RAE-42613-003-4R1
FINAL

URS

CALCULATION OF SUB-SURFACE DCGLs FOR THE SAXTON NUCLEAR EXPERIMENTAL CORPORATION SITE

September 20, 2002

URS CORPORATION
756 East Winchester Street, Suite 400
Salt Lake City, UT 8410

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Prepared for

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September 20, 2002

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1. INTRODUCTION

The Saxton Nuclear Experimental Corporation (SNEC) operated a 23.5-megawatt thermal pressurized water research and training reactor from 1962 to 1972 at its facility near Saxton, PA. As is shown in Figure 1-1, the reactor was located adjacent to a steam-turbine electric generating station that operated from 1924 to 1972. Since the reactor shutdown, GPU Nuclear, Inc. (GPU) has assisted SNEC in removing and disposing of the reactor fuel and internal parts and in characterizing and decontaminating large portions of the site. In preparing to terminate the Nuclear Regulatory Commission (NRC) license for the site, GPU determined Derived Concentration Guideline Levels (DCGLs) for the top meter of site soil that correspond to the 25 mrem/year total radiation dose limit prescribed by NRC for site cleanup and the 4 mrem/year dose limit for drinking water. GPU contracted with URS Corporation (URS) to develop and apply a conceptual model and methodology to determine DCGLs for the sub-surface zone below the top meter of soil at the site.

1.1 CONTAMINANT HISTORY

Radioactive materials are considered to have been on the SNEC Site from the time the site was licensed in 1962 by NRC to possess such materials and fuel the reactor. The operational history of the site indicates that the area (approximately 60 m x 75 m) around the reactor Containment Vessel (CV) included a Control and Auxiliary Building, a Radioactive Waste Disposal Facility, an underground pipe tunnel, a drum storage bunker, and a refueling water storage tank (GPU, 2000a,b). These facilities were decontaminated in 1987 – 1989 and all but

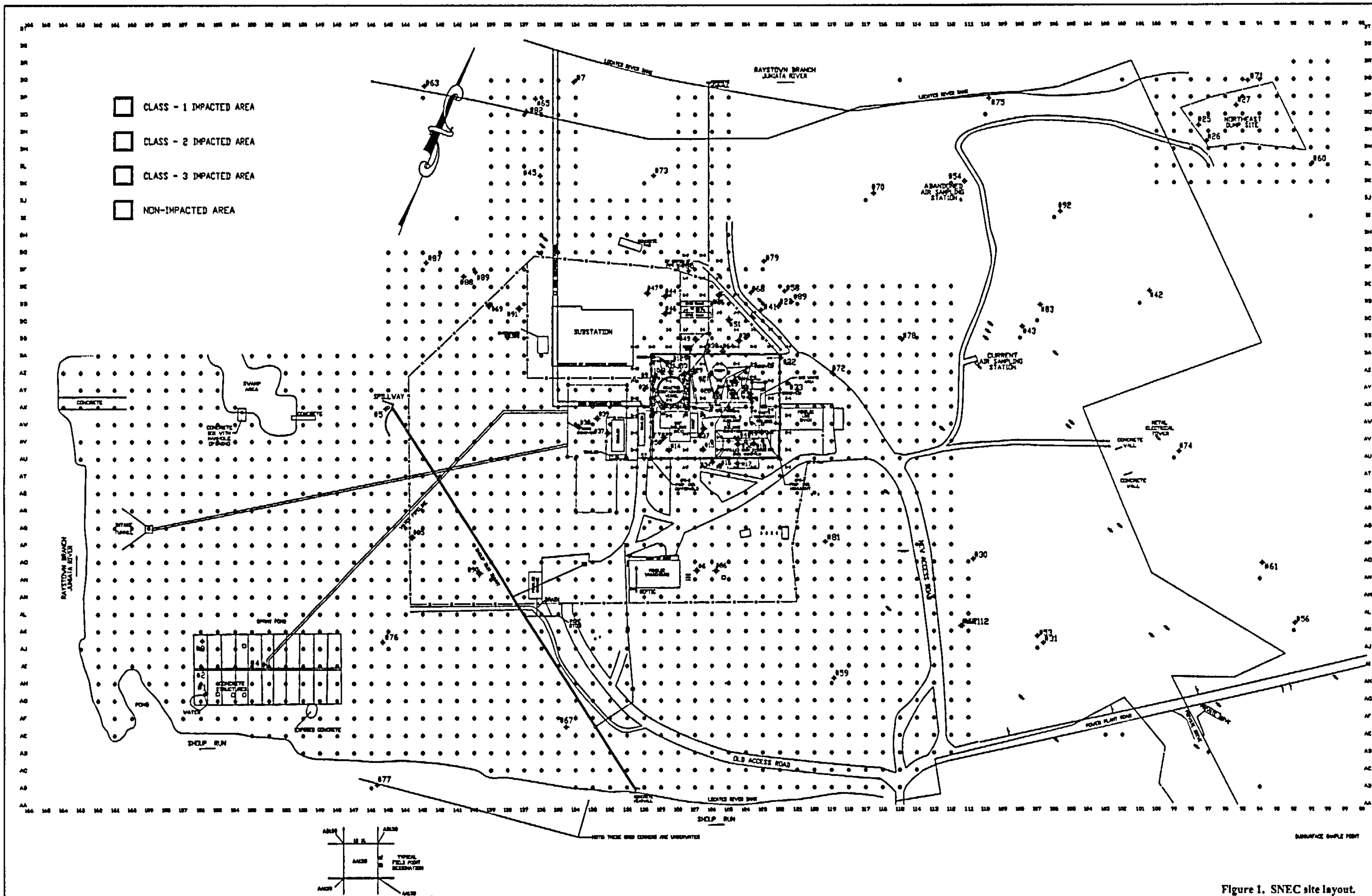

Figure 1. SNEC site layout.

the CV were demolished in 1992 after acceptance of a final release survey by NRC (NRC, 1992). The soils removed around the CV and structures were replaced with clean backfill soil. Although there is no evidence of leakage from the CV itself, the contamination removed from the areas surrounding the outside of the CV suggests the occurrence of surface spills and leaks from buried piping and tunnels.

The Steam Plant features underground concrete intake and discharge tunnels to cycle cooling water from the nearby Raystown Branch of the Juniata River (River). Since the reactor steam contained low levels of radioactivity, further contamination occurred when the steam was utilized in the generating station. When reactor steam was utilized in the station, low levels of radioactivity were cycled through the plant discharge tunnel. There is also a possibility that radioactive contamination occurred in the intake tunnel from warm discharge water that was recycled through the intake tunnel to avoid ice buildups during cold winter periods. Although radioactivity levels in the discharge tunnel were low enough to satisfy the radiation regulations then in effect, some radioactivity tended to accumulate in some Steam Plant structures, tunnel sediments, and surrounding soils near concrete cracks and joint leaks.

A Spray Pond was operated approximately 260 m southwest of the CV to cool water from the steam plant during summer months before release to the River. The pond consisted of arrays of pipes and spray nozzles covering a 40 m x 90 m area of surface soil. The radioactivity in the heated water could have been released and accumulated in the soils in the spray pond vicinity. Some building rubble from demolition of the Steam Plant also was disposed in the former Spray Pond area.

The primary radionuclides identified in analyses of steam plant sediments and soils in the CV vicinity are H-3, Sr-90, Co-60, Cs-137, and Am-241. Additional radionuclides have also been observed in one or more site samples or have been hypothesized to occur in contaminated materials, as listed in Table 1-1. All of these radionuclides will be analyzed for estimating site-subsurface DCGLs.

1.2 OBJECTIVE AND SCOPE

This report presents the DCGLs developed by URS for the SNEC Site materials deeper than one meter. Included in this report is a presentation of the methodology used in the analysis and a summary of the distribution of input parameters chosen to represent the SNEC Site hydrology and meteorology. URS developed these analysis input distributions from reviews of historical and current technical reports furnished by GPU and in consultation with GPU personnel and their hydrologic consultant. The DCGLs are designed to satisfy the 25 mrem/year total dose limit and 4 mrem/year drinking water dose limit for members of the general public that could receive the maximum radiation exposures from the SNEC Site and its environments.

Table 1-1

Radionuclides observed in site samples.

H-3	Ni-63	Eu-152	Pu-241
C-14	Sr-90	Pu-238	Am-241
Co-60	Cs-137	Pu-239	

2. CONCEPTUAL MODEL

The conceptual models of the Site are based upon available site characteristics. These characteristics have been observed through hydrologic well logging activities, and in-situ and laboratory analyses of site soils. These characteristics are used to identify two representative areas of concern. Conceptual models for these two areas are summarized below.

2.1 SITE HYDROGEOLOGY

Well logs show the near-surface hydrogeology to be a consistent pattern of three distinct layers of materials, (A) Fill, (B) Overburden, and (C) Bedrock (illustrated in Figure 2-1). Previous geotechnical and hydrologic investigations provided to URS by GPU identify the characteristics of these materials (H&A, 2001).

The Fill layer near the CV, Steam Plant, and Spray Ponds has been observed to be 0.46 to 1.22 meters thick. It is represented for modeling purposes to be about 1 meter thick with a range from about 0.4 to 2 meters over the larger site area. The Fill generally consists of well-graded silty and clayey fine to coarse sand with fine to medium gravel. In some areas, it also contains a well-graded mixture of ash and cinders from the former Steam Plant. In remediated areas near the CV and Steam Plant, clean backfill from an off-site source comprises the top meter. The Fill is estimated to have a total porosity of 0.46 (range from 0.35 to 0.56), an effective porosity of 0.41 (range from 0.28 to 0.54), a field capacity of 0.136 (range from 0.079 to 0.192), and a hydraulic conductivity of 32.3 meters/year. Although generally unsaturated, higher water levels during significant rainfall events cause periods of transient saturation.

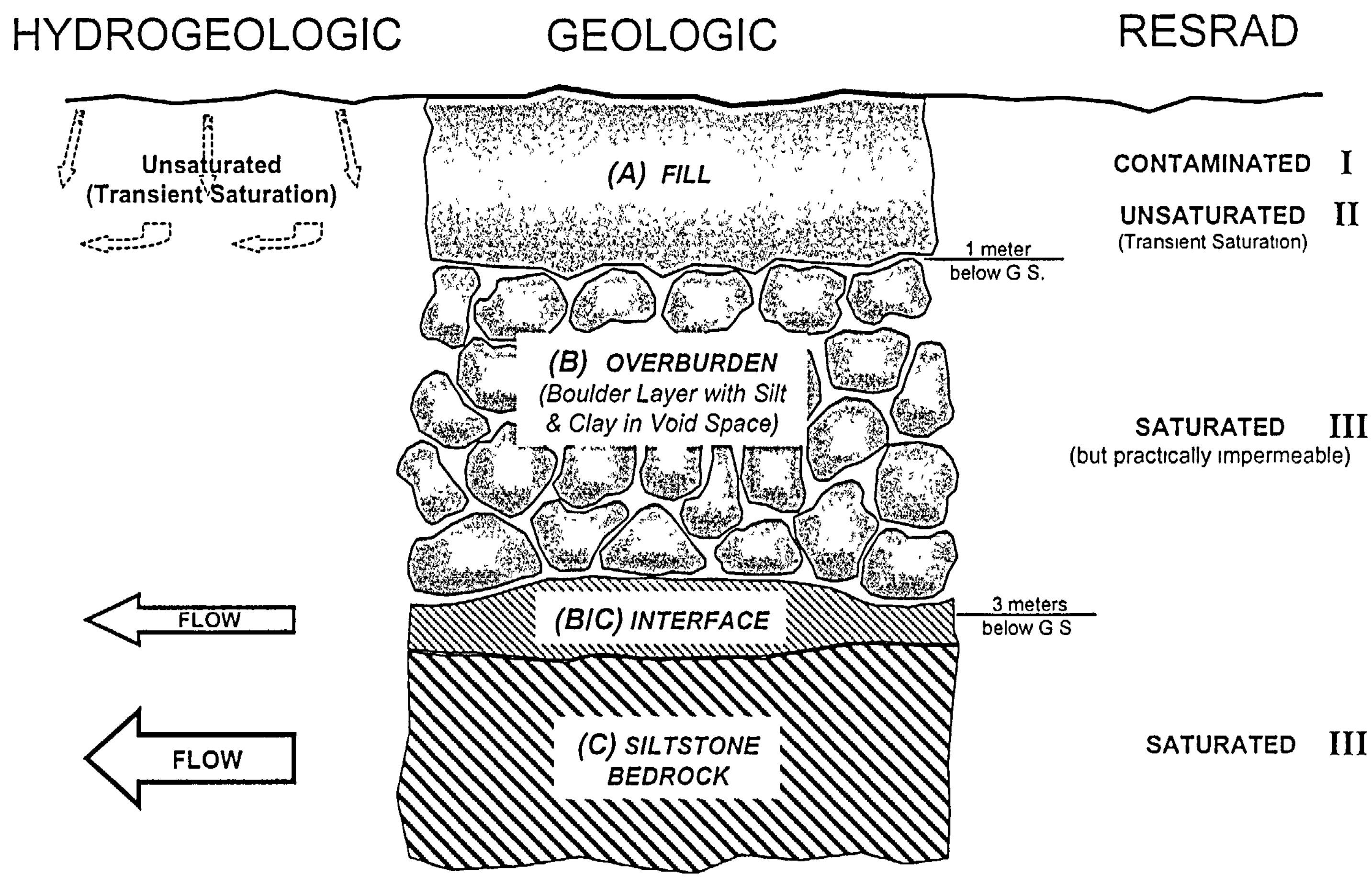

Figure 2. Conceptual representation of the hydrogeology at the SNEC site.

The Overburden or boulder layer thickness is observed to range from less than 1 meter to about 3 meters and is represented for modeling purposes by about 2 meters. The Overburden features rounded boulders interspersed with a dense mixture of sand, silt and clay. The boulders consist of hard quartzite with negligible porosity. The Overburden behaves like glacial till, with a low permeability on the order of 10^{-7} cm/s (0.032 m/y). Its bulk or total porosity is estimated at 0.10 to 0.15. Hydraulic gradients in the Overburden range from 0.02 to 0.03 based on gradients between the Site, tunnel, and river. The Overburden acts as a hydraulic barrier to flow between the Fill and Bedrock in undisturbed areas.

The Bedrock consists of fractured and weathered siltstone that begins at depths of 2.1 to 5.5 meters below the surface and is believed to extend to depths of more than several dozen meters. Saturated groundwater flow in the Bedrock generally occurs along bedding planes and within its fractures. The total porosity of the Bedrock ranges from 0.21 to 0.41 and the effective porosity is measured at approximately 0.0275. Hydraulic gradients in the Bedrock range from 0.013 to 0.03 based on gradients between the Site, tunnel, and river. The hydraulic conductivity of the Bedrock for fracture flow is estimated to be 67.9 meters/year.

The site hydrology is dominated by westward flow toward the River. The Bedrock features saturated water flow in the B/C interface and in Bedrock fractures and bedding planes. Although the Bedrock water flow probably extends throughout the deeper parts of the Bedrock, the regional gradient promotes relatively horizontal flow in the top 20 meters that drains to the River. The Bedrock is intersected by the CV, which extends approximately 15 m beneath the surface, and by the basement of the Steam Plant, which extends approximately 7.5 m beneath the surface. Utility tunnels near the CV also extend into the Bedrock, as do the plugged intake and drainage tunnels that connect the Steam Plant basement to the River. The disturbances of the Overburden layer in constructing the CV, Steam Plant, and concrete tunnels cause highpermeability zones at their interfaces with the Overburden that hydraulically connect the Fill and Bedrock.

2.2 AREAS OF CONCERN

Two areas of concern were selected to represent the parts of the SNEC Site that have the greatest potential to cause present or future radiation exposure to members of the public. These areas are illustrated in Figure 2-2. They include the Steam Plant area and the remainder of the general SNEC Site (excluding the Steam Plant area). These areas were chosen to represent the site because of their potential for elevated radionuclide concentrations or their association with radiation exposure pathways.

2.2.1 Steam Plant Area

The Steam Plant Area is defined to include the existing basement of the Steam Plant and the underground intake and discharge tunnels that connect the former plant basement to the River. This area was selected because it received reactor steam, it was a conduit for discharging reactor secondary cooling water, it is hydraulically connected with the CV Area, it contains sediments and sumps with trace Cs-137 and other contaminants, and it contains channels that hydraulically connect the Fill-layer and the Bedrock. The Steam Plant basement has been filled with demolition rubble from the former Steam Plant building and covered with 1 meter of clean fill. Potential residual contamination of soils, debris, and ground water may remain in this area or may occur from seepage through plugged tunnels from the CV Area.

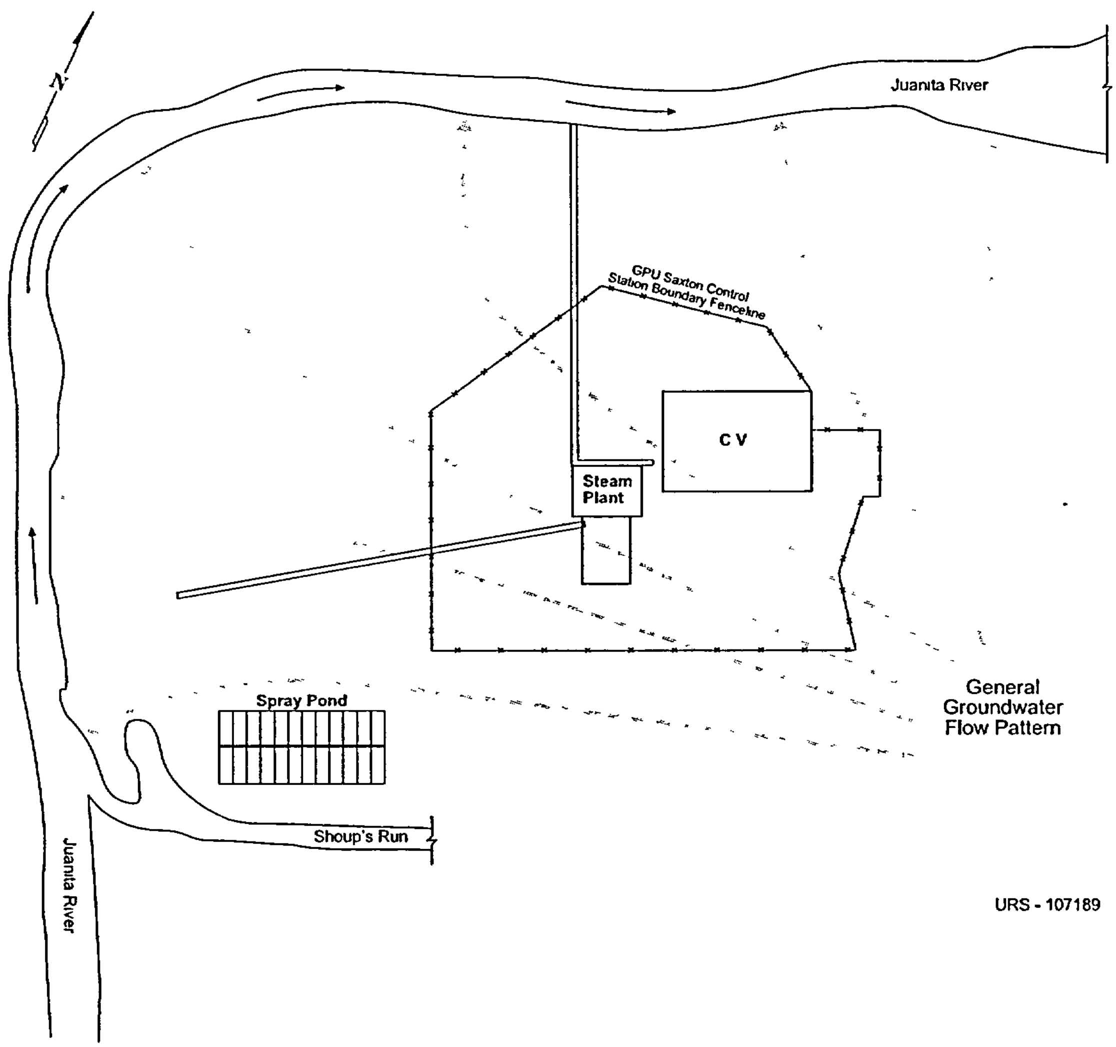

Figure 2- 2. Areas of concern at the SNEC site.

The intake and discharge tunnels that connect the Steam Plant to the River affect migration of water and potential contaminants from other parts of the site. The tunnels generally feature a permeable zone along their exterior boundaries owing to less-compact backfill and removal of clays from the Overburden cobbles during tunnel construction. The intake tunnel (1.8 m x 2.4 m) is sufficiently large to intersect the Fill and Overburden layers in some areas and the Overburden-Bedrock interface in others. The intake tunnel hydraulically connects the Fill-layer and Bedrock over its entire length. The discharge tunnel has similar size and acts as a permeable path that intercepts Fill-layer water from the CV Area and diverts it to the River via the permeable zone along its exterior. The discharge tunnel hydraulically connects the Fill and Bedrock layers along approximately half its length near the Steam Plant and remains in the Fill and Overburden layers in areas closer to the River. The tunnels can therefore conduct contaminants from the permeable basement of the Steam Plant into the Fill layer, the Bedrock, or both.

2.2.2 General SNEC Area

The general SNEC area of concern includes the CV and Spray Pond areas. The areas of and near the CV include the CV and the former auxiliary and waste management operations. This area is of concern because it was the original source of most man-made radioactivity at the site and because it contains backfill that hydraulically connects the Fill layer and the Bedrock. Although the reactor core, most internal structures and auxiliary facilities, and surrounding contaminated soils have been removed and disposed, potential residual contamination of soils and ground water that originated in this area may still remain. It is therefore considered the area with greatest potential for elevated levels of residual radioactivity. The potential hydraulic connections along CV and tunnel interfaces with native materials could allow migration of any contaminants into the Fill layer, the Bedrock, or both.

The area near the Spray Ponds include the approximate 40 m x 90 m footprint of the former Spray Pond. It is included in the general SNEC area of concern because it seasonally received cooling water from the Steam Plant and it was later covered with building rubble from the Steam Plant. The original surface soils remain in the Spray Pond area beneath building rubble. However, the steel pipe connecting the Spray Pond to the Steam Plant has been excavated, surveyed, and removed. While the Spray Pond was built on the surface of the Fill soil layer and was originally hydraulically isolated from the Bedrock by the overburden layer, recent and planned decontamination activities may create hydrologic transport channels through the Overburden allowing any contamination to seep into the saturated Bedrock layer.

Subsurface materials for the Spray Pond and Reactor areas (excluding the CV excavations) are very similar, consisting of approximately two meters of overburden and a greater thickness of underlying bedrock. The subsurface material in the SSGS consists of crushed, homogenized site debris that is covered with one meter of clean fill. Because of these differences, DCGLs will be estimated for only one material (homogenized debris) in the SSGS and for two materials (overburden and bedrock) in the Spray Pond and Reactor areas.

2.3 RADIATION EXPOSURE SCENARIOS AND TRANSPORT PATHWAYS

Exposures to members of the critical population group are postulated to occur to a hypothetical individual (the Receptor) who is subject to all potential exposure pathways. For both areas of concern, his exposures are considered to originate from similar exposure scenarios because both result from radionuclides buried in sub-surface soils (Overburden, and/or Bedrock) in locations where he could conceivably build a house and reside. The pathways for radiation exposure are illustrated in Figure 2-3.

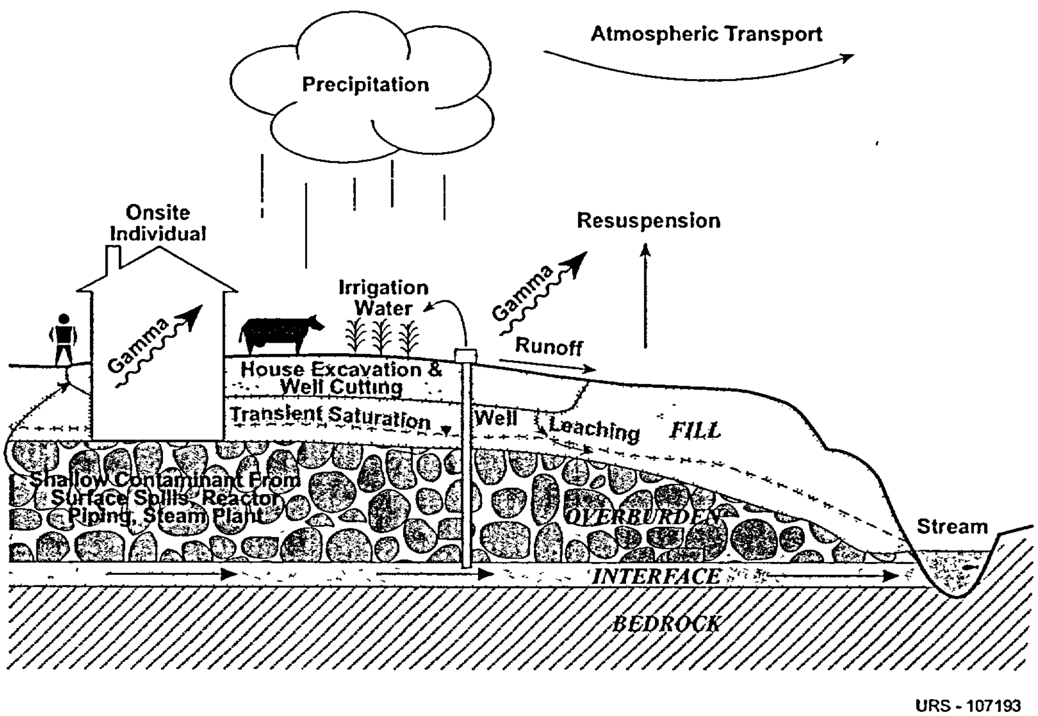

Figure 2- 3. Radiation exposure pathways.

The Receptor is considered to reside in a home in or near areas of concern. The most conservative parameters and their respective distributions are selected from each of the areas of concern to identify a site-wide residential scenario which results in the highest exposure. This site-wide exposure is then used to determine nuclide-specific DCGLs for each subsurface layer. In the scenario, the Receptor is exposed to residual radioactivity in several ways that include (a) excavating and spreading contaminated Overburden material during home construction and yard leveling; (b) consuming drinking water from a Bedrock well; (c) consuming fruits and vegetables grown onsite with irrigation water from the transient flow within the Fill-soil layer; and (d) consuming beef and milk from cattle raised onsite using the same irrigation water. The shallow water table and the boulders in the Overburden layer discourage construction of a basement for the on-site residence. However, excavation and spreading of Fill material from beneath the top meter and into the upper Overburden layer could occur in leveling sloped areas for a home site.

The potential radiation exposure pathways associated with the on-site residential scenarios are analyzed to estimate radiation doses. Gamma radiation exposures occur in the yard and through the house floor from radionuclides mixed into surface soils from excavation (pathway a) and well cuttings (pathway b). Exposures from inhaling contaminated dust occur during site grading (pathway a) and well excavation (pathway b) as well as from garden tillage and wind resuspension of contaminated soils (pathways a, b, c, and d). Exposures from ingesting contaminated soil occur from soil entrained on vegetables (pathway c) and unwashed hands (pathways a, b, c, and d). Exposures from ingesting contaminated drinking water occur from transport in the Bedrock (pathway b). Exposures from ingesting contaminated fruits and vegetables occur via their uptake from contaminated surface soil (pathways a and b) and contaminated irrigation water (pathway c). Exposures from ingesting contaminated beef and milk occur from cattle fed with contaminated crops and water (pathways a, b, and d).

The basement of the hypothetical house built by the resident in the Spray Pond, Steam Plant, or Reactor areas penetrates the 1-m surface fill layer and the top part of the underlying material. The materials excavated for the basement are represented here in the same way as they have been in previous NRC guidance documents. The excavation is considered to penetrate sufficiently deep for construction of the basement, and the excavated material is considered to be mixed with overlying fill material and placed in the vicinity of the house (NRC, 1986, 1999). Figures 2-4 and 2-5 illustrate the basement excavations and surface placement of the excavated materials for the different Site areas. The footprint area of the hypothetical house and its basement excavation is chosen to be 200 m^2, which corresponds to the house areas used in the previous NRC analyses (NRC, 1986, 1999).

The height of the basement, h_b, is chosen to be 2 meters based on both the previous NRC guidance and conservative assessment of the site parameters. The previous NRC guidance documents used basement depths of 3 meters for disposal cells that were covered by 2 m of clean soil or cap material (NRC, 1986). This resulted in 1-meter intrusion depths into the contaminated material. For the present Site, where fill soil layers are 1 m thick, a 2-m basement excavation provides the same 1-m intrusion depth into potentially-contaminated material.

The Spray Pond area, Reactor area (except the back-filled CV excavation), and undisturbed areas of the Site feature a 2-m layer of boulder-laden overburden between the 1-m fill soil layer and bedrock, as shown in Figure 2-4. The overburden discourages excavation because of its large boulders and interstitial cobbles. The hypothetical 2-m basement excavation (1-m into the boulder layer) is therefore conservatively deeper than would normally be expected. Furthermore, the water table at the Site varies between 0.7 and 2.3 m, making the hypothetical 2-m basement excavation conservatively deeper than the average estimated water table depth.

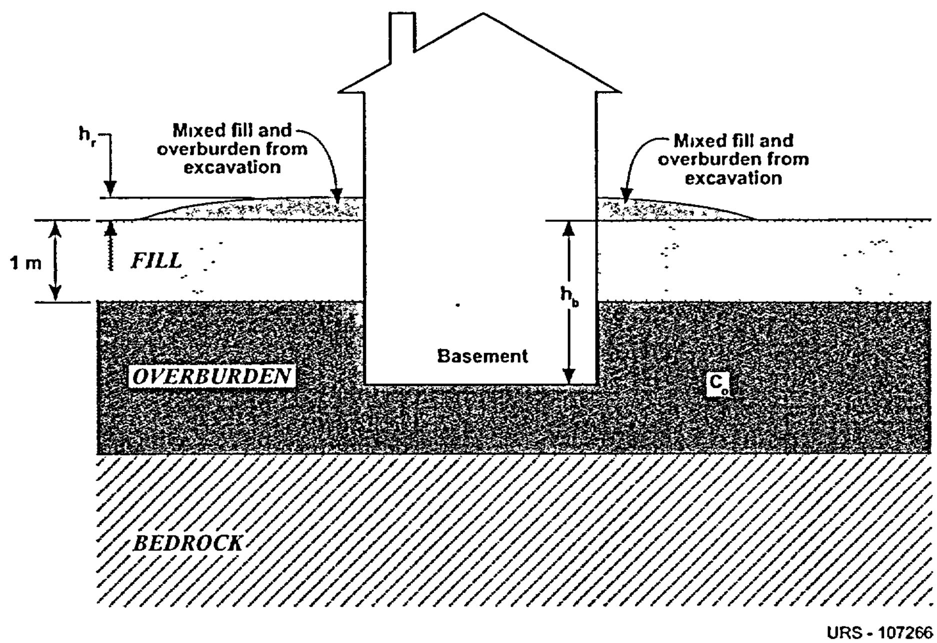

Figure 2- 4. Basement excavation model for general site area.

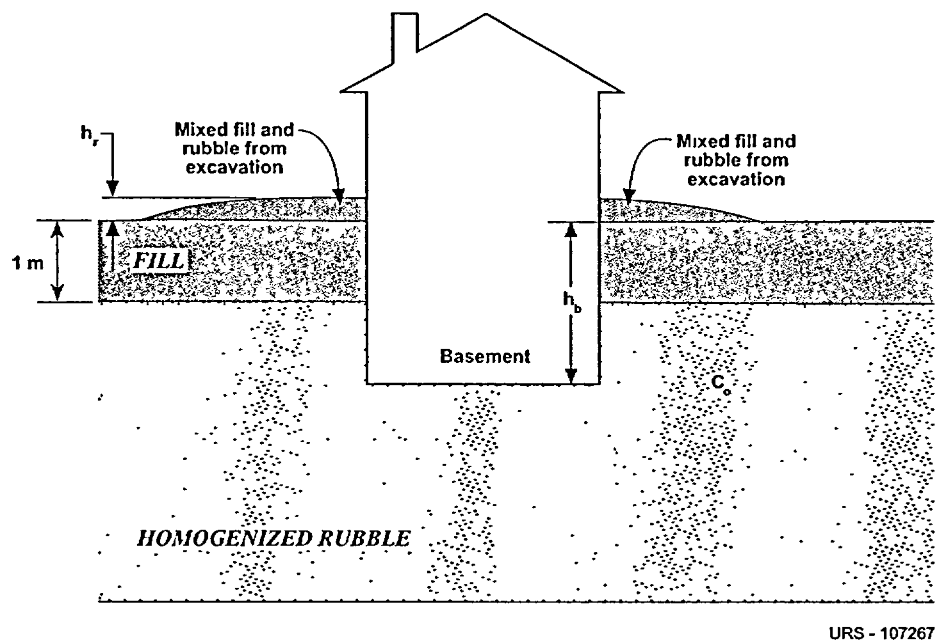

Figure 2- 5. Basement excavation model for steam plant backfill.

The Steam Plant basement contains homogenized rubble instead of overburden in the bottom half of the hypothetical 2-m excavation (see Figure 2-5). The hypothetical Steam Plant excavation therefore intrudes to the same extent (1 m) into potentially-contaminated material as in the Spray Pond area and is subject to similar water-table limitations as in other parts of the Site.

The native materials in the CV area are replaced with clean backfill to depths well beyond any realistic basement excavation depths. Therefore, any excavations in the CV area would only bring clean backfill to the surface. The surrounding materials in the Reactor area are represented by the same profile as the Spray Ponds, as illustrated in Figure 2-4.

The concentrations of any contaminants in the overburden layer beneath the Spray Ponds or in the homogenized rubble in the Steam Plant are reduced to one-half of their in-situ concentrations by mixing with the top meter of fill soil during their excavation. The two-fold dilution factor results from mixing equal volumes of clean and potentially-contaminated excavation materials using the same calculation approach advocated in the NRC guidance documents (NRC, 1986, 1999).

The mixed material from the basement excavation is considered to be spread around the hypothetical house as in the NRC models (NRC, 1986). The area of this material is conservatively taken to be 2,000 m^2 based on the nominal one-half acre (2,023 m^2) and 1,000 m^2 to 2,000 m^2 area ranges estimated by NRC (NRC, 1986). The average thickness of this layer of mixed material is h_r = 0.20 m [estimated as (200 m^2 basement footprint area) x (2 m depth) / (2,000 m^2 spread area)]. This thickness is conservative in giving an approximate maximum gamma radiation activity and approximating the default crop root depth of 0.15 m in the RESRAD dose assessment code (Yu, 2002). Additionally, the geophysical characteristics of this layer of mixed material are depth-weighted averages of those of the Fill and Overburden layers.

3. CALCULATION MODELS

The RESRAD dose assessment model for sites contaminated with RESidual RADioactive materials is the main tool used to determine the subsurface DCGLs for the Site Bedrock and Site Overburden soils. RESRAD 6.1 was developed and adapted from earlier versions for use with the NRC Standard Review Plan (NRC, 2000) for decommissioning and as a tool for demonstrating compliance with the license termination rule in a risk-informed manner. Version 6.1 also computes probabilistic estimates of radiation dose distributions that result from various distributions of input parameters. RESRAD is used to evaluate the sensitivity of input parameters and identify parameters whose most-probable values and distributions require site-specific measurements or detailed justification. It is also used to compute radiation dose distributions from unit concentrations of radionuclides.

As is illustrated in Figure 3-1, RESRAD's basic transport model assumes three main transport zones: contaminated, unsaturated, and saturated. RESRAD's model assumes water infiltrates into the contaminated zone and leaches radionuclides out of the waste, transporting the contaminated groundwater vertically down through the unsaturated zone and then horizontally through the saturated zone to a well.

RESRAD's representation of horizontal flow within the saturated zone assumes Darcian flow through a homogeneous, saturated, porous medium. Because the SNEC Site is highly heterogeneous, including the transient Fill and Bedrock water pathways, two basic RESRAD data sets are used in the analysis to address these layers separately.

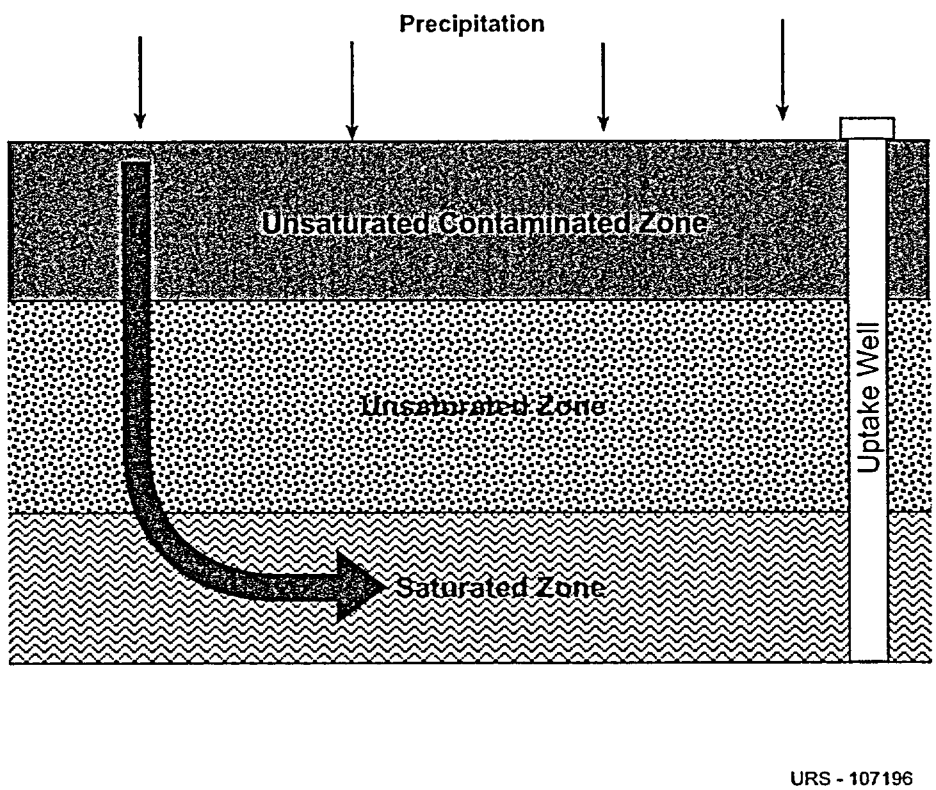

Figure 3- 1. RESRAD's water transport model.

RESRAD calculates radiation doses for a chronically exposed individual, focusing on radioactive contaminants in soil and their transport in air, water, and biological media to a single receptor. It considers nine exposure pathways: direct gamma exposure, inhalation of particulates and radon, and ingestion of plant foods, meat, milk, aquatic foods, water, and soil. Radiation doses, health risks, soil guidelines, and media concentrations are calculated for specified time intervals. The source is adjusted over time to account for radioactive decay and in-growth, leaching, erosion, and mixing.

3.1 STEAM PLANT BACKFILL

RESRAD assesses exposures from the Steam Plant Backfill by assuming that contamination is brought to the surface from well drill cuttings and excavation into the Steam Plant Backfill for a house foundation and yard leveling. Exposures from ingesting contaminated meat, milk, and vegetation; inhaling dust, and direct gamma radiation exposure are evaluated. The application of RESRAD for exposures from the Steam Plant Backfill is illustrated in Figure 3-2. Consistent with RESRAD terminology, the waste is assumed to be brought to the surface, spread, and mixed as a result of house construction, site grading, and well excavation will represent the waste zone. The region below the surface mixing zone, but above the water table is represented as the unsaturated zone (vertical transport region).

Analysis of exposures, resulting from contaminants entrained in the undisturbed Backfill are also evaluated. Contaminants not brought to the surface as part of excavation and site leveling activities are assumed to become leached into vertically traveling groundwater. It is then assumed that these contaminants travel to a well site, where they are pumped to the surface for human and livestock drinking water, as well as crop irrigation. The peak dose and year of occurrence is then computed.

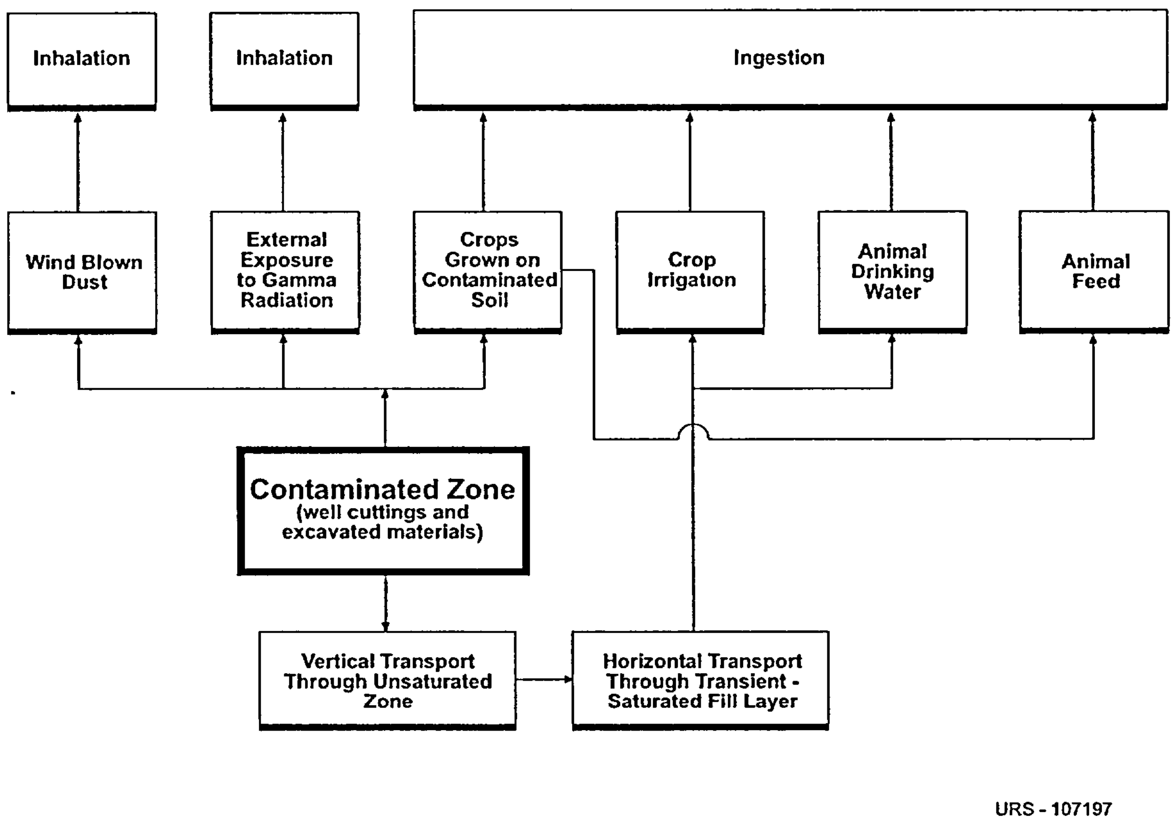

Figure 3- 2. RESRAD representation of the Steam Plant Backfill.

The input parameters and their sources for assessment of exposures related to the Steam Plant Backfill are summarized in Table A-1 of Appendix A. Site-specific values are used, whenever available. When not available, RESRAD default values are used in the analysis. Initial source concentrations of 0.5 pCi/g represent surface concentrations resulting from house construction and site excavation.

3.2 GENERAL SITE OVERBURDEN

RESRAD assesses exposures from the Overburden layer at the Site by assuming that contamination is brought to the surface from well drill cuttings and excavation into the Overburden layer for a house foundation and yard leveling. Exposures from ingesting contaminated meat, milk, and vegetation; inhaling dust, and direct gamma radiation exposure are evaluated. The application of RESRAD for exposures from the Overburden layer is illustrated in Figure 3-3. Consistent with RESRAD terminology, the waste is assumed to be brought to the surface, spread, and mixed as a result of house construction, site grading, and well excavation will represent the waste zone. The region below the surface mixing zone, but above the water table is represented as the unsaturated zone (vertical transport region).

Analysis of exposures, resulting from contaminants entrained in the undisturbed Overburden layer, are also evaluated. Contaminants not brought to the surface as part of excavation and site leveling activities are assumed to become leached into vertically traveling groundwater. It is then assumed that these contaminants travel to a well site, where they are pumped to the surface for human and livestock drinking water, as well as crop irrigation. The peak dose and year of occurrence is then computed.

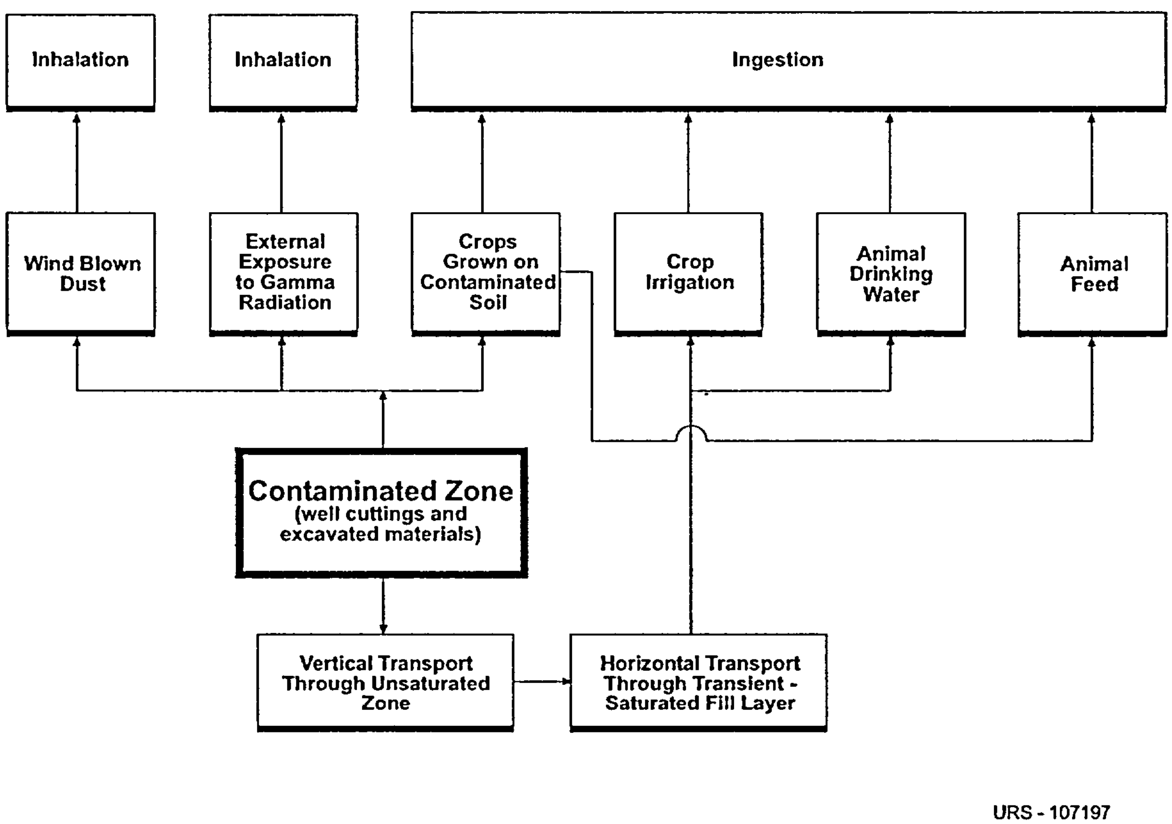

Figure 3- 3. RESRAD representation of the Overburden Layer.

The input parameters and their sources for assessment of exposures related to the Overburden layer are summarized in Table A-2 of Appendix A. Site-specific values are used, whenever available. When not available, RESRAD default values are used in the analysis. Initial source concentrations of 0.5 pCi/g represent surface concentrations resulting from house construction and site excavation.

3.3 BEDROCK

The third RESRAD application evaluates ingestion of drinking water from a well drilled into the Bedrock. Potential waste residing near the base of the CV, Steam Plant, or transported downward from the Spray Pond Fill is modeled by RESRAD as being directly above the water-saturated bedrock. As is illustrated in Figure 3-4, this zone of contamination is represented within RESRAD by assigning the vertical-transport vadose zone a negligible thickness and rapid transport properties (making the contamination immediately available to the groundwater). The input parameters and their sources for assessment of exposures related to the Bedrock layer are summarized in Table A-3 of Appendix A. Site-specific values are used, whenever available. When not available, RESRAD default values are used in the analysis.

3.4 METHODOLOGY

The technical approach and detailed steps for determining the DCGLs for the sub-surface materials at the SNEC Site are identified in Figure 3-5 based on discussions between URS and GPU personnel. The large gray numbers in Figure 3-5 correspond to the step numbers listed below.

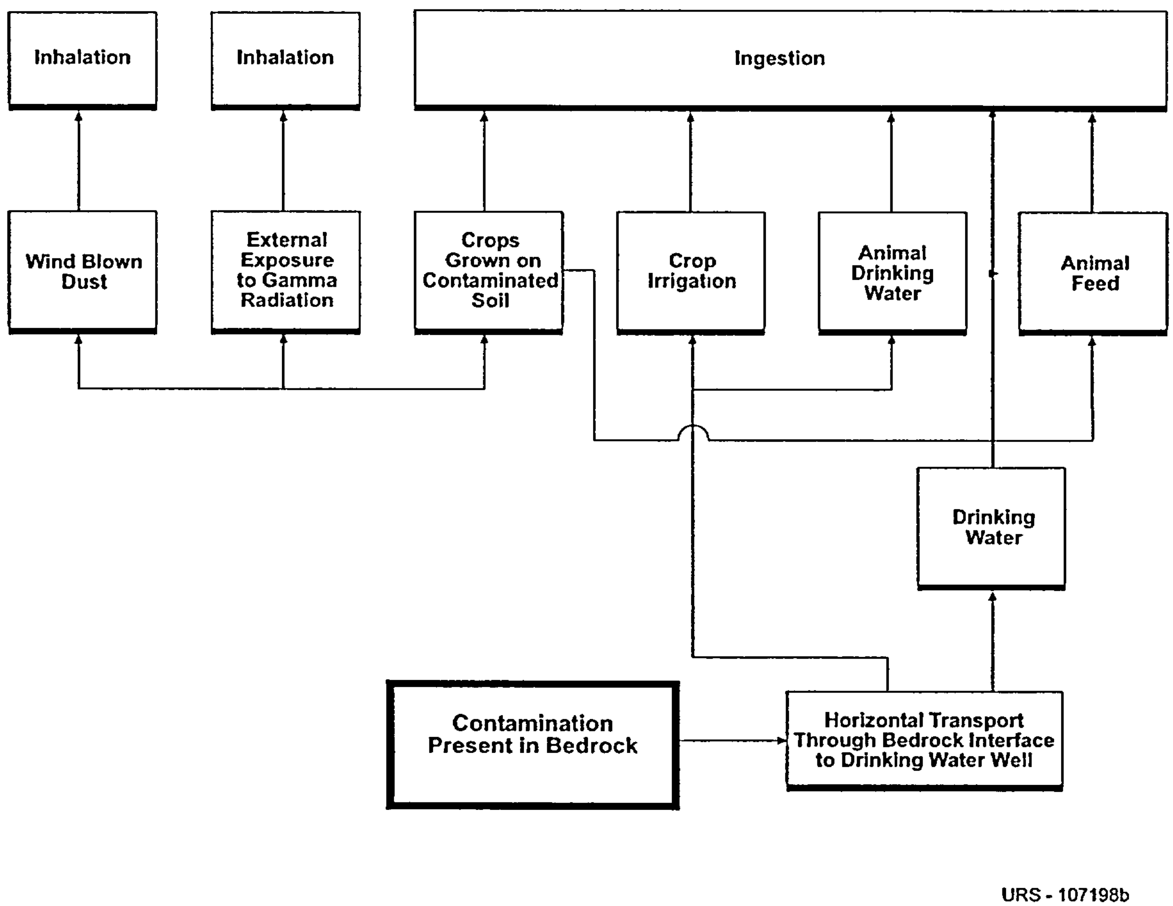

Figure 3- 4. RESRAD representation of the Bedrock Layer.

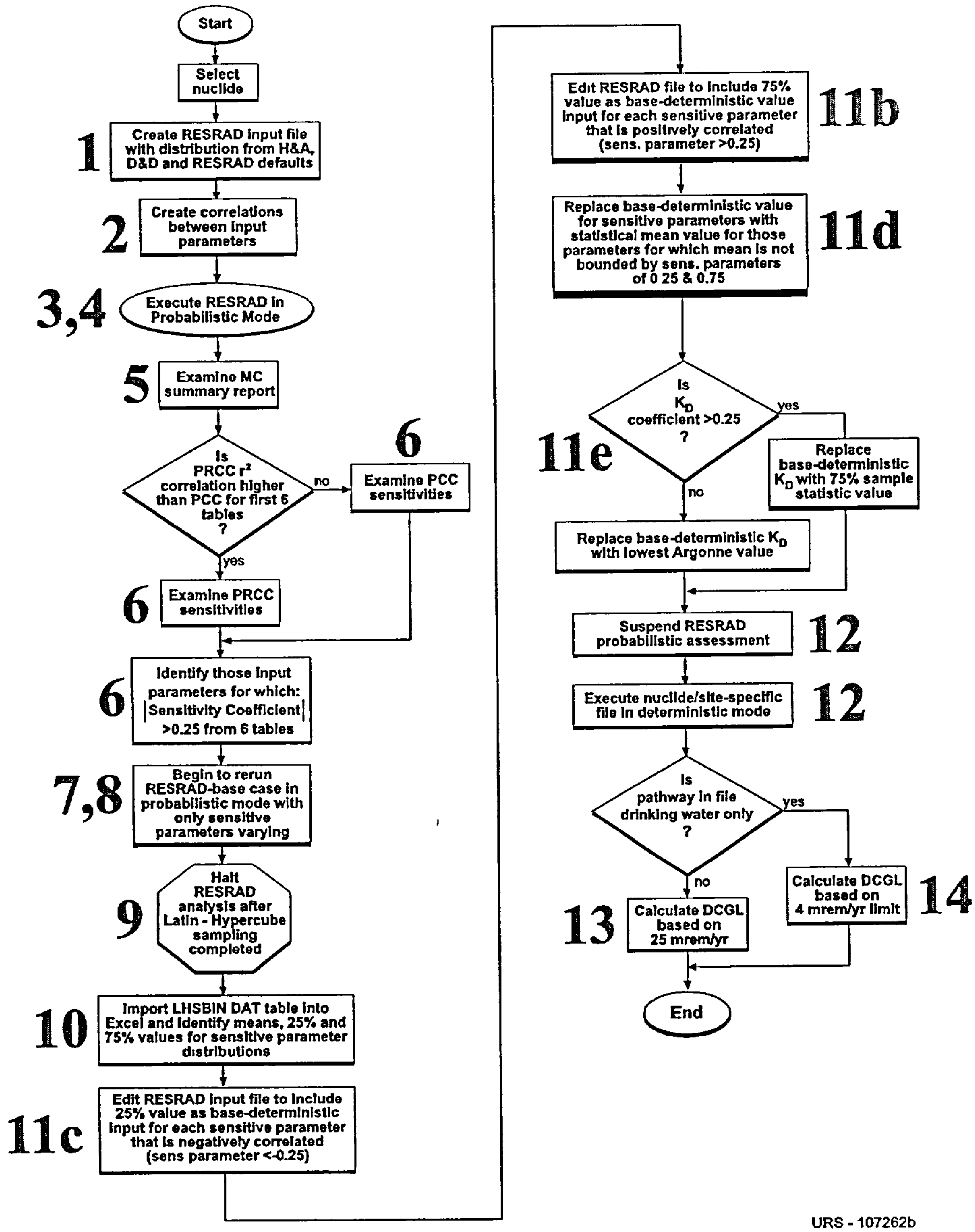

Figure 3- 5. DCGL Methodology.

1) Generate an appropriate RESRAD 6.1 input file containing all Haley and Aldrich (H & A) values and parameter distributions. Where available, DandD default values are used for metabolic and behavior inputs. For parameters for which input guidance is unavailable from either DandD or H & A, default RESRAD values and distributions are used. Uncertainty analysis is performed by RESRAD for each parameter for which a distribution has been input. A list of these values and distributions is presented in Tables A-1 through A-3 of Appendix A.

2) Uncertainty correlations are established between density and total porosity, density and effective porosity, and total porosity and effective porosity with a correlation value specified as 0.99.

3) A random seed of 1,000 is used for the uncertainty sampling. Additionally, the Latin HyperCube Sample (LHS) method is used to generate samples of input values for the probabilistic analysis. The analysis is repeated three times, with between 300 and 500 points selected for each analysis.

4) The RESRAD input file is then processed using the probabilistic analysis feature of RESRAD 6.1.

5) The first 6 correlation tables of the MCSUMMARY.REP file are then extracted. Within these tables, the higher correlation coefficient (r^2 value) between the PRCC and PCC sensitivity methods is highlighted.

6) Sensitive input parameters is then identified and highlighted for those parameters whose sensitivity correlation value is greater than 0.25 or less than -0.25, using the correlation method identified in 5) with the highest r^2 value.

7) A copy of the RESRAD input file generated in numbers 1 through 3 is then made. From within this copy, the uncertainties and input distributions are deleted for all insensitive parameters (those not highlighted in step 6).

8) Reprocessing of the RESRAD input file is then initiated using the probabilistic analysis feature of RESRAD 6.1.

9) Once the RESRAD processing has completed the LHS step, the RESRAD analysis is be halted.

10) The LHSBIN.DAT file is then imported into MS Excel and the MS Excel Data Analysis package is used to analyze the input parameter distributions to determine mean, 25^{th} percentile, and 75^{th} percentile for each sensitive input parameter.

11) The duplicate RESRAD input file, created in step 7, is then edited within RESRAD. Modifications include:

   a. Suppression of the uncertainty analysis.

   b. The 75th percentile value replaces the base-deterministic input value for those sensitive parameters whose coefficients of sensitivity are greater than 0.25.

   c. The 25th percentile value replaces the base-deterministic input value for those sensitive parameters whose coefficients of sensitivity are less than -0.25.

   d. The mean value calculated in step 10 replaces the base-deterministic input value for those sensitive parameters whose mean is not bounded by the 25th and 75th percentile values.

   e. Except when the coefficients of sensitivity for the distribution coefficients (K_d) are greater than 0.25, the minimum Argonne distribution coefficient (K_d) is used.

12) The input file created in step 11 is then analyzed using RESRAD 6.1 in a deterministic mode.

13) The 25 mrem/year dose limit is then divided by the peak dose to determine a DCGL representing exposure from all pathways. This process is performed for each nuclide, soil region, and SNEC area of concern.

14) Steps 1 through 12 are then repeated with all pathways turned off, except the drinking water pathway.

15) The 4 mrem/year drinking water dose limit is then divided by the peak dose from drinking water only to determine a DW DCGL. This process will be repeated for each nuclide, soil region, and SNEC area of concern.

4. ANALYSIS RESULTS

Radiation doses are determined for exposures to excavated and undisturbed contaminants in the Overburden soils and Bedrock for the steam plant and general site areas. The sensitivity of these projected doses to the various uncertainties of the input parameters has been examined. In accordance with the methodology presented in Chapter 3, conservative input values are selected for sensitive input parameters in order to determine DCGLs.

4.1 STEAM PLANT BACKFILL

Peak doses and years of occurrence are estimated for the backfill material present in the steam plant basement. As is discussed in the methodology presented in Chapter 3, doses are estimated from exposure of an onsite resident to excavated and undisturbed materials. These doses are then compared to the 25 mrem/year limit to compute appropriate layer- and area-specific DCLGs. The projected peak doses resulting from the exposure to drinking water only are also compared to the 4 mrem/year drinking water standard to estimate corresponding drinking-water specific DCGLs for the steam plant backfill materials. The resulting DCGLs are summarized in Table 4-1.

As is illustrated in the Table 4-1, DCGLs computed from exposures to excavated materials are most limiting when based upon the 25 mrem/year exposure standard and range from 5.6 pCi/g for Sr-90 to 41,000 pCi/g for Pu-241. DCGLs computed from drinking-water only exposures to excavated materials are significantly higher, ranging from 130 pCi/g for Pu-239 to $8.6x10^{22}$ pCi/g for Ni-63 (with specific activity as limits for Co-60 and Cs-137).

Table 4-1

Steam Plant Backfill DCGLs (pCi/g)

	Excavated Backfiill		Undistubed Backfill		
	All Paths	Drinking Water Only	All Paths	Drinking Water Only	Composite
H-3	2.3E+03	2.1E+04	1.5E+02	3.5E+01	**3.5E+01**
C-14	4.2E+01	2.9E+04	1.1E+01	5.6E+00	**5.6E+00**
Co-60	8.0E+00	- -[a]	5.8E+06	- -	**8.0E+00**
Ni-63	3.2E+03	8.6E+22	1.1E+08	5.6E+18	**3.2E+03**
Sr-90	5.6E+00	4.9E+02	3.3E+00	1.1E+00	**1.1E+00**
Cs-137	2.1E+01	- -	5.5E+08	- -	**2.1E+01**
Eu-152	2.1E+01	3.8E+17	3.8E+07	9.5E+14	**2.1E+01**
Pu-238	1.2E+02	6.6E+03	2.9E+02	9.1E+00	**9.1E+00**
Pu-239	1.1E+02	1.3E+02	1.9E+00	3.0E-01	**3.0E-01**
Pu-241	4.1E+03	8.0E+07	4.9E+04	9.3E+04	**4.1E+03**
Am-241	1.1E+02	1.5E+06	1.7E+03	3.1E+03	**1.1E+02**

[a] DCGL set to individual nuclide's specific activity limit.

DCGLs computed from exposures to the undisturbed backfill materials do not follow this trend. DCGLs based on 25 mrem/year from undisturbed backfill materials range from 1.9 pCi/g for Pu-239 to 5.5×10^{8} pCi/g for Cs-137. Drinking water only-DCGLs developed for undisturbed steam plant backfill range from 0.3 pCi/g for Pu-239 (much lower than the 25-mrem/year DCGL) to 5.6×10^{18} pCi/g for Ni-63 (much higher than the 25-mrem/year DCGL).

A comparison of these four sets of DCGLs (excavated and undisturbed backfill for all pathways and for drinking water only) reveals a single set of conservative DCGLs for the backfill material (see Table 4-1). This composite set ranges from 0.3 pCi/g for Pu-239 to 4,100 pCi/g for Pu-241.

4.2 GENERAL SITE OVERBURDEN

Peak doses and years of occurrence are also estimated for the subsurface overburden material generally present throughout the site area. Doses are estimated from exposure of an onsite resident to excavated and undisturbed overburden materials. These doses are then compared to the 25 mrem/year limit to compute appropriate layer- and area-specific DCLGs. The projected peak doses resulting from the exposure to drinking water only are also compared to the 4 mrem/year drinking water standard to estimate corresponding drinking-water specific DCGLs for the site overburden materials. The resulting DCGLs are summarized in Table 4-2.

As is illustrated in the Table 4-2, DCGLs computed from exposures to excavated materials are most limiting when based upon the 25 mrem/year exposure standard and range from 5.6 pCi/g for Sr-90 to 43,000 pCi/g for Pu-241. DCGLs computed from drinking-water only exposures to excavated materials are significantly higher, ranging from 7.4 pCi/g for Pu-239 to 7.5×10^{21} pCi/g for Ni-63 (with specific activity as limits for Co-60 and Cs-137).

Table 4-2

General Site Area Overburden DCGLs (pCi/g)

	Excavated Overburden		Undistubed Overburden		
	All Paths	Drinking Water Only	All Paths	Drinking Water Only	Composite
H-3	2.2E+03	1.4E+03	1.6E+02	8.0E+01	**8.0E+01**
C-14	4.2E+01	3.7E+03	2.0E+00	7.9E+00	**2.0E+00**
Co-60	8.0E+00	- -[a]	1.6E+02	6.7E+01	**8.0E+00**
Ni-63	3.2E+03	7.5E+21	3.2E+04	1.9E+04	**3.2E+03**
Sr-90	5.6E+00	4.2E+01	2.2E+00	6.0E-01	**6.0E-01**
Cs-137	2.1E+01	- -	7.2E+02	4.0E+02	**2.1E+01**
Eu-152	2.1E+01	2.4E+16	8.4E+03	1.4E+03	**2.1E+01**
Pu-238	1.3E+02	5.7E+02	2.1E+00	4.0E-01	**4.0E-01**
Pu-239	4.6E+01	7.4E+00	1.9E+00	3.0E-01	**3.0E-01**
Pu-241	4.3E+03	1.5E+06	1.3E+02	2.0E+01	**2.0E+01**
Am-241	1.1E+02	9.8E+04	1.2E+01	2.3E+00	**2.3E+00**

[a] DCGL set to individual nuclide's specific activity limit.

DCGLs computed from exposures to the undisturbed Overburden materials do not follow this trend. DCGLs based on 25 mrem/year from undisturbed Overburden materials range from 1.9 pCi/g for Pu-239 to 32,000 pCi/g for Ni-63. Drinking water only-DCGLs developed for undisturbed Overburden materials range from 0.3 pCi/g for Pu-239 to 19,000 pCi/g for Ni-63.

A comparison of these four sets of DCGLs (excavated and undisturbed backfill for all pathways and for drinking water only) reveals a single set of conservative DCGLs for the Overburden material (see Table 4-2). This composite set ranges from 0.3 pCi/g for Pu-239 to 3,200 pCi/g for Ni-63.

4.3 BEDROCK

Peak doses and years of occurrence are also estimated for the bedrock material present throughout the site area. Since it is unfeasible to assume significant excavation into the Bedrock, doses are estimated from exposure of an onsite resident to contaminated water pumped from the bedrock groundwater. These doses are then compared to the 25 mrem/year limit to compute appropriate layer-specific DCLGs. The projected peak doses resulting from the exposure to drinking water only are also compared to the 4 mrem/year drinking water standard to estimate corresponding drinking-water specific DCGLs for the site Bedrock materials. The resulting DCGLs are summarized in Table 4-3.

As is illustrated in the Table 4-3, DCGLs computed from exposures to contaminated water from the Bedrock when based upon the 25 mrem/year exposure standard range from 1.4 pCi/g for Sr-90 to 32,000 pCi/g for Ni-63. DCGLs computed from drinking-water only exposures to bedrock materials range from 0.3 pCi/g for Pu-239 to 20,000 pCi/g for Ni-63.

Table 4-3

General Site Area Bedrock DCGLs (pCi/g)

	Undisturbed Bedrock		
	All Paths	Drinking Water Only	Composite
H-3	1.3E+02	3.1E+01	**3.1E+01**
C-14	3.3E+00	5.4E+00	**3.3E+00**
Co-60	1.5E+02	6.7E+01	**6.7E+01**
Ni-63	3.2E+04	2.0E+04	**2.0E+04**
Sr-90	1.4E+00	6.0E-01	**6.0E-01**
Cs-137	6.6E+02	4.0E+02	**4.0E+02**
Eu-152	5.7E+03	1.4E+03	**1.4E+03**
Pu-238	1.8E+00	4.0E-01	**4.0E-01**
Pu-239	1.6E+00	3.0E-01	**3.0E-01**
Pu-241	8.7E+01	2.0E+01	**2.0E+01**
Am-241	9.9E+00	2.3E+00	**2.3E+00**

A comparison of these two sets of DCGLs (all pathways and for drinking water only) reveals a single set of conservative DCGLs for the Bedrock material (see Table 4-3). This composite set ranges from 0.3 pCi/g for Pu-239 to 20,000 pCi/g for Ni-63.

4.4 K_d UNCERTAINTY

As is described in the methodology presented in Chapter 3, the effects of distributions of uncertainties in input parameters is conservatively incorporated into the estimation of the DCGLs by using 25-percentile and 75-percentile input values for those parameters for which the resulting DCGLs are found to be highly sensitive. When available, input parameter distributions are derived from onsite measurements (e.g., water table fluctuation, individual layer thickness, etc.). When not available, RESRAD and DandD distribution defaults are employed. These distributions are summarized in the Tables included in Appendix A.

A range of site-specific K_d values is included in the distributions given in Appendix A. Individual K_d values were measured for the various materials available at the site. While the minimum and maximum of these K_d values is included in the distribution tables, measurement uncertainty and variation for each material type have not been examined. While a uniform profile is specified for the distribution shapes of H-3 and C-14 (based on historical data – Thibault 1990), no corresponding nuclide-specific distribution shapes can be specified for the remaining materials and isotopes. In addition to this, the use of available site materials for backfill activities as part of the decontamination efforts is also desired.

Because of this, the sensitivity of the composite DCGLs to uniform distributions in K_ds, bounded by the site materials minimum and maximum values, was also evaluated. A uniform distribution was selected in order to minimize the preferential selection of one material's K_d as part of the analysis. This selection is consistent with the RESRAD default distributions.

The RESRAD model default K_d distribution shape for nuclide K_d is generally identified as Log-Normal-N. Additionally, RESRAD includes means and geometric standard deviations as characteristic parameters for the default distributions. Examination of these characteristic parameters reveals that the site-specific K_d ranges are far outside of the RESRAD mean peaks. For example, the RESRAD mean K_d for Am-241 is 7.9, with a geometric standard deviation of 2.3. In comparison, the site specific values range from 1,000 to 5,000. Examination of the section of the RESRAD default distribution shape between the values of 1,000 and 5,000 reveals a relatively uniform shape.

Examination of the effects of variations and uncertainties on the site-composite DCGLs revealed many were unaffected by K_d variation (generally those nuclides for which the groundwater pathway is not a major contributor to the overall dose). For these cases, inclusion of the variations in K_d did not change the identified list of input parameters for which the DCGLs were sensitive.

For some isotopes (particularly those for which groundwater was a major contributor to the overall dose), the K_d parameter was identified as one for which the results were sensitive. For these nuclides, inclusion of variations in K_d did not change the sensitivity of the resulting DCGL to variations in other previously identified parameters. Additionally, examination of the nature of relation between K_d and resulting DCGL revealed a negative correlation (e.g., increases in K_d result in decreases in dose and increases in DCGL). Because of this, the methodology in Chapter 3 would suggest a selection of the 25 percentile value from the distribution of K_d values would be conservative. Therefore, the use of the minimum K_d, which are lower than the 25% value is conservative and maintains the freedom of being able to use any site material in decontamination activities.

5. SUMMARY AND CONCLUSIONS

In preparing to terminate the NRC license for the site, GPU determined DCGLs for the top meter of the SNEC site soil that correspond to the 25 mrem/year radiation dose limit prescribed by NRC for site cleanup. This report documents a conceptual model and methodology developed by URS to determine DCGLs for the sub-surface zone below the top meter of soil.

Two areas of concern are considered for estimating radiation doses for a resident / farmer scenario: the general site area (including the CV and the Spray Pond Areas) and the Steam Plant. Input parameters for which the resulting peak doses are most sensitive are identified. Conservative values are selected for each of these parameters and conservative DCGLs are calculated from the resulting peak radiation doses.

The site hydrology is dominated by a shallow Fill layer and a deeper Bedrock region, separated by a relatively impermeable Overburden layer. The Bedrock drains westward toward the River. Disturbed areas (or planned disturbed areas) of the Overburden at the perimeters of the CV, Steam Plant, tunnels, and Spray Ponds hydraulically connect the Fill and Bedrock and enhance drainage from the Site.

Radiation exposure pathways associated with the resident / farmer scenario are analyzed to estimate radiation doses. Gamma radiation exposures occur in the yard and through the house floor from radionuclides mixed into surface soils from excavation and well cuttings. Exposures from inhaling contaminated dust occur during site grading, well excavation, garden tillage, and wind resuspension. Exposures from ingesting contaminated soil occur from soil entrained on vegetables and unwashed hands. Exposures from ingesting contaminated drinking water occur from transport in the Bedrock. Exposures from ingesting contaminated fruits and vegetables occur via their uptake from contaminated surface soil and contaminated irrigation water. Exposures from meat and milk occur from contaminants in animal feed and water. Gamma radiation exposures occur in recreation while fishing, boating, and swimming. Additional recreation exposures also occur from ingesting contaminated water while swimming and from consuming fish from the River.

RESRAD Version 6.1is used to estimate and combine the exposure distributions for the critical times. RESRAD Version 6.1 computes probabilistic estimates of radiation dose distributions that result from various distributions of input parameters.

In order to account for plans of using heterogeneous Site materials for backfill and remediation, the lowest nuclide distribution coefficients are used in the analysis. This minimizes transport retardation and decay of contaminants, before they reach the point of exposure. This modeling conservatism allows single assessments of the Bedrock and Overburden layers to be conservatively applied site-wide. The first application of RESRAD represents the Fill layer and associated surface exposures. The second evaluates ingestion of drinking water and use for irrigation from a well drilled into the Bedrock.

NRC's site cleanup criterion of 25 mrem/year and the EPA 4 mrem/year drinking water criterion are used to determine the DCGLs for each nuclide in each subsurface material layer, based on the temporal peaks of the mean doses. As are listed in Table 5-1, the most limiting DCGLs are conservatively proposed as site-wide subsurface DCGLs for the materials deeper than one meter. This composite set ranges from 0.3 pCi/g for Pu-239 to 32,000 pCi/g for Ni-63.

Table 5-1

Site-Wide Composite Subsurface DCGLs (pCi/g)

	BACKFILL COMPOSITE	OVERBURDEN COMPOSITE	BEDROCK COMPOSITE	SITE-WIDE SUBSURFACE COMPOSITE
H-3	3.5E+01	8.0E+01	3.1E+01	**3.1E+01**
C-14	5.6E+00	2.0E+00	3.3E+00	**2.0E+00**
Co-60	8.0E+00	8.0E+00	6.7E+01	**8.0E+00**
Ni-63	3.2E+03	3.2E+03	2.0E+04	**3.2E+03**
Sr-90	1.1E+00	6.0E-01	6.0E-01	**6.0E-01**
Cs-137	2.1E+01	2.1E+01	4.0E+02	**2.1E+01**
Eu-152	2.1E+01	2.1E+01	1.4E+03	**2.1E+01**
Pu-238	9.1E+00	4.0E-01	4.0E-01	**4.0E-01**
Pu-239	3.0E-01	3.0E-01	3.0E-01	**3.0E-01**
Pu-241	4.1E+03	2.0E+01	2.0E+01	**2.0E+01**
Am-241	1.1E+02	2.3E+00	2.3E+00	**2.3E+00**

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APPENDIX A

RESRAD INPUT DISTRIBUTIONS

Appendix A

This appendix contains the input parameter distributions that are used to determine the DCGLs for the Steam Plant Backfill, Overburden layer, and River sediments. The resulting peak doses and DCGLs for these subsurface layers are also summarized.

TABLE A-1
Steam Plant Backfill Input Parameter Distributions

Menu	Class	PARAMETERS	Basic RESRAD Input	SNEC Range of Values Min.	SNEC Range of Values Max.	Assigned Distribution	Basis
C14	P	Thickness of Soil Evasion Layer of C-14 in Soil (m)	0.3	0.2	0.6	Triangular	SNEC 5/13/02
D-5	P	Bioaccumulation Factors, Fresh Water	Default Values	Varies	Varies	Lognormal	SNEC 5/13/02
D-34	P	Food Transfer Factors	Default Values	Varies	Varies	Lognormal	SNEC 5/13/02
RO11	P	Area of Contaminated Zone (m^2)	2000	N/A	N/A	N/A	URS Technical Approach 6/18/02
RO11	NRC	Basic Radiation Dose Limit (mrem/y) (NRC)	25	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Length Parallel to Aquifer Flow (m)	50.5	N/A	N/A	N/A	RESRAD Data Collection Handbook
RO11	P	Thickness of Contaminated Zone 1 (m)	2.000E-01	N/A	N/A	N/A	URS Technical Approach 6/18/02
RO11	P	Time Since Placement of Materials (yr)	0	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	1	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	3	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	10	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	35	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	150	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	300	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	1000	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	10000	N/A	N/A	N/A	SNEC 5/13/02
RO13	P	Average Annual Wind Speed (m/sec)	4.07	3.13	4.83	Uniform	SNEC 5/13/02
RO13	P	Contaminated Zone Field Capacity	0.1360	0.0790	0.1920	Uniform	Backfill properties assumed same as fill soil as per GPU direction 5/13/02
RO13	P	Contaminated Zone b Parameter	5.60	4.05	7.12	Uniform	Backfill properties assumed same as fill soil as per GPU direction 5/13/02
RO13	P, B	Contaminated Zone Erosion Rate (m/yr)	0.000345	0.00009	0.0006	Loguniform	Backfill properties assumed same as fill soil as per GPU direction 5/13/02
RO13	P	Contaminated Zone Hydraulic Conductivity (m/yr)	32.30	0.36	25400.00	Loguniform	Backfill properties assumed same as fill soil as per GPU direction 5/13/02
RO13	P	Contaminated Zone Total Porosity	0.460	0.350	0.560	Uniform	Backfill properties assumed same as fill soil as per GPU direction 5/13/02
RO13	P	Cover Depth (m)	0	N/A	N/A	N/A	SNEC 5/13/02
RO13	P	Density of Contaminated Zone (g/cc)	1.60	1.28	1.92	Uniform	Weighted average of fill and overburden as per URS Technical Approach 6/5/06
RO13	P	Density of Cover Material (g/cc)	Not Used	N/A	N/A	N/A	SNEC 5/13/02
RO13	P	Evapotranspiration Coefficient (m/yr)	0.59	0.5	0.67	Uniform	SNEC 5/13/02
RO13	P	Humidity in Air (g/m^3)	8 (H-3) not used for others	2.58E+00	2.03E+01	Truncated Lognormal-N	SNEC 5/13/02
RO13	B	Irrigation (m/yr)	0.2	---	---	None Assigned	SNEC 5/13/02
RO13	B	Irrigation Mode (Overhead)	Overhead	N/A	N/A	N/A	SNEC 5/13/02
RO13	P	Precipitation (m/y)	0.936	0.688	1.327	Uniform	SNEC 5/13/02
RO13	P	Runoff Coefficient	0.35	0.3	0.4	Uniform	SNEC 5/13/02
RO13	P	Watershed Area for Nearby Stream or Pond (m^2)	5.00E+06	---	---	None Assigned	SNEC 5/13/02
RO14	P	Density of Saturated Zone (g/cc)	1.6	1.28	1.92	Uniform	SNEC 5/13/02
RO14	P	Model: Non-dispersion (ND) or Mass-Balance (MB)	Non-Dispersion	N/A	N/A	N/A	SNEC 5/13/02
RO14	P	Saturated Zone b Parameter	Not Used	N/A	N/A	N/A	SNEC 5/13/02
RO14	P	Saturated Zone Effective Porosity	0.41	0.28	0.54	Loguniform	SNEC 5/13/02
RO14	P	Saturated Zone Hydraulic Conductivity (m/yr)	32.3	0.362	25400	Uniform	SNEC 5/13/02
RO14	P	Saturated Zone Hydraulic Gradient	0.02	0.013	0.03	Uniform	SNEC 5/13/02
RO14	P	Saturated Zone Total Porosity	0.46	0.35	0.56	Uniform	SNEC 5/13/02
RO14	P	Water Table Drop Rate (m/yr)	0	---	---	None Assigned	SNEC 5/13/02
RO14	P	Well Pump Intake Depth (m)	30.2	10.2	50.2	Uniform	SNEC 5/13/02 + 0.2m excavation as per URS Technical Approach 6/18/02
RO14	B, P	Well Pumping Rate (m^3/yr)	286.2	207.3	365	Uniform	SNEC 5/13/02
RO14	P	Saturated Zone Field Capacity	0.136	0.079	0.192	Uniform	SNEC 5/13/02
RO15	P	Density of Unsaturated Zone 1 (g/cc)	1.6	1.28	1.92	Uniform	SNEC 5/13/02
RO15	P	Effective Porosity of Unsaturated Zone 1	0.41	0.28	0.54	Uniform	SNEC 5/13/02
RO15	P	Hydraulic Conductivity of Unsaturated Zone 1 (m/yr)	32.3	0.362	25400	Loguniform	SNEC 5/13/02
RO15	P	Number of Unsaturated Zone Strata	1	N/A	N/A	N/A	SNEC 5/13/02
RO15	P	Thickness of Unsaturated Zone 1 (m)	1.25	1.00	1.50	Uniform	SNEC 5/13/02 + 1.0m original fill soil layer as per URS Technical Approach 6/18/02
RO15	P	Total porosity of Unsaturated Zone 1	0.46	0.35	0.56	Uniform	SNEC 5/13/02
RO15	P	Unsaturated Zone 1 b Parameter	5.6	4.05	7.12	Uniform	SNEC 5/13/02
RO15	P	Unsaturated Zone Field Capacity	0.136	0.079	0.192	Uniform	SNEC 5/13/02
RO17	P	External Gamma Shielding Factor	0.7	4.400E-02	1	Bounded Lognormal-N	SNEC 5/13/02
RO17	P, B	Indoor Dust Filtration Factor	0.4	0.15	0.95	Uniform	SNEC 5/13/02
RO17	B	Indoor Time Fraction	0.66	0	1	Continuos Linear	SNEC 5/13/02
RO17	M, P	Inhalation Rate (m^3/yr)	8400	4380	13100	Triangular	SNEC 5/13/02
RO17	P, B	Mass Loading for Inhalation (g/m^3)	0.0001	0	0.0001	Continuos Linear	SNEC 5/13/02
RO17	B	Fraction of Time Spent Outdoors	0.12	---	---	None Assigned	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Aquatic Food	1	0	1	Triangular	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Drinking Water	1	---	---	None Assigned	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Household Water	Not Used	N/A	N/A	N/A	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Irrigation Water	1	---	---	None Assigned	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Livestock Water	1	---	---	None Assigned	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Meat	1	---	---	None Assigned	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Milk	1	---	---	None Assigned	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Plant Food	1	---	---	None Assigned	SNEC 5/13/02
RO18	M, B	Drinking Water Intake (L/yr)	478.5	90.4	1860	Truncated Lognormal-N	SNEC 5/13/02
RO18	M, B	Fish Consumption (kg/yr)	20.6	---	---	None Assigned	SNEC 5/13/02
RO18	M, B	Fruit, Vegetable, and Grain Consumption (kg/yr)	111.8	135	318	Triangular	SNEC 5/13/02
RO18	M, B	Leafy Vegetable Consumption (kg/yr)	21.4	---	---	None Assigned	SNEC 5/13/02

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TABLE A-1

Steam Plant Backfill Input Parameter Distributions

RO18	M, B	Meat and Poultry Consumption (kg/yr)	67	---	---	None Assigned	SNEC 5/13/02
RO18	M, B	Milk Consumption	233	60	200	Triangular	SNEC 5/13/02
RO18	M, B	Other Seafood Consumption (kg/yr)	0.9	---	---	None Assigned	SNEC 5/13/02
RO18	M, B	Soil Ingestion Rate (g/yr)	18.3	0	36.5	Triangular	SNEC 5/13/02
RO19	M, B	Livestock Water Intake for Milk	60	---	---	None Assigned	SNEC 5/13/02
RO19	M, B	Depth of Roots (m)	0.9	0.3	1	Uniform	SNEC 5/13/02
RO19	M, B	Depth of Soil Mixing Layer (m)	0.15	0	0.6	Triangular	SNEC 5/13/02
RO19B	M, B	Weathering Removal Constant of all Vegetation	20	5.1	84	Triangular	SNEC 5/13/02
RO19B	M, B	Wet Crop Yield for Fodder (kg/m^2)	1.1	---	---	None Assigned	SNEC 5/13/02
RO19B	M, B	Wet Crop Yield for Leafy (kg/m^2)	1.5	---	---	None Assigned	SNEC 5/13/02
RO19B	M, B	Wet Crop Yield for Non-Leafy (kg/m^2)	0.7	0.397	7.72	Truncated Lognormal-N	SNEC 5/13/02
RO19B	M, B	Wet Foliar Inception Fraction of Leafy Vegetables	0.25	0.06	0.95	Triangular	SNEC 5/13/02
STOR	B	Storage Times for Livestock Fodder	0	---	---	None Assigned	SNEC 5/13/02
		Distribution Coefficient for Americium & Curium	*Value Used*	*ANL Min.*	*ANL Max.*	*Distribution Type*	
R16	P	1. Contaminated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
		Distribution Coefficient for Carbon	*ANL Value*	*GPU Min.*	*GPU Max.*	*Distribution Type*	
R16	P	1. Contaminated Zone (cm^3/g)	~1	0	5	Uniform	SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	~1	0	5	Uniform	SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	~1	0	5	Uniform	SNEC 5/13/02
		Distribution Coefficient for Cesium	*Value Used*	*ANL Min.*	*ANL Max.*	*Distribution Type*	
R16	P	1. Contaminated Zone (cm^3/g)	2131	2131	28341		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	2131	2131	28341		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	2131	2131	28341		SNEC 5/13/02
		Distribution Coefficient for Cobalt	*Value Used*	*ANL Min.*	*ANL Max.*	*Distribution Type*	
R16	P	1. Contaminated Zone (cm^3/g)	200	200	1000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	200	200	1000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	200	200	1000		SNEC 5/13/02
		Distribution Coefficient for Europium	*Value Used*	*ANL Min.*	*ANL Max.*	*Distribution Type*	
R16	P	1. Contaminated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
		Distribution Coefficient for Hydrogen	*ANL Value (GPU)*	*GPU Min.*	*GPU Max.*	*Distribution Type*	
R16	P	1. Contaminated Zone (cm^3/g)	~1 (0.25)	0	0.5	Uniform	SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	~1 (0.25)	0	0.5	Uniform	SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	~1 (0.25)	0	0.5	Uniform	SNEC 5/13/02
		Distribution Coefficient for Iron	*Value Used*	*GPU Min.*	*GPU Max.*	*Distribution Type*	
R16	P	1. Contaminated Zone (cm^3/g)	10000	10000	50000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	10000	10000	50000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	10000	10000	50000		SNEC 5/13/02
		Distribution Coefficient for Lead	*Value Used*	*ANL Min.*	*ANL Max.*	*Distribution Type*	
R16	P	1. Contaminated Zone (cm^3/g)	9700	9700	160000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	9700	9700	160000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	9700	9700	160000		SNEC 5/13/02
		Distribution Coefficient for Nickel	*Value Used*	*ANL Min.*	*ANL Max.*	*Distribution Type*	
R16	P	1. Contaminated Zone (cm^3/g)	1300	1300	10000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	1300	1300	10000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	1300	1300	10000		SNEC 5/13/02
		Distribution Coefficient for Plutonium	*Value Used*	*ANL Min.*	*ANL Max.*	*Distribution Type*	
R16	P	1. Contaminated Zone (cm^3/g)	160	160	600		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	160	160	600		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	160	160	600		SNEC 5/13/02
		Distribution Coefficient for Strontium	*Value Used*	*ANL Min.*	*ANL Max.*	*Distribution Type*	
R16	P	1. Contaminated Zone (cm^3/g)	11	11	475		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	11	11	475		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	11	11	475		SNEC 5/13/02
		Distribution Coefficient for Uranium	*Value Used*	*ANL Min.*	*ANL Max.*	*Distribution Type*	
R16	P	1. Contaminated Zone (cm^3/g)	16	16	5200		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	16	16	5200		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	16	16	5200		SNEC 5/13/02

NOTE: ANL Kd values may be "greater than" values. The ANL Min. value is the lowest reported value for this element and the ANL Max. value is the highest reported value.

NOTE: Items in RED type face are SNEC input values.

NOTE: Items in GREEN type face are URS input values.

NOTE: Items with BLUE background are D & D default values, while items with a YELLOW background are RESRAD default values. Unlisted parameters are RESRAD defaults.

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TABLE A-2
General Area Overburden Input Parameter Distributions

Menu	Class	PARAMETERS	Basic RESRAD Input	SNEC Range of Values Min.	SNEC Range of Values Max.	Assigned Distribution	Basis
C14	P	Thickness of Soil Evasion Layer of C-14 in Soil (m)	0.3	0.2	0.6	Triangular	SNEC 5/13/02
D-5	P	Bioaccumulation Factors, Fresh Water	Default Values	Varies	Varies	Lognormal	SNEC 5/13/02
D-34	P	Food Transfer Factors	Default Values	Varies	Varies	Lognormal	SNEC 5/13/02
RO11	P	Area of Contaminated Zone (m^2)	2000	N/A	N/A	N/A	URS Technical Approach 6/18/02
RO11	NRC	Basic Radiation Dose Limit (mrem/y) (NRC)	25	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Length Parallel to Aquifer Flow (m)	50.5	N/A	N/A	N/A	RESRAD Data Collection Handbook
RO11	P	Thickness of Contaminated Zone 1 (m)	2.000E-01	N/A	N/A	N/A	URS Technical Approach 6/18/02
RO11	P	Time Since Placement of Materials (yr)	0	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	1	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	3	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	10	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	35	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	150	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	300	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	1000	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	10000	N/A	N/A	N/A	SNEC 5/13/02
RO13	P	Average Annual Wind Speed (m/sec)	4.07	3.13	4.83	Uniform	SNEC 5/13/02
RO13	P	Contaminated Zone Field Capacity	0.1360	0.0790	0.1920	Uniform	overburden as per URS Technical Approach 6/18/02
RO13	P	Contaminated Zone b Parameter	5.60	4.05	7.12	Uniform	Weighted average of fill and overburden as per URS Technical Approach 6/5/03
RO13	P, B	Contaminated Zone Erosion Rate (m/yr)	0.000345	0.00009	0.0006	Loguniform	SNEC 5/13/02
RO13	P	Contaminated Zone Hydraulic Conductivity (m/yr)	50.11	7.98	13154.77	Loguniform	Weighted average of fill and overburden as per URS Technical Approach 6/5/03
RO13	P	Contaminated Zone Total Porosity	0.410	0.330	0.485	Uniform	Weighted average of fill and overburden as per URS Technical Approach 6/5/03
RO13	P	Cover Depth (m)	0	N/A	N/A	N/A	SNEC 5/13/02
RO13	P	Density of Contaminated Zone (g/cc)	1.60	1.28	1.92	Uniform	Weighted average of fill and overburden as per URS Technical Approach 6/5/06
RO13	P	Density of Cover Material (g/cc)	Not Used	N/A	N/A	N/A	SNEC 5/13/02
RO13	P	Evapotranspiration Coefficient (m/yr)	0.59	0.5	0.67	Uniform	SNEC 5/13/02
RO13	P	Humidity in Air (g/m^3)	8 (H-3) not used for others	2.58E+00	2.03E+01	Truncated Lognormal-N	SNEC 5/13/02
RO13	B	Irrigation (m/yr)	0.2	---	---	None Assigned	SNEC 5/13/02
RO13	B	Irrigation Mode (Overhead)	Overhead	N/A	N/A	N/A	SNEC 5/13/02
RO13	P	Precipitation (m/y)	0.936	0.688	1.327	Uniform	SNEC 5/13/02
RO13	P	Runoff Coefficient	0.35	0.3	0.4	Uniform	SNEC 5/13/02
RO13	P	Watershed Area for Nearby Stream or Pond (m^2)	5.00E+06	---	---	None Assigned	SNEC 5/13/02
RO14	P	Density of Saturated Zone (g/cc)	1.6	1.28	1.92	Uniform	SNEC 5/13/02
RO14	P	Model: Non-dispersion (ND) or Mass-Balance (MB)	Non-Dispersion	N/A	N/A	N/A	SNEC 5/13/02
RO14	P	Saturated Zone b Parameter	Not Used	N/A	N/A	N/A	SNEC 5/13/02
RO14	P	Saturated Zone Effective Porosity	0.028	0.005	0.05	Loguniform	SNEC 5/13/02
RO14	P	Saturated Zone Hydraulic Conductivity (m/yr)	67.91	15.59	909.53	Uniform	SNEC 5/13/02
RO14	P	Saturated Zone Hydraulic Gradient	0.02	0.013	0.03	Uniform	SNEC 5/13/02
RO14	P	Saturated Zone Total Porosity	0.36	0.31	0.41	Uniform	SNEC 5/13/02
RO14	P	Water Table Drop Rate (m/yr)	0	---	---	None Assigned	SNEC 5/13/02
RO14	P	Well Pump Intake Depth (m)	30.2	10.2	50.2	Uniform	SNEC 5/13/02 + 0.2m excavation as per URS Technical Approach 6/18/02
RO14	B, P	Well Pumping Rate (m^3/yr)	286.2	207.3	365	Uniform	SNEC 5/13/02
RO14	P	Saturated Zone Field Capacity	0.136	0.079	0.192	Uniform	SNEC 5/13/02
RO15	P	Density of Unsaturated Zone 1 (g/cc)	1.6	1.28	1.92	Uniform	SNEC 5/13/02
RO15	P	Effective Porosity of Unsaturated Zone 1	0.41	0.28	0.54	Uniform	SNEC 5/13/02
RO15	P	Hydraulic Conductivity of Unsaturated Zone 1 (m/yr)	32.3	0.362	25400	Loguniform	SNEC 5/13/02
RO15	P	Number of Unsaturated Zone Strata	1	N/A	N/A	N/A	SNEC 5/13/02
RO15	P	Thickness of Unsaturated Zone 1 (m)	1.25	1.00	1.50	Uniform	SNEC 5/13/02 + 1.0m original fill soil layer as per URS Technical Approach 6/18/02
RO15	P	Total porosity of Unsaturated Zone 1	0.46	0.35	0.56	Uniform	SNEC 5/13/02
RO15	P	Unsaturated Zone 1 b Parameter	5.6	4.05	7.12	Uniform	SNEC 5/13/02
RO15	P	Unsaturated Zone Field Capacity	0.136	0.079	0.192	Uniform	SNEC 5/13/02
RO17	P	External Gamma Shielding Factor	0.7	4.400E-02	1	Bounded Lognormal-N	SNEC 5/13/02
RO17	P, B	Indoor Dust Filtration Factor	0.4	0.15	0.95	Uniform	SNEC 5/13/02
RO17	B	Indoor Time Fraction	0.66	0	1	Continuos Linear	SNEC 5/13/02
RO17	M, P	Inhalation Rate (m^3/yr)	8400	4380	13100	Triangular	SNEC 5/13/02
RO17	P, B	Mass Loading for Inhalation (g/m^3)	0.0001	0	0.0001	Continuos Linear	SNEC 5/13/02
RO17	B	Fraction of Time Spent Outdoors	0.12	---	---	None Assigned	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Aquatic Food	1	0	1	Triangular	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Drinking Water	1	---	---	None Assigned	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Household Water	Not Used	N/A	N/A	N/A	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Irrigation Water	1	---	---	None Assigned	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Livestock Water	1	---	---	None Assigned	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Meat	1	---	---	None Assigned	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Milk	1	---	---	None Assigned	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Plant Food	1	---	---	None Assigned	SNEC 5/13/02
RO18	M, B	Drinking Water Intake (L/yr)	478.5	90.4	1860	Truncated Lognormal-N	SNEC 5/13/02
RO18	M, B	Fish Consumption (kg/yr)	20.6	---	---	None Assigned	SNEC 5/13/02
RO18	M, B	Fruit, Vegetable, and Grain Consumption (kg/yr)	111.8	135	318	Triangular	SNEC 5/13/02
RO18	M, B	Leafy Vegetable Consumption (kg/yr)	21.4	---	---	None Assigned	SNEC 5/13/02
RO18	M, B	Meat and Poultry Consumption (kg/yr)	67	---	---	None Assigned	SNEC 5/13/02
RO18	M, B	Milk Consumption	233	60	200	Triangular	SNEC 5/13/02

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TABLE A-2

General Area Overburden Input Parameter Distributions

RO18	M, B	Other Seafood Consumption (kg/yr)	0.9	---	---	None Assigned	SNEC 5/13/02
RO18	M, B	Soil Ingestion Rate (g/yr)	18.3	0	36.5	Triangular	SNEC 5/13/02
RO19	M, B	Livestock Water Intake for Milk	60	---	---	None Assigned	SNEC 5/13/02
RO19	M, B	Depth of Roots (m)	0.9	0.3	1	Uniform	SNEC 5/13/02
RO19	M, B	Depth of Soil Mixing Layer (m)	0.15	0	0.6	Triangular	SNEC 5/13/02
RO19B	M, B	Weathering Removal Constant of all Vegetation	20	5.1	84	Triangular	SNEC 5/13/02
RO19B	M, B	Wet Crop Yield for Fodder (kg/m^2)	1.1	---	---	None Assigned	SNEC 5/13/02
RO19B	M, B	Wet Crop Yield for Leafy (kg/m^2)	1.5	---	---	None Assigned	SNEC 5/13/02
RO19B	M, B	Wet Crop Yield for Non-Leafy (kg/m^2)	0.7	0.397	7.72	Truncated Lognormal-N	SNEC 5/13/02
RO19B	M, B	Wet Foliar Inception Fraction of Leafy Vegetables	0.25	0.06	0.95	Triangular	SNEC 5/13/02
STOR	B	Storage Times for Livestock Fodder	0	---	---	None Assigned	SNEC 5/13/02
		Distribution Coefficient for Americium & Curium	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
		Distribution Coefficient for Carbon	***ANL Value***	***GPU Min.***	***GPU Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	~1	0	5	Uniform	SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	~1	0	5	Uniform	SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	~1	0	5	Uniform	SNEC 5/13/02
		Distribution Coefficient for Cesium	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	2131	2131	28341		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	2131	2131	28341		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	2131	2131	28341		SNEC 5/13/02
		Distribution Coefficient for Cobalt	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	200	200	1000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	200	200	1000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	200	200	1000		SNEC 5/13/02
		Distribution Coefficient for Europium	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
		Distribution Coefficient for Hydrogen	***ANL Value (GPU)***	***GPU Min.***	***GPU Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	~1 (0.25)	0	0.5	Uniform	SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	~1 (0.25)	0	0.5	Uniform	SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	~1 (0.25)	0	0.5	Uniform	SNEC 5/13/02
		Distribution Coefficient for Iron	***Value Used***	***GPU Min.***	***GPU Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	10000	10000	50000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	10000	10000	50000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	10000	10000	50000		SNEC 5/13/02
		Distribution Coefficient for Lead	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	9700	9700	160000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	9700	9700	160000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	9700	9700	160000		SNEC 5/13/02
		Distribution Coefficient for Nickel	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	1300	1300	10000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	1300	1300	10000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	1300	1300	10000		SNEC 5/13/02
		Distribution Coefficient for Plutonium	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	160	160	600		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	160	160	600		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	160	160	600		SNEC 5/13/02
		Distribution Coefficient for Strontium	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	11	11	475		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	11	11	475		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	11	11	475		SNEC 5/13/02
		Distribution Coefficient for Uranium	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	16	16	5200		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	16	16	5200		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	16	16	5200		SNEC 5/13/02

NOTE: ANL Kd values may be "greater than" values. The ANL Min. value is the lowest reported value for this element and the ANL Max. value is the highest reported value.
NOTE: Items in RED type face are SNEC input values.
NOTE: Items in GREEN type face are URS input values.
NOTE: Items with BLUE background are D & D default values, while items with a YELLOW background are RESRAD default values. Unlisted parameters are RESRAD defaults.

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TABLE A-3
Bedrock Input Parameter Distributions

Menu	Class	PARAMETERS	Basic RESRAD Input	SNEC Range of Values Min.	SNEC Range of Values Max.	Assigned Distribution	Basis
C14	P	Thickness of Soil Evasion Layer of C-14 in Soil (m)	0.3	0.2	0.6	Triangular	SNEC 5/13/02
D-5	P	Bioaccumulation Factors, Fresh Water	Default Values	Varies	Varies	Lognormal	SNEC 5/13/02
D-34	P	Food Transfer Factors	Default Values	Varies	Varies	Lognormal	SNEC 5/13/02
RO11	P	Area of Contaminated Zone (m^2)	10000	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO11	NRC	Basic Radiation Dose Limit (mrem/y) (NRC)	4	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Length Parallel to Aquifer Flow (m)	112.8	N/A	N/A	N/A	RESRAD Data Collection Handbook
RO11	P	Thickness of Contaminated Zone 1 (m)	2.000E+00	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO11	P	Time Since Placement of Materials (yr)	0	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	1	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	3	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	10	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	35	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	150	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	300	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	1000	N/A	N/A	N/A	SNEC 5/13/02
RO11	P	Times for Calculations (yr)	10000	N/A	N/A	N/A	SNEC 5/13/02
RO13	P	Average Annual Wind Speed (m/sec)	4.07	3.13	4.83	Uniform	SNEC 5/13/02
RO13	P	Contaminated Zone Field Capacity	0.136	0.079	0.192	Uniform	SNEC 5/13/02
RO13	P	Contaminated Zone b Parameter	5.6	4.05	7.12	Uniform	SNEC 5/13/02
RO13	P, B	Contaminated Zone Erosion Rate (m/yr)	0.000345	0.00009	0.0006	Loguniform	SNEC 5/13/02
RO13	P	Contaminated Zone Hydraulic Conductivity (m/yr)	67.91	15.59	909.53	Uniform	SNEC 5/13/02
RO13	P	Contaminated Zone Total Porosity	0.36	0.31	0.41	Uniform	SNEC 5/13/02
RO13	P	Cover Depth (m)	3.0	N/A	N/A	N/A	SNEC 5/13/02 & URS Technical Approach 6/5/02
RO13	P, B	Cover Depth Erosion Rate (m/yr)	0.000345	0.00009	0.0006	Loguniform	SNEC 5/13/02
RO13	P	Density of Contaminated Zone (g/cc)	1.6	1.28	1.92	Uniform	SNEC 5/13/02
RO13	P	Density of Cover Material (g/cc)	1.6 (reported as not used by RESRAD)	1.28	1.92	Uniform	SNEC 5/13/02
RO13	P	Evapotranspiration Coefficient (m/yr)	0.59	0.5	0.67	Uniform	SNEC 5/13/02
RO13	P	Humidity in Air (g/m^3)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO13	B	Irrigation (m/yr)	0.2	---	---	None Assigned	SNEC 5/13/02
RO13	B	Irrigation Mode (Overhead)	Overhead	N/A	N/A	N/A	SNEC 5/13/02
RO13	P	Precipitation (m/y)	0.936	0.688	1.327	Uniform	SNEC 5/13/02
RO13	P	Runoff Coefficient	0.35	0.3	0.4	Uniform	SNEC 5/13/02
RO13	P	Watershed Area for Nearby Stream or Pond (m^2)	5.00E+06	---	---	None Assigned	SNEC 5/13/02
RO14	P	Density of Saturated Zone (g/cc)	1.6	1.28	1.92	Uniform	SNEC 5/13/02
RO14	P	Model: Non-dispersion (ND) or Mass-Balance (MB)	Mass Balance	N/A	N/A	N/A	SNEC 5/13/02
RO14	P	Saturated Zone b Parameter	Not Used	N/A	N/A	N/A	SNEC 5/13/02
RO14	P	Saturated Zone Effective Porosity	0.028	0.005	0.05	Loguniform	SNEC 5/13/02
RO14	P	Saturated Zone Hydraulic Conductivity (m/yr)	67.91	15.59	909.53	Uniform	SNEC 5/13/02
RO14	P	Saturated Zone Hydraulic Gradient	0.02	0.013	0.03	Uniform	SNEC 5/13/02
RO14	P	Saturated Zone Total Porosity	0.36	0.31	0.41	Uniform	SNEC 5/13/02
RO14	P	Water Table Drop Rate (m/yr)	0	---	---	None Assigned	SNEC 5/13/02
RO14	P	Well Pump Intake Depth (m)	30.2	10.2	50.2	Uniform	SNEC 5/13/02 + 0.2m excavation as per URS Technical Approach 6/5/02
RO14	B, P	Well Pumping Rate (m^3/yr)	286.2 (reported as not used by RESRAD)	207.3	365	Uniform	SNEC 5/13/02
RO14	P	Saturated Zone Field Capacity	0.136	0.079	0.192	Uniform	SNEC 5/13/02
RO15	P	Density of Unsaturated Zone 1 (g/cc)	1.6	1.28	1.92	Uniform	SNEC 5/13/02
RO15	P	Effective Porosity of Unsaturated Zone 1	0.41	0.28	0.54	Uniform	SNEC 5/13/02
RO15	P	Hydraulic Conductivity of Unsaturated Zone 1 (m/yr)	67.91	15.59	909.53	Loguniform	SNEC 5/13/02
RO15	P	Number of Unsaturated Zone Strata	1	N/A	N/A	N/A	SNEC 5/13/02
RO15	P	Thickness of Unsaturated Zone 1 (m)	0.0010	N/A	N/A	N/A	URS Technical Approach 6/5/02 (effectively zero)
RO15	P	Total porosity of Unsaturated Zone 1	0.46	0.35	0.56	Uniform	SNEC 5/13/02
RO15	P	Unsaturated Zone 1 b Parameter	5.6	4.05	7.12	Uniform	SNEC 5/13/02
RO15	P	Unsaturated Zone Field Capacity	0.136	0.079	0.192	Uniform	SNEC 5/13/02
RO17	P	External Gamma Shielding Factor	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO17	P, B	Indoor Dust Filtration Factor	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO17	B	Indoor Time Fraction	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO17	M, P	Inhalation Rate (m^3/yr)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO17	P, B	Mass Loading for Inhalation (g/m^3)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO17	B	Fraction of Time Spent Outdoors	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO18	B, P	Contaminated Fraction of Aquatic Food	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO18	B, P	Contaminated Fraction of Drinking Water	1	---	---	None Assigned	SNEC 5/13/02
RO18	B, P	Contaminated Fraction of Household Water	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO18	B, P	Contaminated Fraction of Irrigation Water	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO18	B, P	Contaminated Fraction of Livestock Water	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO18	B, P	Contaminated Fraction of Meat	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO18	B, P	Contaminated Fraction of Milk	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO18	B, P	Contaminated Fraction of Plant Food	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO18	M, B	Drinking Water Intake (L/yr)	478.5	90.4	1860	Truncated Lognormal-N	SNEC 5/13/02
RO18	M, B	Fish Consumption (kg/yr)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO18	M, B	Fruit, Vegetable, and Grain Consumption (kg/yr)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02

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TABLE A-3
Bedrock Input Parameter Distributions

RO18	M, B	Leafy Vegetable Consumption (kg/yr)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO18	M, B	Meat and Poultry Consumption (kg/yr)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO18	M, B	Milk Consumption	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO18	M, B	Other Seafood Consumption (kg/yr)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO18	M, B	Soil Ingestion Rate (g/yr)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO19	M, B	Livestock Water Intake for Milk	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO19	M, B	Depth of Roots (m)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO19	M, B	Depth of Soil Mixing Layer (m)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO19B	M, B	Weathering Removal Constant of all Vegetation	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO19B	M, B	Wet Crop Yield for Fodder (kg/m^2)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO19B	M, B	Wet Crop Yield for Leafy (kg/m^2)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO19B	M, B	Wet Crop Yield for Non-Leafy (kg/m^2)	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
RO19B	M, B	Wet Foliar Inception Fraction of Leafy Vegetables	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
STOR	B	Storage Times for Livestock Fodder	N/A	N/A	N/A	N/A	URS Technical Approach 6/5/02
		Distribution Coefficient for Americium & Curium	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
		Distribution Coefficient for Carbon	***ANL Value***	***GPU Min.***	***GPU Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	~1	0	5	Uniform	SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	~1	0	5	Uniform	SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	~1	0	5	Uniform	SNEC 5/13/02
		Distribution Coefficient for Cesium	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	2131	2131	28341		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	2131	2131	28341		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	2131	2131	28341		SNEC 5/13/02
		Distribution Coefficient for Cobalt	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	200	200	1000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	200	200	1000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	200	200	1000		SNEC 5/13/02
		Distribution Coefficient for Europium	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	1000	1000	5000		SNEC 5/13/02
		Distribution Coefficient for Hydrogen	***ANL Value (GPU)***	***GPU Min.***	***GPU Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	~1 (0.25)	0	0.5	Uniform	SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	~1 (0.25)	0	0.5	Uniform	SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	~1 (0.25)	0	0.5	Uniform	SNEC 5/13/02
		Distribution Coefficient for Iron	***Value Used***	***GPU Min.***	***GPU Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	10000	10000	50000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	10000	10000	50000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	10000	10000	50000		SNEC 5/13/02
		Distribution Coefficient for Lead	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	9700	9700	160000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	9700	9700	160000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	9700	9700	160000		SNEC 5/13/02
		Distribution Coefficient for Nickel	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	1300	1300	10000		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	1300	1300	10000		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	1300	1300	10000		SNEC 5/13/02
		Distribution Coefficient for Plutonium	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	160	160	600		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	160	160	600		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	160	160	600		SNEC 5/13/02
		Distribution Coefficient for Strontium	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	11	11	475		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	11	11	475		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	11	11	475		SNEC 5/13/02
		Distribution Coefficient for Uranium	***Value Used***	***ANL Min.***	***ANL Max.***	***Distribution Type***	
R16	P	1. Contaminated Zone (cm^3/g)	16	16	5200		SNEC 5/13/02
R16	P	2. Unsaturated Zone (cm^3/g)	16	16	5200		SNEC 5/13/02
R16	P	3. Saturated Zone (cm^3/g)	16	16	5200		SNEC 5/13/02

NOTE: ANL Kd values may be "greater than" values. The ANL Min. value is the lowest reported value for this element and the ANL Max. value is the highest reported value.
NOTE: Items in RED type face are SNEC input values.
NOTE: Items in GREEN type face are URS input values.
NOTE: Items with BLUE background are D & D default values, while items with a YELLOW background are RESRAD default values. Unlisted parameters are RESRAD defaults.

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TABLE A-4
DOSE AND DCGL SUMMARY

	SPRAY POND AND GENERAL AREA							
	Excavated Overburden on Surface				Undisturbed Overburden			
	All Paths		Drinking Water Only		All Paths		Drinking Water Only	
Limit->	25 (mrem/yr)		4 (mrem/yr)		25 (mrem/yr)		4 (mrem/yr)	
	Peak Dose (mrem/yr) [year]	DCGL	Peak Dose (mrem/yr) [year]	DCGL	Peak Dose (mrem/yr) [year]	DCGL	Peak Dose (mrem/yr) [year]	DCGL
H-3	1.14E-02 0	2.2E+03	2.78E-03 2	1.4E+03	1.57E-01 0	1.6E+02	5.03E-02 0	8.0E+01
C-14	5.94E-01 0	4.2E+01	1.09E-03 8	3.7E+03	1.23E+01 0	2.0E+00	5.04E-01 0	7.9E+00
Co-60	3.09E+00 0	8.0E+00	- -		1.56E-01 1	1.6E+02	5.94E-02 1	6.7E+01
Ni-63	7.76E-03 0	3.2E+03	5.31E-22 4,879	7.5E+21	7.89E-04 6	3.2E+04	2.08E-04 4	1.9E+04
Sr-90	4.40E+00 0	5.6E+00	9.45E-02 54	4.2E+01	1.10E+01 0	2.2E+00	6.55E+00 0	6.0E-01
Cs-137	1.18E+00 0	2.1E+01	- -		3.48E-02 9	7.2E+02	1.01E-02 5	4.0E+02
Eu-152	1.21E+00 0	2.1E+01	1.69E-16 3,587	2.4E+16	2.97E-03 4	8.4E+03	2.77E-03 2	1.4E+03
Pu-238	2.00E-01 0	1.3E+02	6.96E-03 471	5.7E+02	1.18E+01 1	2.1E+00	9.49E+00 1	4.0E-01
Pu-239	5.46E-01 970	4.6E+01	5.39E-01 894	7.4E+00	1.31E+01 1	1.9E+00	1.07E+01 1	3.0E-01
Pu-241	5.86E-03 34	4.3E+03	2.64E-06 3,949	1.5E+06	1.99E-01 0	1.3E+02	2.02E-01 0	2.0E+01
Am-241	2.32E-01 0	1.1E+02	4.10E-05 1,040	9.8E+04	2.14E+00 4	1.2E+01	1.73E+00 7	2.3E+00

	BEDROCK			
	Undisturbed Bedrock			
	All Paths		Drinking Water Only	
Limit->	25 (mrem/yr)		4 (mrem/yr)	
	Peak Dose (mrem/yr) [year]	DCGL	Peak Dose (mrem/yr) [year]	DCGL
H-3	1.89E-01 0	1.3E+02	1.28E-01 0	3.1E+01
C-14	7.57E+00 0	3.3E+00	7.31E-01 0	5.4E+00
Co-60	1.63E-01 1	1.5E+02	5.99E-02 1	6.7E+01
Ni-63	7.74E-04 6	3.2E+04	1.99E-04 9	2.0E+04
Sr-90	1.69E+01 0	1.4E+00	6.55E+00 0	6.0E-01
Cs-137	3.81E-02 7	6.6E+02	1.01E-02 5	4.0E+02
Eu-152	4.36E-03 3	5.7E+03	2.77E-03 2	1.4E+03
Pu-238	1.38E+01 1	1.8E+00	9.54E+00 1	4.0E-01
Pu-239	1.54E+01 1	1.6E+00	1.07E+01 1	3.0E-01
Pu-241	2.88E-01 1	8.7E+01	2.02E-01 0	2.0E+01
Am-241	2.51E+00 4	9.9E+00	1.73E+00 7	2.3E+00

	SSGS							
	Excavated Backfill on Surface				Undistubed Backfill			
	All Paths		Drinking Water Only		All Paths		Drinking Water Only	
Limit->	25 (mrem/yr)		4 (mrem/yr)		25 (mrem/yr)		4 (mrem/yr)	
	Peak Dose (mrem/yr) [year]	DCGL	Peak Dose (mrem/yr) [year]	DCGL	Peak Dose (mrem/yr) [year]	DCGL	Peak Dose (mrem/yr) [year]	DCGL
H-3	1.08E-02 0	2.3E+03	1.91E-04 1	2.1E+04	1.69E-01 1	1.5E+02	1.15E-01 1	3.5E+01
C-14	5.94E-01 0	4.2E+01	1.40E-04 9	2.9E+04	2.25E+00 8	1.1E+01	7.11E-01 8	5.6E+00
Co-60	3.09E+00 0	8.0E+00	- -		4.34E-06 0	5.8E+06	- -	
Ni-63	7.76E-03 0	3.2E+03	4.64E-23 4,881	8.6E+22	2.19E-07 1,222	1.1E+08	7.11E-19 4,616	5.6E+18
Sr-90	4.40E+00 0	5.6E+00	8.19E-03 41	4.9E+02	7.45E+00 34	3.3E+00	3.39E+00 28	1.1E+00
Cs-137	1.18E+00 0	2.1E+01	- -		4.54E-08 0	5.5E+08	- -	
Eu-152	1.21E+00 0	2.1E+01	1.04E-17 3,131	3.8E+17	6.64E-07 0	3.8E+07	4.21E-15 2,358	9.5E+14
Pu-238	2.02E-01 0	1.2E+02	6.07E-04 471	6.6E+03	8.61E-02 614	2.9E+02	4.35E-01 391	9.1E+00
Pu-239	2.23E-01 0	1.1E+02	3.13E-02 756	1.3E+02	1.28E+01 1	1.9E+00	1.05E+01 391	3.0E-01
Pu-241	6.14E-03 38	4.1E+03	4.97E-08 1,664	8.0E+07	5.07E-04 1,693	4.9E+04	4.31E-05 1,456	9.3E+04
Am-241	2.32E-01 0	1.1E+02	2.74E-06 4,455	1.5E+06	1.49E-02 1,702	1.7E+03	1.29E-03 1,459	3.1E+03

	SITE SUBSURFACE MINIMUM
	DCGL
H-3	3.1E+01 *
C-14	2.0E+00
Co-60	8.0E+00
Ni-63	3.2E+03
Sr-90	6.0E-01 *
Cs-137	2.1E+01
Eu-152	2.1E+01
Pu-238	4.0E-01 *
Pu-239	3.0E-01 *
Pu-241	2.0E+01 *
Am-241	2.3E+00 *

*(based on 4 mrem/yr)

C07