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APPENDIX 8.0-7 SENSITIVITY AND UNCERTAINTY ANALYSIS

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8.0-7 SENSITIVITY AND UNCERTAINTY ANALYSIS

This appendix identifies sensitive parameters used in the detailed calculations and evaluates the effects of variations of these parameters on the calculated doses. The water infiltration calculations from the Hydrologic Evaluation of Landfill Performance (HELP) model were evaluated to address the effects of unusual conditions and cover system degradation. By varying certain parameters in the HELP model, a range of infiltration values was developed. Parameter variations in the Residual Radiation Risk Assessment Computer Code (RESRAD) dose calculations were evaluated for a similar set of unusual conditions and cover degradation modes. In addition, a probabilistic uncertainty calculation was conducted with the RESRAD model to evaluate the potential range of individual doses.

Parameter uncertainty arises from several sources, including uncertainty associated with field measurements, uncertainty in determining parameters values used in computer models, and uncertainty from the intrinsic heterogeneity of the natural site. Parameter uncertainty reflects an incomplete knowledge of the Site. For example, the site geology is based on data from boreholes that characterize the geologic strata. The data are analyzed to produce a reasonable and consistent description of the Site, rather than drill boreholes at every location to remove all parameter uncertainty. Parameter uncertainty is addressed in a series of deterministic sensitivity simulations and in a Monte Carlo uncertainty analysis.

Parameter ranges used in the sensitivity analysis are based, as much as possible, on measurements of site characteristics. For example, a range of measurements are available for the red bed clay conductivity. The measurements are from Resource Conservation and Recovery Act (RCRA) liner tests and in situ measurements of the red bed clay. The range of measured conductivity values is used as the basis for the sensitivity analysis on clay conductivity.

8.0-7.1 HELP Sensitivity Analysis

The HELP model (USAE 1997) evaluates cover system performance for a baseline case that represents the expected performance of the cover and for several varied conditions. The sensitivity cases address increased precipitation, degradation of the performance cover hydraulic conductivity, degradation of the lateral drainage system, the effect of layer thickness above and below the performance cover, the combined effects of high precipitation and cover degradation, and cover erosion. The sensitivity cases are summarized in Table 8.0-7-1.

Table 8.0-7-1. Conditions Evaluated in HELP Sensitivity Analysis

Condition	Parameters Varied
Baseline	All parameters at baseline values
1. High Precipitation	29" precipitation, Wichita climate
2. Cover Degradation, High Conductivity	Conductivity of performance cover increased by factor of 6 (95 th percentile of measured values)
3. Cover Degradation, Reduced Lateral Drainage	Conductivity of lateral drainage layer decreased by factor of 10
4. Cover Performance, Layer Thickness	Layer thicknesses above and below performance cover
5. Combined High Precipitation and Cover Degradation	29" precipitation and performance cover conductivity increased by factor of 6
6. Eroded Cover	Thinner surface layer to account for 50,000 years erosion

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The first sensitivity case examined the effect of higher than normal precipitation. The normal precipitation at the Site is 16 inches per year. For the high rainfall sensitivity case, the rainfall was increased to 29 inches per year. The increase is based on the future climate study and uses a climate similar to Wichita, Kansas, which is cooler and wetter than present-day conditions at the Site. Both the Compact Waste Facility (CWF) and Federal Waste Facility (FWF) cover systems were modeled. The FWF cover system extends over both the Federal Waste Facility-Canister Disposal Unit (FWF-CDU) and the Federal Waste Facility Non-Canister Disposal Unit (FWF-NCDU).

The second sensitivity case modeled degradation of the performance cover. The performance cover is the final barrier to infiltrating water before water encounters the waste layer. It is also the layer with the lowest hydraulic conductivity in the cover system. Degradation of the performance cover was simulated by a six-fold increase in its hydraulic conductivity, from the baseline value of $4.0\text{E-}9$ cm/s to $2.4\text{E-}8$ cm/s. The conductivity range is based on measured data from the WCS RCRA facility liner and on in situ measurements of red bed clay. The high conductivity value is equal to the 95th percentile of the measured values.

The third sensitivity case modeled the degradation of the lateral drainage layer above the performance cover. The sand layer above the performance cover was designed to provide a means of diverting water laterally across the top of the performance cover to minimize vertical infiltration through the compacted clay below. The effectiveness of the lateral drainage layer depends on maintaining a high hydraulic conductivity. For this sensitivity case, clogging of the lateral drainage layer was simulated by reducing its hydraulic conductivity by a factor of ten.

The fourth sensitivity case evaluated the effects of changing the thickness of layers in the cover system. The performance cover is sloped with its highest point at the center of the respective facility (CWF or FWF). At the edge of each facility the performance cover is near the same elevation as the top of the waste. Because of the slope, the crown of the performance cover (at the center of each facility) has the greatest amount of fill material beneath it and the least amount of fill above it. Conversely, at the toe of the cover (at the edge of each facility) the performance cover has almost no fill material beneath it and the maximum amount above it. The baseline analysis used the layer thicknesses at a point midway between the crown and the toe of the performance cover. This sensitivity case evaluates the infiltration rate using the layer thicknesses at the toe of the cover.

The fifth sensitivity case evaluated the combined effects of increased precipitation and increased hydraulic conductivity of the performance cover. This uses the high precipitation (29"/yr) from sensitivity case 2 and the increased hydraulic conductivity from sensitivity case 3.

The sixth, and last, infiltration sensitivity case evaluated the effect of erosion on the cover system. Based on the Soil and Water Assessment Tool (SWAT) analysis in Attachment 3.0-3.29, water and wind erosion could remove up to 23 inches of material from the ground surface over the next 50,000 years. While there is evidence that the Site is aggrading, the erosion analysis looks at a worst case condition in which the cover is eroded over time. For this sensitivity analysis, the surface layers of the cover were reduced by 23 inches to account for 50,000 years of erosion.

The results of the infiltration sensitivity analyses are shown in Table 8.0-7-2. The baseline infiltration rates were 0.0960 cm/yr for the CWF and 0.0974 cm/yr for the FWF. The FWF

infiltration rate was slightly higher because the drainage layer above the performance cover was sloped at only 3 percent, compared to 4 percent in the CWF. In addition, the slope length on the FWF was longer (650 feet vs. 365 feet for the Compact). The FWF's lower slope and longer slope length both served to decrease the amount of lateral drainage and, therefore, slightly increased the infiltration. For both cover systems, the total infiltration was approximately equal to the hydraulic conductivity of the compacted red bed clay in the performance cover. The performance cover was assumed to have a hydraulic conductivity of $4.0E-9$ cm/s. In these units, the infiltration rates were $3.0E-09$ cm/s for the CWF and $3.1E-09$ cm/s for the FWF.

Table 8.0-7-2. Infiltration Sensitivity Results

Condition	Compact Facility Infiltration (cm/yr)	Federal Facility Infiltration (cm/yr)
Baseline	9.60E-02	9.74E-02
1. High Precipitation	1.29E-01	1.32E-01
2. Cover Degradation, High Conductivity	2.38E-01	2.42E-01
3. Cover Degradation, Reduced Lateral Drainage	1.07E-01	1.18E-01
4. Cover Performance, Layer Thickness	9.60E-02	9.74E-02
5. Combined High Precipitation and Cover Degradation	7.57E-01	7.78E-01
6. Eroded Cover	1.27E-01	1.30E-01

In the first sensitivity case, the rainfall was increased to 29 inches per year from 16 inches per year. While the rainfall increased by a factor of 1.8, the infiltration rates through the cover increased by less than a factor of 1.4. The difference was because the high precipitation case had higher runoff and evapotranspiration.

The second sensitivity case varied the hydraulic conductivity of the performance cover, which is the final barrier to deep infiltration rate increased by a factor of six to $2.4E-08$ cm/s. The infiltration increased, but by much less than a factor of six. The CWF and FWF infiltration rates both increased to about 2.4 times the baseline value. The increase was less than a factor of six because deep infiltration was limited by the availability of water in the deep layers. This is because almost all of the precipitation returned to the atmosphere from the near-surface layers of the cover system.

The third sensitivity case considered the effect of reduced lateral drainage from the performance cover. The drainage layer above the compacted clay layer served to divert water laterally from the performance cover. Over time, the drainage layer could become clogged with fine particles and fail to operate as it was designed. For this sensitivity case, the hydraulic conductivity of the drainage layer was reduced by factor of ten. Under these conditions, neither the CWF nor the FWF infiltration rates changed significantly from the baseline value. In both cases, the change in infiltration rate was small compared to the change in hydraulic conductivity. The CWF and FWF infiltration rates increased by 10% and 20%, respectively. This indicates that a factor of ten reduction in the conductivity of the drainage layer still provides sufficient flow for effective lateral drainage.

The fourth sensitivity case varied the layer thicknesses above and below the performance cover. At the midpoint between the crown and toe of the CWF cover, the baseline case used a thickness of 216 inches of fill above the performance cover and 126 inches of fill below it. At the Federal

facilities, the baseline analysis used 246 inches fill above and 114 inches of fill below the performance cover. The sensitivity cases for both facilities used 6 inches of fill below the performance cover and sufficient material above it to maintain the same total cover thickness. The results showed that the infiltration was unchanged from the baseline values. This shows that the water infiltration rate through the performance cover is limited by its low hydraulic conductivity and not by the amount of fill material above or below it.

The fifth sensitivity case combined the high precipitation case with the high conductivity case. The resulting infiltration increased by a factor of 8 for both the CWF and FWF. This indicates that the high precipitation makes more water available at the top of the performance cover and the increased conductivity allows more of it to infiltrate. This is the greatest increase in infiltration of all the sensitivity cases. This result will be used in the RESRAD sensitivity and uncertainty analysis to be described below.

The final sensitivity case evaluated the effect of cover erosion. The 24-inch layer below the topsoil was decreased from its baseline thickness to only one inch. This accounts for 23 inches of erosion (the amount of water and wind erosion conservatively predicted to occur over 50,000 years). The top layer of soil was assumed to maintain the characteristics of topsoil as erosion progresses. The results show about a 30% increase in infiltration through the entire cover system. The thinner surface layer has a reduced capacity to return water to the atmosphere by evapotranspiration.

In addition to the sensitivity cases evaluated above, the HELP model automatically varies many other parameters as part the synthetic weather generation capability. The HELP model varies the daily rainfall, temperature, evapotranspiration and solar radiation automatically. All HELP infiltration calculations were run for a 100-year simulation period with automatic generation of meteorological parameters. The baseline computer outputs show that the precipitation was varied from the baseline value with a standard deviation equal to 36 percent of the baseline value. The infiltration rate for the CWF was calculated as 0.0378 inches/yr with a standard deviation of 0.0136 inches/yr. The FWF had a calculated infiltration rate of 0.0383 inches/yr with a standard deviation of 0.0136 inches/yr. Therefore, uncertainties in the distribution of daily rainfall, temperature, evapotranspiration, and solar radiation result in a 36 percent standard deviation in the infiltration, which is small compared to the factor of 8 increase seen in sensitivity case 5.

Considering all the sensitivity runs, a consistent picture emerged in which almost all of the precipitation at the Site was returned to the atmosphere through evaporation and plant transpiration. Very little, if any, water infiltrates from the surface to the depth of the performance cover. The infiltration rate through the performance cover is similar in magnitude to its hydraulic conductivity. The lack of water flow at depth leads to a very low infiltration rate that is controlled by the hydraulic conductivity of the performance cover and is largely independent of conditions at the ground surface.

The range of infiltration rates from the HELP model was used in RESRAD to calculate the effects on doses to individuals. The RESRAD sensitivity cases are described in the next section.

8.0-7.2 RESRAD Sensitivity Analysis

The RESRAD model (DOE 2001) was used to evaluate the groundwater pathways in the performance assessment. The RESRAD sensitivity analysis evaluated six conditions that varied from the baseline analysis. These were high infiltration, enhanced nuclide leaching, enhanced nuclide transport in the red beds, changes in the red bed clay conductivity, and an analysis of chelated metals. The RESRAD sensitivity cases are summarized in Table 8.0-7-3. These sensitivity cases were evaluated for groundwater pathway G3, which was the only groundwater pathway to show doses within a 100,000-year baseline simulation. Pathway G3 is described in Appendix 8.0-6, Section 8.0-6.10.

Table 8.0-7-3. Conditions Evaluated in RESRAD Sensitivity Analysis

Condition	Parameters varied
Baseline	All parameters at baseline values
1. High Infiltration	Infiltration 8 times baseline value
2. Enhanced Leaching	Waste zone K_d s decreased to one tenth of baseline value
3. Enhanced Transport	Red bed K_d s decreased to one tenth of baseline value
4. High erosion	
5. Red bed clay hydraulic conductivity	Red bed clay conductivity 6 times baseline value (95 th percentile) to 7.57E-03 m/yr
6. Chelated metals in CWF and FWF-CDU	Red bed K_d s decreased to 0 for Co, Cr, Fe, Mn, Ni, Cs, Sb, Sr, Np, U, Pu, Am, Cm

Based on the results of the HELP model sensitivity analysis, the maximum infiltration rate varied from its baseline value by a factor of eight. For the RESRAD sensitivity analysis, this increased infiltration rate was carried through to assess its effect on nuclide release and transport. The RESRAD simulation for the high infiltration rate used the high precipitation of 29 inches per year (0.74 m/yr) and the corresponding runoff and evapotranspiration amounts calculated by HELP. The RESRAD runoff coefficient was 0.0685 and the evapotranspiration coefficient was 0.9887.

The second sensitivity case evaluated enhanced nuclide release rates by decreasing the waste zone K_d values. In all of the RESRAD modeling, the release rates were based on the nuclide K_d values in the waste zone. For the sensitivity analysis, the enhanced nuclide release rates were simulated by decreasing the waste zone K_d s of all nuclides by a factor of ten. The lower K_d values caused higher nuclide release rates by partitioning the nuclides more readily into infiltrating water.

Enhanced radionuclide transport through the red beds was evaluated in the third sensitivity case. The transport in the red beds was controlled by the nuclide-specific unsaturated zone K_d s, which were used to calculate retardation factors. For this sensitivity case, the enhanced transport was simulated by decreasing all of the red bed nuclide K_d s by a factor of ten, leading to lower retardation factors.

The fourth sensitivity analysis varied the surface erosion rate. Based on the SWAT analysis in Attachment 3.0-3.29, the combined erosion rate from wind and water could be as high as 1.2E-05 m/yr under current site conditions. This value was used in the baseline analysis. For wetter

climatic conditions (29-inch annual rainfall, Wichita climate), the combined wind and water erosion rate could be as high as $2.2E-05$ m/yr. This value was used in the erosion sensitivity analysis.

The fifth sensitivity analysis evaluated the effect of changing the red bed hydraulic conductivity. The baseline hydraulic conductivity of $4.0E-9$ cm/s was increased by a factor of six to $2.4E-08$ cm/s. The value is based on red bed hydraulic conductivity measurements from in situ tests and from measurements of the WCS RCRA liner. The value used in the sensitivity analysis is the upper 95 percentile from the set of measured values.

The sixth and final sensitivity case evaluated the effect of chelated metals in the CWF and FWF-CDU. Small amounts of chelating agents are likely to be present in some CWF waste streams. The FWF-CDU may also contain chelating agents in small amounts. Chelating agents are contained in some resin wastes. Metal ions are bound by the chelating agents and the chelating agents are bound by the resins. The metal-chelating agent complexes can not be released from the resin unless the resin is treated with a strong acid or the resin degrades. Resins are stabilized before disposal by dewatering or solidification, so the nuclide release rates from the waste form will be minimal. The K_d release model used in RESRAD assumes that all nuclides are immediately available for leaching and transport. No credit is taken for nuclides being bound by the waste form, such as resins or solidified waste.

According to a recent NRC report (NRC 2002), chelating agents can cause certain metals to be transported in the environment with little or no adsorption. The NRC report identifies 13 metals that can be affected by chelating agents. The metals are cobalt, chromium, iron, manganese, nickel, cesium, antimony, strontium, neptunium, uranium, plutonium, americium, and curium. To simulate the absence of adsorption, the red bed K_d values for these elements were all set equal to zero. This results in a retardation factor of unity and the nuclides are transported in the red beds without adsorption. This sensitivity case was not evaluated for the FWF-NCDU because no chelating agents are expected.

The NRC report (NRC 2002) also notes that most complexes consisting of chelating agents and metals tend to dissociate readily during interaction with soils. Divalent transition metals, namely nickel and cobalt, are an exception to this generalization. However, in the sensitivity analysis, all of the metals are assumed to remain mobile in the red bed clay. An additional conservatism is that the entire inventory of the metals is assumed to be mobilized, even though chelating agents are only present in certain reactor decontamination resins. The results show that when all of the 13 metals (transition metals, lanthanides, and actinides) listed in the NRC report become mobile, the groundwater dose increases by less than 10 percent.

Limiting Quantity of Chelating Agents – A limiting quantity of chelating agents in the FWF-CDU was determined by estimating the amount of EDTA that would be required to mobilize all of the transition metals, lanthanides, and actinides listed in NRC 2002. The NRC report lists 13 metals that readily form complexes with chelating agents. The metals are chromium, manganese, iron, cobalt, nickel, strontium, antimony, cesium, uranium, neptunium, plutonium, americium, and curium. The FWF-CDU has the largest inventory of these radionuclides.

The quantity of chelating agent necessary to mobilize the entire inventory of the 13 metals is equivalent to about 8% by weight, averaged over all of the FWF-CDU waste. The analysis first calculates the mass of the 13 metals in the FWF-CDU waste. On a mass basis, U-238 accounts

for over 99% of the mass of the 13 metals. This is because of the very long half-life and large inventory of U-238. Therefore, the calculation can focus on the mass of U-238 in the disposal unit and the other 12 metals are insignificant in comparison. The mass of U-238 in the FWF-CDU is 7.25E+07 kg (24,200 Ci inventory divided by 3.34E-04 Ci/kg specific activity). This is equal to 3.04E+08 moles of U-238 (0.238 kg/mole). Assuming there is a one-to-one correspondence between the atoms of U-238 and the molecules of chelating agent, it requires 3.04E+08 moles of chelating agent to complex with all of the uranium. Using EDTA as a typical chelating agent (molecular weight 292), a mass of 8.89E+07 kg of EDTA would be required (3.04E+08 moles times 0.292 kg/mole). The total mass of waste in the FWF-CDU is 1.10E+09 kg (688,000 m³ times 1600 kg/m³). Therefore, the weight percent of EDTA would be 8.89E+07 kg of EDTA divided by 1.10E+09 kg of waste, or about 8%.

Based on this analysis, the limiting weight percent of chelating agent is proposed at 8% for all waste streams. This limit will be applicable to the CWF, the FWF-CDU, and the FWF-NCDU. Both the CWF and the FWF-NCDU contain much lower inventories (on a mass basis) of the 13 metals than the FWF-CDU.

RESRAD Sensitivity Results – The sensitivity cases were evaluated for Pathway G3, which was the only groundwater pathway to show doses in a 100,000-year simulation. Pathway G3 is described in Appendix 8.0-6, Section 8.0-6.10. The RESRAD sensitivity results are shown in Table 8.0-7-4.

The baseline case for Pathway G3 showed no doses within 10,000 years. The only sensitivity case to show a peak dose within 10,000 years was the high infiltration case. The high infiltration case yielded the highest peak dose for the CWF. The highest peak doses for the FWF-CDU and FWF-NCDU were from the enhanced leaching sensitivity case. The greatest relative increase in dose for any of the cases was a factor of 2.4 for the CWF high infiltration case. The highest sensitivity dose was 5.0 mrem/yr, from the FWF-NCDU enhanced leaching case. The high erosion, high red bed conductivity, and chelated metal simulations showed almost no effect at any of the three disposal units.

All of the doses in the RESRAD sensitivity analysis were from long-lived radionuclides with K_d values of 1 ml/g or lower. The only four radionuclides to cause doses in the sensitivity analyses were C-14, Cl-36, Tc-99 and I-129. In all cases, the first radionuclide to reach the well location was Cl-36, whose baseline K_d value was 0.1 ml/g. The three other radionuclides that reached the well location after Cl-36 were C-14, Tc-99, and I-129, all with baseline K_d values of 1 ml/g.

Table 8.0-7-4. RESRAD Sensitivity Results, Pathway G3

Condition	CWF		FWF-CDU		FWF-NCDU	
	Max. Dose (mrem/yr)	Time (yr)	Max. Dose (mrem/yr)	Time (yr)	Max. Dose (mrem/yr)	Time (yr)
Baseline	0.58	15,600	1.1	36,400	3.4	36,400
High infiltration	1.4	6,700	1.2	4,600	3.5	4,600
Enhanced leaching	0.81	15,600	1.6	36,400	5.0	36,400
Enhanced transport	0.79	14,000	1.2	12,800	3.7	12,800
High erosion	0.58	15,600	1.1	36,400	3.4	36,400
High red bed cond.	0.59	14,500	1.1	35,600	3.4	35,600

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Chelated metals	0.59	15,600	1.2	36,400	(a)	(a)
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(a) No chelating agents present in bulk waste.

Of the four long-lived mobile radionuclides, C-14 had the shortest half-life (5,700 years). Because of the long travel time to the well, C-14 underwent significant radioactive decay during transport and was a minor contributor to the total dose. Radioactive decay was not significant for Cl-36 (half-life 301,000 years), Tc-99 (half-life 213,000 years), and I-129 (half-life 15,700,000 years).

8.0-7.3 RESRAD Uncertainty Analysis

A probabilistic uncertainty analysis was conducted using the RESRAD code. In the uncertainty analysis, a number of input parameters were allowed to vary according to probability distributions specified by the user. The RESRAD code selected parameter values from the specified probability distributions and calculated the corresponding doses.

Pathway G3 was used for the uncertainty analysis, because it was the only groundwater pathway that showed doses within a 100,000-year simulation period. The parameters selected for the uncertainty analysis were the same ones that were used to model the high infiltration, enhanced leaching, enhanced transport, high erosion, and high conductivity sensitivity cases. However, in the uncertainty analysis, all of the parameters were allowed to vary simultaneously. The parameter ranges and probability distributions are shown in Table 8.0-7-5.

Table 8.0-7-5. Parameters for RESRAD Uncertainty Analysis

Parameter	Range	Uniform	Comment
Precipitation (m/yr)	0.41 – 0.74	Uniform	From climate study
Runoff coefficient	0.0482 – 0.0682	Uniform (a)	From HELP output
Evapotranspiration coeff.	0.9887 – 0.9975	Uniform (a)	From HELP output
Erosion rate (m/yr)	0 – 2.2E-05 Mode 1.2E-05	Triangular	From zero to max. rate from SWAT analysis
Red bed conductivity (cm/s)	4.0E-09 to 2.4E-08	Uniform	Baseline to 95 th percentile of measured values
Contaminated zone K _d	0.1x baseline to 10x baseline	Log-uniform	Varies leach rate
Unsaturated zone K _d	0.1x baseline to 10x baseline	Log-uniform	Varies retardation factors in red beds

(a) Correlated with precipitation (based on HELP and SWAT results); higher precipitation is correlated with higher erosion and runoff coefficient, but lower evapotranspiration coefficient.

Values for the uncertainty parameters were selected from their respective probability distributions using Latin Hypercube sampling. A total of 300 values were selected for each parameter and the parameter values were grouped to make 300 data sets for RESRAD. Erosion and runoff were positively correlated with precipitation (0.9 correlation coefficient) and the evapotranspiration coefficient was negatively correlated with precipitation (-0.9 correlation coefficient). The 300 data sets were run with the RESRAD code in three groups of 100 samples each. Statistics were calculated among the three groups. The minimum, maximum, and various

percentile doses were calculated from among the 300 simulations. The CWF, FWF-CDU, and FWF-NCDU were evaluated using 300 samples each. The dose results for the RESRAD uncertainty analysis are shown in Table 8.0-7-6.

Table 8.0-7-6. RESRAD Uncertainty Results, Pathway G3

Doses (mrem/yr)	CWF	FWF-CDU	FWF-NCDU
Maximum dose in first 10,000 years	9.48E-01	1.15E+00	3.55E+00
Minimum dose in 100,000-year simulation	5.53E-01	1.08E+00	3.45E+00
50 th percentile dose, 100,000-year simulation	6.02E-01	1.16E+00	3.57E+00
90 th percentile dose, 100,000-year simulation	1.18E+00	1.18E+00	3.58E+00
95 th percentile dose, 100,000-year simulation	1.24E+00	1.18E+00	3.58E+00
Maximum dose in 100,000-year simulation	1.35E+00	1.18E+00	3.58E+00

For the CWF, the only doses within the first 10,000 years were from the long-lived, mobile radionuclides C-14, Cl-36, I-129, and Tc-99. The maximum dose at year 10,000 was 0.948 mrem/yr, primarily from Cl-36 and C-14. From among the 300 samples, the smallest peak dose from any 100,000-year simulation was 0.553 mrem/yr. The peak doses at the 50th, 90th, and 95th percentiles were 0.602, 1.18 and 1.24 mrem/yr, respectively. The maximum peak dose from any 100,000-year simulation was 1.35 mrem/yr.

For the FWF-CDU, the maximum dose within the first 10,000 years was 1.15 mrem/yr. The dose was almost entirely from Tc-99, although C-14, Cl-36, and I-129 also contributed slightly to the total. From among the 300 samples, the smallest peak dose from any of the 100,000-year simulations was 1.08 mrem/yr. The peak doses at the 50th, 90th, and 95th percentiles were 1.16, 1.18, and 1.18 mrem/yr, respectively. The maximum peak dose from any 100,000-year simulation was also 1.18 mrem/yr.

For the FWF-NCDU, the maximum dose within the first 10,000 years was 3.55 mrem/yr. The dose was almost entirely from Tc-99, although C-14, Cl-36, I-129 also contributed slightly. From among the 300 samples, the smallest peak dose from any of the 100,000-year simulations was 3.45 mrem/yr. The peak doses at the 50th, 90th, and 95th percentiles were 3.57, 3.58, and 3.58 mrem/yr, respectively. The highest peak dose from any 100,000-year simulation was also 3.58 mrem/yr.

All doses within the first 100,000 years were below the 25 mrem/yr dose limit in the performance objective. The only radionuclides to reach the well within 100,000 years were C-14, Cl-36, Tc-99, and I-129.

8.0-7.4 Other Pathway Sensitivities

A formal sensitivity and uncertainty analysis was not conducted for the other pathways in the performance assessment. These include Pathways A1, A3, A6, A8, A9, S1, S3, W2, D1, and D3. The other pathway calculations used simple linear models that were implemented as spreadsheet calculations. The input parameters can easily be varied in the spreadsheets to determine the effect on the calculated doses. Due to the simplicity of the models, a formal sensitivity analysis was thought to add little to the understanding of the models and results. The spreadsheets are available on request to interested reviewers.

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