Meeting with US NRC

Discuss Clarifications of NRC RAIs/Observations on NEI 22-01, Revision 1

July 2, 2025

NUCLEAR ENERGY INSTITUTE

RAI 1 Determining Dose Contributions from Backfill

- NRC Request: Further discussions between NEI and the NRC staff are warranted on the topic of assessing potential dose from backfill. Based on these discussions, NEI should add specific language to Section 5.2.8 stating that reporting of actual results is recommended along with a discussion regarding the use of negative values for summary statistics and statistical tests vs. dose estimation as outlined above.

- NEI Discussion Points:
  - Non-impacted barrow areas to have no dose assignment
  - Backfill from impacted areas have appropriate surveying to attribute dose to filled area
  - Adequate sample density
  - Use of actual sample values or critical detection limits

RAI 2 Reporting Groundwater Radionuclides Results

- NRC Request: Clarify in NEI 22-01 the treatment and reporting of analytical results that fall between the critical level and the MDC for estimating residual radioactivity and dose due to residual radioactivity in groundwater. Clarify the interpretation of laboratory analytical results between the critical level and MDC. Discussions between NEI and the NRC staff are warranted to ensure agreement on the clarifications.

- NEI Discussion Points:
  - Reporting analytical results >Lc
  - Our processes must accept 5% frequency of results >Lc as expected and not automatic “Positive”
  - Unnecessary expense

RAI 3 Sorption Coefficient (Kd) Estimates (1/12)

- RAI Summary - Clarify in the NEI 22-01 guidance that measurements of sorption coefficients are not required at sites based on NRC's guidance in DUWP-ISG-02. Further discussions between NEI and the NRC staff are warranted on what is meant by site-dependent information and representativeness of site information to the appropriate media (e.g., contaminated zone or groundwater flow pathways).
- NEI Reply – NEI will add discussion to NEI 22-01 concerning Kd from DUWP-ISG-02, Section 3.3.2, *Determining if a Parameter Value is Risk-Significant*. The following slides summarize these additions.

RAI 3 Sorption Coefficient (Kd) Estimates (2/12)

- Excerpt from DUWP-ISG-02 – *Therefore, as a starting point, only Kd values for radionuclides that have a potential to lead to doses greater than 0.025 mSv/yr may require additional support, and only if they are found to be risk-significant. For example, if there is little uncertainty in the Kd value, additional support is likely unneeded.*

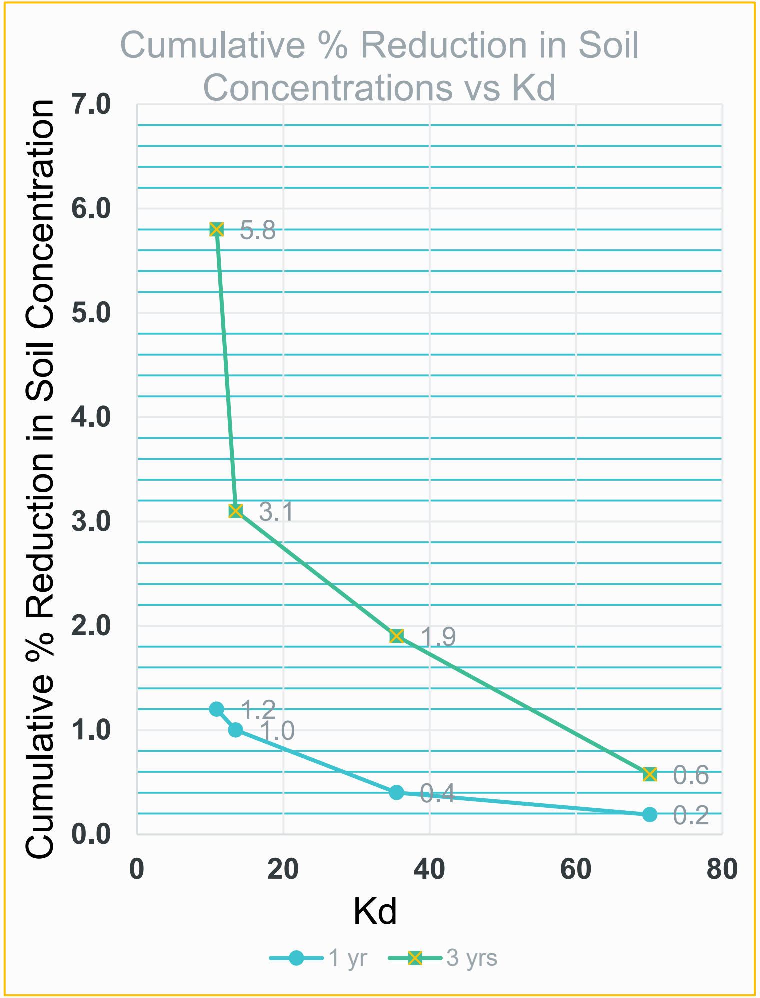
- Proposed discussion in NEI 22-01, Significant Radionuclides: Past experiences from typical power plant sites have shown that only:
  - A few radionuclides have been detected in soil in quantities that would sum to a dose that would exceed 0.025 mSv/yr
  - Only a very few radionuclides have been detected in groundwater

RAI 3 Sorption Coefficient (Kd) Estimates (3/12)

- Proposed discussion in NEI 22-01, Significant Radionuclides (Cont.): DUWP-ISG-002, Table 3.6 provides a list of radionuclides including some characterized as having a relatively high uncertainty in defining the values for Kd and/or for which a site-specific study is recommended. NEI has performed a review of experiences at US nuclear plants including the LTPs of five plant sites that used RESRAD with the resident farmer scenario to determine DCGLs for soil. The following are the results that review for the subset of radionuclides discussed in DWUP-ISG-002 concerning:
  - Concentrations of these radionuclides in soil and groundwater
  - Results of sensitivity analysis for radionuclides measured in significant quantities

RAI 3 Sorption Coefficient (Kd) Estimates (4/12)

- Using the results of the RESRAD code from the Connecticut Yankee LTP*, the graph shows the cumulative reduction in contaminated zone soil concentration as a function of the Kd used for in the analysis. The graph shows that for a Kd of 13.5, the soil concentration would reduce by 1% in one year and reduce by approximately 0.35% in one year for a Kd of 50.
- This shows that for Kds 13.5 and above:
  - Peak dose for the nuclide (except for Pu-241**) occurs at time zero when all dose is from unsaturated soil related dose pathways
  - Increasing the values of Kd above 13.5 will not increase the DCGL by more than 1%



Kds Used:
Sr-90: 10.9
Tc-99: 13.5
Ni-63: 35.5
C-14: 70.1

*Haddam Neck Plant License Termination Plan, Revision 1

**Peak dose for Pu-241 is at 62 years due to decay to Am-241 but all dose is from unsaturated soil related pathways.

RAI 3 Sorption Coefficient (Kd) Estimates (5/12)

- Am-241- Radionuclide has not been detected at significant quantities in soil at any power plant site except Connecticut Yankee (CY). At CY, elevated quantities of Am-241 were measured in the sand bed directly below an outside tank that had experienced long-term leakage. The contamination was on top of the concrete base slab for the tank and did not spread any distance from the slab. The Am-241 contamination and was totally remediated as high levels of Co-60 and Cs-137 were also present. Am-241 was not detected in groundwater at the site.

- Concerning the sensitivity of dose to the Americium Kd, for the four approved LTPs reviewed where sensitivity to Kd was analyzed, it was not sensitive for three cases and showed positive sensitivity (i.e., PRCC>0.25) in one case (Yankee Rowe). The lowest Kd used at any of these sites was 1,250 (Ft Calhoun using median value). These experiences show that to use very low Kds for Am-241 would actually increase the DCGL as the parameter is positively correlated to dose.

RAI 3 Sorption Coefficient (Kd) Estimates (6/12)

- Other radionuclides for which additional support in selecting a Kd value from literature parameter range is unlikely considered the criteria stated in DWUP-ISG-002, contingent on the results of characterization surveys:
  - C-14 - Radionuclide was detected in soil at three of the sites reviewed (CY Rancho Seco and Yankee Rowe) at low fractions of the DCGL concentrations. Concerning the sensitivity of dose to the C-14 Kd, for the four approved LTPs reviewed, it was only sensitive for two cases (both positive correlations for Fort Calhoun and Connecticut Yankee). These experiences show that to use low Kds for C-14 would increase the DCGL.
  - Fe-55 - Radionuclide has been detected but only at levels that are a small fraction of the very high Fe-55 DCGL (typical soil DCGL value 27,400 pCi/g for CY). We are not aware of any power plant site where Fe-55 has been detected in groundwater.

RAI 3 Sorption Coefficient (Kd) Estimates (7/12)

- Radionuclides that are likely to be considered insignificant (cont.):
  - I-129 – Radionuclide has not been detected at the five plant sites reviewed and it was determined not to be a radionuclide of concern at any of these sites.
  - Tc-99 - Radionuclide has not been detected in significant concentrations at the sites reviewed and it has not been determined to be a radionuclide of concern at any of these plants. It should be noted that concerning the sensitivity of dose to the Tc-99 Kd, for the four LTPs where sensitivity to Kd was analyzed, positive sensitivity was shown in all cases. These experiences show that to use very low Kds for Tc-99 could increase the DCGL.
  - Plutonium Radionucides were not been detected in soil at concentrations that are significant compared to their DCGLs at the sites reviewed. Plutonium has not been detected in groundwater at any US power plant site.

RAI 3 Sorption Coefficient (Kd) Estimates (8/12)

- Ni-63 - Radionuclide has been detected in low concentrations in soil and groundwater at a few plant sites. Ni-63 was deselected for Fort Calhoon as there were no detections there. Remediations at CY were not driven by Ni-63 as the concentrations were a very small fraction of the DCGLs (723 pCi/g).

  Concerning the sensitivity of dose to the Ni-63 Kd, for the four LTPs where sensitivity to Kd was analyzed, it was not sensitive for three cases and showed positive sensitivity in one cases (Fort Calhoun). The lowest Kd used at any of these sites was 62 (from soil testing at Zion). Using higher Kds than this value would likely have less than a 1 percent increase of the DCGL.

  Although most sites should be able to classify Ni-63 as insignificant, sites that detect high levels of Ni-63 in soil and/or groundwater (i.e., approaching the EPA MCLs) should consider further evaluation of the mobility of Ni-63.

RAI 3 Sorption Coefficient (Kd) Estimates (9/12)

- H-3 - Radionuclide has been detected in soil and groundwater at many power plant sites (although mostly at relatively low concentrations). Tritium was deselected for Fort Calhoon, Rancho Seco and Zion as there were little or no detections there. Although elevated levels of H-3 were measured in groundwater at CY and Yankee Rowe, remediations at these sites were not driven by H-3, as the soil concentrations were a very small fraction of the DCGLs (lowest value, 372 pCi/g at Yankee Rowe).

  Concerning the sensitivity of dose to the H-3 Kd, for the four LTPs where H-3 Kd sensitivity was analyzed, Kd was not a sensitive parameter for Rancho Seco and a negative sensitivity was shown in the other three cases. For these later three sites, a H-3 Kd of 0.043 was selected from the parameter range. DWUP-ISG-002 recommends a Kd of zero for H-3. The DCGL analysis at CY showed that only 15.4 % of the dose from H-3 was from water dependent pathways. Use of a H-3 Kd value of zero could result in higher H-3 DCGLs for soil.

  Although many sites may be able to classify H-3 as insignificant, sites that detect high levels of H-3 in soil and/or groundwater (i.e., approaching the EPA MCLs) will likely need to consider H-3 as a radionuclide of concern.

RAI 3 Sorption Coefficient (Kd) Estimates (10/12)

- Sr-90 – Although not a radionuclide for which DWUP-ISG-002 recommends further justification for the Kd selection, a few sites may consider it a radionuclide of concern if it is detected in high concentrations in soil and/or groundwater (i.e., approaching the EPA MCLs). At Connecticut Yankee, although shallow soil remediations were driven by Co-60 and Cs-137, deep soil and bedrock remediation was driven by Sr-90 to reduce levels of Sr-90 in groundwater below the EPA MCLs. Sites that have a similar situation to CY will likely have performed more extensive groundwater and soil characteristic studies such that information to support a selection of Kd for Sr-90 should be available.

  It is noteworthy that although the Kd value for Sr-90 determined by testing of soil at Zion was 2.3, the resulting soil DCGL calculated for Zion showed good agreement with the Sr-90 soil DCGLs calculated for Connecticut Yankee and Yankee Rowe where much higher Kds were used. One possible explanation for this is that the sensitivity of dose to the Sr-90 Kd, for the four LTPs reviewed, no sensitivity was shown in three cases and a positive sensitivity was shown in one cases (Fort Calhoun).

RAI 3 Sorption Coefficient (Kd) Estimates (11/12)

- Co-60 and Cs-137 – Although these are the primary radionuclides in contamination at power plant sites being decommissioned, dose has not been shown to sensitive to Kd for all sites reviewed except for a positive sensitivity for Co-60 at Fort Calhoun. Neither radionuclide has been detected in groundwater except for Cs-137 in wells very near two source areas at Connecticut Yankee. As the lowest Cs-137 Kd used at sites reviewed is 446 at CY, increasing Kd above this values would have had minimum effect on the Cs-137 DCGL.

RAI 3 Sorption Coefficient (Kd) Estimates (12/12)

- Summary:
  - At most nuclear power plant sites for which LTPs have been approved and the resident farmer scenario has been used in determining DCGLs:
    - Only a few of radionuclides have been detected in concentrations that are greater that a few percent of the soil DCGLs and would therefore meet the criteria in DWUP-ISG-002 to be recommended for further evaluation of their Kd for use in dose modeling.
    - Of these few radionuclides, only H-3 has shown a sensitivity where dose could be affected by the Kd selected.
  - Power plant sites should review their soil characterization results to determine if either of the two criteria stated in DWUP-ISG-002 apply and the need for further justification of the Kd parameter evaluated.

Observation 2: In-situ Gamma Spectroscopy

- NRC Proposed Change: Language could be included, when using in-situ gamma spectroscopy to reflect that efforts should be made to ensure this instrumentation is used for relatively homogeneous materials. As such, preliminary scans using handheld gamma detectors may be practical to provide assurance that “hot spots” are not being averaged out due to wide field-of-view settings. If an elevation is detected, the instrument may need to be brought closer to provide a smaller field-of view, to assess “hot spot” contamination levels. It is also necessary to provide a good model of the contamination profile in the material being analyzed, so some characterization may be required. Lastly, the efficiency model should be of the actual materials being analyzed while some of the criteria may be in “dry” units (e.g., pCi/g criteria in soil). Sampling may be necessary to assess the percent moisture or similar parameters to correct the measurement data for proper comparison
- NEI Discussion Points:
  - Agree for use in radiological areas (open land areas and excavations)
  - For out-lying non-radiological open land areas less concerns for confirmatory sampling, water content, hot spots, etc.
    - Usually, class 3 or non-impacted area characterization
    - Less than 10% of DCGL
    - Primarily direct exposure pathway

Observation 3: Monitoring Plan for Groundwater to support FSS

- Observation Summary - Licensees should provide an evaluation of groundwater monitoring network and a plan for the sampling program that meets the needs specified in the LTP for the final status survey. This evaluation and plan should consider the need for trends in groundwater data over some period of time after completion of potential soil disturbance activities such as excavations, building demolition, or other demolition activities that may mobilize radionuclides. The period of time is site-dependent but generally on the order of two years.

- NEI Reply – It should be clarified that for some sites, soil disturbance activities such as those mentioned above will be carried out in locations were there are little or no mobile radionuclides present. In these cases, there is no need to perform a post disturbance monitoring period as these activities would have minimal impact on groundwater.

  Additionally, experience has shown at power lant sites that groundwater concentration increases typically occur as a result of seasonal high precipitation periods. For power plant sites that have measured groundwater contamination levels that approach or exceed the MCLs, and depending on the beginning of the post disturbance monitoring period, an 18-month period may cover two annual high precipitation seasons.

Observation 5: Objectives of Site Characterization

- NRC Proposed Change, Second Paragraph: Language could be added to note that samples of the highest activity materials in the reactor vessel and surrounding concrete should be taken to obtain concentrations in support of potential discrete radioactive particles (DRP) assessments.

- NEI Discussion Points:
  - RV samples very expensive and not needed. Can use calculations used for waste disposal.
  - Concrete samples must wait until RV removed
  - Dose models not yet available

Observation 6: Surrogate Radionuclides

- Topics of NRC Proposed Change:
  - Surrogate radionuclides presume some similarity in movement/causality is present.
  - The primary and surrogate radionuclides should have a well-defined relationship.
  - Surrogate ratios are for a given survey area and may not apply across the whole site.
  - Extending the use of surrogates beyond one inferred radionuclide is difficult to do.
- NEI Discussion Points:
  - Very Few NPPs have multiple surrogates
  - Surrogates can vary substantially even within a survey area. Therefore, combining many samples and establishing a conservative surrogate relationship is appropriate
  - No NPPs have detected Tc-99, Np-237 in groundwater. Positive analytes have included H-3, Ni-63, Sr-90 and Cs-137. Surrogates generally have not been used in groundwater monitoring

Observation 14: Small Decision Units

- Observation Summary - Additional information could be added to Section 5.3.2 explicitly advising FSS to be performed prior to backfilling. Additional surveys of backfilled materials may also be warranted. Surveying backfilled/impacted areas prior to covering with non-impacted materials/grading could avoid additional costs for subsurface sampling. **Language could also be added to Section 5.3.2 noting that when using a GeoProbe or boring to get samples, the entire length of the core should be scanned with a gamma detector to verify that there is no “layer” of contamination that will be averaged out when compiling the sample from the core.**
- NEI Reply: The need to scan the entire length of the core depends on the scenario used for dose modeling. For example, if the scenario is the resident farmer and the assumed contamination thickness in the dose model is 1 meter, there is no need to scan the length of a 1-meter core as the model assumes that the contamination is averaged of the full 1 meter depth. Additionally, NRC guidance on the excavation and well drilling scenarios in NUREG-1757 seems to disagree with the bolded statement above as the NUREG states that the contamination in the soil removed under these scenarios is averaged over the material removed. The highlighted statement should be qualified.

Observation 15: Removable Activity (but appears to be related to FSS report content)

- NRC Proposed Change: Incorporate the following bullets in the “other information to be included in the survey unit and FSS reports,” portion of Section 9.2.
  - What existed in the survey unit
  - What radiological operations occurred in the survey unit
  - What remediation was performed or what structures removed
  - Were any DRPs identified during FSS
  - Was a FSS failed and had to be reperformed, and if so, what was the scope of any post FSS remediation
  - Did scanning identify significant elevations that required investigation
  - Were any elevations identified
  - Are there any unusual characteristics that the reviewer should be aware of (e.g., two surveys reported for a survey unit...one of bottom of excavation and another of top of backfill,), etc.
- NEI Discussion Points:
  - Do we need histories of an area to show the as left conditions meet the clearance criteria?
  - Do the scan surveys and sample data support the clearance criteria?
  - Was the information produced in accordance with the LTP?

Observation 24: Data Trends

- NRC Observation: Section 2.5.1, "Identifying Data Trends and Statistical Observations," of NEI 22-01, Revision 1, states that, "[t]he purpose of this trending is to ascertain which data sets can be grouped together in the event there are ROCs specific to such groupings." This section also states that, "in evaluating the potential data trends, the reported measurement uncertainties should be considered for whether data should be included within a trend group." Measurement uncertainties are considered in the DQA step and unreliable results are to be discarded. It is not clear what this has to do with a "trend group".
- NRC Proposed Change: Clarify these sentences. It is not clear what NEI would like to convey. Also, clarity is needed regarding the equation. The need to "grow-in" Am-241 is questionable, as most DCGLs include the progeny in their derivation.
- NEI Discussion Point:
  - Used to normalize the data to a common date, maybe at projected License Termination, not related to DCGLs

Observation 25: Activity Fractions

- NRC Proposed Change: Adding an introductory paragraph to explain why the activity fractions need to be calculated would be beneficial. The introduction might also explain that these calculations should be performed among similar media with similar modes of contamination. For example, Cs-137:U-38 rations in wet soil will likely be very different from that in dry sand. Water samples will be completely different as well.
- NEI Discussion Points:
  - Why are activity fractions needed?
    - The data is evaluated to determine the media that can be grouped based on similar fractions.
    - The example provided using U-238 is not applicable to an NPP.
    - To calculated IC dose and final ROCs.
    - Must use data with substantial activity for statistical power. Soil and groundwater typically has low activity.

Observation 26: Insignificant Radionuclides

- NRC Observation: Section 2.5.3, "Determining Insignificant Radionuclides," of NEI 22-01, Revision 1, discusses insignificant contributors that must be accounted for in the final operational DCGLs.
- NRC Proposed Change: Provide clarity that this determination should be made for each media for which DCGLs will be determined (water, soils). Radionuclides may behave differently in various media (uranium may be mobile or immobile depending on the pH, U-234 can come o/o equilibrium in water, etc…)

- NEI Discussion Points:
  - Typically, not enough activity for water and soils.
  - U-234 not a good example for NPPs

Observation 27: Surrogates

- NRC Observation: Section 2.5.5, "Surrogate Radionuclides," of NEI 22-01, Revision 1, discusses the selection of surrogate radionuclides in order to speed analysis, reduce analytical costs, and to account for hard to detect radionuclides. The approach described in this section would likely be inadequate as described, and might be rejected in the LTP review.
- NRC Proposed Change: Provide clarity regarding why this could or should be done. Depending on the environment being sampled, the relationship between the two can be highly variable. In some cases, the relationship between two radionuclides might not be well established or not reliable. In those cases, no surrogate could be used, or a VERY conservative ratio would be selected and documented.
- NEI Discussion Points:
  - The approach described was used for an approved LTP.
  - The approach used, applies a statistical analysis and selects a conservative ratio (95%) as suggested in NRC comment.

Observation 32 (First Item): NRC Letter Dated April 30, 2024, Comments Remaining to Be Addressed

- Observation Summary - No response to NRC Suggestion 2.50 “Critical Group” has been provided. **Original Comment from April 30, 2024 letter:** *Should expand and clarify the discussion of relevance of soil survey results to ROCs for structures*.

- NEI Reply: Mention of soil samples in Table F-11 of NEI 22-01, Rev O was in error. This note was changed from “soil samples” to "concrete samples" in Rev 1 of the table. We feel that this comment has been resolved in Rev 1 of NEI 22-01.

Observations 8, 13, 19, 20, 22 – Various Topics

- NEI Reply: Portions of these observations for which further NRC guidance is needed: These observations include aspects that involve the measurement and handling of discrete radioactive particles (DRPs).

  In order to completely address these observations, the NRC's guidance in DUWP-ISG-03 needs to be finalized, particularly the portion having to do with the doses that would apply to the intake of DRPs. We look forward to being able to review the upcoming revision to DUWP-ISG-03.

