**Peer Review Comments on the Authorized
Limits Technical Document (OREM-19-2573)
for Disposal of Waste Containing Residual
Radioactive Material at the U.S. Department
of Energy Industrial Landfill IV, Y-12 National
Security Complex, Oak Ridge, Tennessee**

Environmental Science Division

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1 INTRODUCTION

Argonne National Laboratory is assigned responsibility by DOE/EM-4 to conduct a peer review of the proposed Authorized Limits (ALs) for disposal of waste containing residual radioactive material at the U.S. Department of Energy (DOE) Industrial Landfill IV, Y-12 National Security Complex, Oak Ridge, Tennessee. The ALs document package (Document Number OREM-19-2573, dated May 2020) was sent to Argonne by DOE on June 1, 2020 (Oak Ridge 2020a). Argonne started the review immediately and held several BlueJeans meetings with Oak Ridge and DOE to discuss review comments.

The first BlueJeans meeting was June 17, 2020. Oak Ridge presented a briefing of the AL package, followed by discussion of the assumptions, methodology, and parameters used in the analysis. A follow-up BlueJeans meeting was held on June 24, 2020, at which Argonne presented both general and specific review comments in PowerPoint slides. This set of slides—Review Comments on the “Authorized Limits for Disposal of Waste Containing Residual Radioactive Material at DOE Industrial Landfill IV, Y-12 National Security Complex, Oak Ridge, Tennessee”—was then emailed to Oak Ridge and DOE after the BlueJeans meeting on June 24, 2020. A PDF version of this slide set is included as Appendix A.

On June 30, 2020, Argonne received “Questions for ANL from the June 24, 2020, Presentation” from Oak Ridge. A BlueJeans meeting was held on July 1, 2020, to discuss these questions. After the meeting, Argonne sent “ANL Response to Oak Ridge Questions from June 24, 2020, Presentation” to Oak Ridge and DOE. A copy of this response is included as Appendix B.

On August 6, 2020, Argonne received from DOE a writeup prepared by Oak Ridge regarding “Comments, Responses, and Path Forward from ANL Review” (Oak Ridge 2020b). Argonne reviewed Oak Ridge’s writeup and sent an email to DOE and Oak Ridge on August 10, 2020, stating that the proposed path forward looked reasonable and providing one suggestion to Oak Ridge, that the explanation in the writeup, about the reason why an offsite receptor scenario is highly unlikely for the next 100 years, should be included or discussed in the ALs Technical Support document.

On September 24, 2020, Argonne received the revised ALs document packages from DOE including updated Technical Support report OREM-19-2573 with an effective date of 2020 (Oak Ridge 2020c), the draft Appendix A titled, “Estimates of Potential Radiological Impacts from Disposal Operations at Industrial Landfill IV,” and “Crosswalk of the DOE Desk Reference for Authorized Limits and Independent Verification and the Technical Support Document for Industrial Landfill IV Authorized Limits.” A BlueJeans meeting was held September 30, 2020, to discuss Argonne’s comments on the revised ALs document. Argonne provided verbal comments during the BlueJeans meeting and then prepared written comments. The written comments were sent to Oak Ridge and DOE on October 2, 2020. A copy of the written comments is included as Appendix C.

On November 30, 2020, Argonne received the main text (without appendix) of the updated Technical Support document OREM-19-2573 Revision: 1 with an effective date of December 2020 (Oak Ridge 2020d) that addressed the written comments sent to Oak Ridge on October 2, 2020. The report was later updated to add few clarifications in the Executive Summary after a Microsoft Teams meeting held on December 1, 2020.

2 SUMMARY OF OAK RIDGE PROPOSED APPROACH

Authorized limits and TDEC dose-based screening criteria have been established for the Industrial Landfill V (ILF-V) and Construction/ Demolition Landfill VII (CDL-VII) in Oak Ridge for disposal of waste with residual volumetric levels of radiological materials. Oak Ridge proposed to use the same authorized limits and screening criteria shown in Table 1 for Industrial Landfill IV.

The existing criteria for disposal of volumetrically contaminated wastes have been successfully implemented for a number of years at ILF-V and later at CDL-VII.

The DOE Office of the Inspector General recommended that DOE make even greater efforts to segregate wastes that can be safely and economically disposed of at the Oak Ridge Reservation (ORR) solid waste landfills to preserve disposal capacity for wastes that require management as radioactive waste at the ORR onsite radioactive waste disposal facility, the Environmental Management Waste Management Facility (EMWMF).

In response to that recommendation, the Oak Ridge 2020a report evaluated implementing the same screening criteria and authorized limits as previously approved for ILF-V and CDL-VII for ILF-IV based on updated information on model input parameters and expected future waste stream masses and contaminants for four scenarios. The Oak Ridge 2020a report used the latest RESRAD-ONSITE code (Version 7.2) with updated transfer factors and dose coefficients, calculated the concentration limit for each radionuclide of concern, and compared them with previously approved authorized limits for ILF-V and CDL-VII.

TABLE 1 Proposed ALs and TDEC Dose-based Screening Criteria for Industrial Landfill IV

Radionuclide	Authorized Limit (pCi/g) ^{a,b}	TDEC Dose-based Screening Criteria ^c
Am-241	3	17
C-14	30	60
Co-60	2	2
Cs-137	10	10
Eu-152	5	5
Eu-154	5	5
H-3	150	150
Np-237	3	5
Pu-238	3	19
Pu-239	3	12
Ra-226 ^d	3	3
Sr-90	30	850
Tc-99	40	100
Th-230 ^d	3	5
Th-232 ^d	3	4
U-234	35	73
U-235	35	35
U-238	35	55
Total uranium ^e	35	61

^a Applicable when single radionuclide is present in a particular volume of waste.

^b Including background concentrations of each radionuclide (except for radium and thorium; see footnote d).

^c Applicable when multiple radionuclides are present in the waste stream and used in the sum of fractions calculation. The sum of fractions must not exceed unity.

^d The Th-230/Ra-226 and Th-232 decay series are limited to 3 pCi/g each; in addition, the combined concentrations of the Th-230/Ra-226 and Th-232 decay series are limited to 5 pCi/g above background consistent with DOE O 458.1.

^e Assumed activity ratio of natural uranium (~49% each U-234 and U-238, ~2% U-235).

Note: The proposed authorized limits and TDEC dose-based screening criteria for Industrial Landfill IV are equivalent to the existing authorized limits and TDEC dose-based screening criteria for Industrial Landfill V and Construction/Demolition Landfill VII.

Source: Oak Ridge 2020d, Tables ES-1, 2, and 8.

The four scenarios considered were (1) Current Landfill Operations Worker (time period, 0–40 years), (2) Future Landfill Maintenance Worker (time period, landfill closure to 1,000 years), (3) Future Resident (time period, 30 years post closure to 1,000 years), and (4) Future Subsistence Farmer (time period, 100 years post closure to 1,000 years). Table 2 (taken from Table 7 of the Oak Ridge 2020a report) lists the limiting scenario and associated dose-based concentration limits for ILF-IV and compares the dose-based concentration limits with the proposed authorized limits. Note that the derived dose-based concentration limits, rather than the proposed authorized limits, are used in sum-of-fractions calculations.

TABLE 2 Comparison of Proposed ALs with the Dose-Based Concentration Limits for ILF-IV Landfill

Radionuclide	Proposed Authorized Limit/Screening Criteria	Limiting Scenario and Associated Dose-Based Concentration Limit for ILF-IV	
		Dose-Based limit (pCi/g)	Scenario
Am-241	3	1.84E+04	Future Subsistence Farmer
C-14	30	8.48E+05	Future Subsistence Farmer
Co-60	2	2.40E+01	Current Operations Worker
Cs-137	10	2.96E+02	Current Operations Worker
Eu-152	5	7.80E+01	Current Operations Worker
Eu-154	5	7.40E+01	Current Operations Worker
H-3	150	3.78E+09	Future Subsistence Farmer
Np-237	3	6.99E+02	Future Subsistence Farmer
Pu-238	3	1.29E+06	Future Subsistence Farmer
Pu-239	3	2.56E+04	Future Subsistence Farmer
Ra-226	3	4.00E+00	Future Subsistence Farmer
Sr-90	30	1.86E+05	Current Operations Worker
Tc-99	40	9.79E+02	Future Subsistence Farmer
Th-230	3	8.00E+00	Future Subsistence Farmer
Th-232	3	9.00E+00	Future Subsistence Farmer
U-234	35	5.15E+02	Future Subsistence Farmer
U-235	35	6.50E+02	Future Subsistence Farmer
U-238	35	6.39E+02	Future Subsistence Farmer

Argonne reviewed the updated information and the expected future waste stream and contaminants and raised questions/comments on the May 2020 Oak Ridge report. Questions were raised on the following parameters: initial soil concentration, dose coefficient library (Reference Person Internal Dose Library versus Adult Internal Dose Library), cover thickness used in analysis of the Current Operations Worker scenario, plant transfer factors in the Future Resident and Future Subsistence Farmer scenarios, infiltration rate, and occupancy parameters for the Current and Future Operations Worker scenarios, and adding analysis of a hypothetical Current Offsite Receptor scenario. Oak Ridge responded to these questions/comments and developed a Path Forward and submitted a revised Report to DOE in September 2020 (Oak Ridge 2020b).

The review and analysis on the Oak Ridge May 2020 report for each scenario, as well as the questions/comments raised on the Oak Ridge September 2020 report, are summarized in the next section.

3 REVIEW COMMENTS ON THE MAY 2020 REPORT

Argonne reviewed the Oak Ridge May 2020 ALs report and presented review comments in the form of a PowerPoint file during a BlueJeans meeting with DOE and Oak Ridge. A PDF version of the slides file is included in Appendix A. In general, Argonne agreed with the approach of using previously approved ALs (approved for ILF-V and CDL-VII) for ILF-IV because of their physical proximity. Argonne also agreed with the “two-tiered” approach, that is, using ALs as absolute concentration limits and using the dose-based Single Radionuclide Soil Guidelines (SRSGs) as the denominators in the sum-of-fractions calculation. Since the dose-based SRSGs are already being used for ILF-V and CDL-VII, it is logical to use the same set of dose-based SRSGs (derived for ILF-V and CDL-VII) when applying the sum-of-fractions rule for ILF-IV, as long as those SRSGs derived for ILF-V and CDL-VII are more conservative than the actual dose-based SRSGs derived for ILF-IV.

3.1 QUESTIONS RAISED BY ARGONNE ON THE MAY 2020 OAK RIDGE REPORT

In the review, Argonne raised questions on some parameters used in the analysis. These questions/comments are summarized in the following paragraphs.

Initial Soil Concentration

Soil concentration limits for each radionuclide in the report were estimated based on the total capacity (71,799 yd³) of the lined Area 2 of the ILF-IV Landfill. Area 1 is closed and is not part of this analysis. As of 2018, 15,708 yd³ of the modeled capacity is already filled, and 56,091 yd³ is the remaining capacity (Oak Ridge 2020a, Section 1.2). It is unlikely already filled waste volume will be disturbed while new waste is being placed.

Argonne suggested that the assumption that “authorized limits waste fills ILF-IV from current date forward at an evenly distributed concentration throughout the 4.1-m thickness” be changed. ANL suggested that waste placed to date be accounted for and the thickness of the remaining volume be reduced to 3.2 m. If it is assumed the radioactive waste at authorized limit is mixed in the remaining capacity of the landfill, the depth would be lowered to 3.2 m from 4.1 m and the soil concentration would be increased by 28%.

Dose Coefficient Library

The Oak Ridge May 2020 Report stated that the DCFPAK 3.02 Reference Person Internal Dose Library is used in the analysis (Section A.6.2.1, Table A.5). However, it was noted that the DCFPAK 3.02 Adult Internal Dose Library, instead of the DCFPAK 3.02 Reference Person Library, was used in the modeling described in Appendix A of the Oak Ridge May 2020 report. It was suggested that the DCFPAK 3.02 Adult Library be used for the two Operations Worker scenarios and the DCFPAK 3.02 Reference Person Library for the Future Resident and Subsistence Farmer scenarios.

Cover Thickness Used in the Current Operations Worker Scenario

A 1-foot-cover thickness (Oak Ridge 2020a, Section 3.1) was used in analyzing the Current Operations Worker scenario. From experience it was thought 1 foot of cover may not be appropriate for the worker who will be placing waste at the landfill, and therefore Argonne requested verification of the actual cover thickness that will be used for current workers at site operations.

Plant Transfer Factors

The site used plant transfer factors from the Staven et al. (2003) report, which provides plant transfer factors for four different types of plants. However, RESRAD-ONSITE code uses only one plant transfer factor in the analysis. Oak Ridge first calculated the average plant transfer factor for three plant types (fruits, grains, and root vegetables), and then this average transfer was averaged with the leafy vegetable transfer factor (Oak Ridge 2020a, section A.6.2.1.1) for use in the RESRAD-ONSITE analysis. Argonne questioned why the consumption-based average plant transfer factor was not used. Table 3 compares the RESRAD-ONSITE default plant transfer factors with the different plant transfer factors in the Staven et al. (2003) report and the transfer factors used in ILF-IV modeling.

TABLE 3 Comparison of Plant Transfer Factors

Element	RESRAD (default)	PNNL, Fresh Weight (Staven et al. 2003)				ILF-IV Modeling	Max from PNNL
		Leafy Vegetables	Fruits	Grains	Root Vegetables		
Ac	2.5E-03	9.4E-05	4.5E-05	2.0E-05	8.8E-05	7.25E-05	9.40E-05
Am	1.0E-03	9.4E-05	4.5E-05	2.0E-05	8.8E-05	7.25E-05	9.40E-05
C	5.5E+00	1.4E-01	1.3E-01	6.4E-01	1.8E-01	2.28E-01	6.40E-01
Co	8.0E-02	4.6E-02	1.3E-03	3.4E-03	1.7E-02	2.66E-02	4.60E-02
Cs	4.0E-02	9.2E-02	4.0E-02	2.4E-02	3.3E-02	6.22E-02	9.20E-02
Eu	2.5E-03	4.E-03	3.6E-03	1.8E-02	5.E-03	6.43E-03	1.80E-02
Gd	2.5E-03	4.0E-03	3.6E-03	1.8E-02	5.0E-03	6.43E-03	1.80E-02
H	4.8E-00	NA	NA	NA	NA	4.80E+00	4.80E+00
Nd	2.4E-03	4.0E-03	3.6E-03	1.8E-02	5.E-03	6.43E-03	1.80E-02
Np	2.0E-02	6.4E-03	1.8E-03	2.5E-03	3.3E-03	4.47E-03	6.40E-03
Pa	1.0E-02	9.4E-05	4.5E-05	2.E-05	8.8E-05	7.25E-05	9.40E-05
Pb	1.0E-02	2.0E-03	1.8E-03	4.3E-03	1.5E-03	2.27E-03	4.30E-03
Pu	1.0E-03	1.2E-05	8.1E-06	7.8E-06	2.8E-04	5.53E-05	2.80E-04
Ra	4.0E-02	9.8E-03	1.1E-03	1.1E-03	5.E-04	5.35E-03	9.80E-03
Sm	2.5E-03	4.0E-03	3.6E-03	1.8E-02	5.0E-03	6.43E-03	1.80E-02
Sr	3.0E-01	6.0E-01	3.6E-02	1.9E-01	1.3E-01	3.59E-01	6.00E-01
Tc	5.0E-00	4.2E+01	2.7E-01	6.6E-01	6.0E-02	2.12E+01	4.20E+01
Th	1.0E-03	3.6E-04	4.5E-05	3.1E-05	8.3E-05	2.07E-04	3.60E-04
U	2.5E-03	1.7E-03	7.2E-04	1.2E-03	3.0E-03	1.67E-03	3.00E-03

Infiltration

According to Oak Ridge analysis (Section A.6.1.3) in the May 2020 report, the HELP model predicted an infiltration rate of approximately 1.24 in./yr. However, in the RESRAD-ONSITE run, a higher infiltration rate was used. The effect of lower infiltration rate on the SRSGs was evaluated for the Future Resident and Subsistence Farmer scenarios.

Sum-of-Fractions

As mentioned earlier, Oak Ridge is using a “two-tiered” approach, that is, ALs as absolute concentration limits and dose-based SRSGs as the denominators in the sum-of-fractions calculation. The sum-of-fractions approach is discussed in Appendix A of the ALs document. Argonne recommends that the sum-of-fractions approach become part of the main section of the document.

RESRAD-OFFSITE Simulations for Hypothetical Offsite Receptors

Argonne suggested considering hypothetical offsite receptors using RESRAD-OFFSITE code. In some situations, especially for radionuclides with high infiltration, it is likely for the sites that have institutional control that the current offsite receptor may get a higher dose than a future onsite resident. The scenario suggested was for a resident to occupy a home near the landfill within the first 100 years of closure.

Future Worker Indoor Occupancy

Based on professional judgment it was thought that indoor occupancy in the Future Operations Worker scenario may not be appropriate, and Argonne requested verification that future worker indoor occupancy will occur.

3.2 EFFECT OF PARAMETERS ON DIFFERENT SCENARIOS

Argonne conducted RESRAD analysis and evaluated the effect of several parameters, including dose coefficients, on different scenarios. The results are summarized in the following paragraphs.

Effect of Cover Thickness on the Current Worker Guidelines

Argonne evaluated the effect of cover thickness on SRSGs in the Current Operations Worker scenario; they are derived based on a 1 mrem/yr dose criterion. Table 4 lists the derived SRSGs with different cover thicknesses and compares them with the proposed authorized limit.

TABLE 4 SRSGs (pCi/g) @ 1 mrem/yr Dose Criterion for Current Operations Worker Scenario

Radionuclide	0.3 m-Cover ^a	0.15-m Cover	No Cover (Adult)	Authorized Limit
Am-241	3.26E+08	7.78E+05	69.76	3
C-14	4.48E+12	4.31E+04	25600.00	30
Co-60	24	3	0.44	2
Cs-137	296	24	2.00	10
Eu-152	78	9	0.96	5
Eu-154	74	8	0.90	5
H-3	9.62E+15	9.62E+15	3570000.00	150
Np-237	4.46E+03	1.57E+02	5.57	3
Pu-238	9.06E+09	3.45E+07	110.50	3
Pu-239	4.70E+07	1.05E+06	99.94	3
Ra-226	36	5	0.60	3
Sr-90	1.86E+05	7.04E+03	149.70	30
Tc-99	6.61E+09	1.92E+07	40740.00	40
Th-230	2.08E+03	2.76E+02	26.35	3
Th-232	20	3	0.44	3
U-234	1.10E+07	1.11E+06	898.50	35
U-235	1.95E+04	3.91E+02	8.35	35
U-238	6.17E+03	5.40E+02	37.19	35

^a 0.3-m cover guidelines match with values in Table 6 (page 28) and Table A.1, page A-38 of the Oak Ridge 2020a report.

Note: In Oak Ridge 2020a, Tables ES-1 (page ES-2) and Table 2 (page 9) do not list Am-241 but it is listed in Table 7 on page 30.

Effect of Using Reference Person Library, Maximum Plant Transfer Factor, and Low Infiltration in the Future Resident Scenario

The effect of different parameters on SRSGs in the Future Resident scenario was evaluated. Table 5 shows the effect of using the Reference Person Library instead of the Adult Library, maximum plant transfer factor with the Adult Library, and low infiltration rate with the Reference Person Library.

TABLE 5 SRSGs (pCi/g) @ 15 mrem/yr Dose Criterion for Future Resident Scenario

Radionuclide	Adult Library ^a	Reference Person Library	Adult Library and Max. Plant Transfer Factor	Reference Person Library and Low Infiltration Rate	Authorized Limit
Am-241	1.89E+04	1.62E+04	1.45E+04	1.57E+04	3
C-14	4.82E+02	442.2	4.82E+02	3.02E+02	30
Co-60	7.51E+08	7.51E+08	7.51E+08	7.49E+08	2
Cs-137	4.40E+06	4.50E+06	2.98E+06	4.47E+06	10
Eu-152	7.53E+08	7.53E+08	7.53E+08	7.19E+08	5
Eu-154	1.78E+09	1.78E+09	1.71E+09	1.70E+09	5

TABLE 5 (Cont.)

Radionuclide	Adult Library ^a	Reference Person Library	Adult Library and Max. Plant Transfer Factor	Reference Person Library and Low Infiltration	Authorized Limit
H-3	1.29E+05	1.18E+05	1.29E+05	3.08E+05	150
Np-237	7.25E+02	6.20E+02	5.07E+02	1.34E+02	3
Pu-238	1.69E+06	1.51E+06	3.51E+05	7.73E+05	3
Pu-239	2.59E+04	2.33E+04	5.12E+03	5.16E+03	3
Ra-226	1.34E+01	9.32E+00	7.53E+00	9.07E+00	3
Sr-90	1.24E+06	9.42E+05	7.39E+05	4.52E+05	30
Tc-99	8.27E+01	5.90E+01	4.53E+01	2.14E+02	40
Th-230	2.51E+01	1.74E+01	1.41E+01	1.70E+01	3
Th-232	1.16E+01	5.84E+00	7.06E+00	5.69E+00	3
U-234	2.20E+03	1.77E+03	1.23E+03	6.25E+02	35
U-235	2.94E+03	9.18E+02	1.69E+03	3.25E+02	35
U-238	2.93E+03	2.48E+03	1.67E+03	7.19E+02	35

^a Adult Library guidelines match with values in Table 6 (page 28) and Table A.1, page A-38 of the Oak Ridge 2020a report except for the highlighted values.

Note: In Oak Ridge 2020a, Tables ES-1 (page ES-2) and Table 2 (page 9) do not list Am-241 but it is listed in Table 7 on page 30.

Effect of Using Reference Person Library, Maximum Plant Transfer Factor, and Low Infiltration in the Future Subsistence Farmer Scenario

The effect of different parameters on SRSGs in the Future Subsistence Farmer scenario was evaluated. Table 6 shows the effect of using the Reference Person Library instead of the Adult Library, maximum plant transfer factor with the Adult Library, and low infiltration rate with the Reference Person Library.

TABLE 6 SRSGs @ 15 mrem/yr Dose Criterion for Future Subsistence Farmer Scenario

Radionuclide	Adult Library ^a	Reference Person Library	Adult Library and Max. Plant Transfer Factor	Adult Library and Low Infiltration	Reference Person Library and Low Infiltration	Authorized Limit
Am-241	1.84E+04	1.57E+04	1.42E+04	1.79E+04	1.53E+04	3
C-14	8.48E+05	7.79E+05	8.48E+02	4.37E+02	4.01E+02	30
Co-60	1.95E+12	1.95E+12	1.95E+12	1.93E+12	1.93E+12	2
Cs-137	3.40E+05	3.48E+05	2.30E+05	3.38E+05	3.45E+05	10
Eu-152	7.30E+09	7.30E+09	7.30E+09	6.25E+09	6.25E+09	5
Eu-154	1.35E+11	1.35E+11	1.35E+11	1.16E+11	1.16E+11	5
H-3	3.78E+09	3.46E+09	3.78E+09	1.94E+06	1.77E+06	150
Np-237	6.99E+02	5.98E+02	4.88E+02	1.49E+02	1.28E+02	3
Pu-238	1.29E+06	1.14E+06	3.16E+05	4.69E+05	3.93E+05	3
Pu-239	2.56E+04	2.31E+04	5.06E+03	5.67E+03	5.11E+03	3

TABLE 6 (Cont.)

Radionuclide	Adult Library ^a	Reference Person Library	Adult Library and Max. Plant Transfer Factor	Adult Library and Low Infiltration	Reference Person Library and Low Infiltration	Authorized Limit
Ra-226	4.00E+00	3.01E+00	2.36E+00	4.21E+00	2.92E+00	3
Sr-90	8.46E+05	6.46E+05	5.06E+05	4.06E+05	3.09E+05	30
Tc-99	9.79E+02	6.98E+02	8.22E+02	2.75E+02	1.96E+02	40
Th-230	8.00E+00	5.73E+00	4.49E+00	8.02E+00	5.57E+00	3
Th-232	9.00E+00	4.85E+00	5.82E+00	9.02E+00	4.73E+00	3
U-234	5.15E+02	4.20E+02	2.85E+02	1.67E+02	1.40E+02	35
U-235	6.50E+02	3.94E+02	3.67E+02	1.89E+02	1.24E+02	35
U-238	6.39E+02	5.39E+02	3.59E+02	1.85E+02	1.56E+02	35

^a Adult Library guidelines match with values in Table 6 (page 28) and Table A.1, page A-38 of the Oak Ridge 2020a report.

Note: In Oak Ridge 2020a, Tables ES-1 (page ES-2) and Table 2 (page 9) do not list Am-241, but it is listed in Table 7 on page 30.

4 OAK RIDGE PREPARED RESPONSES TO ARGONNE COMMENTS AND PATH FORWARD

Oak Ridge agreed to most of Argonne's comments and prepared a list of questions. Argonne responded to these questions. A copy of the questions and Argonne's responses is included as Appendix B. Oak Ridge then developed a path forward related to each comment (Oak Ridge 2020b). Oak Ridge agreed to make the following changes:

1. For non-uranium radionuclides, soil concentration is increased by 28%, and waste thickness is reduced to 3.2 m from the initial 4.1m. There is no change for uranium radionuclides.
2. The Adult Library is to be used for the Current and Future Worker scenarios and the Reference Person Library for the Future Resident and Future Subsistence Farmer scenarios.
3. The cover thickness in the Current Operations Worker scenario is changed to 0.5 feet based on daily soil cover requirements at the site.
4. RESRAD-OFFSITE version 4.0 is to be used for all scenarios because RESRAD-OFFSITE can handle different plant transfer factors.
5. In response to the question on infiltration rate, HELP modeling is updated and the appropriate infiltration rate is used in the analysis.
6. Occupancy factors for the Current and Future Worker scenarios is to be appropriately adjusted.
7. Sum-of-fractions discussion is to be included in the main text.

After incorporating responses to the comments, Oak Ridge prepared a revised draft report in September 2020 (Oak Ridge 2020c). Argonne reviewed this revised report, and comments are summarized in Section 5.

5 REVIEW COMMENTS ON THE SEPTEMBER 2020 REVISED DRAFT REPORT

The September 2020 Oak Ridge revised draft report (Oak Ridge 2020c) responded to most of the Argonne comments listed in Comments, Response Table Review of ORR LF-IV Auth Limits 09_17_2020. Several issues in the current revised draft were identified and discussed in a BlueJeans meeting on September 30, 2020. A hard copy of the Argonne comments was then sent to Oak Ridge and DOE on October 2, 2020. This hard copy of written comments is included as Appendix C. The comments and issues identified are summarized as follows.

- a. RESRAD uses a special model for H-3 dose estimation, and using a very small leach rate is not appropriate for tritium dose estimation. Please revise Current Operations Worker scenario dose and soil guideline for H-3 using Kd value.
- b. For pasture and silage transfer factors in RESRAD-OFFSITE analysis, grain transfer factors are used, and it is better to use leafy vegetable transfer factors for pasture and silage. Please revise Future Resident and Future Subsistence Farmer scenario results.
- c. Check the results for the Future Resident scenario. For some of the radionuclides (e.g., C-14, H-3, Tc-99) much lower soil guidelines (in the time span 30–1000 years) than the values listed in Table 7 are expected.
- d. In Appendix A Attachments, also provide results for Future Operations Worker and Future Resident scenarios and Radon analysis. Attachments already show results for Current Operations Worker and Future Subsistence Farmer scenarios.
- e. Check uranium isotopes' soil guidelines listed @25mrem/yr limit for Future Subsistence Farmer scenario in Table 7 of the Oak Ridge September 2020 revised report. The ratio should be 1.67 for uranium isotopes, the same ratio as for all other radionuclides.
- f. In Table 8 of the Oak Ridge September 2020 revised report, the Tc-99 dose-based concentration limit for ILF-IV is more restrictive than the dose-based screening criteria (ILF-V, CDL-VII). For Tc-99 using dose-based screening criteria in sum-of-fractions calculation will not be more restrictive.

It is expected that incorporating these comments will not result in changes to the proposed ALs. However, the dose-based concentrations, that is, SRSGs, which are used in the sum-of-fractions calculations, may change.

Oak Ridge incorporated most of the comments in the updated Technical Support Document (Oak Ridge 2020d). The current worker SRSG for H-3 and the subsistence farmer SRSG @25mrem/yr dose limit for uranium isotopes were updated in Table 7. The TDEC dose-based screening criteria used earlier for ILF-V and CDL-VII was corrected in Table 8 for multiple radionuclides. This change resulted in TDEC screening criteria for Tc-99 (for ILF-V and CDL-VII) more restrictive compared to the dose-based concentration limit calculated for ILF-IV. Hence, this correction in the revised document resolves the comment in Section 5, Item f.

6 CONCLUSION

The approach taken by Oak Ridge, including use of previously approved ALs and use of two-tiered approach, is logical. The methodology and assumptions used to derive SRSGs, after incorporating the Argonne comments and suggestions, are reasonable and defensible. Approval by DOE of these ALs and dose-based screening criteria for sum of fractions calculation for ILF-IV is recommended.

7 REFERENCES

Oak Ridge, 2020a, Technical Support Document: Authorized Limits for Disposal of Waste Containing Residual Radioactive Material at DOE Industrial Landfill IV, Y-12 National Security Complex, Oak Ridge, Tennessee, Document Number OREM-19-2573, May.

Oak Ridge, 2020b, Comments, Responses, and Path Forward from ANL Review, prepared by Oak Ridge, September.

Oak Ridge, 2020c, Technical Support Document: Authorized Limits for Disposal of Waste Containing Residual Radioactive Material at DOE Industrial Landfill IV, Y-12 National Security Complex, Oak Ridge, Tennessee, Document Number OREM-19-2573, effective date 2020.

Oak Ridge, 2020d, Technical Support Document: Authorized Limits for Disposal of Waste Containing Residual Radioactive Material at DOE Industrial Landfill IV, Y-12 National Security Complex, Oak Ridge, Tennessee, Document Number OREM-19-2573R1, Revision 1, effective date December 2020.

Staven, L.H., B.A. Napier, K. Rhoads, and D.L. Streng, 2003, A Compendium of Transfer Factors for Agricultural and Animal Products, PNNL-13421, Pacific Northwest National Laboratory, Richland, WA, June.

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**APPENDIX A: JUNE 24, 2020 REVIEW COMMENTS ON THE “AUTHORIZED
LIMITS FOR DISPOSAL OF WASTE CONTAINING RESIDUAL RADIOACTIVE
MATERIAL AT DOE INDUSTRIAL LANDFILL IV, Y-12 NATIONAL SECURITY
COMPLEX, OAK RIDGE, TENNESSEE”**

Review Comments on the “Authorized Limits for Disposal of Waste Containing Residual Radioactive Material at DOE Industrial Landfill IV, Y-12 National Security Complex, Oak Ridge, Tennessee”

Sunita Kamboj and Charley Yu Environmental
Science Division Argonne National Laboratory

1

General Comments (1 of 2)

- The approach of using previously approved Authorized Limits (ALs) for other landfills (Landfill V and Landfill VII) in Oak Ridge for disposal of residual radioactive material at Landfill IV is logical.
- The “two-tiered” ALs approach, i.e., Administrative Limits as absolute concentration limits and dose-based Single Radionuclide Soil Guidelines (SRSGs) as the denominators used in the sum of fractions rule, is presented in Appendix A. This approach should be summarized in the Executive Summary and in the main section of the document. Both sets of concentration limits will need be approved by DOE.
- A set of dose-based SRSGs have already been used for Landfill V and Landfill VII. It seems logical to use the same set of SRSGs when applying the sum of fraction rule, as long as these SRSGs are more conservative than the actual dose-based SRSGs derived using computer models such as RESRAD-ONSITE, etc.

2

General Comments (2 of 2)

- It is stated that using RESRAD-ONSITE to estimate the dose is more conservative than using RESRAD-OFFSITE to estimate the dose to a resident. This statement is generally true if the exposure started at time 0 for both onsite and offsite receptors. If there is an institutional control period to restrict onsite resident scenario, then it is possible that the offsite resident may get a higher dose.
- Both ANSI/HPS N13.12 1999 and 2013 screening values for clearance are mentioned and the document stated that, for several radionuclides, “the original ANSI/HPS-N13.12 criteria remain in effect as the approved administrative limits.” There are radionuclides such as Co-60 the proposed AL (2 pCi/g) is actually lower than the ANSI/HPS N13.12 clearance limit of 3 pCi/g. The conservatism of the proposed ALs for some radionuclides compared to ANSI/HPS N13.12 free release (clearance) limits can be added to the discussion when ANSI/HPS N13.12 is mentioned.

3

Scenarios Considered

- Current Landfill Worker
 - Dose Constraint: 1 mrem/yr, Time frame: 0 – 40 years, one ft. of clean cover, 17% of the time outside, Exposure from direct external, inhalation, and soil ingestion (analyzed what will happen if there is no cover)
- Future Landfill Maintenance Worker
 - Dose Constraint: 1 mrem/yr, Time frame: 0 – 1000 years, 4 ft. of clean cover, 5% of the time outside and 18% inside, Exposure from direct external, inhalation, and soil ingestion
- Future Resident
 - Dose Constraint: 15 mrem/yr (ALARA), Time frame: 30 – 1000 years, 4 ft. of clean cover, 10% inside and 40% outside, Exposure from direct external, inhalation, plant and soil ingestion
- Future Subsistence Farmer
 - Dose Constraint: 15 mrem/yr, Time frame: 100 – 1000 years, 4 ft. of clean cover, 21% inside and 55% outside, Exposure from direct external, inhalation, plant, meat, milk, and soil ingestion

Notes: For Future Resident and Future Subsistence Farmer Scenarios analyzed how results will change if conservative plant TF are used, reference person dose library is used, low infiltration (1.24 inch/yr) to match HELP Code value (page A-10) is used.

4

Initial Soil Concentration

Soil concentration in the report is estimated based on the total capacity of the ILF-

15,708 yd³ capacity is already

56,091 yd³ is the remaining

It unlikely already filled waste volume would be disturbed. If it is assumed the radioactive waste at authorized limit is mixed in the remaining capacity of the landfill, this will result in lowering the depth to ~ 3.2 m from 4.1 m and will increase the soil concentration by ~28%

Radionuclide	Initial Soil Concentration (pCi/g)
Am-241	7.66E-03
C-14	5.34E-03
Co-60	5.16E-03
Cs-137	
	1.52E-03
Eu-154	8.97E-03
H-3	5.24E-02
Np-237	1.27E-02
Pu-238	5.60E-03
Pu-	5.27E-03
Ra-226	8.27E-02
Sr-90	8.21E-02
Tc-99	1.43E-01
Th-230	1.39E-01
Th-232	8.88E-02
U-234	2.29E+00
U-238	2.30E+00

5

Landfill Current Worker

- DCFPAK 3.02 Adult Library instead of DCFPAK 3.02 Reference Person Library is used – results in no change in dose because with cover inhalation and ingestion pathway doses are zero
- By removing the cover, dose changes from 7.24E-3 to 0.4293 [0.527] mrem/yr @ 40 years for Adult and to 0.4309 mrem/yr for Reference person
- By assuming Th-232 is in equilibrium with Ra-228 and Th-228, the doses changes to 0.4729 mrem/yr @ 0 years for Adult and to 0.4742 mrem/yr for Reference person

Note: Internal dose library used DOE-STD-1196-2011 (Reference Person) (see page A-11, Table A.5).

It is likely decay progeny Ra-228 (half life 5.75 y) and Th-228 (Half life 1.912 y) of Th-232, are present at the same concentration as Th-232.

6

Current Worker Guidelines (@ 1 mrem/yr dose criterion) from Different Analysis & Comparison with Authorized Limits

Radionuclide	0.3 m Cover*	No Cover (Adult)	Authorized Limit
Am-241	3.26E+08	70	3
C-14	4.48E+12	25600	30
Co-60	24	0.44	2
Cs-137	296	2.0	10
Eu-152	78	0.96	5
Eu-154	74	0.90	5
H-3	9.62E+15	3570000	150
Np-237	4.46E+03	5.57	3
Pu-238	9.06E+09	111	3
Pu-239	4.70E+07	100	3
Ra-226	36	0.60	3
Sr-90	1.86E+05	150	30
Tc-99	6.61E+09	40740	40
Th-230	2.08E+03	26	3
Th-232	20	0.44	3
U-234	1.10E+07	899	35
U-235	1.95E+04	8.4	35
U-238	6.17E+03	37	35

* 0.3 m cover guidelines match with values in Table 6 (Page 28) and Table A.1, page A-38

Note: Tables ES-1 (Page ES-2) and Table 2 (Page 9) do not list Am-241 (Am-241 is not listed in previously approved AL) but is listed in Table 7 (Proposed AL) on Page 30.

7

Plant Transfer Factors

Element	RESRAD (default)	PNNL - Fresh Weight (Staven et al. 2003)					Max from PNNL
		Leafy Vegetables	Fruits	Grains	Root Vegetables	ILF-IV Modeling	
Ac	2.5×10^{-3}	9.4×10^{-5}	4.5×10^{-5}	2.0×10^{-5}	8.8×10^{-5}	7.25E-05	9.40E-05
Am	1.0×10^{-3}	9.4×10^{-5}	4.5×10^{-5}	2.0×10^{-5}	8.8×10^{-5}	7.25E-05	9.40E-05
C	5.5×10^0	1.4×10^{-1}	1.3×10^{-1}	6.4×10^{-1}	1.8×10^{-1}	2.28E-01	6.40E-01
Co	8.0×10^{-2}	4.6×10^{-2}	1.3×10^{-3}	3.4×10^{-3}	1.7×10^{-2}	2.66E-02	4.60E-02
Cs	4.0×10^{-2}	9.2×10^{-2}	4.0×10^{-2}	2.4×10^{-2}	3.3×10^{-2}	6.22E-02	9.20E-02
Eu	2.5×10^{-3}	$4. \times 10^{-3}$	3.6×10^{-3}	1.8×10^{-2}	$5. \times 10^{-3}$	6.43E-03	1.80E-02
Gd	2.5×10^{-3}	4.0×10^{-3}	3.6×10^{-3}	1.8×10^{-2}	5.0×10^{-3}	6.43E-03	1.80E-02
H	4.8×10^0	NA	NA	NA	NA	4.80E+00	4.80E+00
Nd	2.4×10^{-3}	4.0×10^{-3}	3.6×10^{-3}	1.8×10^{-2}	$5. \times 10^{-3}$	6.43E-03	1.80E-02
Np	2.0×10^{-2}	6.4×10^{-3}	1.8×10^{-3}	2.5×10^{-3}	3.3×10^{-3}	4.47E-03	6.40E-03
Pa	1.0×10^{-2}	9.4×10^{-5}	4.5×10^{-5}	$2. \times 10^{-5}$	8.8×10^{-5}	7.25E-05	9.40E-05
Pb	1.0×10^{-2}	2.0×10^{-3}	1.8×10^{-3}	4.3×10^{-3}	1.5×10^{-3}	2.27E-03	4.30E-03
Pu	1.0×10^{-3}	1.2×10^{-5}	8.1×10^{-6}	7.8×10^{-6}	2.8×10^{-4}	5.53E-05	2.80E-04
Ra	4.0×10^{-2}	9.8×10^{-3}	1.1×10^{-3}	1.1×10^{-3}	$5. \times 10^{-4}$	5.35E-03	9.80E-03
Sm	2.5×10^{-3}	4.0×10^{-3}	3.6×10^{-3}	1.8×10^{-2}	5.0×10^{-3}	6.43E-03	1.80E-02
Sr	3.0×10^{-1}	6.0×10^{-1}	3.6×10^{-2}	1.9×10^{-1}	1.3×10^{-1}	3.59E-01	6.00E-01
Tc	5.0×10^0	4.2×10^1	2.7×10^1	6.6×10^1	6.0×10^2	2.12E+01	4.20E+01
Th	1.0×10^{-3}	3.6×10^{-4}	4.5×10^{-5}	3.1×10^{-5}	8.3×10^{-5}	2.07E-04	3.60E-04
U	2.5×10^{-3}	1.7×10^{-3}	7.2×10^{-4}	1.2×10^{-3}	3.0×10^{-3}	1.67E-03	3.00E-03

Note: RESRAD-ONSITE code uses one plant transfer factor for all plant types including fodder. Maximum from PNNL are used in the analysis.

8

Future Resident

- DCFPAK 3.02 Adult Library instead of DCFPAK 3.02 Reference Person Library is used – dose changes from 0.319 to 0.5166 mrem/yr
- By using the maximum plant TF, the dose changes from 0.319 for the Adult to 0.5515 mrem/yr @1,000 years

9

Future Resident Guidelines @ 15 mrem/yr Dose Criterion from Different Analysis & Comparison with Authorized Limits

Radionuclide	Adult Library	Reference Person Library	Adult Library & Max Plant TF	RP + Low Infiltration	Authorized Limit
Am-241	1.89E+04	1.62E+04	1.45E+04	1.57E+04	3
C-14	4.82E+02	442.2	4.82E+02	3.02E+02	30
Co-60	7.51E+08	7.51E+08	7.51E+08	7.49E+08	2
Cs-137	4.40E+06	4.50E+06	2.98E+06	4.47E+06	10
Eu-152	7.53E+08	7.53E+08	7.53E+08	7.19E+08	5
Eu-154	1.78E+09	1.78E+09	1.71E+09	1.70E+09	5
H-3	1.29E+05	1.18E+05	1.29E+05	3.08E+05	150
Np-237	7.25E+02	6.20E+02	5.07E+02	1.34E+02	3
Pu-238	1.69E+06	1.51E+06	3.51E+05	7.73E+05	3
Pu-239	2.59E+04	2.33E+04	5.12E+03	5.16E+03	3
Ra-226	1.34E+01	9.32E+00	7.53E+00	9.07E+00	3
Sr-90	1.24E+06	9.42E+05	7.39E+05	4.52E+05	30
Tc-99	8.27E+01	5.90E+01	4.53E+01	2.14E+02	40
Th-230	2.51E+01	1.74E+01	1.41E+01	1.70E+01	3
Th-232	1.16E+01	5.84E+00	7.06E+00	5.69E+00	3
U-234	2.20E+03	1.77E+03	1.23E+03	6.25E+02	35
U-235	2.94E+03	9.18E+02	1.69E+03	3.25E+02	35
U-238	2.93E+03	2.48E+03	1.67E+03	7.19E+02	35

* Adult Library guidelines match with values in Table 6 (Page 28) and Table A.1, page A-38 except for the highlighted values

Note: Tables ES-1 (Page ES-2) and Table 2 (Page 9) do not list Am-241 (Am-241 is not listed in previously approved AL) but is listed in Table 7 (Proposed AL) on Page 30.

10

Subsistence Farmer

- DCFPAK 3.02 Adult Library instead of DCFPAK 3.02 Reference Person Library is used – dose changes from 0.8016 to 1.202 mrem/yr
- By using the maximum plant TF, the dose changes from 0.8016 for the Adult to 1.441 mrem/yr @ 1,000 years
- Sensitivity analysis on infiltration rate (by a factor = 1.18 on Evapotranspiration coefficient), low infiltration dose = 1.1 and high infiltration dose = 0.7 mrem/yr compared to 0.8016 mrem/yr.

11

Future Subsistence Farmer Guidelines @ 15 mrem/yr dose criterion from Different Analysis & Comparison with Authorized Limits

Am-241	1.84E+04	1.57E+04	1.42E+04	1.79E+04	1.53E+04	3
C-14	8.48E+05	7.79E+05	8.48E+02	4.37E+02	4.01E+02	30
Co-60	1.95E+12	1.95E+12	1.95E+12	1.93E+12	1.93E+12	2
Cs-137	3.40E+05	3.48E+05	2.30E+05	3.38E+05	3.45E+05	10
Eu-152	7.30E+09	7.30E+09	7.30E+09	6.25E+09	6.25E+09	5
Eu-154	1.35E+11	1.35E+11	1.35E+11	1.16E+11	1.16E+11	5
H-3	3.78E+09	3.46E+09	3.78E+09	1.94E+06	1.77E+06	150
Np-237	6.99E+02	5.98E+02	4.88E+02	1.49E+02	1.28E+02	3
Pu-238	1.29E+06	1.14E+06	3.16E+05	4.69E+05	3.93E+05	3
Pu-239	2.56E+04	2.31E+04	5.06E+03	5.67E+03	5.11E+03	3
Ra-226	4.00E+00	3.01E+00	2.36E+00	4.21E+00	2.92E+00	3
Sr-90	8.46E+05	6.46E+05	5.06E+05	4.06E+05	3.09E+05	30
Tc-99	9.79E+02	6.98E+02	8.22E+02	2.75E+02	1.96E+02	40
Th-230	8.00E+00	5.73E+00	4.49E+00	8.02E+00	5.57E+00	3
Th-232	9.00E+00	4.85E+00	5.82E+00	9.02E+00	4.73E+00	3
U-234	5.15E+02	4.20E+02	2.85E+02	1.67E+02	1.40E+02	35
U-235	6.50E+02	3.94E+02	3.67E+02	1.89E+02	1.24E+02	35
U-238	6.39E+02	5.39E+02	3.59E+02	1.85E+02	1.56E+02	35

* Adult Library guidelines match with values in Table 6 (Page 28) and Table A.1, page A-38

* Note: Tables ES-1 (Page ES-2) and Table 2 (Page 9) do not list Am-241 (Am-241 is not listed in previously approved AL) but is listed in Table 7 (Proposed AL) on Page 30.

12

Individual Radionuclide Guidelines from Different Scenarios

Radionuclide	Current Landfill Worker (No Cover-Adult)	Future Resident (RP + Low Infiltration)	Future Subsistence Farmer (RP + Low Infiltration)	Most Restrictive Guideline	Scenario
Am-241	6.98E+01	1.57E+04	1.53E+04	6.98E+01	Current LF Worker
C-14	2.56E+04	3.02E+02	4.01E+02	3.02E+02	Future Resident
Co-60	4.37E-01	7.49E+08	1.93E+12	4.37E-01	Current LF Worker
Cs-137	2.00E+00	4.47E+06	3.45E+05	2.00E+00	Current LF Worker
Eu-152	9.59E-01	7.19E+08	6.25E+09	9.59E-01	Current LF Worker
Eu-154	8.96E-01	1.70E+09	1.16E+11	8.96E-01	Current LF Worker
H-3	3.57E+06	3.08E+05	1.77E+06	3.08E+05	Future Resident
Np-237	5.57E+00	1.34E+02	1.28E+02	5.57E+00	Current LF Worker
Pu-238	1.11E+02	7.73E+05	3.93E+05	1.11E+02	Current LF Worker
Pu-239	9.99E+01	5.16E+03	5.11E+03	9.99E+01	Current LF Worker
Ra-226	5.99E-01	9.07E+00	2.92E+00	5.99E-01	Current LF Worker
Sr-90	1.50E+02	4.52E+05	3.09E+05	1.50E+02	Current LF Worker
Tc-99	4.07E+04	2.14E+02	1.96E+02	1.96E+02	Subsistence Farmer
Th-230	2.64E+01	1.70E+01	5.57E+00	5.57E+00	Subsistence Farmer
Th-232	4.45E-01	5.69E+00	4.73E+00	4.45E-01	Current LF Worker
U-234	8.99E+02	6.25E+02	1.40E+02	1.40E+02	Subsistence Farmer
U-235	8.35E+00	3.25E+02	1.24E+02	8.35E+00	Current LF Worker
U-238	3.72E+01	7.19E+02	1.56E+02	3.72E+01	Current LF Worker

13

Table 7. Proposed TDEC Screening Criteria and DOE Authorized Limits for Residual Radioactive Material in Waste for Disposal at ILF-IV

Radionuclide	Volumetric Concentration Criteria (pCi/g)		
	Proposed Authorized Limit/ Screening Criterion	Limiting Scenario and Associated Dose-Based Concentration Limit for ILF-IV	
		Dose-based limit	Limiting Scenario ^{a,b}
Tritium	150	3.78E+09	Subsistence farmer
Carbon-14	30	8.48E+05	Subsistence farmer
Cobalt-60	2	24	Current worker
Strontium-90	30	1.86E+05	Current worker
Technetium-99	40	979	Subsistence farmer
Cesium-137	10	296	Current worker
Europium-152	5	78	Current worker
Europium-154	5	74	Current worker
Radium-226 ^c	3	4	Subsistence farmer
Thorium-230 ^c	3	8	Subsistence farmer
Thorium-232 ^c	3	9	Subsistence farmer
Uranium-234	35	515	Subsistence farmer
Uranium-235	35	650	Subsistence farmer
Uranium-238	35	639	Subsistence farmer
Uranium-total	35	572	Subsistence farmer
Neptunium-237	3	699	Subsistence farmer
Plutonium-238	3	1.29E+06	Subsistence farmer
Plutonium-239	3	2.56E+04	Subsistence farmer
Americium-241	3	1.84E+04	Subsistence farmer

^a Current landfill operations worker scenario derived using RESRAD-ONSITE computer code, based on dose constraint of 1 mrem/year.

^b Future subsistence farmer scenario derived using RESRAD-ONSITE computer code. Values here are based on the ALARA dose constraint goal of ≤ 15 mrem/year; scenario dose constraint is 25 mrem/year.

^c The Th-230/Ra-226 and Th-232 decay series are limited to 3 pCi/g each; in addition, the combined concentrations of the Th-230/Ra-226 and Th-232 decay series are limited to 5 pCi/g above background, consistent with DOE O 458.1.

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Comparison of Dose Based Concentration Limits from ANL and Oak Ridge Analysis

Radionuclide	ANL Analysis		Oak Ridge Analysis		Proposed Authorized Limits/ Administrative limits
	Most Restrictive Guideline	Scenario	Most Restrictive Guideline	Scenario	
Am-241	6.98E+01	Current LF Worker	1.84E+04	Subsistence Farmer	3
C-14	3.02E+02	Future Resident	8.48E+05	Subsistence Farmer	30
Co-60	4.37E-01	Current LF Worker	2.40E+01	Current LF Worker	2
Cs-137	2.00E+00	Current LF Worker	2.96E+02	Current LF Worker	10
Eu-152	9.59E-01	Current LF Worker	7.80E+01	Current LF Worker	5
Eu-154	8.96E-01	Current LF Worker	7.40E+01	Current LF Worker	5
H-3	3.08E+05	Future Resident	3.78E+09	Subsistence Farmer	150
Np-237	5.57E+00	Current LF Worker	6.99E+02	Subsistence Farmer	3
Pu-238	1.11E+02	Current LF Worker	1.29E+06	Subsistence Farmer	3
Pu-239	9.99E+01	Current LF Worker	2.56E+04	Subsistence Farmer	3
Ra-226	5.99E-01	Current LF Worker	4.00E+00	Subsistence Farmer	3
Sr-90	1.50E+02	Current LF Worker	1.86E+05	Current LF Worker	30
Tc-99	1.96E+02	Subsistence Farmer	9.79E+02	Subsistence Farmer	40
Th-230	5.57E+00	Subsistence Farmer	8.00E+00	Subsistence Farmer	3
Th-232	4.45E-01	Current LF Worker	9.00E+00	Subsistence Farmer	3
U-234	1.40E+02	Subsistence Farmer	5.15E+02	Subsistence Farmer	35
U-235	8.35E+00	Current LF Worker	6.50E+02	Subsistence Farmer	35
U-238	3.72E+01	Current LF Worker	6.39E+02	Subsistence Farmer	35

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**APPENDIX B: ANL RESPONSE TO OAK RIDGE QUESTIONS
FROM JUNE 24, 2020 PRESENTATION**

ANL Response to Oak Ridge Questions from June 24, 2020 Presentation

We sincerely appreciate your comments. We have a few clarifying questions that we are hoping the ANL team can answer to assist potential model updates.

ANL responses are in shaded dark blue text.

Slide 5 (Initial Soil Concentration)

- It is understood that the ~28% concentration increase shown on the slide was calculated by applying a factor of 4.1/3.2 to the original source concentration. Please clarify if there were any adjustments of SRSG values calculated directly from RESRAD-Onsite. Also, during simulations was the unsaturated zone thickness increased by the simulated 0.9m decrease in waste thickness?

Response

This slide shows that the soil concentration could be ~28% higher. There were no adjustments made to SRSG values calculated directly from RESRAD-ONSITE code. It is correct that decreasing the thickness of contaminated zone, the unsaturated zone thickness will increase correspondingly.

Slide 6 (Landfill Current Worker)

- For each scenario (Current Worker, Future Worker, Future Resident, Future Subsistence Farmer) does ANL consider Adult or Reference Person most applicable? Reconsidering previous assumptions, it seems that Reference Adult would be most applicable for both Worker scenarios given the potential receptor. Regarding the other two longer term scenarios (Future Resident and Future Subsistence Farmer), we refer to ICPR 101 and request ANL's input.

Response

The issue is the inconsistency in the description of the scenario where it was stated that the Reference Person internal dose library was used, whereas in the actual run, the Adult internal dose library was used. For both Worker Scenarios, using the Adult dose library is appropriate. For Future Resident and Future Subsistence Farmer scenarios, it seems that Reference Person dose library can be used.

- From ICPR 101, P. 26-27 – Use of Adult
(77) Paragraph 20 points out that the dose constraint is set, at least in part, on the basis of exposures to individuals that are assumed to continue to occur for a number of years into the future. Most facilities are expected to operate for a period of at least 50 years. Therefore, it is the same individual being exposed for a number of years for whom compliance is being determined. This fundamental concept of continuing exposure to the same individual justifies the use of a limited number of age categories that cover several years of a person's life. In the case of disposal of long-lived radioactive waste, where dose to the public may be incurred in the far future over the entire life of the individual, the Commission has stated that '...it is then reasonable to calculate the annual dose/risk averaged over the lifetime of the individuals, which means that it is not necessary to calculate

doses to different age groups; this average can be adequately represented by the annual dose/risk to an adult' (ICRP, 2000).

- Please verify that ANL agrees with specifying the cover thickness as 0.5 feet for the Current Landfill Worker.

Response

ANL agrees to use 0.5 feet cover thickness only if it is the current practice at the ILF-IV landfill to place a 0.5 feet cover during operation. However, it seems not practical to maintain a 0.5-feet cover at the time of actual placement of waste. The time used in placing the waste will also not be 17% (it will depend on how often the waste is brought on the landfill [say 50 times a year] how much time it takes to place the waste [say 4 hours/trip] and after that it will take some time to cover the waste [say 4 hours/trip] because that's the requirement).

Slide 8 (Plant Transfer Factors)

- It is apparent that specification of max plant transfer factors was used for simulations presented on slide 8. During the 17June2020 call it was requested by ANL that the plant transfer factors be weighted by consumption (instead of averaged), as was done previously for meat. Please clarify if the max transfer factors were used or if the plant transfer factors were consumption weighted. If max plant transfer factors were specified, please provide guidance as to why the use of max plant transfer factors is more appropriate than using the consumption weighted transfer factors. Would specification of consumption weighted plant transfer factors be appropriate for the base case with a sensitivity analysis performed applying the higher and lower values shown in the last three columns summarizing Appendix A values (average), Max values, and Consumption Weighted Factors, respectively?

Response

For human plant ingestion dose calculations, it is OK to use consumption rate weighted plant transfer factors. In RESRAD-ONSITE code, only one plant transfer factor is used for all plant types including the fodder/grass consumed by meat and milk cow. Therefore, when using RESRAD-ONSITE code, it is more conservative to use the maximum plant transfer factors. Note that RESRAD-OFFSITE code allows four different plant transfer factors. For offsite resident scenarios, it is recommended to use RESRAD-OFFSITE code.

Element	PNNL-Fresh Weight (Staven et al. 2003)					Appendix A (Average)	Max (ANL Review)	Consumptive Rate Weighted
	RESRAD (default)	Leafy Vegetables	Fruits	Grains	Root Vegetables			
Ac	2.50E-03	9.40E-05	4.50E-05	2.00E-05	8.80E-05	7.25E-05	9.40E-05	5.48E-05
Am	1.00E-03	9.40E-05	4.50E-05	2.00E-05	8.80E-05	7.25E-05	9.40E-05	5.48E-05
C	5.5	1.40E-01	1.30E-01	6.40E-01	1.80E-01	2.28E-01	6.40E-01	2.48E-01
Co	8.00E-02	4.60E-02	1.30E-03	3.40E-03	1.70E-02	2.66E-02	4.60E-02	1.06E-02
Cs	4.00E-02	9.20E-02	4.00E-02	2.40E-02	3.30E-02	6.22E-02	9.20E-02	3.76E-02
Eu	2.50E-03	4.00E-03	3.60E-03	1.80E-02	5.00E-03	6.43E-03	1.80E-02	8.44E-03
Gd	2.50E-03	4.00E-03	3.60E-03	1.80E-02	5.00E-03	6.43E-03	1.80E-02	8.44E-03
H	4.80E+00	NA	NA	NA	NA	4.80E+00	4.80E+00	4.80E+00
Nd	2.40E-03	4.00E-03	3.60E-03	1.80E-02	5.00E-03	6.43E-03	1.80E-02	8.44E-03
Np	2.00E-02	6.40E-03	1.80E-03	2.50E-03	3.30E-03	4.47E-03	6.40E-03	2.87E-03
Pa	1.00E-02	9.40E-05	4.50E-05	2.00E-05	8.80E-05	7.25E-05	9.40E-05	5.48E-05
Pb	1.00E-02	2.00E-03	1.80E-03	4.30E-03	1.50E-03	2.27E-03	4.30E-03	2.49E-03
Pu	1.00E-03	1.20E-05	8.10E-06	7.80E-06	2.80E-04	5.53E-05	2.80E-04	9.10E-05
Ra	4.00E-02	9.80E-03	1.10E-03	1.10E-03	5.00E-04	5.35E-03	9.80E-03	1.68E-03
Sm	2.50E-03	4.00E-03	3.60E-03	1.80E-02	5.00E-03	6.43E-03	1.80E-02	8.44E-03
Sr	3.00E-01	6.00E-01	3.60E-02	1.90E-01	1.30E-01	3.59E-01	6.00E-01	1.61E-01
Tc	5.00E+00	4.30E+01	2.70E-01	6.60E-01	6.00E-02	2.12E+01	4.20E+01	4.00E+00
Th	1.00E-03	3.60E-04	4.50E-05	3.10E-05	8.30E-05	2.07E-04	3.60E-04	8.00E-05
U	2.50E-03	1.70E-03	7.20E-04	1.20E-03	3.00E-03	1.67E-03	3.00E-03	1.65E-03

Slides 10 and 11 (Infiltration)

- Regarding infiltration, the reviewed Appendix A included simulation results for various infiltration rates (1.24 in/yr, 7.13 in/yr, 11.7 in/yr.). Which infiltration rate was used for simulations shown in the table on slide 10? Also, can we obtain the evapotranspiration and runoff coefficients specified in the model?

Response

Attachment B in Appendix A does provide simulation results for various infiltration rates but does not provide dose-based single radionuclide soil guidelines (SRSGs) corresponding to those infiltration rates.

In our calculations, 1.24 in/yr infiltration rate was used for simulation results shown in the Table on slide 10. For this run, the evapotranspiration coefficient used was at 0.968 and runoff coefficient was 0.388.

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**APPENDIX C: COMMENTS ON REVISED DRAFT REPORT TITLED “TECHNICAL
SUPPORT DOCUMENT: AUTHORIZED LIMITS FOR DISPOSAL OF WASTE
CONTAINING RESIDUAL RADIOACTIVE MATERIAL AT THE U.S. DEPARTMENT
OF ENERGY INDUSTRIAL LANDFILL IV, Y-12 NATIONAL SECURITY COMPLEX,
OAK RIDGE, TENNESSEE” (OREM-19-2573)**

Comments on Revised Draft Report Titled “Technical Support Document: Authorized Limits for Disposal of Waste Containing Residual Radioactive Material at the U.S. Department of Energy Industrial Landfill IV, Y-12 National Security Complex, Oak Ridge, Tennessee” (OREM-19-2573)

General Comment

The Revised Draft report responded to most of the comments identified earlier as listed in Comments, Response Table Review of ORR LF-IV Auth Limits 09_17_2020.

However, the following issues in the current revised draft are identified. Note Authorized Limits are conservative and will not change based on the issues identified. However, the dose-based concentrations are used in the sum-of-fraction calculations and those may change.

Specific Comments

- RESRAD uses a special model for H-3 dose estimation; using very small leach rate is not appropriate for tritium dose estimation. Please revise Current Worker scenario dose and soil guideline for H-3 using Kd value.
- For pasture and silage transfer factors in RESRAD-OFFSITE analysis, grain transfer factors are used; it is better to use leafy vegetable transfer factors for pasture and silage. Please revise Resident and Subsistence Farmer scenario results.
- Check the results for Resident scenario, for some of the radionuclides (e.g., C-14, H-3, Tc-99) one expects to see much lower soil guidelines (in the time span 30 – 1000 years) compared to the values listed in Table 7.
- In Appendix A Attachments, also provide results for Future Worker and Resident scenarios, and Radon analysis. Attachments already show results for Current Worker and Subsistence Farmer Scenarios.
- Check uranium isotopes’ soil guidelines listed @25mrem/yr limit for Subsistence Farmer scenario in Table 7; table below shows the ratio of 25 to 15 mrem guidelines (the ratio should be 1.67, but for uranium isotopes it is 1.15) listed in Table 7. For all other radionuclides, ratios are correct.

Radionuclide	Subsistence Farmer Scenario SRSG (pCi/g)		Ratio (25/15)
	@ 15 mrem/yr	@ 25 mrem/yr	
Am-241	4.29E+04	7.15E+04	1.67E+00
C-14	3.10E+04	5.16E+04	1.66E+00
Co-60	2.45E+13	4.08E+13	1.67E+00
Cs-137	6.44E+08	1.07E+09	1.66E+00
Eu-152	1.12E+11	1.87E+11	1.67E+00
Eu-154	2.10E+12	3.50E+12	1.67E+00
H-3	1.23E+08	2.04E+08	1.66E+00
Np-237	1050	1740	1.66E+00
Pu-238	1.85E+06	3.08E+06	1.66E+00
Pu-239	1.54E+04	2.56E+04	1.66E+00
Ra-226	4.1	6.83	1.67E+00
Sr-90	1.61E+09	2.69E+09	1.67E+00
Tc-99	107	179	1.67E+00
Th-230	7.88	13.1	1.66E+00
Th-232	37.4	62.3	1.67E+00
U-234	518	5.95E+02	1.15E+00
U-235	717	8.24E+02	1.15E+00
U-238	697	8.00E+02	1.15E+00

- g. In Table 8, Tc-99 dose-based concentration limit for ILF-IV is more restrictive than the dose-based screening criteria (ILF-V, CDL-VII). For Tc-99 using dose-based screening criteria in sum-of-fraction calculations will not be more restrictive.

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