b)(15) may be interpreted very broadly

to include detailed mineralogical and whole rock chemistry analyses for each geologic layer to a minimum depth of 100 feet. It also can be interpreted more narrowly to require analysis of each geologic layer for those parameters specified in Section 845.600. But either of these types of detailed, geologic chemistry information are generally not required or necessary for the development of groundwater monitoring systems. Illinois EPA seems to agree with this and intended that Section 845.620 instead should require a more general description of the chemical and physical properties of the geologic layers based on available site-specific boring log observations and any available or applicable literature information on the mineralogical makeup of the geologic layers. While additional specific chemistry information may need to be developed in future evaluations to support potential numerical modeling of contaminant transport and chemical reactions between impacted groundwater and the aquifer matrix, that would be a very specific situational requirement that would warrant the development of more extensive chemical and physical properties of the geologic layers at that time. To avoid confusion, the language of Section 845.620(b)(15) should be clarified to more specifically describe the type of data that must be included as part of the site characterization.

C. Section 845.630 Groundwater Monitoring Systems

Section 845.630(a)(1) and (2) starts the discussion of requirements for development of proper background for the monitoring system. Both sections correctly state that background must “accurately represent the quality of background groundwater that has not been affected by leakage from a landfill containing CCR or CCR surface impoundment” and “accurately represent the quality of groundwater passing the waste boundary of the CCR surface impoundment.” Accordingly, I agree with the Agency that a “landfill containing CCR” has the same meaning as

CCR landfill in Part 257 of the Federal Rule. (Ex. 2, pp. 35-36, Agency Answer to Question 22.a.; Ex. 3, pp. 23-24, Agency Answer to Question 66).

The Agency's approach is correct because it is critical to consider the actual groundwater quality immediately prior to its passing beneath the impoundment and to incorporate this background data/information into the statistical evaluations and interpretations of the data. Understanding the background groundwater quality prior to passing beneath a specific regulated unit boundary is important in developing an effective groundwater monitoring program for the regulated unit. Without this information, a source of groundwater impacts other than the regulated impoundment may be misunderstood or overlooked resulting in an incorrect conclusion on whether the subject regulated unit is actually the source. This situation may occur where there is another impoundment or other potential source that has impacted the groundwater upgradient of the subject impoundment that then passes beneath the subject impoundment. Without a monitoring program that can adequately distinguish between upgradient impoundment or non-impoundment sources and the subject impoundment caused impacts to groundwater, needless time and effort may be spent in evaluating and addressing an impoundment which is not the cause of the groundwater conditions that need to be addressed.

Moreover, while the purpose of the Draft Rule is to specifically regulate CCR surface impoundments, that does not mean that the other areas and the underlying groundwater of a Station are unregulated. The Stations have always been subject to the general groundwater rules in Part 620. In fact, Section 620.420 specifically addresses historic fill, including slag and ash. During the Part 620 rulemaking, the Illinois EPA explained that it drafted Section 620.420 to apply to sites that applied fill material before the effective date. *See* Excerpt of Illinois EPA Statement of Reasons, *In the Matter of: Groundwater Quality Standards (35 IAC 620)*, PCB R89-14(B), May

15, 1991, attached as Attachment 2. Similarly, Richard P. Cobb stated in his Part 620 rulemaking pre-filed testimony that as part of its evaluation, Illinois EPA acknowledged that extensive areas in Illinois were filled with slag or other fill. *See* Excerpt of R. Cobb Pre-filed Testimony, *In the Matter of: Groundwater Quality Standards (35 IAC 620)*, PCB R89-14(B), May 15, 1991 attached as Attachment 3. Additionally, Illinois EPA specifically stated in this CCR rulemaking that other potential CCR sources at a Station are subject to Section 12 of the Environmental Protection Act and Part 620 of the Board Rules. Ex. 3, p. 50, Agency Answer to Question 57. Illinois EPA also stated that the other areas at a Station do not evade any regulation by not being included in Part 845. Ex. 3, p. 50, Agency Answer to Question 58. There are also other regulatory remediation programs within the IPCB regulations under which any groundwater impacts associated with historic operational issues can and should be properly addressed. (e.g., the Site Remediation Program in 35 Ill. Admin. Code Parts 740 and 742).

D. Section 845.640 Groundwater Sampling and Analysis Requirements

The groundwater sampling and analysis requirements in the Draft Rule generally follow best practices to ensure consistent collection of accurate data. However, Section 845.640 states that all units at all Stations must analyze groundwater on a quarterly basis through post-closure care, and possibly longer, for *all* parameters listed in Section 845.600. This “one-size-fits-all approach” does not reflect the unique or special circumstances at each Station. For example, often the CCR stored in a CCR surface impoundment does not contain or release all of the parameters listed in Section 845.600. In fact, Section 845.220(a)(2)(A) of the Draft Rule requires analysis/characterization of the CCR as part of the construction permit requirements. During the Illinois Pollution Control Board (IPCB) hearings held on August 11 through 13, 2020, when the Agency was asked why such detailed information was necessary, it responded that this site-specific information and detail

may be useful in the design and operation of the unit.¹ I believe that this type CCR characterization information would also be useful in developing a more targeted, site specific groundwater monitoring program. If it can be shown that the ash placed within a specific impoundment does not contain or leach a specific compound on the list of parameters provided in Section 845.600, then there is no reason to monitor for that parameter on a quarterly basis for 30-plus years.

Developing a site-specific monitoring program is consistent with other existing Illinois regulations that apply to groundwater assessments, such as in the Illinois landfill regulations under Section 811.319 of the Board regulations. It is also an accepted approach for Resource Conservation and Recovery Act (RCRA) units as discussed in the U.S.EPA Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance, EPA 530-R-09-007 (March 2009). Some portions of that guidance which note using waste specific characteristics in sampling program development are included in Attachment 4. The link to the full guidance document, which is over 800 pages, is <https://archive.epa.gov/epawaste/hazard/web/html/index-12.html>. Additionally, if the owner/operator would choose to develop such a site-specific approach to monitoring program development, the Rule should also require that the waste characterization be re-evaluated whenever there is a change in either the coal supply source or the combustion process equipment.

Accordingly, this section should also include a provision to allow an owner/operator the option to complete a representative waste characterization of the ash being placed into the regulated unit. The representative waste characterization would be required to include, at a minimum, sampling and analysis for all the parameters listed in Section 845.600. If the waste characterization sampling shows that some of the listed parameters are not associated with the ash being placed into the unit,

¹ *In the matter of Coal Combustion Residuals in Surface Impoundments: Proposed new 35 Ill. Adm. Code 845, PCB R20-19, August 11, 2020 Transcript, p. 155.*

then the monitoring program list of parameters can be narrowed to the relevant parameters of actual consequence.

Section 845.650 Groundwater Monitoring Program

As proposed, the groundwater monitoring program will likely not generate data that accurately reflects the constituents and their background concentrations in the groundwater before it passes the waste boundary of existing CCR surface impoundments because of the limited time to collect the background data set. Moreover, the Agency's decision to reduce the time to trigger an assessment of corrective measures from 360 days to 90 days is too stringent and is not founded in technically or scientifically sound basis.

a. 180 Days to Establish Background Groundwater Quality Will Not Provide Representative Data

Section 845.650(b)(1)(A) requires a minimum of eight independent samples from each background and downgradient monitoring well to be collected and analyzed for all constituents at all existing CCR surface impoundments within 180 days of the effective date of the Rule. The purpose of the initial sampling is to develop data to establish the background concentrations of the groundwater before it passes the waste boundary of the CCR surface impoundment. Under the Federal Rule, the timeline to conduct the initial groundwater monitoring for existing CCR surface impoundments was two years – from October 15, 2015 to October 17, 2017. 40 CFR 257.94(b). The Illinois EPA's proposal to require eight rounds of sampling for existing impoundments in only 180 days is not consistent with the Federal CCR Rule, may not develop data representative of true background given it covers a period of only 180 days, and may provide inaccurate and misleading monitoring results comparisons from the start of the groundwater monitoring program.²

² While certain of the CCR surface impoundments in Illinois have already conducted groundwater monitoring pursuant to the Federal CCR program that may be used to establish the background data, the Illinois EPA has

The development of background groundwater quality should include understanding potential seasonal changes in constituent concentrations, particularly in Illinois where seasonal temperatures and precipitation fluctuate significantly. To understand potential seasonal changes, at least one full year of monitoring that covers all four seasons should be required. In some cases, even a year's worth of monitoring may still not provide the data needed to understand seasonal fluctuations, but it is certainly better than conducting the sampling over only a 180-day period. Limiting the timeframe to 180-days completely eliminates addressing seasonal or temporal fluctuations within the statistical program for analysis of the monitoring results. In other State of Illinois programs, such as the Standards for New Solid Waste Landfills in Part 811 of the Board Rules, Illinois EPA requires a minimum of four consecutive quarters of groundwater sampling to account for seasonal fluctuations. 35 IAC 811.320. This Rule should do the same.

Also, limiting the initial sampling to 180 days will likely not result in truly representative data. In order to obtain eight rounds of sampling within 180 days, the wells need to be sampled at least every 22.5 days or less. Standard analytical turnaround for most parameters is two to three weeks and longer for radium as previously discussed. To finish the monitoring within the 180-day period, the next round of samples must be collected before receiving and evaluating the previous round of analyses. Even more importantly, some impoundment sites within Illinois may be located in clayey, silty clay or silty aquifer matrix materials (*i.e.*, generally lower permeability) which impede groundwater flow velocities. For such sites, the required short timeframe between sampling events will likely result in sampling the same water, similar to a confirmation sampling event, as opposed to providing sampling results on potential water quality variability over time, which is one of the objectives of background development. The resulting data, although from independent sampling

identified additional areas that are not a part of the Federal CCR program that may become existing CCR surface impoundments.

events, may be highly autocorrelated requiring some data manipulations/corrections to account for this shortcoming. See Excerpts from Unified Guidance provided Attachment 4. Autocorrelation is a similarity between measurements as a function of the time elapsed between those measurements. In other words, collecting this much data in such a relatively short time period may not provide a representative database on which to characterize the potential natural variability of groundwater quality conditions. The more potential database manipulations that are required to address this deficiency, the more uncertainty and hence, unreliability is introduced into the subsequent evaluations.

The Draft Rule should be modified to allow an owner/operator to conduct a longer background collection timeframe for existing surface impoundments consistent with the Federal CCR Rule. At a minimum, the Rule should allow at least one full year for the development of proper background data and that the background calculations based on the one-year of sampling data should be revisited after the second full year of quarterly sampling. This approach also would be consistent with groundwater monitoring requirements for Standards for New Solid Waste Landfills in Section 811.320(d) of the Board Rules.

b. The Timeline From Detection to Initiation of Assessment of Corrective Measures is Not Reasonable

Section 845.650(d)'s proposed requirement for a response if there is an exceedance of a standard for any of the parameters in Section 845.600 at any time following an "immediate resample" is not a technically sound strategy. The Illinois EPA shifted the groundwater monitoring program from the Federal CCR Rule two-tiered approach in 40 CFR 257.90 through 257.95 to a one-tier approach with groundwater protection standards (GWPSs) for all parameters. By switching to a one-tier approach, the Draft Rule is inconsistent with the Federal Rule. Specifically, the main differences are as follows:

- The Federal CCR Rule groundwater monitoring program has a “detection monitoring” tier and an “assessment monitoring” tier.
 - Detection monitoring is conducted semi-annually and includes seven screening parameters (Appendix III). If a monitoring event detects a statistically significant increase (SSI) over established background in one or more of the seven parameters, which is subsequently confirmed by a resampling, then a notification is made within the operating record documenting the SSI and either a successful Alternate Source Demonstration (ASD) is completed or the unit is transitioned into assessment monitoring. This process is allowed 90-days to complete from the time of detection of the SSI. 40 CFR 257.94.
 - Once triggered, assessment monitoring is to commence within 90 days (180 days cumulative from initial detection monitoring SSI documentation). 40 CFR 257.95. Assessment monitoring includes an initial round of groundwater sampling for 15 additional specific parameters (Appendix IV) that have an established Federal maximum contaminant limit (MCL) or, if an MCL is not available, risk-based comparison criteria as provided in Section 257.95, in addition to the seven Appendix III parameters. Once this data is available, within 90 days (270 days cumulative from initial detection monitoring SSI) a second round of assessment monitoring is completed analyzing only for those Appendix IV parameters detected in the first round of sampling plus the standard Appendix III parameters. Upon receipt of the second round of sampling data, GWPSs for the Appendix IV parameters are established and if there is a GWPS exceedance of an Appendix IV parameter, a notification is placed in the operating record and either a successful ASD is completed or work is to commence an assessment of corrective measures. This process allows for 90 days to complete that ASD and/or start on the assessment of corrective measures (360 days cumulative from initial detection monitoring SSI documentation).
- The Illinois EPA Draft Rule eliminates the detection monitoring tier and requires establishment of GWPSs for all parameters within the Federal CCR Rule Appendix III and IV based on Illinois Part 620 Class I groundwater standards as compared to statistical background (the higher of the two values becomes the GWPS for that parameter similar to the development of Appendix IV GWPSs under the Federal CCR Rule). Groundwater monitoring is then required on a quarterly basis (as opposed to semi-annual) and if a parameter is detected at a concentration above the GWPS for that parameter, a potential SSI is documented requiring a confirmatory resampling and, if appropriate, an ASD. If the resampling confirms the GWPS exceedance(s) and the ASD is not successful, an assessment of corrective measures must be initiated within 90-days of the initial GWPS exceedance(s). This 90-days includes up to 60 days for the operator to complete the ASD and 30 days for Illinois EPA to review the document.

In essence, the Draft Rule establishes a more rigid and unnecessarily shorter in that quarterly monitoring is required (as opposed to semi-annual), the detection monitoring tier was completely

eliminated and instead the program starts the monitoring with established GWPSs for all Federal CCR Rule Appendix III and IV parameters (the Federal CCR Rule only has GWPSs established for Appendix IV parameters), and the timeframe from the initial detection of an SSI to the start of an assessment of corrective measures is reduced from up to 360 days to no more than 90 days. This approach is also inconsistent with the Board Rules for new landfills. *See* 35 IAC 811.319. The groundwater monitoring program for new landfills in Section 811.319 of the Board Rules has a two-tier approach, like the Federal CCR Rule. In Section 811.319(a) and (b), a new landfill must conduct detection monitoring and, if required, the operator must begin an assessment monitoring program to confirm that the landfill is the source of the impacts. 35 IAC 811.319(a), (b). Although I understand the driving force behind establishment of the GWPSs up front based on Illinois specific Part 620 Class I groundwater standards, and the desire to streamline the program to initiate potential corrective measures in a more expeditious manner, this should not be done on an unreasonably short schedule that sacrifices the timeframes required for an owner/operator to complete technically sound evaluations.

Moreover, the Draft Rule's requirement that one data point of one constituent, even with an immediate resample, requires an immediate assessment of corrective measures is meaningless and does not indicate a release has occurred from a CCR surface impoundment. In responses to comments regarding this issue, Illinois EPA stated that a confirmatory resample is also being collected which would provide two data points upon which that determination is being made. (Ex. 3, pp. 20-21, Answer to Question 55). That confirmatory resampling generally occurs very shortly after the initial data is received with the primary intent being to ensure that the detection is not an analytical or sampling aberration. The resampling does not provide any indication whether the exceedance may be a short-term, unrelated transient anomaly or whether the exceedance is truly

reflective of a potential actual release from the subject impoundment. This concern is especially true for parameters that are usually “not detected”. Under the Unified Guidance these instances should employ the Double Quantification Rule. *See* Attachment 4. Under the Double Quantification Rule “a confirmed exceedance is registered if any well-constituent pair in the 100% non-detect group exhibits quantified measurements (*i.e.*, at or above the reporting limit (RL)) in two consecutive sample and resample events.” This alone would be two quarters of data, but the current Draft Rule 90-day timeframe for initiating an assessment of corrective action allows for only one quarter of data thereby potentially inappropriately and unnecessarily triggering this response action.

Under the Federal CCR Rule and the Illinois landfill regulations, the two-tiered approach to monitoring allows for several additional quarterly rounds of groundwater sampling, which ensures sufficient data is available to make a determination regarding appropriate corrective action measures before triggering the initiation of an evaluation of corrective measures. With the shift in monitoring program philosophy to a single-tiered approach this whole decision process has been reduced to 90 days, which is based on a single quarter of sampling (*i.e.*, basically a single confirmed data point). Instead, similar to the Federal Rule and the Illinois landfill regulations, this Rule should require a targeted follow-up sampling of the well(s) displaying a potential exceedance for at least an additional quarter to document that the elevated detection was not an unrelated short-term occurrence prior to potentially triggering an assessment of corrective measures.

c. The Rule Should Allow For Modifications Based Upon Site-Specific Conditions

Also, similar to my comments on Section 845.640, Section 845.650 should allow for modifications of the groundwater monitoring program so that it reflects the site-specific groundwater at each Station. Specifically, Section 845.650(b)(1) identifies that the monitoring

frequency for all constituents with a groundwater protection standard in Section 845.600 and Calcium shall be tested on at least a quarterly basis during the active life of the unit and the post-closure care period or that period specified if closure is completed by removal. Based on my experience, there may be compounds on the all-inclusive list that are never detected for a specific unit. If an owner/operator of a CCR surface impoundment is not allowed to develop a tailored monitoring list based on a characterization of the ash being placed into the unit as suggested above, this Section should allow an owner/operator to reduce the monitoring list if a compound is not detected after a set period of time (*e.g.*, 3 or 5 years). Otherwise, data is being generated at a substantial cost over time that is not useful in any way. This type of provision would be consistent with the monitoring requirements for existing landfill operational permits issued by Illinois EPA.

Further, I agree with the Agency's suggestion for alternative chemical and monthly elevation schedules. (Ex. 3, p. 48, Answer to Question 51). Relative to groundwater flow determination, in my experience, after the first few years of monitoring generally stable conditions are documented and the groundwater flow system beneath the regulated unit is sufficiently understood by the Professional Engineer to evaluate and assess the ongoing effectiveness of the monitoring system. Once the flow system is sufficiently understood, measuring water elevations on a monthly schedule only provides duplicative and unnecessary data. The Final Rule should also allow, if appropriate, the operator shift to a semi-annual monitoring frequency which would also be consistent with Section 811.319 of the Illinois landfill regulations. Coal ash impoundment monitoring need not be more stringent than a landfill, particularly because ash removed from an impoundment can be disposed of in a landfill that is regulated under Part 811. It is an arbitrary distinction to require more frequent monitoring of a CCR impoundment once stable conditions are documented than is required of a landfill in which CCR may be disposed.

d. Additional Time is Required to Prepare an Adequate Alternate Source Demonstration under Section 845.650(d)

I agree with the Illinois EPA's proposal to allow an Alternate Source Demonstration (ASD) (Section 845.650(d)(4)), however, the timeframe of 60 days from the detected exceedance to complete an ASD is too short for many reasons. First, the Draft Rule appears to require that the ASD is due 60 days from the date of the "initial sampling." Because Section 845.650(d) allows for a resample, the due date for the ASD should be based on the "date of receipt of the results of the confirmation sampling" and not the initial sampling date. Second, the 60-day timeframe is not sufficient to develop and complete a technically sound and meaningful ASD. For example, an ASD may need to look at various leaching characteristics/chemistry of the ash material within the impoundment to compare against the groundwater data. This information provides an understanding of what components of the ash chemistry may in fact be leaching out of the ash and potentially mobilize into the groundwater system. Some commonly accepted and used tests include Toxicity Characteristic Leaching Procedure (TCLP), Synthetic Precipitation Leaching Procedure (SPLP), and various Leaching Environmental Assessment Framework (LEAF) methods (EPA Methods 1313, 1314, 1315 and 1316; see Attachment 5). The LEAF methods provide for more definitive and insightful data for the purposes of an ASD for a CCR impoundment. LEAF is a leaching evaluation system, which includes four different leaching methods and scenario assessment approaches designed to work individually or integrated to provide a description of the release of inorganic constituents of potential concern for a wide range of solid materials. The LEAF methods have been designed to consider the effect of key environmental conditions and waste properties on leachate chemistry. LEAF sampling and testing are intended to provide a more robust dataset that can be used to evaluate CCR over a wider range of pH and site-specific conditions than TCLP or SPLP testing. The established LEAF analytical methods and procedures analytical

turnarounds are from 28 days (EPA Methods 1313 and 1316), to 42 days (EPA Method 1314) and as long as 84 days (EPA Method 1315, See attachment 5). The various LEAF test methods provide data on leaching of constituents as a function of pH, liquid-solid ratios and/or information on mass transfer rates. Such information can provide valuable insight into the site-specific ash leachate conditions and characteristics. The above noted analytical timeframes do not include the time required for developing, scheduling and implementing a representative impoundment sampling plan or the backend data evaluation time which may require analytical modeling and/or other quantitative data assessment.

Accordingly, to allow for development of a scientifically and technically valid ASD, the deadline to submit an ASD should be longer than 60 days. For example, the Federal CCR Rule provides for 90 days to complete an ASD, and even that time allotment is tight. I would suggest that the ASD timeframe be 90 days, consistent with the Federal Rule, but an owner/operator should also be allowed to obtain an extension if a sufficiently justified technical and factual basis can be made for the extension.

E. Section 845.660 Assessment of Corrective Measures

Overall, the Draft Rule's provisions for the assessment of corrective measures will accurately develop the proper corrective measures to respond to confirmed releases. However, as described above, an assessment of corrective measures should not be triggered by any exceedance of a GWPS based on a single quarterly round of sampling. Section 845.660(a)(1) should be drafted to be consistent with my recommendation to facilitate at least an additional quarterly sampling to better understand the nature of the potential exceedance (see discussion under Section 845.650).

II. “Free Liquids” are Liquids That Easily Separate From the CCR Solids and Not Groundwater

The Illinois EPA is correct that “free liquids” are “the easily removed liquids that separate from the CCR solids under ambient temperature and pressure. This does not mean all groundwater flow into and out of the impoundment has been eliminated.” (Ex. 2, p. 65, Answer to Question 24). In the case of CCR surface impoundments, the “free liquids” are the transport water used to move the CCR into the surface impoundment. Once this transport water reaches the impoundment, the ash settles and the water is decanted, however, at least some portion of the separated free liquid may remain in the impoundment over an extended period of time based on operational design such as using it as a protective measure to reduce the potential for dust emissions from the impoundment.

When the time comes for closure, if the closure plan provides for closure in place, then the “free liquids” must be removed to facilitate access to the ash to properly regrade and compact the material to allow for construction of the designed cover system. If closure is to be completed by removal, then the “free liquids” need to be removed from the ash to allow for proper landfill disposal. In both cases the removal of “free liquids” can be accomplished by separating or decanting the liquid portion of the CCR material and removing these “free liquids” from the impoundment. Accordingly, the Illinois EPA is correct. The free liquids required to be removed are those that are associated with the placement of the waste (in this case ash) and that separate from the solids under ambient temperature and pressure conditions. The term “free liquids” does not, and should not, include groundwater potentially in contact with the ash.

The Agency’s conclusion and my concurring opinion are supported by several recognized sources. First, in a recent proposed modification to the Federal CCR Rule, 85 F.R. 12456-12478 (March 3, 2020), the U.S. EPA indicated that it interprets “free liquids” in this same way. The

U.S.EPA stated that “free liquids must be eliminated by removing liquid wastes ...” *Id.* (emphasis added). It did not refer in any way to groundwater that comes into contact with the ash in a surface impoundment to describe what it means by the term “free liquids.” It solely referenced “liquid wastes.”

That “free liquids” is defined as liquid waste, is further supported by federal, state and local standards and guidance for other regulatory programs. As demonstrated below, the definition and concept of “free liquids” as only liquid waste has been consistent over time and across regulatory programs. In each guidance and standard set forth below, “free liquids” is always used to refer to a characteristic of the waste stream itself which needs to be considered and addressed, and not any groundwater that may come in contact with the waste.

- 1) EPA 40 CFR Part 265 [SW-FRL 1999-31 Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities AGENCY: Environmental Protection Agency. ACTION: Proposed amendments to rule, 1982 <https://www.epa.gov/sites/production/files/2016-03/documents/47fr8307.pdf>

“The Agency has not found compelling merit in the criticisms about the necessity of restricting the introduction of free liquids or liquid wastes into landfills. EPA strongly believes that introduction of containerized free liquids in landfills should be minimized to the extent possible, if not prohibited, for the reasons set forth in the preamble to the May 19, 1980 promulgation of the Part 265 standards.”

- 2) Illinois Emergency Management Agency, Division of Nuclear Safety, 2011 <http://public.iema.state.il.us/Applications/WaterTreatment/Documents/Guidance.pdf>

“Testing for free liquids Generators must ensure that the treatment residuals they are disposing of meet IEPA disposal requirements. Systems must perform the Paint Filter Liquids Test (or PFLT; EPA SW 846 Method 9095) to determine if the waste contains any “free liquids” because solid waste landfills cannot accept waste that contains free liquids. If free liquids are present, the system will need to employ an intermediate processing method and determine an appropriate method of disposal for the liquid residuals generated by dewatering.”

- 3) TITLE 35: ENVIRONMENTAL PROTECTION SUBTITLE G: WASTE DISPOSAL CHAPTER I: POLLUTION CONTROL BOARD SUBCHAPTER c: HAZARDOUS WASTE OPERATING REQUIREMENTS PART 720 HAZARDOUS WASTE MANAGEMENT SYSTEM: GENERAL SECTION 720.110 DEFINITIONS <http://www.ilga.gov/commission/jcar/admincode/035/035007200B01100R.html>

"Free liquids" means liquids that readily separate from the solid portion of a waste under ambient temperature and pressure. [This is the same definition used in the Draft Rule].

"No free liquids", as used in 35 Ill. Adm. Code 721.104(a)(26) and (b)(18), means that solvent-contaminated wipes may not contain free liquids, as determined by Method 9095B (Paint Filter Liquids Test), included in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", incorporated by reference in Section 720.111, and that there is no free liquid in the container holding the wipes. No free liquids may also be determined using another standard or test method that the Agency has determined by permit condition is equivalent to Method 9095B."

- 4) RULES AND REGULATIONS FOR LANDFILLS, LIQUID WASTE HANDLING FACILITIES AND TRANSFER STATIONS OPERATED WITHIN THE CITY OF CHICAGO, 1998

"Liquid Waste" means any waste which maintains the physical state of continuous volume relatively independent of pressure and which takes the shape of its container at ambient temperature; or is determined to contain "free liquids" as defined by Method 9095 (Paint Filter Liquids Test), as described in "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods" (EPA Pub. No. SW-846).

- 5) CHICAGO DEPARTMENT OF PUBLIC HEALTH: LIQUID WASTE FEE, 2020
https://www.chicago.gov/city/en/depts/cdph/provdrs/healthy_communities/svcs/pay_liquid_wastefee.html

"Liquid waste is special waste as defined by the Illinois Environmental Protection Agency which includes hazardous waste, industrial process waste, pollution control waste, and potentially infectious medical waste that has free liquids."

- 6) EPA: DEFINITION OF "LIQUID WASTE", 1981

"A liquid waste is any material that will pass through a 0.45 micron filter at a pressure differential of 75 psi. If the material to be evaluated consists of two or more phases, then the phases should be separated by centrifugation or other means prior to evaluating whether any of the phases meet the above definition. Free liquids as defined in 260.10 (a)(25) are defined as any liquid which passes through the Paint Filter Test (method 9095)."

- 7) IEPA>Topics>Waste Management>Waste Disposal>Special Waste DO I HAVE A SPECIAL WASTE?

"What is a Liquid Waste? Liquid waste is any waste material that is determined to contain "free liquids." Used cutting oil is a typical liquid waste. For sludges or other wastes that you cannot easily determine is liquid, you can use the paint filter test. The test requires pouring the waste through a specific filter to determine if the waste contains "free liquids."

- 8) TITLE 35: ENVIRONMENTAL PROTECTION SUBTITLE F: PUBLIC WATER SUPPLIES CHAPTER I: POLLUTION CONTROL BOARD PART 615 EXISTING ACTIVITIES IN A SETBACK ZONE OR REGULATED RECHARGE AREA SECTION 615.102 DEFINITIONS

"Free liquids" means liquids which readily separate from the solid portion of a waste under ambient temperature and pressure. To demonstrate the absence or presence of free liquids in either a containerized or a bulk waste, the following test must be used: Method 9095 (Paint Filter Liquids Test) as described in "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods" (EPA Publication No. SW-846), incorporated by reference at Section 615-103."

Section 845.750(b)(1) states that free liquids must be eliminated by removing liquid wastes or solidifying the remaining liquid wastes and waste residues. The "free liquids" are specific to the waste itself: the CCR and the transport water used to move the CCR into the CCR surface impoundment. It is my opinion that any potential groundwater in contact with CCR within unlined impoundment is not part of the initially placed waste stream.

Moreover, potentially impacted groundwater is correctly addressed on a site-specific basis under Draft Rule Section 845.710 coupled with Section 845.750(a)(1). Under 845.710, applicable closure alternatives are identified and evaluated based on a number of technical considerations including both short- and long-term effectiveness. The closure options to be evaluated must include complete removal as one of the alternatives. Under Section 845.750(a)(1), if the impoundment is to be closed in-place, the owner/operator must control, minimize or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate or contaminated run-off to the ground or surface water or to the atmosphere. In addition, under 845.780(b)(3) Post-Closure Care groundwater monitoring is required in accordance with Subpart F until all GWPs are met, or at least 30-years if closure in-place is the selected alternative. That groundwater monitoring will determine whether additional corrective action measures must be considered and implemented or whether the selected closure alternative is performing as designed.

Thank you for your time and consideration in this matter.

Richard R Gnat

8/27/20

Richard Gnat, P.G.

Date

ATTACHMENT 1

Curriculum Vitae of Richard Gnat

RICHARD R. GNAT, P.G.

KPRG & Associates, Inc.
14665 West Lisbon Road, Suite #2B
Brookfield, WI 53005
richardg@kprginc.com
(262) 781-0475--Phone
(262) 781-0478--Facsimile

Experience Summary:

Over 36 years of professional experience in the environmental site investigation and remediation. Impaired property transfer/transaction support includes over 100 Phase I/II ESAs for clients throughout the country, Central America and England. Acted as environmental due diligence support project manager for the acquisition of Union Texas Petroleum by Western Gas Resources which included the assessment of 108 properties across Texas, Nebraska and Louisiana.

Site investigation experience has included over 100 projects as the technical lead for the planning and implementation of CERCLA Remedial Investigations/Feasibility Studies (RI/FSs), RCRA Facility Investigations (RFIs), site investigations in support of industrial/brownfield property transactions, UST investigations and landfill studies. Investigation methods have included soil/bedrock drilling, monitoring well installation/sampling, use of field screening technologies and in-field analytical laboratories to guide real-time field decisions, well tests (single and multiple well) and geophysical surveys.

Soil remediation experience has included developing and managing a variety of large-scale projects including direct removals, in-situ treatment and stabilizations. Groundwater remediation projects have included interceptor trenches, augmentation of in-situ biodegradation, pump and treat systems, in-situ chemical oxidation and the use of natural attenuation to meet cleanup objectives. Managed a natural attenuation evaluation in support of the shut-down of a large scale pump and treat system for an industrial client in Puerto Rico. The study convinced the regulators to allow the shutdown and eventual decommissioning of the system after only 3 years of operation out of the originally designed 15-year groundwater recovery program.

Credentials:

M.S., Geosciences, University of Illinois at Chicago, 1984
B.S., Earth Sciences, Northeastern Illinois University, 1981
Additional Hydrogeology, Eastern Michigan University, 1985
Professional Geologist - Wisconsin (#G-149)
Professional Geologist - Illinois (#196-000900)
Professional Geologist - Minnesota (#30513), Inactive
Professional Geologist- Arkansas (#0259), Inactive

Employment History:

2001 - Present	KPRG and Associates, Inc.
1990 - 2000	Hydro-Search, Inc. / Geotrans
1989 - 1990	Versar Inc.
1984 - 1989	Roy F. Weston, Inc.

Publications:

Shestag, S., Gnat, R., et. al., 1994, Recovery, Evaluation and Decontamination of Landfilled Pentaborane Cylinders, Former Liquid Propellant Testing Facility, Washoe County, Nevada. Joint Army-Navy-NASA-Air Force Interagency Propulsion Committee

Gnat, R., Loch, M. et al., 1996. Machias Gravel Pit -Assessment through Remediation in Under Three Years. Hazardous and Industrial Wastes; Proceedings of the Twenty-Eighth Mid-Atlantic Industrial and Hazardous Waste Conference. Technomic Publishing Company, Inc., Lancaster, PA.

ATTACHMENT 2

Excerpt of Illinois EPA Statement of Reasons

PCB 89-04(B)

*RPC
copy
5/17/91*

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:)
GROUNDWATER QUALITY STANDARDS) PCB R89-14 (B)
(35 ILL. ADM. CODE 620))
)
)
)

NOTICE

To: Dorothy Gunn, Clerk
Illinois Pollution Control Board
SOIC, Suite 11-500
100 W. Randolph
Chicago, IL 60601

Michelle C. Dresdow
Hearing Office
Illinois Pollution Control Board
P.O. Box 505
DeKalb, IL 60115

SEE ATTACHED LIST

Please take notice that I have filed with the Clerk of the Illinois Pollution Control Board the Illinois Environmental Protection Agency's Statement of Reasons and Testimony of Richard P. Cobb, a copy of which is served upon you. This Testimony will be presented by Mr. Cobb at the Illinois Pollution Control Board hearing to be held in Chicago on May 30, 1991.

Illinois Environmental Protection Agency

By: Stephen C. Ewart
Stephen C. Ewart
Deputy Counsel
Division of Public Water Supplies

Date: May 15, 1991
2200 Churchill Road
P.O. Box 19276
Springfield, Illinois 62794-9276
(217)782-5544

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:)
GROUNDWATER QUALITY STANDARDS) PCB R89-14 (B)
(35 ILL. ADM. CODE 620))
)
)

STATEMENT OF REASONS

Pursuant to 35 Ill. Adm. Code 102.120(b), the Illinois Environmental Protection Agency ("Agency") hereby submits to the Illinois Pollution Control Board ("Board") a statement of reasons in support of the proposal of regulations which was submitted on February 15, 1991. The following statement of reasons provides a discussion of sections that are significantly different in First Notice, Docket B from previous Agency proposals. The sections not discussed in these comments have not been changed significantly from previous Agency testimony and statement of reasons. In addition, several sections have been amended since submission of the Agency's revised proposal on February 15, 1991 to the Board. These revisions were made as a result of public participation efforts to further narrow certain issues between interest groups. The amendments which are described in this Statement of Reasons are contained in the text of 35 Ill. Adm. Code 620 which is provided in Attachment 1.

I. STATUTORY AUTHORITY

Section 2(b) of the Illinois Groundwater Protection Act ("IGPA") (Ill. Rev. Stat. 1989, ch. 111 1/2, par. 7452(b)) sets forth that:

The Agency has eliminated the alternate on-site background level of earlier drafts and has incorporated a similar concept as an exception to certain Class II Inorganic Chemical Constituents for sites that have been filled with slag. As proposed, the Agency has limited the application of this exception to those inorganic constituents listed in Section 620.420(a)(2) because of comments that there was no basis for exempting the inorganics in Section 620.420(a)(1).

The Agency has proposed that the Board apply this exception to sites which have applied fill material before the effective date of this Part and for sites which are in the process of applying fill material on the effective date of this Part and are proceeding in a reasonably continuous manner. The latter provision is similar to those provisions provided for new potential sources and routes under the Act.

In response to recent comments, the Agency has provided a 10-foot zone within parent material to more adequately address the problem and has expanded the application of these provisions to sites other than just the industrial property class. However, the Agency recommends that the application not be extended to rural property classes.

Section 620.420(b)(2) recognizes existing use of pesticide chemicals in a controlled manner which are applied to cropland consistent with the Federal Insecticide and Fungicide, and Rodenticide Act ("FIFRA"), and the Illinois Pesticide Act ("IPA"). This section has also been amended after submission of the proposal to the Board, in response to comments received that

ATTACHMENT 3

Excerpt of Testimony of Richard P. Cobb

PCB 89-04(B)

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:)
GROUNDWATER QUALITY STANDARDS) PCB R89-14 (B)
(35 ILL. ADM. CODE 620))
)
)
)

TESTIMONY OF RICHARD P. COBB

The Illinois Environmental Protection Agency hereby prefiles the attached TESTIMONY of RICHARD P. COBB. This testimony will be presented by Mr. Cobb at the Illinois Pollution Control Board hearings to be held in Chicago on May 30, 1991.

Illinois Environmental Protection
Agency

By: Stephen C. Ewart
Stephen C. Ewart
Deputy Counsel
Division of Public Water
Supplies

DATED: May 15, 1991
2200 Churchill Road
P.O. Box 19276
Springfield, IL 62794-9276
217/782-5544

TESTIMONY OF RICHARD P. COBB
ON R89-14 DOCKET (B)

My name is Richard P. Cobb and I am Manager of the Hydrogeology Unit of the Groundwater Section of the Illinois Environmental Protection Agency's Division of Public Water Supplies. The statement of reasons included with this testimony describes that following submission of the Agency's proposal, *OK* several additional comments were received through public participation efforts which merited revisions in the submission. The amendments made were as a result of trying to reach as much of a consensus as was possible between the various interest groups.

My testimony today will primarily focus upon the sections and concepts of the proposal that are new, and have not been discussed in previous extensive testimony presented by the Agency.

CARCINOGENS

The Agency has discussed in previous testimony as well as several other participants in this proceeding that the carcinogens regulated by the groundwater standards should be consistent with their regulation under the Safe Drinking Water Act ("SDWA"), and the guidelines and principles as mandated by Section 8(a) of the IGPA.

The SDWA regulates organic constituents as carcinogens if they are considered to be a Group A, B₁, or B₂ carcinogen. The SDWA does not regulate Group C carcinogens in the same manner.

received which prompted this amendment. The reason for including these additional parameters is that Class I waters should be able to be used for all uses. The constituents which were added to Class I were boron, cobalt, nickel, zinc, and phenols. The basis for the standards for these constituents are irrigation, livestock, MCL, and 35 Ill. Adm. Code 302.208, respectively.

The Agency has revised the applicability of the Class II groundwater standard for pH from 10 feet to a depth of 5 feet from the land surface. This amendment is necessary to ensure proper remedial response in the event of spill of caustic or acidic materials as well as to allow for sound land management and agricultural practices (e.g. lime, de-icing agents etc.) during the application of pH sensitive materials

The provisions for alternate on-site background, and the on-site exception have been deleted from this proposal. However, several comments have been made in this proceeding which discuss that extensive areas have been filled with slag and other fill material, and that these conditions may cause violations of the standards for certain constituents. Several examples have been provided which indicate that significant parts of southeastern Chicago and East St. Louis have been filled with such material. Therefore, to provide recognition for these prior conditions, a provision has been incorporated into the Class II standards in relation to the specific constituents of concern. To further accommodate these conditions a 10 foot buffer zone into parent material, and a exclusion for fill material, has been provided. This buffer zone should reasonably accommodate these conditions.

In addition, for sites which are in the process of applying fill material on the effective date of this Part and are proceeding in a reasonably continuous manner, the Agency has proposed a provision to allow for recognition of these situations. This was modeled after a similar provision provided for construction of new potential sources or routes in the Act.

To recognize existing uses of pesticide chemical constituents which have been applied in a manner consistent with the requirements of the Federal Insecticide Fungicide and Rodenticide Act ("FIFRA") and the Illinois Pesticide Act ("IPA"), the Agency has proposed the establishment of an attenuation zone for pesticide chemical constituents listed in Subsection 620.420(b)(1). This attenuation zone has been established at 10 feet to be consistent with the 10 foot zone of surficial interaction established for Class I groundwater. The Class I, or II standards will apply below this depth. This provision was built into the Class II standards so that it could specifically be related to the constituents of concern.

Illinois is a highly agricultural state and these regulations must recognize pesticides that have been applied in compliance with federal and state regulations. The Illinois Department of Agriculture provided the following from page 2 of their comments of February 15, 1991 to the Board:

"The Department fully supports the development and adoption of groundwater quality standards which will protect this valuable resource, however, these standards must provide this protection without having a disproportionately negative impact on other equally important resources. The use of agrichemicals is somewhat unique in that these compounds are

ATTACHMENT 4

**Excerpts from U.S. EPA Statistical Analysis of Groundwater
Monitoring Data at RCRA Facilities – Unified Guidance March
2009 (EPA-530-R-09-007)**



STATISTICAL ANALYSIS OF
GROUNDWATER MONITORING DATA AT
RCRA FACILITIES

UNIFIED GUIDANCE

OFFICE OF RESOURCE CONSERVATION AND RECOVERY
PROGRAM IMPLEMENTATION AND INFORMATION DIVISION
U.S. ENVIRONMENTAL PROTECTION AGENCY

MARCH 2009

The difficulties in identifying a valid statistical framework for groundwater monitoring highlight a fundamental assumption governing almost every statistical procedure and test. It is the presumption that sample data from a given population should be *independent* and *identically distributed*, commonly abbreviated as *i.i.d.* All of the mathematics and statistical formulas contained in this guidance are built on this basic assumption. If it is not satisfied, statistical conclusions and test results may be invalid or in error. The associated statistical uncertainty may be different than expected from a given test procedure.

Random sampling of a single, fixed, stationary population will guarantee independent, identically-distributed sample data. Routine groundwater sampling typically does not. Consequently, the Unified Guidance discusses both below and in later chapters what assumptions about the sample data must be routinely or periodically checked. Many but not all of these assumptions are a simple consequence of the *i.i.d.* presumption. The guidance also discusses how sampling ought to be conducted and designed to get as close as possible to the *i.i.d.* goal.

3.2 COMMON STATISTICAL ASSUMPTIONS

Every statistical test or procedure makes certain assumptions about the data used to compute the method. As noted above, many of these assumptions flow as a natural consequence of the presumption of *independent, identically-distributed* data (*i.i.d.*). The most common assumptions are briefly described below:

3.2.1 STATISTICAL INDEPENDENCE

A major advantage of truly random sampling of a population is that the measurements will be *statistically independent*. This means that observing or knowing the value of one measurement does not alter or influence the probability of observing any other measurement in the population. After one value is selected, the next value is sampled again at random without regard to the previous measurement, and so on. By contrast, groundwater samples are not chosen at random times or at random locations. The locations are fixed and typically few in number. The intervals between sampling events are fixed and fairly regular. While samples of independent data exhibit no *pairwise correlation* (*i.e.*, no statistical association of similarity or dissimilarity between pairs of sampled measurements), *non-independent* or *dependent* data *do* exhibit pairwise correlation and often other, more complex forms of correlation. Aliquot split sample pairs are generally not independent because of the *positive correlation* induced by the splitting of the same physical groundwater sample. Split measurements tend to be highly similar, much more so than the random pairings of data from distinct sampling events.

In a similar vein, measurements collected close together in time from the same well tend to be more highly correlated than pairs collected at longer intervals. This is especially true when the groundwater is so slow-moving that the same general volume of groundwater is being sampled on closely-spaced consecutive sampling events. Dependence may also be exhibited spatially across a well field. Wells located more closely in space and screened in the same hydrostratigraphic zone may show greater similarity in concentration patterns than wells that are farther apart. For both of these temporal or time-related and spatial dependencies, the observed correlations are a result not only of the non-random nature of the sampling but also the fact that many groundwater populations are not uniform throughout the subsurface. The aquifer may instead exhibit pockets or sub-zones of higher or lower concentration, perhaps due to location-specific differences in natural geochemistry or the dynamics of contaminant plume behavior over time.

chosen, and the frequency of background versus compliance well testing. The number of compliance wells and annual frequency of testing also affect overall costs, but are generally site-specific considerations. By limiting the number of constituents and ensuring adequate background sample sizes, it is possible to select certain statistical tests which help minimize future compliance (and total) sample requirements.

Selection of an appropriate number of detection monitoring constituents should be dictated by the knowledge of waste or waste leachate composition and the corresponding groundwater concentrations. When historical background data are available, constituent choices may be influenced by their statistical characteristics. A few representative constituents or analytes may serve to accurately assess the potential for a release. These constituents should stem from the regulated wastes, be sufficiently mobile, stable and occur at high enough concentrations to be readily detected in the groundwater. Depending on the waste composition, some non-hazardous organic or inorganic indicator analytes may serve the same purpose. The guidance suggests that between 10-15 formal detection monitoring constituents should be adequate for most site conditions. Other constituents can still be reported but not directly incorporated into formal detection monitoring, especially when large simultaneously analyzed suites like ICP-trace elements, volatile or semi-volatile organics data are run. The focus of adequate background and future compliance test sample sizes can then be limited to the selected monitoring constituents.

The RCRA regulations do not consistently specify how many observations must be collected in background. Under the Part 265 Interim Status regulations, four quarterly background measurements are required during the first year of monitoring. Recent modifications to Part 264 for Subtitle C facilities require a sequence of at least four observations to be collected in background during an interval approved by the Regional Administrator. On the other hand, at least four measurements must be collected from each background well during the first semi-annual period along with at least one additional observation during each subsequent period, for Subtitle D facilities under Part 258. Although these are minimum requirements in the regulations, are they adequate sample sizes for background definition and use?

Four observations from a population are rarely enough to adequately characterize its statistical features; statisticians generally consider sample sizes of $n \leq 4$ to be insufficient for good statistical analysis. A decent population survey, for example, requires several hundred and often a few to several thousand participants to generate accurate results. Clinical trials of medical treatments are usually conducted on dozens to hundreds of patients. In groundwater tests, such large sample sizes are a rare luxury. However, it is feasible to obtain small sample sets of up to $n = 20$ for individual background wells, and potentially larger sample sizes if the data characteristics allow for pooling of multiple well data.

The Unified Guidance recommends that a minimum of at least 8 to 10 independent background observations be collected before running most statistical tests. Although still a small sample size by statistical standards, these levels allow for minimally acceptable estimates of variability and evaluation of trend and goodness-of fit. However, this recommendation should be considered a temporary minimum until additional background sampling can be conducted and the background sample size enlarged (see further discussions below).

Small sample sizes in background can be particularly troublesome, especially in controlling statistical test false positive and negative rates. False negative rates in detection monitoring, *i.e.*, the

statistical error of failing to identify a real concentration increase above background, are in part a function of sample size. For a fixed false positive test rate, a smaller sample size results in a higher false negative rate. This means a decreased probability (*i.e.*, *statistical power*) that real increases above background will be detected. With certain parametric tests, control of the false positive rate using very small sample sets comes at the price of extremely low power. Power may be adequate using a non-parametric test, but control of the false positive can be lost. In both cases, increased background sample sizes result in better achievable false positive and false negative errors.

The overall recommendation of the guidance is to establish background sample sizes as large as feasible. The final tradeoff comes in the selection of the type of detection tests to be used. Prediction limit, control chart, and tolerance limit tests can utilize very small future sample sizes per compliance well (in some cases a single initial sample), but require larger background sample sizes to have sufficient power. Since background samples generally are obtained from historical data sets (plus future increments as needed), total annual sample sizes (and costs) can be somewhat minimized in the future.

5.2.2 BASIC ASSUMPTIONS ABOUT BACKGROUND

Any background sample should satisfy the key statistical assumptions described in **Chapter 3**. These include statistical independence of the background measurements, temporal and spatial stationarity, lack of statistical outliers, and correct distribution assumptions of the background sample when a parametric statistical approach is selected. How independence and autocorrelation impact the establishment of background is presented below, with additional discussions on outliers, spatial variability and trends in the following sections. Stationarity assumptions are considered both in the context of temporal and spatial variation.

Both the Part 264 and 258 groundwater regulations require statistically independent measurements (**Chapter 2**). Statistical *independence* is indicated by random data sets. But randomness is only demonstrated by the presence of mean and variance *stationarity* and the lack of evidence for effects such as *autocorrelation, trends, spatial and temporal variation*. These tests (described in **Part II** of this guidance) generally require at least 8 to 10 separate background measurements.

Depending on site groundwater velocity, too-frequent sampling at any given background well can result in highly *autocorrelated*, non-independent data. Current or proposed sampling frequencies can be tested for autocorrelation or other statistical dependence using the diagnostic procedures in **Chapter 14**. Practically speaking, the best way to ensure some degree of statistical independence is to allow as much time as possible to elapse between sampling events. But a balance must be drawn between collecting as many measurements as possible from a given well over a specified time period, and ensuring that the sample measurements are statistically independent. If significant dependence is identified in already collected background, the interval between sampling events may need to be lengthened to minimize further autocorrelation. With fewer sampling events per evaluation period, it is also possible that a change in statistical method may be needed, say from analysis of variance [ANOVA], which requires at least 4 new background measurements per evaluation, to prediction limits or control charts, which may require new background only periodically (*e.g.*, during a biennial update).

by eliminating historically non-detected constituents in background from the formal list of detection monitoring constituents (discussed further in the following section). These constituents are still analyzed and informally tested, but do not count against the SWFPR.

Results of waste and leachate testing and possibly soil gas analysis should serve as the initial basis for designating constituents that are reliable leak detection indicators. Such specific constituents actually present in, or derivable from, waste or soil gas samples, should be further evaluated to determine which can be analytically detected a reasonable proportion of the time. This evaluation should include considerations of how soluble and mobile a constituent may be in the underlying aquifer. Additionally, waste or leachate concentrations should be high enough relative to the groundwater levels to allow for adequate detection. By limiting monitoring and statistical tests to fewer parameters with reasonable detection frequencies and that are significant components of the facility's waste, unnecessary statistical tests can be avoided while focusing on the reliable identification of truly contaminated groundwater.

Initial leachate testing should not serve as the sole basis for designating monitoring parameters. At many active hazardous waste facilities and solid waste landfills, the composition of the waste may change over time. Contaminants that initially were all non-detect may not remain so. Because of this possibility, the Unified Guidance recommends that the list of monitoring parameters subject to formal statistical evaluation be periodically reviewed, for example, every three to five years. Additional leachate compositional analysis and testing may be necessary, along with the measurement of constituents not on the monitoring list but of potential health or environmental concern. If previously undetected parameters are discovered in this evaluation, the permit authority should consider revising the monitoring list to reflect those analytes that will best identify potentially contaminated groundwater in the future.

Further reductions are possible in the number of constituents used for formal detection monitoring tests, even among constituents periodically or always detected. EPA's experience at hazardous waste sites and landfills across the country has shown that VOCs and SVOCs detected in a release generally occur in clusters; it is less common to detect only a single constituent at a given location. Statistically, this implies that groups of detected VOCs or SVOCs are likely to be correlated. In effect, the correlated constituents are measuring a release in similar fashion and not providing fully independent measures. At petroleum refinery sites, benzene, toluene, ethylbenzene and xylenes measured in a VOC scan are likely to be detected together. Similarly at sites having releases of 1,1,1-trichloroethane, perhaps 10-12 intermediate chlorinated hydrocarbon degradation compounds can form in the aquifer over time. Finally, among water quality indicators like common ions and TDS, there is a great deal of geochemical inter-relatedness. Again, two or three indicators from each of these analyte groups may suffice as detection monitoring constituents.

The overall goal should be to select only the most reliable monitoring constituents for detection monitoring test purposes. Perhaps 10-15 constituents may be a reasonable target, depending on site-specific needs. Those analytes not selected should still continue to be collected and evaluated. In addition to using the informal test to identify previously undetected constituents described in the next section, information on the remaining constituents (e.g., VOCs, SVOCs and trace elements) can still be important in assessing groundwater conditions, including additional confirmation of a detected release.

DOUBLE QUANTIFICATION RULE

From the previous discussion, a full set of site historical monitoring parameters can be split into three distinct groups: a) those reliable indicators and hazardous constituents selected for formal detection monitoring testing and contributing to the SWFPR; b) other analytes which may be occasionally or even frequently detected and will be monitored for general groundwater quality information but not tested; and c) those meeting the "never-detected" criteria. The last group may still be of considerable interest for eventual formal testing, should site or waste management conditions change and new compounds be detected. All background measurements in the "never-detected" group should be non-detects, whether the full historical set or a subgroup considered most representative (e.g., recently collected background measurements using an improved analytical method.⁵). The following rule is suggested to provide a means of evaluating "never-detected" constituents.

The Double Quantification rule implies that statistical tests should be designed for each of the constituents in the first group. Calculations involving the SWFPR should cover these constituents, but *not* include constituents in second and the third '100% non-detect' categories. Any constituent in this third group should be evaluated by the following simple, quasi-statistical rule⁶:

A confirmed exceedance is registered if any well-constituent pair in the '100% non-detect' group exhibits quantified measurements (i.e., at or above the reporting limit [RL]) in two consecutive sample and resample events.

It is assumed when estimating an SWFPR using the Bonferroni-type adjustment, that each well-constituent test is at *equal risk* for a *specific, definable* false positive error. As a justification for this Double Quantification rule, analytical procedures involved in identifying a reported non-detect value suggest that the error risk is probably much *lower* for most chemicals analyzed as "never-detected." Reporting limits are set high enough so that if a chemical is *not present at all* in the sample, a detected amount will rarely be recorded on the lab sheet. This is particularly the case since method detection limits [MDLs] are often intended as 99% upper prediction limits on the measured signal of an uncontaminated laboratory sample. These limits are then commonly multiplied by a factor of 3 to 10 to determine the RL.

Consequently, a series of measurements for VOCs or SVOCs on samples of uncontaminated groundwater will tend to be listed as a string of non-detects with possibly a very occasional low-level detection. Because the observed measurement levels (*i.e.*, instrument signal levels) are usually known only to the chemist, an approximate prediction limit for the chemical basically has to be set at the RL. However, the true measurement distribution is likely to be clustered much more closely around zero than the RL (**Figure 6-1**), meaning that the false positive rate associated with setting the RL as the prediction

⁵ Note: Early historical data for some constituents (e.g., certain filtered trace elements) may have indicated occasional and perhaps unusual detected values using older analytical techniques or elevated reporting limits. If more recent sampling exhibits no detections at lower reporting limits for a number of events, the background review discussed in **Chapter 5** may have determined that the newer, more reliable recent data should be used as background. These analytes could also be included in the '100% non-detect' group.

⁶ The term "quasi-statistical" indicates that although the form is a statistical prediction limit test, only an approximate false positive error rate is implied for the reporting limit critical value. The test form follows 1-of-2 or 1-of-3 non-parametric prediction limit tests using the maximum value from a background data set (**Chapter 19**).

6.3 HOW KEY ASSUMPTIONS IMPACT STATISTICAL DESIGN

6.3.1 STATISTICAL INDEPENDENCE

IMPORTANCE OF INDEPENDENT, RANDOM MEASUREMENTS

Whether a facility is in detection monitoring, compliance/assessment, or corrective action, having an appropriate and valid sampling program is critical. All statistical procedures *infer* information about the underlying population from the observed sample measurements. Since these populations are only sampled a few times a year, observations should be carefully chosen to provide accurate information about the underlying population.

As discussed in **Chapter 3**, the mathematical theory behind standard statistical tests assumes that samples were *randomly* obtained from the underlying population. This is necessary to insure that the measurements are *independent* and *identically distributed* [i.i.d.]. Random sampling means that each possible concentration value in the population has an equal or known chance of being selected any time a measurement is taken. Only random sampling guarantees with sufficiently high probability that a set of measurements is adequately representative of the underlying population. It also ensures that human judgment will not bias the sample results, whether by intention or accident.

A number of factors make classical random sampling of groundwater virtually impossible. A typical small number of wells represent only a very small portion of an entire well-field. Wells are screened at specific depths and combine potentially different horizontal and vertical flow regimes. Only a minute portion of flow that passes a well is actually sampled. Sampling normally occurs at fixed schedules, not randomly.

Since a typical aquifer cannot be sampled at random, certain assumptions are made concerning the data from the available wells. It is first assumed that the selected well locations will generate concentration data similar to a randomly distributed set of wells. Secondly, it is assumed that groundwater flowing through the well screen(s) has a concentration distribution identical to the aquifer as a whole. This second assumption is unlikely to be valid unless groundwater is flowing through the aquifer at a pace fast enough and in such a way as to allow adequate mixing of the distinct water volumes over a relatively short (*e.g.*, every few months or so) period of time, so that groundwater concentrations seen at an existing well could also have been observed at other possible well locations.

Adequate sampling of aquifer concentration distributions cannot be accomplished unless enough time elapses between sampling events to allow different portions of the aquifer to pass through the well screen. Most closely-spaced sampling events will tend to exhibit a statistical dependence (*autocorrelation*). This means that pairs of consecutive measurements taken in a series will be positively correlated, exhibiting a stronger similarity in concentration levels than expected from pairs collected at random times. This would be particularly true for overall water quality indicators which are continuous throughout an aquifer and only vary slowly with time.

Another form of statistical dependence is *spatial correlation*. Groundwater concentrations of certain constituents exhibit natural spatial variability, *i.e.*, a distribution that varies depending on the location of the sampling coordinates. Spatially variable constituents exhibit mean and occasionally

ATTACHMENT 5

Leaching Test Procedures and Turnaround Times

Leaching Tests Supported by TestAmerica

Current Methods SW-846 1311 & 1312;

Low-level Radioactive Wastes ANSI/ANS-16.1;

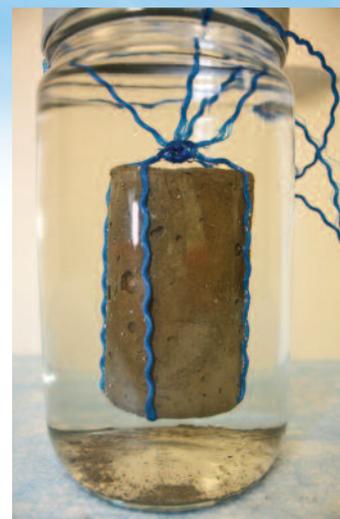
LEAF EPA Methods 1313, 1314, 1315 & 1316

Leaching tests are tools to estimate the potential release of constituents of potential concern (COPC) from waste material after its disposal, or to assess the waste treatment, or to evaluate the material for beneficial use.

Overview of Leaching

In environmental testing, leaching is the process to transfer constituents from a solid (waste, soil, sludge, sediment, combustion residues, coal combustion residue (CCR), stabilized materials, construction materials, or mining wastes) to an aqueous phase or contact liquid. The extent to which constituents in the solid phase will transfer is dependent on site conditions and material specific physical, chemical, and biologic conditions and the length of time involved.

There are a variety of leaching tests and no one leachate test can be used to evaluate the leaching behavior of a wide variety of materials over a broad range of field scenarios. The following describes two current SW-846 leaching methods, ANSI/ANS 16.1 and four newer EPA methods to assess leaching characteristics.



Executive Methods Summary

CURRENT METHODS	
<p>Method 1311 Toxicity Characteristic Leachate Procedure (TCLP)</p>	<p>This is a single point leachate test. Predicts the mobility of both organics and inorganics analytes in landfills. It is used to classify material as hazardous or non-hazardous for purposes of disposal in a landfill.</p>
<p>Method 1312 Synthetic Precipitation Leachate Procedure (SPLP)</p>	<p>This is a single point leachate test. Predicts the mobility of both organics and inorganics analytes into ground and surface waters. SPLP fluid simulates precipitation.</p>

LOW-LEVEL RADIOACTIVE WASTES	
<p>ANSI/ANS-16.1 Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure</p>	<p>This standard was designed for low-level radioactive wastes to determine the leaching characteristics of the solidified material. This standard can be used to measure the leach resistance of any waste solidified into a well-defined geometric shape.</p>

LEAF EPA METHODS	
<p>LEAF EPA Method 1313 Liquid-Solid Partitioning as a Function of Extract pH for Constituents in Solid Materials using a Parallel Batch Extraction Procedure</p>	<p>This method is designed to provide aqueous extracts representing the liquid-solid partitioning (LSP) curve as a function of pH for inorganics and non-volatile organics in solid materials.</p>
<p>LEAF EPA Method 1314 Liquid-Solid Partitioning as a Function of Liquid-to-Solid Ratio for Constituents in Solid Materials using an Up-Flow Percolation Column Procedure</p>	<p>This method is designed to provide the liquid-solid partitioning (LSP) of inorganic constituents and non-volatile organics in granular solid material as a function of liquid-to-solid (L/S) ratio under percolation conditions.</p>
<p>LEAF EPA Method 1315 Mass Transfer Rates of Constituents in Monolithic or Compacted Granular Materials using a Semi-dynamic Tank Leaching Procedure</p>	<p>This method is designed to provide the mass transfer (release rates) of inorganic analytes contained in a monolith or compacted granular material. Under diffusion controlled release conditions, as a function of leaching time.</p>
<p>LEAF EPA Method 1316 Liquid-Solid Partitioning as a Function of Liquid-to-Solid Ratio for Constituents in Solid Materials using a Parallel Batch Extraction Procedure</p>	<p>This method is designed to provide the liquid-solid partitioning (LSP) of inorganic and non-volatile organics at the natural pH of the solid material as a function of liquid-to-solid ratio (L/S) under conditions that approach liquid-solid chemical equilibrium.</p>

***See Back Cover for the Expanded Methods Summary.**

CURRENT METHODS

Method 1311
Toxicity Characterization Leaching Procedure (TCLP)

TCLP is designed to simulate the leaching a waste will undergo if disposed of in a sanitary landfill.

TCLP has a specific list of regulated compounds with regulatory levels based on health based concentration limits and dilution attenuation factors developed using a subsurface fate and transport model. Federal regulation for the use of TCLP can be found in 40 CFR 261.24. If the TCLP extract contains any one of the TC constituents in an amount equal to or exceeding the concentrations specified in 40 CFR 261.24, the waste possesses the characteristic of toxicity and is a hazardous waste.

TCLP is appropriate for its intended use as a screening test for wastes which may be disposed of in a solid waste landfill or similar conditions. TCLP does not simulate the release of contaminants to non-groundwater pathways.

Method 1312
Synthetic Precipitation Leaching Procedure (SPLP)

SPLP was designed to estimate the mobility/leachability of both organic and inorganic analytes in liquids, soils and wastes in a mono-disposal situation. The extraction fluid is based on the region of the country where the sample is located. The SPLP extraction fluid is intended to simulate precipitation. East of the Mississippi River the extraction fluid is at a pH of 4.2 and west of the river the pH is 5.0. The method indicates that the user compare constituents of concern concentrations in the 1312 extract with levels identified in the appropriate regulations. There are no federal regulations requiring the use of SPLP.

Since the 1990s, there has been concern that TCLP or SPLP would be used outside of their intended use or users may not be familiar with the resulting limitations of the data. TCLP and SPLP are single point batch leachate tests based on pH. Different factors can affect the leaching potential of constituents of concern. They include: pH, redox conditions, liquid-to-solid ratio (L/S), and solubility. Other factors which can affect the leaching potential of organic constituents of concern include: partitioning or solubility, presence of organic carbon, and non-aqueous phase extraction.

LOW-LEVEL RADIOACTIVE WASTES

ANSI/ANS-16.1-2003 [R2008]

American National Standards Institute/America Nuclear Society
Measurement of the Leachability of Solidified Low-Level Nuclear
Wastes by a Short-Term Test Procedure.

This method is the American Nuclear Society's standardization of the International Atomic Energy Agency's 1971 standard leachate test. The goal is to

have a standard leachate test for low level radioactive material to allow for data comparisons. The test provides a leachability index, which quantifies the leaching characteristics of a solidified material and the release of radioisotopes that come in contact with the material. It is a short-term exposure under controlled conditions with a well-defined leachant. This method can also be used to measure the leach resistance of any solidified waste in a well-defined geometric shape.

LEAF METHODS

Leaching Environmental Assessment Framework (LEAF)

U.S. EPA developed four additional non-regulatory leachate tests to better characterize and model the leachability of wastes. The sources of these methods are from published leaching methods and international standards with additional collaboration between Vanderbilt University and the Energy Research Centre of the Netherlands and DHI in Denmark.

The LEAF Methods are a suite of leaching tests which include batch, column, and tank tests which can be interpreted individually or integrated. They provide information on the leaching behavior of a solid material over a wide range of potential scenarios.

The central mechanism for the leachate tests are either equilibrium or mass transfer control. Equilibrium control release occurs for slow percolation through a

porous or granular material. Mass transfer rate control release occurs when flow is at the external boundary of a monolith or percolation is very rapid relative to mass transfer of constituent release to the percolating waters.

These methods are applicable to a wide range of solid materials including combustion residues, coal combustion residues (CCR), soils, sediments, industrial process residues, and construction materials with the focus on disposal, beneficial use, waste delisting, and the evaluation of treatment effectiveness.

LEAF is a tiered testing approach which increases in detail and complexity depending on the purpose of the testing. Tier 1 testing is for screening purposes and can be a single batch extraction or modified versions of leaching tests. Tier 2 is equilibrium based testing to characterize the liquid solid partitioning over a broad range of scenarios as a function of pH and liquid-to-solid ratio (L/S). The equilibrium testing for Tier 2 includes Methods 1313, 1314 and 1316. Tier 3 is

the mass transfer testing using Method 1315.

LEAF Method 1313

Liquid-Solid Partitioning as a Function of Extract pH for Constituents in Solid Materials using a Parallel Batch Extraction

LEAF Method 1313 is a leaching method which requires particle-size reduced solids material. Using dilute acids and bases at pH values ranging from 2 to 13 and natural conditions, ten eluates are generated from the solid material in parallel extractions. The eluates are then analyzed for the constituents of concern as a function of pH. The constituents of concern can be inorganics and non-volatile organics. This data can be used to estimate the liquid-solid partitioning of the constituents of concern.

LEAF Method 1314

Liquid-Solid Partitioning as a Function of Liquid-to-Solid Ratio for Constituents in Solid Materials using an Up-flow Percolation Column Procedure

LEAF Method 1314 is a column leaching method which requires particle-size reduction to accommodate the column diameter. It is an equilibrium based up-flow percolation column test. The constituents of concern can be inorganics and non-volatile organics. This leaching test is used to characterize the liquid/solid partitioning between solid phase and the eluate as a function of the liquid to solid ratio. This method provides five options for the generation of the eluate and the subsequent preparation of the analytical samples based on the level of detailed data which is required.

LEAF Method 1315

Mass Transfer Rates of Constituents in Monolithic or Compacted Granular Materials using a Semi-dynamic Tank Leaching Procedure

LEAF Method 1315 is a flux based leachate method for the analysis of a monolith or compacted granular material. The material is continuously immersed in reagent water at a specified liquid to solid surface area. The constituents of concern are inorganics. This leaching test provides the mass transfer rates of the constituents of concern under diffusion controlled release conditions as a function of leaching time through the material.

LEAF Method 1316

Liquid-Solid Partitioning as a Function of Liquid-to-Solid Ratio for Constituents in Solid Materials using a Parallel Batch Extraction Procedure

LEAF Method 1316 is a leaching method which requires particle-size reduced solids material. Using natural pH of the solid material, five eluates are generated from the solid material in parallel extractions over a range of liquid to solid ratios. The eluates are then analyzed for the constituents of concern. The constituents of concern can be inorganics and non-volatile organics. This data can be used to estimate the liquid/solid partitioning of these constituents of concern.

Liquid-Solid Partitioning as a Function of Extract pH using a Parallel Batch Extraction Procedure



This method is intended to be used as part of an environmental leaching assessment for the evaluation of disposal, beneficial use, treatment effectiveness and site remediation options.

Scope:

U.S. EPA Method 1313 is designed to provide aqueous extracts representing the liquid-solid partitioning (LSP) curve as a function of pH for inorganic constituents, semi-volatile organic constituents and non-volatile organic constituents in solid materials. The LSP curve is evaluated as a function of final extract pH at a liquid-to-solid ratio of 10 mL extractant/g dry sample and conditions that approach liquid-solid equilibrium. This method also yields the acid/base titration and buffering capacity of the tested material.

The method is a leaching characterization method that is used to provide values for intrinsic material parameters that control leaching of inorganic and some organic species under equilibrium conditions. The test is intended as a means for obtaining a series of extracts of a solid material, which may be used to estimate the LSP of constituents as a function of pH.

Summary of Method:

The method consists of nine parallel extractions of a particle-size reduced solid material in dilute acid or base and reagent water. The table below details the leaching

time required based on the particle size of the sample. In addition, the table indicates the minimum dry sample mass required for leaching.

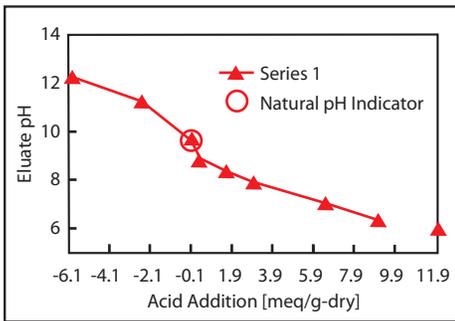
A schedule of acid and base additions is formulated from a pre-test titration curve or prior knowledge indicating the required equivalents/g acid or base to be added to the series of extraction vessels so as to yield a series of eluates having specified pH values in the range of 2-13 (2, 4, 5.5, 7, 8, 9, 12, 13, and natural). The pre-test titration curve is utilized to determine the actual amount of acid or base added to the samples to hit the method specified pH values or client driven pH values.

If the natural pH falls within the method subscribed pH values then a pH value of 10.5 will be performed. In addition to the nine test extractions, three method blanks without solid material are carried through the procedure in order to verify that analyte interferences are not introduced as a consequence of reagent impurities or equipment contamination.

The twelve bottles are tumbled in an end-over-end fashion for a specified contact time, which depends on the particle size of the sample. At the end of the specified contact interval, the liquid and solid phases are separated

Particle Size (85% wt less than) (mm)	US Sieve Size	Minimum Dry Mass (mass g-dry)	Contact Time (hrs)	Suggested Vessel Size (mL)
0.3	50	20 ± 0.02	24 ± 2	250
2	10	40 ± 0.02	48 ± 2	500
5	4	80 ± 0.02	72 ± 2	1,000

Extraction Parameters as Function of Max. Particle Size



Pre-test Titration Curve

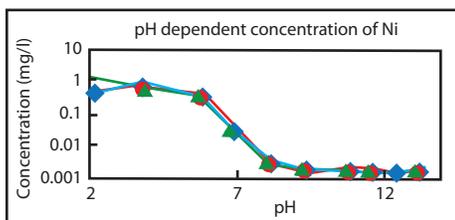
via centrifugation. Extract pH, conductivity, and ORP measurements are then made on an aliquot of the liquid phase and the remaining eluate is filtered thru a 0.45 micron filter. Analytical samples of the filtered eluate are collected and preserved as appropriate for the desired chemical analyses. The eluate concentrations contaminants of potential concern (COPC) are determined and reported. Note: The end user can request specific pH ranges.

Data Results:

An LSP curve can be generated for each COPC following chemical analyses of all extracts by plotting the target analyte concentration in the liquid phase as a function of the measured extract pH for each extract.

The shape of the LSP curve is indicative of the speciation of the COPC in the solid phase with characteristic LSP curve shapes.

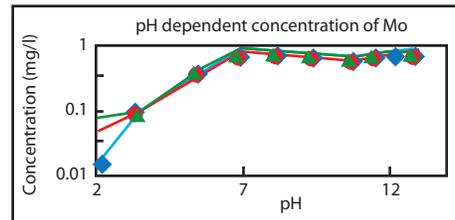
Cationic Species: The LSP curve typically has a maximum concentration in the acidic pH range that decreases to lower values at alkaline pH.



LSP Curve of Cationic Species

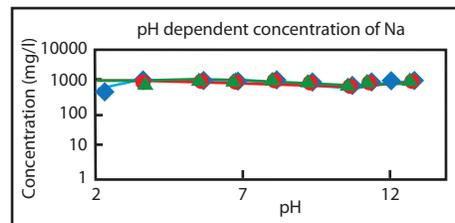
Amphoteric Species: The LSP curves tend to be similar in shape to cationic LSP curves with greater concentrations in the acidic pH range. However, the concentrations pass through a minimum in the near neutral to slightly acidic pH range only to increase again for alkaline pH values.

Oxyanionic Species: The LSP curve often show maximum in the neutral to slightly alkaline range



LSP Curve of Oxyanionic Species

Highly Soluble Species: The LSP curve is only a weak function of pH.



LSP Curve of Highly Soluble Species

In Summary:

The method provides solutions considered indicative of eluate under field conditions, only where the field leaching pH is the same as the final laboratory extract pH and the LSP is

controlled by aqueous phase saturation of the constituent of interest.

The maximum mass of constituent released over the range of method pH conditions (2<pH<13) may be considered an estimate of the maximum mass of the constituent leachable under field leaching conditions for intermediate time frames and the domain of the laboratory tests.

References:

U.S. EPA. SW846 Method 1313 July 2017
<https://www.epa.gov/hw-sw846/validated-test-methods-recommended-waste-testing>

Leaching Environmental Assessment Framework (LEAF) How-To Guide, October 2017

Additional Information:

Recommend bottle type for samples: 32-ounce jar

Sample Size: Minimum 800 grams. Sample size will vary based on analysis requested

Preservation: None

Holding Time: Holding time for leachate generation is within 1 month of receipt. The analytical holding times do apply to the environmental samples generated and which are subsequently analyzed for COPCs

Constituents of Potential Concern: Inorganics and non-volatile organics

Approximate Turnaround for Leaching and Subsequent Analysis: 24 to 72 hours for leaching, depending on particles size of the material; 21 days for analysis, for a total of 28-day turnaround.

Liquid-Solid Partitioning as a Function of Liquid-to-Solid Ratio for Constituents in Solid Materials

*using an Up-flow Percolation
Column Procedure*



The method is intended to be used as part of an environmental leaching assessment for the evaluation of disposal, beneficial use, treatment effectiveness, and site remediation options.

Scope:

U.S. EPA Method 1314 is designed to provide the liquid-solid partitioning (LSP) of inorganic constituents and non-volatile organic constituents in a granular solid material as a function of liquid-to-solid ratio (L/S) under percolation conditions. The first eluates of the column test may provide insight into the composition of the pore solution either in a granular bed or in the pore space of low-permeability material.

The method is intended as a means for obtaining a series of extracts of a granular solid material which may be used to show eluate concentrations and/or cumulative release as a function of L/S which can be related to a time scale when data on mean infiltration rate, density, and height of application are available.

Summary of Method:

In preparation of solid materials for use in this method, particle-size reduction or exclusion of samples with large grain size is used to enhance approach toward liquid-solid equilibrium over the residence time of eluant in the column. A 30 cm, straight cylindrical column with an inner diameter of 5 cm is currently being used. The

particle size of the material must be $<1/20$ of the column diameter. Based off of this information, the current particle size is 2.5 mm.

Eluant is introduced into a column of moderately-packed granular material in an up-flow pumping mode. The eluate collection performed as a function of the cumulative L/S. Up-flow pumping is used to minimize air entrainment and flow channeling. The default eluant for most material is reagent water. The flow rate is maintained between 0.5-1.0 L/S per day to increase the likelihood of local equilibrium between the solid and liquid phases, due to residence times longer than 1 day.

Eluate volumes are chemically analyzed for a combination of inorganic and non-volatile organic analytes depending on the constituents of potential concern (COPC). The entire eluant volume up to 10mL/g dry sample is collected in nine specific aliquots of varying



Multiple Columns for Method 1314

volume. A limited subset of eluants volumes within the same L/S range may be collected and analyzed for regulatory and compliance purposes. The table below reflects collection times of a sample.

Data Results:

The method provides options for the preparation of analytical samples that provide flexibility based on the level of detail required:

Option A – Complete

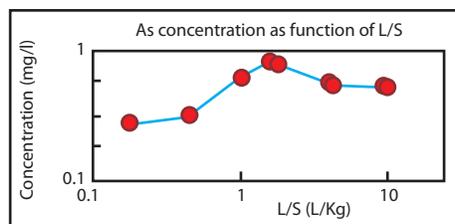
Characterization: Eluate concentrations may be used in conjunction with information regarding environmental management scenarios to estimate anticipated leaching concentrations, release rates, and extent of release for individual material constituents in the management scenarios evaluated. The nine eluate collections are analyzed and reported.

Option B – Limited Analysis:

Under a limited analysis approach, nine eluate collections and analysis of six analytical samples are required. If evaluation is based on eluate concentrations, six eluate fractions are chemically analyzed. If evaluation is based on cumulative release, some eluate fractions are composited by volume-weighted averaging to create a set of six analytical samples. The concentrations of composited analytical samples cannot be interpreted along with eluate fractions on the basis of concentration.

Option C – Index Testing: For the determination of consistency between the subject material and previously characterized materials, nine eluate collections and analysis of three analytical samples are required. If consistency is to be determined by eluate concentrations, three discrete eluate fractions are chemically analyzed. If consistency is to be determined by cumulative release, some eluate fractions are composited by volume-weighted averaging to create a set of three analytical samples. The concentrations of composited analytical samples cannot be interpreted along with eluate fractions on the basis of concentration.

Eluate concentrations of contaminants of concern are then plotted versus the cumulative liquid-to-solid ratio.



Eluate Concentrations versus Cumulative L/S

In Summary:

The method provides eluate solutions considered indicative of leachate under field conditions only where the field leaching pH is controlled by the alkalinity or acidity of the solid material and the field leachate is not subject to dilution or other attenuation mechanisms. The cumulative mass of constituent released over an L/S range may be considered an estimate of the maximum mass of that constituent to be leached under field leaching over intermediate time frames and the domain of the laboratory test pH.

References:

U.S. EPA. SW846 Method 1314 July 2017
<https://www.epa.gov/hw-sw846/validated-test-methods-recommended-waste-testing>

Leaching Environmental Assessment Framework (LEAF) How-To Guide, October 2017

Additional Information:

Recommend bottle type for samples: 32-ounce jar

Sample Size: Minimum 1,200 grams. Sample size will vary based on analysis requested

Preservation: None

Holding Time: Holding time for leachate generation is within 1 month of receipt. The analytical holding times do apply to the environmental samples generated and which are subsequently analyzed for COPCs

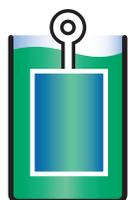
Constituents of Potential Concern: Inorganics and non-volatile organics

Approximate Turnaround for Leaching and Subsequent Analysis: 14 days for leaching; 42 total days for leaching and analysis.

Fraction Label	Sum L/S Ratio (mL/g-dry)	Fraction Volume (mL)	Scheduled Collection (date/time)
-	0	10	11/28/12 8:20 AM
T01	0.20	164	11/28/12 2:02 PM
T02	0.50	260	11/28/12 11:05 PM
T03	1.00	434	11/29/12 2:11 PM
T04	1.50	434	11/30/12 5:16 AM
T05	2.00	434	11/30/12 8:22 PM
T06	4.50	2,170	12/3/12 11:50 PM
T07	5.00	434	12/4/12 2:56 PM
T08	9.50	3,906	12/10/12 6:47 AM
T09	10.00	434	12/10/12 9:53 PM

Collection Times of a Sample

Mass Transfer Rates of Constituents in Monolithic or Compacted Granular Material *using a Semi-dynamic Tank Leaching Procedure*



1315

The leaching characterization method provides intrinsic material parameters for release of inorganic species under mass transfer-controlled leaching conditions. The method is intended as a means for obtaining a series of eluants which may be used to estimate the diffusivity of constituents and physical retention parameter of the solid material under specified laboratory conditions.

Scope:

U.S. EPA Method 1315 is designed to provide the mass transfer rates of inorganic analytes contained in a monolithic or compacted granular material, under diffusion-controlled release conditions, as a function of leaching time.

The geometry of the monolithic samples may be rectangular, cubes, wafers, or cylinders. Samples may also have a variety of faces exposed to the eluant forming anything from 1-dimensional through 3-dimensional mass transfer cases. In all cases, a minimum sample size of 5 cm in the direction of mass transfer must be employed and the liquid-surface-area ratio (L/A) must be maintained at 9 ± 1 mL/cm². **Note:** *The surface area of the sample must be determined by the laboratory or an outside contractor.*

Monolith samples should be suspended or held in the leaching fluid such that at least 98% of the entire sample surface area is exposed to eluant and the bulk of the eluant is in contact with the exposed sample surface.

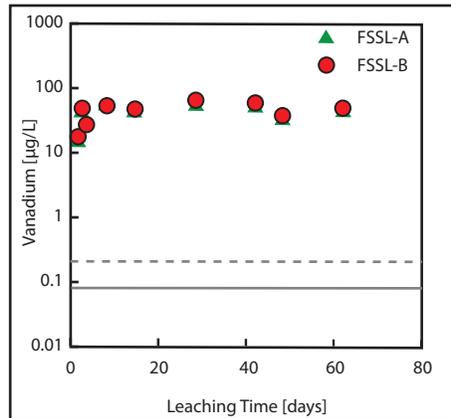
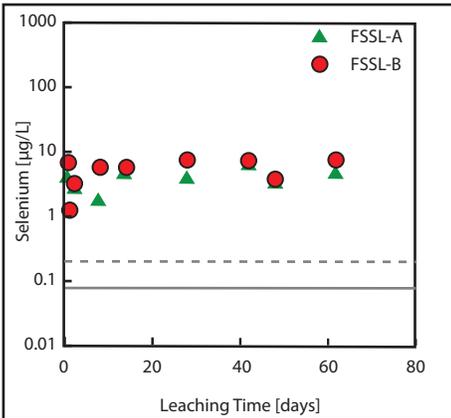
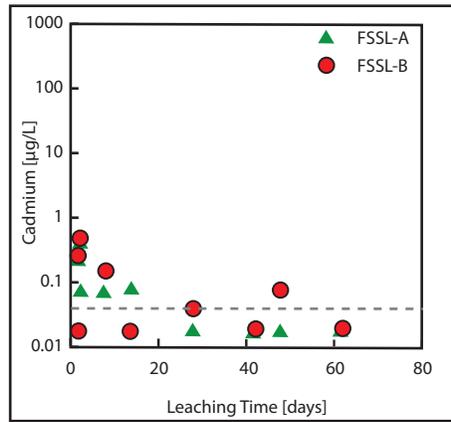
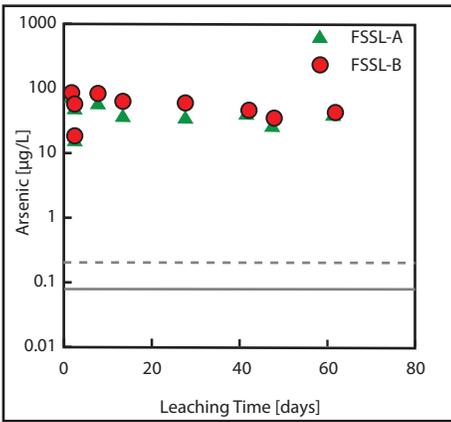
Summary of Method:

The method comprises leaching of continuously water-saturated monolithic or compacted granular material in an eluant-filled tank with periodic renewal of the leaching solution. Samples are contacted with reagent water at the specified L/A. The leaching solution is exchanged with fresh reagent water at nine pre-determined intervals listed below:

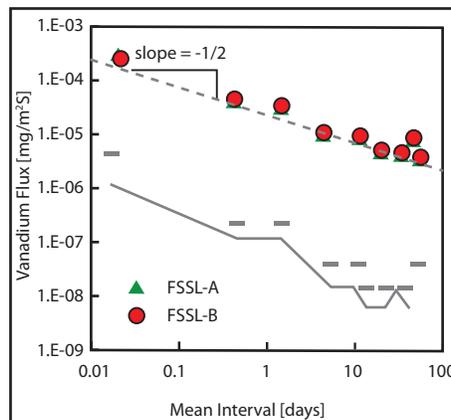
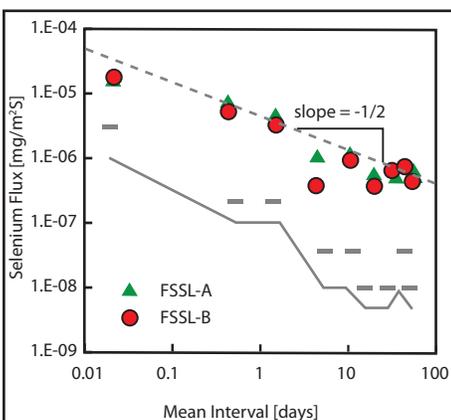
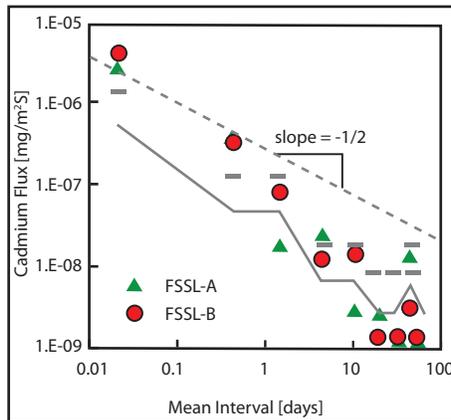
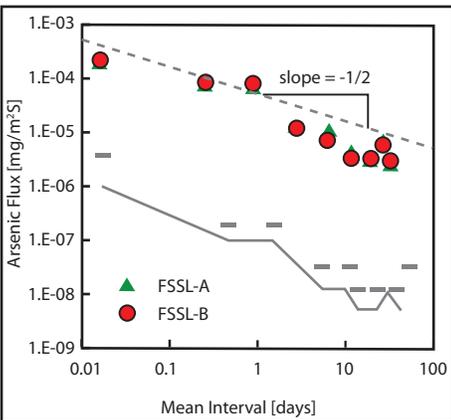
The sample is freely drained and the mass is recorded to monitor the amount of eluant absorbed into the solid matrix at the end of each leaching interval. The eluate pH, specific conductance, and ORP are measured for each time interval. Analytical samples are collected and preserved accordingly based on the determinative methods to be performed on the eluate. **Note:** *Though the method references analyzing for inorganic parameters, TestAmerica is licensed by Vanderbilt University to perform a patented, modified version of the method for analyzing volatiles and semi volatiles.*

Fraction Label	Interval Duration (hrs)	Interval Duration (hrs)	Cumulative Leaching Time (d)
T01	2.0 ± 0.25	–	0.08
T02	23.0 ± 0.5	–	1.0
T03	23.0 ± 0.5	–	2.0
T04	–	5.0 ± 0.1	7.0
T05	–	7.0 ± 0.11	14.0
T06	–	14.0 ± 0.1	28.0
T07	–	14.0 ± 0.1	42.0
T08	–	7.0 ± 0.1	49.0
T09	–	14.0 ± 0.1	63.0

Pre-determined Intervals of Leaching Solution Exchange



Interval Concentration Graphs



Interval Flux Graphs

Data Results:

Eluate concentrations are plotted as a function of time, as a mean interval flux, and as cumulative release as a function of time.

In Summary:

The method is a characterization method and does not provide a solution considered to be representative of eluate under field conditions. This method is similar in structure and use to predecessor methods such as MT001.1, NEN 7345, ANSI 16.1, and ASTM C1308. However, this method differs from previous methods in that: (a) leaching intervals are modified to improve quality control, (b) sample preparation accounts for mass transfer from compacted granular samples, and (c) mass transfer may be interpreted by more complex release models that account for physical retention of the porous medium and chemical retention at the pore wall through geochemical speciation modeling.

References:

- U.S. EPA. SW846 Method 1315 July 2017
- <https://www.epa.gov/hw-sw846/validated-test-methods-recommended-waste-testing>

Leaching Environmental Assessment Framework (LEAF) How-To Guide, October 2017

Additional Information:

- Recommend bottle type for samples:** 32-ounce jar
- Sample Size:** Current method allows for varied shapes/sizes as long as the L/Area ratio is 9 ± 1 mL/cm².
- Preservation:** None
- Holding Time:** There is no holding time defined to generate the leachate from the monolith. The analytical holding times do apply to the environmental samples generated and which are subsequently analyzed for COPCs
- Constituents of Potential Concern:** Inorganics and non-volatile organics
- Approximate Turnaround for Leaching and Subsequent Analysis:** 63 days for leaching; 84 days for analysis and leaching turnaround.

Liquid-Solid Partitioning as a Function of Liquid-to-Solid Ratio in Solid Materials

using a Parallel Batch Procedure



1316

The method is intended to be used as part of an environmental leaching assessment for the evaluation of disposal, beneficial use, treatment effectiveness, and site remediation options.

Scope:

U.S. EPA Method 1316 is designed to provide the liquid-solid partitioning (LSP) of inorganic constituents and non-volatile organic constituents at the natural pH of the solid material as a function of liquid-to-solid ratio (L/S) under the conditions that approach liquid-solid chemical equilibrium.

The eluate concentrations at a low L/S provide insight into pore solution composition either in a granular bed (e.g., soil column) or in the pore space of low-permeability materials (e.g., solidified monolithic or compacted granular fill).

Summary of Method:

This method consists of five parallel extractions of a particle-size reduced solid material in reagent water over a range of L/S values from 0.5 to 10 mL eluant/g dry material. In addition to the five test extractions, a method blank without solid sample is carried through the procedure in order to verify that analyte interferences are not introduced as a consequence of reagent impurities or equipment contamination.

In total, six bottles (i.e., five test positions and one method blank) are tumbled in an end-over-end fashion for a specified contact time based on the maximum particle size of the solid. At the end of the contact interval, the liquid and solid phases are roughly separated via settling or centrifugation. Extract pH, ORP, and specific conductance measurements are then taken on an aliquot of the liquid phase. The bulk of the eluate is clarified by pressure or vacuum filtration in preparation for constituent analysis. Analytical aliquots of the extracts are collected and preserved accordingly based on the determinative methods to be performed. The eluate constituent concentrations are plotted as a function of L/S and compared to QC and assessment limits.

Data Results:

A constituent LSP curve can be generated for each COPC after chemical analysis of all extracts by plotting the constituent concentration in the liquid phase as a function of L/S used for each extraction. The curve indicates the equilibrium concentration of the COPC as a function of L/S at the natural pH.

In Summary:

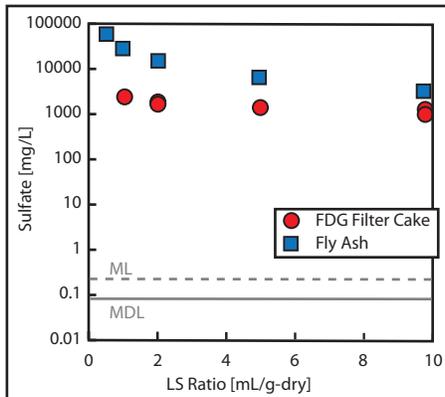
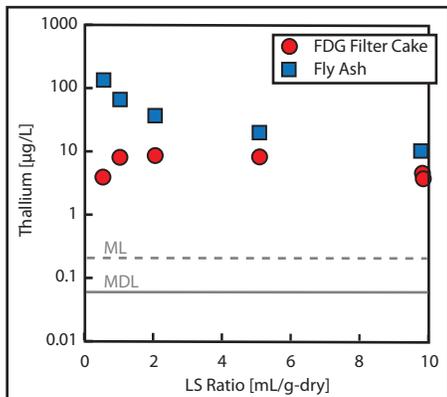
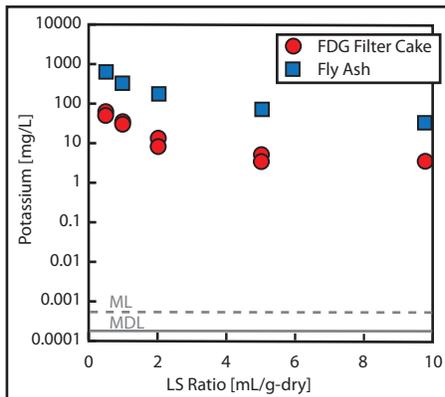
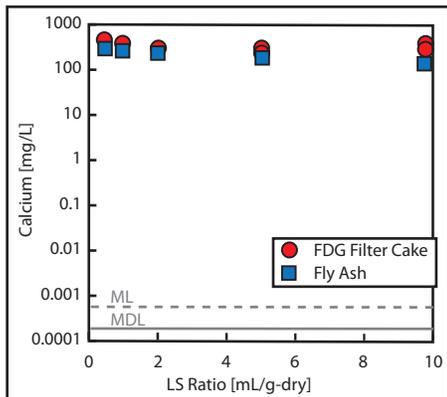
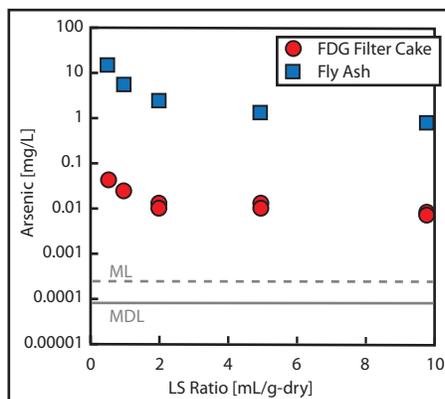
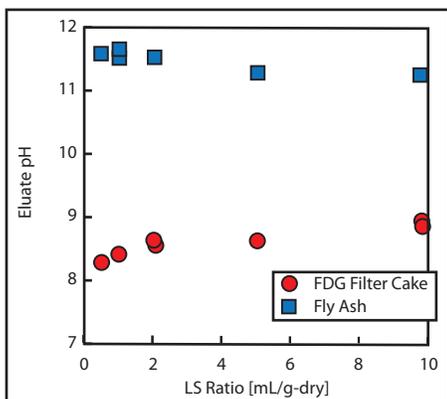
This method is a leaching characterization method used to provide intrinsic material parameters that control leaching of inorganic species under equilibrium conditions. This test method is intended as a means for obtaining an extract (i.e., the eluate) of a solid material which may be used to estimate the solubility and release of inorganic constituents under the laboratory conditions described in

Test Position	Target L/S	Minimum Dry Mass (g-dry)	Moisture "As Tested" Sample (g)	Moisture "As Tested" Sample (g)	Volume Reagent Water (mL)	Recommended Bottle Size (mL)
T01	10.0	20	22.2	2.2	198	250
T02	5.0	40	44.4	4.4	196	250
T03	2.0	100	111.1	11.1	189	500
T04	1.0	200	222.2	22.2	178	500
T05	0.5	400	444.4	44.4	156	1000
B03	QC				200	250
Total			844.4		1120	

Example Schedule for Extraction Setup

Particle Size (85% wt less than) (mm)	US Sieve Size	Min Dry Mass (mass g-dry)	Contact Time (hrs)	Suggested Vessel Size (mL)
0.3	50	20 ± 0.05	24 ± 2	250
2	10	40 ± 0.1	48 ± 2	500
5	4	80 ± 0.1	72 ± 2	1,000

Extraction Parameters as Function of Maximum Particle Size



Equilibrium Concentration as a Function of L/S at the Natural pH

this method. Extract concentrations may be used in conjunction with information regarding environmental management scenarios to estimate anticipated leaching concentrations, release rate and extent for individual material constituents in the management scenarios evaluated. Extract concentrations may also be used along with geochemical speciation modeling to infer the mineral phases that control the LSP in the pore structure of the solid material.

References:

- U.S. EPA. SW846 Method 1316 July 2017
- <https://www.epa.gov/hw-sw846/validated-test-methods-recommended-waste-testing>
- Leaching Environmental Assessment Framework (LEAF) How-To Guide, October 2017

Additional Information:

Recommend bottle type for samples: 32-ounce jar

Sample Size: Minimum 1,000 grams. Sample size will vary based on analysis requested

Preservation: None

Holding Time: Holding time not applicable to the generation of the eluate. The analytical holding times do apply to the environmental samples generated and which are subsequently analyzed for COPCs

Constituents of Potential Concern: Inorganics and non-volatile organics

Approximate Turnaround for Leaching and Subsequent Analysis: 24 to 72 hours for leaching, depending on particle size of the material; 21 days for analysis, for a total of 28-day turnaround.

CURRENT METHODS

Method 1311
Toxicity
Characteristic
Leachate Procedure
(TCLP)

This is a single point leachate test. Predicts the mobility of both organics and inorganics analytes in landfills. It is used to classify material as hazardous or non-hazardous for purposes of disposal in a landfill. **Summary Description:** Samples are preliminarily evaluated for solids and particle size. The liquid to solid ratio is 20:1. The sample is then leached with appropriate fluid. A pH 2.9 acetic acid is used for moderately to high alkaline material and pH 4.9 acetate buffer is used for all other materials. The total time for the leachate generation is 18 hours.

Method 1312
Synthetic
Precipitation
Leachate Procedure
(SPLP)

This is a single point leachate test. Predicts the mobility of both organics and inorganics analytes into ground and surface waters. SPLP fluid simulates precipitation. **Summary Description:** Samples are preliminarily evaluated for solids and particle size. The liquid to solid ratio is 20:1 and the samples are then leached with appropriate fluid. The extraction fluid is based on the region of the country where the sample is located. For samples east of the Mississippi River the extraction fluid pH is 4.2 and for materials west the pH is 5.0. The total time for the leachate generation is 18 hours.

LOW-LEVEL RADIOACTIVE WASTES

ANSI/ANS-16.1-2003 [R2008]
Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure

This standard was designed for low-level radioactive wastes to determine the leaching characteristics of the solidified material. This standard can be used to measure the leach resistance of any waste solidified into a well-defined geometric shape. **Summary Description:** Leaching of continuously water saturated monolithic or compacted granular material in an eluate-filled tank with periodic renewal of the leaching solution. L/S ratio of 10 mL eluate per cm² of surface area. Eluate is collected at predetermined times and analyzed for COPCs. Eluate is centrifuged and filtered for COPCs. Total time of test can be as long as 43 days.

NEW LEAF METHODS

LEAF Method 1313
Liquid-Solid
Partitioning as a
Function of Extract
pH for Constituents
in Solid Materials
using a Parallel
Batch Extraction
Procedure

This method is designed to provide aqueous extracts representing the liquid-solid partitioning (LSP) curve as a function of pH for inorganics and non-volatile organics in solid materials. **Summary Description:** This is a pH dependent batch leaching procedure. Ten parallel extractions of a particle sized reduced solid material in dilute acid or base and reagent water. Series of eluates having pH values ranging from 2-13 as well as natural condition. Liquid solid ratio is 10:1. Eluate is centrifuged and filtered and then analyzed for constituents of concern. Total time to generate the eluate is 5 days for material with 85% or greater solids or 8 days for material with less than 85% solids.

LEAF Method 1314
Liquid-Solid
Partitioning as a
Function of
Liquid-to-Solid Ratio
for Constituents in
Solid Materials using
an Up-Flow
Percolation Column
Procedure

This method is designed to provide the liquid-solid partitioning [LSP] of inorganic constituents and non-volatile organics in granular solid material as a function of liquid to solid (L/S) ratio under percolation conditions. **Summary Description:** This is a dynamic leaching procedure. Eluate is introduced into a column with packed particle sized reduced solid material in an up-flow pumping mode. Flow rate is maintained between 0.5-1.0 L/Day. Eluate is collected at predetermined times, filtered and analyzed for constituents of concern. Total time to generate the eluate is approximately 14 days.

LEAF Method 1315
Mass Transfer Rates
of Constituents in
Monolithic or
Compacted Granular
Materials using a
Semi-dynamic Tank
Leaching Procedure

This method is designed to provide the mass transfer (release rates) of inorganic analytes contained in a monolith or compacted granular material. Under diffusion controlled release conditions, as a function of leaching time. **Summary Description:** This is a hybrid batch and dynamic leaching procedure. Leaching of continuously water saturated monolithic or compacted granular material in an eluate-filled tank with periodic renewal of the leaching solution. L/S ratio of 9 mL eluate per cm² of surface area is used. Eluate is collected at predetermined times and analyzed for constituents of concern. Eluate is centrifuged and filtered for constituents of concern. Total time to generate the eluate is approximately 63 days.

LEAF Method 1316
Liquid-Solid
Partitioning as a
Function of
Liquid-to-Solid Ratio
for Constituents in
Solid Materials using
a Parallel Batch
Extraction Procedure

This method is designed to provide the liquid-solid partitioning (LSP) of inorganic and non-volatile organics at the natural pH of the solid material as a function of liquid-to-solid ratio (L/S) under conditions that approach liquid-solid chemical equilibrium. **Summary Description:** Five parallel extractions of a particle-size reduced solid material in reagent water over a range of L/S values from 0.5 to 10 mL eluate/g dry material. Depending on particle size, sample is tumbled between 24 and 72 hours. Eluate is centrifuged and filtered for constituents of concern. Total time to generate the eluate is between 1 and 3 days..



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