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Engineering Design File

Project No. 25057

Groundwater Assessment for TAN-607: Hot Shop Area

Idaho Cleanup Project

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ENGINEERING DESIGN FILE

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5. Summary:

This engineering design file (EDF) documents the results of a screening-level groundwater pathway risk assessment for the Test Area North Maintenance and Assembly (TAN-607) facility Hot Shop area. This work was performed to support an environmental evaluation and cost analysis for the decontamination and decommissioning (D&D) of the TAN-607A facility.

This assessment indicates that the risks from groundwater contaminants of concern at TAN-607 are well below the regulatory risk limit of 1×10^{-4}. The maximum predicted groundwater pathway risk is 1×10^{-6}. The groundwater pathway is not a pathway of concern for radionuclide contamination at TAN-607.

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

	R/A	Typed Name/Organization	Signature	Date
Performer/ Author	R	James M. McCarthy	James M. McCarthy	12/7/06
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Groundwater Assessment for TAN-607: Hot Shop Area

1. INTRODUCTION

This engineering design file (EDF) documents the results of a screening-level groundwater pathway risk assessment for the Hot Shop and area around the Hot Shop in the Test Area North Maintenance and Assembly (TAN-607) facility. The area evaluated includes the Hot Shop, Hot Cell, Storage Pool, and Ancillary Areas. This work was performed to support an environmental evaluation and cost analysis (EE/CA) for the decontamination and decommissioning (D&D) of the TAN-607 facility. The input and output files for the computations are provided in Appendix A. The analysis plan is provided in Appendix B.

TAN-607 is a building at the Technical Support Facility (TSF) located at the north end of the Idaho National Laboratory (INL) in an area known as Test Area North (TAN). The facilities at TAN were established in the 1950s to support nuclear-powered aircraft research. Upon termination of this research, TAN facilities were converted to support a variety of other Department of Energy (DOE) sponsored projects including reactor research-related programs, the primary purpose of the TSF. The TAN-607 floor plan is shown in Figures 1, 2, and 3. The TAN-607 concrete slab is 16 inches (0.4 m) thick. The TAN-607 facilities considered for this groundwater assessment are:

- Hot Shop, including the Special Equipment Services (SES) area and tunnel – significant contributor to the inventory. The area is 60.5 m by 15.5 m or ~940 m2.
- Hot Cell – significant contributor to inventory. The area is 3.0 m by 10.7 m or ~32 m2. In the figure, the Hot Cell is identified as RML-109 and 110.
- Storage Pool – significant contributor to inventory. The area is 14.6 m by 21.3 m or ~312 m2.
- Warm Shop (or Cold Assembly Room) – no significant sources of radioactivity.
- Ancillary areas north and east of the Process Experimental Pilot Plant (PREPP, Room 140) north and east walls – no significant sources of radioactivity.

The total contaminated area is assumed to be the sum of the Hot Shop, Hot Cell, and Storage Pool areas, which are the significant contributors to the source inventory. The assumed contaminated area is ~1,285 m^2.

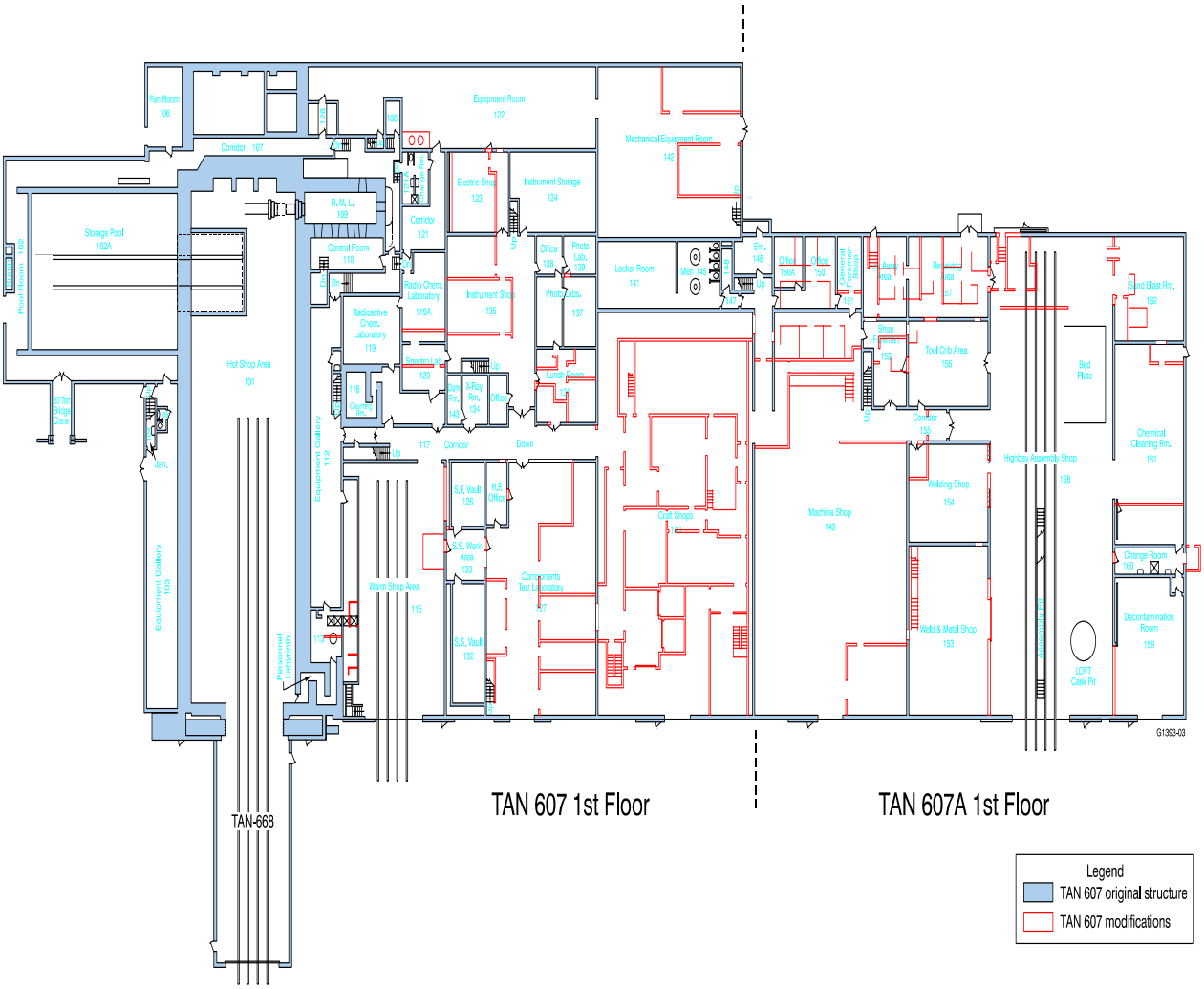

Figure 1. TAN-607 and TAN 607A floor plan, first floor (from Appendix A, EDF-7173).

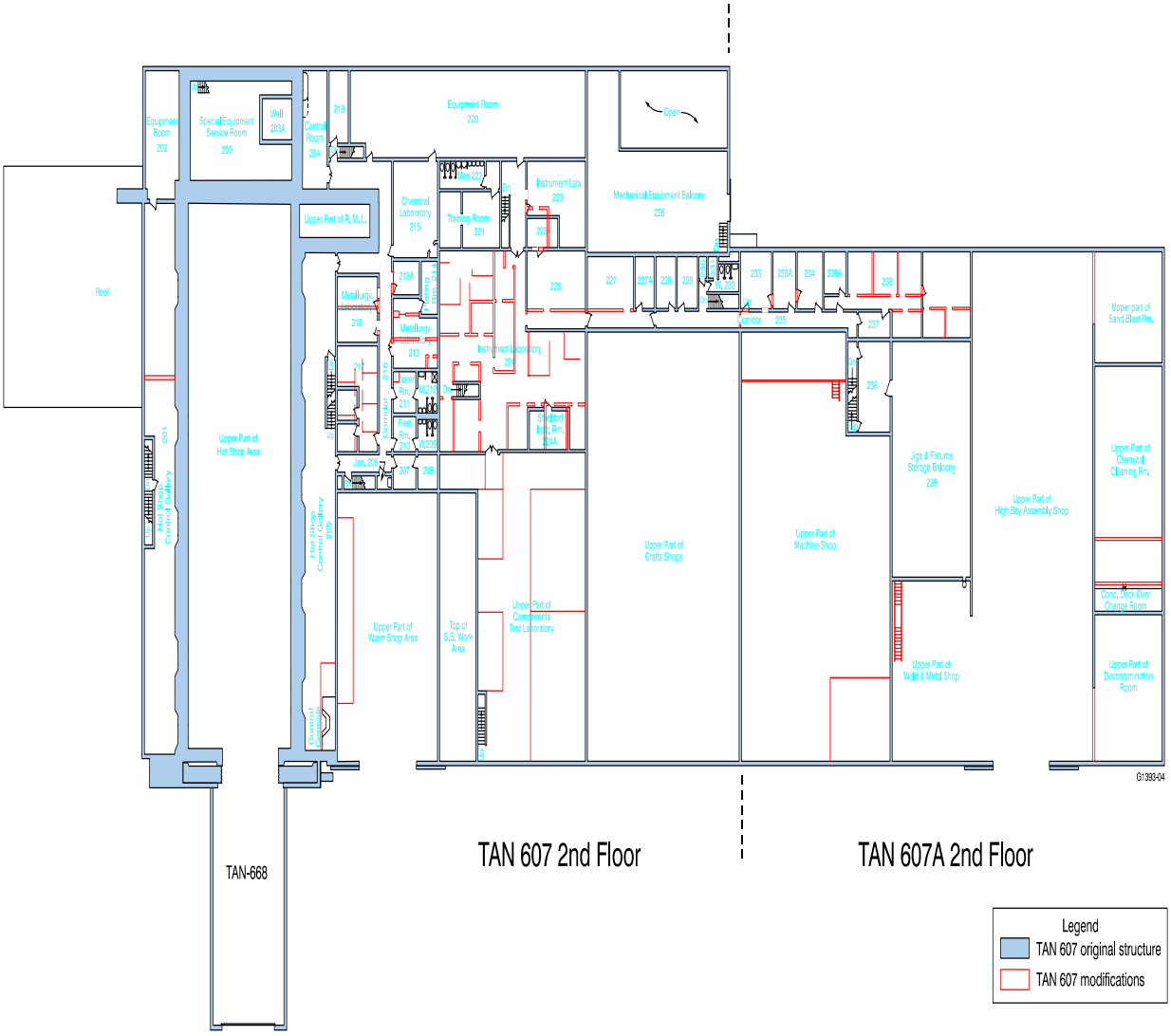

Figure 2. TAN-607 and TAN 607A floor plan, second floor (from Appendix A, EDF-7173).

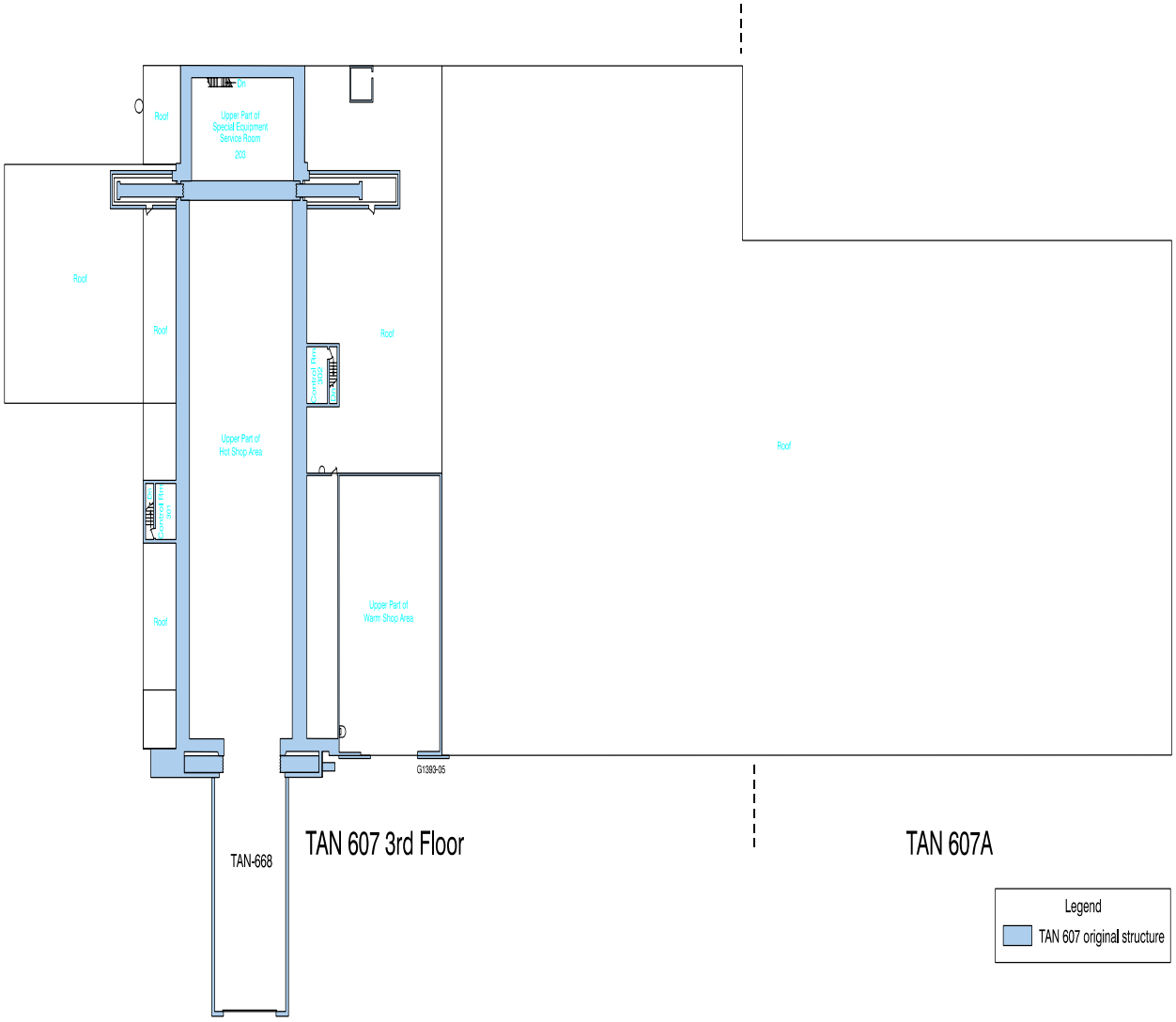

Figure 3. TAN-607 and TAN 607A floor plan, third floor (from Appendix A, EDF-7173).

2. ANALYSIS APPROACH

The radiological contamination at the TAN-607 area of interest is primarily on the concrete floors, with a small amount of contamination in the paint on the walls. For purposes of this analysis, the radionuclide contamination is assumed to be all in the concrete slab.

The radionuclides evaluated in the risk assessment are not a comprehensive list but contain the "typical" groundwater radionuclide contaminants of concern commonly found at INL facilities such as the RWMC, TRA, INTEC, and TAN. Using conservative inventory estimates for these "typical" radionuclides groundwater contaminants of concern, it is possible to assess the likelihood that any other radionuclides potentially present at TAN-607 could be a significant contributor to the groundwater risk.

The groundwater assessment code GWSCREEN 2.5a (08/11/2005) (Rood 2203) was the numerical tool used to conduct this risk assessment. The Track 2 risk assessment approach was used to evaluate these radionuclides for purposes of conservatively assessing the potential for risk to the aquifer.

The Track 2 assessment approach is based on the assumptions of the document "Track 2 Sites: Guidance for Assessing Low Probability Hazard Sites at the INEL" (DOE/ID-10389, 1994). The Track 2 approach was developed specifically for the INL to streamline the implementation of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The goal of the Track 2 groundwater pathway risk assessment approach is to use existing qualitative and quantitative data to conservatively evaluate human health risk with the objective of identifying the need for additional site characterization. If this screening level (conservative) analysis indicates acceptable risk levels, then no additional data collection or analysis would be necessary. The GWSCREEN code was develop to support the CERCLA evaluations. The Track 2 groundwater model assumptions and parameter values assigned were chosen to provide a conservative estimate of the groundwater pathway risk. Over the past 15 years these assumptions and parameters have been used for at least tens of risk assessments including DD&D of the CPP-603 (EDF-4488) and the TAN-607A Maintenance and Assembly Area concrete slab (EDF-6926).

The source term for the Track 2 assessments is assumed to be soils. However, for TAN-607, the contamination is currently on or embedded in the top surface of the concrete slab. In order for the contamination to reach the vadose zone and be transported to the aquifer, it is necessary for the concrete slab to degrade to the point that water can leach through it. At that time, the contaminants can be transported, by water, into and then through the concrete slab. Water chemistry within the concrete is assumed to be significantly different than the water chemistry in native soils. This chemistry difference is assumed to affect the transport of the radionuclides. Contaminants are generally less mobile in a concrete chemical environment than in the INL native soils. Therefore, in addition to a risk assessment with the Track 2 assumptions, a second set of calculations was conducted using concrete-water partition coefficients for contaminants in the concrete slab. Both results are presented in this report.

3. RADIONUCLIDE INVENTORY

The radionuclide inventory for TAN-607 is summarized in this section. Details are presented in EDF-7173. Table 1 is a copy of Table 9 in EDF-7173 which summarizes the estimated total inventory at TAN-607.

For this screening level risk assessment, most of the TAN-607 inventories from EDF-7173 are used directly. However, there are a number of nuclides for which the groundwater pathway risk resulting from subsurface transport is from the ingrowth and subsequent transport of progeny rather than transport of the

parent nuclides. The TAN-607 inventory simulated is shown in Table 2. As shown in this table, it is conservatively assumed that:

- All of the Am-241 and Pu-241 instantaneously decays to Np-237 and is added to the original Np-237 inventory
- All of the Cm-242 and Pu-238 instantaneously decays to U-234 and is added to the original U-234 inventory
- All of the Cm-244 instantaneously decays to Pu-240 and is added to the original Pu-240 inventory.

Table 1. Summary of radiological activity in TAN-607 (Curies) in 2006 and decayed to 2095 (exact copy of Table 9 in EDF-7173).

Isotope	Tables 3-5 Hot Shop and Tunnel	Table 6 Storage Pool	Table 7 TAN Hot Cell	Table 8 Hot Shop Sumps/Drains	TOTAL **2006** CURIES	TOTAL **2095** CURIES
Ag-108m				5.58E-04	5.58E-04	3.43E-04
Am-241	5.99E-02	7.92E-02	9.50E-03	4.48E-01	5.97E-01	6.83E-01
C-14				2.74E-04	2.74E-04	2.71E-04
* Cl-36						
Cm-242			4.28E-07		4.28E-07	4.68E-67
Cm-244			1.35E-03		1.35E-03	4.48E-05
Co-60	5.30E-01	7.01E-01	7.76E-04	1.05E-01	1.34E+00	1.11E-05
Cs-137	6.17E+00	8.18E+00	1.15E-01	1.56E+01	3.01E+01	3.90E+00
Eu-152			1.43E-03		1.43E-03	1.53E-05
Eu-154			2.47E-03		2.47E-03	2.23E-05
Eu-155			4.60E-04		4.60E-04	1.82E-09
H-3	2.81E-02	3.72E-02		6.24E-02	1.28E-01	8.42E-04
** I-129		1.38E-04			1.38E-04	1.38E-04
Ni-63	1.39E-01	1.84E-01		4.19E-01	7.42E-01	4.01E-01
Np-237			2.18E-06		2.18E-06	2.22E-05
Pu-238	1.14E-02	1.51E-02	6.92E-03	4.37E-02	7.71E-02	3.82E-02
Pu-239	4.49E-02	5.94E-02	4.87E-03	4.22E-01	5.31E-01	5.30E-01
Pu-240	4.49E-02	5.94E-02			1.04E-01	1.03E-01
Pu-241	7.78E-01	1.03E+00	1.23E-01	3.71E+00	5.64E+00	7.78E-02
Sr-90	5.48E+00	7.26E+00	1.77E-01	2.48E+01	3.77E+01	4.36E+00
Tc-99			3.60E-05		3.60E-05	3.60E-05
U-233	1.99E-03	2.63E-03		2.05E-03	6.67E-03	6.67E-03
U-234	1.99E-03	2.63E-03	1.25E-04	2.05E-03	6.80E-03	6.81E-03
U-235	1.32E-04	1.75E-04	6.70E-06	5.23E-04	8.37E-04	8.37E-04
U-238	3.30E-04	4.38E-04	7.11E-06	9.24E-04	1.70E-03	1.70E-03
TOTAL	1.33E+01	1.76E+01	4.43E-01	4.56E+01	7.70E+01	1.03E+01

* Cl-36 has not been identified in historical documentation of analyses for TAN
** I-129 is scaled in at abundance listed in EDF-4820 per INEEL/EXT-02-00342
Cs-137 and Sr-90 daughters Ba-137m and Y-90 not reported
2006 isotopes decayed to 2095 in Microshield v. 6.20 licensed to INL

Table 2. Radionuclide inventory used for the TAN-607 groundwater pathway risk assessment.

Isotope	Radioactive Decay Half Life (yr)	TAN-607 Activity (EDF-7173) (Ci)	TAN-607 Activity Simulated (Ci)	Comment [a]
Ag-108m	4.18E+02	5.58E-04	5.58E-04	
Am-241	4.32E+02	5.97E-01	Not simulated	Simulated as Np-237 (~1.20E-04 Ci)
C-14	5.70E+03	2.74E-04	2.74E-04	
Cl-36	3.01E+05	0.00E+00	0.00E+00	No activity identified in EDF-7173
Cm-242	4.46E-01	4.28E-07	Not simulated	Simulated as U-234 (~7.78E-13 Ci)
Cm-244	1.81E+01	1.35E-03	Not simulated	Simulated as Pu-240 (~3.72E-06 Ci)
Co-60	5.27E+00	1.34E+00	1.34E+00	
Cs-137	3.01E+01	3.01E+01	3.01E+01	
Eu-152	1.35E+01	1.43E-03	1.43E-03	
Eu-154	8.59E+00	2.47E-03	2.47E-03	
Eu-155	4.76E+00	4.60E-04	4.60E-04	
H-3	1.23E+01	1.28E-01	1.28E-01	
I-129	1.57E+07	1.38E-04	1.38E-04	
Ni-63	1.00E+02	7.42E-01	7.42E-01	
Np-237	2.14E+06	2.18E-06	1.60E-04	Includes decay ingrowth from Am-241 (75%) and Pu-241 (23.5%). Initial Np-237 makes up only 1.5% of the Np-237 simulated.
Pu-238	8.77E+01	7.71E-02	Not simulated	Simulated as U-234 (~2.75E-05 Ci)
Pu-239	2.41E+04	5.31E-01	5.31E-01	
Pu-240	6.56E+03	1.04E-01	1.04E-01	Includes decay ingrowth from Cm-244
Pu-241	1.43E+01	5.64E+00	Not simulated	Simulated as Np-237 (~3.76E-05 Ci)
Sr-90	2.88E+01	3.77E+01	3.77E+01	
Tc-99	2.11E+05	3.60E-05	3.60E-05	
U-233	1.59E+05	6.67E-03	6.67E-03	
U-234	2.46E+05	6.80E-03	6.83E-03	Includes decay ingrowth from Cm-242 and Pu-238
U-235	7.04E+08	8.37E-04	8.37E-04	
U-238	4.47E+09	1.70E-03	1.70E-03	

a. The progeny activity from Am-241, Cm-242, Cm-244, Pu-238, and Pu-241 are estimated as the parent activity times the ratio of the parent radioactive half-life to the progeny radioactive half-life.

4. MODELING APPROACH AND ASSUMPTIONS

For this analysis, the TAN-607 contamination was assumed to be primarily surface contamination on the floors. Two basic sets of calculations were performed. The first set of calculations used Track 2 assumptions to evaluate the risk to the aquifer assuming a soil source term. The second set of calculations is similar to the first except that the soil-water sorption coefficients were based on a concrete source term. A concrete source term changes the contaminant release to the vadose zone but does not affect the vadose zone or the aquifer transport because all other model parameters are unchanged.

This screening-level risk assessment used a conservative implementation of the groundwater screening model GWSCREEN Version 2.5a (08/11/2005) (Rood 2003) to calculate groundwater concentrations and carcinogenic risk for a set of radionuclides that includes the "typical" groundwater pathway contaminants of concern at the INL. The GWSCREEN model was developed to address CERCLA sites at the INL. The code, coupled with a set of default parameter values identified in the CERCLA Track 2 risk assessment process (DOE-ID 1994), provides conservative estimates of groundwater concentrations and ingestion doses at the INL.

The GWSCREEN conceptual model is illustrated in Figure 4. The following is a list of important assumptions made for the risk assessment:

- Radionuclides at TAN-607 are assumed to be mixed homogeneously with soil and placed in a volume represented by the volume of the concrete slab under the area of interest.

- The area of contamination is assumed to be a square with a total area equal to the area of the concrete floor below the Hot Shop, Hot Cell, and Storage Pool. As stated in Section 1, the total area is ~1,285 m^2. Therefore, the length and width of the simulated contaminated area are simulated as each 35.8 m.

- The source thickness was assumed to be approximately 0.4 m, which is an average thickness of the TAN-607 area of interest. In reality, the contamination is currently on the surface of the floor. Over time, the concrete will degrade and the contamination will first be leached into the concrete, creating a source term from the concrete. Then the radionuclides will move through the concrete, and eventually be released to the vadose zone for transport to the aquifer. This conservative assumption places the contamination in the concrete foundation now, assumes the concrete has already failed, and will allow water to readily flow through and leach contaminants from the concrete from the beginning of the simulation.

- The difference between the two scenarios is in the Kd used in the source area of the model. One scenario assumes the contaminants are in soil and the other in failed concrete. The concrete is assumed to have failed so that water can move through in the same way it moves through soil. But the chemistry of a concrete source is different from the INL native soils and, therefore, affects the assumed Kd values.

- Results are presented for both Track 2 default INL soil sorption coefficients and concrete sorption coefficients (i.e., Kd) in the source area (floor). All contaminants are assumed to be mixed homogeneously with soil or concrete and placed in a volume represented by the volume of the slab. For some of the radionuclides, there are no concrete Kds available, therefore, they were only simulated using the soil source term.

- The contaminant solubility is conservatively assumed to be infinite for these analyses.

- The radionuclides are assumed to be exposed to infiltrating water and contaminants are leached into the subsurface at different rates depending on their sorptive properties. The INL Track 2 default infiltration rate is 10 cm/yr (3.9 in./yr). The conceptual model assumes no containment or engineered barriers that would reduce this infiltration rate.

- The subsurface environment at the INL Site is composed of basalt flows separated by sedimentary interbeds. The basalt flows are often times fractured, allowing water to move freely in the vertical direction. The Track 2 methodology (DOE-ID 1994) recognized this feature of the system and assumed that water transport through the fractured basalt is relatively instantaneous. The overall vadose transit time is controlled by the presence of sedimentary interbeds. Therefore, only transport through sedimentary interbeds was considered when computing contaminant transport in the vadose zone. One-dimensional transport in a 4-m-thick vadose zone composed of sedimentary interbeds is assumed.

- Water and contaminants are assumed to move straight down through the vadose zone sediments via plug flow transport. There is no dispersion in the vadose zone and no horizontal spreading on interbeds or different layers of basalt.

- All radioactive progeny are assumed to move with the parent radionuclide. Under most circumstances, this assumption leads to conservative dose estimates at the receptor point. However, when considering the transport of a short-lived immobile parent that has a long-lived mobile progeny, results can be distorted and in many cases are not conservative. This situation occurs for the Pu-241⇒Am-241⇒Np-237, Cm-242⇒Pu-238⇒U-234, and Cm-244⇒Pu-240 decay chains. In these cases, the relatively short-lived immobile parent nuclide never leaves the waste zone and instead decays to its more mobile long-lived progeny. Therefore, the parent activity was assumed to instantaneously decay to the more mobile and long-lived progeny, and the simulation was performed assuming parameters of the progeny. This is provides a very conservative but more accurate simulation of the future risk from the short-lived parent radionuclides. The simulated inventories in Table 2 include this assumption.

- The aquifer was assumed to be a homogeneous isotropic medium of infinite lateral extent and finite thickness.

- Contaminants entering the aquifer from the vadose zone mix with water in the aquifer over a depth defined by a typical well screen of 15 m (49.2 ft).

- The receptor well was placed below the downgradient edge of TAN-607. Note that the receptor distance is measured from the center of the source; therefore, the distance to the receptor well is 35.8 m ÷ 2 = 17.9 m. This receptor is the point where the highest concentrations in the aquifer are computed.

The generalized conceptual model used for the analysis is shown in Figure 4. The parameter values used in the GWSCREEN simulations that are not contaminant specific are shown in Table 3. The contaminant-specific parameter values are shown in Table 4.

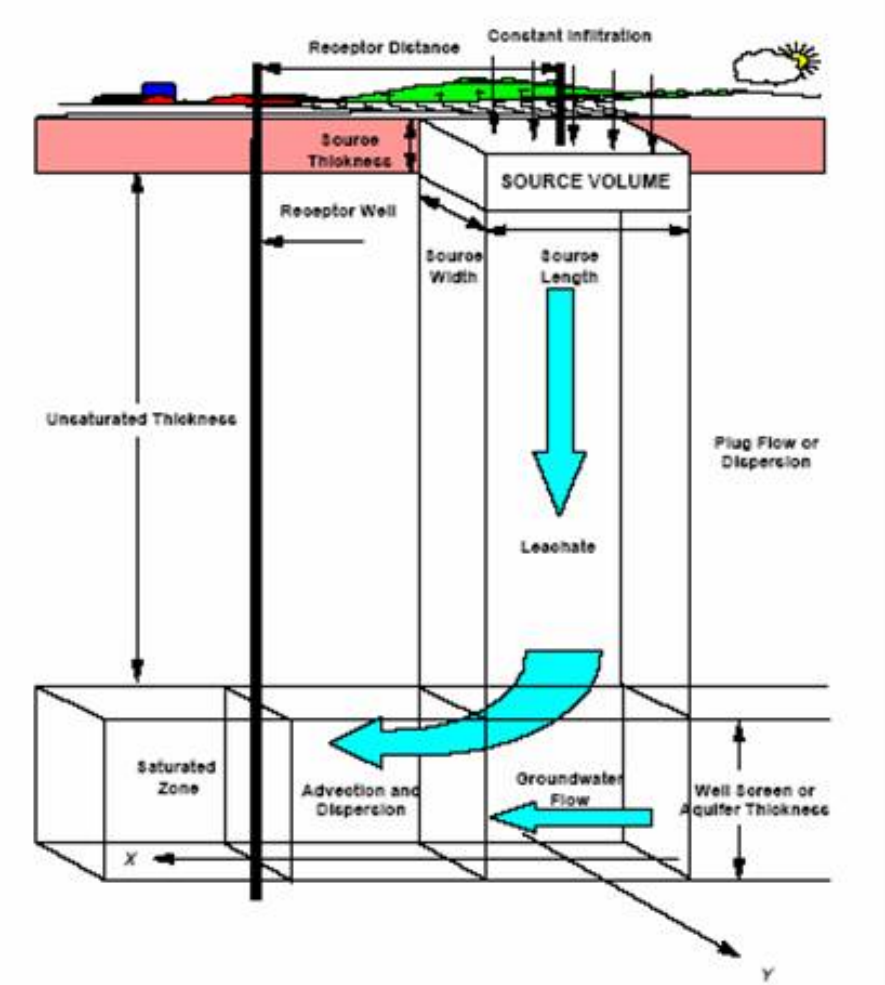

Figure 4. Generalized GWSCREEN conceptual model for the source volume, vadose zone, and aquifer (Rood 2003).

Table 3. Non-parameter dependent GWSCREEN parameter values.

Parameter	Value	Reference
Source		
Length parallel to groundwater flow	35.8 m	TAN-607A footprint length evaluated
Width perpendicular to groundwater flow	35.8 m	TAN-607A footprint width evaluated
Thickness of source	0.4 m	Concrete slab thickness
Background percolation rate	0.1 m/yr	DOE-ID (1994)
Water-filled porosity – source	0.3	DOE-ID (1994)
Bulk density – source	1.5 g/cm^3	DOE-ID (1994)
Vadose Zone		
Cumulative vadose zone interbed thickness	4 m	TAN RI/FS Blackmore et al. (1997), Table B-43, and Kaminsky et al. (1993).[b]
Water-filled porosity – vadose zone	0.3	DOE-ID (1994)
Bulk density – vadose zone	1.5 g/cm^3	Assumed to be sediment like source
Longitudinal dispersivity	0 mL/g	Generally conservative plug flow model
Aquifer		
Aquifer thickness	15 m	DOE-ID (1994) – 2D model
Well screen thickness[a]	15 m	DOE-ID (1994)
Aquifer porosity	0.1	DOE-ID (1994)
Darcy velocity in aquifer (q)	57 m/yr	Average linear velocity times porosity
Average linear velocity (v)	570 m/yr	DOE-ID (1994)
Longitudinal dispersivity	9 m	DOE-ID (1994)
Transverse dispersivity	4 m	DOE-ID (1994)
Bulk density – saturated zone	1.9 g/cm^3	DOE-ID (1994) (assumes basalt)
Receptor Distance From the Center of the Source		
Parallel to groundwater flow direction	17.9 m	Edge of TAN-607 simulated facility
Perpendicular to groundwater flow direction	0 m	Centerline of the contaminant plume
Residential Receptor Scenario		
Averaging time (radionuclides)	25,550 day	70 years, DOE-ID (1994)
Water ingestion rate for receptor	2 L/d	DOE-ID (1994)
Exposure frequency	350 d/yr	DOE-ID (1994)
Exposure duration	30 yr	DOE-ID (1994)

a. A vertically averaged solution is used per Track 2 Guidance. Thickness of the vertical section is taken to be the well screen thickness.

Table 4. Radionuclide-specific parameters.

Nuclides Parent/Progeny	Half-life (Yr)	Soil-Water Partition Coefficient (Kd)			Carcinogenic Slope Factor [d] (Risk/Ci)	SF Note [e]
		Soil [a] (mL/g)	Aquifer [b] (mL/g)	Concrete [c] (mL/g)		
Ag-108m	4.18E+02	90	3.6	Not used in model	8.14E+00	
C-14	5.70E+03	0.1	0.004	1,000	1.55E+00	
Co-60	5.27E+00	10	0.4	Not used in model	1.57E+01	
Cs-137	3.01E+01	500	20	Not used in model	3.04E+01	+D
Eu-152	1.35E+01	240	9.6	Not used in model	6.07E+00	
Eu-154	8.59E+00	240	9.6	Not used in model	1.03E+01	
Eu-155	4.76E+00	240	9.6	Not used in model	1.90E+00	
H-3	1.23E+01	0	0	0	1.12E-01	
I-129	1.57E+07	0	0	2	1.48E+02	
Ni-63	1.00E+02	100	4	Not used in model	6.70E-01	
Np-237	2.14E+06	8	0.32	5,000	6.18E+01	
U-233	1.59E+05	6	0.24	Not used in model	7.18E+01	
Th-229	7.34E+03	100	4	Not used in model	5.28E+02	+D
Pu-239	2.41E+04	22	0.88	5,000	1.35E+02	
U-235	7.04E+08	6	0.24	Not used in model	6.96E+01	
Pa-231	3.28E+04	550	22	Not used in model	1.73E+02	
Ac-227	2.18E+01	450	18	Not used in model	4.86E+02	+D
Pu-240	6.56E+03	22	0.88	5,000	1.35E+02	
U-236	2.34E+07	6	0.24	Not used in model	6.70E+01	
Th-232	1.41E+10	100	4	Not used in model	1.01E+02	
Ra-228	1.60E+03	100	4	Not used in model	1.04E+03	
Th-228	1.91E+00	100	4	Not used in model	3.03E+02	+D
Sr-90	2.88E+01	12	0.48	1	7.40E+01	+D
Tc-99	2.11E+05	0.2	0.008	1,000	2.75E+00	
U-233	1.59E+05	6	0.24	5,000	7.18E+01	
Th-229	7.34E+03	100	4	Not used in model	5.28E+02	+D
U-234	2.46E+05	6	0.24	5,000	7.07E+01	
Th-230	7.54E+04	100	4	Not used in model	9.10E+01	
Ra-226	1.60E+03	100	4	Not used in model	3.85E+02	
Pb-210	2.20E+01	100	4	Not used in model	1.27E+03	+D

Table 4. (continued).

Nuclides Parent/Progeny	Half-life (Yr)	Soil-Water Partition Coefficient (Kd)			Carcinogenic Slope Factor [d] (Risk/Ci)	SF Note [e]
		Soil [a] (mL/g)	Aquifer [b] (mL/g)	Concrete [c] (mL/g)		
U-235	7.04E+08	6	0.24	5,000	6.96E+01	
Pa-231	3.28E+04	550	22	Not used in model	1.73E+02	
Ac-227	2.18E+01	450	18	Not used in model	4.86E+02	+D
U-238	4.47E+09	6	0.24	5,000	6.40E+01	
U-234	2.46E+05	6	0.24	Not used in model	7.07E+01	
Th-230	7.54E+04	100	4	Not used in model	9.10E+01	
Ra-226	1.60E+03	100	4	Not used in model	3.85E+02	
Pb-210	2.20E+01	100	4	Not used in model	1.27E+03	+D

a. The soil Kd value is used for the soil source term and for the vadose zone interbeds. Nuclides not listed in Track 2 document (DOE 1994) or generally modified for use at the INL since 1994 (i.e., C, Eu, Np, Pa, Ac, Sr, and Tc) are from the ICDF Performance Assessment (DOE/ID 2003).
b. The ratio of the aquifer basalt-to-soil K_d value was estimated in the Idaho Nuclear Technology and Engineering Center (INTEC) Remedial Investigation/Baseline Risk Assessment (RI/BRA) (DOE-ID 1997) to be 0.04 and this value has been commonly used at the INL in later studies and is used for this analysis.
c. The concrete Kd estimates for I, Np, Pu, Tc, and U are the values used for grouted waste in the INL high-level waste EIS (DOE 2002). The concrete Kd estimate for C is the minimum Kd estimated for grout and reported by ICP (2005) and Bradbury and Sarott (1995).
d. The carcinogenic slope factors are from the Environmental Protection Agency (EPA 1999).
e. Slope factors with a +D note include the influence on risk of the daughters and are commonly referred to as +D slope factors.

5. RESULTS

The predicted peak and maximum average aquifer concentrations, time of peak, and maximum risk results for the radionuclide risk assessment are summarized in Table 5. Two sets of results are presented. The first set of results is based on the conservative Track 2 assumptions and the assumption that the contaminants coexist in a soil source; soil-water distribution coefficients from the Track 2 guidance were used. In Table 5, these results are under the "Soil Source Term". If the concrete slab is left in place, the most likely scenario is that, in time, the concrete slab will degrade and water will begin to move through the slab, carrying the contaminants with it. The second set of results is also based on the conservative Track 2 assumptions but assumes that the contaminants coexist in a chemical environment of concrete; the model uses soil-water distribution coefficients for concrete. In Table 5, the second set of results is under the "Concrete Source Term". Concrete Kds are not readily available for all of the nuclides. Therefore, nuclides with predicted very low risks for which concrete Kd values are not available (Ag-108m, Co-60, Cs-137, Eu-152, Eu-154, Eu-155, H-3, and Ni-63) were not re-simulated and are identified in Table 5 with "NA".

For the soil source analysis, only Pu-239 was calculated to have a maximum risk in the aquifer greater than the regulatory risk limit of 1×10^{-4}. When a concrete source is assumed, the maximum risk for Pu-239 dropped to 1×10^{-6}. For all other radionuclides, the maximum predicted risk is less than 1×10^{-6} (see Table 5). In order to have a risk greater than the regulatory risk limit of 1×10^{-4}, the inventory estimate for Pu-239 would have to be increased by a factor of 100.

Table 5. Groundwater pathway risk assessment results. Risk values is bold are greater than the regulatory limit of 1×10^{-4}.

			Soil Source Term				Concrete Source Term			
Parent	Progeny	Estimated Inventory[a] (Ci)	Predicted Peak Concentration (pCi/L)	Years to Peak Concentration (years)	Peak 30-yr Average Concentration (pCi/L)	Maximum Risk	Predicted Peak Concentration (pCi/L)	Years to Peak Concentration (years)	Peak 30-yr Average Concentration (pCi/L)	Maximum Risk
Ag-108m		5.58E-04	3.09E-06	5.43E+03	2.75E-06	5E-13	NA	NA	NA	NA
C-14		2.74E-04	3.43E+00	1.82E+01	2.33E-01	8E-09	1.14E-03	2.13E+01	1.14E-03	4E-11
Co-60		1.34E+00	4.80E-33	6.13E+02	1.27E-33	< 1E-20	NA	NA	NA	NA
Cs-137		3.01E+01	0.00E+00	5.08E+04	0.00E+00	< 1E-20	NA	NA	NA	NA
Eu-152		1.43E-03	0.00E+00	2.44E+04	0.00E+00	< 1E-20	NA	NA	NA	NA
Eu-154		2.47E-03	0.00E+00	2.44E+04	0.00E+00	< 1E-20	NA	NA	NA	NA
Eu-155		4.60E-04	0.00E+00	2.44E+04	0.00E+00	< 1E-20	NA	NA	NA	NA
H-3		1.28E-01	1.18E+03	1.22E+01	5.25E+01	1E-07	NA	NA	NA	NA
I-129		1.38E-04	2.52E+00	1.22E+01	1.19E-01	4E-07	2.57E-01	1.23E+01	1.04E-01	3E-07
Ni-63		7.42E-01	2.15E-17	6.03E+03	1.88E-17	< 1E-20	NA	NA	NA	NA
Np-237		1.60E-04	7.87E-02	4.94E+02	6.05E-02	8E-08	1.34E-04	5.14E+02	1.34E-04	2E-10
	U-233		2.16E-04		1.70E-04		3.82E-07		3.82E-07	
	Th-229		3.57E-07		2.88E-07		6.59E-10		6.59E-10	
Pu-239		5.31E-01	9.31E+01	1.34E+03	8.38E+01	**2E-04**	4.27E-01	1.34E+03	4.14E-01	1E-06
	U-235		3.98E-04		3.61E-04		1.83E-06		1.79E-06	
	Pa-231		7.43E-08		6.80E-08		3.44E-10		3.36E-10	
	Ac-227		8.67E-08		7.93E-08		4.01E-10		3.92E-10	
Pu-240		1.04E-01	1.65E+01	1.34E+03	1.48E+01	4E-05	7.55E-02	1.34E+03	7.31E-02	2E-07
	U-236		2.23E-03		2.02E-03		1.03E-05		9.99E-06	
	Th-232		5.41E-12		4.95E-12		2.50E-14		2.45E-14	
	Ra-228		9.19E-13		8.46E-13		4.25E-15		4.19E-15	
	Th-228		9.13E-13		8.41E-13		4.23E-15		4.16E-15	

Table 5. (continued).

Parent	Progeny	Estimated Inventory[a] (Ci)	Soil Source Term				Concrete Source Term			
			Predicted Peak Concentration (pCi/L)	Years to Peak Concentration (years)	Peak 30-yr Average Concentration (pCi/L)	Maximum Risk	Predicted Peak Concentration (pCi/L)	Years to Peak Concentration (years)	Peak 30-yr Average Concentration (pCi/L)	Maximum Risk
Sr-90		3.77E+01	2.64E-04	7.34E+02	1.69E-04	3E-10	2.34E-03	7.33E+02	5.87E-04	9E-10
Tc-99		3.60E-05	3.44E-01	2.42E+01	3.06E-02	2E-09	1.51E-04	2.77E+01	1.50E-04	9E-12
U-233		6.67E-03	4.33E+00	3.73E+02	3.06E+00	5E-06	5.57E-03	3.90E+02	5.57E-03	9E-09
	Th-229		1.08E-02		7.91E-03		1.46E-05		1.45E-05	
U-234		6.83E-03	4.44E+00	3.73E+02	3.14E+00	5E-06	5.71E-03	3.90E+02	5.71E-03	8E-09
	Th-230		1.10E-03		8.02E-04		1.48E-06		1.47E-06	
	Ra-226		8.42E-05		6.34E-05		1.18E-07		1.18E-07	
	Pb-210		7.13E-05		5.39E-05		1.00E-07		1.00E-07	
U-235		8.37E-04	5.44E-01	3.73E+02	3.85E-01	6E-07	7.00E-04	3.90E+02	7.00E-04	1E-09
	Pa-231		5.67E-05		4.14E-05		7.62E-08		7.62E-08	
	Ac-227		6.35E-05		4.65E-05		8.56E-08		8.56E-08	
U-238		1.70E-03	1.11E+00	3.73E+02	7.82E-01	1E-06	1.42E-03	3.90E+02	1.42E-03	2E-09
	U-234		1.16E-03		8.49E-04		1.56E-06		1.56E-06	
	Th-230		1.44E-07		1.08E-07		2.02E-10		2.02E-10	
	Ra-226		7.45E-09		5.80E-09		1.09E-11		1.09E-11	
	Pb-210		5.85E-09		4.58E-09		8.63E-12		8.64E-12	

a. The Np-237 inventory includes the activity from the estimated Np-237 inventory plus the total Np-237 inventory that can ever grow in from Am-241 and Pu-241. The Pu-240 inventory includes the activity from the estimated Pu-240 inventory plus the total Pu-240 inventory than can ever grow in from Cm-244. The U-234 inventory includes the activity from the estimated U-234 inventory plus the total U-234 inventory that can ever grow in from Cm-242 and Pu-238.

NA – identifies a nuclide for which no concrete parameters were identified. In all cases, the predicted risk is far below the risk limit; therefore, they were not re-simulated with concrete parameters.

Sr-90 was the only radionuclide for which the soil Kd (12 mL/g) is greater than the concrete Kd (1 mL/g). For Sr-90, the risk from the concrete source is about three times larger than the risk from the soil source. However, in both cases the risk is more than six orders of magnitude below the regulatory risk limit of 1×10^{-4}. Therefore, Sr-90 is not a significant contributor to the groundwater pathway risk at TAN-607.

As explained in the analysis approach section, the radionuclides evaluated include the "typical" groundwater radionuclide contaminants of concern at the INL Site. These "typical" groundwater radionuclide contaminants are a sufficiently large and varied group of nuclides to include all potentially significant contributors to the risk through the groundwater pathway.

Conservative inventory estimates of these radionuclides and conservative flow and transport parameters have been used for the groundwater risk assessment. Since the groundwater pathway risks calculated for this "typical" set of groundwater radionuclide contaminants is at or below 1×10^{-6} risk, it is not reasonable to expect that any other radionuclide at TAN-607 could be a significant contributor to a 1×10^{-4} groundwater risk.

This conservative groundwater risk assessment indicates that the radiological risks from groundwater contaminants at TAN-607 are at or below 1×10^{-6} risk. The regulatory risk limit is 1×10^{-4}; therefore, the groundwater pathway is not a pathway of concern for radionuclide contamination assumed to be present at TAN-607.

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Appendix A

GWSCREEN Input and Output Files

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Appendix A

GWSCREEN Input and Output Files

GWSCREEN Input File Based on the Track 2 Assumptions - Soil Source Volume (Scenario 1)

```
Radionuclide Evaluation for TAN-607 (Soil Kd values)  (Card 1)
2 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  350.  30.  1.0E-6         (Card 5) bw,at,wi,ef,ed,dlim
0.  0.                                       (Card 6) x0,y0
35.8 35.8 0.1                                (Card 7) l,w,perc
0.4  1.5                                     (Card 8b) thicks,rhos
0.3                                          (Card 8c) thetas
4. 1.5  0                                    (Card 9) depth,rhou,axu
0.3                                          (Card 9a) thetau
9.0  4.0   5.0e-4   15.  15.                 (Card 10) ax,ay,az,b,z
57.0 0.1 1.9                                 (Card 11) u,phi,rhoa
1                                            (Card 12a nrecept
17.9  0.                                     (Card 12b) xrec(i) yrec(i)
19                                           (Card 14) ncontam
$  ------------------------ Ag-108m ------------------------ 1
 0  90  90  108  5.58E-04  0. 1.00E+06  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'Ag-108m'  4.18E+02  3.6  8.14E+00           (card14b) cname thalf kda dcf (SF)
$  ------------------------ C-14 ------------------------ 2
 0  0.1  0.1  14  2.74E-04  0. 1.00E+06  0.  (card14a) nprog kds kdu zmw qi rmi sl other
'C-14'  5.70E+03  0.004  1.55E+00            (card14b) cname thalf kda dcf (SF)
$  ------------------------ Co-60 ------------------------ 3
 0  10  10  60  1.34E+00  0. 1.00E+06  0.    (card14a) nprog kds kdu zmw qi rmi sl other
'Co-60'  5.27E+00  0.4  1.57E+01             (card14b) cname thalf kda dcf  (SF)
$  ------------------------ Cs-137 ------------------------ 4
 0  500  500  137  3.01E+01  0. 1.00E+06  0. (card14a) nprog kds kdu zmw qi rmi sl other
'Cs-137'  3.01E+01  20  3.04E+01             (card14b) cname thalf kda dcf (SF+D)
$  ------------------------ Eu-152 ------------------------ 5
 0  240  240  152  1.43E-03  0. 1.00E+06  0. (card14a) nprog kds kdu zmw qi rmi sl other
'Eu-152'  1.35E+01  9.6  6.07E+00            (card14b) cname thalf kda dcf  (SF)
$  ------------------------ Eu-154 ------------------------ 6
 0  240  240  154  2.47E-03  0. 1.00E+06  0. (card14a) nprog kds kdu zmw qi rmi sl other
'Eu-154'  8.59E+00  9.6  1.03E+01            (card14b) cname thalf kda dcf  (SF)
$  ------------------------ Eu-155 ------------------------ 7
 0  240  240  155  4.60E-04  0. 1.00E+06  0. (card14a) nprog kds kdu zmw qi rmi sl other
'Eu-155'  4.76E+00  9.6  1.90E+00            (card14b) cname thalf kda dcf  (SF)
$  ------------------------ H-3 ------------------------ 8
 0  0  0  3  1.28E-01  0. 1.00E+06  0.       (card14a) nprog kds kdu zmw qi rmi sl other
'H-3'  1.23E+01  0  1.12E-01                 (card14b) cname thalf kda dcf  (SF)
$  ------------------------ I-129 ------------------------ 9
 0  0  0  129  1.38E-04  0. 1.00E+06  0.     (card14a) nprog kds kdu zmw qi rmi sl other
'I-129'  1.57E+07  0  1.48E+02               (card14b) cname thalf kda dcf (SF)
$  ------------------------ Ni-63 ------------------------ 10
 0  100  100  63  7.42E-01  0. 1.00E+06  0.  (card14a) nprog kds kdu zmw qi rmi sl other
'Ni-63'  1.00E+02  4  6.70E-01               (card14b) cname thalf kda dcf (SF)
$  ------------------------ Np-237 ------------------------ 11
 2  8  8  237  1.60E-04  0. 1.00E+06  0.     (card14a) nprog kds kdu zmw qi rmi sl other
'Np-237'  2.14E+06  0.32  6.18E+01           (card14b) cname thalf kda dcf (SF)
'U-233'  1.59E+05  0.24  7.18E+01            (card14b) cname thalf kda dcf (SF)
'Th-229'  7.34E+03  4  5.28E+02              (card14b) cname thalf kda dcf (SF+D)
$  ------------------------ Pu-239 ------------------------ 12
 3  22  22  239  5.31E-01  0. 1.00E+06  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'Pu-239'  2.41E+04  0.88  1.35E+02           (card14b) cname thalf kda dcf (SF)
'U-235'  7.04E+08  0.24  6.96E+01            (card14b) cname thalf kda dcf (SF)
'Pa-231'  3.28E+04  22  1.73E+02             (card14b) cname thalf kda dcf (SF)
'Ac-227'  2.18E+01  18  4.86E+02             (card14b) cname thalf kda dcf (SF+D)
$  ------------------------ Pu-240 ------------------------ 13
 4  22  22  240  1.04E-01  0. 1.00E+06  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'Pu-240'  6.56E+03  0.88  1.35E+02           (card14b) cname thalf kda dcf (SF)
'U-236'  2.34E+07  0.24  6.70E+01            (card14b) cname thalf kda dcf (SF)
```

```
'Th-232'  1.41E+10  4  1.01E+02              (card14b) cname thalf kda dcf (SF)
'Ra-228'  1.60E+03  4  1.04E+03              (card14b) cname thalf kda dcf (SF)
'Th-228'  1.91E+00  4  3.03E+02              (card14b) cname thalf kda dcf (SF+D)
$  ------------------------ Sr-90 ------------------------ 14
 0  12  12  90  3.77E+01  0. 1.00E+06  0.    (card14a) nprog kds kdu zmw qi rmi sl other
'Sr-90'  2.88E+01  0.48  7.40E+01            (card14b) cname thalf kda dcf (SF+D)
$  ------------------------ Tc-99 ------------------------ 15
 0  0.2  0.2  99  3.60E-05  0. 1.00E+06  0.  (card14a) nprog kds kdu zmw qi rmi sl other
'Tc-99'  2.11E+05  0.008  2.75E+00           (card14b) cname thalf kda dcf (SF)
$  ------------------------ U-233 ------------------------ 16
 1  6  6  233  6.67E-03  0. 1.00E+06  0.     (card14a) nprog kds kdu zmw qi rmi sl other
'U-233'  1.59E+05  0.24  7.18E+01            (card14b) cname thalf kda dcf (SF)
'Th-229'  7.34E+03  4  5.28E+02              (card14b) cname thalf kda dcf (SF+D)
$  ------------------------ U-234 ------------------------ 17
 3  6  6  234  6.83E-03  0. 1.00E+06  0.     (card14a) nprog kds kdu zmw qi rmi sl other
'U-234'  2.46E+05  0.24  7.07E+01            (card14b) cname thalf kda dcf (SF)
'Th-230'  7.54E+04  4  9.10E+01              (card14b) cname thalf kda dcf (SF)
'Ra-226'  1.60E+03  4  3.85E+02              (card14b) cname thalf kda dcf (SF)
'Pb-210'  2.23E+01  4  1.27E+03              (card14b) cname thalf kda dcf (SF+D)
$  ------------------------ U-235 ------------------------ 18
 2  6  6  235  8.37E-04  0. 1.00E+06  0.     (card14a) nprog kds kdu zmw qi rmi sl other
'U-235'  7.04E+08  0.24  6.96E+01            (card14b) cname thalf kda dcf (SF)
'Pa-231'  3.28E+04  22  1.73E+02             (card14b) cname thalf kda dcf (SF)
'Ac-227'  2.18E+01  18  4.86E+02             (card14b) cname thalf kda dcf (SF+D)
$  ------------------------ U-238 ------------------------ 19
 4  6  6  238  1.70E-03  0. 1.00E+06  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'U-238'  4.47E+09  0.24  6.40E+01                   (card14b) cname thalf kda dcf
'U-234'  2.46E+05  0.24  7.07E+01            (card14b) cname thalf kda dcf (SF)
'Th-230'  7.54E+04  4  9.10E+01              (card14b) cname thalf kda dcf (SF)
'Ra-226'  1.60E+03  4  3.85E+02              (card14b) cname thalf kda dcf (SF)
'Pb-210'  2.23E+01  4  1.27E+03              (card14b) cname thalf kda dcf (SF+D)
```

GWSCREEN Output File Based on the Track 2 Assumptions - Soil Source Volume (Scenario 1)

```
 ************************************************
 *                                              *
 *     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 *
 *                  08/11/2005                  *
 *                 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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================================================================================

 OUTPUT FILE NAME: tan-607-soil.out
 INPUT FILE NAME: tan-607-soil.par
Title: Radionuclide Evaluation for TAN-607 (Soil Kd values)  (Card 1)
--------------------------------------------------------------------------------
Model Run Options
--------------------------------------------------------------------------------
IMODE Contaminant Type and Impacts:                              2
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: Carcinogenic incidence risk for radionuclides
Output mass/activity units:   Ci
Output concentration units:   Ci/m**3
Dose/Risk Conversion Units:   1/Ci
Output health effects units:  carcinogenic risk
--------------------------------------------------------------------------------
Exposure Parameters
--------------------------------------------------------------------------------
Body Mass (kg):              70.       Averaging Time (days):      25550.
Water Ingestion (L/d):       2.000E+00 Exposure Freq (day/year):   3.500E+02
Exposure Duration (y):       3.000E+01 Limiting Dose:              1.000E-06
--------------------------------------------------------------------------------
Site Parameters
--------------------------------------------------------------------------------
X Coordinate:                0.000E+00  Y Coordinate:               0.000E+00
```

```
Source Length (m):           3.580E+01  Source Width (m):           3.580E+01
Percolation Rate (m/y):      1.000E-01
Source Thickness (m):        4.000E-01  Src Bulk Density (g/cc):    1.500E+00
Source Moisture Content:     3.000E-01
--------------------------------------------------------------------------------
Unsaturated Zone Parameters
--------------------------------------------------------------------------------
Unsat Zone Thickness (m):    4.000E+00  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):       1.500E+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):  1.2816E+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:               Ag-108m
 Number of Progeny:              0
 Half Life (y):                  4.180E+02
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               9.000E+01
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        1.080E+02
 Initial mass/activity:          5.580E-04
 Kd Unsat (ml/g):                9.000E+01
 Kd Aquifer (ml/g):              3.600E+00
 Risk/Dose Conversion Factor:    8.140E+00
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                     1.6582E-03
Percolation Leach Rate Constant (1/y):     1.8477E-03
Initial Pore Water Conc (Ci or mg/m**3):   8.0447E-09
Solubility Limited Mass (mg):              6.9362E+13
Solubility Limited Act (Ci):               5.4974E+11
Unsaturated Retardation Factor:            4.5100E+02
Mean Unsaturated Transit Time (y):         5.4120E+03
Aquifer Retardation Factor:                6.940E+01
Minimum Peak Window Time (y):              5.4120E+03
Maximum Peak Window Time (y):              9.1688E+03
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):             3.086E-15
Time of Peak (y):                         5.4271E+03
Concentrations Averaged Between:       5.4121E+03 and  5.4421E+03 years
Average Concentration (Ci/m**3):          2.753E-15
Maximum Dose:                             4.706E-13
Maximum Allowable Inventory (Ci):         1.186E+03
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               C-14
 Number of Progeny:              0
 Half Life (y):                  5.700E+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:          2.740E-04
```

```
 Kd Unsat (ml/g):                1.000E-01
 Kd Aquifer (ml/g):              4.000E-03
 Risk/Dose Conversion Factor:    1.550E+00
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                      1.2160E-04
Percolation Leach Rate Constant (1/y):      5.5556E-01
Initial Pore Water Conc (Ci or mg/m**3):    1.1877E-06
Solubility Limited Mass (mg):               2.3070E+11
Solubility Limited Act (Ci):                1.0343E+09
Unsaturated Retardation Factor:             1.5000E+00
Mean Unsaturated Transit Time (y):          1.8000E+01
Aquifer Retardation Factor:                 1.076E+00
Minimum Peak Window Time (y):               1.8000E+01
Maximum Peak Window Time (y):               3.0562E+01
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):             3.428E-09
Time of Peak (y):                         1.8190E+01
Concentrations Averaged Between:       1.8000E+01 and  4.8000E+01 years
Average Concentration (Ci/m**3):          2.332E-10
Maximum Dose:                             7.592E-09
Maximum Allowable Inventory (Ci):         3.609E-02
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               Co-60
 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:          1.340E+00
 Kd Unsat (ml/g):                1.000E+01
 Kd Aquifer (ml/g):              4.000E-01
 Risk/Dose Conversion Factor:    1.570E+01
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                      1.3153E-01
Percolation Leach Rate Constant (1/y):      1.6340E-02
Initial Pore Water Conc (Ci or mg/m**3):    1.7084E-04
Solubility Limited Mass (mg):               7.8436E+12
Solubility Limited Act (Ci):                8.8754E+12
Unsaturated Retardation Factor:             5.1000E+01
Mean Unsaturated Transit Time (y):          6.1200E+02
Aquifer Retardation Factor:                 8.600E+00
Minimum Peak Window Time (y):               6.1200E+02
Maximum Peak Window Time (y):               1.0369E+03
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):             4.802E-42
Time of Peak (y):                         6.1319E+02
Concentrations Averaged Between:       6.1200E+02 and  6.4200E+02 years
Average Concentration (Ci/m**3):          1.271E-42
Maximum Dose:                             4.191E-40
Maximum Allowable Inventory (Ci):         3.197E+33
WARNING: PORE WATER CONCENTRATION OF THE MAXIMUM ALLOWABLE INVENTORY
         EXCEEDS THE SOLUBILITY LIMIT OF THE CONTAMINANT
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               Cs-137
 Number of Progeny:              0
 Half Life (y):                  3.010E+01
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               5.000E+02
```

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 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        1.370E+02
 Initial mass/activity:          3.010E+01
 Kd Unsat (ml/g):                5.000E+02
 Kd Aquifer (ml/g):              2.000E+01
 Risk/Dose Conversion Factor:    3.040E+01
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                     2.3028E-02
Percolation Leach Rate Constant (1/y):     3.3320E-04
Initial Pore Water Conc (Ci or mg/m**3):   7.8254E-05
Solubility Limited Mass (mg):              3.8465E+14
Solubility Limited Act (Ci):               3.3374E+13
Unsaturated Retardation Factor:            2.5010E+03
Mean Unsaturated Transit Time (y):         3.0012E+04
Aquifer Retardation Factor:                3.810E+02
Minimum Peak Window Time (y):              3.0012E+04
Maximum Peak Window Time (y):              5.0840E+04
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):            0.000E+00
Time of Peak (y):                        5.0839E+04
Concentrations Averaged Between:       5.0824E+04 and  5.0854E+04 years
Average Concentration (Ci/m**3):         0.000E+00
Maximum Dose:                            0.000E+00
Maximum allowable inventory is infinite
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               Eu-152
 Number of Progeny:              0
 Half Life (y):                  1.350E+01
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               2.400E+02
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        1.520E+02
 Initial mass/activity:          1.430E-03
 Kd Unsat (ml/g):                2.400E+02
 Kd Aquifer (ml/g):              9.600E+00
 Risk/Dose Conversion Factor:    6.070E+00
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                     5.1344E-02
Percolation Leach Rate Constant (1/y):     6.9387E-04
Initial Pore Water Conc (Ci or mg/m**3):   7.7419E-09
Solubility Limited Mass (mg):              1.8471E+14
Solubility Limited Act (Ci):               3.2206E+13
Unsaturated Retardation Factor:            1.2010E+03
Mean Unsaturated Transit Time (y):         1.4412E+04
Aquifer Retardation Factor:                1.834E+02
Minimum Peak Window Time (y):              1.4412E+04
Maximum Peak Window Time (y):              2.4414E+04
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):            0.000E+00
Time of Peak (y):                        2.4413E+04
Concentrations Averaged Between:       2.4398E+04 and  2.4428E+04 years
Average Concentration (Ci/m**3):         0.000E+00
Maximum Dose:                            0.000E+00
Maximum allowable inventory is infinite
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               Eu-154
 Number of Progeny:              0
 Half Life (y):                  8.590E+00
 Other Source Loss Rate (1/y):   0.000E+00
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 Kd Source (ml/g):               2.400E+02
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        1.540E+02
 Initial mass/activity:          2.470E-03
 Kd Unsat (ml/g):                2.400E+02
 Kd Aquifer (ml/g):              9.600E+00
 Risk/Dose Conversion Factor:    1.030E+01
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                      8.0692E-02
Percolation Leach Rate Constant (1/y):      6.9387E-04
Initial Pore Water Conc (Ci or mg/m**3):    1.3372E-08
Solubility Limited Mass (mg):               1.8471E+14
Solubility Limited Act (Ci):                4.9958E+13
Unsaturated Retardation Factor:             1.2010E+03
Mean Unsaturated Transit Time (y):          1.4412E+04
Aquifer Retardation Factor:                 1.834E+02
Minimum Peak Window Time (y):               1.4412E+04
Maximum Peak Window Time (y):               2.4413E+04
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):             0.000E+00
Time of Peak (y):                         2.4412E+04
Concentrations Averaged Between:       2.4397E+04 and  2.4427E+04 years
Average Concentration (Ci/m**3):          0.000E+00
Maximum Dose:                             0.000E+00
Maximum allowable inventory is infinite
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               Eu-155
 Number of Progeny:              0
 Half Life (y):                  4.760E+00
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               2.400E+02
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        1.550E+02
 Initial mass/activity:          4.600E-04
 Kd Unsat (ml/g):                2.400E+02
 Kd Aquifer (ml/g):              9.600E+00
 Risk/Dose Conversion Factor:    1.900E+00
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                      1.4562E-01
Percolation Leach Rate Constant (1/y):      6.9387E-04
Initial Pore Water Conc (Ci or mg/m**3):    2.4904E-09
Solubility Limited Mass (mg):               1.8471E+14
Solubility Limited Act (Ci):                8.9574E+13
Unsaturated Retardation Factor:             1.2010E+03
Mean Unsaturated Transit Time (y):          1.4412E+04
Aquifer Retardation Factor:                 1.834E+02
Minimum Peak Window Time (y):               1.4412E+04
Maximum Peak Window Time (y):               2.4411E+04
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):             0.000E+00
Time of Peak (y):                         2.4411E+04
Concentrations Averaged Between:       2.4396E+04 and  2.4426E+04 years
Average Concentration (Ci/m**3):          0.000E+00
Maximum Dose:                             0.000E+00
Maximum allowable inventory is infinite
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               H-3
 Number of Progeny:              0
 Half Life (y):                  1.230E+01
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 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:          1.280E-01
 Kd Unsat (ml/g):                0.000E+00
 Kd Aquifer (ml/g):              0.000E+00
 Risk/Dose Conversion Factor:    1.120E-01
-------------------------------------------------------------------------------
Calculated Contaminant Values
-------------------------------------------------------------------------------
Decay Constants (1/y):                     5.6353E-02
Percolation Leach Rate Constant (1/y):     8.3333E-01
Initial Pore Water Conc (Ci or mg/m**3):   8.3227E-04
Solubility Limited Mass (mg):              1.5380E+11
Solubility Limited Act (Ci):               1.4913E+12
Unsaturated Retardation Factor:            1.0000E+00
Mean Unsaturated Transit Time (y):         1.2000E+01
Aquifer Retardation Factor:                1.000E+00
Minimum Peak Window Time (y):              1.2000E+01
Maximum Peak Window Time (y):              2.0397E+01
-------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
-------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):            1.179E-06
Time of Peak (y):                        1.2158E+01
Concentrations Averaged Between:       1.2000E+01 and  4.2000E+01 years
Average Concentration (Ci/m**3):         5.251E-08
Maximum Dose:                            1.235E-07
Maximum Allowable Inventory (Ci):        1.036E+00
-------------------------------------------------------------------------------
Contaminant Data
-------------------------------------------------------------------------------
 Contaminant Name:               I-129
 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:          1.380E-04
 Kd Unsat (ml/g):                0.000E+00
 Kd Aquifer (ml/g):              0.000E+00
 Risk/Dose Conversion Factor:    1.480E+02
-------------------------------------------------------------------------------
Calculated Contaminant Values
-------------------------------------------------------------------------------
Decay Constants (1/y):                     4.4150E-08
Percolation Leach Rate Constant (1/y):     8.3333E-01
Initial Pore Water Conc (Ci or mg/m**3):   8.9729E-07
Solubility Limited Mass (mg):              1.5380E+11
Solubility Limited Act (Ci):               2.7170E+04
Unsaturated Retardation Factor:            1.0000E+00
Mean Unsaturated Transit Time (y):         1.2000E+01
Aquifer Retardation Factor:                1.000E+00
Minimum Peak Window Time (y):              1.2000E+01
Maximum Peak Window Time (y):              2.0398E+01
-------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
-------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):            2.522E-09
Time of Peak (y):                        1.2162E+01
Concentrations Averaged Between:       1.2000E+01 and  4.2000E+01 years
Average Concentration (Ci/m**3):         1.189E-10
Maximum Dose:                            3.697E-07
Maximum Allowable Inventory (Ci):        3.733E-04
-------------------------------------------------------------------------------
Contaminant Data
-------------------------------------------------------------------------------
 Contaminant Name:               Ni-63
 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:          7.420E-01
 Kd Unsat (ml/g):                1.000E+02
 Kd Aquifer (ml/g):              4.000E+00
 Risk/Dose Conversion Factor:    6.700E-01
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                    6.9315E-03
Percolation Leach Rate Constant (1/y):    1.6633E-03
Initial Pore Water Conc (Ci or mg/m**3):  9.6298E-06
Solubility Limited Mass (mg):             7.7052E+13
Solubility Limited Act (Ci):              4.3760E+12
Unsaturated Retardation Factor:           5.0100E+02
Mean Unsaturated Transit Time (y):        6.0120E+03
Aquifer Retardation Factor:               7.700E+01
Minimum Peak Window Time (y):             6.0120E+03
Maximum Peak Window Time (y):             1.0185E+04
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):            2.152E-26
Time of Peak (y):                        6.0250E+03
Concentrations Averaged Between:       6.0120E+03 and  6.0420E+03 years
Average Concentration (Ci/m**3):         1.875E-26
Maximum Dose:                            2.638E-25
Maximum Allowable Inventory (Ci):        2.813E+18
WARNING: PORE WATER CONCENTRATION OF THE MAXIMUM ALLOWABLE INVENTORY
         EXCEEDS THE SOLUBILITY LIMIT OF THE CONTAMINANT
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               Np-237
 Number of Progeny:              2
 Progeny Names:                 U-233        Th-229
 Half Life (y):                  2.140E+06 1.590E+05 7.340E+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:          1.600E-04
 Kd Unsat (ml/g):                8.000E+00
 Kd Aquifer (ml/g):              3.200E-01 2.400E-01 4.000E+00
 Risk/Dose Conversion Factor:    6.180E+01 7.180E+01 5.280E+02
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                    3.2390E-07 4.3594E-06 9.4434E-05
Percolation Leach Rate Constant (1/y):    2.0325E-02
Initial Pore Water Conc (Ci or mg/m**3):  2.5374E-08
Solubility Limited Mass (mg):             6.3057E+12
Solubility Limited Act (Ci):              4.4484E+06
Unsaturated Retardation Factor:           4.1000E+01
Mean Unsaturated Transit Time (y):        4.9200E+02
Aquifer Retardation Factor:               7.080E+00 5.560E+00 7.700E+01
Minimum Peak Window Time (y):             4.9200E+02
Maximum Peak Window Time (y):             8.3359E+02
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+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):            7.871E-11  2.155E-13  3.573E-16
Time of Peak (y):                        4.9374E+02
Concentrations Averaged Between:       4.9200E+02 and  5.2200E+02 years
Average Concentration (Ci/m**3):         6.054E-11  1.698E-13  2.883E-16
Maximum Dose:                            7.857E-08  2.560E-10  3.197E-12
```

```
Total Dose (all members):                7.883E-08
Maximum Allowable Inventory (Ci):        2.030E-03
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               Pu-239
 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:          5.310E-01
 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:    1.350E+02 6.960E+01 1.730E+02 4.860E+02
--------------------------------------------------------------------------------
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):    7.5075E-03
Initial Pore Water Conc (Ci or mg/m**3):  3.1105E-05
Solubility Limited Mass (mg):             1.7071E+13
Solubility Limited Act (Ci):              1.0604E+09
Unsaturated Retardation Factor:           1.1100E+02
Mean Unsaturated Transit Time (y):        1.3320E+03
Aquifer Retardation Factor:               1.772E+01 5.560E+00 4.190E+02 3.430E+02
Minimum Peak Window Time (y):             1.3320E+03
Maximum Peak Window Time (y):             2.2567E+03
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+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):            9.306E-08  3.979E-13  7.432E-17  8.666E-17
Time of Peak (y):                        1.3364E+03
Concentrations Averaged Between:       1.3320E+03 and  1.3620E+03 years
Average Concentration (Ci/m**3):         8.381E-08  3.612E-13  6.800E-17  7.932E-17
Maximum Dose:                            2.376E-04  5.279E-10  2.470E-13  8.095E-13
Total Dose (all members):                 2.376E-04
Maximum Allowable Inventory (Ci):        2.235E-03
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               Pu-240
 Number of Progeny:              4
 Progeny Names:                 U-236        Th-232       Ra-228       Th-228
 Half Life (y):                  6.560E+03 2.340E+07 1.410E+10 1.600E+03 1.910E+00
 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):        2.400E+02
 Initial mass/activity:          1.040E-01
 Kd Unsat (ml/g):                2.200E+01
 Kd Aquifer (ml/g):              8.800E-01 2.400E-01 4.000E+00 4.000E+00 4.000E+00
 Risk/Dose Conversion Factor:    1.350E+02 6.700E+01 1.010E+02 1.040E+03 3.030E+02
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                    1.0566E-04 2.9622E-08 4.9159E-11 4.3322E-04 3.6290E-01
Percolation Leach Rate Constant (1/y):    7.5075E-03
Initial Pore Water Conc (Ci or mg/m**3):  6.0920E-06
Solubility Limited Mass (mg):             1.7071E+13
Solubility Limited Act (Ci):              3.8796E+09
Unsaturated Retardation Factor:           1.1100E+02
Mean Unsaturated Transit Time (y):        1.3320E+03
Aquifer Retardation Factor:               1.772E+01 5.560E+00 7.700E+01 7.700E+01 7.700E+01
Minimum Peak Window Time (y):             1.3320E+03
Maximum Peak Window Time (y):             2.2567E+03
--------------------------------------------------------------------------------
```

```
Results for Receptor X =  1.79000E+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):           1.645E-08  2.229E-12  5.410E-21  9.186E-22  9.133E-22
Time of Peak (y):                       1.3364E+03
Concentrations Averaged Between:      1.3320E+03 and  1.3620E+03 years
Average Concentration (Ci/m**3):        1.480E-08  2.022E-12  4.949E-21  8.462E-22  8.413E-22
Maximum Dose:                           4.196E-05  2.845E-09  1.050E-17  1.848E-17  5.353E-18
Total Dose (all members):                4.196E-05
Maximum Allowable Inventory (Ci):       2.479E-03
-------------------------------------------------------------------------------
Contaminant Data
-------------------------------------------------------------------------------
 Contaminant Name:              Sr-90
 Number of Progeny:             0
 Half Life (y):                 2.880E+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:         3.770E+01
 Kd Unsat (ml/g):               1.200E+01
 Kd Aquifer (ml/g):             4.800E-01
 Risk/Dose Conversion Factor:   7.400E+01
-------------------------------------------------------------------------------
Calculated Contaminant Values
-------------------------------------------------------------------------------
Decay Constants (1/y):                    2.4068E-02
Percolation Leach Rate Constant (1/y):    1.3661E-02
Initial Pore Water Conc (Ci or mg/m**3):  4.0185E-03
Solubility Limited Mass (mg):             9.3816E+12
Solubility Limited Act (Ci):              1.2950E+12
Unsaturated Retardation Factor:           6.1000E+01
Mean Unsaturated Transit Time (y):        7.3200E+02
Aquifer Retardation Factor:               1.012E+01
Minimum Peak Window Time (y):             7.3200E+02
Maximum Peak Window Time (y):             1.2402E+03
-------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
-------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):           2.643E-13
Time of Peak (y):                       7.3398E+02
Concentrations Averaged Between:      7.3200E+02 and  7.6200E+02 years
Average Concentration (Ci/m**3):        1.690E-13
Maximum Dose:                           2.626E-10
Maximum Allowable Inventory (Ci):       1.436E+05
-------------------------------------------------------------------------------
Contaminant Data
-------------------------------------------------------------------------------
 Contaminant Name:              Tc-99
 Number of Progeny:             0
 Half Life (y):                 2.110E+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:         3.600E-05
 Kd Unsat (ml/g):               2.000E-01
 Kd Aquifer (ml/g):             8.000E-03
 Risk/Dose Conversion Factor:   2.750E+00
-------------------------------------------------------------------------------
Calculated Contaminant Values
-------------------------------------------------------------------------------
Decay Constants (1/y):                    3.2851E-06
Percolation Leach Rate Constant (1/y):    4.1667E-01
Initial Pore Water Conc (Ci or mg/m**3):  1.1704E-07
Solubility Limited Mass (mg):             3.0759E+11
Solubility Limited Act (Ci):              5.2685E+06
Unsaturated Retardation Factor:           2.0000E+00
Mean Unsaturated Transit Time (y):        2.4000E+01
```

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Aquifer Retardation Factor:              1.152E+00
Minimum Peak Window Time (y):            2.4000E+01
Maximum Peak Window Time (y):            4.0727E+01
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):           3.439E-10
Time of Peak (y):                       2.4215E+01
Concentrations Averaged Between:       2.4000E+01 and  5.4000E+01 years
Average Concentration (Ci/m**3):        3.056E-11
Maximum Dose:                           1.765E-09
Maximum Allowable Inventory (Ci):       2.040E-02
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:              U-233
 Number of Progeny:             1
 Progeny Names:                Th-229
 Half Life (y):                 1.590E+05 7.340E+03
 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):       2.330E+02
 Initial mass/activity:         6.670E-03
 Kd Unsat (ml/g):               6.000E+00
 Kd Aquifer (ml/g):             2.400E-01 4.000E+00
 Risk/Dose Conversion Factor:   7.180E+01 5.280E+02
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                   4.3594E-06 9.4434E-05
Percolation Leach Rate Constant (1/y):   2.6882E-02
Initial Pore Water Conc (Ci or mg/m**3):  1.3990E-06
Solubility Limited Mass (mg):            4.7677E+12
Solubility Limited Act (Ci):             4.6045E+07
Unsaturated Retardation Factor:          3.1000E+01
Mean Unsaturated Transit Time (y):       3.7200E+02
Aquifer Retardation Factor:              5.560E+00 7.700E+01
Minimum Peak Window Time (y):            3.7200E+02
Maximum Peak Window Time (y):            6.3029E+02
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):           4.329E-09  1.084E-11
Time of Peak (y):                       3.7335E+02
Concentrations Averaged Between:       3.7200E+02 and  4.0200E+02 years
Average Concentration (Ci/m**3):        3.064E-09  7.910E-12
Maximum Dose:                           4.620E-06  8.770E-08
Total Dose (all members):                4.707E-06
Maximum Allowable Inventory (Ci):       1.417E-03
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:              U-234
 Number of Progeny:             3
 Progeny Names:                Th-230       Ra-226       Pb-210
 Half Life (y):                 2.460E+05 7.540E+04 1.600E+03 2.230E+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:         6.830E-03
 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:   7.070E+01 9.100E+01 3.850E+02 1.270E+03
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                   2.8177E-06 9.1929E-06 4.3322E-04 3.1083E-02
Percolation Leach Rate Constant (1/y):   2.6882E-02
Initial Pore Water Conc (Ci or mg/m**3):  1.4326E-06
```

```
Solubility Limited Mass (mg):             4.7677E+12
Solubility Limited Act (Ci):              2.9634E+07
Unsaturated Retardation Factor:           3.1000E+01
Mean Unsaturated Transit Time (y):        3.7200E+02
Aquifer Retardation Factor:               5.560E+00 7.700E+01 7.700E+01 7.700E+01
Minimum Peak Window Time (y):             3.7200E+02
Maximum Peak Window Time (y):             6.3029E+02
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+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):            4.435E-09  1.098E-12  8.424E-14  7.125E-14
Time of Peak (y):                        3.7335E+02
Concentrations Averaged Between:       3.7200E+02 and  4.0200E+02 years
Average Concentration (Ci/m**3):         3.139E-09  8.017E-13  6.339E-14  5.390E-14
Maximum Dose:                            4.661E-06  1.532E-09  5.125E-10  1.438E-09
Total Dose (all members):                 4.664E-06
Maximum Allowable Inventory (Ci):        1.464E-03
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               U-235
 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:          8.370E-04
 Kd Unsat (ml/g):                6.000E+00
 Kd Aquifer (ml/g):              2.400E-01 2.200E+01 1.800E+01
 Risk/Dose Conversion Factor:    6.960E+01 1.730E+02 4.860E+02
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                    9.8458E-10 2.1133E-05 3.1796E-02
Percolation Leach Rate Constant (1/y):    2.6882E-02
Initial Pore Water Conc (Ci or mg/m**3):  1.7556E-07
Solubility Limited Mass (mg):             4.7677E+12
Solubility Limited Act (Ci):              1.0311E+04
Unsaturated Retardation Factor:           3.1000E+01
Mean Unsaturated Transit Time (y):        3.7200E+02
Aquifer Retardation Factor:               5.560E+00 4.190E+02 3.430E+02
Minimum Peak Window Time (y):             3.7200E+02
Maximum Peak Window Time (y):             6.3029E+02
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+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):            5.441E-10  5.674E-14  6.349E-14
Time of Peak (y):                        3.7335E+02
Concentrations Averaged Between:       3.7200E+02 and  4.0200E+02 years
Average Concentration (Ci/m**3):         3.851E-10  4.143E-14  4.649E-14
Maximum Dose:                            5.629E-07  1.505E-10  4.745E-10
Total Dose (all members):                 5.635E-07
Maximum Allowable Inventory (Ci):        1.485E-03
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               U-238
 Number of Progeny:              4
 Progeny Names:                 U-234        Th-230       Ra-226       Pb-210
 Half Life (y):                  4.470E+09 2.460E+05 7.540E+04 1.600E+03 2.230E+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:          1.700E-03
```

```
 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:    6.400E+01 7.070E+01 9.100E+01 3.850E+02 1.270E+03
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                     1.5507E-10 2.8177E-06 9.1929E-06 4.3322E-04 3.1083E-02
Percolation Leach Rate Constant (1/y):     2.6882E-02
Initial Pore Water Conc (Ci or mg/m**3):   3.5657E-07
Solubility Limited Mass (mg):              4.7677E+12
Solubility Limited Act (Ci):               1.6034E+03
Unsaturated Retardation Factor:            3.1000E+01
Mean Unsaturated Transit Time (y):         3.7200E+02
Aquifer Retardation Factor:                5.560E+00 5.560E+00 7.700E+01 7.700E+01 7.700E+01
Minimum Peak Window Time (y):              3.7200E+02
Maximum Peak Window Time (y):              6.3029E+02
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+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):            1.105E-09  1.162E-12  1.438E-16  7.454E-18  5.846E-18
Time of Peak (y):                        3.7335E+02
Concentrations Averaged Between:       3.7200E+02 and  4.0200E+02 years
Average Concentration (Ci/m**3):         7.822E-10  8.485E-13  1.084E-16  5.795E-18  4.579E-18
Maximum Dose:                            1.051E-06  1.260E-09  2.072E-13  4.685E-14  1.221E-13
Total Dose (all members):                 1.053E-06
Maximum Allowable Inventory (Ci):        1.615E-03
Execution Time (Seconds):    0
```

GWSCREEN Input File Based on the Track 2 Assumptions - Concrete Source Volume (Scenario 2)

```
Radionuclide Evaluation for TAN-607 (concrete Kd values)  (Card 1)
2 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  350.  30.  1.0E-6       (Card 5) bw,at,wi,ef,ed,dlim
0.  0.                                     (Card 6) x0,y0
35.8 35.8 0.1                              (Card 7) l,w,perc
0.4  1.5                                   (Card 8b) thicks,rhos
0.3                                        (Card 8c) thetas
4. 1.5  0                                  (Card 9) depth,rhou,axu
0.3                                        (Card 9a) thetau
9.0  4.0   5.0e-4   15.  15.               (Card 10) ax,ay,az,b,z
57.0 0.1 1.9                               (Card 11) u,phi,rhoa
1                                          (Card 12a nrecept
17.9  0.                                   (Card 12b) xrec(i) yrec(i)
11                                         (Card 14) ncontam
$  ---- C-14 (ICP/EXT-04-00699 formerly PEI-EDF-1023)  --------- 1
 0 1000. 0.1  14  2.74E-04  0. 1.00E+06  0.  (card14a) nprog kds kdu zmw qi rmi sl other
'C-14'  5.70E+03  0.004  1.55E+00           (card14b) cname thalf kda dcf (SF)
$  -- I-129 (ICP/EXT-04-00699 formerly PEI-EDF-1023)   ------------- 2
 0 2.  0  129  1.38E-04  0. 1.00E+06  0.    (card14a) nprog kds kdu zmw qi rmi sl other
'I-129'  1.57E+07  0  1.48E+02             (card14b) cname thalf kda dcf (SF)
$  ------------------------- Np-237 ------------------------ 3
 2 5000. 8  237  1.60E-04  0. 1.00E+06  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'Np-237'  2.14E+06  0.32  6.18E+01          (card14b) cname thalf kda dcf (SF)
'U-233'  1.59E+05  0.24  7.18E+01           (card14b) cname thalf kda dcf (SF)
'Th-229'  7.34E+03  4  5.28E+02             (card14b) cname thalf kda dcf (SF+D)
$  ------------------------- Pu-239 ------------------------ 4
 3 5000. 22  239  5.31E-01  0. 1.00E+06  0.  (card14a) nprog kds kdu zmw qi rmi sl other
'Pu-239'  2.41E+04  0.88  1.35E+02          (card14b) cname thalf kda dcf (SF)
'U-235'  7.04E+08  0.24  6.96E+01           (card14b) cname thalf kda dcf (SF)
'Pa-231'  3.28E+04  22  1.73E+02            (card14b) cname thalf kda dcf (SF)
'Ac-227'  2.18E+01  18  4.86E+02            (card14b) cname thalf kda dcf (SF+D)
$  ------------------------- Pu-240 ------------------------ 5
 4 5000. 22  240  1.04E-01  0. 1.00E+06  0.  (card14a) nprog kds kdu zmw qi rmi sl other
'Pu-240'  6.56E+03  0.88  1.35E+02          (card14b) cname thalf kda dcf (SF)
'U-236'  2.34E+07  0.24  6.70E+01           (card14b) cname thalf kda dcf (SF)
'Th-232'  1.41E+10  4  1.01E+02             (card14b) cname thalf kda dcf (SF)
'Ra-228'  1.60E+03  4  1.04E+03             (card14b) cname thalf kda dcf (SF)
'Th-228'  1.91E+00  4  3.03E+02             (card14b) cname thalf kda dcf (SF+D)
$  - Sr-90 (ICP/EXT-04-00699 formerly PEI-EDF-1023)  --------- 6
 0  1.  12  90  3.77E+01  0. 1.00E+06  0.    (card14a) nprog kds kdu zmw qi rmi sl other
'Sr-90'  2.88E+01  0.48  7.40E+01            (card14b) cname thalf kda dcf (SF+D)
$  ------ Tc-99 (ICP/EXT-04-00699 formerly PEI-EDF-1023)   -------- 7
 0 1000.  0.2  99  3.60E-05  0. 1.00E+06  0. (card14a) nprog kds kdu zmw qi rmi sl other
'Tc-99'  2.11E+05  0.008  2.75E+00           (card14b) cname thalf kda dcf (SF)
$  ------------------------- U-233 ------------------------ 8
 1 5000. 6  233  6.67E-03  0. 1.00E+06  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'U-233'  1.59E+05  0.24  7.18E+01            (card14b) cname thalf kda dcf (SF)
'Th-229'  7.34E+03  4  5.28E+02             (card14b) cname thalf kda dcf (SF+D)
$  ------------------------- U-234 ------------------------ 9
 3 5000. 6  234  6.83E-03  0. 1.00E+06  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'U-234'  2.46E+05  0.24  7.07E+01            (card14b) cname thalf kda dcf (SF)
'Th-230'  7.54E+04  4  9.10E+01             (card14b) cname thalf kda dcf (SF)
'Ra-226'  1.60E+03  4  3.85E+02             (card14b) cname thalf kda dcf (SF)
'Pb-210'  2.23E+01  4  1.27E+03             (card14b) cname thalf kda dcf (SF+D)
$  ------------------------- U-235 ------------------------ 10
 2 5000. 6  235  8.37E-04  0. 1.00E+06  0.     (card14a) nprog kds kdu zmw qi rmi sl other
'U-235'  7.04E+08  0.24  6.96E+01            (card14b) cname thalf kda dcf (SF)
'Pa-231'  3.28E+04  22  1.73E+02             (card14b) cname thalf kda dcf (SF)
'Ac-227'  2.18E+01  18  4.86E+02             (card14b) cname thalf kda dcf (SF+D)
$  ------------------------- U-238 ------------------------ 11
 4 5000. 6  238  1.70E-03  0. 1.00E+06  0.   (card14a) nprog kds kdu zmw qi rmi sl other
'U-238'  4.47E+09  0.24  6.40E+01                (card14b) cname thalf kda dcf
'U-234'  2.46E+05  0.24  7.07E+01            (card14b) cname thalf kda dcf (SF)
'Th-230'  7.54E+04  4  9.10E+01             (card14b) cname thalf kda dcf (SF)
'Ra-226'  1.60E+03  4  3.85E+02             (card14b) cname thalf kda dcf (SF)
'Pb-210'  2.23E+01  4  1.27E+03             (card14b) cname thalf kda dcf (SF+D)
```

GWSCREEN Output File Based on the Track 2 Assumptions - Concrete Source Volume (Scenario 2)

```
 ************************************************
 *                                              *
 *     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 *
 *                  08/11/2005                  *
 *                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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================================================================================

 OUTPUT FILE NAME: tan-607-concrete.out
 INPUT FILE NAME: tan-607-concrete.par
Title: Radionuclide Evaluation for TAN-607 (concrete Kd values)  (Card 1)
--------------------------------------------------------------------------------
Model Run Options
--------------------------------------------------------------------------------
IMODE Contaminant Type and Impacts:                              2
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: Carcinogenic incidence risk for radionuclides
Output mass/activity units:   Ci
Output concentration units:   Ci/m**3
Dose/Risk Conversion Units:   1/Ci
Output health effects units:  carcinogenic risk
--------------------------------------------------------------------------------
Exposure Parameters
--------------------------------------------------------------------------------
Body Mass (kg):              70.       Averaging Time (days):      25550.
Water Ingestion (L/d):       2.000E+00 Exposure Freq (day/year):   3.500E+02
Exposure Duration (y):       3.000E+01 Limiting Dose:              1.000E-06
--------------------------------------------------------------------------------
Site Parameters
--------------------------------------------------------------------------------
X Coordinate:                0.000E+00  Y Coordinate:               0.000E+00
```

```
Source Length (m):           3.580E+01  Source Width (m):           3.580E+01
Percolation Rate (m/y):      1.000E-01
Source Thickness (m):        4.000E-01  Src Bulk Density (g/cc):    1.500E+00
Source Moisture Content:     3.000E-01
-------------------------------------------------------------------------------
Unsaturated Zone Parameters
-------------------------------------------------------------------------------
Unsat Zone Thickness (m):    4.000E+00  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):       1.500E+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):  1.2816E+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:               C-14
 Number of Progeny:              0
 Half Life (y):                  5.700E+03
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               1.000E+03
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        1.400E+01
 Initial mass/activity:          2.740E-04
 Kd Unsat (ml/g):                1.000E-01
 Kd Aquifer (ml/g):              4.000E-03
 Risk/Dose Conversion Factor:    1.550E+00
-------------------------------------------------------------------------------
Calculated Contaminant Values
-------------------------------------------------------------------------------
Decay Constants (1/y):                     1.2160E-04
Percolation Leach Rate Constant (1/y):     1.6663E-04
Initial Pore Water Conc (Ci or mg/m**3):   3.5624E-10
Solubility Limited Mass (mg):              7.6914E+14
Solubility Limited Act (Ci):               3.4485E+12
Unsaturated Retardation Factor:            1.5000E+00
Mean Unsaturated Transit Time (y):         1.8000E+01
Aquifer Retardation Factor:                1.076E+00
Minimum Peak Window Time (y):              1.8000E+01
Maximum Peak Window Time (y):              4.1615E+04
-------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
-------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):            1.143E-12
Time of Peak (y):                        2.1340E+01
Concentrations Averaged Between:       1.8000E+01 and  4.8000E+01 years
Average Concentration (Ci/m**3):         1.138E-12
Maximum Dose:                            3.705E-11
Maximum Allowable Inventory (Ci):        7.395E+00
-------------------------------------------------------------------------------
Contaminant Data
-------------------------------------------------------------------------------
 Contaminant Name:               I-129
 Number of Progeny:              0
 Half Life (y):                  1.570E+07
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               2.000E+00
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        1.290E+02
 Initial mass/activity:          1.380E-04
```

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 Kd Unsat (ml/g):                0.000E+00
 Kd Aquifer (ml/g):              0.000E+00
 Risk/Dose Conversion Factor:    1.480E+02
-------------------------------------------------------------------------------
Calculated Contaminant Values
-------------------------------------------------------------------------------
Decay Constants (1/y):                     4.4150E-08
Percolation Leach Rate Constant (1/y):     7.5758E-02
Initial Pore Water Conc (Ci or mg/m**3):   8.1572E-08
Solubility Limited Mass (mg):              1.6918E+12
Solubility Limited Act (Ci):               2.9887E+05
Unsaturated Retardation Factor:            1.0000E+00
Mean Unsaturated Transit Time (y):         1.2000E+01
Aquifer Retardation Factor:                1.000E+00
Minimum Peak Window Time (y):              1.2000E+01
Maximum Peak Window Time (y):              1.0358E+02
-------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
-------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):            2.567E-10
Time of Peak (y):                        1.2278E+01
Concentrations Averaged Between:       1.2000E+01 and  4.2000E+01 years
Average Concentration (Ci/m**3):         1.039E-10
Maximum Dose:                            3.228E-07
Maximum Allowable Inventory (Ci):        4.275E-04
-------------------------------------------------------------------------------
Contaminant Data
-------------------------------------------------------------------------------
 Contaminant Name:               Np-237
 Number of Progeny:              2
 Progeny Names:                 U-233        Th-229
 Half Life (y):                  2.140E+06 1.590E+05 7.340E+03
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               5.000E+03
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        2.370E+02
 Initial mass/activity:          1.600E-04
 Kd Unsat (ml/g):                8.000E+00
 Kd Aquifer (ml/g):              3.200E-01 2.400E-01 4.000E+00
 Risk/Dose Conversion Factor:    6.180E+01 7.180E+01 5.280E+02
-------------------------------------------------------------------------------
Calculated Contaminant Values
-------------------------------------------------------------------------------
Decay Constants (1/y):                     3.2390E-07 4.3594E-06 9.4434E-05
Percolation Leach Rate Constant (1/y):     3.3332E-05
Initial Pore Water Conc (Ci or mg/m**3):   4.1612E-11
Solubility Limited Mass (mg):              3.8451E+15
Solubility Limited Act (Ci):               2.7125E+09
Unsaturated Retardation Factor:            4.1000E+01
Mean Unsaturated Transit Time (y):         4.9200E+02
Aquifer Retardation Factor:                7.080E+00 5.560E+00 7.700E+01
Minimum Peak Window Time (y):              4.9200E+02
Maximum Peak Window Time (y):              2.0845E+05
-------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+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):            1.338E-13  3.817E-16  6.589E-19
Time of Peak (y):                        5.1437E+02
Concentrations Averaged Between:       4.9937E+02 and  5.2937E+02 years
Average Concentration (Ci/m**3):         1.338E-13  3.816E-16  6.589E-19
Maximum Dose:                            1.736E-10  5.753E-13  7.306E-15
Total Dose (all members):                 1.742E-10
Maximum Allowable Inventory (Ci):        9.185E-01
-------------------------------------------------------------------------------
Contaminant Data
-------------------------------------------------------------------------------
 Contaminant Name:               Pu-239
 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):               5.000E+03
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        2.390E+02
 Initial mass/activity:          5.310E-01
 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:    1.350E+02 6.960E+01 1.730E+02 4.860E+02
--------------------------------------------------------------------------------
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):    3.3332E-05
Initial Pore Water Conc (Ci or mg/m**3):  1.3810E-07
Solubility Limited Mass (mg):             3.8451E+15
Solubility Limited Act (Ci):              2.3885E+11
Unsaturated Retardation Factor:           1.1100E+02
Mean Unsaturated Transit Time (y):        1.3320E+03
Aquifer Retardation Factor:               1.772E+01 5.560E+00 4.190E+02 3.430E+02
Minimum Peak Window Time (y):             1.3320E+03
Maximum Peak Window Time (y):             2.0929E+05
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+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):            4.270E-10  1.832E-15  3.435E-19  4.006E-19
Time of Peak (y):                        1.3412E+03
Concentrations Averaged Between:       1.3320E+03 and  1.3620E+03 years
Average Concentration (Ci/m**3):         4.140E-10  1.785E-15  3.362E-19  3.922E-19
Maximum Dose:                            1.174E-06  2.609E-12  1.221E-15  4.003E-15
Total Dose (all members):                 1.174E-06
Maximum Allowable Inventory (Ci):        4.524E-01
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               Pu-240
 Number of Progeny:              4
 Progeny Names:                 U-236        Th-232       Ra-228       Th-228
 Half Life (y):                  6.560E+03 2.340E+07 1.410E+10 1.600E+03 1.910E+00
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               5.000E+03
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        2.400E+02
 Initial mass/activity:          1.040E-01
 Kd Unsat (ml/g):                2.200E+01
 Kd Aquifer (ml/g):              8.800E-01 2.400E-01 4.000E+00 4.000E+00 4.000E+00
 Risk/Dose Conversion Factor:    1.350E+02 6.700E+01 1.010E+02 1.040E+03 3.030E+02
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                    1.0566E-04 2.9622E-08 4.9159E-11 4.3322E-04 3.6290E-01
Percolation Leach Rate Constant (1/y):    3.3332E-05
Initial Pore Water Conc (Ci or mg/m**3):  2.7048E-08
Solubility Limited Mass (mg):             3.8451E+15
Solubility Limited Act (Ci):              8.7382E+11
Unsaturated Retardation Factor:           1.1100E+02
Mean Unsaturated Transit Time (y):        1.3320E+03
Aquifer Retardation Factor:               1.772E+01 5.560E+00 7.700E+01 7.700E+01 7.700E+01
Minimum Peak Window Time (y):             1.3320E+03
Maximum Peak Window Time (y):             2.0929E+05
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+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):            7.545E-11  1.026E-14  2.497E-23  4.251E-24  4.226E-24
Time of Peak (y):                        1.3403E+03
Concentrations Averaged Between:       1.3320E+03 and  1.3620E+03 years
Average Concentration (Ci/m**3):         7.311E-11  9.994E-15  2.447E-23  4.185E-24  4.161E-24
```

```
Maximum Dose:                              2.073E-07  1.406E-11  5.190E-20  9.140E-20  2.648E-20
Total Dose (all members):                   2.073E-07
Maximum Allowable Inventory (Ci):          5.017E-01
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:                 Sr-90
 Number of Progeny:                0
 Half Life (y):                    2.880E+01
 Other Source Loss Rate (1/y):     0.000E+00
 Kd Source (ml/g):                 1.000E+00
 Solubility Limit (mg/L):          1.000E+06
 Molecular Weight (mg/L):          9.000E+01
 Initial mass/activity:            3.770E+01
 Kd Unsat (ml/g):                  1.200E+01
 Kd Aquifer (ml/g):                4.800E-01
 Risk/Dose Conversion Factor:      7.400E+01
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                      2.4068E-02
Percolation Leach Rate Constant (1/y):      1.3889E-01
Initial Pore Water Conc (Ci or mg/m**3):    4.0855E-02
Solubility Limited Mass (mg):               9.2278E+11
Solubility Limited Act (Ci):                1.2738E+11
Unsaturated Retardation Factor:             6.1000E+01
Mean Unsaturated Transit Time (y):          7.3200E+02
Aquifer Retardation Factor:                 1.012E+01
Minimum Peak Window Time (y):               7.3200E+02
Maximum Peak Window Time (y):               7.8271E+02
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):              2.337E-12
Time of Peak (y):                          7.3333E+02
Concentrations Averaged Between:       7.3200E+02 and  7.6200E+02 years
Average Concentration (Ci/m**3):           5.873E-13
Maximum Dose:                              9.127E-10
Maximum Allowable Inventory (Ci):          4.130E+04
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:                 Tc-99
 Number of Progeny:                0
 Half Life (y):                    2.110E+05
 Other Source Loss Rate (1/y):     0.000E+00
 Kd Source (ml/g):                 1.000E+03
 Solubility Limit (mg/L):          1.000E+06
 Molecular Weight (mg/L):          9.900E+01
 Initial mass/activity:            3.600E-05
 Kd Unsat (ml/g):                  2.000E-01
 Kd Aquifer (ml/g):                8.000E-03
 Risk/Dose Conversion Factor:      2.750E+00
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                      3.2851E-06
Percolation Leach Rate Constant (1/y):      1.6663E-04
Initial Pore Water Conc (Ci or mg/m**3):    4.6806E-11
Solubility Limited Mass (mg):               7.6914E+14
Solubility Limited Act (Ci):                1.3174E+10
Unsaturated Retardation Factor:             2.0000E+00
Mean Unsaturated Transit Time (y):          2.4000E+01
Aquifer Retardation Factor:                 1.152E+00
Minimum Peak Window Time (y):               2.4000E+01
Maximum Peak Window Time (y):               4.1621E+04
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):              1.505E-13
Time of Peak (y):                          2.7676E+01
```

```
Concentrations Averaged Between:       2.4000E+01 and  5.4000E+01 years
Average Concentration (Ci/m**3):         1.501E-13
Maximum Dose:                            8.669E-12
Maximum Allowable Inventory (Ci):        4.152E+00
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               U-233
 Number of Progeny:              1
 Progeny Names:                 Th-229
 Half Life (y):                  1.590E+05 7.340E+03
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               5.000E+03
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        2.330E+02
 Initial mass/activity:          6.670E-03
 Kd Unsat (ml/g):                6.000E+00
 Kd Aquifer (ml/g):              2.400E-01 4.000E+00
 Risk/Dose Conversion Factor:    7.180E+01 5.280E+02
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                    4.3594E-06 9.4434E-05
Percolation Leach Rate Constant (1/y):    3.3332E-05
Initial Pore Water Conc (Ci or mg/m**3):  1.7347E-09
Solubility Limited Mass (mg):             3.8451E+15
Solubility Limited Act (Ci):              3.7135E+10
Unsaturated Retardation Factor:           3.1000E+01
Mean Unsaturated Transit Time (y):        3.7200E+02
Aquifer Retardation Factor:               5.560E+00 7.700E+01
Minimum Peak Window Time (y):             3.7200E+02
Maximum Peak Window Time (y):             2.0832E+05
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+01 Y = 0.00000E+00
--------------------------------------------------------------------------------
Peak Concentration (Ci/m**3):            5.571E-12  1.455E-14
Time of Peak (y):                        3.8968E+02
Concentrations Averaged Between:       3.7468E+02 and  4.0468E+02 years
Average Concentration (Ci/m**3):         5.569E-12  1.454E-14
Maximum Dose:                            8.396E-09  1.612E-10
Total Dose (all members):                 8.557E-09
Maximum Allowable Inventory (Ci):        7.794E-01
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:               U-234
 Number of Progeny:              3
 Progeny Names:                 Th-230       Ra-226       Pb-210
 Half Life (y):                  2.460E+05 7.540E+04 1.600E+03 2.230E+01
 Other Source Loss Rate (1/y):   0.000E+00
 Kd Source (ml/g):               5.000E+03
 Solubility Limit (mg/L):        1.000E+06
 Molecular Weight (mg/L):        2.340E+02
 Initial mass/activity:          6.830E-03
 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:    7.070E+01 9.100E+01 3.850E+02 1.270E+03
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                    2.8177E-06 9.1929E-06 4.3322E-04 3.1083E-02
Percolation Leach Rate Constant (1/y):    3.3332E-05
Initial Pore Water Conc (Ci or mg/m**3):  1.7763E-09
Solubility Limited Mass (mg):             3.8451E+15
Solubility Limited Act (Ci):              2.3899E+10
Unsaturated Retardation Factor:           3.1000E+01
Mean Unsaturated Transit Time (y):        3.7200E+02
Aquifer Retardation Factor:               5.560E+00 7.700E+01 7.700E+01 7.700E+01
Minimum Peak Window Time (y):             3.7200E+02
Maximum Peak Window Time (y):             2.0832E+05
--------------------------------------------------------------------------------
```

```
Results for Receptor X =  1.79000E+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):           5.708E-12  1.475E-15  1.179E-16  1.004E-16
Time of Peak (y):                       3.8972E+02
Concentrations Averaged Between:      3.7472E+02 and  4.0472E+02 years
Average Concentration (Ci/m**3):        5.706E-12  1.474E-15  1.179E-16  1.004E-16
Maximum Dose:                           8.471E-09  2.817E-12  9.530E-13  2.678E-12
Total Dose (all members):                8.478E-09
Maximum Allowable Inventory (Ci):       8.057E-01
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:              U-235
 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):              5.000E+03
 Solubility Limit (mg/L):       1.000E+06
 Molecular Weight (mg/L):       2.350E+02
 Initial mass/activity:         8.370E-04
 Kd Unsat (ml/g):               6.000E+00
 Kd Aquifer (ml/g):             2.400E-01 2.200E+01 1.800E+01
 Risk/Dose Conversion Factor:   6.960E+01 1.730E+02 4.860E+02
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                   9.8458E-10 2.1133E-05 3.1796E-02
Percolation Leach Rate Constant (1/y):   3.3332E-05
Initial Pore Water Conc (Ci or mg/m**3): 2.1768E-10
Solubility Limited Mass (mg):            3.8451E+15
Solubility Limited Act (Ci):             8.3156E+06
Unsaturated Retardation Factor:          3.1000E+01
Mean Unsaturated Transit Time (y):       3.7200E+02
Aquifer Retardation Factor:              5.560E+00 4.190E+02 3.430E+02
Minimum Peak Window Time (y):            3.7200E+02
Maximum Peak Window Time (y):            2.0832E+05
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+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):           7.002E-13  7.622E-17  8.562E-17
Time of Peak (y):                       3.8978E+02
Concentrations Averaged Between:      3.7478E+02 and  4.0478E+02 years
Average Concentration (Ci/m**3):        7.000E-13  7.620E-17  8.559E-17
Maximum Dose:                           1.023E-09  2.768E-13  8.736E-13
Total Dose (all members):                1.024E-09
Maximum Allowable Inventory (Ci):       8.172E-01
--------------------------------------------------------------------------------
Contaminant Data
--------------------------------------------------------------------------------
 Contaminant Name:              U-238
 Number of Progeny:             4
 Progeny Names:                U-234        Th-230       Ra-226       Pb-210
 Half Life (y):                 4.470E+09 2.460E+05 7.540E+04 1.600E+03 2.230E+01
 Other Source Loss Rate (1/y):  0.000E+00
 Kd Source (ml/g):              5.000E+03
 Solubility Limit (mg/L):       1.000E+06
 Molecular Weight (mg/L):       2.380E+02
 Initial mass/activity:         1.700E-03
 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:   6.400E+01 7.070E+01 9.100E+01 3.850E+02 1.270E+03
--------------------------------------------------------------------------------
Calculated Contaminant Values
--------------------------------------------------------------------------------
Decay Constants (1/y):                   1.5507E-10 2.8177E-06 9.1929E-06 4.3322E-04 3.1083E-02
Percolation Leach Rate Constant (1/y):   3.3332E-05
```

```
Initial Pore Water Conc (Ci or mg/m**3):  4.4212E-10
Solubility Limited Mass (mg):             3.8451E+15
Solubility Limited Act (Ci):              1.2932E+06
Unsaturated Retardation Factor:           3.1000E+01
Mean Unsaturated Transit Time (y):        3.7200E+02
Aquifer Retardation Factor:               5.560E+00 5.560E+00 7.700E+01 7.700E+01 7.700E+01
Minimum Peak Window Time (y):             3.7200E+02
Maximum Peak Window Time (y):             2.0832E+05
--------------------------------------------------------------------------------
Results for Receptor X =  1.79000E+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):           1.422E-12  1.561E-15  2.018E-19  1.090E-20  8.631E-21
Time of Peak (y):                       3.8978E+02
Concentrations Averaged Between:       3.7478E+02 and  4.0478E+02 years
Average Concentration (Ci/m**3):        1.422E-12  1.561E-15  2.018E-19  1.091E-20  8.642E-21
Maximum Dose:                           1.911E-09  2.317E-12  3.856E-16  8.820E-17  2.305E-16
Total Dose (all members):                1.913E-09
Maximum Allowable Inventory (Ci):       8.886E-01
Execution Time (Seconds):    0
```

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Appendix B

Analysis Plan

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Appendix B - Analysis Plan

The objective of the analysis is to calculate the groundwater pathway risk from the radionuclides in the TAN-607 Hot Shop and related facilities. The calculated risks are used in an EE/CA to support the decision making process for the deactivation, decontamination, and decommissioning (DD&D) of the TAN-607 Hot Shop and related areas.

The TAN-607 Hot Shop groundwater pathway risk assessment is conducted in accordance MCP-2374 (Analysis and Calculations). The calculations are associated with a facility that is permanently shut down and has been identified for deactivation, decontamination, and decommissioning (DD&D). Therefore, the quality level of the structures, systems, and components (SSC), as defined in MCP-540 (Assigning Quality Level), does not apply to this analysis.

The GWSCREEN computer code, Version 25a (Enterprise Architecture Identification Number 121200) will be used to conduct the calculations for this EDF. GWSCREEN 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 (LSC) or Mission Critical software. Classification Level "B" software applications generally meet one or more of the following criteria:

A. Application failure would have an unacceptable impact by causing significant ICP mission failure and significant production investment costs and/or recovery costs

B. Application is important to continued operations of the business and is used to support decisions regarding operating activities

C. Application is used to comply with regulatory laws, environmental permits or regulations, and/or other commitments to compliance

D. Application is required for emergency communications with local, state, and federal government agencies

E. Application provides primary support to a process that must be back on-line within a period of time not to exceed five (5) days, and for which delays exceeding five days would jeopardize some aspect of ICP mission success

F. DOE Idaho approval is required to institute alternative support mechanisms or operate without the process.

The deliverable for this project is an EDF documenting the calculations and computer files with the input and output for the simulations. The EDF will include a description of the electronic files that would allow someone to reproduce the results.

Technical checking will include verification that input data are appropriate and input and output documented in the EDF match the input and output files for GWSCREEN. The conclusions will be reviewed to ensure they are consistent with the analysis that was presented. The technical checker will also verify that GWSCREEN was appropriate for this use and that the formulas and calculations in any spreadsheets are correct.