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Engineering Design File

Project No. 24128

Groundwater Pathway Risk Assessment for the PBF Closure – 2007 Update

Idaho Cleanup Project

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Groundwater pathway risk assessment was performed in 2004 and documented in an Engineering Design File (EDF)-4869, "Groundwater Pathway Risk Assessment for the PBF Closure," that showed that there is no groundwater pathway risk concern from the Power Burst Facility (PBF) closure. Since that time, the radionuclide inventory estimates have been refined and some contaminated components at PBF have been removed. The revised inventory is documented in EDF-7000, "Power Burst Facility (PBF) Below and Above Grade Source Terms." Since the radionuclide inventory estimates have changed, the results and conclusions of EDF-4869 must be updated. This EDF presents the updated inventory, results, and conclusions. Estimates for the nonradionuclide inventory have not changed significantly since the 2004 groundwater pathway risk assessment (EDF-4869); therefore, no update is needed for the nonradionuclides.

Based on the streamlined groundwater risk assessment approach presented in EDF-4869 and the revised results presented in this document, filling the PBF facility with either soil or grout while leaving revised source inventories in place results in predicted groundwater concentrations that meet the required performance criteria. For groundwater, the radionuclide performance criteria requires that concentrations in the Snake River Plain Aquifer do not exceed a cumulative carcinogenic risk level of 1×10^{-4} in 2095 and beyond.

6. Review (R) and Approval (A) and Acceptance (Ac) Signatures:
   (See instructions for definitions of terms and significance of signatures.)

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FIGURES

TABLES

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ACRONYMS

D&D	decommissioning and demolition
EDF	Engineering Design File
NCRP	National Council on Radiation Protection
PBF	Power Burst Facility

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Groundwater Pathway Risk Assessment for the PBF Closure – 2007 Update

1. INTRODUCTION

The Power Burst Facility (PBF) reactor building (PBF-620) will be decommissioned and demolished (D&D). A groundwater pathway risk assessment was performed in 2004 and documented in an Engineering Design File (EDF)-4869, "Groundwater Pathway Risk Assessment for the PBF Closure," using the groundwater pathway risk assessment code GWSCREEN (Rood 2003). The screening level risk assessment showed no unacceptable groundwater pathway risk from the PBF closure. Since that time, the radionuclide inventory estimates have been refined and some contaminated components at PBF have been removed. The revised inventory is documented in EDF-7000, "Power Burst Facility (PBF) Below and Above Grade Source Terms." Since the radionuclide inventory estimates have changed, the results and conclusions of EDF-4869 must be updated. This EDF presents the updated inventory, results, and conclusions. Estimates for the nonradionuclide inventory have not changed since the 2004 groundwater pathway risk assessment (EDF-4869); therefore, no update is needed for the nonradionuclides. Figure 1 is a map showing the location of PBF and other major Idaho National Laboratory facilities. Figure 2 is an aerial photo of the PBF facility in 2007. Details regarding PBF and the groundwater pathway risk model are discussed in EDF-4869. Details regarding the current understanding of the radionuclide inventory at PBF can be found in EDF-7000. The work plan for this EDF is described in Appendix A.

2. UPDATED PBF RADIONUCLIDE INVENTORY

Table 1 contains the revised PBF radionuclide inventory estimates from EDF-7000. The revised inventory accounts for the contaminated components removed from PBF and the refinements in the inventory estimates since the analysis in 2004.

Figure 1. Map of the Idaho National Laboratory Site showing the location of the Power Burst Facility and other facilities.

Figure 2. Aerial view of the Power Burst Facility in 2007.

Table 1. Summary of radionuclide contributions from all sources in PBF (from EDF-7000).

Isotope	Current Inventory (EDF-7000, Table 8) (Ci)
Ac-227	1.51E-07
Ag-108m	7.89E-05
Ag-110m	9.24E-06
Am-241	9.58E-03
Am-243	4.32E-07
Be-10	3.89E-06
C-14	9.88E-03
Ce-144	2.90E-09
Cl-36	2.35E-04
Cm-243	2.34E-07
Cm-244	1.25E-06
Cm-245	4.92E-11
Cm-246	9.41E-13
Cm-247	2.67E-19
Cm-248	5.89E-20
Co-60	1.39E+01
Cs-134	8.37E-04
Cs-137	2.59E+01
Eu-152	1.07E-02
Eu-154	7.73E-03
H-3	9.02E-01
I-129	4.48E-04
Mn-54	5.13E-06
Nb-94	5.33E-04
Ni-59	6.65E-02
Ni-63	6.94E+00
Np-237	1.29E-07
Pa-231	4.46E-07
Pb-210	7.09E-09
Pu-238	7.68E-05
Pu-239	3.84E-04
Pu-240	1.14E-04
Pu-241	1.45E-03
Pu-242	8.47E-09
Pu-244	1.84E-17
Ra-226	2.39E-08
Ru-106	2.82E-08
Sb-125	1.33E-03
Sr-90	1.24E+00
Tc-99	3.71E-03
Th-228	2.76E-07

Table 1. (continued).

Isotope	Current Inventory (EDF-7000, Table 8) (Ci)
Th-229	3.27E-10
Th-230	1.80E-07
Th-232	2.79E-07
U-232	8.30E-09
U-233	1.51E-07
U-234	8.14E-04
U-235	3.69E-05
U-236	1.93E-06
U-238	1.88E-05
Zn-65	1.08E-07

3. UPDATED EDF-4869 RESULTS

The conclusion of the 2004 groundwater pathway risk assessment (EDF-4869) was that none of the radionuclides are significant contributors to the groundwater pathway risk. The screening process involved two steps as listed below. The results of the revised screening (based on the revised radionuclide inventory) are shown in Tables 2 and 3.

- The National Council on Radiation Protection (NCRP) (NCRP 1996) dose screening step (Phase I in EDF-4869) is used to eliminate radionuclides with predicted radiological doses that are very small. A dose is calculated and compared against a limit of 10^{-5} Sv (for calculation and limit details see EDF-4869). The NCRP screening dose was recalculated using the revised PBF radionuclide inventory (Table 1) and the results are shown in Table 2. The EDF-4869 Phase I screening results are shown in Appendix B.

- Radionuclides that were not eliminated based on the NCRP dose screening were evaluated using a Track 2 (DOE-ID 1994) screening level approach (Phase II in EDF-4869). The Track 2 screening results were recalculated using the revised PBF radionuclide inventory (Table 1) and GWSCREEN (Rood 2003) and the results are shown in Table 3. A complete description of the Track 2 screening level groundwater pathway risk calculations is given in EDF-4869. The EDF-4869 Phase II screening results are shown in Appendix B.

The updated results shown in Table 2 and 3 are similar to the results in EDF-4869. All radionuclides that screened in the EDF-4869 Phase I screening also screened in the revised Phase I NCRP screening (Table 2). In addition, Nb-94 screened in the revised Phase I NCRP screening. The Table 2 values for radionuclide half-life and groundwater ingestion NCRP Screening Factor are taken directly from Table 3 in EDF-4869. The other columns are recalculated for this analysis based on the revised radionuclide inventory estimates.

Similar to the results shown in EDF-4869, the revised Phase II Track 2 screening results (Table 3) are all significantly below the 10^{-4} risk based limit. The Table 3 values for radioactive decay half-life, Kd, Ingestion dose conversion factor (DCF), and Morbidity Risk Coefficient are taken directly from Table 5 in EDF-4869. The other columns are recalculated for this analysis based on the revised radionuclide inventory estimates.

Table 2. Phase I screening results for radionuclides using the NCRP screening factors. Highlighted radionuclides are not screened. Update of Table 3 in EDF-4869.

Radionuclide	Radioactive Decay Half-Life (years)	PBF Inventory (Ci)	PBF Inventory (Bq)	Groundwater Ingestion NCRP Screening Factor (Sv/Bq)	Screening Dose (Sv)	Is Screening Dose <1 mrem? (<1×10^{-5} Sv?)
Ac-227	2.18E+01	1.51E-07	5.59E+03	8.1E-12	4.5E-08	yes
Ag-108m	1.27E+02	7.89E-05	2.92E+06	4.2E-14	1.2E-07	yes
Ag-110m	6.84E-01	9.24E-06	3.42E+05	5.2E-15	1.8E-09	yes
Am-241	**4.32E+02**	9.58E-03	**3.54E+08**	**5.9E-13**	**2.1E-04**	**no**
Am-243	7.38E+03	4.32E-07	1.60E+04	6.0E-13	9.6E-09	yes
Be-10	1.60E+06	3.89E-06	1.44E+05	1.4E-14	2.0E-09	yes
C-14	**5.73E+03**	9.88E-03	**3.66E+08**	**1.6E-13**	**5.8E-05**	**no**
Ce-144	7.78E-01	2.90E-09	1.07E+02	3.6E-15	3.9E-13	yes
Cl-36	3.01E+05	2.35E-04	8.70E+06	8.3E-13	7.2E-06	yes
Cm-243	2.85E+01	2.34E-07	8.66E+03	1.5E-13	1.3E-09	yes
Cm-244	1.81E+01	1.25E-06	4.63E+04	1.1E-13	5.1E-09	yes
Cm-245	8.50E+03	4.92E-11	1.82E+00	5.1E-13	9.3E-13	yes
Cm-246	4.75E+03	9.41E-13	3.48E-02	2.9E-13	1.0E-14	yes
Cm-247	1.56E+07	2.67E-19	9.88E-09	3.0E-13	3.0E-21	yes
Cm-248	3.39E+05	5.89E-20	2.18E-09	1.1E-12	2.4E-21	yes
Co-60	**5.27E+00**	1.39E+01	**5.14E+11**	**5.8E-14**	**3.0E-02**	**no**
Cs-134	2.06E+00	8.37E-04	3.10E+07	4.2E-15	1.3E-07	yes
Cs-137	**3.02E+01**	2.59E+01	**9.58E+11**	**7.7E-14**	**7.4E-02**	**no**
Eu-152	1.36E+01	1.07E-02	3.96E+08	9.1E-15	3.6E-06	yes
Eu-154	8.80E+00	7.73E-03	2.86E+08	1.1E-14	3.1E-06	yes
H-3	**1.23E+01**	9.02E-01	**3.34E+10**	**5.9E-14**	**2.0E-03**	**no**
I-129	**1.57E+07**	4.48E-04	**1.66E+07**	**1.9E-10**	**3.1E-03**	**no**
Mn-54	8.56E-01	5.13E-06	1.90E+05	3.8E-15	7.2E-10	yes
Nb-94	2.03E+04	5.33E-04	1.97E+07	2.7E-14	5.3E-07	yes
Ni-59	7.60E+04	6.65E-02	2.46E+09	3.2E-16	7.9E-07	yes
Ni-63	**1.00E+02**	6.94E+00	**2.57E+11**	**8.6E-16**	**2.2E-04**	**no**
Np-237	2.14E+06	1.29E-07	4.77E+03	2.4E-10	1.1E-06	yes
Pa-231	3.73E+04	4.46E-07	1.65E+04	1.5E-11	2.5E-07	yes
Pb-210	2.23E+01	7.09E-09	2.62E+02	5.4E-12	1.4E-09	yes

Table 2. (continued)

Radionuclide	Radioactive Decay Half-Life (years)	PBF Inventory (Ci)	PBF Inventory (Bq)	Groundwater Ingestion NCRP Screening Factor (Sv/Bq)	Screening Dose (Sv)	Is Screening Dose <1 mrem? (<1×10^{-5} Sv?)
Pu-238	8.78E+01	7.68E-05	2.84E+06	1.7E-12	4.8E-06	yes
Pu-239	**2.41E+04**	3.84E-04	**1.42E+07**	**2.0E-12**	**2.8E-05**	**no**
Pu-240	6.57E+03	1.14E-04	4.22E+06	2.0E-12	8.4E-06	yes
Pu-241	1.44E+01	1.45E-03	5.37E+07	6.1E-14	3.3E-06	yes
Pu-242	3.76E+05	8.47E-09	3.13E+02	1.9E-12	6.0E-10	yes
Pu-244	8.26E+07	1.84E-17	6.81E-07	2.2E-12	1.5E-18	yes
Ra-226	1.60E+03	2.39E-08	8.84E+02	4.6E-12	4.1E-09	yes
Ru-103 [b]	1.08E-01	0.00E+00	0.00E+00	1.4E-20	0.0E+00	yes
Ru-106	1.01E+00	2.82E-08	1.04E+03	6.5E-14	6.8E-11	yes
Sb-125	2.77E+00	1.33E-03	4.92E+07	3.6E-15	1.8E-07	yes
Sr-90	**2.86E+01**	1.24E+00	**4.59E+10**	**3.5E-12**	**1.6E-01**	**no**
Tc-99	**2.13E+05**	3.71E-03	**1.37E+08**	**3.2E-12**	**4.4E-04**	**no**
Th-228	1.91E+00	2.76E-07	1.02E+04	2.1E-15	2.1E-11	yes
Th-229	7.34E+03	3.27E-10	1.21E+01	3.6E-13	4.4E-12	yes
Th-230	7.70E+04	1.80E-07	6.66E+03	5.2E-13	3.5E-09	yes
Th-232	1.40E+10	2.79E-07	1.03E+04	4.8E-13	5.0E-09	yes
U-232	7.20E+01	8.30E-09	3.07E+02	3.3E-11	1.0E-08	yes
U-233	1.59E+05	1.51E-07	5.59E+03	1.1E-11	6.1E-08	yes
U-234	**2.44E+05**	8.14E-04	**3.01E+07**	**4.2E-12**	**1.3E-04**	**no**
U-235	**7.04E+08**	3.69E-05	**1.37E+06**	**1.4E-11**	**1.9E-05**	**no**
U-236	2.34E+07	1.93E-06	7.14E+04	3.4E-12	2.4E-07	yes
U-238	**4.47E+09**	1.88E-05	**6.96E+05**	**1.4E-10**	**9.7E-05**	**no**
Zn-65	**6.69E-01**	1.08E-07	**4.00E+03**	2.9E-15	**1.2E-11**	yes

a. The Am-241 will be simulated as Np-237 in the Phase II screening. All 9.58E-03 Ci of Am-241 is instantaneously decayed and becomes 1.97E-06 Ci of Np-237.

b. The revised inventory for Ru-103 is 0.

Table 3. Radionuclide Phase II groundwater pathway screening results using Track 2 (DOE-ID 1994) assumptions. Update of Table 5 in EDF-4869.

Nuclide	Progeny	Decay Half-life (years)	K_d (mL/g)[a]	Predicted Peak Concen. (pCi/L)	Years to Peak Concen. (years)	Ingestion DCF (rem/Ci)[b]	Peak Decay Chain Dose (mrem)[c]	Morbidity Risk Coefficient (risk/Ci)	Peak Risk[d]
Am-241 (Np)[e]		2.14E+06	8	4.07E-05	1.28E+03	4.44E+06	1.32E-04	6.18E+01	6E-11
	U-233	1.59E+05	6	2.89E-07		2.89E+05	6.09E-08	7.18E+01	5E-13
	Th-229	7.34E+03	100	1.20E-09		4.03E+06	3.53E-09	2.24E+02	6E-15
Total Am-241 (Np)							1.32E-04		6E-11
C-14		5.73E+03	0.1	5.52E+00	4.72E+01	2.09E+03	8.41E-03	1.55E+00	2E-07
Co-60		5.27E+00	10	0.00E+00	na	2.69E+04	na	1.57E+01	na
Cs-137		3.02E+01	500	0.00E+00	na	5.00E+04	na	3.04E+01	na
H-3		1.23E+01	0	1.29E+02	3.15E+01	6.40E+01	6.00E-03	5.07E-02	1E-07
I-129		1.57E+07	0	3.76E-01	3.15E+01	2.76E+05	7.58E-02	1.48E+02	1E-06
Nb-94[f]		2.03E+04	100 (1)	5.28E-04	1.57E+04	7.14E+03	2.75E-06	7.77E+00	9E-11
Ni-63		1.00E+02	100	0.00E+00	na	5.77E+02	na	6.70E-01	na
Pu-239[g]		2.41E+04	22	2.65E-03	3.47E+03	3.54E+06	6.85E-03	1.35E+02	8E-09
	U-235	7.04E+08	6	3.04E-08		2.67E+05	5.92E-09	6.96E+01	5E-14
	Pa-231	3.73E+04	550 (2)	1.47E-11		1.06E+07	1.13E-10	1.73E+02	6E-17
	Ac-227	2.18E+01	450 (2)	1.76E-11		1.48E+07	1.90E-10	2.01E+02	8E-17
Total Pu-239							6.85E-03		8E-09
Sr-90		2.86E+01	12 (1)	1.50E-19	1.91E+03	1.42E+05	1.55E-20	5.59E+01	2E-25
Tc –99		2.13E+05	0.2 (1)	1.56E+00	6.28E+01	1.46E+03	1.67E-03	2.75E+00	9E-08
U-234		2.44E+05	6	1.13E-02	9.70E+02	2.83E+05	2.33E-03	7.07E+01	2E-08
	Th-230	7.70E+04	100	7.24E-06		5.48E+05	2.89E-06	9.10E+01	1E-11
	Ra-226	1.60E+03	100	1.33E-06		1.33E+06	1.29E-06	3.85E+02	1E-11
	Pb-210	2.23E+01	100	1.25E-06		7.27E+06	6.64E-06	8.81E+02	2E-11
Total U-234[g]							2.34E-03		2E-08
U-235		7.04E+08	6	1.01E-03	9.70E+02	2.67E+05	1.96E-04	6.96E+01	2E-09
	Pa-231	3.73E+04	550	2.71E-07		1.06E+07	2.10E-06	1.73E+02	1E-12
	Ac-227	2.18E+01	450	3.21E-07		1.48E+07	3.46E-06	2.01E+02	1E-12
Total U-235							2.02E-04		2E-09
U-238		4.47E+09	6	5.14E-04	9.70E+02	2.70E+05	1.01E-04	6.40E+01	7E-10
	U-234	2.44E+05	6	1.41E-06		2.83E+05	2.91E-07	7.07E+01	2E-12
	Th-230	7.70E+04	100	4.52E-10		5.48E+05	1.81E-10	9.10E+01	9E-16
	Ra-226	1.60E+03	100	5.72E-11		1.33E+06	5.55E-11	3.85E+02	5E-16
	Pb-210	2.23E+01	100	5.21E-11		7.27E+06	2.76E-10	8.81E+02	1E-15
Total U-238							1.02E-04		7E-10

a. Unless otherwise noted, all K_d values from DOE-ID (1994). Noted sources are (1) DOE-ID (1997); (2) Sheppard and Thibault (1990); (3) NCRP (1996).
b. Dose conversion factors from EPA (1988).
c. Dose = C × I(2L/d×365d/y) × DCF×1E9 (converts rem/Ci to mrem/pCi). C = concentration (pCi/d) and I = ingestion rate (L/y).
d. Risk = C×I(2L/d) × ED(10950d) × RC × 1E-12Ci/pCi. I = water ingestion rate, ED = 30 y exposure duration, RC = risk coeff(risk/Ci), C = conc (pCi/L).
e. Np-237 was the decay chain modeled in the simulation. All Am-241 activity was converted to equivalent activity of this Np-237.
f. In Table 2 Nb-94 was screened. However, Nb-94 is included in this table because Nb-94 was not screened in EDF-4869 Phase I screening.
g. Plutonium K_d has been shown to be much larger than 22 mL/g, but the Track 2 value is used here for screening purposes.

As discussed in EDF-4869, this analysis is not meant to provide accurate dose or risk calculations but is rather a conservative screening analysis that shows the inventory of radionuclides to be left at PBF is not a significant contributor to the groundwater pathway risk. A number of conservative assumptions are used in the screening analysis including the assumptions from the report *Track 2 Sites: Guidance for Assessing Low Probability Hazard Sites at the INEL* (DOE-ID 1994). The following is a list of the primary assumptions (modified from EDF-4869):

- The analysis was done assuming the facility was filled with soils and the radionuclides are immediately available for release after closure. If the PBF is filled with grout, the radionuclides will be immobilized for 500 years. At 500 years, the grouted PBF facility would begin to fail and water will be able to move through the PBF facility, leaching out radionuclides. This will move the predicted peak concentrations out at least 500 years.

- As explained above, soil, rather than grout, K_d values are used for the screening calculations. In general, radionuclides are less mobile in a high pH environment. Therefore, if the PBF facility is filled with grout, the radionuclide mobility will generally decrease, which will decrease the predicted contaminant concentrations in the aquifer.

- The contaminant solubility is conservatively assumed to be infinite.

- Some of the radionuclides are currently in the form of solid metal, such as stainless-steel pipes. The screening assumes that the contaminants are readily available for leaching out of PBF to the vadose zone and then transported to the aquifer. In fact, the metal must first corrode before the radionuclides become available for transport. Therefore, the predicted peak concentrations are conservative for those nuclides.

- In the screening process, water and contaminants are assumed to move straight down through the vadose zone sediments. The contaminant velocity through the sediments depends on the contaminant-specific sediment K_d. There is no retardation effect from the basalt and there is no horizontal spreading in the vadose zone because the basalt is not included in the conceptual model.

- The receptor is assumed to be at the edge of the PBF facility. This is the location of the peak concentration in the aquifer. Any movement of the receptor will result in decreased predictions of peak concentration.

- The predicted time of the peak concentrations range over many millennia. Therefore, very few of the predicted peak concentrations would be expected to occur simultaneously.

- The infiltration rate is assumed to be 10 cm/yr, based on the Track 2 screening assumptions. If a soil cover were to be placed over the PBF in the future, the infiltration rate would be reduced to an undisturbed background infiltration rate of 1 cm/yr. This would decrease the predicted peak concentrations in the aquifer by a factor of 10 or more.

- Consistent with EDF-4869, the risk values calculated in Table 3 are based on the predicted peak aquifer concentration. This is a conservative estimate since the morbidity risk coefficient is based on a 30-year exposure duration. For mobile nuclides, the 30-year average concentration in the aquifer can be significantly smaller than the peak concentration in the aquifer.

4. SUMMARY

Based on the streamlined groundwater risk assessment approach presented in EDF-4869, the revised PBF inventories (EDF-7000), and the revised results presented in this document, filling the PBF facility with either soil or grout while leaving revised source inventories in place results in predicted groundwater concentrations that meet the required performance criteria. For groundwater, the radionuclide performance criteria requires that concentrations in the Snake River Plain Aquifer do not exceed a cumulative carcinogenic risk level of 1×10^{-4} in 2095 and beyond.

As explained in the introduction, the screening level groundwater pathway analysis presented in EDF-4869 showed that groundwater concentrations resulting from the inventory of nonradionuclides at PBF are below the drinking water standards. Estimates for the nonradionuclide inventory have not changed since the 2004 groundwater pathway risk assessment (EDF-4869); therefore, no update is needed for the nonradionuclides.

From a cumulative risk standpoint, this streamlined risk assessment demonstrates that leaving radionuclides in place in the PBF substructure would not result in a significant contribution to the cumulative risk in the vicinity of the PBF. The predicted future concentrations of contaminants in the aquifer, as a result of leaving PBF contaminants in place, are orders of magnitude below the risk-based concentrations corresponding to the remedial action objectives defined in the Operable Unit 5-12 Record of Decision (Holdren et al. 1999).

5. REFERENCES

DOE-ID, 1994, *Track 2 Sites: Guidance for Assessing Low Probability Hazard Sites at the INEL,* DOE/ID-10389, Rev. 6, U.S. Department of Energy Idaho Operations Office, January 1994.

EDF-4869, 2004, "Groundwater Pathway Risk Assessment for the PBF Closure," Rev. 0, Idaho National Engineering and Environmental Laboratory, Idaho Completion Project, July 2004.

EDF-7000, 2006, "Power Burst Facility (PBF) Below and Above Grade Source Terms," Rev. 0, Idaho National Laboratory, Idaho Cleanup Project, September 2006.

Holdren, K. J., C. M. Hiaring, D. E. Burns, N. L. Hampton, B. J. Broomfield, E. R. Neher, R. L. VanHorn, I. E. Stepan, R. P. Wells, R. L. Chambers, L. Schmeising, and R. Henry, 1999, *Waste Area Group 5 Operable Unit 5-12 Comprehensive Remedial Investigation/Feasibility Study*, DOE/ID-10607, U.S. Department of Energy Idaho Operations Office, January 1999.

NCRP, 1996, *Screening Models for Releases of Radionuclides to Atmosphere, Surface Water, and Ground*, NCRP Report No. 123, National Council on Radiation Protection, 1996.

Rood, A. S., 2003, *GWSCREEN: A Semi-Analytical Model for Assessment of the Groundwater Pathway from Surface or Buried Contamination: Version 2.0 Theory and User's Manual*, INEEL/EXT-98-00750, Rev. 1, Idaho National Engineering and Environmental Laboratory, February 2003.

Appendix A

Work Plan

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Appendix A

Work Plan

The objective of the analysis is to calculate the groundwater pathway dose and risk from selected radionuclides in the PBF. The calculated risks are used in an engineering evaluation/cost analysis to support the decision making process for the D&D of the PBF.

The PBF groundwater pathway risk assessment is conducted in accordance MCP-2374, "Analyses and Calculations." The calculations are associated with a facility that is permanently shut down and has been identified for D&D. Therefore, the quality level of the structures, systems, and components, as defined in MCP-540, "Assigning Quality Levels," does not apply to this analysis.

The GWSCREEN computer code, Version 2.5a (Enterprise Architecture Identification Number 121200) was used to conduct the original risk screening calculations. GWSCREEN (Rood 2003) has been validated and controlled in accordance with MCP-3039, "Analysis Software Control." The calculations performed are Classification Level B. As defined in MCP-550, "Software Management," the "B" classification level generally includes low safety consequence or mission critical software. Classification Level "B" software applications generally meet one or more of the following criteria.

- Application failure would have an unacceptable impact by causing significant Idaho Cleanup Project mission failure and significant production investment costs and/or recovery costs.
- Application is important to continued operations of the business and is used to support decisions regarding operating activities.
- Application is used to comply with regulatory laws, environmental permits or regulations, and/or other commitments to compliance.
- Application is required for emergency communications with local, state, and federal government agencies.
- Application provides primary support to a process that must be back online within a period of time not to exceed five days and for which delays exceeding five days would jeopardize some aspect of Idaho Cleanup Project mission success.
- U.S. Department of Energy Idaho Operations Office approval is required to institute alternative support mechanisms or operate without the process.

The deliverable for this project is an EDF documenting the calculations.

Technical checking will include verification that the inventory and risk numbers are all accurately transferred from their reference documents and the scaling calculations are accurate. The conclusions will be reviewed to ensure they are consistent with the analysis that was presented.

References

MCP-540, 2006, "Assigning Quality Levels," Rev. 17, Idaho National Laboratory, Idaho Cleanup Project, September 2006.

MCP-550, 2006, "Software Management," Rev. 11, Idaho National Laboratory, Idaho Cleanup Project, October 2006.

MCP-2374, 2006, "Analyses and Calculations," Rev. 14, Idaho National Laboratory, Idaho Cleanup Project, December 2006.

MCP-3039, 2005, "Analysis Software Control," Rev. 6, Idaho National Laboratory, Idaho Cleanup Project, July 2005.

Rood, A. S., 2003, *GWSCREEN: A Semi-Analytical Model for Assessment of the Groundwater Pathway from Surface or Buried Contamination: Version 2.0 Theory and User's Manual*, INEEL/EXT-98-00750, Rev. 1, Idaho National Engineering and Environmental Laboratory, February 2003.

Appendix B

Radionuclide Risk Results From EDF-4869

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Appendix B

Radionuclide Risk Results From EDF-4869

This appendix contains the dose and risk results from the 2004 PBF groundwater risk assessment (EDF-4869). Table B-1 is a copy of Table 3 in EDF-4869. Table B-2 is a copy of Table 5 in EDF-4869.

Table B-1. Phase I screening results for radionuclides using the NCRP screening factors (copy of EDF-4869, Table 3).

Radionuclide	Radioactive Half-Life (years)	PBF Inventory (Ci)	PBF Inventory (Bq)	Groundwater Ingestion NCRP Screening Factor (Sv/Bq)	Screening Dose (Sv)	Is Screening Dose <1 mrem? (<1×10^{-5} Sv?)
Ac-227	2.18E+01	6.18E-07	2.29E+04	8.1E-12	1.9E-07	yes
Ag-108m	1.27E+02	8.62E-04	3.19E+07	4.2E-14	1.3E-06	yes
Ag-110m	6.84E-01	2.67E-09	9.88E+01	5.2E-15	5.1E-13	yes
Am-241[a]	**4.32E+02**	**9.59E-03**	**3.55E+08**	**5.9E-13**	**2.1E-04**	**no**
Am-243	7.38E+03	4.32E-07	1.60E+04	6.0E-13	9.6E-09	yes
Be-10	1.60E+06	3.90E-06	1.44E+05	1.4E-14	2.0E-09	yes
C-14	**5.73E+03**	**1.26E-02**	**4.66E+08**	**1.6E-13**	**7.5E-05**	**no**
Ce-144	7.78E-01	1.21E-08	4.48E+02	3.6E-15	1.6E-12	yes
Cl-36	3.01E+05	2.66E-04	9.84E+06	8.3E-13	8.2E-06	yes
Cm-243	2.85E+01	2.34E-07	8.66E+03	1.5E-13	1.3E-09	yes
Cm-244	1.81E+01	1.25E-06	4.63E+04	1.1E-13	5.1E-09	yes
Cm-245	8.50E+03	4.92E-11	1.82E+00	5.1E-13	9.3E-13	yes
Cm-246	4.75E+03	9.41E-13	3.48E-02	2.9E-13	1.0E-14	yes
Cm-247	1.56E+07	2.67E-19	9.88E-09	3.0E-13	3.0E-21	yes
Cm-248	3.39E+05	5.89E-20	2.18E-09	1.1E-12	2.4E-21	yes
Co-60	**5.27E+00**	**2.65E+01**	**9.81E+11**	**5.8E-14**	**5.7E-02**	**no**
Cs-134	2.06E+00	2.37E-03	8.77E+07	4.2E-15	3.7E-07	yes
Cs-137	**3.02E+01**	**2.80E+01**	**1.04E+12**	**7.7E-14**	**8.0E-02**	**no**
Eu-152	1.36E+01	1.11E-02	4.11E+08	9.1E-15	3.7E-06	yes
Eu-154	8.80E+00	7.77E-03	2.87E+08	1.1E-14	3.2E-06	yes
H-3	**1.23E+01**	**9.03E-01**	**3.34E+10**	**5.9E-14**	**2.0E-03**	**no**
I-129	**1.57E+07**	**3.51E-06**	**1.30E+05**	**1.9E-10**	**2.5E-05**	**no**
Mn-54	8.56E-01	1.28E-05	4.74E+05	3.8E-15	1.8E-09	yes
Nb-94	**2.03E+04**	**1.23E-01**	**4.55E+09**	**2.7E-14**	**1.2E-04**	**no**

Table B-1. (continued).

Radionuclide	Radioactive Half-Life (years)	PBF Inventory (Ci)	PBF Inventory (Bq)	Groundwater Ingestion NCRP Screening Factor (Sv/Bq)	Screening Dose (Sv)	Is Screening Dose <1 mrem? (<1×10^{-5} Sv?)
Ni-59	7.60E+04	4.74E-01	1.75E+10	3.2E-16	5.6E-06	yes
Ni-63	**1.00E+02**	**5.00E+01**	**1.85E+12**	**8.6E-16**	**1.6E-03**	**no**
Np-237	2.14E+06	1.63E-07	6.03E+03	2.4E-10	1.4E-06	yes
Pa-231	3.73E+04	1.83E-06	6.77E+04	1.5E-11	1.0E-06	yes
Pb-210	2.23E+01	2.33E-08	8.62E+02	5.4E-12	4.7E-09	yes
Pu-238	8.78E+01	7.58E-05	2.80E+06	1.7E-12	4.8E-06	yes
Pu-239	**2.41E+04**	**4.11E-04**	**1.52E+07**	**2.0E-12**	**3.0E-05**	**no**
Pu-240	6.57E+03	1.12E-04	4.14E+06	2.0E-12	8.3E-06	yes
Pu-241	1.44E+01	1.45E-03	5.37E+07	6.1E-14	3.3E-06	yes
Pu-242	3.76E+05	8.47E-09	3.13E+02	1.9E-12	6.0E-10	yes
Pu-244	8.26E+07	1.84E-17	6.81E-07	2.2E-12	1.5E-18	yes
Ra-226	1.60E+03	1.00E-07	3.70E+03	4.6E-12	1.7E-08	yes
Ru-103	1.08E-01	0.00E+00	0.00E+00	1.4E-20	0.0E+00	yes
Ru-106	1.01E+00	1.09E-07	4.03E+03	6.5E-14	2.6E-10	yes
Sb-125	2.77E+00	1.52E-03	5.62E+07	3.6E-15	2.0E-07	yes
Sr-90	**2.86E+01**	**1.28E+00**	**4.74E+10**	**3.5E-12**	**1.7E-01**	**no**
Tc-99	**2.13E+05**	**3.02E-04**	**1.12E+07**	**3.2E-12**	**3.6E-05**	**no**
Th-228	1.91E+00	4.89E-08	1.81E+03	2.1E-15	3.8E-12	yes
Th-229	7.34E+03	1.71E-10	6.33E+00	3.6E-13	2.3E-12	yes
Th-230	7.70E+04	1.02E-06	3.77E+04	5.2E-13	2.0E-08	yes
Th-232	1.40E+10	3.32E-08	1.23E+03	4.8E-13	5.9E-10	yes
U-232	7.20E+01	1.80E-08	6.66E+02	3.3E-11	2.2E-08	yes
U-233	1.59E+05	7.90E-08	2.92E+03	1.1E-11	3.2E-08	yes
U-234	**2.44E+05**	**4.23E-03**	**1.57E+08**	**4.2E-12**	**6.6E-04**	**no**
U-235	**7.04E+08**	**1.92E-04**	**7.10E+06**	**1.4E-11**	**9.9E-05**	**no**
U-236	2.34E+07	5.67E-06	2.10E+05	3.4E-12	7.1E-07	yes
U-238	**4.47E+09**	**8.64E-05**	**3.20E+06**	**1.4E-10**	**4.5E-04**	**no**
Zn-65	6.69E-01	1.43E-09	5.29E+01	2.9E-15	1.5E-13	yes

a. The Am-241 will be simulated as Np-237 in the Phase II screening. If all 9.59E-03 Ci of Am-241 is instantaneously decayed and becomes 1.97E-06 Ci of Np-237.

Table B-2. Radionuclide Phase II groundwater pathway screening results using Track 2 (DOE-ID 1994) assumptions (copy of EDF-4869, Table 5).

Nuclide	Progeny	Half-life (years)	K_d (mL/g)[a]	Predicted Peak Concen. (pCi/L)	Years to Peak Concen. (years)	Ingestion DCF (rem/Ci)[b]	Peak Decay Chain Dose (mrem)[c]	Morbidity Risk Coefficient (risk/Ci)[d]	Peak Risk
Am-241 (Np)[e]		2.14E+06	8	4.07E-05	1.28E+03	4.44E+06	1.32E-04	6.18E+01	5.51E-11
	U-233	1.59E+05	6	2.89E-07		2.89E+05	6.09E-08	7.18E+01	4.54E-13
	Th-229	7.34E+03	100	1.20E-09		4.03E+06	3.53E-09	2.24E+02	5.88E-15
Total Am-241 (Np)							**1.32E-04**		**5.55E-11**
C-14		5.73E+03	0.1	7.03E+00	4.72E+01	2.09E+03	**1.07E-02**	1.55E+00	**2.39E-07**
Co-60		5.27E+00	10	0.00E+00	NA	2.69E+04	**NA**	1.57E+01	**NA**
Cs-137		3.02E+01	500	0.00E+00	NA	5.00E+04	**NA**	3.04E+01	**NA**
H-3		1.23E+01	0	1.29E+02	3.15E+01	6.40E+01	**6.01E-03**	5.07E-02	**1.43E-07**
I-129		1.57E+07	0	2.95E-03	3.15E+01	2.76E+05	**5.94E-04**	1.48E+02	**9.53E-09**
Nb-94		2.03E+04	100 (1)	1.22E-01	1.57E+04	7.14E+03	**6.35E-04**	7.77E+00	**2.07E-08**
Ni-63		1.00E+02	100	6.62E-46	1.56E+04	5.77E+02	**2.79E-49**	6.70E-01	**9.70E-54**
Pu-239		2.41E+04	22[f]	2.84E-03	3.47E+03	3.54E+06	7.33E-03	1.35E+02	8.37E-09
	U-235	7.04E+08	6	3.25E-08		2.67E+05	6.34E-09	6.96E+01	4.95E-14
	Pa-231	3.73E+04	550 (2)	1.57E-11		1.06E+07	1.21E-10	1.73E+02	5.94E-17
	Ac-227	2.18E+01	450 (2)	1.88E-11		1.48E+07	2.03E-10	2.01E+02	8.29E-17
Total Pu-239							**7.33E-03**		**8.37E-09**
Sr-90		2.86E+01	12 (1)	1.55E-19	1.91E+03	1.42E+05	**1.60E-20**	5.59E+01	**1.89E-25**
Tc –99		2.13E+05	0.2 (1)	1.27E-01	6.28E+01	1.46E+03	**1.36E-04**	2.75E+00	**7.67E-09**
U-234		2.44E+05	6	1.15E-01	9.70E+02	2.83E+05	2.38E-02	7.07E+01	1.78E-07
	Th-230	7.70E+04	100	7.39E-05		5.48E+05	2.96E-05	9.10E+01	1.47E-10
	Ra-226	1.60E+03	100	1.36E-05		1.33E+06	1.32E-05	3.85E+02	1.15E-10
	Pb-210	2.23E+01	100	1.28E-05		7.27E+06	6.78E-05	8.81E+02	2.46E-10
Total U-234							**2.39E-02**		**1.79E-07**
U-235		7.04E+08	6	5.25E-03	9.70E+02	2.67E+05	1.02E-03	6.96E+01	7.99E-09
	Pa-231	3.73E+04	550	1.41E-06		1.06E+07	1.09E-05	1.73E+02	5.34E-12
	Ac-227	2.18E+01	450	1.67E-06		1.48E+07	1.80E-05	2.01E+02	7.34E-12
Total U-235							**1.05E-03**		**8.00E-09**
U-238		4.47E+09	6	2.36E-03	9.70E+02	2.70E+05	4.65E-04	6.40E+01	3.31E-09
	U-234	2.44E+05	6	6.47E-06		2.83E+05	1.34E-06	7.07E+01	1.00E-11
	Th-230	7.70E+04	100	2.08E-09		5.48E+05	8.30E-10	9.10E+01	4.14E-15
	Ra-226	1.60E+03	100	2.63E-10		1.33E+06	2.55E-10	3.85E+02	2.21E-15
	Pb-210	2.23E+01	100	2.39E-10		7.27E+06	1.27E-09	8.81E+02	4.61E-15
Total U-238							**4.66E-04**		**3.32E-09**

a. Unless otherwise noted, all K_d values from DOE-ID (1994). Noted sources are (1) DOE-ID (1997); (2) Sheppard and Thibault (1990); (3) NCRP (1996).
b. Dose conversion factors from EPA (1988).
c. Drinking water doses were based on ingestion of 2 L of water per day for 365 days per year.
d. EDF-4869 has an error in its units for Morbidity Risk Coefficient which has been fixed in this table. Changed risk/pCi to risk/Ci.)
e. Np-237 was the decay chain modeled in the simulation. All Am-241 activity was converted to equivalent activity of this Np-237.
f. Plutonium K_d has been shown to be much larger than 22 mL/g, but the Track 2 value is used here for screening purposes.

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Appendix C

2007 UPDATE - GWSCREEN INPUT AND OUTPUT FILES

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Appendix C

2007 UPDATE - GWSCREEN INPUT AND OUTPUT FILES

GWSCREEN input – 2007-PBF-dose-rad.par

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ICDF- Screening calculation for PBF nuclides - April 05, 2007
$ this is an update to the 2004 simulations documented in EDF-4869
$ the only changes are the inventory estimates which are now based on the inventory
$ in EDF-7000.
1 1 0 1 1                                (Card 2) imode,itype,idisp,kflag,idil
1 1 1 1 1                                (Card 3) imodel,isolve,isolveu,imoist,imoistu
6 12 0.001                               (Card 4) jstart jmax eps
70. 2.555E+04 2.0  365.  1.  0.004       (Card 5) bw,at,wi,ef,ed,dlim
0.   0.                                  (Card 6) x0,y0
35.  35.  0.10                           (Card 7) l,w,perc
10.  1.5                                 (Card 8b) thicks, rhos, (source term values)
0.30                                     (Card 8c) thetas (source term mc)
10.4  1.5  0.                            (Card 9) depth,rhou,axu
0.30                                     (Card 9a) thetau
9.0 4.0  0.1   76.  15.                  (Card 10) ax,ay,az,b,z(well screen thickness)
57.  0.1  1.9                            (Card 11) u,phi,rhoa
1                                        (Card 12a) nrecept
17.5  0.                                 (Card 12b) xrec yrec
14                                       (Card 14) ncontam
$  ----- 9.58E-03 Ci of Am-241 as 1.97E-06 Ci of Np237 ------------------ 1
 2  8  8  237  1.97E-6  0. 1.E+6  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'Am-241(Np)'  2.14E+06  0.32  4.44E+06 (card14b) cname thalf kda dcf
'U-233'      1.59E+05  0.24  2.89E+05  (card14b) cname thalf kda dcf
'Th-229'     7.43E+03     4  4.03E+06  (card14b) cname thalf kda dcf
$  ------------------------- C-14 ------------------------ 2
0 0.1 0.1 14 9.88E-3 0. 1.E+6 0.   (card14a) nprog kds kdu zmw qi rmi sl other
'C-14'  5.730E+03  0.004  2.09E+3      (card14b) cname thalf kda dcf
$  ------------------------- Co60 ------------------------ 3
 0  10  10  60  1.39E+1  0. 1.E+6  0.  (card14a) nprog kds kdu zmw qi rmi sl other
'Co60'  5.27E+00  0.4  2.69E+04        (card14b) cname thalf kda dcf
$  ------------------------ Cs137 ----------------------- 4
 0  500  500  137 2.59E+01  0. 1.E+6  0. (card14a) nprog kds kdu zmw qi rmi sl other
'Cs137'  3.02E+01  20  5.00E+04          (card14b) cname thalf kda dcf
$  ------------------------- H3 ------------------------- 5
 0  0  0  3  9.02E-01  0. 1.E+6  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'H3'  1.23E+01  0  6.40E+01           (card14b) cname thalf kda dcf
$  ------------------------ I129 ------------------------ 6
 0  0  0  129  4.48E-04  0. 1.E+6  0. (card14a) nprog kds kdu zmw qi rmi sl other
'I129'  1.57E+07  0  2.76E+05         (card14b) cname thalf kda dcf
$  ------------------------ Nb-94  ----------------- 7
 0 100. 100.  94  5.33E-4  0. 1.E+6  0. (card14a) nprog kds kdu zmw qi rmi sl other
'Nb94'  2.03E+04  4. 7.14E+03           (card14b) cname thalf kda dcf
$  ------------------------ Ni-63 ----------------------- 8
 0 100. 100. 63  6.94E+0  0. 1.E+6  0.  (card14a) nprog kds kdu zmw qi rmi sl other
'Ni63'  1.00E+2  4. 5.77E+02            (card14b) cname thalf kda dcf
$  ------------------------ Pu239 ----------------------- 9
 3  22  22  239  3.84E-04  0. 1.E+6  0. (card14a) nprog kds kdu zmw qi rmi sl other
'Pu239'  2.41E+04  0.88  3.54E+06       (card14b) cname thalf kda dcf
'U-235'  7.04E+08  0.24  2.67E+05       (card14b) cname thalf kda dcf
'Pa-231'  3.28E+04  22  1.06E+07        (card14b) cname thalf kda dcf
'Ac-227'  2.18E+01  18  1.48E+07        (card14b) cname thalf kda dcf
$  ------------------------ Sr90 ------------------------ 10
 0  12  12  90  1.24E+0  0. 1.E+6  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'Sr90'  2.86E+01  0.48  1.42E+05        (card14b) cname thalf kda dcf
$  ------------------------ Tc99 ------------------------ 11
 0  0.2  0.2  99  3.71E-3  0. 1.E+6  0. (card14a) nprog kds kdu zmw qi rmi sl other
'Tc99'  2.13E+05  0.008  1.46E+03       (card14b) cname thalf kda dcf
$  ------------------------ U234 ------------------------ 12
 3  6  6  234  4.14E-04  0. 1.E+6  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'U234'  2.44E+05  0.24  2.83E+05        (card14b) cname thalf kda dcf
```

```
'Th-230'  7.54E+04  4  5.48E+05         (card14b) cname thalf kda dcf
'Ra-226'  1.60E+03  4  1.33E+06         (card14b) cname thalf kda dcf
'Pb-210'  2.20E+01  4  7.27E+06         (card14b) cname thalf kda dcf
$  ------------------------ U235 ----------------------- 13
 2  6  6  235  3.69E-05  0. 1.E+6  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'U235'  7.04E+08  0.24  2.67E+05        (card14b) cname thalf kda dcf
'Pa-231'  3.28E+04  22  1.06E+07        (card14b) cname thalf kda dcf
'Ac-227'  2.18E+01  18  1.48E+07        (card14b) cname thalf kda dcf
$  ------------------------ U238 ----------------------- 14
 4  6  6  238  1.88E-05  0. 1.E+6  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'U238'  4.47E+09  0.24  2.70E+05        (card14b) cname thalf kda dcf
'U-234'  2.45E+05  0.24  2.83E+05       (card14b) cname thalf kda dcf
'Th-230'  7.54E+04  4  5.48E+05         (card14b) cname thalf kda dcf
'Ra-226'  1.60E+03  4  1.33E+06         (card14b) cname thalf kda dcf
'Pb-210'  2.20E+01  4  7.27E+06         (card14b) cname thalf kda dcf
```

GWSCREEN output – 2007-PBF-dose-rad.out

```
  ************************************************
  *                                              *
  *     This output was produced by the model:   *
  *                                              *
  *                    GWSCREEN                  *
  *                   Version 2.5a               *
  *    A semi-analytical model for the assessment *
  *    of the groundwater pathway from the leaching *
  *    of surficial and buried contamination and  *
  *  release of contaminants from percolation ponds *
  *                   01/23/2007                 *
  *                 Arthur S. Rood               *
  *         Idaho National Engineering and       *
  *            Environmental Laboratory          *
  *                   PO Box 1625                *
  *             Idaho Falls, Idaho 83415         *
  ************************************************
 ================================================================================
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                  LIMITATION OF LIABILITY

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 DOE Field Office, Idaho, Contract Number DE-AC07-76ID01570.
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 Cambridge University Press.
 ================================================================================

 OUTPUT FILE NAME: 2007-PBF-dose-rad.out
 INPUT FILE NAME: 2007-PBF-dose-rad.par
Title: ICDF- Screening calculation for PBF nuclides - April 05, 2007
--------------------------------------------------------------------------------
Model Run Options
--------------------------------------------------------------------------------
IMODE Contaminant Type and Impacts:                              1
ITYPE (1) Vert Avg (2) 3D Point (3) 3d Avg:                      1
IDISP (0) Fixed Dispersivity (1-3) Spatially Varying:            0
KFLAG (1) Max Conc (2) Conc vs Time (3) Grid Output:             1
IDIL (1) No dilution factor (2) Include Dilution Factor:         1
IMOIST Source Moisture Content Option:                           1
IMOISTU Unsaturated Moisture Content Option:                     1
IMODEL (1) Surface/Burried Src (2) Pond (3) Usr Def:             1
```

```
ISOLVE (1) Gaussian Quarature (2) Simpsons Rule: (Aquifer)      1
ISOLVEU (1) Gaussian Quarature (2) Simpsons Rule: (Unsat Zone)  1
Health Effects: Committed effective dose equivalent calculation
Output mass/activity units:   Ci
Output concentration units:   Ci/m**3
Dose/Risk Conversion Units:   rem/Ci
Output health effects units:  rem
-------------------------------------------------------------------------------
Exposure Parameters
-------------------------------------------------------------------------------
Body Mass (kg):              70.       Averaging Time (days):      25550.
Water Ingestion (L/d):       2.000E+00 Exposure Freq (day/year):   3.650E+02
Exposure Duration (y):       1.000E+00 Limiting Dose:              4.000E-03
-------------------------------------------------------------------------------
Site Parameters
-------------------------------------------------------------------------------
X Coordinate:                0.000E+00  Y Coordinate:               0.000E+00
Source Length (m):           3.500E+01  Source Width (m):           3.500E+01
Percolation Rate (m/y):      1.000E-01
Source Thickness (m):        1.000E+01  Src Bulk Density (g/cc):    1.500E+00
Source Moisture Content:     3.000E-01
-------------------------------------------------------------------------------
Unsaturated Zone Parameters
-------------------------------------------------------------------------------
Unsat Zone Thickness (m):    1.040E+01  Unsat Bulk Density:         1.500E+00
Unsat Dispersivity (m):      0.000E+00  Unsat Moisture Content:     3.000E-01
-------------------------------------------------------------------------------
Aquifer Zone Parameters
-------------------------------------------------------------------------------
Longitudinal Disp (m):       9.000E+00  Transverse Disp (m):        4.000E+00
Aquifer Thickness (m):       7.600E+01  Well Screen Thickness (m):  1.500E+01
Darcy Velocity (m/y):        5.700E+01  Aquifer Porosity:           1.000E-01
Bulk Density (g/cc):         1.900E+00
-------------------------------------------------------------------------------
Calculated Flow Parameters
-------------------------------------------------------------------------------
Percolation Water Flux (m3/y):  1.2250E+02
Unsat Pore Velocity (m/y):      3.3333E-01
Aquifer Pore Velocity (m/y):    5.7000E+02
Longitudinal Disp (m**2/y):     5.1300E+03
Transverse Disp (m**2/y):       2.2800E+03
-------------------------------------------------------------------------------
Contaminant Data
-------------------------------------------------------------------------------
 Contaminant Name:               Am-241(Np)
 Number of Progeny:              2
 Progeny Names:                 U-233        Th-229
 Half Life (y):                  2.140E+06 1.590E+05 7.430E+03
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               8.000E+00
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        2.370E+02
 Initial mass/activity:          1.970E-06
 Kd Unsat (ml/g):                8.000E+00
 Kd Aquifer (ml/g):              3.200E-01 2.400E-01 4.000E+00
 Risk/Dose Conversion Factor:    4.440E+06 2.890E+05 4.030E+06
-------------------------------------------------------------------------------
Calculated Contaminant Values
-------------------------------------------------------------------------------
Decay Constants (1/y):                    3.2390E-07 4.3594E-06 9.3290E-05
Percolation Leach Rate Constant (1/y):    8.1301E-04
Initial Pore Water Conc (Ci or mg/m**3):  1.3074E-11
Solubility Limited Mass (mg):             1.5068E+14
Solubility Limited Act (Ci):              1.0629E+08
Unsaturated Retardation Factor:           4.1000E+01
Mean Unsaturated Transit Time (y):        1.2792E+03
Aquifer Retardation Factor:               7.080E+00 5.560E+00 7.700E+01
Minimum Peak Window Time (y):             1.2792E+03
Maximum Peak Window Time (y):             9.8055E+03
-------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
```

```
--------------------------------------------------------------------------------
 NOTE: Concentrations and Doses Reported in Order of the Decay Chain
 NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m**3):           4.068E-14  2.888E-16  1.200E-18
Time of Peak (y):                       1.2821E+03
Maximum Dose:                           1.318E-07  6.092E-11  3.530E-12
Total Dose (all members):                1.319E-07
Maximum Allowable Inventory (Ci):       5.974E-02
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:              C-14
 Number of Progeny:             0
 Half Life (y):                 5.730E+03
 Other Source Loss Rate (1/y):  0.000E+00
 Kd Source (ml/g):              1.000E-01
 Solubility Limit (mg/L):       1.000E+06
 Molecular Weight (mg/L):       1.400E+01
 Initial mass/activity:         9.880E-03
 Kd Unsat (ml/g):               1.000E-01
 Kd Aquifer (ml/g):             4.000E-03
 Risk/Dose Conversion Factor:   2.090E+03
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                   1.2097E-04
Percolation Leach Rate Constant (1/y):   2.2222E-02
Initial Pore Water Conc (Ci or mg/m**3): 1.7923E-06
Solubility Limited Mass (mg):            5.5125E+12
Solubility Limited Act (Ci):             2.4586E+10
Unsaturated Retardation Factor:          1.5000E+00
Mean Unsaturated Transit Time (y):       4.6800E+01
Aquifer Retardation Factor:              1.076E+00
Minimum Peak Window Time (y):            4.6800E+01
Maximum Peak Window Time (y):            3.5880E+02
--------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):           5.515E-09
Time of Peak (y):                       4.7163E+01
Maximum Dose:                           8.414E-06
Maximum Allowable Inventory (Ci):       4.697E+00
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:              Co60
 Number of Progeny:             0
 Half Life (y):                 5.270E+00
 Other Source Loss Rate (1/y):  0.000E+00
 Kd Source (ml/g):              1.000E+01
 Solubility Limit (mg/L):       1.000E+06
 Molecular Weight (mg/L):       6.000E+01
 Initial mass/activity:         1.390E+01
 Kd Unsat (ml/g):               1.000E+01
 Kd Aquifer (ml/g):             4.000E-01
 Risk/Dose Conversion Factor:   2.690E+04
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                   1.3153E-01
Percolation Leach Rate Constant (1/y):   6.5359E-04
Initial Pore Water Conc (Ci or mg/m**3): 7.4163E-05
Solubility Limited Mass (mg):            1.8742E+14
Solubility Limited Act (Ci):             2.1208E+14
Unsaturated Retardation Factor:          5.1000E+01
Mean Unsaturated Transit Time (y):       1.5912E+03
Aquifer Retardation Factor:              8.600E+00
Minimum Peak Window Time (y):            1.5912E+03
Maximum Peak Window Time (y):            1.2197E+04
--------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
```

```
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):           0.000E+00
Time of Peak (y):                       1.2197E+04
Maximum Dose:                           0.000E+00
Maximum allowable inventory is infinite
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:              Cs137
 Number of Progeny:             0
 Half Life (y):                 3.020E+01
 Other Source Loss Rate (1/y):  0.000E+00
 Kd Source (ml/g):              5.000E+02
 Solubility Limit (mg/L):       1.000E+06
 Molecular Weight (mg/L):       1.370E+02
 Initial mass/activity:         2.590E+01
 Kd Unsat (ml/g):               5.000E+02
 Kd Aquifer (ml/g):             2.000E+01
 Risk/Dose Conversion Factor:   5.000E+04
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                   2.2952E-02
Percolation Leach Rate Constant (1/y):   1.3328E-05
Initial Pore Water Conc (Ci or mg/m**3): 2.8179E-06
Solubility Limited Mass (mg):            9.1912E+15
Solubility Limited Act (Ci):             7.9483E+14
Unsaturated Retardation Factor:          2.5010E+03
Mean Unsaturated Transit Time (y):       7.8031E+04
Aquifer Retardation Factor:              3.810E+02
Minimum Peak Window Time (y):            7.8031E+04
Maximum Peak Window Time (y):            5.9812E+05
--------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):           0.000E+00
Time of Peak (y):                       5.9812E+05
Maximum Dose:                           0.000E+00
Maximum allowable inventory is infinite
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:              H3
 Number of Progeny:             0
 Half Life (y):                 1.230E+01
 Other Source Loss Rate (1/y):  0.000E+00
 Kd Source (ml/g):              0.000E+00
 Solubility Limit (mg/L):       1.000E+06
 Molecular Weight (mg/L):       3.000E+00
 Initial mass/activity:         9.020E-01
 Kd Unsat (ml/g):               0.000E+00
 Kd Aquifer (ml/g):             0.000E+00
 Risk/Dose Conversion Factor:   6.400E+01
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                   5.6353E-02
Percolation Leach Rate Constant (1/y):   3.3333E-02
Initial Pore Water Conc (Ci or mg/m**3): 2.4544E-04
Solubility Limited Mass (mg):            3.6750E+12
Solubility Limited Act (Ci):             3.5634E+13
Unsaturated Retardation Factor:          1.0000E+00
Mean Unsaturated Transit Time (y):       3.1200E+01
Aquifer Retardation Factor:              1.000E+00
Minimum Peak Window Time (y):            3.1200E+01
Maximum Peak Window Time (y):            2.3922E+02
--------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):           1.285E-07
Time of Peak (y):                       3.1467E+01
```

```
Maximum Dose:                          6.001E-06
Maximum Allowable Inventory (Ci):      6.012E+02
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:              I129
 Number of Progeny:             0
 Half Life (y):                 1.570E+07
 Other Source Loss Rate (1/y):  0.000E+00
 Kd Source (ml/g):              0.000E+00
 Solubility Limit (mg/L):       1.000E+06
 Molecular Weight (mg/L):       1.290E+02
 Initial mass/activity:         4.480E-04
 Kd Unsat (ml/g):               0.000E+00
 Kd Aquifer (ml/g):             0.000E+00
 Risk/Dose Conversion Factor:   2.760E+05
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                    4.4150E-08
Percolation Leach Rate Constant (1/y):    3.3333E-02
Initial Pore Water Conc (Ci or mg/m**3):  1.2190E-07
Solubility Limited Mass (mg):             3.6750E+12
Solubility Limited Act (Ci):              6.4923E+05
Unsaturated Retardation Factor:           1.0000E+00
Mean Unsaturated Transit Time (y):        3.1200E+01
Aquifer Retardation Factor:               1.000E+00
Minimum Peak Window Time (y):             3.1200E+01
Maximum Peak Window Time (y):             2.3922E+02
--------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):          3.762E-10
Time of Peak (y):                      3.1520E+01
Maximum Dose:                          7.580E-05
Maximum Allowable Inventory (Ci):      2.364E-02
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:              Nb94
 Number of Progeny:             0
 Half Life (y):                 2.030E+04
 Other Source Loss Rate (1/y):  0.000E+00
 Kd Source (ml/g):              1.000E+02
 Solubility Limit (mg/L):       1.000E+06
 Molecular Weight (mg/L):       9.400E+01
 Initial mass/activity:         5.330E-04
 Kd Unsat (ml/g):               1.000E+02
 Kd Aquifer (ml/g):             4.000E+00
 Risk/Dose Conversion Factor:   7.140E+03
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                    3.4145E-05
Percolation Leach Rate Constant (1/y):    6.6534E-05
Initial Pore Water Conc (Ci or mg/m**3):  2.8949E-10
Solubility Limited Mass (mg):             1.8412E+15
Solubility Limited Act (Ci):              3.4522E+11
Unsaturated Retardation Factor:           5.0100E+02
Mean Unsaturated Transit Time (y):        1.5631E+04
Aquifer Retardation Factor:               7.700E+01
Minimum Peak Window Time (y):             1.5631E+04
Maximum Peak Window Time (y):             1.1982E+05
--------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):          5.279E-13
Time of Peak (y):                      1.5662E+04
Maximum Dose:                          2.752E-09
Maximum Allowable Inventory (Ci):      7.748E+02
--------------------------------------------------------------------------------
```

```
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               Ni63
 Number of Progeny:              0
 Half Life (y):                  1.000E+02
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               1.000E+02
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        6.300E+01
 Initial mass/activity:          6.940E+00
 Kd Unsat (ml/g):                1.000E+02
 Kd Aquifer (ml/g):              4.000E+00
 Risk/Dose Conversion Factor:    5.770E+02
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                     6.9315E-03
Percolation Leach Rate Constant (1/y):     6.6534E-05
Initial Pore Water Conc (Ci or mg/m**3):   3.7693E-06
Solubility Limited Mass (mg):              1.8412E+15
Solubility Limited Act (Ci):               1.0456E+14
Unsaturated Retardation Factor:            5.0100E+02
Mean Unsaturated Transit Time (y):         1.5631E+04
Aquifer Retardation Factor:                7.700E+01
Minimum Peak Window Time (y):              1.5631E+04
Maximum Peak Window Time (y):              1.1982E+05
--------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):            0.000E+00
Time of Peak (y):                        1.1982E+05
Maximum Dose:                            0.000E+00
Maximum allowable inventory is infinite
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               Pu239
 Number of Progeny:              3
 Progeny Names:                 U-235        Pa-231       Ac-227
 Half Life (y):                  2.410E+04 7.040E+08 3.280E+04 2.180E+01
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               2.200E+01
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        2.390E+02
 Initial mass/activity:          3.840E-04
 Kd Unsat (ml/g):                2.200E+01
 Kd Aquifer (ml/g):              8.800E-01 2.400E-01 2.200E+01 1.800E+01
 Risk/Dose Conversion Factor:    3.540E+06 2.670E+05 1.060E+07 1.480E+07
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                     2.8761E-05 9.8458E-10 2.1133E-05 3.1796E-02
Percolation Leach Rate Constant (1/y):     3.0030E-04
Initial Pore Water Conc (Ci or mg/m**3):   9.4135E-10
Solubility Limited Mass (mg):              4.0792E+14
Solubility Limited Act (Ci):               2.5339E+10
Unsaturated Retardation Factor:            1.1100E+02
Mean Unsaturated Transit Time (y):         3.4632E+03
Aquifer Retardation Factor:                1.772E+01 5.560E+00 4.190E+02 3.430E+02
Minimum Peak Window Time (y):              3.4632E+03
Maximum Peak Window Time (y):              2.6546E+04
--------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
 NOTE: Concentrations and Doses Reported in Order of the Decay Chain
 NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m**3):            2.652E-12  3.037E-17  1.466E-20  1.760E-20
Time of Peak (y):                        3.4706E+03
Maximum Dose:                            6.853E-06  5.920E-12  1.134E-13  1.901E-13
Total Dose (all members):                 6.853E-06
Maximum Allowable Inventory (Ci):        2.241E-01
```

```
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               Sr90
 Number of Progeny:              0
 Half Life (y):                  2.860E+01
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               1.200E+01
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        9.000E+01
 Initial mass/activity:          1.240E+00
 Kd Unsat (ml/g):                1.200E+01
 Kd Aquifer (ml/g):              4.800E-01
 Risk/Dose Conversion Factor:    1.420E+05
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                      2.4236E-02
Percolation Leach Rate Constant (1/y):      5.4645E-04
Initial Pore Water Conc (Ci or mg/m**3):    5.5314E-06
Solubility Limited Mass (mg):               2.2418E+14
Solubility Limited Act (Ci):                3.1161E+13
Unsaturated Retardation Factor:             6.1000E+01
Mean Unsaturated Transit Time (y):          1.9032E+03
Aquifer Retardation Factor:                 1.012E+01
Minimum Peak Window Time (y):               1.9032E+03
Maximum Peak Window Time (y):               1.4589E+04
--------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):             1.500E-28
Time of Peak (y):                         1.9054E+03
Maximum Dose:                             1.554E-23
Maximum Allowable Inventory (Ci):         3.191E+20
WARNING: PORE WATER CONCENTRATION OF THE MAXIMUM ALLOWABLE INVENTORY
         EXCEEDS THE SOLUBILITY LIMIT OF THE CONTAMINANT
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               Tc99
 Number of Progeny:              0
 Half Life (y):                  2.130E+05
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               2.000E-01
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        9.900E+01
 Initial mass/activity:          3.710E-03
 Kd Unsat (ml/g):                2.000E-01
 Kd Aquifer (ml/g):              8.000E-03
 Risk/Dose Conversion Factor:    1.460E+03
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                      3.2542E-06
Percolation Leach Rate Constant (1/y):      1.6667E-02
Initial Pore Water Conc (Ci or mg/m**3):    5.0476E-07
Solubility Limited Mass (mg):               7.3500E+12
Solubility Limited Act (Ci):                1.2471E+08
Unsaturated Retardation Factor:             2.0000E+00
Mean Unsaturated Transit Time (y):          6.2400E+01
Aquifer Retardation Factor:                 1.152E+00
Minimum Peak Window Time (y):               6.2400E+01
Maximum Peak Window Time (y):               4.7838E+02
--------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):             1.564E-09
Time of Peak (y):                         6.2802E+01
Maximum Dose:                             1.667E-06
Maximum Allowable Inventory (Ci):         8.904E+00
--------------------------------------------------------------------------------
```

```
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:              U234
 Number of Progeny:             3
 Progeny Names:                Th-230       Ra-226       Pb-210
 Half Life (y):                 2.440E+05 7.540E+04 1.600E+03 2.200E+01
 Other Source Loss Rate (1/y):  0.000E+00
 Kd Source (ml/g):              6.000E+00
 Solubility Limit (mg/L):       1.000E+06
 Molecular Weight (mg/L):       2.340E+02
 Initial mass/activity:         4.140E-04
 Kd Unsat (ml/g):               6.000E+00
 Kd Aquifer (ml/g):             2.400E-01 4.000E+00 4.000E+00 4.000E+00
 Risk/Dose Conversion Factor:   2.830E+05 5.480E+05 1.330E+06 7.270E+06
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                    2.8408E-06 9.1929E-06 4.3322E-04 3.1507E-02
Percolation Leach Rate Constant (1/y):    1.0753E-03
Initial Pore Water Conc (Ci or mg/m**3):  3.6340E-09
Solubility Limited Mass (mg):             1.1392E+14
Solubility Limited Act (Ci):              7.1391E+08
Unsaturated Retardation Factor:           3.1000E+01
Mean Unsaturated Transit Time (y):        9.6720E+02
Aquifer Retardation Factor:               5.560E+00 7.700E+01 7.700E+01 7.700E+01
Minimum Peak Window Time (y):             9.6720E+02
Maximum Peak Window Time (y):             7.4139E+03
--------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
 NOTE: Concentrations and Doses Reported in Order of the Decay Chain
 NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m**3):           1.128E-11  7.236E-15  1.330E-15  1.251E-15
Time of Peak (y):                       9.6950E+02
Maximum Dose:                           2.330E-06  2.895E-09  1.291E-09  6.638E-09
Total Dose (all members):                2.341E-06
Maximum Allowable Inventory (Ci):       7.075E-01
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:              U235
 Number of Progeny:             2
 Progeny Names:                Pa-231       Ac-227
 Half Life (y):                 7.040E+08 3.280E+04 2.180E+01
 Other Source Loss Rate (1/y):  0.000E+00
 Kd Source (ml/g):              6.000E+00
 Solubility Limit (mg/L):       1.000E+06
 Molecular Weight (mg/L):       2.350E+02
 Initial mass/activity:         3.690E-05
 Kd Unsat (ml/g):               6.000E+00
 Kd Aquifer (ml/g):             2.400E-01 2.200E+01 1.800E+01
 Risk/Dose Conversion Factor:   2.670E+05 1.060E+07 1.480E+07
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                    9.8458E-10 2.1133E-05 3.1796E-02
Percolation Leach Rate Constant (1/y):    1.0753E-03
Initial Pore Water Conc (Ci or mg/m**3):  3.2390E-10
Solubility Limited Mass (mg):             1.1392E+14
Solubility Limited Act (Ci):              2.4638E+05
Unsaturated Retardation Factor:           3.1000E+01
Mean Unsaturated Transit Time (y):        9.6720E+02
Aquifer Retardation Factor:               5.560E+00 4.190E+02 3.430E+02
Minimum Peak Window Time (y):             9.6720E+02
Maximum Peak Window Time (y):             7.4139E+03
--------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
 NOTE: Concentrations and Doses Reported in Order of the Decay Chain
 NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m**3):           1.008E-12  2.713E-16  3.207E-16
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Time of Peak (y):                       9.6950E+02
Maximum Dose:                           1.965E-07  2.099E-09  3.465E-09
Total Dose (all members):                2.020E-07
Maximum Allowable Inventory (Ci):       7.306E-01
-------------------------------------------------------------------------------
Contaminant Data
-------------------------------------------------------------------------------
 Contaminant Name:              U238
 Number of Progeny:             4
 Progeny Names:                U-234        Th-230       Ra-226       Pb-210
 Half Life (y):                 4.470E+09 2.450E+05 7.540E+04 1.600E+03 2.200E+01
 Other Source Loss Rate (1/y):  0.000E+00
 Kd Source (ml/g):              6.000E+00
 Solubility Limit (mg/L):       1.000E+06
 Molecular Weight (mg/L):       2.380E+02
 Initial mass/activity:         1.880E-05
 Kd Unsat (ml/g):               6.000E+00
 Kd Aquifer (ml/g):             2.400E-01 2.400E-01 4.000E+00 4.000E+00 4.000E+00
 Risk/Dose Conversion Factor:   2.700E+05 2.830E+05 5.480E+05 1.330E+06 7.270E+06
-------------------------------------------------------------------------------
Calculated Contaminant Values
-------------------------------------------------------------------------------
Decay Constants (1/y):                   1.5507E-10 2.8292E-06 9.1929E-06 4.3322E-04 3.1507E-02
Percolation Leach Rate Constant (1/y):   1.0753E-03
Initial Pore Water Conc (Ci or mg/m**3): 1.6502E-10
Solubility Limited Mass (mg):            1.1392E+14
Solubility Limited Act (Ci):             3.8315E+04
Unsaturated Retardation Factor:          3.1000E+01
Mean Unsaturated Transit Time (y):       9.6720E+02
Aquifer Retardation Factor:              5.560E+00 5.560E+00 7.700E+01 7.700E+01 7.700E+01
Minimum Peak Window Time (y):            9.6720E+02
Maximum Peak Window Time (y):            7.4139E+03
-------------------------------------------------------------------------------
Results for Receptor X =  1.75000E+01 Y = 0.00000E+00
-------------------------------------------------------------------------------
 NOTE: Concentrations and Doses Reported in Order of the Decay Chain
 NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m**3):           5.136E-13  1.407E-15  4.515E-19  5.715E-20  5.205E-20
Time of Peak (y):                       9.6950E+02
Maximum Dose:                           1.012E-07  2.906E-10  1.806E-13  5.548E-14  2.762E-13
Total Dose (all members):                1.015E-07
Maximum Allowable Inventory (Ci):       7.408E-01
Execution Time (Seconds):    0
```