



**STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION**

Division of Remediation, Oak Ridge Office
761 Emory Valley Road
Oak Ridge, Tennessee 37830

October 28, 2025

Mr. Roger Petrie
Federal Facility Agreement Manager
U.S. Department of Energy
Oak Ridge Office of Environmental Management
Post Office Box 4067
Oak Ridge, Tennessee 37831

Dear Mr. Petrie

TDEC Comments: Supplemental Analysis for the Environmental Management Disposal Facility (UCOR-5843)

The Tennessee Department of Environment and Conservation (TDEC), Division of Remediation - Oak Ridge Office, received the subject document on July 28, 2025. TDEC offers the enclosed comments to support finalization of this report and its incorporation into the Waste Acceptance Criteria (WAC) Compliance Plan (WCP, [DOE/OR/01-3012&D1](#)) for the Environmental Management Disposal Facility (EMDF).

As described in the *Record of Decision for Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Oak Ridge Reservation Waste Disposal at the Environmental Management Disposal Facility, Oak Ridge, Tennessee [ROD]* ([DOE/OR/01-2794&D2/R2](#)), the supplemental "bathtubbing" analysis documented in the report is performed to 1) inform WAC, including inventory limits, for radionuclides and other chemicals to be placed in the landfill, 2) support landfill design, and 3) use CERCLA methodology to demonstrate that the landfill will protect public health over the long term. Consistent with the [Federal Facility Agreement for the Oak Ridge Reservation \(FFA\)](#), the results reported in this secondary document will be incorporated into the WCP, which is a primary document that requires review and approval by TDEC and the U.S. Environmental Protection Agency (EPA).

Questions or comments concerning the contents of this letter should be directed to Brad Stephenson at the above address, by phone at 865-352-1235, or by e-mail at brad.stephenson@tn.gov.

Sincerely

Eileen T. Marcillo
FFA Project Manager
Division of Remediation – Oak Ridge Office

Enclosure

ec: Joanna Hardin, DOE
Dennis Mayton, DOE
Sam Scheffler, DOE
Erin Sutton, DOE
Cathy Amoroso, EPA
John Sayer, EPA
Samantha Urquhart- Foster, EPA
Bruce Stearns, Pro2Serve
Sid Garland, UCOR
Douglas Hanahan, UCOR/RSI EnTech
Steve Kenworthy, UCOR/Strata-G
Jennifer Linton, UCOR
Mary Magleby, UCOR
Annette Primrose, UCOR
Tanya Salamacha, UCOR
Ethan Sweet, TDEC
Randy C. Young, TDEC
OREM Mailroom
ORSSAB

xc: Wade Creswell, ORRCA
Amy Fitzgerald, ORRCA
Terry Frank, ORRCA
Warren Gooch, ORRCA

ENCLOSURE

General Comments

- 1) As a condition for signing the *Record of Decision for Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Oak Ridge Reservation Waste Disposal at the Environmental Management Disposal Facility, Oak Ridge, Tennessee [ROD]* ([DOE/OR/01-2794&D2/R2](#)), the Tennessee Department of Environment & Conservation (TDEC) required additional work to demonstrate that the selected remedy of onsite waste disposal will protect public health over the long term in a manner consistent with CERCLA methodology. The U.S. Department of Energy (DOE) elected to accomplish that objective by conducting a supplemental “bathtubbing” analysis similar to one completed as part of the *Performance Assessment for the Environmental Management Disposal Facility at the Y-12 National Security Complex, Oak Ridge, Tennessee* (PA, [UCOR-5094/R2](#)).

TDEC’s primary objective for requesting additional work was to ensure that waste acceptance criteria (WAC) include protective limits on the inventories of radionuclides and other chemicals to be placed in the landfill. The Supplemental Analysis (SA) report emphasizes protective landfill design, which TDEC also supports.

Revise text throughout the document to acknowledge the objective of informing analytic WAC, as is indicated in the second paragraph of Section 1. Examples of text that warrants revision to highlight the role of the SA with respect to protective inventory limits include, and may not be limited to, Page 2, first and third paragraphs, last sentences; Page 47, last sentence; and Page 47, Section 5.4.

It is important for the SA report to support the protectiveness of EMDF inventory limits, regardless of whether the SA results warrant additional or revised limits in the WAC Compliance Plan (WCP, [DOE/OR/01-3012&D1](#)) beyond those documented in the ROD.

- 2) TDEC acknowledges that the DOE commitments for continuous post-closure monitoring, maintenance, and institutional controls (ICs) made in the EMDF ROD contribute to long-term protectiveness of the remedy. However, the SA is performed as a standalone, quantitative evaluation, regardless of how effectively land use controls (LUCs) may be implemented in the future. The SA should objectively evaluate the risks in terms of ELCR and HI associated with realistic waste inventory ranges to support risk management decisions regarding WAC and ICs, including LUCs, in future documents.

Revise the document to clarify language including and similar to the following statement on Page 3, second paragraph: “...this bathtub release combined with a residential exposure scenario...is inconsistent with long-term ICs, which provides a highly pessimistic (conservative) estimate of potential future human health impacts.” Another example is found on Page 22, Section 4.2 middle paragraph, 3rd and 4th sentences.

ENCLOSURE

In the EMDF ROD ([DOE/OR/01-2794&D2/R2](#), p. 2-50), DOE, EPA, and TDEC agree to assess a bathtubbing scenario as a site-specific approach to evaluating long-term protectiveness after other protections fail and to inform landfill design and WAC. The ROD (p. 2-61) also requires that protectiveness be expressed in terms of the CERCLA risk range (i.e., 1×10^{-4} to 1×10^{-6}) and hazard index (HI) (i.e., $HI \leq 1$).

Statements in the report like those cited above should focus on the SA's role in objectively evaluating risks under reasonable maximum exposure assumptions for potential future land uses to support the need for ICs like LUCs as part of a protective remedial action. As written, these sentences obscure that relationship. Other wording that may benefit from revision include the following.

- a) Page 1, Section 1, 3rd paragraph: The text references "continuous post-closure monitoring, maintenance, and institutional controls" among the attributes upon which the long-term protectiveness of the Environmental Management Disposal Facility (EMDF) will depend. DOE Manual 435.1, Chapter IV(G)(1)(d), cites "minimizing the need for long-term active maintenance" as one of the requirements of waste acceptance at a low-level waste facility.

Revise text (including Page 6, second paragraph, first two sentences) to clarify that the ROD requires completion of the SA as a standalone evaluation, despite the ROD's commitment to perpetual ICs and maintenance as part of the selected CERCLA remedy.

- b) Page 3, Section 2.1, 2nd paragraph, 3rd sentence and Page 21, Section 4.1, 1st paragraph: Revise the sentences to clarify that, while the ROD commits to perpetual monitoring and maintenance as part of the selected remedy, the standalone SA does not rely on that commitment or expectations/probabilities regarding future landfill performance.
- 3) TDEC acknowledges that it is standard CERCLA practice to qualify risk assessments with discussions of the likelihoods of, and uncertainties regarding, elements of the conceptual site model (CSM), future land use, and exposure scenarios. At the same time, CERCLA risk assessments do not assume the effectiveness of future ICs, such as LUCs. Rather, they assess "potential adverse health effects (current or future) caused by hazardous substance releases from a site in the absence of any actions to control or mitigate these releases (i.e., *under an assumption of no action*)" ([EPA Risk Assessment Guidance for Superfund, Part A](#), Section 1.1.2, italics added for emphasis). Objectively evaluating risks under reasonable maximum exposure assumptions for potential future land uses supports selection of a remedial action that may need to include ICs like LUCs to be protective.

ENCLOSURE

TDEC recommends revision of the report (e.g., Sections 2.1, 4.1, and elsewhere) to focus on the role of the SA in supporting the EMDF remedial action (protective WAC) rather than uncertainties regarding the likelihood of bathtubbing or future residential land use. As stated in the ROD (p. 2-50), "The supplemental analysis evaluates long-term protectiveness after other protections fail (such as the aforementioned site characteristics, facility design) and will be used to inform the design and the WAC."

Examples of text that would benefit from revision include, and may not be limited to, the following.

- a) Page 7, Section 2.3.2, 3rd paragraph: The text states that there is significant uncertainty in the amount of leachate that might escape through the liner versus bathtubbing and that "typical engineering design approaches to modeling liner performance do not address scenarios without a functional leachate collection and drainage system (LCS)." Revise the text to clarify that the SA is a standalone evaluation intended to support finalization of inventory limits that are protective over the long term, not to model liner performance during the short term when the LCS is functioning as designed. As noted in the previous comment, the ROD (p. 2-50) calls for the SA to evaluate protectiveness after other protections fail.
- b) Page 21, Section 4.1, 1st paragraph, 3rd sentence: Delete the comma and the subsequent text regarding the lack of a CERCLA requirement. This language is not consistent with the subsequent sentence, which correctly states that the CERCLA ROD requires evaluating a landfill bathtub release scenario.
- 4) The report appropriately highlights the need to evaluate the noncarcinogenic toxicity of uranium (U), which is widely recognized to contribute more potential risk to human health than its potential to cause cancer due to its radioactivity. Therefore, the document should clarify why the SA *assigns* "a total EMDF facility average uranium concentration of 400 mg/kg" rather than using the SA to estimate the maximum concentrations of total U and other projected contaminants that can be released through the bathtubbing scenario without posing unacceptable risks to the residential receptors evaluated in the assessment, as was done for all other contaminants, excluding mercury. Revise the SA to show the cumulative risk using the trigger levels proposed in the WCP for U (800 mg/kg) and mercury (1,000 mg/kg).
 - a) Revise the SA to clarify that CERCLA protectiveness is determined by the ELCR range and HI thresholds, not simply by meeting the critical organ dose criteria in a single Applicable or Relevant and Appropriate Requirement (ARAR), TDEC 0400-20-11-.16(2).
 - b) The report notes that infiltration rates, inventories, and exposure factors come from the PA, but the text does not always cite the specific source within that large document. Insert direct cross-references to the PA (e.g., "see PA Section 3.4.2, Table 7.5") or other documents where appropriate.

ENCLOSURE

- c) The SA reports only four deterministic cases (0% leak, 50% leak, 90% leak, and 50% leak with higher K_d [partition coefficient]). None are designed to evaluate a cumulative HI near 1, and the approach does not quantify uncertainty in key inputs, such as liner leak fraction, infiltration rate, K_d , etc. As a result, for U and mercury, neither the total inventories *assumed* in the SA report nor the trigger levels in the [WCP](#) are shown to be risk-consistent across a realistic range of conditions.

For example, the U inventory *assumed* in the SA report is an average concentration of 400 milligrams per kilogram (mg/kg) throughout the 2.2-million-cubic-yard landfill, and the [WCP](#) assigns a trigger level of 800 mg/kg. The mercury inventory *estimated* in the SA report is an average concentration of 10.1 mg/kg, and the [WCP](#) assigns a trigger level of 1,000 mg/kg. The trigger levels for these two risk drivers are 2 and approximately 100 times greater than the *assumed* concentrations, respectively.

Revise the SA report to provide a probabilistic analysis that captures the ranges of input parameters. Alternatively, show more combinations of input parameters, such as liner leakage rate, K_d values, etc. WAC should be defensible across a range of uncertainty, not just for a handful of point cases. Because the SA specifies that metals HIs scale with the leak-driven groundwater pathway, using single values for leakage and K_d can misrepresent true risk (either too lenient or too conservative).

- 5) The SA report assumes that meteoric water infiltrates through the landfill cover system at an average rate of 0.43 inches per year (in/yr). The report asserts that this rate is “appropriate and protective” (Page 6, third paragraph) and “is considered representative of a bathtub release scenario occurring between 100- and 1000-years post closure” (Page 11, Section 3.2, 1st paragraph). However, text on Page 47 (Section 5.4, first paragraph) notes that greater risks may be associated with larger cover infiltration rates resulting from more severe cover degradation.
- a) Page 6, 3rd paragraph: Add text to explain the origin of the assumed infiltration rate (e.g., Hydrologic Evaluation of Landfill Performance [HELP] model output flux for partial design performance [201–1000 years] from PA Table 3.1.3) and support the assertion that it is reasonable to expect “post-closure cover infiltration will be less than 1 in./yr for at least several centuries, and likely for more than 1000 years.”
- b) Page 6, Section 2.3.1, 5th paragraph and Page 11, Section 3.2, 1st paragraph: Revise the SA to apply, or analyze the sensitivity of, the same range of cover infiltration rates that were evaluated in the PA base case and uncertainty analyses. The EMDF PA base case assumes that infiltration increases linearly from 0.43 in/yr to 0.88 in/yr over the post-closure period of 200 to 1000 years. Since the future cover infiltration rate is independent of whether liquid is released through the liner or through bathtubbing, the cover infiltration rate assumed in the SA should not be less than the PA base case.

ENCLOSURE

- c) Page 47, Section 5.4, 1st paragraph: Revise the text to describe the nature of potential future degradation mechanisms to provide context on the likelihood of such degradation occurring in the absence of perpetual ICs.
- 6) Revise the SA report in accordance with the EMDF ROD, which states (p. 2-57) that the “supplemental analysis will evaluate *additional* assumptions regarding future landfill performance and exposure pathways” (italics added for emphasis). For example, the SA evaluates *fewer* assumptions with respect to cover-system infiltration rates; a lower U inventory; and does not evaluate risks related to isotopes of radon, which are progeny of parent radionuclides evaluated in Table 2.5 of the EMDF ROD.

Specific Comments

- 1) Page 3, Section 2.2, 1st paragraph:
 - a) Reword the last sentence to clarify how the SA addresses uncertainty in the degree of cover and liner system degradation, permeability of the degraded barriers, and the potential for accumulation of leachate on the liner system.
 - b) Add a sentence explaining the rationale for evaluating the bathtub release scenario. It is logical and realistic to evaluate a scenario that assumes a landfill cover system exposed to weather at the ground surface degrades faster than a liner system protected from the elements by a thick layer of overlying material.
- 2) Page 4, Figure 1:
 - a) Replace the figure with a sharper, more legible image. Contour labels and text in the title block are blurry.
 - b) Show the assumed location of the groundwater supply well on the map.
 - c) Symbolize all streams the same or add the tributary symbol to the legend.
 - d) Label the pink-shaded area or define it more clearly in the legend.
- 3) Page 5, 1st partial paragraph: The text contains a sentence that appears inconsistent with the discussion of water balance in Section 3.2: “Most of the leachate released at the EMDF surface will be mixed with run-off from the cover system during and immediately following precipitation events.” As noted in Section 3.2, there is considerable uncertainty in the relationship between the timing of precipitation events and leachate overflow rate, and no quantitative model for evaluating this relationship has been developed. Remove this sentence or revise it to reflect the state of knowledge with associated references.

ENCLOSURE

- 4) Page 5, Section 2.3, 1st sentence: Change “detailed” to “summarized.” The Proposed Plan ([DOE/OR/01-2695&D2/R1](#)) *summarizes* the preliminary or conceptual design features for the liner and cover systems.
- 5) Page 5, Section 2.3.1, 1st paragraph: If, as stated, cover degradation is a key determinant of potential future risk, revise the text to elaborate on the levels of degradation that are possible and how degradation is envisioned to occur—e.g., erosion due to incision, sheet flow, or hillslope failures. Consider summarizing this information with reference to the discussion of this topic in the PA.
- 6) Page 5, Section 2.3.1, 2nd paragraph, last sentence: The text states, “Even if cover system maintenance and institutional control of the EMDF site are discontinued, the cover composite barrier (geomembrane and low-permeability clay) should perform well as long as the cover system is not severely eroded or damaged over a large portion of the cover area.” This is a critical statement, since long-term cover system maintenance and ICs cannot be assumed in the analysis and taken as a basis for long-term landfill performance, even if the results support the need for maintenance and ICs. Define what constitutes severe erosion and damage over a large portion of the cover and provide a basis for why these conditions would not be expected to occur in the absence of maintenance and ICs.
- 7) Page 6, 1st paragraph: The text invokes cover infiltration modeling performed for the PA. Consider removing or revising this text. TDEC does not concur with the assumption that modeled cover infiltration rates used for the PA (a gradual twofold increase in infiltration rates between 200 and 1000 years post-closure) are “conservative estimates (higher than expected).”
- 8) Page 6, 2nd paragraph: Amend the text to explain how the cited references relating to Saltstone disposal units and grouted tanks in South Carolina (SRMC 2021 and 2022) support the stated expectation that infiltration rates will be below 1 in/yr for 10,000 years at the EMDF. The revised text should describe reasonable expectations regarding cover erosion over the 10,000-year span in the absence of maintenance and ICs.
- 9) Page 7, Figure 2: Since the bathtub release occurs at the contact between the cover and liner systems, add a cross-sectional diagram that focuses on that interface (potential leachate spillover area).
- 10) Page 8, Section 2.4; Pages 14-15, Section 3.2.1; Page 43, Section 5.2: The report presents several deterministic scenarios for liner leakage rates (0%, 50%, 90%) but does not quantify uncertainty in key parameters such as K_d , infiltration rates, mixing ratios, or contaminant inventories (e.g., total U, mercury). Expand the analysis to include probabilistic uncertainty quantification (e.g., Monte Carlo simulation). Provide median, 95th percentile, and sensitivity results for a range of risk metrics.

ENCLOSURE

- 11) Page 8, Section 2.4, 1st paragraph: Revise the text to clarify why the cover clay infiltration barrier is stated to be less permeable than the clay liner.
- 12) Page 8, Section 2.4, 2nd paragraph, last sentence: Revise the text to explain the rationale for calculating the leachate release volume based on the total liner area, including why that approach is appropriate if the liner system is not horizontal.
- 13) Page 8, Section 2.4, 3rd paragraph, 1st sentence: Revise the text for clarity. It is not clear how the water balance asserts "that there is essentially no chance of zero leakage through the basal liner system."
- 14) Page 8, Section 2.4, 2nd or 3rd paragraph: Consider adding text to clarify that the zero-liner-leak scenario is the worst case with respect to the hypothetical bathtubbing scenario and associated potential exposure and risk.
- 15) Page 9, Section 3.1.1, 1st paragraph: The text states, "This SA evaluates risk for 53 radionuclides identified in Table 2.5 of the EMDF ROD, with the exception of Th-228 (U-232 progeny with short half-life) and the addition of Se-79." Revise the text to explain how the SA evaluates Tier 2 radioisotopes, as indicated in the ROD Table 2.7 (CODE T2), and why the SA does not evaluate risks related to isotopes of radon, which are progeny of parent radionuclides evaluated in ROD Table 2.5.
- 16) Page 9, Section 3.1.1, 1st sentence: Consider revising the sentence as follows for clarity: "Estimated facility average EMDF waste concentrations for radionuclides and metals are based on information from similar facilities."
- 17) Page 9, Section 3.1.1, 2nd paragraph:
 - a) The text states that 12 metals, plus beryllium and mercury, evaluated in the WAC Attainment Plan for the Environmental Management Waste Management Facility (EMWMF) were identified for inclusion in the SA in the EMDF ROD. However, there are 20 metals in Table A.1 of the EMWMF WAC Attainment Plan. Revise the text to provide the rationale for evaluating only a subset of the 20 metals associated with the EMWMF.
 - b) There are approximately 50 organic chemicals listed in Table A.1 of the EMWMF WAC Attainment Plan, including phthalates, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and volatile organic compound (VOCs). Revise the text to explain why no organic chemicals are evaluated in the EMDF SA.
- 18) Page 9, Section 3.1.1, 2nd paragraph, last sentence: Revise the text to explain the rationale for asserting that Alpha-2 and Beta-1 mercury concentrations are adequate for estimating the facility average EMDF mercury concentrations in waste that will be derived from West End Mercury Area (WEMA) facilities, including Alpha-4, Alpha-5, and Beta-4. During meetings of the Y-12 National Security Complex (Y-12) project team, DOE

ENCLOSURE

stated that Alpha-2 mercury levels are minor compared to those in WEMA and that no elemental mercury is expected at Beta-1.

19) Page 9, last paragraph (continuing to the top of Page 10):

- a) The SA *assigns* an average U concentration of 400 mg/kg at landfill closure. This value is approximately one-third the conservatively estimated (biased high) concentration (1,130 mg/kg), which the SA report cites as being developed in the Performance Assessment (PA, [UCOR-5094/R2](#)). Revise the text to better explain the assignment of 400 mg/kg as the assumed U concentration, including why the U concentration assumed in the PA is not appropriate for the SA. Consider basing the anticipated U concentrations on information regarding future waste streams, including those from cleanup projects at the Oak Ridge National Laboratory (ORNL) and Y-12 cleanup projects.
- b) Revise the text to cite the specific PA section that discusses the origin of the 1,130 mg/kg value, as TDEC is unable to find that information. Based on the average activity concentrations (picocuries per gram, pCi/g) of U isotopes in EMDF waste from PA Table B.6, TDEC estimates the total U concentration as 2,170 mg/kg, of which uranium-238 (U-238) comprises 2,130 mg/kg.
- c) The SA only supports the 400-mg/kg estimate through a qualitative comparison with the current total U inventory estimate for EMWMF (approximately 200 mg/kg) and a subjective statement that the EMDF is expected to receive less U than EMWMF. Revise the text to clarify how this expectation will be managed, given the potential for different ratios of soil waste, debris waste, and clean fill, as well as the lack of an inventory limit for total U in the WCP ([DOE/OR/01-3012&D1](#)).

20) Page 10, 1st partial paragraph, last sentence: Explain why only U-238 is discussed. Were the leachate activity concentrations of uranium-235 (U-235) and uranium-234 (U-234) similarly defined?

21) Page 10, 1st full paragraph and Page 34, Section 4.3: Revise the text to clarify the basis for evaluating lead using the drinking-water Maximum Contaminant Level (MCL) and not estimating toxicity risks while taking the opposite approach for U, which also has an MCL. Health effects related to lead must be evaluated in a CERCLA risk assessment. Comparison of modeled lead concentrations to ARARs, such as the Tennessee lead MCL, is only one of two CERCLA threshold criteria that must be addressed, the other being protection of human health and the environment.

22) Page 10, Section 3.1.2, 1st paragraph:

- a) Second sentence and p. 12-14, Table 1: Revise Table 1 to include the specific references or rationales for the lower and higher waste K_d values.

ENCLOSURE

- b) Revise the text to clarify how estimated leachate concentrations for the lower and higher K_d values were applied.
 - c) Last sentence: The ORNL report cited in this sentence states that fourteen “sediment” and saprolite samples were collected at locations based on the types of materials which EMDF waste may contact. The ORNL report does not show the locations on a map, nor does it provide coordinates for the sample locations. Add the sample locations and results to the SA report and/or the Oak Ridge Environmental Information System (OREIS).
- 23) Page 11, Section 3.2, 2nd paragraph: Provide a diagram in the report that shows the contour elevations discussed in this paragraph.
- 24) Pages 11-12, Section 3.2, 3rd paragraph: The text describes a conceptualization of how bathtub leachate release is expected to mix with uncontaminated cover runoff and drainage, with some flow entering Northern Tributary 10 (NT-10) and some infiltrating the ground and percolating downward to recharge the saturated zone in the area near the toe of the berm. Add a figure to the report showing a cross-section view of the vadose and saturated zones in this area to support this conceptual model.
- 25) Page 12, 1st full paragraph (above Table 1), last two sentences: The text states that conservative simplifications regarding lead concentrations are described in later subsections of Section 3.2. Review of Sections 3.2.1 and 3.2.2 does not reveal significant conservative simplifications. Discounting of sorption outside the waste zone is unlikely to impact concentrations in water since only dissolved contaminants are released with leachate and groundwater transport times and distances are short. Revise the text to remove reference to conservative simplifications or describe them and explain why they are potentially significant.
- 26) Pages 12-14, Table 1:
- a) Add a column indicating the PA base case waste zone K_d value for each element and provide a footnote describing the basis for values that have been revised for the SA.
 - b) Footnote a: The estimated average activity concentration of U-238 in landfill waste is set based on the *assigned* 400 mg/kg total U inventory. As noted in a previous comment, this value is not consistent with the 1,130-mg/kg value cited elsewhere in the document or the 2,130-mg/kg U-238 value TDEC calculates from PA Table B.6. If the 400-mg/kg average U concentration is revised, it will be necessary to update the estimated average U-238 activity concentration accordingly.
- 27) Pages 12-14, Table 1, K_d values: The lower and higher K_d values in Table 1 for iodine (I), technetium (Tc), and possibly U isotopes, are based on information presented in a study by the Savannah River National Laboratory ([SRNL-STI-2021-00404, Revision 1 \(Hill](#)

ENCLOSURE

[Kaplan, and Roberts, 2023](#)). The following comments relate to the selection and use of K_d values for these radionuclides.

- a) Page 10, Section 3.1.2, 1st paragraph: The text references "laboratory measurements of carbon, technetium, iodine and uranium K_d values for materials collected from the Maryville Limestone and Nolichucky Shale at the EMDF site." A critical assumption when using K_d values for specific geologic material to estimate waste zone leachate concentrations is that this material will comprise the backfill used during waste placement to fill voids, as well as any contaminated soil disposals. Document in the text that the geologic nature of the backfill material and any contaminated soil that will be emplaced at the EMDF is consistent with the specific material for which large Tc, I and U K_d values are recorded in SRNL-STI-2021-00404 and applied in the SA. If the use of a specific type of geologic material for EMDF backfill is necessary to limit the mobility of these radionuclides, reference the WAC Compliance Plan for information on how use of this specific backfill material will be ensured during landfill operations.
- b) Pages 13-14, Table 1: The SA applies large K_d values for I, Tc, and U based on SRNL-STI-2021-00404 that measured these values under assumed reducing conditions.
 1. Revise the SA report to document why it is appropriate to assume reducing conditions when applying these values to the SA considering the primary reference (SRNL-STI-2021-00404) describes the site as "primarily oxidizing." How are K_d values derived from tests representing "reducing microenvironments" representative of the entire waste zone?
 2. Revise the SA report to provide a technical basis demonstrating the persistence of reducing conditions of the waste zone for the 1,000-year evaluation period. Studies of landfills (Abiriga, et al., 2021 and Basberg, et al., 1998) show that reducing conditions can degrade and revert to oxidizing conditions as reducing material is depleted.

References

Abiriga, D., Vestgarden, L.S., & Klempe, H. (2021). [*Long-term redox conditions in a landfill-leachate-contaminated groundwater*](#). Science of the Total Environment, 755, 143725.

Basberg, L., Banks, D., & Sæther, O. M. (1998). [*Redox Processes in Groundwater Impacted by Landfill Leachate*](#). Aquatic Geochemistry, 4, 253–272.

- c) Tables 3-1, 3-3, and Appendix Table 5-3 of SRNL-STI-2021-00404 show that the I and Tc K_d values for Nolichucky formation material are far lower than values for Maryville and Chestnut Ridge formation materials and similar to values applied in the EMDF PA for these elements. The lower and upper K_d values for I shown in Table 1 of the

ENCLOSURE

SA correspond to the Maryville and Chestnut Ridge mean K_d values in Table 3-3 of SRNL-STI-2021-00404, but the Nolichucky K_d value of 1.5 milliliters per gram (mL/g) has been ignored. Revise the text to explain exclusion of the K_d values for Nolichucky formation material.

- d) Table 3-1 of SRNL-STI-2021-00404 indicates pH values between approximately 4.5 and 5.5 for the K_d sample preparations, but Table 2-2 of that document shows that the pH of the groundwater used to prepare the samples for K_d measurements was approximately 7. The accompanying text states that the water was collected from a well near the EMDF that “is expected to be representative of the water that may receive radionuclides leached from the disposed waste.” In any case, for the SA it is the anticipated pH of leachate in the EMDF waste zone over time that is relevant for judging the applicability of the proposed K_d values referenced to SRNL-STI-2021-00404. Revise the text to explain why the measured K_d values reported in SRNL-STI-2021-00404 for an acidic environment are applicable to the SA.
 - e) Section 3.3.2 of SRNL-STI-2021-00404 states that previously measured U K_d values ranging from 0 to 95 mL/g for Oak Ridge Melton Branch Ridgetop sediment used U concentrations 100 times higher than those applied in the SRNL study and allowed only 3 days for equilibration rather than 14 days. These conditions were said to be “less conducive to sediment binding of U than would be expected under EMDF conditions.” The text of Section 3.3.2 further states that the previous K_d measurements provided little information for informing a U K_d “under relevant PA conditions.” Revise the SA report to explain the basis for these statements and explain why only the SRNL-STI-2021-00404 U K_d results were considered.
 - f) SRNL-STI-2021-00404 describes an experimental design for measuring I, Tc, and U K_d values for 14 geological materials with two replicates per material. The analytical results provided in Appendix Table 5-3 do not indicate any “greater-than” values for Tc, but mean K_d values for Tc in Table 3-3 have “greater-than” values for Maryville and Chestnut Ridge materials. Investigate and reconcile this discrepancy and apply this information to support the selection of lower- and upper-bound Tc K_d values for the SA.
- 28) Page 14, Section 3.2.1: Revise the document to include graphics that help explain the ratios discussed in the text.
- 29) Page 14, 2nd paragraph: Add a discussion of the dataset that underlies the meteorological inputs and describes whether and how the 100 years of stochastically simulated daily meteorological inputs account for infrequent high-magnitude storms.
- 30) Page 15, 1st partial paragraph:
- a) Revise the text to explain the assumption of 54.3 inches of annual precipitation. The 30-year moving average annual rainfall reported in the *2025 Remediation*

ENCLOSURE

Effectiveness Report for the U.S. Department of Energy Oak Ridge Site Oak Ridge, Tennessee (DOE/OR/01-2989&D1) is 56.4 inches.

- b) The volumetric infiltration rate is estimated based on average runoff and infiltration rates that are applied across the entire landfill area. Revise the text to summarize the potential mechanisms for future cover degradation and, if some mechanisms could focus degradation on certain parts of the system more than others, explain how the averaging addresses this.

31) Page 16, 1st and 2nd paragraphs and Table 2:

- a) Add text to explain the rationale for selecting the 100-meter (m) or 150-foot (ft) saturated zone buffer between the leachate release area (edge of waste), as well as the basis for mixing metric and imperial units.
- b) Revise the text to support selection of the 40-m (131-ft) groundwater well intake interval. This assumes a well intake that is approximately 26 times longer than the interval of the only domestic water supply well found at the EMDF site. That historical hand-dug well was approximately 20 ft deep with a water level approximately 15 ft below ground, equating to an intake interval of 5 ft.
- c) The equation shows the volumetric groundwater flux (Q) used to calculate the second mixing ratio in Table 2 is directly proportional to the saturated zone width. Revise the text to explain the statement that the saturated zone recharge to groundwater mixing ratio is independent of the assumed distance of the well from the edge of the waste
- d) The water supply well is assumed to draw groundwater from the water table to a depth of 131 ft (40 m). The equation shows the Q used to calculate the second mixing ratio in Table 2 is directly proportional to the assumed well depth. Revise the text to describe the approximate well interval that would be adequate to support a domestic supply well, given site-specific aquifer characteristics.
- e) Revise the document to provide a three-dimensional diagram of the region to which the groundwater flow equation applies. The dimensions shown for equations inputs are difficult to visualize.
- f) Revise the document to provide a reference for the hydraulic conductivity of the Nolichucky Shale saprolite zone and discuss the uncertainty associated with this value. Since conductivity could be expected to vary widely in a saprolite zone, consider evaluating the sensitivity of this parameter within reasonable bounds.

32) Page 16, 3rd & 4th paragraphs and Table 2: Provide an attachment containing the details and references for the values, equations, and assumptions used to develop Table 2. The text summary is difficult to follow. Consider using material that DOE presented to TDEC

ENCLOSURE

and EPA that describe these calculations with supporting diagrams to help explain the methods and underlying assumptions.

- 33) Page 16, 4th paragraph, last sentence and Page 21, 1st paragraph, 3rd sentence: Reword these sentences to avoid confusion regarding the role of the SA for evaluating CERCLA protectiveness following EPA guidance versus the role of the PA for assessing performance following DOE orders. TDEC requested the SA and agreed to the bathtubting evaluation to evaluate potential future health risks in support of WAC development, rather than to “demonstrate the significance of liner performance uncertainty on potential risk outcomes” or “evaluate risk sensitivity to uncertainty in performance of the liner system.”
- 34) Page 17, Table 3: Revise the text to explain why lower and higher K_d value calculations are presented for only one liner leak scenario or to present an evaluation of representative combinations of liner leak rates and K_d values.
- 35) Page 19, Section 3.2.2: Surface water concentrations driving fish ingestion risk are based on a fixed mixing ratio (1,130) and are not coupled to liner performance (leakage rates) or discharge rates from bathtubting. As a result, the fish ELCR is independent of the liner leakage rate. Revise the analysis to couple surface-water concentrations to liner performance or revise the text to explain why a fixed ratio is appropriate.
- 36) Page 19, Section 3.2.2, 1st paragraph: Bear Creek surface water flow is referenced to daily estimated stream flow data from the flow monitoring station at Bear Creek Kilometer 9.2 (BCK 9.2) from 2001 through 2018. Based on the ratio noted in the second paragraph of Section 3.2.2, it appears that a daily Bear Creek flow rate of 599 gallons per minute (gpm) at NT-10 is assumed based on the median of the daily flow values from the 18-year period. Revise the text to provide this information and compare the calculated Bear Creek concentrations to estimated concentrations in NT-10 below the leachate surface inflow to provide an approximate measure of the dilution between the two surface water bodies.
- 37) Page 21, 2nd paragraph:
- a) This paragraph contains a sentence stating that exposure to contaminants in soil is not evaluated because irrigation with groundwater is assumed to be confined to the garden. This suggests that individuals who garden would not be exposed to garden soil. Consider including garden soil exposure pathways in the risk assessment or revise the text to explain why such pathways contribute negligible exposure.
 - b) 2nd sentence: Revise the text to explain the basis for assuming that irrigation with groundwater is confined to the garden. Also explain how this would preclude

ENCLOSURE

evaluating direct-contact risk associated with contaminated soil.

38) Page 22, Table 4: The only exposure media identified are groundwater and Bear Creek fish. However, a resident using a groundwater well near the landfill could have some exposure to NT-10 surface water and/or soil contamination along the area where bathtub flow overtops the liner. Revise the text to explain why these possible exposure pathways are not evaluated.

39) Page 23, Figure 3:

- a) Revise the conceptual exposure diagram and associated text to include soil ingestion as an exposure pathway or explain the decision to exclude it. If there is potential for surface runoff to carry contaminants, it is reasonable to evaluate risk from soil that may be contaminated as part of the runoff. Irrigating garden soil with groundwater could contaminate the soil and represent an exposure pathway.
- b) Revise the document to present the metal-toxicity direct-contact soil risk calculations in the appendix along with the radiological calculations. Section 4.2.2 provides a brief discussion of negligible risk from radiological contaminants, but there is limited explanation of how such risk was determined or why metals were excluded.

40) Page 24, Section 4.2.1:

- a) 3rd paragraph: Revise the text to explain why a 300-square ft (ft²) garden is assumed rather than the default minimum 600-ft² garden required to feed a family of four, as cited in the report. The explanation for defining the 50% fraction of food that is home grown seems circular. The assumption of a 10-by-30-ft garden appears to be arbitrary, but the relation of this size to a 600 ft² garden required to feed a family of 4 year-round is the basis for the home-grown food fraction. Compare the home-grown food ingestion rates in the SA to rates for produce, chicken meat and eggs described in [Chapter 13](#) of [EPA's Exposure Factors Handbook](#) to provide a measure of the reasonableness of the values.
- b) Revise the text to define the length of the growing season used in the risk calculations.
- c) Revise the text to clarify how irrigation assumptions are expressed. Does the percentage of time for irrigation represent the number of days requiring irrigation within the growing season? Does it refer to the amount of time, e.g., hours within a day regardless of number of days?

ENCLOSURE

- 41) Page 24, Section 4.2.2, 2nd paragraph: Is “1000-year timeframe for residential exposures” a typographical error? If not, revise the text to clarify its application.
- 42) Pages 24-25, Section 4.2.2: This section describes the elimination of exposure pathways related to contaminated garden soil and ingestion of meat from game animals foraging in the home garden. The contaminated garden soil pathways were eliminated by calculating soil concentrations related to buildup from irrigation and comparing these concentrations to preliminary remediation goals (PRGs) calculated using web-based tools ([ORNL RAIS Chemical Risk Calculator](#) and [ORNL/EPA PRGs for Radionuclides calculator](#)). It is not clear why this screening was performed, instead of simply including garden soil pathway in the calculations, since these calculators were also used to perform the risk calculations for metals and radionuclides. Water immersion external cancer risk was included as a pathway in the dose assessment, although the risk results shown in Appendix A were below 1E-10, so the basis of the screening seems unrelated to the magnitude of the results. Include all potentially complete exposure pathways in the risk calculations or provide the rationale for selectively screening out pathways.
- 43) Page 25, middle paragraph, 1st sentence: The text states that estimated concentrations of radionuclides and metals in soil from irrigation are less than the PRGs and HIs. Revise the text to clarify whether this refers to risks for individual contaminants or cumulative risk for all soil contaminants. Also, clarify the rationale for presenting the radionuclide calculations while excluding metal toxicity calculations. Preferably, include both in Appendix A.
- 44) Page 26, 2nd complete paragraph; Page 28, 1st paragraph Page 37, Section 5.1, 3rd paragraph; Page 38, Table 6 and all paragraphs; and Page 47, Table 12:
- a) The text states that, with the exception of fish ingestion rates, default exposure parameters from the [ORNL RAIS Chemical Risk Calculator](#), the [EPA PRGs for Radionuclides calculator](#), and Pacific Northwest National Laboratory ([PNNL-13421](#)) were used in the assessment. Subsequently, the text suggests that exceptions may include water-to-fish bioconcentration factor (BCF) values for the risk drivers, which are carbon-14 (C-14), plutonium-238, -239, and -240 (Pu-238, Pu-239, and Pu-240). The report also states that sensitivity of the results for those four radionuclides to the BCF values is evaluated.

Revise the text to clarify whether the risk results are based on the default BCF values for these radionuclides or the “10% of fish ingestion for C-14, Pu-238, -239, and -240” cited in Table 6. It is unclear whether the results are calculated based on default BCFs for all radionuclides evaluated; all radionuclides except the four, for which 10% of the risk is assumed; or 10% of the risk from only the four radionuclides while the rest are discounted based on measured concentrations being below instream water quality criteria (Table 12). A meeting may help the FFA Parties reach a common understanding regarding how risks were calculated.

ENCLOSURE

b) Revise the text to explain the selection of 10%.

- 45) Page 26, last paragraph and Page 46, last paragraph: Revise the SA to apply the fish consumption rates and BCFs that the FFA Parties agreed to use for developing landfill wastewater PRGs for the ROD or justify the use of different values.

Although fish-tissue data during a single recent year do not indicate bioaccumulation of C-14 or plutonium isotopes, it is not clear whether that finding would hold true during a period when those isotopes are being discharged to the stream at higher concentrations and/or when larger, longer-lived fish are present. Because of these uncertainties, the FFA Parties agreed to apply the standard EPA hierarchy for selecting BCFs/transfer factors (default BCFs) to develop PRGs for the wastewater management focused feasibility study (FFS) and EMDF ROD.

- 46) Page 28, 1st paragraph: Revise the document to add a table with the fish, vegetable and fruit concentration ratios, and the egg and poultry meat transfer factors for each element and the associated reference. The table should include rationales for any supplemental or substituted values that were applied in the risk calculations.

- 47) Page 28, 2nd paragraph: If the equations shown for carcinogenic and noncarcinogenic health effects are taken from documentation for the Chemical Risk and Preliminary Remediation Goals for Radionuclides Calculators, cite the references. If other sources were used, or if modifications were made, cite and explain these changes.

- 48) Page 34, Section 4.4.1: The title of this section indicates that the text provides a discussion of the methods used to calculate risk for carcinogenic effects, but the text is limited to a discussion of the 10^{-6} to 10^{-4} risk management range and baseline cancer incidence rates. Add text that describes the calculation methods and related assumptions pertaining to the calculator tools used to perform the risk calculations. The text should explain how the generic risk calculators are applicable to the conceptual exposure models for use of domestic groundwater and ingestion of biota from impacted surface water.

- 49) Page 35, Section 4.4.3, 3rd paragraph, 3rd sentence: Consider changing " K_d " to " K_d within the landfill" to remind the reader that K_d is not being applied to leaching of contaminants released by the overflow from bathtubbing.

- 50) Page 37, Section 5.1: Revise the text to explain why higher K_d values are assumed to be reasonable when a range of K_d values is available. TDEC recommends including a sensitivity analysis that evaluates K_d value ranges. Selection of higher K_d values assumes greater affinity for contaminant adsorption within the waste and less mobility from the landfill. Therefore, it is important to explain the selection of such values.

- 51) Page 43, Section 5.2: Add text to describe uncertainties with the CSM beyond the risk assessment itself, including sensitivity of risk calculations to other factors, such as the

ENCLOSURE

groundwater well intake interval and K_d values. Those factors might be addressed in Sections 5.2.1 and 5.2.2, respectively.

- 52) Page 43, Section 5.2.1, 2nd sentence: Cite the mentioned CERCLA guidance.
- 53) Page 44, Table 9: Revise the table and the analysis to apply the correct MCL for mercury, which is 0.002 or 2.00E-03 milligrams per liter (mg/L) or 2 micrograms per liter (µg/L), not 2.00 (2.00E+00) mg/L.
- 54) Page 46, last paragraph: Provide the following literature cited in the text: Fesenko et al., 2011 and Yankovich et al., 2013.
- 55) Page 46, Section 5.3.2, last paragraph, 7th sentence: Should this sentence be worded to clarify that lower BCF values would yield higher *criteria* and/or lower *concentrations*?
- 56) Page A-9: The table lists the BCF for U (soluble salts) as 0.96 liters per kilogram (L/kg), but the values listed in the Risk Assessment Information System (RAIS) are 10 L/kg for the soluble salts and 0.96 L/kg for U isotopes. Revise the table to correct these apparent discrepancies or revise the text to explain them.
- 57) Pages A-10 through A-12: Revise the report to explain the rationale or basis for adjusting default input parameters. For radionuclides in homegrown produce, most of the ingestion fraction parameters are adjusted to 60 to 65% of the default values and contaminated fractions are adjusted by 50%.