Response to Comments: Leaching Environmental Assessment Framework (LEAF) How-To Guide

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1. Introduction

1.1 EPA Request for Comments

The Agency recently added four new tests for assessing the leaching potential of waste to the SW-846 validated methods page. The four tests (EPA Methods 1313, 1314, 1315 and 1316), known as the Leaching Environmental Assessment Framework (LEAF) Tests, evaluate how waste constituent leaching changes with different environmental conditions. The tests are intended to be more accurate than other leaching tests by assessing constituent leaching potential under actual or plausible disposal conditions. Because the LEAF test methods represent a new approach to evaluating leaching potential, the Agency is developing technical implementation guidance (The LEAF How-To Guide) to help potential users understand the LEAF tests and how to use them. The guidance will also help users interpret the data generated by these tests and provide examples of how the test data can be used for assessing possible constituent release and provide a source term for groundwater fate and transport models used in risk assessment.

The Agency sought public comment for 90 days, beginning November 2, 2017 and ending January 31, 2018, on the LEAF Test Methods and companion How-To Guide to be sure that the guide clearly and accurately presents the test methods and methods for evaluation and does so for the range of anticipated users of the tests. This document summarizes the comments the Agency received and describes how the Agency intends to address comments, if appropriate.

1.2 Comment Summary

EPA reviewed and organized individual comments associated with each public submission made to EPA Docket Number EPA-HQ-OLEM-2017-0210. Comment excerpts were grouped into several categories, as shown in Table 1-1 below, and provide a collective summary of all comments received for a particular topic. A count of unique comments received for each category is summarized.

Table 1-1. Number of Comments per Topic

Category/Topic	Number of Comments
Method-Specific Comments	**2**
Method(s) Applications	**8**
Results Interpretation	**3**
Testing Costs	**4**
Case Studies	**9**
Policy Considerations	**4**
Editorial Comments	**9**
Other Topics[1]	**5**
Total	**44**

[1] The Other Topics category is used to capture comments not otherwise classified.

Table 1-2 presents a summary of the docket submission information related to public comments that were received. A total of 11 public comments were received

Table 1-2. Docket Submission Information

Docket Control Number (DCN)	COMMENTER	AFFILIATION	NOTES
EPA-HQ-OLEM-2017-0210-0092	Brenda Brickhouse VP Environment and Energy Policy	TVA – Tennessee Valley Authority	
EPA-HQ-OLEM-2017-0210-0093	Hans van der Sloot	Individual, formerly of Netherlands Energy Research Foundation, Waste Management	
EPA-HQ-OLEM-2017-0210-0094	Constance L. Senior VP of Technology	Advanced Emissions Solutions, Inc.	
EPA-HQ-OLEM-2017-0210-0095	James R. Roewer Executive Director	Utility Solid Waste Activities Group (USWAG)	
EPA-HQ-OLEM-2017-0210-0096	Environmental Standards Inc.	Environmental Standards Inc.	Annotated comments in modified file
EPA-HQ-OLEM-2017-0210-0097	Kathleen Prather Chair on ASTSWMO Beneficial Use Task Force	Association of State and Territorial Solid Waste Management Officials (ASTSWMO)	Comments from Beneficial Use Task Force within the Materials Management Subcommittee
EPA-HQ-OLEM-2017-0210-0098	Robert N. Chapman VP Energy and Environment (Ken Ladwig)	Electric Power Research Institute (EPRI)	Cover letter included
EPA-HQ-OLEM-2017-0210-0099	Albert Kruger et al.	Department of Energy – Office of River Protection	Offer to assist with additional examples. 10 references included with comments
EPA-HQ-OLEM-2017-0210-0099	Albert Kruger et al.	Department of Energy – Office of River Protection	Duplicate submission of -0099; excluded

Sections 2 through 9 of this document presents the compilation of comments and responses. The sections correlate with the primary categories identified in Table 1 and individual excerpts are identified by the DCN from which they originate.

1.3 Comment Responses

EPA reviewed each submission and has prepared responses to describe how EPA has addressed considerations raised. In cases where submitters raised a similar issue/consideration, EPA developed a single response. For the remaining instances that touch on specific considerations, EPA has prepared individual responses for each. The Draft How-To Guide has been revised based on public comment and the Agency's responses below.

2. Method-Specific Comments

DCN: EPA-HQ-OLEM-2017-0210-0094

Excerpt: Page 4-25: The issue of the reducing-oxidizing potential in the tests and in the real-world situations can be very important, as noted. Is measuring ORP during a LEAF test sufficient? How would one evaluate the effects of potential changes in ORP on leaching in the specific environmental scenario? Is this outside of the scope of the LEAF methods?

EPA Response: Measuring oxidation reduction potential (ORP) during lab testing provides some insight into the potential redox conditions in the field. The results from ORP can be translated into pE as explained in Section 4.3.1. Knowledge of the anticipated pH and pE of a scenario can help estimate redox conditions in the field. Additional text on the use of pE to anticipate redox conditions in the field has been added to Section 4.3.1 to better illustrate this. In some cases, further analysis outside the scope of LEAF testing such as geochemical speciation may be needed to estimate field conditions.

DCN: EPA-HQ-OLEM-2017-0210-0099

Excerpt: Applicability of LEAF as a Process for Evaluating Glass

Two of the tests methods, EPA-1313 and EPA-1315, hold promise for applications with waste glasses because they are aimed at evaluating the leaching rate of glass specimens with changes in pH and over time in different forms, albeit changes to the existing procedures will be needed (especially for EPA-1315) in order to obtain measurable release rates for a typical glass over the suggested testing duration. The other two methods, EPA-1314 and EPA-1316, are not as applicable but could be considered for applications with glass as well. When considering variations to the EPA-1313 and EPA-1315 procedures, it is important to optimize test conditions for different types of materials. For glasses, the kinetics and thermodynamics of dissolution as well as the various corrosion mechanisms can change significantly from the other materials often evaluated with these procedures including industrial wastes, soils, sludges, construction materials, and mining wastes. For this reason, we propose that a subsection may need to be added within Methods 1313 and 1315 that addresses some specific concerns related to vitrified and/or non-porous materials of a homogenous nature.

EPA Response: The Agency has developed the LEAF tests and How-To Guide for general use. This use may include evaluating waste glasses. However, the Agency is not aware of leaching from waste glass being of enough general interest and utility to the public to warrant developing additional testing guidance tailored to the leaching from waste glasses at this time.

3. Method(s) Applications

DCN: EPA-HQ-OLEM-2017-0210-0092

Excerpt: While there are several improvements incorporated to bracket a wide range of conditions (i.e. pH, liquid/solid ratios) significant differences in conditions between laboratory data and field conditions remain. These include different compaction densities, flow gradients, and intermittency of exposures. For instance, the Method 1314 utilizes a column test compacted by hand. This is significantly different than the density achieved by advanced machine compaction techniques currently in use.

EPA Response: The LEAF tests were designed to estimate a wide range of anticipated environmental conditions by varying parameters that significantly affect leaching such as pH and liquid to solid ratios. The Agency studied how well LEAF testing can estimate a range of field conditions in Leaching Test Relationships, Laboratory-to-Field Comparisons and Recommendations for Leaching Evaluation using the Leaching Environmental Assessment Framework (LEAF) (See U.S. EPA 2014, EPA 600/R-14/061). Specific field conditions may require additional assumptions in order to estimate leaching behavior. The agency has not investigated or validated test methods that vary compaction of material as a factor for leaching. Method 1314 relies on a moderate compaction of material in order to preserve the original porosity of the material. Method 1315 relies on a standard method for compaction of soil (ASTM D 1557).

DCN: EPA-HQ-OLEM-2017-0210-0092

Excerpt: Finally, due to the costs associated with the LEAF testing methods TVA is concerned that there are limitations to its applicability, as it would be inordinately expensive to spatially characterize leaching behavior at large disposal sites. It is our opinion that the developers never intended an application of the LEAF methods for this purpose.

EPA Response: The LEAF tests were developed to allow for evaluation of a wide range of materials and anticipated environmental conditions. The use of LEAF on a site-specific basis needs to be tailored to the questions being asked. It is not anticipated that all samples taken at a site be subjected to LEAF testing. Furthermore, LEAF is not a required test under RCRA. The document has been modified to clarify that use of LEAF needs to be tailored to the specific site circumstances and used appropriately (See Section 1.3).

LEAF requires more testing and generates more data compared to single point testing. As a result, the testing costs are higher. Furthermore, the Agency anticipates that management scenarios with a large quantity of material will allow material management costs to scale favorably versus fixed testing costs. The Agency has added a new section 3.2.5 that provides estimates of testing costs and a section 3.2.6 that provides an estimate of processing time for the LEAF tests. It is expected that testing costs will change over time as commercial laboratories adopt the LEAF tests as part of their offered services.

DCN: EPA-HQ-OLEM-2017-0210-0095

Excerpt: USWAG has no general objections to the use of the LEAF testing protocol for modeling leachate characteristics when used appropriately in site-specific circumstances. We caution EPA, however, on the possible inappropriate use of LEAF testing or data derived from LEAF. For example, LEAF data may not reflect actual field conditions in many circumstances, which can lead to erroneous conclusions in assessments based solely on LEAF data. It is critical, therefore, to understand that LEAF-derived data can only predict potential performance in instances where actual site conditions reflect those simulated in the LEAF analysis. Any data derived from LEAF methods should be validated though comparison with actual site-specific conditions.

EPA Response: EPA agrees with the comment. LEAF testing is useful when the test results reflect field conditions and often must be tailored to site specific conditions. LEAF testing may be used when needed to support a decision and needs to be tailored to the site-specific conditions. We expect to further emphasize this in the document.

The Agency developed LEAF testing to provide tests that address release controlling factors for inorganic COPCS that may vary under plausible use or disposal conditions: pH, the L/S of the test material relative to the leaching environment, and whether leaching is controlled by chemical equilibrium or by mass transport rates. In addition, the agency has studied the laboratory to field performance of LEAF testing (U.S. EPA. 2014, EPA-600/R-14/061). These studies informed and are reflected in the general approach and technical guidance presented in the How-To Guide.

The Agency does not intend for LEAF testing to be applied to situations where the test results do not appropriately estimate the anticipated environmental conditions. The Agency has added language in Section 1.3: When Can LEAF be Used, to address this earlier in the document.

DCN: EPA-HQ-OLEM-2017-0210-0096

Excerpt: The Guidance appropriately indicates that LEAF testing is not a regulatory requirement, and differentiates LEAF testing from other methods such as TCLP and SPLP that are required in certain regulatory arenas. The Guidance should include applications for which LEAF is not appropriate (e.g., for hazardous waste characterization or disposal classification). The Guidance states (Section 1.3) that the methods, ... "may also find application in support of cleanup decisions under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) that address specific contaminants on a site-specific basis." This is a very open-ended statement. US EPA must provide detailed guidance as to the specific circumstances in which the leachate data from the LEAF methods would be accepted as functionally equivalent as a "source term" for fate and transport purposes.

EPA Response: The Agency agrees with the commenter that under the federal regulations, LEAF testing is not a regulatory requirement. The TCLP and SPLP tests have specific uses that are not replaced with LEAF testing. The Agency believes that the LEAF testing may be used in support of cleanup decisions under CERCLA in some situations. However, the Agency has not identified those situations in this document. EPA expects to develop additional guidance and examples as experience with LEAF evolves. LEAF examples need to be tailored to the site-specific circumstances and the information needed to support a decision. Under CERCLA, groundwater is to be restored to beneficial use throughout the plume. For treated waste or contaminated media disposed in a CERCLA waste management area, the point of compliance is at the unit boundary and fate and transport analysis would not be appropriate.

When using LEAF testing in support of cleanup decisions under CERCLA or RCRA, decision makers should work closely with EPA and state programs to appropriately address site-specific needs.

DCN: EPA-HQ-OLEM-2017-0210-0096

Excerpt: It is requested that clarification is provided regarding the intent of the following set of statements from the Guidance (Section 1.3):

The performance values against which LEAF would be evaluated may differ depending on the specific regulatory program involved. For example, site-specific data are used to determine whether action is warranted at a site. Furthermore, under CERCLA as stated in the National Oil and Hazardous Substances Pollution Contingency Plan, "levels generally should be attained throughout the contaminated plume, or at and beyond the waste management area when waste is left in place" (55 FR 8753, March 8, 1990).

What other site-specific data would be required with LEAF data as inputs to a site model to determine whether action is warranted? Should LEAF data be compared to a background, and if so how is that background established? This section implies that LEAF may be useful to inform cleanup decisions; however, clear guidance on the use of this is data is lacking.

EPA Response: Under RCRA and CERCLA, cleanup decisions depend on site-specific factors. General guidance on use of LEAF data that would be applicable to all sites is impractical and beyond the scope of the How to Guide**.** As such, EPA expects to provide additional guidance on use the LEAF for CERCLA response actions as experience with LEAF evolves. Please see response to EPA-HQ-OLEM-2017-0210-0096 above.

DCN: EPA-HQ-OLEM-2017-0210-0097

Excerpt: LEAF appears to be a useful tool for the evaluation of waste materials in beneficial use scenarios such as agricultural land application, grade-adjustment fill, or any placement of material on the land. It appears the potential impact of such placement on groundwater quality can be evaluated empirically using these leaching test methods.

A specific concern facing regulators is the development of limits for pollutants in waste materials land -applied for agricultural benefit. These limits must take into account a variety of agricultural sites and soil types. Would EPA see LEAF being helpful in this decision-making scenario, and if so, how?

EPA Response: EPA developed LEAF to evaluate materials under a range of potential environmental conditions. These environmental conditions could include beneficial use scenarios involving placement on the land. LEAF test results may be useful in providing information within one factor in an assessment, the leaching of COPCs from material. However, a state might consider other factors such as background concentrations or exposure. The factors chosen by a state for a beneficial use evaluation of industrial non-hazardous secondary materials remains at the prerogative of the state program. EPA has provided guidance in the form of a Methodology for Evaluating Beneficial Uses of Industrial Non-Hazardous Secondary Materials, the Beneficial Use Compendium: A collection of Resources and Tools to Support beneficial Use Evaluations (U.S. EPA, 2016.)

DCN: EPA-HQ-OLEM-2017-0210-0097

Excerpt: Members recommend EPA continue to review and encourage the development of LEAF methods suitable for organic chemical constituents.

EPA Response: The Agency is currently developing test methods suitable for organic chemical constituents.

DCN: EPA-HQ-OLEM-2017-0210-0099

Excerpt: (Note: refer to docket submission for study details)

Introduction

An investigation of EPA Methods EPA-1313, EPA-1314, EPA-1315, and EPA-1316 by the team of researchers listed above has been conducted for several years to evaluate the use of these methods for glass dissolution for low-activity waste (LAW) planned for vitrification at the Hanford site in southeastern Washington State at the Hanford Tank Waste Treatment and Immobilization Plant (WTP). The Hanford site was used by the U.S. government to produce nuclear materials for the U.S. strategic defense arsenal. The large inventory of radioactive mixed waste is stored in underground single- and double-shell tanks. The waste will be separated into high-level waste (HLW) and LAW fractions that will then be vitrified.

The vitrification of LAW at the WTP is expected to generate between 1.6 to 2.8 × 105 m3 of glass. The DOE Office of River Protection (ORP) plans to permanently dispose of the LAW glass on site in a shallow subsurface disposal facility. The immobilized LAW (ILAW) glass must meet a variety of requirements with respect to protection of the environment before they can be accepted for disposal.

There is a need for a standard test method(s) to evaluate waste glass for disposal. Presently, several procedures have been developed within the DOE national laboratory complex and are used to govern LAW disposal. These procedures are designed to accelerate glass corrosion so that reasonable timescales can be used to evaluate dissolution behavior under conditions of elevated temperatures (i.e., 90°C, 200°C), high pressures, and high surface-area-to-volume ratios so that data can be drawn about how a given glass might perform over geologic timescales. Standard procedures designed for evaluating waste forms for long-term disposal and environmental protection are necessary and will give DOE a defensible position for waste burial on public lands. The methods presented by LEAF may be purposed to DOE as a defensible means to evaluate and predict the long-term performance of the glass.

Efforts have been made by this team to evaluate different simulated LAW glasses (i.e., LAWA44 and ORP-LB2) to determine the applicability of the LEAF test methods towards glass waste forms. Some of the results of this testing are presented below along with comments regarding Methods 1313 and 1315.

EPA Response: The Agency has developed the LEAF tests and How-To Guide for general use. This use may include evaluating waste glasses. However, the Agency is not aware of leaching from waste glass being of enough general interest and utility to the public to warrant developing additional testing guidance tailored to the leaching from waste glasses at this time.

4. Results Interpretation

DCN: EPA-HQ-OLEM-2017-0210-0092

Excerpt: As noted, the level of detail and complexity of the methods would increase depending on the overall purpose of the leach testing, the amount of leaching mechanism detail needed, and the scenario to be evaluated. Therefore, the methodologies present concerns with repeatability and consistency of results that might arise due to bias between analysts, test equipment, and laboratories.

EPA Response: The Agency agrees with the commenter that the level of detail and complexity of the methods will change depending on the objectives, purpose of testing, and complexity of the scenario. The How-To Guide presents information to assist a user in developing an appropriate testing scheme for an anticipated scenario. A more detailed evaluation may more accurately estimate leaching in the field when compared to a simpler assessment approach using assumptions in place of additional testing. The Agency added language to Section 4.2.2 Assessment Objectives to clearly state that all the assumptions built into an anticipated scenario need to be fully described so that results can be meaningfully compared between assessments. As with all tests, site-specific variability of the contaminants' concentration and the associated geomorphology of the soil and rock matrix may result in variability of results.

The Agency conducted interlaboratory studies to quantify the repeatability and reproducibility of testing (U.S. EPA. 2012, EPA 600/R-12/623, U.S. EPA. 2012, EPA 600/R-12/624) performed at different laboratories with different analysts and different equipment. The application of the LEAF tests to the same sample in a repeated fashion should give repeatable results.

DCN: EPA-HQ-OLEM-2017-0210-0092

Excerpt: Both the EPA and developers of the methods recognize that the simulated leachate extracted from the solid materials include the extremes which are not necessarily representative of those concentrations that are released to the environment. Nevertheless, TVA has concerns regarding the potential for individuals and/or entities to misinterpret the results or misapply the LEAF procedures to support biased projections of risk. In our opinion, the LEAF methods and data may be useful in assessing leaching impacts on a site-specific basis; however, the LEAF procedure should not be used in a universal application, i.e. as part of a general risk assessment.

EPA Response: The Agency agrees that LEAF testing must accurately estimate the environmental field conditions in order to be effective. However, extreme values may provide a worst case management scenario for an evaluator to screen against or to use as a starting point for a more detailed evaluation. Furthermore, in some situations site specific conditions may change over time and the range of testing conditions may be indicative of potential impacts from those changes. LEAF testing may be appropriate to use within a risk assessment so long as the testing results are able to accurately estimate the anticipated environmental conditions in the risk assessment. For example, the Agency has successfully used LEAF testing in the past to evaluate risk while developing regulations for coal combustion residuals (See 2014 CCR Risk Assessment (Final), EPA Docket ID: EPA-HQ-RCRA-2009-0640).

DCN: EPA-HQ-OLEM-2017-0210-0093

Excerpt: Page 5-4: Issue in judgement on the basis of concentration only. If for a constituent release is solubility controlled (meaning constant concentration irrespective of L/S until the controlling phase runs out) and the level is just below the regulatory concentration limit, then the long term release into the environment can become quite high. Is this a consideration or is there another way around that?

EPA Response: The potential for accumulation over time as a result of a continued release may be a consideration that is factored in when developing the goal for testing. However, it is not a specific element of the leaching test.

5. Testing Costs

DCN: EPA-HQ-OLEM-2017-0210-0092

Excerpt: Finally, due to the costs associated with the LEAF testing methods TVA is concerned that there are limitations to its applicability, as it would be inordinately expensive to spatially characterize leaching behavior at large disposal sites. It is our opinion that the developers never intended an application of the LEAF methods for this purpose.

DCN: EPA-HQ-OLEM-2017-0210-0096

Excerpt: The costs associated with the four US EPA Methods, 1313 - 1316, and the associated analyte measurements are extreme. As an example, if a single material sample undergoes all four LEAF methods plus the leachate characterization, costs would exceed $10,000, even with abbreviated conditions. Neither the US EPA Guidance nor the supporting documents include cost analysis, yet by publishing these methods, US EPA is advocating their use and further burdening the current high costs for investigation and remediation.

DCN: EPA-HQ-OLEM-2017-0210-0096

Excerpt: In general, commercial availability of LEAF testing is very limited. For a viable commercial product, analytical laboratories are burdened with a significant investment in equipment and time to develop standard procedures. LEAF leaching methods are highly labor intensive manual bench tests requiring skilled and knowledgeable chemists. Entities with a demonstrated appropriate need for LEAF testing are reliant on a very few commercial providers and may face significant time delays due to limited industry capacity.

DCN: EPA-HQ-OLEM-2017-0210-0097

Excerpt: A discussion of the cost of performing various LEAF methods would be useful for regulators, even as a round-figure range of prices polled from various laboratories.

DCN: EPA-HQ-OLEM-2017-0210-0095

Excerpt: Finally, in addition to the specific concerns raised above, USWAG has a broader concern that the costs associated with LEAF testing, coupled with the limited number of laboratories that can perform LEAF testing, may limit the application and practicality of LEAF testing.

EPA Response To Testing Cost Comments: The application of LEAF testing needs to be tailored to the purpose of the analysis and the question that is being asked. Therefore, monitoring samples may not generally be expected to undergo LEAF testing as a matter of general practice. The use of LEAF testing is voluntary and is expected to be used when practical to meet the needs of a specific application.

The LEAF tests were developed to allow for evaluation of a wide range of materials and anticipated environmental conditions. This requires more testing and generates more data compared to single point testing. As a result, the testing costs are expected to be higher. The Agency anticipates that management scenarios with a large quantity of material will allow material management costs to scale favorably versus fixed testing costs. The Agency has added a new section 3.2.5 that provides estimates of testing costs and a section 3.2.6 that provides an estimate of processing time for the LEAF tests. It is expected that testing costs will change over time as commercial laboratories adopt the LEAF tests as part of their offered services.

6. Case Studies

DCN: EPA-HQ-OLEM-2017-0210-0093

Excerpt: The examples are limited to coal fly ash. However relevant that matrix is, the scope of the LEAF methods is much wider, as it covers a wider spectrum of wastes, slags, ashes, sludges, (contaminated) soil, mine waste, municipal solid waste, incinerator waste, construction products, [etc.] This should be reflected in the examples provided (as appendices), may be not to the same detailed degree (one example with all the possible output suffices, but an illustration of release behaviour of other matrices would be very useful. To the extent that key release controlling aspects can be highlighted, that would be useful for reader too. Current shortcomings include:

- no examples for diffusion-controlled release from monoliths or compacted granular materials,
- no examples that consider aging effects (e.g., carbonation), and
- no examples that illustrate the integrated use of geochemical speciation modelling.

DCN: EPA-HQ-OLEM-2017-0210-0096

Excerpt: In the Guidance, EPA identifies several potentially appropriate applications. However, a Case Study is provided for only one very specific application (Evaluating Coal Combustion Fly Ash for Use as Structural Fill Material). Additional Case Studies representing the range of potential appropriate applications should be developed and included in the guidance.

DCN: EPA-HQ-OLEM-2017-0210-0097

Excerpt: The How-To Guide is sufficiently lengthy and detailed that it appears to be more appropriate for someone who has affirmatively decided to use LEAF than for someone looking to answer the basic question of whether LEAF should be considered. Commenters recommend EPA continue to develop and post companion FAQs, case studies, and decision tools to promote LEAF and help the regulatory community understand whether it should be considered.

DCN: EPA-HQ-OLEM-2017-0210-0098

Excerpt: The primary shortcoming of the Guidance is the lack of examples for implementing the LEAF protocol. Only one Case Study is provided in Section 5; this is incongruous with the detailed geochemical discussion in the first four sections of the document. Moreover, the Case Study describes the most straight-forward use of LEAF data in direct comparison of maximum concentrations to threshold values (maximum contaminant levels, MCLs), or comparison of concentrations modified by an assumed dilution-attenuation factor (DAF). In essence, this is the same way that single-point test data have historically been used. For example, TCLP data are compared to MCLs for eight trace constituents modified by an assumed DAF of 1001.

DCN: EPA-HQ-OLEM-2017-0210-0098

Excerpt: Using LEAF requires significantly more resources than TCLP for the laboratory extraction and analysis, and the robust datasets generated provide rich opportunities for use with geochemical and groundwater transport models. The authors of the Guidance recognized the importance of more sophisticated approaches for using LEAF data at several points in the document. Importantly, they note that, “The data collected from leaching tests is not directly representative of field leachates, but is used to estimate how a material will leach when managed in the field,” (Page 1-4). However, the Case Study does not provide any guidance on how to use the full LEAF dataset to understand the leaching process on a site-specific basis.

DCN: EPA-HQ-OLEM-2017-0210-0098

Excerpt: The use of only maximum concentrations in the Case Study fails to fully exploit the value that the detailed LEAF data provide in understanding how a waste might leach under a variety of possible environmental conditions. The strength of the protocol is the ability to understand the processes, not simply to compare maximum concentrations to a threshold. Method 1313 allows prediction of geochemical controls based on solubility/adsorption under varying pH conditions. Methods 1314 and 1316 provide changes in leachate concentrations as a function of liquid/solid (L/S) ratio, data that can be used to estimate time-varying source concentrations. Method 1315 provides insight into the more difficult concepts of monolithic behavior and diffusion, and the Guidance specifically states that “Method 1315 eluate concentrations should not be applied to comparisons with threshold concentrations”. But there are no Case Examples to demonstrate how to use the LEAF results in these contexts.

DCN: EPA-HQ-OLEM-2017-0210-0098

Excerpt: The Guidance document will benefit greatly from additional Case Studies. In practice, LEAF will be more useful for risk-based assessments with reactive transport modeling, as suggested by the authors on pages 4-6. The cost of generating the additional LEAF data may be difficult to justify without more application information on using the full spectrum of data with more powerful analysis tools that are available.

DCN: EPA-HQ-OLEM-2017-0210-0098

Excerpt:

Use in Models (Section 4.4.8): This section addresses the importance of using all of the LEAF data in a meaningful way to develop a complete source term for use in “sophisticated” mass transport models. This is the best and most probable use for the large amount of data generated by the LEAF protocol, given the cost of generating the data. The Guidance could be improved by including Case Studies of how to use the LEAF data to develop realistic source terms for use with models, rather than just on direct comparison of maximum leach test concentrations to thresholds.

DCN: EPA-HQ-OLEM-2017-0210-0099

Excerpt: One of the drawbacks to the handbook is a broad application to various materials for testing. Thus far, only one example is given in the handbook. Our suggestion is to have a number of examples present to give the reader practical suggestions of how the methods could be used. Waste glass may be a helpful suggestion as it contains both hazardous components (e.g., CrO42-) as well as radioactive inventory (e.g., TcO4-). Other suggestions may be cementitious materials, mining tailings, and metal debris.

EPA Response: We recognize that the guidance would benefit from the inclusion of a variety of additional case studies. The Agency has developed and included a second case study that includes the use of Method 1315 data. EPA anticipates providing information on other examples in the future as the experience using LEAF evolves.

7. Policy Considerations

DCN: EPA-HQ-OLEM-2017-0210-0092

Excerpt: The LEAF method is designed to simulate a broad range of leaching behaviors and as a result provides significantly more data for evaluating the process of leaching. Because the LEAF test methods are relatively new, the body of data available for scientific evaluation is relatively small. A larger body of LEAF data needs to be developed over a period of years to identify trends and potential sources of error in the sampling or testing methods that may not represent the actual site conditions. In addition, site-specific considerations, including hydraulic conductivity, soil type, hydraulic gradient, proximity of the groundwater table in relation to the waste matrix, etc., need to be included in the assessment. We believe that further application and evaluation of the method is necessary before the methods are used to develop site-specific decisions regarding disposal options for solid waste materials.

Response: EPA agrees that as we develop experience with using LEAF we need to continue to develop example scenarios that will help in the use of the methodology. Furthermore, we agree that site specific considerations are important as leaching strategies are developed.

LEAF testing was designed to study the parameters that EPA considered to be common driving factors for leaching of inorganics (e.g., pH, L/S ratio) in many leaching scenarios. A leaching evaluation using LEAF tests can be tailored for a site-specific decision by choosing the appropriate tests and test parameters for the specific site. EPA encourages evaluators to consider the specific scenario and the questions that is being asked and design the test accordingly taking into consideration site specific factors.

DCN: EPA-HQ-OLEM-2017-0210-0095

Excerpt: Further, while USWAG does not disagree with the technical support components of the Guidance, we are concerned that the addition of the LEAF testing protocol to SW-846 may be viewed as a precursor to using LEAF in a regulatory compliance action. The LEAF protocol is not a regulatory test and should not be used as such. For example, LEAF should not be used for waste characterization in determining whether a waste is a characteristic hazardous waste. The Toxicity Characteristic Leaching Procedure ("TCLP") is the proper test method for waste characterization.

Response: The Agency compiled the SW-846 Compendium to provide comprehensive guidance to analysts, data users, and other interested parties regarding test methods that may be employed for the evaluation of solid waste and other testing specified in regulations under RCRA. Except where explicitly specified in a regulation, the use of SW-846 methods is not mandatory in response to federal testing requirements. LEAF testing can be used as supplemental information to affirm decision-making for waste management. For example, the Agency used LEAF testing when evaluating disposal of coal combustion residual waste (Reference CCR Risk Assessment).

DCN: EPA-HQ-OLEM-2017-0210-0095

Excerpt: USWAG recognizes that LEAF testing may have some utility for assessing potential impacts of certain waste management or byproduct utilization activities. However, LEAF should only be regarded as one option—rather than a standard or mandated testing procedure—in estimating potential impacts for waste handling or byproduct utilization activities. Depending on site-specific considerations, the LEAF protocol may not be an appropriate or accurate method of assessment for certain beneficial use applications, closure of waste disposal units, no migration determinations, or remediation decisions under the Comprehensive Environmental Response, Compensation and Liability Act.

Response: The Agency agrees that LEAF has utility for assessing potential impacts of certain waste management or byproduct utilization activities and that other options exist for evaluation. A leaching test is only appropriate and useful when the test accurately estimates the anticipated environmental conditions and in some cases LEAF testing alone may not be able to accurately estimate leaching in the environment. The Agency has developed the How-To Guide in part to help decision makers understand when the use of LEAF testing may be beneficial to them.

DCN: EPA-HQ-OLEM-2017-0210-0096

Excerpt: The US EPA has published the four methods, along with this Guidance document and has stated in the Docket letter, "The Agency recognizes that while the LEAF tests are not required for use, there may be a wide variety of voluntary applications of these methods." However, there are instances where State regulatory agencies have required the use of these methods as part of environmental investigations without justifying the intended use of the resulting data. The requirement to perform LEAF testing without clear goals puts the entity in an untenable position, especially given the huge costs associated with the analyses. Request that the US EPA make it clear to state and local regulators that these are not regulatory tests and are voluntary. There appears to be a push to use these without consideration of the significant cost and effort that may not provide useful additional information to project decisions.

Response:

The LEAF test methods are designed to provide scientific support in decision-making. These tests methods are not required under the federal RCRA regulations. State programs authorized to implement the federal RCRA Subtitle C regulations may add requirements that are broader in scope or more stringent than the federal requirements. If adopted together with regulatory changes to an authorized state's definition of hazardous waste, the LEAF method-related state regulatory requirements would likely be broader in scope, since they may identify more wastes as hazardous under those revised authorized state requirements than would have been identified under only the federal RCRA Subtitle C requirements. In addition, in some cases the LEAF method-related test results could identify fewer wastes as hazardous, a result that would not be allowed to stand under an authorized state's authorized hazardous waste program. Depending on the direction in which LEAF-method-associated regulatory limits were set, an authorized state's LEAF method-related state regulatory requirements might also be more stringent than the comparable federal TCLP hazardous waste identification requirements in 40 CFR 261.24 (less stringent requirements would not be allowed to be a part of the authorized state's hazardous waste program).

EPA has included language in the Guidance to clarify that the use of LEAF is not a RCRA Subtitle C requirement and its use needs to be tailored to site-specific circumstances for which the information may help support a decision.

8. Editorial Comments

DCN: EPA-HQ-OLEM-2017-0210-0093

Excerpt: It is a lot of text and presently the level of reading of manuals and guidance by users is not optimal. The interest span is generally short. Hence the challenge I see is how key aspects of the whole test use and interpretation can be condensed into short (graphical) explanations. And possibly focus some more on indexing key questions to specific sections of the guide. An executive summary of a couple of pages with key points and, in particular, graphical explanations may work.

EPA Response: The Agency acknowledges that the How-To Guide has a potentially diverse user base. The introductory section has been expanded to better detail the concepts and topics within the guide. A new figure was developed to illustrate the relation between the test methods, environmental factors affecting leaching, and approaches presented in the guidance.

DCN: EPA-HQ-OLEM-2017-0210-0093

Excerpt: Page xi - Abstract: Last sentence second paragraph: Formulation rather weak, while the test set provides multiple times more insight and understanding of leaching issues.

EPA Response: The abstract has been rewritten.

Excerpt: Page 1-1: I miss a reference to Annex A, as development of the test methods in EU and US ran in parallel. In parts EU was first and now US has progressed quicker by provide an integrated Guide and the valuable Lab to field work (US-EPA, 2014c).

EPA Response: A reference to Appendix A has been added

Excerpt: Page 1-4 – section 1.3.2: replace numerous by several (not all are capable of handling the type of information provided by LEAF)

EPA Response: "Numerous" has been replaced with "several" in the text.

Excerpt: Page 1-5 section 1.4: The link as provided by the Lab to Field comparison (US-EPA 2014c) should be listed more explicitly, as it is key to the question how relevant the tests are for actual practice!!

EPA Response: Explanation of the agreement between LEAF testing and field estimates was added to the reference to the Lab to Field in section 1.3

Excerpt: Page 2-4 section 2.4.1: explicitly mention under the first bullet more comprehensive minerals, adsorption/desorption on oxide surfaces, clays and "natural" organic matter as solubility controlling phases for inorganic COPCS.

EPA Response: Added explanation that multiple mineral phases may exist that affect solubility

Excerpt: Page 2-5 section 2.4.1.1.: Not necessarily one mineral controlling solubility over the applicable pH range. In fact, in many cases it is an assemblage of minerals with varying proportions depending on pH.

EPA Response: Added a sentence on preferential flow and directed reader to section 4.4.4 for more information.

Excerpt: Page 2-6 bottom: preferential flow is an issue here, that cannot be ignored.

EPA Response: Added additional language on preferential flow.

Excerpt: Page 2-7 section 2.4.2: here the role of soluble species can be addressed to assess tortuosity and porosity effects on release of all substances affected by matrix interaction.

EPA Response: This comment is beyond the scope of this document and more relevant for calibration of geochemical speciation.

Excerpt: Page 2-7 section 2.4.3: Add a bullet of integrate preferential flow in one of the bullets as that is a key factor in relation to leachability in the field.

EPA Response: A bullet on preferential flow has been added to section 2.4.3.

Excerpt: Page 3-1, 3-3, 3-5. 3-8 and 3-10: provide a sentence to refer to the EU and ISO Soil methods listed in Annex A or at least on page 3-1.

EPA Response: An explanation of analogous methods developed in the EU was added to page 3-1

Excerpt: Page 3-7: Here the up-flow condition in the lab test vs the down-flow condition in most field scenarios can be mentioned and its effects on release (no or very limited effect on solubility-controlled substances, but a substantial effect on highly soluble substances).

EPA Response: A footnote was added along with citations to clarify this issue. See footnote 10 under section 3.1.2.

Excerpt: Page 3-11: Would be good to insert a section on the interrelationship between 1313, 1314 and 1316? It is addressed later, but would fit quite well here (see also section 4.4.5).

EPA Response: This issue was addressed through input from EPA staff during development of the guide and is now addressed elsewhere in the document (as acknowledged in the comment). Thus, no change is made in response to the comment.

Excerpt: Page 3-13: Note: Often pH is not reported in TCLP test reports, hence the type of comparison shown in Fig 3-9 are impossible then.

EPA Response: The draft was revised to note that TCLP testing often does not report pH.

Excerpt: Page 3-24: Data available on a much wider spectrum of materials – contaminated soil, mineral processing slags, sludges, mine tailings, industrial waste streams (e.g red mud), fertilizers, municipal solid waste and incineration residues, construction products, etc.

EPA Response: The suggested examples were added to the text.

Excerpt: Page 4-3 section 4.1.2: First mention of analogues EU and ISO soil methods, see remark before.

EPA Response: The EU and ISO methods are now mentioned earlier in the document.

Excerpt: Page 4-4 first paragraph: In a guide like this it would be better to provide references to examples of geochemical speciation modelling for a range of materials.

EPA Response: Clarification was added into Section 4.2: "…(iii) subsequent analyses such as the combining of LEAF source terms with fate and transport or geochemical speciation modeling representing environmental processes not accounted for by LEAF." Providing specific examples of geochemical speciation modeling for a range of materials is beyond the scope of this document.

Excerpt: Page 4-6 Section 4.2.3.1: Figure 4-4 placed too far from the text, where it is described.

EPA Response: Figure 4-4 has been moved closer to the text that initially describes it. It is now Figure 4-2.

Excerpt: Page 4-8: The fixed choices for pH are understandable, but will not always match with peak concentration for anions. This relates in particular to pH 9 condition. We have seen a rather sharp peak in leaching of fluoride from phosphate slag at pH 10 due to partially overlapping solubility controlling phases, which leaves a peak in between the two controlling phases. This is probably a very specific case, but one to be recognized in full testing.

EPA Response: The Agency acknowledges that this case can occur in rare circumstances, but a pragmatic compromise was made in the guide to provide a uniform basis that simplifies implementation and provides a good estimation in the vast majority of the cases (even for the identified case, concentrations at pH 9 are a much improved estimate compared to current practice). An acknowledgment that the Method 1313 endpoint pH does not always match the pH in the environment was added to Section 4.2.3.1. The specific example of flouride from phosphate slag was not added.

Excerpt: Page 4-11: helpful illustration, but the differences can be orders of magnitude, which is not directly evident from the graph.

EPA Response: A footnote was added to clarify that the change in concentration in the figure is an example and actual results will vary depending on the materials and testing.

Excerpt: Page 4-15 – Fig 4.3: How is the lower bound defined? If it is related to full carbonation then the calcite solubility control is more appropriate 7.8 or 7.5, if one wants to choose a lower bound.

EPA Response: pH 7.0 is a reasonable bounding condition that corresponds with a specific test condition, while pH 7.8 or 7.5 do not align with test conditions. See section 4.2.5.1. No change

Excerpt: Page 4-17 – Fig4-5: Legend missing. Could be clearer, if in the left bottom figure – max over L/S domain would be inserted.

EPA Response: The legend has been added to the figure as well as the maximum over the L/S domain.

Excerpt: Page 4-22 section 4.2.5.3 - 1st paragraph: …actual field may have significantly lower COPC concentrations because of preferential flow pathways. This is true for very soluble substances like Na, K, but in many cases it may not be true for solubility controlled substances!!

EPA Response: Additional language has been added to explain the difference in field results due to preferential flow for available content-limited versus solubility-limited constituents to the reader.

Excerpt: Page 4-23 section 4.3 last line of first paragraph: … a significant effect on ….

EPA Response: The word "effect" was added.

Excerpt: Page 4-23 bullets: External stresses – acids, carbon dioxide and dissolved organic matter are also the result of biological degradation of organic matter and hence can be a consequence of the biological reactions mentioned in the first bullet. These effects can be internal to the material to be assessed or from external sources.

EPA Response: clarification added "…, including the change in redox, production of carbon dioxide, organic acids or other products of biodegradation that may change pH or liquid-solid partitioning of some constituents;"

Excerpt: Page 4-23 5th bullet: add chloride

EPA Response: Chloride has been added to the fifth bullet.

Excerpt: Page 4-23 just before 4.3.1: Possibly add example on role of DOC due to degradation and redox variation through modelling (MSWpaper 2017)

EPA Response: Test added to provide clarification: "…As a result, understanding how the variability of the different chemical and physical factors (e.g., pH, redox, dissolved organic carbon) can affect the leachability of each constituent of concern is key to understanding how the material will behave from a leaching perspective in an application scenario. Insights to these affects can be gained both through LEAF testing and geochemical speciation modeling (U.S. EPA. (2014c); van der Sloot et al, 2017)."

Excerpt: Page 4-25 first line: add municipal solid waste

EPA Response: Municipal solid waste has been added.

Excerpt: Page 4-26 line 8: add reference to MSWpaper 2017 in Waste management

EPA Response: The reference, MSWpaper 2017, has been added.

Excerpt: Page 4-26 section 4.3.2: … soluble Pb(OH)4-2-may precipitate as insoluble Pb(OH)2.Note: Pb(OH)2 is very insoluble over a wide pH range and Pb-carbonate may form, but sorption on to hydrated iron oxide is more likely at almost neutral pH.

EPA Response: The potential for lead oxides formation has been added to the section.

Excerpt: Page 4-31: …………. Fig 4-10: reference to Book: Harmonisation of Leaching extraction methods 1997.

EPA Response: The reference has been added.

Excerpt: Page 4-36 section 4.4.3: to equation 4-14 add reference to Hjelmar 1990.

EPA Response: The reference has been added.

Excerpt: Page 4-38 first bullet: replace other constituents by major elements.

EPA Response: "other constituents" has been replaced with "non-COPCs."

Excerpt: Page 4-43: Note that solubility control may occur over a section of the full pH range. Plotting 1316 and 1314 data in a pH dependence plot obtained with 1313 data in mg/l and mg/kg also reveals what condition applies. And there are intermediate situations, where it is not entirely one or the other.

EPA Response: A footnote was added to explain this concept.

Excerpt: Page 4-44 - bottom left figure: in case of solubility control slope is 1 or very close to 1.

EPA Response: Added clarifying text (as indicated by underline): "…For solubility-limited release, the mass release Method 1316 usually is a strong function of L/S <u>(slope of approximately 1 of concentration as a function of L/S)</u>, increasing with L/S to a value that is only a fraction of the available content under laboratory conditions."

Excerpt: Page 4-47 last line: Figure 3-6 has no 1313 data only 1315 data.

EPA Response: The document was revised to refer to Figure 4-18 instead as the correct comparison of 1313 to 1315 is available.

Excerpt: Page 4-48 fig 4-19: Color coding not clear and legend missing.

EPA Response: Figure 4-19 was removed and Figure 4-18 was used to illustrate similar points with different species.

Excerpt: Page 4-48 second bullet: Fig 3-6 does not show this

EPA Response: The document was revised to refer to Figure 4-18 instead as the correct comparison of data from 1313 and 1315 testing is available.

Excerpt: Page 4-48 bottom of page: Here the difference between the interior of the product (higher pH at low L/S in pores) and the outside surface and external solution results in a pH gradient and hence in a Al concentration gradient leading to Al diffusing out.

EPA Response: The pH gradient between the interior and outside surface of the product has been explained in the text.

Page 4-50 Middle of page: add reference to Van der Sloot et al, 2017 on MSW.

EPA Response: The reference has been added to the text.

Excerpt: Page 4-50 paragraph in the middle – last line: add changes in the level of dissolved and particulate organic matter due to biological degradation.

EPA Response: The suggested insertion has been added.

Excerpt: Page 5-1: Additional case showing the assessment for a monolithic product would be helpful.

EPA Response: An additional case study for monolithic soil has been added.

Excerpt: Page 5-1 to 5-13: Very clear layout of steps.

EPA Response: Thank you for your comment. No change.

Excerpt: Page 5-4: Issue in judgement on the basis of concentration only. If for a constituent release is solubility controlled (meaning constant concentration irrespective of L/S until the controlling phase runs out) and the level is just below the regulatory concentration limit, then the long-term release into the environment can become quite high. Is this a consideration or is there another way around that?

EPA Response: EPA agrees that it is not always appropriate to judge the leachability of a material based on leach test concentrations alone. For example, in some situations contaminant concentrations may increase with time. In other situations, contaminant concentrations may release at a constant rate until the available mass depletes. In the case study, Method 1313 and Method 1314 results are assumed to be representative of field conditions based on knowledge of the environmental conditions.

Excerpt: Page 5-13 Table 5-6: I am puzzled by the selection of Cr III and Se IV in this calculation. Often there is a distribution of Cr III and some Cr VI. They can exist together as has been shown. The same is true for Se VI and Se IV. Generally, the leachable part is the more mobile fraction. Hence one should calculate with the more mobile species rather than the immobile ones. In our experience Cr and Se are mobile in fly ash systems.

EPA Response: The indicated table and associated content was removed due to broader concerns that the example provided an oversimplification of dilution and attenuation.

DCN: EPA-HQ-OLEM-2017-0210-0093

Excerpt: Appendices Comments

Page A-1: PrEN 15863 should be EN 15863

EPA Response: The reference has been changed to EN 15863.

Excerpt: Page A-1 : For 1316 there is an equivalent in EU for Waste: EN 12457-1 (L/S=2) and EN 12457-2 (L/S=10) these form 2 of the 5 steps in 1316.

EPA Response: The referenced test methods have been added.

Excerpt: Page A-2: EN 12457 reference web link

EPA Response: The reference and web link has been added.

Excerpt: Page A-2: Replace PrEN 14405 by EN 14405 with new weblink

EPA Response: The reference has been changed to EN 14405.

Excerpt: Page B-2 and 3: Fig legend missing Green square - interpolated 1313 data

EPA Response: The figure legend has been updated.

Excerpt: Page B-3: it is confusing to have legend symbols that are not in the graph.

EPA Response: The figure legend has been updated.

Excerpt: Page B2 to B-11: In addition to the individual graphs, it would be good to show the interrelation between the 1313-1316 series methods.

Response: The interrelation between the 1313-1316 series methods is shown in Figure 4-5 of the How-To Guide. To demonstrate this for all data series would generate a large number of additional tables.

Excerpt: Page B-12 and following: Instead of showing all tables for EaFA and CaFA, it might be sufficient to show the tables for EAFA and supplement the Appendix with graphical data for a few other relevant matrices such as contaminated soil, municipal solid waste incinerator ash, recycled concrete aggregate, red mud, …. for Guide users that have more affinity with other matrices than coal fly ash. Alternatively, such information could be made available through LeachXS Lite.

Response: The intended audience for the LEAF How-To Guide is diverse and some users may benefit from the tables currently in the appendix. As EPA continues to develop supporting materials for LEAF we will consider adding other relevant matrices.

DCN: EPA-HQ-OLEM-2017-0210-0094

Excerpt: In the Introduction, the authors state that laboratory leaching tests provide the basis for:

(1) Estimating which constituents will leach;

(2) Estimating the rate at which constituents will leach; and

(3) Identifying the factors that control leaching.

I believe that the document provides potential users of the LEAF methods with sufficient information to answer these questions. The document does a good job of explaining how to do screening assessments. The tables that provide potential uses for the individual LEAF methods (e.g., Table 3-2) are a good to help potential users apply the methods. However, these tables (or a subsequent summary) could be combined with more general instruction such as the flowchart in Figure 4-6.

EPA Response: The introduction has been revised to include a table summarizing the key topics in each section and a new figure that relates the LEAF test methods to the environmental parameters varied by the tests and the assessment approaches outlined in the document.

DCN: EPA-HQ-OLEM-2017-0210-0094

Excerpt: Potential users will often start out with a specific problem such as "can we safely dispose of a specific material in a landfill?" or "can we safely incorporate a coal combustion byproduct into this end-use application?" The guide should make it easy for potential users to answer these questions, give them guidance on how to structure a testing program, and finally provide information on which specific tests to carry out. This information is all in the guide, but not easy to find in one place. Can the Introduction be revised to provide high-level guidance (similar to Figure 4-6) up front, and then better guide readers to the appropriate sections of the guide?

EPA Response: The introduction has been revised to include a table summarizing the key topics in each section and a new figure that relates the LEAF test methods to the environmental parameters varied by the tests and the assessment approaches outlined in the document.

DCN: EPA-HQ-OLEM-2017-0210-0094

Excerpt: Here are a few specific comments related to the text itself:

a) Page 1-2: "LEAF provides a consistent approach [to] estimating leaching…" Preposition appears to be missing.
b) Page 1-2: Sentence ending "…placement on land and COPC release under the conditions defined in the scenario" is missing a period at the end.
c) Page 2-1: Has the acronym POC been previously defined?
d) Page 4-1: Has the acronym DAF been previously defined?
e) Page 4-25: The issue of the reducing-oxidizing potential in the tests and in the real-world situations can be very important, as noted. Is measuring ORP during a LEAF test sufficient? How would one evaluate the effects of potential changes in ORP on leaching in the specific environmental scenario? Is this outside of the scope of the LEAF methods?

EPA Response:

a) The sentence has been revised.

b) A period has been added to the end of the sentence.
c) The acronym POC is previously defined as point of compliance. POC has been added to the list of acronyms and abbreviations.
d) The acronym DAF is now defined as dilution and attenuation factor on page 4-1.
e) The relation to redox and use of ORP measurements has been expanded in Section 4.3.1 Reducing and Oxidizing Conditions.

DCN: EPA-HQ-OLEM-2017-0210-0094

Excerpt: Overall, this is a well-written guidance document, which is needed to help potential users gain maximum advantage from the LEAF methods. It would benefit from better high-level guidance early in the document.

EPA Response: The introduction has been revised to include a table summarizing the key topics in each section and a new figure that relates the LEAF test methods to the environmental parameters varied by the tests and the assessment approaches outlined in the document.

DCN: EPA-HQ-OLEM-2017-0210-0097

Excerpt: The LEAF How-To Guide explains many terms and methods used in LEAF in the plainest language our commenters have seen to date. Nonetheless, many explanations will be difficult to understand for those without a chemistry background.

EPA Response: The document is written for a diverse audience. The terms and methods used in the How-To Guide will provide more of a benefit to some users than others. The Agency will continue to consider a broad audience as it develops future materials.

DCN: EPA-HQ-OLEM-2017-0210-0098

Excerpt:

Page xii: The definition for leachate uses the word “leachate”. “Water” or “liquid” may be a more appropriate word.

EPA Response: The word “leachate” has been replaced with “leachant” in the definition of leachate.

Excerpt:

Page 2-3 Footnote: The discussion of adsorption-controls versus solubility-controls is important and well-stated. Depending on the surface charge of a granular material, adsorption can result in a constituent concentration much lower than expected based on solubility alone.

EPA Response: The dependence on surface charge has been added to the footnote on page 2-3.

Excerpt:

Page 2-7 Bulleted List: We suggest adding a bullet for diagenesis, as a broad term that could include both self-cementation and natural weathering.

EPA Response: A bullet point was added to specifically mention weathering and self-cementation.

DCN: EPA-HQ-OLEM-2017-0210-0098

Excerpt:

Available Content: It is important to note that available content as described by leaching at pH 2, 9, and 12 represents an available mass and not a maximum leachate concentration (unless it is within the expected pH domain). This point is made in the document. However in some of the discussion it is treated more as a concentration, such as Table 5-1, where it is expressed in units of mg/L. This may lead to confusion and inappropriate use of the available content values as leachate concentrations. Consider expressing the available content in units of mg/kg, as is done with other similar measures such as environmentally recoverable content, to avoid misuse or misunderstanding of the data.

Excerpt:

From the example provided, it appears that pH 2 and 13 would generally be sufficient to characterize available content. The pH 9 concentration was the maximum in only 1 of 18 cases in Table 4-1 (SWA Se; Mo was within the uncertainty), and would be captured if it was in the relevant pH domain anyway.

EPA Response: The available content is expressed as mass per dry mass. The use of concentrations is from testing of available content using Method 1313. The user will have to convert concentrations from Method 1313 to a mass per dry mass basis. The pH endpoints of 2, 9, and 13 were chosen to provide an available content estimate for the majority of materials and environmental conditions. In some cases, pH 9 will have the highest available content estimate. The measurement of leaching in the relevant pH domain is beyond the scope of estimating the available content using the pH endpoints of 2, 9 and 13.

DCN: EPA-HQ-OLEM-2017-0210-0098

Excerpt:

Screening Assessments: It is somewhat confusing that Step 3 of the procedure uses L/S adjusted equilibrium-pH concentrations for constituents with available content driven behavior, and Step 4 uses equilibrium-pH concentrations that are not adjusted. This would benefit from clarification. For samples with only solubility controls, there would be no need to proceed to Step 4, as the maximum concentrations could only be higher when using the highest concentration of Step 3 or 4. This limitation should also be noted on Figure 4-2, because most constituents are unlikely to see the implied maximum concentration decrease shown in Step 4.

It is interesting to note that in the Case Study, the maximum concentrations in the Full LSP assessment for available content driven constituents (Sb and Mo) were significantly lower than their L/S adjusted equilibrium-pH concentrations. More importantly, it seems inappropriate to use the maximum concentrations from the column test or L/S adjusted equilibrium-pH tests in an “infinite source” screening assessment, because this concentration may only represent very early data that occurs for a short time period at the beginning of the test.

EPA Response: The commenter is correct that the equilibrium L/S testing will provide similar leaching values to equilibrium pH testing if the system is not limited by mass transfer, or percolation. However, without the equilibrium L/s testing, the user would be assuming the system is solubility limited. The infinite source screening assessment is relying on pore water concentrations, which are estimated by the maximum concentrations that occur at the beginning of the test.

DCN: EPA-HQ-OLEM-2017-0210-0098

Excerpt

Determining the Applicable pH Domain: This step is critical when using Method 1313 to estimate long-term leachate concentrations, and EPRI concurs with EPA's decision to include this in the Guidance. Given its importance, we suggest more discussion and examples of how to determine the applicable pH range. The Guidance establishes a standard range of 5.5 to 9.0 for coal ash, and provides instances where this could be expanded (e.g., alkaline coal ash could increase the upper end of the range), but not reduced. However, no justification is provided for the standard range based on the evolution of ash pH in a natural environment. For example, what environmental conditions and timeframes would be necessary for pH of a highly alkaline ash to decrease to 5.5? Similarly, what environmental conditions and timeframes would be required for an acidic ash to increase to pH 9? The document would benefit from a discussion on how one can estimate a realistic pH range based on site-specific conditions.

EPA Response: The standard range of 5.5 to 9.0 is applicable to a general environmental scenario. The expansion of the pH range for coal ash is an example of an assessment but is not necessarily applicable to coal ash under all conditions. The Agency agrees that further discussion of adapting pH to site specific conditions is important and will consider this when developing supporting materials in the future.

DCN: EPA-HQ-OLEM-2017-0210-0098

Excerpt

Percolation Scenarios (Section 4.2.5.3): This section contains a good discussion of the potential differences between field concentrations and Method 1314 data due to preferential flow pathways, indicating that field concentrations may be an order of magnitude lower than the 1314 results. More guidance/examples for using 1314 data to develop realistic time-varying source concentration and for adjusting 1314 concentrations for preferential flow would be helpful. It is unlikely that the very high concentrations sometimes observed in the early stages of a column test will be realized or persist in the field.

EPA Response: Thank you for the comment. Additional examples and studies of 1314 data versus field results could be important to refining leaching estimates. The Agency will consider this when developing future supporting materials.

DCN: EPA-HQ-OLEM-2017-0210-0098

Excerpt

Mass Transport Limited Leaching Scenarios (Section 4.2.5.4 and Section 4.4.6): These sections contain a good discussion of why the Method 1315 data may be biased high based on an "infinite bath" approach, and therefore should not be used for direct estimation of field leachate. However, more practical guidance/examples of how to use the Method 1315 data with Fickian diffusion models to develop source terms for monolithic materials is needed. Mass transport limited leaching is one of the least understood of the leaching mechanisms by most practitioners.

EPA Response: A new case study has been developed to provide example estimation of field leachate from Method 1315. The Agency will consider the need for further examples on mass transport limited leaching when developing future supporting materials.

DCN: EPA-HQ-OLEM-2017-0210-0098

Excerpt

Figure 4-13: What data were used for this figure? Was coal ash total porosity or effective porosity used?

Equation 4-16: Please clarify that "Cleach_max is the estimated maximum concentration for COPC within the applicable pH range."

Figure 5-1: Although referenced in the text and the figure legend, there were no orange diamonds or open circles on the figure.

Page 5-7 and Table 5-3: The text states that only barium is acceptable based on the calculated AR. The ARs for boron and lead are also below 1, so these constituents would also would be acceptable using this criteria.

EPA Response: The data for Figure 4-13 is coal fly ash. Porosity for the coal ash was estimated from annual infiltration rates for the locations in the CCR risk assessment. Cleach_max has been clarified to be the estimated maximum concentration for the COPC [mg/L] (within the applicable pH domain when using Method 1313 results or L/S range when using results from either Method 1314 or Method 1316. Figure 5-1 has been fixed so that there are now orange diamonds and open circles. The text describing the results in Table 5-3 has been updated to reflect that boron and lead are also acceptable based on the AR being below 1.

9. Other Topics

DCN: EPA-HQ-OLEM-2017-0210-0093

Excerpt: General: Great to have a guide on leaching test use with explanations on what tests are for and how to use them!!

EPA Response: Thank you for your comment. No change.

DCN: EPA-HQ-OLEM-2017-0210-0097

Excerpt: Not all members were aware that compilations existed of LEAF studies already performed on various waste streams, especially on coal combustion residuals. Members recommend EPA continue to announce when peer-reviewed studies using LEAF on other waste streams have been completed. Waste and by-product streams of concern to Task Force members include, but are not limited to, construction and demolition debris fines, steelmaking slag, oil and gas development drill cuttings, and dredged material.

EPA Response: The Agency continues to develop more tools and studies on leaching of wastes. You can check https://www.epa.gov/hw-sw846 and sign up for the SW-846 mailing list to receive updates as they are available.

DCN: EPA-HQ-OLEM-2017-0210-0098

Excerpt: Overall this Guidance is well written and provides an excellent resource on general leaching geochemistry as well as the rationale behind the various tests comprising the LEAF protocol. The LEAF suite of tests and the data they generate are more complicated to use and understand than the conventional single-point tests such as TCLP and SPLP. As a result, this Guidance is highly technical in nature, and provides a good reference for leaching geochemistry and the basis of the LEAF methodologies, including the fundamental strengths and weaknesses of the approach. Given the complexity of the framework there is a clear need for a Guidance such as this, as evidenced by the confusion and misuse/misinterpretation of data generated using LEAF since its development.

EPA Response: Thank you for your comment. No change.

DCN: EPA-HQ-OLEM-2017-0210-0099

Excerpt: The LEAF How-to Handbook is very helpful in understanding the LEAF process and methods. The contents outlines the intended use of LEAF, defines conditions for use, demonstrates how to set up a program, and outlines the methods.

EPA Response: Thank you for your comment. No change.